# LOUISIANA COASTAL AREA, BARATARIA BASIN BARRIER SHORELINE RESTORATION PROJECT LAFOURCHE, JEFFERSON, AND PLAQUEMINES PARISHES, LOUISIANA FINAL REPORT

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## COMMUNICATION

FROM

## THE ASSISTANT SECRETARY, ARMY, CIVIL WORKS, THE DEPARTMENT OF DEFENSE

TRANSMITTING

LOUISIANA COASTAL AREA, BARATARIA BASIN BARRIER SHORELINE RESTORATION PROJECT LAFOURCHE, JEFFERSON, AND PLAQUEMINES PARISHES, LOUISIANA FINAL REPORT

## PART 2 OF 3

JULY 8, 2013.—Referred to the Committee on Transportation and Infrastructure and ordered to be printed

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U.S. GOVERNMENT PRINTING OFFICE

81–892 WASHINGTON : 2013

AUTHENTICATED
U.S. GOVERNMENT
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# LOUISIANA COASTAL AREA
# BARATARIA BASIN BARRIER SHORELINE RESTORATION
# FINAL CONSTRUCTION REPORT
# AND
# FINAL ENVIRONMENTAL IMPACT STATEMENT

## ENGINEERING APPENDIX
## APPENDIX A

# LOUISIANA COASTAL AREA, BARATARIA BASIN BARRIER SHORELINE RESTORATION FINAL CONSTRUCTION REPORT AND FINAL ENVIRONMENTAL IMPACT STATEMENT

## ENGINEERING APPENDIX

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# LOUISIANA COASTAL AREA, BARATARIA BASIN BARRIER SHORELINE RESTORATION FINAL CONSTRUCTION REPORT AND FINAL ENVIRONMENTAL IMPACT STATEMENT

## ENGINEERING APPENDIX

### GENERAL

This Engineering Appendix outlines the engineering and design work done to support the preparation of the Louisiana Coastal Area (LCA), Barataria Basin Barrier Shoreline Restoration (BBBS) Construction Report and Final Environmental Impact Statement. The Barataria Basin Barrier Shoreline is the regional segment of the Gulf Coast of Louisiana that is situated between the west bank of the Mississippi River at the active delta and the eastern shore of Terrebonne Bay (figure 1). The design for this study covers the Caminada Headland and Shell Island reaches of the Barataria Basin Barrier Island Chain. A value engineering study was completed in March 2006 and its recommendations incorporated in the alternative analyses.

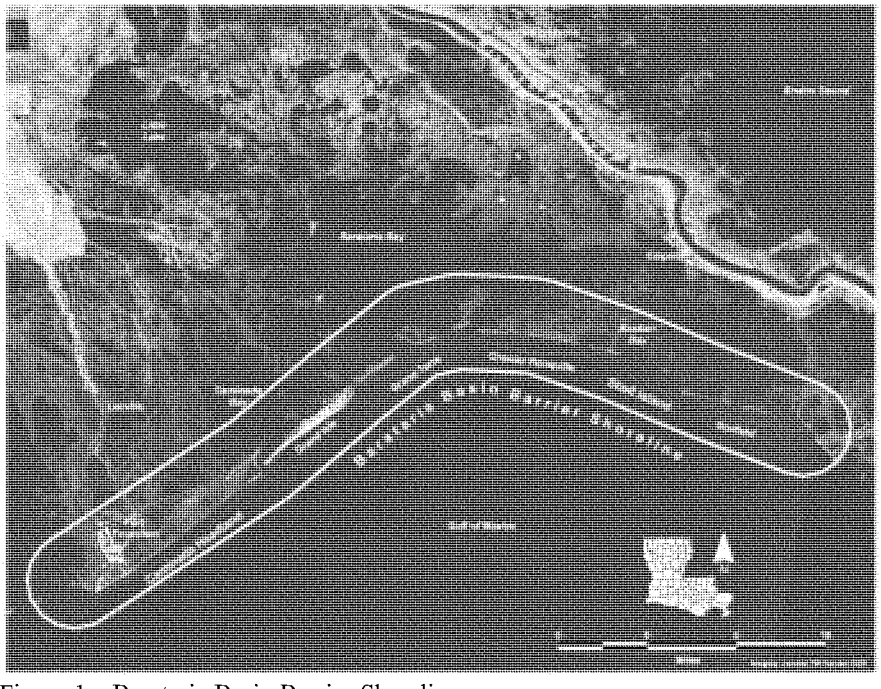

Figure 1 – Barataria Basin Barrier Shoreline

## ENGINEERING AND DESIGN

Engineering and design details for the project can be found in annex 1 for the Caminada Headland reach of the project and annex 2 for the Shell Island Reach of the project. These annexes cover surveying and mapping, hydraulics and hydrology, geotechnical analysis, design and cost estimating aspects of the project design. Additional modeling and engineering information can be found in Annex 3. Additional design and cost information is shown below.

### *Caminada*

General

The Caminada Headland Project site is located in Lafourche Parish and is approximately 13 miles long, extending from the Belle Pass entrance to Port Fourchon on the west to Caminada Pass on the eastern end of the Headland (figure 2). The project area is bounded by the Gulf of Mexico to the south and Highway 1 to the north. The Caminada Headland consists of a sand dune, beach berm, barrier marshes, and Chenier ridges interspersed with lagoons and small bayous.

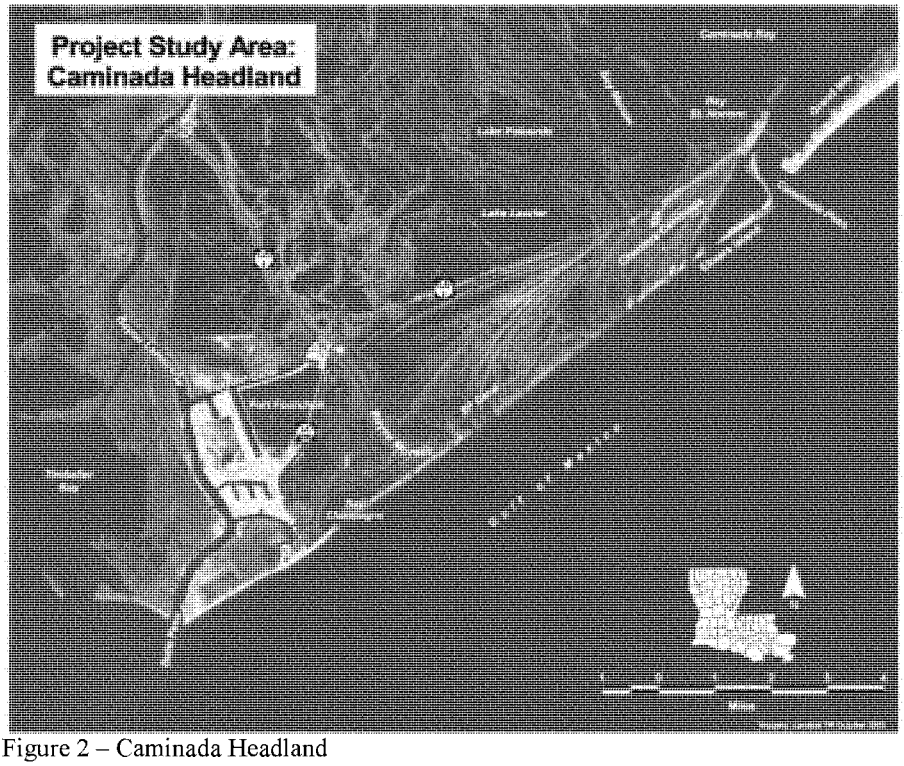


Figure 2 – Caminada Headland

Modeling

Cross-shore sediment transport modeling was performed using the Storm-induced Beach Change (SBEACH) model for various normal and storm conditions on the proposed alternative fill templates to determine how the fill material would adjust and equilibrate under various storm scenarios. Five alternatives were used as input in the numerical model for comparison of the progression of profile evolution. These alternatives are described below. Further details of the modeling can be found in annex 1.

1) Existing beach profile
2) Marsh fill only - Marsh on the landward side of the dune at an elevation of +2.
3) Beach fill with a low and wide dune crest – Dune elevation was increased from +4 to +6 with a 200 ft wide dune crest.
4) Beach fill with a high and narrow dune crest – Dune elevation raised from +4 to +8 with a 125 ft dune crest width.
5) Landward beach fill with an intermediate dune crest and significant majority of the fill volume placed on the landward part of the profile – Dune crest elevation increased from +4 to +7 with a crest width of 465 feet with a large landward fill and no seaward fill component.

Alternative Analysis

Based on modeling results alternatives 2 through 5 listed above were chosen for further analysis. These 4 alternative templates and slight variations thereof were used to develop 10 alternatives of varying combination and nourishment intervals. The 10 alternatives were evaluated based on technical, environmental, fiscal, and institutional planning constraints. Details of the plan selection process are included in the Main Report. The tentatively selected plan has a dune height of +7 feet North American Vertical Datum (NAVD)1988 with a dune width of 290 feet. The landward and seaward slopes are 20 horizontal to 1 vertical. Marsh fill would be placed on the landward side of the beach and dune at an elevation of +2.0 feet NAVD. Plan view and cross sections are shown in figures 3 and 4. Additional design details can be found in annex 1.

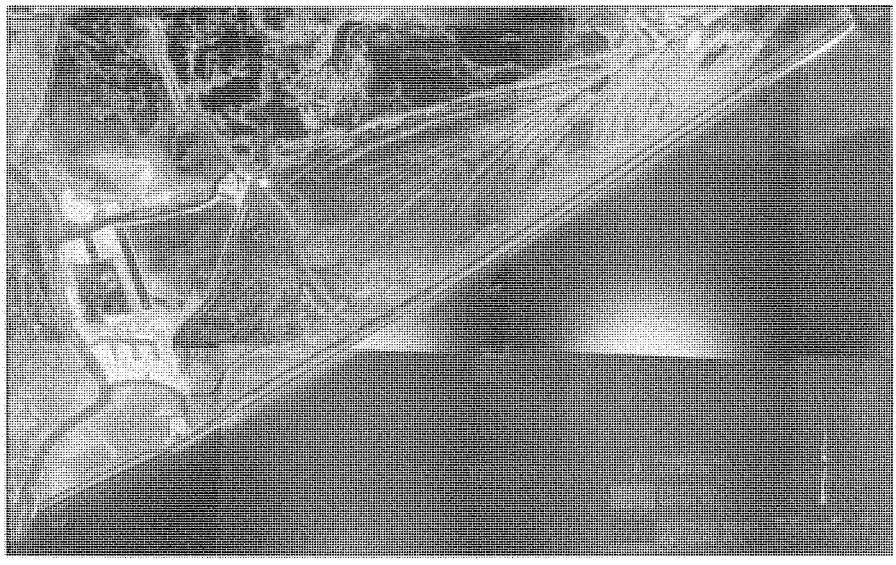

Figure 3 – Plan View Caminada

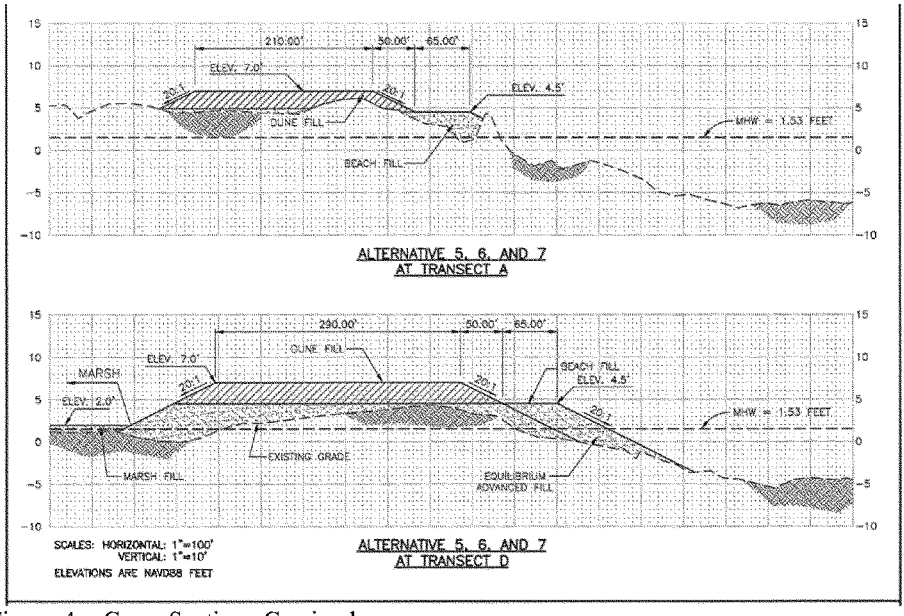


Figure 4 - Cross Sections Caminada

Construction

Approximately 880 acres of beach/dune and 1,186 acres of marsh would be created, resulting in a total of 2,066 acres. Fill quantities for the dune and marsh fills are 5.1 million and 5.36 million cubic yards, respectively. For the dune area, material from Ship Shoal would be pumped from two hopper dredges to the beach. The material would then be worked on the beach by bulldozers and front-end loaders. Points of direct access to the project area are Louisiana Highway 3090 and a beach road at Elmer's Island on the eastern end. For the marsh area, the material would be pumped from the offshore borrow site south of Bayou Moreau using a cutterhead dredge. The dune would serve as the southern dike for the marsh fill. Additional dikes would be constructed around the remaining perimeter. These operations would be completed in a manner that would minimize turbidity of the water at the dredge site and the discharge site. It is estimated that construction would last 936 days.

Approximately 71,500 feet of sand fencing would be installed. On the Caminada Headland, the fences would be constructed near Louisiana Highway 3090 to promote dune stabilization and reduce environmental damages to the newly constructed dunes. Vegetative plantings would include a variety of native species. The recommended planting density is no greater than 8-foot centers. The estimated duration of plantings is 750 days over a 3-year period.

The borrow area identified for the beach/dune restoration is Ship Shoal, a large submerged sand body in the Gulf of Mexico located offshore in south-central Louisiana. The shoal is about 31 miles long and 7 miles wide, lying in water depths of 9 feet to 30 feet. Preliminary studies have shown it is the remaining seaward shoal from one of the older, abandoned Mississippi River deltas. It is composed of well-graded quartz sand and

is suitable for use in restoring the Caminada Headland since its grain size is similar to the sand found on the Headland. The sediment is to originate from a section of Ship Shoal, South Pelto, Blocks 12 and 13, which is approximately 30 to 40 miles from the project site (figure 5). The borrow site for the marsh restoration is located approximately 1.5 miles south of the central portion of the Caminada Headland, and 4.7 miles southwest of Caminada Pass (figure 5).

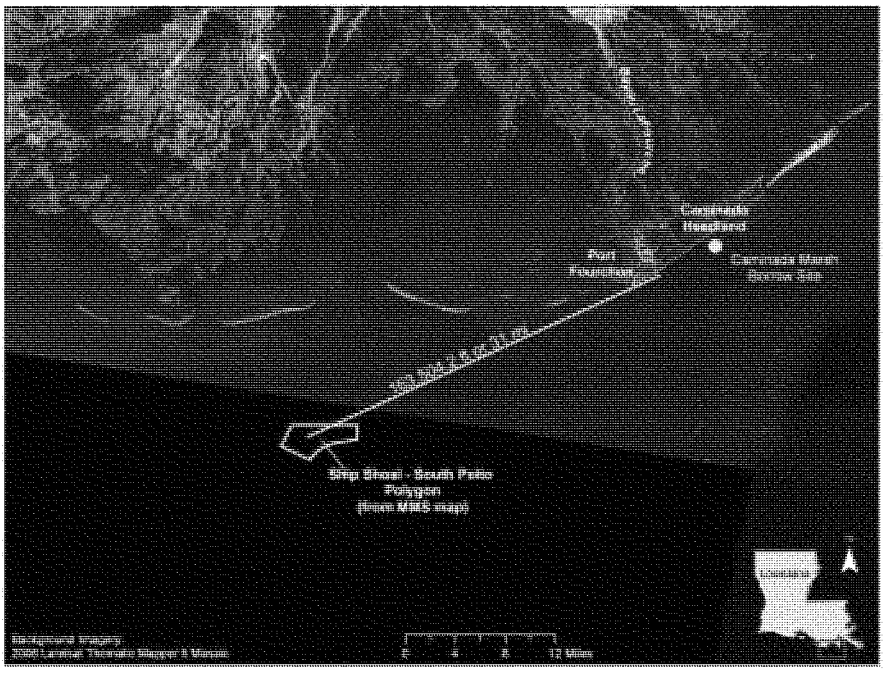


Figure 5 – Borrow Sources for the Caminada Headland

Renourishment

USACE operations and maintenance dredging of the Bayou Lafourche, Louisiana (Belle Pass) navigation project yields on average approximately 650,000 cubic yards of material every 1.5 to 2 years. This material will be placed in the littoral drift south of Bayou Moreau where the long shore transport of material splits going east and west. The material will be placed, allowing the long shore transport and wave action to move and place the sediment along the headland. Over each 10 year period, an estimated 3.9 million cubic yards of material will be returned to the headland.

***Shell Island***

General

Shell Island is located in Plaquemines Parish, immediately west of the Empire Jetties (figure 6). The Shell Island Reach is currently highly fragmented into small, shallow shoals and islands, which represent only a fraction of the once continuous shoreline.

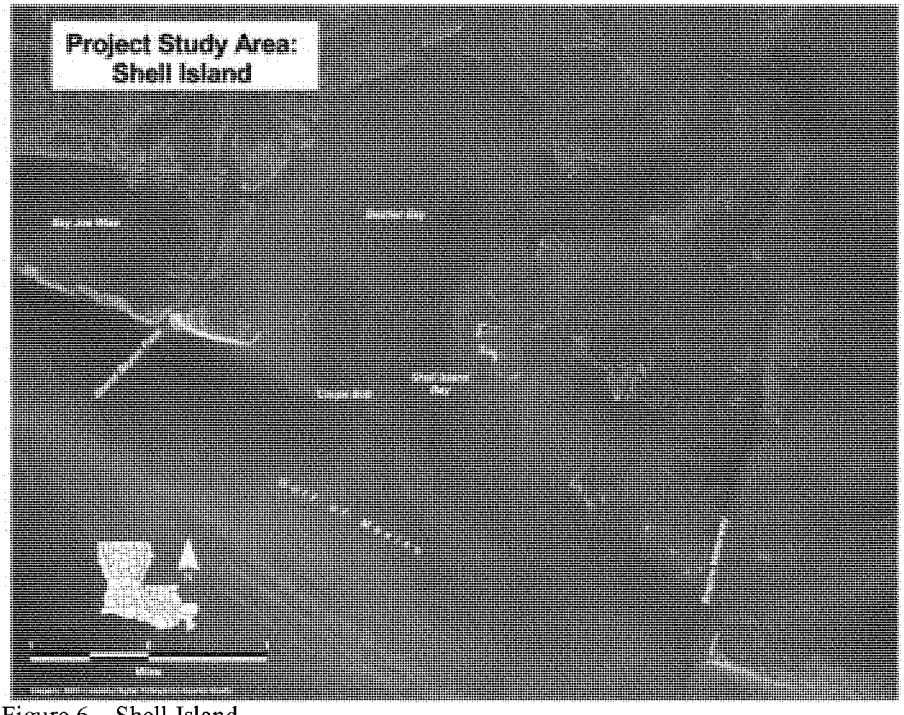


Figure 6 – Shell Island

Modeling

Cross-shore modeling (SBEACH) was used to evaluate the performance of proposed cross-sections with respect to overtopping and post-storm dune elevation. Details of this modeling can be found in annex 2.

The goal of the analysis was to determine a cross-section that would resist breaching and maintain a sufficient dune elevation to prevent overtopping by more frequent storm events. A post-storm dune elevation of +4 feet was chosen as a minimum acceptable average post-storm dune elevation for the Shell Island design cross-section. The modeling suggested that a 100-foot design dune crest was needed to achieve a +4 feet (NAVD88) post-storm crest elevation under the worst-case scenario.

Alternative Analysis

Using the template suggested by the modeling results, beach fill platforms were developed for eight alternatives. These alternatives included one island and two island alternatives with variations in advanced fill volume and renourishment intervals. The single island alternatives, alternatives 3 – 8, have the same initial construction template and include closing Coupe Bob and creating one single island. These alternatives also include marsh fill behind the beach fill platforms. Taking into account existing geotechnical conditions and future sea level rise, the marsh was designed to obtain an elevation above +1.2 at target year (TY) 50. Marsh would be constructed to elevation +2.0 to +2.5 depending on renourishment.

These eight alternatives were evaluated based on technical and environmental performance and planning constraints.

The tentatively selected plan for Shell Island is restoration of the reach into a single island. The island has a dune crest with an elevation of +6.0 feet NAVD88 with a marsh elevation of +2.0 feet NAVD88. The island will have a width of 1,240 feet following equilibration of the shoreline fill including a uniform marsh width of 735 feet. The dune crest width is a uniform 189 feet along the length of the island. Plan view and cross sections are shown in figure 7, figure 8, figure 9 and figure 10. Further design details can be found in annex 2.

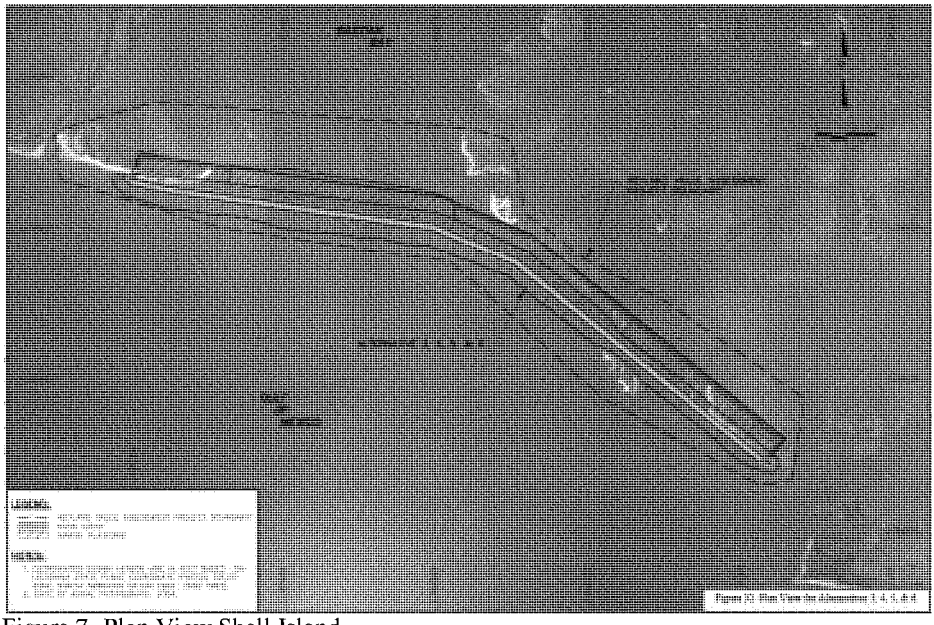

Figure 7- Plan View Shell Island

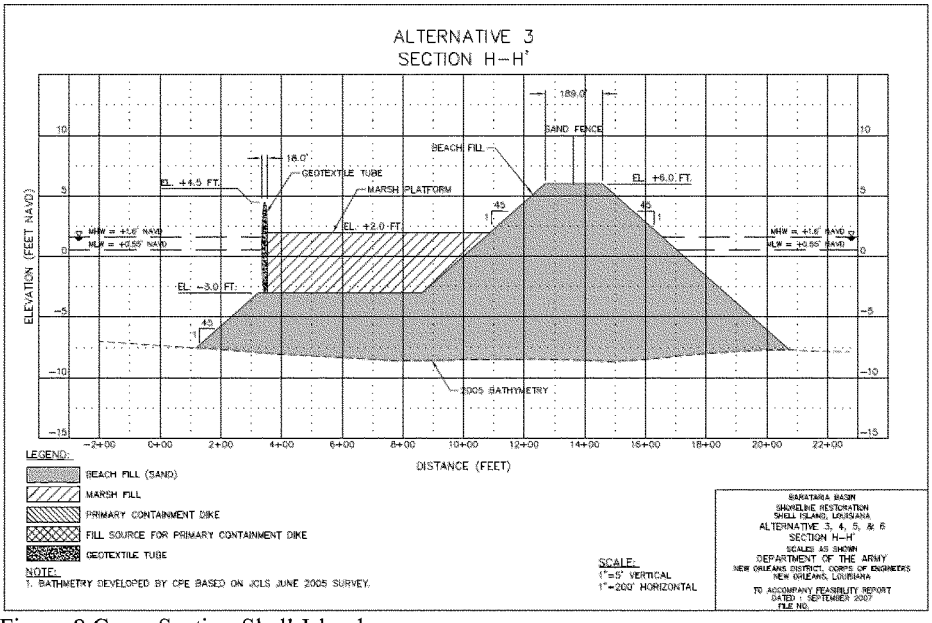


Figure 8 Cross Section Shell Island

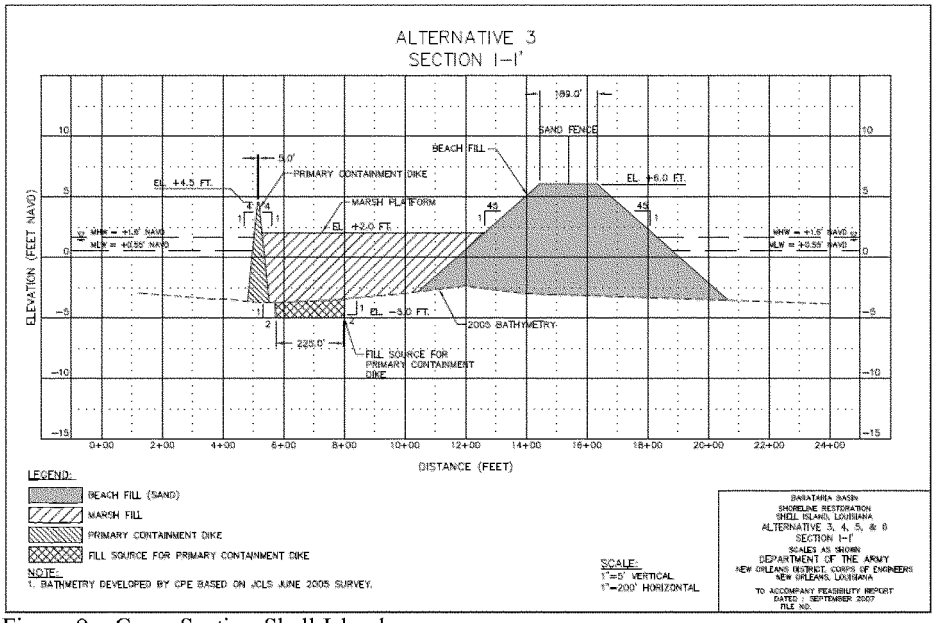


Figure 9 – Cross Section Shell Island

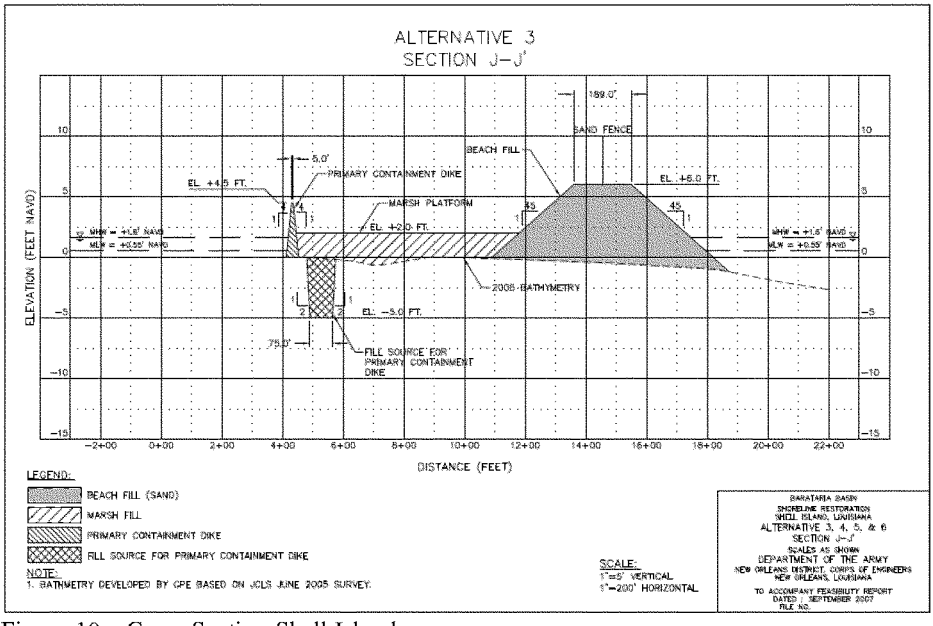


Figure 10 – Cross Section Shell Island

Construction

The TSP would create 317 acres of dune/beach and 466 acres of marsh. . Approximately 5,611,700 cubic yards of beach fill and 2,138,500 cubic yards of marsh would be required to construct the TSP.

Coupe Bob will be closed by stockpiling extra material on each side of the final closure section of the inlet. Sheet pile 100 to 200 feet in length would be placed on each side of the final opening to allow sand material to be piled up. When the tide range is the lowest the material will be pushed into the breach.

The contractor will construct a containment dike for marsh creation using material from within the existing footprint. In deeper water it is recommended to construct a sand base to elevation -3.0 with marsh fill on top to reduce settlement. In these deeper areas a geotextile tube will be used for containment of the marsh fill.

Sand fencing and vegetative plantings would be similar to those described for the Caminada Headland alternative.

The borrow source for the dune/beach is a large sand deposit near Nairn in the Mississippi River between mile markers 32 and 34, approximately 11 miles north of the project area. The borrow site is located in a river meander where greater sediment thickness is anticipated due to the presence of relict (vertically stacked) sand bars. USACE boring data indicates sand thickness of at least 70 feet. Based on samples obtained from vibracores, the sand grain size is comparable to the sand at the project site. The dredged material would be pumped from the Mississippi River via pipeline. The pipeline corridor would cross the Mississippi River levee and two highways, traversing property owned by Plaquemines Parish. The pipeline would then be submerged, first crossing, and then following, the western right of way of the Empire Waterway, a Federal waterway. The Empire Waterway terminates at the eastern end of Shell Island. Five booster pumps would be required to move the material from the river to the project area. The borrow source for the marsh restoration is the Empire deposit, approximately 1.5 miles from the Empire Jetties (figure 11). Water depths in the borrow area are from 16 feet to 20 feet. The sedimentary characteristics indicate a silt content of about 40 percent, a clay content of about 22 percent and sand content of about 38 percent. The material would be pumped via cutterhead dredge and pipeline from the borrow source to the project area, requiring one booster pump.

Figure 11 – Borrow Sources for Shell Island

Renourishment

The beach/dune portion of the island would be re-nourished 20 years and 40 years after initial construction to the original template. Marsh fill would also be re-nourished to its initial construction template at this time interval. Borrow source for the re-nourishment would be the same as for the original construction. Re-nourishment requirements would be 1,512,000 cy of beach fill in years 20 and 40 and 907,200 cy and 643,600 cy of marsh fill in years 20 and 40 respectively.

**EFFECTS OF RECENT HURRICANES**

***Caminada***

Hurricane Katrina

Post Storm Impact. The Caminada Headland project area had some breaching and overwash prior to Hurricane Katrina as illustrated in figures C-1-4 and C-1-5 of chapter 1 of annex 1.

As shown on figure C-1-6, additional breaching and overwash occurred in the Caminada Headland with the passage of Hurricane Katrina. Sea floor change and project volumes in the Caminada Headland project area were updated following Hurricane Katrina, as shown on page C-3-16. The Louisiana Department of Natural Resources (LDNR) in conjunction with the USGS has initiated a Barrier Island Comprehensive Monitoring (BICM) Program in Louisiana. Bathymetric data that BICM collected on the Caminada Headland after the passage of Hurricane Katrina was included in the updated analysis described previously (see page C-10-3 of annex 1).

A post-Katrina review of coastal restoration projects in the vicinity of Caminada Headland by the NOAA Habitat Restoration Program reveals that projects on Grand Terre Island, along Bayou Lafourche at the Bayou Lafourche Bank Stabilization, and at the Wisner Restoration project area were minimally impacted.

Storm Modeling. The Caminada Headland project area was located in the left front quadrant of Hurricane Katrina. The magnitude of the storm surge on the project area at Caminada Headland was significantly lower than areas along the Louisiana and Mississippi coast that were located in the right front quadrant relative to Hurricane Katrina. While the storm surge impact of Hurricane Katrina was extraordinary on the Mississippi Gulf Coast and in the eastern extremes of St. Bernard and Plaquemines Parishes of Louisiana, the storm surge impact on the project areas at the Caminada Headland was well within the limits of the long term records that were used for modeling the project performance of the proposed project.

Wind Speed. A review of wind speeds at the wind gage closest to the project sites on Grand Isle, east of the project area, and closer to the track of Hurricane Katrina shows that the wind speeds of Hurricane Katrina reached a maximum of 70 knots and the higher wind speeds were limited to a 6-hour period. The wind speed at the Caminada Headland during Hurricane Katrina was well within the limits of the long term records that were used for modeling the project performance.

Other Hurricanes

Shoreline Change. The historical erosion rate that spans a long-term record ~ 100 years for the headland is 45 feet per year. This rate includes storms of the same magnitude as Hurricanes Gustav and Ike, e.g. Betsy, Andrew, Lili, and Isidore. Annex 1 includes local information regarding storm impacts such as Tropical Storm Bill, which eroded Caminada 60 feet to 80 feet in 2003 alone. The short-term erosion rate estimates based on surveys in 2000 and 2005 (pre-Katrina) were 25 percent less than the long-term rates. The long-term rate was used in the analyses, thus storm effects on shoreline change of the magnitude of Hurricanes Gustav and Ike are accounted for in the erosion analysis.

Sediment Budget. The calculations for the sediment budget include an analysis of both short- and long-term trends. Survey data along with dredge records and available literature were analyzed for use in completing the headland's sediment budget. The majority of the headland's gulf front erosion has been in the form of island overwash.

Storms of the magnitude of Hurricanes Gustav and Ike generally overtop low-lying barrier islands resulting in overwash. Visual observations and photographs provided by the Louisiana Office of Coastal Protection and Restoration confirm that significant overwash occurred on the Caminada Headland. Thus storm effects on sediment transport of the magnitude of Hurricanes Gustav and Ike are accounted for in the sediment budget.

Storm Modeling. The design storms selected for the modeling were extracted from the available data sets and targeted recent storms that caused the most significant impact to the project area. The analysis includes the Grand Isle gage data for the hurricanes that were modeled including Hurricanes Isidore and Lili. The Grand Isle gage data that recorded the water levels in the project area during Hurricanes Gustav and Ike was recently obtained. The record for Hurricanes Isidore and Lili in 2002 depicts that the peak water levels were approximately 5.0 feet NAVD88 and 4.8 feet NAVD88, respectively. The record for Hurricanes Gustav and Ike depicts that the peak water levels were approximately 5.7 feet NAVD88 and 5.6 feet NAVD88, respectively. Thus the storm effects on water levels of the magnitude of Hurricanes Gustav and Ike are accounted for in the storm modeling. In addition to the water levels, wave heights recorded in the Gulf of Mexico during Hurricanes Gustav and Ike were obtained. The data were obtained from NOAA's NDBC Station 42001 located 200 miles south of Southwest Pass, LA. The STWAVE model was used to propagate the recorded wave heights to the Caminada Headland and compute the corresponding nearshore wave conditions. The results of the wave analysis yielded peak wave heights for Hurricanes Gustav and Ike on the order of 14.2 feet and 14.5 feet, respectively. For comparison, the peak nearshore wave heights for Hurricanes Juan, Andrew, Isidore and Lili were 14.5 feet, 13.3 feet, 12.6 feet, and 13.5 feet, respectively. Thus, the range of wave heights presented in the storm modeling includes wave heights of the magnitude of Hurricanes Gustav and Ike.

***Shell Island***

Hurricane Katrina

The Shell Island project area was located close to the center of the track of Hurricane Katrina as the hurricane made its initial landfall on the Gulf Coast. Given the low profile of the existing portions of Shell Island and the fact that Shell Island in its current configuration has a channel separating it, the vast majority of storm surge and wind/wave action of Hurricane Katrina was over the island during the height of the storm. An analysis of post-Katrina photography indicated no impacts to Shell Island, most likely due to the high surge received at Shell Island and only a remnant of the original island remaining. In addition, the modeling done as part of the project supports the assumption that once the island is overtopped the impact of an increased storm event does not increase significantly because the majority of the wave energy passes over the island.

Other Hurricanes

General. Storms are included in the "background" erosion depending on the analysis period. By basing shoreline change estimates on a long enough record, the effect of storms such as Hurricanes Ike and Gustav are incorporated into the analysis. Based on storm surge levels measured at Grand Isle and wave heights based on offshore NOAA buoys, Hurricane Ike was close to a one in 10-year event. Hurricane Gustav had a lower frequency storm surge (one in 30-year event), but a higher wave frequency (one in 4-year event).

Shell Island West. The future without project condition for Shell Island West was based on shoreline change between 1988 and 2004. Over this 16-year period, one or two 10-year storm events or larger can be reasonably expected. Furthermore, the modeling suggested that once the island is overtopped, the impact of an increased storm event does not increase significantly because the majority of the wave energy passes over the island. Observations following the passage of Hurricane Katrina appeared to confirm the validity of this modeling. Thus, the shoreline change projections for Shell Island West can reasonably be expected to include the effects of events such as Hurricanes Gustav and Ike.

Shell Island East. The future without project condition for Shell Island East was based only on subsidence and assuming that mass was conserved by rollover. The coarse grain size remaining on the remnant islands and very low elevation were the bases for this assumption. Applying a shoreline recession rate to the remnant islands on Shell Island East would have resulted in their disappearance by 2006. Given that the island remnants are still there, the subsidence only assumption appears to be valid. The passage of Hurricanes Gustav and Ike are not specifically included in the performance of Shell Island East and thus do not impact the conditions assessment. The analysis for the future with project condition was based on the 1956 to 1973 time period. Again, storms are included in the background erosion and performance expectation. Events such as Hurricanes Gustav and Ike are therefore included in the performance projection.

**WATER QUALITY**

A water quality analysis was done as a part of this study. Results of this analysis are detailed in annex 4 and summarized as follows.

Short-term impacts to the water quality and natural communities would be anticipated during the construction activities. Construction impacts to water quality would result from increased concentrations of Total Suspended Solids (TSS, greater turbidity, potential increases in ambient surface water concentrations of mercury and other metals, and mobilization of nutrient parameters based upon elutriate results. The impacts to water quality could vary spatially and temporally depending on the dredging and material placement methods.

The increased concentrations of TSS, higher turbidity, and potentially increased mercury and other metal concentrations would occur in close proximity to the construction activities, with concentrations decreasing with distance away from the construction activities. Mitigation methods may include controlling sediment dispersion near the construction site or providing a barrier for outside activities. Methods to reduce sediment dispersion in open water areas resulting from construction activities may include silt/turbidity screens or other devices.

The increased concentrations of TSS and turbidity would result in short term disruption and some temporary displacement of aquatic communities in the restoration areas during the construction phase of the project. No adverse impacts from TSS or turbidity would be expected to persist beyond the construction phase. The release of nitrogen and phosphorus forms from sediments would result in short-term increased availability of nutrient parameters in the water column in the near vicinity of the active dredging sites within the borrow areas, and in the vicinity of active deposition at the restoration sites.

The likely release and mobilization of mercury from sediments in dissolved fractions and fractions adsorbed to fine particles (silt/clay) would result in the short-term increase in ambient concentrations in the water column at and near the construction (deposition) areas. The form of mercury that can potentially affect aquatic organisms is methylmercury. Oxidation of some portion of the methylmercury to forms with less potential to affect aquatic organisms would occur in connection with the turbulence associated with sediment dredging, transport, and deposition. The mobilization of methylmercury into the water column from sediments has the potential for increased exposure to aquatic organisms through direct bioaccumulation from the water column and through food web bioaccumulation. The increased potential for exposure to aquatic organisms would be localized and of short duration.

The scale of the predicted impacts would not be anticipated to differ significantly from those that would occur in connection with natural disturbances, such as tropical storms and hurricanes.

**RELOCATIONS**

Field investigations were conducted to determine facilities that could be possibly impacted by the placement of material for this project. All facilities affected by this project can be described as either gas or petroleum pipelines. Thirty four pipeline facilities were identified within the proposed work areas (plate 1). The affected facilities are listed in table 1. Facility owners were contacted to verify the location and ownership of the identified facilities.

| Table 1<br>List of Affected Facilities | |
|---|---|
| | |
| Facility Owner | Facility Description |
| | |
| ChevronTexaco | 10" Oil Pipeline |
| ChevronTexaco | 10" Spare Pipeline |
| Chevron Production | 8" Wet Oil Pipeline |
| Chevron Production | 8" Wet Oil Pipeline |
| Chevron Production | 10" Oil Pipeline |
| Chevron Production | 10" Oil Pipeline |
| Chevron Production | 8" Oil Pipeline |
| Chevron Production | 4" Oil Pipeline |
| Chevron Production | 4" Oil Pipeline |
| Chevron Production | 4" Oil Pipeline |
| Chevron Production | 6" Oil Pipeline |
| Shell Pipeline Inc. | 24" Crude Pipeline (Mars Offshore Crude) |
| Shell Pipeline Inc. | 24" Crude Pipeline (Amberjack Offshore Crude) |
| Tennessee Gas Pipeline | 16" Gas Pipeline (524G-100) |
| Tennessee Gas Pipeline | 16" Gas Pipeline (524C-100) |
| Tennessee Gas Pipeline | 6" Gas Pipeline (523A-100) |
| Tennessee Gas Pipeline | 24" Gas Pipeline (526D-100) |
| Tennessee Gas Pipeline | 20" Gas Pipeline (526C-100) |
| Tennessee Gas Pipeline | 12" Gas Pipeline (526A-1800) |
| Tennessee Gas Pipeline | 20" Gas Pipeline (526A-100) |
| Tennessee Gas Pipeline | 6" Gas Pipeline (523A-100) |
| Tennessee Gas Pipeline | 24" Gas Pipeline (500) |
| Tennessee Gas Pipeline | 30" Gas Pipeline (522A-200) |
| Southern Natural Gas | 18" Gas Pipeline (WD105) |
| Southern Natural Gas | 12" Gas Pipeline (WD30) |
| Southern Natural Gas | 20" Gas Pipeline (ML397) |
| Plains All American | 12' BOA Pipeline (Main Line) |
| Plains All American | 12' BOA Pipeline (Loop Line) |
| Loop Inc. | 10" Oil Pipeline |
| Loop Inc. | 10" Oil Pipeline |
| Loop Inc. | 48" Oil Pipeline |
| Loop Inc. | 30" Brine |
| Loop Inc. | 4" Diesel |
| Crosstex/LIG | 12" Oil Pipeline |

No relocations would be anticipated since the work consists of placing additional fill material on top of existing facilities. A meeting with the facility owners was held on October 16, 2006. Possible project features were presented and letters of no objection were requested from the facility owners. These letters are included as annex 5.

## COST ESTIMATES

### *General*

Cost estimates for all alternatives were developed as described in annex 1 for Caminada and annex 2 for Shell Island. An MII estimate was developed for the recommended plan as described below. The MII estimate is included in annex 6.

Cost estimates were developed for the features of the study. The estimated costs were based upon an analysis of each line item evaluating quantity, production rate, and time, together with the appropriate equipment, labor and material costs. All of the construction work is generally common to the New Orleans District. In addition, all labor, equipment and materials are typical of this type of construction. The estimate development used the standard approaches for a feasibility estimate structure regarding labor, equipment, materials, crews, unit prices, quotes, sub- and prime contractor markups. The estimate provides a "fair and reasonable" estimate that depicts the local market conditions.

Labor Rates are based upon local information, contractor payroll data from the New Orleans District, Government hopper dredge, and estimators with experiences this past year. Equipment rates used are based on prevailing industry rates and from the USACE EP-1110-1-8, Region III, 2007. USACE Costs to manage design (E&D) and construction (S&A) are based on data on actual expenditures at MVN.

### *Access*

LA Hwy 1 and Hwy 3090 is the only land access onto the Caminada Headland. Access to the Caminada Headland is also available from the Gulf of Mexico. Access to Shell Island is available from the Gulf of Mexico and Empire Waterway.

### *Contingency*

Contingencies are based on a Cost Risk Analysis using Crystal Ball software. Results of this analysis are discussed in the Risk Analysis Section below.

### *Escalation*

Escalation is based upon the US Army Corps of Engineers Engineering Manual (EM) 1110-2-1304 Civil Works Construction Cost Index System (CWCCIS) revised 30 September 2010. The additional escalation due to the Risk Adjusted project schedule was added to the base contingency resulting in an adjusted contingency.

Escalation has been included to the anticipated midpoint of the construction features. Dune and marsh creation is to start approx October 2013 + 1/2 duration based on the schedule for the project. The planting will follow in the years after construction of the dune and marsh.

*Risk Analysis*

A cost risk analysis was performed for this project in accordance with ER-1110-2-1302, Paragraph 7.e.2 and ER-1110-2-1302, appendix B, paragraph 4. The results of the cost risk analysis are shown in the Barataria Basin Barrier Shoreline Restoration Project Cost and Schedule Risk Analysis Report included in annex 6.

The most likely fully funded total project cost for the project is estimated to be approximately $340 Million. Based on the results of the analysis, the New Orleans District Cost Engineering Section recommends a contingency value of approximately $107Million, or 31%, for a total project cost of $447 Million.

The following tables portray both the baseline cost, the October 2011 cost, and fully funded cost, respectively, of the recommended alternatives based on the anticipated contracts. The contingency is based on an 80% confidence level, as per accepted USACE Civil Works guidance.

**Table 2 Cost Summary – October 2011 Cost**

| BBBS Restoration Total Project Costs | | COST ($1,000) | CNTG ($1,000) | TOTAL ($1,000) |
|---|---|---|---|---|
| 01 | Lands and Damages | 2,929 | 732 | 3,661 |
| 17 | Beach Replenishment | 306,858 | 97,209 | 404,067 |
| 30 | Planning, Engineering, and Design | 5,440 | 1,360 | 6,800 |
| 31 | Adaptive Management/Monitoring | 986 | 313 | 1,299 |
| 31 | Construction Management | 9,417 | 3,018 | 12,435 |
| | **TOTAL PROJECT COSTS** | **325,630** | **102,632** | **428,262** |

Notes:

1) Costs include all contingencies and escalation, supported by a risk analysis

2) Costs exclude O&M and Life Cycle Cost estimates

3) Costs taken from TPCS

**Table 3 Cost Summary – Fully Funded Project Cost**

| BBBS Restoration Total Project Costs | | COST ($1,000) | CNTG ($1,000) | TOTAL ($1,000) |
|---|---|---|---|---|
| **01** | Lands and Damages | 2,929 | 732 | 3,661 |
| **17** | Beach Replenishment | 320,611 | 101,556 | 422,167 |
| **30** | Planning, Engineering, and Design | 5,440 | 1,360 | 6,800 |
| **31** | Adaptive Management/Monitoring | 1,282 | 407 | 1,690 |
| **31** | Construction Management | 10,626 | 3,408 | 14,034 |
| | **TOTAL PROJECT COSTS** | **340,888** | **107,463** | **448,351** |

Notes:

1) Costs include all contingencies and escalation, supported by a risk analysis

2) Costs exclude O&M and Life Cycle Cost estimates

3) Costs taken from TPCS

***Renourishment Cost***

Costs for re-nourishment are shown below. These costs are in October 2011 dollars and include construction, S&A and contingency.

Costs for Caminada include contingency of 29.72%. Construction costs are the incremental cost over the Federal Standard. Cost for each re-nourishment event is $7.35M. Costs for Shell Island include contingency of 33.76%. Cost for the first re-nourishment event is $63.3M and cost for the second re-nourishment event is $60.9M.

**CONSTRUCTION SEQUENCE**

***General***

The anticipated construction contracts for the project are listed below.

Contract 1 – Caminada Beach and Marsh Restoration. This contract covers the initial beach and marsh restoration at Caminada.

Contract 2 – Caminada Plantings 1

Contract 3 – Caminada Plantings 2

Contract 4 – Caminada Plantings 3

Contract 5 – Shell Island Beach and Marsh Restoration. This contract covers the initial beach and marsh restoration at Shell Island

Contract 6 – Shell Island Plantings 1

Contract 7 – Shell Island Plantings 2

Contract 8 – Shell Island Plantings 3

***Construction Schedule***

Table 4 shows the design and construction schedule for the project.

**Table 4**
**Design and Construction Schedule**

| Contract | Design | | Construction | |
|---|---|---|---|---|
| | Start | Complete | Start | Complete |
| 1–Caminada Beach and Marsh Restoration | Jun 2012 | Apr 2013 | Oct 2013 | Apr 2016 |
| 2-Caminada Plantings 1 | | | May 2016 | Dec 2016 |
| 3-Caminada Plantings 2 | | | May 2017 | Mar 2018 |
| 4-Caminada Plantings 3 | | | May 2018 | Apr 2017 |
| 5-Shell Island Beach and Marsh Restoration | Jun 2012 | Apr 2013 | Oct 2013 | Nov 2015 |
| 6-Shell Island Plantings 1 | | | Dec 2015 | Mar 2016 |
| 7-Shell Island Plantings 2 | | | Dec 2016 | Apr 2017 |
| 8-Shell Island Plantings 3 | | | Dec 2017 | Feb 2018 |

# Annex 1: Barataria Barrier Shoreline Restoration Feasibility Study – Caminada Headland

## EXECUTIVE SUMMARY

# BARATARIA BASIN BARRIER ISLAND SHORELINE RESTORATION FEASIBILITY STUDY APPENDIX C CAMINADA HEADLAND LDNR CONTRACT NO. 2503-08-06 MAY, 2008

This Report presents a summary of preliminary field investigations, alternatives analyses, and recommendations for the implementation of the Barataria Basin Barrier Island Shoreline Restoration of Caminada Headland for the Louisiana Department of Natural Resources (LDNR).

The purpose of this Project is to protect and preserve the structural integrity of the barrier shoreline of the Caminada Headland. The Project provides for the restoration of the coastal barrier shoreline along the Headland and for the marsh platform creation and restoration of hydrologic conditions, ecosystem processes and habitats for these coastal segments and nearby estuaries. Restoration and maintenance of the Headland shoreline will protect and sustain significant and unique coastal habitats and protect threatened and endangered species. The restored barrier shoreline will reduce wave energy and salt-water intrusion from the Gulf of Mexico into back-barrier environments, including chenier ridges, marshes and bays.

The Scope of Services includes the following tasks:

- Review of Existing / Collected Data
- Sand Suitability Assessment including a compatibility analysis
- Coastal processes studies and analyses including shoreline and volume change analyses, regional wave and storm statistics, conceptual sediment budget and hydrodynamic modeling
- Sea level rise, subsidence and consolidation
- Preliminary design criteria
- Development of design templates to include conceptual plans and performance analyses, adaptive management plan and wetland value assessment model
- Estimates of probable cost including a cost breakdown and description of assumptions.

The Project's design objectives include the following:

- Maintain the Caminada Headland without disrupting the natural hydrologic regime
- Preserve the integrity of the barrier Headland by closing existing breaches
- Sustain and improve shoreline, dune, and interior marsh habitat for essential fish and wildlife species

- Reduce wave energy transmission by providing a natural storm protective buffer for interior marsh and chenier ridge habitats north of Caminada Headland.

As part of the engineering feasibility initiation a number of restoration alternatives were proposed by the project stakeholders. These proposed alternatives were narrowed down and grouped into three major restoration options which were screened through selection criteria to determine which warranted further analysis. The three groups of restoration options were No Action Option, Beach/Dune/Marsh Restoration Options, and Beach/Dune/Marsh Options with Structural Compliments. Screening criteria considered were habitat creation, storm protection, and overall environmental impacts on adjacent barrier islands. Only the Beach/Dune/Marsh Restoration Option templates met all of the screening criteria and were carried forward to the alternatives analysis.

Application of the various templates and adaptive management nourishment cycles resulted in the development of ten Beach/Dune/Marsh Restoration alternatives. These ten alternatives were evaluated based on technical, environmental, fiscal, and institutional planning constraints set forth in the Louisiana Coastal Area (LCA) Study (USACE, 2004c). The alternatives were arranged into three subgroups classified as Alternatives 1 through 4 (Dune and Marsh Alternatives), 5 through 7 (Preferred Dune Alternatives), and 8 through 10 (Optimized Alternatives). The subgroups were analyzed and the results of the analyses were used to compare all ten alternatives and score them based on environmental benefit longevity, storm protection and Project costs.

Of the ten alternatives evaluated, Alternative 9 - Optimized Project with Expanded Marsh, scored the highest of all the alternatives. This alternative is renourished every 10 years and provides the optimal balance of storm protection for infrastructure, longevity of environmental benefits, and cost effectiveness. Alternative 9 proposes a dune height of +7 feet NAVD and dune width of 290 feet with a landward beach and dune component in order to maximize acreage and longevity. The landward and seaward slopes are set to 20 horizontal on 1 vertical. The marsh fill is proposed on the landward side of the beach and dune at an elevation of +2.0 feet NAVD creating 1186 acres of marsh. Alternative 9 includes initial fill quantities for the beach/dune and marsh fills of 5.1 million and 5.4 million cubic yards, respectively. Compatible sediment for the dune and beach berm construction is to originate from South Pelto, Blocks 12 and 13, of Ship Shoal which is approximately 40 miles from the Project site.

The identification and evaluation of the Ship Shoal borrow area was conducted by LDNR and was identified in the LCA Study as a significant potential borrow source area that could be used to supply compatible sediment for barrier shoreline restoration. Ship Shoal is a large submerged sand body in the Gulf of Mexico located just offshore in south-central Louisiana (Figure C-1-2). The shoal is about 31 miles long and 7 miles wide, lying in water depths of 9 to 30 feet. Preliminary studies have shown it is the remaining seaward shoal from one of the older abandoned Mississippi River deltas (USACE, 2004c). It is composed of well-graded quartz sand and suitable for use in restoring the Caminada Headland since its grain size is similar to the sand found on the Headland.

CEC File No: 05211

# BARATARIA BARRIER SHORELINE RESTORATION FEASIBILITY STUDY
# APPENDIX C
# CAMINADA HEADLAND
# LDNR CONTRACT NO. 2503-08-06
## LAFOURCHE PARISH LOUISIANA

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May 2008

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## Acronyms and Abbreviations

| | |
|---|---|
| BA | Borrow Area |
| BIVA | Barrier Island Value Assessments |
| CEC | Coastal Engineering Consultants, Inc. |
| CPE | Coastal Planning & Engineering, Inc. |
| CWPPRA | The Coastal Wetlands Planning, Protection and Restoration Act |
| ERDC/CHL | U.S. Army Corps of Engineers Engineering Research & Development Center and Coastal Hydraulics Laboratory |
| $H_s$ | Significant Wave Height |
| LCA | Louisiana Coastal Area |
| LDNR | Louisiana Department of Natural Resources |
| LOOP | Louisiana Offshore Oil Port |
| LUMCON | Louisiana Universities Marine Consortium |
| MHW | Mean High Water |
| MHHW | Mean Higher High Water |
| MLLW | Mean Lower Low Water |
| MLW | Mean Low Water |
| MPH | Morris P. Herbert, Inc. |
| MSL | Mean Sea Level |
| NAVD | North American Vertical Datum, 1988 |
| NBDC | National Buoy Data Center |
| NED | National Economic Development |
| PED | Preconstruction Engineering and Design Phase |
| PI | Point of Intersection |
| PMP | Project Management Plan |
| POB | Point of Beginning |
| POE | Point of Ending |
| $R_a$ | Overfill Factor |
| $R_j$ | Renourishment Factor |
| SBEACH | Storm-Induced BEAch CHange Model |
| STE | Soil Testing Engineers, Inc. |
| SJB | SJB Group, Inc. |
| USACE | U. S. Army Corps of Engineers |
| USGS | U.S. Geological Survey |
| WIS | Wave Information Study |
| WVA | Wetland Value Assessments |

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## Addendum: Datum Clarification

*The following changes should be followed as required by the district datum coordinator*

### A. Section C-2-2-3-1 Short-Term Erosion Rates, Page C-2-4

The following sentence "Based on the survey comparisons, the changes in shoreline position at the average existing dune elevation, 3.5 feet NAVD, and Mean High Water (MHW), 1.53 feet NAVD, were computed." should be replaced with "Based on the survey comparisons, the changes in shoreline position at the average existing dune elevation, 3.5 feet NAVD, and Mean High Water (MHW), 0.83 feet NAVD, were computed." All other references to MHW in Section C-2 should refer to +0.83 ft NAVD.

### B. Section C-3-1-3 Tides, Page C-3-4

Table C-3-6 should be replaced with the following:

**Table C-3-6. Grand Isle Tidal Datum**

| DESCRIPTION | NAVD 88 |
|---|---|
| Highest Observed Water level (8/29/2005) | 5.37 |
| Mean Higher High Water (MHHW) | 0.84 |
| Mean High Water (MHW) | 0.83 |
| Mean Sea Level (MSL) | 0.31 |
| Mean Tide Level (MLT) | 0.31 |
| North American Vertical Datum of 1988 - NAVD88 (2004.65) | 0.00 |
| Mean Low Water (MLW) | -0.21 |
| Mean Lower Low Water (MLLW) | -0.22 |
| Lowest Observed Water Level (12/24/1989) | -2.42 |

**Source: NOAA - 5 September 2009, http://www.co-ops.nos.noaa.gov/benchmarks/8761724**
**Tidal datums referenced to Modified Tidal Datum Epoch 2002-2006**
**NAVD88 relationships are based on NAVD88 (2004.65) elevation on 876 1724 Tidal 11 of 3.12 feet.**

### C. Section C-3-1-7 Depth of Closure, Page C-3-9

The 1 foot difference between MSL and NAVD88 is verified by the difference in datums reported from the analysis and the updated difference in NAVD 88 values from Table 4-2 of the main report and Table C-3-6, as directly applicable to this section, but does not fit the updated tidal datum table.

### D. ANNEX C3 CAMINADA HEADLAND CROSS-SHORE SEDIMENT TRANSPORT MODELING REPORT SBEACH Model Conclusions, Page 25

The following sentence "The retreat was calculated at two elevations, +1.53 ft NAVD, which corresponds to the Mean High Water (MHW), and +4 ft NAVD, which approximately corresponds to the existing dune." should be replaced with "The retreat was calculated at two elevations, +0.83 ft NAVD, which corresponds to the Mean High Water (MHW), and +4 ft NAVD, which approximately corresponds to the existing dune. All other references to MHW in ANNEX C3 should refer to +0.83 ft NAVD.

## Addendum: Datum Clarification

E. ANNEX C4 WETLAND HABITAT ACREAGE CALCULATIONS, Page 2

A computed Mean High Water (MHW) reference of 1.53 feet NAVD88 was used for analysis of erosion rates, but this does not fit the revised MHW relationship shown in the updated tidal datum table that was determined from published NGS and NOAA information.

# C-1 GENERAL

## C-1-1 INTRODUCTION

The Louisiana Coastal Area (LCA) Ecosystem Restoration Study (LCA Study) has identified the Barataria Basin Shoreline Restoration as a near-term critical project to restore or rebuild the natural ecological function of the two coastal barrier shorelines, known as Caminada Headland and Shell Island Reaches. Appendix C of the Barataria Barrier Shoreline Restoration Feasibility Study addresses the technical design and engineering alternatives for restoration specific to Caminada Headland only. The Barataria Barrier Shoreline Restoration Project is considered critical due to the greatly degraded state of this shoreline and its key role in protecting and preserving larger inland wetland areas and bays. If this fragile area were not addressed quickly, restoration would be far more difficult and costly. Additionally, the Barataria Basin Barrier Shoreline Restoration project is deemed most critical because it maintains the integrity of the gulf shoreline and protects the interior coast from further deterioration. Appendix C has been prepared in accordance with Engineering Regulation (ER) 5-1-11, ER 1105-2-100 (USACE, 2000).

### C-1-1-1 Study Authority

The Barataria Barrier Shoreline Restoration Feasibility Study as described in the LCA Study is recommended for authorization based on resolutions adopted by the Committees on Public Works of the U.S. House of Representatives and Senate, dated October 19, 1967 and April 19, 1967, respectively. The LCA Study was approved and signed by the Chief of Engineers, U.S. Army Corps of Engineers (USACE) on January 31, 2005 and the Project has been recommended for specific Congressional authorization with implementation subject to approval by the Assistant Secretary of the Army for Civil Works (USACE and LDNR, 2005).

### C-1-1-2 Study Purpose

The purpose of the Project is to protect and preserve the structural integrity of the barrier shoreline of the Caminada Headland. The Project would provide for the restoration of the coastal barrier shoreline along the Headland and provide for marsh platform creation and restoration of hydrologic conditions, ecosystem processes and habitats for these coastal segments and nearby estuaries. Restoration and maintenance of the Headland shoreline would protect and sustain significant and unique coastal habitats and protect threatened and endangered species. The

restored barrier shoreline would reduce wave energy and salt-water intrusion from the Gulf of Mexico into back-barrier environments, including chenier ridges, marshes and bays. These features host a number of crucial habitats in the Headland, including chenier maritime forests, and mangrove thickets that provide shelter and feeding areas for migratory birds. Reducing the wave energy and salinity in bays behind the barrier protects habitats used by commercial and recreation fisheries species, as well as threatened and endangered Gulf Sturgeon. Restoration and maintenance of the Headland barrier shoreline also provides a sediment source to sustain barrier beaches east and west of the Headland. Incidental benefits from this ecologic restoration would protect Port Fourchon, local and state highways, and the only hurricane evacuation route along U.S. Highway 1 available to the region.

### C-1-1-3 Scope of Services

The Scope of Services for this project was done in support of the implementation of the "Surveying Services and Engineering Assistance for Coastal Restoration Projects" Louisiana Department of Natural Resources (LDNR) Contract No. 2503-05-47. The federal sponsor is the USACE. The Feasibility Study is funded as part of the Louisiana Coastal Area (LCA) Ecosystem Restoration Program. The engineering and design work referenced by this Scope of Services will be financed and approved by the LDNR and USACE.

The engineering feasibility study addresses the restoration of the Caminada Headland reach of the Barataria Basin Barrier Shoreline. The Project location is depicted in Figure C-1-1 (USACE, 2005). The engineering feasibility study will also identify and assess sources of borrow material for shoreline and marsh creation and nourishment, including offshore sites, e.g., Ship Shoal which is depicted in Figures C-1-2 (USACE, 2005) and C-1-3 (Coastal Planning & Engineering, 2005).

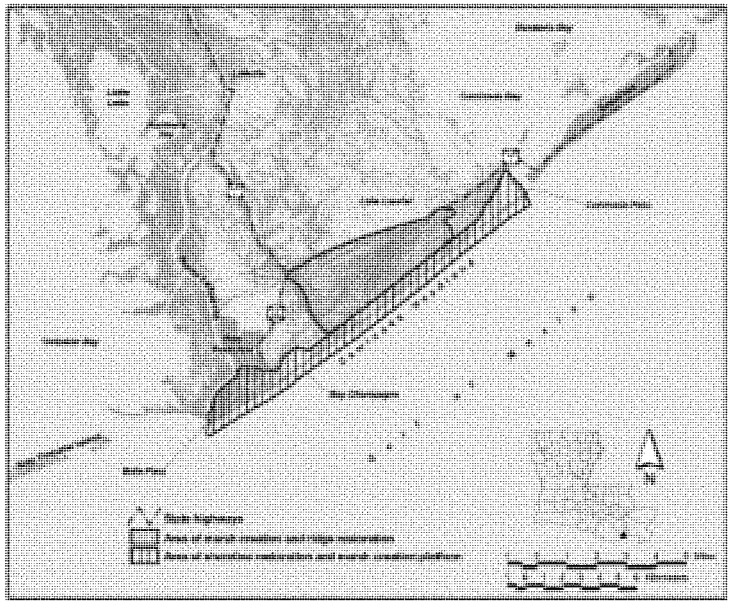


**Figure C-1-1. Restoration Features for the Caminada Headland**

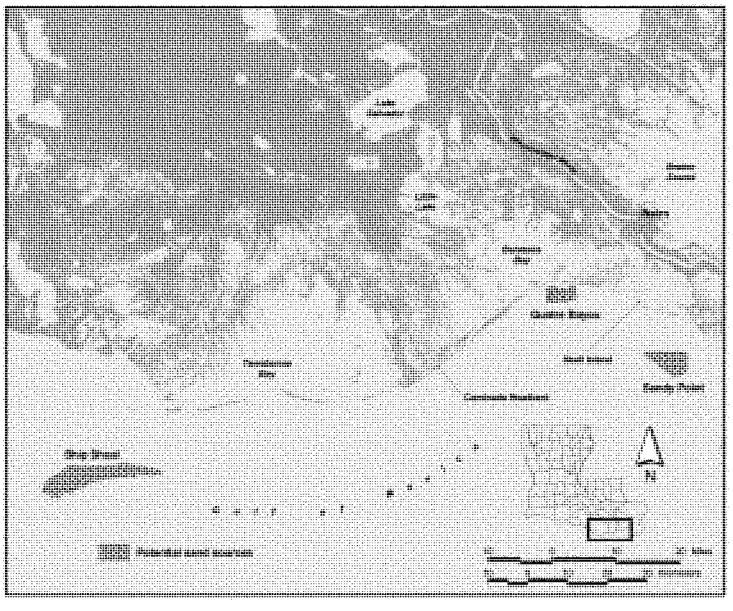


**Figure C-1-2. Potential Sources of Borrow Material for Barrier Shoreline Restoration**

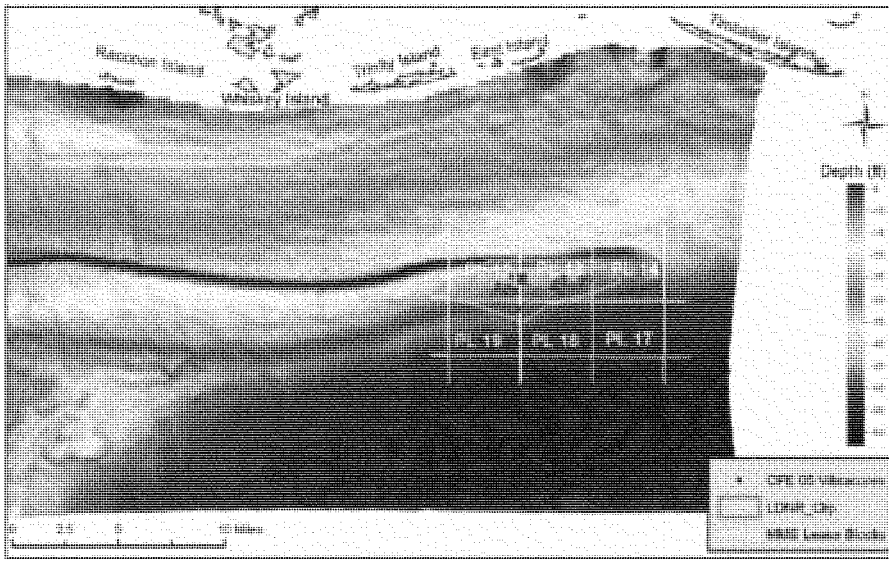


**Figure C-1-3. Borrow Area**
**"South Pelto" blocks of Ship Shoal**

The Scope of Services included in this engineering feasibility study involves the following tasks:

Review of Existing / Collected Data

Conduct a data review of existing and collected materials and prepare a Summary Technical Memorandum.

Engineering and Design

Develop a minimum of three conceptual stabilization design templates capable of meeting the overall project goal of maintaining the Caminada Headland reach of the Barataria shoreline for the 50-year project life. The main components to be restored and maintained are the dune and beach berm as well as back-bay marsh areas. Restoration strategies, with subsequent operation and maintenance over 50 years will:

- Maintain the Caminada Headland without disrupting the natural hydrologic regime
- Preserve the integrity of the barrier Headland by closing existing breaches
- Sustain and improve shoreline, dune, and interior marsh habitat for essential fish and wildlife species

- Reduce wave energy transmission by providing a natural storm protective buffer for interior marsh and chenier ridge habitats north of Caminada Headland.

Engineering and design work to support these restoration strategies include:

- Sand Suitability Assessment including a compatibility analysis
- Coastal processes studies and analyses including shoreline and volume change analyses, regional wave and storm statistics, conceptual sediment budget and hydrodynamic modeling
- Sea level rise, subsidence and consolidation
- Preliminary design criteria
- Development of design templates to include conceptual plans and performance analyses, adaptive management plan and wetland value assessment model
- Estimates of probable cost including a cost breakdown and description of assumptions.

### C-1-1-4 Prior Studies and Reports

Numerous regional and site-specific investigations of erosion and shoreline loss have been conducted along the Louisiana gulf coast. Because of the large number of projects that have been completed, or are planned, SJB Group Inc. (SJB), in association with Coastal Engineering Consultants, Inc. (CEC), presented the Literature Review Technical Memorandum for the project (SJB and CEC, 2005). The goal of the memorandum was to summarize the results of the literature review, describe how the data reviewed will be utilized in the engineering feasibility study, and identify information gaps which may require data collection in subsequent phases of work. Data sources were categorized relative to major scope of work tasks and were provided in the memorandum.

The document of most significance is the LCA Study which encompasses the scope of the Barataria Basin Barrier Louisiana shoreline and surrounding areas. This comprehensive document provides details and information necessary to assess the conditions and problems which exist, as well as a plan to afford alternatives to a viable solution.

Specifically, the LCA Plan of the LCA Study has identified three critical needs. The first critical need is to prevent future land loss where it is predicted to occur. Preserving this Headland certainly meets this need since it is highly likely to continue the transgressive process and fragment into three islands in the next 5 to 50 years. If the Headland is preserved it is possible that 10 percent of the predicted loss in the marshes to the north could be prevented. The second critical need is to preserve endangered, critical geomorphic structure. This Headland is highly

endangered since it is in the process of becoming barrier islands, a process which would destroy its biological diversity. It is critical to the stabilization of the western terminus of the Barataria Basin. As a Headland, it preserves lower salinities in the lakes and bays to its north. It also provides protection to interior marsh to its north. The third critical need is to protect local, regional and national infrastructure (USACE, 2004c).

## C-1-2 EXISTING CONDITIONS

### C-1-2-1 Study Area

The Caminada Headland Project site is located in Lafourche Parish and is approximately 13 miles long, extending from the Belle Pass entrance to Port Fourchon on the west to Caminada Pass on the eastern end of Headland (Figure C-1-1). The Project area is bounded by the Gulf of Mexico to the South and Highway 1 to the North. The approximate center coordinate of the project area is: 29° 8' 57" N latitude and 90° 8' 11" W longitude.

### C-1-2-2 Caminada Headland

As described in the LCA Ecosystem Restoration Plan Near Term Critical Restoration Feature Assessment, the Caminada Headland consists of a sand dune, beach berm, barrier marshes, and chenier ridges interspersed with lagoons and small bayous. CEC participated along with USACE and LDNR representatives in a site visit of the Project area in July 2005. CEC took aerial photographs of the shoreline conditions, jetties, overwash fans, breaches, chenier ridges and Caminada Pass. Figures C-1-4 and C-1-5 illustrate a typical dune and overwash area and a breach area of the Caminada Headland, respectively. Figure C-1-6 is an aerial photograph taken by LDNR in September 2005 after Hurricane Katrina struck the Louisiana coastline illustrating the significant number of breached areas and overwash.

**Figure C-1-4. Aerial View East along Headland of Typical Dune and Overwash Area, July 2005**

**Figure C-1-5. Aerial View North of Breached Area on Caminada Headland, July 2005**

**Figure C-1-6. Aerial View North of 2005 Hurricane Katrina aftermath, September 2005**

Several of the Headland features are shown in Figure C-1-7 (USACE, 2005). Oil and gas facilities described in Section C-1-2-5 are located on the Headland. There is a heliport at the port with accommodation for several helicopters. Free public facilities include a dock for commercial fishermen, public boat launch with restroom facilities and an oilfield service dock for boats not under contract.

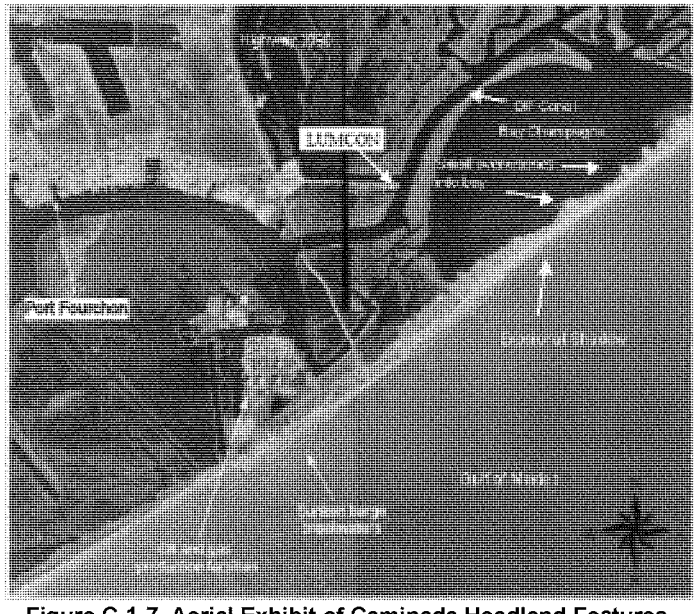



**Figure C-1-7. Aerial Exhibit of Caminada Headland Features**

There is a state-owned laboratory facility under the auspices of the Louisiana Universities Marine Consortium (LUMCON). It is available to all state universities and public and private schools. There are also numerous private camps north and east of Bay Champagne.

Louisiana Highway 1 is the only land access onto the Caminada Headland. It runs south along Bayou Lafourche and then turns eastward toward Grand Isle at the point where the Headland joins the mainland. At that same point, Louisiana Highway 3090 extends southwestward from Highway 1 to Port Fourchon, providing the only land access to the port. Highway 1 averages 10,000 vehicles per day, 1,000 of which are cargo trucks carrying supplies for oil and gas platforms in the Gulf of Mexico. Highway 1 is the only hurricane evacuation route for the towns of Grand Isle, Port Fourchon and Leeville.

The state-leased, 21,600-acre, Wisner Wildlife Management Area lies immediately north and partially on the Caminada Headland and is protected from the Gulf of Mexico by the eastern end of the Headland. This wildlife management area is under conservation management while also providing public access for hunting and fishing.

Fourchon Beach is a public beach on the western end of the Headland with vehicle access to the beach for camping, fishing and crabbing. For many years, Elmer's Island at the east end of the Caminada Headland was a heavily used private beach. Elmer's Island was open to the public for a small daily fee. After the death of the owner a few years ago, the property was put up for sale. There is significant public pressure for the state to purchase some or all of Elmer's Island for conservation and public recreational use (USACE, 2004c).

## C-1-2-3 Coastal Structures

### C-1-2-3-1 Belle Pass Jetties

In 1935 the major navigation inlet through Belle Pass was stabilized with the construction of the jetties (Ritchie et al., 1995). The jetties were constructed of rip-rap and have been modified over time with additional rip-rap placed in the nearshore zone just east of the Belle Pass east jetty on the Caminada Headland (Figure C-1-8).

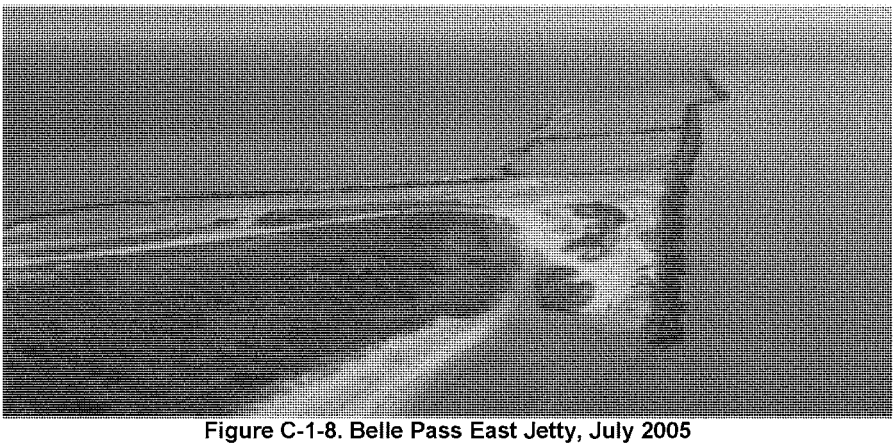


**Figure C-1-8. Belle Pass East Jetty, July 2005**

The jetties have an impact on the longshore transport along the Headland to the west, trapping sand, and causing a significant downdrift impact on the Timbalier Islands to the west. Williams et al. (1992) reported an erosion rate of approximately 70 feet per year between 1978 and 1988 for East Timbalier Island.

### C-1-2-3-2 Boudin Bags

Following Hurricane Juan, in 1986 a section of the Caminada Headland seaward of Port Fourchon was armored with a cement-filled bag revetment locally referred to as the Boudin bags (Figure C-1-9). The central and eastern parts of the seaward face were constructed with additional cement blocks to provide toe stability. Over 458,000 cu yds of dredge spoil was backfilled landward of the revetment and over 196,000 cu yds was added to the beach. Monitoring through 1988 measured erosion rates to the west, at the revetment, and to the east of 10.5, 19.3 and 32.2 feet per year respectively. The revetment is an interruption of the natural coastal processes including cross shore sediment transport by both washover/backwash events as well as Aeolian processes. In 1992 Hurricane Andrew struck the Louisiana coastline causing considerable damage to the revetment, displacing the bags as much as 130 feet landward (Ritchie et al., 1995).

**Figure C-1-9. Boudin Bag Revetment, July 2005**

### C-1-2-3-3 Breakwaters

In an attempt to prevent erosion along the Headland fronting the oil and gas facilities, private oil companies constructed thirteen (13) breakwaters by sinking barges in the nearshore zone (Figure C-1-10). Subsequently, the barges were filled with rip-rap. Based on a review of existing conditions, historical and current photographs, and the shoreline change analyses presented in the engineering feasibility study, the breakwaters contribute to a reduction in shoreline erosion when compared to the average shoreline erosion along the Headland.

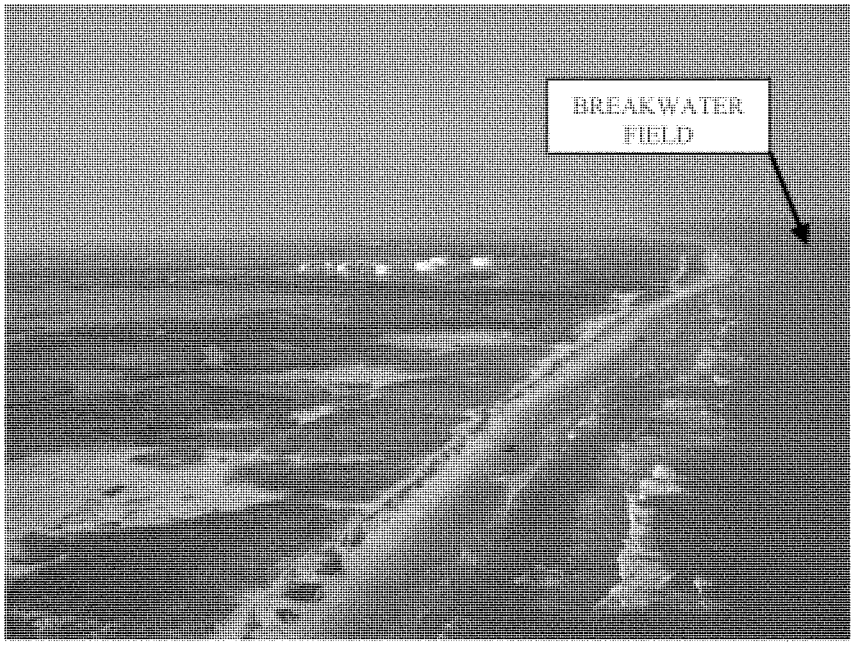



**Figure C-1-10. Breakwater Field, July 2005**

## C-1-2-4 Environmental Habitats

The LCA Study (USACE, 2004a) describes the Louisiana coastal area as one of the largest expanses of coastal wetlands in the continental United States, and 90 percent of the wetlands loss in the Nation's coastal marshes occurs in this area. The landforms of coastal Louisiana, including wetlands, lakes, bays and barrier shorelines, have been produced by the deltaic processes of the Mississippi River. This region contains an extraordinary diversity of coastal habitats that range from natural levees and beach ridges to forested swamps, freshwater, intermediate, brackish and saline marshes, freshwater lakes, and bays of variable salinity.

These landforms, along with their related hydrologic and biological processes, provide unique habitats that are crucial to the viability of migratory birds, commercial and recreational fisheries, and a great variety of terrestrial and aquatic species. Coastal wetlands also contribute to water quality in the region by reducing suspended sediment and nutrient loading in the aquatic environment. In human terms, these coastal wetlands have been a center for culturally diverse social development recognized and appreciated worldwide. In addition, coastal landforms and wetlands reduce the impact of flooding and storm surges on infrastructure in the coastal region,

including highways, oil and gas production facilities, pipelines, and navigation features, such as ports and channels.

The Caminada Headland contains three distinct habitats formed by deltaic and coastal processes. Its barrier shoreline is composed of a narrow beach, a low-lying dune, and some overwash areas. Shoreline sediments have been graded by wave action leaving behind mostly sands which are more resistant to erosion than the marsh it protects. The back-barrier marsh behind the shoreline beach and dune areas is relatively constant in elevation with the exception of tidal bayous, creeks and ponds and is home to many vegetative and aquatic species. To the north of the back-barrier marsh, the topography begins to vary in a unique area of parallel chenier ridges interspersed with saline marsh, linear ponds and small lagoons. The tops of the ridges are covered with a rare chenier maritime forest which functions as a vital resting area for trans-gulf migrating birds. There are also coastal mangrove thickets dominated by black mangroves. Some of the higher portions of the Headland are covered with patches of rare coastal dune shrub thicket.

Several threatened and endangered species utilize the Headland and adjacent waters: the threatened piping plover and Gulf sturgeon and the endangered brown pelican and Kemp's Ridley turtle.

### C-1-2-5 Pipeline and Gas Infrastructure

The Barataria Basin Barrier Shoreline Restoration area is part of one of the most intensively developed and productive oil and gas producing areas in the world. Infrastructure located within the Project area include oil and gas wellheads and control structures as well as oil and gas gathering lines and pipelines. Further, there are numerous oil and gas collector lines, pipelines and production structures located in proximity to the offshore borrow areas.

Port Fourchon is a multipurpose port utilized by over 125 companies. It is located just northwest of the breakwaters and about a mile inland from the Gulf. The port provides land-based support for about 75 % of the deepwater oil and gas activity in the Gulf (USACE, 2004c). The Louisiana Offshore Oil Port (LOOP) has its land-based facilities at the port. The pipelines come ashore from the offshore docking area and booster pumps send the oil further north to a salt-dome storage area east of Galliano. There are oil and gas producing facilities immediately behind the beach and south of Port Fourchon. There is also the BP Canal which parallels the barrier shoreline and is used as a protected route to access oil and gas infrastructure (Figure C-1-11).

**Figure C-1-11. Aerial View West of Port Fourchon and the BP Canal, July 2005**

### C-1-2-6 Oyster Leases

The project sponsors will coordinate appropriate oyster lease surveys to enable assessment of potential impacts to oyster resources related to the proposed project.

## C-1-3 PROBLEM IDENTIFICATION

As identified in the LCA Ecosystem Restoration Project PMP (USACE, 2005a), the Caminada Headland has historically suffered loss of wetland habitat and diminished function within the gulf shoreline. It is likely that the observed average coastal erosion rate at the Caminada Headland of 45 feet per year will continue for the foreseeable future. In addition, man-made structures have contributed to coastal erosion and loss of wetlands in the area. The beach has eroded and the dune ridge has been breached by overwash from storm surges at several locations along the Caminada Headland shoreline, including multiple shoreline breaches during the 2002, 2004 and 2005 hurricane seasons. It is likely that within the next several years, erosion will accelerate due to the significant number of breaches, connecting Bay Champagne to the Gulf, and subjecting the upland habitats, e.g. chenier ridge, mangrove thicket and maritime forest habitats, to degradation by wave action and saltwater intrusion. These rare mangrove and dune habitats would be destroyed, increasing stress on the wildlife that rely on these areas for food, nesting and resting. In addition, the northern shoreline along the bay would be susceptible to erosion due to direct wave attack and salt-water intrusion. These processes will accelerate the loss of marsh, chenier and estuary habitats as the embayment increases in size.

A coastal Louisiana land loss model presented in the LCA Study (USACE, 2004c) indicates that with no intervention, the Caminada Headland will not remain as it is now. The prediction from 2000 to 2050 is a projected land loss of 3,750 acres from the Headland and 14,780 acres from the area to the north from 2000 to 2050. Only a skeletal framework of wetlands will remain in 2050. The area around Port Fourchon would be further isolated from the remaining mainland, and could become a detached small barrier island.

The LCA Ecosystem Restoration Project PMP (USACE, 2005a) stresses that preserving the Caminada Headland would allow these features to continue to function as a major structural element of the regional coastline and shoreline providing protection to Bayou Lafourche which separates Terrebonne Bay and Barataria Bay. Restoration of the Caminada Headland will contribute to the stability of this major geomorphic feature. It is more feasible to protect this erosional Headland before it splits into multiple barrier islands as the shoreline is further breached and degraded. Pumping sand and marsh fill onto an existing framework of dunes, remnant ridges, marshes, and shallow ponds is more efficient and would have greater stability and longevity than attempts at restoration of fragmented shoreline or deep-water embayment. Delaying the Project would allow further deterioration of this major feature of the Barataria Basin shoreline, resulting in higher costs, and possibly resulting in major impacts to the Project area that could not be remedied.

# C-2 SURVEYING AND MAPPING

## C-2-1 BARRIER HEADLAND PHYSICAL CHARACTERISTICS

### C-2-1-1 Gulf Shoreline

The Caminada Headland gulf shoreline is approximately 13 miles long extending from Caminada Pass on the eastern end, separating the Headland from Grand Isle, to Belle Pass on the western end. The Timbalier Islands lie west of the Headland. The shoreline is quickly retreating and is mostly comprised of a narrow seaward beach, low lying dunes, several overwash areas, and multiple existing breaches. Hurricane Katrina which struck the Louisiana coastline in August 2005 increased the number of shoreline breaches.

### C-2-1-2 Back-Barrier Marsh

The back-barrier marsh component of the Caminada Headland is bounded to the north by the BP Canal and to the south by the gulf shoreline. This portion of the headland considered to be marsh extends from the open bay near Elmer's Island westward to Bay Champagne. The marsh is relatively constant in elevation with the exception of areas altered by oil and gas canals and some open water areas characterized as tidal bayous, creeks and ponds. The marsh is being threatened by shoreline encroachment and breaching which connects the area directly to the gulf leading to the intrusion of higher salinities and tidal scour. A graphical depiction of each of the project components is shown in Figure C-2-1.

### C-2-1-3 Barrier Headland Morphology

In the 1800's several tidal inlets and former distributaries segmented the Caminada Headland. Raccoon Pass formed the western boundary between the Headland and the Timbalier Islands, which has been open continuously from pre-1887 to present. No major changes in morphology occurred by 1934. Of note, Belle Pass, Pass Fourchon, and Bayou Moreau segmented the central Headland area. By 1956, the land area fronting Lake Champagne was breached as the shoreline retreated. Bay Marchand decreased over 70 percent in response to shoreline retreat. Moreover, the downdrift offset west of Belle Pass began to develop.

Both Bayou Lafourche and Pass Fourchon widened by 1978, while the downdrift offset was more acute. Shoreline retreat reduced Bay Marchand to a small pond and intercepted Bayou Moreau to segment the distributary. By 1988, shoreline retreat had removed large quantities of sediment from the central Headland area. This sediment was transported downdrift to Grand Isle but blocked from reaching the Timbalier Islands by the Belle Pass jetties, causing the magnitude of downdrift offset to increase west of Belle Pass. Bay Champagne experienced extensive size reductions, while Bay Marchand was close to complete disappearance.

Coastal Engineering Consultants Inc.
FIGURE C-2-1: CAMINADA HEADLAND SHORELINE AND MARSH COMPONENTS
AUGUST, 2007
SJB GROUP
PROPOSED SEAGRASS AND MARSH TILL
PROPOSED MARSH TILL

Bayou Moreau intersected the shoreline in several locations and numerous dredge canals dissected the coastal landscape (Williams et al., 1992).

## C-2-2 SURVEY COMPARISONS

### C-2-2-1 2000 – 2001 Coast 2050 Survey

Morris P. Hebert, Inc. (MPH) was contracted by LDNR to conduct a topographic and bathymetric survey of five individual reaches of barrier shoreline in the Barataria Basin including the Caminada Headland, Grand Terre Islands, Chaland Headland, Scofield Island and Shell Island. This information served as the baseline survey in the engineering feasibility study to analyze short-term shoreline changes.

MPH constructed five secondary control point monuments along the coast and established horizontal and vertical control of these monuments using four NGS points during a static GPS survey. The station used for the Caminada area survey was named HEADLANDS and is located on the Louisiana Highway 1 Bridge over Bayou Ferblanc and is just west of the Town of Grand Isle, Louisiana.

The locations of the survey transects were determined from data furnished by LDNR. The horizontal location of all transects was staked utilizing differentially correct GPS technology to an accuracy of approximately one meter. Vertical data on land and adjacent shallow water areas was gathered utilizing conventional level equipment or centimeter level GPS technology. Transects in deeper water areas were surveyed utilizing boat-based bathymetric surveying techniques. Field work was performed in late 2000 and early 2001. Survey results are presented in Annex C-1.

### C-2-2-2 2005 Survey

C.H. Fenstermaker & Associates, Inc. (Fenstermaker) was contracted by LDNR to conduct a topographic and bathymetric survey of the Caminada Headland to be used in the LCA Barataria Basin Barrier Island Shoreline Restoration Feasibility Study.

Prior to commencement of field work, field personnel recovered three (3) Primary Monuments that are part of LDNR's Louisiana Coastal Zone (LCZ) Primary GPS Network. These monuments were utilized to establish two (2) new secondary GPS monuments as part of the South Louisiana Coastal Wetlands Secondary GPS Network. Installation of the new monuments was performed in accordance with the guidelines established in the manual A Contractor's Guide to Minimum Standards for Contractors.

The survey was performed in the following four (4) stages:

- Stage 1 – Recover Primary Monument and establish two (2) Secondary GPS monuments.

- Stage 2 – Establish a survey baseline along the length of the project by the installation of ¾" Iron Pipes at the Point of Beginning (POB), Point of Ending (POE), and at each Point of Intersection (PI) along the baseline.
- Stage 3 - Establish LDNR transect lines by establishing the points of intersection between the survey baseline and the transect lines. Said intersections were marked by ¾" Iron Pipes installations next to flagged survey stakes.
- Stage 4 – Perform a survey along the established LDNR transect lines recording elevations every twenty-five feet along each transect line and at each break line encountered.

Fenstermaker began the survey on June 22, 2005 and completed it on July 12, 2005. The results of the survey are presented in Annex C-1.

## C-2-2-3 Shoreline Change Analysis

### C-2-2-3-1 Short-Term Erosion Rates

A review of the two survey data sets revealed that the transects were not necessarily run along the same profile azimuth nor in the same location along the Headland. The survey transect locations are shown in Figure C-2-2. To enable a more accurate comparison, the original MPH data were utilized to create a three-dimensional surface by which new profiles were cross sectioned at the locations and azimuths of the Fenstermaker transects. The comparisons between the modified Coast 2050 survey and 2005 survey are presented in Annex C-1.

Based on the survey comparisons, the changes in shoreline position at the average existing dune elevation, 3.5 feet NAVD, and Mean High Water (MHW), 1.53 feet NAVD, were computed. These values are presented in Tables C-2-1 and C-2-2 and represent the short-term erosion rates along the Headland. The erosion rates range from approximately 8 to 49 feet per year at the dune with an average of approximately 34 feet per year. The erosion rates at MHW are slightly higher, ranging from approximately 10 to 54 feet per year with an average of approximately 36 feet per year.

**Table C-2-1. Shoreline Changes at Dune Crest**

| Existing Dune (+3.50 ft NAVD) | | | | | |
|---|---|---|---|---|---|
| Fenstermaker Transect | MPH Profile | Distance from Baseline - Fenstermaker Survey (ft) | Distance from Baseline - Hebert Survey (ft) | Shoreline Change (ft) | Shoreline Change Rate (ft/yr) |
| A | 1 | 39.26 | 178.31 | -139.05 | -27.81 |
| B | 3 | 5.04 | 110.79 | -105.75 | -21.15 |
| C | 7 | 28.78 | 273.02 | -244.24 | -48.85 |
| D | 10 | 5.09 | 198.43 | -193.34 | -38.67 |
| E | 12 | -19.52 | 214.16 | -233.68 | -46.74 |
| F | 14 | 10.12 | 49.73 | -39.61 | -7.92 |
| G | 16 | 99.18 | 329.54 | -230.36 | -46.07 |
| | | | | Average | -33.89 |

**Table C-2-2. Shoreline Changes at Mean High Water**

| Mean High Water (+1.53 ft NAVD) | | | | | |
|---|---|---|---|---|---|
| Fenstermaker Transect | MPH Profile | Distance from Baseline - Fenstermaker Survey (ft) | Distance from Baseline - Hebert Survey (ft) | Shoreline Change (ft) | Shoreline Change Rate (ft/yr) |
| A | 1 | 84.70 | 213.02 | -128.32 | -25.66 |
| B | 3 | 53.07 | 206.73 | -153.66 | -30.73 |
| C | 7 | 46.22 | 314.31 | -268.09 | -53.62 |
| D | 10 | 39.69 | 224.64 | -184.95 | -36.99 |
| E | 12 | 5.13 | 231.81 | -226.68 | -45.34 |
| F | 14 | 67.51 | 117.62 | -50.11 | -10.02 |
| G | 16 | 180.43 | 421.23 | -240.80 | -48.16 |
| | | | | Average | -35.79 |

### C-2-2-3-2 Long-Term Erosion Rates

Over the last 100 years, the Caminada Headland has experienced an average shoreline erosion rate of 45 feet per year (USACE, 2004c). This is attributed to background erosion rates which have varied from 9 to 45 feet per year and tropical storms and hurricanes. Tropical Storm Bill alone eroded the Caminada beach by 60 to 80 feet in 2003. The Headland also suffered severe erosion from Hurricane Katrina in August of 2005. Damages from Hurricane Katrina are currently being assessed, some of which can be seen in Figure C-1-6.

Williams et al. (1992) examined the magnitude and impact of shoreline change along the Louisiana coastline including the Caminada Headland. Their technique for shoreline mapping included comparing topographic or near-vertical aerial surveys over time. The high-water line was used as the shoreline for comparison purposes. Between Belle Pass and Caminada Pass 43 transects (No.s 81 through 85, and No.s 1 through 38) were analyzed (Figure C-2-3). Between 1887 and 1988, their derived shoreline changes ranged from approximately 970 feet to 6,640 feet with an average of approximately 4,620 feet. These changes over the 101 year time frame equate to rates of approximately 9.6 to 65.8 feet per year, with an average of approximately 45.8 feet per year. The rates were highest just east of Bay Champagne, reducing slightly to the west to Belle Pass. However, the rates reduced significantly to the east to Caminada Pass. Figure C-2-3 also portrays the significant land loss over time along the Headland between 1887 (yellow) and 1988 (brown).

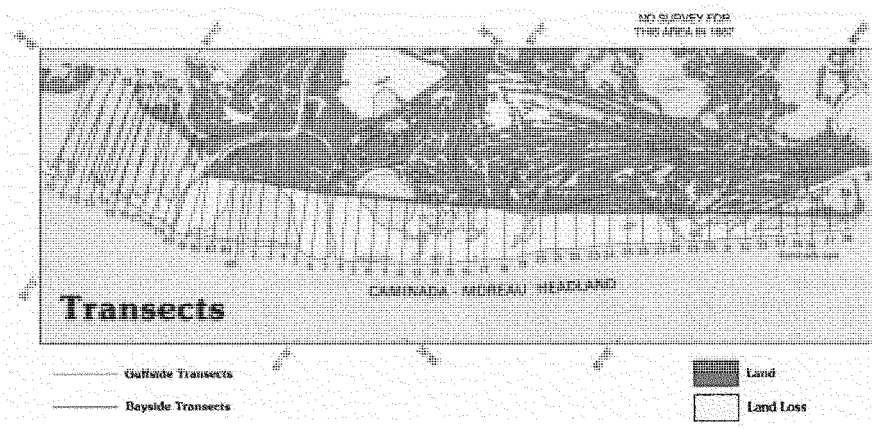



**Figure C-2-3. Historic Shoreline Change Atlas, 1887 - 1988**

The average computed short-term erosion rates are approximately 25% less than the published long-term erosion rates, thus the long-term erosion rate of 45 feet per year is recommended as a conservative estimate for the design shoreline erosion rate.

### C-2-2-4 Volumetric Change Analysis

Comparisons between the modified Coast 2050 survey (Section C-2-2) and 2005 survey were analyzed to compute the volumetric shoreline changes. Gulf-side erosion and overwash accumulation on the landward side of the existing dune are the two components which make up the cumulative volumetric change which is presented in Table C-2-3. The cumulative volume change along the Headland from Transect A to G equals approximately (-)615,000 cu yds per year. The overwash accumulation on the landward side of the existing dune for the same time period between Transects D and G equals approximately (+)311,000 cu yds per year (Table C-2-

4). Therefore, the total net gulf shoreline erosion loss equals approximately 926,000 cu yds per year as shown in the equation below.

Gulf-side Erosional Loss = Overall Change – Overwash = (-615,000) – 311,000 = (-926,000) cu yds per year

**Table C-2-3. Cumulative Shoreline Volume Changes**

| Fenstermaker Transect | MPH Profile | Cross Section Change (sq ft) | Length (feet) | Total Volume Change (cu yds) | Volume Change Rate (cu yds / year) |
|---|---|---|---|---|---|
| A | 1 | -513 | | | |
| | | | 9,458 | -569,097 | -113,819 |
| B | 3 | -2737 | | | |
| | | | 11,169 | -1,274,734 | -254,947 |
| C | 7 | -3426 | | | |
| | | | 14,836 | -1,128,504 | -225,701 |
| D | 10 | -681 | | | |
| | | | 10,579 | -480,920 | -96,184 |
| E | 12 | -1774 | | | |
| | | | 10,589 | -132,419 | -26,484 |
| F | 14 | 1098 | | | |
| | | | 10,532 | 513,044 | 102,609 |
| G | 16 | 1532 | | | |
| | | | Total | -3,072,630 | -614,526 |

Table C-2-4 presents the overwash volumes calculated based on the survey comparisons. Only four of the surveyed cross sections (Transects D through G) were included in the overwash volume calculations due to MPH profiles 1, 3, and 7 not extending far enough northward to make an accurate comparison.

**Table C-2-4. Overwash Volume Changes**

| Fenstermaker Transect | MPH Profile | Cross Section Change (sq ft) | Length (feet) | Total Volume Change (cu yd) | Volume Change Rate (cu yd / year) |
|---|---|---|---|---|---|
| D | 10 | 1722.96 | | | |
| | | | 10,579 | 544,713 | 108,943 |
| E | 12 | 1057.52 | | | |
| | | | 10,589 | 519,758 | 103,952 |
| F | 14 | 1593.14 | | | |
| | | | 10,532 | 490,105 | 98,021 |
| G | 16 | 919.85 | | | |
| | | | Total | 1,554,576 | 310,915 |

It was necessary to compute the overwash accumulation rate for the entire Headland to account for overwash processes in the area. Where insufficient data existed to compute the value, specifically between Transects A and D, the rate was computed by taking the total volume change of 311,000 cu yds per year (Transects D through G) and dividing by the length between transects, equal to approximately 31,735 feet. This yielded a rate of 9.8 cu yds per year per foot. Multiplying this rate by the length between Transects A and D equal to approximately 35,950 feet, resulted in 352,000 cu yds per year. Reducing the overwash rate equal to the reduction of 33% in erosion rate measured at MHW for the western end, the overwash accumulation between Transects A through D was computed to be approximately 236,000 cu yds per year. Therefore the total overwash rate for the entire Headland was estimated to be approximately 547,000 cu yds per year.

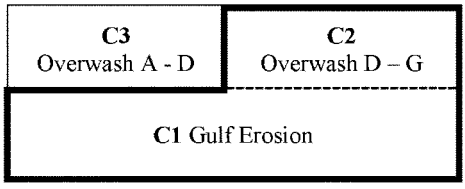



**Figure C-2-4. Volume Change Analysis**

$$C1 + C2 = -615{,}000$$
$$C1 + 311{,}000 = -615{,}000$$
$$C1 = -926{,}000$$

$$C3 = 236{,}000$$
$$\text{Net} = C1 + C2 + C3 = -926{,}000 + 311{,}000 + 236{,}000 = \mathbf{-379{,}000}$$

### C-2-2-5 Native Marsh Elevation

The native marsh elevation for the Caminada Headland back-barrier marsh was determined to be 0.94 feet NAVD. This was determined by taking an average of all of the elevations recorded in the proposed marsh creation area during the Fenstermaker 2005 survey. Fenstermaker transects which crossed the proposed marsh creation area described in Section C-5-1-2-1 include transects D, E, and F.

# C-3 COASTAL PROCESSES

## C-3-1 PHYSICAL PROCESSES

### C-3-1-1 Winds

Wind data statistics were generated using the USACE (2000b) Wave Information Study (WIS) Wave Hindcast Study from 1980 to 1999 at WIS Station 130, located in 60 feet water depth at 90.0 Longitude, 29.0 Latitude, offshore of the Caminada Headland, and are presented in Table C-3-1.

**Table C-3-1. Directional Wind Statistics**

| ANGLE BAND | AVERAGE WIND SPEED (MPH) | % OCCURRENCE |
|---|---|---|
| 0 - 22.5 | 17.2 | 7.7% |
| 22.5 - 45 | 15.8 | 6.7% |
| 45 - 67.5 | 15.0 | 7.1% |
| 67.5 – 90 | 13.9 | 6.7% |
| 90 – 112.5 | 13.7 | 8.5% |
| 112.5 – 135 | 13.6 | 7.8% |
| 135 – 157.5 | 14.1 | 9.0% |
| 157.5 – 180 | 14.0 | 7.7% |
| 180 – 202.5 | 13.0 | 6.3% |
| 202.5 – 225 | 12.3 | 4.3% |
| 225 – 247.5 | 11.5 | 3.9% |
| 247.5 – 270 | 11.7 | 3.2% |
| 270 – 292.5 | 12.1 | 5.1% |
| 292.5 – 315 | 13.4 | 4.4% |
| 315 – 337.5 | 15.3 | 5.8% |
| 337.5 - 360 | 16.1 | 5.5% |

Storm wind statistics were compiled by CPE (2003) at the Grand Isle tide station from 1984 to 2001, and are presented in Table C-3-2. The source was the National Data Buoy Center Station.

**Table C-3-2. Storm Wind Statistics**

| FREQUENCY | STAGE (NAVD, FT) | SPEED (MPH) | DIRECTION (DEG) |
|---|---|---|---|
| QUARTERLY | 1.6 | 41 | 2 |
| SEMI-ANNUAL | 1.6 | 45 | 22 |
| ANNUAL | 1.6 | 47 | 24 |
| 2-YEAR | 1.6 | 50 | 19 |
| 3-YEAR | 2.7 | 51 | 350 |
| 4-YEAR | 3.4 | 52 | 321 |
| 5-YEAR | 4.0 | 53 | 301 |

These wind data along with the individual storm statistics (C-3-1-5) are recommended for use as design criteria for the Project design.

## C-3-1-2 Waves

Wave data statistics from 1980 to 1999 were also generated using WIS Station 130 at the location depicted in Figure C-3-1. The mean significant wave height, period and dominant wave direction for all the waves were approximately 3.0 feet, 5 seconds, and 145 degrees, respectively. The average shoreline orientation from west to east is 50 degrees, thus the angle band of onshore waves is 50 to 230 degrees. Directional, seasonal and extremal wave statistics are presented in Tables C-3-3, C-3-4, and C-3-5, respectively.

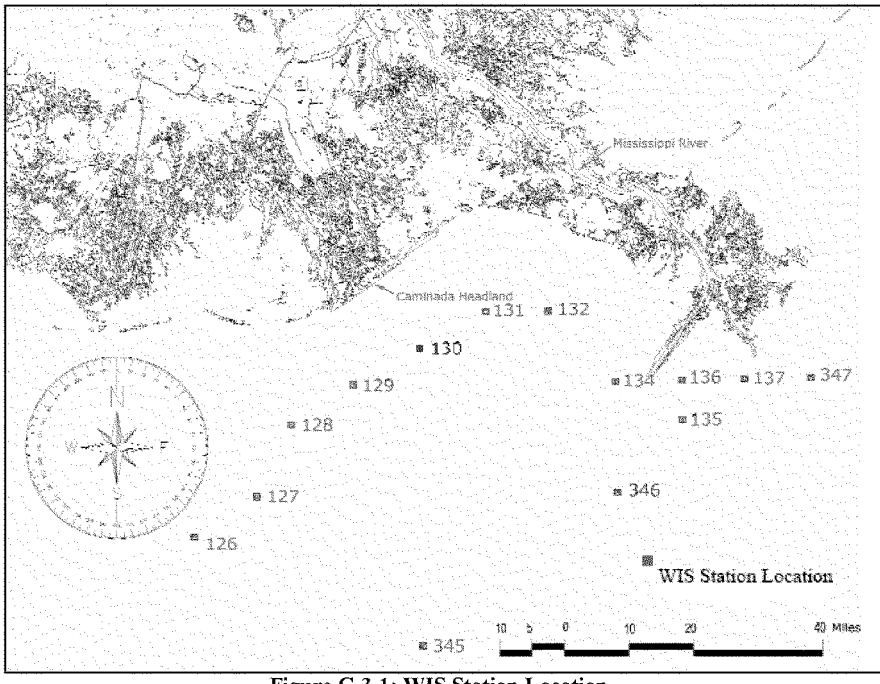



**Figure C-3-1: WIS Station Location**

**Table C-3-3. Directional Wave Statistics**

| ANGLE BAND (DEG) | AVG. WAVE HEIGHT (FT) | % OCCURRENCE | AVG. PERIOD (SEC) |
|---|---|---|---|
| 0 – 22.5 | 3.0 | 4.9% | 3.8 |
| 22.5 – 45 | 3.2 | 6.4% | 4.1 |
| 45 – 67.5 | 3.0 | 5.0% | 4.0 |
| 67.5 – 90 | 3.0 | 5.1% | 4.2 |
| 90 – 112.5 | 3.5 | 7.1% | 4.5 |
| 112.5 – 135 | 2.7 | 18.4% | 4.4 |
| 135 – 157.5 | 3.6 | 20.0% | 5.0 |
| 157.5 – 180 | 3.9 | 10.1% | 5.0 |
| 180 – 202.5 | 3.0 | 4.9% | 4.3 |
| 202.5 – 225 | 2.4 | 3.5% | 4.0 |
| 225 – 247.5 | 2.0 | 3.1% | 3.8 |
| 247.5 – 270 | 2.4 | 2.3% | 3.9 |
| 270 – 292.5 | 2.7 | 2.0% | 3.9 |
| 292.5 – 315 | 2.4 | 1.7% | 3.6 |
| 315 – 337.5 | 2.6 | 2.5% | 3.6 |
| 337.5-360 | 2.8 | 3.1% | 3.7 |

**Table C-3-4. Offshore Wave Statistics - From WIS Generated Tables for Station 130.**

| MONTH | WAVE HEIGHT (FT) | | PERIOD | DIRECTION |
|---|---|---|---|---|
| | AVG. | MAX | (SEC) | (DEG) |
| Jan. | 3.6 | 16.1 | 11 | 164 |
| Feb. | 3.7 | 13.1 | 9 | 158 |
| March | 3.8 | 14.1 | 11 | 158 |
| April | 3.6 | 12.5 | 10 | 267 |
| May | 2.9 | 10.8 | 10 | 167 |
| June | 2.5 | 8.2 | 7 | 202 |
| July | 2.0 | 13.5 | 8 | 160 |
| Aug. | 1.9 | 20.7 | 11 | 133 |
| Sept. | 2.7 | 18.7 | 12 | 110 |
| Oct. | 3.2 | 31.5 | 14 | 144 |
| Nov. | 3.6 | 13.5 | 10 | 158 |
| Dec. | 3.6 | 12.5 | 10 | 149 |
| Annual | 3.7 | 11.1 | 14 | 145 |

**Table C-3-5. Offshore Gulf Waves vs. Return Period**

| RETURN PERIOD (YEARS) | WAVE HEIGHT (FT) | WAVE PERIOD (SEC) | PROBABILITY* | PROBABILITY** |
|---|---|---|---|---|
| 2 | 15.6 | 7.6 | 0.5 | 0.750 |
| 5 | 20.9 | 9.1 | 0.2 | 0.672 |
| 10 | 25.8 | 10.1 | 0.1 | 0.651 |
| 20 | 31.0 | 11.0 | 0.05 | 0.641 |
| 50 | 38.9 | 12.2 | 0.02 | 0.636 |
| 100 | 42.3 | 13.1 | 0.01 | 0.634 |

* indicates the probability of the event occurring in any given year (e.g., the probability of a 20-year storm occurring in 2007 is 0.05 or 5% chance)

** indicated the probability of the event occurring during the corresponding return period (e.g., the probability of a 10-year storm occurring during 2007-2016 is 0.651 or 65.1% chance)

These wave data are recommended for use as design criteria for the Project design.

### C-3-1-3 Tides

The tidal datum at Grand Isle is presented in Table C-3-6. The tidal datum is based on a five year record from January 1990 through December 1994. The tidal epoch is 1960 – 1978 (NOAA, 2000).

**Table C-3-6. Grand Isle Tidal Datum**

| DESCRIPTION | NAVD (FT) |
|---|---|
| Highest Observed Water Level (10/27/1985) | 4.93 |
| Mean Higher High Water (MHHW) | 1.56 |
| Mean High Water (MHW) | 1.53 |
| Mean Sea Level (MSL) | 1.01 |
| Mean Tide Level (MTL) | 1.00 |
| Mean Low Water (MLW) | 0.48 |
| Mean Lower Low Water (MLLW) | 0.45 |
| North American Vertical Datum, 1988 (NAVD) | 0.00 |
| Lowest Observed Water Level (02/03/1951) | -2.31 |

### C-3-1-4 Currents

The Project area lies within the Barataria Basin, which compromises the area between the Mississippi River and Bayou Lafourche. Freshwater input to the basin includes rainfall and urban stormwater runoff, municipal discharges, and flow from the Mississippi River through the Harvey and Algiers locks and the Davis Pond Freshwater Diversion Project. Within the estuaries, circulation and flushing patterns are driven by hydraulic gradients produced by tidal action at the inlets, freshwater inputs, and winds. Offshore and littoral current velocities average between 0.4 to 0.6 knots and 0.7 to 1.0 knots, respectively (USACE, July 2002).

### C-3-1-5 Storms

Wave and water level data for storms having an impact on the Caminada Headland from 1985 to 2004 were assembled. All data were referenced to NAVD. The primary extreme storm events experienced at Caminada are hurricanes and intense tropical storms. Storm selection was based primarily on landfall location, but also on wave height and water level elevations associated with the storm. Landfall locations were obtained from the NOAA Coastal Services Historical Hurricane storm track data (http://hurricane.csc.noaa.gov/hurricanes/). Wave and wind data were obtained from two sources: WIS hindcast at Station 130 for storms prior to December 31, 1999 and the NOAA/NCEP analysis data predicted by the Wavewatch-III model for storms that occurred after December 31, 1999. The NOAA/NCEP data were obtained at WIS Station 130 location to be consistent with the WIS Station 130 data. Water level data were obtained from verified/historical records at NOAA/NOS CO-OPS Station 8761724 located at the Coast Guard Station on Grand Isle.

Using the STWAVE model (Smith et al., 2001), waves were transformed from the offshore deep water depth (60-ft) of WIS Station 130 to the depth of the SBEACH offshore boundary (20-ft) (Annex C-3). STWAVE is a steady-state finite difference model. It simulates depth-induced wave refraction and shoaling, current-induced refraction and shoaling, depth and steepness induced wave breaking, diffraction, wind driven wave growth, and wave-wave interaction and whitecapping that redistribute and dissipate energy in a growing wave field. The major storms that approached within 175 miles of Lafourche, Louisiana and designated as a hurricane (H1 through H5) since 1985 are listed in Table C-3-7. The table lists Year, Month, Days of Occurring Peak Wind Speed, Peak Wind Speed, and Storm Category.

Because the Sediment Transport Parameter calibration was determined from the previous Grand Isle report, the same five storms were used for analysis of the Caminada Headland. These include Hurricane Juan (1985), Andrew (1992), Danny (1997), Lili (2002), and Tropical Storm Isidore (2002). These five storms "... were judged to be the most severe from an erosion standpoint due to their high peak water levels, storm duration, and wave characteristics. In terms of measured peak water level only, these four events are representative of storms that occur every 5 to 7 years...". The input storm wave conditions for Hurricane Lili also include the data from Tropical Storm Isidore, which occurred approximately two weeks before Lili, and as in the Grand Isle report, they were treated as a single storm event (USACE, July 2004). Figures C-3-2 through C-3-5 show the input records used in SBEACH for each of the four modeled storms.

**Table C-3-7. NOAA Historical Hurricane Tracks (1985-2004)**

| STORM NAME | YEAR | MONTH | DAY | WIND SPEED (KNOTS) | CATEGORY |
|---|---|---|---|---|---|
| DANNY | 1985 | 8 | 15 | 80 | H1 |
| ELENA | 1985 | 9 | 2 | 105 | H3 |
| JUAN | 1985 | 10 | 29 | 75 | H1 |
| BONNIE | 1986 | 6 | 26 | 70 | H1 |
| ANDREW | 1992 | 8 | 26 | 125 | H4 |
| OPAL | 1995 | 10 | 4 | 130 | H4 |
| DANNY | 1997 | 7 | 19 | 70 | H1 |
| EARL | 1998 | 9 | 2 | 85 | H2 |
| GEORGES | 1998 | 9 | 28 | 95 | H2 |
| ISIDORE | 2002 | 9 | 23 | Not Available | TS |
| LILI | 2002 | 10 | 3 | 125 | H4 |
| IVAN | 2004 | 9 | 15 | 115 | H4 |

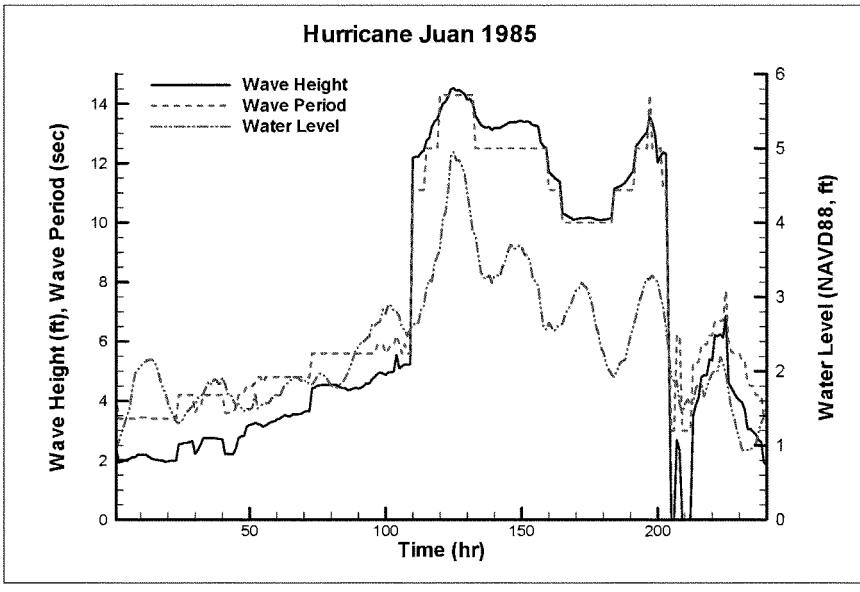



**Figure C-3-2. SBEACH Input Records, Juan 1985**

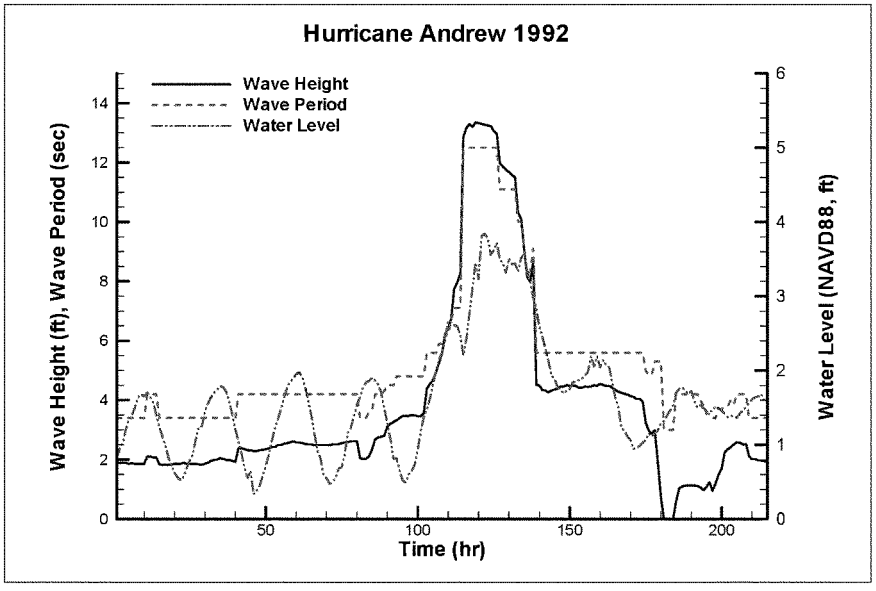



**Figure C-3-3. SBEACH Input Records, Andrew 1992**

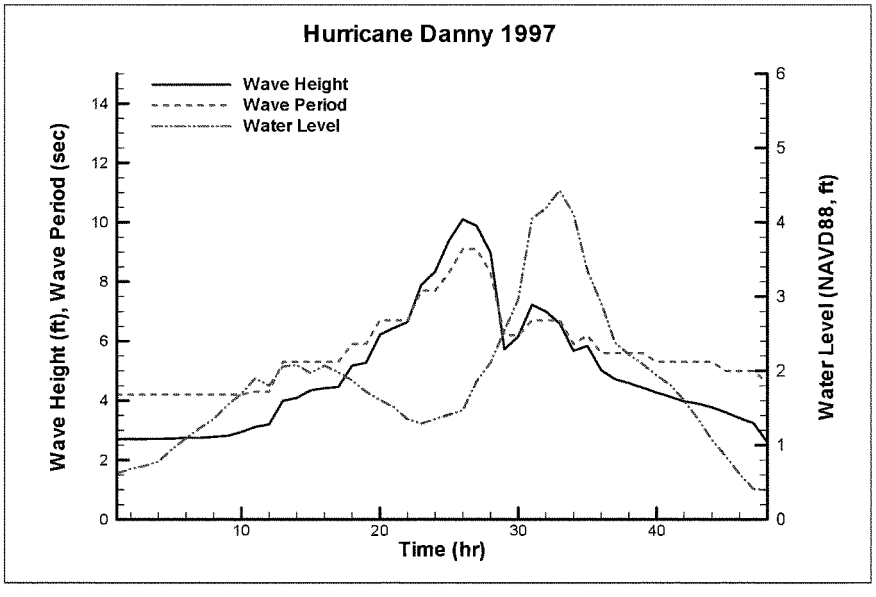



**Figure C-3-4. SBEACH Input Records, Danny 1997**

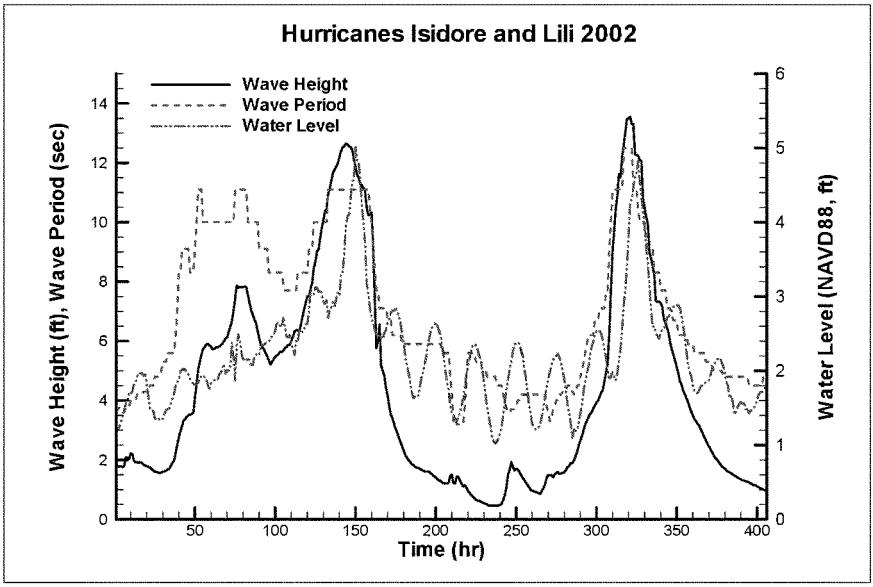



**Figure C-3-5. SBEACH Input Records, Isidore-Lili 2002**

## C-3-1-6 Sea Level Rise

Sea level rise statistics have been compiled by several sources, e.g. LCA Study (USACE 2004b). The predicted design rate for sea level rise of 0.013 feet per year is recommended as design criteria for the Project.

## C-3-1-7 Depth of Closure

The depth of closure is defined as the seaward limit of active sand transport. It is determined by one of two methods, either empirically or using historic profile comparisons. Both methods are employed herein along with comparisons to published values. Based on the analysis, the depth of closure is defined and recommendations made to further refine the analysis.

### C-3-1-7-1 Empirical Computations

WIS Station 130 data were utilized to compute the "effective" wave height, $H_e$, which is the significant wave height that is exceeded during only 12 hours per year. The effective wave height at WIS Station 130 was equal to 11.9 feet and the associated period, $T_e$, was equal to 8.0 seconds. The STWAVE model was used to propagate the WIS Station 130 effective wave closer to the

shore. The calculated nearshore effective wave height and period were 8.0 feet and 8.3 seconds, respectively. These data were used to calculate the depth of closure, $h_c$, by applying the empirical method developed by Hallermeier (1981):

$$h_c = 2.28H_e - 68.5\left(\frac{H_e^2}{gT_e^2}\right)$$

The calculated depth of closure was equal to approximately 16 feet referenced to Mean Sea Level (MSL) or approximately -15 feet NAVD. Further analysis using the Birkemeier (1985) method and the STWAVE model presented in Annex C-4 predicted a smaller depth of closure of approximately -12 feet MSL or -11 feet NAVD.

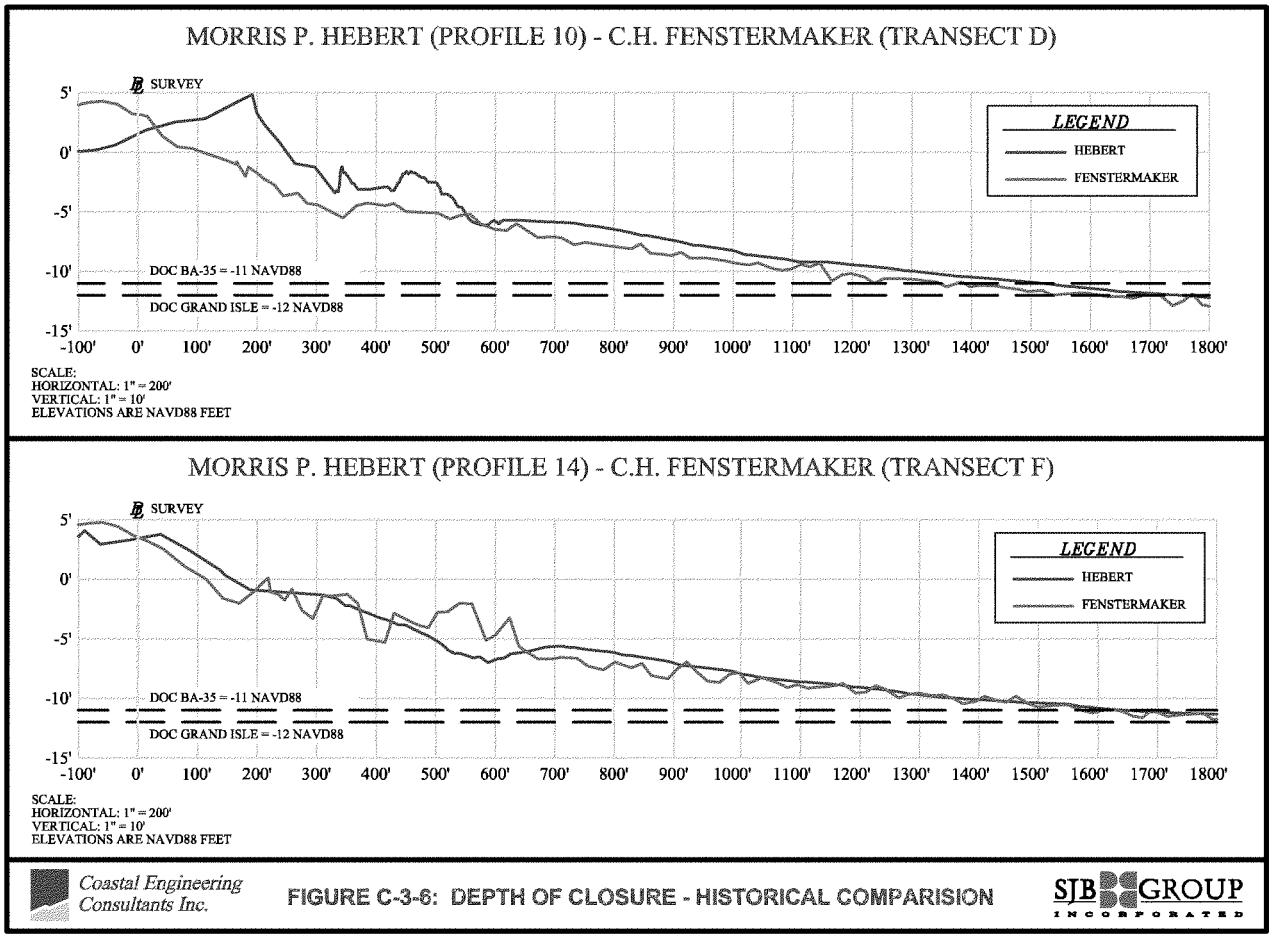
### C-3-1-7-2 Comparisons with the Literature

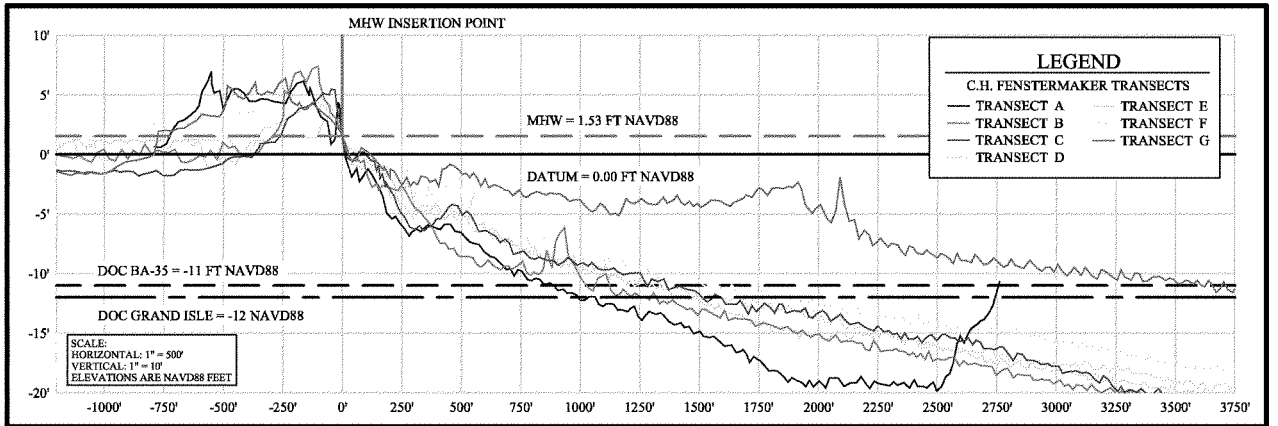
A review of recent Louisiana projects was conducted to identify the published depth of closure values in similar geologic settings experiencing similar coastal processes. USACE (July 2004) computed the depth of closure equal to -12 feet NAVD on Grand Isle. SJB and CEC (2005) computed the depth of closure equal to -11 feet NAVD for CWPPRA Project BA-35, Pass Chaland to Grand Bayou barrier restoration. The Grand Isle project setting most closely matches that Caminada Headland Project setting due to the proximity of the two projects.

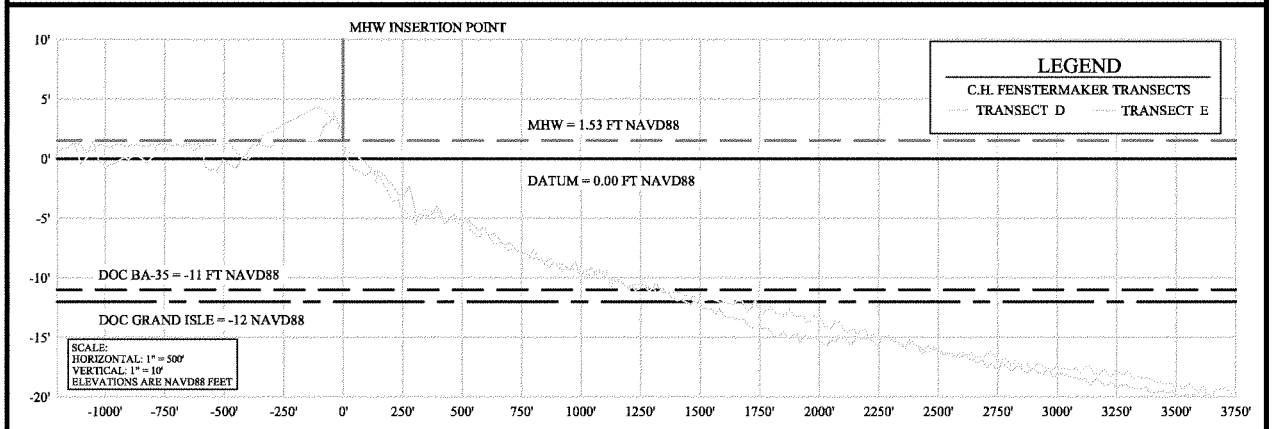
### C-3-1-7-3 Profile Comparisons

Empirical methods should be considered in conjunction with other pertinent information and analyses when determining the seaward depth of closure (Birkemeier, 1985 and Hallermeier, 1981), defined as the seawardmost point at a consistent elevation along the shoreline at which profile differential elevation changes end, that is, are on the order of a few tenths of a foot and within the accuracy of the surveys. Although historic profile comparisons are limited, an analysis was made of the MPH and Fenstermaker surveys. Figure C-3-6 depicts two of the transects and evidence of profile correlation is observed in the nearshore zone between -8 and -12 feet NAVD, relating well to the published depth of closure values for recent Louisiana projects described above.

Further, the Fenstermaker survey profiles were compared by overlaying the profiles along the shoreline and translating them to a common point at the intersection of the profile with MHW (Figure C-3-7). A review of these comparisons indicates the following. There is fairly good profile correlation in the nearshore zone among the transects, C through F (Figure C-2-1), along the central Headland, outside the influence of the two inlets and breakwaters, transects A and B and G, respectively. The transects most central to the shoreline, D and E, are detailed in Figure C-3-7 and compared to the published depth of closure values for recent Louisiana projects described above. There is evidence of profile correlation in the nearshore zone between -6 and -12 feet NAVD.


MORRIS P. HEBERT (PROFILE 10) - C.H. FENSTERMAKER (TRANSECT D)
SURVEY
LEGEND
HEBERT
FENSTERMAKER
DOC BA-35 = -11 NAVD88
DOC GRAND ISLE = -12 NAVD88
5'
0'
-5'
-10'
-15'
-100' 0' 100' 200' 300' 400' 500' 600' 700' 800' 900' 1000' 1100' 1200' 1300' 1400' 1500' 1600' 1700' 1800'
SCALE:
HORIZONTAL: 1" = 200'
VERTICAL: 1" = 10'
ELEVATIONS ARE NAVD88 FEET
MORRIS P. HEBERT (PROFILE 14) - C.H. FENSTERMAKER (TRANSECT F)
SURVEY
LEGEND
HEBERT
FENSTERMAKER
DOC BA-35 = -11 NAVD88
DOC GRAND ISLE = -12 NAVD88
5'
0'
-5'
-10'
-15'
-100' 0' 100' 200' 300' 400' 500' 600' 700' 800' 900' 1000' 1100' 1200' 1300' 1400' 1500' 1600' 1700' 1800'
SCALE:
HORIZONTAL: 1" = 200'
VERTICAL: 1" = 10'
ELEVATIONS ARE NAVD88 FEET
Coastal Engineering Consultants Inc.
FIGURE C-3-6: DEPTH OF CLOSURE - HISTORICAL COMPARISION
SJB GROUP INCORPORATED




Coastal Engineering Consultants Inc.

FIGURE C-3-7: TRANSECT COMPARISIONS AT MEAN HIGH WATER

SJB GROUP INCORPORATED

### C-3-1-7-4 Additional Analyses

The calculation of depth of closure is critical to the Project design for determining the expected beach fill erosion rates and evaluating project performance. As segments of the Caminada Headland are sand starved due to the significant erosion experienced over time, recent survey profile comparisons may not fully reflect the seaward limit of active sand transport. Since the methods employed herein are approximate, it is recommended that additional analyses be undertaken as follows.

A field effort is recommended in Preconstruction Engineering and Design Phase (PED) to attempt to ascertain the depth of closure. The object of the field work would be to measure the sand cover thickness over the underlying cohesive profile. The recommended technique to be employed includes sampling the sediment at specific locations along the shoreline and at specific elevation intervals along the profile. The upper stratum shall be collected via coring and visual observations shall be made to measure the sand cover thickness. At some seaward elevation, it is predicted the sand layer will diminish as the sediments turn to silts, muds and clays. If the elevation at this interface between sands to muds is consistent with the analysis presented herein, then it would serve as the recommended depth of closure. This will enable adjustments to the pertinent design criteria as necessary. Until additional analyses are conducted, based upon available data, the recommended design criteria for depth of closure is –12 feet NAVD.

## C-3-2 INLET PROCESSES

The Caminada Headland Project area is bounded to the west by Belle Pass and to the east by Caminada Pass. In 1935 the major navigation inlet through Belle Pass was stabilized with the construction of the jetties (Ritchie et al., 1995). The jetties were constructed of rip-rap and have been modified over time. The jetties have an impact on the longshore transport along the Headland to the west, trapping sand, and causing a significant downdrift impact on the Timbalier Islands to the west. The federal channel is maintained by a hydraulic dredge and the quantity is on the order of 300,000 cu yds per year (USACE, 2005b) giving some order of magnitude estimate of the sediment transport rate off the Headland to the west noting that there are other sources of this fine grained material, e.g. freshwater inputs and stormwater runoff.

Caminada Pass is unarmored and unstructured. There is evidence of longshore transport from west to east along the eastern section of the Headland including spit growth at an unknown rate (Ritchie et al., 1995) and bypassing of 83,000 cu yds per year to the downdrift shoreline on Grand Isle (USACE, July 2004).

Information on ebb and flood shoal changes, current velocities and tidal prism for both inlets is unavailable in the literature.

## C-3-3 SEDIMENT BUDGET

### C-3-3-1 Historical Sediment Transport Patterns

Ritchie et al. (1995) presented a summary of the historical sediment transport patterns along the Caminada Headland that were confirmed in multiple publications. Specifically, there exists a divergence of sediment transport from the central area of the Headland going both to the east and to the west. Figure C-3-8 depicts the general Headland features and divergence of transport with the node located in the vicinity of Bayou Moreau.

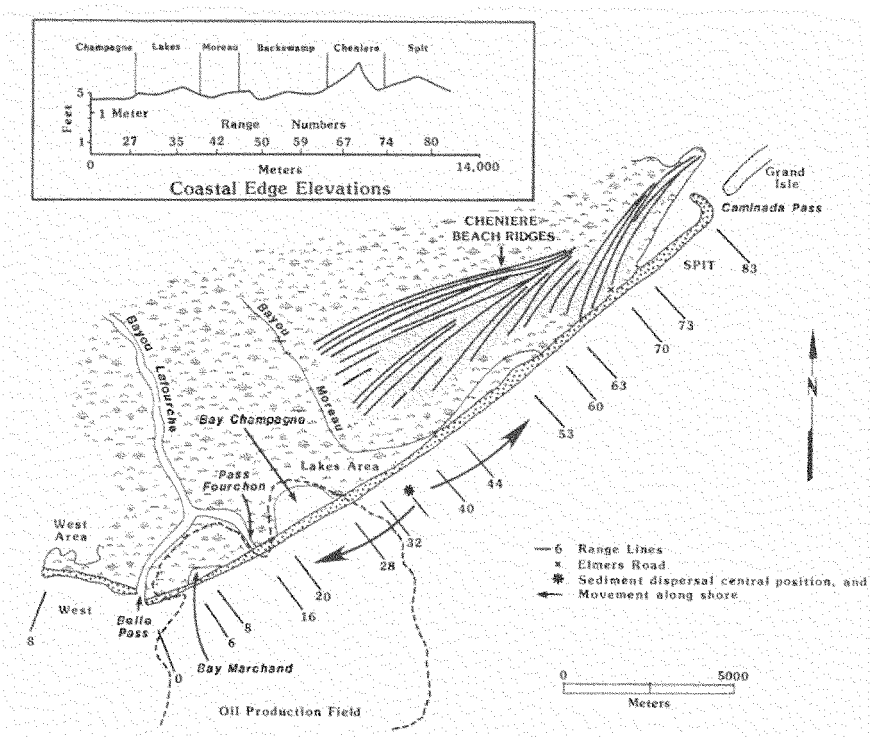



**Figure C-3-8. Historical Sediment Transport Patterns**

Williams et al. (1992) reported the historical shoreline changes along the Caminada Headland. The reported rates were highest just east of Bay Champagne corresponding to the location of sediment divergence reported by Ritchie et al. (1995), then reducing slightly to the west to Belle Pass and reducing significantly to the east to Caminada Pass. These historical rates support the

theory that a nodal zone exists on the central area of the Headland. It is likely that because the central part of the Headland is a promontory point along this stretch of the Louisiana coastline, it is eroding at a higher rate and experiencing this sediment divergence.

A review of historical photographs indicates the Caminada spit off the eastern end of the Headland is growing into the tidal inlet both easterly and northerly since 1956.

### C-3-3-2 Current Sediment Transport Patterns

The computed shoreline change rates at MHW (Section C-2-2-3) were highest at Transect C, which crosses Bay Champagne, then reducing by approximately 33% to the west attributed to the breakwaters and jetty impounding sand. The rates to the east do not exhibit any trend. To improve the understanding of the transport rates, it is recommended in PED that additional analyses be undertaken including profile measurement to determine average cross section and digitizing the current shoreline and comparing it to the 1988 historical shoreline to document short-term spit growth and attempt to estimate the rate.

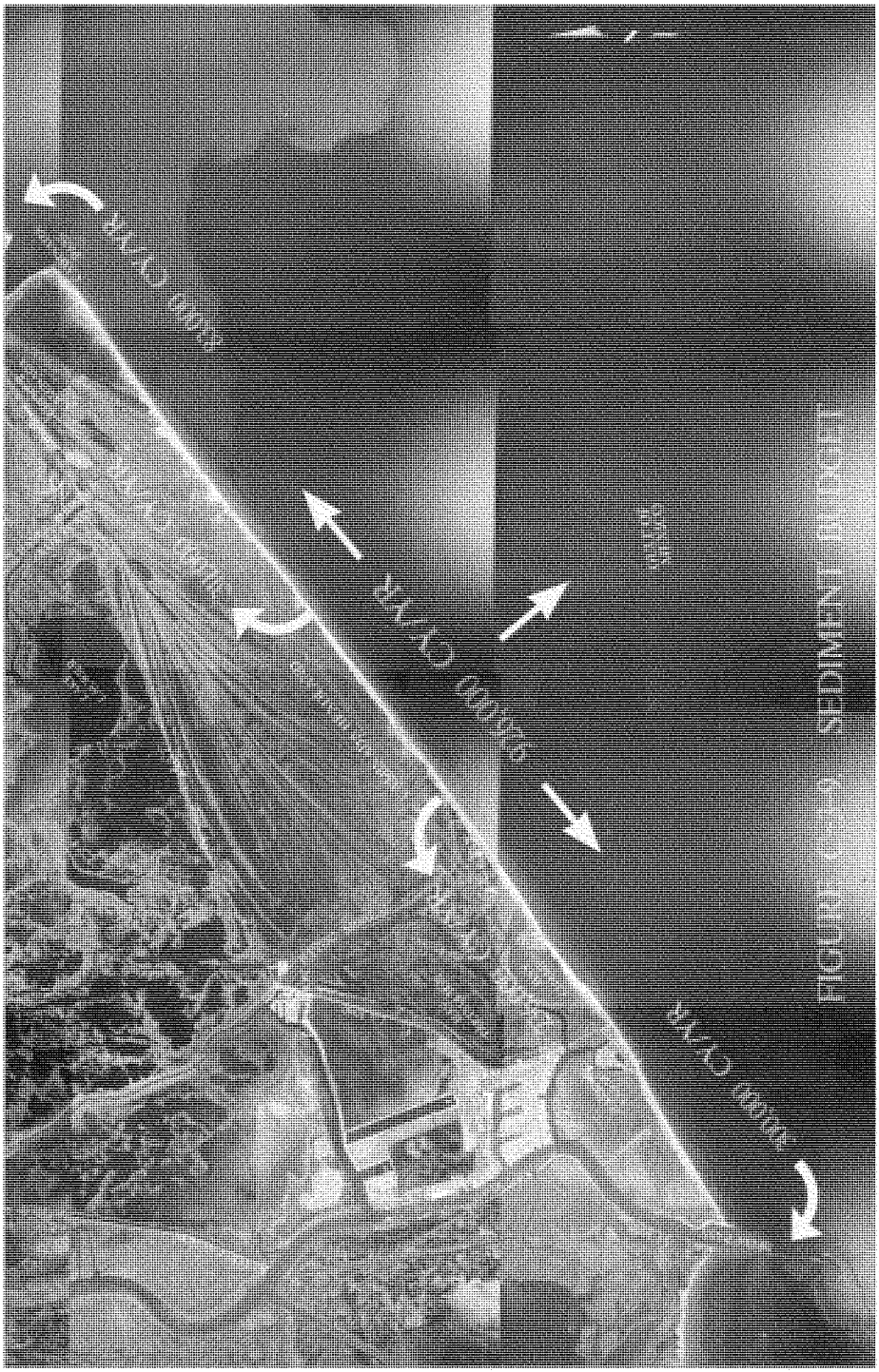
### C-3-3-3 Balancing the Budget

The total net gulf shoreline erosion loss and approximations for the overwash accumulation rate were calculated in the Section C-2-2-4 Volumetric Change Analysis. The total net gulf shoreline erosion loss was approximately 926,000 cu yds per year and the total overwash rate was approximately 547,000 cu yds per year.

The loss from the headland is derived from the total net gulf shoreline erosion loss minus the total overwash accumulation resulting in an erosion rate of 379,000 cu yds per year.

926,000 cu yds per year – 547,000 cu yds per year = 379,000 cu yds per year

Assuming the significant majority of the infilling rate of 300,000 cu yds per year in Belle Pass is due to sediment losses off the Headland to the west, and including the reported bypass rate to Grand Isle of 83,000 cu yds per year (presented in Section C-3-2), the sediment budget balances to within a few thousand cu yds per year, or less than 0.4% of the total gulf side erosion losses. The sediment budget is presented in Figure C-3-9.


SEDIMENT IN DOLE

## C-3-4 SEAFLOOR CHANGE

The long-term seafloor change along the Caminada Headland was calculated based on the Caminada Region 1980's to 2006 seafloor change map (LDNR, 2007) presented in Figure C-3-10.

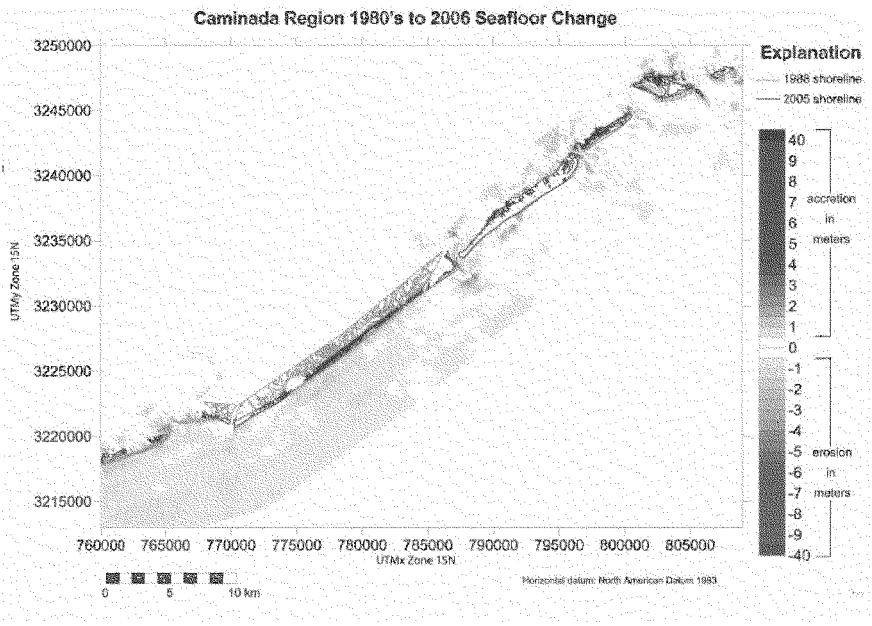



**Figure C-3-10. Caminada Headland Seafloor Change Map** (LDNR, 2007)

After the map was digitized, the seafloor changes were computed along Transects A through G. The results are presented in Figure C-3-11. Table C-3-8 presents average seafloor changes and corresponding volumetric changes for each transect. Between the 1980's and 2006, Transects A through F were subject to seafloor erosion which ranged from 1.0 foot for Transect B to 6.6 feet for Transect C, however, the average seafloor elevation along Transect G accreted approximately 2.0 feet. Volumetric losses resulting from the seafloor erosion during the 1980's – 2006 time period ranged from approximately 110 cu yds per foot for Transect B to 800 cu yds per foot for Transect C.

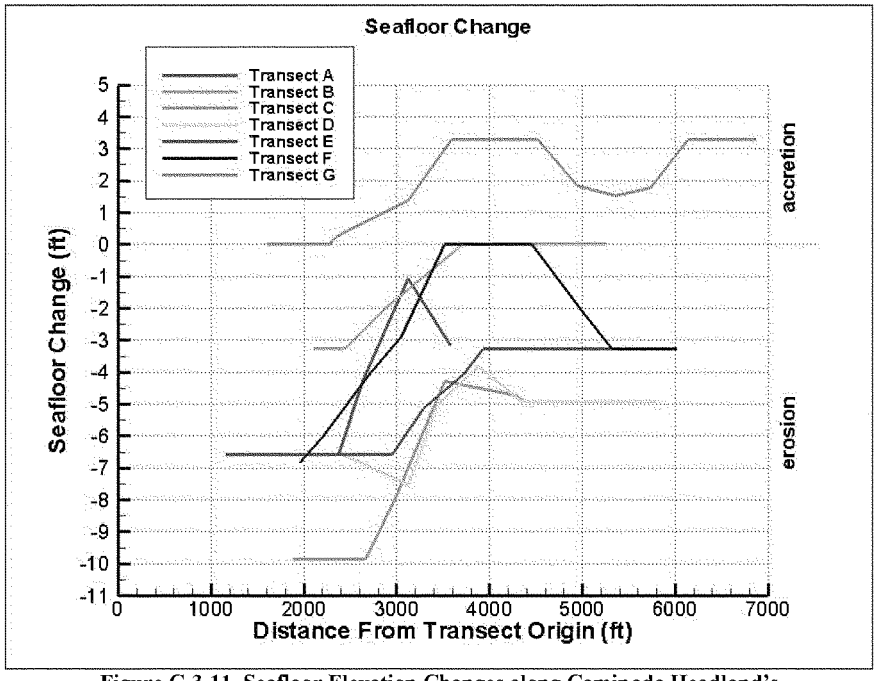



**Figure C-3-11. Seafloor Elevation Changes along Caminada Headland's Transects A through G**

**Table C-3-8. Seafloor Volumes Changes along Caminada Headland's Transects A through G**

| TRANSECT | AVERAGE SEAFLOOR CHANGE EROSION(-) / ACCRETION(+) (FEET) | VOLUMETRIC CHANGE EROSION(-) / ACCRETION(+) (CU YDS PER FOOT) |
|---|---|---|
| A | -4.8 | -430 |
| B | -1.0 | -110 |
| C | -6.6 | -800 |
| D | -5.4 | -680 |
| E | -4.3 | -600 |
| F | -2.4 | -360 |
| G | +2.0 | +390 |

## C-3-5 BEACH AND DUNE BENEFITS

### C-3-5-1 General

The purpose and benefits of beach and dune nourishment are well documented in the literature including National Research Council (1995), Dean (2002), and Silvester and Hsu (1997).

Federal shore protection projects quantify these benefits in the design process. Project examples of similar magnitude include Absecon Island[1] and Long Beach Island[2] in New Jersey, Fort Pierce Beach[3] and Broward County[4] in Florida, and Tybee Island[5] in Georgia.

1. http://www.nap.usace.army.mil/cenap-dp/projects/absecon/absecon.htm
2. http://www.state.nj.us/dep/ec/lbi_project.htm
3. http://www.saj.usace.army.mil/digitalproject/dpn/sajb_074.htm
4. http://www.saj.usace.army.mil/pd/envdocs/Broward/BC_Beach_Erosion_Control_Proj/index.html
5. http://www.sas.usace.army.mil/projects/projects/tybee.htm

### C-3-5-2 Background Erosion

Background erosion can refer to the historical erosion as determined from previous survey data. For Caminada Headland, the historical data indicate a background erosion rate of 45 feet/year (USACE, 2004). According to Dean (2002), the magnitude of the background erosion should be accounted for in project design as it can have a significant effect on the performance of a beach nourishment project. Further, Dean states that although there is no strong physical basis guiding the manner of accounting for effects of background erosion, it is usually assumed that the pre-nourishment background erosion rates can be superimposed on the shoreline changes induced by the nourishment.

To illustrate the benefits provided by beach nourishment, Dean's (2002) methodology of accounting for background erosion was implemented using the following Headland physical characteristics and assumed parameters:

Headland
Project length = 13 miles
Depth of closure = 12 feet
Berm height = 4.5 feet
Background erosion rate = 45 feet per year

Assumed Parameters
Longshore diffusivity = 0.1 sq feet per second
Nourishment volume density ≈ 100 cu yds per foot

Based on the volume density to berm height combined with depth of closure ratio, the post-nourishment equilibrated shoreline advancement equals 175 feet. Table C-3-9 presents the computed erosion rates and shoreline positions "with" and "without" beach nourishment as they evolve in time.

**Table C-3-9. Erosion Rates and Shoreline Positions Computed "with" and "without" Beach Nourishment Based on Dean's (2002) Methodology**

| PROJECT YEAR | BACKGROUND EROSION RATE, FEET PER YEAR | EROSION RATE DUE TO SPREADING, FEET PER YEAR | TOTAL EROSION RATE, FEET PER YEAR | | SHORELINE POSITION*, FEET | |
|---|---|---|---|---|---|---|
| | | | "WITHOUT" | "WITH" | "WITHOUT" | "WITH" |
| 0 | - | - | - | - | 0 | 175 |
| 1 | 45 | 7 | 45 | 52 | -45 | 123 |
| 2 | 45 | 3 | 45 | 48 | -90 | 75 |
| 3 | 45 | 1 | 45 | 46 | -135 | 29 |
| 4 | 45 | 0 | 45 | 45 | -180 | -16 |
| 5 | 45 | 0 | 45 | 45 | -225 | -61 |

* - shoreline position relative to pre-construction shoreline

This example demonstrates that although the total erosion rate "with" nourishment is greater than that "without" nourishment, it decreases in time. Further, the benefit of the nourished beach is that after five years its shoreline is located 164 feet seaward of the "without" nourishment shoreline location.

### C-3-5-3 Dune Benefits

Sand dunes protect the beach from storm-induced erosion. Larger dunes provide more protection to the shoreline since it takes longer to be eroded by the waves. They can also provide more protection to areas further landward. If the dunes are large enough, the waves and storm surge are prevented from washing across the barrier island. The sand stored in the dunes and eroded during storms reduces the incoming waves thus decreasing storm-induced erosion compared to areas without dunes.

# C-4 GEOTECHNICAL

## C-4-1 BACK-BARRIER MARSH GEOTECHNICAL EVALUATION

In order to develop the marsh creation design templates, settlement and consolidation curves must be generated and used in conjunction with sea level rise and subsidence data to arrive at target fill elevations. Geotechnical data from the following neighboring Coastal Wetland Planning, Protection and Restoration Act (CWPPRA) projects were used to estimate settlement and consolidation: Pass Chaland to Grand Bayou Pass Barrier Shoreline Restoration (BA-35) (Soil Testing Engineers, Inc., 2004), Chaland Headland Restoration (BA-38) (STE, 2003), and East and West Grand Terre Island Restoration (BA-30) (MPH and Eustis, 2004). Geotechnical reports from each of the three projects present settlement curves for various marsh fill elevations. Comparisons of the curves are presented in Figures C-4-1 to C-4-5. The settlement rates represented include a combination of effects from three major sources:

- Settlement due to the weight of the marsh fill
- Self-weight consolidation within the marsh fill
- Geologic subsidence

Estimates of geologic subsidence vary from 2.5 feet per century to 2.9 feet per century within the CWPPRA geotechnical reports listed above. Sea level rise is also represented in the mean high water (MHW) and mean low water (MLW) curves shown on the graphs. The Intercontinental Panel on Climate Change (IPCC) provides the range of peer-reviewed projections for eustatic sea level change through calendar year 2100. The USGS (1992) reported that sea level rise could rise from 15 to 95 cm by the year 2100. This converts to a rate ranging from 0.5 feet per century to 3.1 feet per century. The USACE recommends using the mid range value, resulting in a 1.3 feet per century sea level rise (IPCC, 2001). To determine the design marsh fill elevation, Figure C-4-5 was analyzed to determine which curve resulted in an intertidal marsh for the longest percentage of time over a twenty year nourishment period.

Based on the results presented in Table C-4-1 and Figure C-4-5, elevation +2.0 feet NAVD was chosen as the design marsh fill elevation because it results in an intertidal marsh for the greatest percentage during each nourishment period.

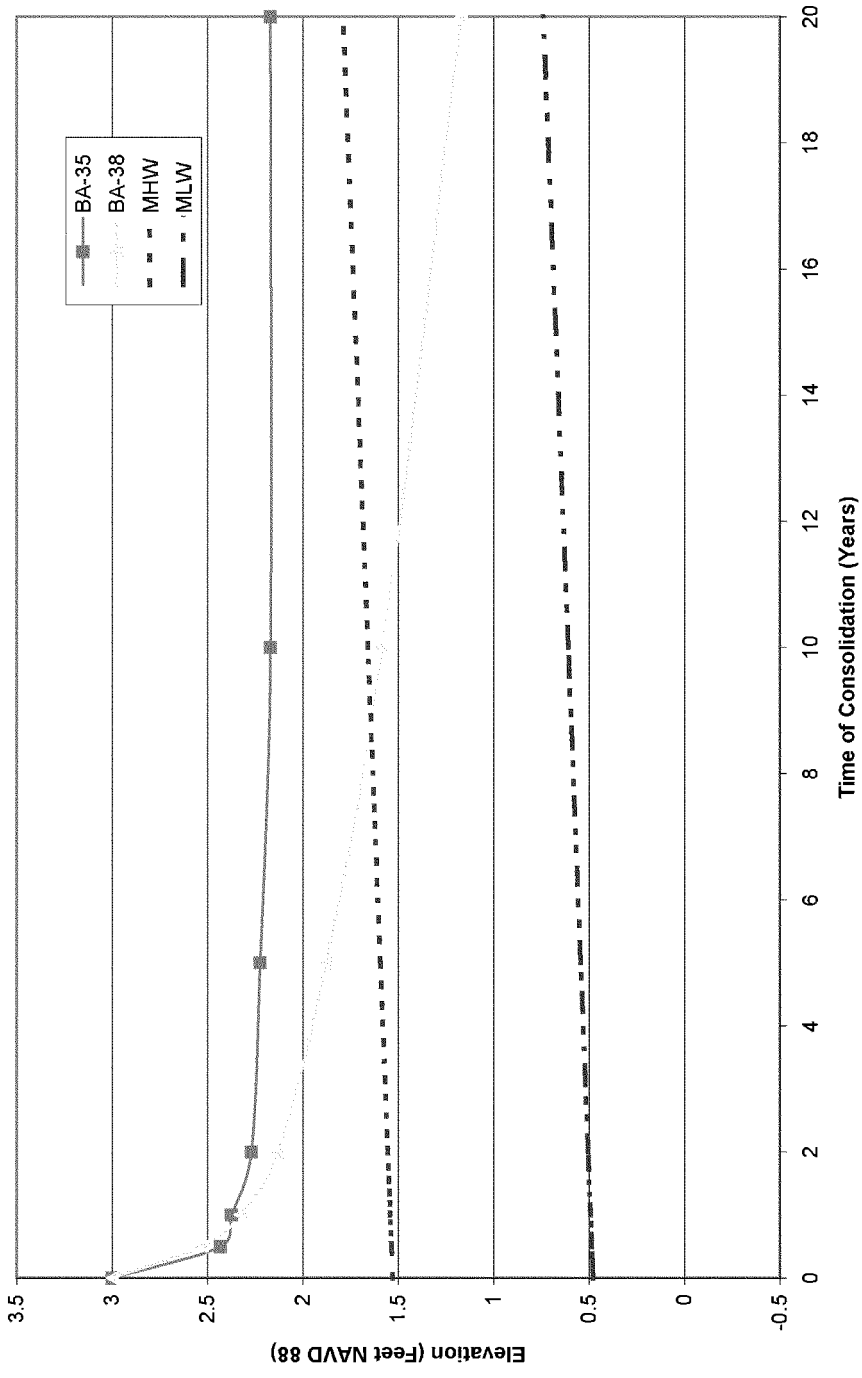
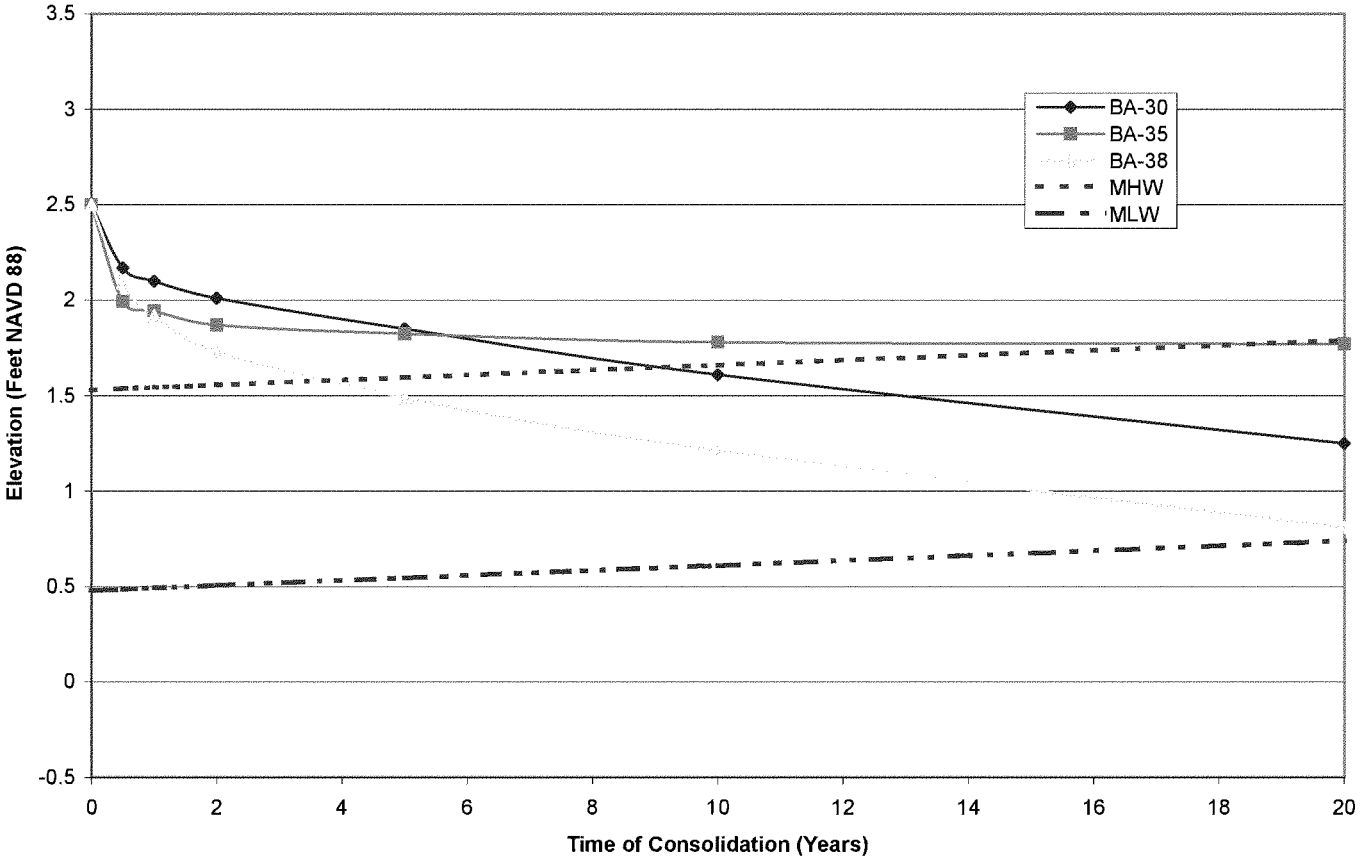



**Figure C-4-1. Back-Barrier Marsh Creation Settlement Curve Comparison Elevation +3.0' NAVD 88 (Subsidence Included)**

**Figure C-4-2. Back-Barrier Marsh Creation Settlement Curve Comparison**
**Elevation +2.5' NAVD 88 (Subsidence Included)**



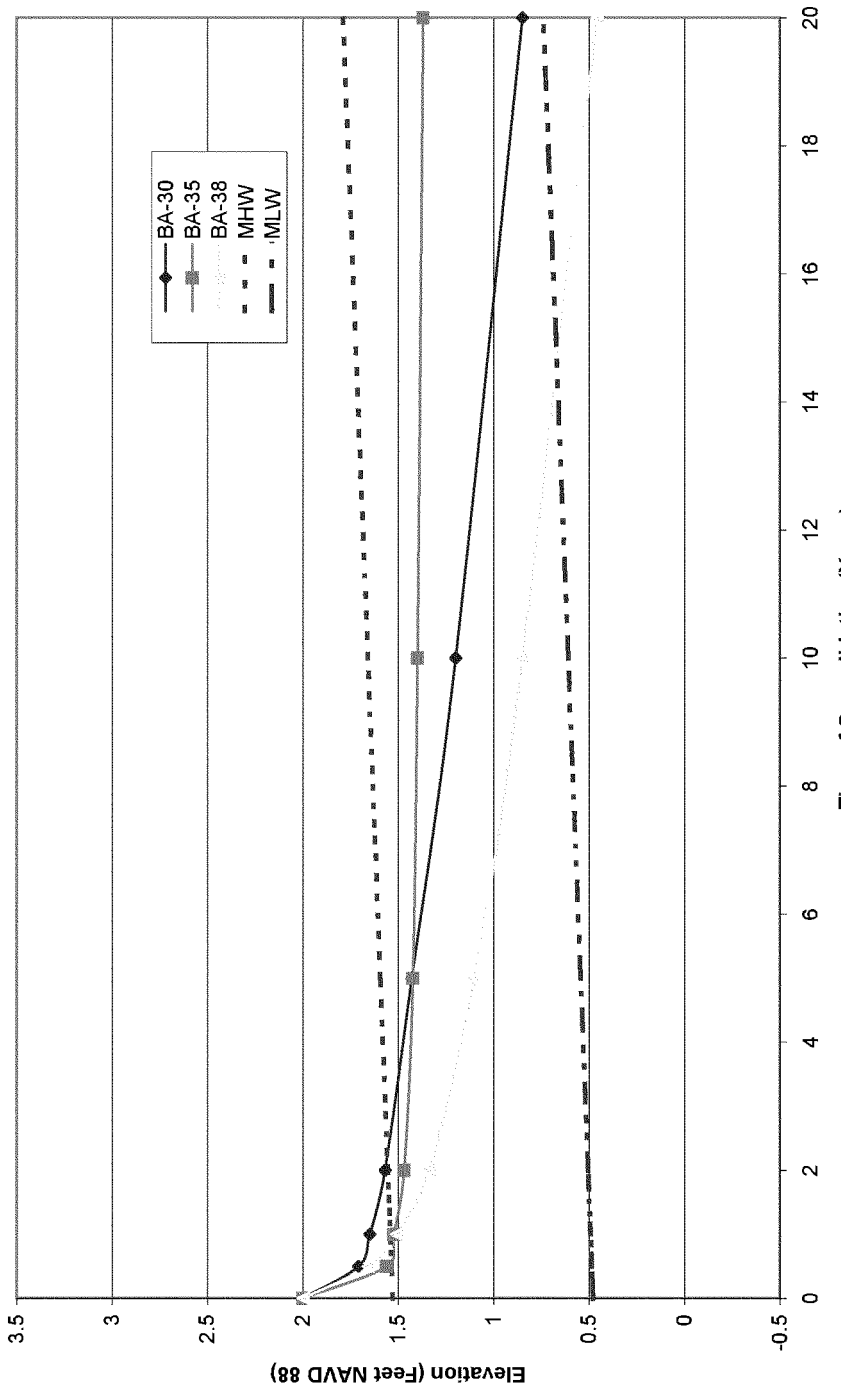



**Figure C-4-3. Back-Barrier Marsh Creation Settlement Curve Comparison Elevation +2.0' NAVD 88 (Subsidence Included)**

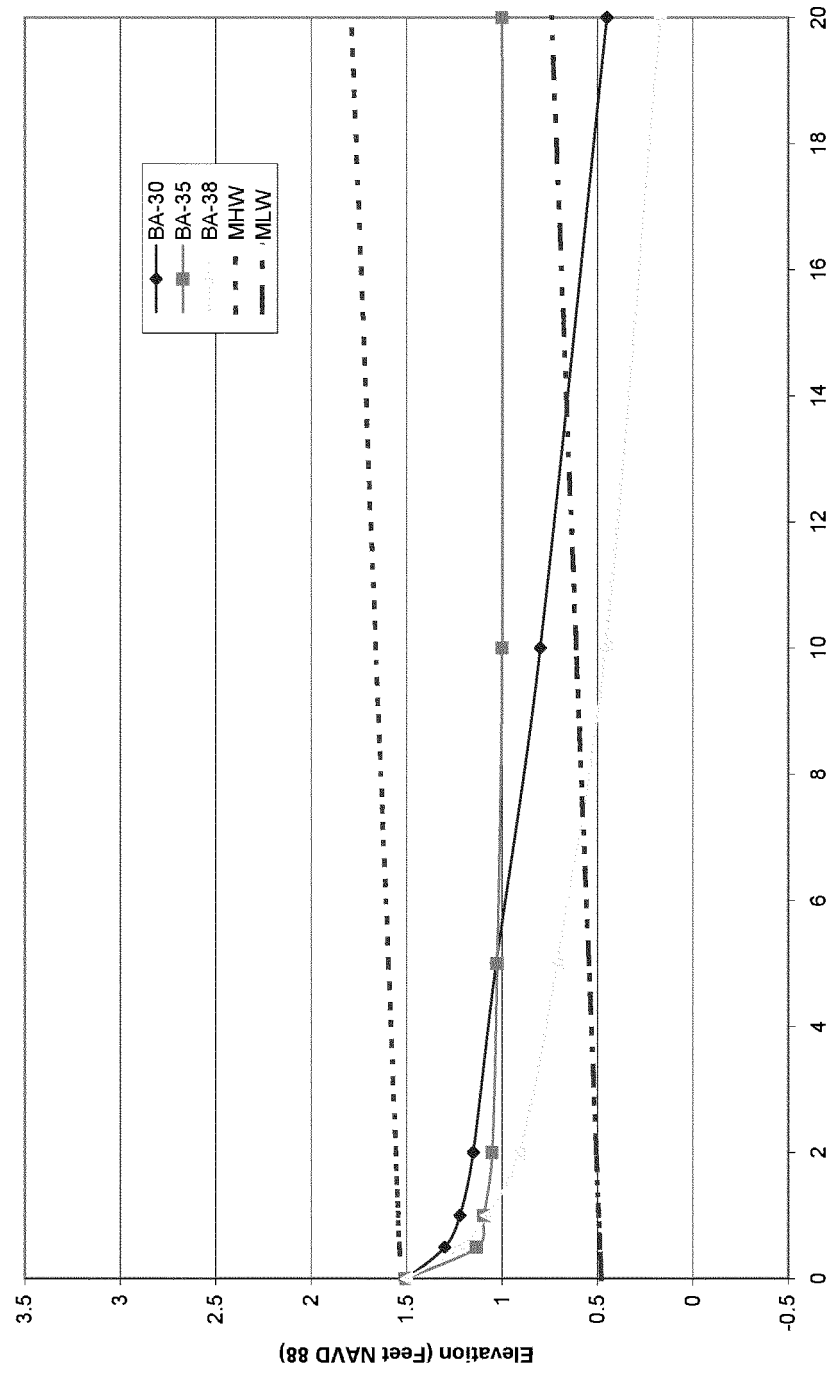



Figure C-4-4. Back-Barrier Marsh Creation Settlement Curve Comparison
Elevation +1.5' NAVD 88 (Subsidence Included)

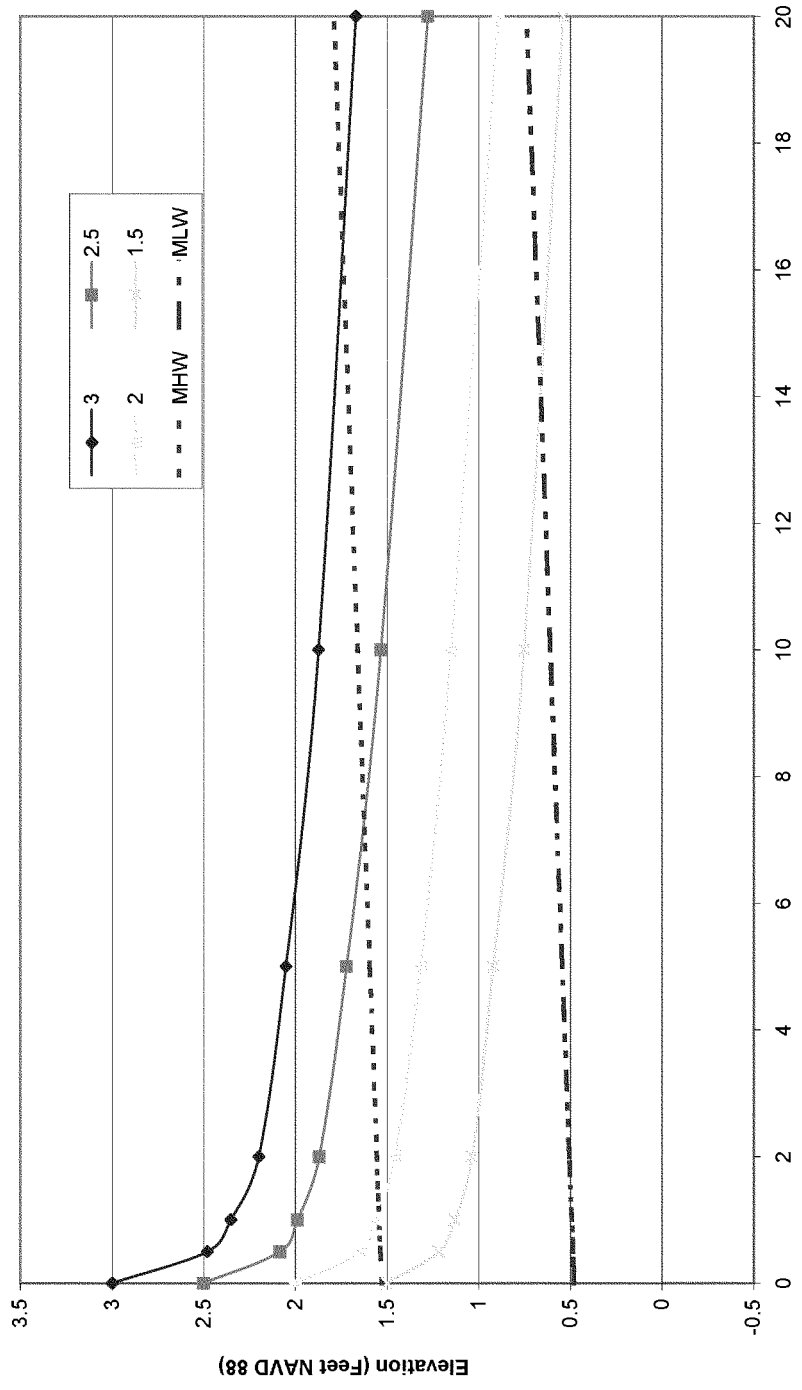



**Figure C-4-5. Back-Barrier Marsh Creation Settlement Curve Comparison Averages (Subsidence Included)**

**Table C-4-1. Intertidal Zone Analysis**

| Proposed Marsh Fill Elevation (feet NAVD) | Time to Reach MHW (years) | Time to Reach MLW (years) | Time within Intertidal Zone (years) | Percentage of Nourishment Period (%) |
|---|---|---|---|---|
| +3.0 | 16.2 | 20 | 3.8 | 38 |
| +2.5 | 7.4 | 20 | 12.6 | 126 |
| +2.0 | 1 | 20 | 19 | 190 |
| +1.5 | 0 | 14 | 14 | 140 |

## C-4-2 NATIVE SEDIMENT CHARACTERISTICS

### C-4-2-1 Background

The Caminada Headland is a barrier coastal segment comprised of cohesive deltaic sediments, sandy beach ridges, sand spits, and sand overwash onto landward lagoon and marsh environments that have resulted from the reworking and winnowing of sediments of the former Lafourche delta (Penland et al., 1988).

Alternatives considered in the engineering feasibility study for restoring the Caminada Headland include restoration of various features that exist naturally on the Headland including hundreds of acres of marsh restoration along with millions of yards of sand placement for dune and beach creation. It is necessary to characterize the native sediments in the existing environment to enable successful design of sediment restoration systems.

### C-4-2-2 Sediment Sampling and Testing

Sediment samples from representative native sediment environments were collected by CEC during a site visit to Caminada Headland on July 25, 2005 and submitted for textural analysis to enable sediment evaluation and comparison to available borrow material.

The native sediment sample locations are shown in Figure C-4-6. As a basis for definition of native beach, dune, and marsh sediments, fifteen (15) samples were collected from four (4) shore perpendicular transects (Figure C-2-1) along the shoreline. As presented in Figure C-4-6, samples were located in order to provide a representation of the active beach profile including samples from the surf zone, mid-tide beach face, and dune or overwash area, as well as the native marsh.

Results of the initial grain size analyses for the sediment samples are presented in Table C-4-2. Transects C and D each included a marsh sample. Note that these marsh samples, as expected, reflect an elevated silt, clay and organic content percentage. Sample D, taken from the surf zone,

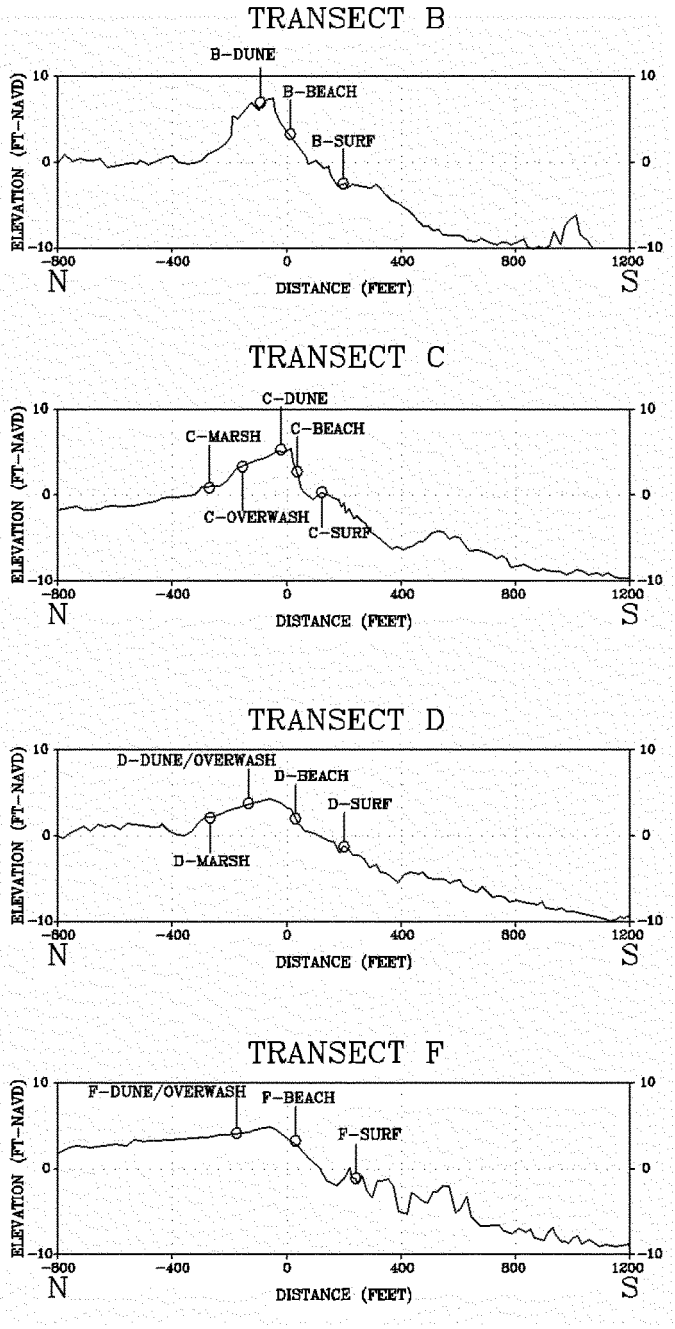



**Figure C-4-6. Native Beach Transects with Sample Locations**

also exhibits very high silt and clay percentage and represents a marsh peat outcrop exposed in the surf along this rapidly eroding section of shoreline.

**Table C-4-2. Native Sediment Grain Size Distributions**

| Transect | Identification | Gravel (%) | Sand (%) | Silt (%) | Clay (%) | Organic Content (%) | Fines (%) |
|---|---|---|---|---|---|---|---|
| B | Surf | 0.0 | 97.5 | 1.5 | 1.0 | N/A* | 2.5 |
| B | Beach | 0.0 | 99.1 | N/A* | N/A* | N/A* | 0.9 |
| B | Dune | 0.0 | 99.1 | N/A* | N/A* | N/A* | 0.9 |
| C | Surf | 1.0 | 96.6 | N/A* | N/A* | N/A* | 2.4 |
| C | Beach | 0.5 | 97.5 | N/A* | N/A* | N/A* | 2.0 |
| C | Dune | 0.0 | 99.0 | N/A* | N/A* | N/A* | 1.0 |
| C | Marsh | 0.1 | 76.5 | 18.4 | 5.0 | 2.4 | 23.4 |
| C | Overwash | 0.0 | 98.7 | N/A* | N/A* | N/A* | 1.3 |
| D | Surf | 0.0 | 8.3 | 55.0 | 36.8 | N/A* | 91.7 |
| D | Beach | 0.3 | 96.5 | 2.2 | 1.0 | N/A* | 3.2 |
| D | Marsh | 0.0 | 22.7 | 56.3 | 21.0 | 7.4 | 77.3 |
| D | Overwash | 0.0 | 98.3 | N/A* | N/A* | N/A* | 1.7 |
| F | Surf | 0.0 | 97.1 | 1.9 | 1.0 | N/A* | 2.9 |
| F | Beach | 0.0 | 97.3 | 1.7 | 1.0 | N/A* | 2.7 |
| F | Dune/Overwash | 0.0 | 98.7 | 0.3 | 1.0 | N/A* | 1.3 |

*Not Available

The range in sample mean grain size (mm) is presented in Table C-4-3. There is a wide range of mean grain size both within and between the various environments sampled. The individual sample data tables and grain size statistics including mean, median, sorting, sample skewness and plotted individual sample frequency curves are provided in Annex C-2.

**Table C-4-3. Native Sediment Range of Sample Means**

| Location | Mean Range (mm) |
|---|---|
| Surf | .136 - .175 |
| Beach | .147 - .200 |
| Dune | .166 - .203 |
| Overwash | .163 - .190 |
| Marsh | .020 - .119 |

### C-4-2-3 Native Beach Design Criteria

Initial sieve analysis used only three sieves, #50, #100, and #200 to represent the native beach sediment distribution in the size range of 0.3 mm to 0.075 mm. Due to the very uniform size of sediment material, over 90 percent of the sample fell on only two sieves. Therefore, nine (9) representative native samples were selected for additional detailed sieving. These samples best characterized the native materials for the purpose of design analysis. The data have been summarized in Table C-4-4. The individual sample data tables, size statistics, and sample frequency curves are provided in Annex C-2.

The detailed sieve analysis is also presented according to grain diameters with median diameter, $D_{50}$, and computed mean grain diameter, $M_\varphi$ for each sample in Table C-4-5. The estimated mean grain size, $M_\varphi$, is computed according to EM 1110-2-1100 (USACE, 2002a) where

$$M_\varphi = \frac{(\varphi_{16} + \varphi_{50} + \varphi_{84})}{3}$$

and $M_\varphi$ is converted to D (mm) using $D=2^{-\varphi}$. The samples in this analysis ranged from 0.132 mm to 0.189 mm with a composite sample mean of 0.164 mm.

Using the data from Table C-4-4, a composite frequency curve and native beach reference range are plotted and presented in Figure C-4-7. The reference range was developed by using the finer and coarser extremes on each sieve from the representative samples.

### C-4-2-4 Native Marsh Design Criteria

The goal of obtaining sediments for marsh restoration purposes is to provide stable sediment that imitates the natural marsh soil. Native marsh samples were collected and analyzed for grain size distribution to allow numerical characterization of the natural marsh sediment, providing a basis for comparison and evaluation of potential borrow materials for use in marsh creation. Table C-4-2 includes the grain size distribution for the native marsh samples. The percent sand ranged from 22.7% to 76.5%, percent silts/clays from 23.4% to 77.3%, and organic content from 2.4% to 7.4%.

In addition to optimal elevation of the marsh surface for rapid vegetation colonization, the marsh supports a diverse range of aquatic species that live in and breed or feed in the marsh sediment. It is important to have initial soil stability to support plant installation and growth along with a soil to support the organisms.

**Table C-4-4. Native Beach Individual and Composite Grain Size Distributions**

| Sieve | Size (mm) | BEACH B %Retained | BEACH C %Retained | BEACH D %Retained | BEACH F %Retained | DUNE B %Retained | DUNE C %Retained | DUNE F %Retained | OVER/W C %Retained | OVER/W D %Retained | Native Composite % Retained |
|---|---|---|---|---|---|---|---|---|---|---|---|
| #4 | 4.750 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| #5 | 4.000 | 0.41 | 0.00 | 0.05 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.06 |
| #10 | 2.000 | 0.08 | 0.00 | 0.25 | 0.03 | 0.07 | 0.00 | 0.00 | 0.05 | 0.17 | 0.07 |
| #14 | 1.410 | 0.11 | 0.01 | 0.09 | 0.02 | 0.15 | 0.01 | 0.02 | 0.08 | 0.19 | 0.08 |
| #18 | 1.000 | 0.05 | 0.02 | 0.18 | 0.02 | 0.24 | 0.00 | 0.06 | 0.11 | 0.27 | 0.11 |
| #25 | 0.828 | 0.19 | 0.05 | 0.15 | 0.03 | 0.35 | 0.03 | 0.06 | 0.18 | 0.25 | 0.14 |
| #35 | 0.569 | 0.15 | 0.12 | 0.28 | 0.09 | 0.39 | 0.00 | 0.08 | 0.17 | 0.21 | 0.17 |
| #45 | 0.350 | 0.59 | 0.27 | 0.20 | 0.20 | 0.54 | 0.02 | 0.14 | 0.25 | 0.25 | 0.27 |
| #60 | 0.250 | 1.32 | 0.99 | 0.43 | 0.61 | 3.23 | 0.80 | 0.47 | 3.87 | 0.78 | 1.39 |
| #80 | 0.180 | 45.02 | 62.97 | 6.43 | 11.36 | 39.34 | 32.77 | 37.56 | 67.33 | 37.11 | 37.77 |
| #120 | 0.130 | 42.58 | 30.87 | 55.13 | 60.00 | 48.00 | 58.17 | 50.34 | 21.18 | 50.72 | 46.33 |
| #170 | 0.090 | 8.93 | 4.36 | 34.12 | 25.83 | 7.04 | 7.21 | 10.57 | 6.17 | 9.34 | 12.62 |
| #230 | 0.060 | 0.55 | 0.31 | 2.58 | 1.54 | 0.57 | 0.83 | 0.68 | 0.54 | 0.66 | 0.92 |
| PAN | | 0.01 | 0.01 | 0.10 | 0.23 | 0.07 | 0.17 | 0.03 | 0.08 | 0.05 | 0.08 |

**Table C-4-5. Native Beach Individual Sample Means and Composite**

| Grain Diameter | BEACH B (phi) | DUNE B (phi) | BEACH C (phi) | DUNE C (phi) | OVERWASH C (phi) | BEACH D (phi) | OVERWASH D (phi) | BEACH F (phi) | DUNE / OW F (phi) | Average Composite (phi) | Average Composite (mm) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| D05 | 3.250 | 3.190 | 2.990 | 3.220 | 3.150 | 3.470 | 3.270 | 3.440 | 3.300 | 3.25 | 0.105 |
| D16 | 2.920 | 2.910 | 2.820 | 2.930 | 2.780 | 3.300 | 2.940 | 3.220 | 2.950 | 2.97 | 0.127 |
| D25 | 2.820 | 2.820 | 2.670 | 2.860 | 2.570 | 3.170 | 2.850 | 3.050 | 2.860 | 2.85 | 0.138 |
| D50 | 2.520 | 2.560 | 2.390 | 2.640 | 2.340 | 2.880 | 2.610 | 2.810 | 2.620 | 2.60 | 0.165 |
| D75 | 2.250 | 2.250 | 2.190 | 2.370 | 2.150 | 2.650 | 2.310 | 2.600 | 2.320 | 2.34 | 0.197 |
| D84 | 2.150 | 2.140 | 2.120 | 2.230 | 2.080 | 2.570 | 2.190 | 2.530 | 2.200 | 2.25 | 0.211 |
| D95 | 2.020 | 2.000 | 2.030 | 2.060 | 2.000 | 2.260 | 2.040 | 2.170 | 2.060 | 2.07 | 0.238 |
| Mean (phi) | 2.530 | 2.537 | 2.443 | 2.600 | 2.400 | 2.917 | 2.580 | 2.853 | 2.590 | 2.606 | |
| Mean (mm) | 0.173 | 0.172 | 0.184 | 0.165 | 0.189 | 0.132 | 0.167 | 0.138 | 0.166 | | 0.164 |

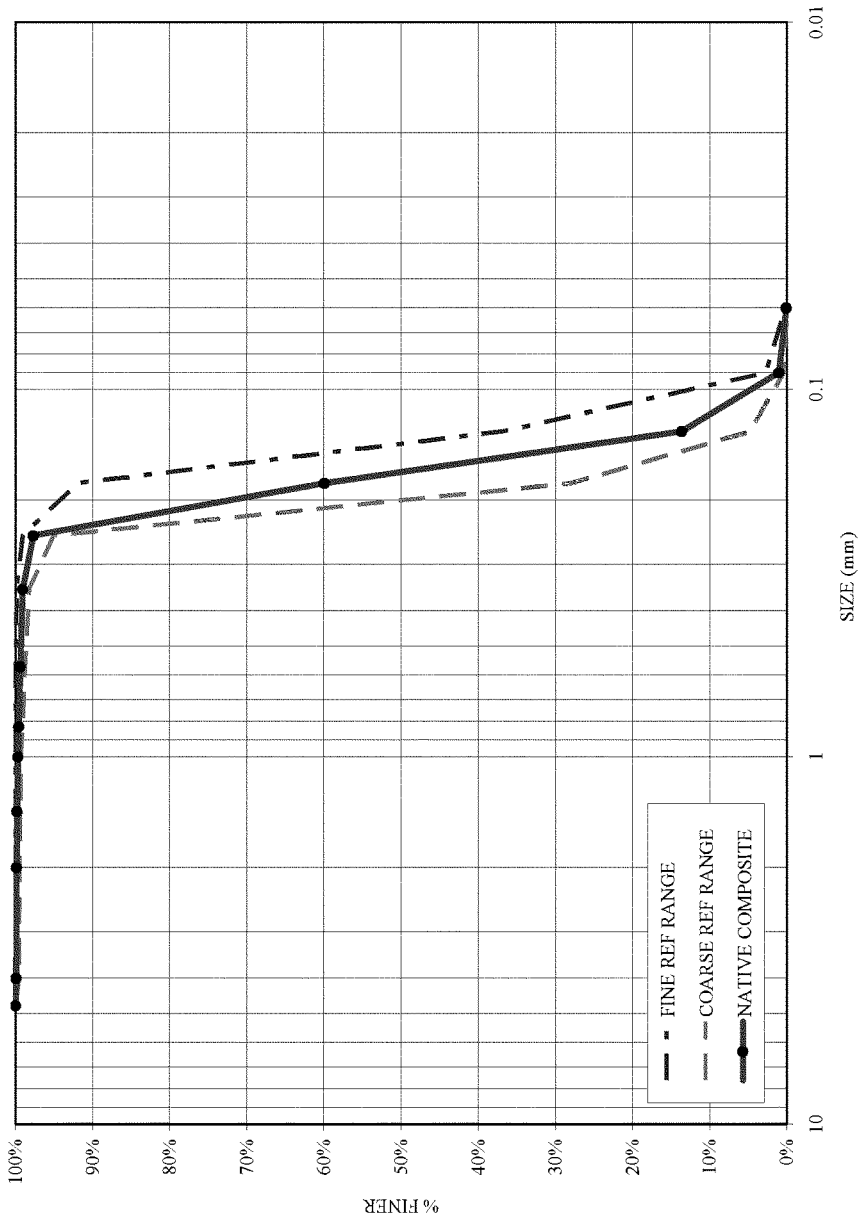



**Figure: C-4-7. Native Beach Composite and Reference Range**

## C-4-3 OFFSHORE BORROW AREA INVESTIGATION

### C-4-3-1 Background

The identification and evaluation of a borrow area to obtain suitable materials to construct the Project has been conducted by LDNR. Ship Shoal was identified in the LCA Study (USACE, 2004c) as a significant potential borrow source area that could be used to supply material for barrier shoreline restoration. Ship Shoal is a large offshore submerged sand body in the Gulf located approximately 50 miles southwest of Belle Pass (Figure C-1-2). It is about 31 miles long and 7 miles wide, lying at a depth of 9 to 30 feet. Preliminary studies (USACE, 2004c), have shown it is the remaining seaward shoal from one of the older abandoned Mississippi River deltas. It is composed of well-graded quartz sand and should be suitable for use in restoring the Caminada Headland since its grain size is similar to the sand found on the Headland. Material for the dune and beach berm construction is to come from South Pelto, Blocks 12 and 13, of Ship Shoal.

### C-4-3-2 Geotechnical Analysis

The Ship Shoal - South Pelto Blocks 12 and 13 borrow area sample data was provided by LDNR (CPE, 2005) for the sand suitability analyses. Sample grain size analyses of recently obtained vibracores were accomplished at the Coastal Planning & Engineering (CPE) lab in Boca Raton, Florida and the results are summarized below. The sample granularmetric reports and frequency curves are provided in Annex C-2.

Table C-4-6 presents the grain size for the primary grain diameters used for statistical representation of the sediments from the nineteen (19) core samples taken in the South Pelto Block. The grain size analysis for the sample group yields a mean grain size for the borrow area composite of 0.183 mm, with individual sample means ranging from 0.140 to 0.301, as determined using EM 1110-2-1100 (USACE, 2002a).

Table C-4-7 is a summary of the sieve analysis results showing percent retained and percent passing each sieve for the borrow area composite sample. Using the data from Annex C-2 and Table C-4-7, individual and composite frequency curves are plotted and presented in Figure C-4-8. Review of the data indicates that sample 05-11 is significantly coarser than and sample 05-12 is somewhat finer than the other samples.

Table C-4-6. South Pelto Block Grain Size Data

| Sample Name | Grain Diameter | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | D05 | | D16 | | D25 | | D50 | | D75 | | D84 | | D95 | | Mean | |
| | (phi) | (mm) | (phi) | (mm) | (phi) | (mm) | (phi) | (mm) | (phi) | (mm) | (phi) | (mm) | (phi) | (mm) | (phi) | (mm) |
| CHVC-05-01 | 3.73 | 0.075 | 3.28 | 0.103 | 3.07 | 0.119 | 2.82 | 0.142 | 2.62 | 0.163 | 2.54 | 0.172 | 2.18 | 0.221 | 2.81 | 0.143 |
| CHVC-05-02 | 3.37 | 0.097 | 2.98 | 0.127 | 2.91 | 0.133 | 2.72 | 0.152 | 2.53 | 0.173 | 2.33 | 0.199 | 2.00 | 0.250 | 2.67 | 0.157 |
| CHVC-05-03 | 3.46 | 0.091 | 3.08 | 0.118 | 2.95 | 0.129 | 2.75 | 0.149 | 2.56 | 0.170 | 2.43 | 0.186 | 2.03 | 0.245 | 2.69 | 0.155 |
| CHVC-05-04 | 3.00 | 0.125 | 2.91 | 0.133 | 2.83 | 0.141 | 2.62 | 0.163 | 2.30 | 0.203 | 2.13 | 0.228 | 1.68 | 0.312 | 2.46 | 0.182 |
| CHVC-05-05 | 3.86 | 0.069 | 3.13 | 0.114 | 2.93 | 0.131 | 2.63 | 0.162 | 2.25 | 0.210 | 2.10 | 0.233 | 1.59 | 0.332 | 2.48 | 0.179 |
| CHVC-05-06 | 3.28 | 0.103 | 2.92 | 0.132 | 2.83 | 0.141 | 2.56 | 0.170 | 2.13 | 0.228 | 1.85 | 0.277 | -1.50 | 2.828 | 2.19 | 0.219 |
| CHVC-05-07 | 3.24 | 0.106 | 2.92 | 0.132 | 2.84 | 0.140 | 2.61 | 0.164 | 2.27 | 0.207 | 2.11 | 0.232 | 1.68 | 0.312 | 2.50 | 0.177 |
| CHVC-05-08 | 3.18 | 0.110 | 2.91 | 0.133 | 2.82 | 0.142 | 2.57 | 0.168 | 2.20 | 0.218 | 2.04 | 0.243 | 1.08 | 0.473 | 2.34 | 0.198 |
| CHVC-05-09 | 3.26 | 0.104 | 2.93 | 0.131 | 2.85 | 0.139 | 2.63 | 0.162 | 2.31 | 0.202 | 2.13 | 0.228 | 1.66 | 0.316 | 2.50 | 0.177 |
| CHVC-05-10 | 3.27 | 0.104 | 2.93 | 0.131 | 2.85 | 0.139 | 2.61 | 0.164 | 2.22 | 0.215 | 2.03 | 0.245 | -0.75 | 1.682 | 2.26 | 0.209 |
| CHVC-05-11 | 3.22 | 0.107 | 2.91 | 0.133 | 2.81 | 0.143 | 2.54 | 0.172 | 2.04 | 0.243 | 1.18 | 0.441 | -3.48 | 11.158 | 1.73 | 0.301 |
| CHVC-05-12 | | | 3.50 | 0.088 | 3.33 | 0.099 | 2.92 | 0.132 | 2.65 | 0.159 | 2.55 | 0.171 | 2.15 | 0.225 | 2.85 | 0.139 |
| CHVC-05-13 | 3.48 | 0.090 | 3.18 | 0.110 | 2.98 | 0.127 | 2.76 | 0.148 | 2.55 | 0.171 | 2.40 | 0.189 | 2.06 | 0.240 | 2.74 | 0.150 |
| CHVC-05-14 | 2.98 | 0.127 | 2.83 | 0.141 | 2.71 | 0.153 | 2.39 | 0.191 | 2.08 | 0.237 | 1.90 | 0.268 | 1.37 | 0.387 | 2.20 | 0.218 |
| CHVC-05-15 | 3.55 | 0.085 | 3.18 | 0.110 | 2.98 | 0.127 | 2.76 | 0.148 | 2.55 | 0.171 | 2.38 | 0.192 | 2.04 | 0.243 | 2.73 | 0.151 |
| CHVC-05-16 | 2.99 | 0.126 | 2.84 | 0.140 | 2.71 | 0.153 | 2.38 | 0.192 | 2.08 | 0.237 | 1.93 | 0.262 | 1.56 | 0.339 | 2.34 | 0.198 |
| CHVC-05-17 | 3.00 | 0.125 | 2.88 | 0.136 | 2.78 | 0.146 | 2.51 | 0.176 | 2.19 | 0.219 | 2.08 | 0.237 | 1.73 | 0.301 | 2.46 | 0.182 |
| CHVC-05-18 | 3.41 | 0.094 | 3.04 | 0.122 | 2.94 | 0.130 | 2.74 | 0.150 | 2.54 | 0.172 | 2.39 | 0.191 | 2.07 | 0.238 | 2.71 | 0.153 |
| CHVC-05-19 | 3.26 | 0.104 | 2.93 | 0.131 | 2.85 | 0.139 | 2.62 | 0.163 | 2.28 | 0.206 | 2.11 | 0.232 | 1.51 | 0.351 | 2.38 | 0.192 |
| Borrow Composite | 3.31 | 0.102 | 3.01 | 0.125 | 2.89 | 0.14 | 2.64 | 0.161 | 2.33 | 0.200 | 2.14 | 0.233 | 1.19 | 1.077 | 2.48 | 0.183 |

Table C-4-7. South Pelto Combined Sediment Sample Data

| Sieve # | Size (mm) | Borrow Area Composite % Retained | Borrow Area Composite Cumulative % Retained |
|---|---|---|---|
| 3/4" | 19.03 | 0.10 | 0.10 |
| 5/8" | 16.00 | 0.27 | 0.37 |
| 7/16" | 11.31 | 0.31 | 0.68 |
| 5/16" | 8.00 | 0.35 | 1.04 |
| 3.5 | 5.66 | 0.35 | 1.39 |
| 4 | 4.76 | 0.10 | 1.49 |
| 5 | 4.00 | 0.12 | 1.61 |
| 7 | 2.83 | 0.23 | 1.84 |
| 10 | 2.00 | 0.23 | 2.08 |
| 14 | 1.41 | 0.22 | 2.30 |
| 18 | 1.00 | 0.22 | 2.53 |
| 25 | 0.71 | 0.22 | 2.75 |
| 35 | 0.50 | 0.31 | 3.06 |
| 45 | 0.35 | 0.84 | 3.91 |
| 60 | 0.25 | 5.93 | 9.83 |
| 80 | 3.00 | 24.03 | 33.86 |
| 120 | 3.75 | 52.64 | 86.51 |
| 170 | 4.00 | 10.01 | 96.52 |
| 200 | 3.75 | 0.53 | 97.05 |
| 230 | 4.00 | 0.36 | 97.41 |
| PAN | - | 2.59 | 100.00 |

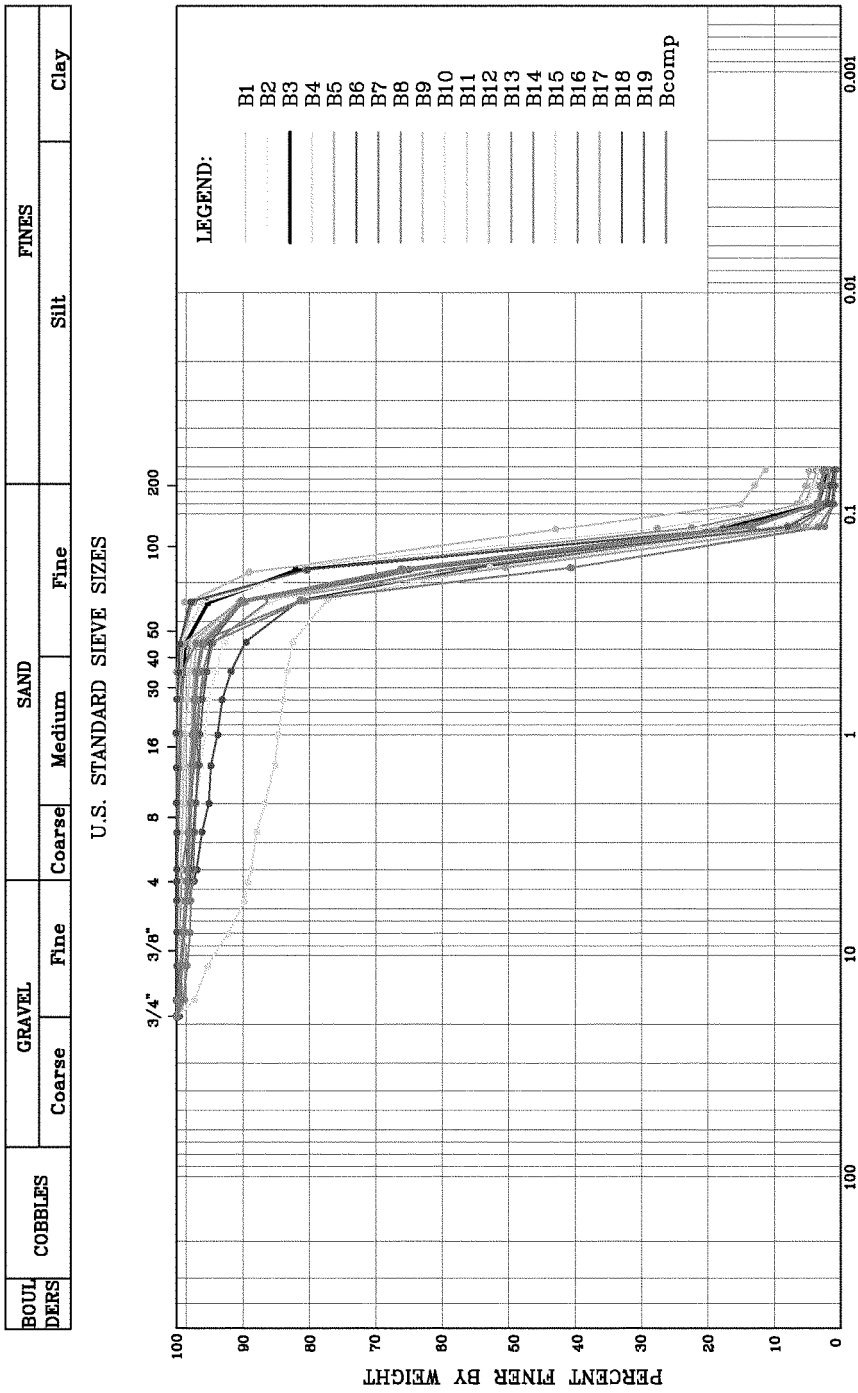



Figure C–4–8. Borrow Area Individual and Composite Samples

## C-4-3-3 Suitability Analysis

### C-4-3-3-1 Compatibility Analysis

A compatibility analysis was conducted to compare the grain size of native samples with borrow area samples to evaluate borrow area sediments for use as beach and dune fill. The native beach and borrow area sample data have composite mean grain sizes of 0.164 mm and 0.183 mm, respectively, which is fine sand according to ASTM D2487-92.

Figure C-4-9 presents the cumulative grain-size distributions of the composite native beach sediments compared to the composite borrow area sediments. The curves have a high degree of similarity. Also presented are the reference ranges for the native beach and borrow area samples. The ranges depict the coarse and fine extremes of the samples for each grouping. The two ranges exhibit a fair degree of similarity indicating the borrow area sediments are compatible with the native beach.

### C-4-3-3-2 Overfill Ratio

The evaluation of the borrow sediments uses the overfill ratio method proposed by Dean (1986). An overfill ratio is a means of predicting the quantity of borrow material needed for one unit of stable beach material for use in dune and beach restoration. An overfill ratio of 1.05 means that 1.05 cubic yards of sand has to be dredged from a borrow area and placed on the beach for each cubic yard of beach fill that is desired to remain in place on a nourished beach. This technique does not include losses due to the dredging process nor background erosion rates.

Table C-4-8 presents the overfill ratios between the selected borrow area individual and composite samples and the native beach composite sample. The individual borrow samples overfill ratios range from 1.01 to 1.17, and the composite overfill ratio is 1.03.

### C-4-3-3-3 Overfill Factor ($R_A$)

A second overfill comparison used for compatibility analysis is provided following the procedure dictated in the Coastal Engineering Manual EM 1110-2-1100 (Part V) (USACE, 2002a). The overfill factor ($R_A$) considers both mean sediment diameter and sorting values of the native beach and borrow sediments. This estimate provides an estimate of the overfill ratio due to sorting. Grain size distribution of core samples from the borrow area and the native beach samples (Table C-4-9) were evaluated by the equations listed below to determine the mean sediment diameter ($M_\varphi$) and the standard deviation or sorting of the material ($\sigma_\varphi$).

$$M_\varphi = \frac{(\varphi_{16} + \varphi_{50} + \varphi_{84})}{3} \qquad \sigma_\varphi = \frac{(\varphi_{84} - \varphi_{16})}{4} + \frac{(\varphi_{95} - \varphi_5)}{6}$$

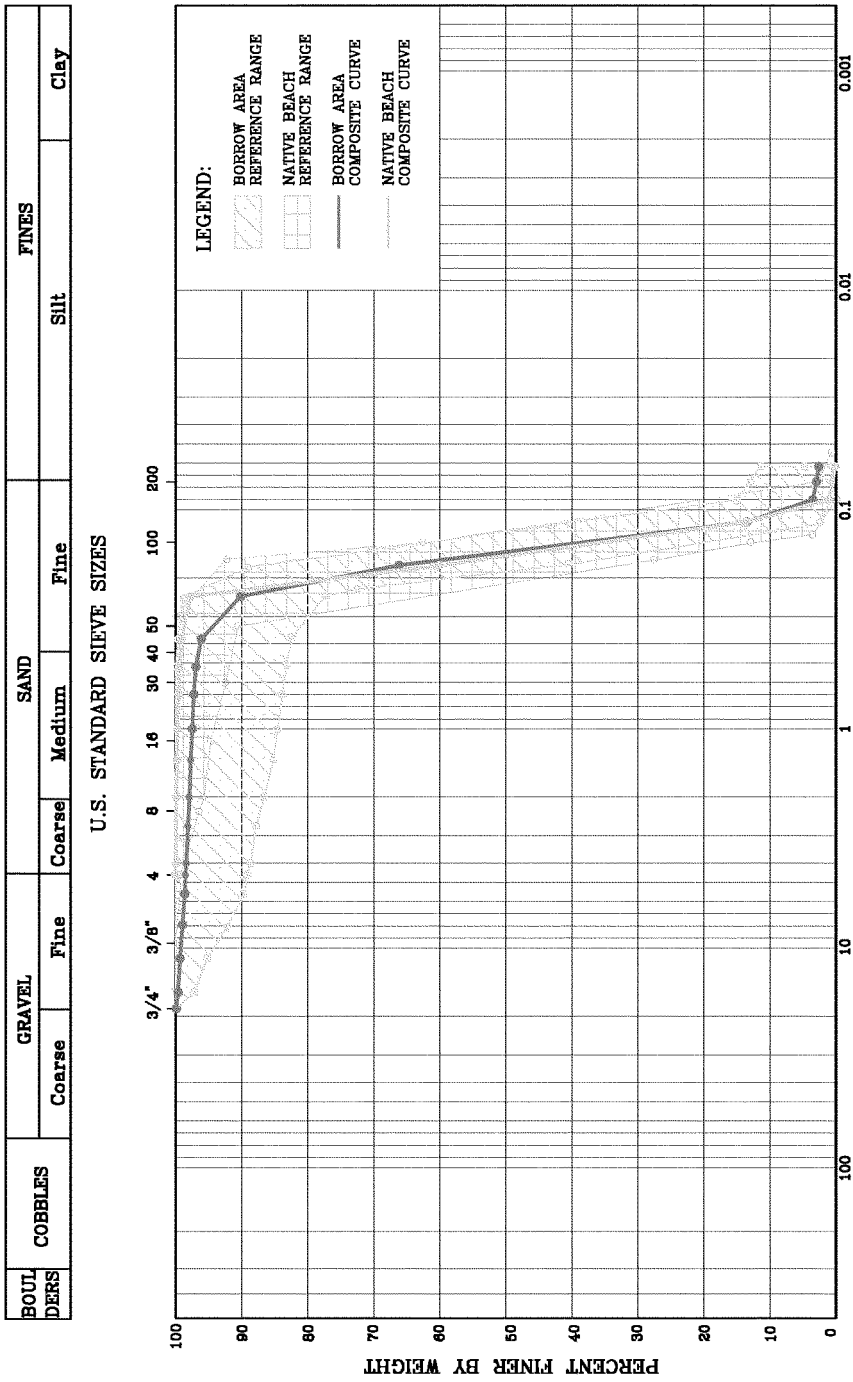



Figure C–4–9. Native Beach Composite vs. South Pelto Composite Samples

Table C-4-8. Overfill Ratios

| Borrow Cores | Dean Overfill Ratio |
|---|---|
| 05-01 | 1.17 |
| 05-02 | 1.10 |
| 05-03 | 1.12 |
| 05-04 | 1.02 |
| 05-05 | 1.03 |
| 05-06 | 1.01 |
| 05-07 | 1.01 |
| 05-08 | 1.01 |
| 05-09 | 1.03 |
| 05-10 | 1.01 |
| 05-11 | 1.01 |
| 05-12 | 1.17 |
| 05-13 | 1.12 |
| 05-14 | 1.01 |
| 05-15 | 1.11 |
| 05-16 | 1.01 |
| 05-17 | 1.01 |
| 05-18 | 1.11 |
| 05-19 | 1.02 |
| Borrow Composite | 1.03 |

**Table C-4-9. Native Beach and Borrow Area Composites**

| Grain Diameter | Native Beach Composite (phi) | Native Beach Composite (mm) | | Borrow Area Composite (phi) | Borrow Area Composite (mm) |
|---|---|---|---|---|---|
| D05 | 3.25 | 0.105 | | 3.31 | 0.102 |
| D16 | 2.97 | 0.127 | | 3.01 | 0.125 |
| D25 | 2.85 | 0.139 | | 2.89 | 0.140 |
| D50 | 2.60 | 0.165 | | 2.64 | 0.161 |
| D75 | 2.34 | 0.197 | | 2.33 | 0.200 |
| D84 | 2.25 | 0.211 | | 2.14 | 0.233 |
| D95 | 2.07 | 0.238 | | 1.19 | 1.077 |
| Mean | 2.61 | 0.164 | | 2.48 | 0.183 |

Using the values below and Figure V-4-9, EM 1110-2-1100, $R_A$ was determined to be approximately 1.22.

Borrow $\sigma_\varphi$ / Native $\sigma_\varphi$ =1.508 (Borrow $M_\varphi$ – Native $M_\varphi$) / Native $\sigma_\varphi$ = 0.024

**Overfill Factor ($R_A$) ~ 1.22**

### C-4-3-3-4 Renourishment Factor (Rj)

An additional analysis useful for the evaluation of beach fill performance is the renourishment factor (Rj). This analysis provides an estimate of how often fill placement would be required to maintain a specific beach dimension. The renourishment factor (Rj) (James, 1975) is a relative stability indicator. It attempts to predict long-term performance of different fill sediments. Table C-4-10 presents the Rj factor for the individual core samples in the borrow area. An Rj of 1.0 infers that the borrow sediments would perform the same as the native sediments. The average Rj factor is 0.75, which suggests the borrow area would provide suitable sediments for the Project.

It is important to note that the Rj values ranged from a low of 0.00 to a high of 1.72. The sediments with an Rj greater than 1.0 tend to have a finer sand size than the native beach

Table C-4-10. Renourishment Factor

| Core Sample | d | s | D | Rj |
|---|---|---|---|---|
| CHVC-05-01 | 0.724 | 1.170 | 1.000 | 1.72 |
| CHVC-05-02 | 0.187 | 1.031 | 1.000 | 1.17 |
| CHVC-05-03 | 0.390 | 1.058 | 1.000 | 1.39 |
| CHVC-05-04 | -0.138 | 1.095 | 1.000 | 0.79 |
| CHVC-05-05 | 0.038 | 1.678 | 1.000 | 0.42 |
| CHVC-05-06 | -0.428 | 2.808 | 1.000 | 0.02 |
| CHVC-05-07 | -0.156 | 1.220 | 1.000 | 0.67 |
| CHVC-05-08 | -0.261 | 1.497 | 1.000 | 0.41 |
| CHVC-05-09 | -0.112 | 1.231 | 1.000 | 0.69 |
| CHVC-05-10 | -0.217 | 2.361 | 1.000 | 0.08 |
| CHVC-05-11 | -1.044 | 4.088 | 1.000 | 0.00 |
| CHVC-05-12 | 1.014 | - | 1.000 | - |
| CHVC-05-13 | 0.460 | 1.139 | 1.000 | 1.37 |
| CHVC-05-14 | -0.613 | 1.321 | 1.000 | 0.37 |
| CHVC-05-15 | 0.442 | 1.192 | 1.000 | 1.26 |
| CHVC-05-16 | -0.587 | 1.229 | 1.000 | 0.43 |
| CHVC-05-17 | -0.305 | 1.086 | 1.000 | 0.67 |
| CHVC-05-18 | 0.310 | 1.018 | 1.000 | 1.34 |
| CHVC-05-19 | -0.138 | 1.310 | 1.000 | 0.61 |
| | | | AVERAGE | 0.75 |

$\delta = (M_{\varphi core} - M_{\varphi native}) / \sigma_{\varphi native}$

$\sigma = \sigma_{\varphi core} / \sigma_{\varphi native}$

$\Delta =$ WINNOWING FUNCTION

$R_j = \exp[\Delta(\delta) - (\Delta^2/2)((\sigma_{\varphi core}^2/\sigma_{\varphi native}^2)-1)]$

sediments, e.g., sample 05-01. The sediments with an Rj less than 1.0 tend to have a coarser sand size than the native beach sediments, e.g., 05-11. If such sediments can be localized during the dredge process and avoided, then a resultant fill would be more compatible, providing optimal performance for the beach and dune fill.

### C-4-3-3-5 Cut to Fill Ratios

Losses due to the dredge and fill process, that is, excavation of the borrow area sediments, transport to the fill area, and dewatering of the fill sections, are a function of the percent fines (silts and clays), construction techniques, and erosional losses of the fill template due to storm activity prior to survey and acceptance. The average percent fine content in the 19 borrow area vibracores (see Annex C-2) is 3%. Additionally, the anticipated losses due to the construction techniques to be employed on this Project are estimated to be 10%. Hence, a cut to fill ratio of 1.13 is predicted for the beach and dune fill. Because no geotechnical data is available for potential marsh borrow areas, a more conservative cut to fill ratio of 1.6 is predicted for the marsh fill.

### C-4-3-3-6 Summary

Sediment samples collected from Caminada Headland non cohesive beach environments have a composite sample mean grain size of 0.164 mm. Vibracore samples from Ship Shoal - South Pelto Blocks 12 and 13 have a composite sample mean grain size of 0.183 mm. The composite curves have a high degree of similarity. Initial compatibility analysis determined an overfill ratio of 1.03. The reference ranges and composite curves exhibit fair to high degrees of similarity, respectively. Comparison of the native and South Pelto samples using the overfill factor ($R_A$) analysis resulted in a value on the order of 1.22. Comparative analysis of the sediments using the Renourishment Factor (Rj) results in an average value of 0.75.

It is concluded that the sediments from the South Pelto Block are suitable for beach and dune restoration. It is recommended that an overfill ratio of 1.03 be used in design volume analysis.

Depending on core locations, when detail design of the borrow area is conducted, selective dredging analysis may be beneficial in providing a more compatible borrow area material for constructing the beach and dune fill on the Caminada Headland.

## C-4-4 NEARSHORE BORROW AREA INVESTIGATION

LDNR is currently performing a nearshore borrow area investigation in addition to the Ship Shoal investigation for the purpose of creating the back-barrier marsh fill platform. It is recommended that this include an evaluation of the potential borrow materials for compatibility with the native marsh design criteria presented in Section C-4-2-4.

# C-5 SCREENING ANALYSIS OF RESTORATION OPTIONS

## C-5-1 INTRODUCTION

### C-5-1-1 Planning Objectives

Planning objectives were developed during the preparation of the LCA Near-Term Critical Restoration Assessment as part of the LCA Study (USACE, 2004a). The objectives were developed to guide engineering feasibility efforts and are listed below.

- 50-Year Design Life
- Protect & Preserve Structural Integrity of Barrier Shoreline by Creating Beach and Dune Areas
- Close Present Breaches and Prevent Breaching During Design Life
- Transport Sand from Ship Shoal - South Pelto Blocks 12 and 13
- Create Back-Barrier Marsh
- Nourish Additional Marsh
- Vegetate Newly Created Marsh and Dune Areas
- Install Sand Fencing on Dune Areas
- Address Existing Breakwaters
- Implement Adaptive Management Plan for Entire Design Life

### C-5-1-2 Design Components

#### C-5-1-2-1 Marsh Fill

The Project includes two different marsh fill templates. Both templates include the design of a marsh platform contiguous with the BP Canal on its northern boundary and the beach and dune fill component along its southern boundary. The marsh fill for Template 1A will only be implemented along a portion of the Headland from the eastern edge of Bay Champagne to the western edge of Bay Caminada. Template 1B marsh fill builds on Template 1A marsh with the marsh fill extending west through Bay Champagne and to the eastern edge of the project boundary near Caminada Pass and a 75 acre addition west of the Chevron Facility. The design elevation of the marsh to achieve the tidal zone design objective is +2.0 feet NAVD as determined in Section C-4-1. Quantity estimates of dredged material required to construct the marsh platform vary depending on whether or not the beach and dune component is located seaward or landward of the existing dune as described in Section C-6-2. The marsh platform shall be planted with appropriate vegetation.

#### C-5-1-2-2 Beach and Dune Fill

The Project includes design of a beach and dune fill to address gulf-front erosion and to close and prevent breaches. The dune platform shall be planted with appropriate vegetation. Various fill templates were developed using the constraints described above and evaluated during the modeling tasks to determine the optimum project performance in terms of storm protection benefits.

#### C-5-1-2-3 Borrow Areas

Borrow area investigations are being completed by LDNR for the marsh and beach and dune fill components. LDNR has targeted the Ship Shoal - South Pelto Blocks 12 and 13 as an offshore borrow area for sand. Compatible marsh fill sediments will be dredged from a nearshore borrow area in close proximity to the Project site. These investigations are described in further detail in Sections C-4-3 and C-4-4.

## C-5-2 OPTION DESCRIPTIONS

As part of the engineering feasibility initiation a number of restoration alternatives were proposed by the project stakeholders. These proposed alternatives were narrowed down and grouped into three major restoration options which were screened through selection criteria to determine which warranted further analysis. The three groups of restoration options described below are as follows: No Action Option, Beach/Dune/Marsh Restoration Options, and Beach/Dune/Marsh Options with Structural Compliments. Screening criteria considered were habitat creation, storm protection, and overall environmental impacts on adjacent barrier islands. The options that passed the screening test were carried forward to the alternatives analysis (Chapter 6).

### C-5-2-1 No Action Option

This option allows for conditions to remain in their present state with no restoration construction. A coastal Louisiana land loss model presented in the LCA Study (USACE, 2004c) indicates that with no intervention, the Caminada Headland will not remain as it is now. The prediction from 2000 to 2050 is a projected land loss of 3,750 acres from the Headland and 14,780 acres from the area to the north from 2000 to 2050. Only a skeletal framework of wetlands will remain in 2050. The area around Port Fourchon would be further isolated from the remaining mainland, and could become a detached small barrier island.

### C-5-2-2 Beach/Dune/Marsh Restoration Option

Using newly collected survey data described in Chapter 2, three unique design templates were developed to include a beach and dune as well as marsh creation components. The templates were

designed with the same fill volume cost using assumed unit prices for the beach/dune and marsh fills for balanced comparisons. Marsh fill boundaries are further described in Chapter 6.

### C-5-2-2-1 Template 1 - Marsh Restoration

Template 1 proposes the 1B marsh fill template as described in section C-5-1-2-1 on the landward side of the dune. The elevation of the marsh fill is +2.0 NAVD which was determined in Section C-4-1 as the optimum fill elevation for intertidal marsh longevity considering the effects of settlement and consolidation, geologic subsidence, and sea level rise. These boundaries and fill elevations result in a marsh fill quantity of 3.8 million cubic yards. Plan view and typical cross sections for Template 1 are shown in Figures C-5-1 and C-5-2, respectively.

### C-5-2-2-2 Template 2 - Low and Wide Dune

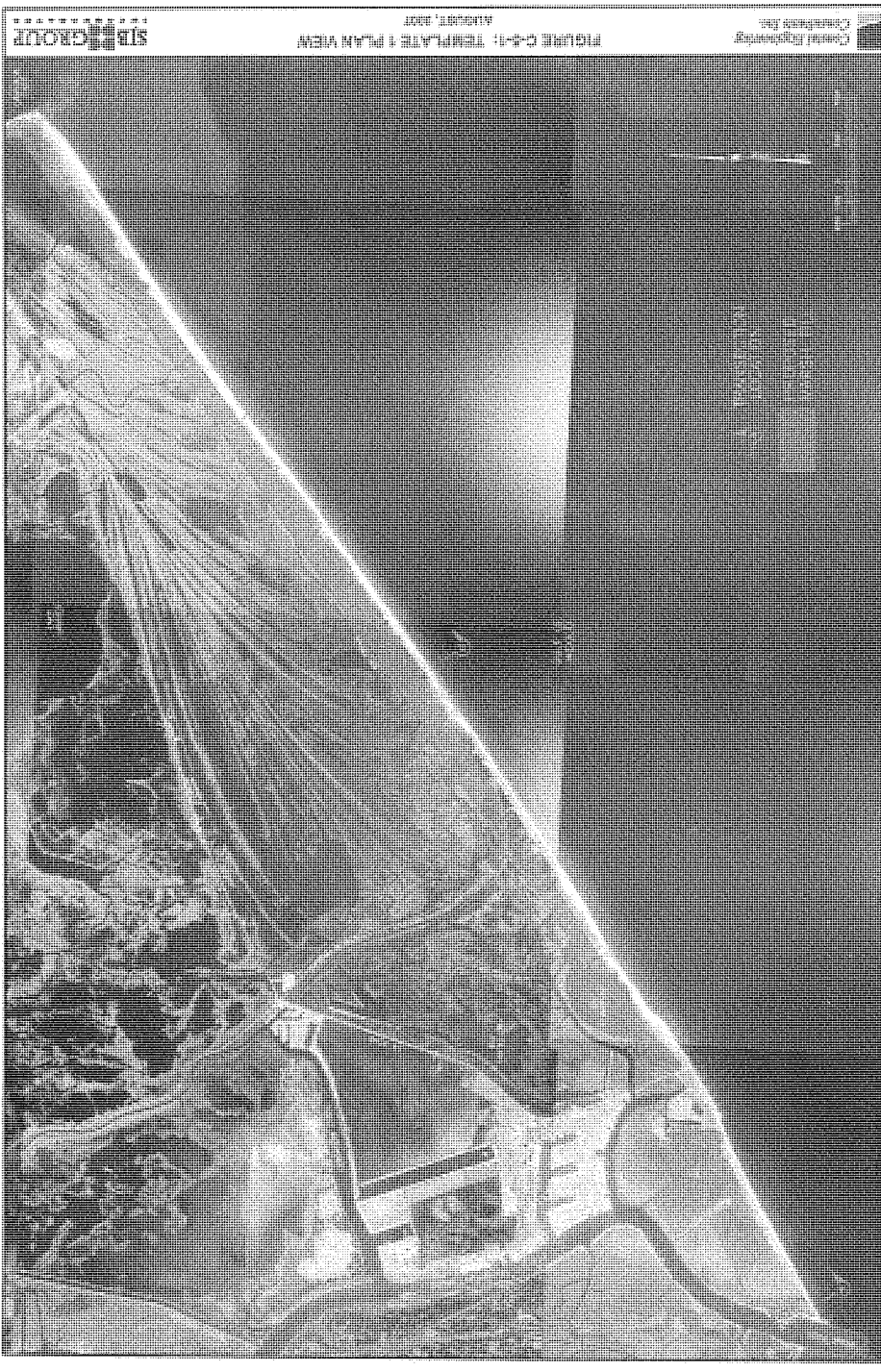
Template 2 proposes a dune width of 200 feet and dune height of +6 feet NAVD which is slightly higher than the existing dune elevation in the area of +4 feet NAVD. This dune is centered over the existing dune and slopes down to an advanced beach berm at elevation +4.5 NAVD. The template was then optimized for density and alignment to address the existing breaches and longshore erosion processes. The template density refers to the volume of sand per unit length of beach. The optimization process consisted of adjusting the template gulfward or landward at each cross section so that all cross sections contain the same volume of sand. This was done so that the project would perform uniformly along the entire length of the Headland.

The landward, seaward, and dune crest to berm slopes for Template 2 were set to 20 horizontal to 1 vertical. The beach fill template has a 75 foot wide seaward berm at an elevation of +4.5 feet NAVD and a marsh fill template is proposed on the landward side of the dune at an elevation of +2 feet NAVD. Fill quantities for the beach/dune and marsh fills are 5.7 million and 3.8 million cubic yards, respectively. Plan view and typical cross sections for Template 2 are shown in Figures C-5-3 and C-5-4, respectively.

### C-5-2-2-3 Template 3 - High and Narrow Dune

Template 3 proposes a dune higher and narrower than Template 2 for performance comparisons. The Template 3 dune height was set at +8 feet NAVD and with the exception of the fill tapers at the eastern and western ends of the template, contains a 125 foot dune crest width. This dune is centered over the existing dune and slopes down to a construction berm that is extended seaward until the fill volume is achieved. The template was then optimized for density and alignment to address the existing breaches and longshore erosion processes.

The landward, seaward, and dune crest to berm slopes for Template 3 were set to 20 horizontal to 1 vertical. With the exception of the fill tapers, the beach fill template has a 75 foot wide seaward beach berm at an elevation of +4.5 feet NAVD and a marsh fill template is proposed on the



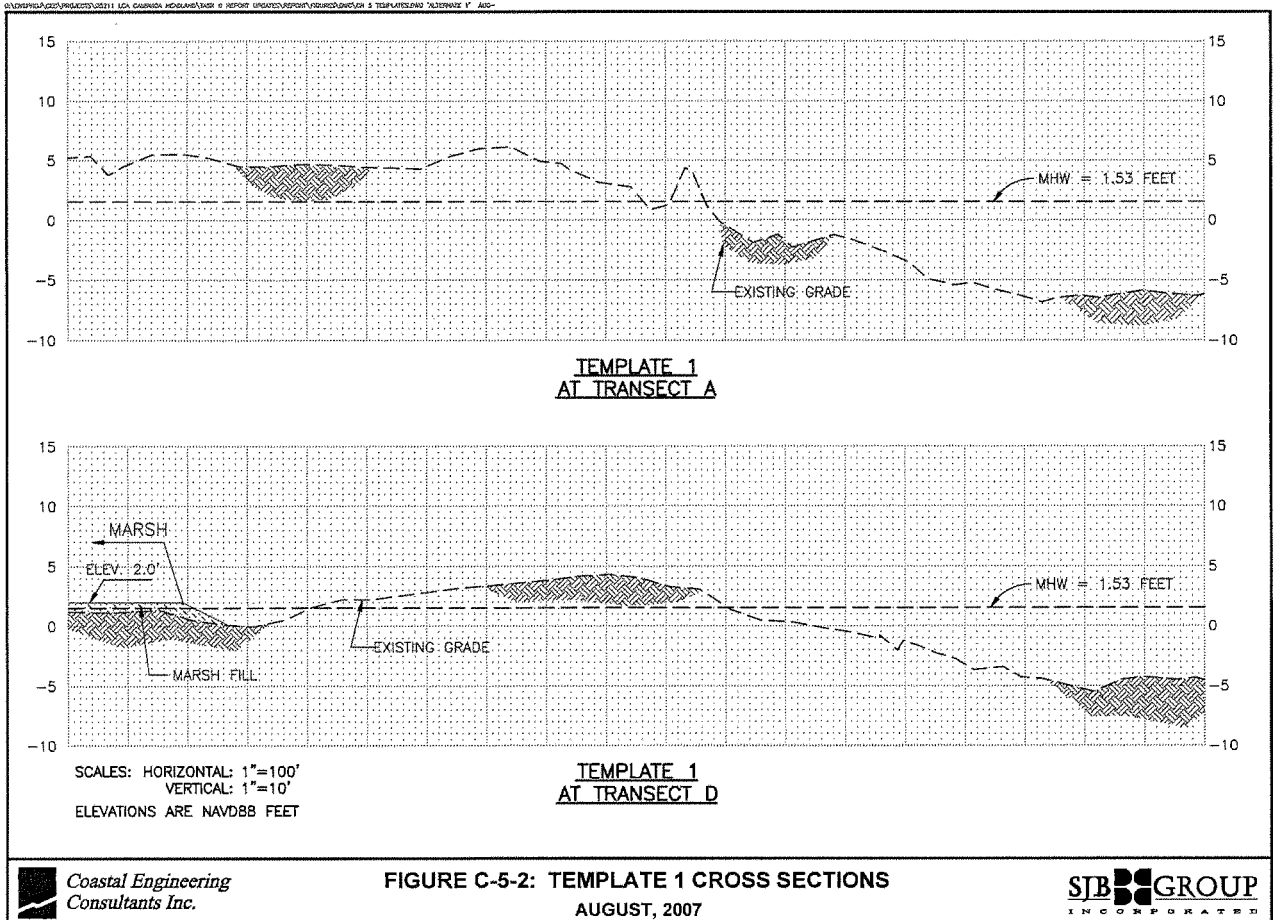



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**FIGURE C-5-2: TEMPLATE 1 CROSS SECTIONS**

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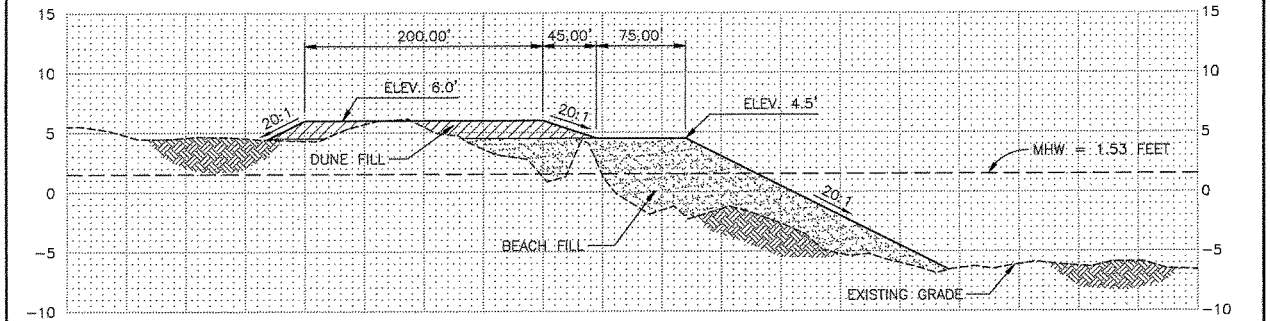
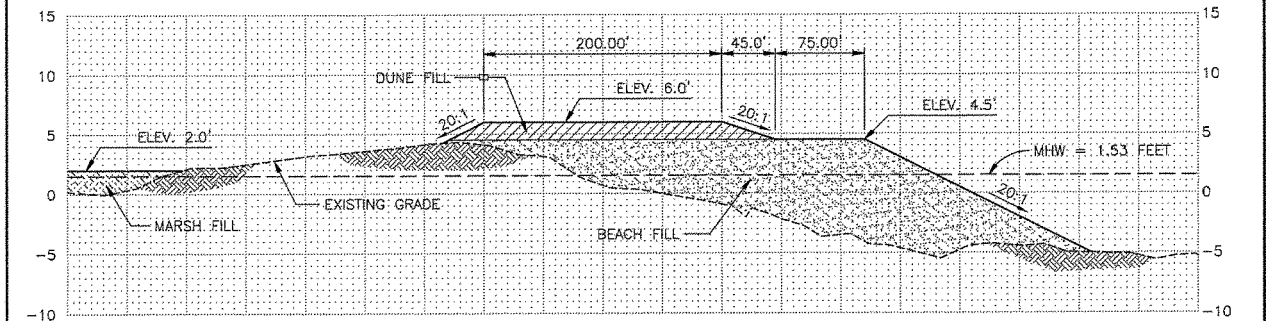



TEMPLATE 2
AT TRANSECT A




TEMPLATE 2
AT TRANSECT D

SCALES: HORIZONTAL: 1"=100'
VERTICAL: 1"=10'
ELEVATIONS ARE NAVD88 FEET

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**FIGURE C-5-4: TEMPLATE 2 CROSS SECTIONS**
**AUGUST, 2007**

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landward side of the dune at an elevation of +2 feet NAVD. Fill quantities for the beach/dune and marsh fills are 5.7 million and 3.8 million cubic yards, respectively. Plan view and typical cross sections for Template 3 are shown in Figures C-5-5 and C-5-6, respectively.

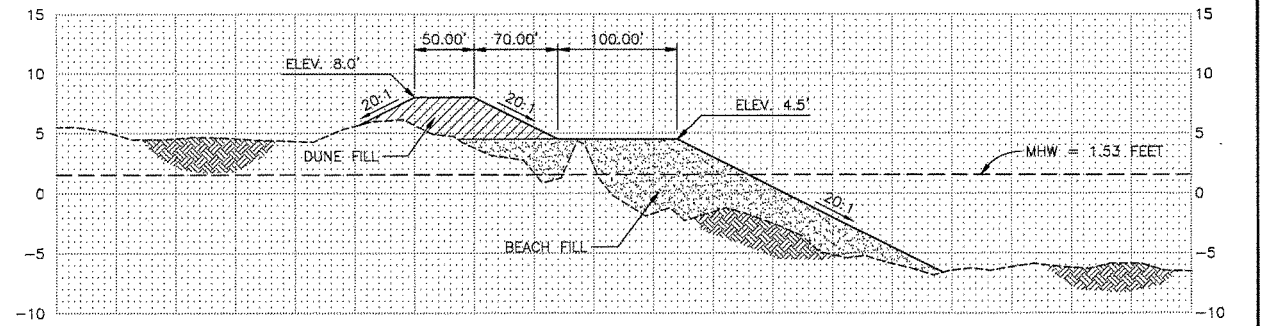
### C-5-2-2-4 Template 4 - Landward Beach and Dune

Template 4 proposes a dune height of +7 feet NAVD. The modeling analyses (Annex C-3) demonstrate that the higher dune proposed in Template 3 at +8 feet NAVD offers more storm protection between future maintenance events than the lower dune proposed in Template 2 at +6 feet NAVD. Although the higher dune offers more storm protection, there may be ecological concerns with constructing a dune higher than the Headland's existing dune elevations. To balance storm protection benefits with ecological concerns, Template 4 dune height is proposed at +7 feet NAVD.

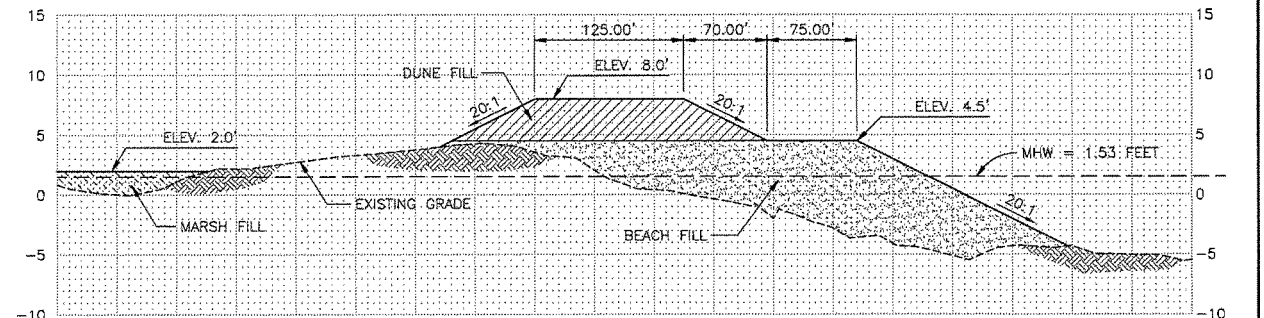
Template 4 also proposes a landward beach and dune component compared to the seaward beach component in both Templates 2 and 3, which eroded significantly during the modeling analyses of storm impacts (Annex C-3). Because the fill is sited landward over existing higher elevations, the dune could be extended over the significant majority of the beach fill. The width of this landward template is limited from Belle Pass to the western edge of the existing breakwater field by environmental habitats and infrastructure to the north of the barrier shoreline. In this area the fill width is 300 feet tapering toward the shoreline at the western edge of the breakwaters. No sand will be placed in this landward template behind the breakwaters due to geographic constraints, that is, the proximity of oil and gas facilities and Highway 3090. From the eastern end of the breakwater field to Caminada Pass, the fill tapers northward to a maximum width of 465 feet determined by balancing quantities with the marsh fill template which was reduced due to the landward encroachment by the beach and dune fill.

The landward and seaward slopes for Template 4 were set to 20 horizontal to 1 vertical. The marsh fill template is proposed on the landward side of the beach/dune at an elevation of +2 feet NAVD. Fill quantities for the beach/dune and marsh fills are 6.2 million and 2.3 million cubic yards, respectively. Plan view and typical cross sections for Template 4 are shown in Figures C-5-7 and C-5-8, respectively.

FIGURE C-4-A TEMPLATE 3 PLAN VIEW
AUGUST 2007




TEMPLATE 3
AT TRANSECT A




SCALES: HORIZONTAL: 1"=100'
VERTICAL: 1"=10'
ELEVATIONS ARE NAVD88 FEET

TEMPLATE 3
AT TRANSECT D

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**FIGURE C-5-6: TEMPLATE 3 CROSS SECTIONS**
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FIGURE C-6-1: TEMPLATE 4 PLAN VIEW
AUGUST, 2007
STB GROUP

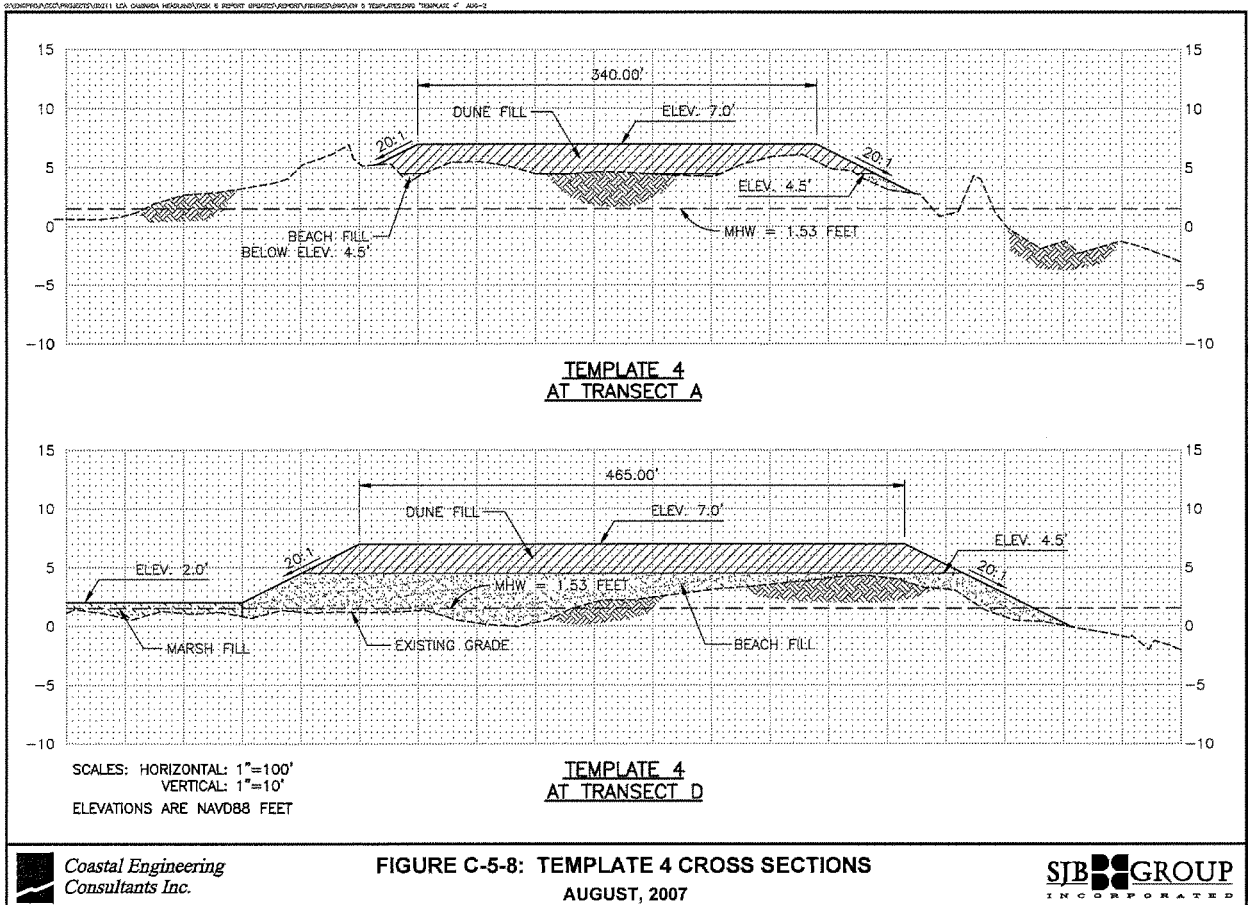


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**FIGURE C-5-8: TEMPLATE 4 CROSS SECTIONS**

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### C-5-2-3 Beach/Dune/Marsh Restoration Options with Structural Compliments

A combination of beach/dune/marsh restoration and shoreline protection features were proposed. The two types of shoreline protection features evaluated were segmented breakwaters and a terminal groin. Due to the lack of available data, the shoreline protection components were based on a reconnaissance level analysis. Modeling analyses of wave energy reduction were performed for the segmented breakwaters and the length of influence of the terminal groin along the updrift shoreline was predicted to assess the structures' feasibility (Annex C-3).

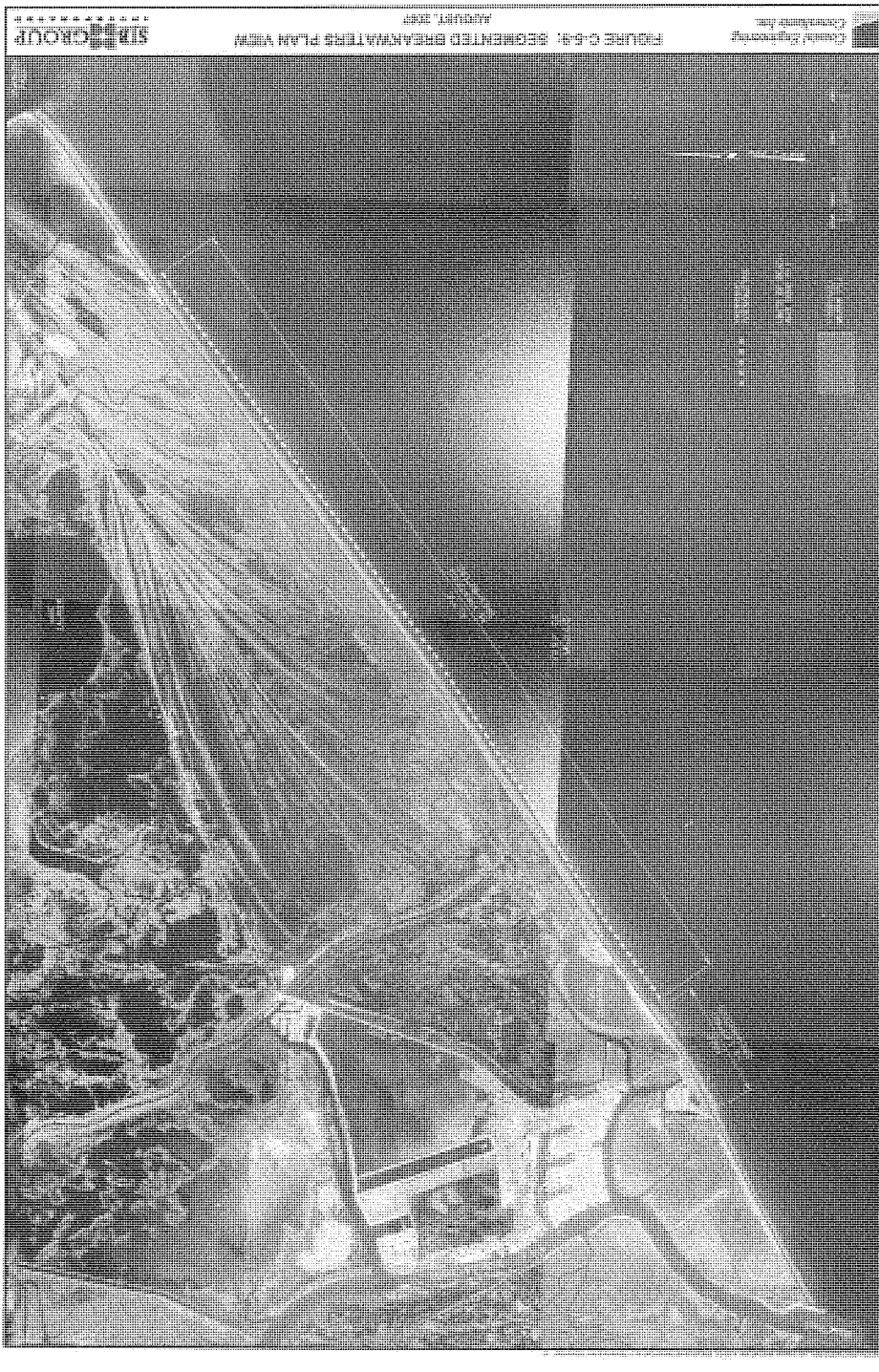
#### C-5-2-3-1 Segmented Breakwaters

The performance of the existing breakwaters was measured by comparing shoreline erosion rates in the vicinity of the breakwaters to the overall erosion rate of the Headland. Available survey information indicates that the erosion rate near the existing breakwater field, Transects A and B, is approximately 30 feet per year (Section C-2-2-3). Comparing to the average Headland erosion rate of 45 feet per year, the shoreline in the lee of the existing breakwaters is experiencing a reduction in erosion by approximately 33%. The Belle Pass east jetty may also contribute to the reduction in erosion rate on the western end of the Headland as sand is impounded by the structure. Due to the limited available survey information, a conservative estimate of 25% is assumed for the reduction in erosion losses from the fill with the addition of breakwaters.

Original sand quantities calculated for Template 2 and 3 were reduced by the 25% estimate of reduction in losses. Breakwater design criteria include an average breakwater length of 250 feet and average breakwater spacing of 250 feet based on past breakwater barrier island shoreline protection projects in Louisiana. This results in an additional 21,375 linear feet of breakwaters equal to an additional 42,750 linear feet of shoreline protection. Combined with the existing 5,600 linear feet spanned by the existing breakwaters, a total of 9.2 miles of the 13-mile Headland could be protected by segmented breakwaters. The 25% reduction in sand volume was applied on the 9.2 mile stretch of beach behind the proposed breakwaters. The sand template density for the remaining unprotected 3.8 miles of the Headland remained identical to Template 2 and 3 densities. A plan view of the segmented breakwaters design is shown in Figure C-5-9.

#### C-5-2-3-2 Terminal Groin

The eastern end of the Headland contains no coastal structures. There is a net transport of sand alongshore off the Headland into Caminada Pass, a portion of which is then naturally bypassed to the downdrift shoreline on Grand Isle. Based on the Grand Isle Report (USACE, July 2004) approximately 83,000 cu yds per year are naturally bypassed from the Caminada Headland to Grand Isle. This net easterly transport equates to only 9% of the total sediment budget (Section C-3-3).



Placement of a terminal groin on the eastern end of the Headland would alter the natural sediment transport patterns, impounding sand on the Headland, thus reducing the amount of sand bypassed to Grand Isle. The maximum extent of the terminal groin influence can only include that portion of the Headland that experiences a net transport to the east. Thus the maximum reduction in erosion losses off the proposed fill that could be attained by constructing a terminal groin is 9%, equal to the net easterly transport. To achieve this, the terminal groin would have to be designed and constructed to impound 100% of the sand moving alongshore to the east.

The Shore Protection Manual (USACE, 1984) provides the relationship between terminal groin length and its length of influence along the updrift shoreline. In order to interrupt the longshore transport, the groin should extend between the -5 to -10 foot contour. Based on the existing profile adjacent to Caminada Pass, Transect G, and this relationship, the groin length equals approximately 2,500 feet measured from +3.5 to -8 feet NAVD, where a break in offshore slope is observed. A plan view of the terminal groin design is shown in Figure C-5-10. Assuming 10 years of sand impoundment on the updrift side of the terminal groin, the length of influence of the structure extends approximately 1 mile.

## C-5-3 Performance Analysis Results

One of the considerations in designing alternatives for rebuilding the barrier shoreline and marsh composing the Caminada Headland is how the fill material will adjust and equilibrate under various storm scenarios. In order to evaluate this aspect of the alternative designs, a cross-shore sediment transport model was conducted for various normal and storm conditions on the proposed alternative fill templates (Annex C-3).

The results of the performance analysis are summarized below:

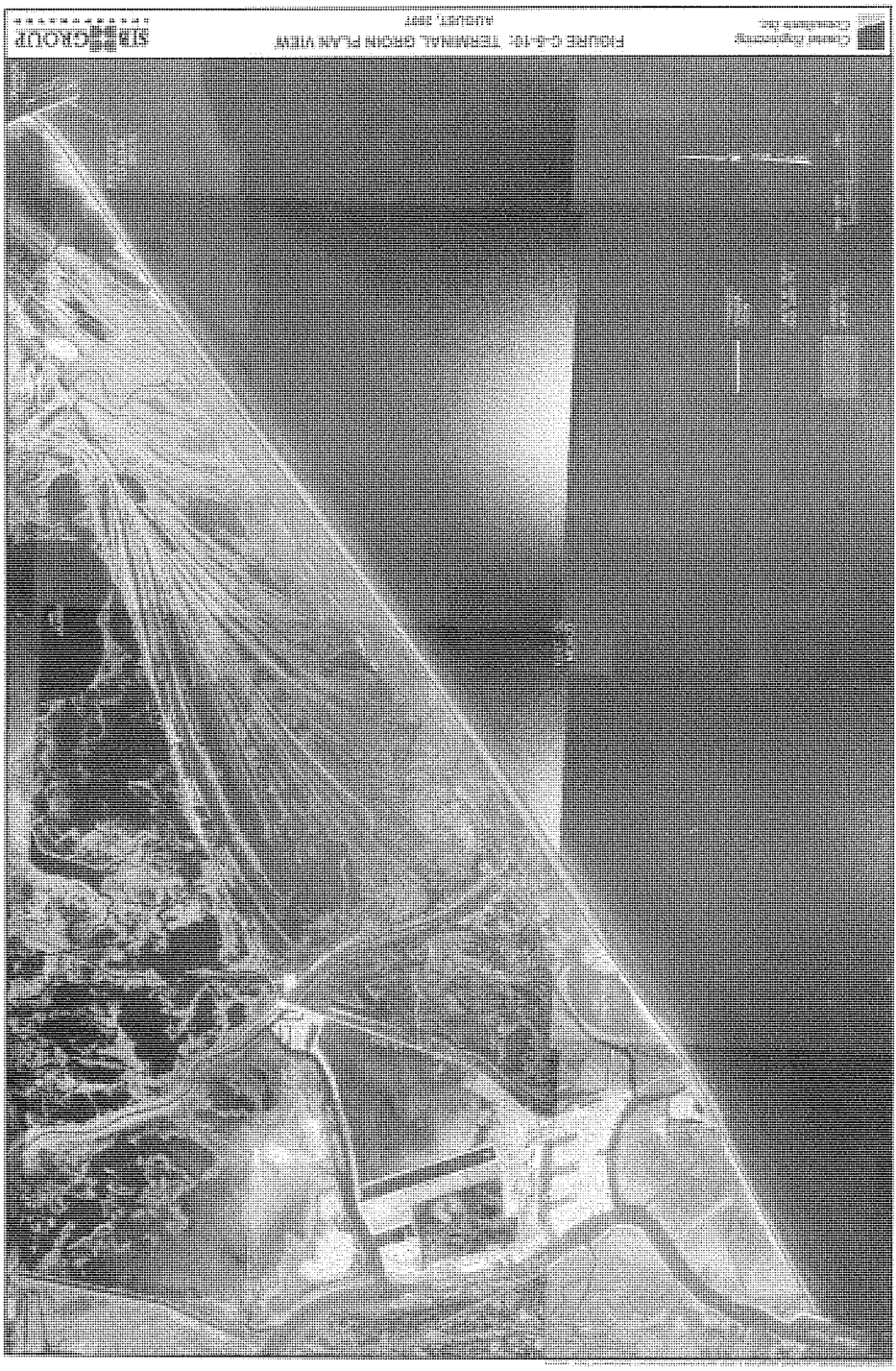
1) **No Action Option**

   The SBEACH model was applied to this option in order to predict the evolution of the existing beach profiles due to historical storm events (Annex C-3). It was concluded that the existing beach profiles were extremely vulnerable to the modeled storm conditions. They were inadequate for upland and/or marsh protection and were completely eroded. Thus, this option did not achieve any of the design objectives.

2) **Beach/Dune/Marsh Option**

   Template 1 - Marsh Restoration

   Modeling analysis presented in Annex C-3 was performed for Template 1 in order to predict its evolution due to historical storm events. It was concluded that creating a marsh



on the landward side of the dune and leaving the existing dune vulnerable provided insufficient storm protection as the existing dune was completely overwashed landward during the modeled storms. This template alone will not mitigate the erosion of the Headland; however, Template 1 provided some measure of storm protection for the Headland. Therefore, it will be evaluated further in the Alternative Analysis in Chapter 6.

Template 2 - Low and Wide Dune

Modeling analysis presented in Annex C-3 was performed for Template 2 in order to predict its evolution 2 due to historical storm events. It was concluded that Template 2 sustained significant erosion to the seaward dune face and part of the dune crest under the modeled storm conditions. The modeled dune profile still maintained a large portion of the original volume of material and the prediction suggested some increased protection to the lee of the dune from severe storm events in comparison to the existing profile (No Action Option) and Template 1. Template 2 will also be evaluated further in the Alternative Analysis in Chapter 6.

Template 3 - High and Narrow Dune

Modeling analysis presented in Annex C-3 was performed for Template 3 in order to predict its evolution due to historical storm events. It was concluded that Template 3 sustained some erosion of the seaward dune face under the modeled storm conditions but maintained the original dune crest elevation with little significant impact predicted to the seaward face of the dune crest. Model results suggested that Template 3 might provide adequate protection in the lee of the dune system and significantly increase the upland storm protection over the existing dune profile (No Action Option) and Templates 1 and 2. Template 3 will also be evaluated further in the Alternative Analysis in Chapter 6.

Template 4 - Landward Beach and Dune

Modeling analysis presented in Annex C-3 was performed for Template 4 in order to predict its evolution due to historical storm events. It was concluded that Template 4 sustained some erosion of the seaward dune face under the modeled storm conditions but maintained the original dune crest elevation with little significant impact predicted to the seaward face of the dune crest. Modeling results suggest that because of the initial width of Template 4's landward fill and its proposed position on the existing profile, the dune system remaining at the site following an initial storm impact may provide more residual protection under the effects of subsequent storms than either Template 2 or Template 3, and therefore, may require less frequent maintenance. Template 4 will also be evaluated further in the Alternative Analysis in Chapter 6.

**3) Beach/Dune/Marsh Restoration with Structural Compliments Option**

Segmented Breakwaters

Modeling analyses presented in Annex C-3 were performed to assess the feasibility of the proposed breakwaters. The STWAVE and SBEACH models were used to predict wave energy reduction and shoreline recession effects of the existing breakwaters, respectively. Results for the given storm and resulting wave fields indicated that the breakwaters have the potential to reduce wave energies on the order of 47% and had a positive effect on the shoreline by reducing the recession rate within the area of the structures' influence. However, significant impacts to the adjacent shorelines may occur due to interruption of the longshore transport, and therefore this alternative was eliminated from further consideration.

Terminal Groin

The length of influence of the terminal groin along the updrift shoreline was predicted to assess the structures' feasibility. Due to impacts on adjacent shorelines and limited performance, the terminal groin was not considered to be a practical alternative and was eliminated from further consideration.

## C-5-4 Alternative Screening Conclusions

In this chapter, the three restoration options were screened to determine which warranted further analysis. The screening process was based on habitat creation, environmental impacts and storm protection. Through this screening it was concluded that:

1) The No Action Option did not create any habitat, was inadequate for upland and/or marsh protection, and would allow the existing beach profile to completely erode under severe storm conditions. The USACE (2004c) prediction for this option is a projected loss of 3,750 acres from the Headland through 2050 leaving only a skeletal framework of wetlands. Therefore, the No Action Option did not achieve any of the design objectives, was not considered to be a practical alternative, and was removed from any further analysis.

2) The Beach/Dune/Marsh Option Templates 1 through 4 created the most habitat out of the three options. In addition to that, these templates offered storm protection to the Headland and did not impact any of the adjacent barrier islands negatively. Although Template 1 (Marsh Only) left the existing dune vulnerable, it did provide some measure of storm protection for the Headland. Therefore, Templates 1 through 4 will be analyzed in further detail in the Alternatives Analysis (Chapter 6).

3) The Beach/Dune/Marsh Restoration with Structural Compliments Option created new habitat and provided storm protection. While the results of the segmented breakwaters were favorable for the Caminada Headland, they indicated potential significant impacts to the adjacent barrier island systems to the East and West of the Project area. The conceptual sediment budget (Section C-3-3) indicates that there is 83,000 cubic yards of sediment transported to the East and 300,000 cubic yards transported to the West each year. It is approximated that the breakwater field would interrupt a maximum of 1,950,500 and 7,050,000 cubic yards of sand transport to the East and West, respectively, over the 50-year life of the Project. Similarly, the terminal groin which would be designed to trap all sediment moving to the East of the headland would interrupt a maximum of approximately 1,950,500 cubic yards of sand transport, which would be detrimental to Grand Isle. Due to these predicted environmental impacts to the adjacent barrier islands, both types of the shoreline protection were removed from any further analysis.

The screening criteria and elimination process are summarized in Figure C-5-11.

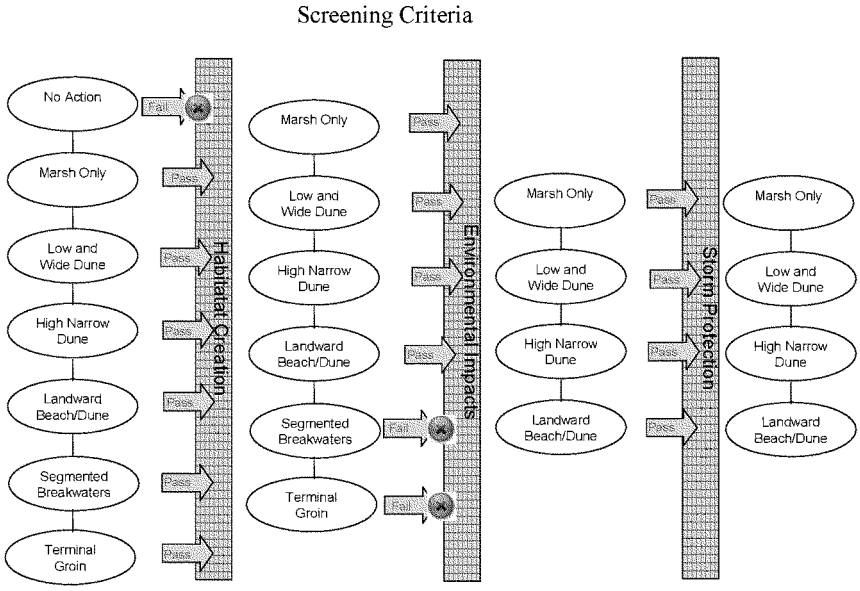



**Figure C-5-11. Diagram of Screening Criteria and Elimination Process**

# C-6 PROJECT DESIGN

Three restoration options were screened in Chapter 5 Alternative Screening based on habitat creation, environmental impacts and storm protection. Through alternative screening it was determined that four (4) Beach/Dune/Marsh Restoration Option templates would be evaluated in the Alternative Analysis to determine the most feasible Project design that balances the technical, environmental, fiscal, and institutional constraints and achieves the Project goals. Application of the various templates and adaptive management nourishment cycles resulted in the selection of ten (10) Beach/Dune/Marsh Restoration alternatives.

## C-6-1 PLAN FORMULATION

### C-6-1-1 Planning Constraints

Planning constraints were developed during the preparation of the LCA Near-Term Critical Restoration Assessment as part of the LCA Study (USACE, 2004a). The constraints were developed to guide engineering feasibility efforts and are listed below.

- Technical
  - Maintenance requirements
  - Mitigation of erosion
  - Storm protection benefits
- Environmental
  - Impacts
  - Enhancements and benefits
- Fiscal
  - Value engineering analysis
  - Preliminary opinion of cost
- Institutional
  - Stakeholder concerns
  - Infrastructure protection

#### C-6-1-1-1 Technical Constraints

The LCA Study presented a preliminary alternatives investigation that resulted in general Project goals and features to be advanced to feasibility level. This investigation and the resulting conceptual features are summarized below.

Three alternatives were considered in the LCA Study for restoring the Caminada Headland. The first alternative considered a dune only, approximately 1000 feet wide. The second alternative considered the same dune and 177 acres of marsh creation. The third alternative considered the same dune with 385 acres of marsh creation and 1200 acres of marsh nourishment (USACE, 2004c).

A limited modeling effort was conducted by an interagency team lead by the USACE to assess Project benefits. Benefits were calculated using Wetland Value Assessments (WVA) and Barrier Island Value Assessments (BIVA) as part of the Louisiana Gulf Shoreline Restoration Report (USACE, 2004b). The third alternative produced the greatest benefits at similar unit costs per acre benefited as the second alternative. It also provided the greatest amount of marsh platform for the dune to roll back on, which contributes to Project longevity. Therefore, the third alternative was used to formulate a plan, which would be evaluated for feasibility.

The LCA Study recommended the following primary Project features for the engineering feasibility study:

- Beach and Dune - 13 miles long by 1000 feet wide at an estimate of 10 million cubic yards of sand. The borrow source targeted for this sand is Ship Shoal - South Pelto Blocks 12 and 13.
- Adaptive Management – Re-Nourishment of the beach and dune every 10 years at 2 million cubic yards for each event over a 50 year design life.
- Marsh Creation and Nourishment – 400 acres of marsh creation and 1200 acres of marsh nourishment at a combined total of 6 million cubic yards of marsh fill.

These conceptual features served as the basis for the engineering feasibility study and were evaluated based on coastal processes, developed design criteria, performance analyses, and Project benefits.

### C-6-1-1-2 Environmental Constraints

In support of the WVA, an analysis of benefit acres was performed for each alternative and included in Annex C-4. Acreage calculations were used to compare Project benefits. Because the benefits constantly change over the life of the Project due to coastal processes and adaptive management re-nourishment cycles, weighted averages were calculated over the 50 year Project life for a balanced comparison of alternatives. An example weighted average calculation is shown below:
The benefit acres below were calculated for the target years listed:

| TY1 | TY2 | TY3 | TY5 | TY10 | TY20 | TY50 |
|---|---|---|---|---|---|---|
| 1186 | 1186 | 1186 | 1186 | 1043 | 65 | 26 |

Weighted average calculation =
[(TY1 + TY2) / 2)]*(# of yrs between TY/49) + [(TY2 + TY3) / 2]* (# of yrs between TY/49) + [(TY3 + TY5) / 2]* (# of yrs between TY/49) + [(TY5 + TY10) / 2]* (# of yrs between TY/49) + [(TY10 + TY20) / 2]* (# of yrs between TY/49) + [(TY20 + TY50) / 2]* (# of yrs between TY/49) = [(1186 + 1186) / 2]*1/49 + [(1186 + 1186) / 2]*1/49 + [(1186 + 1186) / 2]*2/49 + [(1186 + 1043) / 2]*5/49 + [(1043 + 65) / 2]*10/49 + [(65 + 26) / 2]*30/49 = **351 acres**

### C-6-1-1-3 Fiscal Constraints

The total estimated cost of the Barataria Barrier Island Restoration Project listed in the LCA Study is $247,204,000 (USACE, 2004c). $153,600,000 of this budget was allocated for Caminada Headland construction costs. These costs included landrights, feasibility, engineering and design, construction, supervision and administration, monitoring, and contingencies for the Caminada Headland and Shell Island Projects. Through the development of this engineering feasibility study it was found that this budget was not sufficient to meet Project goals because of escalating construction costs and unforeseen maintenance throughout the 50 year Project life. Initial construction costs were evaluated as well as adaptive management costs for the entire 50 year Project life. Fiscal and environmental constraints were also compared in combination to evaluate cost effectiveness and environmental benefits. Details on the development of the cost estimates including updated unit costs and how they affect Project alternatives are discussed in Chapter 9.

### C-6-1-1-4 Institutional Constraints

The Project design must be coordinated with the interests of Project stakeholders including governmental, industrial, public, and private entities. This requires a Project design that avoids adverse impacts and potentially adds protection as an incidental benefit to existing infrastructure. Such infrastructure includes Port Fourchon and other oil and gas producing facilities and pipelines, Louisiana Highway 1 and 3090, the LUMCON research facility, the Wisner Wildlife Management Area, public beach access, nearby public and private docks, and private camps.

## C-6-2 ALTERNATIVE ANALYSIS

Four templates were chosen for further analysis based on the alternative screening presented in Chapter 5. These four templates were used to develop ten alternatives of varying combination and nourishment intervals to achieve Project goals over the 50 year Project life. The ten alternatives were evaluated based on technical, environmental, fiscal, and institutional planning constraints set forth in Section C-6-1-1. Table C-6-1 provides a description of the ten alternatives that were evaluated.

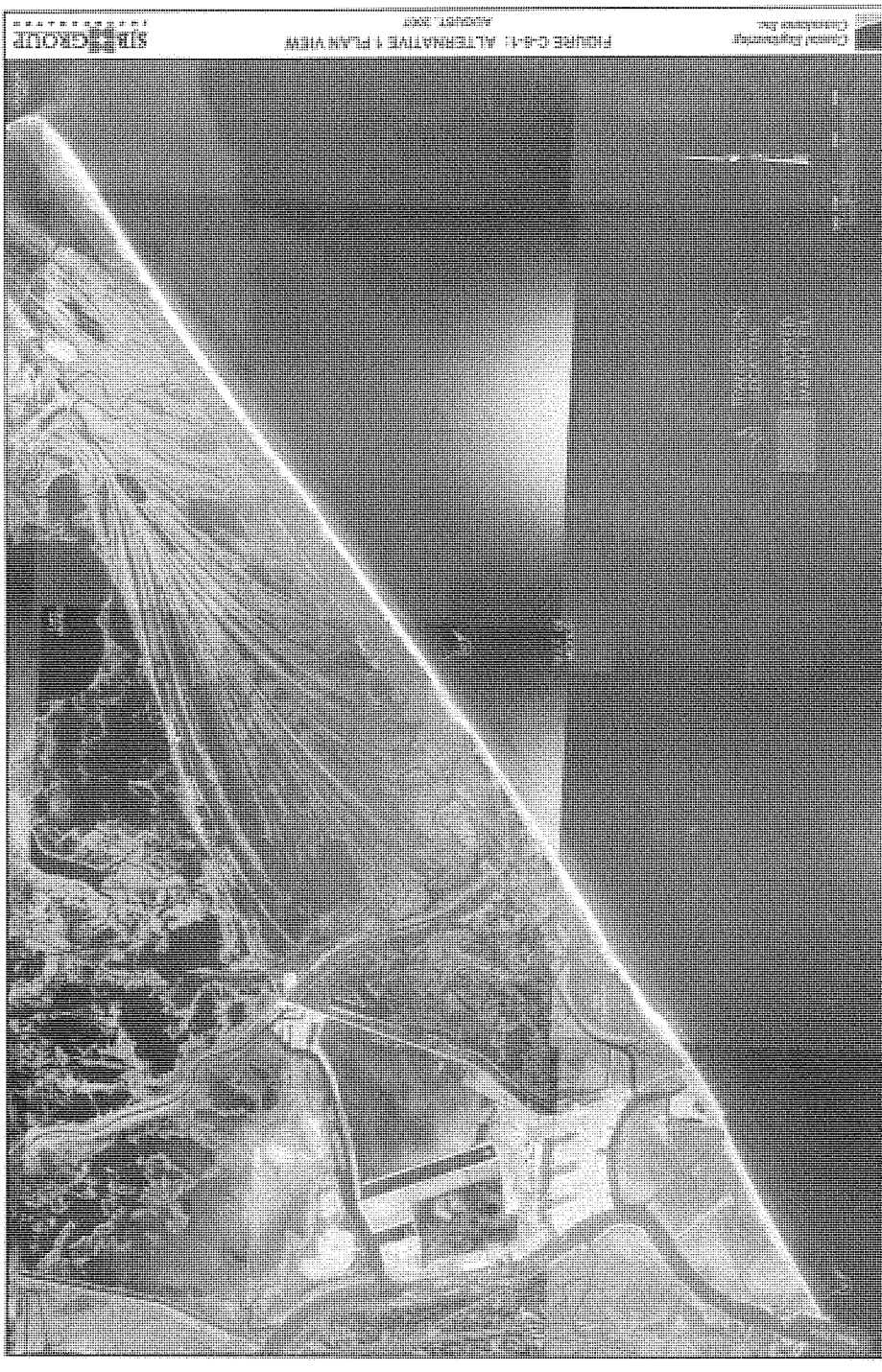
**Table C-6-1. Alternative Descriptions**

| Alternative | Alternative Description | Template Numbers | Number of Beach Re-nourishment Intervals | Beach Re-nourishment Cycles (yrs) | Marsh Re-nourishment Cycles (yrs) |
|---|---|---|---|---|---|
| 1 | Base Marsh Only | 1B | 0 | 0 | 0 |
| 2 | Low & Wide Dune w/ Base Marsh | 1A, 2 | 0 | 0 | 0 |
| 3 | High & Narrow Dune w/ Base Marsh | 1A, 3 | 0 | 0 | 0 |
| 4 | Landward Dune w/ Base Marsh | 1A, 4 | 0 | 0 | 0 |
| 5 | Preferred Dune w/ Expanded Marsh | 1B, 4* | 0 | 0 | 0 |
| 6 | Preferred Dune w/ Expanded Marsh and 1 Renourishment | 1B, 4* | 1 | 25 | 25 |
| 7 | Preferred Dune w/ Expanded Marsh and 2 Renourishments | 1B, 4* | 2 | 20, 40 | 20, 40 |
| 8 | Optimized Project w/ Base Marsh and 4 Renourishments | 1A, 4* | 4 | 10, 20, 30, 40 | 20, 40 |
| 9 | Optimized Project w/ Expanded Marsh and 4 Renourishments | 1B, 4* | 4 | 10, 20, 30, 40 | 20, 40 |
| 10 | Optimized Project w/ Expanded Marsh and 4 Renourishments and full storm protection | 1B, 4** | 4 | 10, 20, 30, 40 | 20, 40 |

*Includes advanced fill for beach equilibrium
**Includes advanced fill for beach equilibrium and storm protection

### C-6-2-1 Alternative 1 – Marsh Only

Alternative 1 proposes to create 1111 acres of marsh extending west through Bay Champagne to the eastern edge of the Project boundary near Caminada Pass and 75 acres of additional marsh to the west of the oil and gas facility on the western end of the Headland. Alternative 1 proposes this marsh fill on the landward side of the dune at an elevation of +2.0 feet NAVD with boundaries as described in section C-5-1-3-1. Fill quantities for the marsh fills are 5.4 million cubic yards. Plan view and typical cross sections for Alternative 1 are shown in Figures C-6-1 and C-6-2 respectively. This alternative was also evaluated further in combination with beach and dune restoration in subsequent alternatives.



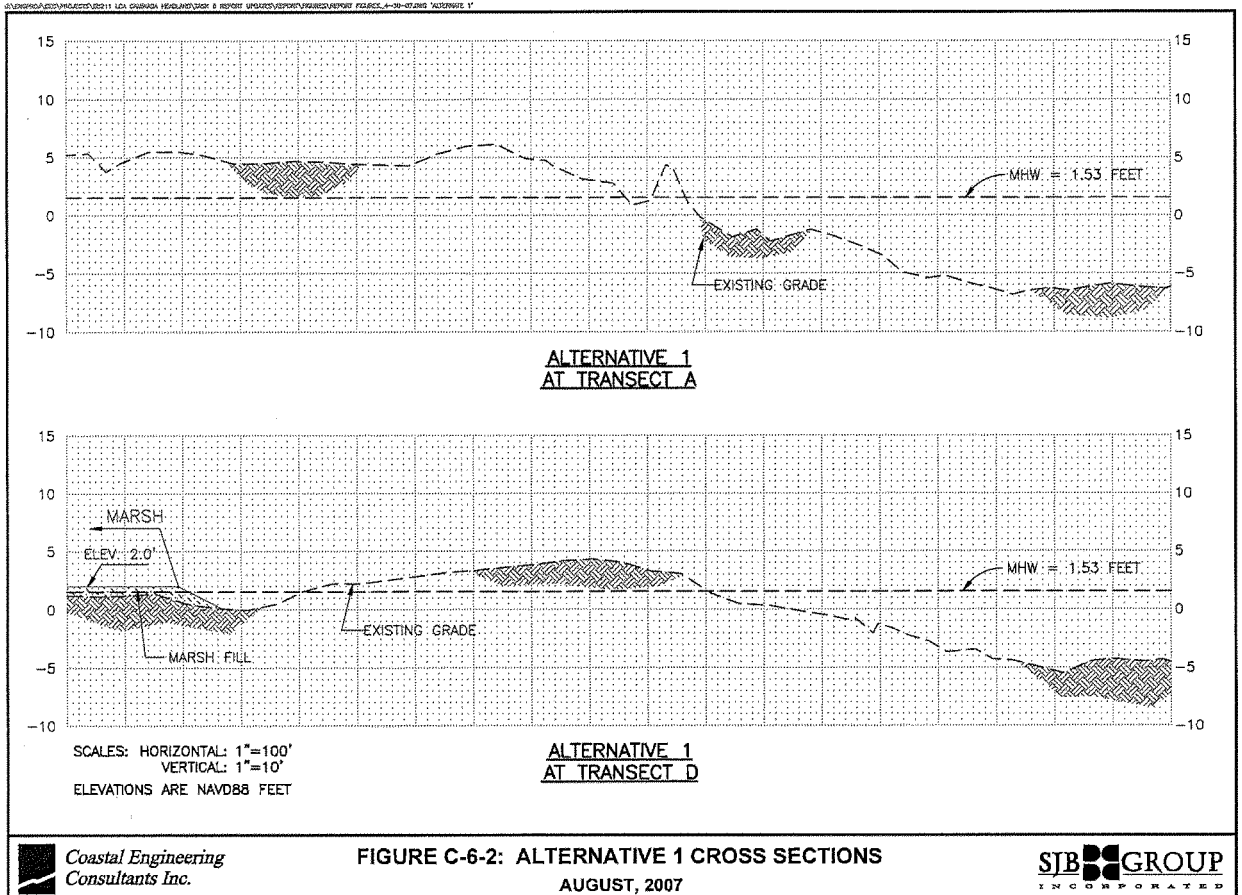



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**FIGURE C-6-2: ALTERNATIVE 1 CROSS SECTIONS**

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## C-6-2-2 Dune and Marsh Alternatives

### C-6-2-2-1 Alternative 2 – Low & Wide Dune

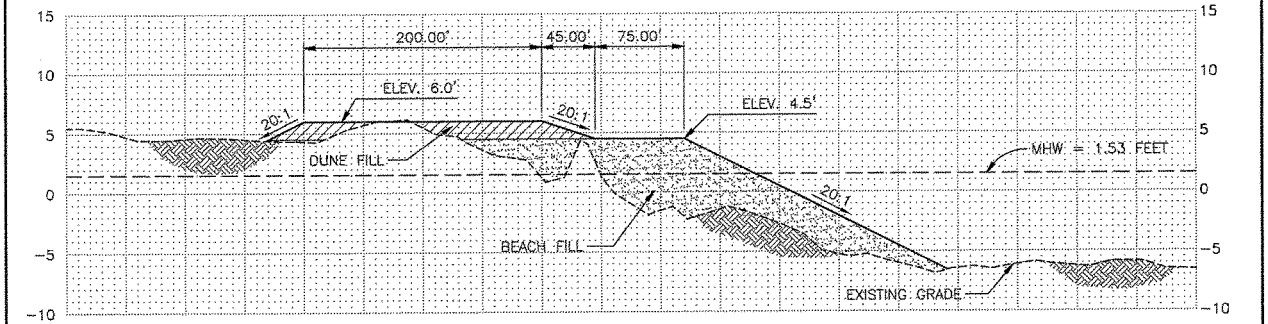
Alternative 2 proposes a dune height of +6 feet NAVD which is slightly higher than the existing dune elevation in the area of +4 feet NAVD. The proposed dune width is 200 feet. This dune is centered over the existing dune and slopes down to a construction berm that is extended seaward until the budget constraint is reached. The alternative was then optimized for density and alignment to address the existing breaches and longshore erosion processes. The alternative density refers to the volume of sand per unit length of beach. The optimization process consisted of adjusting the alternative gulfward or landward at each cross section so that all cross sections contain the same volume of sand. This was done so that the Project would perform uniformly along the entire length of the Headland.

The landward, seaward, and dune crest to berm slopes for Alternative 2 are all set to 20 horizontal to 1 vertical. The beach fill alternative has a 75 feet wide seaward berm at an elevation of +4.5 feet NAVD and a marsh fill alternative is proposed on the landward side of the dune at an elevation of +2.0 feet NAVD with boundaries as described in section C-5-1-2-1. Fill quantities for the beach/dune and marsh fills are 5.7 million and 3.8 million cubic yards, respectively. Plan view and typical cross sections for Alternative 2 are shown in Figures C-6-3 and C-6-4, respectively.

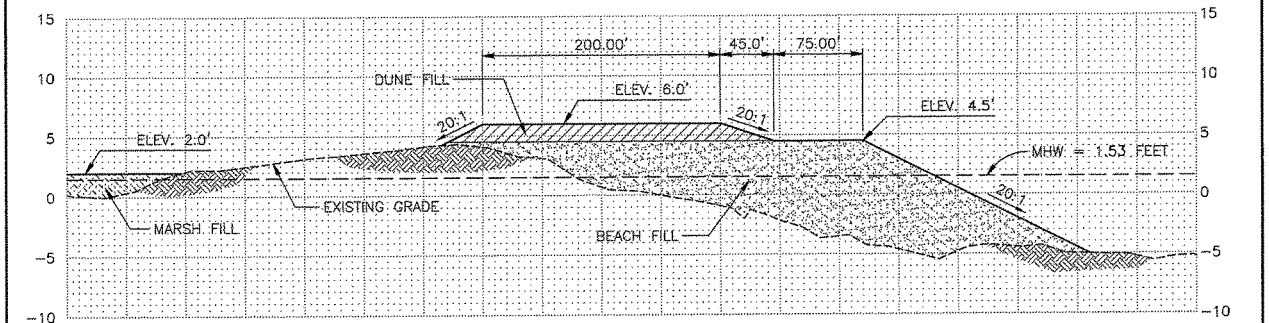
### C-6-2-2-2 Alternative 3 – High & Narrow Dune

Alternative 3 proposes a dune higher and narrower than 2 for performance comparisons. The Alternative 3 dune height was set at +8 feet NAVD and with the exception of the fill tapers, contains a 125 foot dune crest width. This dune is centered over the existing dune and slopes down to a construction berm that was extended seaward until the budget constraint was reached. The alternative was then optimized for density and alignment to address the existing breaches and longshore erosion processes.

The landward, seaward, and dune crest to berm slopes for Alternative 3 are all set to 20 horizontal to 1 vertical. With the exception of the fill tapers, the beach fill alternative has a 75 feet wide seaward construction berm at an elevation of +4.5 feet NAVD and marsh fill is proposed on the landward side of the dune at an elevation of +2.0 feet NAVD with boundaries as described in section C-5-1-2-1. Fill quantities for the beach/dune and marsh fills are 5.7 million and 3.8 million cubic yards respectively. Plan view and typical cross sections for Alternative 3 are shown in Figures C-6-5 and C-6-6, respectively.




ALTERNATIVE 2
AT TRANSECT A




SCALES: HORIZONTAL: 1"=100'
VERTICAL: 1"=10'
ELEVATIONS ARE NAVD88 FEET

ALTERNATIVE 2
AT TRANSECT D

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**FIGURE C-6-4: ALTERNATIVE 2 CROSS SECTIONS**

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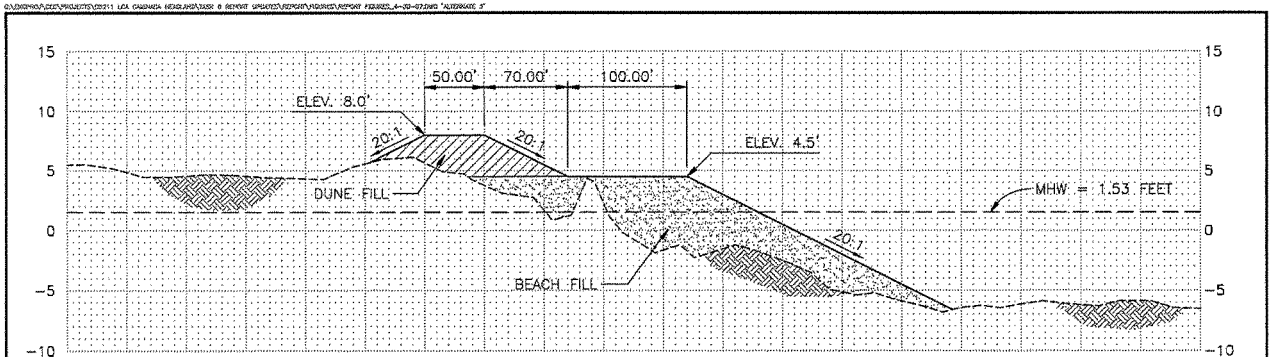
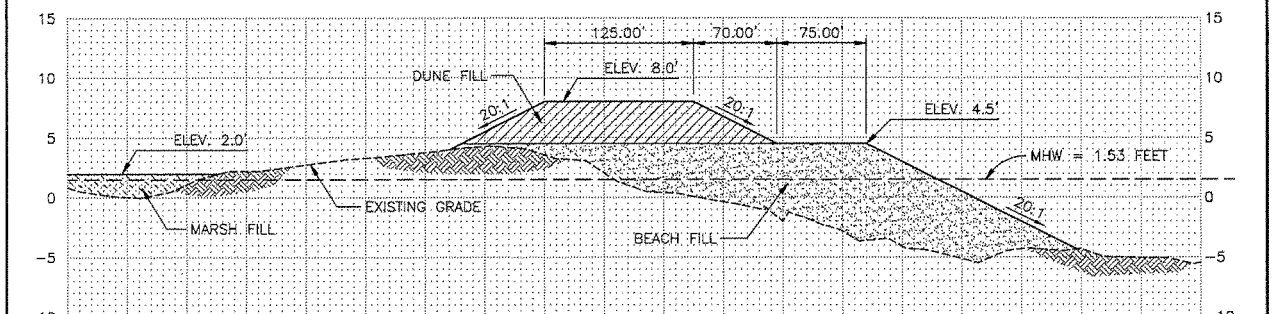



ALTERNATIVE 3
AT TRANSECT A




SCALES: HORIZONTAL: 1"=100'
VERTICAL: 1"=10'
ELEVATIONS ARE NAVD88 FEET

ALTERNATIVE 3
AT TRANSECT D

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**FIGURE C-6-6: ALTERNATIVE 3 CROSS SECTIONS**

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### C-6-2-2-3 Alternative 4 – Landward Dune

Alternative 4 proposes a dune height of +7 feet NAVD. The modeling analyses summarized in Annex C-3 demonstrate that the higher dune proposed in Alternative 3 at +8 feet NAVD offers more storm protection between future maintenance events than the lower dune proposed in Alternative 2 at +6 feet NAVD. Although the higher dune offers more storm protection, there may be ecological concerns with constructing a dune higher than the Headland's existing dune elevations. To balance storm protection benefits with ecological concerns, Alternative 4 dune height is proposed at +7 feet NAVD.

Alternative 4 also proposes a landward beach and dune component compared to the seaward beach component in both Alternatives 2 and 3, which eroded completely during the analysis of storm impacts (Annex C-3). Because the fill is sited landward over existing higher elevations, the dune could be extended over the significant majority of the beach fill. The width of this landward alternative is limited from Belle Pass to the western edge of the existing breakwater field by environmental habitats and oilfield canals to the north of the barrier shoreline. In this area the fill width is 300 feet tapering toward the shoreline at the western edge of the breakwaters. No sand will be placed in this landward alternative behind the breakwaters due to geographic constraints, that is, the proximity of oil and gas facilities and Highway 3090. From the eastern end of the breakwater field to Caminada Pass, the fill tapers northward to a maximum width of 465 feet determined by budget constraints and balancing quantities with the marsh fill alternative which was reduced due to the landward encroachment by the beach and dune fill.

The landward and seaward slopes for Alternative 4 are set to 20 horizontal to 1 vertical. The marsh fill is proposed on the landward side of the beach/dune at an elevation of +2.0 feet NAVD with boundaries as described in section C-5-1-2-1. Fill quantities for the beach/dune and marsh fills are 6.0 million and 2.6 million cubic yards respectively. Plan view and typical cross sections for Alternative 4 are shown in Figures C-6-7 and C-6-8, respectively.

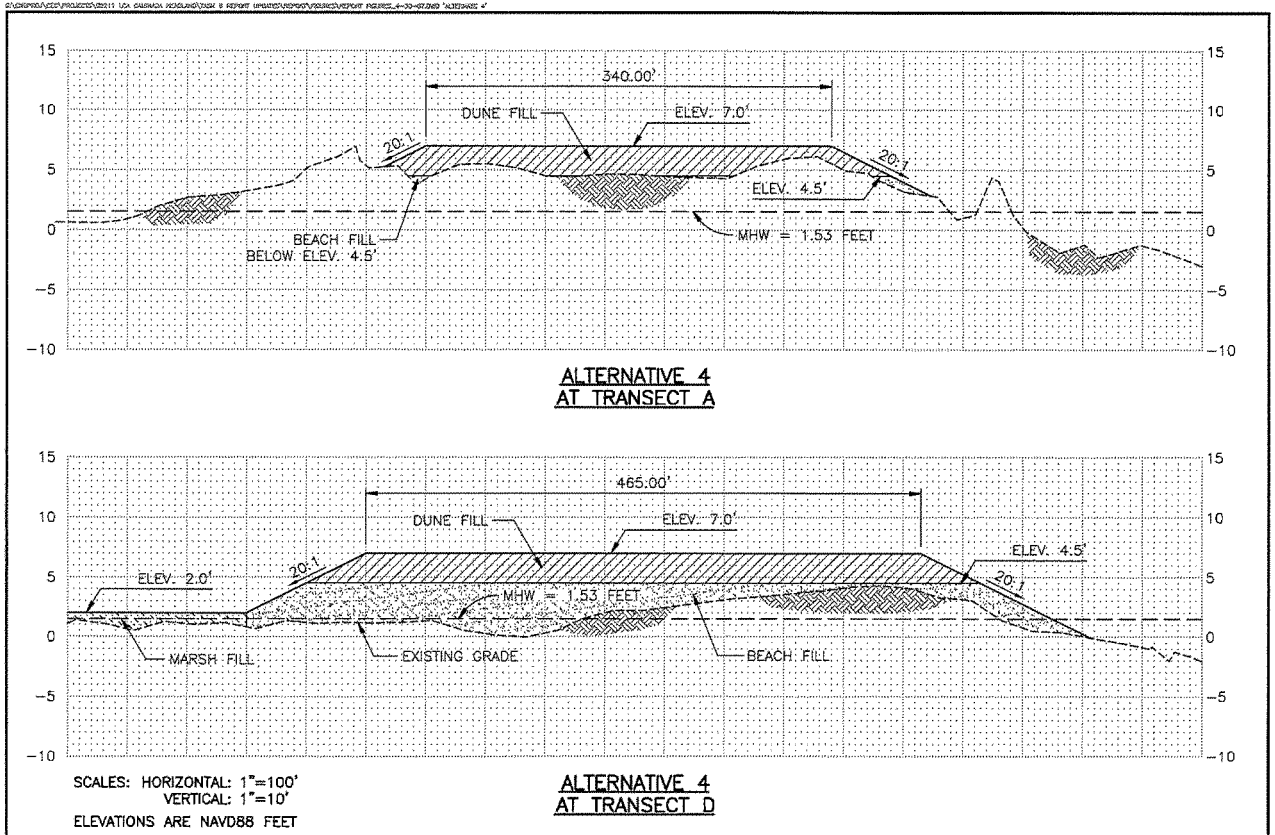


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**FIGURE C-6-8: ALTERNATIVE 4 CROSS SECTIONS**

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## C-6-2-3 Evaluation of Alternatives 1 Through 4

The alternatives were evaluated based on the following four constraints: technical, environmental, fiscal, and institutional constraints.

### C-6-2-3-1 Technical

The technical constraints considered when evaluating the alternatives were maintenance requirements, mitigation of erosion, and storm protection benefits. Alternative 4 would provide more residual storm protection benefits than Alternatives 1, 2, and 3. Alternative 4 also proposes a wider beach and dune platform resulting lower quantity of marsh fill because of its landward orientation. This landward orientation also requires less fill depth to achieve the template design elevation allowing sand quantities to be more widely distributed over the existing Headland platform resulting in more habitat acreage. For these reasons, Alternative 4 may also require less frequent maintenance than Alternatives 1, 2, and 3. However, none of these alternatives maintain the acreages currently present on the Headland for more than 10 years because of the lack of re-nourishment.

### C-6-2-3-2 Environmental

The alternatives were evaluated based on environmental enhancements, impacts and benefits. Although Alternative 4 creates the most beach/dune acreage, it creates significantly less marsh acreage due to the landward fill design. In total, Alternative 4 and Alternative 1 create less total habitat than the seaward alternatives. Alternative 2 provides the most created habitat as it extends the farthest seaward. Alternative 4 has slightly more environmental impact than Alternatives 2 and 3 because the landward beach and dune fill covers existing marsh. Alternative 1 fills in Bay Champagne and Bay Caminada with marsh sediments which may cause adverse environmental impacts. Table C-6-2 summarizes the habitat created by each alternative. Only Alternative 1 results in some habitat at TY 50 due to the expanded marsh fill extension into the Indirect Boundary.

**Table C-6-2. Habitat Area Created**

| Alternative | Initial Beach/Dune Area (Acres) | Initial Marsh Area (Acres) | Total Initial Created Area (Acres) | Total Area at 50 years (Acres) | Weighted Average over 50 years (Acres) |
|---|---|---|---|---|---|
| 1 | 0 | 1186 | 1186 | 26 | 351 |
| 2 | 879 | 936 | 1815 | 0 | 700 |
| 3 | 826 | 939 | 1765 | 0 | 680 |
| 4 | 955 | 667 | 1622 | 0 | 597 |

### C-6-2-3-3 Fiscal

The fiscal constraints were evaluated based on cost to benefit acres ratio. Table C-6-3 summarizes the 50 year present value total costs presented in Chapter 9 for each alternative. The table also compares the cost to weighted average benefit ratios. Alternative 1 is the most cost effective of Alternatives 1 - 4.

**Table C-6-3. Comparison of Costs (50 yr)**

| Alternative | 50 Year P.V. Cost ($ millions) | Cost to Weighted Average Benefit Ratio ($/Acre) |
|---|---|---|
| 1 | 47 | 133,000 |
| 2 | 191 | 273,000 |
| 3 | 191 | 281,000 |
| 4 | 191 | 319,000 |

### C-6-2-3-4 Institutional

Alternative 1 provides the least protection of the oil and gas facility and Highway 3090 immediately behind the beach in the vicinity of the existing breakwaters. Also Alternative 1 may present land rights issues as some stakeholders may be opposed to filling Bay Champagne and Bay Caminada with marsh sediments. Alternative 4 also provides minimal protection because a portion of the infrastructure precludes the landward beach and dune construction because of its proximity to the existing shoreline. Alternative 3 provides more protection to these facilities because the beach and dune are constructed seaward and the higher dune offers more residual storm protection than Alternative 2.

## C-6-2-4 Preferred Dune Alternatives

The development of Alternative 5, 6, and 7 builds upon Templates 1, 2, 3 and 4 analyses and comparisons.

The conceptual design for Alternative 5, 6, and 7 includes design fill and advanced fill. For the design fill a dune height of +7 feet NAVD is proposed. The modeling analyses summarized in Annex C-3 demonstrates that the higher dune proposed in Alternative 3 at +8 feet NAVD offers more storm protection between future re-nourishment events than the lower dune proposed in Alternative 2 at +6 feet NAVD. Although the higher dune offers more storm protection, there may be ecological concerns with constructing a dune higher than the Headland's existing dune elevations. To balance storm protection benefits with ecological concerns, the dune height is proposed at +7 feet NAVD which is consistent with Alternative 4. The design fill is also consistent with Alternative 4 in that the majority of it is sited landward over existing higher elevations, maximizing acreage and longevity.

The advanced fill quantities account for initial losses due to shoreline equilibrium. Three methods were considered to determine the average shoreline erosion which would occur due to equilibrium. The first method considered was developed by Dean (1977), which predicts profile shape as a function of depth of water based on distance from the shoreline and grain size. Due to the varying sediment types across the profile, that is, transition from fine sands to silts and clays, this method did not accurately predict the nearshore and offshore profile shapes thus it was eliminated. The second method considered was to use monitoring surveys from nearby constructed projects. Because no data was found comparing construction templates to post-construction equilibrium profiles, this method was also eliminated. Lastly, a mass balance was performed by comparing existing profiles to construction profiles. The theory used was that the construction template would reform through coastal processes to gulfward slopes similar to those of existing profiles. It was assumed that the volume of beach and dune erosion would equal the amount of sand transported to the depth of closure. By using these two criteria, it was determined that an average of 65 feet of shoreline retreat would occur from cross-shore transport during the equilibrium process.

### C-6-2-4-1 Alternative 5 – Preferred Dune – Initial Construction Only

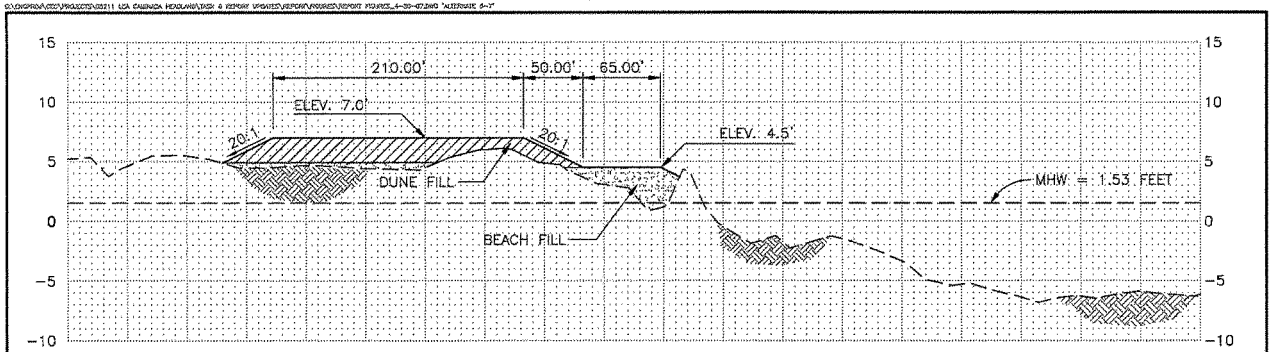
Alternative 5 proposes a dune height of +7 feet NAVD with a proposed dune width of 290 feet. Alternative 5 also proposes a landward beach and dune component in order to maximize acreage and longevity. The landward and seaward slopes are set 20 horizontal to 1 vertical. The marsh fill is proposed on the landward side of the beach and dune at an elevation of +2.0 feet NAVD. Fill quantities for the beach and marsh fills are 5.1 million and 5.4 million cubic yards, respectively. Plan view and typical cross sections for Alternative 5 are shown in Figures C-6-9 and C-6-10, respectively.

### C-6-2-4-2 Alternative 6 – Preferred Dune with 1 Re-nourishment

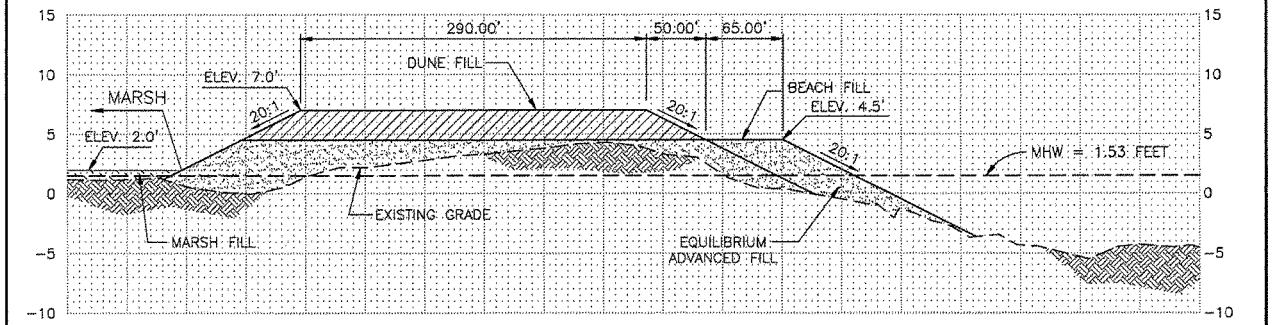
Alternative 6 proposes a dune height of +7 feet NAVD with a proposed dune width of 290 feet. Alternative 6 also proposes a landward beach and dune component in order to maximize acreage and longevity. The landward and seaward slopes are set 20 horizontal to 1 vertical. The marsh fill is proposed on the landward side of the beach and dune at an elevation of +2.0 feet NAVD. Alternative 6 is different from Alternative 5 in that Alternative 6 has one re-nourishment event at year 25. Re-nourishment volumes for the alternatives were based on the "hold the line" re-nourishment scenario which is discussed in detail in Chapter C-8 Adaptive Management Plan. Initial fill quantities for the beach and marsh fills are 5.1 million and 5.4 million cubic yards respectively. Plan view and typical cross sections for Alternative 6 are shown in Figures C-6-9 and C-6-10, respectively.

### C-6-2-4-3 Alternative 7 – Preferred Dune with 2 Re-nourishments

Alternative 7 proposes a dune height of +7 feet NAVD with a proposed dune width of 290 feet. Alternative 7 also proposes a landward beach and dune component in order to maximize acreage and longevity. The landward and seaward slopes are set 20 horizontal to 1 vertical. The marsh fill is proposed on the landward side of the beach and dune at an elevation of +2.0 feet NAVD. Alternative 7 is different from Alternatives 5 and 6 because Alternative 7 has two re-nourishment events at year 20 and 40. Initial fill quantities for the beach and marsh fills are 5.1 million and 5.4 million cubic yards respectively. Plan view and typical cross sections for Alternative 7 are shown in Figures C-6-9 and C-6-10, respectively.




ALTERNATIVE 5, 6, AND 7
AT TRANSECT A




SCALES: HORIZONTAL: 1"=100'
VERTICAL: 1"=10'
ELEVATIONS ARE NAVD88 FEET

ALTERNATIVE 5, 6, AND 7
AT TRANSECT D

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**FIGURE C-6-10: ALTERNATIVE 5, 6, AND 7 CROSS SECTIONS**
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## C-6-2-5 Evaluation of Alternatives 5 Through 7

The alternatives were evaluated based on the following four constraints: technical, environmental, fiscal, and institutional constraints.

### C-6-2-5-1 Technical

The technical constraints considered when evaluating the alternatives were maintenance requirements, mitigation of erosion, and storm protection benefits. The beach, dune, and marsh fill templates for Alternatives 5, 6, and 7 are identical in terms of size. The expanded marsh template provided by Alternative 5, 6, and 7 in Bay Champagne and Bay Caminada should provide additional stability to the Headland with a more consistent marsh platform to migrate northward on and for the dune to roll over on. Alternative 5 does not have any re-nourishment events and only maintains TY 0 habitat acreages for approximately 14 years. Alternative 6 is re-nourished one time at TY 25 and Alternative 7 is renourished at TY 20 and 40. Alternative 7 will provide the most storm protection benefits throughout the design life because of the two re-nourishment intervals.

**Table C-6-4. Re-nourishment Intervals**

| Alternative | Re-nourishment Intervals (years) |
|---|---|
| 5 | none |
| 6 | 25 |
| 7 | 20, 40 |

### C-6-2-5-2 Environmental

The alternatives were evaluated based on environmental enhancements and benefits. Alternative 5 is not re-nourished and only maintains a small amount of marsh acreage at the end of the 50 year design life. The re-nourishment events of Alternatives 6 and 7 enhance the Headland's environmental habitat by adding more benefit acres over the life of the Project. Even though Alternative 7 experiences some time below TY 0 acreages between re-nourishment events, it offers the most habitat longevity throughout the life of the Project and at the end of 50 years. Alternatives 5, 6, and 7 fill in Bay Champagne and Bay Caminada which may create adverse environmental impacts. Table C-6-5 summarizes the habitat created by each alternative.

**Table C-6-5. Habitat Area Created**

| Alternative | Initial Beach/Dune Area | Initial Marsh Area | Total Initial Created Area | Total Area at 50 years | Weighted Average over 50 years |
|---|---|---|---|---|---|
| | (Acres) | (Acres) | (Acres) | (Acres) | (Acres) |
| 5 | 880 | 1186 | 2066 | 26 | 818 |
| 6 | 880 | 1186 | 2066 | 564 | 1279 |
| 7 | 880 | 1186 | 2066 | 1451 | 1461 |

### C-6-2-5-3 Fiscal

The fiscal constraints were evaluated based on cost to benefit acre ratio. Alternative 5 has the highest cost to benefit ratio as it is the least effective in sustaining Project benefits. Although Alternative 7 provides the most benefits it is also the most expensive to maintain per acre. Alternative 6 is the most cost effective of the three alternatives. Table C-6-6 summarizes the 50 year present value total costs presented in Chapter 9 for each alternative. The table also compares the cost to benefit ratios using the weighted average benefits.

**Table C-6-6. Comparison of Costs (50 yr)**

| Alternative | 50 Year P.V. Cost | Cost to Weighted Average Benefit Ratio |
|---|---|---|
| | ($ millions) | ($/Acre) |
| 5 | 188 | 230,000 |
| 6 | 295 | 230,000 |
| 7 | 345 | 236,000 |

### C-6-2-5-4 Institutional

Alternatives 5, 6, and 7 may present more land rights issues as some stakeholders may be opposed to filling Bay Champagne and Bay Caminada with marsh sediments. Alternative 5 provides the least amount of protection to the oil and gas facilities because it does not have any re-nourishment intervals which results in the smallest weighted average benefit acreage among the three alternatives. Alternative 7 provides more protection to these facilities with two re-nourishment intervals than Alternative 6 with one re-nourishment interval.

### C-6-2-6 Optimized Project

The development of Alternatives 8, 9, and 10 builds upon Alternatives 5, 6, and 7 analyses and comparisons, with the goal of meeting all the Project objectives set forth by the LCA Study (USACE, 2004a). The previous Alternatives, 1 through 7, were designed to balance Project costs and goals, although not necessarily for the full 50 year Project life. Re-nourishment intervals for Alternatives 6 and 7 were included to boost Project longevity further than initial construction but were not specifically designed to maintain benefits throughout the duration of the Project. To design Project alternatives which would maintain the TY 0 habitat and offer storm protection for 50 years, an optimum re-nourishment interval was determined by comparing construction costs for a number of interval durations. Costs were affected by frequency of mobilization, re-nourishment volumes which increase as interval duration increases, and seaward template distance (the longer the duration between re-nourishment intervals, the farther seaward into deeper water the template has to be built to compensate for more erosion).

The conceptual beach design for optimized projects includes two components: design fill and advanced fill. Design fill volumes were calculated using the preferred dune template and the conceptual sediment budget losses of 383,000 cubic yards per year as determined in Section C-3-3. This sediment budget was multiplied by the re-nourishment intervals of 5, 10, 15 and 25 years. Advanced fill quantities were then added to these volumes for additional gulfward protection. Advanced fill quantities included initial losses due to shoreline equilibrium and storm-induced losses due to a design storm event occurring prior to the subsequent re-nourishment project.

As determined in Section C-6-2-4, 65 feet of shoreline loss is estimated for shoreline equilibrium. Storm modeling results yielded a predicted shoreline loss of approximately 80 feet for the design storm chosen. Further details of this analysis are included in Annex C-3 Caminada Headland Supplemental Modeling Draft Report. Because the advanced fill would be placed in the gulfward direction where bottom elevations are deeper, the advanced fill elevation was set at +4.5 feet NAVD to offer storm protection benefits for low magnitude storm events, e.g. less than 5-year storm events, and to balance construction quantities and cost. Reduced fill performance due to this lower elevation would not be anticipated because the cubic yardage density per linear foot of beach would remain consistent.

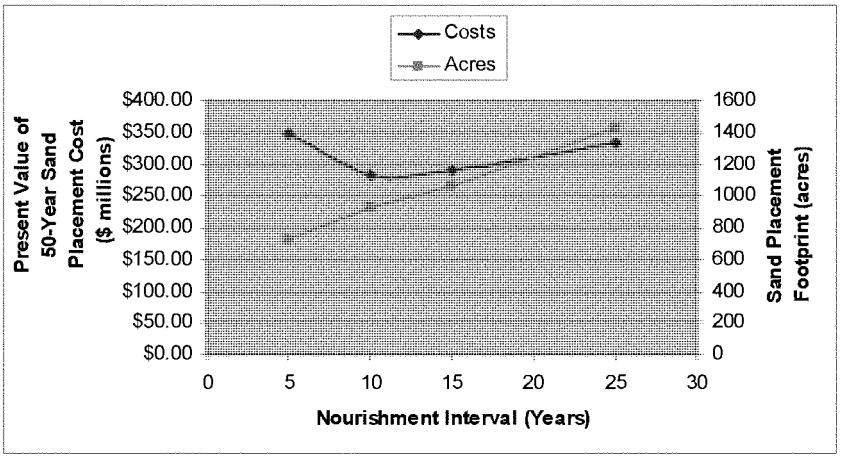
Table C-6-7 summarizes the volume estimates for the re-nourishment cycles analyzed.

**Table C-6-7. Volumes as a Function of Re-Nourishment Interval Duration**

| Nourishment Interval | Design Fill Quantity (Cubic Yards) | Design Storm Advanced Fill Quantity (Cubic Yards) | Equilibrium Advanced Fill Quantity (Cubic Yards) | Total Advanced Fill Quantity (Cubic Yards) | Total Quantity (Cubic Yards) |
|---|---|---|---|---|---|
| 5 | 1,888,200 | 1,245,600 | 1,237,100 | 2,482,700 | 4,370,900 |
| 10 | 3,847,100 | 1,245,600 | 1,237,100 | 2,482,700 | 6,329,800 |
| 15 | 5,740,800 | 1,608,900 | 1,308,400 | 2,917,300 | 8,658,100 |
| 25 | 10,017,900 | 1,900,400 | 1,413,600 | 3,314,000 | 13,331,900 |

All of the re-nourishment intervals presented in Table C-6-7 achieve the Project goals of maintaining the integrity of the Headland, protecting infrastructure, and creating environmental habitat. Therefore, they were compared based on 50-year costs which included mobilization/demobilization and beach and dune fill only. Unit costs for these items were developed in Chapter 9 and applied with a 20% contingency. Other Project features were excluded to maximize comparison consistency. A present value analysis was performed on each interval alternative using a prime interest rate of 8.0% and a linear inflation rate of 2.7%. The results are presented in Figure C-6-11.

**Figure C-6-11. Optimal Re-Nourishment Interval Development**



This analysis illustrates that the Project cost decreases sharply between the 5 year nourishment interval and the 10 year nourishment interval with the cost slowly increasing as time between construction intervals increases. Considering cost contingencies, the minimum cost occurs within the range of the 10 and 13 year nourishment intervals. Nourishment intervals which fall within this range optimize the fill template in terms of fiscal and storm protection benefits. For practical planning purposes, the 10 year interval is recommended because it is evenly divisible into the 50-year Project life and consistent construction quantities could be anticipated for each interval.

Also shown is the sand placement footprint which increases almost linearly with increased time between nourishment intervals. Although more acres are created as interval time increases, this does not correlate exactly to more Project benefits because the goals of the Project are achieved by all of the maintenance interval options.

### C-6-2-6-1 Alternative 8 - Optimized Project with Base Marsh

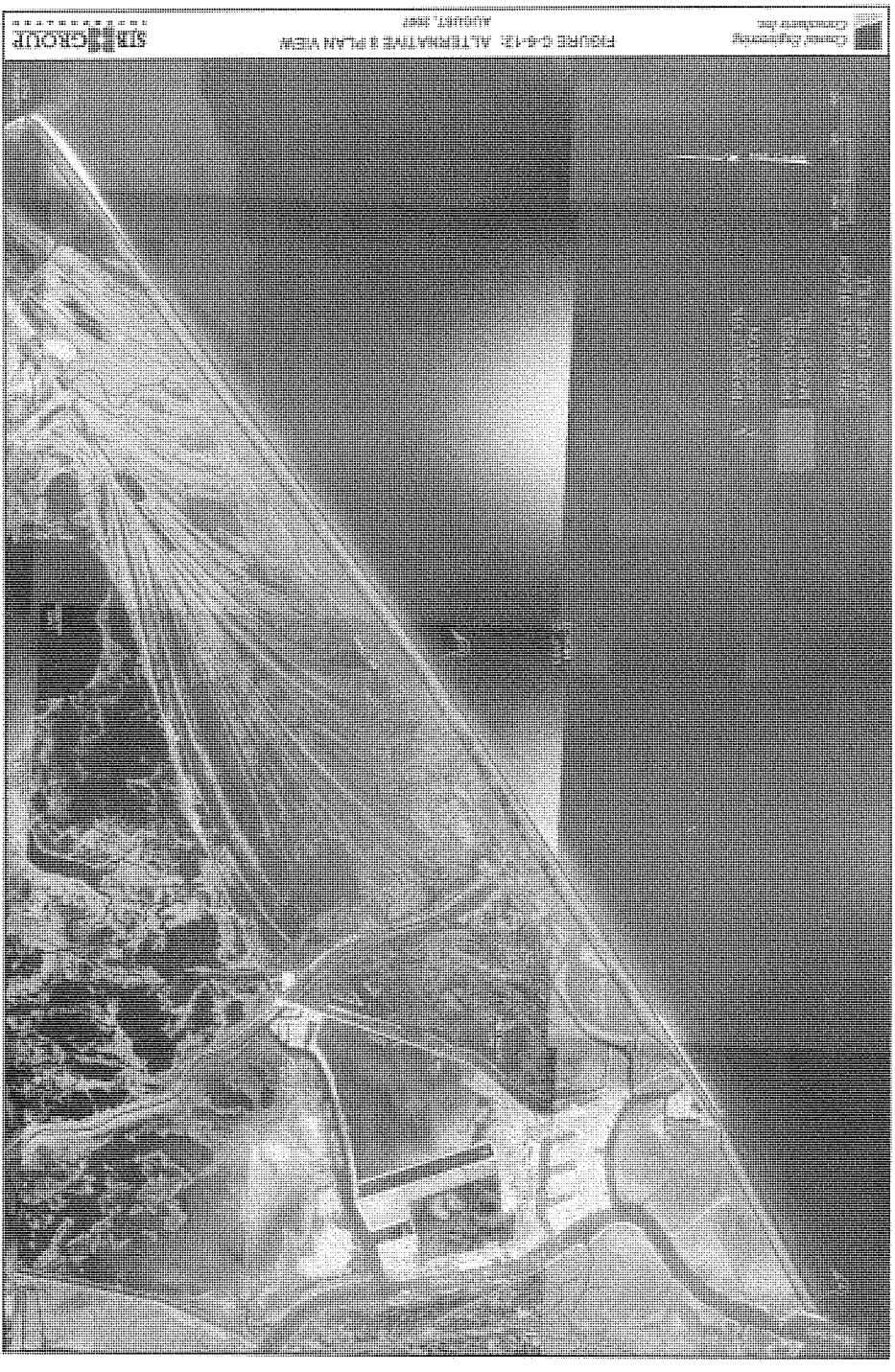
Alternative 8 includes a marsh fill template proposed on the landward side of the dune at an elevation of +2.0 feet NAVD with boundaries as described in section C-5-1-2-1. Initial fill quantities for the beach/dune and marsh fills are 5.1 million and 3.3 million cubic yards respectively. The beach and dune fill for alternative 8 does not include advanced fill for the design storm. Plan view and typical cross sections for Alternative 8 are shown in Figures C-6-12 and C-6-13, respectively.

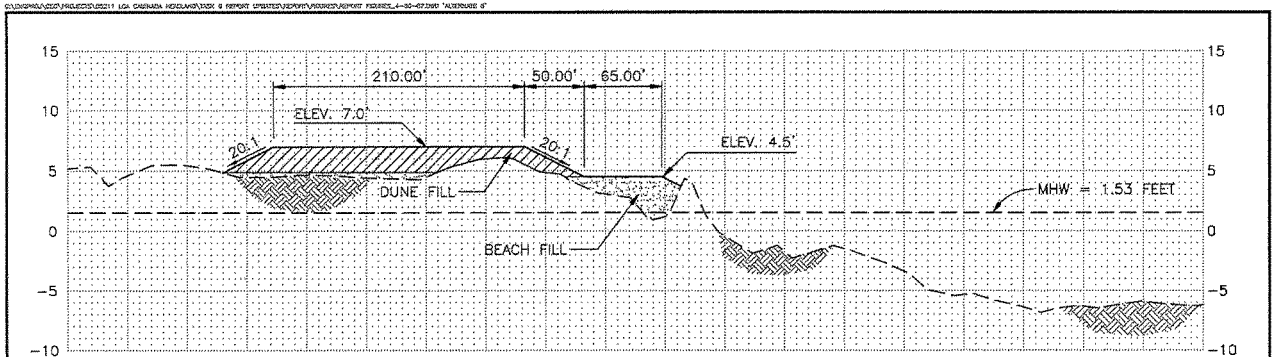
### C-6-2-6-2 Alternative 9 - Optimized Project with Expanded Marsh

The beach and dune fill template for Alternative 9 is identical to Alternative 8 with the addition of marsh fill extending west through Bay Champagne and to the eastern edge of the Project boundary near Caminada Pass. There is also additional marsh in an area to the west of the oil and gas facility on the western end of the Headland. Initial fill quantities for the beach/dune and marsh fills are 5.1 million and 5.4 million cubic yards, respectively. Plan view and typical cross sections for Alternative 9 are shown in Figures C-6-14 and C-6-15, respectively.

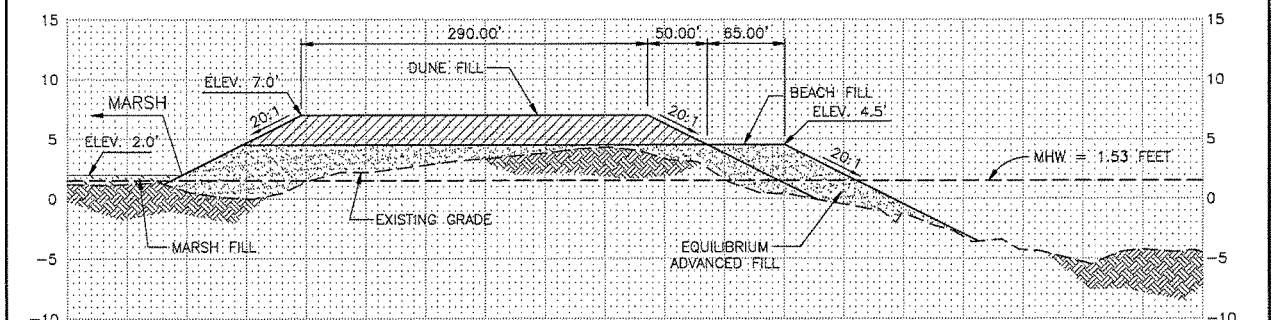
### C-6-2-6-3 Alternative 10 - Optimized Project with Advanced Storm Protection

The beach and dune fill template for Alternative 10 includes full storm protection with the addition of marsh fill extending west through Bay Champagne and to the eastern edge of the Project boundary near Caminada Pass. There is also additional marsh in an area to the west of the oil and gas facility on the western end of the Headland. Initial fill quantities for the beach/dune and marsh fills are 6.3 million and 5.4 million cubic yards, respectively. Plan view and typical cross sections for Alternative 10 are shown in Figures C-6-16 and C-6-17, respectively.






ALTERNATIVE 8
AT TRANSECT A




SCALES: HORIZONTAL: 1"=100'
VERTICAL: 1"=10'
ELEVATIONS ARE NAVD88 FEET

ALTERNATIVE 8
AT TRANSECT D

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**FIGURE C-6-13: ALTERNATIVE 8 CROSS SECTIONS**
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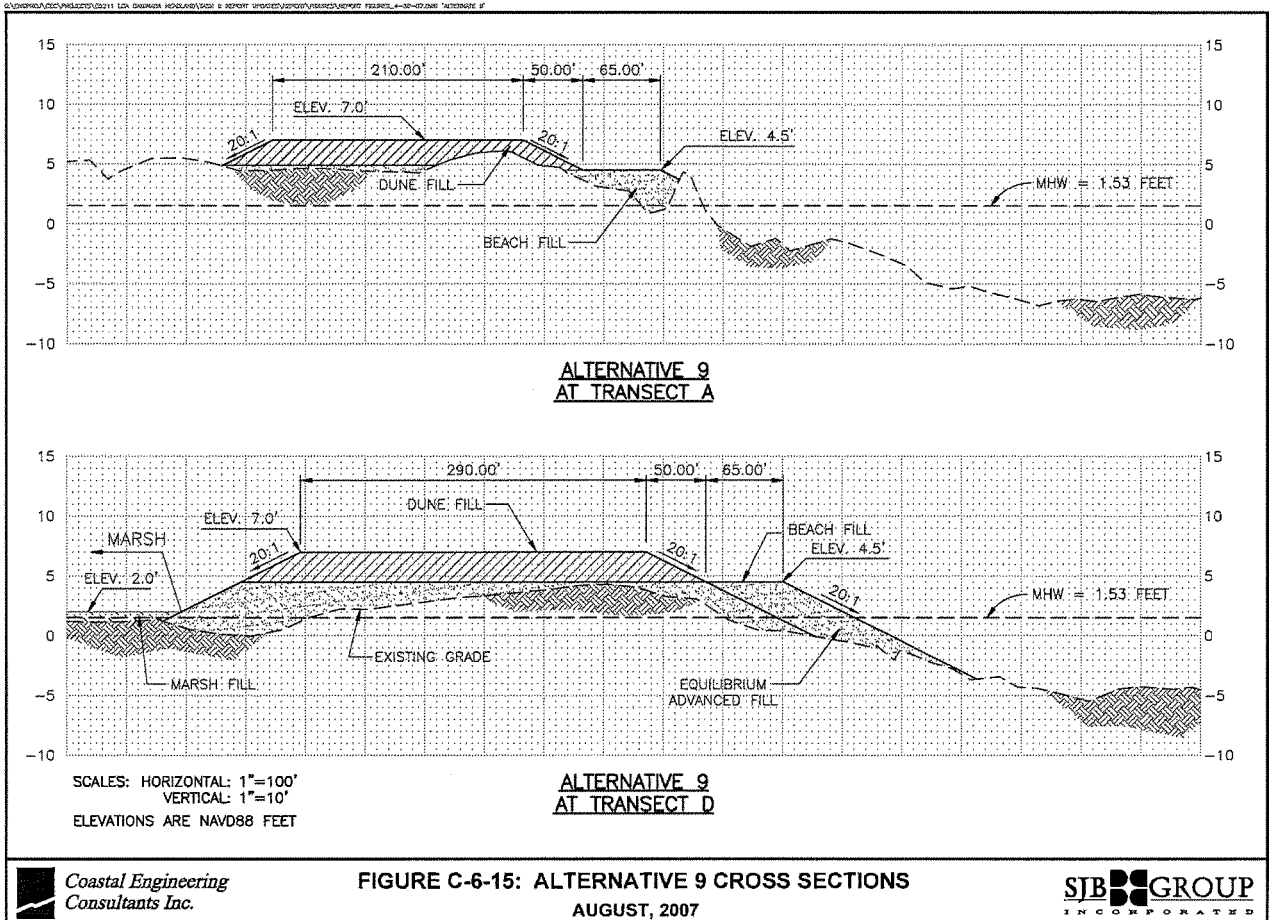


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**FIGURE C-6-15: ALTERNATIVE 9 CROSS SECTIONS**

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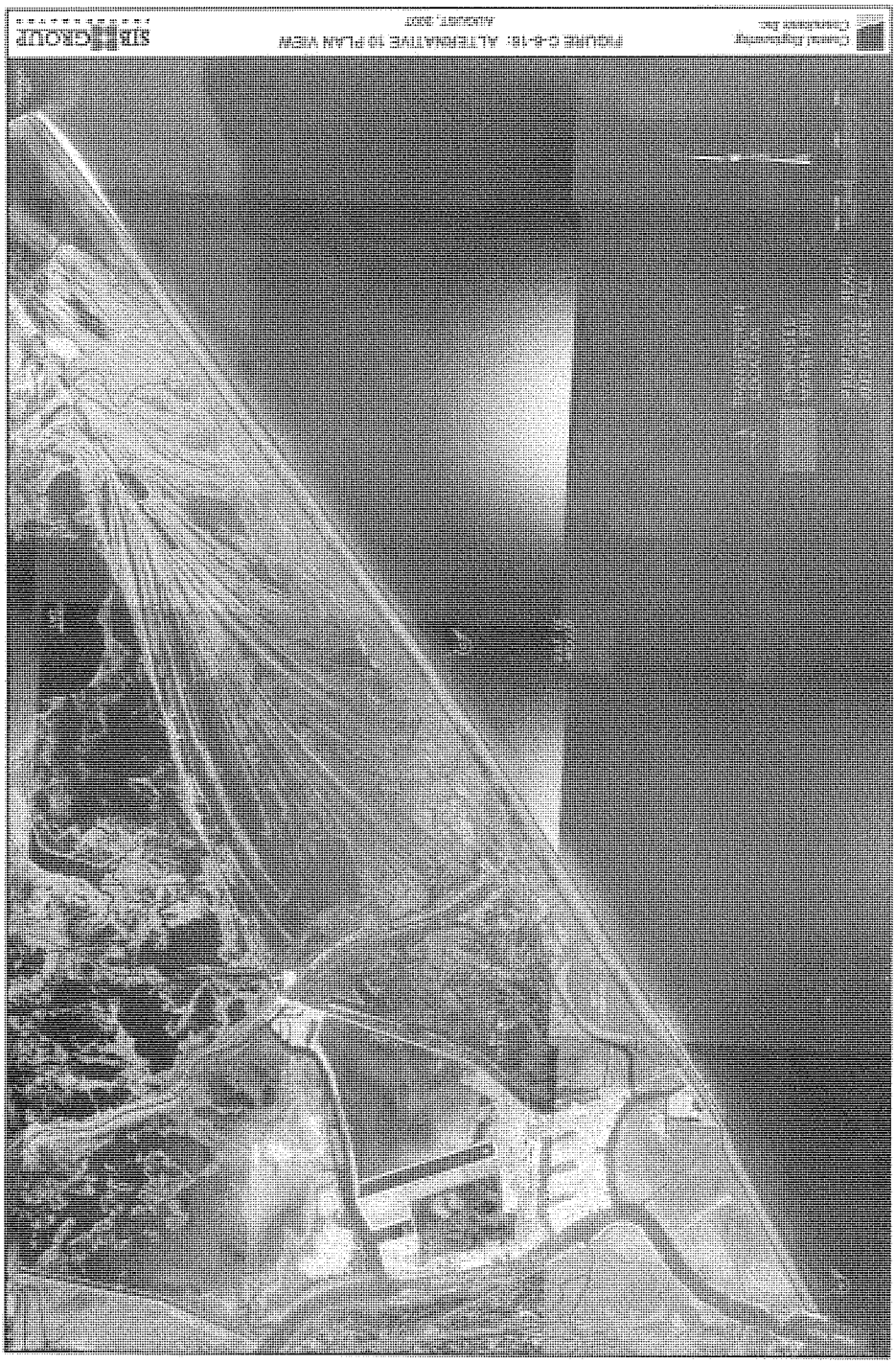

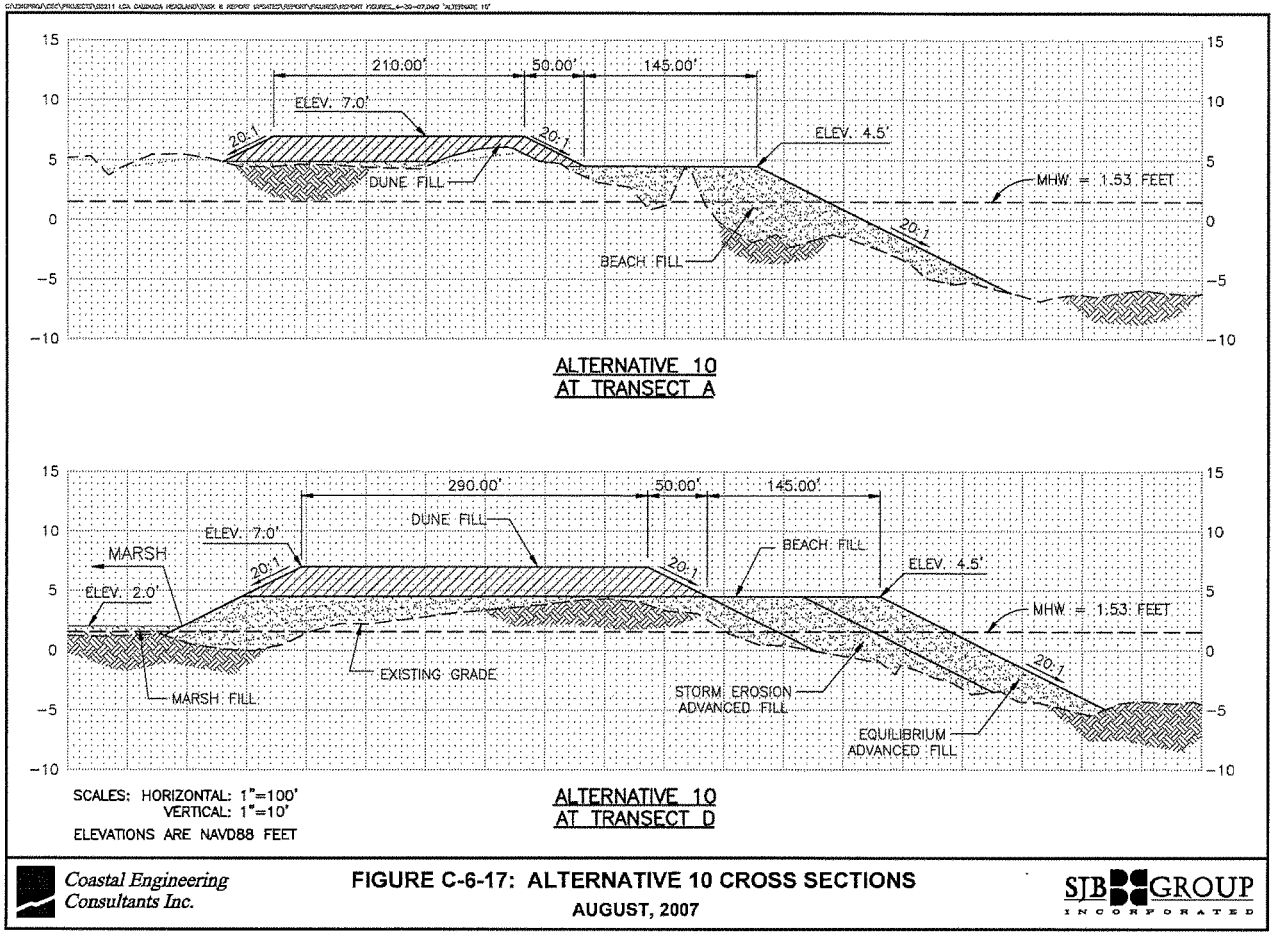


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**FIGURE C-6-17: ALTERNATIVE 10 CROSS SECTIONS**

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## C-6-2-7 Evaluation of Alternatives 8 Through 10

The alternatives were evaluated based on the following four constraints: technical, environmental, fiscal, and institutional constraints.

### C-6-2-7-1 Technical

The technical constraints considered when evaluating the alternatives were maintenance requirements, mitigation of erosion, and storm protection benefits. The beach and dune fill templates for Alternatives 8 and 9 do not contain any advanced fill for the design storm and are identical in terms of size. Alternative 10 meets all of the criteria for the design storm. The additional marsh provided by Alternatives 9 and 10 in Bay Champagne and Bay Caminada compared to Alternative 8 should provide additional stability to the Headland with a more consistent marsh platform to migrate northward on and for the dune to roll over on. Alternatives 8, 9, and 10 are renourished every 10 years (Table C-6-8).

**Table C-6-8. Renourishment Intervals**

| Alternative | Renourishment Intervals (years) |
|---|---|
| 8 | 10, 20, 30, 40 |
| 9 | 10, 20, 30, 40 |
| 10 | 10, 20, 30, 40 |

### C-6-2-7-2 Environmental

The alternatives were evaluated based on environmental enhancements and benefits. Table C-6-9 summarizes the habitat created by each alternative. Alternative 9 and 10 create approximately 44% more marsh habitat than Alternative 8. Alternatives 9 and 10 fill in Bay Champagne and Bay Caminada which may create adverse environmental impacts.

**Table C-6-9. Habitat Area Created**

| Alternative | Initial Beach/Dune Area | Initial Marsh Area | Total Initial Created Area | Total Area at 50 years | Weighted Average over 50 years |
|---|---|---|---|---|---|
| | (Acres) | (Acres) | (Acres) | (Acres) | (Acres) |
| 8 | 880 | 824 | 1704 | 1095 | 1393 |
| 9 | 880 | 1186 | 2066 | 1451 | 1753 |
| 10 | 980 | 1186 | 2166 | 1549 | 1859 |

### C-6-2-7-3 Fiscal

The fiscal constraints were evaluated based on cost to benefit acre ratio. Table C-6-10 summarizes the 50 year present value total costs presented in Chapter 9 for each alternative. The table also compares the cost to weighted average benefit ratios. Alternative 9 is more cost effective than Alternatives 8 and 10.

**Table C-6-10. Comparison of Costs (50 yr)**

| Alternative | 50 Year P.V. Cost ($ millions) | Cost to Weighted Average Benefit Ratio ($/Acre) |
|---|---|---|
| 8 | 434 | 312,000 |
| 9 | 454 | 259,000 |
| 10 | 535 | 288,000 |

### C-6-2-7-4 Institutional

Alternatives 9 and 10 may present more land rights issues as some stakeholders may be opposed to filling Bay Champagne and Bay Caminada with marsh sediments. Alternative 8 provides protection and does not fill in Bay Champagne and Bay Caminada therefore the stakeholders may not oppose this alternative.

## C-6-2-8 Evaluation of Alternatives 1 Through 10

Alternatives 1 through 4 (Dune and Marsh Alternatives), 5 through 7 (Preferred Dune Alternatives), and 8 through 10 (Optimized Alternatives) were evaluated within these subgroups based on the technical, environmental, fiscal, and institutional constraints. In this section, these subgroup evaluations will be used to compare all ten alternatives together and score them accordingly to arrive at alternative recommendations. The ten alternatives will be scored based on environmental benefit longevity, storm protection and Project costs.

### C-6-2-8-1 Environmental Benefits

Table C-6-12 summarizes the habitat created by each alternative.

**Table C-6-11. Habitat Area Created**

| Alternative | Initial Beach/Dune Area | Initial Marsh Area | Total Initial Created Area | Total Area at 50 years | Weighted Average over 50 years |
|---|---|---|---|---|---|
| | (Acres) | (Acres) | (Acres) | (Acres) | (Acres) |
| 1 | 0 | 1186 | 1186 | 26 | 351 |
| 2 | 879 | 936 | 1815 | 0 | 700 |
| 3 | 826 | 939 | 1765 | 0 | 680 |
| 4 | 955 | 667 | 1622 | 0 | 597 |
| 5 | 880 | 1186 | 2066 | 26 | 818 |
| 6 | 880 | 1186 | 2066 | 564 | 1279 |
| 7 | 880 | 1186 | 2066 | 1451 | 1461 |
| 8 | 880 | 824 | 1704 | 1095 | 1393 |
| 9 | 880 | 1186 | 2066 | 1451 | 1753 |
| 10 | 980 | 1186 | 2166 | 1549 | 1859 |

Figure C-6-18 presents a compilation of re-nourishment events and habitat acreages created and sustained over time for all ten alternatives. This figure also shows initial habitat acreage present at TY0 calculated for each alternative Project area as well as the average TY0 habitat acres of all ten alternatives. The goal for habitat creation was established as this TY 0 average for a balanced comparison of alternative performance.

Each alternative was scored for three environmental benefit categories: 1) % of time > TY0 habitat acreage, 2) weighted benefits, and 3) benefit acres remaining after 50 years. Each category was normalized to 1.0 for equal weighting. Category 1 was normalized by dividing each percentage by 100%. Categories 2 and 3 was normalized by dividing by the average TY0 acres (1220). All scores were capped at 1.0 as no credit was given for benefits initially created or sustained beyond the 50 year Project life above the TY 0 goal .

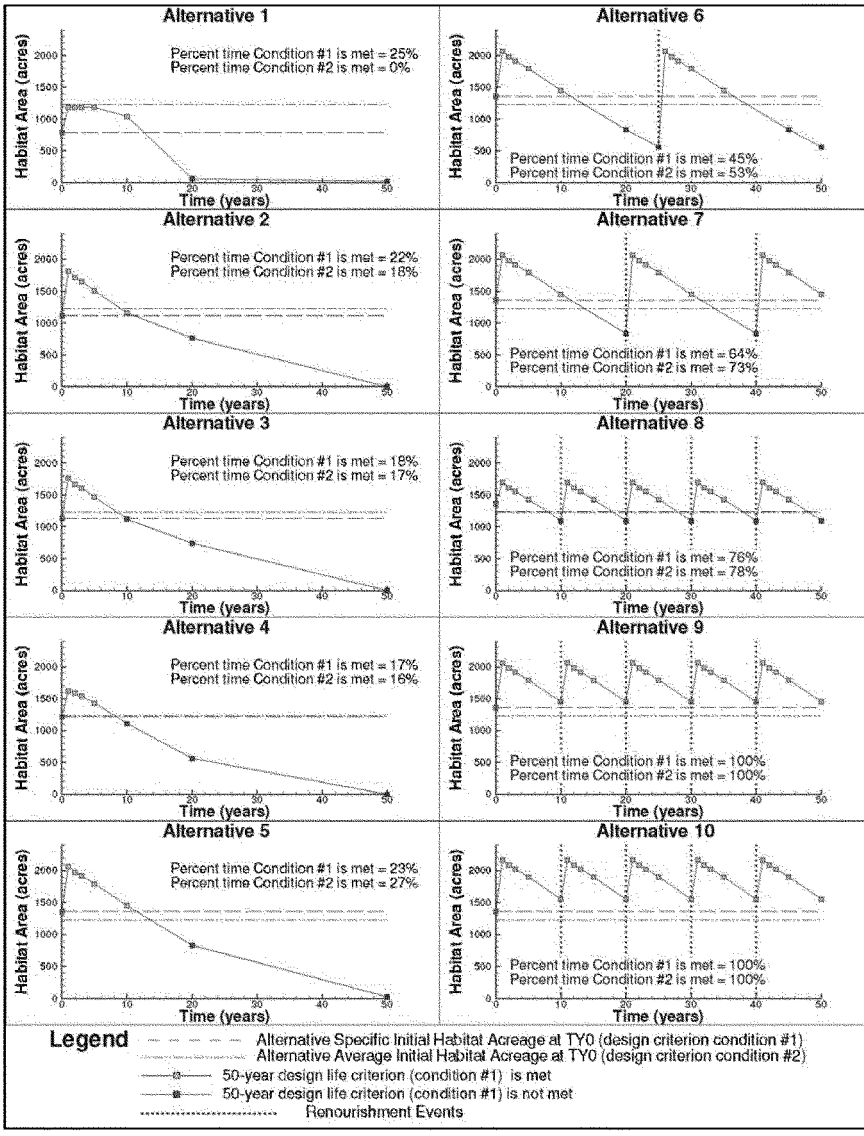


**Figure C-6-18. Habitat Acreage Graphs**

### C-6-2-8-2 Project Costs

The fiscal constraints were evaluated based on cost to benefit acre ratio. Alternatives 4, 8, and 3 were the three most expensive when comparing the cost to benefit ratios. Alternative 1 was the most economical alternative, which was expected as it proposed only the base marsh platform. Table C-6-12 summarizes the 50 year present value total costs presented in Chapter 9 for each alternative. The table also compares the cost to benefit ratios using the weighted average benefits. Table C-6-13 summarizes the estimated costs and benefits for each alternative. The cost estimates are presented in both with and without present value economic analyses. Using the values in Table C-6-13 cost vs. benefit, graphs were prepared and presented in Figures C-6-19 and C-6-20. The graphs are presented as X-Y scatter plots with linearly interpolated trend lines which can be used as decision making tools with respect to Project budget and performance.

**Table C-6-12. Comparison of Costs (50 yr)**

| Alternative | 50 Year P.V. Cost ($ millions) | Cost to Benefit ($/Acre) |
|---|---|---|
| 1 | 47 | 133,000 |
| 2 | 191 | 273,000 |
| 3 | 191 | 281,000 |
| 4 | 191 | 319,000 |
| 5 | 188 | 230,000 |
| 6 | 295 | 231,000 |
| 7 | 345 | 236,000 |
| 8 | 434 | 312,000 |
| 9 | 454 | 259,000 |
| 10 | 535 | 288,000 |

**Table C-6-13. Cost vs. Benefits**

| Alternative | 50 Year P.V. Cost ($ millions) | 50 Year Cost ($ millions) | Weighted Average Benefit (Acre) |
|---|---|---|---|
| 1 | 47 | 47 | 351 |
| 2 | 191 | 191 | 700 |
| 3 | 191 | 191 | 680 |
| 4 | 191 | 191 | 597 |
| 5 | 188 | 188 | 818 |
| 6 | 295 | 918 | 1,279 |
| 7 | 345 | 1,538 | 1,461 |
| 8 | 434 | 1,702 | 1,393 |
| 9 | 454 | 1,737 | 1,753 |
| 10 | 535 | 2,046 | 1,859 |

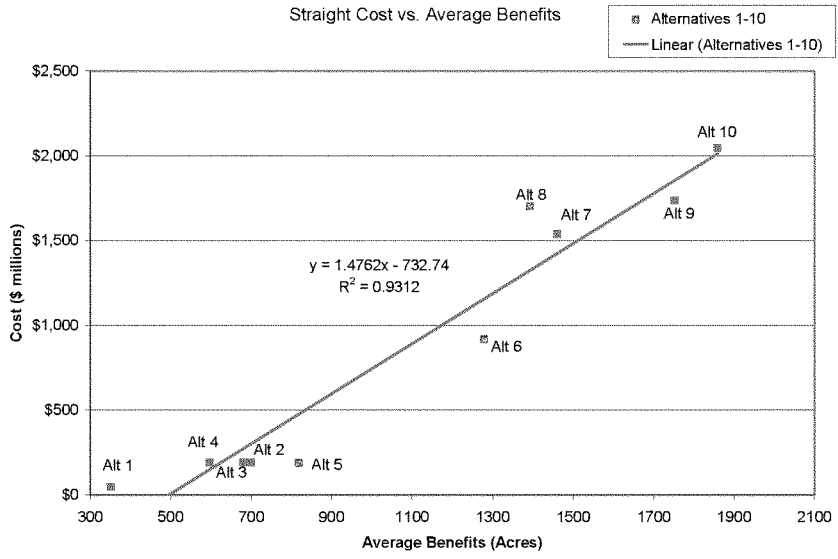


**Figure C-6-19. Straight Cost vs. Average Benefits**

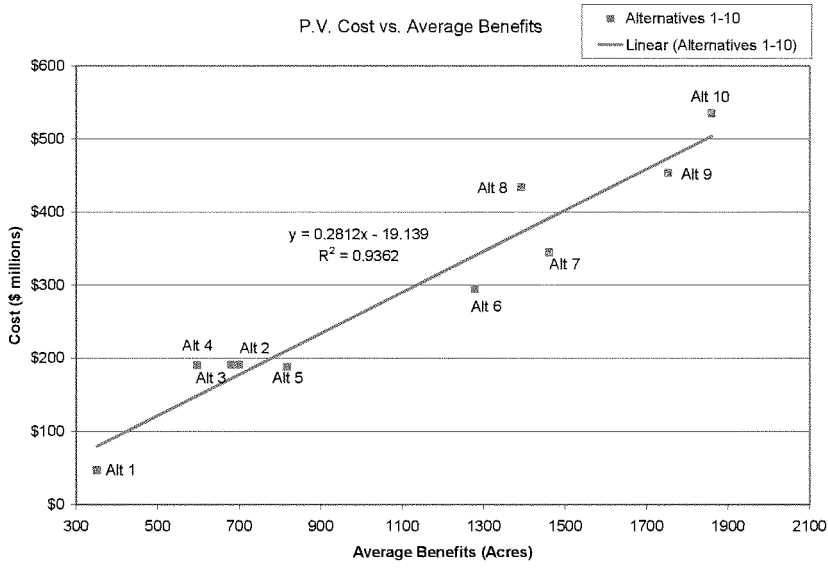


**Figure C-6-20. P.V. Cost vs. Average Benefits**

Each alternative was scored for two cost categories: 1) present value costs 2) cost to benefit ratios. Each category was normalized to 1.0 for equal weighting. Both Categories 1 and 2 were normalized by dividing the smallest cost by the cost of each alternative.

### C-6-2-8-3 Storm Protection

As determined in Annex C-3, storm modeling results yielded a predicted shoreline loss of approximately 80 feet for the design storm chosen. The infrastructure most susceptible to storm damages is the oil and gas facility at the eastern end of the island. Therefore, each alternative was scored based on the amount of time during the 50 year Project life that at least 80 feet of Headland is maintained between the facility and the gulf shoreline. This was determined by applying the background erosion rate of 45 feet per year to each alternative's fill template including re-nourishment events.

## C-6-2-9 Alternative Scoring Results

The scoring analysis presented in Table C-6-14 was performed using the methodologies set forth in Section C-6-2-8 with the highest scores indicating greater success in achieving the Project goals.

**Table C-6-14. Alternative Scoring Results**

| Alternative | Storm Protection | % of Time > TY0 Benefits | Benefit Acres at TY 50 | Weighted Benefits | Present Value Cost | Cost per Benefit | Totals |
|---|---|---|---|---|---|---|---|
| **1** | 0.23 | 0.00 | 0.02 | 0.29 | 1.00 | 1.00 | **2.54** |
| **2** | 0.35 | 0.18 | 0.00 | 0.57 | 0.25 | 0.49 | **1.84** |
| **3** | 0.26 | 0.17 | 0.00 | 0.56 | 0.25 | 0.47 | **1.71** |
| **4** | 0.25 | 0.16 | 0.00 | 0.49 | 0.25 | 0.42 | **1.56** |
| **5** | 0.25 | 0.27 | 0.02 | 0.67 | 0.25 | 0.58 | **2.04** |
| **6** | 0.38 | 0.53 | 0.46 | 1.00 | 0.16 | 0.58 | **3.11** |
| **7** | 0.58 | 0.73 | 1.00 | 1.00 | 0.14 | 0.56 | **4.01** |
| **8** | 1.00 | 0.78 | 0.90 | 1.00 | 0.11 | 0.43 | **4.21** |
| **9** | 1.00 | 1.00 | 1.00 | 1.00 | 0.10 | 0.51 | **4.62** |
| **10** | 1.00 | 1.00 | 1.00 | 1.00 | 0.09 | 0.46 | **4.55** |

Alternative 9 scored the highest of all the alternatives as it provides the optimal balance of storm protection for infrastructure, longevity of environmental benefits, and cost effectiveness. Alternative 10 scored high; however the increase in cost is not justified as Alternative 9 yields the same benefits at a lower cost. Alternative 8 scored well in terms of benefits but is one of the most expensive alternatives and is not justified compared to Alternative 9. Alternative 7 scored well as it offers a significant cost reduction compared to Alternative 9 while meeting environmental benefit criteria for the significant majority of the Project life, and maintaining storm protection for a majority of the Project life. The remainder of the alternatives vary in cost and levels of storm protection, however none of them achieve the desired environmental benefits.

# C-7 CONSTRUCTION PROCEDURES AND ACCESS

## C-7-1 GULF SHORELINE

The method of construction to be used by the contractor is not specified beforehand in the draft contract specifications. However, based on previous beach fill construction along the Gulf shoreline, it is anticipated that the contractor will use a hopper dredge system for excavation of material from the offshore borrow site. The material will then be pumped from the hopper discharge by an appropriate method to the beach through a submerged pipeline. Once on the beach the pipeline will run parallel to the shoreline close to the proposed dune line.

The material will then be worked on the beach by bulldozers and front-end loaders that are equipped with grapple arms to handle pipeline. Miscellaneous equipment to be stored on the beach may include a light tower, fuel tanks with containment, welding machine and temporary shanty for personnel.

Construction methods may vary but it is anticipated that fill placement along the beach will be controlled by advancing a temporary sand dike several hundred feet parallel to shore ahead of the discharge terminus. This aids in reducing initial fill losses offshore and helps control temporary turbidity that may result from the fill operation. In all cases water drainage and discharges will be directed offshore into the Gulf.

Also, it is expected that most of the work in conjunction with the beach fill construction will be done offshore or using waterfront access to the beach. The required grading equipment will be transported via local roads in accordance with State and local regulations including a traffic control plan. Exact access to the beach will be determined and coordinated during the plans and specifications phase and will include the necessary easements. However, the contractor will need to access the beach/dune and marsh areas with equipment such as graders, loaders, dozers, marsh buggy backhoes, etc. to shape beach and dune features and contain dredge materials. Two potential points of direct access include Highway 3090 on the western end of the Headland and a beach road at Elmer's Island on the eastern end.

## C-7-2 BACK-BARRIER MARSH

The method of construction to be used by the contractor is not specified beforehand in the draft contract specifications. However, based on previous marsh construction along the Gulf shoreline, it is anticipated that the contractor will use a hydraulic dredge with direct pump for excavation of material from the designated offshore borrow site. The back-barrier marsh component requires dredging and filling operations to place material for construction of a marsh platform. The dune will serve as the southern dike for the marsh fill, with a system of additional dikes to be

constructed around the remaining perimeter for containment of hydraulic fill with sediment suitable for the marsh system.

These operations will be done in a manner that will minimize turbidity of the water at each dredge site and at the discharge sites from the marsh fills. Discharge and dewatering from the fill sites shall be directed towards the Gulf. To achieve gulf-side discharge, the contractor will be required to orient discharge pipes such that the hydraulic flows move in a gulfward direction. They will also be required to locate any dewatering structures on the gulf side of the Project area. The contractor may employ other methods such as building the north side first, creating a drainage gradient towards the gulf. Regardless of the construction methods used, the contractor will be required by the contract specifications to dewater towards the gulf. No discharge will be allowed to the North of the Project area. If excess turbidity occurs, the contractor will be directed to change the operating procedure to reduce the degree of turbidity.

Also, the contractor will be required to provide a construction access plan for the back-barrier marsh component. The back-barrier marsh component of the Caminada Headland is bounded to the north by the BP Canal and to the south by the gulf shoreline. The marsh is relatively constant in elevation with the exception of areas altered by oil and gas canals and some open water areas characterized as tidal bayous, creeks and ponds. The contractor will be required to submit a construction access plan which should contain provisions for restoring any damaged habitats.

# C-8 ADAPTIVE MANAGEMENT PLAN (OPERATIONS AND MAINTENANCE)

The adaptive management plan is designed to sustain the Caminada Headland for the 50 year project life. The plan accounts for background erosion rates, equilibrium of beach fill after construction, and storm erosion. These factors were developed and quantified in Chapters C-3 Coastal Processes and C-6 Project Design. From these factors, beach and dune fill re-nourishment intervals were calculated for each alternative. Marsh fill re-nourishment intervals were determined to be every 20 years based on the settlement curves presented in Chapter C-4 Geotechnical. Other project features which require re-nourishment during the project life include sand fencing and vegetative plantings for both the dune and marsh features.

## C-8-1 RE-NOURISHMENT METHODOLOGY

Construction volumes were estimated for both "hold the line" and "moving template" re-nourishment scenarios which are illustrated in Figure C-8-1. For each re-nourishment interval, the original project was artificially eroded using documented coastal processes including historical erosion, overwash, and seafloor change rates. The "hold the line" templates were then overlaid onto the eroded profiles and re-nourishment volumes were calculated. Dune heights were then raised at each re-nourishment interval to compensate for relative sea level rise. These volumes are summarized in Table C-8-1. For the "moving template" scenario, re-nourishment cross sections were similar to initial construction. Therefore, initial construction volumes were used again at re-nourishment intervals. For this analysis, it was assumed that the "hold the line" method would be used for the re-nourishment intervals.

## C-8-2 ALTERNATIVES 1 Through 5 (No Re-nourishment)

Alternatives 1 through 5 do not have any re-nourishment intervals and do not sustain the Headland for 50 years. Therefore a 50 year adaptive management plan was not developed for these alternatives.

## C-8-3 ALTERNATIVES 6 Through 10 (Re-nourished)

The development of Alternative 6 through 10 builds upon Templates 1, 2, 3 and 4 analyses and comparisons which were presented in Chapter 5, Screening Design of Restoration Options. The design templates for these alternatives did not incorporate any additional volumes for beach fill equilibrium or storm events which would occur prior to re-nourishment events. Alternatives 6 through 9 include additional volumes for beach fill equilibrium but do not include advanced fill

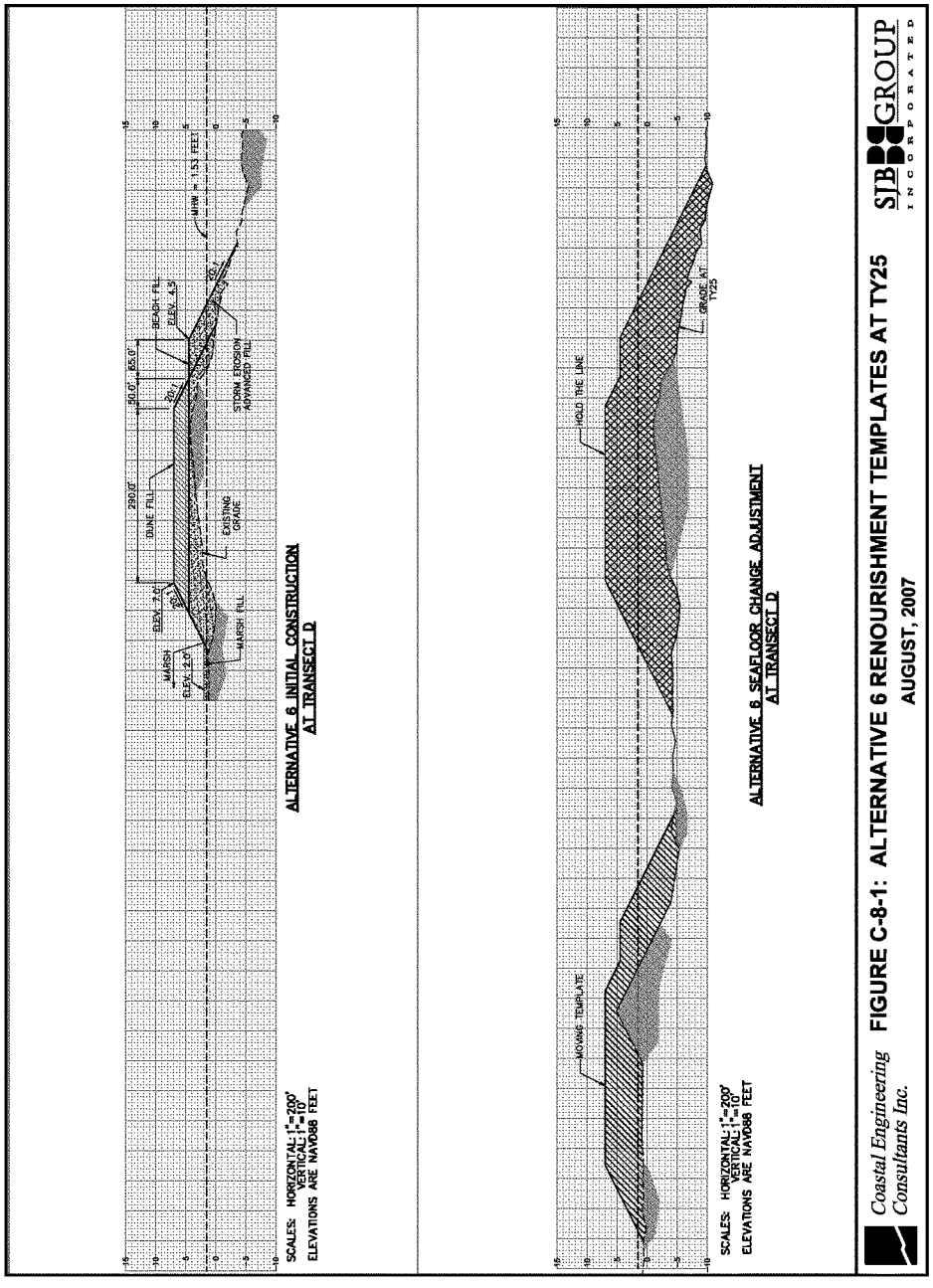


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**FIGURE C-8-1: ALTERNATIVE 6 RENOURISHMENT TEMPLATES AT TY25**

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## Table C-8-1. Renourishment Volumes

| Alternative | Initial Construction Beach Volume (million cy) | Renourishment Beach Volume (million cy) | Beach Renourishment Cycles (yrs) | Initial Construction Marsh Volume (million cy) | Renourishment Marsh Volume (million cy) | Marsh Renourishment Cycles (yrs) |
|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 5.4 | 0 | 0 |
| 2 | 5.7 | 0 | 0 | 3.8 | 0 | 0 |
| 3 | 5.7 | 0 | 0 | 3.8 | 0 | 0 |
| 4 | 6.1 | 0 | 0 | 2.6 | 0 | 0 |
| 5 | 5.1 | 0 | 0 | 5.4 | 0 | 0 |
| 6 | 5.1 | 13.5 | 25 | 5.4 | 5.72 | 25 |
| 7 | 5.1 | 11.9 | 20, 40 | 5.4 | 3.04 | 20, 40 |
| 8 | 5.1 | 7.37 | 10, 20, 30, 40 | 3.3 | 0.97 | 20, 40 |
| 9 | 5.1 | 7.37 | 10, 20, 30, 40 | 5.4 | 1.54 | 20, 40 |
| 10 | 6.3 | 8.92 | 10, 20, 30, 40 | 5.4 | 1.53 | 20, 40 |

**Volume Added for Sea Level Rise Compensation**

| 0.038 ft/yr | Relative Sea Level Rise | |
|---|---|---|
| | | |
| Renourishment Interval Year | Added Dune Height (ft) | Beach Volume Added (cy) |
| 10 | 0.38 | 280,153 |
| 20 | 0.76 | 560,306 |
| 25 | 0.95 | 700,382 |
| 30 | 1.14 | 840,459 |
| 40 | 1.52 | 1,120,612 |

for the design storm. Alternative 10 includes full storm protection in addition to advanced fill for equilibrium.

As presented in Section C-6-2-4, three methods were considered to determine shoreline equilibrium. It was determined that an average of 65 feet of shoreline retreat would occur from cross-shore transport during the equilibrium process. Additionally, storm modeling results yielded a predicted shoreline loss of approximately 80 feet for the design storm. Further details of this analysis are included in Annex C-3 Caminada Headland Supplemental Modeling Draft Report. Using these two criteria, storm and equilibrium volumes were estimated. Storm volumes were subtracted from the total volumes to arrive at a design fill volume.

Because Alternative 6 only includes one beach re-nourishment interval it is scheduled at year 25. Therefore the marsh re-nourishment was also scheduled at year 25 instead of year 20 to reduce mobilization costs. Alternative 7 includes two re-nourishment intervals scheduled for years 20 and 40. Re-nourishment intervals for Alternatives 8, 9, and 10 were determined as part of the design development in Section C-6-2-6. The optimum beach and dune re-nourishment interval for maintaining the Caminada Headland for the extent of the 50 year design life is 10 years.

## C-8-4 COST ESTIMATES

50 year adaptive management cost estimates are presented in Chapter 9 for Alternatives 6 through 10. The estimates included initial construction costs and costs for each year that re-nourishment is performed.

# C-9 COST ESTIMATES

## C-9-1 DEVELOPMENT OF UNIT PRICES

A review was conducted of the unit costs provided in the LCA Near-Term Critical Feature Assessment for the Caminada Headland. New unit costs are recommended based on past experience, current bid tabs, and consultation with national dredging companies. The unit costs take into account construction methods and equipment, transport distances, seasonal variations, technical constraints, construction access, and payment methods.

Following the development of the unit costs submitted in the October 2005 draft of the engineering feasibility report, significant price increases occurred due to various economic factors such as the 2005 hurricanes and rising fuel prices. To account for these price increases, a comparison was performed between the original unit price estimates and a recent bid tab received after the price increase took affect. For similar transport distances and project proximities, mobilization costs and fill prices increased 35% on average. Similarly, average fuel prices increased by 32% from July 2005 to June 2006. Therefore, mobilization costs and fill unit prices were increased by an escalation factor of 35%.

### C-9-1-1 Beach and Dune Fill

Historical bid information from recent Louisiana beach projects was reviewed. Dredge and fill unit prices for beach projects with offshore borrow areas in proximity to the fill site, i.e., less than 10 miles, ranged from $5 to $6 per cubic yard. These prices are based on fill in place payment. USACE (2004c) published dredging costs based on pipeline lengths. For a pumping distance of 12 miles, the reported unit price for dredge and fill was $3.30 per cubic yard. The proposed offshore borrow area at Ship Shoal - South Pelto Blocks 12 & 13 is located over 40 miles from the Project site. Extrapolating these unit costs to the transport distance equates to unit prices ranging from $12 to $24 per cubic yard. Even though the unit cost for transporting sand an unprecedented distance from Ship Shoal does not necessarily have a linear relationship to prices for shorter distances, this extrapolation does present a benchmark or reference range as a starting point. To further refine this reference range, three major national dredging companies were interviewed and asked to provide unit prices based on fill in place for transporting approximately 10 million cubic yards of sand, the estimated quantity based on LCA Study (USACE, 2004c), to the Project site from Ship Shoal - South Pelto Blocks 12 & 13 and constructing beach and dune features.

All of the contractors agreed that hopper dredges would be more economical than hydraulic dredges especially during adverse weather conditions. When weather permits a hydraulic dredge could be used, but dredged sand would be transported in scows rather than using pipelines and booster pumps. The sand would then be delivered to within a few miles of the fill area depending

on draft limitations of the scows. The sand would then either be pumped directly from the scows or dumped on the sea floor and hydraulically pumped to the fill area.

It is likely that a combination of dredge types may be used to efficiently construct the project. The industry may use several hoppers at the same time, with capacities ranging between 6000 and 8000 cubic yards per hopper. By using two or three, a production rate of 15,000 to 20,000 cubic yards per day could be achieved. During better weather months a large hydraulic cutterhead that will discharge thru a spider barge into several 5000 to 6000 cubic yard scows could be used. The production rate for this operation will run between 20,000 to 30,000 cubic yards per day.

At these production rates the project would take a multi-year construction effort. During winter fronts and rough seas, the contractor may seek refuge inside Belle Pass, which provides enough draft for the equipment needed. This could serve as a staging area and a possible pump out site that would have to be permitted.

One technical constraint that the Project faces is the availability of sufficient dredge plant and equipment to undertake such a significant Project, especially in light of the recent hurricane damages to the coastline experienced in 2004 and 2005. The major dredge companies are extremely busy restoring beach and dune projects from North Carolina to Florida and around the gulf coast to Texas including Louisiana.

Construction access could also affect mobilization costs and unit prices. The contractor will need to access the beach/dune and marsh areas with equipment such as graders, loaders, dozers, marsh buggy backhoes, etc. to shape beach and dune features and contain dredge materials. Two potential points of direct access include Highway 3090 on the western end of the Headland and a beach road at Elmer's Island on the eastern end.

Mobilization and per cubic yard unit costs take all of the factors discussed above into account. The unit costs are based on the historical bid data and contractor interviews, and increased to reflect the escalation factor stated above. The unit cost for beach and dune fill is $22.25 per cubic yard and the mobilization / demobilization cost is $4,000,000.

### C-9-1-2 Marsh Fill

The marsh fill unit cost of $6.95 per cubic yard was derived from the review of recent bid tabs mostly from CWPPRA marsh restoration projects. The price is based on fill in place payment, includes cost for containing hydraulically pumped compatible marsh sediments, and is increased to reflect the escalation factor stated above.

### C-9-1-3 Unit Costs: Cut vs. Fill

The cut to fill ratios for the marsh fill and the beach and dune fill estimated in Section C-4-3-3-5 are 1.6 and 1.13, respectively. To convert fill unit costs to the basis of borrow area cut payment,

the marsh fill and beach and dune fill unit costs were divided by the cut to fill ratios, resulting in cut unit costs of $4.34 and $19.69 per cubic yard for marsh fill and beach and dune fill, respectively:

Cut to fill for marsh = 1.6
$6.95 / 1.6 = $4.34 per cubic yard

Cut to fill for beach and dune = 1.13
$22.25 / 1.13 = $19.69 per cubic yard

## C-9-2 COST ESTIMATES OF EVALUATED ALTERNATIVES

Initial project cost estimates were developed for Alternatives 1 through 10 taking into account the unit prices developed in Section C-9-1. These estimates are presented in Tables C-9-1 through C-9-7. Unit costs for sand fencing and vegetative plantings were provided by LDNR.

## C-9-3 50-YEAR PROJECT COST ESTIMATE

For Alternatives 6 through 10, the initial project cost estimates were extended through the entire 50-year project life accounting for all nourishment intervals developed in Chapter 6. Straight costs for Alternatives 1 through 10 are shown in Tables C-9-8 and C-9-9. Also, a present value analysis was performed on each alternative using a prime interest rate of 8.0% and a linear inflation rate of 2.7%. The results are presented in Tables C-9-10 and C-9-11.

TABLE C-9-1
ALTERNATIVE 1 CONCEPTUAL COST ESTIMATE
LCA BARATARIA BARRIER SHORELINE RESTORATION FEASIBILITY STUDY - CAMINADA HEADLAND
CEC File No. 05211
June, 2007

| ITEM DESCRIPTION | UNIT | ESTIMATED QUANTITY | UNIT PRICE | TOTAL |
|---|---|---|---|---|
| CONSTRUCTION | | | | |
| 1. MOBILIZATION / DEMOBILIZATION | L.S. | 1 | $1,350,000 | $1,350,000 |
| 2. MARSH FILL | C.Y | 5,360,000 | $6.95 | $37,252,000 |
| 3. MARSH VEGETATION | EA. | 150,000 | $2.50 | $375,000 |
| | | | SUBTOTAL | $38,977,000 |
| | | | CONTINGENCIES | $7,795,400 |
| | | | GRAND TOTAL | $46,772,400 |

Note: Unit prices for marsh fill and beach and dune fil include excavation, transport and containment of materials based on fill in place.

**TABLE C-9-2**
**ALTERNATIVE 2 AND 3 CONCEPTUAL COST ESTIMATE**
**LCA BARATARIA BARRIER SHORELINE RESTORATION FEASIBILITY STUDY - CAMINADA HEADLAND**
**CEC File No. 05211**
**June, 2007**

| ITEM DESCRIPTION | UNIT | ESTIMATED QUANTITY | UNIT PRICE | TOTAL |
|---|---|---|---|---|
| CONSTRUCTION | | | | |
| 1. MOBILIZATION / DEMOBILIZATION | L.S. | 1 | $4,000,000 | $4,000,000 |
| 2. MARSH FILL | C.Y | 3,800,000 | $6.95 | $26,410,000 |
| 3. BEACH AND DUNE FILL | C.Y | 5,700,000 | $22.25 | $126,825,000 |
| 4. SAND FENCING | L.F. | 71,500 | $8.50 | $607,750 |
| 5. DUNE VEGETATION | EA. | 276,000 | $4.50 | $1,242,000 |
| 6. MARSH VEGETATION | EA. | 150,000 | $2.50 | $375,000 |
| | | | **SUBTOTAL** | **$159,459,750** |
| | | | **CONTINGENCIES** | **$31,891,950** |
| | | | **GRAND TOTAL** | **$191,351,700** |

Note: Unit prices for marsh fill and beach and dune fil include excavation, transport and containment of materials based on fill in place.

**TABLE C-9-3**
**ALTERNATIVE 4 CONCEPTUAL COST ESTIMATE**
**LCA BARATARIA BARRIER SHORELINE RESTORATION FEASIBILITY STUDY - CAMINADA HEADLAND**
**CEC File No. 05211**
**June, 2007**

| ITEM DESCRIPTION | UNIT | ESTIMATED QUANTITY | UNIT PRICE | TOTAL |
|---|---|---|---|---|
| CONSTRUCTION | | | | |
| 1. MOBILIZATION / DEMOBILIZATION | L.S. | 1 | $4,000,000 | $4,000,000 |
| 2. MARSH FILL | C.Y | 2,600,000 | $6.95 | $18,070,000 |
| 3. BEACH AND DUNE FILL | C.Y | 6,050,000 | $22.25 | $134,612,500 |
| 4. SAND FENCING | L.F. | 71,500 | $8.50 | $607,750 |
| 5. DUNE VEGETATION | EA. | 276,000 | $4.50 | $1,242,000 |
| 6. MARSH VEGETATION | EA. | 150,000 | $2.50 | $375,000 |
| | | | **SUBTOTAL** | **$158,907,250** |
| | | | **CONTINGENCIES** | **$31,781,450** |
| | | | **GRAND TOTAL** | **$190,688,700** |

Note: Unit prices for marsh fill and beach and dune fil include excavation, transport and containment of materials based on fill in place.

**TABLE C-9-4**
**ALTERNATIVES 5, 6, AND 7 CONCEPTUAL COST ESTIMATE (INITIAL CONSTRUCTION)**
**LCA BARATARIA BARRIER SHORELINE RESTORATION FEASIBILITY STUDY - CAMINADA HEADLAND**
**CEC File No. 05211**
**June, 2007**

| ITEM DESCRIPTION | UNIT | ESTIMATED QUANTITY | UNIT PRICE | TOTAL |
|---|---|---|---|---|
| CONSTRUCTION | | | | |
| 1. MOBILIZATION / DEMOBILIZATION | L.S. | 1 | $4,000,000 | $4,000,000 |
| 2. MARSH FILL | C.Y | 5,360,000 | $6.95 | $37,252,000 |
| 3. BEACH AND DUNE FILL | C.Y | 5,100,000 | $22.25 | $113,475,000 |
| 4. SAND FENCING | L.F. | 71,500 | $8.50 | $607,750 |
| 5. DUNE VEGETATION | EA. | 276,000 | $4.50 | $1,242,000 |
| 6. MARSH VEGETATION | EA. | 150,000 | $2.50 | $375,000 |
| | | | **SUBTOTAL** | **$156,951,750** |
| | | | **CONTINGENCIES** | **$31,390,350** |
| | | | **GRAND TOTAL** | **$188,342,100** |

Note: Unit prices for marsh fill and beach and dune fil include excavation, transport and containment of materials based on fill in place.

**TABLE C-9-5**
**ALTERNATIVE 8 CONCEPTUAL COST ESTIMATE (INITIAL CONSTRUCTION)**
**LCA BARATARIA BARRIER SHORELINE RESTORATION FEASIBILITY STUDY - CAMINADA HEADLAND**
**CEC File No. 05211**
**June, 2007**

| ITEM DESCRIPTION | UNIT | ESTIMATED QUANTITY | UNIT PRICE | TOTAL |
|---|---|---|---|---|
| CONSTRUCTION | | | | |
| 1. MOBILIZATION / DEMOBILIZATION | L.S. | 1 | $4,000,000 | $4,000,000 |
| 2. MARSH FILL | C.Y | 3,300,000 | $6.95 | $22,935,000 |
| 3. BEACH AND DUNE FILL | C.Y | 5,100,000 | $22.25 | $113,475,000 |
| 4. SAND FENCING | L.F. | 71,500 | $8.50 | $607,750 |
| 5. DUNE VEGETATION | EA. | 276,000 | $4.50 | $1,242,000 |
| 6. MARSH VEGETATION | EA. | 150,000 | $2.50 | $375,000 |
| | | | **SUBTOTAL** | **$142,634,750** |
| | | | **CONTINGENCIES** | **$28,526,950** |
| | | | **GRAND TOTAL** | **$171,161,700** |

Note: Unit prices for marsh fill and beach and dune fil include excavation, transport and containment of materials based on fill in place.

**TABLE C-9-6**
**ALTERNATIVE 9 CONCEPTUAL COST ESTIMATE (INITIAL CONSTRUCTION)**
**LCA BARATARIA BARRIER SHORELINE RESTORATION FEASIBILITY STUDY - CAMINADA HEADLAND**
**CEC File No. 05211**
**June, 2007**

| ITEM DESCRIPTION | UNIT | ESTIMATED QUANTITY | UNIT PRICE | TOTAL |
|---|---|---|---|---|
| CONSTRUCTION | | | | |
| 1. MOBILIZATION / DEMOBILIZATION | L.S. | 1 | $4,000,000 | $4,000,000 |
| 2. MARSH FILL | C.Y | 5,360,000 | $6.95 | $37,252,000 |
| 3. BEACH AND DUNE FILL | C.Y | 5,100,000 | $22.25 | $113,475,000 |
| 4. SAND FENCING | L.F. | 71,500 | $8.50 | $607,750 |
| 5. DUNE VEGETATION | EA. | 276,000 | $4.50 | $1,242,000 |
| 6. MARSH VEGETATION | EA. | 150,000 | $2.50 | $375,000 |
| | | | **SUBTOTAL** | **$156,951,750** |
| | | | **CONTINGENCIES** | **$31,390,350** |
| | | | **GRAND TOTAL** | **$188,342,100** |

Note: Unit prices for marsh fill and beach and dune fil include excavation, transport and containment of materials based on fill in place.

**TABLE C-9-7**
**ALTERNATIVE 10 CONCEPTUAL COST ESTIMATE (INITIAL CONSTRUCTION)**
**LCA BARATARIA BARRIER SHORELINE RESTORATION FEASIBILITY STUDY - CAMINADA HEADLAND**
**CEC File No. 05211**
**June, 2007**

| ITEM DESCRIPTION | UNIT | ESTIMATED QUANTITY | UNIT PRICE | TOTAL |
|---|---|---|---|---|
| CONSTRUCTION | | | | |
| 1. MOBILIZATION / DEMOBILIZATION | L.S. | 1 | $4,000,000 | $4,000,000 |
| 2. MARSH FILL | C.Y | 5,360,000 | $6.95 | $37,252,000 |
| 3. BEACH AND DUNE FILL | C.Y | 6,300,000 | $22.25 | $140,175,000 |
| 4. SAND FENCING | L.F. | 71,500 | $8.50 | $607,750 |
| 5. DUNE VEGETATION | EA. | 276,000 | $4.50 | $1,242,000 |
| 6. MARSH VEGETATION | EA. | 150,000 | $2.50 | $375,000 |
| | | | **SUBTOTAL** | **$183,651,750** |
| | | | **CONTINGENCIES** | **$36,730,350** |
| | | | **GRAND TOTAL** | **$220,382,100** |

Note: Unit prices for marsh fill and beach and dune fil include excavation, transport and containment of materials based on fill in place.

**TABLE C-9-8: STRAIGHT COSTS OF ALTERNATIVES 6 AND 7**
LCA BARATARIA BARRIER SHORELINE RESTORATION FEASIBILITY STUDY - CAMINADA HEADLAND
CEC FILE NO. 05.211
JUNE, 2007

| | | |
|---|---|---|
| Beach and Dune Mobilization | $ | 4,000,000 |
| Marsh Mobilization Only | $ | 1,350,000 |

Alternative 6
Construction and Maintenance at Year 25

| Year | 0 | 25 |
|---|---|---|
| Mobilization | $4,000,000 | $6,700,000 |
| Marsh Fill | $37,252,000 | $66,561,495 |
| Beach and Dune Fill | $113,475,000 | $530,794,701 |
| Sand Fencing | $607,750 | $1,017,981 |
| Dune Vegetation | $1,242,000 | $2,080,350 |
| Marsh Vegetation | $375,000 | $628,125 |
| Contingencies | $31,390,350 | $121,556,531 |
| Total | $188,342,100 | $729,339,183 |
| Total Project Cost | $917,681,283 | |

Alternative 7
Construction and Maintenance at 20 Year Intervals

| Year | 0 | 20 | 40 |
|---|---|---|---|
| Mobilization | $4,000,000 | $6,160,000 | $8,320,000 |
| Marsh Fill | $37,252,000 | $32,521,412 | $43,925,024 |
| Beach and Dune Fill | $113,475,000 | $425,360,802 | $600,444,254 |
| Sand Fencing | $607,750 | $935,935 | $1,264,120 |
| Dune Vegetation | $1,242,000 | $1,912,680 | $2,583,360 |
| Marsh Vegetation | $375,000 | $577,500 | $780,000 |
| Contingencies | $31,390,350 | $93,493,666 | $131,463,352 |
| Total | $188,342,100 | $560,961,995 | $788,780,109 |
| Total Project Cost | $1,538,084,204 | | |

**TABLE C-9-9: STRAIGHT COSTS OF ALTERNATIVE 8, 9, AND 10**
LCA BARATARIA BARRIER SHORELINE RESTORATION FEASIBILITY STUDY - CAMINADA HEADLAND
CEC FILE NO. 05.211
JUNE, 2007

| | |
|---|---|
| Beach and Dune Mobilization | $ 4,000,000 |
| Marsh Mobilization Only | $ 1,350,000 |

Alternative 8
Construction and Maintenance at 10 Year Intervals

| Year | 0 | 10 | 20 | 30 | 40 |
|---|---|---|---|---|---|
| Mobilization | $4,000,000 | $5,080,000 | $6,160,000 | $7,240,000 | $8,320,000 |
| Marsh Fill | $22,935,000 | | $10,401,229 | | $14,048,414 |
| Beach and Dune Fill | $113,475,000 | $216,067,773 | $271,602,884 | $330,504,033 | $392,771,219 |
| Sand Fencing | $607,750 | $771,843 | $935,935 | $1,100,028 | $1,264,120 |
| Dune Vegetation | $1,242,000 | $1,577,340 | $1,912,680 | $2,248,020 | $2,583,360 |
| Marsh Vegetation | $375,000 | | $577,500 | | $780,000 |
| Contingencies | $28,526,950 | $44,699,391 | $58,318,046 | $68,218,416 | $83,953,423 |
| Total | $171,161,700 | $268,196,347 | $349,908,274 | $409,310,496 | $503,720,536 |
| Total Project Cost | $1,702,297,352 | | | | |

Alternative 9
Construction and Maintenance at 10 Year Intervals

| Year | 0 | 10 | 20 | 30 | 40 |
|---|---|---|---|---|---|
| Mobilization | $4,000,000 | $5,080,000 | $6,160,000 | $7,240,000 | $8,320,000 |
| Marsh Fill | $37,252,000 | | $16,466,843 | | $22,240,930 |
| Beach and Dune Fill | $113,475,000 | $216,067,773 | $271,602,884 | $330,504,033 | $392,771,219 |
| Sand Fencing | $607,750 | $771,843 | $935,935 | $1,100,028 | $1,264,120 |
| Dune Vegetation | $1,242,000 | $1,577,340 | $1,912,680 | $2,248,020 | $2,583,360 |
| Marsh Vegetation | $375,000 | | $577,500 | | $780,000 |
| Contingencies | $31,390,350 | $44,699,391 | $59,531,168 | $68,218,416 | $85,591,926 |
| Total | $188,342,100 | $268,196,347 | $357,187,010 | $409,310,496 | $513,551,556 |
| Total Project Cost | $1,736,587,509 | | | | |

Alternative 10
Construction and Maintenance at 10 Year Intervals

| Year | 0 | 10 | 20 | 30 | 40 |
|---|---|---|---|---|---|
| Mobilization | $4,000,000 | $5,080,000 | $6,160,000 | $7,240,000 | $8,320,000 |
| Marsh Fill | $37,252,000 | | $16,425,706 | | $22,185,369 |
| Beach and Dune Fill | $140,175,000 | $259,904,913 | $324,759,732 | $392,980,588 | $464,567,482 |
| Sand Fencing | $607,750 | $771,843 | $935,935 | $1,100,028 | $1,264,120 |
| Dune Vegetation | $1,242,000 | $1,577,340 | $1,912,680 | $2,248,020 | $2,583,360 |
| Marsh Vegetation | $375,000 | | $577,500 | | $780,000 |
| Contingencies | $36,730,350 | $53,466,819 | $70,154,311 | $80,713,727 | $99,940,066 |
| Total | $220,382,100 | $320,800,915 | $420,925,864 | $484,282,363 | $599,640,398 |
| Total Project Cost | $2,046,031,640 | | | | |

**TABLE C-9-10: 50-YEAR ECONOMIC ANALYSIS OF ALTERNATIVES 6 AND 7**
**LCA BARATARIA BARRIER SHORELINE RESTORATION FEASIBILITY STUDY - CAMINADA HEADLAND**
**CEC FILE NO. 05.211**
**JUNE, 2007**

Present Value Factor Data

| | |
|---|---|
| Prime Interest Rate | 6.00% |
| Periods Per Year | 1 |
| Base Rate | 1.060 |
| Rate of Annual Cost Increase | 2.70% |

| | |
|---|---|
| Beach and Dune Mobilization | $ 4,000,000 |
| Marsh Mobilization Only | $ 1,350,000 |

Alternative 6
Construction and Maintenance at Year 25

| Year | 0 | 25 |
|---|---|---|
| Mobilization | $4,000,000 | $6,700,000 |
| Marsh Fill | $37,252,000 | $66,561,495 |
| Beach and Dune Fill | $113,475,000 | $530,794,701 |
| Sand Fencing | $607,750 | $1,017,981 |
| Dune Vegetation | $1,242,000 | $2,080,350 |
| Marsh Vegetation | $375,000 | $628,125 |
| Contingencies | $31,390,350 | $121,556,531 |
| Total | $188,342,100 | $729,339,183 |
| P.V. Factor | 1.00000 | 0.14600 |
| P.V. of Annual Cost | $188,342,100 | $106,483,521 |
| Present Value | $294,825,621 | |

Alternative 7
Construction and Maintenance at 20 Year Intervals

| Year | 0 | 20 | 40 |
|---|---|---|---|
| Mobilization | $4,000,000 | $6,160,000 | $8,320,000 |
| Marsh Fill | $37,252,000 | $32,521,412 | $43,925,024 |
| Beach and Dune Fill | $113,475,000 | $425,360,802 | $600,444,254 |
| Sand Fencing | $607,750 | $935,935 | $1,264,120 |
| Dune Vegetation | $1,242,000 | $1,912,680 | $2,583,360 |
| Marsh Vegetation | $375,000 | $577,500 | $780,000 |
| Contingencies | $31,390,350 | $93,493,666 | $131,463,352 |
| Total | $188,342,100 | $560,961,995 | $788,780,109 |
| P.V. Factor | 1.00000 | 0.21450 | 0.04600 |
| P.V. of Annual Cost | $188,342,100 | $120,326,348 | $36,283,885 |
| Present Value | $344,952,333 | | |

**TABLE C-9-11: 50-YEAR ECONOMIC ANALYSIS OF ALTERNATIVES 8, 9, AND 10**
**LCA BARATARIA BARRIER SHORELINE RESTORATION FEASIBILITY STUDY - CAMINADA HEADLAND**
**CEC FILE NO. 05.211**
**JUNE, 2007**

Present Value Factor Data

| | | | |
|---|---|---|---|
| Prime Interest Rate | 8.00% | Beach and Dune Mobilization $ | 4,000,000 |
| Periods Per Year | 1 | Marsh Mobilization Only $ | 1,350,000 |
| Base Rate | 1.080 | | |
| Rate of Annual Cost Increase | 2.70% | | |

Alternative 8
Construction and Maintenance at 10 Year Intervals

| Year | 0 | 10 | 20 | 30 | 40 |
|---|---|---|---|---|---|
| Mobilization | $4,000,000 | $5,080,000 | $6,160,000 | $7,240,000 | $8,320,000 |
| Marsh Fill | $22,935,000 | | $10,401,229 | | $14,048,414 |
| Beach and Dune Fill | $113,475,000 | $216,067,773 | $271,602,884 | $330,504,033 | $392,771,219 |
| Sand Fencing | $607,750 | $771,843 | $935,935 | $1,100,028 | $1,264,120 |
| Dune Vegetation | $1,242,000 | $1,577,340 | $1,912,680 | $2,248,020 | $2,583,360 |
| Marsh Vegetation | $375,000 | | $577,500 | | $780,000 |
| Contingencies | $28,526,950 | $44,699,391 | $58,318,046 | $68,218,416 | $83,953,423 |
| Total | $171,161,700 | $268,196,347 | $349,908,274 | $409,310,496 | $503,720,536 |
| P.V. Factor | 1.00000 | 0.46320 | 0.21450 | 0.09940 | 0.04600 |
| P.V. of Annual Cost | $171,161,700 | $124,228,548 | $75,055,325 | $40,685,463 | $23,171,145 |
| Present Value | $434,302,181 | | | | |

Alternative 9
Construction and Maintenance at 10 Year Intervals

| Year | 0 | 10 | 20 | 30 | 40 |
|---|---|---|---|---|---|
| Mobilization | $4,000,000 | $5,080,000 | $6,160,000 | $7,240,000 | $8,320,000 |
| Marsh Fill | $37,252,000 | | $16,466,843 | | $22,240,930 |
| Beach and Dune Fill | $113,475,000 | $216,067,773 | $271,602,884 | $330,504,033 | $392,771,219 |
| Sand Fencing | $607,750 | $771,843 | $935,935 | $1,100,028 | $1,264,120 |
| Dune Vegetation | $1,242,000 | $1,577,340 | $1,912,680 | $2,248,020 | $2,583,360 |
| Marsh Vegetation | $375,000 | | $577,500 | | $780,000 |
| Contingencies | $31,390,350 | $44,699,391 | $59,531,168 | $68,218,416 | $85,591,926 |
| Total | $188,342,100 | $268,196,347 | $357,187,010 | $409,310,496 | $513,551,556 |
| P.V. Factor | 1.00000 | 0.46320 | 0.21450 | 0.09940 | 0.04600 |
| P.V. of Annual Cost | $188,342,100 | $124,228,548 | $76,616,614 | $40,685,463 | $23,623,372 |
| Present Value | $453,496,096 | | | | |

Alternative 10
Construction and Maintenance at 10 Year Intervals

| Year | 0 | 10 | 20 | 30 | 40 |
|---|---|---|---|---|---|
| Mobilization | $4,000,000 | $5,080,000 | $6,160,000 | $7,240,000 | $8,320,000 |
| Marsh Fill | $37,252,000 | | $16,425,706 | | $22,185,369 |
| Beach and Dune Fill | $140,175,000 | $259,904,913 | $324,759,732 | $392,980,588 | $464,567,482 |
| Sand Fencing | $607,750 | $771,843 | $935,935 | $1,100,028 | $1,264,120 |
| Dune Vegetation | $1,242,000 | $1,577,340 | $1,912,680 | $2,248,020 | $2,583,360 |
| Marsh Vegetation | $375,000 | | $577,500 | | $780,000 |
| Contingencies | $36,730,350 | $53,466,819 | $70,154,311 | $80,713,727 | $99,940,066 |
| Total | $220,382,100 | $320,800,915 | $420,925,864 | $484,282,363 | $599,640,398 |
| P.V. Factor | 1.00000 | 0.46320 | 0.21450 | 0.09940 | 0.04600 |
| P.V. of Annual Cost | $220,382,100 | $148,594,984 | $90,288,598 | $48,137,667 | $27,583,458 |
| Present Value | $534,986,807 | | | | |

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# ANNEX C1
# SURVEYING AND MAPPING

PLANS OF PROPOSED

# CAMINADA HEADLAND SURVEY

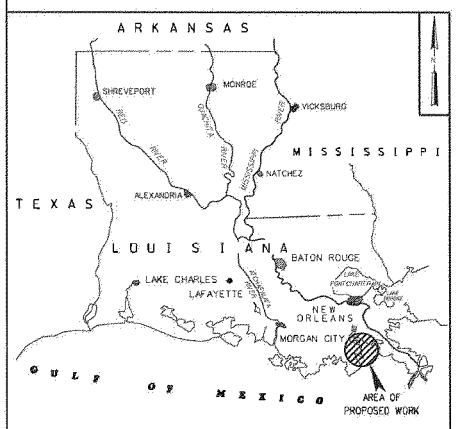
## BARATARIA BASIN BARRIER ISLAND SHORELINE RESTORATION

ENGINEERING DESIGN CONTRACT NO. 2503-05-32

LAFOURCHE / JEFFERSON PARISH, LOUISIANA

***INDEX***

| *SHEET NO.* | *DESCRIPTION* |
|---|---|
| 001 | TITLE SHEET & VICINITY MAP |
| 002 | PROJECT BASE MAP |
| 003-005 | TRANSECTS |




VICINITY MAP

LOUISIANA DEPARTMENT OF NATURAL RESOURCES

***COASTAL ENGINEERING DIVISION***

*JULY 2005*

STATE OF LOUISIANA
KEITH J. ROBERTS
REG. No. 4730
REGISTERED PROFESSIONAL ENGINEER

RECOMMENDED FOR APPROVAL: _____ DATE 7/19/05
C.H. FENSTERMAKER & ASSOCIATES
CIVIL ENGINEERS / ENVIRONMENTAL CONSULTANTS / LAND SURVEYORS

RECOMMENDED FOR APPROVAL: _____ DATE _____
LOUISIANA DEPARTMENT OF NATURAL RESOURCES
COASTAL ENGINEERING DIVISION

C.H. Fenstermaker & Associates, Inc.
Civil Engineers Environmental Consultants Land Surveyors
135 Regency Square
Lafayette, Louisiana
(337) 237-2200

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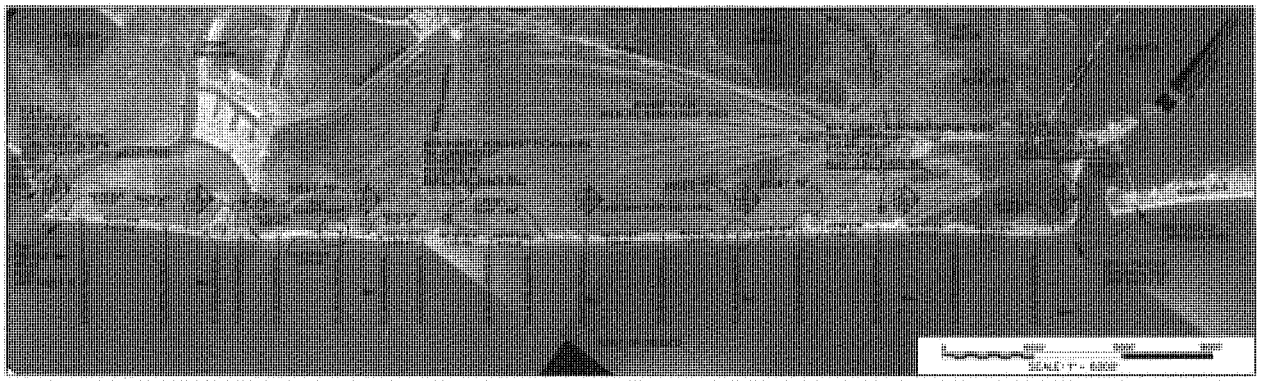


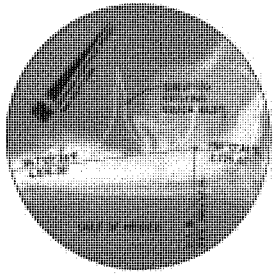

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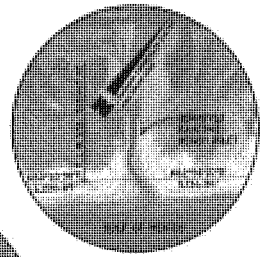

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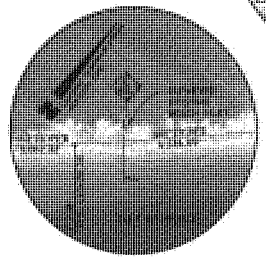

INSET "C"
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NOTES:

1) SURVEY CREWS FROM C.H. FENSTERMAKER WERE DEPLOYED ON JUNE 27, 2005 TO COLLECT BATHYMETRIC DATA AT EACH OF THE CORRESPONDING TRANSECT GEOGRAPHIC LOCATIONS.
2) ALL SURVEY DATA WAS BASED FROM TWO SECONDARY SURVEY MONUMENTS IDENTIFIED AS "BA_CAMINADA01" AND "BA_CAMINADA02". EACH OF THESE TWO MONUMENTS WAS SET BY C.H. FENSTERMAKER & ASSOCIATES ON JUNE 22, 2005 AND JUNE 25, 2005.
3) ALL SURVEY DATA HAS BEEN PROJECTED TO STATE PLANE LOUISIANA SOUTH ZONE N.A.D. 83 COORDINATES, WITH ELEVATIONS ADJUSTED TO N.A.V.D. 88. (U.S. SURVEY FT.)
4) ALL SURVEY BASELINE POINTS OF INFLECTION (P.I.) HAVE BEEN MARKED IN THE FIELD WITH A ¾" IRON PIPE, 1"X1"X4' WOOD STAKES, RED FLAGGING, AND REFLECTIVE TAPE.
5) LOCATIONS WHERE SURVEY TRANSECTS INTERSECT THE SURVEY BASELINE ARE MARKED IN THE FIELD BY 5/8" IRON RODS WITH YELLOW FLAGGING.

STATE OF LOUISIANA
KEITH J. ROBERTS
REG. No. 4780
REGISTERED PROFESSIONAL
7/19/05
KEITH J. ROBERTS, P.L.S. DATE

BARATARIA BASIN
BARRIER ISLAND
SHORELINE RESTORATION
PROJECT BASE MAP

COASTAL ENGINEERING DIVISION

C.H. Fenstermaker & Associates, Inc.

| | |
|---|---|
| SHEET NUMBER | 002 |
| PARISH | LAFOURCHE / JEFFERSON |
| PROJECT | CAMINADA HEADLAND SURVEY |
| DESIGNED / CHECKED / DRAWN / SCALED / DATE | E. BOLT / R.J.P. / C.H. / E. BOLT / 07/19/05 |
| JOB NO. | 2045326.07 |

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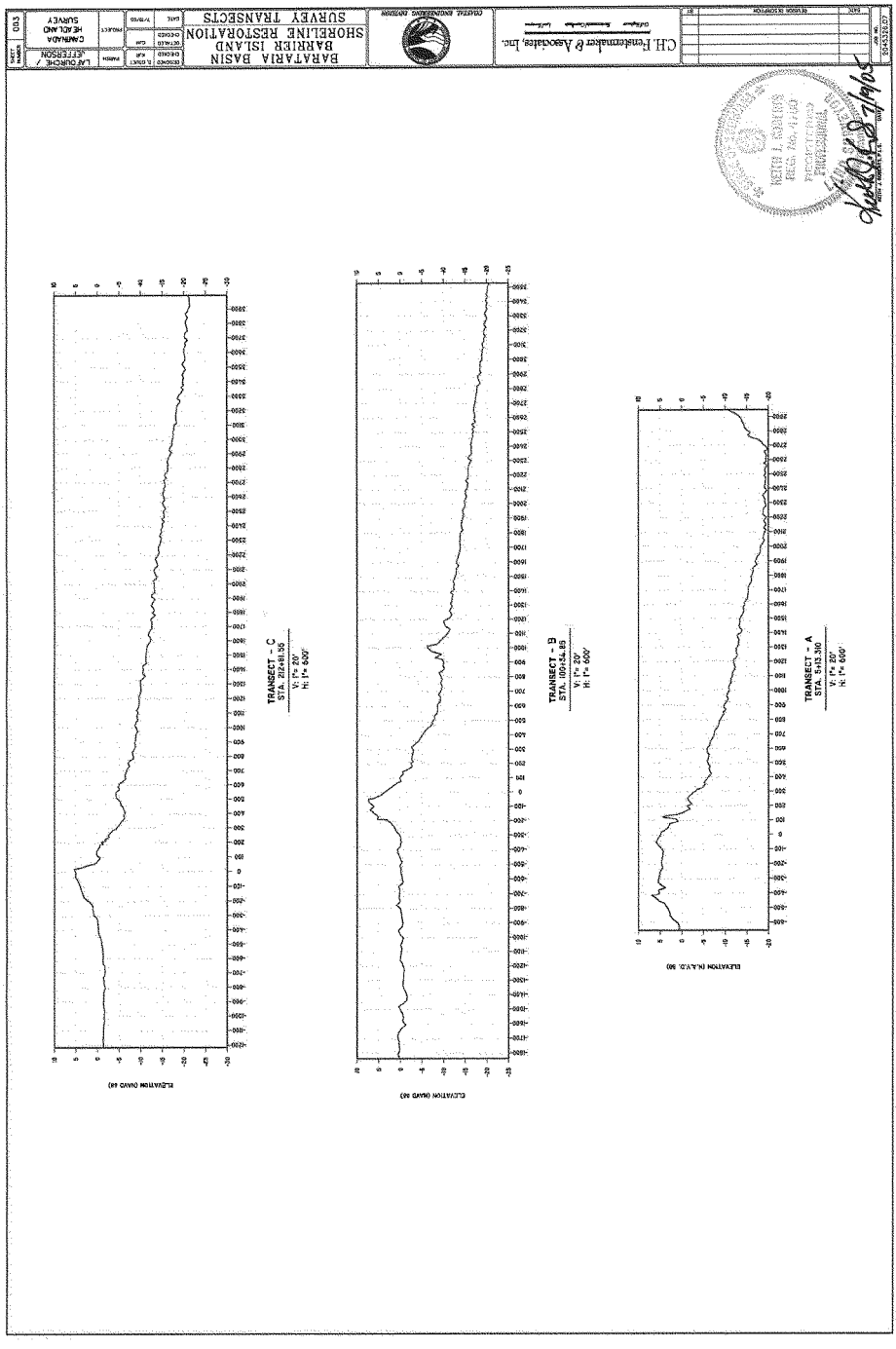
BARTARIA BASIN
BARRIER ISLAND
SHORELINE RESTORATION
SURVEY TRANSECTS
C.H. Fenstermaker & Associates, Inc.
TRANSECT - C
STA. 22+81.55
V: 1"= 20'
H: 1"= 600'
TRANSECT - B
STA. 109+34.48
V: 1"= 20'
H: 1"= 600'
TRANSECT - A
STA. 5+13.300
V: 1"= 20'
H: 1"= 600'
ELEVATION (N.A.V.D. 88)
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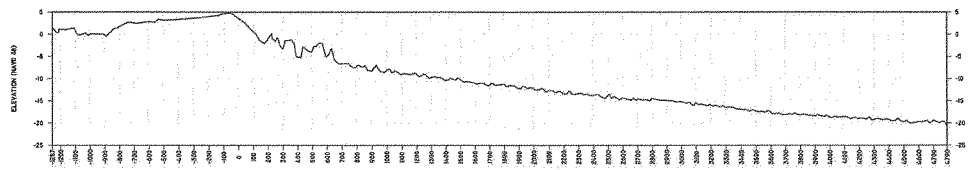


TRANSECT - F
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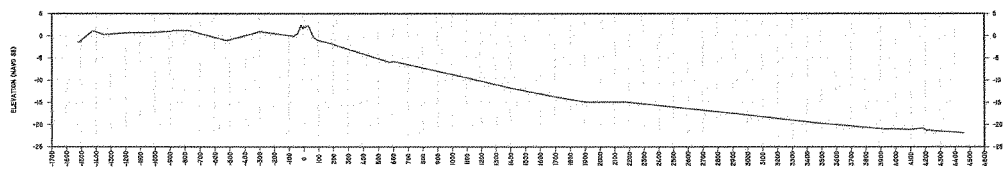
H: 1"= 600'




TRANSECT - E
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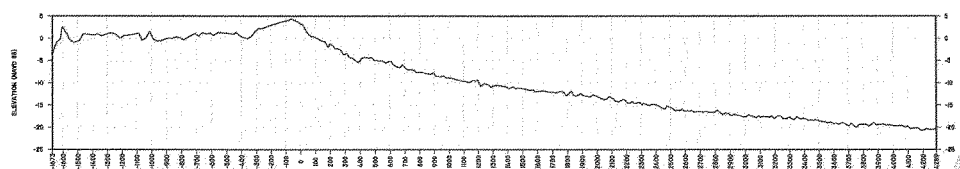
H: 1"= 600'




TRANSECT - D
STA. 361+26.39
V: 1"= 20'
H: 1"= 600'

KEITH J. ROBERTS
REG. No. 4780
REGISTERED PROFESSIONAL ENGINEER
7/19/05

BARATARIA BASIN
BARRIER ISLAND
SHORELINE RESTORATION
SURVEY TRANSECTS

C.H. Fenstermaker & Associates, Inc.

LAFOURCHE / JEFFERSON
CAMINADA HEADLAND SURVEY

SHEET NUMBER 004

JOB NO. 2045326.07

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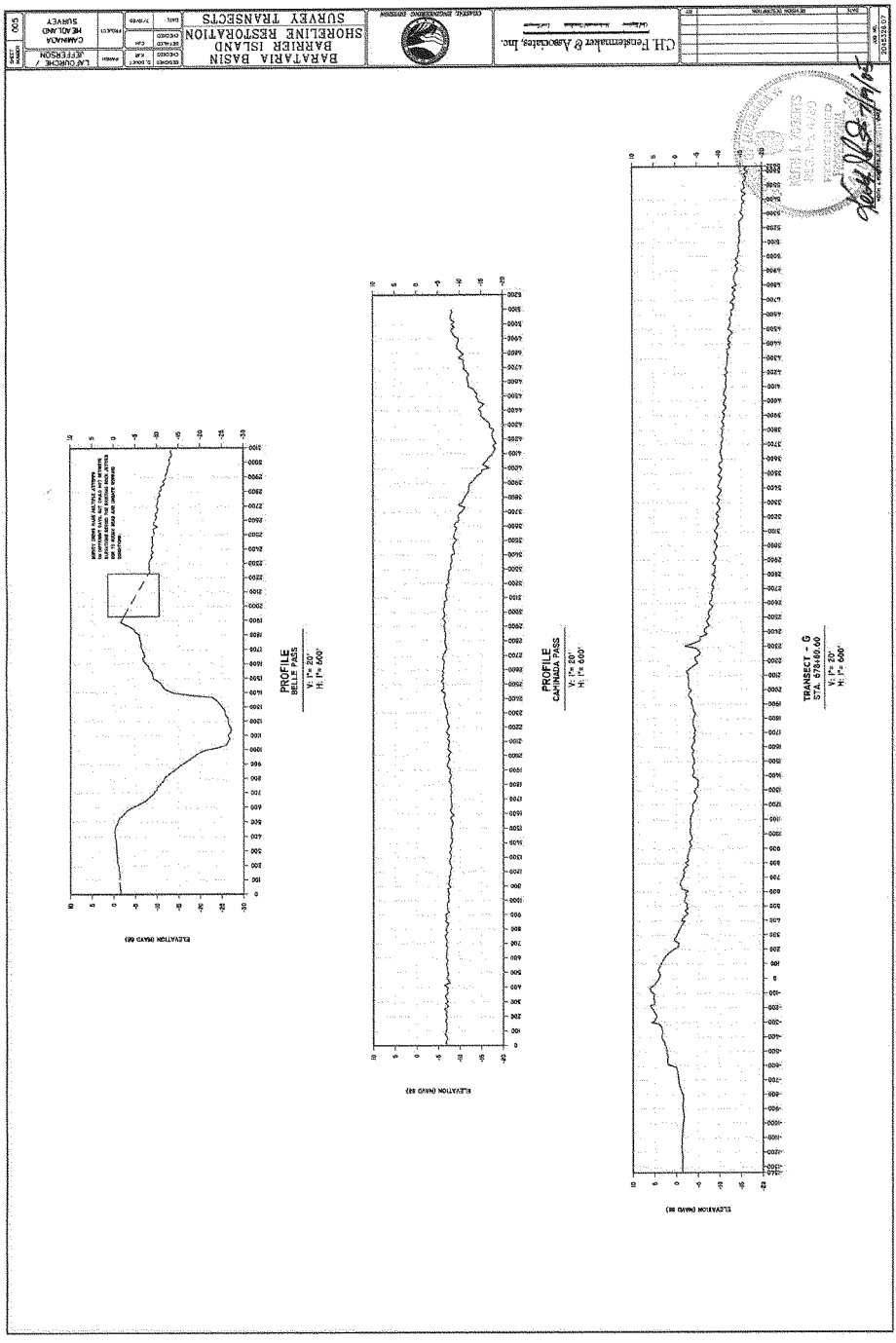
BARATARIA BASIN
BARRIER ISLAND
SHORELINE RESTORATION
SURVEY TRANSECTS
CH Fredermiller & Associates, Inc.
PROFILE
BELLE PASS
V: 1"= 20'
H: 1"= 600'
PROFILE
CAMINADA PASS
V: 1"= 20'
H: 1"= 600'
TRANSECT - G
STA. 678+60.60
V: 1"= 20'
H: 1"= 600'
ELEVATION (NAVD 88)
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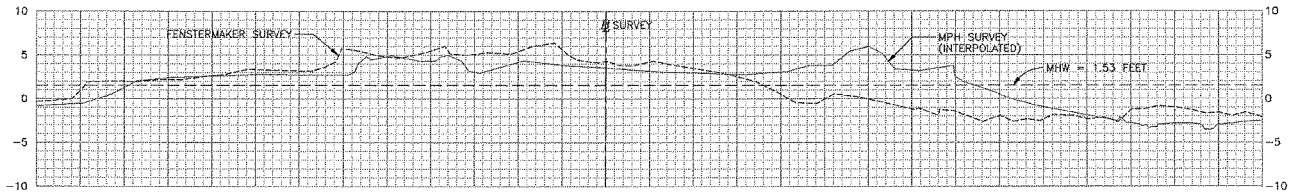
Coastal Engineering Consultants Inc.
SURVEY COMPARISIONS
JUNE, 2006
SLB GROUP
TRANSECT A
TRANSECT B
TRANSECT C
MHW = 1.53 FEET
MPH SURVEY (INTERPOLATED)
FENSTERMAKER SURVEY
SURVEY
SCALES: HORIZONTAL: 1"=100'
VERTICAL: 1"=10'
ELEVATIONS ARE NAVD88 FEET

Coastal Engineering Consultants Inc.
SURVEY COMPARISIONS
JUNE, 2006
SLB GROUP
TRANSECT D
TRANSECT E
TRANSECT F
MHW = 1.53 FEET
MHW - SURVEY (INTERPOLATED)
HEBERT - SURVEY (INTERPOLATED)
FENSTERMAKER - SURVEY
SURVEY
SCALES: HORIZONTAL: 1"=100'
VERTICAL: 1"=10'
ELEVATIONS ARE NAVD88 FEET




SCALES: HORIZONTAL: 1"=100'
VERTICAL: 1"=10'
ELEVATIONS ARE NAVD88 FEET

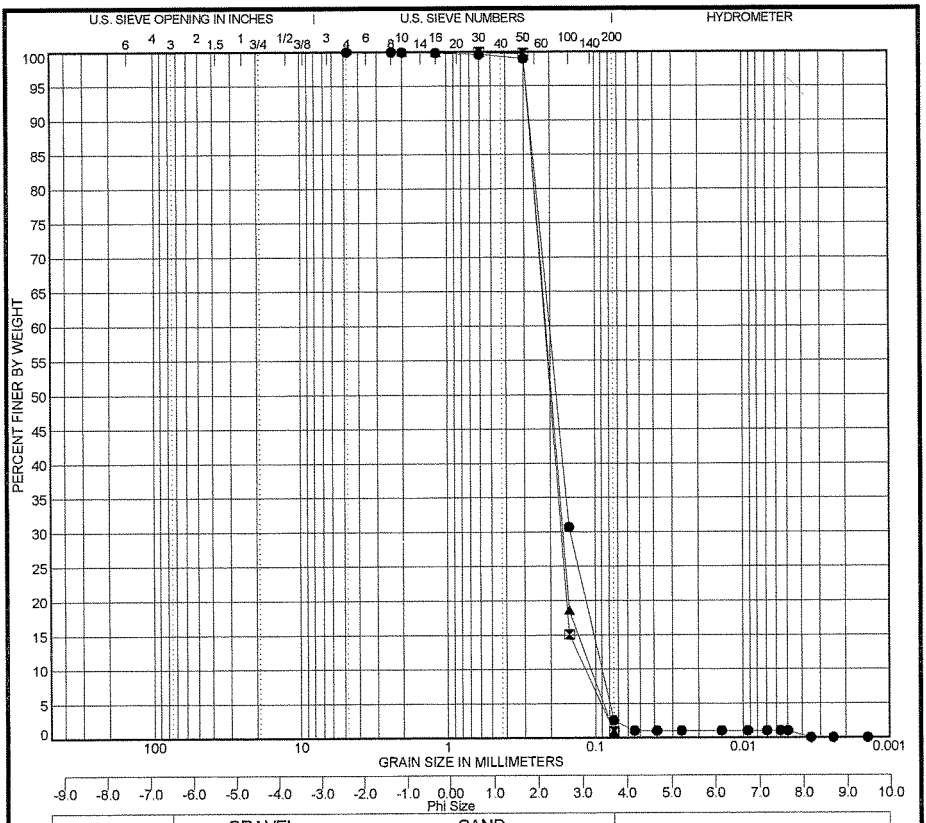
TRANSECT G

SJB GROUP
ENGINEERS & CONSULTANTS

SURVEY COMPARISIONS
JUNE, 2006

Coastal Engineering Consultants Inc.

# ANNEX C2
# GEOTECHNICAL SEDIMENT DATA




| COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|
| | coarse | fine | coarse | medium | fine | |

| Specimen Identification | D05 (mm) | D16 (mm) | D25 (mm) | D50 (mm) | D75 (mm) | D84 (mm) | D95 (mm) |
|---|---|---|---|---|---|---|---|
| ● B Surf | 0.08 | 0.104 | 0.13 | 0.182 | 0.235 | 0.258 | 0.288 |
| ⊠ B Beach | 0.092 | 0.151 | 0.163 | 0.2 | 0.245 | 0.264 | 0.288 |
| ▲ B Dune | 0.088 | 0.135 | 0.158 | 0.196 | 0.243 | 0.262 | 0.288 |

| Specimen Identification | Cc | Cu | Mean (mm) | Mean (Phi) | Median (Phi) | Sorting | Skewness | Kurtosis |
|---|---|---|---|---|---|---|---|---|
| ● B Surf | 1.19 | 2.24 | 0.170 | 2.559 | 2.458 | -0.636 | -0.258 | 0.887 |
| ⊠ B Beach | 1.13 | 1.85 | 0.200 | 2.324 | 2.322 | -0.476 | -0.184 | 1.148 |
| ▲ B Dune | 1.19 | 1.99 | 0.191 | 2.391 | 2.351 | -0.524 | -0.238 | 1.129 |

Specimen Identification includes the Sample No. and Sample Identification Interval.

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316 Highlandia Drive
Baton Rouge, LA 70810
Telephone: (225) 752-4792
Fax: (225) 752-4878
STE
Soil Testing Engineers, Inc.

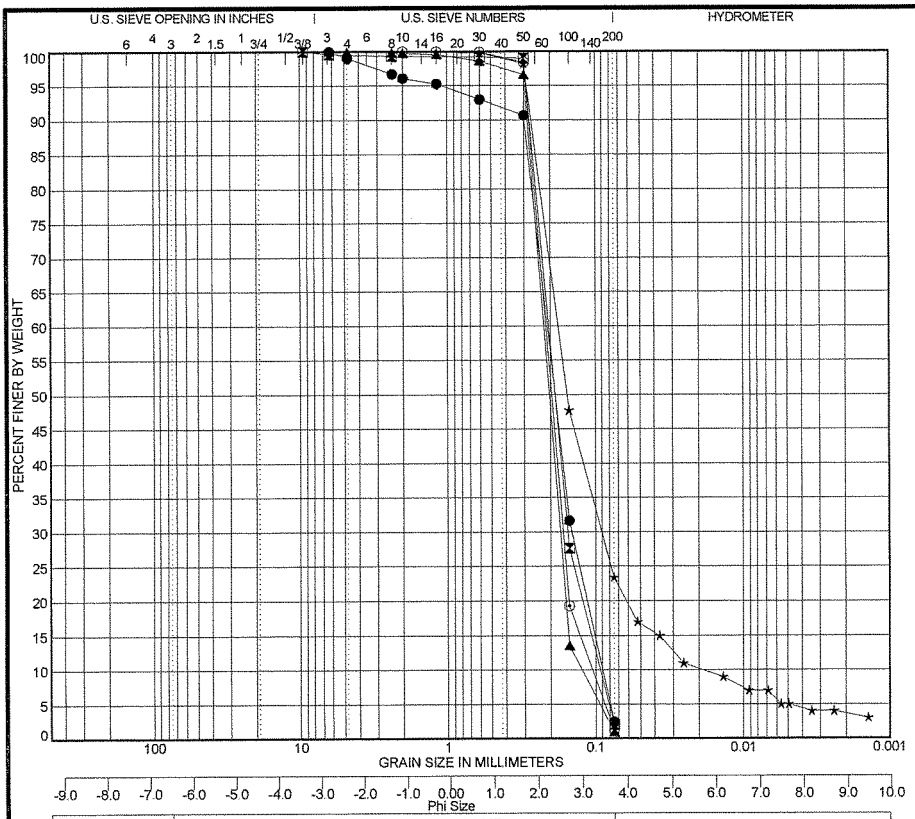
## GRAIN SIZE DISTRIBUTION

Project: Caminada Headland

Location:

Number: 05-1102

05-1102 GS CALCS CAMINADA HEADLAND 051102.GPJ US_LAB.GDT 08/10/05




| COBBLES | GRAVEL coarse | GRAVEL fine | SAND coarse | SAND medium | SAND fine | SILT OR CLAY |
|---|---|---|---|---|---|---|

| Specimen Identification | D05 (mm) | D16 (mm) | D25 (mm) | D50 (mm) | D75 (mm) | D84 (mm) | D95 (mm) |
|---|---|---|---|---|---|---|---|
| ● C Surf | 0.08 | 0.104 | 0.128 | 0.186 | 0.25 | 0.277 | 1.086 |
| ⊠ C Beach | 0.081 | 0.109 | 0.14 | 0.186 | 0.238 | 0.259 | 0.288 |
| ▲ C Dune | 0.094 | 0.153 | 0.165 | 0.203 | 0.25 | 0.27 | 0.296 |
| ★ C Marsh | 0.005 | 0.044 | 0.078 | 0.155 | 0.218 | 0.247 | 0.287 |
| ⊙ C Overwash | 0.087 | 0.132 | 0.158 | 0.196 | 0.244 | 0.264 | 0.291 |

| Specimen Identification | Cc | Cu | Mean (mm) | Mean (Phi) | Median (Phi) | Sorting | Skewness | Kurtosis |
|---|---|---|---|---|---|---|---|---|
| ● C Surf | 1.11 | 2.33 | 0.175 | 2.515 | 2.427 | -0.980 | 0.083 | 1.597 |
| ⊠ C Beach | 1.23 | 2.21 | 0.174 | 2.524 | 2.427 | -0.617 | -0.273 | 0.980 |
| ▲ C Dune | 1.09 | 1.79 | 0.203 | 2.299 | 2.300 | -0.481 | -0.169 | 1.131 |
| ★ C Marsh | 2.46 | 9.46 | 0.119 | 3.071 | 2.690 | -1.596 | -0.578 | 1.615 |
| ⊙ C Overwash | 1.21 | 2.04 | 0.190 | 2.398 | 2.351 | -0.540 | -0.243 | 1.139 |

Specimen Identification includes the Sample No. and Sample Identification Interval.

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Soil Testing Engineers, Inc.
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Baton Rouge, LA 70810
Telephone: (225) 752-4792
Fax: (225) 752-4878

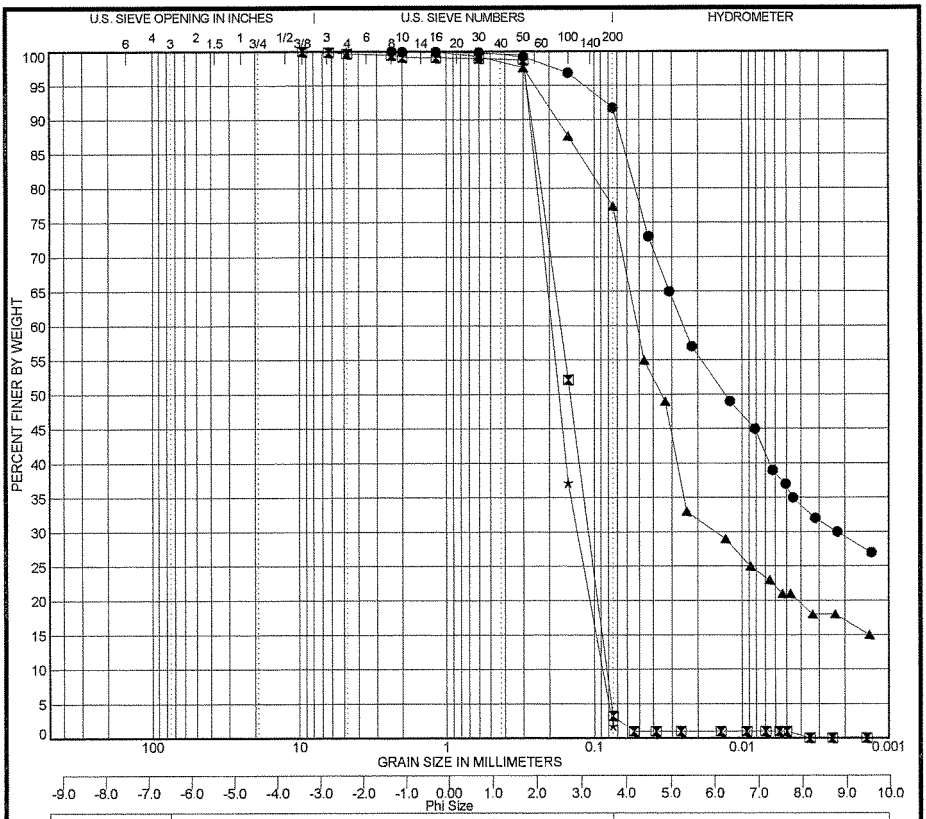
## GRAIN SIZE DISTRIBUTION

Project: Caminada Headland

Location:

Number: 05-1102

05-1102 GS CALCS CAMINADA HEADLAND 051102.GPJ US_LAB.GDT 08/12/05




| COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|
| | coarse | fine | coarse | medium | fine | |

| | | Specimen Identification | D05 (mm) | D16 (mm) | D25 (mm) | D50 (mm) | D75 (mm) | D84 (mm) | D95 (mm) |
|---|---|---|---|---|---|---|---|---|---|
| ● | D | Surf | | | | 0.013 | 0.046 | 0.06 | 0.116 |
| ⊠ | D | Beach | 0.077 | 0.09 | 0.102 | 0.146 | 0.211 | 0.241 | 0.284 |
| ▲ | D | Marsh | | 0.002 | 0.009 | 0.035 | 0.071 | 0.118 | 0.25 |
| ★ | D | Overwash | 0.08 | 0.099 | 0.118 | 0.173 | 0.228 | 0.252 | 0.285 |

| | | Specimen Identification | Cc | Cu | Mean (mm) | Mean (Phi) | Median (Phi) | Sorting | Skewness | Kurtosis |
|---|---|---|---|---|---|---|---|---|---|---|
| ● | D | Surf | | | | | 6.265 | | | |
| ⊠ | D | Beach | 0.86 | 2.04 | 0.147 | 2.768 | 2.776 | -0.669 | 0.019 | 0.736 |
| ▲ | D | Marsh | | | 0.020 | 5.628 | 4.837 | | | |
| ★ | D | Overwash | 1.00 | 2.19 | 0.163 | 2.619 | 2.531 | -0.642 | -0.204 | 0.791 |

Specimen Identification includes the Sample No. and Sample Identification Interval.

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316 Highlandia Drive
Baton Rouge, LA 70810
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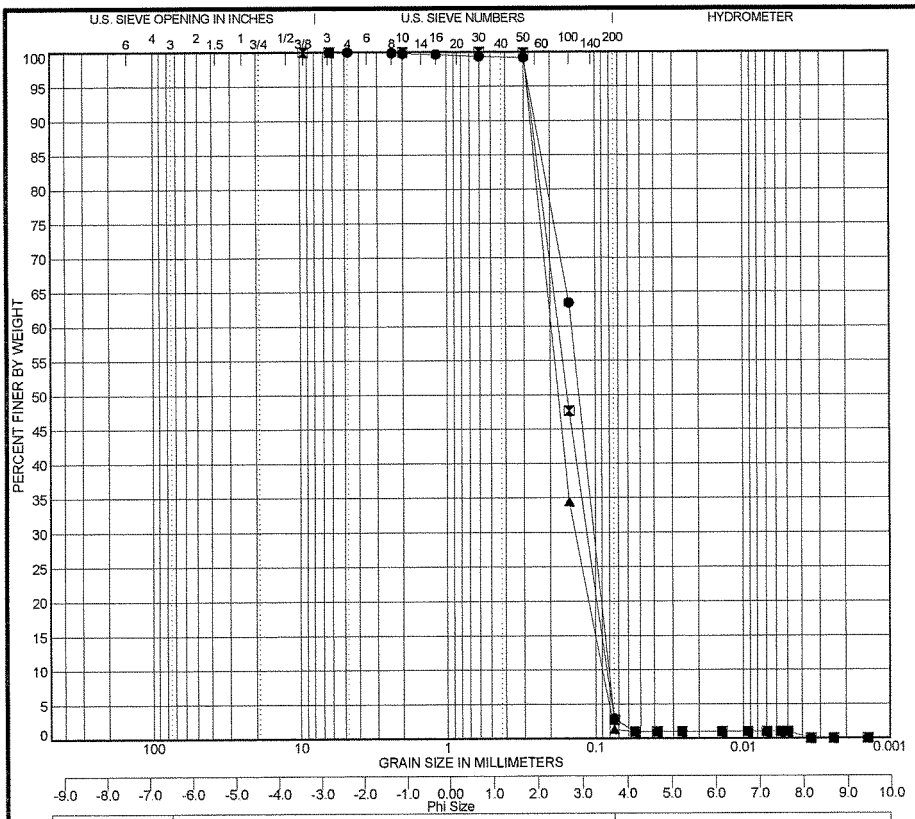
## GRAIN SIZE DISTRIBUTION

Project: Caminada Headland

Location:

Number: 05-1102

05-1102 GS CALCS CAMINADA HEADLAND 051102.GPJ US_LAB.GDT 08/10/05




| COBBLES | GRAVEL coarse | GRAVEL fine | SAND coarse | SAND medium | SAND fine | SILT OR CLAY |
|---|---|---|---|---|---|---|

| Specimen Identification | D05 (mm) | D16 (mm) | D25 (mm) | D50 (mm) | D75 (mm) | D84 (mm) | D95 (mm) |
|---|---|---|---|---|---|---|---|
| ● F Surf | 0.077 | 0.087 | 0.097 | 0.129 | 0.188 | 0.223 | 0.277 |
| ⊠ F Beach | 0.078 | 0.092 | 0.106 | 0.155 | 0.216 | 0.243 | 0.281 |
| ▲ F Dune/Overwash | 0.081 | 0.102 | 0.123 | 0.177 | 0.23 | 0.253 | 0.285 |

| Specimen Identification | Cc | Cu | Mean (mm) | Mean (Phi) | Median (Phi) | Sorting | Skewness | Kurtosis |
|---|---|---|---|---|---|---|---|---|
| ● F Surf | 0.89 | 1.77 | 0.136 | 2.881 | 2.955 | -0.647 | 0.178 | 0.793 |
| ⊠ F Beach | 0.88 | 2.10 | 0.151 | 2.724 | 2.690 | -0.658 | -0.073 | 0.738 |
| ▲ F Dune/Overwash | 1.06 | 2.18 | 0.166 | 2.591 | 2.498 | -0.630 | -0.228 | 0.824 |

Specimen Identification includes the Sample No. and Sample Identification Interval.

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## GRAIN SIZE DISTRIBUTION

Project: Caminada Headland

Location:

Number: 05-1102

05-1102 GS CALCS CAMINADA HEADLAND 051102.GPJ US_LAB.GDT 09/10/05

# Grain Size Analysis

Project Title: Caminada Headland-05211
Project Number: 05-1102
Boring: B Depth: Beach
Material: Gray sand
Total Sample Weight: gm (Dry)
Hydrometer Sample Weight: 50 gm

Date: 8/10/2005
Done by: IK/EEL
Calc by: KA
Hydro No.:
Can after hydro:

## Hydrometer

| Date | True Time | Elapsed Time | Temp (°F) | Reading | Size Calc KL | Size Calc KT | Size Calc d' | Grain Size (mm) | % Calc Temp. corr | % Calc Corr. Rdg. | Raw % Finer | Corr. % Finer |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8/8 | 7:51 | start | | | | | | | | | | |
| | 7:52 | 1 min | 73 | 4 | ####### | 0.966 | 0.0580 | ####### | -5.5 | -1.5 | -3.0% | |
| | 7:53 | 2 min | 73 | 4 | ####### | 0.966 | 0.0410 | ####### | -5.5 | -1.5 | -3.0% | |
| | 7:56 | 5 min | 73 | 4 | ####### | 0.966 | 0.0280 | ####### | -5.5 | -1.5 | -3.0% | |
| | 8:06 | 15 min | 73 | 4 | ####### | 0.966 | 0.0150 | ####### | -5.5 | -1.5 | -3.0% | |
| | 8:21 | 30 min | 73 | 4 | ####### | 0.966 | 0.0100 | ####### | -5.5 | -1.5 | -3.0% | |
| | 8:51 | 1 hr | 73 | 4 | ####### | 0.966 | 0.0074 | ####### | -5.5 | -1.5 | -3.0% | |
| | 9:21 | 1.5 hr | 73 | 4 | ####### | 0.966 | 0.0060 | ####### | -5.5 | -1.5 | -3.0% | |
| | 9:51 | 2 hr | 73 | 4 | ####### | 0.966 | 0.0053 | ####### | -5.5 | -1.5 | -3.0% | |
| | 11:51 | 4 hr | 74 | 4 | ####### | 0.960 | 0.0037 | ####### | -5.0 | -1.0 | -2.0% | |
| | 15:51 | 8 hr | 74 | 4 | ####### | 0.960 | 0.0026 | ####### | -5.0 | -1.0 | -2.0% | |
| | 21:51 | 14 hr | | | | | 0.0020 | | | | | |
| 8/9 | 7:51 | 24 hr | 73 | 5 | 0.975 | 0.966 | 0.0015 | 0.00141 | -5.5 | -0.5 | -1.0% | |

## Sieves

| Sieve | Total Weight (gm) | Tare Weight (gm) | Soil Weight (gm) | Raw % Ret. | Raw % Finer | Corr % Finer | Hydro taken (X) |
|---|---|---|---|---|---|---|---|
| Gravel | | | | | | | |
| 1 1/2 | | | | | | | |
| 1 | | | | | | | |
| 3/4 | | | | | | | |
| 1/2 | | | | | | | |
| 3/8 | | | | | | | |
| 1/4 | | | | | | | |
| #4 | | | | | | | |
| Sand | | | | | | | |
| #8 | | | | | | | |
| #10 | | | | | | | |
| #16 | | | | | | | |
| #20 | | | | | | | |
| #30 | 0.00 | | 0.00 | 0.00% | 100.00% | | |
| #40 | | | | | | | |
| #50 | 0.10 | | 0.10 | 0.20% | 99.80% | | |
| #60 | | | | | | | |
| #80 | | | | | | | |
| #100 | 42.46 | | 42.46 | 84.92% | 15.08% | | |
| #140 | | | | | | | |
| #200 | 49.56 | | 49.56 | 99.12% | 0.88% | | |
| Pan | | | | | | | |

**Total Weight:** 50.0 grams

Initial Water Content
Can No.: 148
126.3 Wet Wt. (grams)
110.7 Dry Wt. (grams)
15.6 Wt. H2O (grams)

Dry Wt.: 110.7
Tare Wt.: 25.3
Weight Sample: 85.4

H2O Content (%): 18.2%

*Oversize Correction*
Corr. % Finer = Raw % Finer x F
F = Ret on last Sieve

Last Sieve =
F =

# Grain Size Analysis

Project Title: Caminada Headland-05211
Project Number: 05-1102
Boring: B Depth: Dune
Material: Light Gray sand w/roots
Total Sample Weight: gm (Dry)
Hydrometer Sample Weight: 50 gm

Date: 8/10/2005
Done by: IK/EEL
Calc by: KA
Hydro No.:
Can after hydro:

## Hydrometer

| Date | True Time | Elapsed Time | Temp (°F) | Reading | Size Calc KL | Size Calc KT | Size Calc d' | Grain Size (mm) | % Calc Temp. corr | % Calc Corr. Rdg. | Raw % Finer | Corr. % Finer |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8/8 | 7:59 | start | | | | | | | | | | |
| | 8:00 | 1 min | 73 | 5 | 0.975 | 0.966 | 0.0580 | 0.05463 | -5.5 | -0.5 | -1.0% | |
| | 8:01 | 2 min | 73 | 5 | 0.975 | 0.966 | 0.0410 | 0.03862 | -5.5 | -0.5 | -1.0% | |
| | 8:04 | 5 min | 73 | 5 | 0.975 | 0.966 | 0.0280 | 0.02637 | -5.5 | -0.5 | -1.0% | |
| | 8:14 | 15 min | 73 | 6 | 0.970 | 0.966 | 0.0150 | 0.01406 | -5.5 | 0.5 | 1.0% | |
| | 8:29 | 30 min | 73 | 6 | 0.970 | 0.966 | 0.0100 | 0.00937 | -5.5 | 0.5 | 1.0% | |
| | 8:59 | 1 hr | 73 | 5 | 0.975 | 0.966 | 0.0074 | 0.00697 | -5.5 | -0.5 | -1.0% | |
| | 9:29 | 1.5 hr | 73 | 6 | 0.970 | 0.966 | 0.0060 | 0.00562 | -5.5 | 0.5 | 1.0% | |
| | 9:59 | 2 hr | 73 | 5 | 0.975 | 0.966 | 0.0053 | 0.00499 | -5.5 | -0.5 | -1.0% | |
| | 11:59 | 4 hr | 74 | 5 | 0.975 | 0.960 | 0.0037 | 0.00346 | -5.0 | 0.0 | 0.0% | |
| | 15:59 | 8 hr | 74 | 5 | 0.975 | 0.960 | 0.0026 | 0.00243 | -5.0 | 0.0 | 0.0% | |
| | 21:59 | 14 hr | | | | | 0.0020 | | | | | |
| 8/9 | 7:59 | 24 hr | 73 | 5 | 0.975 | 0.966 | 0.0015 | 0.00141 | -5.5 | -0.5 | -1.0% | |

## Sieves

| Sieve | Total Weight (gm) | Tare Weight (gm) | Soil Weight (gm) | Raw % Ret. | Raw % Finer | Corr % Finer | Hydro taken (X) |
|---|---|---|---|---|---|---|---|
| Gravel | | | | | | | |
| 1 1/2 | | | | | | | |
| 1 | | | | | | | |
| 3/4 | | | | | | | |
| 1/2 | | | | | | | |
| 3/8 | | | | | | | |
| 1/4 | | | | | | | |
| #4 | | | | | | | |
| Sand | | | | | | | |
| #8 | | | | | | | |
| #10 | 0.00 | | 0.00 | 0.00% | 100.00% | | |
| #16 | 0.03 | | 0.03 | 0.06% | 99.94% | | |
| #20 | | | | | | | |
| #30 | 0.06 | | 0.06 | 0.12% | 99.88% | | |
| #40 | | | | | | | |
| #50 | 0.16 | | 0.16 | 0.32% | 99.68% | | |
| #60 | | | | | | | |
| #80 | | | | | | | |
| #100 | 40.69 | | 40.69 | 81.38% | 18.62% | | |
| #140 | | | | | | | |
| #200 | 49.57 | | 49.57 | 99.14% | 0.86% | | |
| Pan | | | | | | | |

**Total Weight:** 50.0 grams

Initial Water Content
Can No.: 586
138.0 Wet Wt. (grams)
134.9 Dry Wt. (grams)
3.1 Wt. H2O (grams)

Dry Wt.: 134.9
Tare Wt.: 20.9
Weight Sample: 113.9

H2O Content (%): 2.7%

*Oversize Correction*
Corr % Finer = Raw % Finer x F
F = Ret on last Sieve

Last Sieve =
F =

# Grain Size Analysis

Project Title: Caminada Headland-05211
Project Number: 05-1102
Boring: C Depth: Beach
Material: Gray sand w/shells
Total Sample Weight: gm (Dry)
Hydrometer Sample Weight: 50 gm

Date: 8/10/2005
Done by: IK/EEL
Calc by: KA
Hydro No.:
Can after hydro:

## Hydrometer

| Date | True Time | Elapsed Time | Temp (°F) | Reading | Size Calc KL | Size Calc KT | Size Calc d' | Grain Size (mm) | % Calc Temp. corr | % Calc Corr. Rdg. | Raw % Finer | Corr. % Finer |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8/8 | 7:27 | start | | | | | | | | | | |
| | 7:28 | 1 min | 73 | 5 | 0.975 | 0.966 | 0.0580 | 0.05463 | -5.5 | -0.5 | -1.0% | |
| | 7:29 | 2 min | 73 | 4 | ####### | 0.966 | 0.0410 | ####### | -5.5 | -1.5 | -3.0% | |
| | 7:32 | 5 min | 73 | 5 | 0.975 | 0.966 | 0.0280 | 0.02637 | -5.5 | -0.5 | -1.0% | |
| | 7:42 | 15 min | 73 | 5 | 0.975 | 0.966 | 0.0150 | 0.01413 | -5.5 | -0.5 | -1.0% | |
| | 7:57 | 30 min | 73 | 5 | 0.975 | 0.966 | 0.0100 | 0.00942 | -5.5 | -0.5 | -1.0% | |
| | 8:27 | 1 hr | 73 | 5 | 0.975 | 0.966 | 0.0074 | 0.00697 | -5.5 | -0.5 | -1.0% | |
| | 8:57 | 1.5 hr | 73 | 5 | 0.975 | 0.966 | 0.0060 | 0.00565 | -5.5 | -0.5 | -1.0% | |
| | 9:27 | 2 hr | 73 | 4 | ####### | 0.966 | 0.0053 | ####### | -5.5 | -1.5 | -3.0% | |
| | 11:27 | 4 hr | 74 | 5 | 0.975 | 0.960 | 0.0037 | 0.00346 | -5.0 | 0.0 | 0.0% | |
| | 15:27 | 8 hr | 74 | 5 | 0.975 | 0.960 | 0.0026 | 0.00243 | -5.0 | 0.0 | 0.0% | |
| | 21:27 | 14 hr | | | | | 0.0020 | | | | | |
| 8/9 | 7:27 | 24 hr | 73 | 5 | 0.975 | 0.966 | 0.0015 | 0.00141 | -5.5 | -0.5 | -1.0% | |

## Sieves

| Sieve | Total Weight (gm) | Tare Weight (gm) | Soil Weight (gm) | Raw % Ret. | Raw % Finer | Corr % Finer | Hydro taken (X) |
|---|---|---|---|---|---|---|---|
| Gravel | | | | | | | |
| 1 1/2 | | | | | | | |
| 1 | | | | | | | |
| 3/4 | | | | | | | |
| 1/2 | | | | | | | |
| 3/8 | 0.00 | | 0.00 | 0.00% | 100.00% | | |
| 1/4 | 0.22 | | 0.22 | 0.44% | 99.56% | | |
| #4 | | | | | | | |
| Sand | | | | | | | |
| #8 | 0.34 | | 0.34 | 0.68% | 99.32% | | |
| #10 | | | | | | | |
| #16 | | | | | | | |
| #20 | | | | | | | |
| #30 | 0.38 | | 0.38 | 0.76% | 99.24% | | |
| #40 | | | | | | | |
| #50 | 0.48 | | 0.48 | 0.96% | 99.04% | | |
| #60 | | | | | | | |
| #80 | | | | | | | |
| #100 | 36.18 | | 36.18 | 72.36% | 27.64% | | |
| #140 | | | | | | | |
| #200 | 48.99 | | 48.99 | 97.98% | 2.02% | | |
| Pan | | | | | | | |

**Total Weight:** 50.0 grams

Initial Water Content
Can No.: 589
169.7 Wet Wt. (grams)
141.9 Dry Wt. (grams)
27.9 Wt. H2O (grams)

Dry Wt.: 141.9
Tare Wt.: 21.0
Weight Sample: 120.9

H2O Content (%): 23.0%

*Oversize Correction*
Corr. % Finer = Raw % Finer x F
F = Ret on last Sieve

Last Sieve =
F =

# Grain Size Analysis

Project Title: Caminada Headland-05211
Project Number: 05-1102
Boring: C Depth: Dune
Material: Light Gray sand w/roots & shells
Total Sample Weight: 90.5 gm (Dry)
Hydrometer Sample Weight: 50 gm

Date: 8/10/2005
Done by: IK/EEL
Calc by: KA
Hydro No.:
Can after hydro:

## Hydrometer

| Date | True Time | Elapsed Time | Temp (°F) | Reading | Size Calc KL | Size Calc KT | Size Calc d' | Grain Size (mm) | % Calc Temp. corr | % Calc Corr. Rdg. | Raw % Finer | Corr. % Finer |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8/8 | 7:32 | start | | | | | | | | | | |
| | 7:33 | 1 min | 73 | 5 | 0.975 | 0.966 | 0.0580 | 0.05463 | -5.5 | -0.5 | -1.0% | -1.0% |
| | 7:34 | 2 min | 73 | 4 | ####### | 0.966 | 0.0410 | ####### | -5.5 | -1.5 | -3.0% | -3.0% |
| | 7:37 | 5 min | 73 | 4 | ####### | 0.966 | 0.0280 | ####### | -5.5 | -1.5 | -3.0% | -3.0% |
| | 7:47 | 15 min | 73 | 4 | ####### | 0.966 | 0.0150 | ####### | -5.5 | -1.5 | -3.0% | -3.0% |
| | 8:02 | 30 min | 73 | 4 | ####### | 0.966 | 0.0100 | ####### | -5.5 | -1.5 | -3.0% | -3.0% |
| | 8:32 | 1 hr | 73 | 4 | ####### | 0.966 | 0.0074 | ####### | -5.5 | -1.5 | -3.0% | -3.0% |
| | 9:02 | 1.5 hr | 73 | 3 | ####### | 0.966 | 0.0060 | ####### | -5.5 | -2.5 | -5.0% | -5.0% |
| | 9:32 | 2 hr | 73 | 4 | ####### | 0.966 | 0.0053 | ####### | -5.5 | -1.5 | -3.0% | -3.0% |
| | 11:32 | 4 hr | 74 | 4 | ####### | 0.960 | 0.0037 | ####### | -5.0 | -1.0 | -2.0% | -2.0% |
| | 15:32 | 8 hr | 74 | 4 | ####### | 0.960 | 0.0026 | ####### | -5.0 | -1.0 | -2.0% | -2.0% |
| | 21:32 | 14 hr | | | | | 0.0020 | | | | | |
| 8/9 | 7:32 | 24 hr | 73 | 5 | 0.975 | 0.966 | 0.0015 | 0.00141 | -5.5 | -0.5 | -1.0% | -1.0% |

## Sieves

| Sieve | Total Weight (gm) | Tare Weight (gm) | Soil Weight (gm) | Raw % Ret. | Raw % Finer | Corr % Finer | Hydro taken (X) |
|---|---|---|---|---|---|---|---|
| Gravel | | | | | | | |
| 1 1/2 | | | | | | | |
| 1 | | | | | | | |
| 3/4 | | | | | | | |
| 1/2 | | | | | | | |
| 3/8 | | | | | | | |
| 1/4 | 0.00 | | 0.00 | 0.00% | 100.00% | | |
| #4 | 0.02 | | 0.02 | 0.02% | 99.98% | | |
| Sand | | | | | | | |
| #8 | 0.13 | | 0.13 | 0.14% | 99.86% | | |
| #10 | 0.20 | | 0.20 | 0.22% | 99.78% | | x |
| #16 | 0.10 | | 0.10 | 0.20% | 99.80% | 99.58% | |
| #20 | | | | | | | |
| #30 | 0.59 | | 0.59 | 1.18% | 98.82% | 98.60% | |
| #40 | | | | | | | |
| #50 | 1.59 | | 1.59 | 3.18% | 96.82% | 96.61% | |
| #60 | | | | | | | |
| #80 | | | | | | | |
| #100 | 43.21 | | 43.21 | 86.42% | 13.58% | 13.55% | |
| #140 | | | | | | | |
| #200 | 49.52 | | 49.52 | 99.04% | 0.96% | 0.96% | |
| Pan | | | | | | | |

**Total Weight:** 90.5 grams

Initial Water Content
Can No.: 92
121.9 Wet Wt. (grams)
118.5 Dry Wt. (grams)
3.4 Wt. H2O (grams)

Dry Wt.: 118.5
Tare Wt.: 28.0
Weight Sample: 90.5

H2O Content (%): 3.7%

*Oversize Correction*
Corr. % Finer = Raw % Finer x F
F = Ret on last Sieve

Last Sieve = #10
F = 99.78%

# Grain Size Analysis

Project Title: Caminada Headland-05211
Project Number: 05-1102
Boring: C Depth: Surf
Material: Gray sand w/shells
Total Sample Weight: 141.3 gm (Dry)
Hydrometer Sample Weight: 50 gm

Date: 8/10/2005
Done by: IK/EEL
Calc by: KA
Hydro No.:
Can after hydro:

## Hydrometer

| Date | True Time | Elapsed Time | Temp (°F) | Reading | Size Calc KL | Size Calc KT | Size Calc d' | Grain Size (mm) | % Calc Temp. corr | % Calc Corr. Rdg. | Raw % Finer | Corr. % Finer |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8/8 | 7:20 | start | | | | | | | | | | |
| | 7:21 | 1 min | 73 | 5 | 0.975 | 0.966 | 0.0580 | 0.05463 | -5.5 | -0.5 | -1.0% | -1.0% |
| | 7:22 | 2 min | 73 | 5 | 0.975 | 0.966 | 0.0410 | 0.03862 | -5.5 | -0.5 | -1.0% | -1.0% |
| | 7:25 | 5 min | 73 | 5 | 0.975 | 0.966 | 0.0280 | 0.02637 | -5.5 | -0.5 | -1.0% | -1.0% |
| | 7:35 | 15 min | 73 | 5 | 0.975 | 0.966 | 0.0150 | 0.01413 | -5.5 | -0.5 | -1.0% | -1.0% |
| | 7:50 | 30 min | 73 | 5 | 0.975 | 0.966 | 0.0100 | 0.00942 | -5.5 | -0.5 | -1.0% | -1.0% |
| | 8:20 | 1 hr | 73 | 5 | 0.975 | 0.966 | 0.0074 | 0.00697 | -5.5 | -0.5 | -1.0% | -1.0% |
| | 8:50 | 1.5 hr | 73 | 5 | 0.975 | 0.966 | 0.0060 | 0.00565 | -5.5 | -0.5 | -1.0% | -1.0% |
| | 9:20 | 2 hr | 73 | 5 | 0.975 | 0.966 | 0.0053 | 0.00499 | -5.5 | -0.5 | -1.0% | -1.0% |
| | 11:20 | 4 hr | 74 | 5 | 0.975 | 0.960 | 0.0037 | 0.00346 | -5.0 | 0.0 | 0.0% | 0.0% |
| | 15:20 | 8 hr | 74 | 4 | ######## | 0.960 | 0.0026 | ######## | -5.0 | -1.0 | -2.0% | -1.9% |
| | 21:20 | 14 hr | | | | | 0.0020 | | | | | |
| 8/9 | 7:20 | 24 hr | 73 | 5 | 0.975 | 0.966 | 0.0015 | 0.00141 | -5.5 | -0.5 | -1.0% | -1.0% |

## Sieves

| Sieve | Total Weight (gm) | Tare Weight (gm) | Soil Weight (gm) | Raw % Ret. | Raw % Finer | Corr % Finer | Hydro taken (X) |
|---|---|---|---|---|---|---|---|
| Gravel | | | | | | | |
| 1 1/2 | | | | | | | |
| 1 | | | | | | | |
| 3/4 | | | | | | | |
| 1/2 | | | | | | | |
| 3/8 | | | | | | | |
| 1/4 | 0.00 | | 0.00 | 0.00% | 100.00% | | |
| #4 | 1.40 | | 1.40 | 0.99% | 99.01% | | |
| Sand | | | | | | | |
| #8 | 4.63 | | 4.63 | 3.28% | 96.72% | | |
| #10 | 5.53 | | 5.53 | 3.91% | 96.09% | | x |
| #16 | 0.42 | | 0.42 | 0.84% | 99.16% | 95.28% | |
| #20 | | | | | | | |
| #30 | 1.60 | | 1.60 | 3.20% | 96.80% | 93.01% | |
| #40 | | | | | | | |
| #50 | 2.82 | | 2.82 | 5.64% | 94.36% | 90.67% | |
| #60 | | | | | | | |
| #80 | | | | | | | |
| #100 | 33.54 | | 33.54 | 67.08% | 32.92% | 31.63% | |
| #140 | | | | | | | |
| #200 | 48.75 | | 48.75 | 97.50% | 2.50% | 2.40% | |
| Pan | | | | | | | |

**Total Weight:** 141.3 grams

Initial Water Content
Can No.: 151
202.4 Wet Wt. (grams)
170.1 Dry Wt. (grams)
32.3 Wt. H2O (grams)

Dry Wt.: 170.1
Tare Wt.: 28.8
Weight Sample: 141.3

H2O Content (%): 22.8%

*Oversize Correction*
Corr. % Finer = Raw % Finer x F
F = Ret on last Sieve

Last Sieve = #10
F = 96.09%

# Grain Size Analysis

Project Title: Caminada Headland-05211
Project Number: 05-1102
Boring: C Depth: Overwash
Material: Light Gray very fine sand w/shells
Total Sample Weight: gm (Dry)
Hydrometer Sample Weight: 50 gm

Date: 8/10/2005
Done by: IK/EEL
Calc by: KA
Hydro No.:
Can after hydro:

## Hydrometer

| Date | True Time | Elapsed Time | Temp (°F) | Reading | Size Calc KL | Size Calc KT | Size Calc d' | Grain Size (mm) | % Calc Temp. corr | % Calc Corr. Rdg. | Raw % Finer | Corr. % Finer |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8/8 | 7:45 | start | | | | | | | | | | |
| | 7:46 | 1 min | 73 | 4 | ####### | 0.966 | 0.0580 | ####### | -5.5 | -1.5 | -3.0% | |
| | 7:47 | 2 min | 73 | 4 | ####### | 0.966 | 0.0410 | ####### | -5.5 | -1.5 | -3.0% | |
| | 7:50 | 5 min | 73 | 4 | ####### | 0.966 | 0.0280 | ####### | -5.5 | -1.5 | -3.0% | |
| | 8:00 | 15 min | 73 | 4 | ####### | 0.966 | 0.0150 | ####### | -5.5 | -1.5 | -3.0% | |
| | 8:15 | 30 min | 73 | 4 | ####### | 0.966 | 0.0100 | ####### | -5.5 | -1.5 | -3.0% | |
| | 8:45 | 1 hr | 73 | 4 | ####### | 0.966 | 0.0074 | ####### | -5.5 | -1.5 | -3.0% | |
| | 9:15 | 1.5 hr | 73 | 4 | ####### | 0.966 | 0.0060 | ####### | -5.5 | -1.5 | -3.0% | |
| | 9:45 | 2 hr | 73 | 4 | ####### | 0.966 | 0.0053 | ####### | -5.5 | -1.5 | -3.0% | |
| | 11:45 | 4 hr | 74 | 4 | ####### | 0.960 | 0.0037 | ####### | -5.0 | -1.0 | -2.0% | |
| | 15:45 | 8 hr | 74 | 3 | ####### | 0.960 | 0.0026 | ####### | -5.0 | -2.0 | -4.0% | |
| | 21:45 | 14 hr | | | | | 0.0020 | | | | | |
| 8/9 | 7:45 | 24 hr | 73 | 5 | 0.975 | 0.966 | 0.0015 | 0.00141 | -5.5 | -0.5 | -1.0% | |

## Sieves

| Sieve | Total Weight (gm) | Tare Weight (gm) | Soil Weight (gm) | Raw % Ret. | Raw % Finer | Corr % Finer | Hydro taken (X) |
|---|---|---|---|---|---|---|---|
| Gravel | | | | | | | |
| 1 1/2 | | | | | | | |
| 1 | | | | | | | |
| 3/4 | | | | | | | |
| 1/2 | | | | | | | |
| 3/8 | | | | | | | |
| 1/4 | | | | | | | |
| #4 | | | | | | | |
| Sand | | | | | | | |
| #8 | | | | | | | |
| #10 | 0.00 | | 0.00 | 0.00% | 100.00% | | |
| #16 | 0.01 | | 0.01 | 0.02% | 99.98% | | |
| #20 | | | | | | | |
| #30 | 0.04 | | 0.04 | 0.08% | 99.92% | | |
| #40 | | | | | | | |
| #50 | 0.78 | | 0.78 | 1.56% | 98.44% | | |
| #60 | | | | | | | |
| #80 | | | | | | | |
| #100 | 40.36 | | 40.36 | 80.72% | 19.28% | | |
| #140 | | | | | | | |
| #200 | 49.37 | | 49.37 | 98.74% | 1.26% | | |
| Pan | | | | | | | |

**Total Weight:** 50.0 grams

Initial Water Content
Can No.: 25
148.3 Wet Wt. (grams)
147.8 Dry Wt. (grams)
0.5 Wt. H2O (grams)

Dry Wt.: 147.8
Tare Wt.: 22.2
Weight Sample: 125.5

H2O Content (%): 0.4%

*Oversize Correction*
Corr. % Finer = Raw % Finer x F
F = Ret on last Sieve

Last Sieve =
F =

# Grain Size Analysis

Project Title: Caminada Headland-05211
Project Number: 05-1102
Boring: D Depth: Overwash
Material: Gray sand w/shells
Total Sample Weight: 85.6 gm (Dry)
Hydrometer Sample Weight: 50 gm

Date: 8/10/2005
Done by: IK/EEL
Calc by: KA
Hydro No.:
Can after hydro:

## Hydrometer

| Date | True Time | Elapsed Time | Temp (°F) | Reading | Size Calc KL | Size Calc KT | Size Calc d' | Grain Size (mm) | % Calc Temp. corr | % Calc Corr. Rdg. | Raw % Finer | Corr. % Finer |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8/8 | 8:46 | start | | | | | | | | | | |
| | 8:47 | 1 min | 73 | 5 | 0.975 | 0.966 | 0.0580 | 0.05463 | -5.5 | -0.5 | -1.0% | -1.0% |
| | 8:48 | 2 min | 73 | 5 | 0.975 | 0.966 | 0.0410 | 0.03862 | -5.5 | -0.5 | -1.0% | -1.0% |
| | 8:51 | 5 min | 73 | 5 | 0.975 | 0.966 | 0.0280 | 0.02637 | -5.5 | -0.5 | -1.0% | -1.0% |
| | 9:01 | 15 min | 73 | 5 | 0.975 | 0.966 | 0.0150 | 0.01413 | -5.5 | -0.5 | -1.0% | -1.0% |
| | 9:16 | 30 min | 73 | 5 | 0.975 | 0.966 | 0.0100 | 0.00942 | -5.5 | -0.5 | -1.0% | -1.0% |
| | 9:46 | 1 hr | 73 | 5 | 0.975 | 0.966 | 0.0074 | 0.00697 | -5.5 | -0.5 | -1.0% | -1.0% |
| | 10:16 | 1.5 hr | 73 | 5 | 0.975 | 0.966 | 0.0060 | 0.00565 | -5.5 | -0.5 | -1.0% | -1.0% |
| | 10:46 | 2 hr | 73 | 5 | 0.975 | 0.966 | 0.0053 | 0.00499 | -5.5 | -0.5 | -1.0% | -1.0% |
| | 12:46 | 4 hr | 74 | 5 | 0.975 | 0.960 | 0.0037 | 0.00346 | -5.0 | 0.0 | 0.0% | 0.0% |
| | 16:46 | 8 hr | 74 | 5 | 0.975 | 0.960 | 0.0026 | 0.00243 | -5.0 | 0.0 | 0.0% | 0.0% |
| | 22:46 | 14 hr | | | | | 0.0020 | | | | | |
| 8/9 | 8:46 | 24 hr | 73 | 6 | 0.970 | 0.966 | 0.0015 | 0.00141 | -5.5 | 0.5 | 1.0% | 1.0% |

## Sieves

| Sieve | Total Weight (gm) | Tare Weight (gm) | Soil Weight (gm) | Raw % Ret. | Raw % Finer | Corr % Finer | Hydro taken (X) |
|---|---|---|---|---|---|---|---|
| Gravel | | | | | | | |
| 1 1/2 | | | | | | | |
| 1 | | | | | | | |
| 3/4 | | | | | | | |
| 1/2 | | | | | | | |
| 3/8 | | | | | | | |
| 1/4 | | | | | | | |
| #4 | 0.00 | | 0.00 | 0.00% | 100.00% | | |
| Sand | | | | | | | |
| #8 | 0.01 | | 0.01 | 0.01% | 99.99% | | |
| #10 | 0.03 | | 0.03 | 0.04% | 99.96% | | x |
| #16 | 0.02 | | 0.02 | 0.04% | 99.96% | 99.92% | |
| #20 | | | | | | | |
| #30 | 0.13 | | 0.13 | 0.26% | 99.74% | 99.71% | |
| #40 | | | | | | | |
| #50 | 0.22 | | 0.22 | 0.44% | 99.56% | 99.53% | |
| #60 | | | | | | | |
| #80 | | | | | | | |
| #100 | 31.42 | | 31.42 | 62.84% | 37.16% | 37.15% | |
| #140 | | | | | | | |
| #200 | 49.14 | | 49.14 | 98.28% | 1.72% | 1.72% | |
| Pan | | | | | | | |

**Total Weight:** 85.6 grams

Initial Water Content
Can No.: 709
123.1 Wet Wt. (grams)
114.1 Dry Wt. (grams)
9.0 Wt. H2O (grams)

Dry Wt.: 114.1
Tare Wt.: 28.4
Weight Sample: 85.6

H2O Content (%): 10.5%

*Oversize Correction*
Corr. % Finer = Raw % Finer x F
F = Ret on last Sieve

Last Sieve = #10
F = 99.96%

# Grain Size Analysis

Project Title: Caminada Headland-05211
Project Number: 05-1102
Boring: B Depth: Surf
Material: Gray sand w/shell pcs.
Total Sample Weight: 128.6 gm (Dry)
Hydrometer Sample Weight: 50 gm

Date: 8/10/2005
Done by: IK/EEL
Calc by: KA
Hydro No.:
Can after hydro:

## Hydrometer

| Date | True Time | Elapsed Time | Temp (°F) | Reading | Size Calc KL | Size Calc KT | Size Calc d' | Grain Size (mm) | % Calc Temp. corr | % Calc Corr. Rdg. | Raw % Finer | Corr. % Finer |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8/8 | 8:10 | start | | | | | | | | | | |
| | 8:11 | 1 min | 73 | 6 | 0.970 | 0.966 | 0.0580 | 0.05435 | -5.5 | 0.5 | 1.0% | 1.0% |
| | 8:12 | 2 min | 73 | 6 | 0.970 | 0.966 | 0.0410 | 0.03842 | -5.5 | 0.5 | 1.0% | 1.0% |
| | 8:15 | 5 min | 73 | 6 | 0.970 | 0.966 | 0.0280 | 0.02624 | -5.5 | 0.5 | 1.0% | 1.0% |
| | 8:25 | 15 min | 73 | 6 | 0.970 | 0.966 | 0.0150 | 0.01406 | -5.5 | 0.5 | 1.0% | 1.0% |
| | 8:40 | 30 min | 73 | 6 | 0.970 | 0.966 | 0.0100 | 0.00937 | -5.5 | 0.5 | 1.0% | 1.0% |
| | 9:10 | 1 hr | 73 | 6 | 0.970 | 0.966 | 0.0074 | 0.00693 | -5.5 | 0.5 | 1.0% | 1.0% |
| | 9:40 | 1.5 hr | 73 | 6 | 0.970 | 0.966 | 0.0060 | 0.00562 | -5.5 | 0.5 | 1.0% | 1.0% |
| | 10:10 | 2 hr | 73 | 6 | 0.970 | 0.966 | 0.0053 | 0.00497 | -5.5 | 0.5 | 1.0% | 1.0% |
| | 12:10 | 4 hr | 74 | 5 | 0.975 | 0.960 | 0.0037 | 0.00346 | -5.0 | 0.0 | 0.0% | 0.0% |
| | 16:10 | 8 hr | 74 | 5 | 0.975 | 0.960 | 0.0026 | 0.00243 | -5.0 | 0.0 | 0.0% | 0.0% |
| | 22:10 | 14 hr | | | | | 0.0020 | | | | | |
| 8/9 | 8:10 | 24 hr | 73 | 6 | 0.970 | 0.966 | 0.0015 | 0.00141 | -5.5 | 0.5 | 1.0% | 1.0% |

## Sieves

| Sieve | Total Weight (gm) | Tare Weight (gm) | Soil Weight (gm) | Raw % Ret. | Raw % Finer | Corr % Finer | Hydro taken (X) |
|---|---|---|---|---|---|---|---|
| Gravel | | | | | | | |
| 1 1/2 | | | | | | | |
| 1 | | | | | | | |
| 3/4 | | | | | | | |
| 1/2 | | | | | | | |
| 3/8 | | | | | | | |
| 1/4 | | | | | | | |
| #4 | 0.00 | | 0.00 | 0.00% | 100.00% | | |
| Sand | | | | | | | |
| #8 | 0.03 | | 0.03 | 0.02% | 99.98% | | |
| #10 | 0.08 | | 0.08 | 0.06% | 99.94% | | x |
| #16 | 0.05 | | 0.05 | 0.10% | 99.90% | 99.84% | |
| #20 | | | | | | | |
| #30 | 0.16 | | 0.16 | 0.32% | 99.68% | 99.62% | |
| #40 | | | | | | | |
| #50 | 0.46 | | 0.46 | 0.92% | 99.08% | 99.02% | |
| #60 | | | | | | | |
| #80 | | | | | | | |
| #100 | 34.64 | | 34.64 | 69.28% | 30.72% | 30.70% | |
| #140 | | | | | | | |
| #200 | 48.74 | | 48.74 | 97.48% | 2.52% | 2.52% | |
| Pan | | | | | | | |

**Total Weight:** 128.6 grams

Initial Water Content
Can No.: 36
179.0 Wet Wt. (grams)
150.7 Dry Wt. (grams)
28.3 Wt. H2O (grams)

Dry Wt.: 150.7
Tare Wt.: 22.1
Weight Sample: 128.6

H2O Content (%): 22.0%

*Oversize Correction*
Corr % Finer = Raw % Finer x F
F = Ret on last Sieve

Last Sieve = #10
F = 99.94%

# Grain Size Analysis

Project Title: Caminada Headland-05211
Project Number: 05-1102
Boring: B Depth: Beach
Material: Gray sand
Total Sample Weight: gm (Dry)
Hydrometer Sample Weight: 50 gm

Date: 8/10/2005
Done by: IK/EEL
Calc by: KA
Hydro No.:
Can after hydro:

## Hydrometer

| Date | True Time | Elapsed Time | Temp (°F) | Reading | Size Calc KL | Size Calc KT | Size Calc d' | Grain Size (mm) | % Calc Temp. corr | % Calc Corr. Rdg. | Raw % Finer | Corr. % Finer |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8/8 | 7:51 | start | | | | | | | | | | |
| | 7:52 | 1 min | 73 | 4 | ####### | 0.966 | 0.0580 | ####### | -5.5 | -1.5 | -3.0% | |
| | 7:53 | 2 min | 73 | 4 | ####### | 0.966 | 0.0410 | ####### | -5.5 | -1.5 | -3.0% | |
| | 7:56 | 5 min | 73 | 4 | ####### | 0.966 | 0.0280 | ####### | -5.5 | -1.5 | -3.0% | |
| | 8:06 | 15 min | 73 | 4 | ####### | 0.966 | 0.0150 | ####### | -5.5 | -1.5 | -3.0% | |
| | 8:21 | 30 min | 73 | 4 | ####### | 0.966 | 0.0100 | ####### | -5.5 | -1.5 | -3.0% | |
| | 8:51 | 1 hr | 73 | 4 | ####### | 0.966 | 0.0074 | ####### | -5.5 | -1.5 | -3.0% | |
| | 9:21 | 1.5 hr | 73 | 4 | ####### | 0.966 | 0.0060 | ####### | -5.5 | -1.5 | -3.0% | |
| | 9:51 | 2 hr | 73 | 4 | ####### | 0.966 | 0.0053 | ####### | -5.5 | -1.5 | -3.0% | |
| | 11:51 | 4 hr | 74 | 4 | ####### | 0.960 | 0.0037 | ####### | -5.0 | -1.0 | -2.0% | |
| | 15:51 | 8 hr | 74 | 4 | ####### | 0.960 | 0.0026 | ####### | -5.0 | -1.0 | -2.0% | |
| | 21:51 | 14 hr | | | | | 0.0020 | | | | | |
| 8/9 | 7:51 | 24 hr | 73 | 5 | 0.975 | 0.966 | 0.0015 | 0.00141 | -5.5 | -0.5 | -1.0% | |

## Sieves

| Sieve | Total Weight (gm) | Tare Weight (gm) | Soil Weight (gm) | Raw % Ret. | Raw % Finer | Corr % Finer | Hydro taken (X) |
|---|---|---|---|---|---|---|---|
| Gravel | | | | | | | |
| 1 1/2 | | | | | | | |
| 1 | | | | | | | |
| 3/4 | | | | | | | |
| 1/2 | | | | | | | |
| 3/8 | | | | | | | |
| 1/4 | | | | | | | |
| #4 | | | | | | | |
| Sand | | | | | | | |
| #8 | | | | | | | |
| #10 | | | | | | | |
| #16 | | | | | | | |
| #20 | | | | | | | |
| #30 | 0.00 | | 0.00 | 0.00% | 100.00% | | |
| #40 | | | | | | | |
| #50 | 0.10 | | 0.10 | 0.20% | 99.80% | | |
| #60 | | | | | | | |
| #80 | | | | | | | |
| #100 | 42.46 | | 42.46 | 84.92% | 15.08% | | |
| #140 | | | | | | | |
| #200 | 49.56 | | 49.56 | 99.12% | 0.88% | | |
| Pan | | | | | | | |

**Total Weight:** 50.0 grams

Initial Water Content
Can No.: 148
126.3 Wet Wt. (grams)
110.7 Dry Wt. (grams)
15.6 Wt. H2O (grams)

Dry Wt.: 110.7
Tare Wt.: 25.3
Weight Sample: 85.4

H2O Content (%): 18.2%

*Oversize Correction*
Corr % Finer = Raw % Finer x F
F = Ret on last Sieve

Last Sieve =
F =

# Grain Size Analysis

Project Title: Caminada Headland-05211
Project Number: 05-1102
Boring: D Depth: Surf
Material: Dark gray silty clay w/fine sand & orgs
Total Sample Weight: 98.3 gm (Dry)
Hydrometer Sample Weight: 50 gm

Date: 8/10/2005
Done by: IK/EEL
Calc by: KA
Hydro No.:
Can after hydro:

## Hydrometer

| Date | True Time | Elapsed Time | Temp (°F) | Reading | Size Calc KL | Size Calc KT | Size Calc d' | Grain Size (mm) | % Calc Temp. corr | % Calc Corr. Rdg. | Raw % Finer | Corr. % Finer |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8/8 | 8:40 | start | | | | | | | | | | |
| | 8:41 | 1 min | 73 | 42 | 0.770 | 0.966 | 0.0580 | 0.04314 | -5.5 | 36.5 | 73.0% | 73.0% |
| | 8:42 | 2 min | 73 | 38 | 0.790 | 0.966 | 0.0410 | 0.03129 | -5.5 | 32.5 | 65.0% | 65.0% |
| | 8:45 | 5 min | 73 | 34 | 0.815 | 0.966 | 0.0280 | 0.02204 | -5.5 | 28.5 | 57.0% | 57.0% |
| | 8:55 | 15 min | 73 | 30 | 0.840 | 0.966 | 0.0150 | 0.01217 | -5.5 | 24.5 | 49.0% | 49.0% |
| | 9:10 | 30 min | 73 | 28 | 0.850 | 0.966 | 0.0100 | 0.00821 | -5.5 | 22.5 | 45.0% | 45.0% |
| | 9:40 | 1 hr | 73 | 25 | 0.869 | 0.966 | 0.0074 | 0.00621 | -5.5 | 19.5 | 39.0% | 39.0% |
| | 10:10 | 1.5 hr | 73 | 24 | 0.875 | 0.966 | 0.0060 | 0.00507 | -5.5 | 18.5 | 37.0% | 37.0% |
| | 10:40 | 2 hr | 73 | 23 | 0.880 | 0.966 | 0.0053 | 0.00451 | -5.5 | 17.5 | 35.0% | 35.0% |
| | 12:40 | 4 hr | 74 | 21 | 0.892 | 0.960 | 0.0037 | 0.00317 | -5.0 | 16.0 | 32.0% | 32.0% |
| | 16:40 | 8 hr | 74 | 20 | 0.898 | 0.960 | 0.0026 | 0.00224 | -5.0 | 15.0 | 30.0% | 30.0% |
| | 22:40 | 14 hr | | | | | 0.0020 | | | | | |
| 8/9 | 8:40 | 24 hr | 73 | 19 | 0.903 | 0.966 | 0.0015 | 0.00131 | -5.5 | 13.5 | 27.0% | 27.0% |

## Sieves

| Sieve | Total Weight (gm) | Tare Weight (gm) | Soil Weight (gm) | Raw % Ret. | Raw % Finer | Corr % Finer | Hydro taken (X) |
|---|---|---|---|---|---|---|---|
| Gravel | | | | | | | |
| 1 1/2 | | | | | | | |
| 1 | | | | | | | |
| 3/4 | | | | | | | |
| 1/2 | | | | | | | |
| 3/8 | | | | | | | |
| 1/4 | | | | | | | |
| #4 | | | | | | | |
| Sand | | | | | | | |
| #8 | 0.00 | | 0.00 | 0.00% | 100.00% | | |
| #10 | 0.05 | | 0.05 | 0.05% | 99.95% | | x |
| #16 | 0.01 | | 0.01 | 0.02% | 99.98% | 99.93% | |
| #20 | | | | | | | |
| #30 | 0.05 | | 0.05 | 0.10% | 99.90% | 99.85% | |
| #40 | | | | | | | |
| #50 | 0.36 | | 0.36 | 0.72% | 99.28% | 99.23% | |
| #60 | | | | | | | |
| #80 | | | | | | | |
| #100 | 1.54 | | 1.54 | 3.08% | 96.92% | 96.87% | |
| #140 | | | | | | | |
| #200 | 4.10 | | 4.10 | 8.20% | 91.80% | 91.75% | |
| Pan | | | | | | | |

**Total Weight:** 98.3 grams

Initial Water Content
Can No.: 559
178.9 Wet Wt. (grams)
119.1 Dry Wt. (grams)
59.8 Wt. H2O (grams)

Dry Wt.: 119.1
Tare Wt.: 20.8
Weight Sample: 98.3

H2O Content (%): 60.9%

*Oversize Correction*
Corr % Finer = Raw % Finer x F
F = Ret on last Sieve

Last Sieve = #10
F = 99.95%

# Grain Size Analysis

Project Title: Caminada Headland-05211
Project Number: 05-1102
Boring: D Depth: Marsh
Material: Dark gray silty clay w/fine sand,shells, wood
Total Sample Weight: gm (Dry)
Hydrometer Sample Weight: 50 gm

Date: 8/10/2005
Done by: IK/EEL
Calc by: KA
Hydro No.:
Can after hydro:

## Hydrometer

| Date | True Time | Elapsed Time | Temp (°F) | Reading | Size Calc KL | KT | d' | Grain Size (mm) | % Calc Temp. corr | Corr. Rdg. | Raw % Finer | Corr. % Finer |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8/8 | 8:33 | start | | | | | | | | | | |
| | 8:34 | 1 min | 73 | 33 | 0.822 | 0.966 | 0.0580 | 0.04606 | -5.5 | 27.5 | 55.0% | |
| | 8:35 | 2 min | 73 | 30 | 0.840 | 0.966 | 0.0410 | 0.03327 | -5.5 | 24.5 | 49.0% | |
| | 8:38 | 5 min | 73 | 22 | 0.885 | 0.966 | 0.0280 | 0.02394 | -5.5 | 16.5 | 33.0% | |
| | 8:48 | 15 min | 73 | 20 | 0.898 | 0.966 | 0.0150 | 0.01301 | -5.5 | 14.5 | 29.0% | |
| | 9:03 | 30 min | 73 | 18 | 0.908 | 0.966 | 0.0100 | 0.00877 | -5.5 | 12.5 | 25.0% | |
| | 9:33 | 1 hr | 73 | 17 | 0.913 | 0.966 | 0.0074 | 0.00653 | -5.5 | 11.5 | 23.0% | |
| | 10:03 | 1.5 hr | 73 | 16 | 0.918 | 0.966 | 0.0060 | 0.00532 | -5.5 | 10.5 | 21.0% | |
| | 10:33 | 2 hr | 73 | 16 | 0.918 | 0.966 | 0.0053 | 0.0047 | -5.5 | 10.5 | 21.0% | |
| | 12:33 | 4 hr | 74 | 14 | 0.930 | 0.960 | 0.0037 | 0.0033 | -5.0 | 9.0 | 18.0% | |
| | 16:33 | 8 hr | 74 | 14 | 0.930 | 0.960 | 0.0026 | 0.00232 | -5.0 | 9.0 | 18.0% | |
| | 22:33 | 14 hr | | | | | 0.0020 | | | | | |
| 8/9 | 8:33 | 24 hr | 73 | 13 | 0.935 | 0.966 | 0.0015 | 0.00135 | -5.5 | 7.5 | 15.0% | |

## Sieves

| Sieve | Total Weight (gm) | Tare Weight (gm) | Soil Weight (gm) | Raw % Ret. | Raw % Finer | Corr % Finer | Hydro taken (X) |
|---|---|---|---|---|---|---|---|
| Gravel | | | | | | | |
| 1 1/2 | | | | | | | |
| 1 | | | | | | | |
| 3/4 | | | | | | | |
| 1/2 | | | | | | | |
| 3/8 | | | | | | | |
| 1/4 | | | | | | | |
| #4 | | | | | | | |
| Sand | | | | | | | |
| #8 | | | | | | | |
| #10 | 0.00 | | 0.00 | 0.00% | 100.00% | | |
| #16 | 0.05 | | 0.05 | 0.10% | 99.90% | | |
| #20 | | | | | | | |
| #30 | 0.36 | | 0.36 | 0.72% | 99.28% | | |
| #40 | | | | | | | |
| #50 | 1.19 | | 1.19 | 2.38% | 97.62% | | |
| #60 | | | | | | | |
| #80 | | | | | | | |
| #100 | 6.20 | | 6.20 | 12.40% | 87.60% | | |
| #140 | | | | | | | |
| #200 | 11.33 | | 11.33 | 22.66% | 77.34% | | |
| Pan | | | | | | | |

**Total Weight:** 50.0 grams

Initial Water Content
Can No.: 7
368.8 Wet Wt. (grams)
248.7 Dry Wt. (grams)
120.1 Wt. H2O (grams)

Dry Wt.: 248.7
Tare Wt.: 164.2
Weight Sample: 84.5

H2O Content (%): 142.1%

*Oversize Correction*
Corr. % Finer = Raw % Finer x F
F = Ret on last Sieve

Last Sieve =
F =

# Grain Size Analysis

Project Title: Caminada Headland-05211
Project Number: 05-1102
Boring: D Depth: Beach
Material: Dark gray silty fine sand w/shells
Total Sample Weight: 89.6 gm (Dry)
Hydrometer Sample Weight: 50 gm

Date: 8/10/2005
Done by: IK/EEL
Calc by: KA

Hydro No.:
Can after hydro:

## Hydrometer

| Date | True Time | Elapsed Time | Temp (°F) | Reading | Size Calc KL | Size Calc KT | Size Calc d' | Grain Size (mm) | % Calc Temp. corr | % Calc Corr. Rdg. | Raw % Finer | Corr. % Finer |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8/8 | 8:25 | start | | | | | | | | | | |
| | 8:26 | 1 min | 73 | 6 | 0.970 | 0.966 | 0.0580 | 0.05435 | -5.5 | 0.5 | 1.0% | 1.0% |
| | 8:27 | 2 min | 73 | 6 | 0.970 | 0.966 | 0.0410 | 0.03842 | -5.5 | 0.5 | 1.0% | 1.0% |
| | 8:30 | 5 min | 73 | 6 | 0.970 | 0.966 | 0.0280 | 0.02624 | -5.5 | 0.5 | 1.0% | 1.0% |
| | 8:40 | 15 min | 73 | 6 | 0.970 | 0.966 | 0.0150 | 0.01406 | -5.5 | 0.5 | 1.0% | 1.0% |
| | 8:55 | 30 min | 73 | 6 | 0.970 | 0.966 | 0.0100 | 0.00937 | -5.5 | 0.5 | 1.0% | 1.0% |
| | 9:25 | 1 hr | 73 | 6 | 0.970 | 0.966 | 0.0074 | 0.00693 | -5.5 | 0.5 | 1.0% | 1.0% |
| | 9:55 | 1.5 hr | 73 | 6 | 0.970 | 0.966 | 0.0060 | 0.00562 | -5.5 | 0.5 | 1.0% | 1.0% |
| | 10:25 | 2 hr | 73 | 6 | 0.970 | 0.966 | 0.0053 | 0.00497 | -5.5 | 0.5 | 1.0% | 1.0% |
| | 12:25 | 4 hr | 74 | 5 | 0.975 | 0.960 | 0.0037 | 0.00346 | -5.0 | 0.0 | 0.0% | 0.0% |
| | 16:25 | 8 hr | 74 | 5 | 0.975 | 0.960 | 0.0026 | 0.00243 | -5.0 | 0.0 | 0.0% | 0.0% |
| | 22:25 | 14 hr | | | | | 0.0020 | | | | | |
| 8/9 | 8:25 | 24 hr | 73 | 6 | 0.970 | 0.966 | 0.0015 | 0.00141 | -5.5 | 0.5 | 1.0% | 1.0% |

## Sieves

| Sieve | Total Weight (gm) | Tare Weight (gm) | Soil Weight (gm) | Raw % Ret. | Raw % Finer | Corr % Finer | Hydro taken (X) |
|---|---|---|---|---|---|---|---|
| Gravel | | | | | | | |
| 1 1/2 | | | | | | | |
| 1 | | | | | | | |
| 3/4 | | | | | | | |
| 1/2 | | | | | | | |
| 3/8 | 0.00 | | 0.00 | 0.00% | 100.00% | | |
| 1/4 | 0.12 | | 0.12 | 0.13% | 99.87% | | |
| #4 | 0.25 | | 0.25 | 0.28% | 99.72% | | |
| Sand | | | | | | | |
| #8 | 0.50 | | 0.50 | 0.56% | 99.44% | | |
| #10 | 0.75 | | 0.75 | 0.84% | 99.16% | | x |
| #16 | 0.02 | | 0.02 | 0.04% | 99.96% | 99.12% | |
| #20 | | | | | | | |
| #30 | 0.09 | | 0.09 | 0.18% | 99.82% | 98.98% | |
| #40 | | | | | | | |
| #50 | 0.23 | | 0.23 | 0.46% | 99.54% | 98.71% | |
| #60 | | | | | | | |
| #80 | | | | | | | |
| #100 | 23.73 | | 23.73 | 47.46% | 52.54% | 52.10% | |
| #140 | | | | | | | |
| #200 | 48.37 | | 48.37 | 96.74% | 3.26% | 3.23% | |
| Pan | | | | | | | |

**Total Weight:** 89.6 grams

Initial Water Content
Can No.: 515
133.5 Wet Wt. (grams)
110.6 Dry Wt. (grams)
22.9 Wt. H2O (grams)

Dry Wt.: 110.6
Tare Wt.: 21.0
Weight Sample: 89.6

H2O Content (%): 25.6%

*Oversize Correction*
Corr. % Finer = Raw % Finer x F
F = Ret on last Sieve

Last Sieve = #10
F = 99.16%

# Grain Size Analysis

Project Title: Caminada Headland-05211
Project Number: 05-1102
Boring: F Depth: Beach
Material: Gray very fine sand w/shells
Total Sample Weight: 110.2 gm (Dry)
Hydrometer Sample Weight: 50 gm

Date: 8/10/2005
Done by: IK/EEL
Calc by: KA
Hydro No.:
Can after hydro:

## Hydrometer

| Date | True Time | Elapsed Time | Temp (°F) | Reading | Size Calc KL | Size Calc KT | Size Calc d' | Grain Size (mm) | % Calc Temp. corr | % Calc Corr. Rdg. | Raw % Finer | Corr. % Finer |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8/8 | 8:52 | start | | | | | | | | | | |
| | 8:53 | 1 min | 73 | 6 | 0.970 | 0.966 | 0.0580 | 0.05435 | -5.5 | 0.5 | 1.0% | 1.0% |
| | 8:54 | 2 min | 73 | 6 | 0.970 | 0.966 | 0.0410 | 0.03842 | -5.5 | 0.5 | 1.0% | 1.0% |
| | 8:57 | 5 min | 73 | 6 | 0.970 | 0.966 | 0.0280 | 0.02624 | -5.5 | 0.5 | 1.0% | 1.0% |
| | 9:07 | 15 min | 73 | 6 | 0.970 | 0.966 | 0.0150 | 0.01406 | -5.5 | 0.5 | 1.0% | 1.0% |
| | 9:22 | 30 min | 73 | 6 | 0.970 | 0.966 | 0.0100 | 0.00937 | -5.5 | 0.5 | 1.0% | 1.0% |
| | 9:52 | 1 hr | 73 | 6 | 0.970 | 0.966 | 0.0074 | 0.00693 | -5.5 | 0.5 | 1.0% | 1.0% |
| | 10:22 | 1.5 hr | 73 | 6 | 0.970 | 0.966 | 0.0060 | 0.00562 | -5.5 | 0.5 | 1.0% | 1.0% |
| | 10:52 | 2 hr | 73 | 6 | 0.970 | 0.966 | 0.0053 | 0.00497 | -5.5 | 0.5 | 1.0% | 1.0% |
| | 12:52 | 4 hr | 74 | 5 | 0.975 | 0.960 | 0.0037 | 0.00346 | -5.0 | 0.0 | 0.0% | 0.0% |
| | 16:52 | 8 hr | 74 | 5 | 0.975 | 0.960 | 0.0026 | 0.00243 | -5.0 | 0.0 | 0.0% | 0.0% |
| | 22:52 | 14 hr | | | | | 0.0020 | | | | | |
| 8/9 | 8:52 | 24 hr | 73 | 6 | 0.970 | 0.966 | 0.0015 | 0.00141 | -5.5 | 0.5 | 1.0% | 1.0% |

## Sieves

| Sieve | Total Weight (gm) | Tare Weight (gm) | Soil Weight (gm) | Raw % Ret. | Raw % Finer | Corr % Finer | Hydro taken (X) |
|---|---|---|---|---|---|---|---|
| Gravel | | | | | | | |
| 1 1/2 | | | | | | | |
| 1 | | | | | | | |
| 3/4 | | | | | | | |
| 1/2 | | | | | | | |
| 3/8 | 0.00 | | 0.00 | 0.00% | 100.00% | | |
| 1/4 | 0.01 | | 0.01 | 0.01% | 99.99% | | |
| #4 | | | | | | | |
| Sand | | | | | | | |
| #8 | | | | | | | |
| #10 | 0.01 | | 0.01 | 0.01% | 99.99% | | x |
| #16 | | | | | | | |
| #20 | | | | | | | |
| #30 | 0.01 | | 0.01 | 0.02% | 99.98% | 99.97% | |
| #40 | | | | | | | |
| #50 | 0.05 | | 0.05 | 0.10% | 99.90% | 99.89% | |
| #60 | | | | | | | |
| #80 | | | | | | | |
| #100 | 26.15 | | 26.15 | 52.30% | 47.70% | 47.70% | |
| #140 | | | | | | | |
| #200 | 48.65 | | 48.65 | 97.30% | 2.70% | 2.70% | |
| Pan | | | | | | | |

**Total Weight:** 110.2 grams

Initial Water Content
Can No.: 3
167.9 Wet Wt. (grams)
136.7 Dry Wt. (grams)
31.2 Wt. H2O (grams)

Dry Wt.: 136.7
Tare Wt.: 26.5
Weight Sample: 110.2

H2O Content (%): 28.3%

*Oversize Correction*
Corr % Finer = Raw % Finer x F
F = Ret on last Sieve

Last Sieve = #10
F = 99.99%

# Grain Size Analysis

Project Title: Caminada Headland-05211
Project Number: 05-1102
Boring: F Depth: Dune/Overwash
Material: Light Gray very fine sand
Total Sample Weight: gm (Dry)
Hydrometer Sample Weight: 50 gm

Date: 8/10/2005
Done by: IK/EEL
Calc by: KA

Hydro No.:
Can after hydro:

## Hydrometer

| Date | True Time | Elapsed Time | Temp (°F) | Reading | Size Calc KL | Size Calc KT | Size Calc d' | Grain Size (mm) | % Calc Temp. corr | % Calc Corr. Rdg. | Raw % Finer | Corr. % Finer |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8/8 | 8:57 | start | | | | | | | | | | |
| | 8:58 | 1 min | 73 | 6 | 0.970 | 0.966 | 0.0580 | 0.05435 | -5.5 | 0.5 | 1.0% | |
| | 8:59 | 2 min | 73 | 6 | 0.970 | 0.966 | 0.0410 | 0.03842 | -5.5 | 0.5 | 1.0% | |
| | 9:02 | 5 min | 73 | 6 | 0.970 | 0.966 | 0.0280 | 0.02624 | -5.5 | 0.5 | 1.0% | |
| | 9:12 | 15 min | 73 | 6 | 0.970 | 0.966 | 0.0150 | 0.01406 | -5.5 | 0.5 | 1.0% | |
| | 9:27 | 30 min | 73 | 6 | 0.970 | 0.966 | 0.0100 | 0.00937 | -5.5 | 0.5 | 1.0% | |
| | 9:57 | 1 hr | 73 | 6 | 0.970 | 0.966 | 0.0074 | 0.00693 | -5.5 | 0.5 | 1.0% | |
| | 10:27 | 1.5 hr | 73 | 6 | 0.970 | 0.966 | 0.0060 | 0.00562 | -5.5 | 0.5 | 1.0% | |
| | 10:57 | 2 hr | 73 | 6 | 0.970 | 0.966 | 0.0053 | 0.00497 | -5.5 | 0.5 | 1.0% | |
| | 12:57 | 4 hr | 74 | 5 | 0.975 | 0.960 | 0.0037 | 0.00346 | -5.0 | 0.0 | 0.0% | |
| | 16:57 | 8 hr | 74 | 5 | 0.975 | 0.960 | 0.0026 | 0.00243 | -5.0 | 0.0 | 0.0% | |
| | 22:57 | 14 hr | | | | | 0.0020 | | | | | |
| 8/9 | 8:57 | 24 hr | 73 | 6 | 0.970 | 0.966 | 0.0015 | 0.00141 | -5.5 | 0.5 | 1.0% | |

## Sieves

| Sieve | Total Weight (gm) | Tare Weight (gm) | Soil Weight (gm) | Raw % Ret. | Raw % Finer | Corr % Finer | Hydro taken (X) |
|---|---|---|---|---|---|---|---|
| Gravel | | | | | | | |
| 1 1/2 | | | | | | | |
| 1 | | | | | | | |
| 3/4 | | | | | | | |
| 1/2 | | | | | | | |
| 3/8 | | | | | | | |
| 1/4 | | | | | | | |
| #4 | | | | | | | |
| Sand | | | | | | | |
| #8 | | | | | | | |
| #10 | | | | | | | |
| #16 | | | | | | | |
| #20 | | | | | | | |
| #30 | 0.00 | | 0.00 | 0.00% | 100.00% | | |
| #40 | | | | | | | |
| #50 | 0.02 | | 0.02 | 0.04% | 99.96% | | |
| #60 | | | | | | | |
| #80 | | | | | | | |
| #100 | 32.77 | | 32.77 | 65.54% | 34.46% | | |
| #140 | | | | | | | |
| #200 | 49.36 | | 49.36 | 98.72% | 1.28% | | |
| Pan | | | | | | | |

**Total Weight:** 50.0 grams

Initial Water Content
Can No.: 121
124.9 Wet Wt. (grams)
121.3 Dry Wt. (grams)
3.6 Wt. H2O (grams)

Dry Wt.: 121.3
Tare Wt.: 29.1
Weight Sample: 92.2

H2O Content (%): 3.9%

*Oversize Correction*
Corr % Finer = Raw % Finer x F
F = Ret on last Sieve

Last Sieve =
F =

# Grain Size Analysis

Project Title: Caminada Headland-05211
Project Number: 05-1102
Boring: F Depth: Surface Zone
Material: Dark Gray very fine sand w/shells
Total Sample Weight: 141.7 gm (Dry)
Hydrometer Sample Weight: 50 gm

Date: 8/10/2005
Done by: IK/EEL
Calc by: KA
Hydro No.:
Can after hydro:

## Hydrometer

| Date | True Time | Elapsed Time | Temp (°F) | Reading | Size Calc KL | Size Calc KT | Size Calc d' | Grain Size (mm) | % Calc Temp. corr | % Calc Corr. Rdg. | Raw % Finer | Corr. % Finer |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8/8 | 9:02 | start | | | | | | | | | | |
| | 9:03 | 1 min | 73 | 6 | 0.970 | 0.966 | 0.0580 | 0.05435 | -5.5 | 0.5 | 1.0% | 1.0% |
| | 9:04 | 2 min | 73 | 6 | 0.970 | 0.966 | 0.0410 | 0.03842 | -5.5 | 0.5 | 1.0% | 1.0% |
| | 9:07 | 5 min | 73 | 6 | 0.970 | 0.966 | 0.0280 | 0.02624 | -5.5 | 0.5 | 1.0% | 1.0% |
| | 9:17 | 15 min | 73 | 6 | 0.970 | 0.966 | 0.0150 | 0.01406 | -5.5 | 0.5 | 1.0% | 1.0% |
| | 9:32 | 30 min | 73 | 6 | 0.970 | 0.966 | 0.0100 | 0.00937 | -5.5 | 0.5 | 1.0% | 1.0% |
| | 10:02 | 1 hr | 73 | 6 | 0.970 | 0.966 | 0.0074 | 0.00693 | -5.5 | 0.5 | 1.0% | 1.0% |
| | 10:32 | 1.5 hr | 73 | 6 | 0.970 | 0.966 | 0.0060 | 0.00562 | -5.5 | 0.5 | 1.0% | 1.0% |
| | 11:02 | 2 hr | 73 | 6 | 0.970 | 0.966 | 0.0053 | 0.00497 | -5.5 | 0.5 | 1.0% | 1.0% |
| | 13:02 | 4 hr | 74 | 5 | 0.975 | 0.960 | 0.0037 | 0.00346 | -5.0 | 0.0 | 0.0% | 0.0% |
| | 17:02 | 8 hr | 74 | 5 | 0.975 | 0.960 | 0.0026 | 0.00243 | -5.0 | 0.0 | 0.0% | 0.0% |
| | 23:02 | 14 hr | | | | | 0.0020 | | | | | |
| 8/9 | 9:02 | 24 hr | 73 | 6 | 0.970 | 0.966 | 0.0015 | 0.00141 | -5.5 | 0.5 | 1.0% | 1.0% |

## Sieves

| Sieve | Total Weight (gm) | Tare Weight (gm) | Soil Weight (gm) | Raw % Ret. | Raw % Finer | Corr % Finer | Hydro taken (X) |
|---|---|---|---|---|---|---|---|
| Gravel | | | | | | | |
| 1 1/2 | | | | | | | |
| 1 | | | | | | | |
| 3/4 | | | | | | | |
| 1/2 | | | | | | | |
| 3/8 | | | | | | | |
| 1/4 | 0.00 | | 0.00 | 0.00% | 100.00% | | |
| #4 | 0.02 | | 0.02 | 0.01% | 99.99% | | |
| Sand | | | | | | | |
| #8 | 0.18 | | 0.18 | 0.13% | 99.87% | | |
| #10 | 0.34 | | 0.34 | 0.24% | 99.76% | | x |
| #16 | 0.05 | | 0.05 | 0.10% | 99.90% | 99.66% | |
| #20 | | | | | | | |
| #30 | 0.20 | | 0.20 | 0.40% | 99.60% | 99.36% | |
| #40 | | | | | | | |
| #50 | 0.29 | | 0.29 | 0.58% | 99.42% | 99.18% | |
| #60 | | | | | | | |
| #80 | | | | | | | |
| #100 | 18.20 | | 18.20 | 36.40% | 63.60% | 63.45% | |
| #140 | | | | | | | |
| #200 | 48.55 | | 48.55 | 97.10% | 2.90% | 2.89% | |
| Pan | | | | | | | |

**Total Weight:** 141.7 grams

Initial Water Content
Can No.: 174
211.8 Wet Wt. (grams)
170.4 Dry Wt. (grams)
41.4 Wt. H2O (grams)

Dry Wt.: 170.4
Tare Wt.: 28.7
Weight Sample: 141.7

H2O Content (%): 29.2%

*Oversize Correction*
Corr % Finer = Raw % Finer x F
F = Ret on last Sieve

Last Sieve = #10
F = 99.76%

## Granularmetric Report

Depths and elevations based on measured values

COASTAL TECH
Coastal Geology & Sediments Laboratory

Project Name: Caminada Headland
Sample Name: B-Beach
Analysis Date: 09-14-05
Analyzed By: WJD

Coastal Tech
715-G North Dr.
Melbourne, Fl. 32934
ph (321) 751-1135
fax (321) 751-2343

| Easting (m): | Northing (m): | Coordinate System: | Elevation (ft): |
|---|---|---|---|
| | | | |

| USCS: | Munsell: | Comments: |
|---|---|---|
| SP | | |

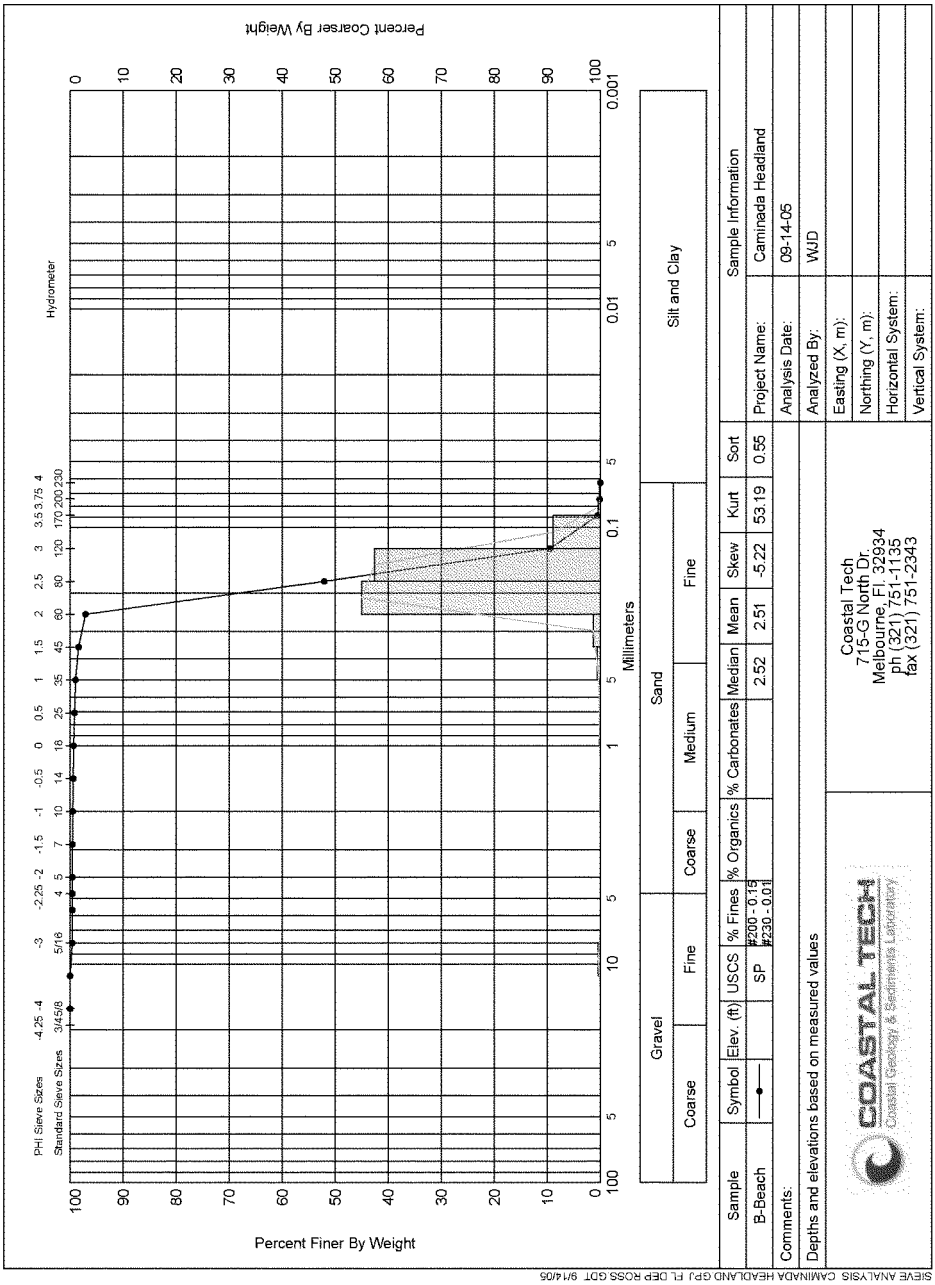
| Dry Weight (g): | Wash Weight (g): | Pan Retained (g): | Sieve Loss (%): | Fines (%): | Organics (%): | Carbonates (%): | Shells (%): |
|---|---|---|---|---|---|---|---|
| 104.55 | | 0.01 | | #200 - 0.15<br>#230 - 0.01 | | | |

| Sieve Number | Sieve Size (Phi) | Sieve Size (Millimeters) | Grams Retained | % Weight Retained | Cum. Grams Retained | C. % Weight Retained |
|---|---|---|---|---|---|---|
| 5/8" | -4.00 | 16.00 | | 0.00 | 0.00 | 0.00 |
| 11/16" | -3.50 | 11.31 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5/16" | -3.00 | 8.00 | 0.43 | 0.41 | 0.43 | 0.41 |
| 3.5 | -2.50 | 5.66 | 0.00 | 0.00 | 0.43 | 0.41 |
| 4 | -2.25 | 4.76 | 0.00 | 0.00 | 0.43 | 0.41 |
| 5 | -2.00 | 4.00 | 0.00 | 0.00 | 0.43 | 0.41 |
| 7 | -1.50 | 2.83 | 0.03 | 0.03 | 0.46 | 0.44 |
| 10 | -1.00 | 2.00 | 0.05 | 0.05 | 0.51 | 0.49 |
| 14 | -0.50 | 1.41 | 0.11 | 0.11 | 0.62 | 0.59 |
| 18 | 0.00 | 1.00 | 0.05 | 0.05 | 0.67 | 0.64 |
| 25 | 0.50 | 0.71 | 0.20 | 0.19 | 0.87 | 0.83 |
| 35 | 1.00 | 0.50 | 0.16 | 0.15 | 1.03 | 0.99 |
| 45 | 1.50 | 0.35 | 0.62 | 0.59 | 1.65 | 1.58 |
| 60 | 2.00 | 0.25 | 1.38 | 1.32 | 3.03 | 2.90 |
| 80 | 2.50 | 0.18 | 47.07 | 45.02 | 50.10 | 47.92 |
| 120 | 3.00 | 0.13 | 44.52 | 42.58 | 94.62 | 90.50 |
| 170 | 3.50 | 0.09 | 9.34 | 8.93 | 103.96 | 99.44 |
| 200 | 3.75 | 0.07 | 0.43 | 0.41 | 104.39 | 99.85 |
| 230 | 4.00 | 0.06 | 0.15 | 0.14 | 104.54 | 99.99 |

| Phi 5 | Phi 16 | Phi 25 | Phi 50 | Phi 75 | Phi 84 | Phi 95 |
|---|---|---|---|---|---|---|
| 3.25 | 2.92 | 2.82 | 2.52 | 2.25 | 2.15 | 2.02 |

| Moment Statistics | Mean Phi | Mean mm | Sorting | Skewness | Kurtosis |
|---|---|---|---|---|---|
| | 2.51 | 0.18 | 0.55 | -5.22 | 53.19 |

GRANULARMETRIC REPORT CAMINADA HEADLAND.GPJ FL DEP ROSS.GDT 9/14/05


Percent Finer By Weight
Percent Coarser By Weight
Phi Sieve Sizes
Standard Sieve Sizes
Hydrometer
Millimeters
Gravel
Sand
Silt and Clay
Coarse
Fine
Coarse
Medium
Fine
Sample
Symbol
Elev. (ft)
USCS
% Fines
% Organics
% Carbonates
Median
Mean
Skew
Kurt
Sort
B-Beach
SP
#200 - 0.15
#230 - 0.01
2.52
2.51
-5.22
53.19
0.55
Comments:
Depths and elevations based on measured values
COASTAL TECH
Coastal Geology & Sediments Laboratory
Coastal Tech
715-G North Dr.
Melbourne, Fl. 32934
ph (321) 751-1135
fax (321) 751-2343
Sample Information
Project Name:
Caminada Headland
Analysis Date:
09-14-05
Analyzed By:
WJD
Easting (X, m):
Northing (Y, m):
Horizontal System:
Vertical System:
SIEVE ANALYSIS CAMINADA HEADLAND.GPJ FL DEP ROSS.GDT 9/14/06

## Granularmetric Report

Depths and elevations based on measured values

COASTAL TECH
Coastal Geology & Sediments Laboratory

Project Name: Caminada Headland
Sample Name: B-Dune
Analysis Date: 09-14-05
Analyzed By: WJD

Coastal Tech
715-G North Dr.
Melbourne, Fl. 32934
ph (321) 751-1135
fax (321) 751-2343

| Easting (m): | Northing (m): | Coordinate System: | Elevation (ft): |
|---|---|---|---|
| | | | |

| USCS: | Munsell: | Comments: |
|---|---|---|
| SP | | |

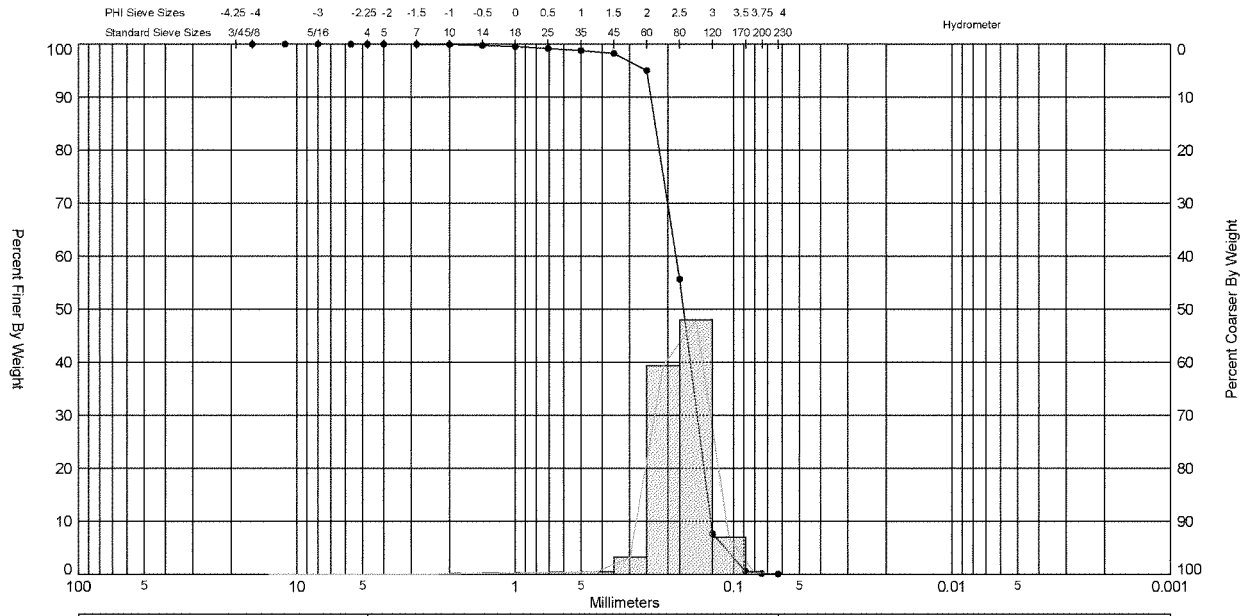
| Dry Weight (g): | Wash Weight (g): | Pan Retained (g): | Sieve Loss (%): | Fines (%): #200 - 0.18 #230 - 0.07 | Organics (%): | Carbonates (%): | Shells (%): |
|---|---|---|---|---|---|---|---|
| 97.13 | | 0.07 | | | | | |

| Sieve Number | Sieve Size (Phi) | Sieve Size (Millimeters) | Grams Retained | % Weight Retained | Cum. Grams Retained | C. % Weight Retained |
|---|---|---|---|---|---|---|
| 5/8" | -4.00 | 16.00 | | 0.00 | 0.00 | 0.00 |
| 11/16" | -3.50 | 11.31 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5/16" | -3.00 | 8.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3.5 | -2.50 | 5.66 | 0.00 | 0.00 | 0.00 | 0.00 |
| 4 | -2.25 | 4.76 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5 | -2.00 | 4.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7 | -1.50 | 2.83 | 0.02 | 0.02 | 0.02 | 0.02 |
| 10 | -1.00 | 2.00 | 0.05 | 0.05 | 0.07 | 0.07 |
| 14 | -0.50 | 1.41 | 0.15 | 0.15 | 0.22 | 0.23 |
| 18 | 0.00 | 1.00 | 0.23 | 0.24 | 0.45 | 0.46 |
| 25 | 0.50 | 0.71 | 0.34 | 0.35 | 0.79 | 0.81 |
| 35 | 1.00 | 0.50 | 0.38 | 0.39 | 1.17 | 1.20 |
| 45 | 1.50 | 0.35 | 0.52 | 0.54 | 1.69 | 1.74 |
| 60 | 2.00 | 0.25 | 3.14 | 3.23 | 4.83 | 4.97 |
| 80 | 2.50 | 0.18 | 38.21 | 39.34 | 43.04 | 44.31 |
| 120 | 3.00 | 0.13 | 46.62 | 48.00 | 89.66 | 92.31 |
| 170 | 3.50 | 0.09 | 6.84 | 7.04 | 96.50 | 99.35 |
| 200 | 3.75 | 0.07 | 0.46 | 0.47 | 96.96 | 99.82 |
| 230 | 4.00 | 0.06 | 0.10 | 0.10 | 97.06 | 99.93 |

| Phi 5 | Phi 16 | Phi 25 | Phi 50 | Phi 75 | Phi 84 | Phi 95 |
|---|---|---|---|---|---|---|
| 3.19 | 2.91 | 2.82 | 2.56 | 2.25 | 2.14 | 2.00 |

| Moment Statistics | Mean Phi | Mean mm | Sorting | Skewness | Kurtosis |
|---|---|---|---|---|---|
| | 2.52 | 0.17 | 0.45 | -2.21 | 16.47 |

GRANULARMETRIC REPORT CAMINADA HEADLAND.GPJ FL DEP ROSS.GDT 9/14/05




| Gravel | | Sand | | | Silt and Clay |
|---|---|---|---|---|---|
| Coarse | Fine | Coarse | Medium | Fine | |

| Sample | Symbol | Elev. (ft) | USCS | % Fines | % Organics | % Carbonates | Median | Mean | Skew | Kurt | Sort |
|---|---|---|---|---|---|---|---|---|---|---|---|
| B-Dune | —●— | | SP | #200 - 0.18<br>#230 - 0.07 | | | 2.56 | 2.52 | -2.21 | 16.47 | 0.45 |

Comments:

Depths and elevations based on measured values

| Sample Information | |
|---|---|
| Project Name: | Caminada Headland |
| Analysis Date: | 09-14-05 |
| Analyzed By: | WJD |
| Easting (X, m): | |
| Northing (Y, m): | |
| Horizontal System: | |
| Vertical System: | |

COASTAL TECH
Coastal Geology & Sediments Laboratory

Coastal Tech
715-G North Dr.
Melbourne, Fl. 32934
ph (321) 751-1135
fax (321) 751-2343

SIEVE ANALYSIS CAMINADA HEADLAND.GPJ FL DEP ROSS.GDT 9/14/05

## Granularmetric Report

Depths and elevations based on measured values

COASTAL TECH
Coastal Geology & Sediments Laboratory

Coastal Tech
715-G North Dr.
Melbourne, Fl. 32934
ph (321) 751-1135
fax (321) 751-2343

Project Name: Caminada Headland
Sample Name: C-Beach
Analysis Date: 09-14-05
Analyzed By: WJD

| Easting (m): | Northing (m): | Coordinate System: | Elevation (ft): |
|---|---|---|---|
| | | | |

| USCS: | Munsell: | Comments: |
|---|---|---|
| SP | | |

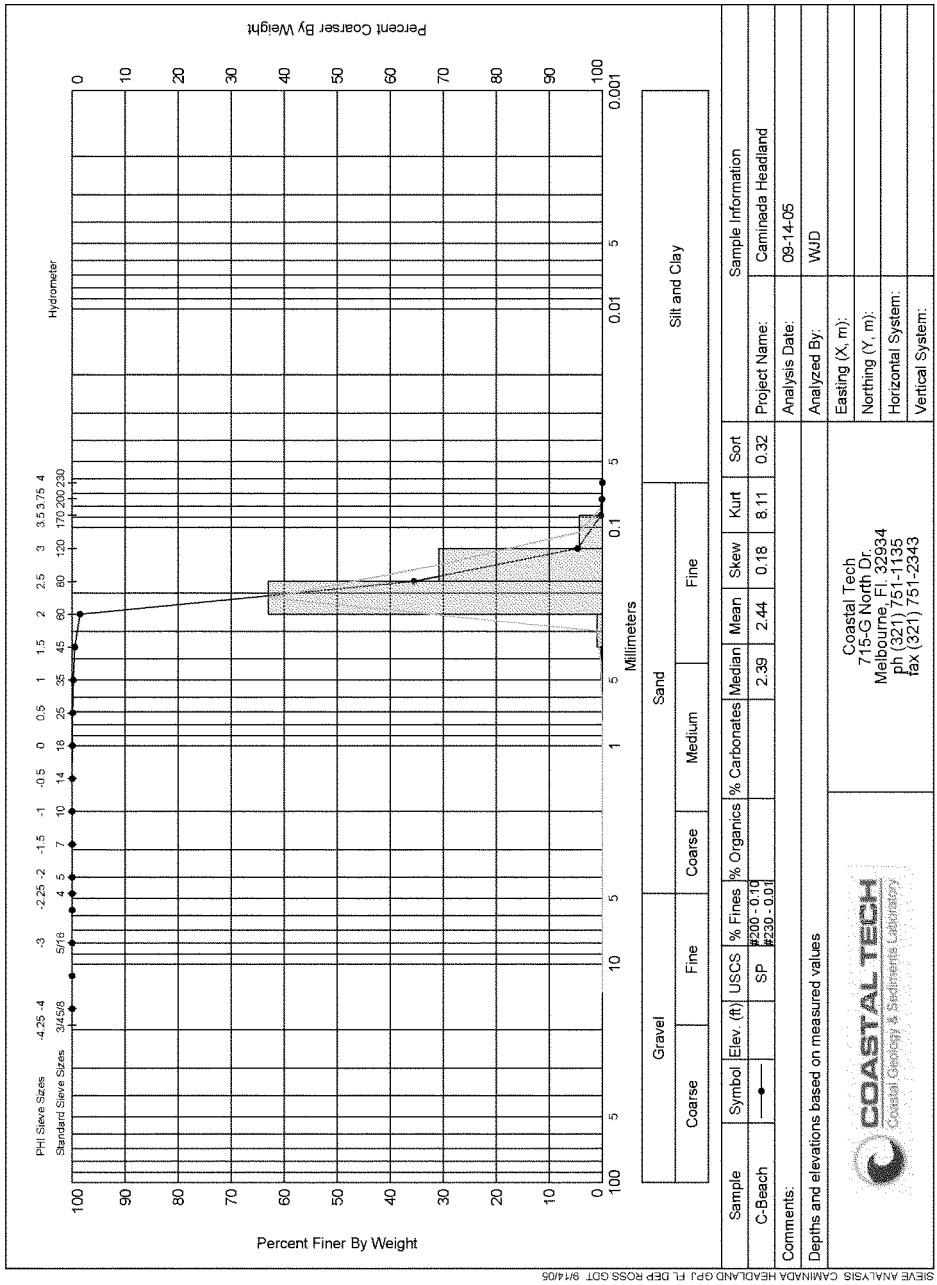
| Dry Weight (g): | Wash Weight (g): | Pan Retained (g): | Sieve Loss (%): | Fines (%): | Organics (%): | Carbonates (%): | Shells (%): |
|---|---|---|---|---|---|---|---|
| 135.01 | | 0.01 | | #200 - 0.10<br>#230 - 0.01 | | | |

| Sieve Number | Sieve Size (Phi) | Sieve Size (Millimeters) | Grams Retained | % Weight Retained | Cum. Grams Retained | C. % Weight Retained |
|---|---|---|---|---|---|---|
| 5/8" | -4.00 | 16.00 | | 0.00 | 0.00 | 0.00 |
| 11/16" | -3.50 | 11.31 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5/16" | -3.00 | 8.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3.5 | -2.50 | 5.66 | 0.00 | 0.00 | 0.00 | 0.00 |
| 4 | -2.25 | 4.76 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5 | -2.00 | 4.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7 | -1.50 | 2.83 | 0.00 | 0.00 | 0.00 | 0.00 |
| 10 | -1.00 | 2.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 14 | -0.50 | 1.41 | 0.02 | 0.01 | 0.02 | 0.01 |
| 18 | 0.00 | 1.00 | 0.03 | 0.02 | 0.05 | 0.04 |
| 25 | 0.50 | 0.71 | 0.07 | 0.05 | 0.12 | 0.09 |
| 35 | 1.00 | 0.50 | 0.16 | 0.12 | 0.28 | 0.21 |
| 45 | 1.50 | 0.35 | 0.37 | 0.27 | 0.65 | 0.48 |
| 60 | 2.00 | 0.25 | 1.34 | 0.99 | 1.99 | 1.47 |
| 80 | 2.50 | 0.18 | 85.02 | 62.97 | 87.01 | 64.45 |
| 120 | 3.00 | 0.13 | 41.68 | 30.87 | 128.69 | 95.32 |
| 170 | 3.50 | 0.09 | 5.89 | 4.36 | 134.58 | 99.68 |
| 200 | 3.75 | 0.07 | 0.29 | 0.21 | 134.87 | 99.90 |
| 230 | 4.00 | 0.06 | 0.13 | 0.10 | 135.00 | 99.99 |

| Phi 5 | Phi 16 | Phi 25 | Phi 50 | Phi 75 | Phi 84 | Phi 95 |
|---|---|---|---|---|---|---|
| 2.99 | 2.82 | 2.67 | 2.39 | 2.19 | 2.12 | 2.03 |

| Moment Statistics | Mean Phi | Mean mm | Sorting | Skewness | Kurtosis |
|---|---|---|---|---|---|
| | 2.44 | 0.18 | 0.32 | 0.18 | 8.11 |

GRANULARMETRIC REPORT CAMINADA HEADLAND.GPJ FL DEP ROSS.GDT 9/14/05


Percent Coarser By Weight
Percent Finer By Weight
Phi Sieve Sizes
Standard Sieve Sizes
Hydrometer
Millimeters
Gravel
Sand
Silt and Clay
Coarse
Fine
Medium
Sample
Symbol
Elev. (ft)
USCS
% Fines
% Organics
% Carbonates
Median
Mean
Skew
Kurt
Sort
C-Beach
SP
#200 - 0.10
#230 - 0.01
2.39
2.44
0.18
8.11
0.32
Comments:
Depths and elevations based on measured values
COASTAL TECH
Coastal Geology & Sediments Laboratory
Coastal Tech
715-G North Dr.
Melbourne, Fl. 32934
ph (321) 751-1135
fax (321) 751-2343
Sample Information
Project Name:
Caminada Headland
Analysis Date:
09-14-05
Analyzed By:
WJD
Easting (X, m):
Northing (Y, m):
Horizontal System:
Vertical System:
SIEVE ANALYSIS CAMINADA HEADLAND GPJ FL DEP ROSS GDT 9/14/05

## Granularmetric Report

Depths and elevations based on measured values

COASTAL TECH
Coastal Geology & Sediments Laboratory

Project Name: Caminada Headland
Sample Name: C-Dune
Analysis Date: 09-14-05
Analyzed By: WJD

Coastal Tech
715-G North Dr.
Melbourne, Fl. 32934
ph (321) 751-1135
fax (321) 751-2343

| Easting (m): | Northing (m): | Coordinate System: | Elevation (ft): |
|---|---|---|---|
| | | | |

| USCS: | Munsell: | Comments: |
|---|---|---|
| SP | | |

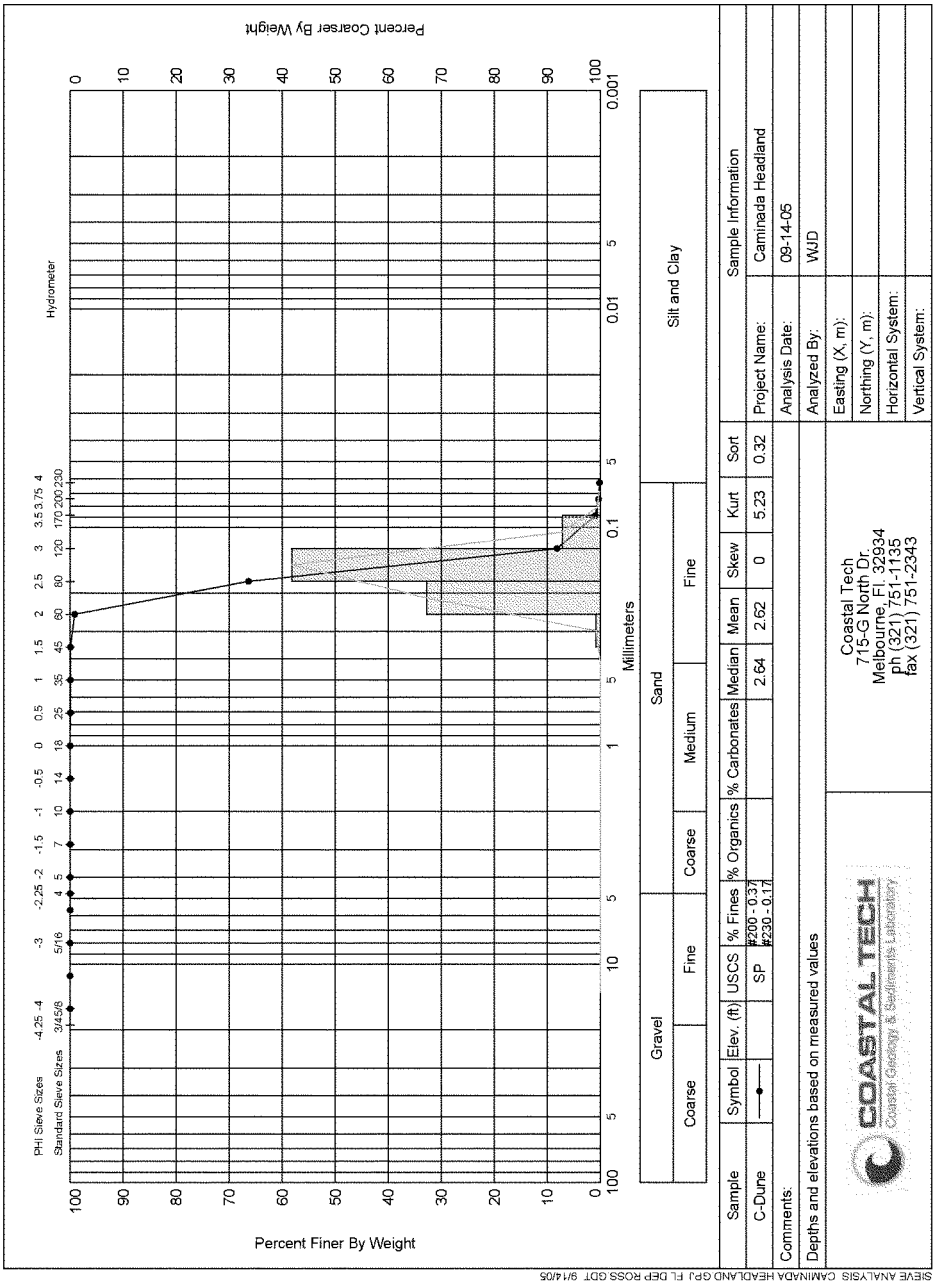
| Dry Weight (g): | Wash Weight (g): | Pan Retained (g): | Sieve Loss (%): | Fines (%): | Organics (%): | Carbonates (%): | Shells (%): |
|---|---|---|---|---|---|---|---|
| 112.11 | | 0.19 | | #200 - 0.37<br>#230 - 0.17 | | | |

| Sieve Number | Sieve Size (Phi) | Sieve Size (Millimeters) | Grams Retained | % Weight Retained | Cum. Grams Retained | C. % Weight Retained |
|---|---|---|---|---|---|---|
| 5/8" | -4.00 | 16.00 | | 0.00 | 0.00 | 0.00 |
| 11/16" | -3.50 | 11.31 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5/16" | -3.00 | 8.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3.5 | -2.50 | 5.66 | 0.00 | 0.00 | 0.00 | 0.00 |
| 4 | -2.25 | 4.76 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5 | -2.00 | 4.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7 | -1.50 | 2.83 | 0.00 | 0.00 | 0.00 | 0.00 |
| 10 | -1.00 | 2.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 14 | -0.50 | 1.41 | 0.01 | 0.01 | 0.01 | 0.01 |
| 18 | 0.00 | 1.00 | 0.00 | 0.00 | 0.01 | 0.01 |
| 25 | 0.50 | 0.71 | 0.03 | 0.03 | 0.04 | 0.04 |
| 35 | 1.00 | 0.50 | 0.00 | 0.00 | 0.04 | 0.04 |
| 45 | 1.50 | 0.35 | 0.02 | 0.02 | 0.06 | 0.05 |
| 60 | 2.00 | 0.25 | 0.90 | 0.80 | 0.96 | 0.86 |
| 80 | 2.50 | 0.18 | 36.74 | 32.77 | 37.70 | 33.63 |
| 120 | 3.00 | 0.13 | 65.21 | 58.17 | 102.91 | 91.79 |
| 170 | 3.50 | 0.09 | 8.08 | 7.21 | 110.99 | 99.00 |
| 200 | 3.75 | 0.07 | 0.71 | 0.63 | 111.70 | 99.63 |
| 230 | 4.00 | 0.06 | 0.22 | 0.20 | 111.92 | 99.83 |

| Phi 5 | Phi 16 | Phi 25 | Phi 50 | Phi 75 | Phi 84 | Phi 95 |
|---|---|---|---|---|---|---|
| 3.22 | 2.93 | 2.86 | 2.64 | 2.37 | 2.23 | 2.06 |

| Moment Statistics | Mean Phi | Mean mm | Sorting | Skewness | Kurtosis |
|---|---|---|---|---|---|
| | 2.62 | 0.16 | 0.32 | 0 | 5.23 |

GRANULARMETRIC REPORT, CAMINADA HEADLAND.GPJ, FL DEP ROSS.GDT, 9/14/05


Percent Finer By Weight
Percent Coarser By Weight
Phi Sieve Sizes
Standard Sieve Sizes
Hydrometer
Millimeters
Gravel
Sand
Silt and Clay
Coarse
Fine
Coarse
Medium
Fine
Sample
Symbol
Elev. (ft.)
USCS
% Fines
% Organics
% Carbonates
Median
Mean
Skew
Kurt
Sort
C-Dune
SP
#200 - 0.37
#230 - 0.17
2.64
2.62
0
5.23
0.32
Comments:
Depths and elevations based on measured values
COASTAL TECH
Coastal Geology & Sediments Laboratory
Coastal Tech
715-G North Dr.
Melbourne, Fl. 32934
ph (321) 751-1135
fax (321) 751-2343
Sample Information
Project Name:
Caminada Headland
Analysis Date:
09-14-05
Analyzed By:
WJD
Easting (X, m):
Northing (Y, m):
Horizontal System:
Vertical System:
SIEVE ANALYSIS CAMINADA HEADLAND GPJ FL DEP ROSS GDT 9/14/05

## Granularmetric Report

Depths and elevations based on measured values

COASTAL TECH
Coastal Geology & Sediments Laboratory

Coastal Tech
715-G North Dr.
Melbourne, Fl. 32934
ph (321) 751-1135
fax (321) 751-2343

Project Name: Caminada Headland
Sample Name: C-Overwash
Analysis Date: 09-15-05
Analyzed By: WJD

| Easting (m): | Northing (m): | Coordinate System: | Elevation (ft): |
|---|---|---|---|
| | | | |

| USCS: | Munsell: | Comments: |
|---|---|---|
| SP | | |

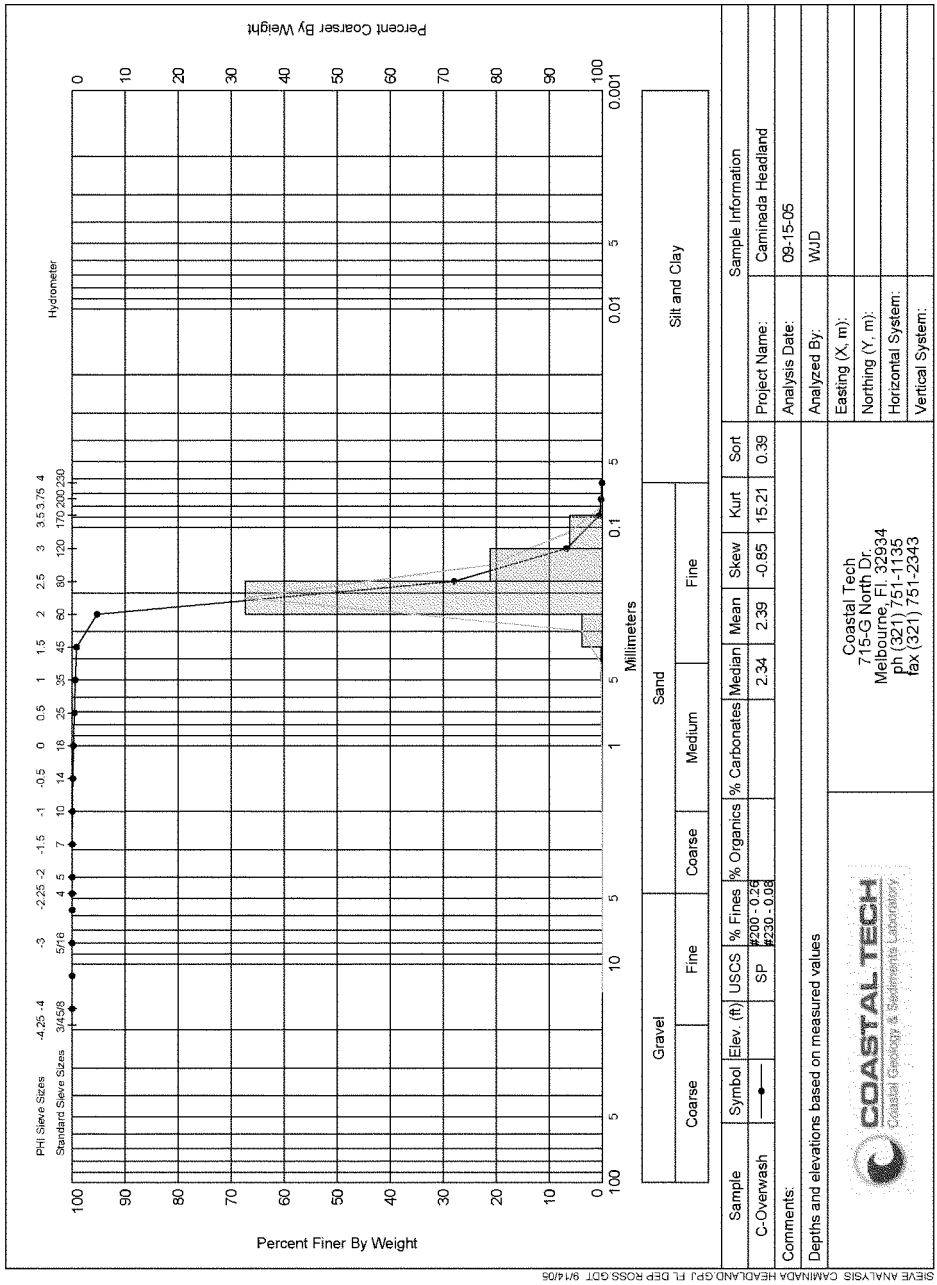
| Dry Weight (g): | Wash Weight (g): | Pan Retained (g): | Sieve Loss (%): | Fines (%): | Organics (%): | Carbonates (%): | Shells (%): |
|---|---|---|---|---|---|---|---|
| 108.26 | | 0.00 | | #200 - 0.26<br>#230 - 0.08 | | | |

| Sieve Number | Sieve Size (Phi) | Sieve Size (Millimeters) | Grams Retained | % Weight Retained | Cum. Grams Retained | C. % Weight Retained |
|---|---|---|---|---|---|---|
| 5/8" | -4.00 | 16.00 | | 0.00 | 0.00 | 0.00 |
| 11/16" | -3.50 | 11.31 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5/16" | -3.00 | 8.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3.5 | -2.50 | 5.66 | 0.00 | 0.00 | 0.00 | 0.00 |
| 4 | -2.25 | 4.76 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5 | -2.00 | 4.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7 | -1.50 | 2.83 | 0.01 | 0.01 | 0.01 | 0.01 |
| 10 | -1.00 | 2.00 | 0.04 | 0.04 | 0.05 | 0.05 |
| 14 | -0.50 | 1.41 | 0.09 | 0.08 | 0.14 | 0.13 |
| 18 | 0.00 | 1.00 | 0.12 | 0.11 | 0.26 | 0.24 |
| 25 | 0.50 | 0.71 | 0.19 | 0.18 | 0.45 | 0.42 |
| 35 | 1.00 | 0.50 | 0.18 | 0.17 | 0.63 | 0.58 |
| 45 | 1.50 | 0.35 | 0.27 | 0.25 | 0.90 | 0.83 |
| 60 | 2.00 | 0.25 | 4.19 | 3.87 | 5.09 | 4.70 |
| 80 | 2.50 | 0.18 | 72.89 | 67.33 | 77.98 | 72.03 |
| 120 | 3.00 | 0.13 | 22.93 | 21.18 | 100.91 | 93.21 |
| 170 | 3.50 | 0.09 | 6.68 | 6.17 | 107.59 | 99.38 |
| 200 | 3.75 | 0.07 | 0.39 | 0.36 | 107.98 | 99.74 |
| 230 | 4.00 | 0.06 | 0.19 | 0.18 | 108.17 | 99.92 |

| Phi 5 | Phi 16 | Phi 25 | Phi 50 | Phi 75 | Phi 84 | Phi 95 |
|---|---|---|---|---|---|---|
| 3.15 | 2.78 | 2.57 | 2.34 | 2.15 | 2.08 | 2.00 |

| Moment Statistics | Mean Phi | Mean mm | Sorting | Skewness | Kurtosis |
|---|---|---|---|---|---|
| | 2.39 | 0.19 | 0.39 | -0.85 | 15.21 |

GRANULARMETRIC REPORT CAMINADA HEADLAND.GPJ FL DEP ROSS.GDT 9/14/05


Phi Sieve Sizes
Standard Sieve Sizes
Hydrometer
Percent Finer By Weight
Percent Coarser By Weight
Millimeters
Gravel
Sand
Silt and Clay
Coarse
Fine
Medium
Sample
Symbol
Elev. (ft)
USCS
% Fines
% Organics
% Carbonates
Median
Mean
Skew
Kurt
Sort
C-Overwash
SP
#200 - 0.26
#230 - 0.08
2.34
2.39
-0.85
15.21
0.39
Comments:
Depths and elevations based on measured values
COASTAL TECH
Coastal Geology & Sediments Laboratory
Coastal Tech
715-G North Dr.
Melbourne, Fl. 32934
ph (321) 751-1135
fax (321) 751-2343
Sample Information
Project Name:
Caminada Headland
Analysis Date:
09-15-05
Analyzed By:
WJD
Easting (X, m):
Northing (Y, m):
Horizontal System:
Vertical System:
SIEVE ANALYSIS CAMINADA HEADLAND.GPJ FL DEP ROSS.GDT 9/14/06

## Granularmetric Report

Depths and elevations based on measured values

COASTAL TECH
Coastal Geology & Sediments Laboratory

Project Name: Caminada Headland
Sample Name: D-Beach
Analysis Date: 09-14-05
Analyzed By: WJD

Coastal Tech
715-G North Dr.
Melbourne, Fl. 32934
ph (321) 751-1135
fax (321) 751-2343

| Easting (m): | Northing (m): | Coordinate System: | Elevation (ft): |
|---|---|---|---|
| | | | |

| USCS: | Munsell: | Comments: |
|---|---|---|
| SP | | |

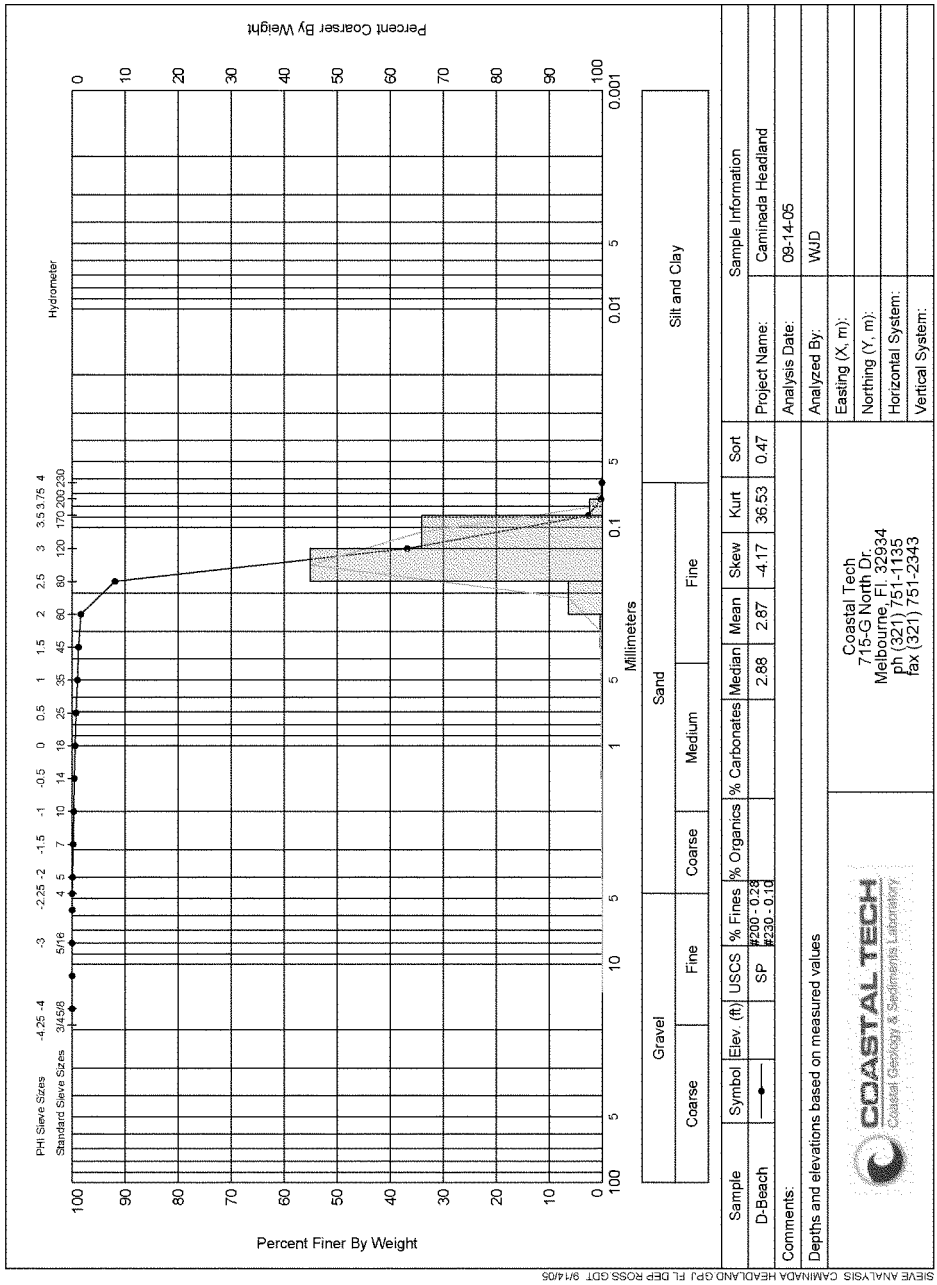
| Dry Weight (g): | Wash Weight (g): | Pan Retained (g): | Sieve Loss (%): | Fines (%): #200 - 0.28 #230 - 0.10 | Organics (%): | Carbonates (%): | Shells (%): |
|---|---|---|---|---|---|---|---|
| 133.93 | | 0.13 | | | | | |

| Sieve Number | Sieve Size (Phi) | Sieve Size (Millimeters) | Grams Retained | % Weight Retained | Cum. Grams Retained | C. % Weight Retained |
|---|---|---|---|---|---|---|
| 5/8" | -4.00 | 16.00 | | 0.00 | 0.00 | 0.00 |
| 11/16" | -3.50 | 11.31 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5/16" | -3.00 | 8.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3.5 | -2.50 | 5.66 | 0.00 | 0.00 | 0.00 | 0.00 |
| 4 | -2.25 | 4.76 | 0.02 | 0.01 | 0.02 | 0.01 |
| 5 | -2.00 | 4.00 | 0.06 | 0.04 | 0.08 | 0.06 |
| 7 | -1.50 | 2.83 | 0.17 | 0.13 | 0.25 | 0.19 |
| 10 | -1.00 | 2.00 | 0.16 | 0.12 | 0.41 | 0.31 |
| 14 | -0.50 | 1.41 | 0.12 | 0.09 | 0.53 | 0.40 |
| 18 | 0.00 | 1.00 | 0.24 | 0.18 | 0.77 | 0.57 |
| 25 | 0.50 | 0.71 | 0.20 | 0.15 | 0.97 | 0.72 |
| 35 | 1.00 | 0.50 | 0.38 | 0.28 | 1.35 | 1.01 |
| 45 | 1.50 | 0.35 | 0.27 | 0.20 | 1.62 | 1.21 |
| 60 | 2.00 | 0.25 | 0.58 | 0.43 | 2.20 | 1.64 |
| 80 | 2.50 | 0.18 | 8.61 | 6.43 | 10.81 | 8.07 |
| 120 | 3.00 | 0.13 | 73.83 | 55.13 | 84.64 | 63.20 |
| 170 | 3.50 | 0.09 | 45.70 | 34.12 | 130.34 | 97.32 |
| 200 | 3.75 | 0.07 | 3.21 | 2.40 | 133.55 | 99.72 |
| 230 | 4.00 | 0.06 | 0.24 | 0.18 | 133.79 | 99.90 |

| Phi 5 | Phi 16 | Phi 25 | Phi 50 | Phi 75 | Phi 84 | Phi 95 |
|---|---|---|---|---|---|---|
| 3.47 | 3.30 | 3.17 | 2.88 | 2.65 | 2.57 | 2.26 |

| Moment Statistics | Mean Phi | Mean mm | Sorting | Skewness | Kurtosis |
|---|---|---|---|---|---|
| | 2.87 | 0.14 | 0.47 | -4.17 | 36.53 |

GRANULARMETRIC REPORT CAMINADA HEADLAND.GPJ FL DEP ROSS.GDT 9/14/05


Percent Finer By Weight
Percent Coarser By Weight
PHI Sieve Sizes
Standard Sieve Sizes
Hydrometer
Millimeters
Gravel
Sand
Silt and Clay
Coarse
Fine
Medium
Sample
Symbol
Elev. (ft)
USCS
% Fines
% Organics
% Carbonates
Median
Mean
Skew
Kurt
Sort
D-Beach
SP
#200 - 0.28
#230 - 0.10
2.88
2.87
-4.17
36.53
0.47
Comments:
Depths and elevations based on measured values
COASTAL TECH
Coastal Geology & Sediments Laboratory
Coastal Tech
715-G North Dr.
Melbourne, Fl. 32934
ph (321) 751-1135
fax (321) 751-2343
Sample Information
Project Name:
Caminada Headland
Analysis Date:
09-14-05
Analyzed By:
WJD
Easting (X, m):
Northing (Y, m):
Horizontal System:
Vertical System:
SIEVE ANALYSIS CAMINADA HEADLAND GPJ FL DEP ROSS GDT 9/14/05

## Granularmetric Report

Depths and elevations based on measured values

COASTAL TECH
Coastal Geology & Sediments Laboratory

Project Name: Caminada Headland
Sample Name: D-Dune/Overwash
Analysis Date: 09-14-05
Analyzed By: WJD

Coastal Tech
715-G North Dr.
Melbourne, Fl. 32934
ph (321) 751-1135
fax (321) 751-2343

| Easting (m): | Northing (m): | Coordinate System: | Elevation (ft): |
|---|---|---|---|
| | | | |

| USCS: | Munsell: | Comments: |
|---|---|---|
| SP | | |

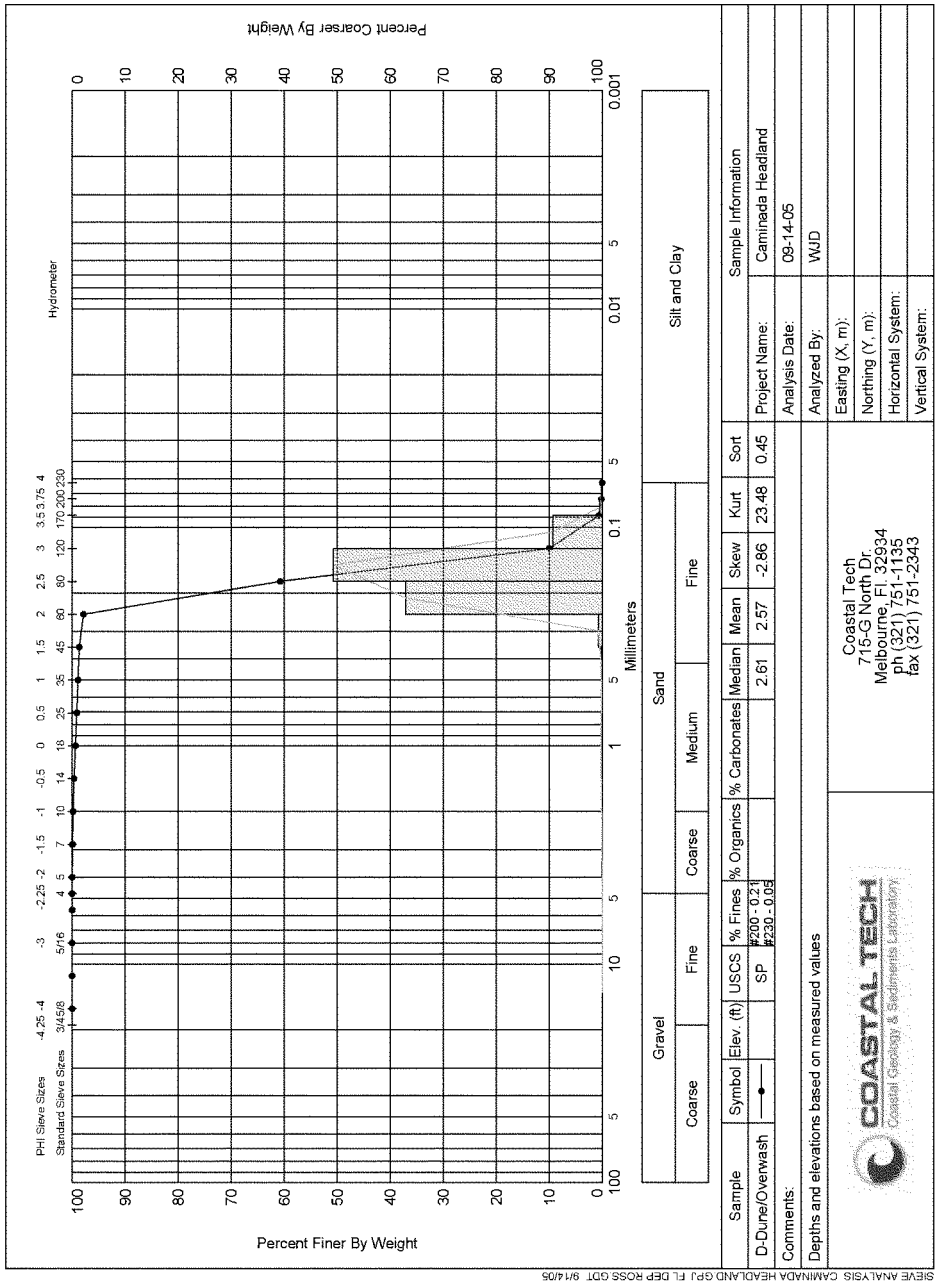
| Dry Weight (g): | Wash Weight (g): | Pan Retained (g): | Sieve Loss (%): | Fines (%): #200 - 0.21 #230 - 0.05 | Organics (%): | Carbonates (%): | Shells (%): |
|---|---|---|---|---|---|---|---|
| 110.95 | | 0.05 | | | | | |

| Sieve Number | Sieve Size (Phi) | Sieve Size (Millimeters) | Grams Retained | % Weight Retained | Cum. Grams Retained | C. % Weight Retained |
|---|---|---|---|---|---|---|
| 5/8" | -4.00 | 16.00 | | 0.00 | 0.00 | 0.00 |
| 11/16" | -3.50 | 11.31 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5/16" | -3.00 | 8.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3.5 | -2.50 | 5.66 | 0.00 | 0.00 | 0.00 | 0.00 |
| 4 | -2.25 | 4.76 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5 | -2.00 | 4.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7 | -1.50 | 2.83 | 0.07 | 0.06 | 0.07 | 0.06 |
| 10 | -1.00 | 2.00 | 0.12 | 0.11 | 0.19 | 0.17 |
| 14 | -0.50 | 1.41 | 0.21 | 0.19 | 0.40 | 0.36 |
| 18 | 0.00 | 1.00 | 0.30 | 0.27 | 0.70 | 0.63 |
| 25 | 0.50 | 0.71 | 0.28 | 0.25 | 0.98 | 0.88 |
| 35 | 1.00 | 0.50 | 0.23 | 0.21 | 1.21 | 1.09 |
| 45 | 1.50 | 0.35 | 0.28 | 0.25 | 1.49 | 1.34 |
| 60 | 2.00 | 0.25 | 0.87 | 0.78 | 2.36 | 2.13 |
| 80 | 2.50 | 0.18 | 41.17 | 37.11 | 43.53 | 39.23 |
| 120 | 3.00 | 0.13 | 56.27 | 50.72 | 99.80 | 89.95 |
| 170 | 3.50 | 0.09 | 10.36 | 9.34 | 110.16 | 99.29 |
| 200 | 3.75 | 0.07 | 0.56 | 0.50 | 110.72 | 99.79 |
| 230 | 4.00 | 0.06 | 0.18 | 0.16 | 110.90 | 99.95 |

| Phi 5 | Phi 16 | Phi 25 | Phi 50 | Phi 75 | Phi 84 | Phi 95 |
|---|---|---|---|---|---|---|
| 3.27 | 2.94 | 2.85 | 2.61 | 2.31 | 2.19 | 2.04 |

| Moment Statistics | Mean Phi | Mean mm | Sorting | Skewness | Kurtosis |
|---|---|---|---|---|---|
| | 2.57 | 0.17 | 0.45 | -2.86 | 23.48 |

GRANULARMETRIC REPORT CAMINADA HEADLAND.GPJ FL DEP ROSS.GDT 9/14/05


Phi Sieve Sizes
Standard Sieve Sizes
Hydrometer
Percent Finer By Weight
Percent Coarser By Weight
Millimeters
Gravel
Sand
Silt and Clay
Coarse
Fine
Medium
Sample
Symbol
Elev. (ft)
USCS
% Fines
% Organics
% Carbonates
Median
Mean
Skew
Kurt
Sort
D-Dune/Overwash
SP
#200 - 0.21
#230 - 0.05
2.61
2.57
-2.86
23.48
0.45
Comments:
Depths and elevations based on measured values
COASTAL TECH
Coastal Geology & Sediments Laboratory
Coastal Tech
715-G North Dr.
Melbourne, Fl. 32934
ph (321) 751-1135
fax (321) 751-2343
Sample Information
Project Name:
Caminada Headland
Analysis Date:
09-14-05
Analyzed By:
WJD
Easting (X, m):
Northing (Y, m):
Horizontal System:
Vertical System:
SIEVE ANALYSIS CAMINADA HEADLAND GPJ FL DEP ROSS GDT 9/14/05

## Granularmetric Report

Depths and elevations based on measured values

COASTAL TECH
Coastal Geology & Sediments Laboratory

Project Name: Caminada Headland
Sample Name: F-Beach
Analysis Date: 09-14-05
Analyzed By: WJD

Coastal Tech
715-G North Dr.
Melbourne, Fl. 32934
ph (321) 751-1135
fax (321) 751-2343

| Easting (m): | Northing (m): | Coordinate System: | Elevation (ft): |
|---|---|---|---|
| | | | |

| USCS: | Munsell: | Comments: |
|---|---|---|
| SP | | |

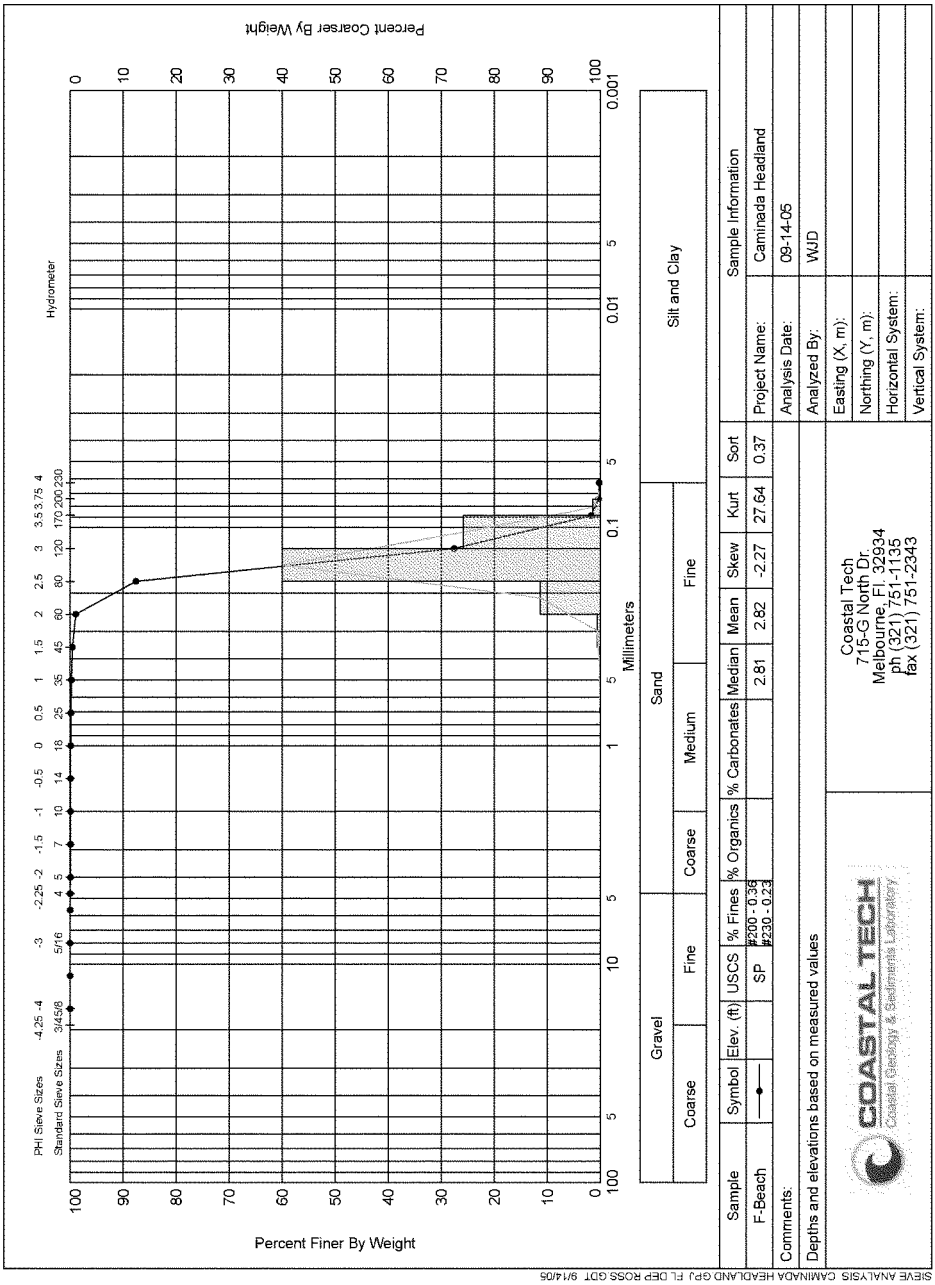
| Dry Weight (g): | Wash Weight (g): | Pan Retained (g): | Sieve Loss (%): | Fines (%): #200 - 0.36 #230 - 0.23 | Organics (%): | Carbonates (%): | Shells (%): |
|---|---|---|---|---|---|---|---|
| 118.35 | | 0.07 | | | | | |

| Sieve Number | Sieve Size (Phi) | Sieve Size (Millimeters) | Grams Retained | % Weight Retained | Cum. Grams Retained | C. % Weight Retained |
|---|---|---|---|---|---|---|
| 5/8" | -4.00 | 16.00 | | 0.00 | 0.00 | 0.00 |
| 11/16" | -3.50 | 11.31 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5/16" | -3.00 | 8.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3.5 | -2.50 | 5.66 | 0.00 | 0.00 | 0.00 | 0.00 |
| 4 | -2.25 | 4.76 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5 | -2.00 | 4.00 | 0.06 | 0.05 | 0.06 | 0.05 |
| 7 | -1.50 | 2.83 | 0.02 | 0.02 | 0.08 | 0.07 |
| 10 | -1.00 | 2.00 | 0.01 | 0.01 | 0.09 | 0.08 |
| 14 | -0.50 | 1.41 | 0.02 | 0.02 | 0.11 | 0.09 |
| 18 | 0.00 | 1.00 | 0.02 | 0.02 | 0.13 | 0.11 |
| 25 | 0.50 | 0.71 | 0.03 | 0.03 | 0.16 | 0.14 |
| 35 | 1.00 | 0.50 | 0.11 | 0.09 | 0.27 | 0.23 |
| 45 | 1.50 | 0.35 | 0.24 | 0.20 | 0.51 | 0.43 |
| 60 | 2.00 | 0.25 | 0.72 | 0.61 | 1.23 | 1.04 |
| 80 | 2.50 | 0.18 | 13.45 | 11.36 | 14.68 | 12.40 |
| 120 | 3.00 | 0.13 | 71.01 | 60.00 | 85.69 | 72.40 |
| 170 | 3.50 | 0.09 | 30.57 | 25.83 | 116.26 | 98.23 |
| 200 | 3.75 | 0.07 | 1.66 | 1.40 | 117.92 | 99.64 |
| 230 | 4.00 | 0.06 | 0.16 | 0.14 | 118.08 | 99.77 |

| Phi 5 | Phi 16 | Phi 25 | Phi 50 | Phi 75 | Phi 84 | Phi 95 |
|---|---|---|---|---|---|---|
| 3.44 | 3.22 | 3.05 | 2.81 | 2.60 | 2.53 | 2.17 |

| Moment | Mean Phi | Mean mm | Sorting | Skewness | Kurtosis |
|---|---|---|---|---|---|
| Statistics | 2.82 | 0.14 | 0.37 | -2.27 | 27.64 |

GRANULARMETRIC REPORT CAMINADA HEADLAND.GPJ FL DEP ROSS.GDT 9/14/05




| Sample | Symbol | Elev. (ft) | USCS | % Fines | % Organics | % Carbonates | Median | Mean | Skew | Kurt | Sort |
|---|---|---|---|---|---|---|---|---|---|---|---|
| F-Beach | | | SP | #200 - 0.36<br>#230 - 0.23 | | | 2.81 | 2.82 | -2.27 | 27.64 | 0.37 |

Comments:

Depths and elevations based on measured values

COASTAL TECH
Coastal Geology & Sediments Laboratory

Coastal Tech
715-G North Dr.
Melbourne, Fl. 32934
ph (321) 751-1135
fax (321) 751-2343

| Sample Information | |
|---|---|
| Project Name: | Caminada Headland |
| Analysis Date: | 09-14-05 |
| Analyzed By: | WJD |
| Easting (X, m): | |
| Northing (Y, m): | |
| Horizontal System: | |
| Vertical System: | |

SIEVE ANALYSIS CAMINADA HEADLAND GPJ FL DEP ROSS GDT 9/14/06

## Granularmetric Report

Depths and elevations based on measured values

COASTAL TECH
Coastal Geology & Sediments Laboratory

Coastal Tech
715-G North Dr.
Melbourne, Fl. 32934
ph (321) 751-1135
fax (321) 751-2343

Project Name: Caminada Headland
Sample Name: F-Dune/Overwash
Analysis Date: 09-14-05
Analyzed By: WJD

| Easting (m): | Northing (m): | Coordinate System: | Elevation (ft): |
|---|---|---|---|
| | | | |

| USCS: | Munsell: | Comments: |
|---|---|---|
| SP | | |

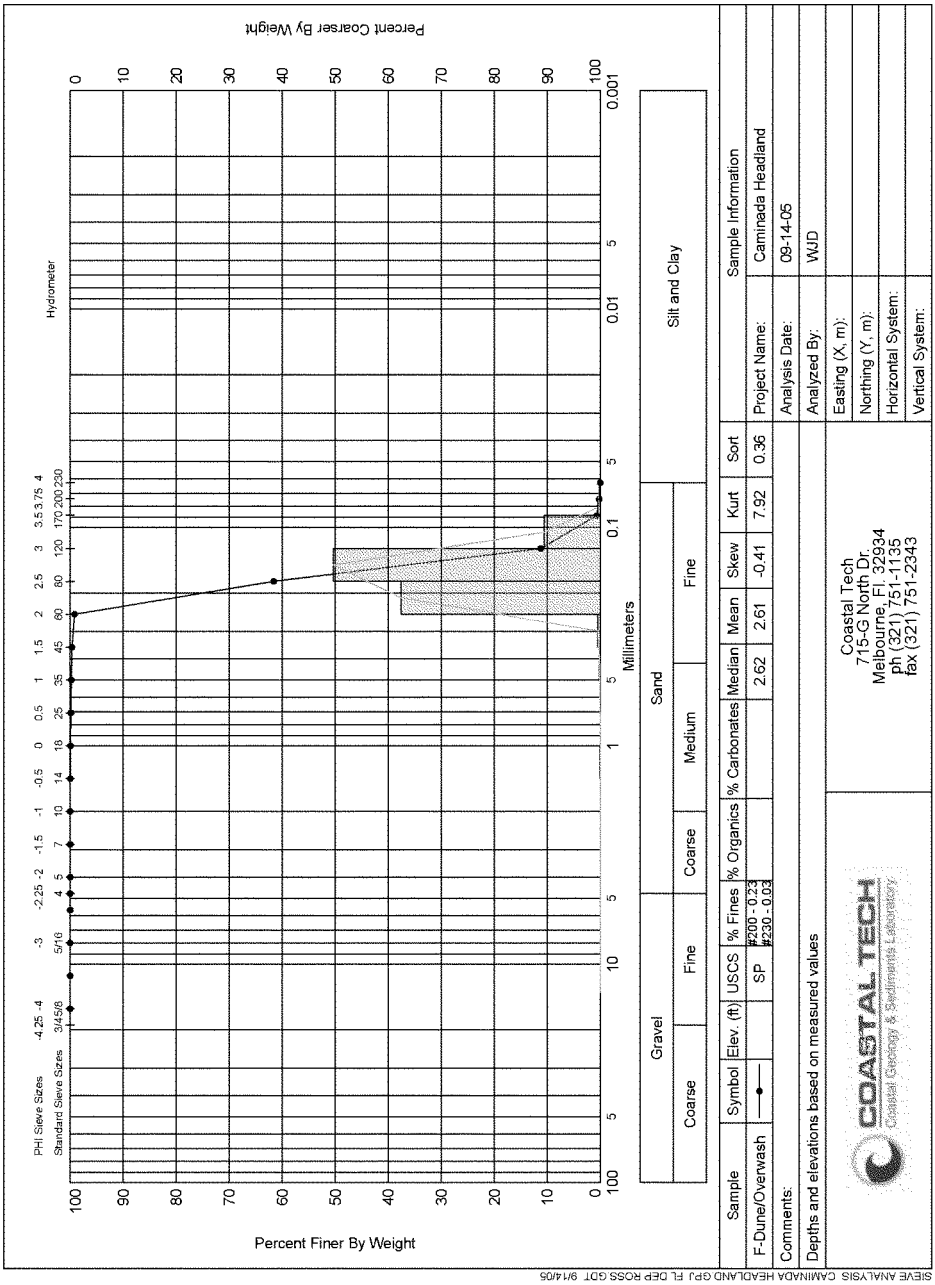
| Dry Weight (g): | Wash Weight (g): | Pan Retained (g): | Sieve Loss (%): | Fines (%): | Organics (%): | Carbonates (%): | Shells (%): |
|---|---|---|---|---|---|---|---|
| 104.88 | | 0.03 | | #200 - 0.23<br>#230 - 0.03 | | | |

| Sieve Number | Sieve Size (Phi) | Sieve Size (Millimeters) | Grams Retained | % Weight Retained | Cum. Grams Retained | C. % Weight Retained |
|---|---|---|---|---|---|---|
| 5/8" | -4.00 | 16.00 | | 0.00 | 0.00 | 0.00 |
| 11/16" | -3.50 | 11.31 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5/16" | -3.00 | 8.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3.5 | -2.50 | 5.66 | 0.00 | 0.00 | 0.00 | 0.00 |
| 4 | -2.25 | 4.76 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5 | -2.00 | 4.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7 | -1.50 | 2.83 | 0.00 | 0.00 | 0.00 | 0.00 |
| 10 | -1.00 | 2.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 14 | -0.50 | 1.41 | 0.02 | 0.02 | 0.02 | 0.02 |
| 18 | 0.00 | 1.00 | 0.06 | 0.06 | 0.08 | 0.08 |
| 25 | 0.50 | 0.71 | 0.06 | 0.06 | 0.14 | 0.13 |
| 35 | 1.00 | 0.50 | 0.08 | 0.08 | 0.22 | 0.21 |
| 45 | 1.50 | 0.35 | 0.15 | 0.14 | 0.37 | 0.35 |
| 60 | 2.00 | 0.25 | 0.49 | 0.47 | 0.86 | 0.82 |
| 80 | 2.50 | 0.18 | 39.39 | 37.56 | 40.25 | 38.38 |
| 120 | 3.00 | 0.13 | 52.80 | 50.34 | 93.05 | 88.72 |
| 170 | 3.50 | 0.09 | 11.09 | 10.57 | 104.14 | 99.29 |
| 200 | 3.75 | 0.07 | 0.50 | 0.48 | 104.64 | 99.77 |
| 230 | 4.00 | 0.06 | 0.21 | 0.20 | 104.85 | 99.97 |

| Phi 5 | Phi 16 | Phi 25 | Phi 50 | Phi 75 | Phi 84 | Phi 95 |
|---|---|---|---|---|---|---|
| 3.30 | 2.95 | 2.86 | 2.62 | 2.32 | 2.20 | 2.06 |

| Moment | Mean Phi | Mean mm | Sorting | Skewness | Kurtosis |
|---|---|---|---|---|---|
| Statistics | 2.61 | 0.16 | 0.36 | -0.41 | 7.92 |

GRANULARMETRIC REPORT CAMINADA HEADLAND.GPJ FL DEP ROSS.GDT 9/14/05


Phi Sieve Sizes
Standard Sieve Sizes
Hydrometer
Percent Finer By Weight
Percent Coarser By Weight
Millimeters
Gravel
Sand
Silt and Clay
Coarse
Fine
Coarse
Medium
Fine
Sample
Symbol
Elev. (ft.)
USCS
% Fines
% Organics
% Carbonates
Median
Mean
Skew
Kurt
Sort
F-Dune/Overwash
SP
#200 - 0.23
#230 - 0.03
2.62
2.61
-0.41
7.92
0.36
Comments:
Depths and elevations based on measured values
COASTAL TECH
Coastal Geology & Sediments Laboratory
Coastal Tech
715-G North Dr.
Melbourne, Fl. 32934
ph (321) 751-1135
fax (321) 751-2343
Sample Information
Project Name:
Caminada Headland
Analysis Date:
09-14-05
Analyzed By:
WJD
Easting (X, m):
Northing (Y, m):
Horizontal System:
Vertical System:
SIEVE ANALYSIS CAMINADA HEADLAND GPJ FL DEP ROSS GDT 9/14/05

## Granularmetric Report

Depths and elevations based on measured values

Project Name: South Pelto, La
Sample Name: CHVC-05-01 COMP
Analysis Date:
Analyzed By:

Coastal Planning & Engineering
2481 NW Boca Raton Blvd, Boca Raton
FL 33431
ph (561) 391-8102
fax (561) 391-9116

| Easting (ft): | Northing (ft): | Coordinate System: | Elevation (ft): |
|---|---|---|---|
| | | | |

| USCS: | Munsell: | Comments: |
|---|---|---|
| SP | | |

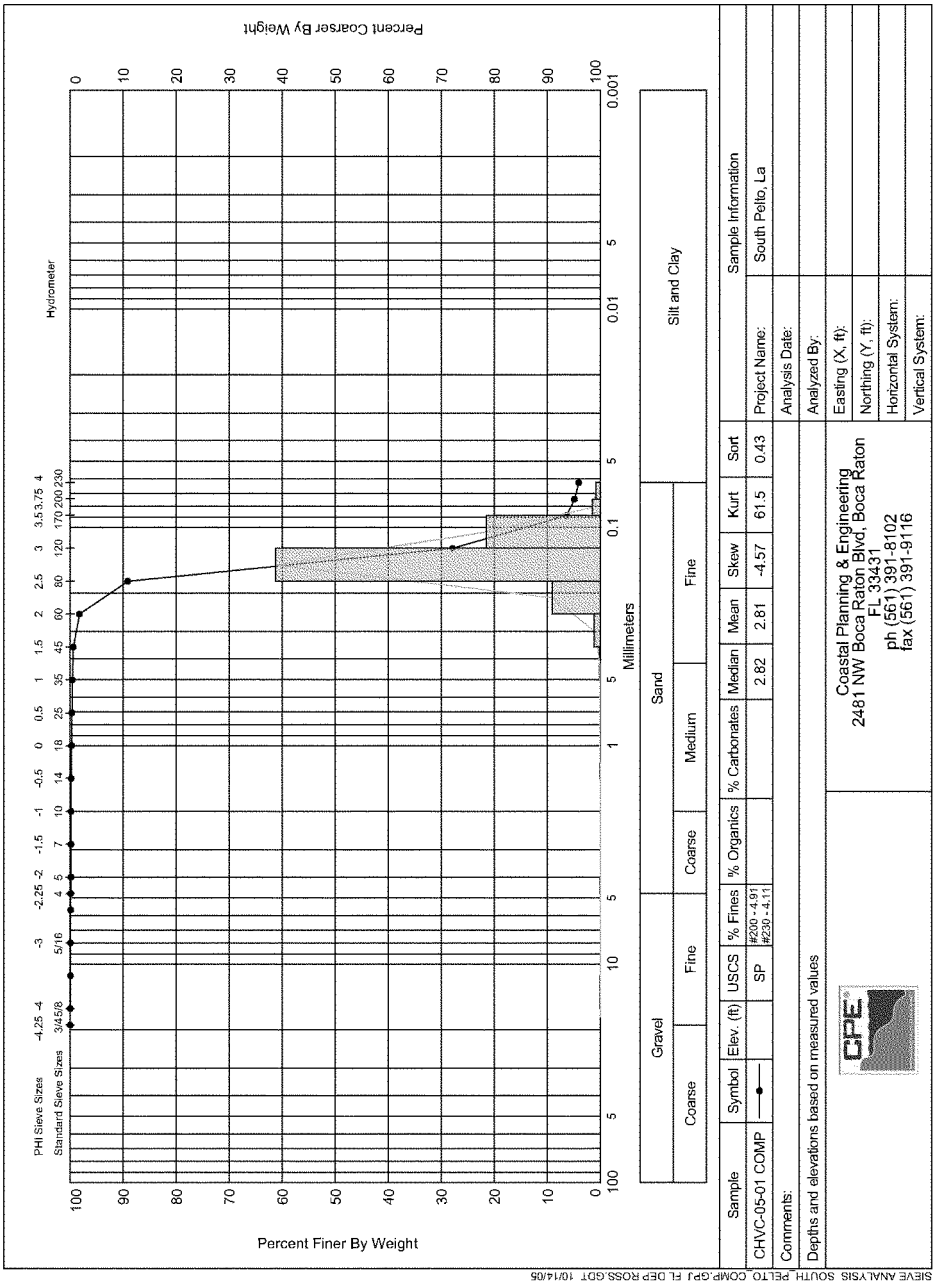
| Dry Weight (g): | Wash Weight (g): | Pan Retained (g): | Sieve Loss (%): | Fines (%): | Organics (%): | Carbonates (%): | Shells (%): |
|---|---|---|---|---|---|---|---|
| 100.00 | 100.00 | 4.01 | 0.10 | #200 - 4.91<br>#230 - 4.11 | | | |

| Sieve Number | Sieve Size (Phi) | Sieve Size (Millimeters) | Grams Retained | % Weight Retained | Cum. Grams Retained | C. % Weight Retained |
|---|---|---|---|---|---|---|
| 3/4" | -4.25 | 19.03 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5/8" | -4.00 | 16.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7/16" | -3.50 | 11.31 | 0.07 | 0.07 | 0.07 | 0.07 |
| 5/16" | -3.00 | 8.00 | 0.00 | 0.00 | 0.07 | 0.07 |
| 3.5 | -2.50 | 5.66 | 0.01 | 0.01 | 0.08 | 0.08 |
| 4 | -2.25 | 4.76 | 0.00 | 0.00 | 0.08 | 0.08 |
| 5 | -2.00 | 4.00 | 0.06 | 0.06 | 0.14 | 0.14 |
| 7 | -1.50 | 2.83 | 0.00 | 0.00 | 0.14 | 0.14 |
| 10 | -1.00 | 2.00 | 0.01 | 0.01 | 0.15 | 0.15 |
| 14 | -0.50 | 1.41 | 0.03 | 0.03 | 0.18 | 0.18 |
| 18 | 0.00 | 1.00 | 0.07 | 0.07 | 0.25 | 0.25 |
| 25 | 0.50 | 0.71 | 0.06 | 0.06 | 0.31 | 0.31 |
| 35 | 1.00 | 0.50 | 0.09 | 0.09 | 0.40 | 0.40 |
| 45 | 1.50 | 0.35 | 0.16 | 0.16 | 0.56 | 0.56 |
| 60 | 2.00 | 0.25 | 1.15 | 1.15 | 1.71 | 1.71 |
| 80 | 2.50 | 0.18 | 9.12 | 9.12 | 10.83 | 10.83 |
| 120 | 3.00 | 0.13 | 61.27 | 61.27 | 72.10 | 72.10 |
| 170 | 3.50 | 0.09 | 21.51 | 21.51 | 93.61 | 93.61 |
| 200 | 3.75 | 0.07 | 1.48 | 1.48 | 95.09 | 95.09 |
| 230 | 4.00 | 0.06 | 0.80 | 0.80 | 95.89 | 95.89 |

| Phi 5 | Phi 16 | Phi 25 | Phi 50 | Phi 75 | Phi 84 | Phi 95 |
|---|---|---|---|---|---|---|
| 3.73 | 3.28 | 3.07 | 2.82 | 2.62 | 2.54 | 2.18 |

| Moment Statistics | Mean Phi | Mean mm | Sorting | Skewness | Kurtosis |
|---|---|---|---|---|---|
| | 2.81 | 0.14 | 0.43 | -4.57 | 61.5 |

GRANULARMETRIC REPORT SOUTH_PELTO_COMP.GPJ FL_DEP ROSS.GDT 10/14/05


Percent Finer By Weight
Percent Coarser By Weight
PHI Sieve Sizes
Standard Sieve Sizes
Hydrometer
Millimeters
Gravel
Sand
Silt and Clay
Coarse
Fine
Medium
Sample
Symbol
Elev. (ft)
USCS
% Fines
% Organics
% Carbonates
Median
Mean
Skew
Kurt
Sort
CHVC-05-01 COMP
SP
#200 -4.91
#230 -4.11
2.82
2.81
-4.57
61.5
0.43
Comments:
Depths and elevations based on measured values
Coastal Planning & Engineering
2481 NW Boca Raton Blvd, Boca Raton
FL 33431
ph (561) 391-8102
fax (561) 391-9116
Sample Information
Project Name:
South Pelto, La
Analysis Date:
Analyzed By:
Easting (X, ft):
Northing (Y, ft):
Horizontal System:
Vertical System:
SIEVE ANALYSIS SOUTH_PELTO_COMP.GPJ FL DEP ROSS.GDT 10/14/05

## Granularmetric Report

Depths and elevations based on measured values

Project Name: South Pelto, La
Sample Name: CHVC-05-02 COMP
Analysis Date:
Analyzed By:

Coastal Planning & Engineering
2481 NW Boca Raton Blvd, Boca Raton
FL 33431
ph (561) 391-8102
fax (561) 391-9116

| Easting (ft): | Northing (ft): | Coordinate System: | Elevation (ft): |
|---|---|---|---|
| | | | |

| USCS: | Munsell: | Comments: |
|---|---|---|
| SP | | |

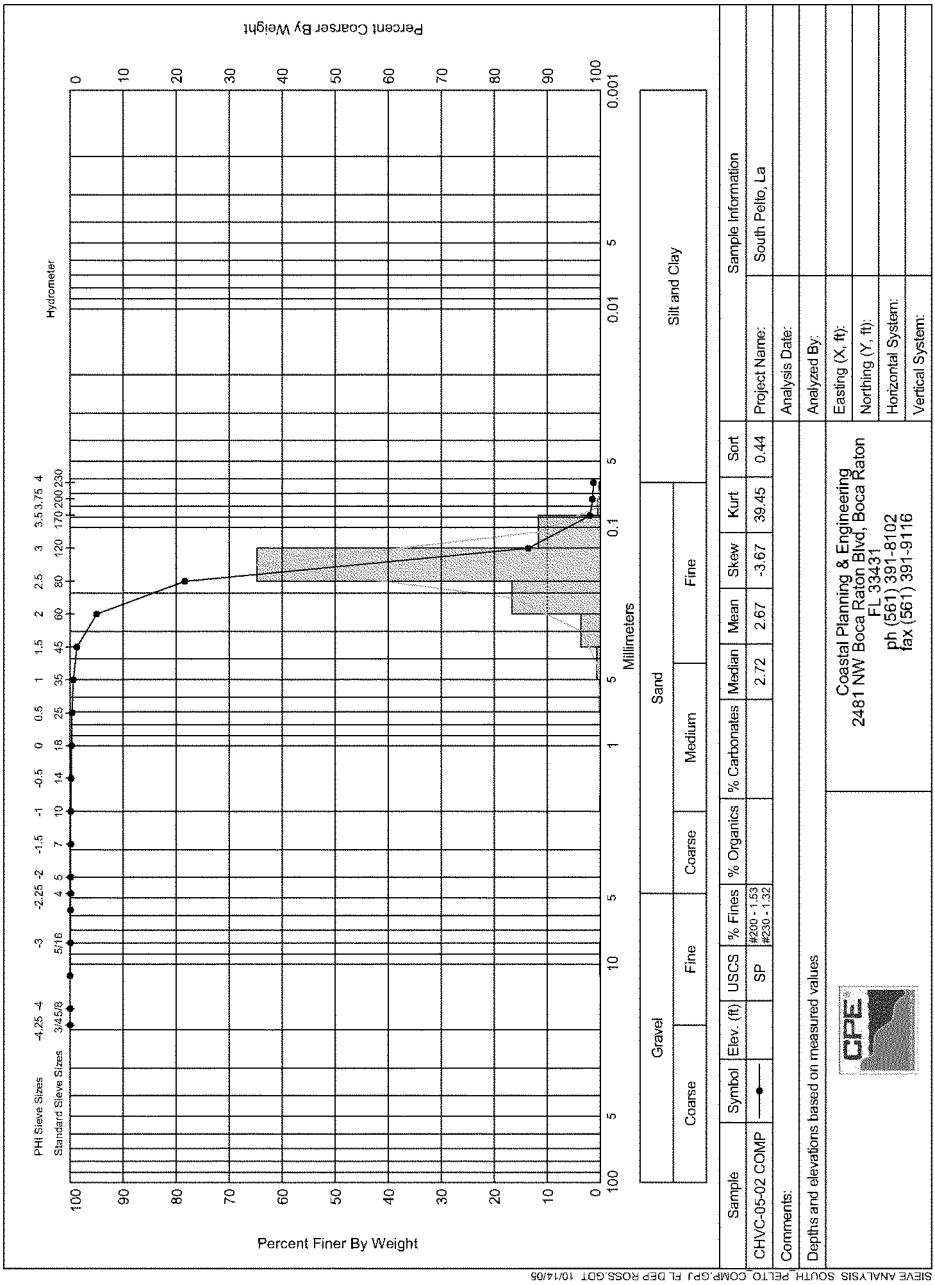
| Dry Weight (g): | Wash Weight (g): | Pan Retained (g): | Sieve Loss (%): | Fines (%): | Organics (%): | Carbonates (%): | Shells (%): |
|---|---|---|---|---|---|---|---|
| 100.00 | 100.00 | 1.15 | 0.17 | #200 - 1.53<br>#230 - 1.32 | | | |

| Sieve Number | Sieve Size (Phi) | Sieve Size (Millimeters) | Grams Retained | % Weight Retained | Cum. Grams Retained | C. % Weight Retained |
|---|---|---|---|---|---|---|
| 3/4" | -4.25 | 19.03 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5/8" | -4.00 | 16.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7/16" | -3.50 | 11.31 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5/16" | -3.00 | 8.00 | 0.07 | 0.07 | 0.07 | 0.07 |
| 3.5 | -2.50 | 5.66 | 0.02 | 0.02 | 0.09 | 0.09 |
| 4 | -2.25 | 4.76 | 0.00 | 0.00 | 0.09 | 0.09 |
| 5 | -2.00 | 4.00 | 0.00 | 0.00 | 0.09 | 0.09 |
| 7 | -1.50 | 2.83 | 0.03 | 0.03 | 0.12 | 0.12 |
| 10 | -1.00 | 2.00 | 0.00 | 0.00 | 0.12 | 0.12 |
| 14 | -0.50 | 1.41 | 0.06 | 0.06 | 0.18 | 0.18 |
| 18 | 0.00 | 1.00 | 0.09 | 0.09 | 0.27 | 0.27 |
| 25 | 0.50 | 0.71 | 0.09 | 0.09 | 0.36 | 0.36 |
| 35 | 1.00 | 0.50 | 0.20 | 0.20 | 0.56 | 0.56 |
| 45 | 1.50 | 0.35 | 0.70 | 0.70 | 1.26 | 1.26 |
| 60 | 2.00 | 0.25 | 3.70 | 3.70 | 4.96 | 4.96 |
| 80 | 2.50 | 0.18 | 16.66 | 16.66 | 21.62 | 21.62 |
| 120 | 3.00 | 0.13 | 64.75 | 64.75 | 86.37 | 86.37 |
| 170 | 3.50 | 0.09 | 11.63 | 11.63 | 98.00 | 98.00 |
| 200 | 3.75 | 0.07 | 0.47 | 0.47 | 98.47 | 98.47 |
| 230 | 4.00 | 0.06 | 0.21 | 0.21 | 98.68 | 98.68 |

| Phi 5 | Phi 16 | Phi 25 | Phi 50 | Phi 75 | Phi 84 | Phi 95 |
|---|---|---|---|---|---|---|
| 3.37 | 2.98 | 2.91 | 2.72 | 2.53 | 2.33 | 2.00 |

| Moment Statistics | Mean Phi | Mean mm | Sorting | Skewness | Kurtosis |
|---|---|---|---|---|---|
| | 2.67 | 0.16 | 0.44 | -3.67 | 39.45 |

GRANULARMETRIC REPORT_SOUTH_PELTO_COMP.GPJ FL DEP ROSS.GDT 10/14/05




SIEVE ANALYSIS SOUTH_PELTO_COMP.GPJ FL DEP ROSS.GDT 10/14/05

## Granularmetric Report

Depths and elevations based on measured values

Project Name: South Pelto, La
Sample Name: CHVC-05-03 COMP
Analysis Date:
Analyzed By:

Coastal Planning & Engineering
2481 NW Boca Raton Blvd, Boca Raton
FL 33431
ph (561) 391-8102
fax (561) 391-9116

| Easting (ft): | Northing (ft): | Coordinate System: | Elevation (ft): |
|---|---|---|---|
| | | | |

| USCS: | Munsell: | Comments: |
|---|---|---|
| SP | | |

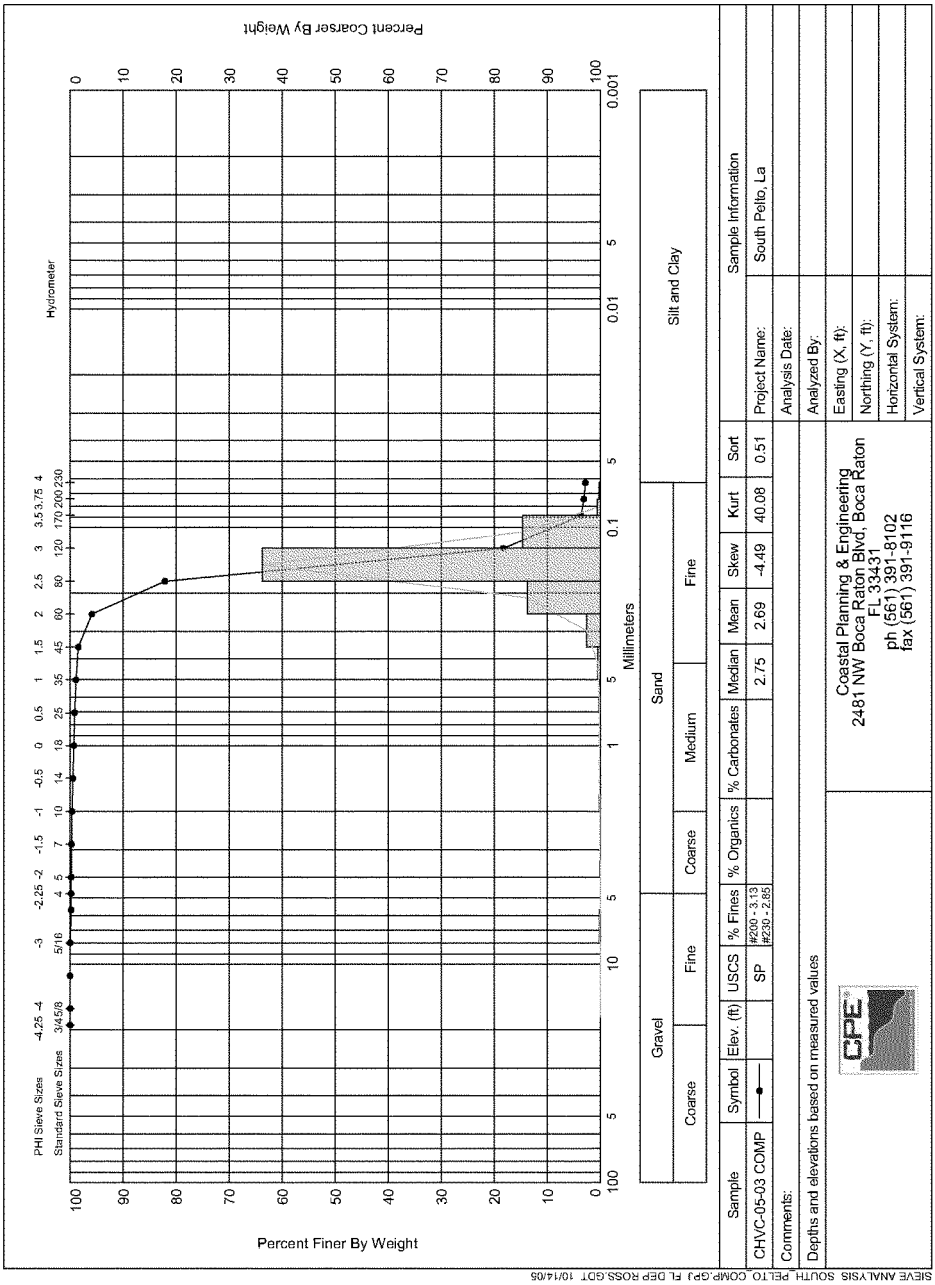
| Dry Weight (g): | Wash Weight (g): | Pan Retained (g): | Sieve Loss (%): | Fines (%): | Organics (%): | Carbonates (%): | Shells (%): |
|---|---|---|---|---|---|---|---|
| 100.00 | 100.00 | 2.62 | 0.23 | #200 - 3.13<br>#230 - 2.85 | | | |

| Sieve Number | Sieve Size (Phi) | Sieve Size (Millimeters) | Grams Retained | % Weight Retained | Cum. Grams Retained | C. % Weight Retained |
|---|---|---|---|---|---|---|
| 3/4" | -4.25 | 19.03 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5/8" | -4.00 | 16.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7/16" | -3.50 | 11.31 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5/16" | -3.00 | 8.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3.5 | -2.50 | 5.66 | 0.18 | 0.18 | 0.18 | 0.18 |
| 4 | -2.25 | 4.76 | 0.00 | 0.00 | 0.18 | 0.18 |
| 5 | -2.00 | 4.00 | 0.00 | 0.00 | 0.18 | 0.18 |
| 7 | -1.50 | 2.83 | 0.05 | 0.05 | 0.23 | 0.23 |
| 10 | -1.00 | 2.00 | 0.12 | 0.12 | 0.35 | 0.35 |
| 14 | -0.50 | 1.41 | 0.17 | 0.17 | 0.52 | 0.52 |
| 18 | 0.00 | 1.00 | 0.17 | 0.17 | 0.69 | 0.69 |
| 25 | 0.50 | 0.71 | 0.14 | 0.14 | 0.83 | 0.83 |
| 35 | 1.00 | 0.50 | 0.24 | 0.24 | 1.07 | 1.07 |
| 45 | 1.50 | 0.35 | 0.47 | 0.47 | 1.54 | 1.54 |
| 60 | 2.00 | 0.25 | 2.57 | 2.57 | 4.11 | 4.11 |
| 80 | 2.50 | 0.18 | 13.75 | 13.75 | 17.86 | 17.86 |
| 120 | 3.00 | 0.13 | 63.77 | 63.77 | 81.63 | 81.63 |
| 170 | 3.50 | 0.09 | 14.67 | 14.67 | 96.30 | 96.30 |
| 200 | 3.75 | 0.07 | 0.57 | 0.57 | 96.87 | 96.87 |
| 230 | 4.00 | 0.06 | 0.28 | 0.28 | 97.15 | 97.15 |

| Phi 5 | Phi 16 | Phi 25 | Phi 50 | Phi 75 | Phi 84 | Phi 95 |
|---|---|---|---|---|---|---|
| 3.46 | 3.08 | 2.95 | 2.75 | 2.56 | 2.43 | 2.03 |

| Moment Statistics | Mean Phi | Mean mm | Sorting | Skewness | Kurtosis |
|---|---|---|---|---|---|
| | 2.69 | 0.15 | 0.51 | -4.49 | 40.08 |

GRANULARMETRIC REPORT_SOUTH_PELTO_COMP.GPJ FL DEP ROSS.GDT 10/14/05


Percent Finer By Weight
Percent Coarser By Weight
Hydrometer
PHI Sieve Sizes
Standard Sieve Sizes
Millimeters
Gravel
Sand
Silt and Clay
Coarse
Fine
Medium
Sample
Symbol
Elev. (ft)
USCS
% Fines
% Organics
% Carbonates
Median
Mean
Skew
Kurt
Sort
CHVC-05-03 COMP
SP
#200 - 3.13
#230 - 2.85
2.75
2.69
-4.49
40.08
0.51
Comments:
Depths and elevations based on measured values
Coastal Planning & Engineering
2481 NW Boca Raton Blvd, Boca Raton
FL 33431
ph (561) 391-8102
fax (561) 391-9116
Sample Information
Project Name:
South Pelto, La
Analysis Date:
Analyzed By:
Easting (X, ft):
Northing (Y, ft):
Horizontal System:
Vertical System:
SIEVE ANALYSIS SOUTH_PELTO_COMP.GPJ FL DEP ROSS.GDT 10/14/05

## Granularmetric Report

Depths and elevations based on measured values

Project Name: South Pelto, La
Sample Name: CHVC-05-04 COMP
Analysis Date:
Analyzed By: AU

Coastal Planning & Engineering
2481 NW Boca Raton Blvd, Boca Raton
FL 33431
ph (561) 391-8102
fax (561) 391-9116

| Easting (ft): | Northing (ft): | Coordinate System: | Elevation (ft): |
|---|---|---|---|
| | | | |

| USCS: | Munsell: | Comments: |
|---|---|---|
| SP | | |

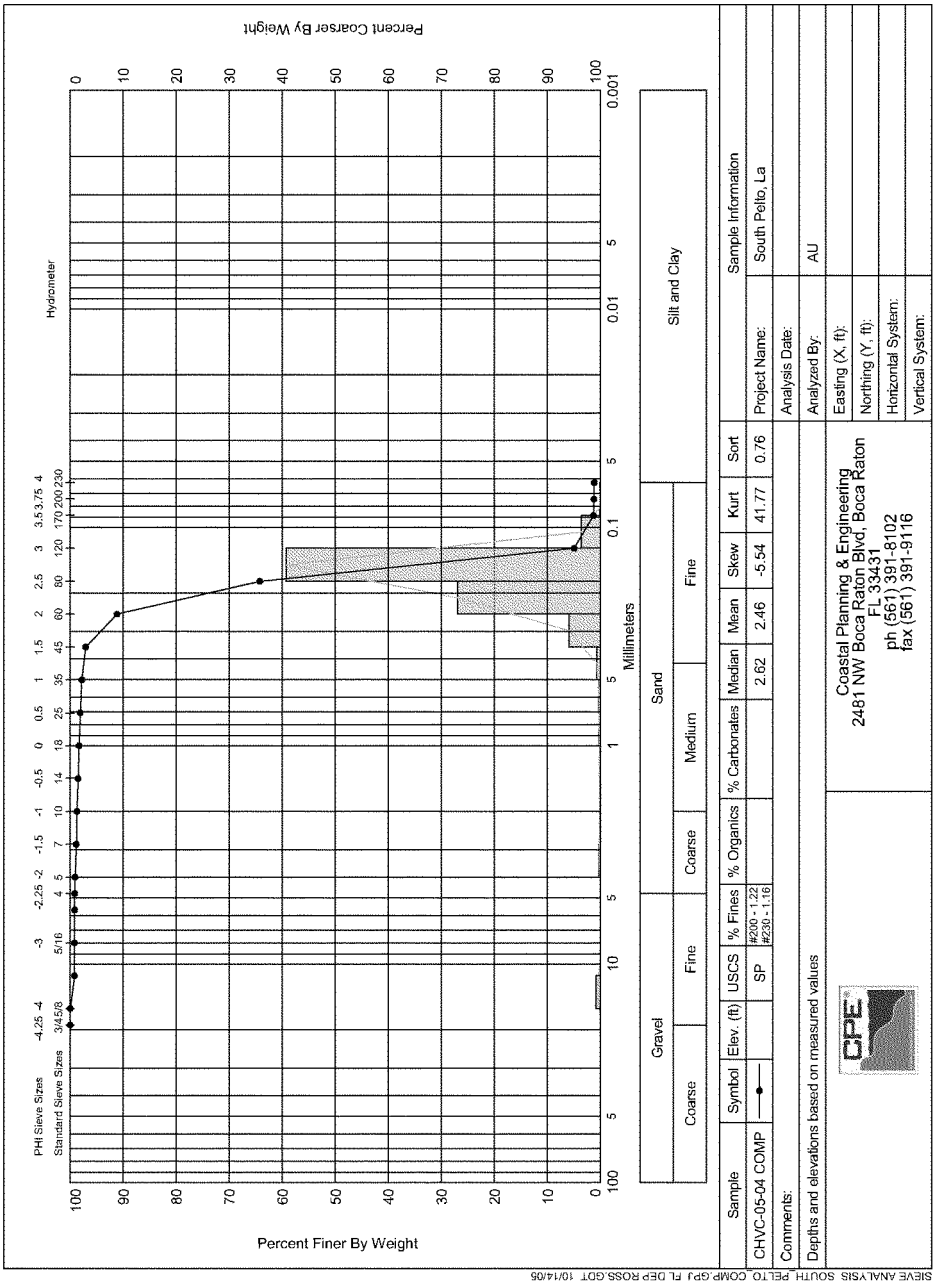
| Dry Weight (g): | Wash Weight (g): | Pan Retained (g): | Sieve Loss (%): | Fines (%): | Organics (%): | Carbonates (%): | Shells (%): |
|---|---|---|---|---|---|---|---|
| 100.00 | 100.00 | 1.02 | 0.14 | #200 - 1.22<br>#230 - 1.16 | | | |

| Sieve Number | Sieve Size (Phi) | Sieve Size (Millimeters) | Grams Retained | % Weight Retained | Cum. Grams Retained | C. % Weight Retained |
|---|---|---|---|---|---|---|
| 3/4" | -4.25 | 19.03 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5/8" | -4.00 | 16.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7/16" | -3.50 | 11.31 | 0.80 | 0.80 | 0.80 | 0.80 |
| 5/16" | -3.00 | 8.00 | 0.00 | 0.00 | 0.80 | 0.80 |
| 3.5 | -2.50 | 5.66 | 0.03 | 0.03 | 0.83 | 0.83 |
| 4 | -2.25 | 4.76 | 0.03 | 0.03 | 0.86 | 0.86 |
| 5 | -2.00 | 4.00 | 0.03 | 0.03 | 0.89 | 0.89 |
| 7 | -1.50 | 2.83 | 0.24 | 0.24 | 1.13 | 1.13 |
| 10 | -1.00 | 2.00 | 0.16 | 0.16 | 1.29 | 1.29 |
| 14 | -0.50 | 1.41 | 0.18 | 0.18 | 1.47 | 1.47 |
| 18 | 0.00 | 1.00 | 0.19 | 0.19 | 1.66 | 1.66 |
| 25 | 0.50 | 0.71 | 0.22 | 0.22 | 1.88 | 1.88 |
| 35 | 1.00 | 0.50 | 0.32 | 0.32 | 2.20 | 2.20 |
| 45 | 1.50 | 0.35 | 0.69 | 0.69 | 2.89 | 2.89 |
| 60 | 2.00 | 0.25 | 5.95 | 5.95 | 8.84 | 8.84 |
| 80 | 2.50 | 0.18 | 26.92 | 26.92 | 35.76 | 35.76 |
| 120 | 3.00 | 0.13 | 59.28 | 59.28 | 95.04 | 95.04 |
| 170 | 3.50 | 0.09 | 3.62 | 3.62 | 98.66 | 98.66 |
| 200 | 3.75 | 0.07 | 0.12 | 0.12 | 98.78 | 98.78 |
| 230 | 4.00 | 0.06 | 0.06 | 0.06 | 98.84 | 98.84 |

| Phi 5 | Phi 16 | Phi 25 | Phi 50 | Phi 75 | Phi 84 | Phi 95 |
|---|---|---|---|---|---|---|
| 3.00 | 2.91 | 2.83 | 2.62 | 2.30 | 2.13 | 1.68 |

| Moment Statistics | Mean Phi | Mean mm | Sorting | Skewness | Kurtosis |
|---|---|---|---|---|---|
| | 2.46 | 0.18 | 0.76 | -5.54 | 41.77 |

GRANULARMETRIC REPORT_SOUTH_PELTO_COMP.GPJ FL DEP ROSS.GDT 10/14/05


Percent Finer By Weight
Percent Coarser By Weight
Millimeters
Hydrometer
Gravel
Sand
Silt and Clay
Coarse
Fine
Medium
PHI Sieve Sizes
Standard Sieve Sizes
Sample
Symbol
Elev. (ft)
USCS
% Fines
% Organics
% Carbonates
Median
Mean
Skew
Kurt
Sort
CHVC-05-04 COMP
SP
#200 - 1.22
#230 - 1.16
2.62
2.46
-5.54
41.77
0.76
Comments:
Depths and elevations based on measured values
Coastal Planning & Engineering
2481 NW Boca Raton Blvd, Boca Raton
FL 33431
ph (561) 391-8102
fax (561) 391-9116
Sample Information
Project Name:
South Pelto, La
Analysis Date:
Analyzed By:
AU
Easting (X, ft):
Northing (Y, ft):
Horizontal System:
Vertical System:
SIEVE ANALYSIS SOUTH_PELTO_COMP.GPJ FL DEP ROSS.GDT 10/14/05

## Granularmetric Report

Depths and elevations based on measured values

Project Name: South Pelto, La
Sample Name: CHVC-05-05 COMP
Analysis Date:
Analyzed By: AU

Coastal Planning & Engineering
2481 NW Boca Raton Blvd, Boca Raton
FL 33431
ph (561) 391-8102
fax (561) 391-9116

| Easting (ft): | Northing (ft): | Coordinate System: | Elevation (ft): |
|---|---|---|---|
| | | | |

| USCS: | Munsell: | Comments: |
|---|---|---|
| | | |

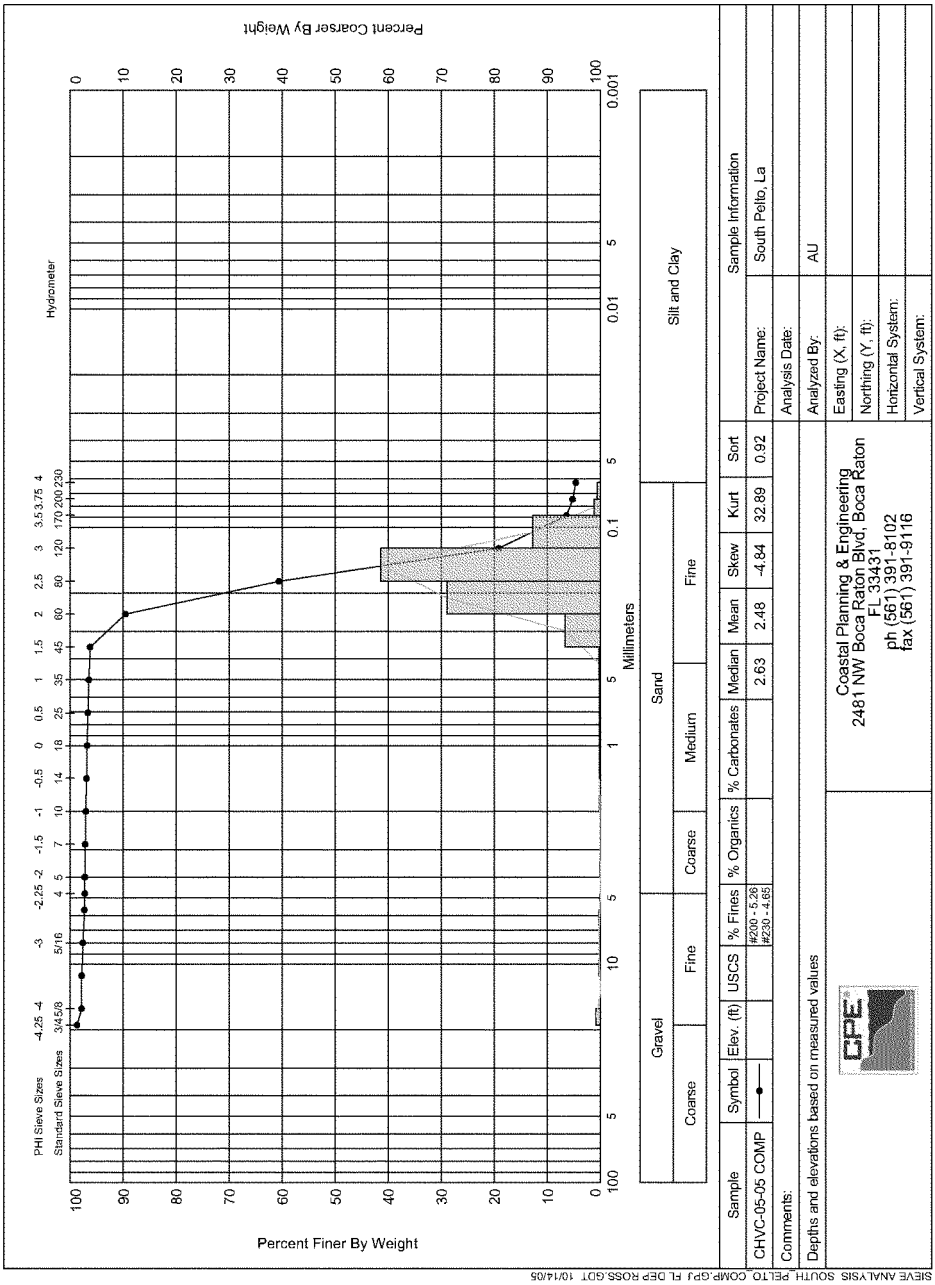
| Dry Weight (g): | Wash Weight (g): | Pan Retained (g): | Sieve Loss (%): | Fines (%): | Organics (%): | Carbonates (%): | Shells (%): |
|---|---|---|---|---|---|---|---|
| 100.00 | 100.00 | 4.49 | 0.16 | #200 - 5.26<br>#230 - 4.65 | | | |

| Sieve Number | Sieve Size (Phi) | Sieve Size (Millimeters) | Grams Retained | % Weight Retained | Cum. Grams Retained | C. % Weight Retained |
|---|---|---|---|---|---|---|
| 3/4" | -4.25 | 19.03 | 1.29 | 1.29 | 1.29 | 1.29 |
| 5/8" | -4.00 | 16.00 | 0.86 | 0.86 | 2.15 | 2.15 |
| 7/16" | -3.50 | 11.31 | 0.01 | 0.01 | 2.16 | 2.16 |
| 5/16" | -3.00 | 8.00 | 0.22 | 0.22 | 2.38 | 2.38 |
| 3.5 | -2.50 | 5.66 | 0.27 | 0.27 | 2.65 | 2.65 |
| 4 | -2.25 | 4.76 | 0.08 | 0.08 | 2.73 | 2.73 |
| 5 | -2.00 | 4.00 | 0.02 | 0.02 | 2.75 | 2.75 |
| 7 | -1.50 | 2.83 | 0.07 | 0.07 | 2.82 | 2.82 |
| 10 | -1.00 | 2.00 | 0.11 | 0.11 | 2.93 | 2.93 |
| 14 | -0.50 | 1.41 | 0.13 | 0.13 | 3.06 | 3.06 |
| 18 | 0.00 | 1.00 | 0.13 | 0.13 | 3.19 | 3.19 |
| 25 | 0.50 | 0.71 | 0.13 | 0.13 | 3.32 | 3.32 |
| 35 | 1.00 | 0.50 | 0.19 | 0.19 | 3.51 | 3.51 |
| 45 | 1.50 | 0.35 | 0.23 | 0.23 | 3.74 | 3.74 |
| 60 | 2.00 | 0.25 | 6.68 | 6.68 | 10.42 | 10.42 |
| 80 | 2.50 | 0.18 | 28.95 | 28.95 | 39.37 | 39.37 |
| 120 | 3.00 | 0.13 | 41.42 | 41.42 | 80.79 | 80.79 |
| 170 | 3.50 | 0.09 | 12.79 | 12.79 | 93.58 | 93.58 |
| 200 | 3.75 | 0.07 | 1.16 | 1.16 | 94.74 | 94.74 |
| 230 | 4.00 | 0.06 | 0.61 | 0.61 | 95.35 | 95.35 |

| Phi 5 | Phi 16 | Phi 25 | Phi 50 | Phi 75 | Phi 84 | Phi 95 |
|---|---|---|---|---|---|---|
| 3.86 | 3.13 | 2.93 | 2.63 | 2.25 | 2.10 | 1.59 |

| Moment Statistics | Mean Phi | Mean mm | Sorting | Skewness | Kurtosis |
|---|---|---|---|---|---|
| | 2.48 | 0.18 | 0.92 | -4.84 | 32.89 |

GRANULARMETRIC REPORT_SOUTH_PELTO_COMP.GPJ FL_DEP_ROSS.GDT 10/14/05


PHI Sieve Sizes
Standard Sieve Sizes
Hydrometer
Percent Finer By Weight
Percent Coarser By Weight
Millimeters
Gravel
Sand
Silt and Clay
Coarse
Fine
Medium
Sample
Symbol
Elev. (ft)
USCS
% Fines
% Organics
% Carbonates
Median
Mean
Skew
Kurt
Sort
CHVC-05-05 COMP
#200 - 5.28
#230 - 4.65
2.63
2.48
-4.84
32.89
0.92
Comments:
Depths and elevations based on measured values
Coastal Planning & Engineering
2481 NW Boca Raton Blvd, Boca Raton
FL 33431
ph (561) 391-8102
fax (561) 391-9116
Sample Information
Project Name:
South Pelto, La
Analysis Date:
Analyzed By:
AU
Easting (X, ft):
Northing (Y, ft):
Horizontal System:
Vertical System:
SIEVE ANALYSIS SOUTH_PELTO_COMP.GPJ FL DEP ROSS.GDT 10/14/05

## Granularmetric Report

Depths and elevations based on measured values

Project Name: South Pelto, La
Sample Name: CHVC-05-06 COMP
Analysis Date:
Analyzed By: AU

Coastal Planning & Engineering
2481 NW Boca Raton Blvd, Boca Raton
FL 33431
ph (561) 391-8102
fax (561) 391-9116

| Easting (ft): | Northing (ft): | Coordinate System: | Elevation (ft): |
|---|---|---|---|
| | | | |

| USCS: | Munsell: | Comments: |
|---|---|---|
| | | |

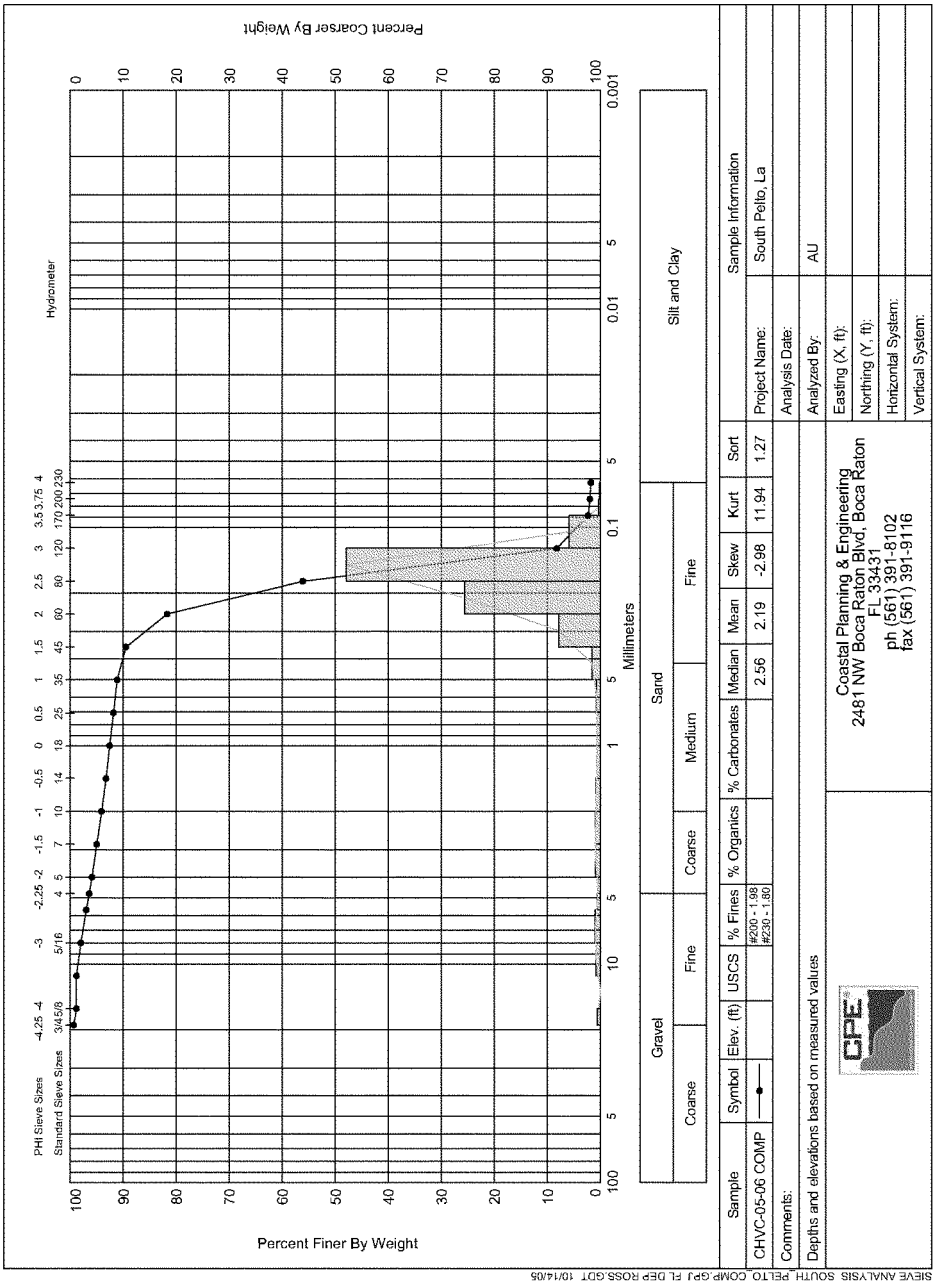
| Dry Weight (g): | Wash Weight (g): | Pan Retained (g): | Sieve Loss (%): | Fines (%): #200 - 1.98 #230 - 1.80 | Organics (%): | Carbonates (%): | Shells (%): |
|---|---|---|---|---|---|---|---|
| 100.00 | 100.00 | 1.67 | 0.13 | | | | |

| Sieve Number | Sieve Size (Phi) | Sieve Size (Millimeters) | Grams Retained | % Weight Retained | Cum. Grams Retained | C. % Weight Retained |
|---|---|---|---|---|---|---|
| 3/4" | -4.25 | 19.03 | 0.64 | 0.64 | 0.64 | 0.64 |
| 5/8" | -4.00 | 16.00 | 0.56 | 0.56 | 1.20 | 1.20 |
| 7/16" | -3.50 | 11.31 | 0.00 | 0.00 | 1.20 | 1.20 |
| 5/16" | -3.00 | 8.00 | 0.81 | 0.81 | 2.01 | 2.01 |
| 3.5 | -2.50 | 5.66 | 1.01 | 1.01 | 3.02 | 3.02 |
| 4 | -2.25 | 4.76 | 0.57 | 0.57 | 3.59 | 3.59 |
| 5 | -2.00 | 4.00 | 0.51 | 0.51 | 4.10 | 4.10 |
| 7 | -1.50 | 2.83 | 0.90 | 0.90 | 5.00 | 5.00 |
| 10 | -1.00 | 2.00 | 0.89 | 0.89 | 5.89 | 5.89 |
| 14 | -0.50 | 1.41 | 0.87 | 0.87 | 6.76 | 6.76 |
| 18 | 0.00 | 1.00 | 0.68 | 0.68 | 7.44 | 7.44 |
| 25 | 0.50 | 0.71 | 0.70 | 0.70 | 8.14 | 8.14 |
| 35 | 1.00 | 0.50 | 0.73 | 0.73 | 8.87 | 8.87 |
| 45 | 1.50 | 0.35 | 1.62 | 1.62 | 10.49 | 10.49 |
| 60 | 2.00 | 0.25 | 7.80 | 7.80 | 18.29 | 18.29 |
| 80 | 2.50 | 0.18 | 25.57 | 25.57 | 43.86 | 43.86 |
| 120 | 3.00 | 0.13 | 47.90 | 47.90 | 91.76 | 91.76 |
| 170 | 3.50 | 0.09 | 5.89 | 5.89 | 97.65 | 97.65 |
| 200 | 3.75 | 0.07 | 0.37 | 0.37 | 98.02 | 98.02 |
| 230 | 4.00 | 0.06 | 0.18 | 0.18 | 98.20 | 98.20 |

| Phi 5 | Phi 16 | Phi 25 | Phi 50 | Phi 75 | Phi 84 | Phi 95 |
|---|---|---|---|---|---|---|
| 3.28 | 2.92 | 2.83 | 2.56 | 2.13 | 1.85 | -1.50 |

| Moment Statistics | Mean Phi | Mean mm | Sorting | Skewness | Kurtosis |
|---|---|---|---|---|---|
| | 2.19 | 0.22 | 1.27 | -2.98 | 11.94 |

GRANULARMETRIC REPORT_SOUTH_PELTO_COMP.GPJ FL_DEP_ROSS.GDT 10/14/05


Percent Finer By Weight
Percent Coarser By Weight
PHI Sieve Sizes
Standard Sieve Sizes
Hydrometer
Millimeters
Gravel
Sand
Silt and Clay
Coarse
Fine
Medium
Sample
Symbol
Elev. (ft)
USCS
% Fines
% Organics
% Carbonates
Median
Mean
Skew
Kurt
Sort
CHVC-05-06 COMP
#200 - 1.98
#230 - 1.60
2.56
2.19
-2.98
11.94
1.27
Comments:
Depths and elevations based on measured values
Coastal Planning & Engineering
2481 NW Boca Raton Blvd, Boca Raton
FL 33431
ph (561) 391-8102
fax (561) 391-9116
Sample Information
Project Name:
South Pelto, La
Analysis Date:
Analyzed By:
AU
Easting (X, ft):
Northing (Y, ft):
Horizontal System:
Vertical System:
SIEVE ANALYSIS SOUTH_PELTO_COMP.GPJ FL DEP ROSS.GDT 10/14/05

## Granularmetric Report

Depths and elevations based on measured values

Project Name: South Pelto, La
Sample Name: CHVC-05-07 COMP
Analysis Date:
Analyzed By: AU

Coastal Planning & Engineering
2481 NW Boca Raton Blvd, Boca Raton
FL 33431
ph (561) 391-8102
fax (561) 391-9116

| Easting (ft): | Northing (ft): | Coordinate System: | Elevation (ft): |
|---|---|---|---|
| | | | |

| USCS: | Munsell: | Comments: |
|---|---|---|
| SP | | |

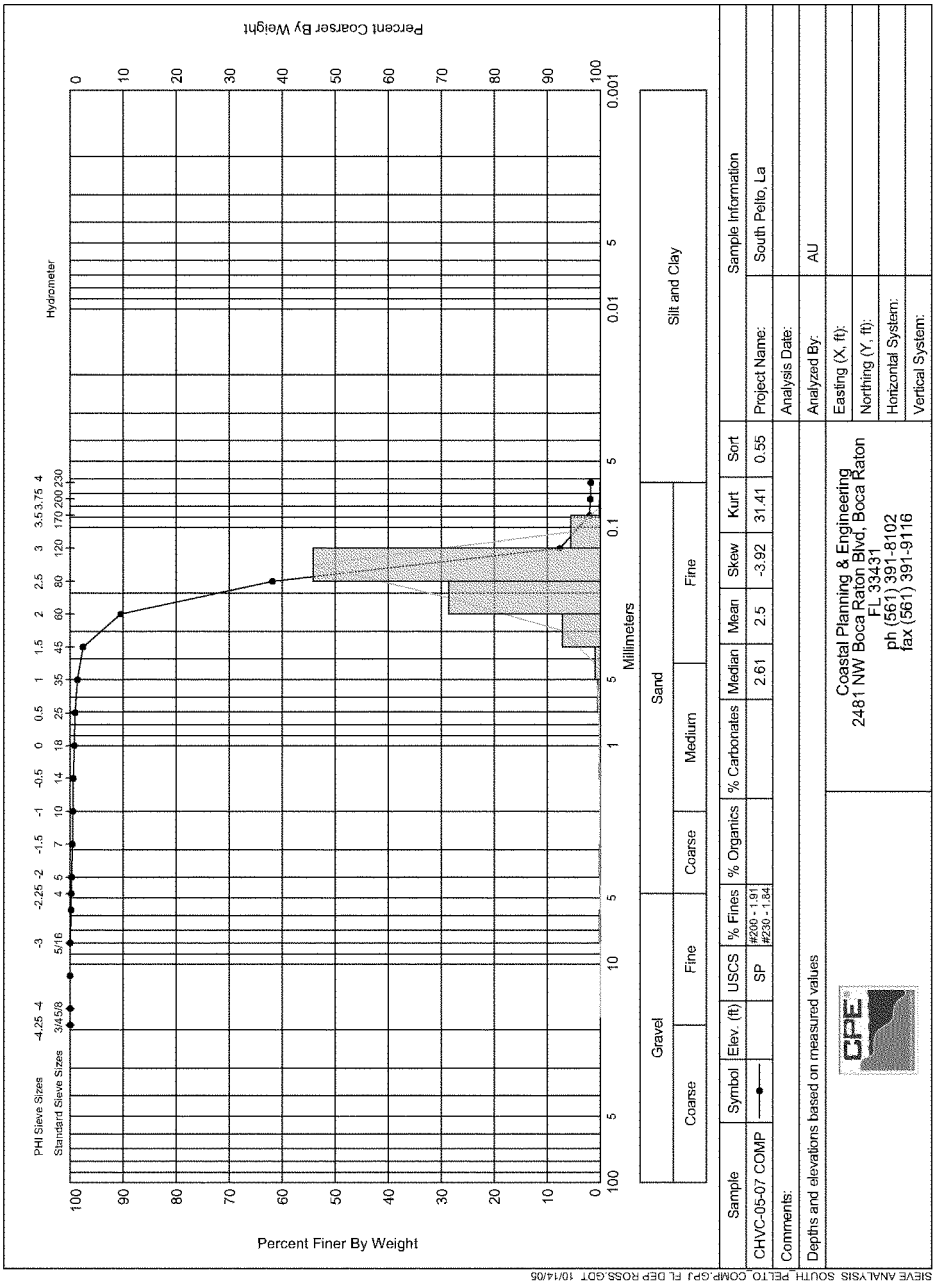
| Dry Weight (g): | Wash Weight (g): | Pan Retained (g): | Sieve Loss (%): | Fines (%): | Organics (%): | Carbonates (%): | Shells (%): |
|---|---|---|---|---|---|---|---|
| 100.00 | 100.00 | 1.68 | 0.16 | #200 - 1.91<br>#230 - 1.84 | | | |

| Sieve Number | Sieve Size (Phi) | Sieve Size (Millimeters) | Grams Retained | % Weight Retained | Cum. Grams Retained | C. % Weight Retained |
|---|---|---|---|---|---|---|
| 3/4" | -4.25 | 19.03 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5/8" | -4.00 | 16.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7/16" | -3.50 | 11.31 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5/16" | -3.00 | 8.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3.5 | -2.50 | 5.66 | 0.18 | 0.18 | 0.18 | 0.18 |
| 4 | -2.25 | 4.76 | 0.02 | 0.02 | 0.20 | 0.20 |
| 5 | -2.00 | 4.00 | 0.05 | 0.05 | 0.25 | 0.25 |
| 7 | -1.50 | 2.83 | 0.15 | 0.15 | 0.40 | 0.40 |
| 10 | -1.00 | 2.00 | 0.09 | 0.09 | 0.49 | 0.49 |
| 14 | -0.50 | 1.41 | 0.11 | 0.11 | 0.60 | 0.60 |
| 18 | 0.00 | 1.00 | 0.17 | 0.17 | 0.77 | 0.77 |
| 25 | 0.50 | 0.71 | 0.14 | 0.14 | 0.91 | 0.91 |
| 35 | 1.00 | 0.50 | 0.46 | 0.46 | 1.37 | 1.37 |
| 45 | 1.50 | 0.35 | 1.03 | 1.03 | 2.40 | 2.40 |
| 60 | 2.00 | 0.25 | 7.14 | 7.14 | 9.54 | 9.54 |
| 80 | 2.50 | 0.18 | 28.59 | 28.59 | 38.13 | 38.13 |
| 120 | 3.00 | 0.13 | 54.20 | 54.20 | 92.33 | 92.33 |
| 170 | 3.50 | 0.09 | 5.62 | 5.62 | 97.95 | 97.95 |
| 200 | 3.75 | 0.07 | 0.14 | 0.14 | 98.09 | 98.09 |
| 230 | 4.00 | 0.06 | 0.07 | 0.07 | 98.16 | 98.16 |

| Phi 5 | Phi 16 | Phi 25 | Phi 50 | Phi 75 | Phi 84 | Phi 95 |
|---|---|---|---|---|---|---|
| 3.24 | 2.92 | 2.84 | 2.61 | 2.27 | 2.11 | 1.68 |

| Moment | Mean Phi | Mean mm | Sorting | Skewness | Kurtosis |
|---|---|---|---|---|---|
| Statistics | 2.5 | 0.18 | 0.55 | -3.92 | 31.41 |

GRANULARMETRIC REPORT_SOUTH_PELTO_COMP.GPJ FL_DEP ROSS.GDT 10/14/05


PHI Sieve Sizes -4.25 -4 -3 -2.25 -2 -1.5 -1 -0.5 0 0.5 1 1.5 2 2.5 3 3.5 3.75 4
Standard Sieve Sizes 3/4 5/8 5/16 4 5 7 10 14 18 25 35 45 60 80 120 170 200 230 Hydrometer
Percent Finer By Weight
Percent Coarser By Weight
100 90 80 70 60 50 40 30 20 10 0
0 10 20 30 40 50 60 70 80 90 100
100 5 10 5 1 5 0.1 5 0.01 5 0.001
Millimeters
Gravel
Coarse Fine
Sand
Coarse Medium Fine
Silt and Clay
Sample Symbol Elev. (ft.) USCS % Fines % Organics % Carbonates Median Mean Skew Kurt Sort
CHVC-05-07 COMP SP #200 - 1.91 #230 - 1.84 2.61 2.5 -3.92 31.41 0.55
Comments:
Depths and elevations based on measured values
Coastal Planning & Engineering
2481 NW Boca Raton Blvd, Boca Raton
FL 33431
ph (561) 391-8102
fax (561) 391-9116
Sample Information
Project Name: South Pelto, La
Analysis Date:
Analyzed By: AU
Easting (X, ft):
Northing (Y, ft):
Horizontal System:
Vertical System:
SIEVE ANALYSIS SOUTH_PELTO_COMP.GPJ FL DEP ROSS.GDT 10/14/05

## Granularmetric Report

Depths and elevations based on measured values

Project Name: South Pelto, La
Sample Name: CHVC-05-08 COMP
Analysis Date:
Analyzed By: AU

Coastal Planning & Engineering
2481 NW Boca Raton Blvd, Boca Raton
FL 33431
ph (561) 391-8102
fax (561) 391-9116

| Easting (ft): | Northing (ft): | Coordinate System: | Elevation (ft): |
|---|---|---|---|
| | | | |

| USCS: | Munsell: | Comments: |
|---|---|---|
| SP | | |

| Dry Weight (g): | Wash Weight (g): | Pan Retained (g): | Sieve Loss (%): | Fines (%): | Organics (%): | Carbonates (%): | Shells (%): |
|---|---|---|---|---|---|---|---|
| 100.00 | 100.00 | 1.39 | 0.15 | #200 - 1.65<br>#230 - 1.54 | | | |

| Sieve Number | Sieve Size (Phi) | Sieve Size (Millimeters) | Grams Retained | % Weight Retained | Cum. Grams Retained | C. % Weight Retained |
|---|---|---|---|---|---|---|
| 3/4" | -4.25 | 19.03 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5/8" | -4.00 | 16.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7/16" | -3.50 | 11.31 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5/16" | -3.00 | 8.00 | 0.58 | 0.58 | 0.58 | 0.58 |
| 3.5 | -2.50 | 5.66 | 0.48 | 0.48 | 1.06 | 1.06 |
| 4 | -2.25 | 4.76 | 0.02 | 0.02 | 1.08 | 1.08 |
| 5 | -2.00 | 4.00 | 0.19 | 0.19 | 1.27 | 1.27 |
| 7 | -1.50 | 2.83 | 0.72 | 0.72 | 1.99 | 1.99 |
| 10 | -1.00 | 2.00 | 0.59 | 0.59 | 2.58 | 2.58 |
| 14 | -0.50 | 1.41 | 0.55 | 0.55 | 3.13 | 3.13 |
| 18 | 0.00 | 1.00 | 0.57 | 0.57 | 3.70 | 3.70 |
| 25 | 0.50 | 0.71 | 0.53 | 0.53 | 4.23 | 4.23 |
| 35 | 1.00 | 0.50 | 0.55 | 0.55 | 4.78 | 4.78 |
| 45 | 1.50 | 0.35 | 1.33 | 1.33 | 6.11 | 6.11 |
| 60 | 2.00 | 0.25 | 7.67 | 7.67 | 13.78 | 13.78 |
| 80 | 2.50 | 0.18 | 28.66 | 28.66 | 42.44 | 42.44 |
| 120 | 3.00 | 0.13 | 50.78 | 50.78 | 93.22 | 93.22 |
| 170 | 3.50 | 0.09 | 4.98 | 4.98 | 98.20 | 98.20 |
| 200 | 3.75 | 0.07 | 0.15 | 0.15 | 98.35 | 98.35 |
| 230 | 4.00 | 0.06 | 0.11 | 0.11 | 98.46 | 98.46 |

| Phi 5 | Phi 16 | Phi 25 | Phi 50 | Phi 75 | Phi 84 | Phi 95 |
|---|---|---|---|---|---|---|
| 3.18 | 2.91 | 2.82 | 2.57 | 2.20 | 2.04 | 1.08 |

| Moment Statistics | Mean Phi | Mean mm | Sorting | Skewness | Kurtosis |
|---|---|---|---|---|---|
| | 2.34 | 0.20 | 0.93 | -3.67 | 18.8 |

GRANULARMETRIC REPORT_SOUTH_PELTO_COMP.GPJ FL_DEP ROSS.GDT 10/14/05

Percent Finer By Weight
Percent Coarser By Weight
Hydrometer
PHI Sieve Sizes
Standard Sieve Sizes
Millimeters
Gravel
Coarse
Fine
Sand
Coarse
Medium
Fine
Silt and Clay
Sample
Symbol
Elev. (ft)
USCS
% Fines
% Organics
% Carbonates
Median
Mean
Skew
Kurt
Sort
CHVC-05-08 COMP
SP
#200 - 1.65
#230 - 1.54
2.57
2.34
-3.67
18.8
0.93
Comments:
Depths and elevations based on measured values
Coastal Planning & Engineering
2481 NW Boca Raton Blvd, Boca Raton
FL 33431
ph (561) 391-8102
fax (561) 391-9116
Sample Information
Project Name:
South Pelto, La
Analysis Date:
Analyzed By:
AU
Easting (X, ft):
Northing (Y, ft):
Horizontal System:
Vertical System:
SIEVE ANALYSIS SOUTH_PELTO_COMP.GPJ FL DEP ROSS.GDT 10/14/05

## Granularmetric Report

Depths and elevations based on measured values

Project Name: South Pelto, La
Sample Name: CHVC-05-09 COMP
Analysis Date:
Analyzed By: AU

Coastal Planning & Engineering
2481 NW Boca Raton Blvd, Boca Raton
FL 33431
ph (561) 391-8102
fax (561) 391-9116

| Easting (ft): | Northing (ft): | Coordinate System: | Elevation (ft): |
|---|---|---|---|
| | | | |

| USCS: | Munsell: | Comments: |
|---|---|---|
| SP | | |

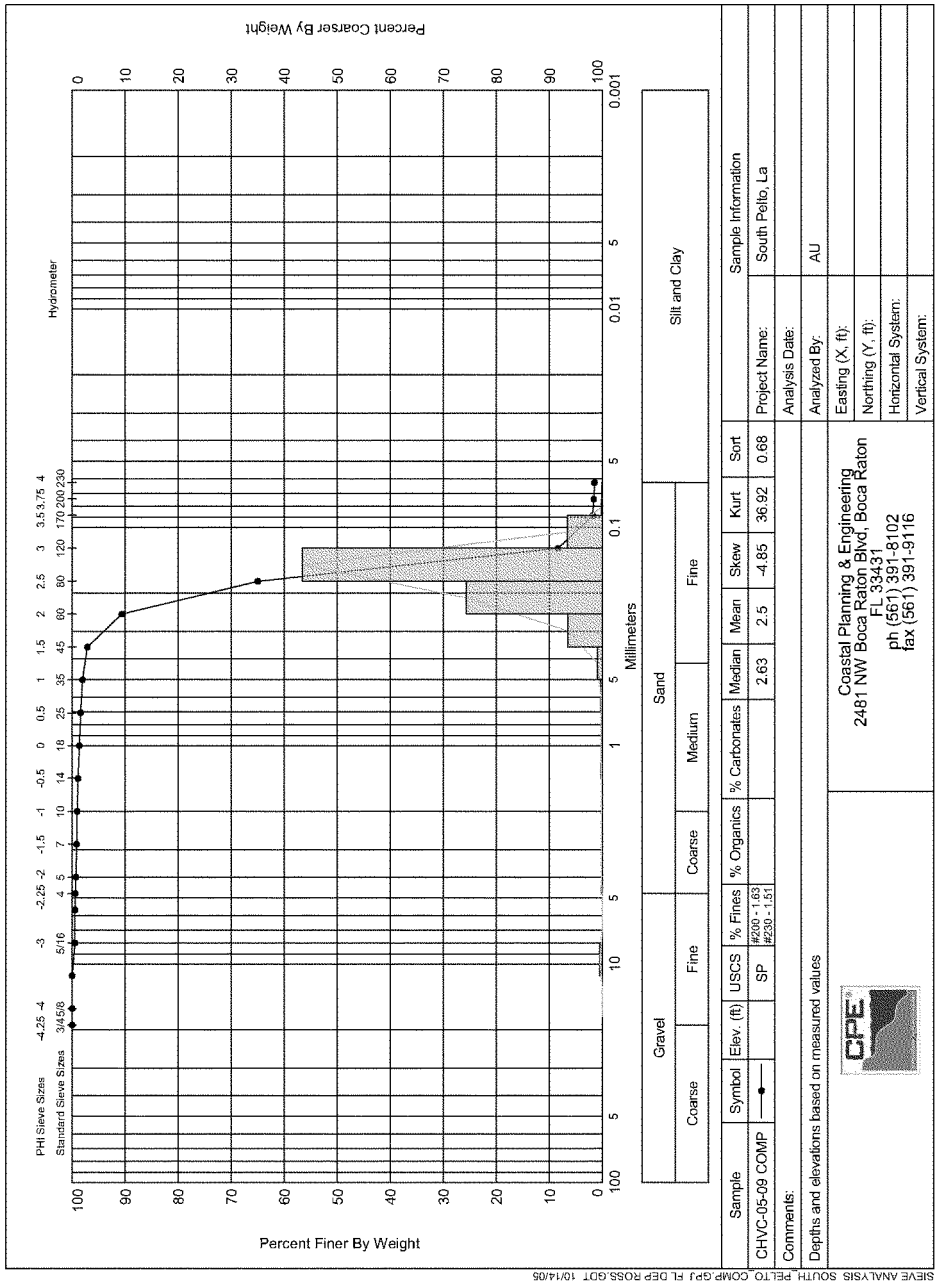
| Dry Weight (g): | Wash Weight (g): | Pan Retained (g): | Sieve Loss (%): | Fines (%): | Organics (%): | Carbonates (%): | Shells (%): |
|---|---|---|---|---|---|---|---|
| 100.00 | 100.00 | 1.50 | 0.01 | #200 - 1.63<br>#230 - 1.51 | | | |

| Sieve Number | Sieve Size (Phi) | Sieve Size (Millimeters) | Grams Retained | % Weight Retained | Cum. Grams Retained | C. % Weight Retained |
|---|---|---|---|---|---|---|
| 3/4" | -4.25 | 19.03 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5/8" | -4.00 | 16.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7/16" | -3.50 | 11.31 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5/16" | -3.00 | 8.00 | 0.53 | 0.53 | 0.53 | 0.53 |
| 3.5 | -2.50 | 5.66 | 0.00 | 0.00 | 0.53 | 0.53 |
| 4 | -2.25 | 4.76 | 0.02 | 0.02 | 0.55 | 0.55 |
| 5 | -2.00 | 4.00 | 0.13 | 0.13 | 0.68 | 0.68 |
| 7 | -1.50 | 2.83 | 0.13 | 0.13 | 0.81 | 0.81 |
| 10 | -1.00 | 2.00 | 0.14 | 0.14 | 0.95 | 0.95 |
| 14 | -0.50 | 1.41 | 0.16 | 0.16 | 1.11 | 1.11 |
| 18 | 0.00 | 1.00 | 0.24 | 0.24 | 1.35 | 1.35 |
| 25 | 0.50 | 0.71 | 0.23 | 0.23 | 1.58 | 1.58 |
| 35 | 1.00 | 0.50 | 0.35 | 0.35 | 1.93 | 1.93 |
| 45 | 1.50 | 0.35 | 0.94 | 0.94 | 2.87 | 2.87 |
| 60 | 2.00 | 0.25 | 6.48 | 6.48 | 9.35 | 9.35 |
| 80 | 2.50 | 0.18 | 25.65 | 25.65 | 35.00 | 35.00 |
| 120 | 3.00 | 0.13 | 56.61 | 56.61 | 91.61 | 91.61 |
| 170 | 3.50 | 0.09 | 6.57 | 6.57 | 98.18 | 98.18 |
| 200 | 3.75 | 0.07 | 0.19 | 0.19 | 98.37 | 98.37 |
| 230 | 4.00 | 0.06 | 0.12 | 0.12 | 98.49 | 98.49 |

| Phi 5 | Phi 16 | Phi 25 | Phi 50 | Phi 75 | Phi 84 | Phi 95 |
|---|---|---|---|---|---|---|
| 3.26 | 2.93 | 2.85 | 2.63 | 2.31 | 2.13 | 1.66 |

| Moment Statistics | Mean Phi | Mean mm | Sorting | Skewness | Kurtosis |
|---|---|---|---|---|---|
| | 2.5 | 0.18 | 0.68 | -4.85 | 36.92 |

GRANULARMETRIC REPORT SOUTH_PELTO_COMP.GPJ FL_DEP ROSS.GDT 10/14/05


Percent Finer By Weight
Percent Coarser By Weight
PHI Sieve Sizes
Standard Sieve Sizes
Hydrometer
Millimeters
Gravel
Coarse
Fine
Sand
Coarse
Medium
Fine
Silt and Clay
Sample
Symbol
Elev. (ft)
USCS
% Fines
% Organics
% Carbonates
Median
Mean
Skew
Kurt
Sort
CHVC-05-09 COMP
SP
#200 - 1.63
#230 - 1.51
2.63
2.5
-4.85
36.92
0.68
Comments:
Depths and elevations based on measured values
Coastal Planning & Engineering
2481 NW Boca Raton Blvd, Boca Raton
FL 33431
ph (561) 391-8102
fax (561) 391-9116
Sample Information
Project Name:
South Pelto, La
Analysis Date:
Analyzed By:
AU
Easting (X, ft):
Northing (Y, ft):
Horizontal System:
Vertical System:
SIEVE ANALYSIS SOUTH_PELTO_COMP.GPJ FL DEP ROSS.GDT 10/14/05

## Granularmetric Report

Depths and elevations based on measured values

Project Name: South Pelto, La
Sample Name: CHVC-05-10 COMP
Analysis Date:
Analyzed By: AU

Coastal Planning & Engineering
2481 NW Boca Raton Blvd, Boca Raton
FL 33431
ph (561) 391-8102
fax (561) 391-9116

| Easting (ft): | Northing (ft): | Coordinate System: | Elevation (ft): |
|---|---|---|---|
| | | | |

| USCS: | Munsell: | Comments: |
|---|---|---|
| SP | | |

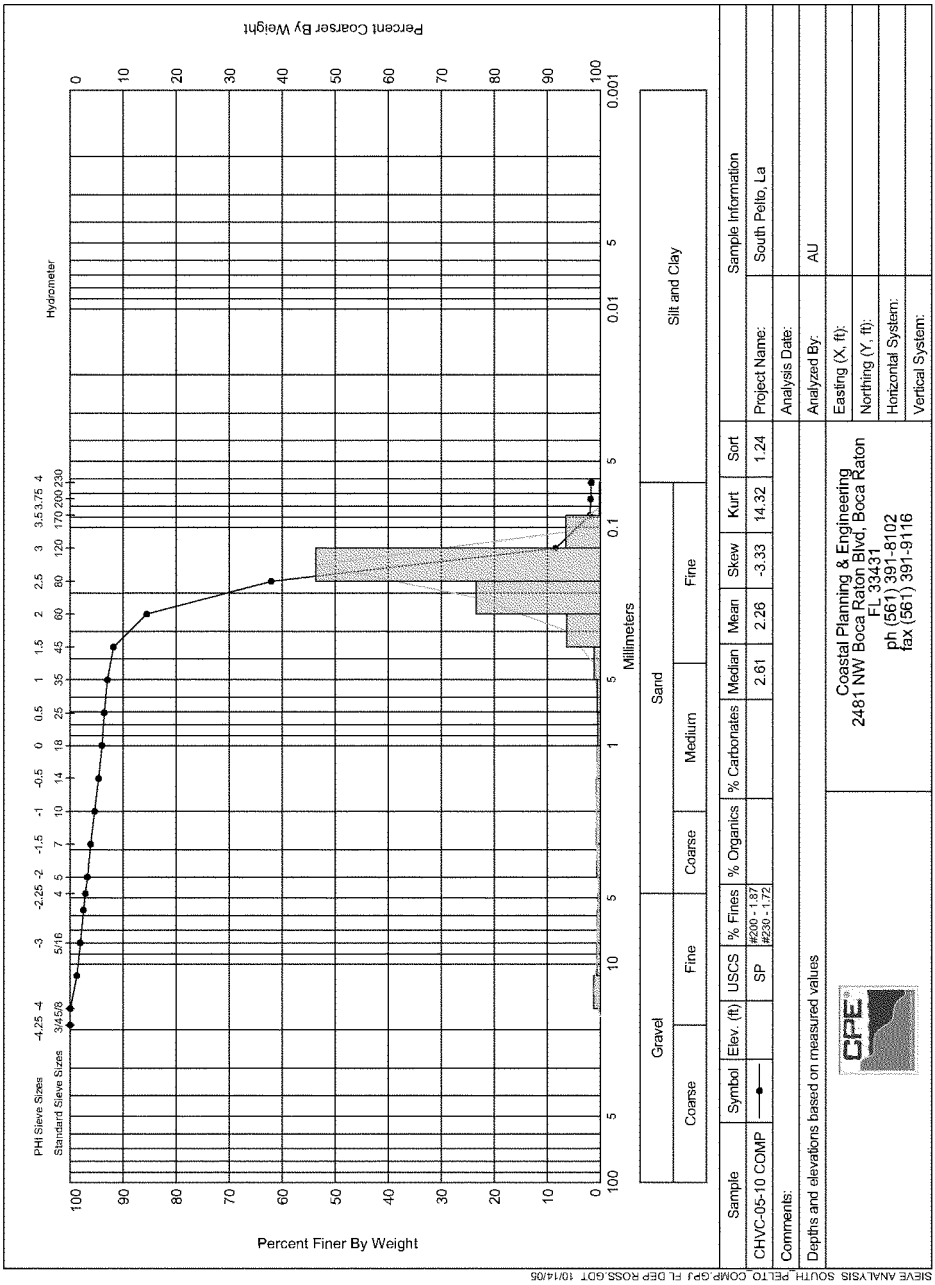
| Dry Weight (g): | Wash Weight (g): | Pan Retained (g): | Sieve Loss (%): | Fines (%): | Organics (%): | Carbonates (%): | Shells (%): |
|---|---|---|---|---|---|---|---|
| 100.00 | 100.00 | 1.61 | 0.11 | #200 - 1.87<br>#230 - 1.72 | | | |

| Sieve Number | Sieve Size (Phi) | Sieve Size (Millimeters) | Grams Retained | % Weight Retained | Cum. Grams Retained | C. % Weight Retained |
|---|---|---|---|---|---|---|
| 3/4" | -4.25 | 19.03 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5/8" | -4.00 | 16.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7/16" | -3.50 | 11.31 | 1.25 | 1.25 | 1.25 | 1.25 |
| 5/16" | -3.00 | 8.00 | 0.64 | 0.64 | 1.89 | 1.89 |
| 3.5 | -2.50 | 5.66 | 0.59 | 0.59 | 2.48 | 2.48 |
| 4 | -2.25 | 4.76 | 0.39 | 0.39 | 2.87 | 2.87 |
| 5 | -2.00 | 4.00 | 0.35 | 0.35 | 3.22 | 3.22 |
| 7 | -1.50 | 2.83 | 0.64 | 0.64 | 3.86 | 3.86 |
| 10 | -1.00 | 2.00 | 0.76 | 0.76 | 4.62 | 4.62 |
| 14 | -0.50 | 1.41 | 0.75 | 0.75 | 5.37 | 5.37 |
| 18 | 0.00 | 1.00 | 0.59 | 0.59 | 5.96 | 5.96 |
| 25 | 0.50 | 0.71 | 0.46 | 0.46 | 6.42 | 6.42 |
| 35 | 1.00 | 0.50 | 0.59 | 0.59 | 7.01 | 7.01 |
| 45 | 1.50 | 0.35 | 1.14 | 1.14 | 8.15 | 8.15 |
| 60 | 2.00 | 0.25 | 6.30 | 6.30 | 14.45 | 14.45 |
| 80 | 2.50 | 0.18 | 23.45 | 23.45 | 37.90 | 37.90 |
| 120 | 3.00 | 0.13 | 53.64 | 53.64 | 91.54 | 91.54 |
| 170 | 3.50 | 0.09 | 6.46 | 6.46 | 98.00 | 98.00 |
| 200 | 3.75 | 0.07 | 0.13 | 0.13 | 98.13 | 98.13 |
| 230 | 4.00 | 0.06 | 0.15 | 0.15 | 98.28 | 98.28 |

| Phi 5 | Phi 16 | Phi 25 | Phi 50 | Phi 75 | Phi 84 | Phi 95 |
|---|---|---|---|---|---|---|
| 3.27 | 2.93 | 2.85 | 2.61 | 2.22 | 2.03 | -0.75 |

| Moment Statistics | Mean Phi | Mean mm | Sorting | Skewness | Kurtosis |
|---|---|---|---|---|---|
| | 2.26 | 0.21 | 1.24 | -3.33 | 14.32 |

GRANULARMETRIC REPORT_SOUTH_PELTO_COMP.GPJ FL_DEP_ROSS.GDT 10/14/05


Percent Finer By Weight
Percent Coarser By Weight
PHI Sieve Sizes
Standard Sieve Sizes
Hydrometer
Millimeters
Gravel
Sand
Silt and Clay
Coarse
Fine
Medium
Sample
Symbol
Elev. (ft)
USCS
% Fines
% Organics
% Carbonates
Median
Mean
Skew
Kurt
Sort
CHVC-05-10 COMP
SP
#200 - 1.87
#230 - 1.72
2.61
2.26
-3.33
14.32
1.24
Comments:
Depths and elevations based on measured values
Coastal Planning & Engineering
2481 NW Boca Raton Blvd, Boca Raton
FL 33431
ph (561) 391-8102
fax (561) 391-9116
Sample Information
Project Name:
South Pelto, La
Analysis Date:
Analyzed By:
AU
Easting (X, ft):
Northing (Y, ft):
Horizontal System:
Vertical System:
SIEVE ANALYSIS SOUTH_PELTO_COMP.GPJ FL DEP ROSS.GDT 10/14/05

## Granularmetric Report

Depths and elevations based on measured values

Project Name: South Pelto, La
Sample Name: CHVC-05-11 COMP
Analysis Date:
Analyzed By: AU

Coastal Planning & Engineering
2481 NW Boca Raton Blvd, Boca Raton
FL 33431
ph (561) 391-8102
fax (561) 391-9116

| Easting (ft): | Northing (ft): | Coordinate System: | Elevation (ft): |
|---|---|---|---|
| | | | |

| USCS: | Munsell: | Comments: |
|---|---|---|
| SP | | |

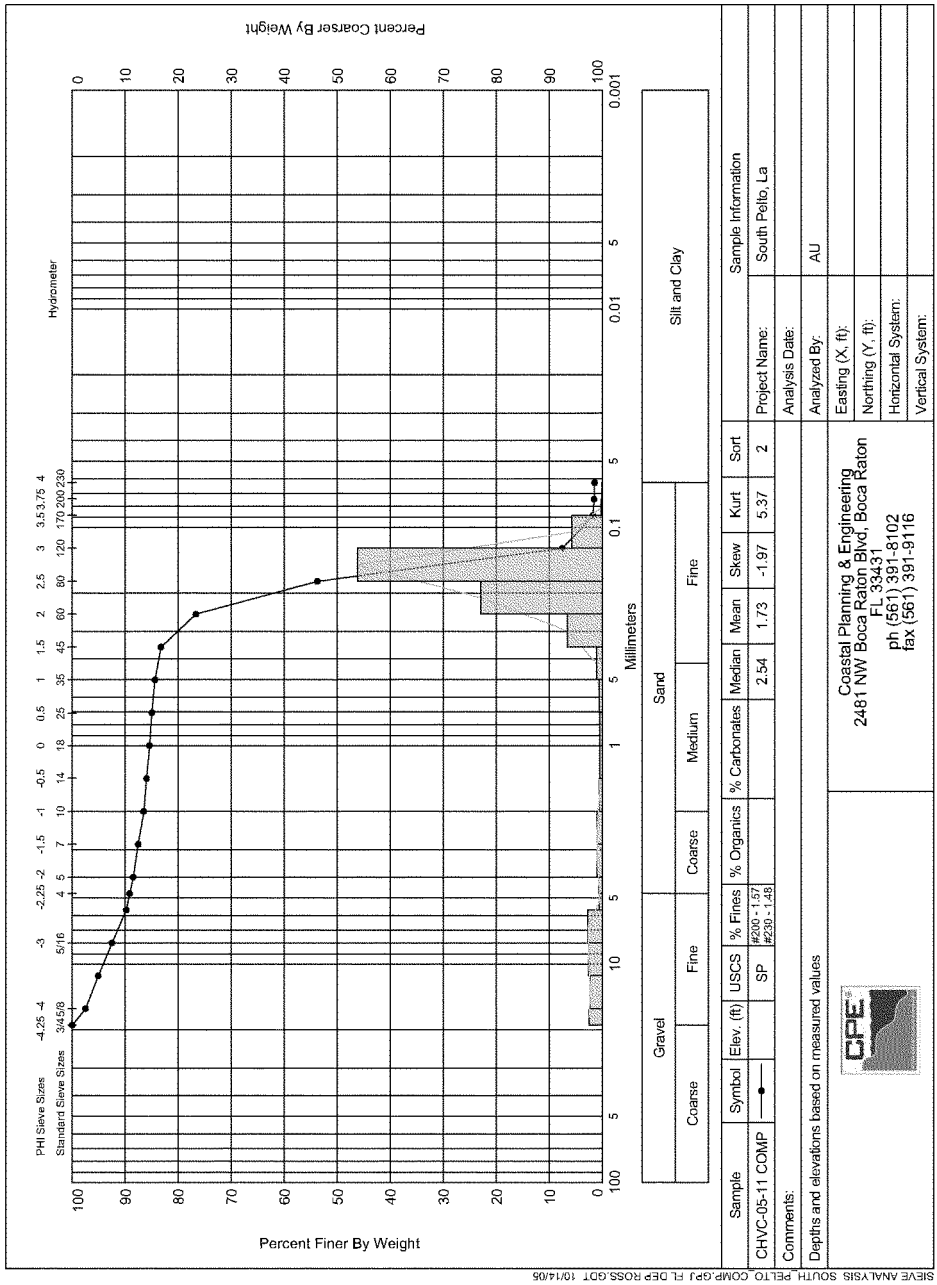
| Dry Weight (g): | Wash Weight (g): | Pan Retained (g): | Sieve Loss (%): | Fines (%): | Organics (%): | Carbonates (%): | Shells (%): |
|---|---|---|---|---|---|---|---|
| 100.00 | 100.00 | 1.42 | 0.06 | #200 - 1.57<br>#230 - 1.48 | | | |

| Sieve Number | Sieve Size (Phi) | Sieve Size (Millimeters) | Grams Retained | % Weight Retained | Cum. Grams Retained | C. % Weight Retained |
|---|---|---|---|---|---|---|
| 3/4" | -4.25 | 19.03 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5/8" | -4.00 | 16.00 | 2.53 | 2.53 | 2.53 | 2.53 |
| 7/16" | -3.50 | 11.31 | 2.37 | 2.37 | 4.90 | 4.90 |
| 5/16" | -3.00 | 8.00 | 2.58 | 2.58 | 7.48 | 7.48 |
| 3.5 | -2.50 | 5.66 | 2.72 | 2.72 | 10.20 | 10.20 |
| 4 | -2.25 | 4.76 | 0.61 | 0.61 | 10.81 | 10.81 |
| 5 | -2.00 | 4.00 | 0.67 | 0.67 | 11.48 | 11.48 |
| 7 | -1.50 | 2.83 | 0.97 | 0.97 | 12.45 | 12.45 |
| 10 | -1.00 | 2.00 | 1.01 | 1.01 | 13.46 | 13.46 |
| 14 | -0.50 | 1.41 | 0.58 | 0.58 | 14.04 | 14.04 |
| 18 | 0.00 | 1.00 | 0.52 | 0.52 | 14.56 | 14.56 |
| 25 | 0.50 | 0.71 | 0.48 | 0.48 | 15.04 | 15.04 |
| 35 | 1.00 | 0.50 | 0.57 | 0.57 | 15.61 | 15.61 |
| 45 | 1.50 | 0.35 | 1.11 | 1.11 | 16.72 | 16.72 |
| 60 | 2.00 | 0.25 | 6.61 | 6.61 | 23.33 | 23.33 |
| 80 | 2.50 | 0.18 | 22.91 | 22.91 | 46.24 | 46.24 |
| 120 | 3.00 | 0.13 | 46.16 | 46.16 | 92.40 | 92.40 |
| 170 | 3.50 | 0.09 | 5.78 | 5.78 | 98.18 | 98.18 |
| 200 | 3.75 | 0.07 | 0.25 | 0.25 | 98.43 | 98.43 |
| 230 | 4.00 | 0.06 | 0.09 | 0.09 | 98.52 | 98.52 |

| Phi 5 | Phi 16 | Phi 25 | Phi 50 | Phi 75 | Phi 84 | Phi 95 |
|---|---|---|---|---|---|---|
| 3.22 | 2.91 | 2.81 | 2.54 | 2.04 | 1.18 | -3.48 |

| Moment | Mean Phi | Mean mm | Sorting | Skewness | Kurtosis |
|---|---|---|---|---|---|
| Statistics | 1.73 | 0.30 | 2 | -1.97 | 5.37 |

GRANULARMETRIC REPORT SOUTH_PELTO_COMP.GPJ FL DEP ROSS.GDT 10/14/05




| Sample | Symbol | Elev. (ft) | USCS | % Fines | % Organics | % Carbonates | Median | Mean | Skew | Kurt | Sort |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CHVC-05-11 COMP | | | SP | #200 - 1.57<br>#230 - 1.48 | | | 2.54 | 1.73 | -1.97 | 5.37 | 2 |

Comments:

Depths and elevations based on measured values

Coastal Planning & Engineering
2481 NW Boca Raton Blvd, Boca Raton
FL 33431
ph (561) 391-8102
fax (561) 391-9116

| Sample Information | |
|---|---|
| Project Name: | South Pelto, La |
| Analysis Date: | |
| Analyzed By: | AU |
| Easting (X, ft): | |
| Northing (Y, ft): | |
| Horizontal System: | |
| Vertical System: | |

SIEVE ANALYSIS SOUTH_PELTO_COMP.GPJ FL DEP ROSS.GDT 10/14/05

## Granularmetric Report

Depths and elevations based on measured values

Project Name: South Pelto, La
Sample Name: CHVC-05-12 COMP
Analysis Date:
Analyzed By: AU

Coastal Planning & Engineering
2481 NW Boca Raton Blvd, Boca Raton
FL 33431
ph (561) 391-8102
fax (561) 391-9116

| Easting (ft): | Northing (ft): | Coordinate System: | Elevation (ft): |
|---|---|---|---|
| | | | |

| USCS: | Munsell: | Comments: |
|---|---|---|
| SS | | |

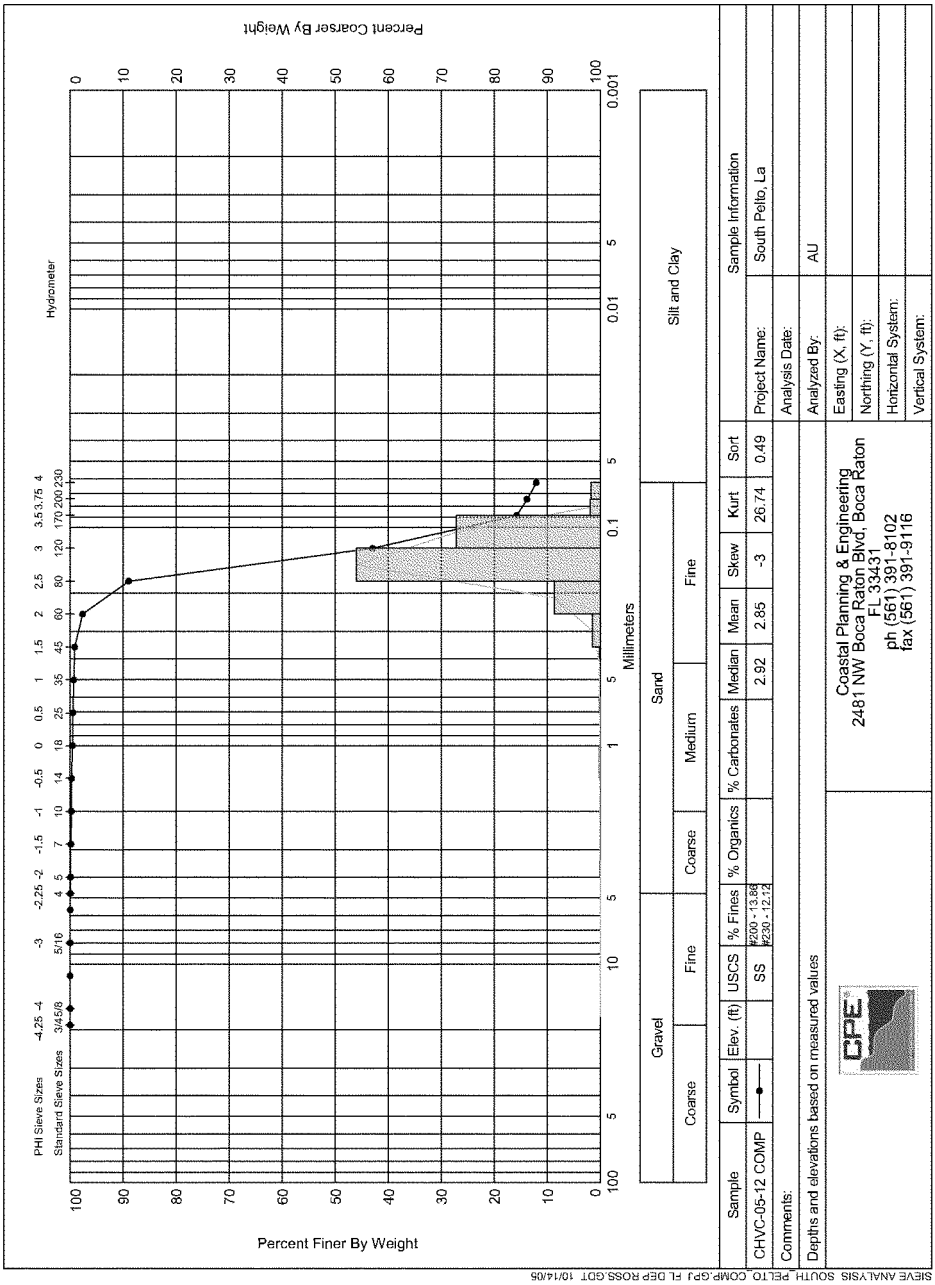
| Dry Weight (g): | Wash Weight (g): | Pan Retained (g): | Sieve Loss (%): | Fines (%): | Organics (%): | Carbonates (%): | Shells (%): |
|---|---|---|---|---|---|---|---|
| 100.00 | 100.00 | 12.02 | 0.10 | #200 - 13.86<br>#230 - 12.12 | | | |

| Sieve Number | Sieve Size (Phi) | Sieve Size (Millimeters) | Grams Retained | % Weight Retained | Cum. Grams Retained | C. % Weight Retained |
|---|---|---|---|---|---|---|
| 3/4" | -4.25 | 19.03 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5/8" | -4.00 | 16.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7/16" | -3.50 | 11.31 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5/16" | -3.00 | 8.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3.5 | -2.50 | 5.66 | 0.02 | 0.02 | 0.02 | 0.02 |
| 4 | -2.25 | 4.76 | 0.00 | 0.00 | 0.02 | 0.02 |
| 5 | -2.00 | 4.00 | 0.03 | 0.03 | 0.05 | 0.05 |
| 7 | -1.50 | 2.83 | 0.07 | 0.07 | 0.12 | 0.12 |
| 10 | -1.00 | 2.00 | 0.10 | 0.10 | 0.22 | 0.22 |
| 14 | -0.50 | 1.41 | 0.06 | 0.06 | 0.28 | 0.28 |
| 18 | 0.00 | 1.00 | 0.13 | 0.13 | 0.41 | 0.41 |
| 25 | 0.50 | 0.71 | 0.10 | 0.10 | 0.51 | 0.51 |
| 35 | 1.00 | 0.50 | 0.14 | 0.14 | 0.65 | 0.65 |
| 45 | 1.50 | 0.35 | 0.20 | 0.20 | 0.85 | 0.85 |
| 60 | 2.00 | 0.25 | 1.48 | 1.48 | 2.33 | 2.33 |
| 80 | 2.50 | 0.18 | 8.68 | 8.68 | 11.01 | 11.01 |
| 120 | 3.00 | 0.13 | 46.01 | 46.01 | 57.02 | 57.02 |
| 170 | 3.50 | 0.09 | 27.17 | 27.17 | 84.19 | 84.19 |
| 200 | 3.75 | 0.07 | 1.95 | 1.95 | 86.14 | 86.14 |
| 230 | 4.00 | 0.06 | 1.74 | 1.74 | 87.88 | 87.88 |

| Phi 5 | Phi 16 | Phi 25 | Phi 50 | Phi 75 | Phi 84 | Phi 95 |
|---|---|---|---|---|---|---|
| | 3.50 | 3.33 | 2.92 | 2.65 | 2.55 | 2.15 |

| Moment Statistics | Mean Phi | Mean mm | Sorting | Skewness | Kurtosis |
|---|---|---|---|---|---|
| | 2.85 | 0.14 | 0.49 | -3 | 26.74 |

GRANULARMETRIC REPORT SOUTH_PELTO_COMP.GPJ FL_DEP ROSS.GDT 10/14/05


Percent Finer By Weight
Percent Coarser By Weight
Hydrometer
PHI Sieve Sizes
Standard Sieve Sizes
Millimeters
Gravel
Sand
Silt and Clay
Coarse
Fine
Medium
Sample
Symbol
Elev. (ft)
USCS
% Fines
% Organics
% Carbonates
Median
Mean
Skew
Kurt
Sort
CHVC-05-12 COMP
SS
#200 - 13.88
#230 - 12.12
2.92
2.85
-3
26.74
0.49
Comments:
Depths and elevations based on measured values
Coastal Planning & Engineering
2481 NW Boca Raton Blvd, Boca Raton
FL 33431
ph (561) 391-8102
fax (561) 391-9116
Sample Information
Project Name:
South Pelto, La
Analysis Date:
Analyzed By:
AU
Easting (X, ft):
Northing (Y, ft):
Horizontal System:
Vertical System:
SIEVE ANALYSIS SOUTH_PELTO_COMP.GPJ FL DEP ROSS.GDT 10/14/05

## Granularmetric Report

Depths and elevations based on measured values

Project Name: South Pelto, La
Sample Name: CHVC-05-13 COMP
Analysis Date:
Analyzed By: AU

Coastal Planning & Engineering
2481 NW Boca Raton Blvd, Boca Raton
FL 33431
ph (561) 391-8102
fax (561) 391-9116

| Easting (ft): | Northing (ft): | Coordinate System: | Elevation (ft): |
|---|---|---|---|
| | | | |

| USCS: | Munsell: | Comments: |
|---|---|---|
| SP | | |

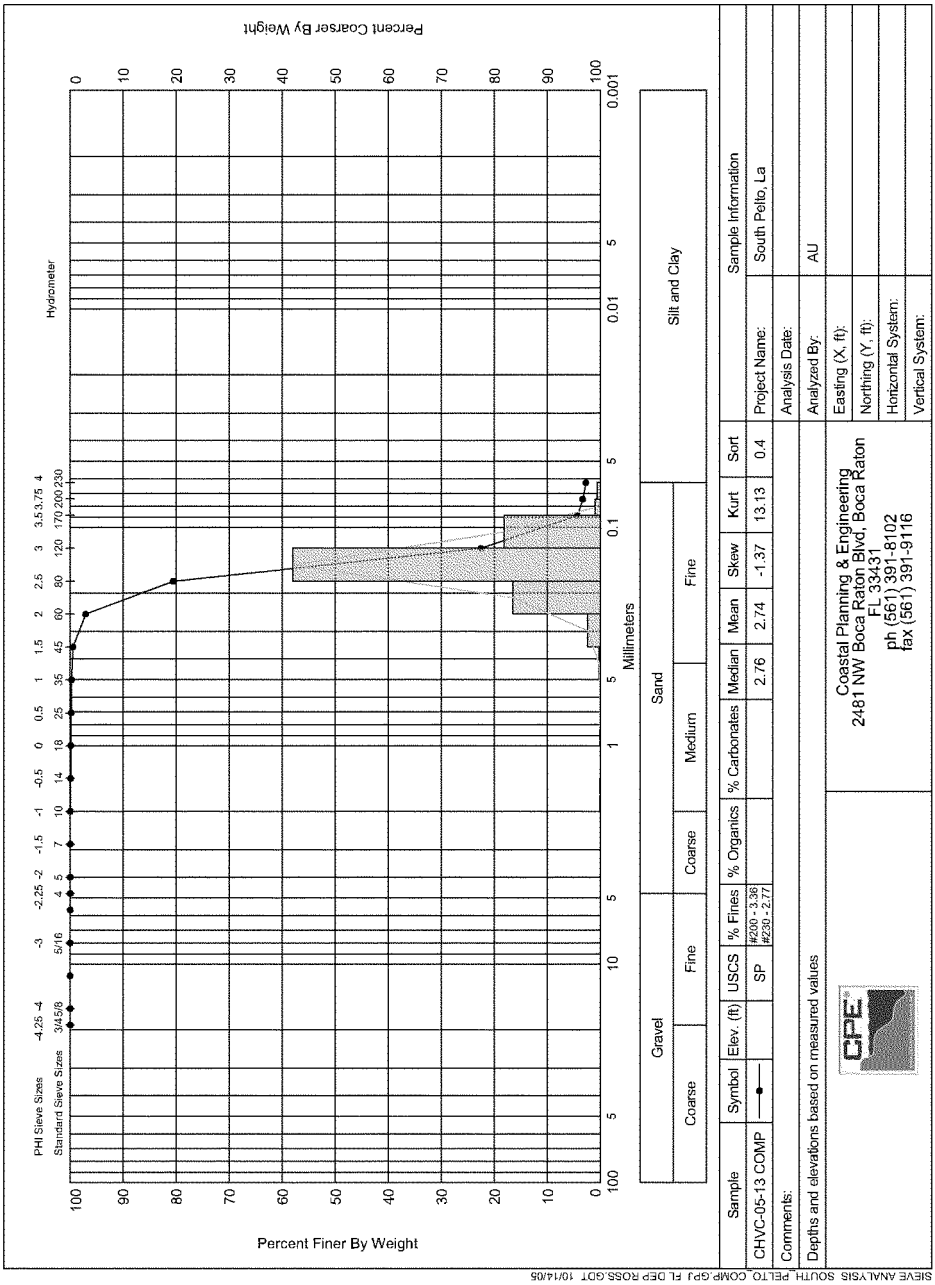
| Dry Weight (g): | Wash Weight (g): | Pan Retained (g): | Sieve Loss (%): | Fines (%): | Organics (%): | Carbonates (%): | Shells (%): |
|---|---|---|---|---|---|---|---|
| 100.00 | 100.00 | 2.58 | 0.19 | #200 - 3.36<br>#230 - 2.77 | | | |

| Sieve Number | Sieve Size (Phi) | Sieve Size (Millimeters) | Grams Retained | % Weight Retained | Cum. Grams Retained | C. % Weight Retained |
|---|---|---|---|---|---|---|
| 3/4" | -4.25 | 19.03 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5/8" | -4.00 | 16.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7/16" | -3.50 | 11.31 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5/16" | -3.00 | 8.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3.5 | -2.50 | 5.66 | 0.00 | 0.00 | 0.00 | 0.00 |
| 4 | -2.25 | 4.76 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5 | -2.00 | 4.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7 | -1.50 | 2.83 | 0.01 | 0.01 | 0.01 | 0.01 |
| 10 | -1.00 | 2.00 | 0.02 | 0.02 | 0.03 | 0.03 |
| 14 | -0.50 | 1.41 | 0.06 | 0.06 | 0.09 | 0.09 |
| 18 | 0.00 | 1.00 | 0.04 | 0.04 | 0.13 | 0.13 |
| 25 | 0.50 | 0.71 | 0.07 | 0.07 | 0.20 | 0.20 |
| 35 | 1.00 | 0.50 | 0.07 | 0.07 | 0.27 | 0.27 |
| 45 | 1.50 | 0.35 | 0.25 | 0.25 | 0.52 | 0.52 |
| 60 | 2.00 | 0.25 | 2.38 | 2.38 | 2.90 | 2.90 |
| 80 | 2.50 | 0.18 | 16.51 | 16.51 | 19.41 | 19.41 |
| 120 | 3.00 | 0.13 | 58.04 | 58.04 | 77.45 | 77.45 |
| 170 | 3.50 | 0.09 | 18.18 | 18.18 | 95.63 | 95.63 |
| 200 | 3.75 | 0.07 | 1.01 | 1.01 | 96.64 | 96.64 |
| 230 | 4.00 | 0.06 | 0.59 | 0.59 | 97.23 | 97.23 |

| Phi 5 | Phi 16 | Phi 25 | Phi 50 | Phi 75 | Phi 84 | Phi 95 |
|---|---|---|---|---|---|---|
| 3.48 | 3.18 | 2.98 | 2.76 | 2.55 | 2.40 | 2.06 |

| Moment | Mean Phi | Mean mm | Sorting | Skewness | Kurtosis |
|---|---|---|---|---|---|
| Statistics | 2.74 | 0.15 | 0.4 | -1.37 | 13.13 |

GRANULARMETRIC REPORT .SOUTH_PELTO_COMP.GPJ FL DEP ROSS.GDT 10/14/05




| Sample | Symbol | Elev. (ft) | USCS | % Fines | % Organics | % Carbonates | Median | Mean | Skew | Kurt | Sort |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CHVC-05-13 COMP | | | SP | #200 - 3.36<br>#230 - 2.77 | | | 2.76 | 2.74 | -1.37 | 13.13 | 0.4 |

Comments:

Depths and elevations based on measured values

Coastal Planning & Engineering
2481 NW Boca Raton Blvd, Boca Raton
FL 33431
ph (561) 391-8102
fax (561) 391-9116

| Sample Information | |
|---|---|
| Project Name: | South Pelto, La |
| Analysis Date: | |
| Analyzed By: | AU |
| Easting (X, ft): | |
| Northing (Y, ft): | |
| Horizontal System: | |
| Vertical System: | |

SIEVE ANALYSIS SOUTH_PELTO_COMP.GPJ FL DEP ROSS.GDT 10/14/05

## Granularmetric Report

Depths and elevations based on measured values

Project Name: South Pelto, La
Sample Name: CHVC-05-14 COMP
Analysis Date:
Analyzed By: AU

Coastal Planning & Engineering
2481 NW Boca Raton Blvd, Boca Raton
FL 33431
ph (561) 391-8102
fax (561) 391-9116

| Easting (ft): | Northing (ft): | Coordinate System: | Elevation (ft): |
|---|---|---|---|
| | | | |

| USCS: | Munsell: | Comments: |
|---|---|---|
| SP | | |

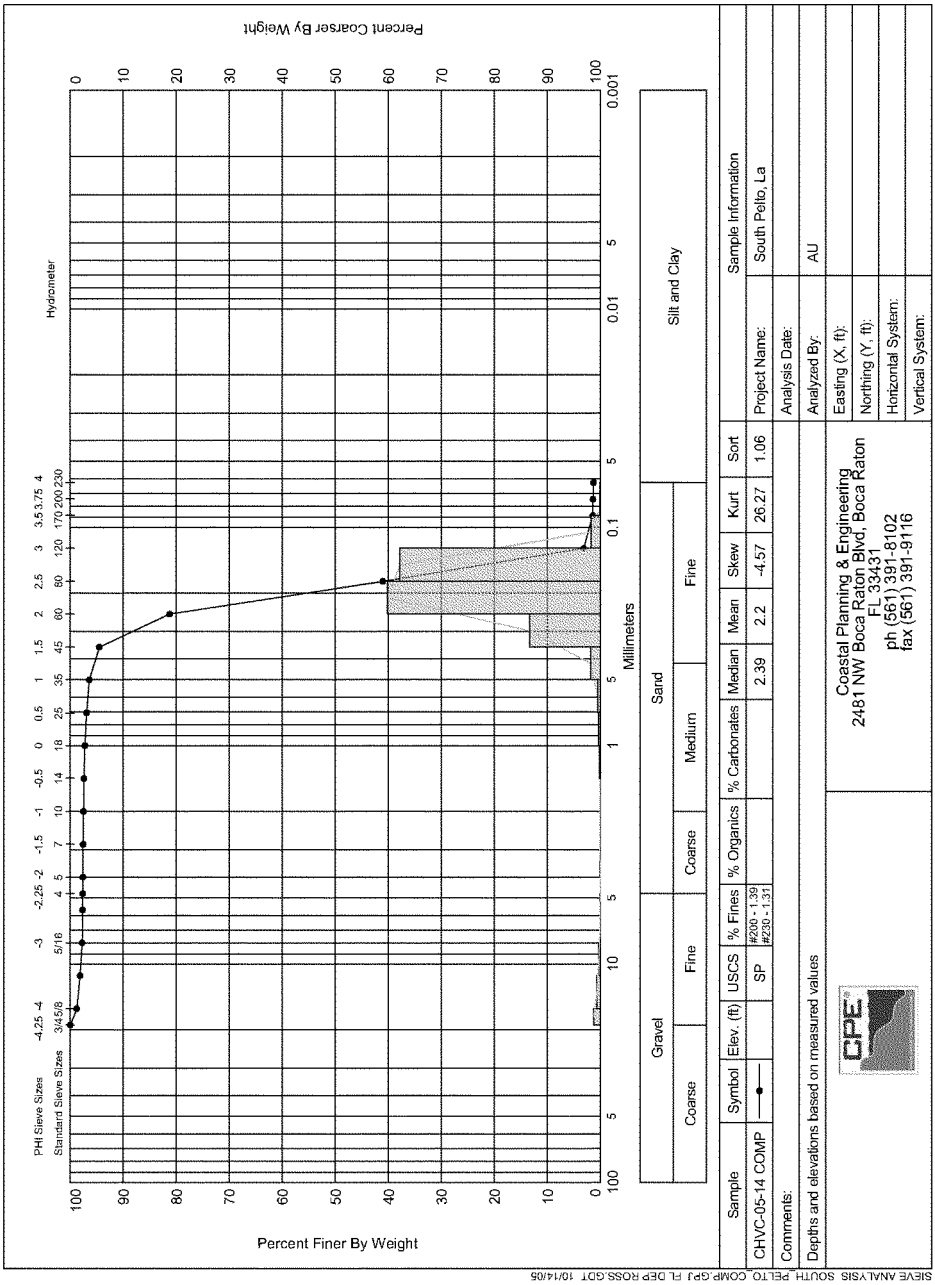
| Dry Weight (g): | Wash Weight (g): | Pan Retained (g): | Sieve Loss (%): | Fines (%): | Organics (%): | Carbonates (%): | Shells (%): |
|---|---|---|---|---|---|---|---|
| 100.00 | 100.00 | 1.11 | 0.20 | #200 - 1.39<br>#230 - 1.31 | | | |

| Sieve Number | Sieve Size (Phi) | Sieve Size (Millimeters) | Grams Retained | % Weight Retained | Cum. Grams Retained | C. % Weight Retained |
|---|---|---|---|---|---|---|
| 3/4" | -4.25 | 19.03 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5/8" | -4.00 | 16.00 | 1.21 | 1.21 | 1.21 | 1.21 |
| 7/16" | -3.50 | 11.31 | 0.66 | 0.66 | 1.87 | 1.87 |
| 5/16" | -3.00 | 8.00 | 0.36 | 0.36 | 2.23 | 2.23 |
| 3.5 | -2.50 | 5.66 | 0.08 | 0.08 | 2.31 | 2.31 |
| 4 | -2.25 | 4.76 | 0.06 | 0.06 | 2.37 | 2.37 |
| 5 | -2.00 | 4.00 | 0.01 | 0.01 | 2.38 | 2.38 |
| 7 | -1.50 | 2.83 | 0.07 | 0.07 | 2.45 | 2.45 |
| 10 | -1.00 | 2.00 | 0.05 | 0.05 | 2.50 | 2.50 |
| 14 | -0.50 | 1.41 | 0.10 | 0.10 | 2.60 | 2.60 |
| 18 | 0.00 | 1.00 | 0.18 | 0.18 | 2.78 | 2.78 |
| 25 | 0.50 | 0.71 | 0.33 | 0.33 | 3.11 | 3.11 |
| 35 | 1.00 | 0.50 | 0.49 | 0.49 | 3.60 | 3.60 |
| 45 | 1.50 | 0.35 | 1.87 | 1.87 | 5.47 | 5.47 |
| 60 | 2.00 | 0.25 | 13.30 | 13.30 | 18.77 | 18.77 |
| 80 | 2.50 | 0.18 | 40.19 | 40.19 | 58.96 | 58.96 |
| 120 | 3.00 | 0.13 | 37.86 | 37.86 | 96.82 | 96.82 |
| 170 | 3.50 | 0.09 | 1.72 | 1.72 | 98.54 | 98.54 |
| 200 | 3.75 | 0.07 | 0.07 | 0.07 | 98.61 | 98.61 |
| 230 | 4.00 | 0.06 | 0.08 | 0.08 | 98.69 | 98.69 |

| Phi 5 | Phi 16 | Phi 25 | Phi 50 | Phi 75 | Phi 84 | Phi 95 |
|---|---|---|---|---|---|---|
| 2.98 | 2.83 | 2.71 | 2.39 | 2.08 | 1.90 | 1.37 |

| Moment | Mean Phi | Mean mm | Sorting | Skewness | Kurtosis |
|---|---|---|---|---|---|
| Statistics | 2.2 | 0.22 | 1.06 | -4.57 | 26.27 |

GRANULARMETRIC REPORT_SOUTH_PELTO_COMP.GPJ FL DEP ROSS.GDT 10/14/05


PHI Sieve Sizes
Standard Sieve Sizes
Hydrometer
Percent Finer By Weight
Percent Coarser By Weight
Millimeters
Gravel
Sand
Silt and Clay
Coarse
Fine
Medium
Sample
Symbol
Elev. (ft)
USCS
% Fines
% Organics
% Carbonates
Median
Mean
Skew
Kurt
Sort
CHVC-05-14 COMP
SP
#200 - 1.39
#230 - 1.31
2.39
2.2
-4.57
26.27
1.06
Comments:
Depths and elevations based on measured values
Coastal Planning & Engineering
2481 NW Boca Raton Blvd, Boca Raton
FL 33431
ph (561) 391-8102
fax (561) 391-9116
Sample Information
Project Name:
South Pelto, La
Analysis Date:
Analyzed By:
AU
Easting (X, ft):
Northing (Y, ft):
Horizontal System:
Vertical System:
SIEVE ANALYSIS SOUTH_PELTO_COMP.GPJ FL DEP ROSS.GDT 10/14/05

## Granularmetric Report

Depths and elevations based on measured values

Project Name: South Pelto, La
Sample Name: CHVC-05-15 COMP
Analysis Date:
Analyzed By: AU

Coastal Planning & Engineering
2481 NW Boca Raton Blvd, Boca Raton
FL 33431
ph (561) 391-8102
fax (561) 391-9116

| Easting (ft): | Northing (ft): | Coordinate System: | Elevation (ft): |
|---|---|---|---|
| | | | |

| USCS: | Munsell: | Comments: |
|---|---|---|
| SP | | |

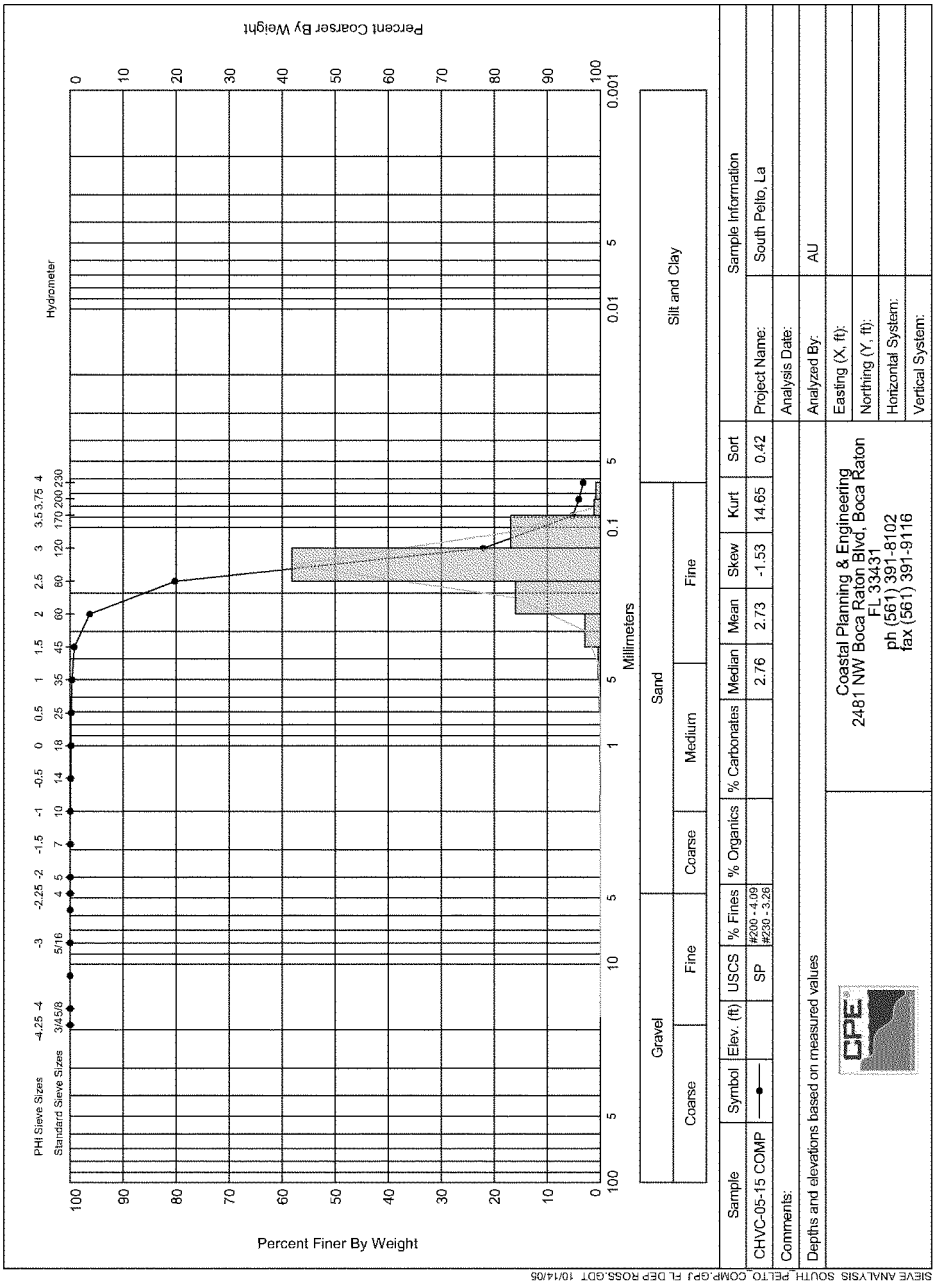
| Dry Weight (g): | Wash Weight (g): | Pan Retained (g): | Sieve Loss (%): | Fines (%): | Organics (%): | Carbonates (%): | Shells (%): |
|---|---|---|---|---|---|---|---|
| 100.00 | 100.00 | 3.10 | 0.16 | #200 - 4.09<br>#230 - 3.26 | | | |

| Sieve Number | Sieve Size (Phi) | Sieve Size (Millimeters) | Grams Retained | % Weight Retained | Cum. Grams Retained | C. % Weight Retained |
|---|---|---|---|---|---|---|
| 3/4" | -4.25 | 19.03 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5/8" | -4.00 | 16.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7/16" | -3.50 | 11.31 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5/16" | -3.00 | 8.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3.5 | -2.50 | 5.66 | 0.00 | 0.00 | 0.00 | 0.00 |
| 4 | -2.25 | 4.76 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5 | -2.00 | 4.00 | 0.02 | 0.02 | 0.02 | 0.02 |
| 7 | -1.50 | 2.83 | 0.01 | 0.01 | 0.03 | 0.03 |
| 10 | -1.00 | 2.00 | 0.01 | 0.01 | 0.04 | 0.04 |
| 14 | -0.50 | 1.41 | 0.05 | 0.05 | 0.09 | 0.09 |
| 18 | 0.00 | 1.00 | 0.07 | 0.07 | 0.16 | 0.16 |
| 25 | 0.50 | 0.71 | 0.04 | 0.04 | 0.20 | 0.20 |
| 35 | 1.00 | 0.50 | 0.13 | 0.13 | 0.33 | 0.33 |
| 45 | 1.50 | 0.35 | 0.41 | 0.41 | 0.74 | 0.74 |
| 60 | 2.00 | 0.25 | 2.94 | 2.94 | 3.68 | 3.68 |
| 80 | 2.50 | 0.18 | 16.03 | 16.03 | 19.71 | 19.71 |
| 120 | 3.00 | 0.13 | 58.15 | 58.15 | 77.86 | 77.86 |
| 170 | 3.50 | 0.09 | 16.91 | 16.91 | 94.77 | 94.77 |
| 200 | 3.75 | 0.07 | 1.14 | 1.14 | 95.91 | 95.91 |
| 230 | 4.00 | 0.06 | 0.83 | 0.83 | 96.74 | 96.74 |

| Phi 5 | Phi 16 | Phi 25 | Phi 50 | Phi 75 | Phi 84 | Phi 95 |
|---|---|---|---|---|---|---|
| 3.55 | 3.18 | 2.98 | 2.76 | 2.55 | 2.38 | 2.04 |

| Moment | Mean Phi | Mean mm | Sorting | Skewness | Kurtosis |
|---|---|---|---|---|---|
| Statistics | 2.73 | 0.15 | 0.42 | -1.53 | 14.65 |

GRANULARMETRIC REPORT .SOUTH_PELTO_COMP.GPJ FL DEP ROSS.GDT 10/14/05


Percent Finer By Weight
Percent Coarser By Weight
PHI Sieve Sizes
Standard Sieve Sizes
Hydrometer
Millimeters
Gravel
Coarse
Fine
Sand
Coarse
Medium
Fine
Silt and Clay
Sample
Symbol
Elev. (ft)
USCS
% Fines
% Organics
% Carbonates
Median
Mean
Skew
Kurt
Sort
CHVC-05-15 COMP
SP
#200 - 4.09
#230 - 3.28
2.76
2.73
-1.53
14.65
0.42
Comments:
Depths and elevations based on measured values
Coastal Planning & Engineering
2481 NW Boca Raton Blvd, Boca Raton
FL 33431
ph (561) 391-8102
fax (561) 391-9116
Sample Information
Project Name:
South Pelto, La
Analysis Date:
Analyzed By:
AU
Easting (X, ft):
Northing (Y, ft):
Horizontal System:
Vertical System:
SIEVE ANALYSIS SOUTH_PELTO_COMP.GPJ FL DEP ROSS.GDT 10/14/05

## Granularmetric Report

Depths and elevations based on measured values

Project Name: South Pelto, La
Sample Name: CHVC-05-16 COMP
Analysis Date:
Analyzed By: AU

Coastal Planning & Engineering
2481 NW Boca Raton Blvd, Boca Raton
FL 33431
ph (561) 391-8102
fax (561) 391-9116

| Easting (ft): | Northing (ft): | Coordinate System: | Elevation (ft): |
|---|---|---|---|
| | | | |

| USCS: | Munsell: | Comments: |
|---|---|---|
| SP | | |

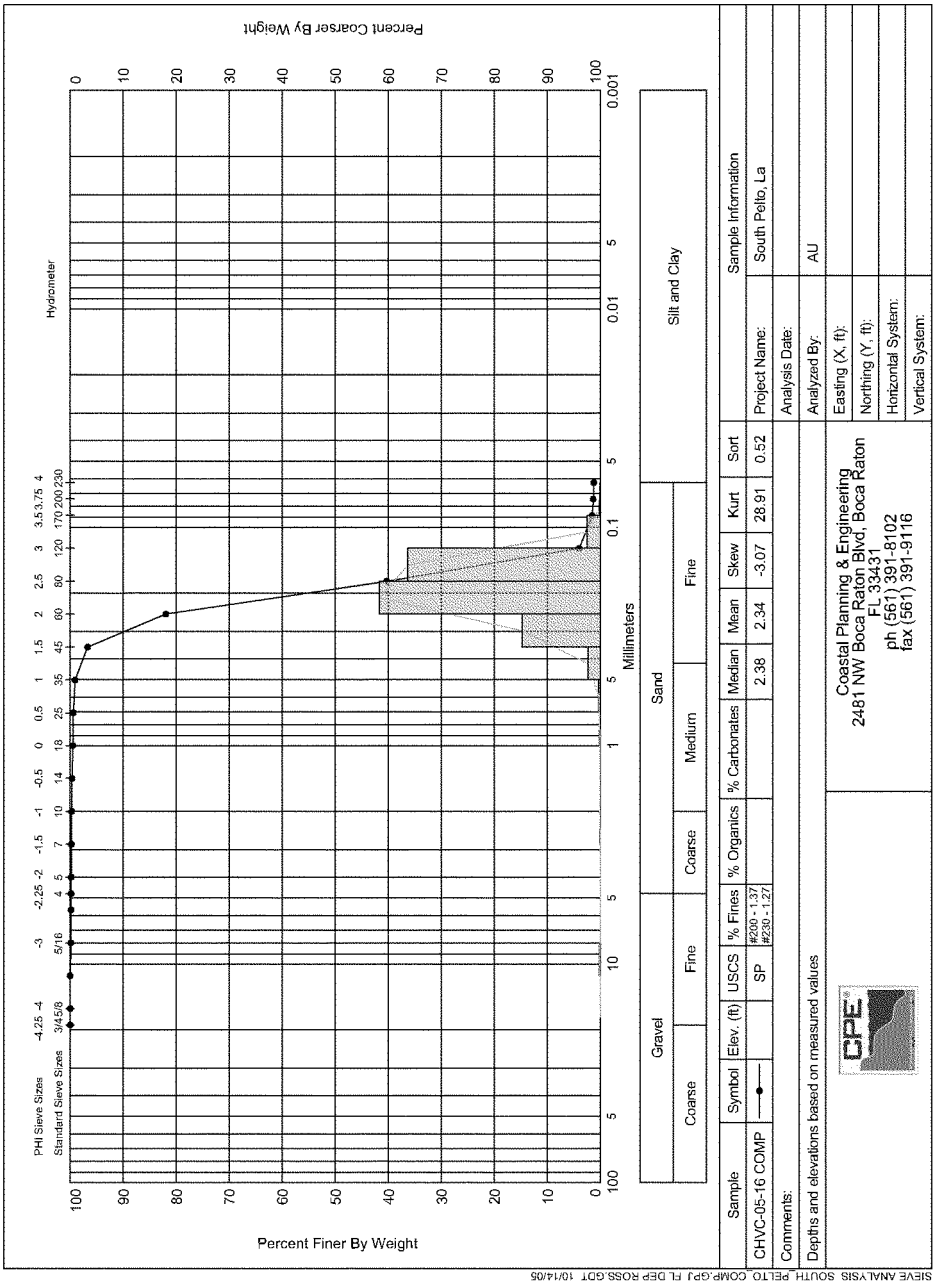
| Dry Weight (g): | Wash Weight (g): | Pan Retained (g): | Sieve Loss (%): | Fines (%): | Organics (%): | Carbonates (%): | Shells (%): |
|---|---|---|---|---|---|---|---|
| 100.00 | 100.00 | 1.20 | 0.07 | #200 - 1.37<br>#230 - 1.27 | | | |

| Sieve Number | Sieve Size (Phi) | Sieve Size (Millimeters) | Grams Retained | % Weight Retained | Cum. Grams Retained | C. % Weight Retained |
|---|---|---|---|---|---|---|
| 3/4" | -4.25 | 19.03 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5/8" | -4.00 | 16.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7/16" | -3.50 | 11.31 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5/16" | -3.00 | 8.00 | 0.14 | 0.14 | 0.14 | 0.14 |
| 3.5 | -2.50 | 5.66 | 0.03 | 0.03 | 0.17 | 0.17 |
| 4 | -2.25 | 4.76 | 0.00 | 0.00 | 0.17 | 0.17 |
| 5 | -2.00 | 4.00 | 0.02 | 0.02 | 0.19 | 0.19 |
| 7 | -1.50 | 2.83 | 0.03 | 0.03 | 0.22 | 0.22 |
| 10 | -1.00 | 2.00 | 0.06 | 0.06 | 0.28 | 0.28 |
| 14 | -0.50 | 1.41 | 0.08 | 0.08 | 0.36 | 0.36 |
| 18 | 0.00 | 1.00 | 0.11 | 0.11 | 0.47 | 0.47 |
| 25 | 0.50 | 0.71 | 0.13 | 0.13 | 0.60 | 0.60 |
| 35 | 1.00 | 0.50 | 0.32 | 0.32 | 0.92 | 0.92 |
| 45 | 1.50 | 0.35 | 2.37 | 2.37 | 3.29 | 3.29 |
| 60 | 2.00 | 0.25 | 14.75 | 14.75 | 18.04 | 18.04 |
| 80 | 2.50 | 0.18 | 41.63 | 41.63 | 59.67 | 59.67 |
| 120 | 3.00 | 0.13 | 36.30 | 36.30 | 95.97 | 95.97 |
| 170 | 3.50 | 0.09 | 2.47 | 2.47 | 98.44 | 98.44 |
| 200 | 3.75 | 0.07 | 0.19 | 0.19 | 98.63 | 98.63 |
| 230 | 4.00 | 0.06 | 0.10 | 0.10 | 98.73 | 98.73 |

| Phi 5 | Phi 16 | Phi 25 | Phi 50 | Phi 75 | Phi 84 | Phi 95 |
|---|---|---|---|---|---|---|
| 2.99 | 2.84 | 2.71 | 2.38 | 2.08 | 1.93 | 1.56 |

| Moment Statistics | Mean Phi | Mean mm | Sorting | Skewness | Kurtosis |
|---|---|---|---|---|---|
| | 2.34 | 0.20 | 0.52 | -3.07 | 28.91 |

GRANULARMETRIC REPORT SOUTH_PELTO_COMP.GPJ FL_DEP ROSS.GDT 10/14/05


PHI Sieve Sizes
Standard Sieve Sizes
Hydrometer
Percent Finer By Weight
Percent Coarser By Weight
Millimeters
Gravel
Sand
Silt and Clay
Coarse
Fine
Medium
Sample
Symbol
Elev. (ft)
USCS
% Fines
% Organics
% Carbonates
Median
Mean
Skew
Kurt
Sort
CHVC-05-16 COMP
SP
#200 - 1.37
#230 - 1.27
2.38
2.34
-3.07
28.91
0.52
Comments:
Depths and elevations based on measured values
Coastal Planning & Engineering
2481 NW Boca Raton Blvd, Boca Raton
FL 33431
ph (561) 391-8102
fax (561) 391-9116
Sample Information
Project Name:
South Pelto, La
Analysis Date:
Analyzed By:
AU
Easting (X, ft):
Northing (Y, ft):
Horizontal System:
Vertical System:
SIEVE ANALYSIS SOUTH_PELTO_COMP.GPJ FL DEP ROSS.GDT 10/14/05

## Granularmetric Report

Depths and elevations based on measured values

Project Name: South Pelto, La
Sample Name: CHVC-05-17 COMP
Analysis Date:
Analyzed By: AU

Coastal Planning & Engineering
2481 NW Boca Raton Blvd, Boca Raton
FL 33431
ph (561) 391-8102
fax (561) 391-9116

| Easting (ft): | Northing (ft): | Coordinate System: | Elevation (ft): |
|---|---|---|---|
| | | | |

| USCS: | Munsell: | Comments: |
|---|---|---|
| SP | | |

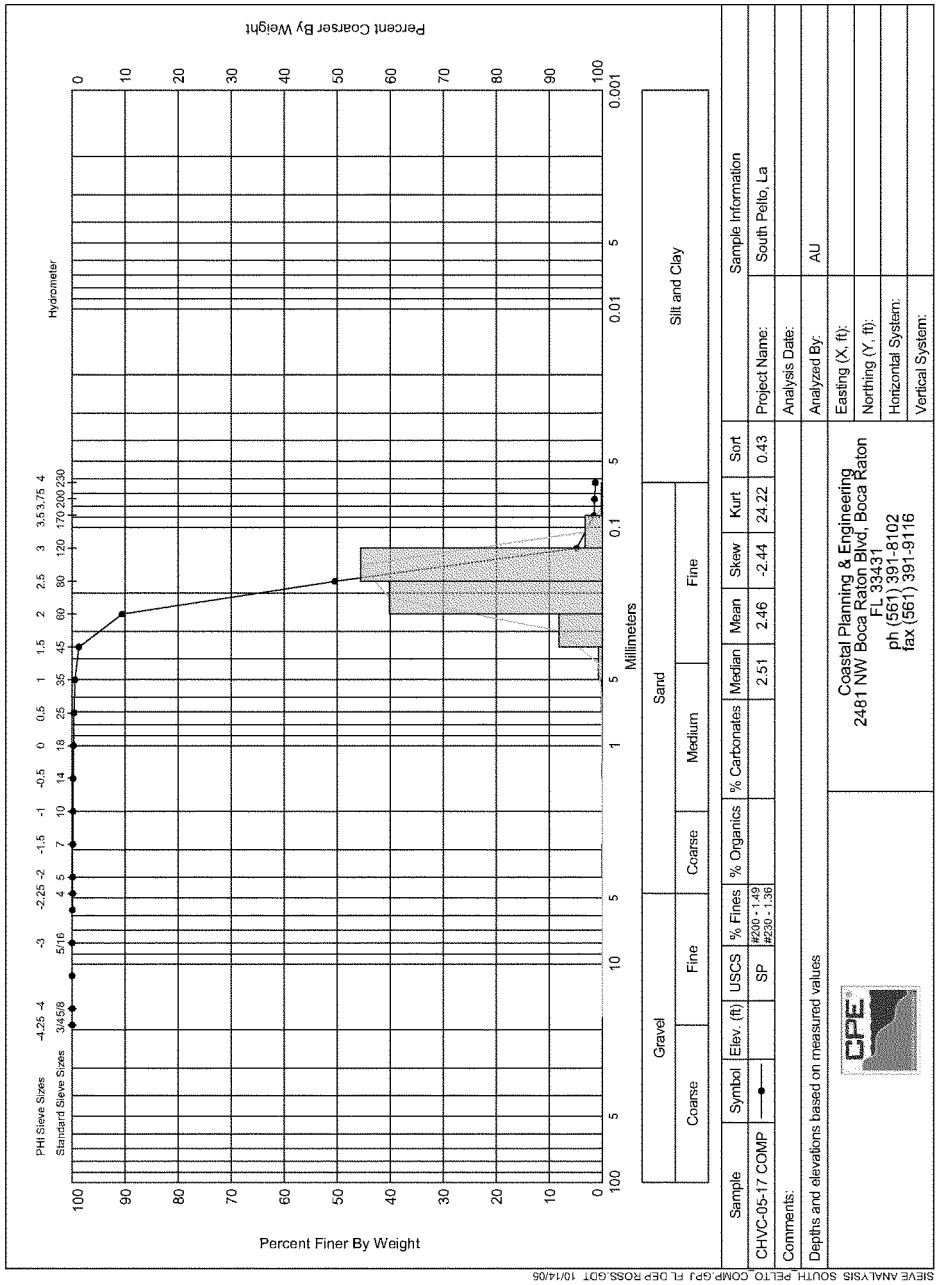
| Dry Weight (g): | Wash Weight (g): | Pan Retained (g): | Sieve Loss (%): | Fines (%): | Organics (%): | Carbonates (%): | Shells (%): |
|---|---|---|---|---|---|---|---|
| 100.00 | 100.00 | 1.24 | 0.12 | #200 - 1.49<br>#230 - 1.36 | | | |

| Sieve Number | Sieve Size (Phi) | Sieve Size (Millimeters) | Grams Retained | % Weight Retained | Cum. Grams Retained | C. % Weight Retained |
|---|---|---|---|---|---|---|
| 3/4" | -4.25 | 19.03 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5/8" | -4.00 | 16.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7/16" | -3.50 | 11.31 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5/16" | -3.00 | 8.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3.5 | -2.50 | 5.66 | 0.04 | 0.04 | 0.04 | 0.04 |
| 4 | -2.25 | 4.76 | 0.02 | 0.02 | 0.06 | 0.06 |
| 5 | -2.00 | 4.00 | 0.00 | 0.00 | 0.06 | 0.06 |
| 7 | -1.50 | 2.83 | 0.05 | 0.05 | 0.11 | 0.11 |
| 10 | -1.00 | 2.00 | 0.04 | 0.04 | 0.15 | 0.15 |
| 14 | -0.50 | 1.41 | 0.02 | 0.02 | 0.17 | 0.17 |
| 18 | 0.00 | 1.00 | 0.06 | 0.06 | 0.23 | 0.23 |
| 25 | 0.50 | 0.71 | 0.10 | 0.10 | 0.33 | 0.33 |
| 35 | 1.00 | 0.50 | 0.19 | 0.19 | 0.52 | 0.52 |
| 45 | 1.50 | 0.35 | 0.71 | 0.71 | 1.23 | 1.23 |
| 60 | 2.00 | 0.25 | 8.17 | 8.17 | 9.40 | 9.40 |
| 80 | 2.50 | 0.18 | 40.14 | 40.14 | 49.54 | 49.54 |
| 120 | 3.00 | 0.13 | 45.58 | 45.58 | 95.12 | 95.12 |
| 170 | 3.50 | 0.09 | 3.26 | 3.26 | 98.38 | 98.38 |
| 200 | 3.75 | 0.07 | 0.13 | 0.13 | 98.51 | 98.51 |
| 230 | 4.00 | 0.06 | 0.13 | 0.13 | 98.64 | 98.64 |

| Phi 5 | Phi 16 | Phi 25 | Phi 50 | Phi 75 | Phi 84 | Phi 95 |
|---|---|---|---|---|---|---|
| 3.00 | 2.88 | 2.78 | 2.51 | 2.19 | 2.08 | 1.73 |

| Moment Statistics | Mean Phi | Mean mm | Sorting | Skewness | Kurtosis |
|---|---|---|---|---|---|
| | 2.46 | 0.18 | 0.43 | -2.44 | 24.22 |

GRANULARMETRIC REPORT SOUTH_PELTO_COMP.GPJ FL DEP ROSS.GDT 10/14/05


Percent Finer By Weight
Percent Coarser By Weight
PHI Sieve Sizes
Standard Sieve Sizes
Hydrometer
Millimeters
Gravel
Sand
Silt and Clay
Coarse
Fine
Medium
Sample
Symbol
Elev. (ft.)
USCS
% Fines
% Organics
% Carbonates
Median
Mean
Skew
Kurt
Sort
CHVC-05-17 COMP
SP
#200 - 1.49
#230 - 1.36
2.51
2.46
-2.44
24.22
0.43
Comments:
Depths and elevations based on measured values
Coastal Planning & Engineering
2481 NW Boca Raton Blvd, Boca Raton
FL 33431
ph (561) 391-8102
fax (561) 391-9116
Sample Information
Project Name:
South Pelto, La
Analysis Date:
Analyzed By:
AU
Easting (X, ft):
Northing (Y, ft):
Horizontal System:
Vertical System:
SIEVE ANALYSIS SOUTH_PELTO_COMP.GPJ FL DEP ROSS.GDT 10/14/05

## Granularmetric Report

Depths and elevations based on measured values

Project Name: South Pelto, La
Sample Name: CHVC-05-18 COMP
Analysis Date:
Analyzed By: AU

Coastal Planning & Engineering
2481 NW Boca Raton Blvd, Boca Raton
FL 33431
ph (561) 391-8102
fax (561) 391-9116

| Easting (ft): | Northing (ft): | Coordinate System: | Elevation (ft): |
|---|---|---|---|
| | | | |

| USCS: | Munsell: | Comments: |
|---|---|---|
| SP | | |

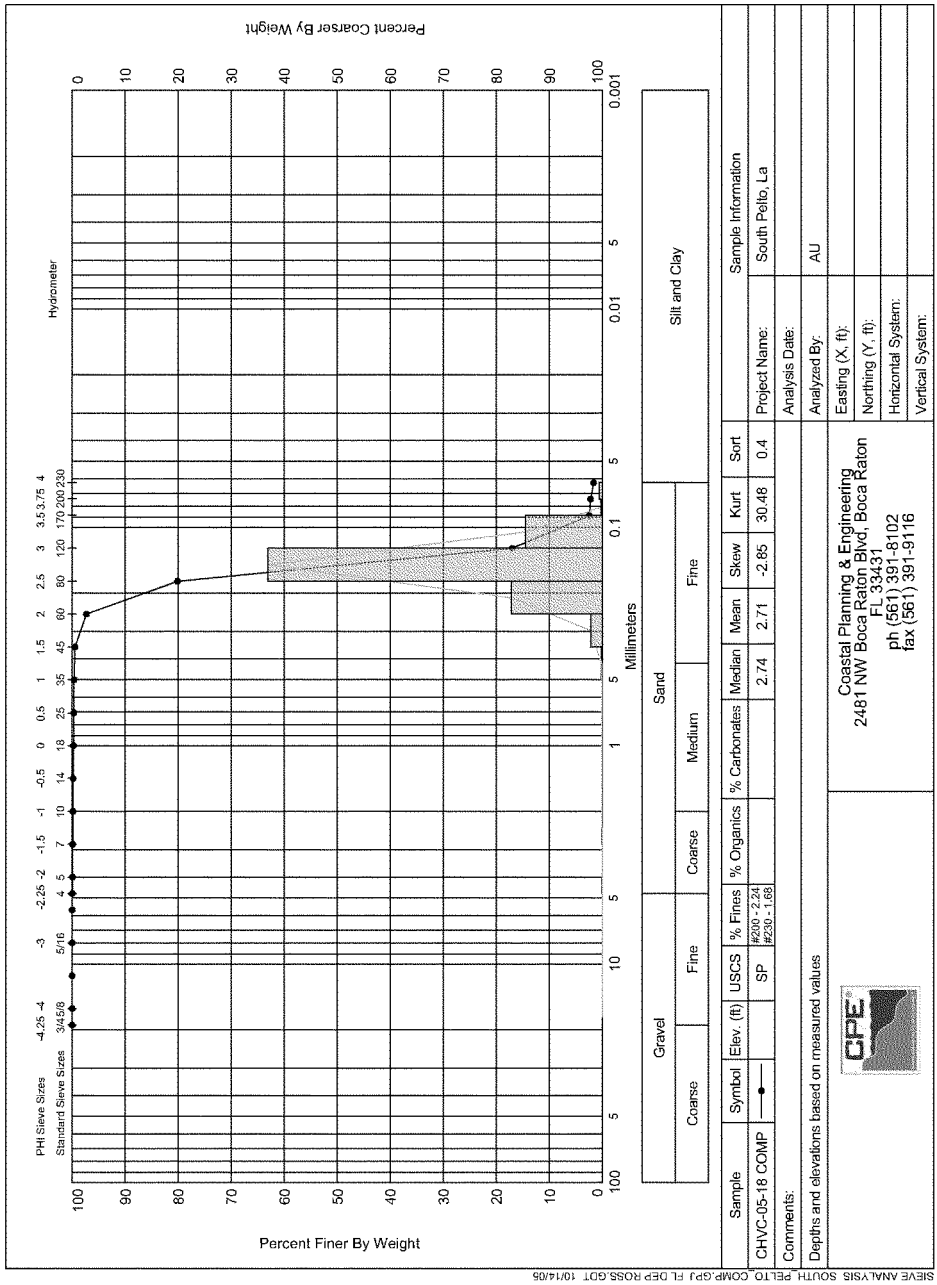
| Dry Weight (g): | Wash Weight (g): | Pan Retained (g): | Sieve Loss (%): | Fines (%): | Organics (%): | Carbonates (%): | Shells (%): |
|---|---|---|---|---|---|---|---|
| 100.00 | 100.00 | 1.61 | 0.07 | #200 - 2.24<br>#230 - 1.68 | | | |

| Sieve Number | Sieve Size (Phi) | Sieve Size (Millimeters) | Grams Retained | % Weight Retained | Cum. Grams Retained | C. % Weight Retained |
|---|---|---|---|---|---|---|
| 3/4" | -4.25 | 19.03 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5/8" | -4.00 | 16.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7/16" | -3.50 | 11.31 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5/16" | -3.00 | 8.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3.5 | -2.50 | 5.66 | 0.00 | 0.00 | 0.00 | 0.00 |
| 4 | -2.25 | 4.76 | 0.01 | 0.01 | 0.01 | 0.01 |
| 5 | -2.00 | 4.00 | 0.05 | 0.05 | 0.06 | 0.06 |
| 7 | -1.50 | 2.83 | 0.02 | 0.02 | 0.08 | 0.08 |
| 10 | -1.00 | 2.00 | 0.06 | 0.06 | 0.14 | 0.14 |
| 14 | -0.50 | 1.41 | 0.05 | 0.05 | 0.19 | 0.19 |
| 18 | 0.00 | 1.00 | 0.06 | 0.06 | 0.25 | 0.25 |
| 25 | 0.50 | 0.71 | 0.05 | 0.05 | 0.30 | 0.30 |
| 35 | 1.00 | 0.50 | 0.07 | 0.07 | 0.37 | 0.37 |
| 45 | 1.50 | 0.35 | 0.16 | 0.16 | 0.53 | 0.53 |
| 60 | 2.00 | 0.25 | 2.17 | 2.17 | 2.70 | 2.70 |
| 80 | 2.50 | 0.18 | 17.15 | 17.15 | 19.85 | 19.85 |
| 120 | 3.00 | 0.13 | 63.10 | 63.10 | 82.95 | 82.95 |
| 170 | 3.50 | 0.09 | 14.54 | 14.54 | 97.49 | 97.49 |
| 200 | 3.75 | 0.07 | 0.27 | 0.27 | 97.76 | 97.76 |
| 230 | 4.00 | 0.06 | 0.56 | 0.56 | 98.32 | 98.32 |

| Phi 5 | Phi 16 | Phi 25 | Phi 50 | Phi 75 | Phi 84 | Phi 95 |
|---|---|---|---|---|---|---|
| 3.41 | 3.04 | 2.94 | 2.74 | 2.54 | 2.39 | 2.07 |

| Moment Statistics | Mean Phi | Mean mm | Sorting | Skewness | Kurtosis |
|---|---|---|---|---|---|
| | 2.71 | 0.15 | 0.4 | -2.85 | 30.48 |

GRANULARMETRIC REPORT SOUTH_PELTO_COMP.GPJ FL_DEP ROSS.GDT 10/14/05


Percent Finer By Weight
Percent Coarser By Weight
Hydrometer
PHI Sieve Sizes
Standard Sieve Sizes
Millimeters
Gravel
Sand
Silt and Clay
Coarse
Fine
Medium
Sample
Symbol
Elev. (ft)
USCS
% Fines
% Organics
% Carbonates
Median
Mean
Skew
Kurt
Sort
CHVC-05-18 COMP
SP
#200 - 2.24
#230 - 1.68
2.74
2.71
-2.85
30.48
0.4
Comments:
Depths and elevations based on measured values
Coastal Planning & Engineering
2481 NW Boca Raton Blvd, Boca Raton
FL 33431
ph (561) 391-8102
fax (561) 391-9116
Sample Information
Project Name:
South Pelto, La
Analysis Date:
Analyzed By:
AU
Easting (X, ft):
Northing (Y, ft):
Horizontal System:
Vertical System:
SIEVE ANALYSIS SOUTH_PELTO_COMP.GPJ FL DEP ROSS.GDT 10/14/05

## Granularmetric Report

Depths and elevations based on measured values

Project Name: South Pelto, La
Sample Name: CHVC-05-19 COMP
Analysis Date:
Analyzed By: AU

Coastal Planning & Engineering
2481 NW Boca Raton Blvd, Boca Raton
FL 33431
ph (561) 391-8102
fax (561) 391-9116

| Easting (ft): | Northing (ft): | Coordinate System: | Elevation (ft): |
|---|---|---|---|
| | | | |

| USCS: | Munsell: | Comments: |
|---|---|---|
| SP | | |

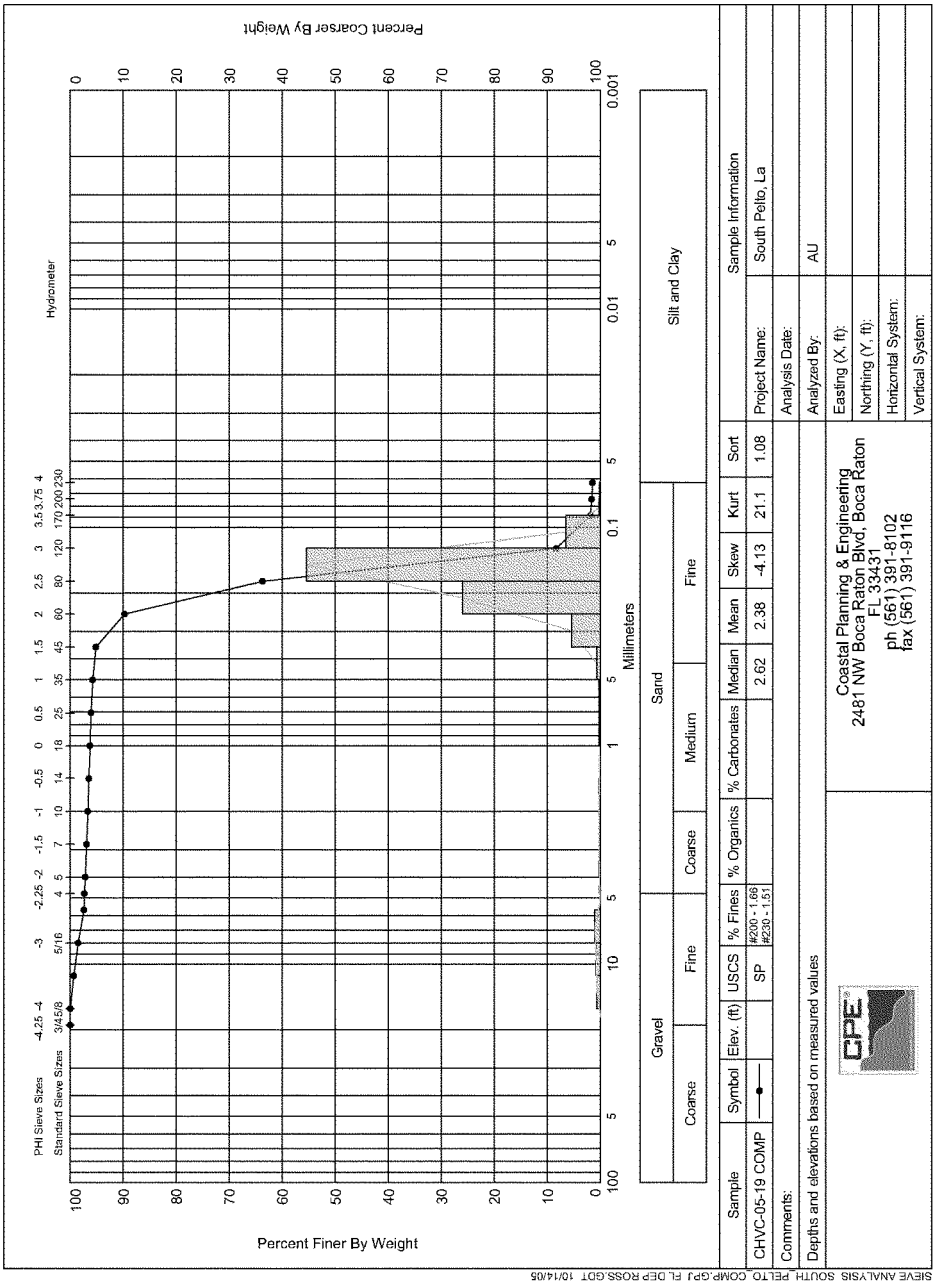
| Dry Weight (g): | Wash Weight (g): | Pan Retained (g): | Sieve Loss (%): | Fines (%): | Organics (%): | Carbonates (%): | Shells (%): |
|---|---|---|---|---|---|---|---|
| 100.00 | 100.00 | 1.47 | 0.04 | #200 - 1.66<br>#230 - 1.51 | | | |

| Sieve Number | Sieve Size (Phi) | Sieve Size (Millimeters) | Grams Retained | % Weight Retained | Cum. Grams Retained | C. % Weight Retained |
|---|---|---|---|---|---|---|
| 3/4" | -4.25 | 19.03 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5/8" | -4.00 | 16.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7/16" | -3.50 | 11.31 | 0.68 | 0.68 | 0.68 | 0.68 |
| 5/16" | -3.00 | 8.00 | 0.81 | 0.81 | 1.49 | 1.49 |
| 3.5 | -2.50 | 5.66 | 1.07 | 1.07 | 2.56 | 2.56 |
| 4 | -2.25 | 4.76 | 0.08 | 0.08 | 2.64 | 2.64 |
| 5 | -2.00 | 4.00 | 0.17 | 0.17 | 2.81 | 2.81 |
| 7 | -1.50 | 2.83 | 0.27 | 0.27 | 3.08 | 3.08 |
| 10 | -1.00 | 2.00 | 0.22 | 0.22 | 3.30 | 3.30 |
| 14 | -0.50 | 1.41 | 0.22 | 0.22 | 3.52 | 3.52 |
| 18 | 0.00 | 1.00 | 0.19 | 0.19 | 3.71 | 3.71 |
| 25 | 0.50 | 0.71 | 0.23 | 0.23 | 3.94 | 3.94 |
| 35 | 1.00 | 0.50 | 0.27 | 0.27 | 4.21 | 4.21 |
| 45 | 1.50 | 0.35 | 0.63 | 0.63 | 4.84 | 4.84 |
| 60 | 2.00 | 0.25 | 5.42 | 5.42 | 10.26 | 10.26 |
| 80 | 2.50 | 0.18 | 26.00 | 26.00 | 36.26 | 36.26 |
| 120 | 3.00 | 0.13 | 55.39 | 55.39 | 91.65 | 91.65 |
| 170 | 3.50 | 0.09 | 6.46 | 6.46 | 98.11 | 98.11 |
| 200 | 3.75 | 0.07 | 0.23 | 0.23 | 98.34 | 98.34 |
| 230 | 4.00 | 0.06 | 0.15 | 0.15 | 98.49 | 98.49 |

| Phi 5 | Phi 16 | Phi 25 | Phi 50 | Phi 75 | Phi 84 | Phi 95 |
|---|---|---|---|---|---|---|
| 3.26 | 2.93 | 2.85 | 2.62 | 2.28 | 2.11 | 1.51 |

| Moment Statistics | Mean Phi | Mean mm | Sorting | Skewness | Kurtosis |
|---|---|---|---|---|---|
| | 2.38 | 0.19 | 1.08 | -4.13 | 21.1 |

GRANULARMETRIC REPORT SOUTH_PELTO_COMP.GPJ FL DEP ROSS.GDT 10/14/05


Percent Finer By Weight
Percent Coarser By Weight
PHI Sieve Sizes
Standard Sieve Sizes
Hydrometer
Millimeters
Gravel
Sand
Silt and Clay
Coarse
Fine
Medium
Sample
Symbol
Elev. (ft)
USCS
% Fines
% Organics
% Carbonates
Median
Mean
Skew
Kurt
Sort
CHVC-05-19 COMP
SP
#200 - 1.66
#230 - 1.51
2.62
2.38
-4.13
21.1
1.08
Comments:
Depths and elevations based on measured values
Coastal Planning & Engineering
2481 NW Boca Raton Blvd, Boca Raton
FL 33431
ph (561) 391-8102
fax (561) 391-9116
Sample Information
Project Name:
South Pelto, La
Analysis Date:
Analyzed By:
AU
Easting (X, ft):
Northing (Y, ft):
Horizontal System:
Vertical System:
SIEVE ANALYSIS SOUTH_PELTO_COMP.GPJ FL DEP ROSS.GDT 10/14/05

# ANNEX C3
# MODELING REPORTS

# 05211

# Caminada Headland
# Cross-Shore Sediment Transport Modeling Report

## June 2007

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Table 9. Post-Storm Profile Position at +4 ft NAVD with Respect to Existing Pre-Storm Profile for Transect D ..... 30

## 1 Model Description

One of the considerations in designing alternatives for rebuilding the barrier shoreline and marsh composing the Caminada Headland is how the fill material will adjust and equilibrate under various storm scenarios. In order to evaluate this aspect of the alternative designs, a cross-shore sediment transport model was conducted for various normal and storm conditions on the proposed alternative fill templates.

Cross-shore sediment transport modeling was performed using the Storm-induced Beach Change (SBEACH) model (Larson and Kraus 1989; Larson, Kraus, and Byrnes 1990). SBEACH is two-dimensional model developed to simulate cross-shore sediment transport primarily due to breaking waves and changing water levels. The model was developed based on extensive analysis of beach profile changes produced in wave tanks and in the field.

SBEACH is intended to predict short-term, storm-induced profile equilibration. A fundamental assumption of the SBEACH model is that profile change is produced solely by cross-shore processes, resulting in a redistribution of sediment across the profile with no net gain or loss of material. Longshore processes are considered to be negligibly small in calculating profile change, and therefore, longshore wave and current sediment transport is not accounted for by SBEACH.

Primary input data for the SBEACH analysis included existing profiles, four proposed design fill templates, and geotechnical information. Additional data obtained for model input included storm data (wind and wave) and total water elevations (tide plus surge).

Calibration and verification of SBEACH for the analysis was based on a previous study conducted by US Army Corps of Engineers Engineering Research and Development Center and Coastal Hydraulics Laboratory (ERDC/CHL) for the Grand Isle, Louisiana, Shore Protection Project (USACE 2004). The Grand Isle report extensively analyzed the pre- and post-storm shoreline profile response for verification and calibration. The existing profiles for Grand Isles and subsequent post-storm profile responses to severe storm conditions were compared for consecutive years at multiple profile transects. The report determined that the default settings for the SBEACH numerical modeling program were sufficient for accurate representation of the equilibrated shoreline at that location.

Therefore, due to limited available historical shoreline profiles and storm impact data at the Caminada Headland and the extensive work performed for Grand Isle, the present report assumed that the default settings in SBEACH for the Sediment Transport Parameter were adequate for representation of post-storm equilibrated cross shore profiles resulting from input storm conditions.

## 2 Storm Input Data

Storm data used for model input includes extreme storm events, namely hurricanes and intense tropical storms impacting the Caminada Headland from 1985 to 2004. To remain consistent with the Sediment Transport Parameter calibration, the storms used were the same as those used for the previous Grand Isle report which included Hurricanes Juan (1985), Andrew (1992), Danny (1997), and a combined storm event of Tropical Storm Isidore (2002) and Hurricane Lili (2002). Wave and water level data were assembled for these storms and are summarized in Section C-3-1 of the Caminada Headland Report.

## 3 Model Input Profiles

The SBEACH input profiles were modeled at Transects C and D from the 2005 Fenstermaker survey described in Section C-2 of the Caminada Headland Report for five scenarios: 1) existing beach profile, 2) marsh fill only (Template 1), 3) beach fill with a low and wide dune crest and marsh fill (Template 2), 4) beach fill with a high and narrow dune crest with marsh fill (Template 3), and 5) landward beach fill with an intermediate dune crest and significant majority of the fill volume placed on the landward part of the profile (Template 4). Figures 1 and 2 show the five initial profiles used in the modeling for Transects C and D, respectively. Note the vertical-horizontal scale distortion. The three beach/dune fill templates increase the dune crest height over the existing dune crest elevation.

Transects C and D are located approximately in the middle of the Caminada Headland Barrier Island (Figure C-2-1 of the Caminada Headland Report). These profiles were chosen because they provide details of the nearshore bathymetry seaward of the dune, existing dune profile, and topography of the marsh flats landward of the dune. Figure 3 shows the existing profiles for Transect C and Transect D aligned at 0.0 ft NAVD. The total volumes of each of the existing dunes are roughly equivalent with a slightly different material distribution. Transect C has a higher and narrower dune with a steeper lee side and seaward slopes. The seaward beach profiles for both profiles are similar with slight variations in the shape and location of nearshore features.

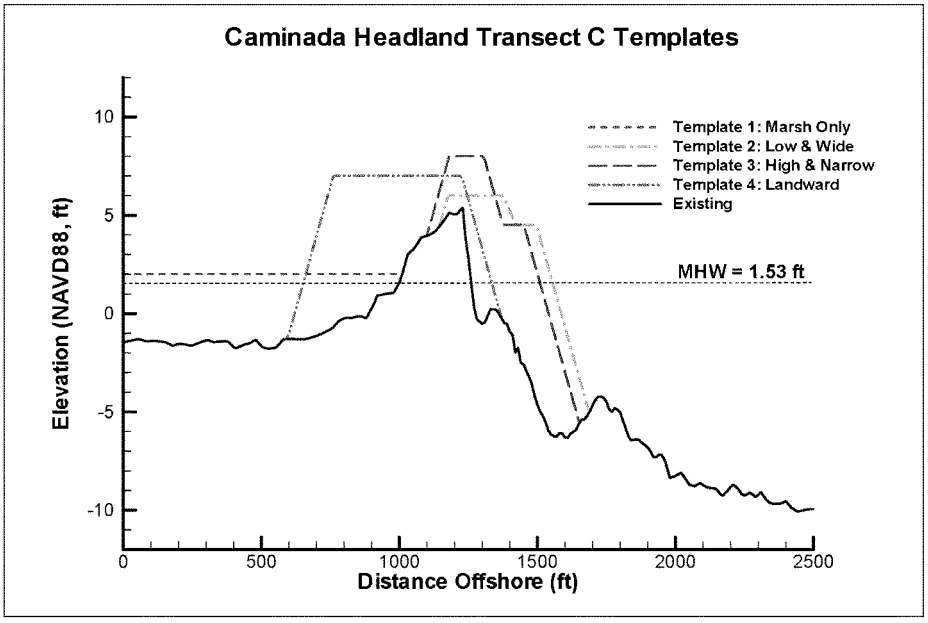


**Figure 1. Transect C Initial (Pre-Storm) SBEACH Input Profiles**

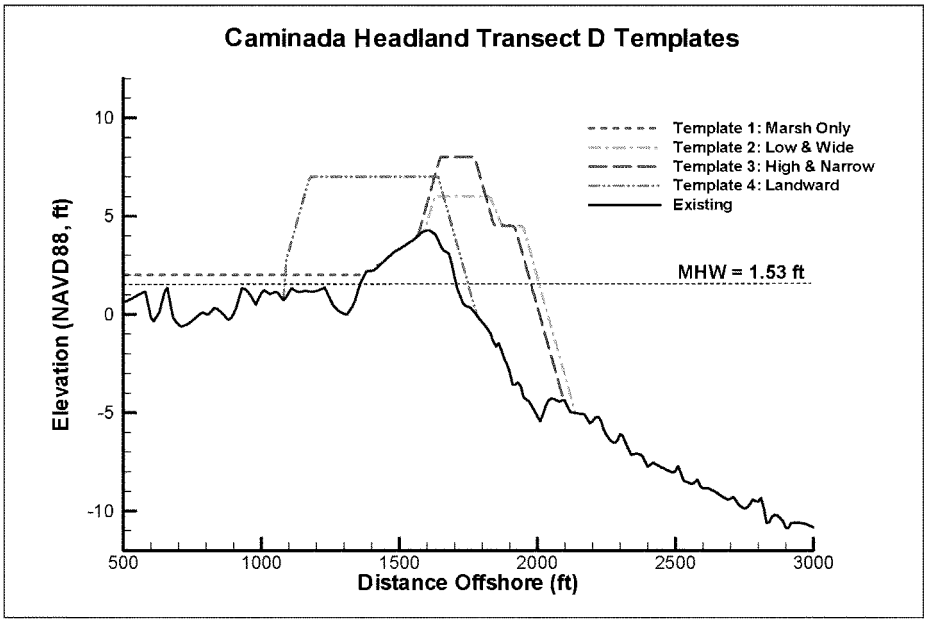


**Figure 2. Transect D Initial (Pre-Storm) SBEACH Input Profiles**

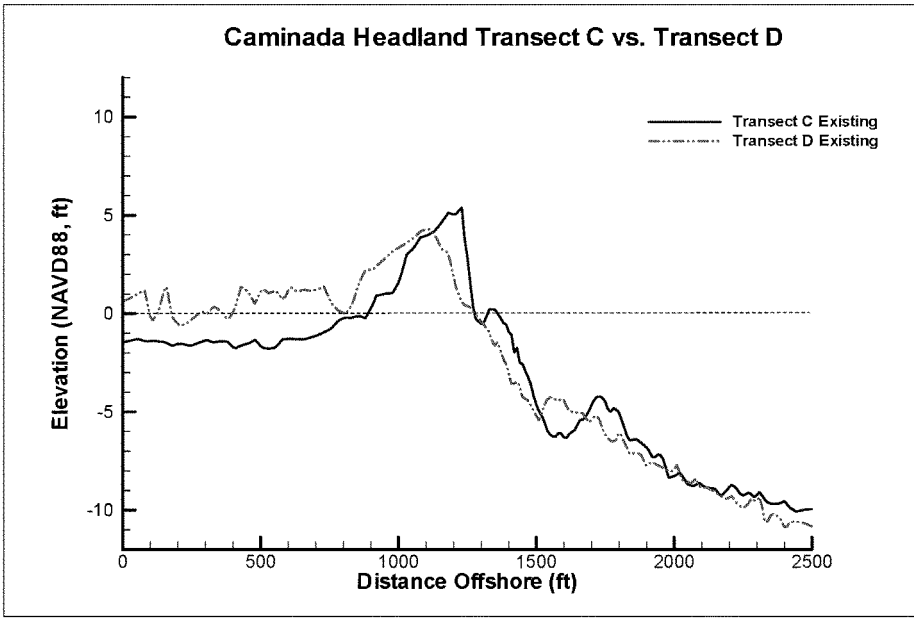


**Figure 3. Profile Comparison, Transect C and Transect D**

One of the SBEACH model input parameters is grain size representative of the input beach profile. The reference literature for SBEACH extensively describes the effect of the input grain size on the predicted profiles. The most substantial contribution of the sediment size on the profile evolution occurs in the formation, location, and geometry of the nearshore bar. The existing profiles and Template 1 (marsh only) profiles for Transects C and D were composed of native sand. A geotechnical investigation was performed at four transects along the Caminada Headland, including Transects C and D, to determine the grain size distribution of the native sediments. This investigation is summarized in Section C-4-2 of the Caminada Headland Report. It was determined that the average median grain size for the native beach was 0.164 mm. For Transect C, one of SBEACH input profiles, the sieve analysis determined the median grain size to be 0.184 mm (beach sample), 0.165 mm (dune sample), and 0.189 mm (overwash sample). For Transect D, the other SBEACH input profile, the sieve analysis determined the median grain size to be 0.132 mm (beach sample) and 0.167 mm (overwash sample). Since the SBEACH model can only use a single grain size value per input profile, the average grain sizes of the individual samples were calculated for Transects C and D. The average native grain sizes used in SBEACH in the existing profile and Template 1 profile simulations were 0.179 mm and 0.150 mm for Transects C and D, respectively. Template 2 (low & wide dune), Template 3 (high & low dune), and Template 4 (landward dune) profiles were designed using sand from the borrow area whose median grain size was determined to be 0.183 mm. Table 1 presents a summary of grain sizes used in SBEACH for the Transect C and D templates.

**Table 1. Grain Size Values Used in SBEACH Simulations**

| Transect | Grain Size (mm) | | | | |
|---|---|---|---|---|---|
| | Existing | Template 1 | Template 2 | Template 3 | Template 4 |
| C | 0.179 | 0.179 | 0.183 | 0.183 | 0.183 |
| D | 0.150 | 0.150 | 0.183 | 0.183 | 0.183 |

## 4 Model Analysis at Transect C

Of the two transects modeled herein, Transect C's existing profile has the higher dune crest elevation at +5.3 ft NAVD and the narrower dune width of 247 ft measured at +2 ft NAVD.

All of the storms completely inundated the existing profile affecting its shape. As shown in Figure 4, when no action was taken to protect the beach, Hurricanes Isidore-Lili, Juan, and Andrew severely impacted the dune system completely eroding the existing dune, washing-out the dune landward and causing the shoreline to retreat. Hurricane Danny is the only storm that left the existing dune somewhat intact due primarily to the fact that it had the lowest peak wave height and the shortest storm duration. Figure 5 shows the erosion envelope of the modeled storms (most severe and lease sever impacts) for the existing profile.

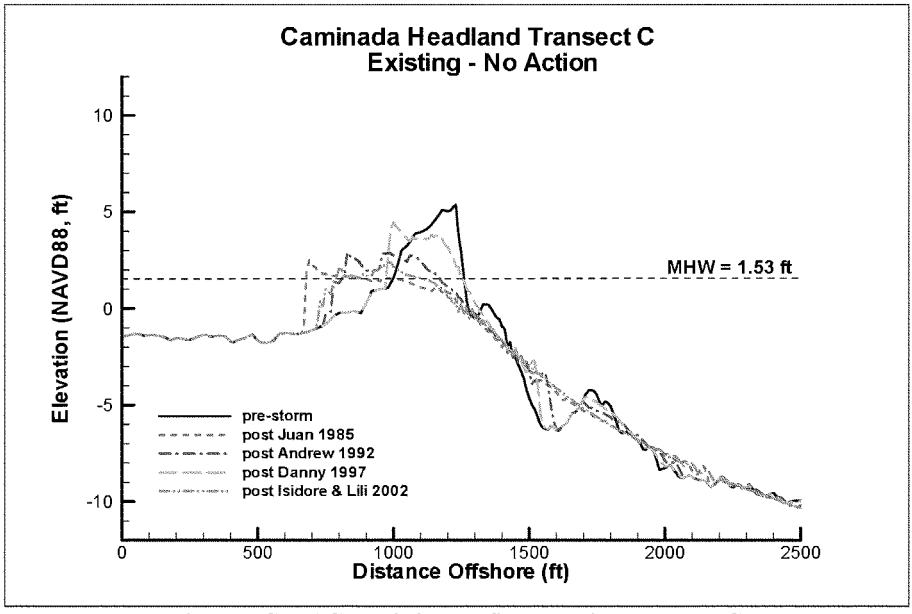


**Figure 4. SBEACH Existing Profile Evolution, Transect C**

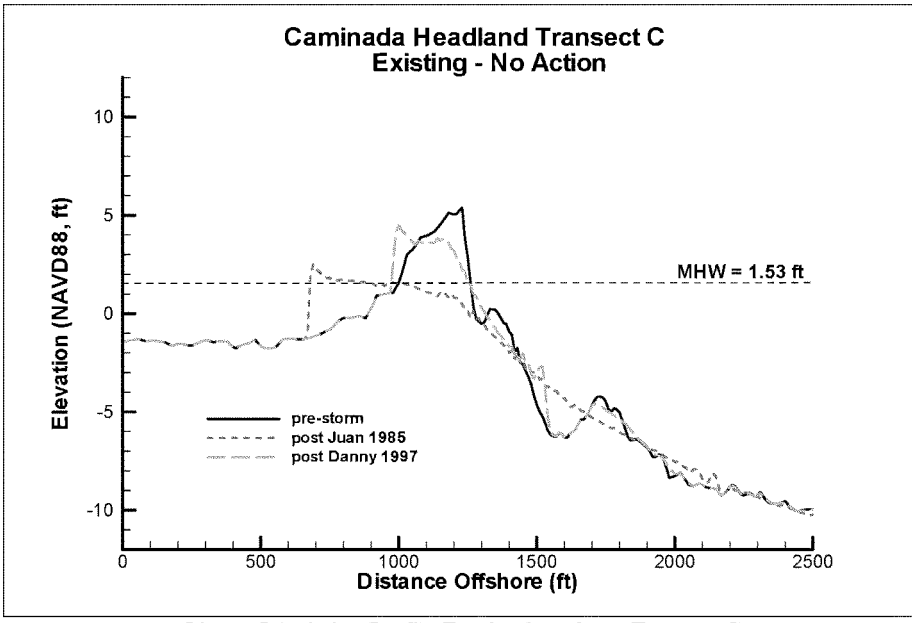


**Figure 5. Existing Profile Erosion Envelope, Transect C**

Figure 6 shows model results for Template 1 with the 'Marsh Only' fill alternative at Transect C. For this fill template, the dune was inundated during the course of each of the storms. Hurricane Juan had the most severe impact to this profile template followed by Isidore-Lili, Andrew, and Danny. Hurricanes Isidore-Lili, Juan, and Andrew completely eroded the existing dune, washed it out landward and caused the shoreline to retreat. Hurricane Danny eroded the seaward edge of the dune crest with minimal impact to the landward side of the dune.

The profile evolution for Template 1 demonstrated that the marsh fill alone provides some measure of storm protection over the existing dune system profile. Figure 7 shows the erosion envelope of the modeled storms (most severe and least severe impacts) for Template 1 at Transect C.

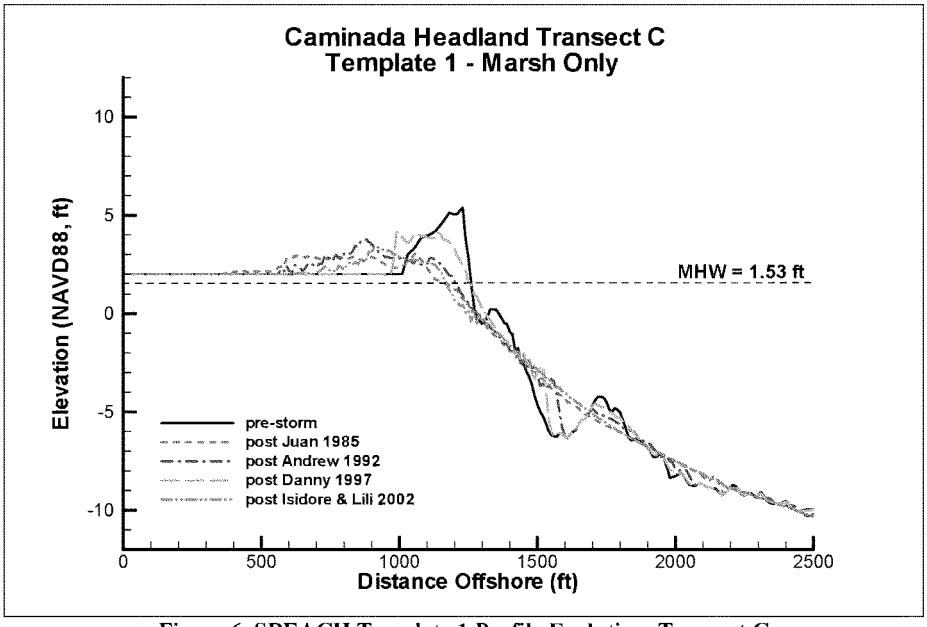


**Figure 6. SBEACH Template 1 Profile Evolution, Transect C**

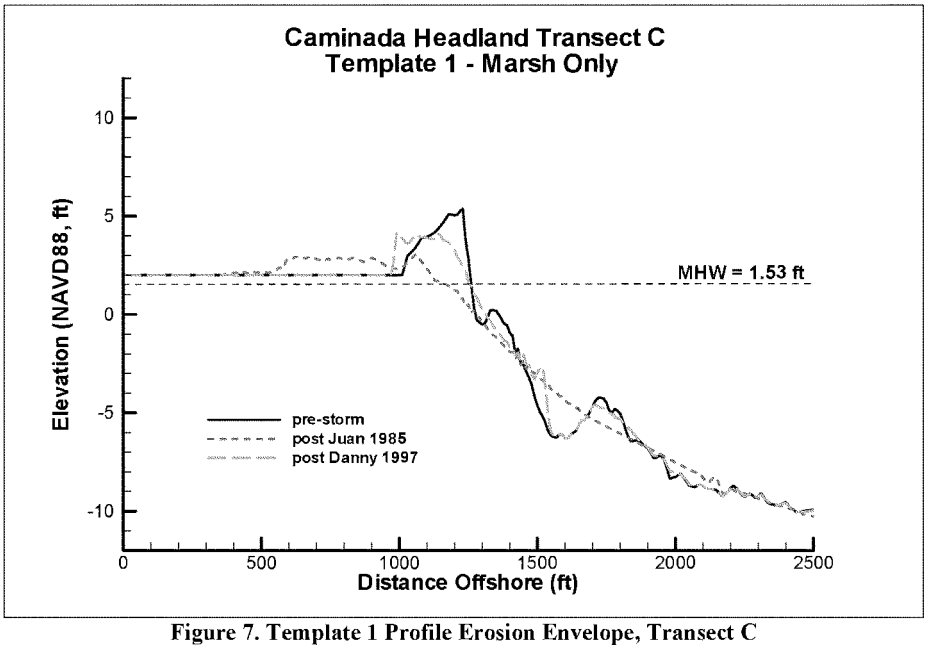


**Figure 7. Template 1 Profile Erosion Envelope, Transect C**

Figure 8 shows model results for Template 2 with the 'Low and Wide' beach fill alternative at Transect C. For this beach fill template, the proposed dune was inundated during the course of each of the storms. Hurricane Juan had the most severe impact to this profile template followed by Isidore-Lili, Andrew, and Danny. Hurricane Juan completely eroded the seaward beach, seaward berm, and all of the dune fill material. Hurricanes Isidore-Lili and Andrew eroded the seaward edge of the dune crest with minimal impact to the landward side of the dune. Danny had the least amount of impact to the dune system eroding only the 75 ft wide seaward berm, but not impacting the dune crest.

The predicted profile evolution for Template 2 demonstrated that the lower and wider dune may provide increased protection over both the existing dune system and the marsh fill profile (Template 1). Further, it illustrated the vulnerability of the lower crest elevation to longer duration peak wave conditions (Hurricane Juan has the widest band of peak storm wave conditions) and subsequent overtopping of the dune system. Figure 9 shows the erosion envelope of the modeled storms (most severe and lease sever impacts) for Template 2 at Transect C.

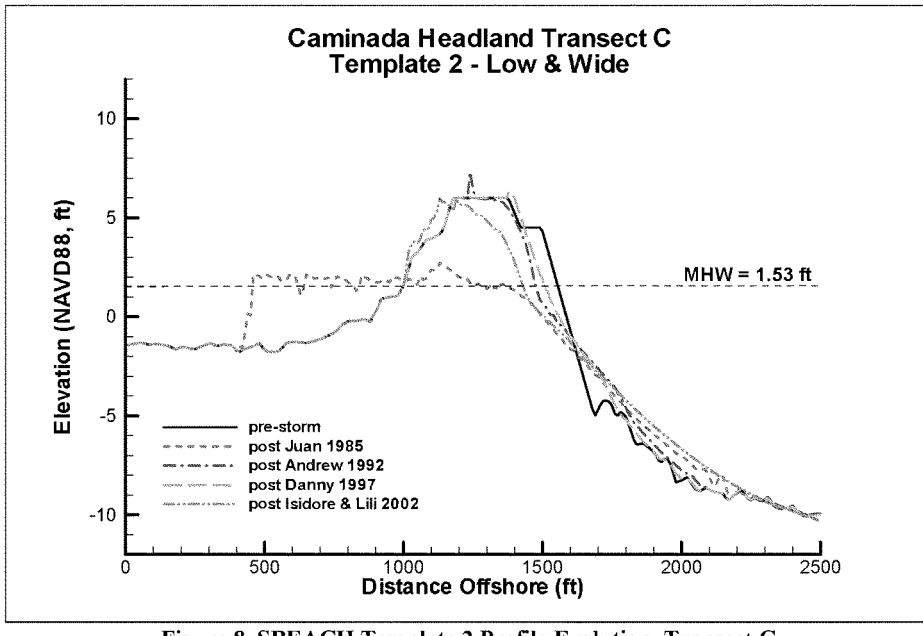


**Figure 8. SBEACH Template 2 Profile Evolution, Transect C**

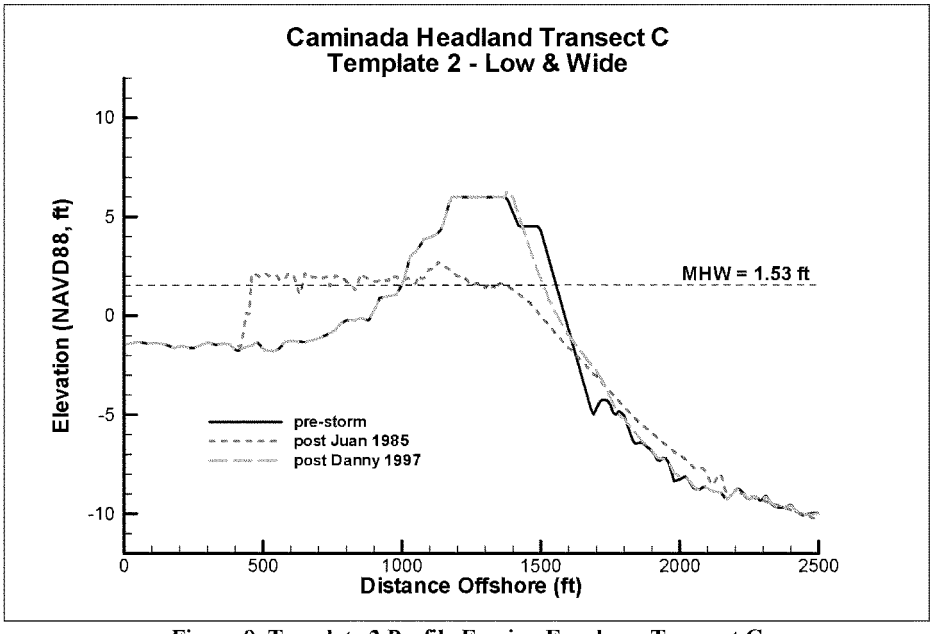


**Figure 9. Template 2 Profile Erosion Envelope, Transect C**

Figure 10 shows model results for Template 3 with the 'High and Narrow' beach fill alternative. For this beach fill template, the dune itself was inundated during the progression of each of the storms. Hurricane Juan had the most severe impact to this profile template followed by Isidore-Lili, Andrew, and Danny. Hurricane Juan impacted the entire dune crest with significant erosion of the seaward dune crest. Hurricanes Isidore-Lili and Andrew also eroded the seaward edge of the dune crest, but had minimal impact to the landward side of the dune. Danny had the least amount of impact to the dune system impacting only the seaward berm.

The profile evolution for Template 3 demonstrated that the higher dune crest elevation may provide increased protection over all of the aforementioned templates: the existing dune system profile, the marsh fill profile (Template 1) and the lower and wider berm profile (Template 2), indicating the importance of a volumetrically substantial beach fill template to maintain the protection inherent in the higher dune system. Figure 11 shows the erosion envelope of the modeled storms (most severe and least severe impacts) for Template 3 at Transect C.

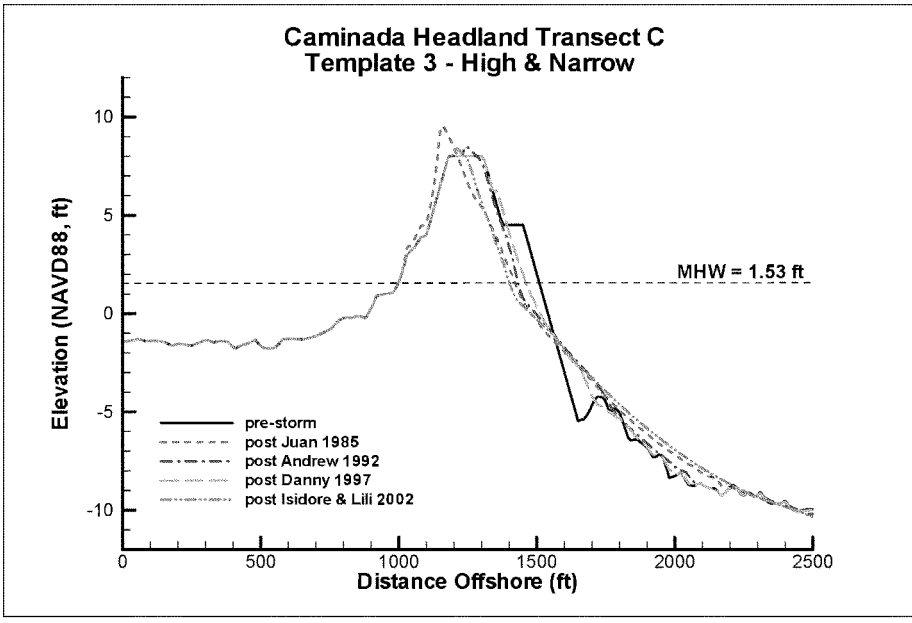


**Figure 10. SBEACH Template 3 Profile Evolution, Transect C**

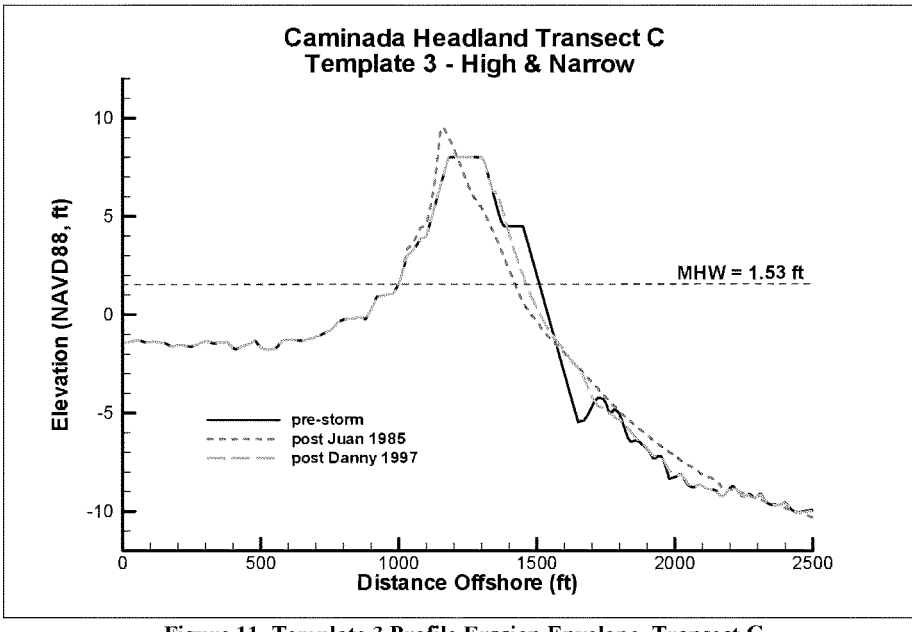


**Figure 11. Template 3 Profile Erosion Envelope, Transect C**

Figure 12 shows model results for Template 4 with the 'Landward' beach fill alternative. Template 4 retained a much greater percentage of its original volume after storm impact than either Templates 2 or 3. Hurricane Juan caused the most severe erosion followed by Isidore-Lili, Andrew, and Danny. It may be seen from the figure that Juan and Isidore-Lili impacted the seaward portion of the dune crest to a greater degree and Andrew impacted the seaward portion of the dune crest to a lesser degree, whereas Danny impacted only the front face of the dune.

The profile evolution for Template 4 demonstrated that the volumetrically larger upland dune system may provide increased protection over the existing dune system profile, the marsh fill profile (Template 1) and the lower berm profile (Template 2), indicating the importance of a volumetrically substantial beach fill template to maintain the protection inherent in the higher dune system. Because of the initial width of Template 4's landward fill, the template may also provide more residual protection under the effects of subsequent storms than the other templates including the higher and narrower berm profile (Template 3), and therefore, may require less frequent maintenance. Figure 13 illustrates the erosion envelope of the modeled storms (most severe and least severe impacts) for Template 4 at Transect C.

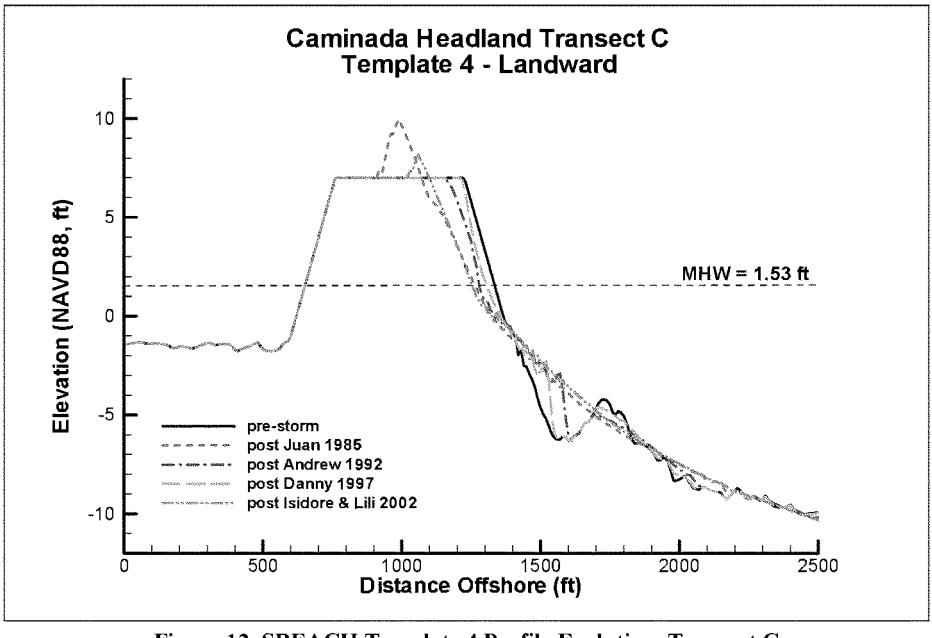


**Figure 12. SBEACH Template 4 Profile Evolution, Transect C**

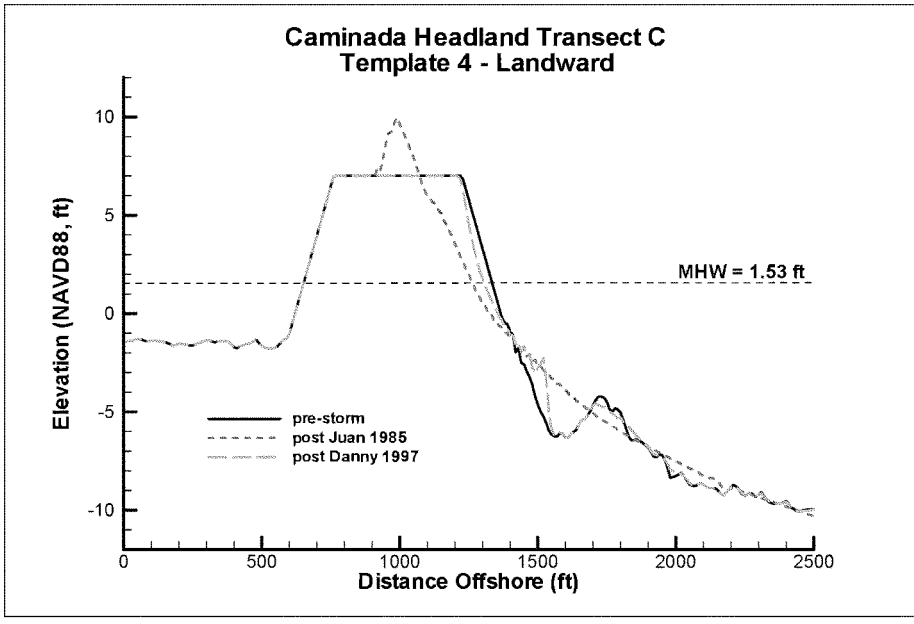


**Figure 13. Template 4 Profile Erosion Envelope, Transect C**

## 5 Model Analysis at Transect D

Of the two transects modeled herein, Transect D's existing profile has the lower dune crest elevation at +4.3 ft NAVD and the wider dune width of 325 ft measured at +2 ft NAVD.

All of the storms completely inundated the existing profile affecting its shape. As shown in Figure 14, when no action was taken to protect the beach, Hurricanes Isidore-Lili, Juan, and Andrew severely impacted the dune system completely eroding the existing dune and washing-out the marsh landward of the dune. Hurricane Danny is the only storm that left the existing dune somewhat intact due primarily to the fact that it had the lowest peak wave height and the shortest storm duration. Figure 15 shows the erosion envelope of the modeled storms (most severe and lease sever impacts) for the existing profile.

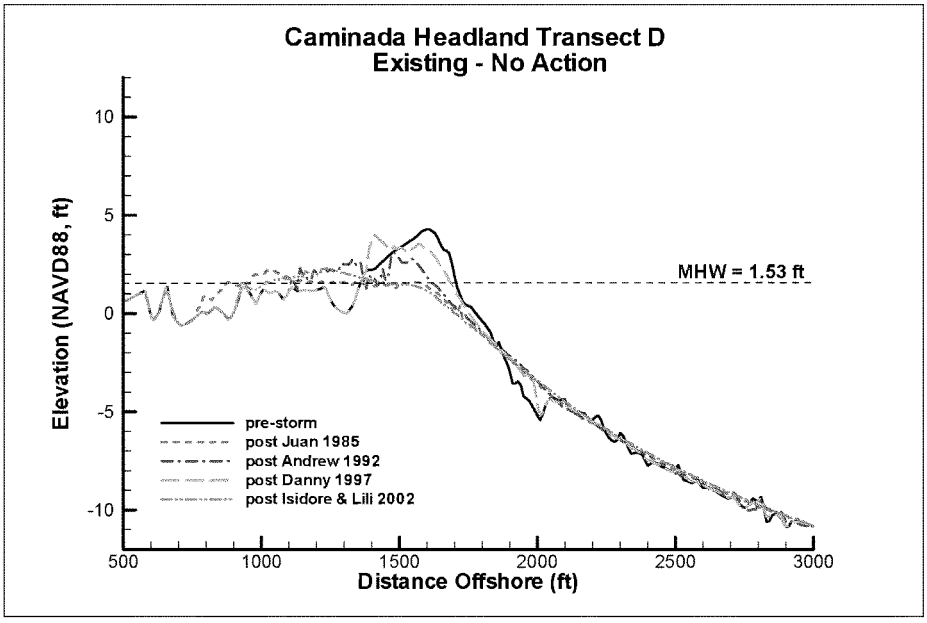


**Figure 14. SBEACH Existing Profile Evolution, Transect D**

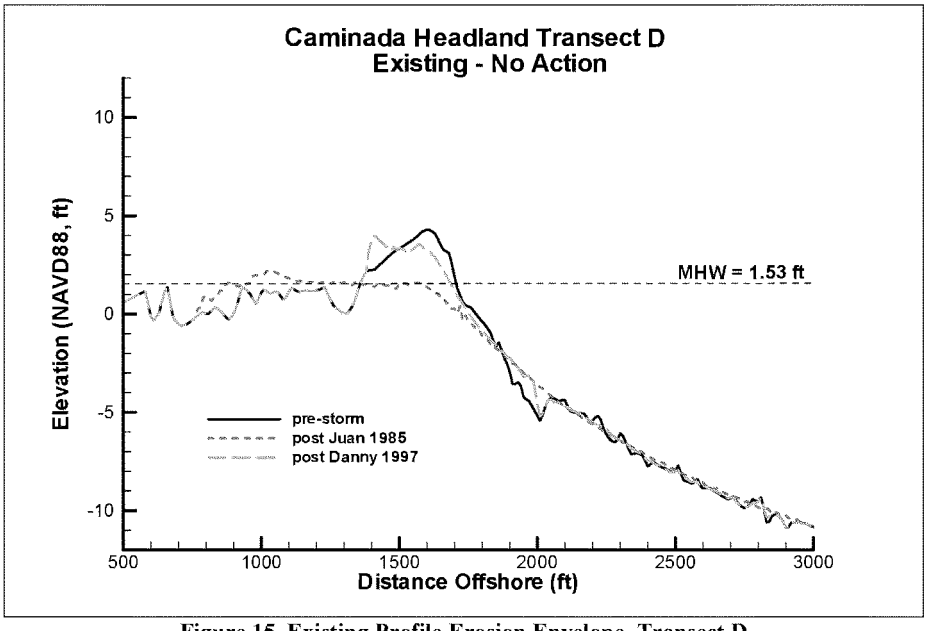


**Figure 15. Existing Profile Erosion Envelope, Transect D**

Figure 16 shows model results for Template 1 with the 'Marsh Only' fill alternative at Transect C. For this fill template, the proposed dune was inundated during the course of each of the storms. Hurricane Juan had the most severe impact to this profile template followed by Isidore-Lili, Andrew, and Danny. Hurricanes Isidore-Lili, Juan, and Andrew completely eroded the existing dune, washed it out landward and caused the shoreline to retreat. Hurricane Danny eroded the seaward edge of the dune crest with minimal impact to the landward side of the dune.

The profile evolution for Template 1 demonstrated that the marsh fill alone does provide some measure of storm protection over the existing dune system profile. Figure 17 shows the erosion envelope of the modeled storms (most severe and lease sever impacts) for Template 1 at Transect D.

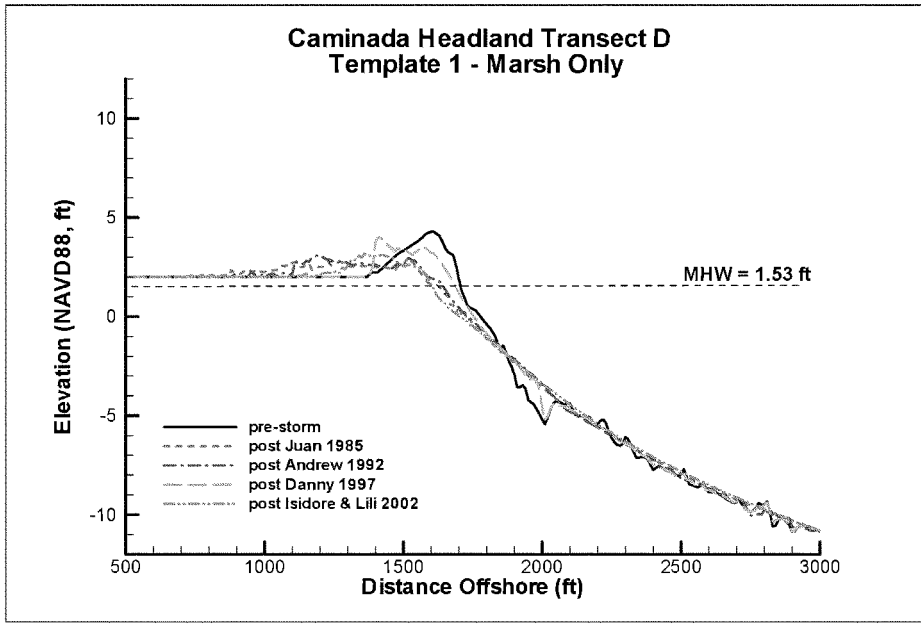


**Figure 16. SBEACH Template 1 Profile Evolution, Transect D**

Figure 18 shows model results for Template 2 with the 'Low and Wide' beach fill template. For this beach fill template, the proposed dune was inundated during the course of each of the storms, which caused the model 'noise' on the dune crest. Isidore-Lili had the most severe impact to the dune followed by Juan and Andrew.

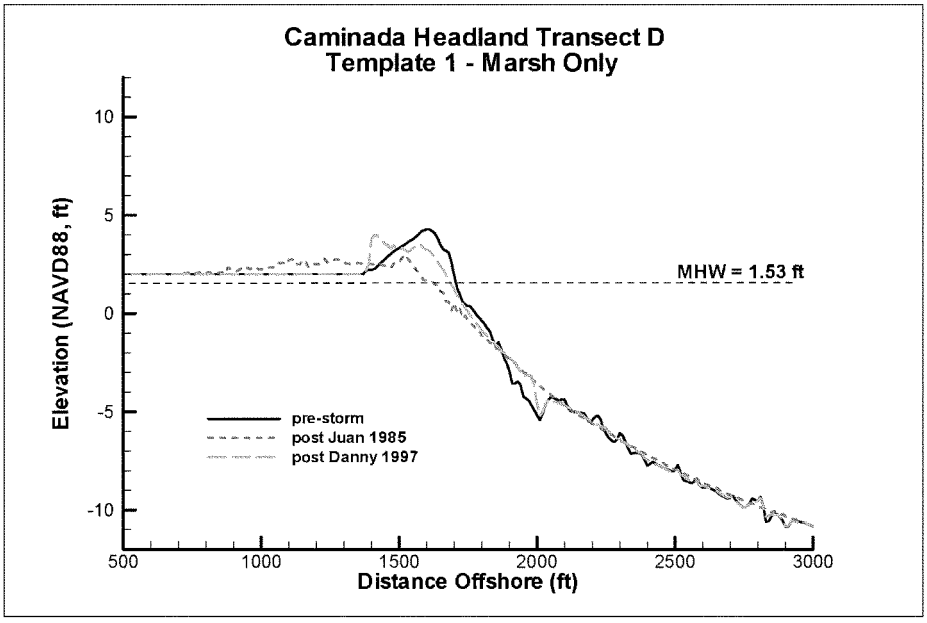


**Figure 17. Template 1 Profile Erosion Envelope, Transect D**

The storms completely eroded the 75 ft seaward berm and severely impacted the crest of the dune; although they had minimal impact to the landward side of the dune. Danny had the least amount on impact to the dune system eroding only the 75 ft wide seaward berm, but not impacting the dune crest. The predicted profile evolution demonstrated the lower and wider dune may provide increased protection over both the existing dune system and the marsh fill profile (Template 1), indicating the importance of the seaward beach fill. Figure 19 shows the erosion envelope of the modeled storms (most severe and lease sever impacts) for Template 2 at Transect D.

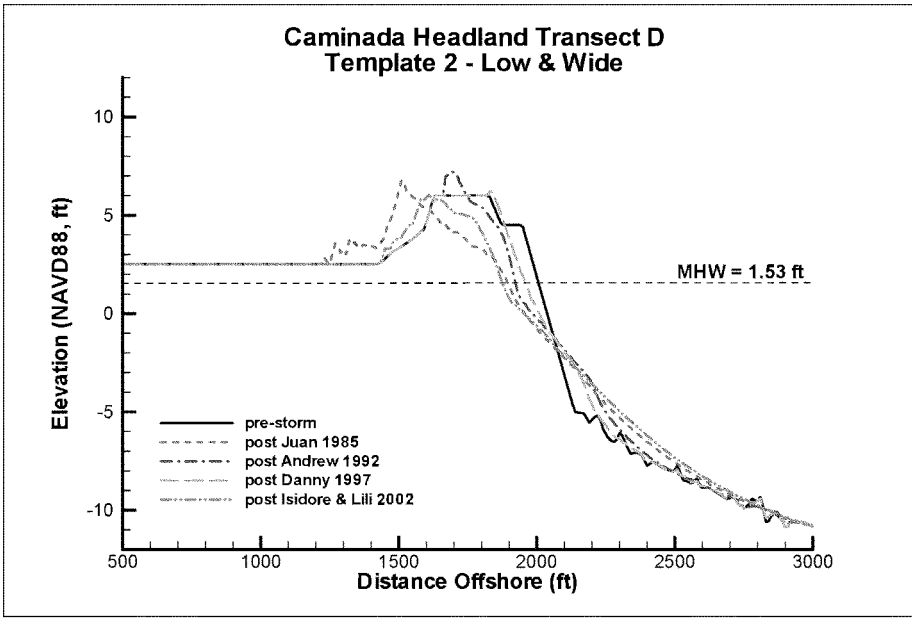


**Figure 18. SBEACH Template 2 Profile Evolution, Section D**

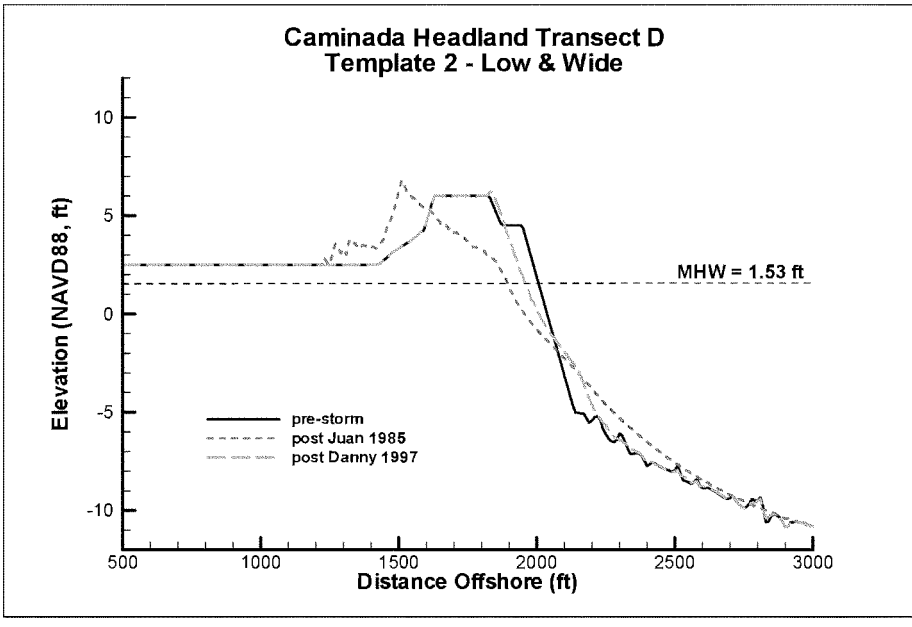


**Figure 19. Template 2 Profile Erosion Envelope, Transect D**

Figure 20 shows model results for Template 3 with the 'High and Narrow' beach fill template. For this beach fill template, the dune itself was inundated during the progression of each of the storms, although there was no reduction in the overall height of the higher proposed dune. The erosion of the seaward berm occurred during each of the storm events with the waves that impacted the seaward edge of the dune crest also causing erosion, but the lee of the dune remained intact. Juan had the most significant erosion to the dune crest followed by Isidore-Lili, Andrew, and Danny. Danny eroded the 75 ft berm, but did not impact the crest of the dune.

The profile evolution for Template 3 demonstrated that the higher dune crest elevation may provide increased protection over all of the aforementioned templates: the existing dune system profile, the marsh fill profile (Template 1) and the lower and wider berm profile (Template 2), indicating the importance of a volumetrically substantial beach fill template to maintain the protection inherent in the higher dune system. Figure 21 shows the erosion envelope of the modeled storms (most severe and least severe impacts) for Template 3 at Transect D.

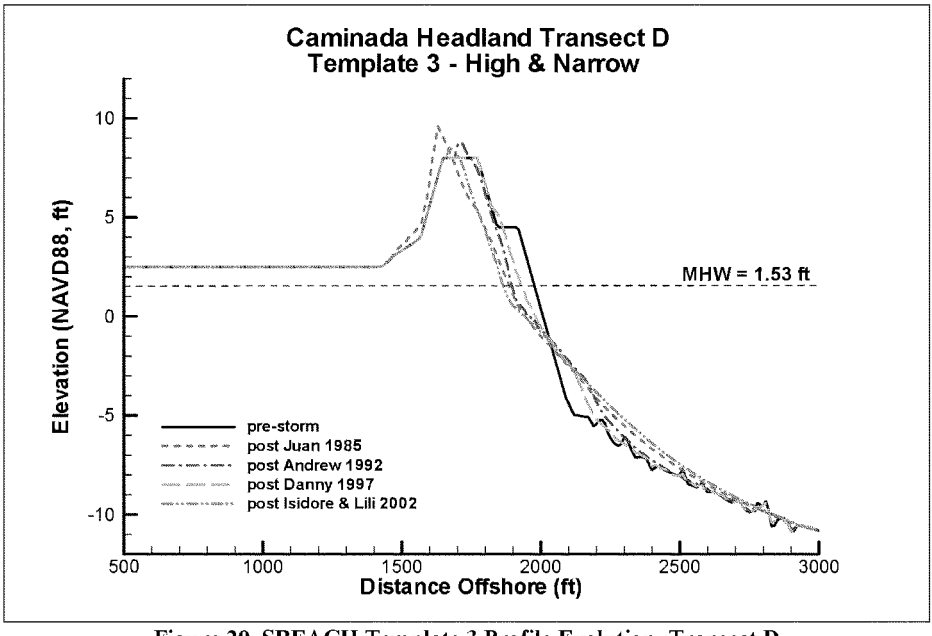


**Figure 20. SBEACH Template 3 Profile Evolution, Transect D**

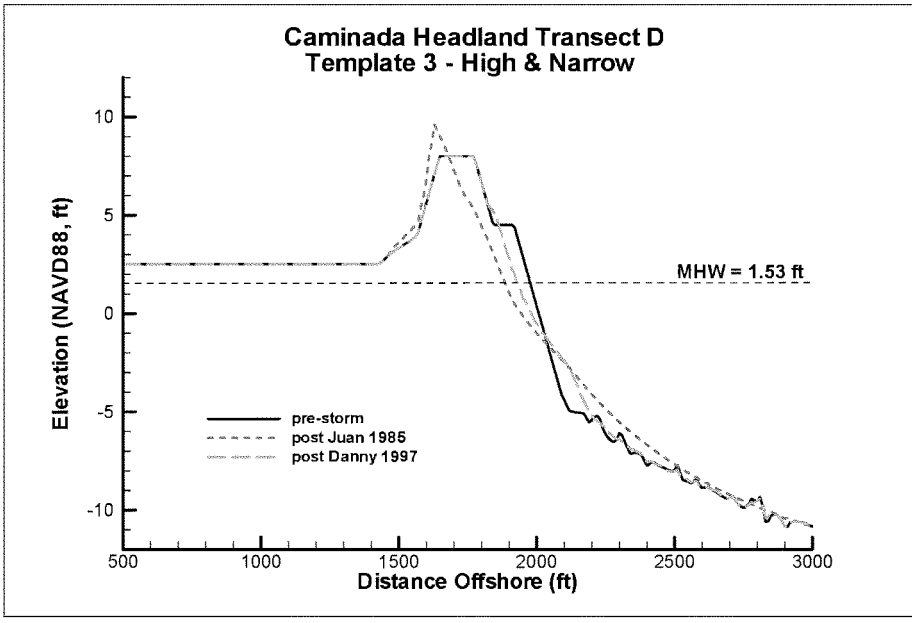


**Figure 21. Template 3 Profile Erosion Envelope, Transect D**

Figure 22 shows model results for Template 4 with the 'Landward' beach fill alternative. Template 4 retained a much greater percentage of its original volume after storm impact than either Templates 2 or 3. Hurricane Juan caused the most severe erosion followed by Isidore-Lili, Andrew, and Danny. It may be seen from the figure that Juan, Isidore-Lili and Andrew impacted the seaward portion of the dune crest, whereas Danny impacted only the front face of the dune.

The profile evolution for Template 4 demonstrated that the volumetrically larger upland dune system may provide increased protection over the existing dune system profile, the marsh fill profile (Template 1) and the lower berm profile (Template 2), indicating the importance of a volumetrically substantial beach fill template to maintain the protection inherent in the higher dune system. Because of the initial width of Template 4's landward fill, the template may also provide more residual protection under the effects of subsequent storms than the other templates including the higher and narrower berm profile (Template 3), and therefore, may require less frequent maintenance. Figure 23 illustrates the erosion envelope of the modeled storms (most severe and least severe impacts) for Template 4 at Transect D.

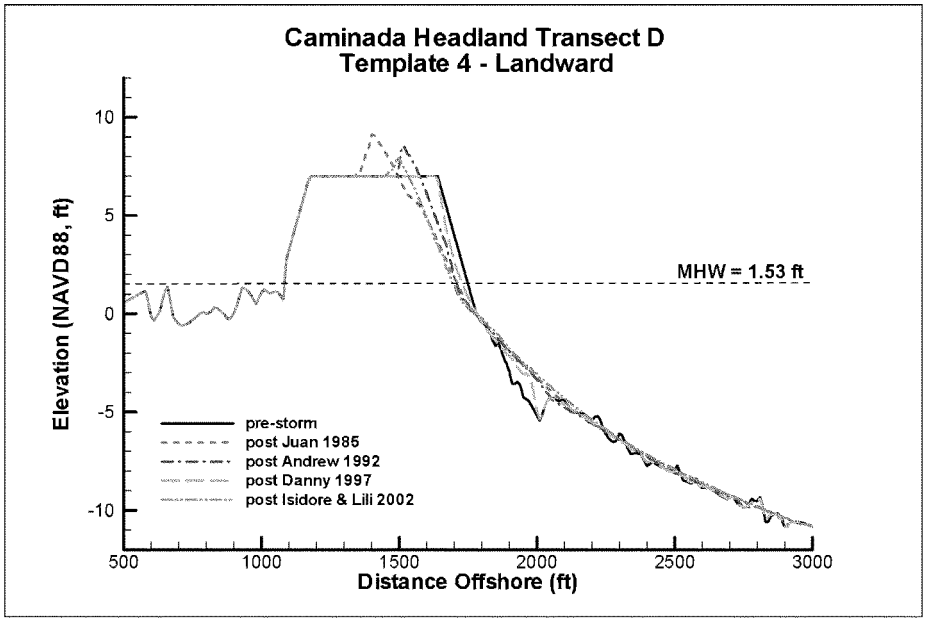


**Figure 22. SBEACH Template 4 Profile Evolution, Transect D**

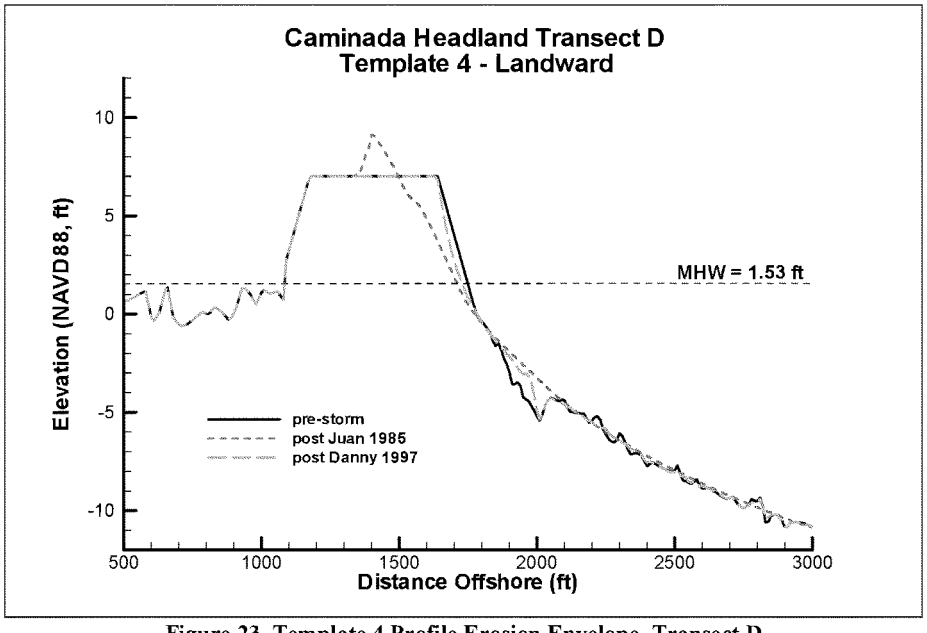


**Figure 23. Template 4 Profile Erosion Envelope, Transect D**

## 6 SBEACH Model Conclusions

The historical storm conditions (wind, waves, and water levels) from 1985 to 2004 were collected for severe storms impacting within 175 miles of the Caminada Headland. From this storm database, four storms were used as input for cross-shore sediment transport analysis in SBEACH: Hurricanes Juan (1885), Andrew (1992), Danny (1997), and the combined passage of Tropical Storm Isidore (2002) and Hurricane Lili (2002).

Five alternatives were used as input in the numerical model for comparison of the progression of profile evolution: 1) existing beach profile, 2) marsh fill only, 3) beach fill with a low and wide dune crest, 4) beach fill with a high and narrow dune crest, and 5) landward beach fill with an intermediate dune crest and significant majority of the fill volume placed on the landward part of the profile. Each alternative was applied to two transects, Transects C and Transect D, which are located approximately in the middle of the Caminada Headland Barrier Island.

The SBEACH storm-induced erosion analyses predicted the following:

1) The model storm with the most severe impact to each of the proposed dune fill templates was Hurricane Juan. This greater impact was likely a result of the extended duration of the storm combined with the largest waves among the modeled storms reaching over 14 ft in height at the depth of the SBEACH offshore boundary (20-ft).

2) The existing profiles are extremely vulnerable to the modeled storm wave conditions. The existing profiles are inadequate for upland and/or marsh protection and are completely eroded under severe storm wave conditions.

3) Template 1, which creates a marsh on the landward side of the dune at an elevation of +2 ft NAVD, left the existing dune vulnerable; however, it did provide some measure of storm protection compared to the existing dune system with no fill.

4) Template 2, which increased the dune crest elevation from +4 ft NAVD to +6 ft NAVD and provided a 200 ft wide dune crest, sustained significant erosion to the seaward dune face and part of the dune crest under the modeled storm conditions. The modeled dune profile still maintained a large portion of the original volume of material and the prediction suggested some increased protection to the lee of the dune from severe storm events in comparison to the existing profile. It was predicted that Template 2 maintained approximately 81.5% and 78.7% of its material following the most severe modeled storm for Transects C and D, respectively. Approximately 18.5% and 21.3% of the material moved seaward of Template 2's fill limits for Transects C and D, respectively.

5) Template 3, which increased the dune crest elevation from +4 ft NAVD to +8 ft NAVD with a 125 ft dune crest width, sustained some erosion of the seaward dune face under the

modeled storm conditions but maintained the original dune crest elevation with little significant impact predicted to the seaward face of the dune crest. Model results suggested that this beach fill template might provide adequate protection in the lee of the dune system and significantly increase the upland storm protection over the existing dune profile. It was estimated that Template 3 maintained approximately 81.9% and 84.2% of its material following the most severe modeled storm for Transects C and D, respectively. Approximately 18.1% and 15.4% of the material moved seaward of Template 3's limits for Transects C and D, respectively.

6) Template 4, which increased the dune crest elevation from +4 ft NAVD to +7 ft NAVD (the intermediate elevation between Templates 2 and 3) with a crest width of 465 ft and placed a large amount of fill material in a landward section without a seaward beach fill component, sustained some erosion of the seaward dune face under the modeled storm conditions but maintained the original dune crest elevation with little significant impact predicted to the seaward face of the dune crest. It was predicted that Template 4 maintained approximately 85.7% and 91% of its material following the most severe modeled storm for Transects C and D, respectively. Approximately 14.3% and 9% of the material moved seaward of Template 4's limits for Transects C and D, respectively.

The net amount of fill remaining on the profiles following the most severe modeled storm wave conditions, and therefore the residual level of protection against on-going profile recession after a hypothetical storm, varied from 78.7% to 91% depending, to a greater degree, on the template type and, to a lesser degree, on the modeled transect. Template 4 maintained more material following the most damaging storm, Hurricane Juan, than any other modeled template. Template 3 maintained more material after the passage of Juan than Template 2.

It also may be concluded from visual comparison of the profile evolution due to modeled storm conditions for Templates 2 and 3, the higher dune crest created in Template 3 would provide more potential protection against wave run-up and breaching for other storms which might exceed the water level impact of the events modeled. Because of the initial width of Template 4's landward fill and its proposed position on the existing profile, the dune system remaining at the site following an initial storm impact may provide more residual protection under the effects of subsequent storms than either Template 2 or Template 3, and therefore, may require less frequent maintenance.

Another approach to assess the performance of the modeled templates was to calculate shoreline and dune retreat caused by each storm at Transects C and D. The retreat was calculated at two elevations, +1.53 ft NAVD, which corresponds to the Mean High Water (MHW), and +4 ft NAVD, which approximately corresponds to the existing dune.

Table 2 presents the shoreline retreat at MHW for all alternatives and modeled storms at Transect C. The second column in the table shows the distance the shoreline was advanced seaward from the existing profile, e.g., the wide and low profile (Template 2) advanced 295 ft seaward and the landward fill profile (Template 4) advanced only 75 ft seaward. Hurricane Juan resulted in the most significant shoreline retreat for the 'No Action' alternative as well as Templates 1 and 2. Combined storm event Isidore-Lili caused the shoreline to retreat the most for Templates 3 and 4. Template 4 sustained the least overall shoreline retreat caused by the modeled storms followed by Templates 1 and 3. The 'No Action' alternative sustained the most overall retreat caused by the modeled storms.

**Table 2. Shoreline Retreat at MHW for Transect C**

| Alternative | Template Advance (+) at MHW=+1.5 ft NAVD from Existing Profile (ft) | Shoreline Retreat (-) at MHW=+1.5 ft NAVD (ft) | | | |
|---|---|---|---|---|---|
| | | Juan 1985 | Andrew 1992 | Danny 1987 | Isidore & Lili 2002 |
| No Action | 0 | -307 | -90 | -9 | -145 |
| Template 1 | 0 | -94 | -55 | -7 | -89 |
| Template 2 | +295 | -182 | -79 | -47 | -125 |
| Template 3 | +250 | -89 | -77 | -49 | -108 |
| Template 4 | +75 | -73 | -57 | -29 | -82 |

Hurricane Juan resulted in a 182-ft retreat of the shoreline for Template 2 (low and wide dune) at Transect C; however, Template 1 (marsh only) sustained only a 94-ft shoreline retreat. This may seem misleading but it should be noted that the Template 1 design did not advance the shoreline seaward of the existing profile (the marsh fill was placed landward of the existing dune system) whereas the Template 2 design filled the beach seaward and advanced the shoreline 295 ft seaward of the existing profile at MHW. Table 3 presents the post-storm profile positions at MHW with respect to the existing pre-storm profile. Template 1's shoreline still retreated 94 ft landward of the existing pre-storm profile due to Juan, however, Template 2's shoreline at MHW was 113 ft seaward of the existing pre-storm profile despite the 182-ft retreat caused by Juan.

**Table 3. Post-Storm Profile Position at MHW with Respect to Existing Pre-Storm Profile for Transect C**

| Alternative | Post-Storm Profile Position at MHW=+1.5 ft NAVD (ft) | | | |
|---|---|---|---|---|
| | Juan 1985 | Andrew 1992 | Danny 1987 | Isidore & Lili 2002 |
| No Action | -307 | -90 | -9 | -145 |
| Template 1 | -94 | -55 | -7 | -89 |
| Template 2 | +113 | +216 | +248 | +170 |
| Template 3 | +161 | +173 | +201 | +142 |
| Template 4 | +2 | +18 | +46 | -7 |

Overall, Template 2's post-storm profiles were the most seaward advanced at MHW with respect to the existing pre-storm profiles at Transect C closely followed by Template 3's post-storm profiles and then Template 4's post-storm profiles.

Table 4 presents the shoreline retreat at MHW for all alternatives and modeled storms at Transect D. The second column in the table shows the distance the shoreline was advanced seaward from the existing profile: the wide and low profile (Template 2) advanced 301 ft seaward and the landward fill profile (Template 4) advanced only 43 ft seaward. Combined storm event Isidore-Lili resulted in the most significant shoreline retreat for all of the templates followed by Hurricane Juan. Template 4 sustained the least overall shoreline retreat caused by the modeled storms followed by Templates 1 and 3. The 'No Action' alternative sustained the most overall retreat caused by the modeled storms.

**Table 4. Shoreline Retreat at MHW for Transect D**

| Alternative | Template Advance (+) at MHW=+1.5 ft NAVD from Existing Profile (ft) | Shoreline Retreat (-) at MHW=+1.5 ft NAVD (ft) | | | |
|---|---|---|---|---|---|
| | | Juan 1985 | Andrew 1992 | Danny 1987 | Isidore & Lili 2002 |
| No Action | 0 | -125 | -85 | -19 | -246 |
| Template 1 | 0 | -81 | -62 | -19 | -103 |
| Template 2 | +301 | -112 | -85 | -50 | -131 |
| Template 3 | +271 | -91 | -82 | -49 | -112 |
| Template 4 | +43 | -38 | -40 | -21 | -52 |

Hurricane Juan resulted in a 112-ft retreat of the shoreline for Template 2 (low and wide dune) at Transect D, however, Template 1 (marsh only) sustained only a 81-ft shoreline retreat which, again, may seem misleading. It should be noted that the Template 1 design did not advance the shoreline seaward of the existing profile (the marsh fill was placed landward of the existing dune system) whereas the Template 2 design filled the beach seaward and advanced the shoreline 301 ft seaward of the existing profile at MHW. Table 5 presents post-storm profile positions at MHW with respect to the existing pre-storm profile. Template 1's shoreline still retreated 81 ft landward of the existing pre-storm profile due to Juan, however, Template 2's shoreline at MHW was 189 ft seaward of the existing pre-storm profile despite the 112-ft retreat caused by Juan.

Overall, Template 2's post-storm profiles were the most seaward advanced at MHW with respect to the existing pre-storm profiles at Transect D closely followed by Template 3's post-storm profiles and then Template 4's post-storm profiles.

**Table 5. Post-Storm Profile Position at MHW with Respect to Existing Pre-Storm Profile for Transect D**

| Alternative | Post-Storm Profile Position at MHW=+1.5 ft NAVD with Respect to Existing Pre-Storm Profile (ft) | | | |
|---|---|---|---|---|
| | Juan 1985 | Andrew 1992 | Danny 1987 | Isidore & Lili 2002 |
| No Action | -125 | -85 | -19 | -246 |
| Template 1 | -81 | -62 | -19 | -103 |
| Template 2 | +189 | +216 | +251 | +170 |
| Template 3 | +180 | +189 | +222 | +159 |
| Template 4 | +5 | +3 | +22 | -9 |

Table 6 presents the dune retreat at +4 ft NAVD for all alternatives and modeled storms at Transect C. The second column in the table shows the distance the dune was advanced seaward from the existing profile at +4 ft NAVD, e.g., the wide and low profile (Template 2) advanced 268 ft seaward and the landward fill profile (Template 4) advanced only 48 ft seaward. Hurricanes Juan, Andrew and Isidore-Lili resulted in a complete wipe-out of the existing dune, thus the dune retreat for the 'No Action' and Template 1 alternatives was not calculated for these storms. The post-Juan profile for Template 2 was also below +4 ft NAVD and the dune retreat was not calculated for this case either. Hurricane Danny caused the least damage to the dune keeping its elevation above +4 ft NAVD for all modeled templates. Hurricane Juan and the combined storm event Isidore-Lili caused the largest dune retreat for Templates 3 and 4. Template 4 sustained the least overall retreat of the dune caused by the modeled storms followed by Template 3.

**Table 6. Dune Retreat at +4 ft NAVD for Transect C**

| Alternative | Template Advance (+) at +4 ft NAVD from Existing Profile (ft) | Dune Retreat (-) at +4 ft NAVD (ft) | | | |
|---|---|---|---|---|---|
| | | Juan 1985 | Andrew 1992 | Danny 1987 | Isidore & Lili 2002 |
| No Action | 0 | N/A | N/A | -212 | N/A |
| Template 1 | 0 | N/A | N/A | -102 | N/A |
| Template 2 | +268 | N/A | -76 | -61 | -147 |
| Template 3 | +222 | -111 | -73 | -58 | -118 |
| Template 4 | +48 | -99 | -42 | -28 | -97 |

Note: N/A means that the entire post-storm profile was below +4 ft NAVD and the shoreline retreat could not be calculated

Table 7 presents the post-storm profile positions at +4 ft NAVD with respect to the existing pre-storm profile. Template 4's dune retreated 49 ft landward of the existing pre-storm dune due to Isidore-Lili, however, Template 3's dune at +4 ft NAVD was 104 ft seaward of the existing pre-storm dune despite the 118-ft retreat caused by Isidore-Lili.

**Table 7. Post-Storm Profile Position at +4 ft NAVD with Respect to Existing Pre-Storm Profile for Transect C**

| Alternative | Post-Storm Profile Position at +4 ft NAVD with Respect to Existing Pre-Storm Profile (ft) | | | |
|---|---|---|---|---|
| | Juan 1985 | Andrew 1992 | Danny 1987 | Isidore & Lili 2002 |
| No Action | N/A | N/A | -212 | N/A |
| Template 1 | N/A | N/A | -102 | N/A |
| Template 2 | N/A | +192 | +207 | +121 |
| Template 3 | +111 | +149 | +164 | +104 |
| Template 4 | -51 | +6 | +20 | -49 |

Note: N/A means that the entire post-storm profile was below +4 ft NAVD and the profile position at +4 ft NAVD could not be calculated

Overall, Template 2's post-storm profiles were the most seaward advanced at +4 ft NAVD with respect to the existing pre-storm profiles at Transect C closely followed by Template 3's post-storm profiles and then Template 4's post-storm profiles. However, the Template 2 design elevation over the dune, +6 ft NAVD, was not high enough to keep it above +4 ft NAVD following Hurricane Juan's passage.

Table 8 presents the dune retreat at +4 ft NAVD for all alternatives and modeled storms at Transect D. Hurricanes Juan, Andrew and Isidore-Lili resulted in a complete wipe-out of the existing dune at Transect D, thus the dune retreat for the 'No Action' and Template 1 alternatives was not calculated for these storms. Combined storm event Isidore-Lili resulted in the most significant dune retreat for all of the templates followed by Hurricane Juan. Template 4 sustained the least overall dune retreat caused by the modeled storms followed by Templates 3 and 2.

**Table 8. Shoreline Retreat at +4 ft NAVD for Transect D**

| Alternative | Template Advance (+) at +4 ft NAVD from Existing Profile (ft) | Shoreline Retreat (-) at +4 ft NAVD (ft) | | | |
|---|---|---|---|---|---|
| | | Juan 1985 | Andrew 1992 | Danny 1987 | Isidore & Lili 2002 |
| No Action | 0 | N/A | N/A | -223 | N/A |
| Template 1 | 0 | N/A | N/A | -223 | N/A |
| Template 2 | +325 | -238 | -83 | -61 | -151 |
| Template 3 | +295 | -113 | -77 | -53 | -121 |
| Template 4 | +68 | -70 | -43 | -24 | -76 |

Note: N/A means that the entire post-storm profile was below +4 ft NAVD and the shoreline retreat could not be calculated

Table 9 presents the post-storm profile positions at +4 ft NAVD with respect to the existing pre-storm profile. Template 4's dune retreated 8 ft landward of the existing pre-storm profile due to Isidore-Lili, however, Template 3's shoreline at +4 ft NAVD was 174 ft seaward of the existing pre-storm profile despite the 121-ft retreat caused by Isidore-Lili.

**Table 9. Post-Storm Profile Position at +4 ft NAVD with Respect to Existing Pre-Storm Profile for Transect D**

| Alternative | Post-Storm Profile Position at +4 ft NAVD with Respect to Existing Pre-Storm Profile (ft) | | | |
|---|---|---|---|---|
| | Juan 1985 | Andrew 1992 | Danny 1987 | Isidore & Lili 2002 |
| No Action | N/A | N/A | -223 | N/A |
| Template 1 | N/A | N/A | -223 | N/A |
| Template 2 | +87 | +242 | +264 | +174 |
| Template 3 | +182 | +218 | +242 | +174 |
| Template 4 | -2 | +25 | +44 | -8 |

Note: N/A means that the entire post-storm profile was below +4 ft NAVD and the profile position at +4 ft NAVD could not be calculated

Overall, Template 3's post-storm profiles were the most seaward advanced at +4 ft NAVD with respect to the existing pre-storm profiles at Transect D closely followed by Template 2's post-storm profiles and then Template 4's post-storm profiles.

## References

Larson, M., and N.C. Kraus, 1989: SBEACH: Numerical model for simulating storm-induced beach change; Report 1: Empirical foundation and model development, Technical Report CERC-89-9, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Larson, M., N.C. Kraus, and M. Bymes, 1990: SBEACH: Numerical model for simulating storm-induced beach change; Report 2: Numerical formulation and model tests, Technical Report CERC-89-9, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

U. S. Army Corps of Engineers. July, 2004. "Coastal Processes Assessment and Project Re-evaluation: Grande Isle, Louisiana, Shore Protection Project", Coastal and Hydraulic Laboratory, Engineering Research and Development Center, Seattle, WA.

# 05211

# Caminada Headland
# Supplemental Modeling Report

## June 2006

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## 1 Wave Modeling

This chapter describes the procedures and results of wave modeling using the STWAVE model. Offshore storm wave and water elevation data were collected and STWAVE was used to propagate waves to the nearshore and calculate wave conditions at offshore ends of the 2005 survey profiles.

### 1.1 Wave Model Description

The Steady-State Spectral Wave Model (STWAVE) was used to evaluate changes to wave refraction and sediment transport patterns resulting from the proposed borrow area excavation.

STWAVE is a steady-state finite difference model (Smith et al., 2001). It simulates depth-induced wave refraction and shoaling, current-induced refraction and shoaling, depth and steepness induced wave breaking, diffraction, wind driven wave growth, and wave-wave interaction and whitecapping that redistribute and dissipate energy in a growing wave field. The version of STWAVE chosen is part of the SMS model, Version 9.0, developed by Environmental Modeling System, Inc. and provided by Veri-Tech, Inc.

### 1.2 Grid Design

STWAVE grid was designed such that its offshore boundary was parallel to Caminada Headland. State Plane NAD83 Louisiana South was used as horizontal reference coordinate system. NAVD88 was chosen as vertical reference datum. The grid was made up of 179 columns (east-west direction) and 182 rows (north-south direction) of grid cells. The origin of the coarse grid, located at the southeast corner, was located at an Easting of 3602100.0 and a Northing of 129500.0. The grid was slightly rotated (30.5° counterclockwise) to accommodate shoreline orientation. Each coarse grid cell was 1000 feet long by 1000 feet wide. This gave a total width of 179,000 feet (east-west) and a total length of 182,000 feet (north-south).

NOAA GEODAS (Sharman et al., 1999) data were used for bathymetry interpolation within the computational domain (http://www.ngdc.noaa.gov/mgg/geodas/geodas.html). The 2005 survey data collected along Caminada Headland were incorporated as well. High resolution (1:70,000) NDGC/NOAA shoreline was utilized to distinguish between land and water (http://rimmer.ngdc.noaa.gov/coast/getcoast.html). A value of -4 feet was assigned to all land grid cells. Positive elevations represent water depths below NAVD88. Figure 1-1 shows the computational domain and its bathymetry elevations composed of GEODAS and the 2005 survey data.

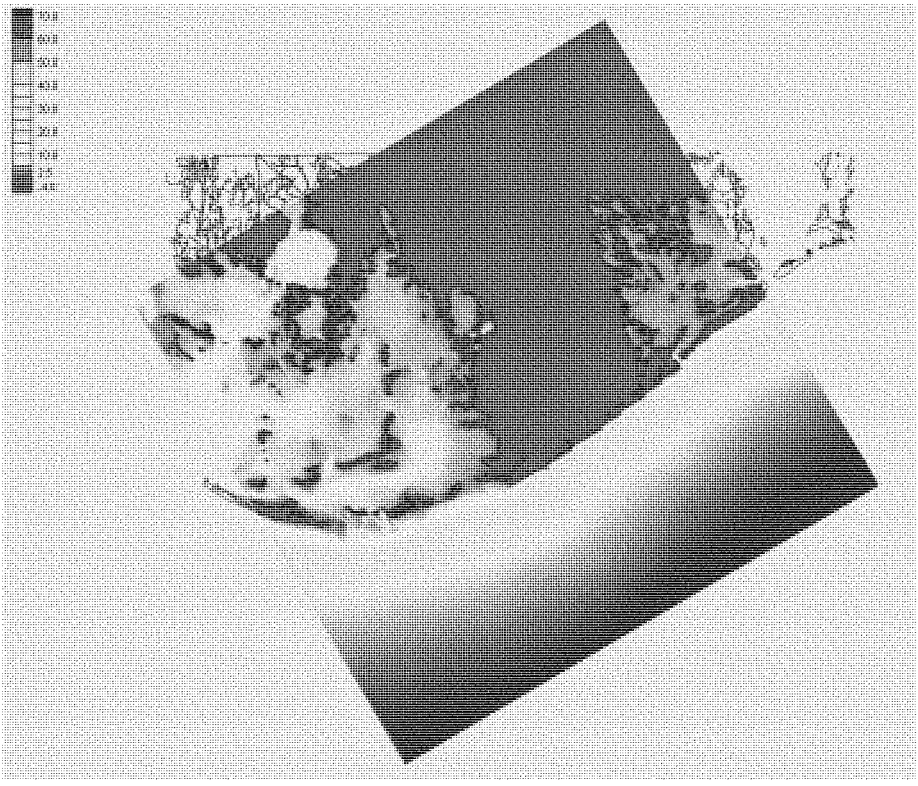

**Figure 1-1. STWAVE computational domain for Caminada Headland**

### 1.3 Storm Data

Storm wave data were obtained from the Wave Information Studies (WIS) project (Hubertz, 1992) which produces a high-quality online database of hindcast, nearshore wave conditions covering U.S. coastlines (http://chl.erdc.usace.army.mil/). The acquired data cover a 20-year period from January 1, 1980 through December 31, 1999. The time interval of the data is one hour. Several storm events were selected including Hurricane Andrew (1992), which is representative of storms that occur every 5 to 7 years (USACE, 2004).

The Caminada Headland computational domain was designed such that WIS station 130, hereafter referred to as WIS-130, was located in the middle of the offshore boundary segment. By doing so, wave boundary conditions used in the STWAVE model were directly imposed based on wave information at the station.

The goal of STWAVE simulations was to propagate waves from WIS-130 to the nearshore and output calculated wave parameters such as wave height, period and

direction at the end of survey profiles (at approximately 20-ft depth). These wave parameters were then used in SBEACH to calculate erosion for each of the profiles.

Figure 1-2 shows WIS-130 wave height and period time series during Andrew (August 21 through August 31, 1992) along with the calculated wave height and period time series at the end of Transect B.

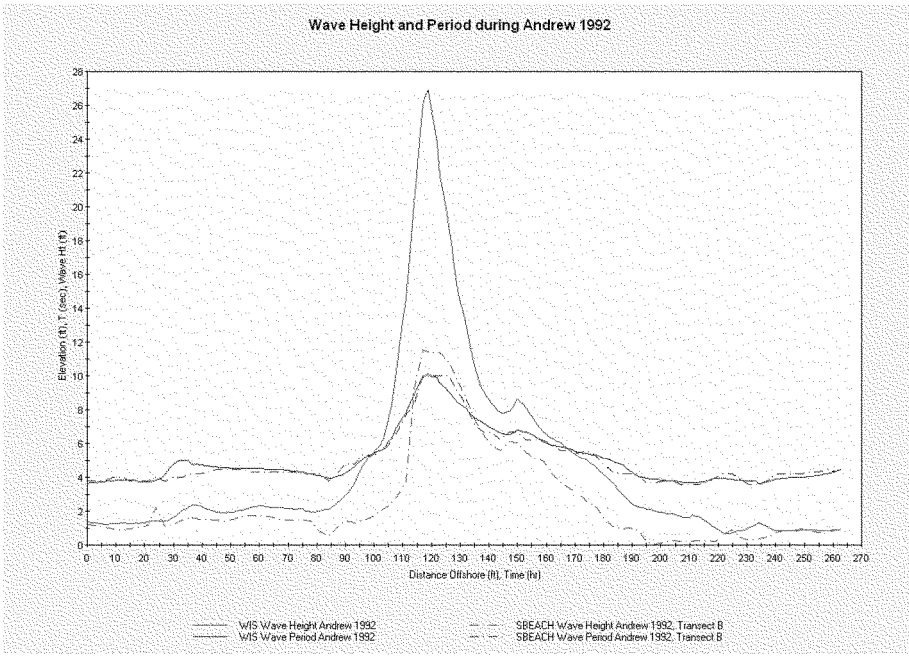


**Figure 1-2. Time series of wave heights and periods at WIS-130 (STWAVE boundary conditions) and the end of Transect B (SBEACH boundary conditions)**

### 1.4 Wave Statistics

WIS data were used to perform a statistical analysis of wave conditions in the area. This analysis allowed identification of the dominant wave parameters that were used for model calibration.

The computational domain was designed in such a way that a WIS station, hereafter referred to as WIS-130, was located at the offshore boundary segment. By doing so, wave boundary conditions used in the STWAVE model were directly imposed based on wave information at the station.

Statistical analysis of the wave and wind data at WIS-130 (see Figure 1-3 and 1-4) shows that there are three dominant directions (22.5°directional bands) that the waves enter the computational domain from: 135° (clockwise from true North), 157.5° and 112.5°, which

occur in 18%, 15% and 13% of all cases, respectively. The average wave heights and periods for the three directions are shown in Table 1-1. The dominant wind direction (135°) is in agreement with the wave direction and the average wind speeds are summarized in Table 1-2

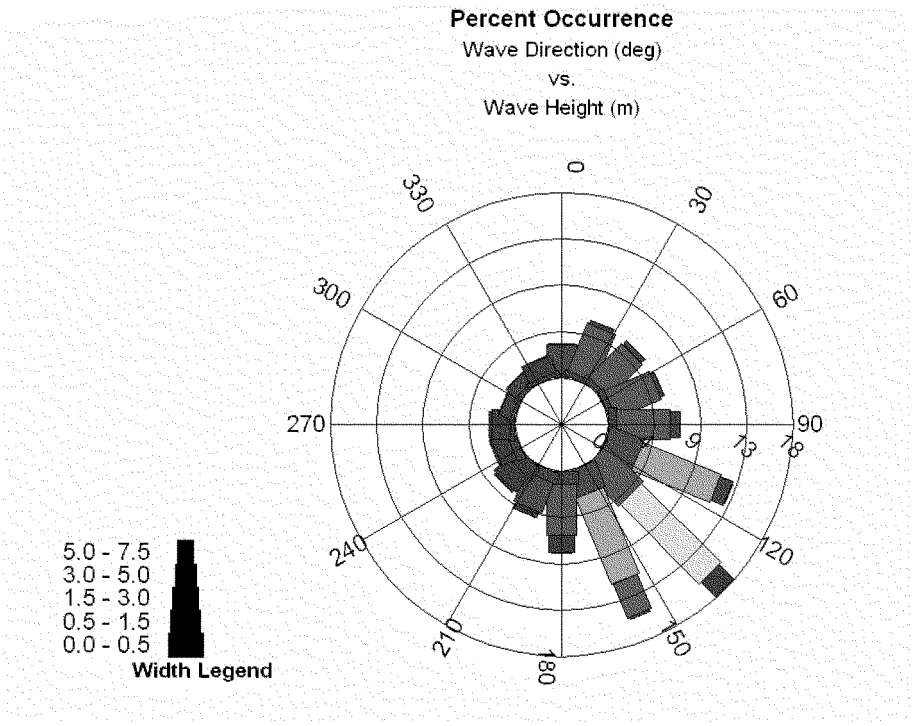


**Figure 1-3. Wave Rose at WIS-130 Based on Hourly Hindcasts During 1980-1999**

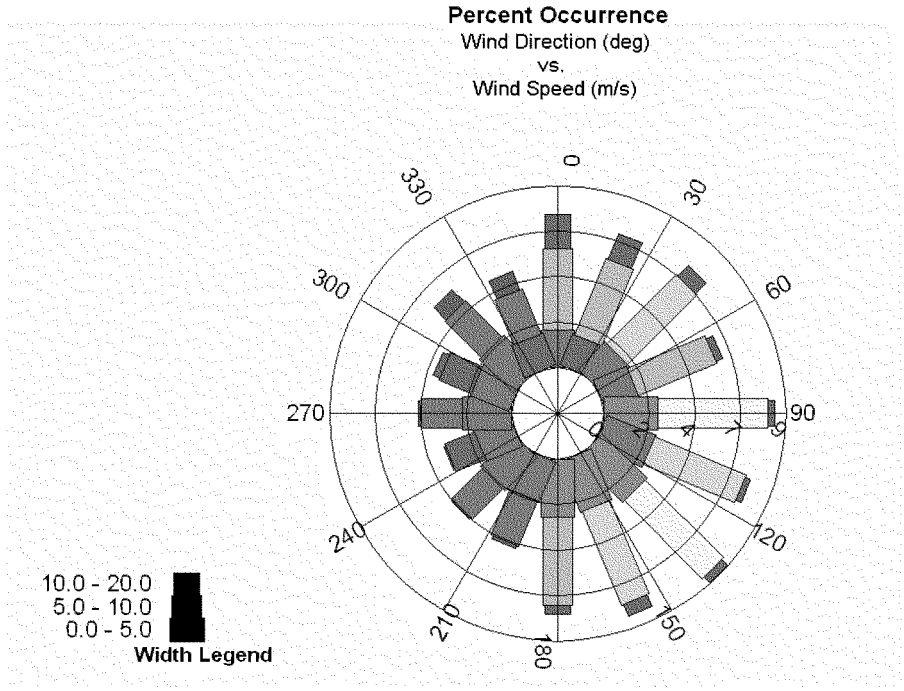


**Figure 1-4. Wind Rose at WIS-130 Based on Hourly Hindcasts During 1980-1999**

Tables 1-1 and 1-2 below list average wave and wind conditions for the three dominant wave directions at WIS-130 along with their average values which are used in STWAVE simulations.

**Table 1-1: Average Wave Heights and Periods and Wind Speed and WIS-130**

| # | **Wave Direction (deg)** | Wave Height (m) | Wave Height (ft) | Wave Period (s) |
|---|---|---|---|---|
| 1 | **135.0** | 0.9 | 3.0 | 4.6 |
| 2 | **157.5** | 1.1 | 3.6 | 5.0 |
| 3 | **112.5** | 0.9 | 3.0 | 4.4 |

**Table 1-2: Average Wind Speeds at WIS-130**

| # | **Wind Direction (deg)** | Wind Speed (m/s) | Wind Speed (ft/s) |
|---|---|---|---|
| 1 | **135.0** | 6.1 | 20.0 |
| 2 | **90.0** | 6.2 | 20.3 |
| 3 | **157.5** | 6.4 | 21.0 |

### 1.5 Depth of Closure

The offshore depth beyond which the net sediment transport does not result in significant changes in mean water depth is known as the depth of closure. According to the Birkemeier (1985), the depth of closure can be estimated as

$$h_c = 1.75H_e - 57.9\left(\frac{H_e^2}{gT_e^2}\right)$$

where $H_e$ is the effective wave height wave height which is exceeded during only 12 hours per year, $T_e$ is the associated period, and g is the acceleration due to gravity.

Since the WIS data covered a 20-year period, the effective wave height and its corresponding period were calculated for each year and then averaged to obtain values representative over the 20-year period, which resulted in 11.9 ft and 8.0 s wave height and period, respectively. The average depth at WIS stations is 75 ft. According to the dispersion relationship (Dean and Dalrymple, 1991), the 11.9-ft 8.0-s wave is 300-ft long. It makes the h/L ratio to be 0.25 (where h is depth and L is wave length) indicating that the wave is an intermediate water wave. In order to calculate the effective wave parameters for shallow water waves whose interaction with bottom is more significant, the STWAVE model was used to propagate the 11.9-ft 8.0-s wave closer to the shore. The calculated effective wave height and period in the nearshore of Caminada Headland were on the order of 8 ft and 8.3 s, respectively. Plugging these values in the equation above yields a depth of closure of 12 ft.

### 1.6 Breakwaters

Twelve detached breakwaters are located seaward of Caminada Headland as shown in Figure 1-5. The breakwaters are approximately 150 to 200 feet long and 50 feet wide. The gaps between the breakwaters are 250 to 280 feet long.

To investigate the effect of the breakwaters on wave height in the lee of the breakwaters, two STWAVE simulations were performed: 1) with the breakwaters placed in the computational domain and 2) without any breakwaters within the domain.

Since the original STWAVE grid (shown in Figure 1-1) was designed so that its grid spacing was 1000 feet, it was necessary to create a nested grid with fine resolution. The nested grid had 50 foot grid spacing and covered the area where the breakwaters were located. The offshore boundary of the grid was set at the 24.5 foot depth. Figures 1-6 and 1-7 show the nested grid with and without the breakwaters, respectively.

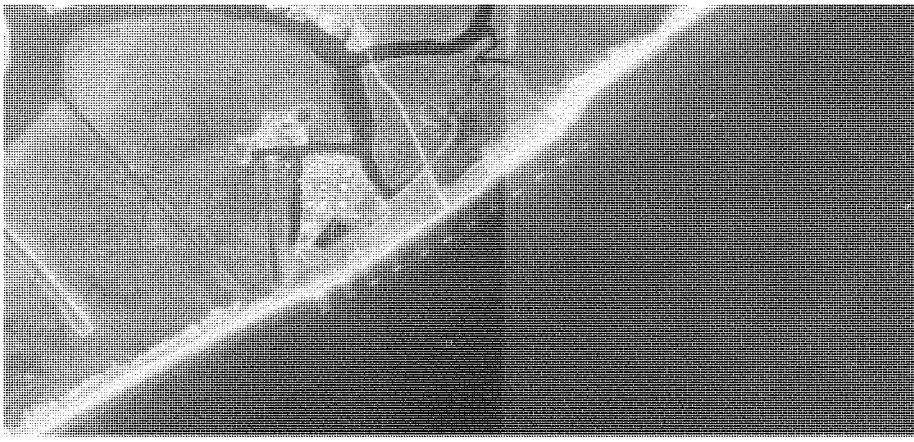

**Figure 1-5. Breakwaters off Caminada Headland**

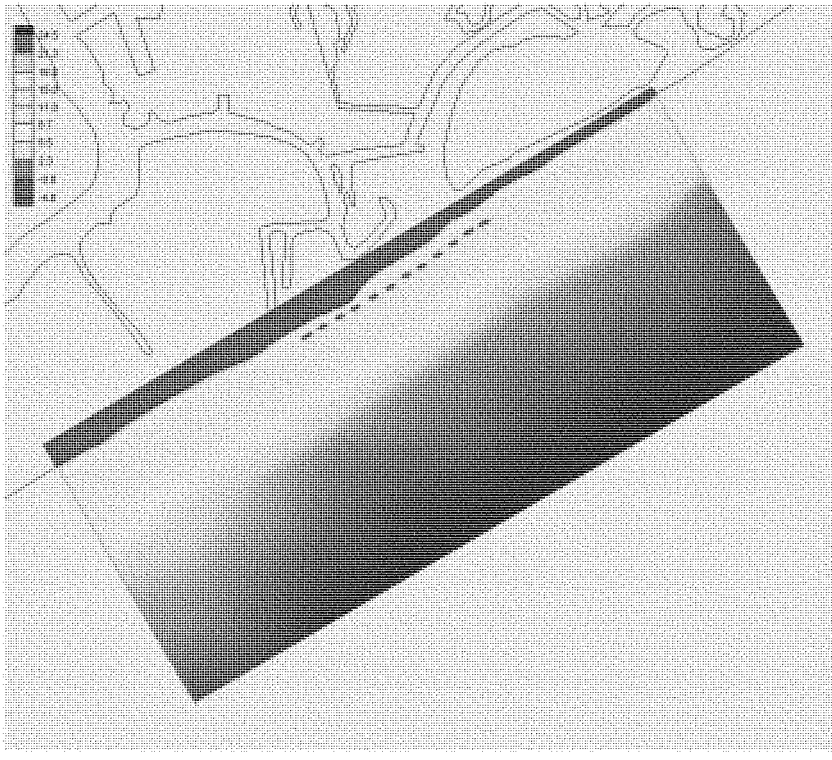

**Figure 1-6. Nested grid with breakwaters**

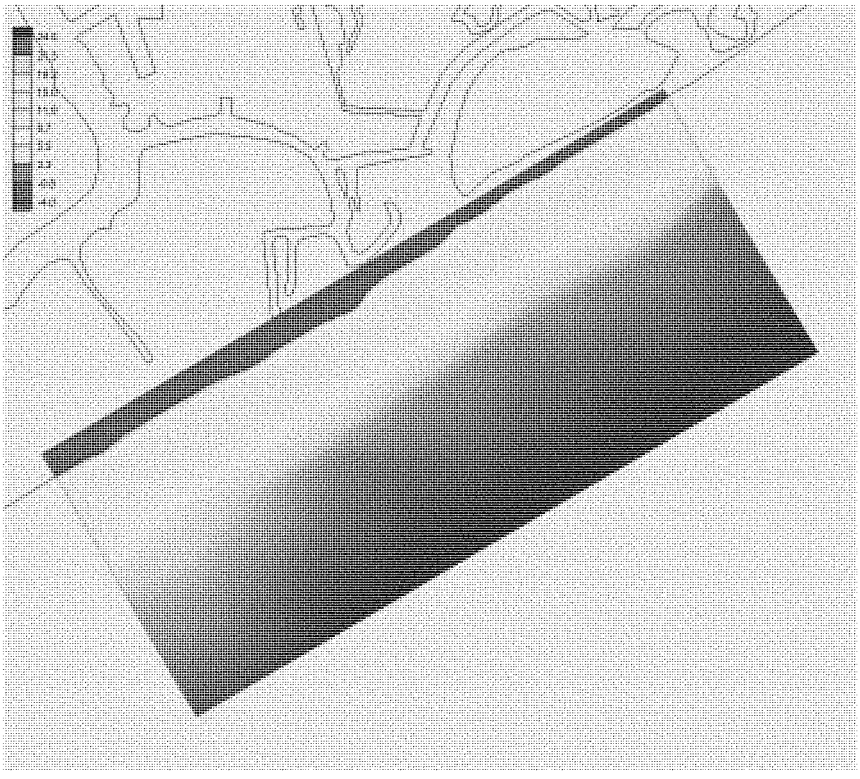

**Figure 1-7. Nested grid without breakwaters**

From the statistical analysis of WIS-130 data (shown in Section 1.4), the average wave height and period of waves coming from SSE (dominant direction) were 3.0 feet and 4.6 s, respectively. The corresponding wind speed was 20 ft/s. These wave conditions were used to propagate the wave field closer to the shore and calculate the corresponding wave height and period at the offshore boundary of the nested grid. These calculated values were 2.7 feet and 4.8 s for wave height and period, respectively. They were used to impose boundary conditions for the two nested grid simulations, with and without the breakwaters.

Figures 1-8 and 1-9 show the simulated wave height fields without and with breakwaters, respectively.

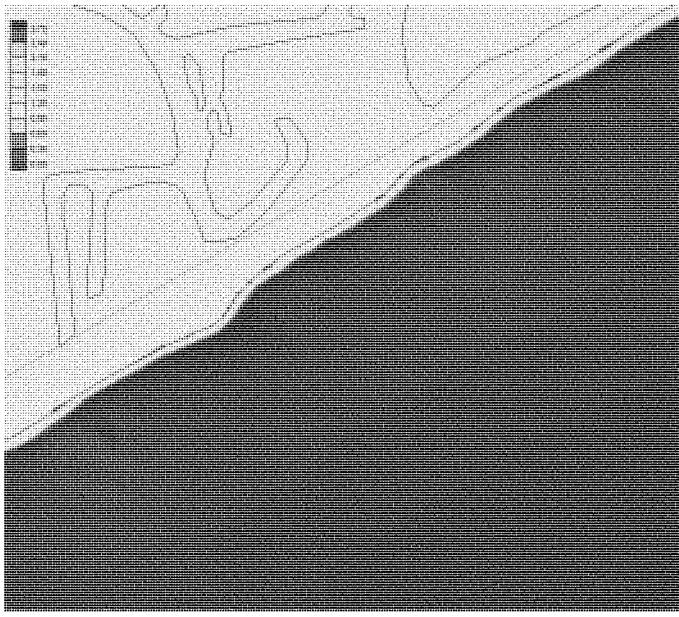

**Figure 1-8. Simulated wave height (in feet) without breakwaters**

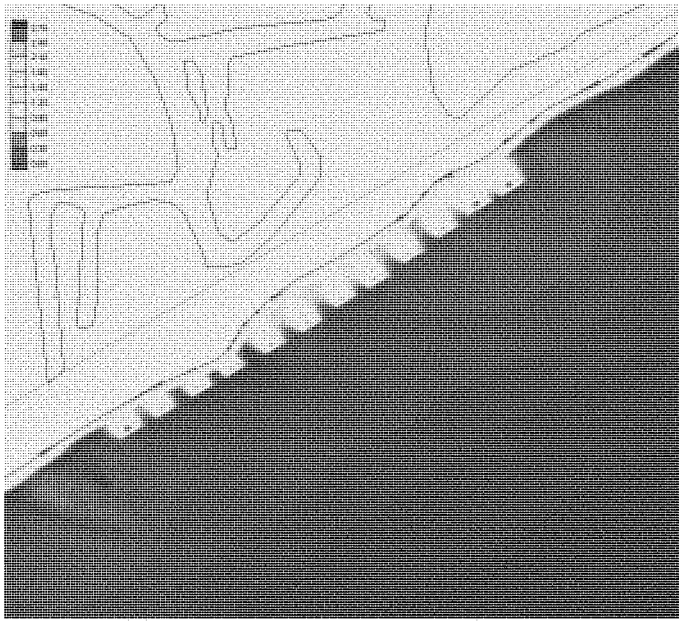

**Figure 1-9. Simulated wave height (in feet) with breakwaters**

The 5-foot depth contour line of the nested grid was chosen for comparison analysis. The contour line paralleled the shoreline in the lee of the breakwaters. The effects of the breakwaters on the calculated wave height and direction are shown in Figures 1-10 and 1-11, respectively.

Figure 1-10 shows the average wave height in the lee of the breakwaters reduced from 2.6 feet to 1.9 feet, equal to an average reduction of approximately 26%, with a maximum wave height reduction of 0.9 feet. Wave heights outside the lee of the breakwaters were not affected significantly. Based on the wave energy equation $\left(E = 1/8\,\rho g H^2\right)$, where H represents wave height, the average wave height reduction of 26% results in an average reduction in wave energy in the lee of the breakwaters equal to approximately 47%. This reduction in wave energy will trap sediment moving in the longshore direction exposing the adjacent shorelines to potential increases in erosion.

Figure 1-11 shows that the breakwaters caused waves to refract resulting in fluctuation of wave direction from one breakwater to another.

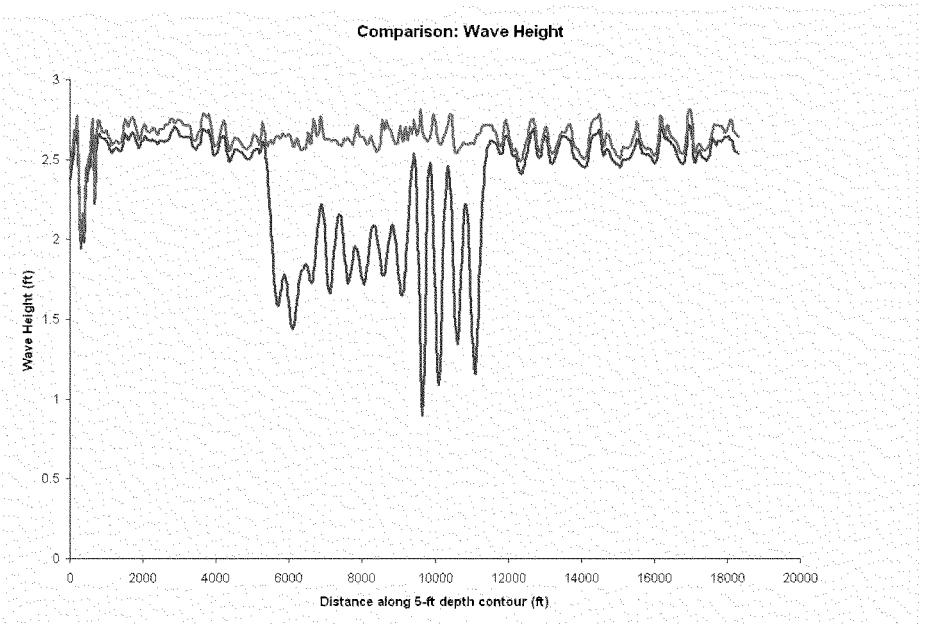


**Figure 1-10. Comparison of wave height along the 5-ft depth contour. The red and blue lines represent the calculated results without and with breakwaters, respectively**

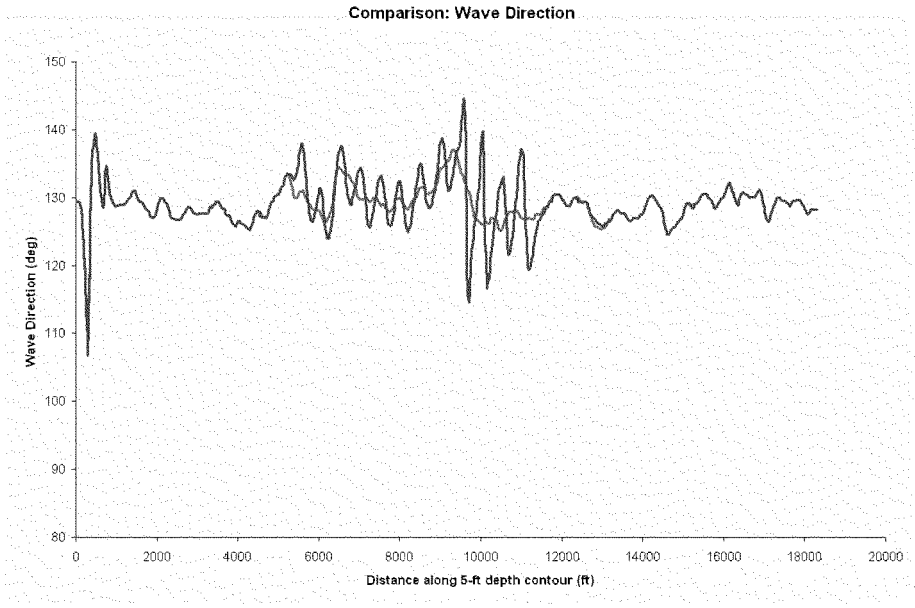


**Figure 1-11. Comparison of wave direction along the 5-ft depth contour. The red and blue lines represent the calculated results without and with breakwaters, respectively**

## 2 Cross-Shore Sediment Transport Modeling

This chapter describes procedures and results of storm-induced cross-shore sediment transport analysis. The SBEACH model was applied to the 2005 survey profiles to calculate beach erosion and shoreline recession during major storm events that occurred in recent years.

### 2.1 SBEACH Model Description

SBEACH (Storm-induced BEAch Change) was developed at the U.S. Army Engineer Waterways Experiment Station, Coastal and Hydraulics Laboratory (CHL), to calculate beach and dune erosion under storm water levels and wave action (Larson and Kraus 1989; Larson, Kraus, and Bymes 1990; Rosati et al. 1993). Model development was based on extensive analysis of beach profile change produced in large wave tanks and in the field. It is a two-dimensional model meaning that longshore wave, current, and sediment transport processes are omitted. Breaking waves and changing water level are the major driving agents in SBEACH that produce sediment transport and beach profile change.

SBEACH has significant capabilities that make it useful for quantitative and qualitative study of beach profile response to storms. It accepts as input varying water levels as produced by storm surge and tide, varying wave heights and periods, and an arbitrary grain size in the fine-to-medium sand range. Either a user-specified schematic dune and berm configuration or a surveyed profile configuration can comprise the initial profile.

The version of SBEACH used in this study has a feature to account for a hard bottom which is considered to be a non-erodible. It may be located anywhere on the subaerial and subaqueous beach.

### 2.2 SBEACH Input

SBEACH requires several inputs: profile configuration, time series of wave parameters (wave height, period and direction), and time series of water elevation. The user must also specify sediment size, grid spacing, time step, and other parameters.

For all of the SBEACH simulations presented here, water elevation time series were obtained from NOAA Grand Isle tide station (http://www.co-ops.nos.noaa.gov/usmap.html) which is located just east of Caminada Headland. The data were converted from MLLW to NAVD88 using the station's vertical datum difference of -0.55 ft. Figure 2-1 shows water elevation recorded at the station during Hurricane Andrew (August 21 through August 31, 1992).

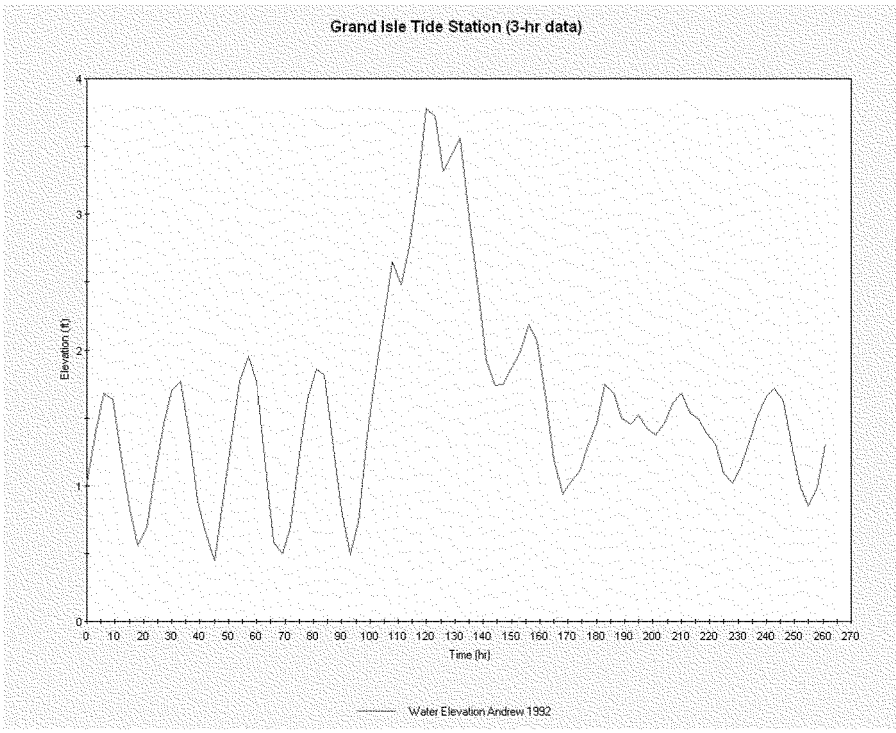


**Figure 2-1. Water Elevation at Grand Isle during Andrew (referenced to NAVD88)**

Wave information was calculated using the STWAVE model as described in Section 1.3 (Storm Data).

The 2005 surveys were used for profile configurations. When a breakwater was placed along a profile (as in case with Transect B), it was treated as a hard bottom not allowing any erosion within the breakwater segment.

Table 2-1 lists simulation cases along with some of the SBEACH parameters used in a particular case.

**Table 2-1. SBEACH simulation cases and their parameters**

| Case # | Transect | Storm Event | Grain Size, mm | Grid Cell Width, m | Time Step, min | Transport Rate Coefficient, $m^4/N$ | Hard Bottom/ Breakwater Presence |
|---|---|---|---|---|---|---|---|
| 1 | B | Andrew | 0.173 | 5.294 | 5 | 1.75e-006 | No |
| 2 | B | Andrew | 0.173 | 5.294 | 5 | 1.75e-006 | Yes |

## 2.3 SBEACH Results

### 2.3.1 Transect B

Two profile configurations were developed for Transect B: 1) original surveyed profile based on the 2005 survey data, and 2) altered profile designed to investigate the effect of a breakwater placed approximately 1000 ft seaward from the dune crest. The breakwater was designed so that it extended from the bottom to the zero level referenced to NAVD88, simulating the existing emergent breakwaters.

Figure 2-2 shows the comparison between the original profile and the eroded profile without the breakwater. Figure 2-3 shows the comparison between the altered profile with the breakwater, before and after the storm. Results of the post-storm profiles are summarized in Figure 2-4.

Table 2-2 summarizes SBEACH simulation results in terms of dune crest and shoreline recession/advancement and dune erosion/accretion. In the context of this study, the shoreline is referenced to the zero elevation NAVD88. Dune erosion/accretion is a cumulative value which signifies dune erosion/accretion across the dune to the point where the shoreline of the initial (pre-storm) profile starts.

**Table 2-2. Results of SBEACH simulations**

| Case # | Description | Dune Crest Recession(-)/ Advancement(+), ft | Shoreline Recession(-)/ Advancement(+), ft | Dune Erosion(-)/ Accretion(+), $ft^3$ per ft of beach width |
|---|---|---|---|---|
| 1 | w/o breakwater | -78 | -24 | -235 |
| 2 | with breakwater | -78 | +34 | -127 |

The results indicate that both profile configurations experienced dune erosion. The dune crest eroded in a similar fashion for both cases. However, in the case with the breakwater, less erosion was observed. With the breakwater, the eroded sand transported from the dune to the beach resulting in shoreline advance. Without the breakwater, the eroded sand transported into the nearshore resulting in shoreline recession. Figure 2-5 shows the effect of the breakwater on the maximum wave height. The maximum wave during Andrew broke at the breakwater reducing the wave height by approximately 50%. Since wave energy is a function of wave height squared $\left(E = 1/8\,\rho g H^2\right)$, reducing wave height by 50% will result in reducing the wave energy four times. As a result, smaller less energetic waves cause less beach profile erosion. Figure 2-6 shows the effect of the breakwater on the maximum water elevation including wave setup. Wave setup is a rise in water level due to waves breaking on a sloping beach. The breakwater caused higher wave setup which resulted in a similar degree of erosion of the dune crest compared to the without the breakwater case, despite the fact that waves were less energetic in the case with the breakwater.

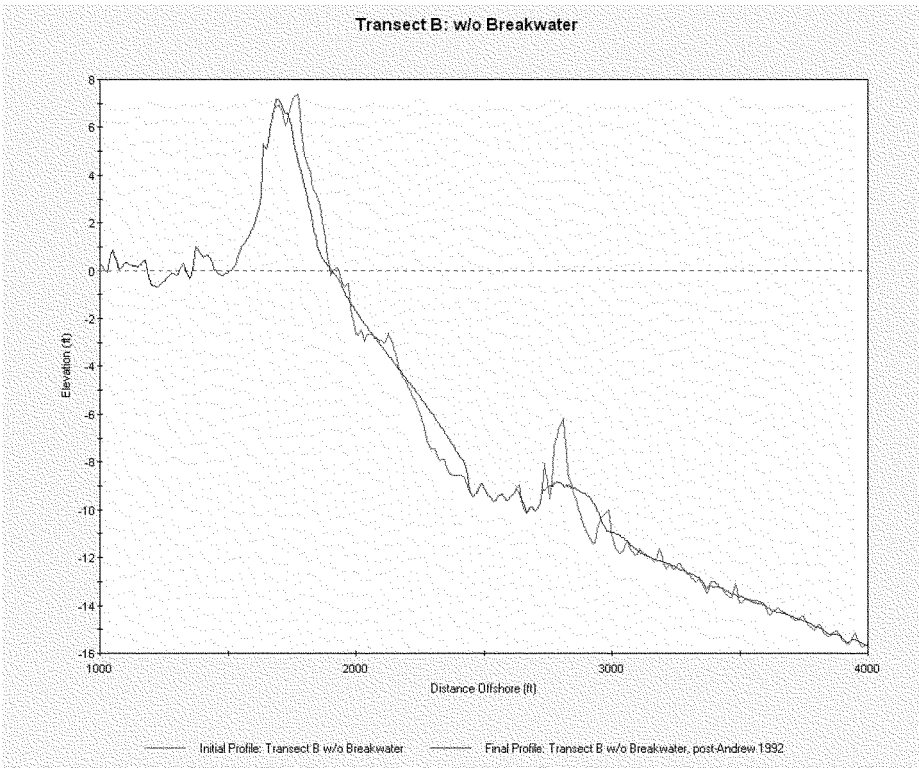


**Figure 2-2. Transect B (original): pre- and post-Andrew profiles**

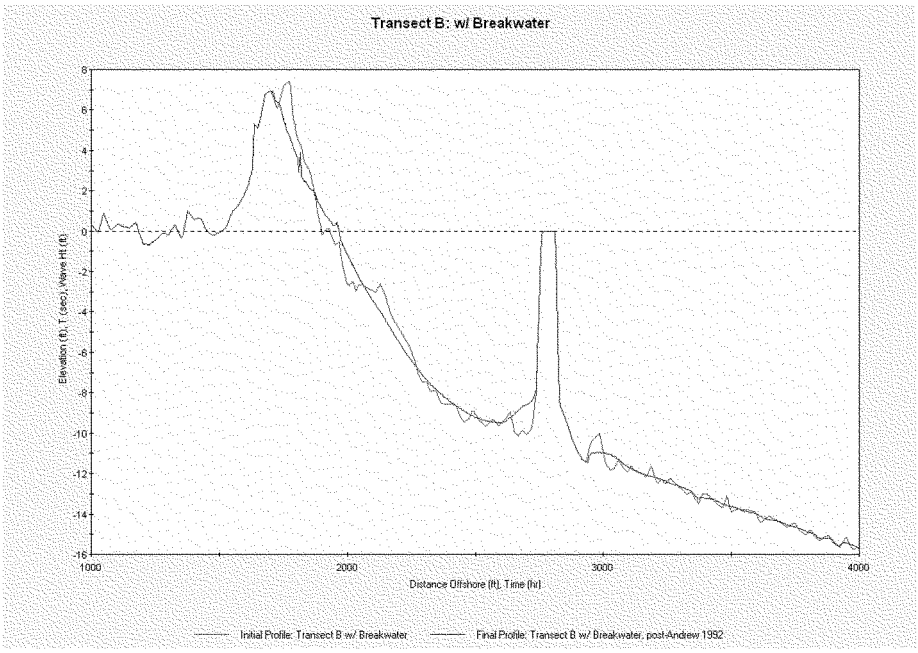


**Figure 2-3. Transect B (with designed breakwater): pre- and post-Andrew profiles**

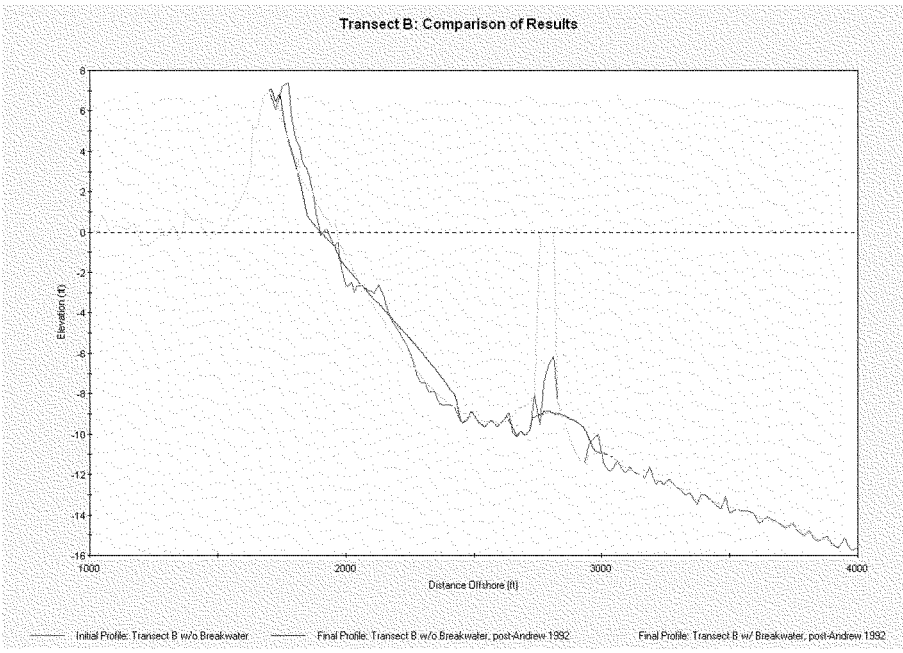


**Figure 2-4. Transect B: comparison between post-Andrew profiles with and withough a breakwater along with the original pre-storm profile**

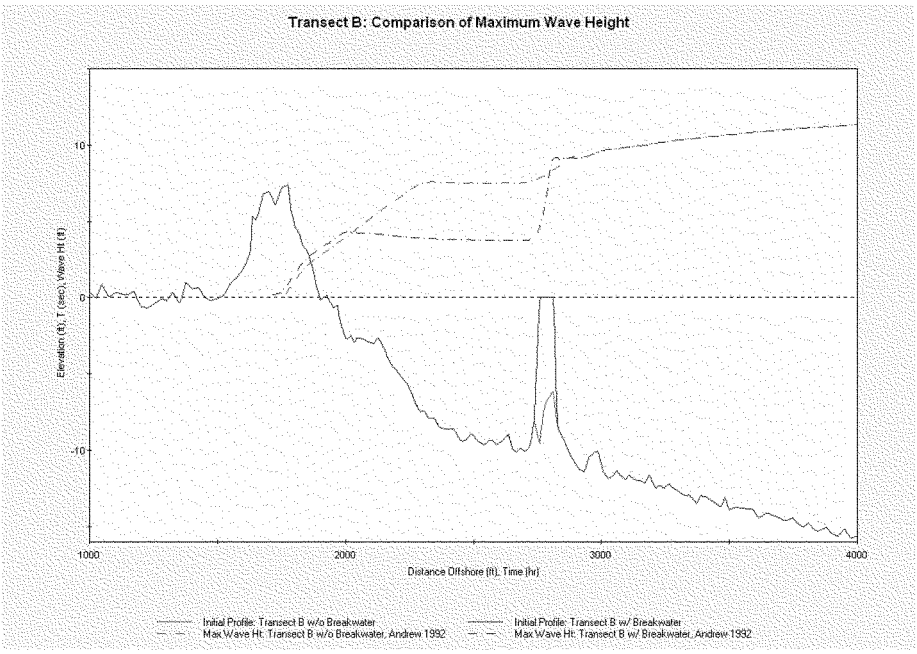


**Figure 2-5. Transect B: the effect of the breakwater on the maximum wave height during Andrew**

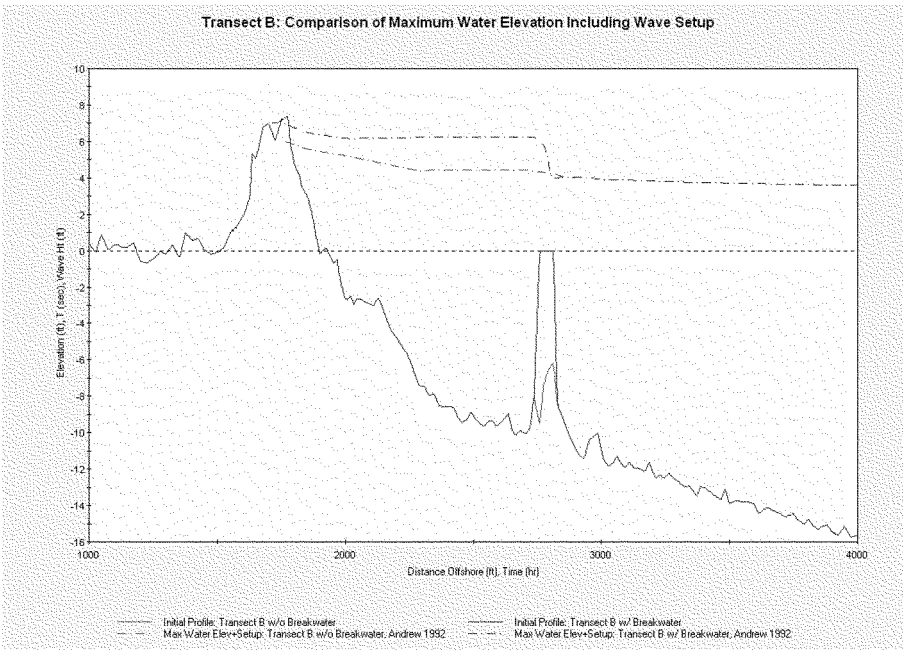


**Figure 2-6. Transect B: the effect of the breakwater on the maximum water elevation including wave setup during Andrew**

## 3 Long-term Shoreline Change Modeling

This chapter describes procedures and results of alongshore sediment transport analysis. The GENESIS model was applied to investigate the effect of breakwaters off Caminada Headland on long-term shoreline change in the area.

### 3.1 GENESIS Model Description

GENESIS (GENEralized model for SImulating Shoreline) was developed to simulate long-term shoreline change on an open coast as produced by spatial and temporal differences in longshore sand transport (Hanson 1987, 1989; Hanson and Kraus 1989). The modeling system is founded on considerable research and applications of shoreline change numerical models. Wave action is the mechanism producing the longshore sand transport, and, in GENESIS, spatial and temporal differences in the transport rate may be caused by such diverse factors as irregular bottom bathymetry, wave diffraction, boundary conditions, line sources and sinks of sand, and constraints on the transport (such as produced by seawalls and groins), factors that are interrelated and may work in different combinations at different times.

The main utility of GENESIS lies in simulating shoreline response to structures and placement of beach fill. Essentially, arbitrary combinations and configurations of structures (groins, jetties, detached breakwaters, and seawalls) and beach fills can be represented on a modeled reach of coast.

### 3.2 GENESIS Input

Input to the GENESIS model includes wave data, initial shoreline position, coastal structure locations (e.g., detached breakwaters) and computational grid.

Two computational grids were used in the analysis (see Figure 3-1). First grid was associated with the STWAVE model which calculated wave transformation from offshore to the nearshore. The grid was 2,500 m (8,202 ft) long in the cross-shore direction (x-axis) and 5,000 m (16,404 ft) wide in the alongshore direction (y-axis). The grid cell spacing was 25 m (82 ft) long and 25 m wide. The origin of the grid (lower left corner in Figure 3-1) was located at an Easting of 1,113,270.3 m (3,652,461.6 ft) and a Northing of 68,777.7 m (225,648.6 ft). The azimuth of the x-axis (cross-shore) was 329.5°.

The shoreline position (white dots in Figure 3-1) was based on aerial photos taken in 2004. The locations of detached breakwaters off Caminada Headland (total of 12) were also based on the aerials.

Wave data used in the model were obtained from 1980-1999 hindcasts at WIS Station 130 located at LAT=29.0N, LON=90.0W. The data were analyzed to identify 172 different wave height, period, and direction combinations that represented wave conditions in the project area. The following ranges were used for the wave parameters:

Height: 0 – 0.5 m; 0.5 – 1.0 m; 1.0 – 3.0 m; 3.0 – 5.0 m; 5.0 – 10.0 m
Period: 0 – 5 s; 5-7 s; 7 – 9 s; 9 – 11 s; 11 – 13 s; 13 – 15 s
Direction: sixteen 22.5° wave angle bands

For each of 172 combinations, wave input spectra for STWAVE were derived. For simplicity, wave spectra based on WIS-130 data were applied directly along the STWAVE offshore boundary. STWAVE was then run to calculate wave transformation to the nearshore. The nearshore output wave stations (blue triangles in Figure 3-1, total of 38) were located along the 4.57-meter (15 feet) bathymetric contour off Caminada Headland in every 5th GENESIS grid cell. The GENESIS grid (dashed line near the right boundary in Figure 3-1) was 4,700 m (15,420 ft) long. The grid cell spacing was 25 m (82 ft).

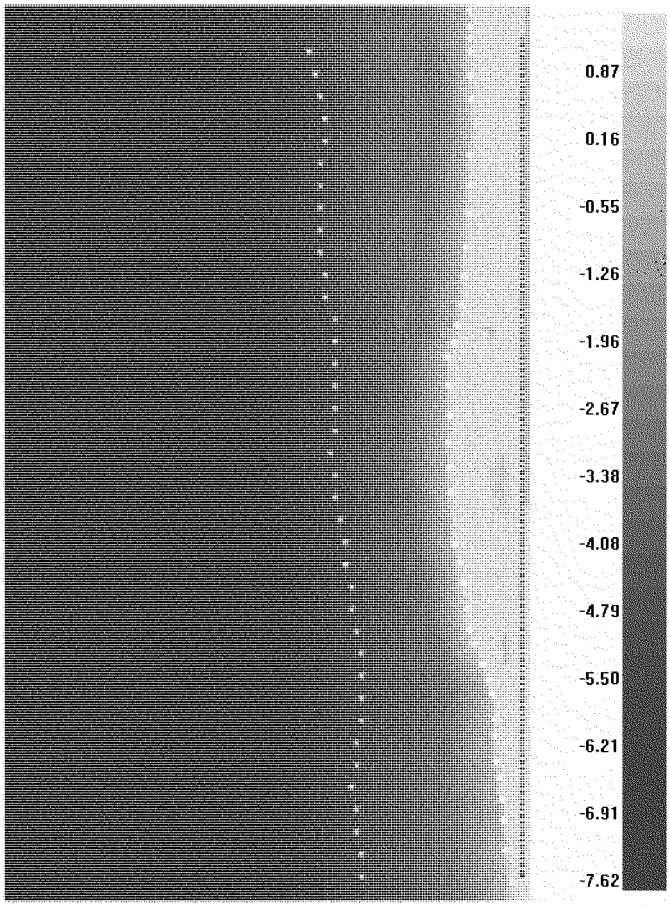


**Figure 3-1. STWAVE (the entire domain) and GENESIS (dashed line near the right boundary) grids. The scale is in meters (negative values mean bathymetry)**

### 3.3 GENESIS Simulations

The goal of GENESIS simulations was to determine the effect of having the breakwaters on long-term alongshore sediment transport and associated with it shoreline change. Two 4-year simulations (January 1, 1995 thru December 31, 1998), one with breakwaters and the other one without them, were performed. Since the information on shoreline position in 1995 was not available, the 2004 shoreline was used instead.

Figures 3-2 and 3-3 show schematic layouts of the area with and without breakwaters respectively.

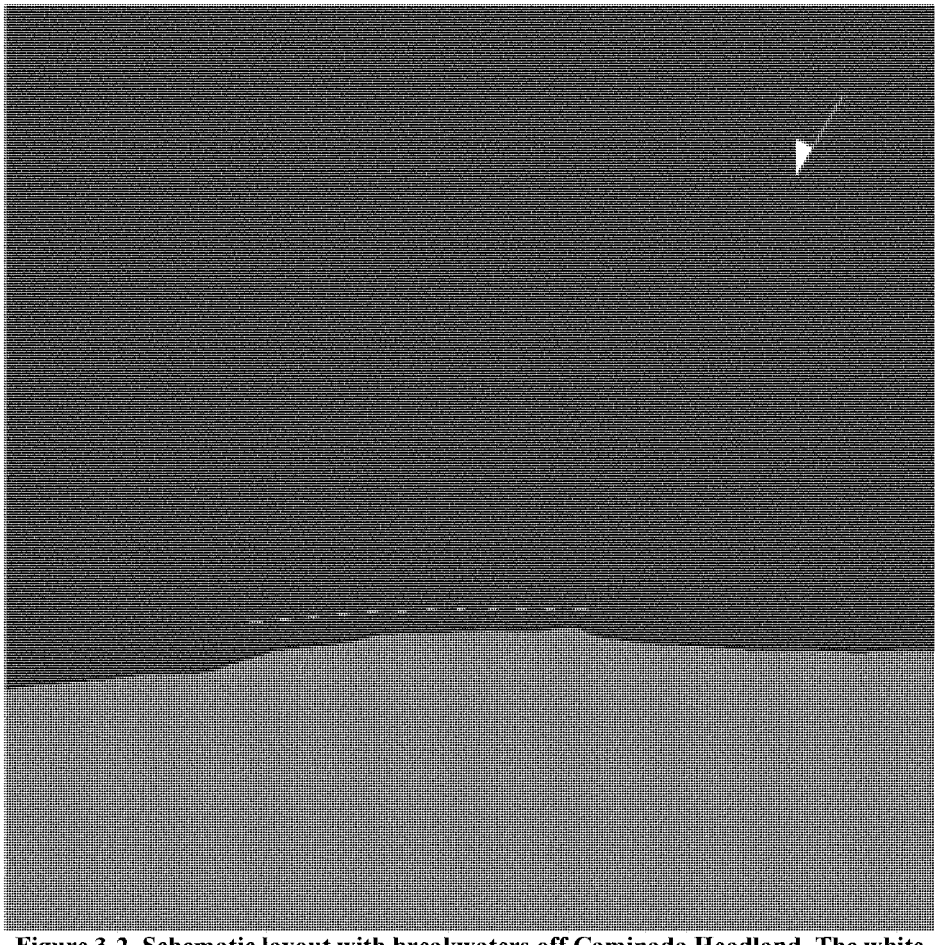

**Figure 3-2. Schematic layout with breakwaters off Caminada Headland. The white arrow indicates North, the blue indicates water, the green indicates land**

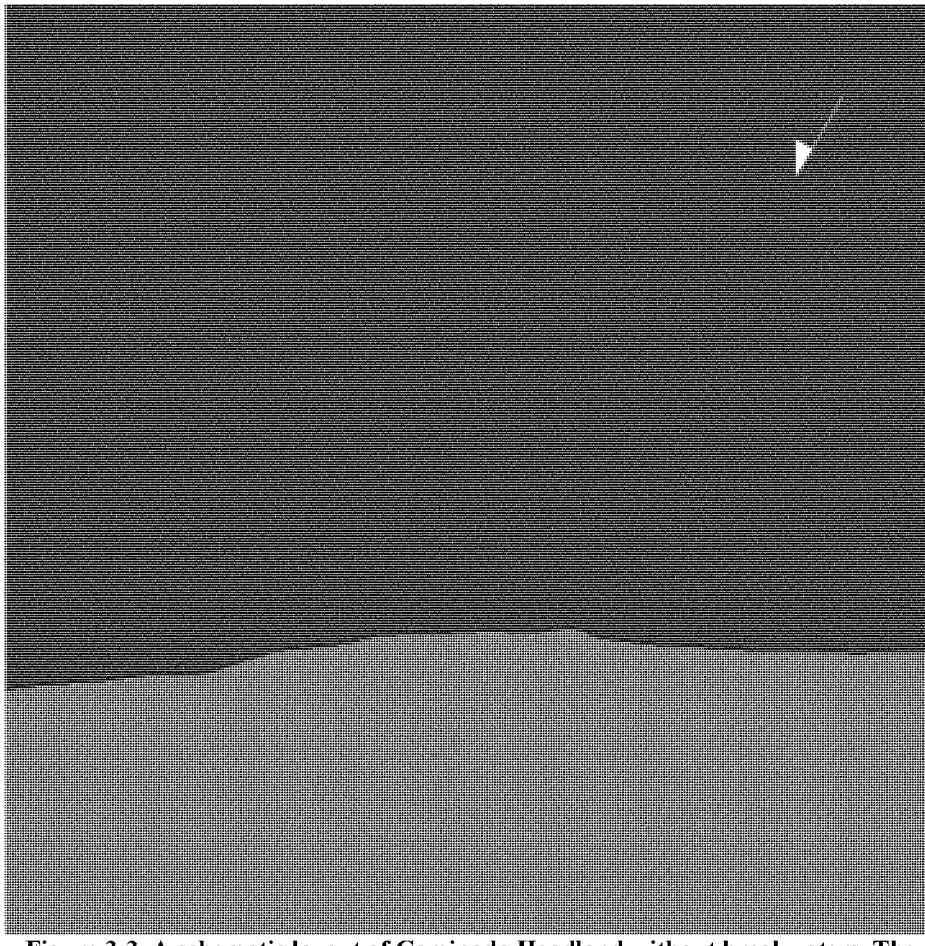

**Figure 3-3. A schematic layout of Caminada Headland without breakwaters. The white arrow indicates North, the blue indicates water, the green indicates land**

For comparative purposes at the feasibility level, pinned boundary conditions were imposed at the east and west ends of the Caminada Headland shoreline segment. These boundary conditions do not allow shoreline change at the boundaries.

The following parameters were used in the GENESIS simulations:

Configuration:

Start date = January 1, 1995
End date = December 31, 1998
Time step = 1 hour
Recording time step = 240 hours

Detached breakwaters (simulation with breakwaters only):
Depth at breakwaters = 2.5 m (8.2 ft)
Transmission coefficient = 0.5 (constant)

Sand, beach, and transport:
Effective grain size = 0.176 mm
Average berm height = 1.2 m (4 ft)
Closure depth = 3.65 m (12 ft)
Longshore sand transport coefficients K1=0.075, K2=0.05

Boundary conditions:
Wave model – external
Number of wave components = 1
Ratio of shoreline cells to wave model cells = 5
Height amplification factor = 1
Angle amplification factor = 1
Angle offset = 0
Lateral BC – pinned

Figures 3-4 and 3-5 show schematic layouts of the Caminada Headland after simulations with and without the breakwaters, respectively. In a case with the breakwaters, cusps were formed along the shoreline. These features can be seen in the aerial photograph (Figure 3-6). The cusps varied in time from being well pronounced to almost flat depending on wave conditions (Figures 3-7 and 3-8).

Figure 3-9 shows comparisons of the final shorelines calculated with and without the breakwaters and Figure 3-10 compares shoreline changes which were calculated by subtracting the final shorelines from the initial shoreline. The Caminada Headland shoreline experienced less erosion in the presence of the breakwaters over the 4-year simulation period. The simulation without breakwaters resulted in significant erosion and flattening of the Headland.

The average erosion in the lee of the breakwaters (the shoreline segment from 4,000 to 9,600 ft in Figure 3-10) was 61 ft. Without the breakwaters, the average erosion increased to 138 ft. Based on this feasibility level modeling analysis, it is predicted that the breakwaters reduce the shoreline erosion rate on the order of 55%, which is in fair agreement with the measured reduction in erosion rate of 33% in the lee of the breakwaters and updrift of the Belle Pass jetty (Section C-2 and C-3).

### 3.4 Summary

The GENESIS model was applied to investigate the effect of breakwaters off Caminada Headland on long-term shoreline change in the area. Based on this analysis, it was concluded that the breakwaters protect the shoreline by reducing erosion on the order of 55% in the lee of the breakwaters. However, the shorelines adjacent to the breakwaters,

especially the west end, experienced significant erosion. Based on the modeling analysis, it is predicted that removing the breakwaters would result in this segment of shoreline experiencing increased erosion as well as redistribution of the sand laterally along the Headland to the adjacent shoreline segments.

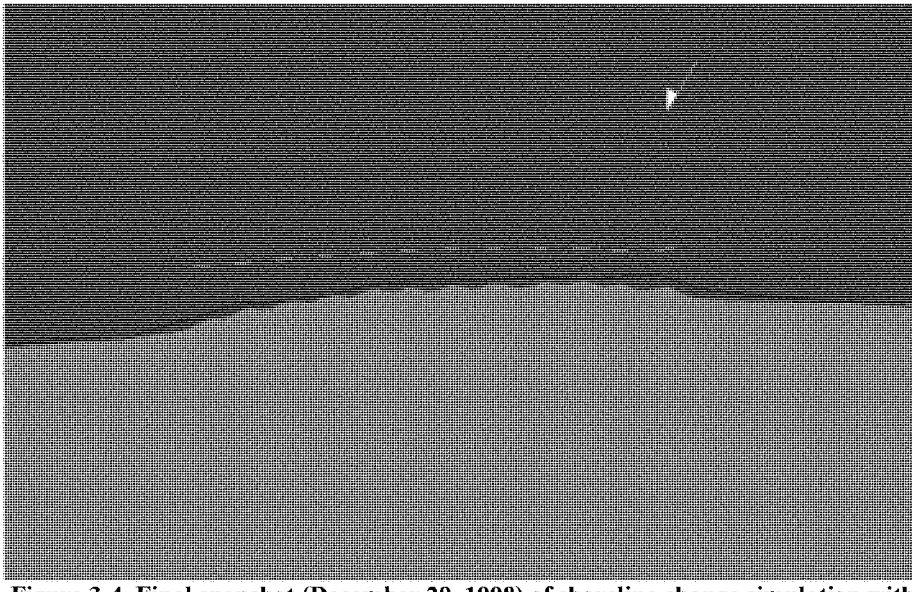

**Figure 3-4. Final snapshot (December 29, 1998) of shoreline change simulation with breakwaters**

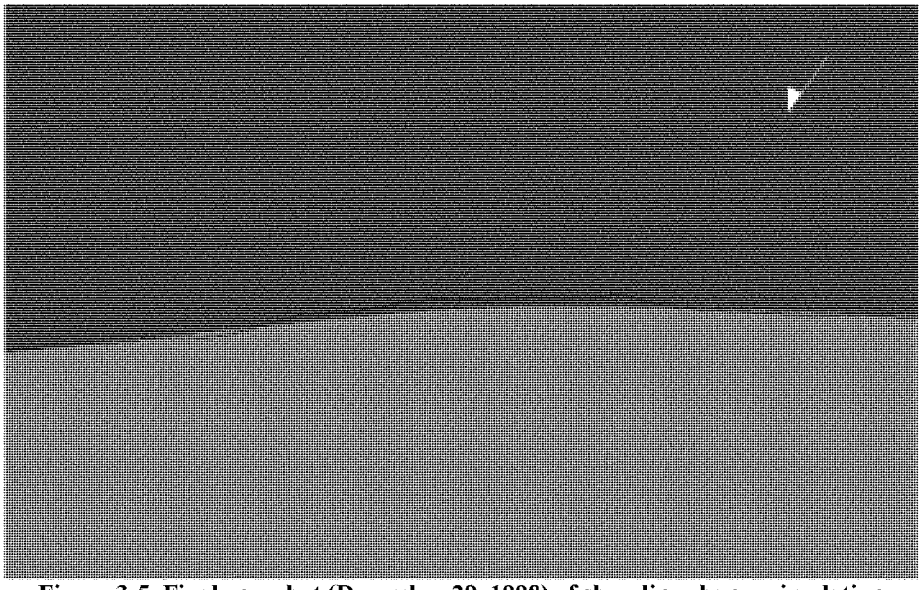

**Figure 3-5. Final snapshot (December 29, 1998) of shoreline change simulation without breakwaters**

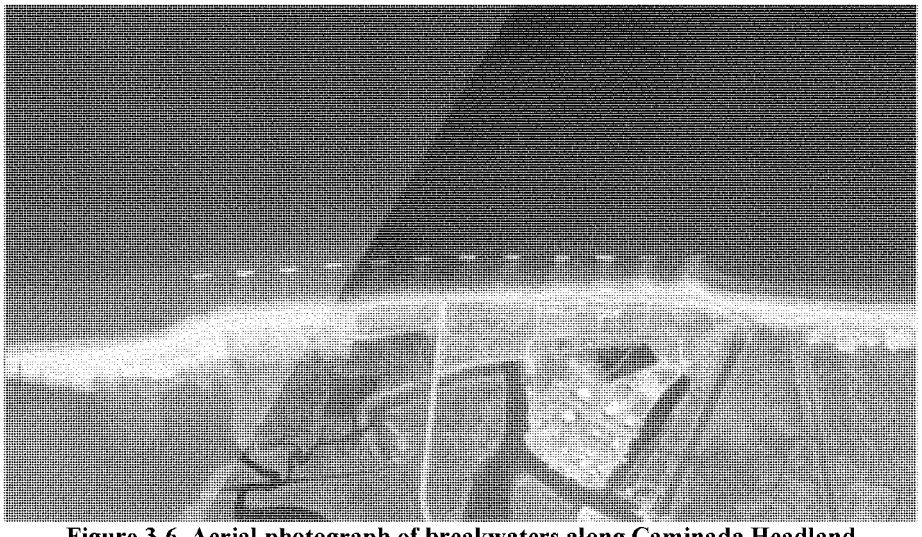

**Figure 3-6. Aerial photograph of breakwaters along Caminada Headland**

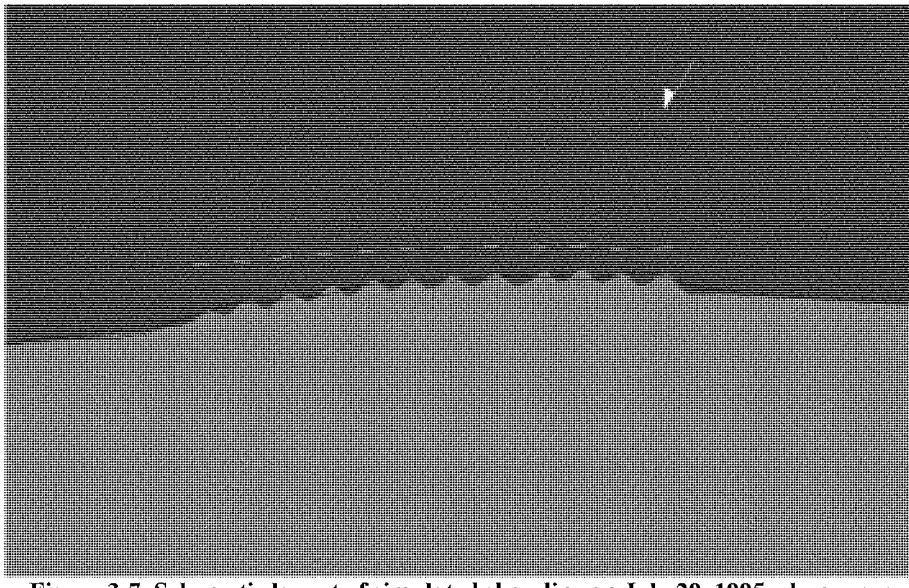

**Figure 3-7. Schematic layout of simulated shoreline on July 29, 1995 when cusps were well pronounced**

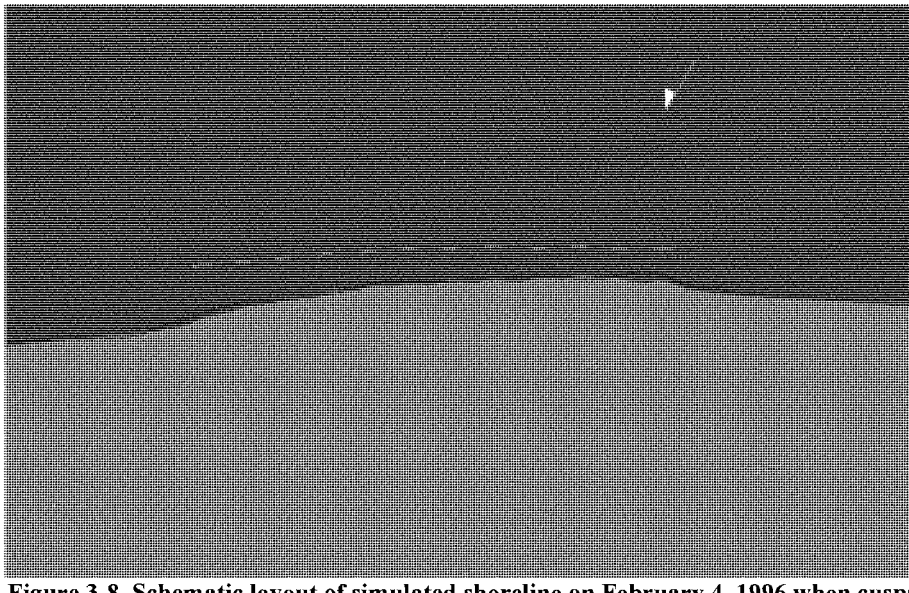

**Figure 3-8. Schematic layout of simulated shoreline on February 4, 1996 when cusps were almost flat**

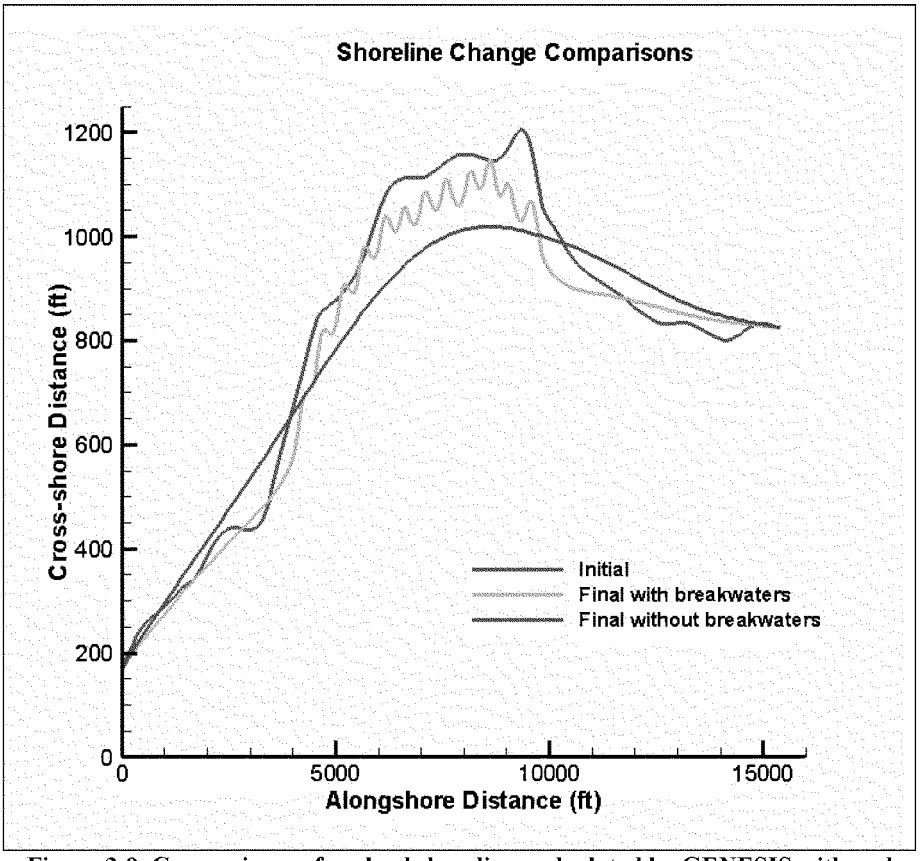


**Figure 3-9. Comparisons of evolved shorelines calculated by GENESIS with and without breakwaters**

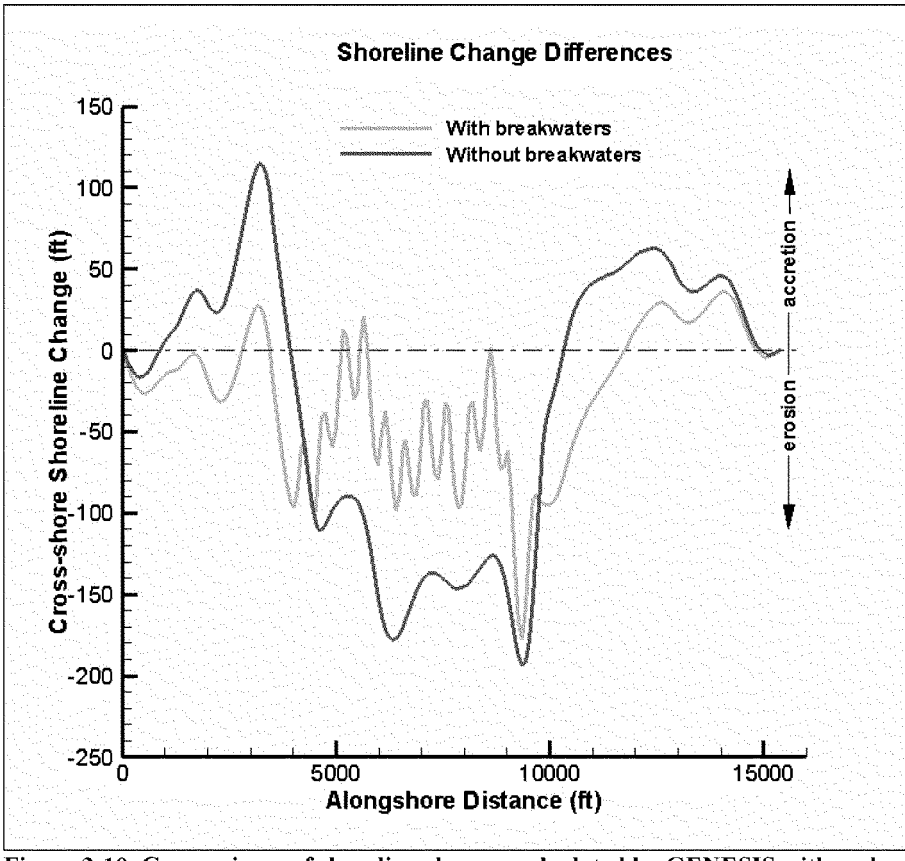


**Figure 3-10. Comparisons of shoreline changes calculated by GENESIS with and without breakwaters**

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# ANNEX C4
# WETLAND HABITAT ACREAGE CALCULATIONS

# BARATARIA BASIN BARRIER ISLAND SHORELINE RESTORATION OF CAMINADA HEADLAND

## WETLAND HABITAT ACREAGE CALCULATIONS

**August 31, 2007**

**Project Name:** Barataria Basin Barrier Island Shoreline Restoration of Caminada Headland Project

**Project Type:** Marsh Creation / Barrier Headland Restoration

**Sponsoring Agency:** U.S. Army Corps of Engineers (USACE)

**Local Sponsor:** Louisiana Department of Natural Resources (LDNR)

**Project Authorization:** The Louisiana Coastal Area (LCA) Ecosystem Restoration Study (LCA Study, 2004)

**Background:** Three project alternatives were initially considered in the LCA Study for restoring the Caminada Headland. The first alternative consisted of a 1000-foot wide dune only. The second alternative combined the same dune with 177 acres of marsh creation. The third alternative included the dune with 385 acres of marsh creation and 1200 acres of marsh nourishment (US Army Corps of Engineers 2004b). An interagency team led by the USACE quantified the project benefits of these alternatives using the Wetland Value Assessment (WVA) and Barrier Island Value Assessments (BIVA) as part of the Louisiana Gulf Shoreline Restoration Report. The benefits for Alternatives 1 through 3, expressed as Average Annual Habitat Units (AAHUs), were 535 AAHUs, 621 AAHUs, 732 AAHUs respectively. The third alternative produced the greatest benefits at similar unit costs per acre as the second alternative while maximizing project longevity by creating a platform for the dune to roll back on. The third alternative was selected and served as the plan for this feasibility study (US Army Corps of Engineers 2004b).

**Model Overviews:** The barrier headland community wetland value assessment model was developed to determine the wetland benefits of headland restoration projects in terms of providing resting, foraging, breeding, and nursery habitat to a diverse assemblage of fish and wildlife species along the Louisiana coast (CWPPRA Task Force 2003). This model was designed to function at a community level and therefore attempts to define an optimal combination of habitat conditions for all fish and wildlife species utilizing barrier headlands. Unlike the barrier island community model, the barrier headland model does not include the vegetated intertidal marsh situated landward of the barrier headland (CWPPRA Task Force 2003). The habitats existing landward of the barrier headland are evaluated using the appropriate

emergent marsh community mode In the case of the Caminada Headland, the saline marsh community model is anticipated.

Barrier headlands consist of many different habitat components including surf zone, beach, dune, supratidal marsh, and unvegetated flats or washover areas. In development of the barrier headland community model, a key assumption was that for barrier headlands to provide optimal conditions for fish and wildlife, all of these habitat components should exist. The variables included in the model are: 1) percent of the subaerial area that is classified as dune habitat; 2) percent of the subaerial area that is classified as supratidal habitat; 3) percent vegetative cover of dune and supratidal habitats; 4) percent vegetative cover by woody species; and 5) beach/surf zone features (CWPPRA Task Force 2003). The dune and supratidal habitats are the most important variables in characterizing habitat quality of the barrier headland and therefore are given greater influence in the model than the remaining variables and account for 64 percent of the model weight.

In terms of habitat suitability, optimal ranges for dune habitat coverage are from 15 percent to 30 percent of the project area. Optimal habitat for percent of the total project area that is classified as supratidal habitat ranges from 70 percent to 85 percent (CWPPRA Task Force 2003). These two variables account for 46 percent of the weight of the habitat suitability index model.

Variables used in the saline marsh community model include: 1) percent of the wetland covered by emergent vegetation, 2) percent of open water covered by aquatic vegetation, 3) marsh edge and interspersion, 4) percent of the open water area $\leq$ 1.5 feet deep, 5) salinity, and 6) aquatic organism access. Optimal vegetative coverage in saline marshes is assumed to occur at 100 percent (CWPPRA Task Force 2003).

**Project Area:** The Caminada Headland Project site is located in Lafourche Parish and is approximately 13 miles long. It extends from the Belle Pass jetties on the western terminus of the Headland at the entrance to Port Fourchon to Caminada Pass on the eastern end of Headland. The Project area is bounded by the Gulf of Mexico to the South and Highway 1 to the North. The Headland maintains the integrity of the gulf shoreline and protects the interior coast from further deterioration. The approximate center coordinate of the project area is: 29 degrees 8' 57" N latitude and 90 degrees 8' 11" W longitude (SJB and CEC, 2005).

**Physical Characteristics:** Based on short-term survey comparisons (2000 to 2005), the changes in shoreline position at the average existing dune elevation, 3.5 feet NAVD, and Mean High Water (MHW), 1.53 feet NAVD, were computed. The erosion rates range from approximately 8 to 49 feet per year at the dune with an average of approximately 34 feet per year. The erosion rates at MHW are slightly higher, ranging from approximately 10 to 54 feet per year with an average of approximately 36 feet per year. The native marsh elevation for the Caminada

Headland back-barrier marsh was determined to be 0.94 feet NAVD. The shoreline is quickly retreating and is mostly comprised of a narrow seaward beach, low-lying dunes, several overwash areas, and three existing breaches. Hurricane Katrina which struck the Louisiana coastline in August 2005 increased the number of shoreline breaches.

**Problem:** Over the last 100 years, the Caminada Headland has experienced an average shoreline erosion rate of 45 feet per year (USACE, 2004). The marsh, wetlands, beach, and dune habitats within the Project reach have undergone significant loss due to man-made structures, storm overtopping and breaching, saltwater intrusion, wind and wave induced erosion, sea level rise, and subsidence. A coastal Louisiana land loss model presented in the LCA Study (USACE 2004) indicates that with no intervention, the Caminada Headland will experience a projected land loss of 3,750 acres from the Headland and 14,780 acres from the area to the north from 2000 to 2050. Only a skeletal framework of wetlands will remain in 2050.

**Goals:** The project goals include the following:

- Project life equal to fifty years (Target Year (TY) 50)
- Sustain and improve shoreline, dune, and interior marsh habitat for essential fish and wildlife species
- Reduce wave energy transmission by providing a natural storm protective buffer for interior marsh and chenier ridge habitats north of Caminada Headland
- Address the severity of erosion along the gulf-front shoreline
- Close the breachments that have occurred due to recent storm and hurricane damage and prevent breaching during the design life
- Vegetate newly created marsh and dune areas
- Provide compatible sediments for marsh, beach and dune restoration
- Avoid impacts to adjacent shorelines from borrow area excavation
- Maintain the Caminada Headland without disrupting the natural hydrologic regime

**Project Features:** As part of the engineering feasibility analysis, ten alternatives were developed to stabilize and restore the Headland. In support of the WVA, an analysis of benefit acres was performed for each alternative..

Alternative 1 consists of 1111 acres of marsh extending west through Bay Champagne to the eastern edge of the project boundary near Caminada Pass and 75 acres of additional marsh to the west of the oil and gas facility on the western end of the Headland for a total of 1186 acres. Alternative 1 proposes this marsh fill on the landward side of the dune at an elevation of + 2.0 feet NAVD with boundaries as described in Section C-5-1-2-1. Fill quantities for the marsh fills are 3.8 million cubic yards. Plan view and typical cross sections for Alternative 1 are shown in Figures 1 and 2 respectively. This alternative was also evaluated further in combination with beach and dune restoration in subsequent alternatives.

Alternative 2 proposes a dune height of +6 feet NAVD which is slightly higher than the existing dune elevation in the area of +4 feet NAVD. The proposed dune width is 200 feet. This dune is centered over the existing dune and slopes down to a construction berm that was extended seaward until the budget constraint was reached. The template was then optimized for density and alignment to address the existing breaches and longshore erosion processes.

The seaward and landward dune slopes for Alternative 2 are set at a 20 horizontal to 1 vertical, and the slope from the dune crest to the seaward berm is set at 20 horizontal to 1 vertical. The beach fill template has a 75 ft wide seaward berm at an elevation of +4.5 feet NAVD and a marsh fill template is proposed on the landward side of the dune at an elevation of + 2.0 feet NAVD (C-5-1-3-1). Fill quantities for the beach/dune and marsh fills are 5.7 million and 3.8 million cubic yards respectively. The proposed project features are presented in plan view along with a typical cross section in Figures 3 and 4.

Alternative 3 proposes a dune higher and narrower than Alternative 2 for performance comparisons. The Alternative 3 dune height is set at +8 feet NAVD and contains a 125 foot dune crest width. This dune is centered over the existing dune and slopes down to a construction berm that was extended seaward until the budget constraint was reached. The template is then optimized for density and alignment to address the existing breaches and longshore erosion processes.

The landward, seaward, and dune crest to berm slopes for Alternative 3 are all set to 20 horizontal to 1 vertical. The beach fill template has a 75 ft wide seaward construction berm at an elevation of +4.5 feet NAVD and a marsh fill template is proposed on the landward side of the dune at an elevation of + 2.0 feet NAVD. Fill quantities for the beach/dune and marsh fills are 5.7 million and 3.8 million cubic yards respectively. The proposed project features are presented in plan view along with a typical cross section in Figures 5 and 6.

Alternative 4 proposes a dune height of +7 feet NAVD. The higher dune proposed in Alternative 3 at +8 feet NAVD offers more storm protection between future maintenance events than the lower dune proposed in Alternative 2 at +6 feet NAVD. Although the higher dune offers more storm protection, there may be ecological concerns with constructing a dune higher than the Headland's existing dune elevations. To balance storm protection benefits with ecological concerns, the Alternative 4 dune height is proposed at +7 feet NAVD.

Alternative 4 also proposes a landward beach and dune component compared to the seaward beach component in both Alternatives 2 and 3, which eroded completely during the analysis of storm impacts. Because the fill is sited landward over existing higher elevations, the dune could be extended over the significant majority of the beach fill. The width of this landward template is limited from Belle Pass to the western edge of the existing breakwater field by environmental

habitats and oilfield canals to the north of the barrier shoreline. In this area the fill width is 300 feet tapering toward the shoreline at the western edge of the breakwaters. No sand will be placed in this landward template behind the breakwaters due to geographic constraints, that is, the proximity of oil and gas facilities and Highway 3090. From the eastern end of the breakwater field to Caminada Pass, the fill tapers northward to a maximum width of 465 feet determined by budget constraints and balancing quantities with the marsh fill template which was reduced due to the landward encroachment by the beach and dune fill.

The landward and seaward slopes for Alternative 4 are set to 20 horizontal to 1 vertical. The marsh fill template is proposed on the landward side of the beach/dune at an elevation of + 2.0 feet NAVD. Fill quantities for the beach/dune and marsh fills are 6.2 million and 2.3 million cubic yards respectively. The proposed project features are presented in plan view along with a typical cross section Figures 7 and 8.

Alternative 5 proposes a dune height of +7 feet NAVD with a proposed dune width of 290 feet. Alternative 5 also proposes a landward beach and dune component in order to maximize acreage and longevity. The landward and seaward slopes are set 20 horizontal to 1 vertical. The marsh fill is proposed on the landward side of the beach and dune at an elevation of +2.0 feet NAVD. Fill quantities for the beach and marsh fills are 6.3 million and 5.4 million cubic yards respectively. Plan view and typical cross sections for Alternative 5 are shown in Figures 10 and 11 respectively.

Alternative 6 proposes a dune height of +7 feet NAVD with a proposed dune width of 290 feet. Alternative 6 also proposes a landward beach and dune component in order to maximize acreage and longevity. The landward and seaward slopes are set 20 horizontal to 1 vertical. The marsh fill is proposed on the landward side of the beach and dune at an elevation of +2.0 feet NAVD. Alternative 6 is different from Alternative 5 in that Alternative 6 has one re-nourishment event at year 25. Fill quantities for the beach and marsh fills are 6.3 million and 5.4 million cubic yards respectively. Plan view and typical cross sections for Alternative 6 are shown in Figures 10 and 11 respectively.

Alternative 7 proposes a dune height of +7 feet NAVD with a proposed dune width of 290 feet. Alternative 7 also proposes a landward beach and dune component in order to maximize acreage and longevity. The landward and seaward slopes are set 20 horizontal to 1 vertical. The marsh fill is proposed on the landward side of the beach and dune at an elevation of +2.0 feet NAVD. Alternative 7 is different from Alternatives 5 and 6 because Alternative 7 has two re-nourishment events at year 20 and 40. Fill quantities for the beach and marsh fills are 6.3 million and 5.4 million cubic yards respectively. Plan view and typical cross sections for Alternative 7 are shown in Figures 10 and 11 respectively.

The design for Alternative 8 includes three components: design fill, advanced fill, and marsh fill. The purpose of the design fill component is to compensate for background erosion rates experienced by the Headland. The volumetric shoreline loss from the Headland is 383,000 cubic yards per year (SJB and CEC, 2005). Enough sand was incorporated in the design fill component to offset this volumetric loss rate for 10 years. A 10 year re-nourishment interval was determined to be the most cost effective over the 50 year project life. The beach and dune fill for Alternative 8 does not include advanced fill for the design storm. Based on performance analyses, a landward fill template was recommended and dune elevations were set at +7 NAVD with widths varying from 210 to 290 feet and 20 to 1 side slopes. The proposed project features are presented in plan view along with a typical cross section in Figures 9 and 11.

An advanced fill template was incorporated into the optimized design for additional gulfward protection. Advanced fill quantities account for initial losses due to shoreline equilibrium and a design storm event occurring between re-nourishment intervals. It was determined that an average of 65 feet of shoreline retreat would occur from cross-shore transport during the equilibrium process. Storm modeling results yielded a predicted shoreline loss of approximately 80 feet for the design storm chosen. Because the advanced fill would be placed in the gulfward direction where bottom elevations are deeper, the advanced fill elevation was set at +4.5 feet NAVD.

Alternative 8 also includes a marsh fill platform contiguous with the BP Canal on its northern boundary and the landward design fill component along its southern boundary. The marsh fill will only be implemented along a portion of the Headland from the eastern edge of Bay Champagne to the western edge of Bay Caminada. The design elevation of the marsh to achieve the tidal zone design objective is 2.0 feet NAVD.

The beach and dune fill template for Alternative 9 is identical to Alternative 8 with the addition of marsh fill extending west through Bay Champagne and to the eastern edge of the project boundary near Caminada Pass. There is also additional marsh in an area to the west of the oil and gas facility on the western end of the Headland. Fill quantities for the beach/dune and marsh fills are 5.1 million and 5.4 million cubic yards respectively. The proposed project features are presented in plan view along with a typical cross section Figures 10 and 11.

The beach and dune fill template for Alternative 10 includes full storm protection with the addition of marsh fill extending west through Bay Champagne and to the eastern edge of the project boundary near Caminada Pass. There is also additional marsh in an area to the west of the oil and gas facility on the western end of the Headland. Fill quantities for the beach/dune and marsh fills are 6.3 million and 5.4 million cubic yards respectively. Plan view and typical cross sections for Alternative 10 are shown in Figures 12 and 13 respectively.

Ship Shoal was identified in the LCA Study (USACE, 2004) as the borrow source to be used to supply material for barrier headland restoration. Material for the design fill and advanced fill construction is to come from the South Pelto Block of Ship Shoal. The marsh fill will be renourished generally every twenty years from a nearshore borrow area to be determined by LDNR for those alternatives that include re-nourishment intervals.

**Wetland Habitat Boundaries:**
*Direct*: Wetland habitat boundary for direct benefits encompasses the proposed footprint for the beach, dune, and marsh fills.

*Indirect*: The wetland habitat boundary for indirect benefits was delineated using the historical Caminada Headland erosion rate of 45 feet per year. The landward extent of this boundary was offset from the TY 0 shoreline by the maximum distance eroded during the life of the project (45 ft/yr x 50 years = 2250 ft). This rate is not expected to increase due to dune disappearance. Review of historic maps has shown that the Headland's natural dune has progressed landward in position but has not disappeared. This boundary is also bordered by the Direct Boundary in the gulfward direction.

Figures 14 through 20 depict the Direct and Indirect Boundaries for the various fill templates in Alternatives 1 through 10.

**Acreage Calculations:** Acreage projections for the desired habitat components at specific target years for both the Future Without Project (FWOP) and Future With Project (FWP) are presented in Tables 1 through 20 and described herein for use in completing the analysis of benefit acres.

The desired habitat components within the direct and indirect boundaries include the following:

- Dune > +5 ft NAVD
- Supratidal > +2 ft NAVD to < +5 ft NAVD
- Marsh > 0 ft NAVD to < +2 ft NAVD, landward of dune
- Open Water < 0 ft NAVD, landward of dune
- Gulf Intertidal > 0 ft NAVD to < +2 ft NAVD, gulfward of dune
- Gulf Subtidal < 0 ft NAVD, gulfward of dune

The target years include the following:
*Future Without Project (FWOP)*: FWOP analyses considered changes that the project area for each alternative will undergo for a no action scenario. The impacts that coastal processes such as erosion, storms, subsidence and sea level rise would have on the existing habitat categories were considered. Habitat types and acreages were determined using the 2005 survey furnished by LDNR. Habitat acreages were calculated for the following target years: TY0, 1, 10, 20, 50. For TY0, the 2005 survey was eroded by two years to represent 2007 conditions.

*Future With Project (FWP)*: FWP analyses considered processes such as equilibrium, storm events, overwash, subsidence, etc., and resulted in an overall change in the platform area or in the conversion of one habitat type to another. TY1 was used to represent "as-built" conditions, and TY2 was used to capture the changes due to initial equilibration of beach fill and the conversion of supratidal elevations in the marsh platform to intertidal elevation through compaction and dewatering. Benefit acres for TY3 and TY5 were calculated to enable the Environmental Workgroup to pro-rate benefits based on vegetative characteristics. Following target years depended on re-nourishment intervals and design storms. Once re-nourishment took place, the process was repeated to account for equilibrium and other coastal processes again.

Using the survey data, aerial photography, historical erosion rate of 45 feet per year, and conceptual sediment budget, the acreages of each habitat component in the land mass within the wetland habitat boundaries were computed and presented in the attached tables.

**Summary:** To compute the habitat goals for the Project design, the TY 0 values for each alternative were computed. Then each alternative was compared to its respective TY 0 value as well as the average TY 0 value, equal to 1220 acres.

The Project Direct Boundary for Alternative 1 includes approximately 787 acres of existing marsh habitat at TY0. Project construction includes approximately 1186 acres of new marsh habitat at TY 1 with approximately 26 acres of these habitats through the Project life at TY50.

The Project Direct Boundary for Alternative 2 includes approximately 1115 acres of existing marsh, dune, supratidal, and gulf intertidal habitats at TY0. Project construction includes approximately 700 acres of new marsh, dune, supratidal and gulf intertidal habitats for a total of approximately 1815 acres at TY 1 with none of these habitats through the Project life at TY50.

The Project Direct Boundary for Alternative 3 includes approximately 1130 acres of existing marsh, dune, supratidal, and gulf intertidal habitats at TY0. Project construction includes approximately 635 acres of new marsh, dune, supratidal and gulf intertidal habitats for a total of approximately 1765 acres at TY 1 with none of these habitats through the Project life at TY50.

The Project Direct Boundary for Alternative 4 includes approximately 1215 acres of existing marsh, dune, supratidal, and gulf intertidal habitats at TY0. Project construction includes approximately 405 acres of new marsh, dune, supratidal and gulf intertidal habitats for a total of approximately 1620 acres at TY 1 with none of these habitats through the Project life at TY50.

The Project Direct Boundary for Alternative 5 includes approximately 1360 acres of existing marsh, dune, supratidal, and gulf intertidal habitats at TY0. Project construction includes approximately 705 acres of new marsh, dune, supratidal and gulf intertidal habitats for a total of

approximately 2065 acres at TY 1 with approximately 26 acres of these habitats through the Project life at TY50.

The Project Direct Boundary for Alternative 6 includes approximately 1360 acres of existing marsh, dune, supratidal, and gulf intertidal habitats at TY0. Project construction includes approximately 705 acres of new marsh, dune, supratidal and gulf intertidal habitats for a total of approximately 2065 acres at TY 1. The beach, dune, and marsh will be rebuilt at 25 years, preserving approximately 565 acres of these habitats through the Project life at TY50.

The Project Direct Boundary for Alternative 7 includes approximately 1360 acres of existing marsh, dune, supratidal, and gulf intertidal habitats at TY0. Project construction includes approximately 705 acres of new marsh, dune, supratidal and gulf intertidal habitats for a total of approximately 2065 acres at TY 1. The beach, dune, and marsh will be rebuilt at year 20 and year 40, preserving approximately 1450 acres of these habitats through the Project life at TY50.

The Project Direct Boundary for Alternative 8 includes approximately 1240 acres of existing marsh, dune, supratidal, and gulf intertidal habitats at TY0. Project construction includes approximately 460 acres of new marsh, dune, supratidal and gulf Intertidal habitats for a total of approximately 1700 acres at TY 1. The beach and dune will be rebuilt every 10 years (5 events) and the marsh will be rebuilt every 20 years, preserving approximately 1095 acres of these habitats through the Project life at TY50.

The Project Direct Boundary for Alternative 9 includes approximately 1360 acres of existing marsh, dune, supratidal, and gulf intertidal habitats at TY0. Project construction includes approximately 705 acres of new marsh, dune, supratidal and gulf Intertidal habitats for a total of approximately 2065 acres at TY 1. The beach and dune will be rebuilt every 10 years and the marsh will be rebuilt every 20 years, preserving approximately 1450 acres of these habitats through the Project life at TY50.

The Project Direct Boundary for Alternative 10 includes approximately 1360 acres of existing marsh, dune, supratidal, and gulf intertidal habitats at TY0. Project construction includes approximately 805 acres of new marsh, dune, supratidal and gulf Intertidal habitats for a total of approximately 2165 acres at TY 1. The beach and dune will be rebuilt every 10 years and the marsh will be rebuilt every 20 years, preserving approximately 1550 acres of these habitats through the Project life at TY50.

With regard to the Indirect Boundary, the existing upland acreage approximately equal to 77 acres (Tank Farm, Chevron Facility) will be preserved through the Project Life at TY50. However, the significant majority of the marsh acreage will disappear over the 50 years through natural subsidence (estimated to be 0.025 feet per year).

**Conclusion:** Based on the available literature and the engineering feasibility study analysis, without the project, most of the Headland will convert to subtidal habitat at TY50, representing a significant ecological loss to the Barataria Basin and coastal Louisiana as a whole.

Presented within the engineering feasibility study are alternatives for restoring and sustaining these ecological habitats. The results of the alternatives analysis in Chapter 6 conclude that several of the alternatives achieve the environmental benefits for the 50 year Project life. Alternative 9, which scored the highest based on environmental benefits, longevity, storm protection, and project costs, sustains the Headland for 50 years at or above the TY 0 goal. The predicted benefits of Alternative 9 at TY50 include 898 acres of marsh, 170 acres of supratidal habitat, 328 acres of dune habitat, and 55 acres of gulf intertidal habitat, for a total of 1451 acres.

Alternative 10 scored as well as Alternative 9 in the environmental benefits categories but at a higher cost as measured by the present value cost and cost per benefit. The predicted benefits of Alternative 10 at TY 50 include 996 acres of marsh, 230 acres of supratidal habitat, 267 acres of dune habitat, and 56 acres of gulf intertidal habitat, for a total of 1549 acres benefited. Alternative 8 had the third highest score overall and is predicted to benefit a total of 1095 acres at TY 50, including 640 acres of marsh, 138 acres of supratidal, 264 acres of dune, and 53 acres of gulf intertidal habitats. Alternative 8 is one of the most expensive alternatives and is not justified compared to the other alternatives. Alternative 7 also scored well and offers a significant cost reduction while benefiting 543 acres of marsh, 395 acres of supratidal, 458 acres of dune, and 55 acres of gulf intertidal habitats for a total of 1451 acres at TY50. The remainder of the alternatives vary in cost and levels of storm protection but do not achieve the desired environmental benefits.

From an ecological standpoint, the marsh created and preserved as a result of the Project will provide nursery habitat for fish and shellfish, as well as feeding, nesting, and resting habitat for waterfowl, wading birds, terns, and gulls. The supratidal and dune habitats created will provide critical nesting, and resting habitat for birds and other wildlife and storm surge protection of interior marshes. The gulf intertidal habitat will provide critical habitat for foraging shorebirds and wading birds as well as habitat for unique nekton assemblages.

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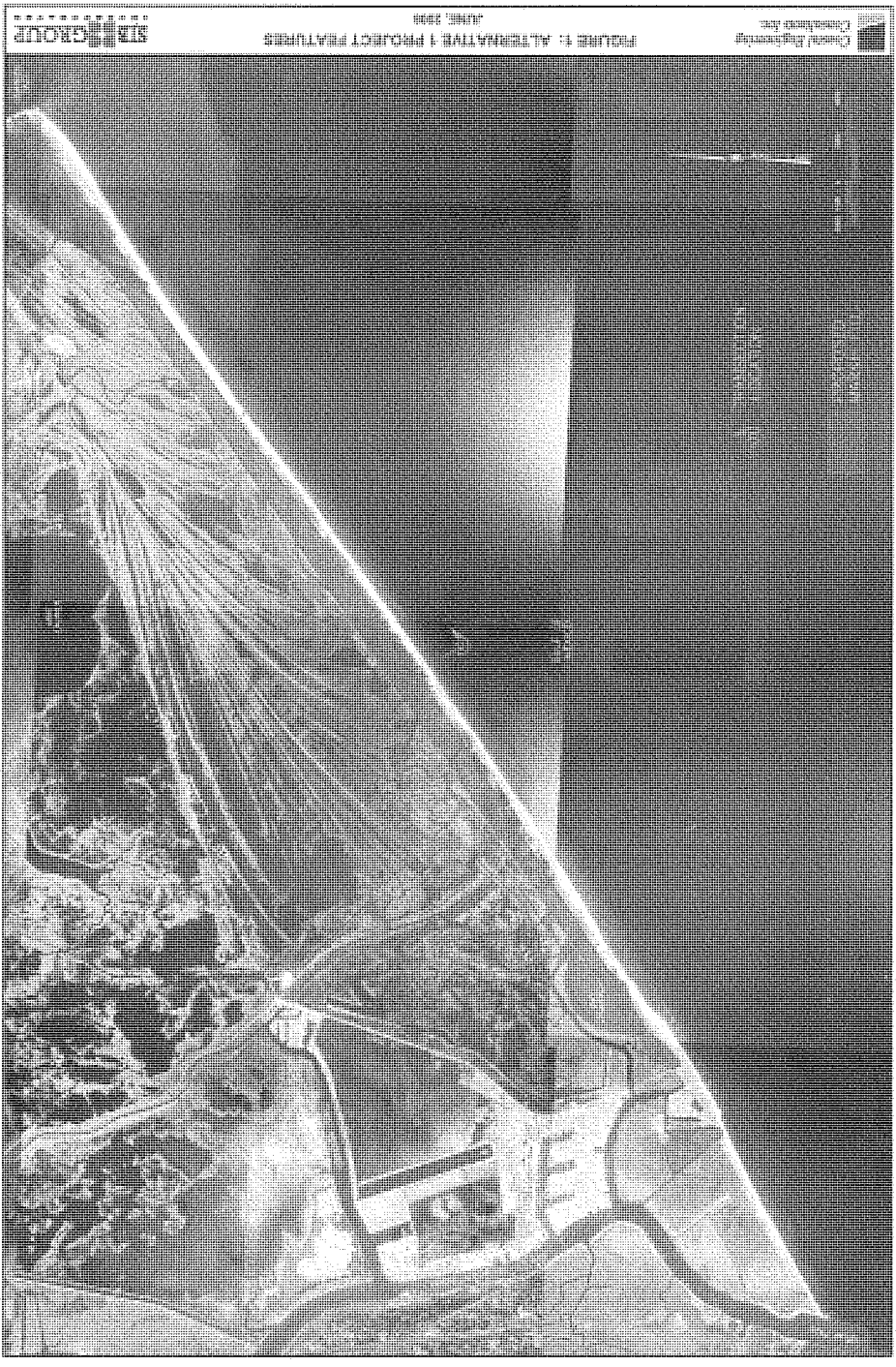

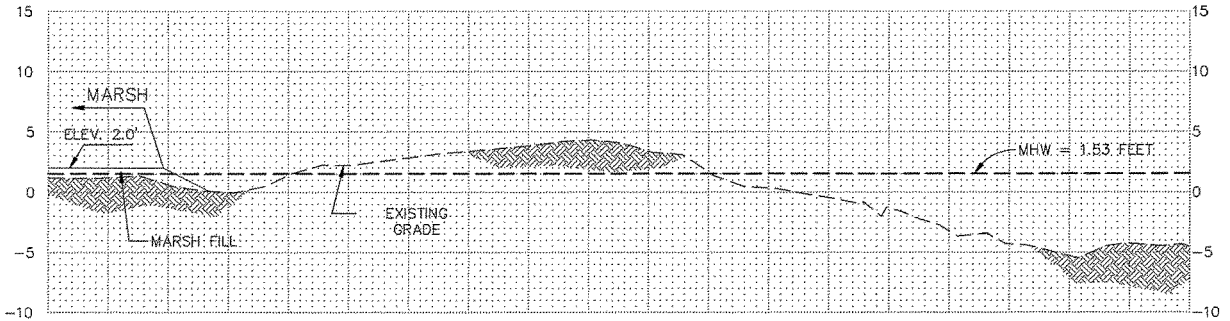


SCALES: HORIZONTAL: 1"=100'
VERTICAL: 1"=10'
ELEVATIONS ARE NAVD88 FEET

ALTERNATIVE 1
AT TRANSECT D

*Coastal Engineering Consultants Inc.*

**FIGURE 2: ALTERNATIVE 1 CROSS SECTION**

**JUNE, 2006**

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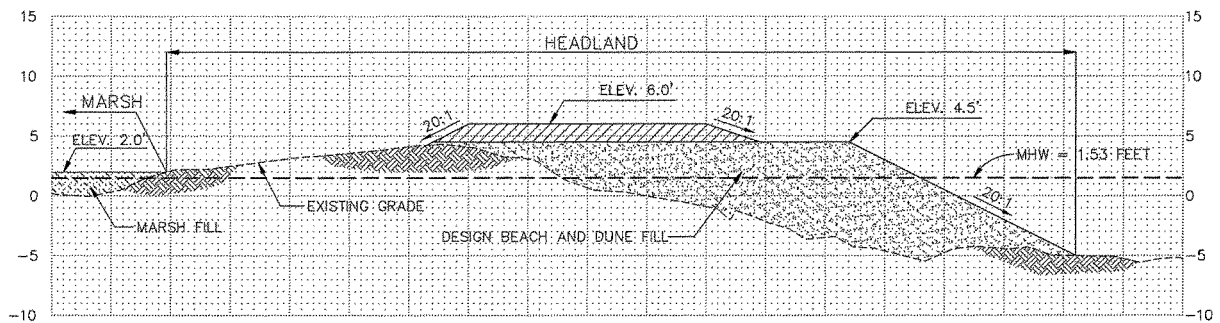


SCALES: HORIZONTAL: 1"=100'
VERTICAL: 1"=10'
ELEVATIONS ARE NAVD88 FEET

ALTERNATIVE 2
AT TRANSECT D

*Coastal Engineering Consultants Inc.*

**FIGURE 4: ALTERNATIVE 2 CROSS SECTIONS**

**JUNE, 2006**

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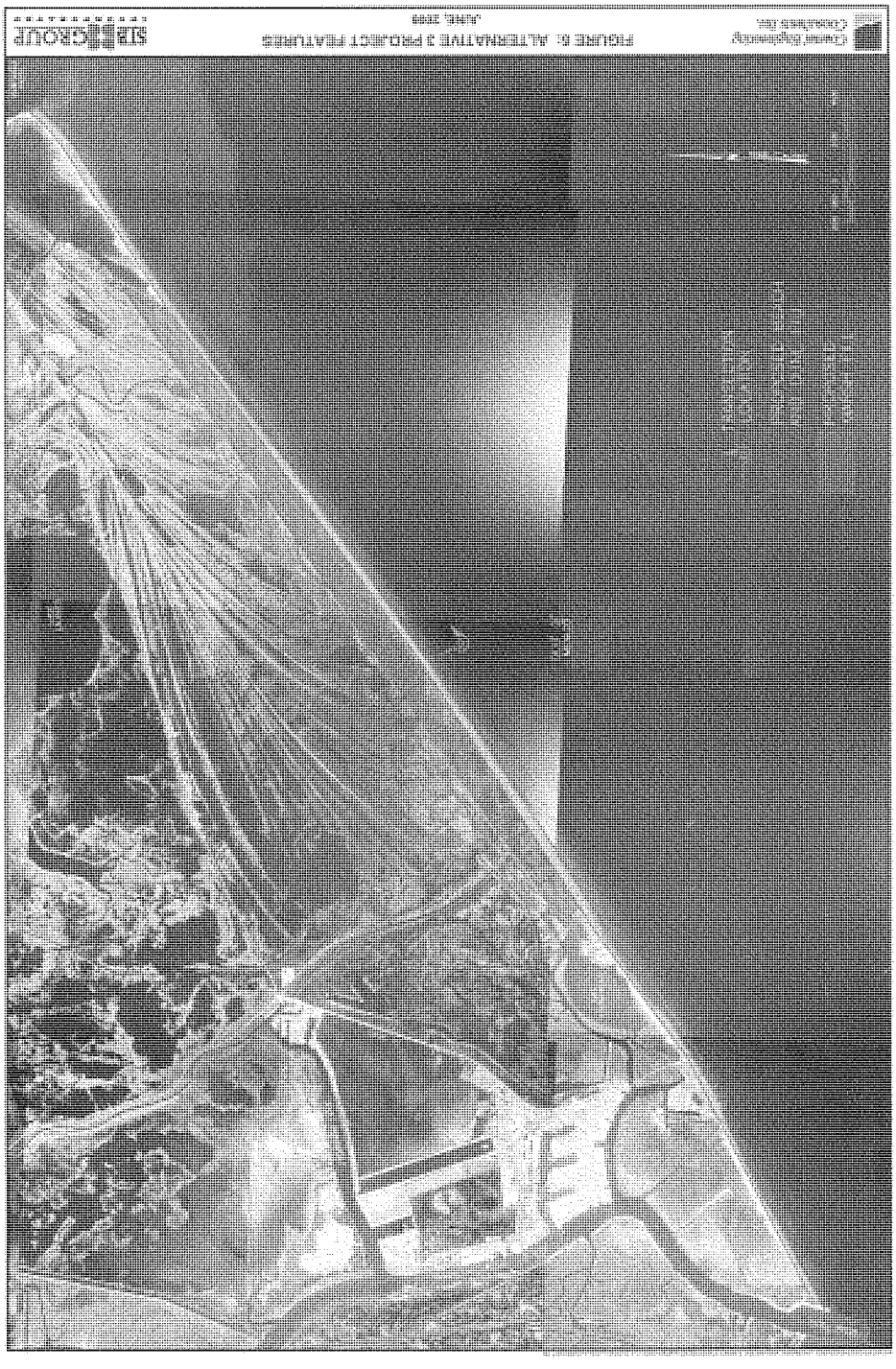

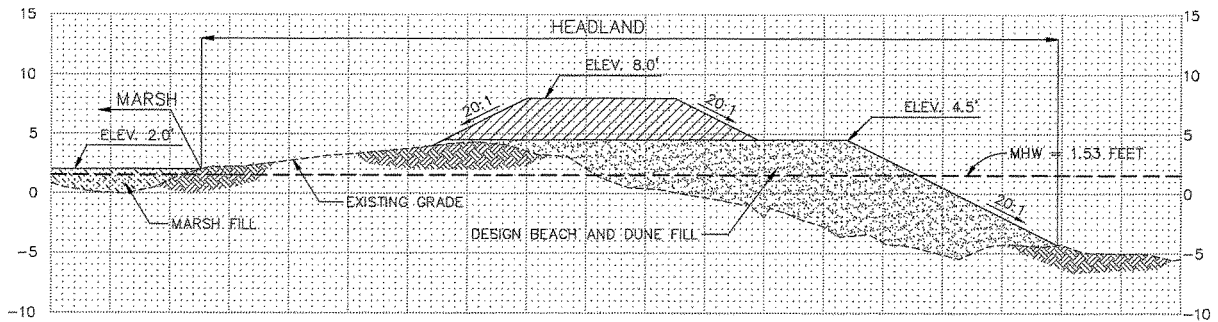


SCALES: HORIZONTAL: 1"=100'
VERTICAL: 1"=10'
ELEVATIONS ARE NAVD88 FEET

ALTERNATIVE 3
AT TRANSECT D

*Coastal Engineering Consultants Inc.*

**FIGURE 6: ALTERNATIVE 3 CROSS SECTIONS**

**JUNE, 2006**

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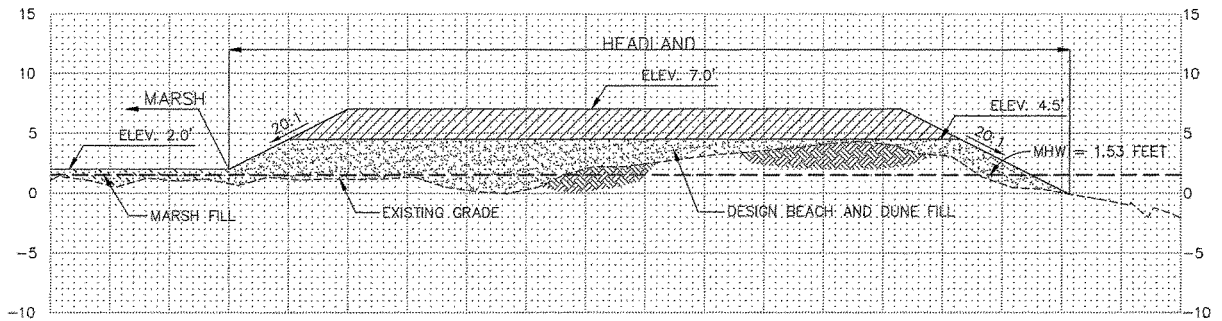
FIGURE 7: ALTERNATIVE 4 PROJECT FEATURES
JUNE 2006




SCALES: HORIZONTAL: 1"=100'
VERTICAL: 1"=10'
ELEVATIONS ARE NAVD88 FEET

ALTERNATIVE 4
AT TRANSECT D

*Coastal Engineering Consultants Inc.*

**FIGURE 8: ALTERNATIVE 4 CROSS SECTIONS**

**JUNE, 2006**

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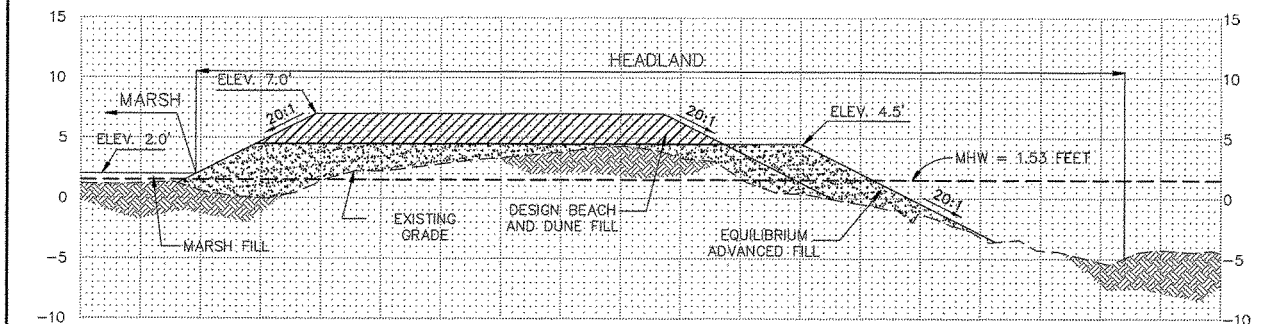
Coastal Engineering Consultants Inc.

FIGURE 10: ALTERNATIVE 6, 6.7, AND 9 PROJECT FEATURES
JUNE, 2005

STB GROUP




SCALES: HORIZONTAL: 1"=100'
VERTICAL: 1"=10'
ELEVATIONS ARE NAVD88 FEET

ALTERNATIVE 5, 6, 7, 8, AND 9
AT TRANSECT D

*Coastal Engineering Consultants Inc.*

**FIGURE 11: ALTERNATIVE 5, 6, 7, 8, AND 9 CROSS SECTIONS**

**JUNE, 2006**

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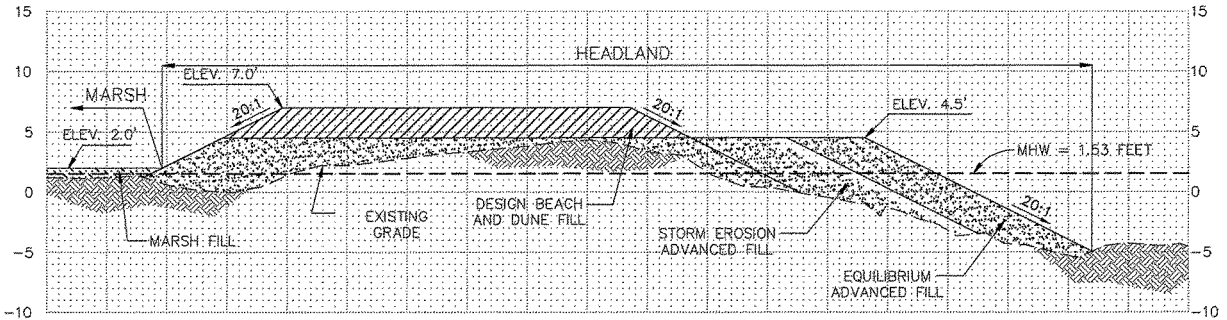


SCALES: HORIZONTAL: 1"=100'
VERTICAL: 1"=10'
ELEVATIONS ARE NAVD88 FEET

ALTERNATIVE 10
AT TRANSECT D

*Coastal Engineering Consultants Inc.*

**FIGURE 13: ALTERNATIVE 10 CROSS SECTION**
**JUNE, 2006**

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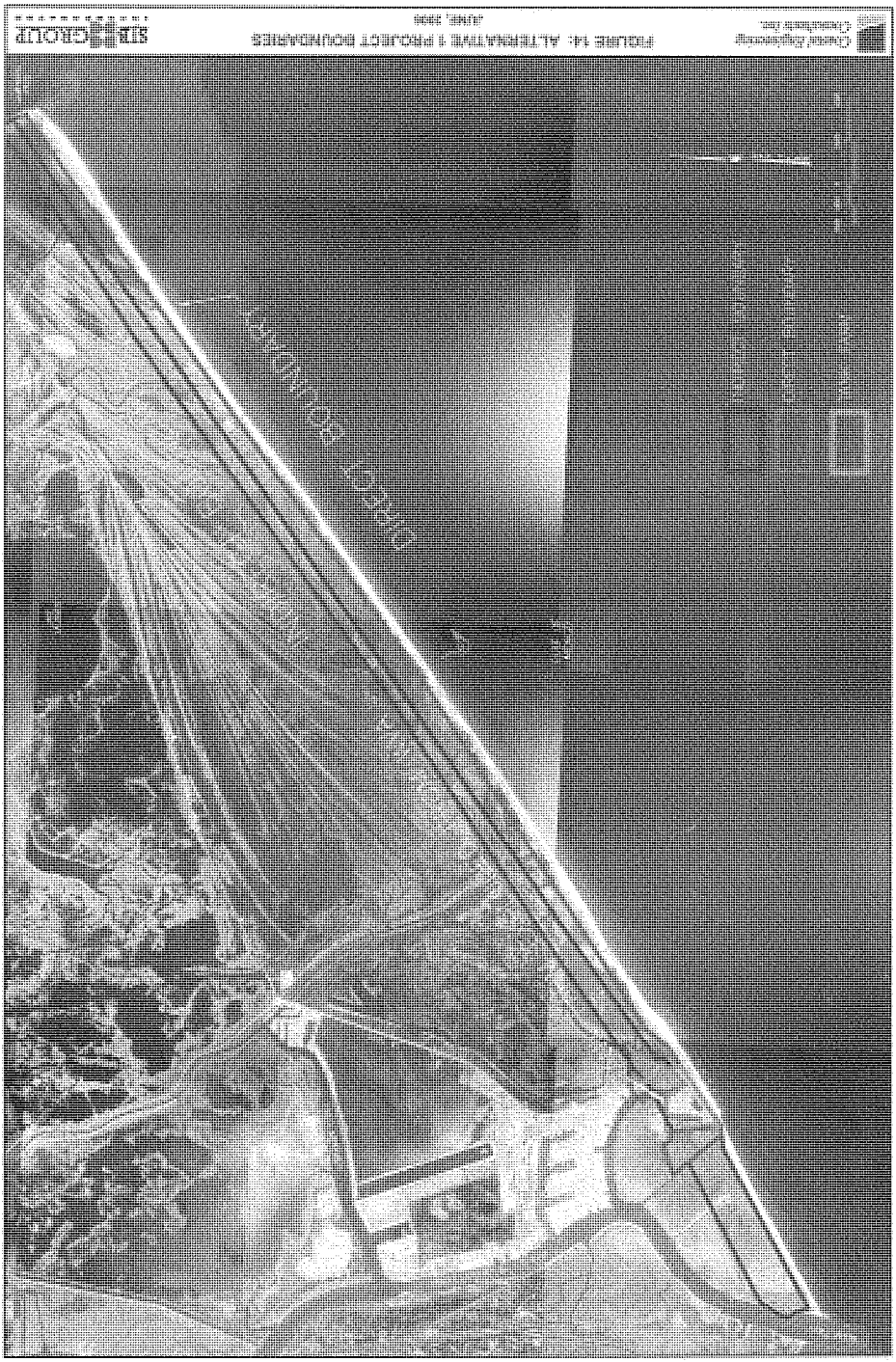

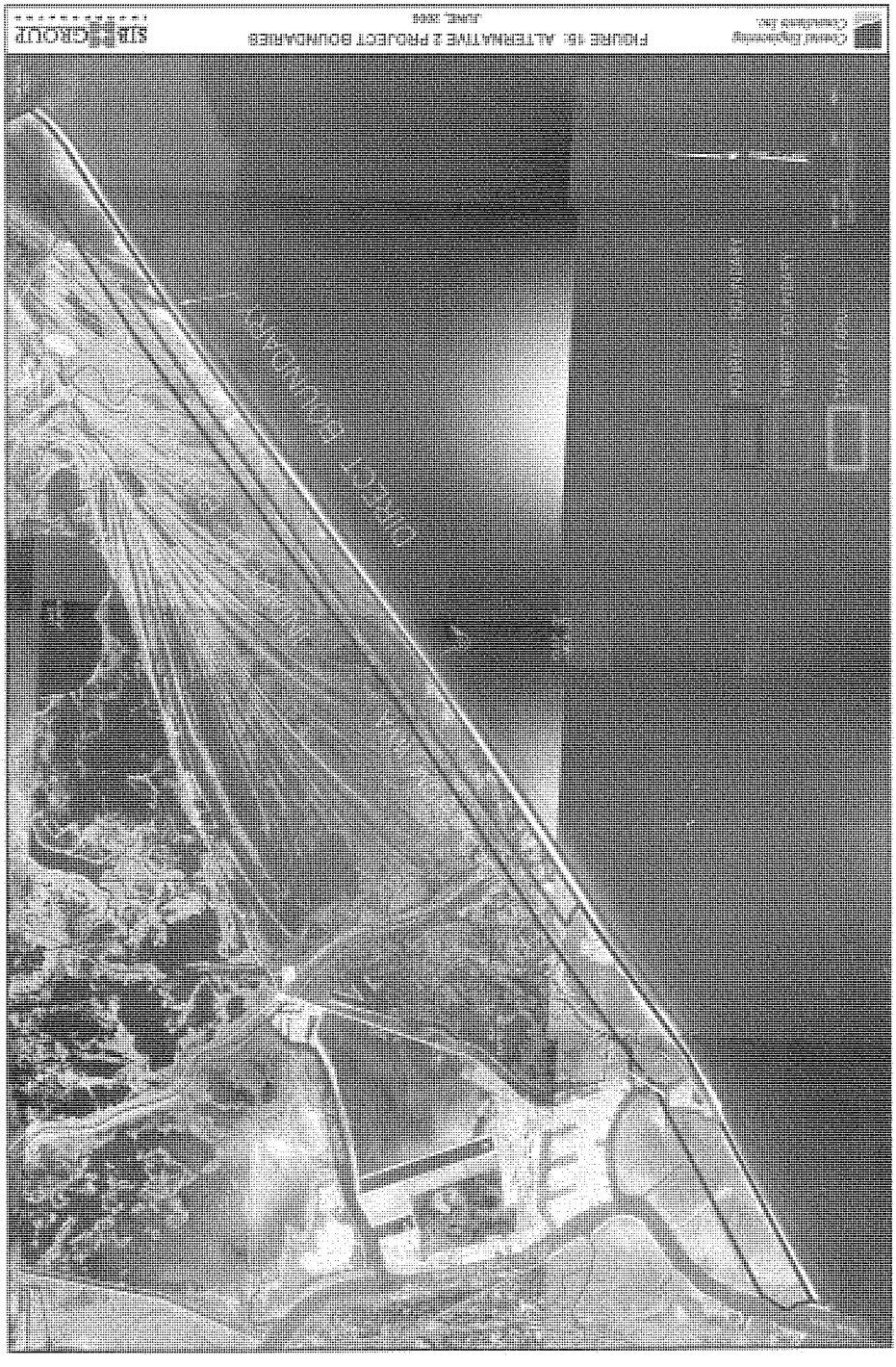

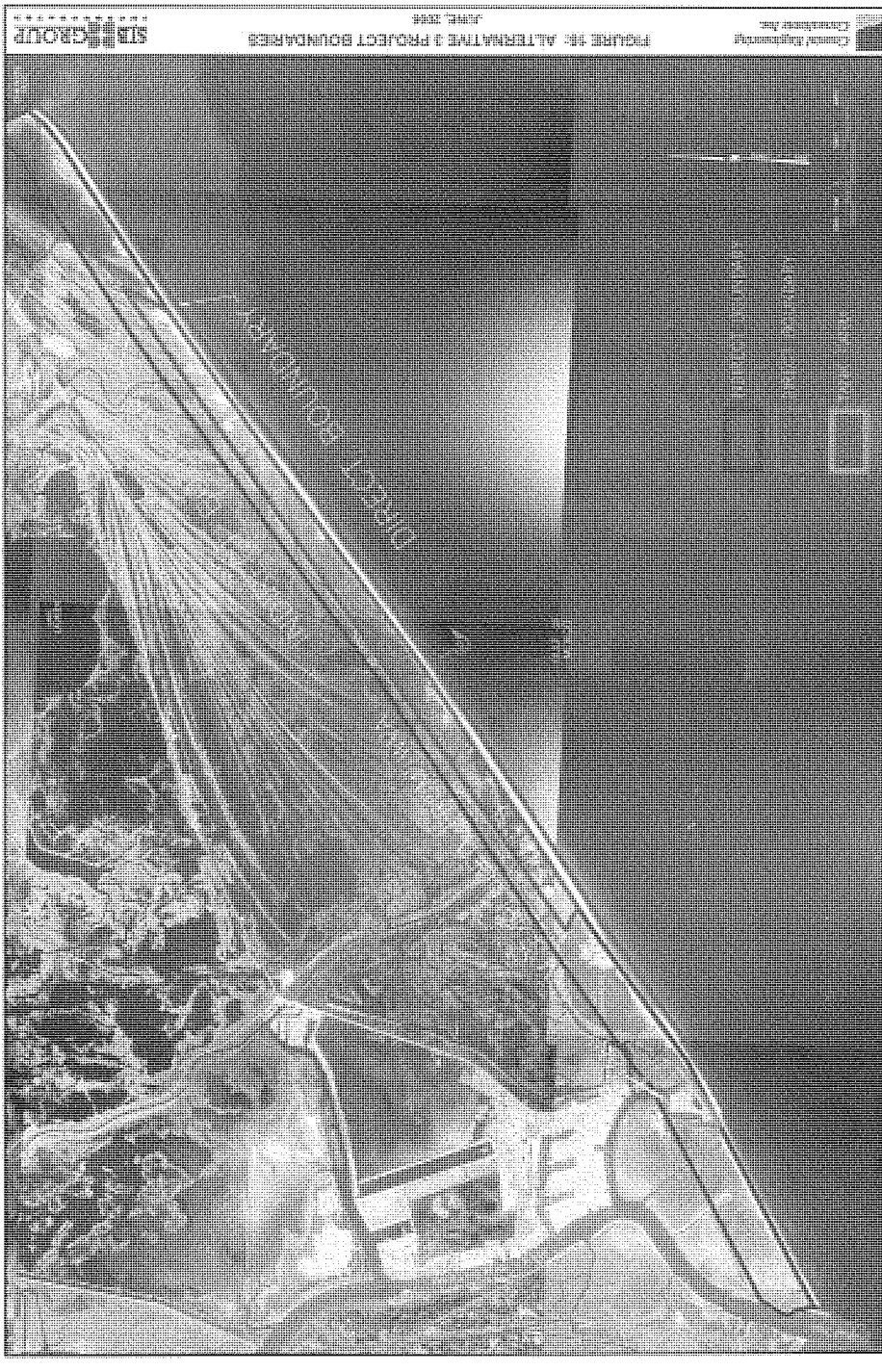

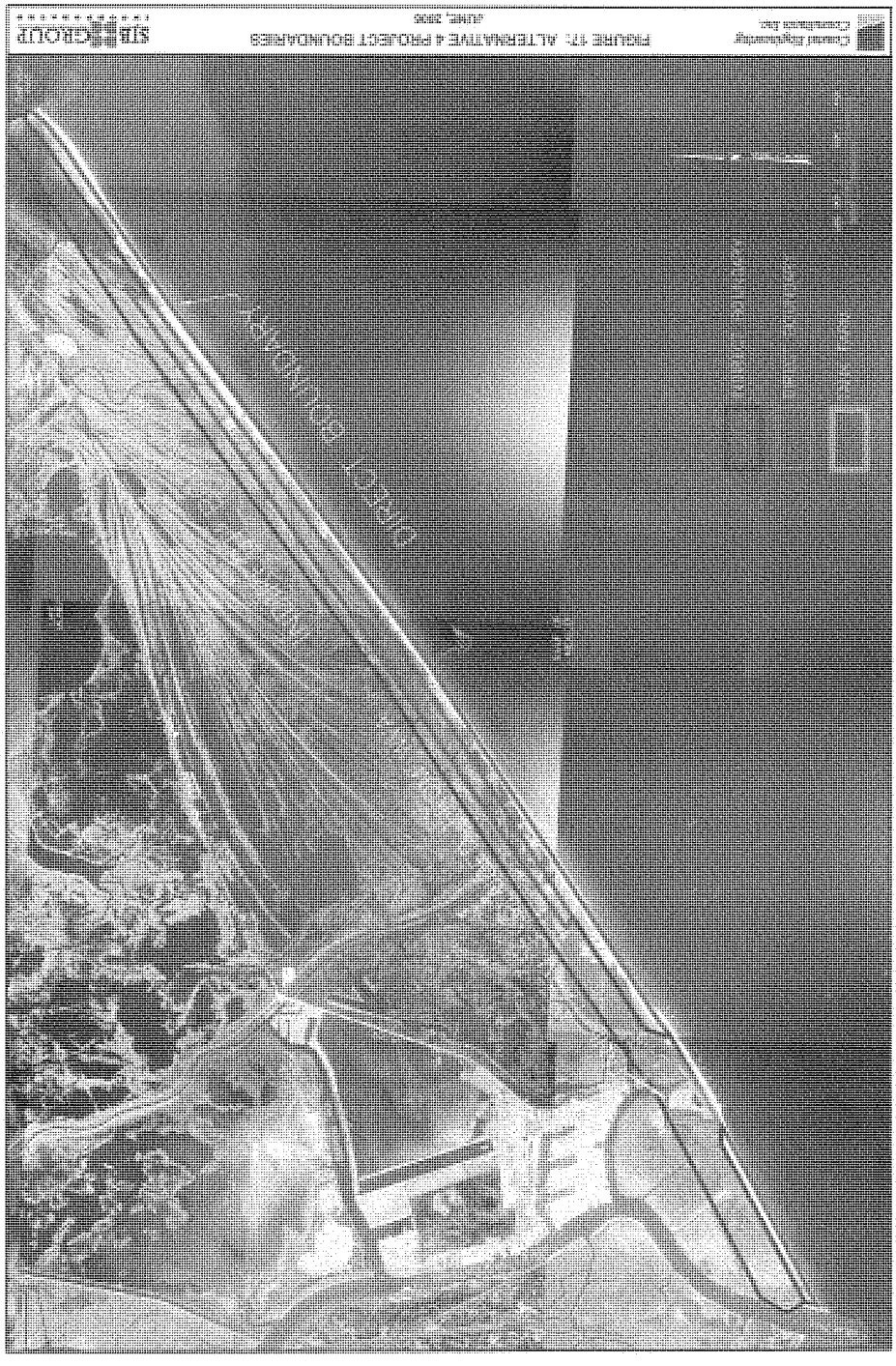

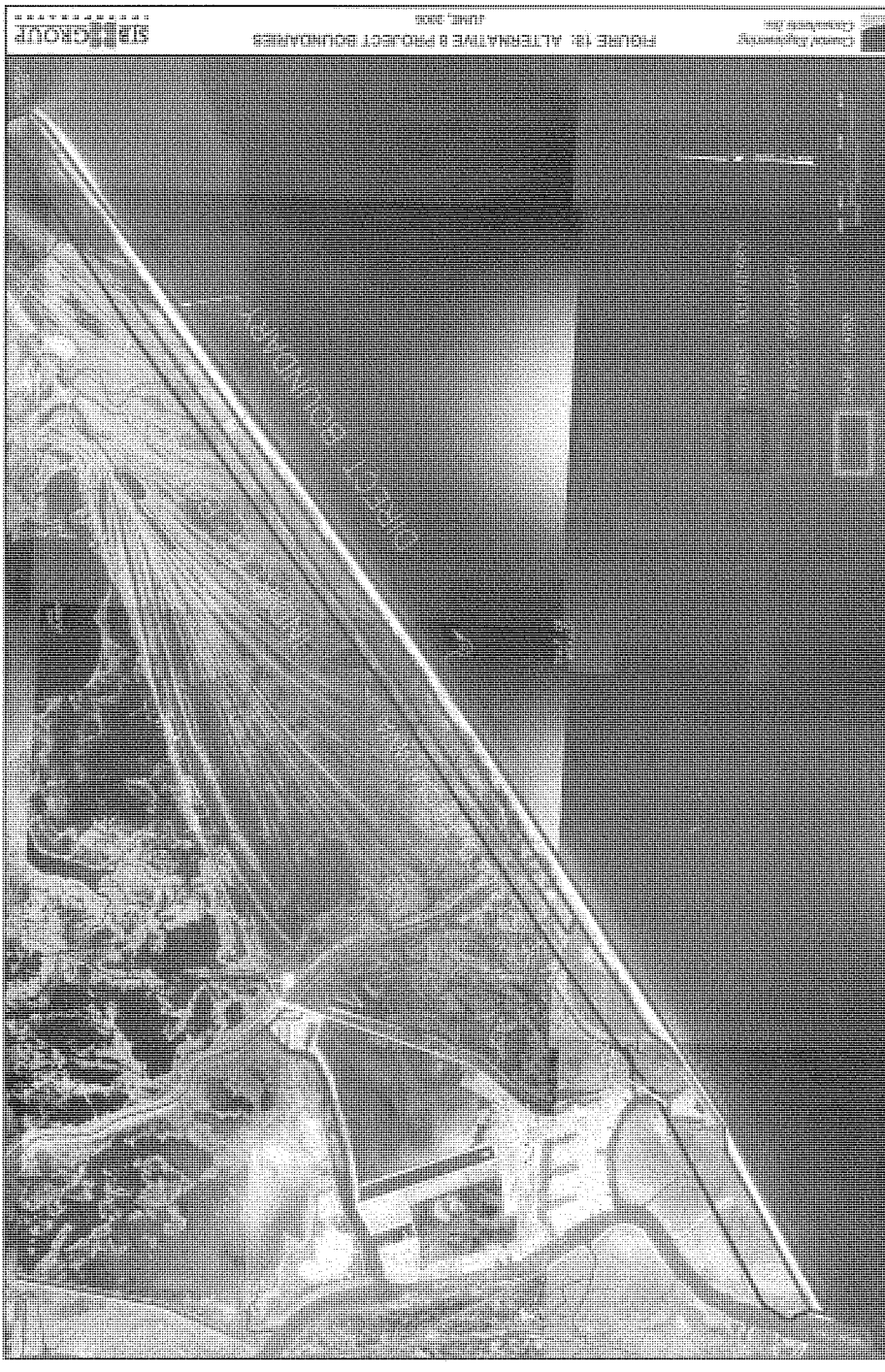

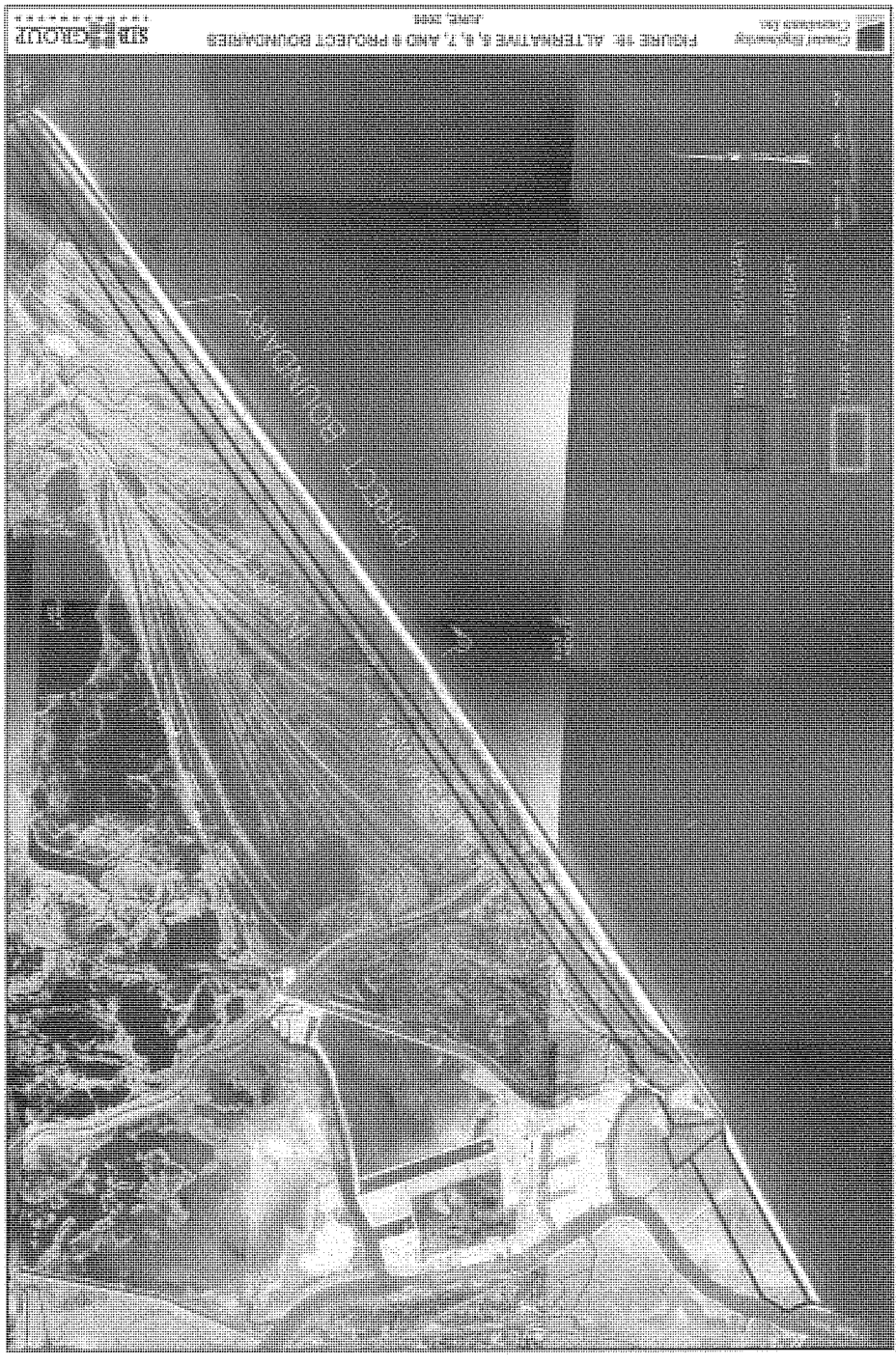

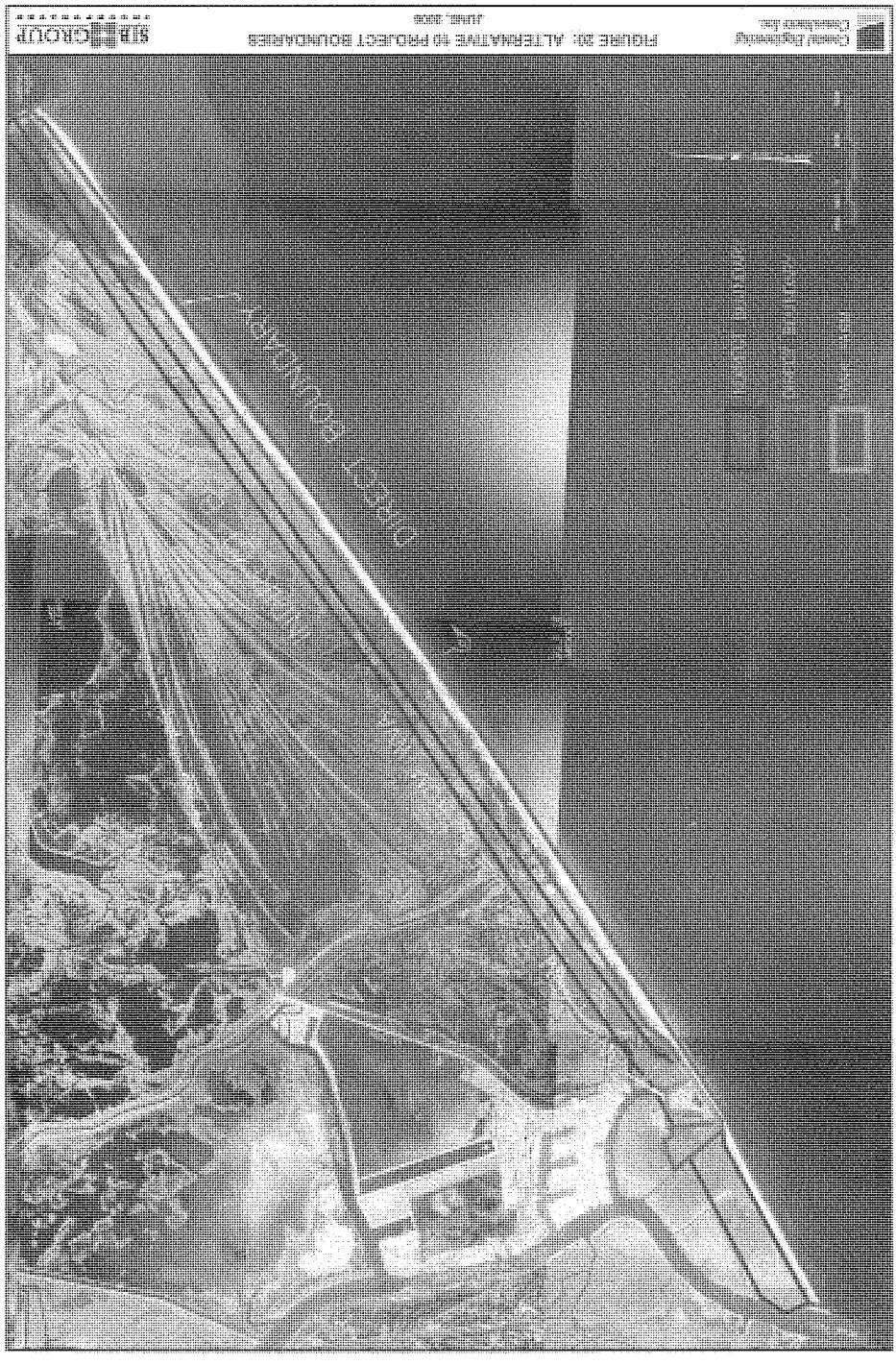

# CAMINADA HEADLAND WVA ACREAGES

| TABLE 1: FUTURE WITHOUT PROJECT (FWOP) - ALTERNATIVE 1<br>BASE MARSH ONLY | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | TY0 | TY1 | TY10 | TY20 | TY50 |
| **DIRECT** | | | | | | |
| MARSH | OPEN WATER | 399 | 399 | 366 | 22 | 5 |
| | MARSH | 787 | 787 | 580 | 43 | 22 |
| HEADLAND | SUPRATIDAL | 0 | 0 | 82 | 0 | 0 |
| | DUNE | 0 | 0 | 0 | 0 | 0 |
| | GULF INTERTIDAL | 0 | 0 | 15 | 0 | 0 |
| | GULF SUBTIDAL | 0 | 0 | 143 | 1121 | 1159 |
| **INDIRECT** | | | | | | |
| MARSH | OPEN WATER | 567 | 567 | 586 | 720 | 1493 |
| | MARSH | 926 | 926 | 907 | 773 | 0 |
| | **TOTALS** | 2679 | 2679 | 2679 | 2679 | 2679 |

CAMINADA HEADLAND WVA ACREAGES

| TABLE 2: FUTURE WITH PROJECT (FWP) - ALTERNATIVE 1<br>BASE MARSH ONLY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| | | TY1 | TY2 | TY3 | TY5 | TY10 | TY20 | TY50 |
| **DIRECT** | | | | | | | | |
| MARSH | OPEN WATER | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | MARSH | 1186 | 1186 | 1186 | 1133 | 946 | 65 | 26 |
| HEADLAND | SUPRATIDAL | 0 | 0 | 0 | 44 | 82 | 0 | 0 |
| | DUNE | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | GULF INTERTIDAL | 0 | 0 | 0 | 9 | 15 | 0 | 0 |
| | GULF SUBTIDAL | 0 | 0 | 0 | 0 | 143 | 1121 | 1160 |
| **INDIRECT** | | | | | | | | |
| MARSH | OPEN WATER | 567 | 567 | 567 | 567 | 586 | 720 | 1493 |
| | MARSH | 926 | 926 | 926 | 926 | 907 | 773 | 0 |
| | **TOTALS** | 2679 | 2679 | 2679 | 2679 | 2679 | 2679 | 2679 |

# CAMINADA HEADLAND WVA ACREAGES

| TABLE 3: FUTURE WITHOUT PROJECT (FWOP) - ALTERNATIVE 2<br>LOW & WIDE DUNE W/ BASE MARSH | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | TY0 | TY1 | TY10 | TY20 | TY50 |
| **DIRECT** | | | | | | |
| MARSH | OPEN WATER | 173 | 171 | 148 | 79 | 0 |
| | MARSH | 766 | 745 | 560 | 263 | 0 |
| HEADLAND | SUPRATIDAL | 267 | 229 | 54 | 52 | 0 |
| | DUNE | 9 | 2 | 0 | 0 | 0 |
| | GULF INTERTIDAL | 72 | 66 | 13 | 11 | 0 |
| | GULF SUBTIDAL | 671 | 746 | 1183 | 1554 | 1958 |
| **INDIRECT** | | | | | | |
| MARSH | OPEN WATER | 857 | 857 | 1062 | 1278 | 2107 |
| | MARSH | 1251 | 1251 | 1045 | 830 | 0 |
| | **TOTALS** | 4066 | 4066 | 4066 | 4066 | 4066 |

CAMINADA HEADLAND WVA ACREAGES

| TABLE 4: FUTURE WITH PROJECT (FWP) - ALTERNATIVE 2 (TY1 - 50) LOW & WIDE DUNE W/ BASE MARSH | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| | | TY1 | TY2 | TY3 | TY5 | TY10 | TY20 | TY50 |
| **DIRECT** | | | | | | | | |
| MARSH | OPEN WATER | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | MARSH | 936 | 936 | 904 | 864 | 728 | 484 | 0 |
| HEADLAND | SUPRATIDAL | 385 | 293 | 305 | 296 | 268 | 242 | 0 |
| | DUNE | 435 | 430 | 386 | 280 | 113 | 0 | 0 |
| | GULF INTERTIDAL | 57 | 57 | 57 | 64 | 51 | 37 | 0 |
| | GULF SUBTIDAL | 146 | 243 | 307 | 454 | 799 | 1197 | 1959 |
| **INDIRECT** | | | | | | | | |
| MARSH | OPEN WATER | 857 | 857 | 857 | 857 | 857 | 1192 | 2107 |
| | MARSH | 1250 | 1250 | 1250 | 1250 | 1250 | 915 | 0 |
| | **TOTALS** | 4066 | 4066 | 4066 | 4066 | 4066 | 4066 | 4066 |

# CAMINADA HEADLAND WVA ACREAGES

| TABLE 5: FUTURE WITHOUT PROJECT (FWOP) - ALTERNATIVE 3<br>HIGH & NARROW DUNE W/ BASE MARSH | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | TY0 | TY1 | TY10 | TY20 | TY50 |
| **DIRECT** | | | | | | |
| MARSH | OPEN WATER | 170 | 169 | 146 | 83 | 0 |
| | MARSH | 769 | 760 | 567 | 249 | 0 |
| HEADLAND | SUPRATIDAL | 280 | 226 | 55 | 59 | 0 |
| | DUNE | 12 | 10 | 0 | 0 | 0 |
| | GULF INTERTIDAL | 68 | 67 | 18 | 17 | 0 |
| | GULF SUBTIDAL | 609 | 675 | 1122 | 1499 | 1908 |
| **INDIRECT** | | | | | | |
| MARSH | OPEN WATER | 857 | 857 | 1057 | 1277 | 2101 |
| | MARSH | 1244 | 1244 | 1044 | 824 | 0 |
| | **TOTALS** | 4009 | 4009 | 4009 | 4009 | 4009 |

CAMINADA HEADLAND WVA ACREAGES

| TABLE 6: FUTURE WITH PROJECT (FWP) - ALTERNATIVE 3 (TY 1 - 50) HIGH & NARROW DUNE W/ BASE MARSH | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| | | TY1 | TY2 | TY3 | TY5 | TY10 | TY20 | TY50 |
| **DIRECT** | | | | | | | | |
| MARSH | OPEN WATER | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | MARSH | 939 | 920 | 890 | 863 | 746 | 489 | 0 |
| HEADLAND | SUPRATIDAL | 362 | 288 | 295 | 282 | 230 | 215 | 0 |
| | DUNE | 406 | 406 | 366 | 259 | 97 | 0 | 0 |
| | GULF INTERTIDAL | 56 | 57 | 57 | 62 | 48 | 38 | 0 |
| | GULF SUBTIDAL | 145 | 237 | 299 | 442 | 787 | 1166 | 1908 |
| **INDIRECT** | | | | | | | | |
| MARSH | OPEN WATER | 857 | 857 | 857 | 857 | 864 | 1160 | 2101 |
| | MARSH | 1244 | 1244 | 1244 | 1244 | 1237 | 941 | 0 |
| | **TOTALS** | 4009 | 4009 | 4009 | 4009 | 4009 | 4009 | 4009 |

# CAMINADA HEADLAND WVA ACREAGES

| TABLE 7: FUTURE WITHOUT PROJECT (FWOP) - ALTERNATIVE 4 LANDWARD BEACH/DUNE W/ BASE MARSH | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | TY0 | TY1 | TY10 | TY20 | TY50 |
| **DIRECT** | | | | | | |
| MARSH | OPEN WATER | 146 | 146 | 143 | 78 | 0 |
| | MARSH | 833 | 814 | 530 | 223 | 0 |
| HEADLAND | SUPRATIDAL | 298 | 278 | 93 | 76 | 0 |
| | DUNE | 28 | 28 | 0 | 0 | 0 |
| | GULF INTERTIDAL | 57 | 56 | 52 | 32 | 0 |
| | GULF SUBTIDAL | 275 | 316 | 820 | 1229 | 1638 |
| **INDIRECT** | | | | | | |
| MARSH | OPEN WATER | 756 | 756 | 756 | 896 | 1756 |
| | MARSH | 1000 | 1000 | 1000 | 860 | 0 |
| | **TOTALS** | 3394 | 3394 | 3394 | 3394 | 3394 |

# CAMINADA HEADLAND WVA ACREAGES

| TABLE 8: FUTURE WITH PROJECT (FWP) - ALTERNATIVE 4 (TY 1 - 50) LANDWARD BEACH/DUNE W/ BASE MARSH | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | TY1 | TY2 | TY3 | TY5 | TY10 | TY20 | TY50 |
| **DIRECT** | | | | | | | | |
| MARSH | OPEN WATER | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | MARSH | 667 | 667 | 667 | 667 | 543 | 189 | 0 |
| HEADLAND | SUPRATIDAL | 162 | 122 | 105 | 65 | 118 | 103 | 0 |
| | DUNE | 757 | 750 | 717 | 645 | 388 | 232 | 0 |
| | GULF INTERTIDAL | 36 | 47 | 49 | 53 | 59 | 38 | 0 |
| | GULF SUBTIDAL | 15 | 52 | 100 | 208 | 530 | 1076 | 1638 |
| **INDIRECT** | | | | | | | | |
| MARSH | OPEN WATER | 756 | 756 | 756 | 756 | 756 | 938 | 1756 |
| | MARSH | 1000 | 1000 | 1000 | 1000 | 1000 | 818 | 0 |
| | **TOTALS** | 3394 | 3394 | 3394 | 3394 | 3394 | 3394 | 3394 |

# CAMINADA HEADLAND WVA ACREAGES

| TABLE 9: FUTURE WITHOUT PROJECT (FWOP) - ALTERNATIVE 5 PREFERRED DUNE W/ EXPANDED MARSH | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | TY0 | TY1 | TY10 | TY20 | TY50 |
| **DIRECT** | | | | | | |
| MARSH | OPEN WATER | 413 | 414 | 366 | 22 | 5 |
| | MARSH | 876 | 868 | 580 | 43 | 22 |
| HEADLAND | SUPRATIDAL | 356 | 316 | 113 | 0 | 0 |
| | DUNE | 29 | 25 | 0 | 0 | 0 |
| | GULF INTERTIDAL | 100 | 78 | 15 | 0 | 0 |
| | GULF SUBTIDAL | 512 | 587 | 1214 | 2222 | 2260 |
| **INDIRECT** | | | | | | |
| MARSH | OPEN WATER | 566 | 565 | 586 | 720 | 1492 |
| | MARSH | 926 | 926 | 905 | 771 | 0 |
| | **TOTALS** | 3779 | 3779 | 3779 | 3779 | 3779 |

CAMINADA HEADLAND WVA ACREAGES

| TABLE 10: FUTURE WITH PROJECT (FWP) - ALTERNATIVE 5 (TY 1 - 50) PREFERRED DUNE W/ EXPANDED MARSH | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | TY1 | TY2 | TY3 | TY5 | TY10 | TY20 | TY50 |
| **DIRECT** | | | | | | | | |
| MARSH | OPEN WATER | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | MARSH | 1186 | 1186 | 1186 | 1062 | 898 | 427 | 26 |
| HEADLAND | SUPRATIDAL | 266 | 179 | 133 | 186 | 170 | 225 | 0 |
| | DUNE | 554 | 554 | 538 | 490 | 328 | 130 | 0 |
| | GULF INTERTIDAL | 58 | 58 | 58 | 53 | 55 | 51 | 0 |
| | GULF SUBTIDAL | 223 | 309 | 370 | 495 | 835 | 1453 | 2260 |
| **INDIRECT** | | | | | | | | |
| MARSH | OPEN WATER | 567 | 567 | 567 | 567 | 567 | 634 | 1493 |
| | MARSH | 926 | 926 | 926 | 926 | 926 | 859 | 0 |
| | **TOTALS** | 3779 | 3779 | 3779 | 3779 | 3779 | 3779 | 3779 |

# CAMINADA HEADLAND WVA ACREAGES

| TABLE 11: FUTURE WITHOUT PROJECT (FWOP) - ALTERNATIVE 6 PREFERRED DUNE W/ EXPANDED MARSH | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | TY0 | TY1 | TY10 | TY20 | TY50 |
| **DIRECT** | | | | | | |
| MARSH | OPEN WATER | 413 | 414 | 366 | 22 | 5 |
| | MARSH | 876 | 868 | 580 | 43 | 22 |
| HEADLAND | SUPRATIDAL | 356 | 316 | 113 | 0 | 0 |
| | DUNE | 29 | 25 | 0 | 0 | 0 |
| | GULF INTERTIDAL | 100 | 78 | 15 | 0 | 0 |
| | GULF SUBTIDAL | 512 | 587 | 1214 | 2222 | 2260 |
| **INDIRECT** | | | | | | |
| MARSH | OPEN WATER | 566 | 565 | 586 | 720 | 1492 |
| | MARSH | 926 | 926 | 905 | 771 | 0 |
| | **TOTALS** | 3779 | 3779 | 3779 | 3779 | 3779 |

| TABLE 12: FUTURE WITH PROJECT (FWP) - ALTERNATIVE 6 (TY 1 - 25) PREFERRED DUNE W/ EXPANDED MARSH AND 1 RENOURISHMENT | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | TY1*** | TY2 | TY3 | TY5 | TY10 | TY20 | TY25 |
| **DIRECT** | | | | | | | | |
| MARSH | OPEN WATER | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | MARSH | 1186 | 1186 | 1186 | 1062 | 898 | 427 | 332 |
| HEADLAND | SUPRATIDAL | 266 | 179 | 133 | 186 | 170 | 225 | 169 |
| | DUNE | 554 | 554 | 538 | 490 | 328 | 130 | 23 |
| | GULF INTERTIDAL | 58 | 58 | 58 | 53 | 55 | 51 | 40 |
| | GULF SUBTIDAL | 223 | 309 | 370 | 495 | 835 | 1453 | 1722 |
| **INDIRECT** | | | | | | | | |
| MARSH | OPEN WATER | 567 | 567 | 567 | 567 | 567 | 634 | 690 |
| | MARSH | 926 | 926 | 926 | 926 | 926 | 859 | 803 |
| | **TOTALS** | 3779 | 3779 | 3779 | 3779 | 3779 | 3779 | 3779 |

| TABLE 12: FUTURE WITH PROJECT (FWP) - ALTERNATIVE 6 (TY 26 - 50) PREFERRED DUNE W/ EXPANDED MARSH AND 1 RENOURISHMENT | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | TY26*** | TY27 | TY28 | TY30 | TY35 | TY45 | TY50 |
| **DIRECT** | | | | | | | | |
| MARSH | OPEN WATER | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | MARSH | 994 | 994 | 994 | 870 | 706 | 427 | 332 |
| HEADLAND | SUPRATIDAL | 435 | 348 | 302 | 355 | 339 | 225 | 169 |
| | DUNE | 577 | 577 | 561 | 513 | 351 | 130 | 23 |
| | GULF INTERTIDAL | 58 | 58 | 58 | 53 | 55 | 51 | 40 |
| | GULF SUBTIDAL | 223 | 309 | 370 | 495 | 835 | 1453 | 1722 |
| **INDIRECT** | | | | | | | | |
| MARSH | OPEN WATER | 690 | 690 | 690 | 690 | 690 | 1493 | 1493 |
| | MARSH | 803 | 803 | 803 | 803 | 803 | 0 | 0 |
| | **TOTALS** | 3779 | 3779 | 3778 | 3779 | 3779 | 3779 | 3779 |

* BEACH RE-NOURISHMENT ONLY
** MARSH RE-NOURISHMENT ONLY
***BEACH AND MARSH RE-NOURISHMENT

# CAMINADA HEADLAND WVA ACREAGES

| TABLE 13: FUTURE WITHOUT PROJECT (FWOP) - ALTERNATIVE 7 PREFERRED DUNE W/ EXPANDED MARSH | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | TY0 | TY1 | TY10 | TY20 | TY50 |
| **DIRECT** | | | | | | |
| MARSH | OPEN WATER | 413 | 414 | 366 | 22 | 5 |
| | MARSH | 876 | 868 | 580 | 43 | 22 |
| HEADLAND | SUPRATIDAL | 356 | 316 | 113 | 0 | 0 |
| | DUNE | 29 | 25 | 0 | 0 | 0 |
| | GULF INTERTIDAL | 100 | 78 | 15 | 0 | 0 |
| | GULF SUBTIDAL | 512 | 587 | 1214 | 2222 | 2260 |
| **INDIRECT** | | | | | | |
| MARSH | OPEN WATER | 566 | 565 | 586 | 720 | 1492 |
| | MARSH | 926 | 926 | 905 | 771 | 0 |
| | **TOTALS** | 3779 | 3779 | 3779 | 3779 | 3779 |

| TABLE 14: FUTURE WITH PROJECT (FWP) - ALTERNATIVE 7 (TY 1 - 20) PREFERRED DUNE W/ EXPANDED MARSH AND 2 RENOURISHMENTS | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | TY1*** | TY2 | TY3 | TY5 | TY10 | TY20 |
| **DIRECT** | | | | | | | |
| MARSH | OPEN WATER | 0 | 0 | 0 | 0 | 0 | 0 |
| | MARSH | 1186 | 1186 | 1186 | 1062 | 898 | 427 |
| HEADLAND | SUPRATIDAL | 266 | 179 | 133 | 186 | 170 | 225 |
| | DUNE | 554 | 554 | 538 | 490 | 328 | 130 |
| | GULF INTERTIDAL | 58 | 58 | 58 | 53 | 55 | 51 |
| | GULF SUBTIDAL | 223 | 309 | 370 | 495 | 835 | 1453 |
| **INDIRECT** | | | | | | | |
| MARSH | OPEN WATER | 567 | 567 | 567 | 567 | 567 | 634 |
| | MARSH | 926 | 926 | 926 | 926 | 926 | 859 |
| | **TOTALS** | 3779 | 3779 | 3779 | 3779 | 3779 | 3779 |

| TABLE 14: FUTURE WITH PROJECT (FWP) - ALTERNATIVE 7 (TY 21 - 40) PREFERRED DUNE W/ EXPANDED MARSH AND 2 RENOURISHMENTS | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | TY21*** | TY22 | TY23 | TY25 | TY30 | TY40 |
| **DIRECT** | | | | | | | |
| MARSH | OPEN WATER | 0 | 0 | 0 | 0 | 0 | 0 |
| | MARSH | 831 | 831 | 831 | 707 | 543 | 427 |
| HEADLAND | SUPRATIDAL | 490 | 404 | 358 | 411 | 395 | 225 |
| | DUNE | 684 | 684 | 669 | 620 | 458 | 130 |
| | GULF INTERTIDAL | 58 | 58 | 58 | 53 | 55 | 51 |
| | GULF SUBTIDAL | 223 | 309 | 370 | 495 | 835 | 1453 |
| **INDIRECT** | | | | | | | |
| MARSH | OPEN WATER | 634 | 634 | 634 | 634 | 634 | 1493 |
| | MARSH | 859 | 859 | 859 | 859 | 859 | 0 |
| | **TOTALS** | 3779 | 3779 | 3779 | 3779 | 3779 | 3779 |

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| TABLE 14: FUTURE WITH PROJECT (FWP) - ALTERNATIVE 7 (TY 41 - 50) PREFERRED DUNE W/ EXPANDED MARSH AND 2 RENOURISHMENTS | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | TY41*** | TY42 | TY43 | TY45 | TY50 |
| **DIRECT** | | | | | | |
| MARSH | OPEN WATER | 0 | 0 | 0 | 0 | 0 |
| | MARSH | 831 | 831 | 831 | 707 | 543 |
| HEADLAND | SUPRATIDAL | 490 | 404 | 358 | 411 | 395 |
| | DUNE | 684 | 684 | 668 | 620 | 458 |
| | GULF INTERTIDAL | 58 | 58 | 58 | 53 | 55 |
| | GULF SUBTIDAL | 223 | 309 | 370 | 495 | 835 |
| **INDIRECT** | | | | | | |
| MARSH | OPEN WATER | 1493 | 1493 | 1493 | 1493 | 1493 |
| | MARSH | 0 | 0 | 0 | 0 | 0 |
| | **TOTALS** | 3779 | 3779 | 3779 | 3779 | 3779 |

* BEACH RE-NOURISHMENT ONLY
** MARSH RE-NOURISHMENT ONLY
***BEACH AND MARSH RE-NOURISHMENT

# CAMINADA HEADLAND WVA ACREAGES

| TABLE 15: FUTURE WITHOUT PROJECT (FWOP) - ALTERNATIVE 8 OPTIMIZED PROJECT W/ BASE MARSH AND 4 RENOURISHMENTS | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | TY0 | TY1 | TY10 | TY20 | TY50 |
| **DIRECT** | | | | | | |
| MARSH | OPEN WATER | 172 | 173 | 125 | 0 | 0 |
| | MARSH | 753 | 745 | 457 | 0 | 0 |
| HEADLAND | SUPRATIDAL | 356 | 316 | 113 | 0 | 0 |
| | DUNE | 29 | 25 | 0 | 0 | 0 |
| | GULF INTERTIDAL | 100 | 78 | 15 | 0 | 0 |
| | GULF SUBTIDAL | 512 | 587 | 1214 | 1923 | 1923 |
| **INDIRECT** | | | | | | |
| MARSH | OPEN WATER | 801 | 801 | 822 | 956 | 1829 |
| | MARSH | 1028 | 1028 | 1007 | 873 | 0 |
| | **TOTALS** | 3752 | 3752 | 3752 | 3752 | 3752 |

| TABLE 16: FUTURE WITH PROJECT (FWP) - ALTERNATIVE 8 (TY 1 - 10) OPTIMIZED PROJECT W/ BASE MARSH AND 4 RENOURISHMENTS | | | | | | |
|---|---|---|---|---|---|---|
| | | TY1*** | TY2 | TY3 | TY5 | TY10 |
| **DIRECT** | | | | | | |
| MARSH | OPEN WATER | 0 | 0 | 0 | 0 | 0 |
| | MARSH | 824 | 824 | 824 | 745 | 640 |
| HEADLAND | SUPRATIDAL | 264 | 178 | 133 | 149 | 138 |
| | DUNE | 554 | 554 | 538 | 481 | 264 |
| | GULF INTERTIDAL | 58 | 58 | 58 | 53 | 53 |
| | GULF SUBTIDAL | 223 | 309 | 370 | 495 | 828 |
| **INDIRECT** | | | | | | |
| MARSH | OPEN WATER | 801 | 801 | 801 | 801 | 808 |
| | MARSH | 1028 | 1028 | 1028 | 1028 | 1021 |
| | **TOTALS** | 3752 | 3752 | 3752 | 3752 | 3752 |

| TABLE 16: FUTURE WITH PROJECT (FWP) - ALTERNATIVE 8 (TY 11 - 20) OPTIMIZED PROJECT W/ BASE MARSH AND 4 RENOURISHMENTS | | | | | | |
|---|---|---|---|---|---|---|
| | | TY11* | TY12 | TY13 | TY15 | TY20 |
| **DIRECT** | | | | | | |
| MARSH | OPEN WATER | 0 | 0 | 0 | 0 | 0 |
| | MARSH | 640 | 640 | 640 | 640 | 640 |
| HEADLAND | SUPRATIDAL | 331 | 245 | 201 | 217 | 138 |
| | DUNE | 671 | 671 | 655 | 518 | 264 |
| | GULF INTERTIDAL | 58 | 58 | 58 | 53 | 53 |
| | GULF SUBTIDAL | 223 | 309 | 370 | 495 | 828 |
| **INDIRECT** | | | | | | |
| MARSH | OPEN WATER | 808 | 808 | 808 | 808 | 808 |
| | MARSH | 1021 | 1021 | 1021 | 1021 | 1021 |
| | **TOTALS** | 3752 | 3752 | 3753 | 3752 | 3752 |

| TABLE 16: FUTURE WITH PROJECT (FWP) - ALTERNATIVE 8 (TY 21 - 30) OPTIMIZED PROJECT W/ BASE MARSH AND 4 RENOURISHMENTS | | | | | | |
|---|---|---|---|---|---|---|
| | | TY21*** | TY22 | TY23 | TY25 | TY30 |
| **DIRECT** | | | | | | |
| MARSH | OPEN WATER | 0 | 0 | 0 | 0 | 0 |
| | MARSH | 640 | 640 | 640 | 640 | 640 |
| HEADLAND | SUPRATIDAL | 331 | 244 | 199 | 216 | 138 |
| | DUNE | 671 | 672 | 656 | 519 | 264 |
| | GULF INTERTIDAL | 58 | 58 | 58 | 53 | 53 |
| | GULF SUBTIDAL | 223 | 309 | 370 | 495 | 828 |
| **INDIRECT** | | | | | | |
| MARSH | OPEN WATER | 808 | 808 | 808 | 808 | 808 |
| | MARSH | 1021 | 1021 | 1021 | 1021 | 1021 |
| | **TOTALS** | 3752 | 3752 | 3752 | 3752 | 3752 |

| TABLE 16: FUTURE WITH PROJECT (FWP) - ALTERNATIVE 8 (TY 31 - 40) OPTIMIZED PROJECT W/ BASE MARSH AND 4 RENOURISHMENTS | | | | | | |
|---|---|---|---|---|---|---|
| | | TY31* | TY32 | TY33 | TY35 | TY40 |
| **DIRECT** | | | | | | |
| MARSH | OPEN WATER | 0 | 0 | 0 | 0 | 0 |
| | MARSH | 640 | 640 | 640 | 640 | 640 |
| HEADLAND | SUPRATIDAL | 331 | 244 | 199 | 216 | 138 |
| | DUNE | 671 | 672 | 656 | 519 | 264 |
| | GULF INTERTIDAL | 58 | 58 | 58 | 53 | 53 |
| | GULF SUBTIDAL | 223 | 309 | 370 | 495 | 828 |
| **INDIRECT** | | | | | | |
| MARSH | OPEN WATER | 808 | 808 | 808 | 808 | 1829 |
| | MARSH | 1021 | 1021 | 1021 | 1021 | 0 |
| | **TOTALS** | 3752 | 3752 | 3752 | 3752 | 3752 |

# CAMINADA HEADLAND WVA ACREAGES

| TABLE 16: FUTURE WITH PROJECT (FWP) - ALTERNATIVE 8 (TY 41- 50) OPTIMIZED PROJECT W/ BASE MARSH AND 4 RENOURISHMENTS | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | TY41*** | TY42 | TY43 | TY45 | TY50 |
| **DIRECT** | | | | | | |
| MARSH | OPEN WATER | 0 | 0 | 0 | 0 | 0 |
| | MARSH | 640 | 640 | 640 | 640 | 640 |
| HEADLAND | SUPRATIDAL | 331 | 244 | 199 | 216 | 138 |
| | DUNE | 671 | 672 | 656 | 519 | 264 |
| | GULF INTERTIDAL | 58 | 58 | 58 | 53 | 53 |
| | GULF SUBTIDAL | 223 | 309 | 370 | 495 | 828 |
| **INDIRECT** | | | | | | |
| MARSH | OPEN WATER | 1829 | 1829 | 1829 | 1829 | 1829 |
| | MARSH | 0 | 0 | 0 | 0 | 0 |
| | **TOTALS** | 3752 | 3752 | 3752 | 3752 | 3752 |

* BEACH RE-NOURISHMENT ONLY
** MARSH RE-NOURISHMENT ONLY
***BEACH AND MARSH RE-NOURISHMENT

# CAMINADA HEADLAND WVA ACREAGES

| TABLE 17: FUTURE WITHOUT PROJECT (FWOP) - ALTERNATIVE 9 PREFERRED DUNE W/ EXPANDED MARSH | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | TY0 | TY1 | TY10 | TY20 | TY50 |
| **DIRECT** | | | | | | |
| MARSH | OPEN WATER | 413 | 414 | 366 | 22 | 5 |
| | MARSH | 876 | 868 | 580 | 43 | 22 |
| HEADLAND | SUPRATIDAL | 356 | 316 | 113 | 0 | 0 |
| | DUNE | 29 | 25 | 0 | 0 | 0 |
| | GULF INTERTIDAL | 100 | 78 | 15 | 0 | 0 |
| | GULF SUBTIDAL | 512 | 587 | 1214 | 2222 | 2260 |
| **INDIRECT** | | | | | | |
| MARSH | OPEN WATER | 566 | 565 | 586 | 720 | 1492 |
| | MARSH | 926 | 926 | 905 | 771 | 0 |
| | **TOTALS** | 3779 | 3779 | 3779 | 3779 | 3779 |

| TABLE 18: FUTURE WITH PROJECT (FWP) - ALTERNATIVE 9 (TY 1 - 10) OPTIMIZED PROJECT W/ EXPANDED MARSH AND 4 RENOURISHMENTS | | | | | | |
|---|---|---|---|---|---|---|
| | | TY1*** | TY2 | TY3 | TY5 | TY10 |
| **DIRECT** | | | | | | |
| MARSH | OPEN WATER | 0 | 0 | 0 | 0 | 0 |
| | MARSH | 1186 | 1186 | 1186 | 1062 | 898 |
| HEADLAND | SUPRATIDAL | 266 | 179 | 133 | 186 | 170 |
| | DUNE | 554 | 554 | 538 | 490 | 328 |
| | GULF INTERTIDAL | 58 | 58 | 58 | 53 | 55 |
| | GULF SUBTIDAL | 223 | 309 | 370 | 495 | 835 |
| **INDIRECT** | | | | | | |
| MARSH | OPEN WATER | 567 | 567 | 567 | 567 | 567 |
| | MARSH | 926 | 926 | 926 | 926 | 926 |
| | **TOTALS** | 3779 | 3779 | 3779 | 3779 | 3779 |

| TABLE 18: FUTURE WITH PROJECT (FWP) - ALTERNATIVE 9 (TY 11 - 20) OPTIMIZED PROJECT W/ EXPANDED MARSH AND 4 RENOURISHMENTS | | | | | | |
|---|---|---|---|---|---|---|
| | | TY11*** | TY12 | TY13 | TY15 | TY20 |
| **DIRECT** | | | | | | |
| MARSH | OPEN WATER | 0 | 0 | 0 | 0 | 0 |
| | MARSH | 898 | 898 | 898 | 898 | 898 |
| HEADLAND | SUPRATIDAL | 374 | 287 | 241 | 294 | 170 |
| | DUNE | 734 | 734 | 718 | 545 | 328 |
| | GULF INTERTIDAL | 58 | 58 | 58 | 53 | 55 |
| | GULF SUBTIDAL | 223 | 309 | 370 | 495 | 835 |
| **INDIRECT** | | | | | | |
| MARSH | OPEN WATER | 567 | 567 | 567 | 567 | 567 |
| | MARSH | 926 | 926 | 926 | 926 | 926 |
| | **TOTALS** | 3779 | 3779 | 3779 | 3779 | 3779 |

| TABLE 18: FUTURE WITH PROJECT (FWP) - ALTERNATIVE 9 (TY 21 - 30) OPTIMIZED PROJECT W/ EXPANDED MARSH AND 4 RENOURISHMENTS | | | | | | |
|---|---|---|---|---|---|---|
| | | TY21*** | TY22 | TY23 | TY25 | TY30 |
| **DIRECT** | | | | | | |
| MARSH | OPEN WATER | 0 | 0 | 0 | 0 | 0 |
| | MARSH | 898 | 898 | 898 | 898 | 898 |
| HEADLAND | SUPRATIDAL | 374 | 287 | 241 | 294 | 170 |
| | DUNE | 734 | 734 | 718 | 545 | 328 |
| | GULF INTERTIDAL | 58 | 58 | 58 | 53 | 55 |
| | GULF SUBTIDAL | 223 | 309 | 370 | 495 | 835 |
| **INDIRECT** | | | | | | |
| MARSH | OPEN WATER | 567 | 567 | 567 | 567 | 567 |
| | MARSH | 926 | 926 | 926 | 926 | 926 |
| | **TOTALS** | 3779 | 3779 | 3779 | 3779 | 3779 |

| TABLE 18: FUTURE WITH PROJECT (FWP) - ALTERNATIVE 9 (TY 31 - 40) OPTIMIZED PROJECT W/ EXPANDED MARSH AND 4 RENOURISHMENTS | | | | | | |
|---|---|---|---|---|---|---|
| | | TY31*** | TY32 | TY33 | TY35 | TY40 |
| **DIRECT** | | | | | | |
| MARSH | OPEN WATER | 0 | 0 | 0 | 0 | 0 |
| | MARSH | 898 | 898 | 898 | 898 | 898 |
| HEADLAND | SUPRATIDAL | 374 | 287 | 241 | 294 | 170 |
| | DUNE | 734 | 734 | 718 | 545 | 328 |
| | GULF INTERTIDAL | 58 | 58 | 58 | 53 | 55 |
| | GULF SUBTIDAL | 223 | 309 | 370 | 495 | 835 |
| **INDIRECT** | | | | | | |
| MARSH | OPEN WATER | 567 | 567 | 567 | 567 | 1493 |
| | MARSH | 926 | 926 | 926 | 926 | 0 |
| | **TOTALS** | 3779 | 3779 | 3779 | 3779 | 3779 |

# CAMINADA HEADLAND WVA ACREAGES

| TABLE 18: FUTURE WITH PROJECT (FWP) - ALTERNATIVE 9 (TY 41 - 50) OPTIMIZED PROJECT W/ EXPANDED MARSH AND 4 RENOURISHMENTS | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | TY41*** | TY42 | TY43 | TY45 | TY50 |
| **DIRECT** | | | | | | |
| MARSH | OPEN WATER | 0 | 0 | 0 | 0 | 0 |
| | MARSH | 898 | 898 | 898 | 898 | 898 |
| HEADLAND | SUPRATIDAL | 374 | 287 | 241 | 294 | 170 |
| | DUNE | 734 | 734 | 718 | 545 | 328 |
| | GULF INTERTIDAL | 58 | 58 | 58 | 53 | 55 |
| | GULF SUBTIDAL | 223 | 309 | 370 | 495 | 835 |
| **INDIRECT** | | | | | | |
| MARSH | OPEN WATER | 1493 | 1493 | 1493 | 1493 | 1493 |
| | MARSH | 0 | 0 | 0 | 0 | 0 |
| | **TOTALS** | 3779 | 3779 | 3779 | 3779 | 3779 |

* BEACH RE-NOURISHMENT ONLY
** MARSH RE-NOURISHMENT ONLY
***BEACH AND MARSH RE-NOURISHMENT

# CAMINADA HEADLAND WVA ACREAGES

| TABLE 19: FUTURE WITHOUT PROJECT (FWOP) - ALTERNATIVE 10 OPTIMIZED PROJECT W/ EXPANDED MARSH AND 4 RENOURISHMENTS AND FULL STORM PROTECTION | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | TY0 | TY1 | TY10 | TY20 | TY50 |
| **DIRECT** | | | | | | |
| MARSH | OPEN WATER | 413 | 414 | 366 | 22 | 5 |
| | MARSH | 876 | 868 | 580 | 43 | 22 |
| HEADLAND | SUPRATIDAL | 356 | 316 | 113 | 0 | 0 |
| | DUNE | 29 | 25 | 0 | 0 | 0 |
| | GULF INTERTIDAL | 100 | 78 | 15 | 0 | 0 |
| | GULF SUBTIDAL | 512 | 587 | 1214 | 2222 | 2260 |
| **INDIRECT** | | | | | | |
| MARSH | OPEN WATER | 566 | 565 | 586 | 720 | 1492 |
| | MARSH | 926 | 926 | 905 | 771 | 0 |
| | **TOTALS** | 3779 | 3779 | 3779 | 3779 | 3779 |

| TABLE 20: FUTURE WITH PROJECT (FWP) - ALTERNATIVE 10 (TY 1 - 10) OPTIMIZED PROJECT W/ EXPANDED MARSH AND 4 RENOURISHMENTS AND FULL STORM PROTECTION | | | | | | |
|---|---|---|---|---|---|---|
| | | TY1*** | TY2 | TY3 | TY5 | TY10 |
| **DIRECT** | | | | | | |
| MARSH | OPEN WATER | 0 | 0 | 0 | 0 | 0 |
| | MARSH | 1186 | 1186 | 1186 | 1186 | 996 |
| HEADLAND | SUPRATIDAL | 371 | 289 | 243 | 175 | 230 |
| | DUNE | 554 | 554 | 538 | 481 | 267 |
| | GULF INTERTIDAL | 55 | 55 | 58 | 59 | 56 |
| | GULF SUBTIDAL | 120 | 201 | 261 | 384 | 737 |
| **INDIRECT** | | | | | | |
| MARSH | OPEN WATER | 567 | 567 | 567 | 567 | 567 |
| | MARSH | 926 | 926 | 926 | 926 | 926 |
| | **TOTALS** | 3779 | 3779 | 3779 | 3779 | 3779 |

| TABLE 20: FUTURE WITH PROJECT (FWP) - ALTERNATIVE 10 (TY 11 - 20) OPTIMIZED PROJECT W/ EXPANDED MARSH AND 4 RENOURISHMENTS AND FULL STORM PROTECTION | | | | | | |
|---|---|---|---|---|---|---|
| | | TY11* | TY12 | TY13 | TY15 | TY20 |
| **DIRECT** | | | | | | |
| MARSH | OPEN WATER | 0 | 0 | 0 | 0 | 0 |
| | MARSH | 996 | 996 | 996 | 996 | 996 |
| HEADLAND | SUPRATIDAL | 561 | 479 | 433 | 365 | 230 |
| | DUNE | 554 | 554 | 538 | 481 | 267 |
| | GULF INTERTIDAL | 55 | 55 | 58 | 59 | 56 |
| | GULF SUBTIDAL | 120 | 201 | 261 | 384 | 737 |
| **INDIRECT** | | | | | | |
| MARSH | OPEN WATER | 567 | 567 | 567 | 567 | 567 |
| | MARSH | 926 | 926 | 926 | 926 | 926 |
| | **TOTALS** | 3779 | 3779 | 3779 | 3779 | 3779 |

| TABLE 20: FUTURE WITH PROJECT (FWP) - ALTERNATIVE 10 (TY 21 - 30) OPTIMIZED PROJECT W/ EXPANDED MARSH AND 4 RENOURISHMENTS AND FULL STORM PROTECTION | | | | | | |
|---|---|---|---|---|---|---|
| | | TY21*** | TY22 | TY23 | TY25 | TY30 |
| **DIRECT** | | | | | | |
| MARSH | OPEN WATER | 0 | 0 | 0 | 0 | 0 |
| | MARSH | 996 | 996 | 996 | 996 | 996 |
| HEADLAND | SUPRATIDAL | 561 | 479 | 433 | 365 | 230 |
| | DUNE | 554 | 554 | 538 | 481 | 267 |
| | GULF INTERTIDAL | 55 | 55 | 58 | 59 | 56 |
| | GULF SUBTIDAL | 120 | 201 | 261 | 384 | 737 |
| **INDIRECT** | | | | | | |
| MARSH | OPEN WATER | 567 | 567 | 567 | 567 | 567 |
| | MARSH | 926 | 926 | 926 | 926 | 926 |
| | **TOTALS** | 3779 | 3779 | 3779 | 3779 | 3779 |

| TABLE 20: FUTURE WITH PROJECT (FWP) - ALTERNATIVE 10 (TY 31 - 40) OPTIMIZED PROJECT W/ EXPANDED MARSH AND 4 RENOURISHMENTS AND FULL STORM PROTECTION | | | | | | |
|---|---|---|---|---|---|---|
| | | TY31* | TY32 | TY33 | TY35 | TY40 |
| **DIRECT** | | | | | | |
| MARSH | OPEN WATER | 0 | 0 | 0 | 0 | 0 |
| | MARSH | 996 | 996 | 996 | 996 | 996 |
| HEADLAND | SUPRATIDAL | 561 | 479 | 433 | 365 | 230 |
| | DUNE | 554 | 554 | 538 | 481 | 267 |
| | GULF INTERTIDAL | 55 | 55 | 58 | 59 | 56 |
| | GULF SUBTIDAL | 120 | 201 | 261 | 384 | 737 |
| **INDIRECT** | | | | | | |
| MARSH | OPEN WATER | 567 | 567 | 567 | 567 | 1493 |
| | MARSH | 926 | 926 | 926 | 926 | 0 |
| | **TOTALS** | 3779 | 3779 | 3779 | 3779 | 3779 |

# CAMINADA HEADLAND WVA ACREAGES

| TABLE 20: FUTURE WITH PROJECT (FWP) - ALTERNATIVE 10 (TY 41 - 50) OPTIMIZED PROJECT W/ EXPANDED MARSH AND 4 RENOURISHMENTS AND FULL STORM PROTECTION | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | TY41*** | TY42 | TY43 | TY45 | TY50 |
| **DIRECT** | | | | | | |
| MARSH | OPEN WATER | 0 | 0 | 0 | 0 | 0 |
| | MARSH | 996 | 996 | 996 | 996 | 996 |
| HEADLAND | SUPRATIDAL | 561 | 479 | 433 | 365 | 230 |
| | DUNE | 554 | 554 | 538 | 481 | 267 |
| | GULF INTERTIDAL | 55 | 55 | 58 | 59 | 56 |
| | GULF SUBTIDAL | 120 | 201 | 261 | 384 | 737 |
| **INDIRECT** | | | | | | |
| MARSH | OPEN WATER | 1493 | 1493 | 1493 | 1493 | 1493 |
| | MARSH | 0 | 0 | 0 | 0 | 0 |
| | **TOTALS** | 3779 | 3779 | 3779 | 3779 | 3779 |

* BEACH RE-NOURISHMENT ONLY
** MARSH RE-NOURISHMENT ONLY
***BEACH AND MARSH RE-NOURISHMENT

# QUANTIFYING BENEFITS OF FEEDER BEACH RENOURISHMENT STRATEGY FOR CAMINADA HEADLAND

## SHORELINE CHANGE MODELING REPORT

**Prepared for:**

**U.S Army Corps of Engineers**
**New Orleans District**

**State of Louisiana Office of Coastal Protection and Restoration**

**December 13, 2010**
**CEC File No. 10.099**

COASTAL ENGINEERING CONSULTANTS INC

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## 1.0 EXECUTIVE SUMMARY

Pursuant to Coastal Engineering Consultants, Inc.'s (CEC) Work Order executed July 8, 2010 for the Barataria Basin Barrier Island Shoreline Restoration-Caminada Headland Segment, CEC has completed a benefits analysis of constructing a feeder beach along the nodal zone of the Caminada Headland through beneficial use of the dredge material from the maintenance dredging of Belle Pass.

This Report details shoreline change modeling based on a coupled wave/shoreline change model performed to evaluate feeder beach management measures. The Steady State Spectral Wave (STWAVE) model was used to transform wave data from offshore locations to locations near the surf zone. The Generalized Model for Simulating Shoreline Change (GENESIS) uses this information to simulate shoreline change due to wave-driven longshore sediment transport. The model assumes that the cross-shore profile is in equilibrium, so that morphological change can be represented by the change in shoreline position alone.

GENESIS coupled with STWAVE is a widely accepted longshore sediment transport model utilized for predicting long-term planform evolution of a beach in response to imposed wave conditions as well as simulating beach fill diffusion and response to coastal structures. The model's use is considered standard practice both in the United States and internationally as evidenced by the many documented applications in professional journals and conference proceedings.

Two measures were evaluated, 1) a one-time feeder beach nourishment and 2) subsequent 2-year cycle feeder beach renourishments. The model results were utilized to assess the performance of the measures on the evolution of habitat acres over time. Based on the modeling, it was concluded that the feeder beach will benefit the Headland both to the east and west as longshore transport nourishes the beach face profile and adds width to the shoreline. With the one-time nourishment, at the end of the 2-year period the feeder beach diffuses to the east and west of its initial placement by approximately 2,000 feet. With the 2-year periodic renourishments, at the end of the 50-year period the feeder beach diffuses to the east and west of its initial placement by approximately 18,600 feet, resulting in approximately 44,000 feet of the Caminada Headland benefiting from the renourishments.

The complexity of the erosional and depositional processes at play in this environment naturally dictates that numerical model results should be used with caution and in conjunction with other empirical evidence. Further, due to the lack of historic shoreline data and wave parameter time series spanning the time frame corresponding to the

historic shorelines, the GENESIS model was not calibrated. Therefore, it is recommended in the Planning, Engineering, and Design (PED) phase that the modeling program be refined through additional model calibration and verification to improve quantifying the benefits from the feeder beach.

## 2.0 INTRODUCTION

Caminada Headland, located in Lafourche Parish, Louisiana, is approximately 13 miles in length and extends from the Belle Pass entrance near Port Fourchon on the western end to Caminada Pass on the eastern end of the headland. The Caminada Headland has historically suffered loss of wetland habitat and diminished function within the gulf shoreline.

The United States Army Corps of Engineers (USACE) has proposed the following strategy to achieve the renourishment requirements for the Tentatively Selected Plan (TSP) for the Caminada Headland per the 2004 Louisiana Coastal Area Ecosystem Restoration Study (USACE, 2004) which included near-shore recovery of 2 million cubic yards of sand every 10 years. The USACE operations and maintenance dredging of the federal navigation channel in Belle Pass yields approximately 500,000 cubic yards of fine grain material every 1.5 to 2 years, equal to an estimated 2 million cubic yards of material over each 10-year period throughout the 50-year period of analysis. This material is to be placed in the littoral drift south of Bayou Moreau at a nodal point where the longshore transport splits, going east and west. The material will be placed to allow the natural longshore transport and wave action to move and distribute the sediment along the headland.

This report details shoreline change modeling based on a coupled STWAVE/GENESIS model performed to evaluate specific management measures. The STWAVE model (Smith et al., 2001) transforms wave data from offshore locations to the surf zone. The GENESIS model (Hanson 1987, 1989; Hanson and Kraus 1989) is a widely accepted longshore sediment transport model utilized for predicting long-term platform evolution of a beach in response to imposed wave conditions as well as simulating beach fill diffusion and response to coastal structures.

One alternative for evaluating the benefits from a feeder beach is to examine the nourishment that will occur on the Caminada Headland as longshore transport processes spread the sand to the east and west as the feeder beach diffuses over time.

## 3.0 GEOMORPHIC SETTING

According to Rosati and Stone (2009), Ritchie and Penland (1988) monitored 13 cross-shore transects over a 10-year period along the Caminada Headland extending from Belle Pass to Caminada Pass. The coastal landforms and morphologic response were characterized as one of four types. (1) The Washover Flat consisted of a low elevation washover sheet with embryonic dunes that could reach 1 m in elevation during non–storm conditions. However, the dunes did not survive more than a year, and vegetation could not be established because of the frequency of overwash, which exceeded 15 events per year. The entire flat was inundated by unrestricted sheet flow. (2) The Washover Terrace was slightly higher in elevation, smooth, and vegetated or broken up with hummocky topography. Vegetation spread and recovered rapidly because of overwash, thereby promoting capture of Aeolian sediment. (3) The Dune Terrace had an elevation 0.5–1.5m higher than the Washover Terrace and exhibited more varied relief. Topographically low points along the frontal dune along the barrier could be overwashed, resulting in washover deposits on the back-barrier. (4) The Continuous Dune was characterized by two or more parallel dune ridges that were vegetated with abundant backshore sand. During storms the seaward-facing dunes were scarped and the fore dunes could be completely removed. Washover fans were sparse because of the height and the morphological integrity of the vegetated dunes.

There are three primary causes of rapid erosion and disintegration of the Headland. The first cause is that it is not connected to any outside sediment source and hence starved of sediments. The second cause is the compaction and subsidence of the underlying deltaic material, which results in a relative lowering of the profile due to the relative sea-level rise. A final cause for the rapid land loss is the impact of catastrophic storm activity which removes material from both the Gulf-side and bay-side, resulting in landward migration which then exposes the underlying deltaic material to wave attack. Anthropogenic influences such as Mississippi River flood control and oil/gas exploration contribute significant to the first two causes.

Cross-shore profiles on these shorelines exhibit a break in slope around the 2 to 3 meter isobaths. Above this point the profile is of the approximate form $y = ax^{2/3}$ and the material is made up of sand with median grain size in the range 0.10 to 0.14 mm. Below this point the profile is distinctly flat and composed mostly of silts and clays. The Headland is low-lying and typically experiences wash-over during major storms. It is noted that the morphologic responses to the two major storm systems – cold fronts and hurricanes – are distinctly different.

Campbell (2005) developed a conceptual morphodynamic model for the shoreline retreat observed west of the Plaquemine-modern delta of the Mississippi River based on the analysis of historical beach profiles. The underlying substrate of the barrier system is made up of mixed deltaic sediment (sand, silt, and clay). This material is covered by a thin veneer of sand which is eroded during storms exposing the underlying marsh sediment. In the aftermath of major storms, this exposed material is subsequently eroded by wave action. Fine sediment is suspended and lost from the littoral system and coarser material is either transported offshore or alongshore, ending up in tidal inlets to be transported into the bays behind the headlands / islands. Inlet formation plays a major role in the landward migration of the headlands / islands, for example, inlets facilitate cross-shore movement of sediment through ebb/flood shoal formation.

## 4.0 DESCRIPTION OF NUMERICAL MODELS

## 4.1 STWAVE Model

Wave information immediately outside of the surf zone is required as input for the longshore sediment transport and shoreline change estimates. Typically, wave information is only available at offshore locations and this information must be transformed to the edge of the surf zone for use by GENESIS. STWAVE was used in this study to perform this wave transformation.

STWAVE is a steady-state, phase-averaged spectral wave model for the simulation of wind-wave growth and propagation in arbitrary depths. The model simulates wind-wave growth; refraction and shoaling due to both bathymetric features and currents; depth- or steepness-limited wave breaking; wave diffraction; wave-wave interactions; and white-capping by solving the spectral action balance equation along backward traced rays (Smith et al., 2001).

The spectral action balance equation is of the form:

$$\left(C_{ga}\right)_x \frac{\partial}{\partial x}\frac{C_a C_{ga}\cos(\mu-\alpha)E(f,\alpha)}{\omega_r}+\left(C_{ga}\right)_y \frac{\partial}{\partial y}\frac{C_a C_{ga}\cos(\mu-\alpha)E(f,\alpha)}{\omega_r}=\sum\left[\frac{S}{\omega_r}\right] \quad [1]$$

where $C_{ga}$ is absolute wave group celerity; $[x,y]$ denote x and y components respectively; $C_a$ is absolute wave celerity; $\mu$ is the current direction; $\alpha$ is the propagation direction of a spectral component; $E$ is the spectral energy density; $f$ is the frequency of spectral component; $\omega_r$ is the relative angular frequency; and $S$ represents energy sources and sinks (i.e. momentum from winds, losses from whitecapping or

breaking, etc.). Numerical solution of the spectral action balance equation is achieved using a finite difference scheme formulated on a Cartesian grid system.

In the surf zone the maximum wave height is limited by water depth and wave steepness based on the Miche criterion:

$$(H_{m0})_{max} = 0.1L \tanh kd \qquad [2]$$

where $H_{m0}$ is the zero-moment wave height, $L$ is wavelength, $k$ is wave number, and $d$ is the total water depth. The STWAVE model assumes: mild slope and limited wave reflection; steady-state waves, currents, and winds; linear refraction and shoaling; depth-uniform current; negligible bottom-friction; and linear radiation stress. Model input required for the shoreline change application are bathymetry, model grid, and offshore directional wave spectrum at the open ocean boundary. The transformed wave conditions are stored at nearshore locations for use by GENESIS.

## 4.2 GENESIS Model

GENESIS belongs to the class of shoreline change models known as one-line models. The underlying assumption is that the cross-shore beach profile does not change with time, so that the active profile only moves parallel to itself. Assuming that the cross-shore profile is in long-term equilibrium (i.e. cross-shore movement of sediment averages out over time), the rate of shoreline change ($\partial y/\partial t$) is simply a function of the variation in longshore sediment transport ($\partial Q/\partial x$). It follows from the principle of mass conservation (Hanson, 1989) that:

$$\frac{\partial y}{\partial t} + \frac{1}{D_B + D_C}\left(\frac{\partial Q}{\partial x} - q\right) = 0 \qquad [3]$$

where $D_C$ is the depth of closure, $D_B$ is the berm height, and $q$ accounts for sediment sources and sinks.

In GENESIS, the longshore transport rate ($Q$) is parameterized on breaking wave conditions as follows:

$$Q = \left\{H^2 C_g \left(a_1 \sin 2\theta - a_2 \cos\theta \frac{\partial H}{\partial x}\right)\right\}_b \qquad [4]$$

where $H$ is the breaking wave height; $C_g$ is the wave celerity, $b$ denotes breaking wave conditions, $\theta$ is the dominant wave direction, and $a_1$ and $a_2$ are dimensionless coefficients given by:

$$a_1 = \frac{K_1}{16\left(\rho_s/\rho\right)(1-p)(1.416)^{5/2}}$$

$$a_2 = \frac{K_2}{8\left(\rho_s/\rho\right)(1-p)\tan\beta\,(1.416)^{7/2}}$$

where $K_1$ and $K_2$ are empirical constants, $\rho_s$ is the density of sand, $\rho$ is the density of water, $p$ is the porosity of sand and $\tan\beta$ is the average slope of the active beach profile. In a coupled STWAVE/GENESIS application, GENESIS receives wave height and wave direction information at the edge of the surf zone. This wave information is transformed by internal wave transformation routines in GENESIS to the point of breaking using Snell's law. Since the model assumes an equilibrium profile, the basic inputs required for running GENESIS are an initial shoreline position, the average height of the beach berm, the depth of closure, and the effective grain diameter which are used to define an equilibrium profile.

# 5.0 DATA

## 5.1 Historical Shorelines

The Barrier Island Comprehensive Monitoring (BICM) project provides a comprehensive dataset of shoreline change data covering the period 1855 to 2005 based on the analysis of historical maps, aerial photography and satellite imagery (Martinez, 2006). Quantification of shoreline change patterns and rates of change were conducted based on shore perpendicular transects spaced at 50-meter intervals using the high-water line as the official shoreline. The average historical (1855-2005) shoreline change rate for the Louisiana Coastal Zone was -2.7 m/yr. Over the past decade this change rate has accelerated to -8.2 m/yr with the impacts of Hurricanes Katrina and Rita accelerating the rate of retreat to -57.8 m/yr between 2004 and 2005 (BICM Task Order 3). The BICM dataset is primarily based on four time periods: 1855-2005, 1920-2005, 1996-2005 and 2004-2005.

## 5.2 Wave and Wind Climate

Wave data was sourced from the Wave Information Studies (WIS) conducted by the Coastal Hydraulics Laboratory (CHL) and Engineer Research and Development Center (ERDC), Vicksburg, Mississippi. WIS data provides directional wave climate information for shorelines of the Gulf of Mexico based on a 20-year hindcast using the 2nd generation wave model WISWAVE. The current hindcast covers the period 1980 to

1999, and provides hourly hindcasts of the significant wave height, peak spectral period and the dominant wave direction. WIS Station 130 was chosen to provide offshore wave data for this work because its location is closest to the center of the Caminada Headland.

Statistical analysis of the wave and wind data at WIS-130 (Figures 1 and 2) indicates that there are three dominant directions (22.5° directional bands) that the waves enter the computational domain from: 135° (clockwise from true North), 157.5° and 112.5°, which occur in 18%, 15% and 13% of all cases, respectively. The average wave heights and periods for the three directions are shown in Table 1. The dominant wind direction, 135°, is in agreement with the dominant wave direction. The average wind speed for three most dominant wind directions are summarized in Table 2.

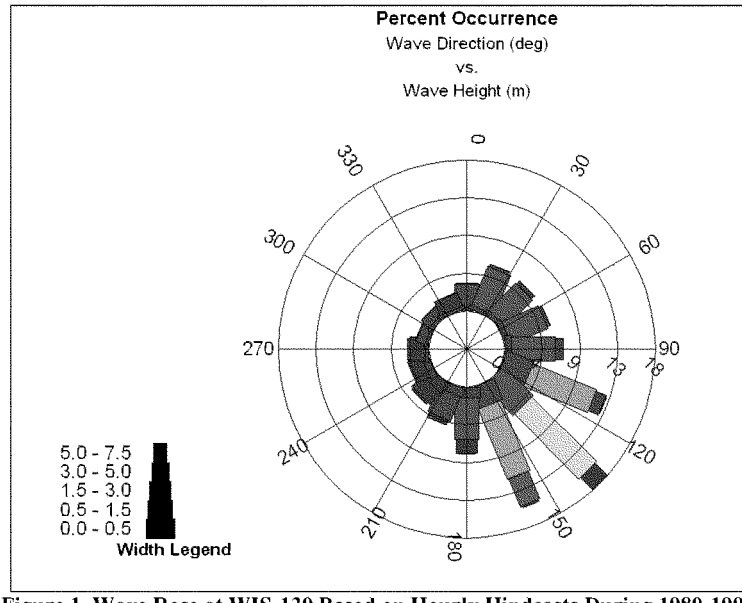


**Figure 1. Wave Rose at WIS-130 Based on Hourly Hindcasts During 1980-1999.**

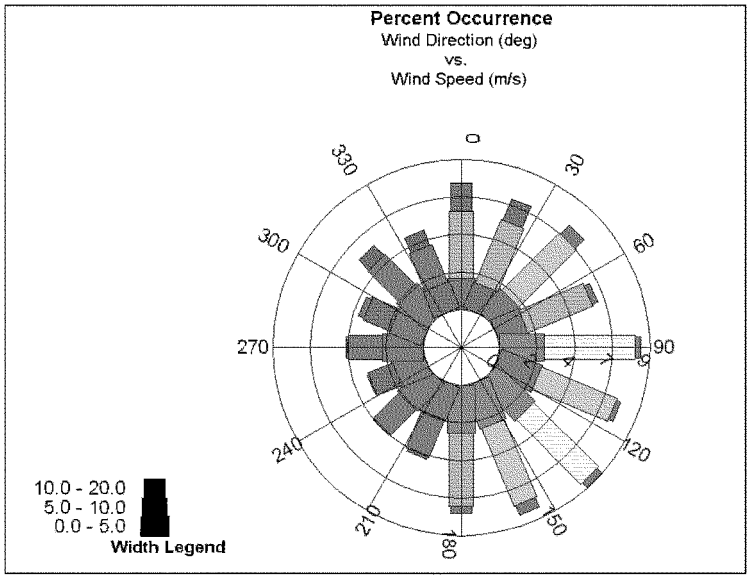


**Figure 2. Wind Rose at WIS-130 Based on Hourly Hindcasts During 1980-1999.**

Tables 1 and 2 below list average wave and wind conditions for the three dominant wave directions at WIS-130 along with their average values which are used in STWAVE simulations.

**Table 1: Average Wave Heights and Periods and Wind Speed and WIS-130.**

| # | **Wave Direction (deg)** | Wave Height (m) | Wave Height (ft) | Wave Period (s) |
|---|---|---|---|---|
| 1 | **135.0** | 0.9 | 3.0 | 4.6 |
| 2 | **157.5** | 1.1 | 3.6 | 5.0 |
| 3 | **112.5** | 0.9 | 3.0 | 4.4 |

**Table 2: Average Wind Speeds at WIS-130.**

| # | **Wind Direction (deg)** | Wind Speed (m/s) | Wind Speed (ft/s) |
|---|---|---|---|
| 1 | **135.0** | 6.1 | 20.0 |
| 2 | **90.0** | 6.2 | 20.3 |
| 3 | **157.5** | 6.4 | 21.0 |

## 5.3 Bathymetry

Bathymetric information for the Caminada Headland area was taken from the 2006 BICM survey data. These data provide dense nearshore profiles in addition to survey information which extends 4 to 5 miles offshore.

## 5.4 Beach and Sediment Transport Characteristics

According to Georgiou *et al.* (2005), who developed longshore sediment transport estimates in coastal Louisiana, the longshore sediment transport rate between Belle Pass, west of the Caminada Headland, and Grand Pass, east of the Caminada Headland, is eastward and equals approximately 146,000 $m^3$/year. Further, there is a drift divide midway along the Caminada Headland.

The sediment data representing the material dredged from Belle Pass indicates the material that comprises the headland is fine grain with low mean grain sizes (d50) on the order of 0.02 to 0.07 mm.

# 6.0 Model Setup

## 6.1 STWAVE Model Setup

The coupled STWAVE/GENESIS model was set up in NEMOS (Nearshore Evolution Modeling System). NEMOS provides a user interface which allows for the efficient generation of both STWAVE and GENESIS model grids and the preparation of model input files. The BICM bathymetric data were imported and triangulated in NEMOS, after which a uniform computational grid was generated.

Figure 3 presents the extent of the STWAVE model grid and the model bathymetry, respectively. The grid was 5,800 m in the cross-shore direction by 20,900 m in the alongshore direction. The grid cell spacing was 25 m for a total of 193,952 grid cells. The azimuth of the x-axis (cross-shore) was 325°. The shoreline position is also depicted in the figure.

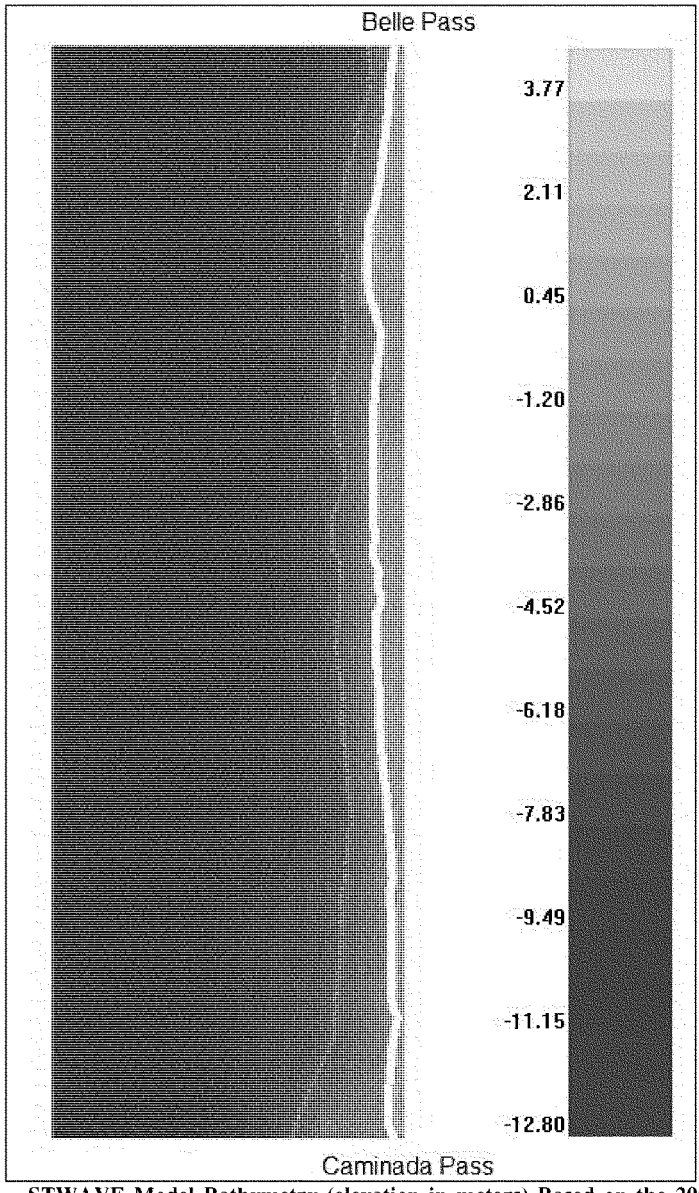


**Figure 3. STWAVE Model Bathymetry (elevation in meters) Based on the 2006 BICM Data. White Line Delineates Shoreline and Blue Triangles Depict Nearshore Wave Stations.**

Because it is impractical to run STWAVE at each shoreline simulation time step, the typical STWAVE/GENESIS application utilizes a time saving procedure in which offshore wave conditions are binned into wave height, wave period and wave direction bands. Combinations of these wave conditions are transformed to nearshore locations at which refraction coefficients are determined for each height-period-direction combination. For every time step in the shoreline simulation, GENESIS applies a unique refraction coefficient for each offshore wave event, which is determined as the ratio of the offshore wave height to the transformed wave height.

Wave data used in the model were obtained from 1980-1999 hindcasts at WIS Station 130 located at LAT=29.0N, LON=90.0W. The data were analyzed to identify 172 different wave height, period, and direction combinations that represented wave conditions in the project area. The following ranges were used for the wave parameters:

Height: 0 – 0.5 m; 0.5 – 1.0 m; 1.0 – 3.0 m; 3.0 – 5.0 m; 5.0 – 10.0 m;
Period: 0 – 5 s; 5-7 s; 7 – 9 s; 9 – 11 s; 11 – 13 s; 13 – 15 s;
Direction: sixteen 22.5° wave angle bands.

Wave input spectra for STWAVE were derived for each of 172 combinations. For simplicity, wave spectra based on WIS-130 data were applied directly along the STWAVE offshore boundary. STWAVE was then run to calculate wave transformation to the nearshore. The nearshore output wave stations (blue triangles in Figure 3) were located along the 5-meter bathymetric contour seaward of the Caminada Headland in every 5$^{th}$ STWAVE grid cell.

## 6.2 GENESIS Model Setup

The one-dimensional (1D) grid required by GENESIS was generated in NEMOS. The GENESIS grid consists of a one-dimensional array of cells along the shoreline where the shoreline is represented as distances from a straight baseline. At each cell and for each simulation time step, the model requires breaking wave height and wave angle information to compute a spatially and temporally varying longshore transport rate. In NEMOS, STWAVE output stations corresponding to GENESIS grid cells can be automatically generated based on some user specified water depth. These stations were specified along the 5-meter depth contour in every 5$^{th}$ STWAVE grid cell. Based on this, a 1-D GENESIS grid was created. The grid is presented in Figure 4 and is 20,875 m in length. The grid cell spacing was 25 m for a total of 835 shoreline cells along the Caminada Headland.

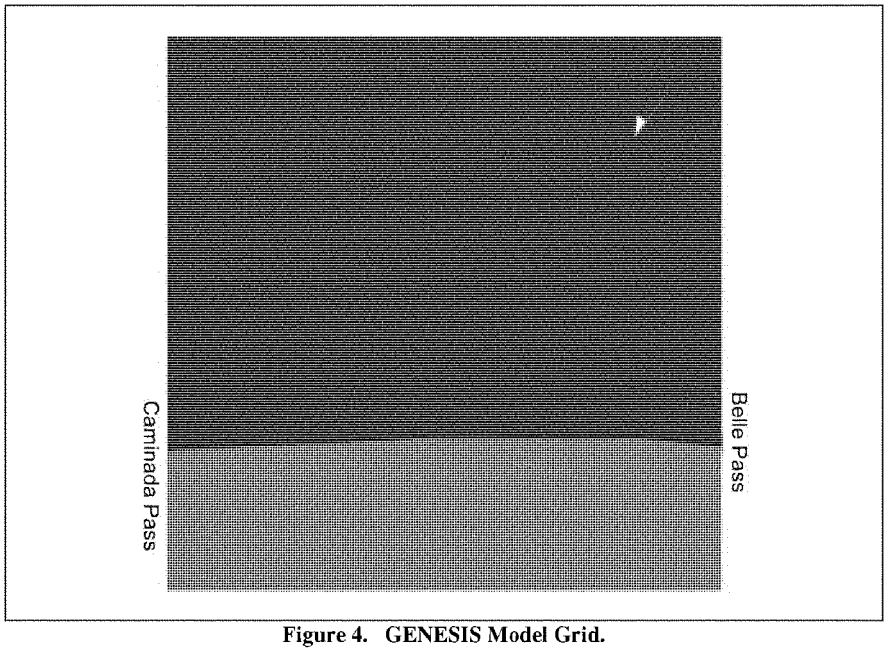


**Figure 4. GENESIS Model Grid.**

A pinned boundary condition was imposed on the east end of the shoreline near Caminada Pass due to time constraints. This boundary condition does not allow shoreline change at the boundary. It is noted the feeder beach area is far field from Caminada Pass such that this boundary condition was considered reasonable and would not affect the outcome of predicting feeder beach diffusion and subsequent benefits. On the west end, a gated groin boundary condition was imposed to represent the Belle Pass jetty.

The following parameters were used in the GENESIS simulations:

Configuration:

- Time step = 1 hour
- Recording time step = 240 hours

Sand, beach, and transport:

- Effective grain size = 0.18 mm
- Average berm height = 1.4 m (4.5 ft)
- Closure depth = 3.65 m (12 ft)
- Longshore sand transport coefficients K1=0.075, K2=0.05

Boundary conditions:

- Wave model – external
- Number of wave components = 1
- Ratio of shoreline cells to wave model cells = 5
- Height amplification factor = 1
- Angle amplification factor = 1
- Angle offset = 0
- Lateral BC – pinned (east), gated groin (west)

It should be noted that because the GENESIS model was not calibrated, model results should be interpreted carefully. It is recommended in PED that the modeling program be refined through additional model calibration and validation.

## 7.0 Performance of Beach Nourishment Measures

### 7.1 One Time Nourishment

The initial GENESIS shoreline was developed from the design template for the TSP. The assumed construction start date was 2012. The equilibrium and advanced fill was removed and two years of background erosion were applied to yield the shoreline position at 2014 equivalent to the first renourishment event. The feeder beach template at 2014 was derived as follows.

Step 1. Conduct a compatibility analysis of the Belle Pass dredge material with the native beach. In this case it will be Ship Shoal sand since the renourishment occurs after the Headland is restored full length using the Ship Shoal borrow area. Input data were the Belle Pass sediment data provided to CEC by the USACE via email of July 14, 2010 and native beach and Ship Shoal South Pelto Blocks 12 and 13 grain size data which were presented in CEC's Caminada Headland Engineering Appendix, Annex C-2 (CEC and SJB, 2008). The average mean grain size of the Belle Pass dredge material was computed to be 0.06 mm. The post-restoration average mean grain size of the Headland is predicted to be approximately 0.18 mm based on the native beach and Ship Shoal sediment data. Thus, the dredge material contains a significant greater percentage of fines requiring additional analyses to determine the effective volume that will be yielded from the renourishment strategy and contribute to the littoral system as a feeder beach.

Step 2. Determine the overfill ratio proposed by Dean (1986) to identify the "fine" percentage of the Belle Pass dredge material which will be lost in profile

equilibration / cross-shore losses and will not contribute to the littoral system. The analysis yielded an overfill ratio of 4.6.

Step 3. Determine the total dredge volume by multiplying the established volume of 500,000 cubic yards (CY) by the average ratio of the gross volume to pay volume, computed to be 1.2, equal to 620,000 CY. The gross and pay volumes were extracted from the historical dredge records provided to CEC via email on July 19, 2010, again not repeated herein for brevity but should be included by the USACE.

Step 4. Subtract the volume of "fine" sediment lost in profile equilibration / cross-shore losses from the total dredge volume to yield the effective volume of 135,000 CY that will contribute to the littoral system as a feeder beach. This "stable" volume will have an approximate mean grain size of 0.18 mm by virtue of the process completed above.

Step 5. Establish the feeder beach design template parameters. The berm elevation was chosen as mean high water (MHW), equal to +1.5 NAVD88. The seaward slope was set equal to 1:20 consistent with the TSP design template. The length of shoreline was set equal to 6,800 feet based on the Caminada Headland Renourishment Location Map provided to CEC by the USACE via email on July 20, 2010. Based on the effective volume, the average berm width was computed to be 125 feet.

Therefore, the shoreline was advanced 125 feet seaward along the 6,800 foot long renourishment location. Two 2-year long GENESIS simulations were performed, without feeder beach (WOFB) and with the feeder beach (WFB).

Figures 5 and 6 present comparisons of initial and final shorelines for the WOFB and WFB model runs, respectively. The results indicate that at the end of the 2-year period the feeder beach diffuses to the east and west of its initial placement by approximately 2,000 feet. It is reiterated that these model results should be interpreted carefully as model calibration and validation were not performed.

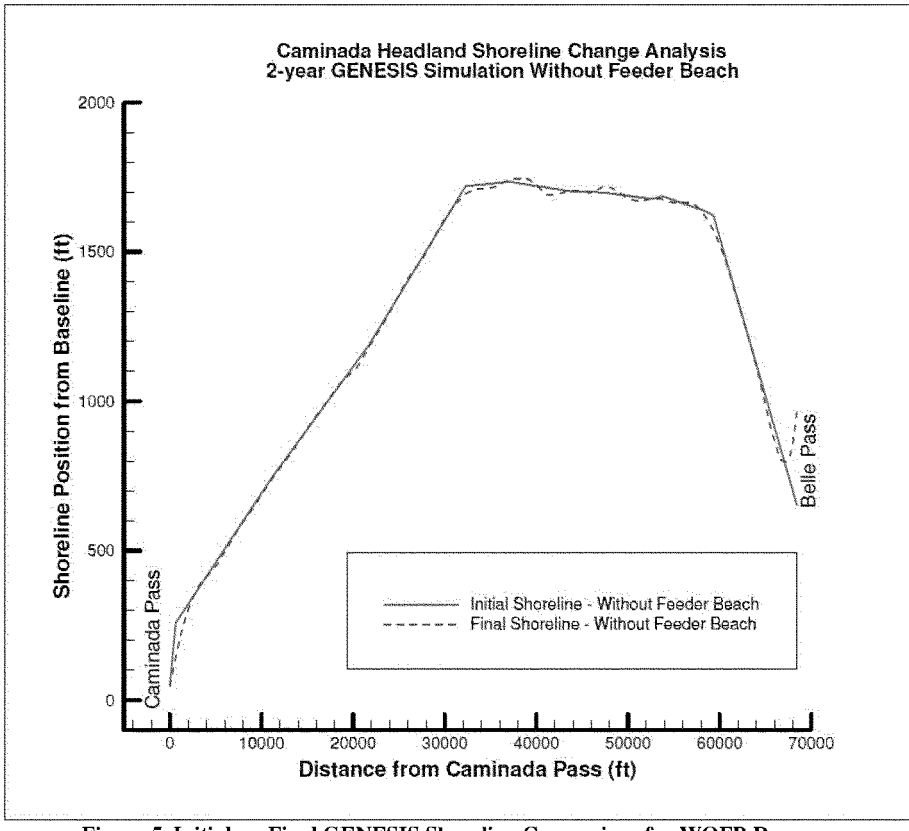


**Figure 5. Initial vs. Final GENESIS Shoreline Comparison for WOFB Run.**

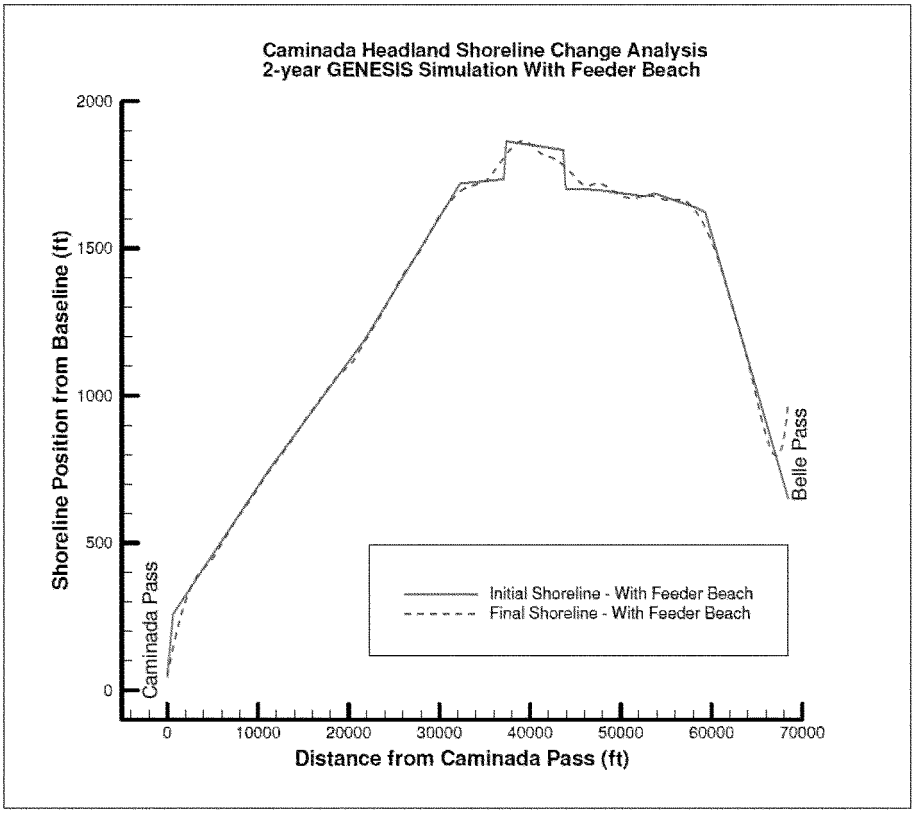


**Figure 6. Initial vs. Final GENESIS Shoreline Comparison for WFB Run.**

## 7.2 Subsequent 2-year Cycle Renourishments

In addition to a one-time feeder beach nourishment model simulation, a scenario with subsequent 2-year cycle renourishments was also developed. Similarly to the one-time nourishment simulation, the assumed construction start date was 2012 and the equilibrium and advanced fill was removed and two years of background erosion were applied to yield the shoreline position at 2014 equivalent to the first renourishment event. To include the feeder beach, the shoreline was advanced 125 feet seaward along the 6,800 foot long renourishment location. After a 2-year long simulation, the shoreline position equivalent at 2016 was advanced another 125 feet seaward along the 6,800 foot long renourishment location. This process was repeated every 2 years over a 50-year period of analysis ending in 2062.

Two 50-year GENESIS simulations, WOFB and WFB, were performed. Results of these simulations are presented in Figure 7. They indicate that at the end of the 50-year period the feeder beach diffuses to the east and west of its initial placement by approximately 18,600 feet resulting in approximately 44,000 feet of the Caminada Headland segment benefiting from the periodic renourishment.

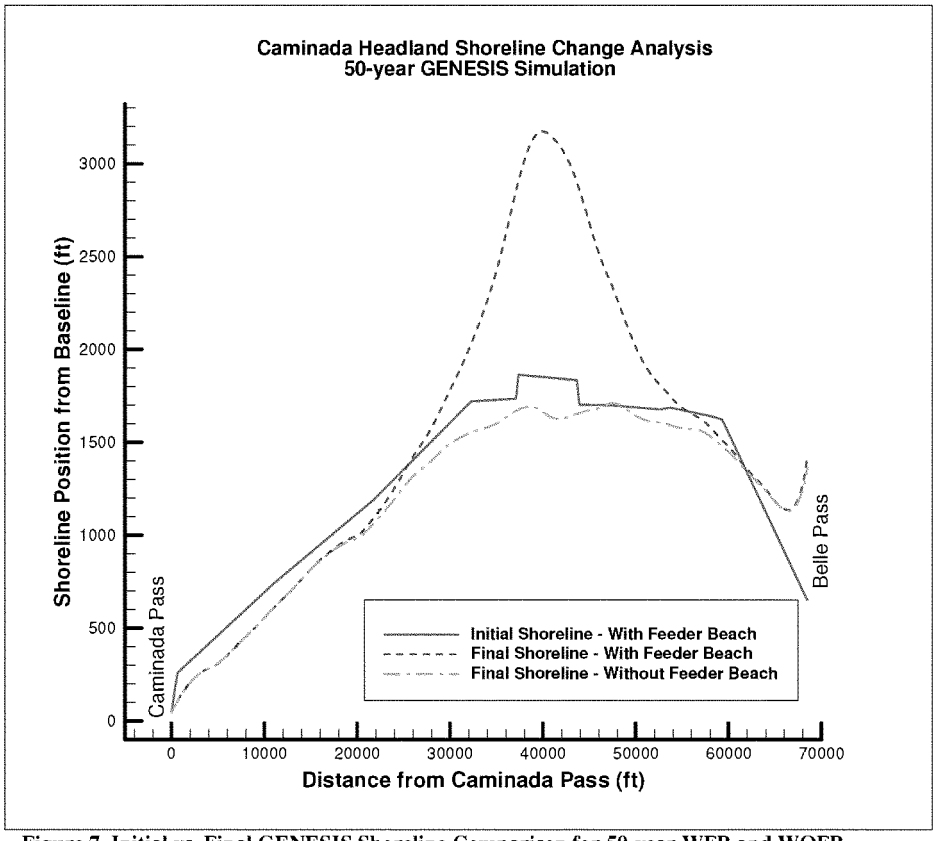


**Figure 7. Initial vs. Final GENESIS Shoreline Comparison for 50-year WFB and WOFB Runs.**

## 8.0 CONCLUSIONS

Based on the understanding of the proposed feeder beach renourishment strategy and dredge and fill method as described by the USACE in multiple correspondence (email) and personal communication, and the literature review and benefits analysis, the dredge material for the feeder beach should be placed subtidally from MHW to depths of two (2)

to three (3) meters along the nodal point on the Caminada Headland subject to improvement through the adaptive management plan. The feeder beach will benefit the Headland both to the east and west as longshore transport nourishes the beach face profile and adds width to the shoreline. The added width will afford protection to the uplands by attenuating wave run-up and thus reducing storm damage. In addition, aeolian transport will move finer sediment into the dune system, bolstering it. All of this will result in benefits to the flora and fauna of the Headland and their habitats.

The logistics of such sediment placement require the discharge to be sited appropriately and moved shore-parallel periodically, so as not to form an island. To maximize the potential benefits, the sediment should be placed inshore of the depth of closure so that it is subject to normal coastal processes, *i.e.*, longshore sediment transport facilitated by tidal flow and wave action. Depending on the volume dredged from Belle Pass, it may be more cost-effective to create a series of feeder lobes than to attempt a single large deposit.

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## Annex 2: Barataria Basin Barrier Shoreline Restoration Feasibility Report – Shell Island, Plaquemines Parish, Louisiana

# BARATARIA BASIN BARRIER SHORELINE RESTORATION FEASIBILITY REPORT, APPENDIX C SHELL ISLAND, PLAQUEMINES PARISH, LOUISIANA

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Louisiana Department of Natural Resources

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Recommended Citation:

Thomson, G.G., Campbell, T.J., Grabowski, V., and Kendrick, B., 2008. *Barataria Basin Barrier Shoreline Restoration Feasibility Report, Appendix C, Shell Island, Plaquemines Parish, Louisiana.* Boca Raton, Florida: Coastal Planning & Engineering. (Prepared for Louisiana Department of Natural Resources)

June 2008

## EXECUTIVE SUMMARY

Shell Island is located in Plaquemines Parish, immediately west of the Empire Jetties. The island has experienced significant shoreline retreat and disintegration. One of the objectives of the Barataria Basin Shoreline Restoration for Shell Island is to restore the island so that it protects the interior bays and recreates marsh and dune acreage.

A Shell Island Restoration Plan developed as part of the LCA planning process (USACE, 2004a) suggested a two-island alternative that created 381 acres of beach/dune and 265 acres of marsh (refined during development to 332 acres of beach and 351 acres of marsh). Budget development during this feasibility analysis set an initial construction cost for this alternative at $76,800,000 (Beau Tate, *personal communication*, 2005). However, the passage of Hurricane Katrina and the increase in fuel costs during the development of this report increased the construction cost estimate of Alternative 1 to $127,091,500. The dune crest has an elevation of +6.0 feet (NAVD) while the constructed marsh elevation is +2.5 feet (NAVD). Post-construction Gulf shoreline retreat rates are expected to be approximately 36 feet/year on Shell Island West and 14 feet/year on Shell Island East, which includes shoreline recession due to relative sea-level rise (Section 5.2). Alternative 1 is a one-time construction and it is estimated that it will have eroded such that no intertidal acreage remains by Target Year 48.

Alternative 2 has a similar planform to Alternative 1, except that the dune crest is 85 feet wider along Shell Island West, which increases the beach/dune acreage to 339 acres of beach/dune. The marsh acreage is similar to Alternative 1 (351 acres). The constructed marsh elevation is +2.0 feet (NAVD) because Alternative 2 incorporates a renourishment project every 10 years for the beach fill and every 20 years for the marsh fill. Renourishment of the project extends the project life. The renourishment enables long term viability, keeping the two islands intact for the full 50-year project life. Post-construction Gulf shoreline retreat rates are expected to be approximately 35 feet/year on Shell Island West and 12 feet/year on Shell Island East, which includes shoreline recession due to relative sea-level rise (Section 5.3). As Alternative 2 will be renourished, it is expected that the shoreline recession rate decrease over time, as the ebb shoal grows. The initial construction cost of Alternative 2 is $129,533,900, while the present worth of the project (interest cost of initial construction plus the present worth of initial and future nourishments) is $214,105,000. The annualized cost for initial construction and subsequent renourishment over the 50-year project life is $13,112,100. Volumetric losses to Coupe Bob should be expected for the two-island options as the introduction of sand into the system will result in the formation of an ebb shoal. While some bypassing may occur prior to the ebb shoal reaching its accommodation volume of approximately 3.4 million cubic yards, the ebb shoal will act primarily as a sediment sink.

Alternatives 3 through 8 are single-island alternatives that extend across Coupe Bob. These options better meet the project goals of reducing wave energy transmission into Bastian Bay and re-establishing the

historic longshore sediment transport than Alternatives 1 and 2. The nourishment volumes are lower for the single-island alternatives since there are no longshore losses into Coupe Bob. The gulfside retreat rate for Alternatives 3, 4, 5, and 6 is approximately 7.9 feet/year. The retreat rates for Alternatives 7 and 8 are slightly higher at 8.3 and 8.5 feet/year respectively. The bayside retreat rate for all single-island options has been estimated at 3.6 feet/year. The five single island alternatives have varying combinations of initial construction volume and renourishment intervals. These are summarized in Table 1.

Table 1. Summary of Construction Alternatives 1 though 8

| Alternative | Island Description | Initial Advanced Fill Volume (years) | Beach Renourishment Interval (years) |
|---|---|---|---|
| 1 | Two Islands | 9 | No Renourishment |
| 2 | Two Islands | 10 | 10 |
| 3 | Single Island | 10 | No Renourishment |
| 4 | Single Island | 10 | 25 |
| 5 | Single Island | 10 | 20 |
| 6 | Single Island | 10 | 10 |
| 7 | Single Island | 20 | 20 |
| 8 | Single Island | 25 | 25 |

Alternative 3 has the lowest cost of the single-island alternatives because there is no renourishment component for either the marsh or the beach. It has the same initial construction cost as Alternatives 4, 5, and 6 and similar acreage benefits through to the first renourishment of the other single-island alternatives. However, since Alternative 3 has no renourishment it will continue to degrade until it breaches, which is expected to occur around TY 30. Following breaching, island loss accelerates and by TY 48 there is no intertidal acreage remaining. Table 2 summarizes the construction cost and construction acreages for the various alternatives.

Table 2. Summary of Construction Acreages and Construction Costs

| Alternative | Construction Acreage | | | Construction Cost Estimate | | |
|---|---|---|---|---|---|---|
| | Beach/Dune | Marsh | Total | Initial | Present Worth | Average Annual |
| 1 | 332 | 351 | 683 | $127,091,500 | $135,475,100 | $8,237,700 |
| 2 | 339 | 351 | 690 | $129,533,900 | $214,105,000 | $13,112,100 |
| 3 | 317 | 466 | 783 | $166,019,500 | $166,019,500 | $12,186,400 |
| 4 | 317 | 466 | 783 | $166,019,500 | $217,650,200 | $13,329,200 |
| 5 | 317 | 466 | 783 | $166,019,500 | $226,486,400 | $13,870,300 |
| 6 | 317 | 466 | 783 | $166,019,500 | $243,996,000 | $14,942,600 |
| 7 | 361 | 466 | 827 | $185,953,700 | $251,609,700 | $15,408,900 |
| 8 | 395 | 466 | 861 | $196,912,700 | $260,036,800 | $15,925,000 |

Notes:
1. Beach/dune acreage is based on the beach fill area above +2 feet, NAVD.
2. Marsh acreage is based on the marsh fill area above 0 feet, NAVD.
3. Initial construction cost does not include interest during construction.

Alternative 4 is a single island alternative that is initially constructed with only 10 years of advanced nourishment though it will only be renourished in TY 25. The costs and acreages assume that Alternative 4 will be constructed prior to breaching of the island, which was calculated to occur in TY 30. However, the exact year that breaching might occur is dependent on many variables, such as the frequency and intensity of hurricane events, so this alternative should be closely monitored if chosen.

Alternative 5 is similar to Alternative 4 except that the renourishment is planned for TY 20 instead of TY 25. There is also one additional nourishment in TY 40, whereas Alternative 4 only has the one renourishment event.

Alternative 6 has a similar construction template to Alternatives 3, 4 and 5 with 10 years of advanced fill. Alternative 6 is the preferred single-island alternative because it follows standard coastal engineering design by having the renourishment interval equal the years of advanced nourishment placed. Since the advanced fill defines the renourishment interval for this alternative, the design section should not be eroded prior to renourishment. Alternative 6 is also the preferred alternative since the ten year renourishment interval has the lowest average annual cost when the design fill is not compromised.

Alternative 7 includes 20 years of advanced nourishment in the initial construction with a 20-year renourishment interval while Alternative 8 includes 25 years of advanced nourishment in the initial construction with a 25-year renourishment interval. Alternative 6 is preferred to these two alternatives due its lower average annual cost.

Several potential sources of sand fill are identified in the report. The Mississippi River sand sources are the least cost, known sources of beach fill and have sufficient volumes of material to construct any alternative. It is suggested that investigations that could potentially identify a sand source within 5 miles of Shell Island be conducted, as a closer borrow area could result in significant cost savings. Empire borrow area has been identified as a good source for marsh fill material, as it contains 30% sand.

A Geographic Information System (GIS) was developed for this study. The GIS contains the plan view of the three alternatives, 2004 DOQQ's of Shell Island, historic shoreline locations, bathymetry, vibracores and core borings (with associated logs), surface samples, seismic data, and CPE and USGS borrow area data for Sandy Point, Scofield, Empire, Quatre Bayou and East West Grand Terre borrow areas.

**BARATARIA BASIN BARRIER SHORELINE RESTORATION**
**FEASIBILITY REPORT, APPENDIX C**
**SHELL ISLAND, PLAQUEMINES PARISH, LOUISIANA**

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## ACRONYMS AND ABBREVIATIONS

**ORGANIZATIONS**

| | |
|---|---|
| CEC | Coastal Engineering Consultants, Inc. |
| CPE | Coastal Planning & Engineering, Inc. |
| CPE-LA | Coastal Planning & Engineering of Louisiana, LLC |
| IWR | Institute for Water Resources (USACE) |
| JCLS | John Chance Land Surveyors, Inc. |
| LCA | Louisiana Coastal Area (Plan) |
| LDNR | Louisiana Department of Natural Resources |
| MPH | Morris P. Hebert |
| NDBC | National Data Buoy Center |
| NEPA | National Environment Planning Agency |
| NOAA | National Oceanographic and Atmospheric Administration |
| NRC | National Research Council |
| SJB | SJB Group, Inc. |
| UNO | University of New Orleans |
| USACE | United States Army Corps of Engineers |
| USGS | United States Geological Survey |

**PARAMETERS**

| | |
|---|---|
| APH | Active Profile Height |
| FY | Fiscal Year |
| MHW | Mean High Water |
| MLW | Mean Low Water |
| MM | Mile Marker |
| Mob/demob | Mobilization/demobilization |
| NAVD | North American Vertical Datum |
| RSLR | Relative Sea-level Rise |
| TY | Target Year |

**UNITS**

| | |
|---|---|
| CY | cubic yards |
| ft | foot |
| hp | horsepower |
| L.S. | Lump Sum |
| M | million |
| m | meter |
| mm | millimeter |
| mph | miles per hour |
| yr | year |

**MODELS**

| | |
|---|---|
| GENESIS | Generalized Model for Simulating Shoreline Change |
| PSDDF | Primary Consolidation, Secondary Compression and Desiccation of Dredge Fill Program |
| SBEACH | Storm Induced Beach Change Model |
| STWAVE | Steady State Spectral Wave Model |

**DATA SOURCES**

| | |
|---|---|
| DOQQ | Digital Ortho Quarter Quad Map |
| GIS | Geographic Information System |
| PMP | Project Management Plan |
| WIS | Wave Information Studies |

**DELIVERABLES**

| | |
|---|---|
| EIS | Environmental Impact Statement |
| WVA | Wetland Value Assessment |

## Addendum: Datum Clarification

*The following changes should be followed as required by the district datum coordinator*

### A. Section 2.2.1 Tides, Page 2-3

Table 3 should be replaced with the following:

**Table 3. Tidal Datums at Grand Isle, LA**

| | Elevation (feet) | | |
|---|---|---|---|
| | MLLW | NGVD 29 | NAVD 88 |
| Highest Observed Water level (8/29/2005) | 5.59 | 5.92 | 5.37 |
| Mean Higher High Water (MHHW) | 1.06 | 1.39 | 0.84 |
| Mean High Water (MHW) | 1.05 | 1.38 | 0.83 |
| Mean Sea Level (MSL) | 0.53 | 0.86 | 0.31 |
| Mean Tide Level (MLT) | 0.53 | 0.86 | 0.31 |
| North American Vertical Datum of 1988 - NAVD88 (2004.65) | 0.22 | 0.55 | 0.00 |
| Mean Low Water (MLW) | 0.01 | 0.34 | -0.21 |
| Mean Lower Low Water (MLLW) | 0.00 | 0.33 | -0.22 |
| National Geodetic Vertical Datum of 1929 - NGVD29 (1983) | -0.33 | 0.00 | -0.55 |
| Lowest Observed Water Level (12/24/1989) | -2.20 | -1.87 | -2.42 |

**Source: NOAA - 5 September 2009, http://www.co-ops.nos.noaa.gov/benchmarks/8761724**
**Tidal datums referenced to Modified Tidal Datum Epoch 2002-2006**
**NAVD88 relationships are based on NAVD88 (2004.65) elevation on 876 1724 Tidal 11 of 3.12 feet.**
**NGVD29 relationships are based on NGVD29 (1983) elevation on 876 1724 Tidal 13 of 3.67 feet.**
**NGVD29 relationships are valid for this benchmark at the time of comparison**

### B. Section 4.4.1 Marsh Design Elements, Page 4-19

Update the MHW (Mean High Water) and MLW (Mean Low Water) values listed to match values in Table 3 unless the values listed are specific to Shell Island alone.

# 1.0 GENERAL

## 1.1 INTRODUCTION

This report for the Barataria Basin Barrier Island Shoreline Restoration of Shell Island was prepared for the Louisiana Department of Natural Resources (LDNR), Coastal Restoration Division. This report summarizes the results of feasibility level engineering and economic analyses. It includes engineering evaluation and analysis, plan and cross-section view drawings, marsh and island creation volume computations for each alternative, and a feasibility level cost estimate. A discussion of potential borrow areas is also provided, including evaluation of potential borrow area impacts on the adjacent coastline and river banks and the preliminary design of each borrow area.

Shoreline recession and erosion have resulted in the disintegration of Shell Island. The few remaining islands and shoal remnants provide limited protection to the back barrier environment from waves and flooding. The construction of the Empire Jetties restricted the east-to-west longshore transport and increased the loss rates of Shell Island. Hurricane Bob created a new inlet (Coupe Bob) in 1979 that accelerated retreat and sediment loss.

Restoration of Shell Island would restore dune and marsh areas that provide habitat for migratory birds. Shell Island would act as a buffer for storm surge and would reduce wave and tidal influence in the back barrier marsh area. Oil and gas infrastructure in the basin would also be provided with increased protection.

## 1.2 STUDY AUTHORITY

The Barataria Basin Barrier Island Shoreline Restoration Feasibility Study, as described in the LCA Ecosystem Restoration Study (LCA Study) is recommended for authorization based on authority provided to the USACE through resolutions adopted by the Committees on Public Works of the U.S. House of Representatives and Senate, dated 19 October 1967 and 19 April 1967, respectively. These resolutions requested a review of the reports of the Chief of Engineers to determine the advisability of improvements or modifications to existing improvements in the coastal area of Louisiana in the interest of hurricane protection, prevention of saltwater intrusion, preservation of fish and wildlife, prevention of erosion, and other water resource purposes. These resolutions contain the following language.

"RESOLVED BY THE COMMITTEE ON PUBLIC WORKS OF THE UNITED STATES SENATE, That the Board of Engineers for Rivers and Harbors created under Section 3 of the River and Harbor Act approved June 13, 1902, be, and is hereby requested to review the reports of the Chief of Engineers on the Mermentau River and Tributaries and Gulf Intracoastal Waterway and connecting waters, Louisiana, published as Senate Document Numbered 231, Seventy-seventh Congress, on the Calcasieu River salt water barrier, Louisiana, published as House Document Numbered 582, Eighty-seventh Congress, and on Bayous Terrebonne, Petit Caillou, DuLarge and connecting channels, Louisiana, and the Atchafalaya River, Morgan City to the Gulf of Mexico, published as House Document Numbered 583, Eighty-seventh Congress, and other pertinent reports including that on Bayou Lafourche and Lafourche-Jump Waterway, Louisiana published as House Document Numbered 112, Eighty-sixth Congress, with a view to determining the advisability of improvements or modifications to existing improvements in the coastal area of Louisiana in the interest of hurricane protection, prevention of saltwater intrusion, preservation of fish and wildlife, prevention of erosion, and related water resource purposes.

## 1.3 PROJECT AUTHORIZATION

In his report to Congress dated 31 January 2005, the Chief of Engineers recommended the Barataria Basin Barrier Shoreline Restoration Feature for specific Congressional authorization with project implementation subject to review and approval of the feasibility level of detail decision document by the Secretary of the Army. If Congress authorizes the project prior to the approval of the Feasibility Study and the associated decision document, the project becomes eligible for inclusion in the President's budget and for appropriations. Funding for construction would be released upon approval by the Assistant Secretary of the Army. If Congress does not specifically authorize the project for construction prior to approval of the decision document, the Feasibility Study will be used to seek the authorization for project implementation from Congress. Construction funding would be requested as part of the standard USACE budget and appropriations process. Based on the current project schedule, and assuming Congressional Authorization prior to Army approval, the decision document would be completed to allow inclusion of project construction funding in the President's Fiscal Year (FY 09) budget request. Any specific authorization for the project would be determined by the provisions of authorizing legislation passed by Congress.

Specific funding and authorizations for activities described in this report are provided in the USACE operating budget, which has been appropriated by Congress.

## 1.4 PROJECT APPROVAL

The LCA Study, including a recommendation for authorization of the Barataria Basin Barriers Shoreline Restoration project, was approved and signed by the Chief of Engineers on 31 January 2005. The LCA Study was completed by working in cooperation with other Federal agencies, the State of Louisiana, environmental groups, stakeholders, and interested parties to ensure that the recommendations for restoration best meet near-term restoration objectives. The Barataria Basin Barrier Shoreline Restoration Project addresses the most critical restoration needs for these shoreline reaches that could be addressed in the near-term.

If authorized by Congress, the Assistant Secretary of the Army for Civil Works can approve the decision document for design and construction of the recommended plan. The selection of the recommended plan will be based on the information and analysis conducted during this Feasibility Study. The analysis of benefits for project alternatives in the Feasibility Study will be completed using the methodology described in the USACE Institute for Water Resources (IWR) Report 97-R-15. The decision document will describe the evaluation of alternatives and the identification of the specific project sites at Shell Island, will identify adaptive management procedures, and will specify features and benefits necessary to achieve restoration objectives, and provide project justification, and will complete the National Environmental Policy Act (NEPA) process.

Planning and management of the LCA restoration efforts will include a decision support system that relies on clearly defined procedures to assess the relevant uncertainties and to develop analytical tools for the decision making process. Many of the uncertainties regarding restoration projects address analysis of natural processes and development of new engineering techniques. The scientific and technical needs of the LCA Program will be addressed through research and monitoring studies. These efforts will be directed by the Science and Technology (S&T) Office. New technological applications and decision support tools developed for this project will be supported by the S&T Office, consistent with the schedule provided in the PMP.

Implementation of the Barataria Basin Barrier Shoreline Restoration Project will constitute a major federal action, as defined by NEPA. Complying with NEPA will require preparation of an Environmental Impact Statement (EIS). The PMP includes the tasks, milestones, and work products of an EIS that are required to document the impact analysis and decision process. Public participation and decision documentation required by NEPA will be used for approval of the project alternative identified for implementation in the Feasibility Study, concurrent with USACE decision-making procedures.

## 1.5 PROJECT AREA AND LOCATION

The Barataria/Plaquemines barrier island complex lies approximately 49 miles south-southeast of New Orleans, Louisiana. The barrier island complex is characterized by tidal creeks, man-made canals, marshlands, sandy barrier islands, and several bays. The remnants of Shell Island are located between Fontanelle Pass (Empire Jetties) and Grand Bayou Pass. Shell Island used to enclose both Bastian Bay and Shell Island Bay but has since disintegrated into several smaller islands and shoals. The project area is located in Plaquemines Parish. A map of the project area appears in Figure 1.

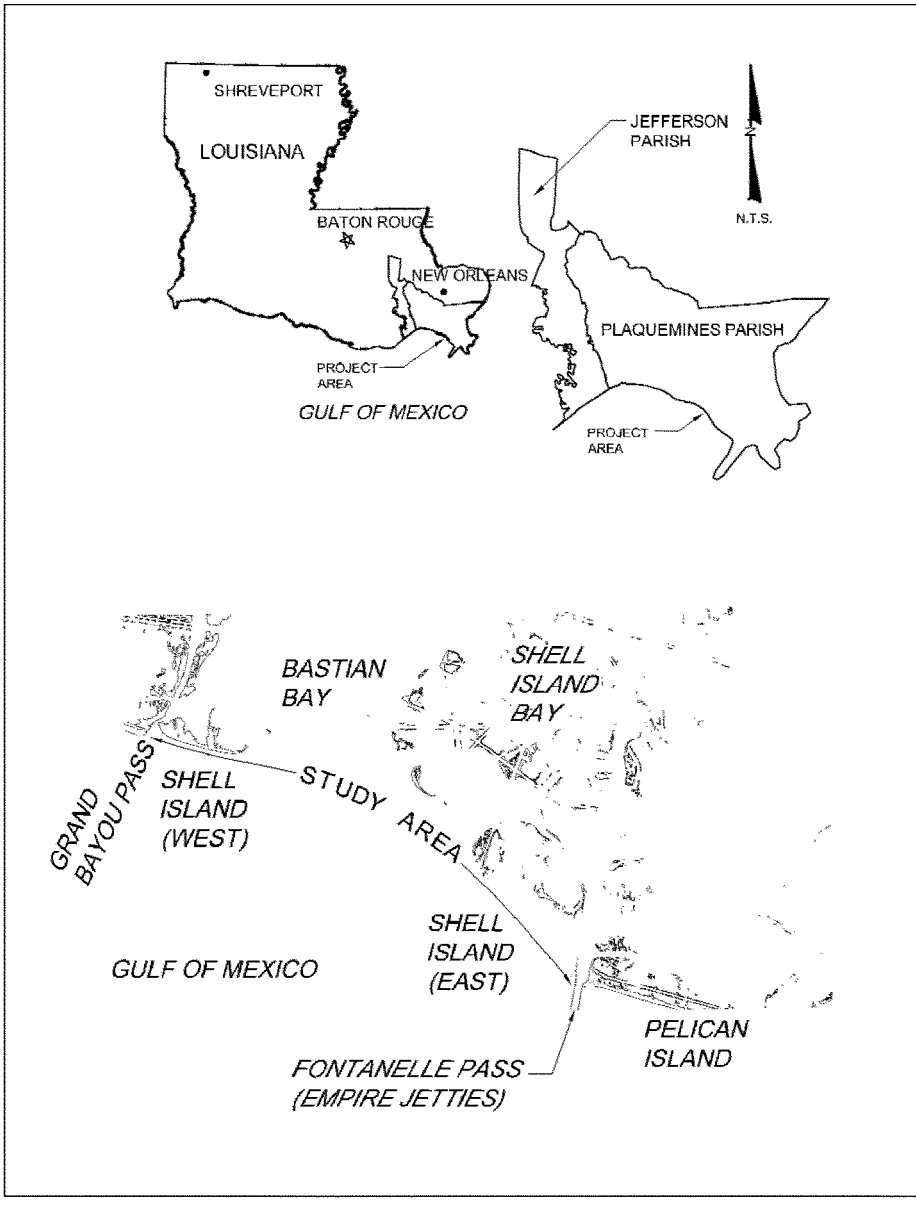



Figure 1. Location Map

## 1.6 PROJECT GOALS AND OBJECTIVES

In cooperation with LDNR and the USACE staff, the following objectives have been identified for the Shell Island Project:

A. Re-establish a barrier(s) between a threatened estuarine ecosystem and the Gulf of Mexico.

B. Increase the sustainability of the barrier island shoreline system.

C. Restore the geomorphic function of the barrier shoreline in the vicinity of Shell Island.

D. Restore shoreline, dune, and back-barrier marsh to increase habitat utilization by essential fish and wildlife species both on the barrier island and in the consequently developed quiescent bays.

E. Reduce wave energy transmission by providing a protective buffer to the interior bays and marshes north of Shell Island Bay.

F. Promote the re-establishment of historic longshore transport patterns along the Gulf shoreline.

Shell Island incorporates a marsh construction element along with the shoreline and dune restoration. The USACE (2004) developed a plan for reconstructing Shell Island. The following specific, post-construction acreage goals were identified:

G. Achieve 158 acres of dune and supratidal acreage on Shell Island West.

H. Achieve 74 acres of marsh (intertidal acreage) on Shell Island West.

I. Achieve 223 acres of dune and supratidal acreage on Shell Island East.

J. Achieve 191 acres of marsh (intertidal acreage) on Shell Island East.

# 2.0 COASTAL PROCESSES

## 2.1 DATA REVIEW AND COLLECTION

Morris P. Hebert (MPH) conducted a hydrographic survey in the vicinity of Shell Island in December 2000 as part of the Coast 2050 study. A total of 16 survey lines were performed. John Chance Land Surveyors, Inc. (JCLS) conducted beach surveys within the project area in June 2005. JCLS repeated the tracklines surveyed in 2000 but also extended the tracklines bayward and Gulfward to cover a larger area. An additional 3 survey lines were performed, which provided for a total of 19 survey lines. The onshore sections were collected using a rod and level while the offshore data was collected using hydrographic survey methods. Figure 2 shows the survey lines that were collected along with the bathymetry developed from the survey data.

Historic shorelines from 1884, 1932, 1956, 1973, 1983 and 2003 were collected from various sources. The 1884 and 1973 digitized shorelines were obtained from Williams *et al.* (2003) while the 1932 and 1956 shorelines were digitized from Williams *et al.* (1992). The 1983 shoreline was digitized from a quad map (USGS, 2005). The 2003 shoreline was based on Lidar data provided by LDNR. These shorelines were incorporated into the GIS database that accompanies this report.

FIGURE 2
2005 BATHYMETRY
BASED ON JOHN CHANCE SURVEY
COASTAL PLANNING & ENGINEERING, INC.
2481 NW BOCA RATON BLVD.
BOCA RATON, FL 33431

McClelland Engineering collected 158 vibracores along Shell Island in the 1980's. CPE collected an additional 16 vibracores within the Mississippi River, in the vicinity of Nairn, in August 2005. Data from these cores have been incorporated into the GIS database that accompanies this report.

Coastal Planning & Engineering (2003a) developed a GIS for LDNR, which contained vibracore, bathymetry, seismic, and borrow area data for the Barataria/Plaquemines Barrier Shoreline Restoration Project. This previous GIS contained data collected by Coastal Planning & Engineering and the United States Geological Survey (USGS).

## 2.2 PHYSICAL CHARACTERISTICS OF THE PROJECT AREA

### 2.2.1 Tides

While site specific tidal information is not available, the closest tide gauge is located at Grand Isle, Louisiana, which is approximately 18 miles west of Shell Island. Tides at Grand Isle are diurnal, with a mean tide range of approximately 1.1 feet. Tidal datums, determined by NOAA over a five year period between January 1997 and December 2001, are provided in Table 3.

Table 3. Tidal Datums at Grand Isle, Louisiana

| | Elevation (feet) | | |
|---|---|---|---|
| | MLLW | NGVD 1929 | NAVD 1988 |
| Highest Observed Water Level (8/29/2005) | 5.59 | 5.84 | 6.13 |
| Mean Higher High Water (MHHW) | 1.06 | 1.31 | 1.60 |
| Mean High Water (MHW) | 1.05 | 1.30 | 1.60 |
| Mean Sea Level (MSL) | 0.54 | 0.79 | 1.08 |
| Mean Tide Level (MTL) | 0.53 | 0.78 | 1.08 |
| Mean Low Water (MLW) | 0.01 | 0.26 | 0.55 |
| Mean Lower Low Water (MLLW) | 0.00 | 0.25 | 0.54 |
| National Geodetic Vertical Datum-1929 (NGVD) | -0.25 | 0.00 | 0.29 |
| North American Vertical Datum-1988 (NAVD) | -0.54 | -0.29 | 0.00 |
| Lowest Observed Water Level (02/03/1951) | -2.85 | -2.60 | -2.31 |

Source: NOAA (2003), http://www.co-ops.nos.noaa.gov/benchmarks/8761724.html.

### 2.2.2 Currents

Peak ebb and flood current velocities in Grand Bayou Pass were measured to be 3.6 feet/second and 2.4 feet/second (SJB and CEC, 2004). No current velocity data was found for Coupe Bob or Fontanelle Pass.

### 2.2.3 Gulf Waves

Waves impacting the project areas are generated primarily by local winds, though significant wave events may occur due to distant storms. Tropical storms also generate large but rare wave events. However, the restricted fetch of the Gulf of Mexico basin limits the size and associated wave period of significant storm events.

Wave statistics generated for the project areas utilize the 1980-1999 hindcast at WIS Station 132 (USACE, 2004). The location of this station is 29°5' N, 89°40' W at a mean depth of 62 feet. The average wave height is 2.7 feet, with a corresponding period and direction of 4.1 seconds and 144° (SSE). Approximately 70% of the waves propagate from the offshore direction band, 110° to 290°. Within this band, the average height is 2.8 feet, with a corresponding period and direction of 4.3 seconds and 167° (SSE). The largest storm waves occur in August and October during hurricane season. With the exception of tropical storm events, the highest waves under normal conditions occur in March, with the lowest occurring in July and August. The average wave direction varies from 88° (E) in October to 187° (SSW) in July. However, within the onshore direction band, the wave direction is relatively constant throughout the year. The largest and longest waves under normal conditions come from the south-southeasterly direction band. Directional and seasonal wave statistics appear in Figures 3 through 5.

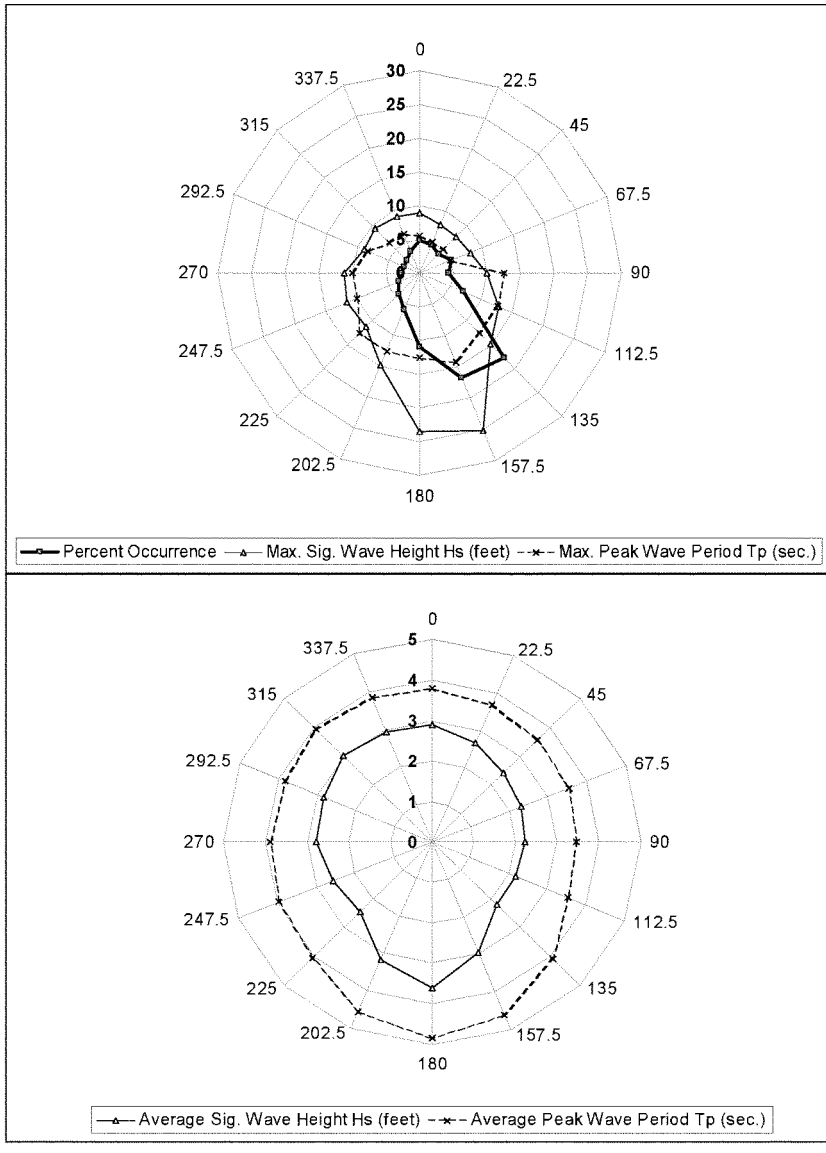



Figure 3. Directional Wave Statistics, WIS Station 132, Shell Island, LA

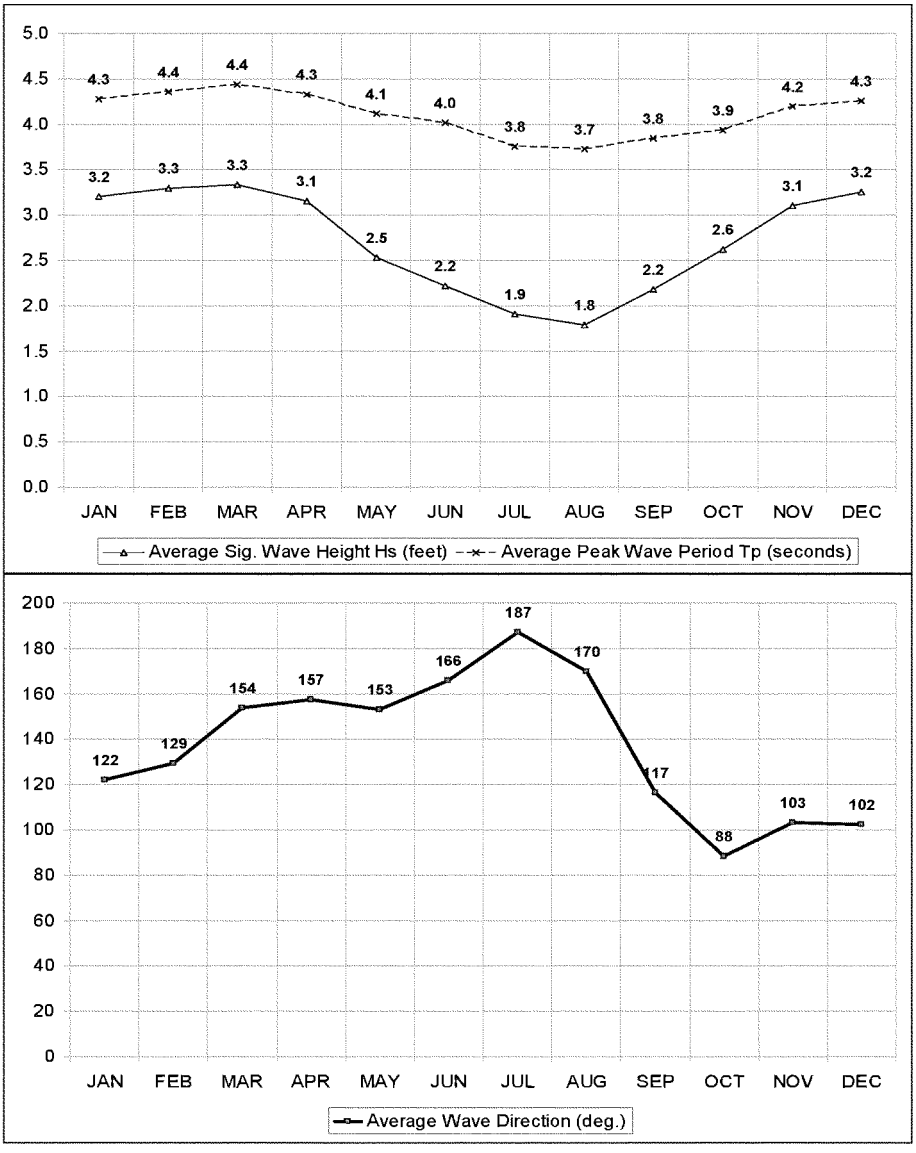



Figure 4. Seasonal Wave Statistics, WIS Station 132, Shell Island, LA

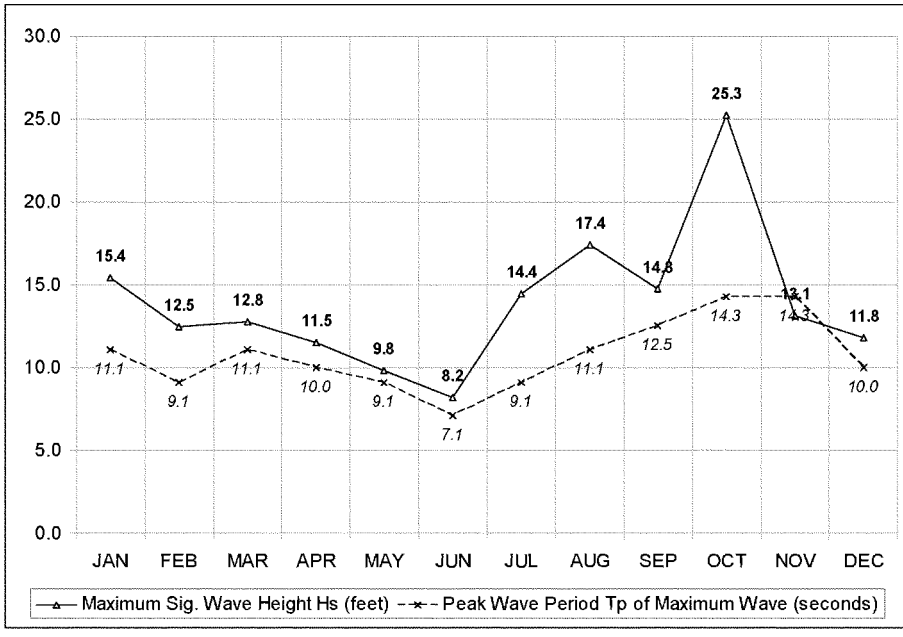



Figure 5. Seasonal Wave Statistics, WIS Station 132, Shell Island, LA

Waves under storm conditions appear in Table 4 and Figure 6 (USACE, 2000; CPE, 2004). The extremal wave statistics account for hurricanes, tropical storms, and extra tropical storms. Offshore wave heights for the 5, 10, and 20 year conditions range from 15 to 20 feet, with a corresponding period of 11 to 13 seconds, and a corresponding direction near 183°. Figure 6 also provides extremal water levels based on measurements collected at Grand Isle (NOAA, 2003).

Table 4. Offshore Gulf Waves at WIS Station 132

| Return Period (years) | Wave Height $H_{mo}$ (feet) | +/- σ | Wave Period $T_p$ (seconds) | +/- σ |
|---|---|---|---|---|
| 1 | 10.9 | 0.9 | 7.4 | 0.4 |
| 2 | 12.2 | 1.1 | 9.5 | 0.4 |
| 3 | 13.4 | 1.6 | 10.4 | 0.5 |
| 4 | 14.3 | 2.1 | 10.9 | 0.6 |
| 5 | 15.0 | 2.5 | 11.3 | 0.7 |
| 6 | 15.6 | 2.8 | 11.6 | 0.7 |
| 7 | 16.2 | 3.1 | 11.9 | 0.8 |
| 8 | 16.6 | 3.4 | 12.1 | 0.8 |
| 9 | 17.1 | 3.6 | 12.3 | 0.9 |
| 10 | 17.5 | 3.8 | 12.4 | 0.9 |
| 15 | 19.1 | 4.7 | 13.0 | 1.0 |
| 20 | 20.2 | 5.4 | 13.5 | 1.1 |
| 25 | 21.2 | 5.9 | 13.8 | 1.2 |
| 30 | 22.0 | 6.4 | 14.0 | 1.2 |
| 35 | 22.6 | 6.7 | 14.2 | 1.3 |
| 40 | 23.2 | 7.1 | 14.4 | 1.3 |
| 45 | 23.8 | 7.4 | 14.6 | 1.3 |
| 50 | 24.2 | 7.7 | 14.7 | 1.4 |
| 60 | 25.1 | 8.1 | 15.0 | 1.4 |

Notes: WIS Station 132 located at 29°5'N, 89°40'W, depth 18.9m (62 ft).

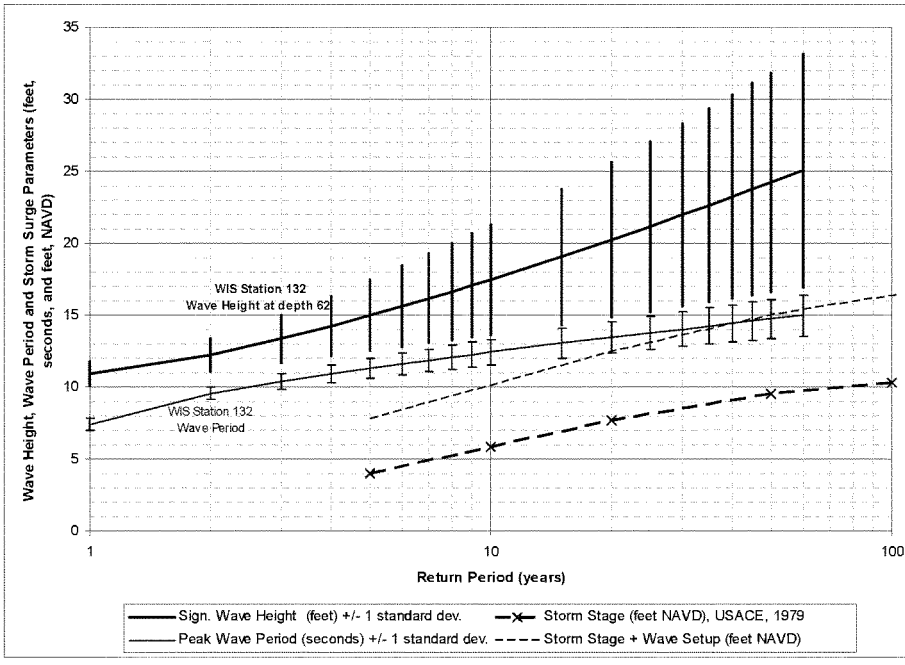



Figure 6. Extremal Waves and Water Levels

### 2.2.4 Storm Surge

Storm surge is defined as the rise of the sea surface above its astronomical tide level due to storm forces. The elevation that the storm surge reaches is known as the storm stage. The increased elevation is attributable to a variety of factors, including waves, wind shear stress, and atmospheric pressure. An estimate of these water level changes is important to the development of the design of a beach fill. Storm stages for the project area are based on observed water levels at Grand Isle dating from 1893 to 2002. Storm stage estimates appear in Table 5 and Figure 6, and include the effects of wind setup, barometric pressure, and astronomical tides.

Wave setup is the superelevation in the mean water level due to wave action. During storms, wave setup raises the nearshore water level above the storm stage. To estimate wave setup, the waves in Table 4 were transformed to breaking depth using linear wave theory. The corresponding wave setup was then estimated using the *Coastal Engineering Manual* (USACE, 2001) method. Wave setup elevations appear in Table 5 and the combined storm stage plus wave setup is shown in Figure 6.

Table 5. Storm Stage, Grand Isle, LA

| Return Period (years) | Storm Stage (feet NAVD) | Wave Setup (feet) | Stage+Wave Setup (feet, NAVD) |
|---|---|---|---|
| 5 | 2.8 | 3.6 | 6.4 |
| 10 | 3.9 | 4.2 | 8.1 |
| 20 | 5.2 | 4.6 | 9.7 |
| 50 | 6.9 | 5.4 | 12.3 |
| 100 | 8.4 | 5.9 | 14.3 |

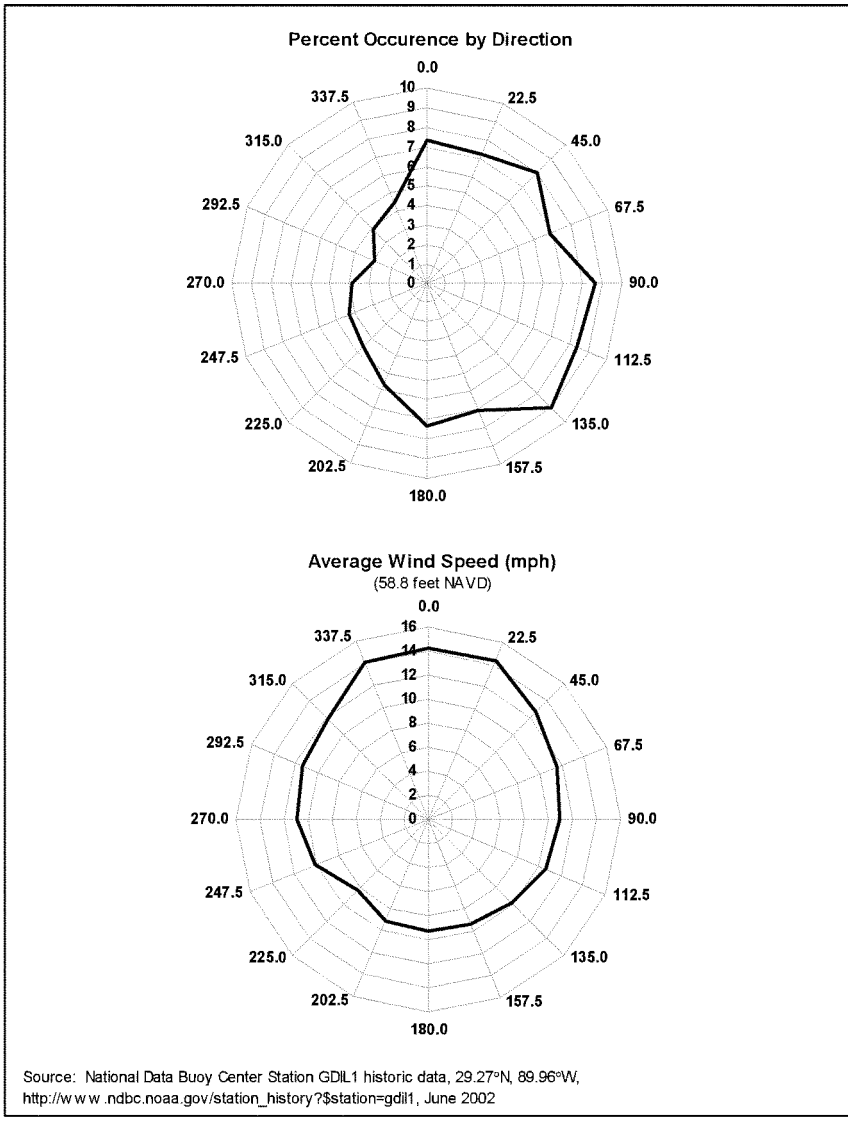
### 2.2.5 Winds

Direct wind measurements for the study area were collected at the Grand Isle tide station (NDBC, 2002), with data available from 1984 to 2001. The prevailing winds were from the east to southeast, with a mean speed of 11 mph and a mean direction of 97° (E). During storm conditions, however, winds can arrive from all directions. Directional wind statistics appear in Figure 7. Winds during frequent storm events appear in Table 6.

Table 6. Wind Speed and Direction During Frequent Storm Events Grand Isle, LA 1984-2001

| Frequency | Wind Speed (mph) | Wind Direction (deg) |
|---|---|---|
| Quarterly | 41 | 2 |
| Semi-Annual | 45 | 22 |
| Annual | 47 | 24 |
| 2-Year | 50 | 19 |
| 3-Year | 51 | 350 |
| 4-Year | 52 | 321 |
| 5-Year | 53 | 301 |

Sources:
Winds: National Data Buoy Center Station GDIL1 Historic Data, 29.27oN, 89.96oW, http://www.ndbc.noaa.gov/station_history?$station=gdil1, 2002.




Source: National Data Buoy Center Station GDIL1 historic data, 29.27°N, 89.96°W, http://www.ndbc.noaa.gov/station_history?$station=gdil1, June 2002

Figure 7. Directional Wind Statistics, 1984-2001, Grand Isle, LA

## 2.3 SUBSIDENCE AND RELATIVE SEA-LEVEL RISE

A primary factor governing land loss along the Louisiana shoreline is relative sea-level rise, the rise in sea-level relative to the adjacent coastlands. Relative sea-level rise consists of two components (NRC, 1987), as follows:

1. Eustatic sea-level change. Eustatic sea-level change is defined as the global change in oceanic water level relative to a fixed datum (e.g. North American Vertical Datum of 1988).

2. Subsidence. Subsidence is defined as the local change in land elevation relative to a fixed vertical datum.

Along the Louisiana coast, the land elevation is decreasing while the mean sea-level elevation is increasing, resulting in significant land loss.

The eustatic sea level rise rate recommended by the USACE was reported by the International Program on Climate Change (IPCC) in their Climate Change 2001: The Scientific Basis report. The IPCC expressed the global average sea level rise, $\Delta h(t)$, as a function of time (t) and several components (Equation 1):

$$\Delta h(t) = X(t) + g(t) + G(t) + A(t) + I(t) + p(t) + s(t) \qquad [1]$$

where:

X = thermal expansion

g = loss of mass of glaciers and ice caps

G = loss of mass of the Greenland ice sheet due to projected and recent climate change

A = loss of mass of the Antarctic ice sheet due to projected and recent climate change

I = loss of mass of Greenland and Antarctic ice sheets due to the ongoing adjustment to past climate change

p = runoff from thawing of permafrost

s = deposition of sediment on the ocean floor.

Seven Atmosphere-Ocean General Circulation Models (AOGCMs) were calibrated to project the components X, g, G, and A based on varying influencing factors such as climate sensitivity, heat uptake, and different emissions scenarios. The components I, p, and s were assumed to contribute to sea-level rise at a constant rate, independent of AOGCM and scenario. Using variations of the projected

components, 35 Special Report on Emission Scenarios (SRES) were estimated to have a sea level rise ranging from 0.09 to 0.88m from 1990 to 2100, with a central value of 0.48m. Figure 8 below represents the range of global average sea level rise rates based on each SRES scenario. The USACE recommends using the mid range value for sea-level rise that suggests a 0.013 feet/year increase.

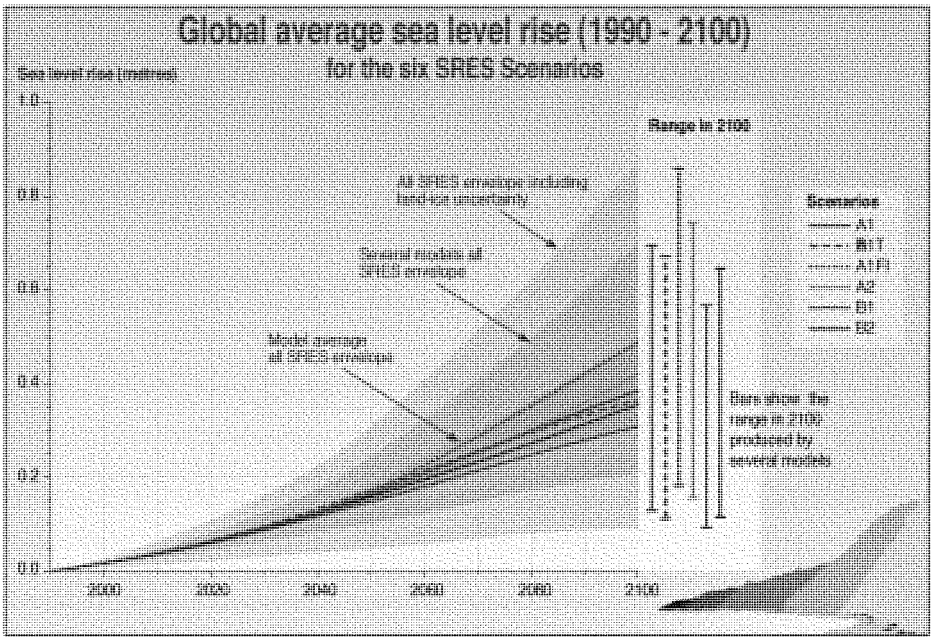



Figure 8. IPCC Global Average Sea Level Rise Projections

An alternate method of estimating relative sea-level rise is to use tidal records and the NRC methodology. For a tidal record to be sufficient for this purpose, it must be at least 37 years long, or twice the length of the 18.6 year lunar nodal tide cycle. Tide measurements have been gathered at Grand Isle since the 1940's, permitting estimates of relative sea-level rise by Penland and Ramsey (1990) and by the National Research Council (1995).

The National Research Council (1995) developed a numerical relationship (Equation 2) for estimating the total relative sea-level rise for any location, given a known rate of subsidence, as follows:

$$T(t) = (0.0039 + M)t + bt^2 \qquad [2]$$

where:

T = Change in sea-level rise between 1986 and year "t" in feet

M = Subsidence in feet/year

b = Acceleration in the rate of eustatic sea-level change in feet/year$^2$ = 0.000092, 0.000217, or 0.000344

The NRC (1987) estimated subsidence, M, at Grand Isle to be 0.0292 feet/year. The calculated relative sea-level rise best matched the observed relative sea-level rise when using the lowest value of "b" (0.000092 feet/year$^2$) in equation [2] (NRC, 1987). Using a subsidence value of 0.0292 feet/year and "b" value of 0.000092 feet/year$^2$, the expected relative sea-level rise at construction (2009) is 0.0372 feet/year. Over the 50-year project life (2009 to 2059) the relative sea-level rise is increasing and a relative sea-level rise rate of 0.0463feet/year was calculated for 2059. The rate of relative sea-level rise will be treated as a constant over the 50-year project life, equal to 0.043 feet/year. Figure 9 shows a schematic of relative sea-level rise and subsidence and highlights that approximately 70% of the relative sea-level rise at this location is due to subsidence.

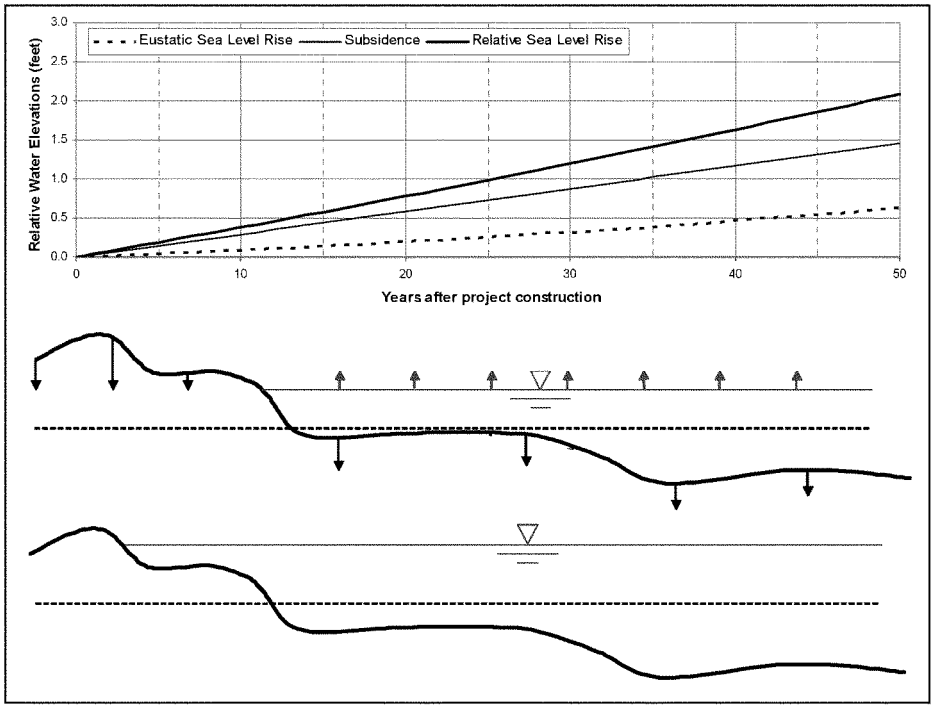



Figure 9. Sea-level Rise, Grand Isle, LA

NOAA (July 2004) has published updated subsidence rates in south Louisiana that suggest a higher subsidence rate than that developed by the NRC for Grand Isle. An average subsidence rate of 0.0430 feet/year was calculated by averaging the subsidence rate of 65 monuments located between Venice and Port Sulphur, compared to the historic value of 0.292 feet/year. However, the USACE has indicated a preference to use 0.0292 feet/year as the subsidence rate to maintain consistency with other project analyses (E-mail correspondence with Beau Tate, 2007). The concern is that the recently measured values may be influenced by their location adjacent to developed areas, which due to development may be causing localized subsidence and thus not representative of subsidence along the barrier island chain.

## 2.4 SHORELINE CHANGE ANALYSIS

The following shoreline change analysis shows that the formation of Coupe Bob caused a quadrupling of the retreat rates along Shell Island and is the major reason for the disintegration of the island. Shoreline retreat rates of 230 feet/year were measured adjacent to the pass following the formation of Coupe Bob. The construction of the Empire Jetties in 1950 by contrast, only increased shoreline recession approximately 10 feet/year along 5,000 to 8,000 feet on the eastern end of the island. The Empire Jetties are a contributing factor but not the major cause of the demise of Shell Island.

The shoreline along Shell Island has receded since the first recorded measurement in 1884, when Shell Island was one continuous island. The source of the historic shorelines was discussed in Section 2.1. Table 7 shows the total and annualized shoreline changes over various time periods, while Figure 10 provides a graphical representation of island retreat and location of the USGS transects. Historic shoreline analysis shows that Shell Island has a history of small inlets cutting through the island but these inlets closed naturally, as Grand Bayou and Fontanelle Pass were the dominant inlets connecting Bastian Bay and Shell Bay to the Gulf of Mexico.

Table 7. Historic Shoreline Changes for Shell Island

| USGS Transect Line | Approximate Distance From Empire Jetty | Shoreline Change (feet) | | | | | Annualized Shoreline Change (ft/yr) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1884 to 1932 | 1932 to 1956 | 1956 to 1973 | 1973 to 1988 | 1988 to 2004 | 1884 to 1932 | 1932 to 1956 | 1956 to 1973 | 1973 to 1988 | 1988 to 2004 |
| 81 | 850 | -768 | -589 | -669 | -902 | - | -16 | -25 | -39 | -60 | - |
| 80 | 1,890 | -1184 | -820 | -365 | -899 | - | -25 | -34 | -21 | -60 | - |
| 79 | 3,140 | -1667 | -678 | -554 | -630 | -2462 | -35 | -28 | -33 | -42 | -154 |
| 78 | 4,430 | -2231 | -574 | -512 | -748 | -2585 | -46 | -24 | -30 | -50 | -162 |
| 77 | 5,770 | -2090 | -710 | -480 | -988 | - | -44 | -30 | -28 | -66 | - |
| 76 | 7,810 | - | - | -401 | -1421 | -1324 | - | - | -24 | -95 | -83 |
| 75 | 10,010 | -636 | -672 | -463 | -2267 | - | -13 | -28 | -27 | -151 | - |
| 74 | 12,060 | -157 | -563 | -474 | -2398 | - | -3 | -23 | -28 | -160 | - |
| 73 | 13,660 | -105 | -391 | -466 | - | - | -2 | -16 | -27 | - | - |
| 72 | 15,110 | -240 | -243 | -400 | - | - | -5 | -10 | -24 | - | - |
| 71 | 16,750 | -66 | 51 | -470 | -3448 | - | -1 | 2 | -28 | -230 | - |
| 70 | 18,440 | 374 | 13 | -400 | -843 | - | 8 | 1 | -24 | -56 | - |
| 69 | 20,180 | - | 269 | -323 | -761 | - | - | 11 | -19 | -51 | - |
| 68 | 21,660 | 387 | 1024 | -241 | -686 | - | 8 | 43 | -14 | -46 | - |
| 67 | 23,050 | 92 | 653 | -133 | -512 | -963 | 2 | 27 | -8 | -34 | -60 |
| 66 | 24,060 | -174 | 54 | 260 | -177 | -672 | -4 | 2 | 15 | -12 | -42 |
| 65 | 25,650 | - | - | -274 | - | -516 | - | - | -16 | - | -32 |
| Average (feet) | | -605 | -212 | -374 | -1191 | -1420 | -13 | -9 | -22 | -79 | -89 |

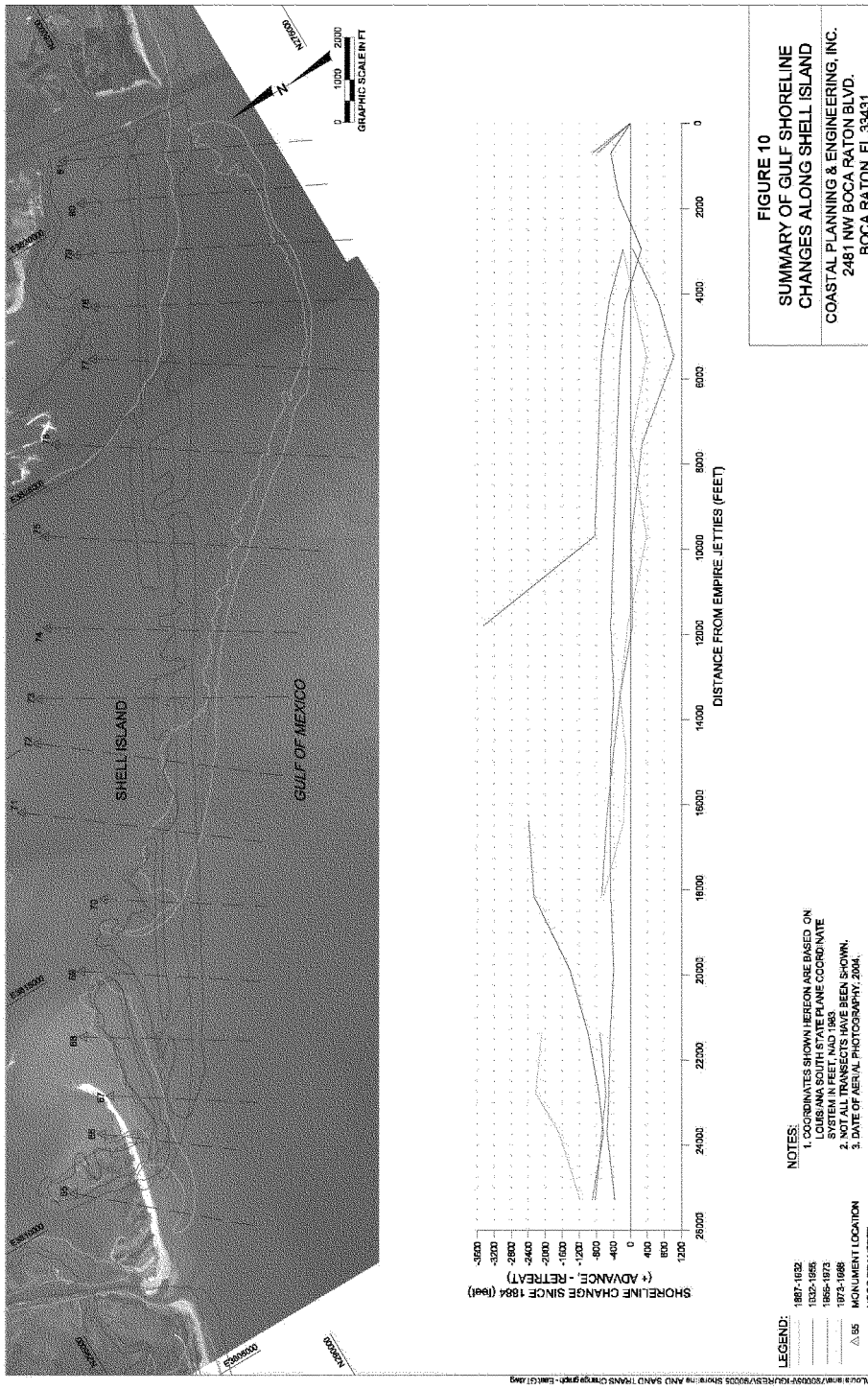



FIGURE 10
SUMMARY OF GULF SHORELINE CHANGES ALONG SHELL ISLAND

COASTAL PLANNING & ENGINEERING, INC.
2481 NW BOCA RATON BLVD.
BOCA RATON, FL 33431

Shoreline recession between 1884 and 1932 averaged 13 feet/year but maximum recession rates of 46 feet/year occurred in the vicinity of the breach located at USGS transect line 76. Figure 11 shows a comparison of the 1884 and 1932 land mass. The east end is exhibiting more of a rollover feature while the west end is undergoing migration due to longshore transport.

Average shoreline recession rates remained relatively constant between 1932 and 1956 at 9 feet/year but larger shoreline recession rates (34 feet/year) were observed at the east end of the island (USGS transect 80). Higher erosion rates (28 and 30 feet/year) were measured adjacent to the breach in the vicinity of USGS transect 76, but this breach had closed by 1956 (Figure 12). Shoreline advance was observed at the west end of the island between USGS transects 66 and 71. This suggests east-to-west longshore transport when combined with the erosion observed on the east end. Island retreat due to storm overwash (combined with relative sea-level rise) appears to be prevalent along the majority of the island while the west end continues to elongate.

The construction of the Empire Jetties in 1950 (USACE, 1989) interrupted the east-to-west littoral drift and partially explains the increase in the average shoreline recession rate between 1956 and 1973. The shoreline within 5,000 feet of the jetties eroded 4 feet/year faster in the later time period. An even-odd analysis discussion later in this report suggests an average impact of 10 feet/year over an 8,000-foot area. The construction of the jetties is also highlighted by the spike in shoreline recession adjacent to the jetties (USGS transect 81). The shoreline retreated more uniformly (Figure 13) than in the previous time period analyzed (Table 7). The increase in shoreline recession in the center of the island at USGS transects 68 to 73 was most likely caused by storm overwash on a narrow island section that was becoming vulnerable to breaching.

The erosion rates adjacent to the jetty continued to increase in the 1973 to 1988 time frame. However, the erosional affect of the jetties was overshadowed by the passage of Hurricane Bob in 1979. Hurricane Bob breached the center of the island and shoreline recession rates of 160 and 230 feet/year were measured adjacent to the breach. The breach has turned into an inlet, called Coupe Bob, and was approximately 8,400 feet wide in 2004. Following the formation of Coupe Bob, Shell Island East underwent a shoreline retreat and reorientation to a southeast northwest alignment that has resulted in disintegration of the island (Figure 14). Only a few scattered sections of Shell Island East remain today. An inlet opened between the end of the Empire Jetties and Shell Island Bay during this time period. The shoreline retreat rate increased further to 79 feet/year on the east side of Shell Island and exhibited a rollover pattern. Shell Island West continued to undergo retreat due to rollover and migration to the west.

Shell Island East continued to disintegrate between 1988 and 2004. Shoreline recession rates do not accurately reflect island change but the few lines that provide recession rates suggest a retreat rate of 89 feet/year. Recession rates are higher on the remnants of the east end of Shell Island where recession rates vary from 83 feet/year to 162 feet/year. The islands are approximately 2,000 feet north of the landward end of the western Empire Jetty. Coupe Bob has captured much of the tidal prism from Grand Bayou allowing shoaling of Grand Bayou with sand from the ebb shoal. This has allowed the westerly movement of Shell Island West, which has reduced the width of Grand Bayou to an observed width of approximately 120 feet in July 2005.

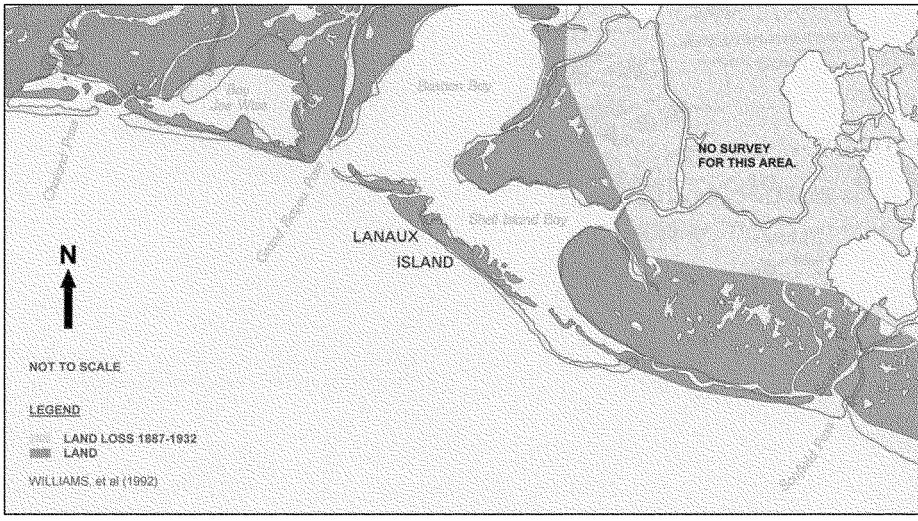



Figure 11. Shoreline Change between 1884 and 1932

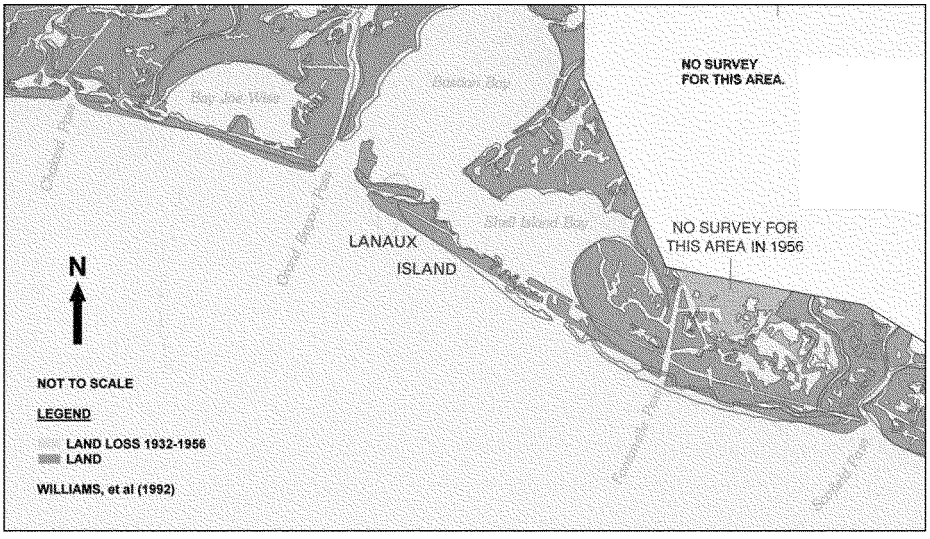



Figure 12. Shoreline Change between 1932 and 1956

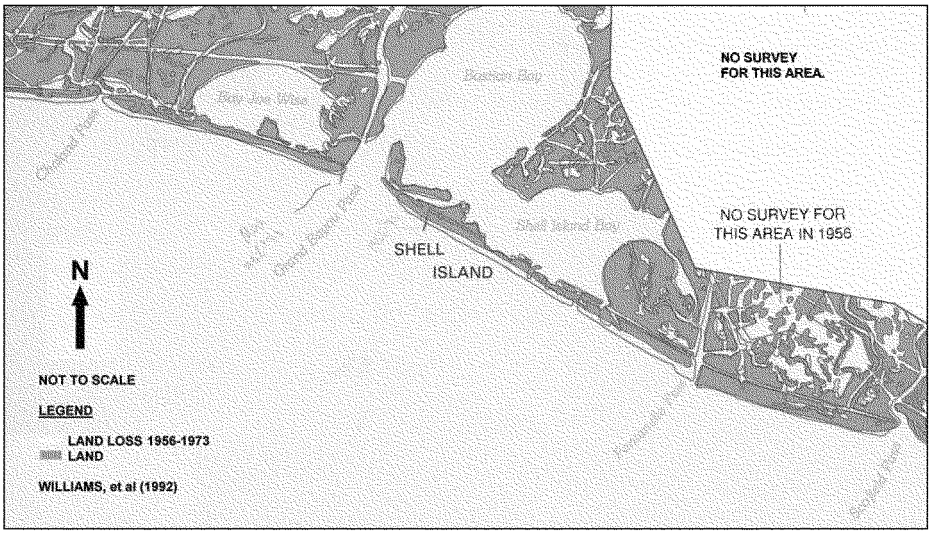



Figure 13. Shoreline Change between 1956 and 1973

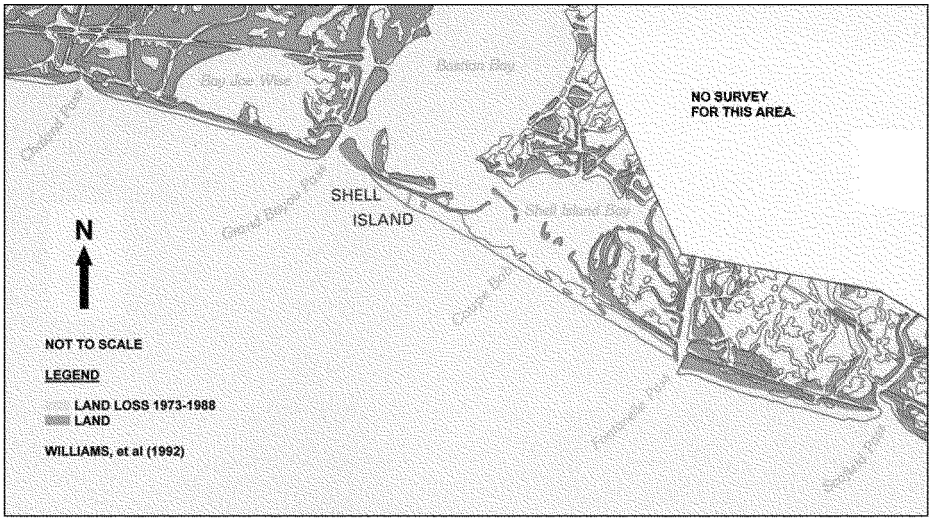



Figure 14. Shoreline Change between 1973 and 1988

In summary, the effect of the formation of Coupe Bob was, and still is, an order of magnitude larger impact on Shell Island than the construction of the Empire Jetties. The Empire Jetties however, have interrupted the littoral drift and thus the sediment supply to Shell Island, which has contributed to its demise.

## 2.5 EVEN-ODD ANALYSIS OF EMPIRE JETTIES

The shoreline change analysis suggested that the construction of the Empire Jetties resulted in an increased shoreline recession rate along Shell Island. An even-odd analysis was performed to determine the effect of the jetties on the shoreline recession rate.

Work and Dean (1990) suggested that shoreline changes can be mathematically decomposed and analyzed to determine a structure's influence on coastal processes. They suggest breaking the volume response into an even component and an odd component around the center of the study area. The even function is symmetric about the center and gives an indication of the net accretion or erosion that has occurred within the time period independent of the effects of the structure. In this case, it represents the background erosion occurring along the beach. The odd function is anti-symmetric about the center of the study area and is used to interpret the effects of a variation of alongshore sediment transport along a

site. The odd function should therefore highlight the role of the jetty in this system because it blocks the east-west flow of sediment along the study area.

The centerline of Fontanelle Pass was taken as the center of the even-odd analysis. The study length extended east and west of this point. Figure 15 graphs the shoreline change decomposition for the time period 1956 to 1973. The even function shows that the background shoreline recession is approximately -22 feet/year, which was consistent with the average shoreline recession along the island. The odd function suggests that the jetties increased shoreline retreat by approximately 10 feet/year, which was likely caused by the jetties interrupting longshore transport. The jetties simultaneously slowed the shoreline retreat to the east by approximately the same amount.

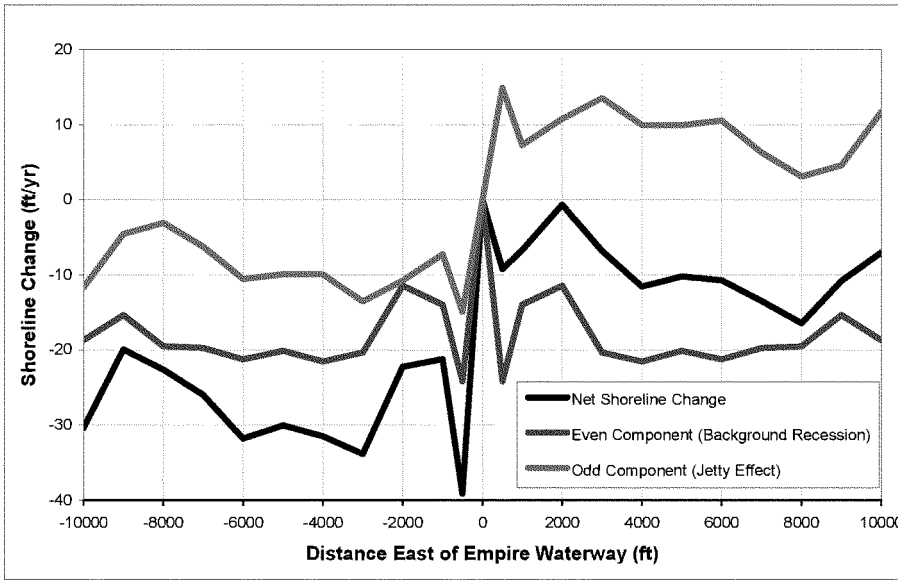



Figure 15. Even-Odd Analysis between 1956 and 1973

Where the only influence on shoreline change is background recession and the structure effect, the odd function will return to zero at the limit of the jetty effect. In this case, there have been other influences on shoreline retreat (such as breaches or inlets) so that the odd function does not return to zero. Interpretation of the 1956-1973 analysis suggests that the extent of the jetty effect is limited to approximately 8,000 feet. The increase in the odd function beyond here suggests that there are other

influences either updrift or downdrift of the jetties that have a greater affect on shoreline change than the jetties.

An even-odd analysis of the 1973 to 1988 time period suggests that the effect of the Empire Jetties on shoreline retreat is limited to approximately 3,000 feet west of the jetty, as this is the point where the odd function most closely approaches zero (Figure 16). Beyond this point, the odd function increases dramatically suggesting that there is another influence affecting the analysis. The additional influence in this case is Coupe Bob, and the magnitude of the odd function suggests that Coupe Bob has a much larger influence on shoreline retreat than the jetties.

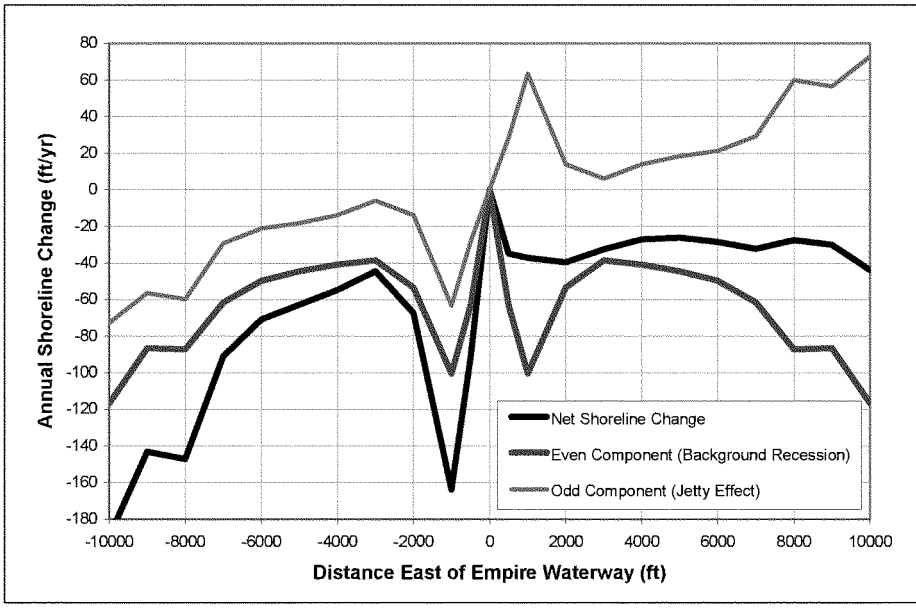



Figure 16. Even-Odd Analysis between 1973 and 1988

In summary, the even-odd analysis shows the following:

1. Empire Jetties are responsible for a shoreline recession of approximately 10 feet/year along a portion of Shell Island.

2. The downdrift effect of the Empire Jetties appears to be limited to 3,000 to 8,000 feet west of the jetties.

3. The effect of Coupe Bob on shoreline retreat is greater than the effect of the Empire Jetties.

## 2.6 VOLUMETRIC CHANGES

The 2000 survey by Morris P. Hebert (MPH) and the 2005 survey by John Chance Land Surveyors (JCLS) are the only recent profile data available for the area. Only two of the profile lines cross the existing islands and therefore the profiles could not provide volume change estimates along Shell Island. Shoreline data was available over a longer time period (since 1884) and allowed for a greater number of comparison points along the island. Therefore, it was decided to base the volumetric change estimate on the shoreline change data.

Volumetric changes can be estimated by multiplying the shoreline change by the active profile height and alongshore distance between profiles. Previous investigations (Mann and Thomson, 2001) found that volumetric changes could be estimated from shoreline changes when the break in slope was used as the bottom of the active profile height (APH). The following paragraphs describe the active profile height.

Comparisons of beach profiles in Louisiana suggest that the submerged profile is comprised of two distinct shapes. The upper section of the profile, extending several feet below mean high water, follows a profile shape described by Dean's (1987) equilibrium beach profile. Dean's equilibrium profile equation is presented in Equation 3.

$$y = A x^{2/3} \qquad [3]$$

where:

y = depth below mean high water (ft)

A = 0.107 ($ft^{1/3}$) (Dean's empirically derived coefficient for 0.12 mm grain size)

x = distance from mean high water (ft)

The lower section of the profile is relatively flat, with slopes of 1V:400H. The elevation at which the two sections meet is approximately -5 feet (NAVD). This interception point will be called the break in slope or bottom of the erosive face for the remainder of this report. The flat offshore profile suggests that as the island recedes there is little volumetric change seaward of the break in slope compared to the erosion occurring along the island face. The elevation of the break in slope is therefore important when calculating volume changes. Figure 17 shows the cross-shore profile at the west end of Shell Island along with Dean's equilibrium profile.

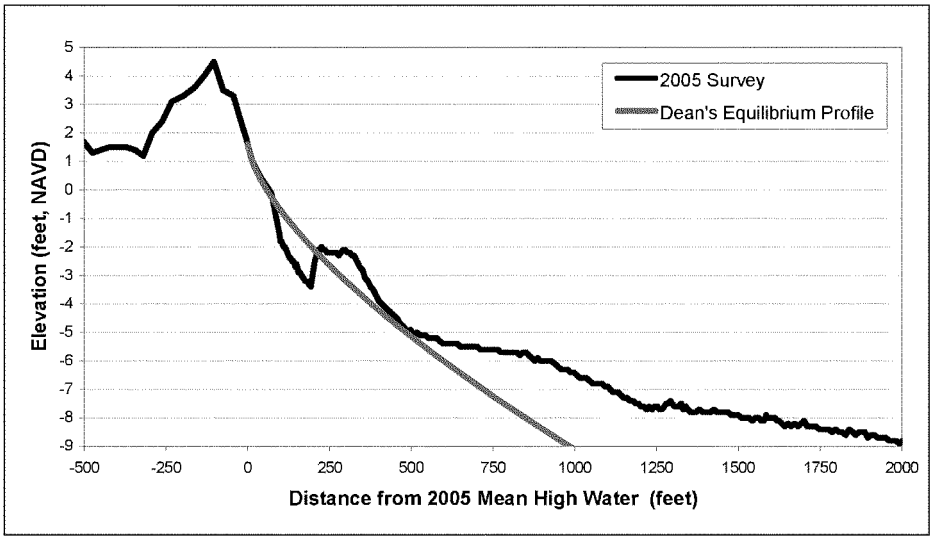



Figure 17. Cross-shore Profile at the West End of Shell Island (West)

The top of the active profile height, when calculating longterm shoreline recession on Louisiana barrier islands, is the marsh elevation (+1.5 feet, NAVD). The island volume above the marsh remains relatively constant with time due to overwash, whereas the true volume change of the island occurs between the top of the marsh and the break in slope.

Volume changes were calculated based on shoreline changes between 1956 and 1973. This time period was chosen as it is the latest time period that had an intact shoreline. Using later time periods where the shoreline is broken does not provide an accurate assessment of volume change.

Table 8 presents the volume change rate along the project area along with the shoreline change, active profile height, and distance between profiles used to develop the volume change.

Table 8. Shell Island Volume Change (Gulf Side) between 1956 and 1973

| USGS Transect Number | Distance From Jetty (ft) | Cell Width (ft) | Active Profile Height (ft) | Shoreline Change (ft/yr) | Shoreline based Volume Change | |
|---|---|---|---|---|---|---|
| | | | | | cy/yr | cy/ft/yr |
| 81 | 850 | 1,370 | 6.5 | -39.3 | -13,000 | -7.2 |
| 80 | 1,890 | 1,145 | 6.5 | -21.5 | -6,000 | -5.2 |
| 79 | 3,140 | 1,270 | 6.5 | -32.6 | -10,000 | -7.9 |
| 78 | 4,430 | 1,315 | 6.5 | -30.1 | -9,600 | -7.3 |
| 77 | 5,770 | 1,690 | 6.5 | -28.3 | -11,500 | -6.8 |
| 76 | 7,810 | 2,120 | 6.5 | -23.6 | -12,100 | -5.7 |
| 75 | 10,010 | 2,125 | 6.5 | -27.2 | -14,000 | -6.6 |
| 74 | 12,060 | 1,825 | 6.5 | -27.9 | -12,300 | -6.7 |
| 73 | 13,660 | 1,525 | 6.5 | -27.4 | -10,100 | -6.6 |
| 72 | 15,110 | 1,545 | 6.5 | -23.5 | -8,800 | -5.7 |
| 71 | 16,750 | 1,665 | 6.5 | -27.7 | -11,100 | -6.7 |
| 70 | 18,440 | 1,715 | 6.5 | -23.5 | -9,800 | -5.7 |
| 69 | 20,180 | 1,610 | 6.5 | -19.0 | -7,400 | -4.6 |
| 68 | 21,660 | 1,435 | 6.5 | -14.2 | -4,900 | -3.4 |
| 67 | 23,050 | 1,200 | 6.5 | -7.8 | -2,300 | -1.9 |
| 66 | 24,060 | 1,300 | 6.5 | 15.3 | 4,800 | 3.7 |
| 65 | 25,650 | 795 | 6.5 | -16.1 | -3,100 | -3.9 |
| Total | | | | | -141,200 | |

Note: A negative value signifies shoreline recession or volumetric loss.

## 2.7 DYNAMIC MORPHOSEDIMENTARY MODEL

A dynamic morphosedimentary model (Campbell, 2005) was used to estimate the total longshore and cross-shore sediment transport for Shell Island. Louisiana's barrier islands typically have a Gulfside face that is composed of sand while the main body of the island is composed both of sand and fine sediment (Figure 18). As the island retreats, the material from the main body of the island is exposed and the fine sediment is suspended and moved offshore while the sand concentrates at the front face of the island. Sand is then removed from the face of the island by both longshore and cross-shore transport. A site visit to Shell Island suggested that a similar morphologic response was occurring, though a greater shell fraction was observed compared to other Louisiana barrier islands.

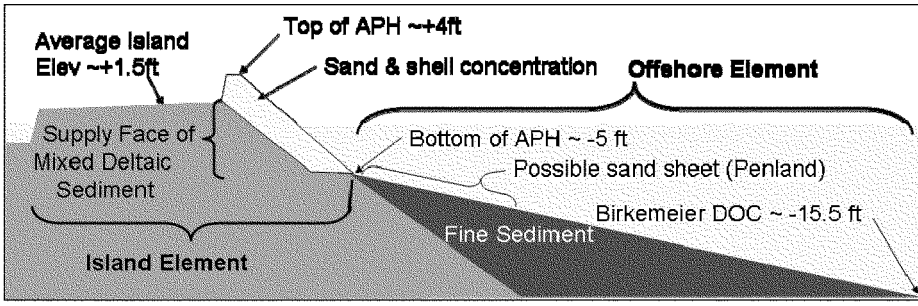



Figure 18. Schematic of Cross-shore Profile for a Barrier Island

### 2.7.1 Model Inputs

The model is based on the following data that can either be measured, or directly calculated:

1. Shoreline retreat rate.
2. Rate of relative sea-level rise.
3. Break in the profile slope.
4. Birkemeier's (1985) depth of closure.
5. Elevation of the marsh platform.
6. Width of the island.
7. Distance to Birkemeier's depth of closure.

Section 2.4 discusses shoreline change rates. The measured shoreline retreat was estimated to be 26 feet/year for the 1956 to 1973 analysis period between USGS transects 68 and 81. This time period was chosen for input into the model as it was after the construction of the Empire Jetties but prior to the formation of Coupe Bob in 1979. The dynamic morphosedimentary model was developed by considering barrier islands with uniform shoreline retreats; it does not account for sediment loss due to tidal flow. Tidal currents through a breach such as Coupe Bob can increase the shoreline retreat rates non-uniformly, so the model should be applied in the pre-Hurricane Bob time period. USGS transects 65, 66, and 67 (shown in Figure 10) were omitted when calculating the shoreline change for input into the model due to the possible influence of Grand Bayou Pass on the shoreline change.

Relative sea-level rise was discussed in Section 2.3 and estimated to be 0.043 feet/year for this section of Louisiana between 2009 and 2059. However, the model was calibrated for the 1956 to 1973 time period when relative sea-level rise rates were lower. A relative sea-level rise rate of 0.039 feet/year was used in the dynamic morphosedimentary model based on rates presented in the Chaland Headland and Pelican Island Barrier Shoreline Restoration Project (CPE, 2003b).

The depth at which there is a significant change in the offshore slope was discussed in Section 2.6 and was determined to be -5 feet (NAVD). This is located approximately 500 feet from the mean high water line.

### 2.7.2 Birkemeier's Depth of Closure

Cross-shore removal of material from the face of the island results in deposition of both fine sediment and sand in the offshore profile. Sand is typically deposited closer to the shore while silt is transported much further offshore. Birkemeier's equation was used to define the effective depth that this occurs for volumetric continuity.

Birkemeier's method of determining the depth of closure is based on the significant wave height and wave period exceeded 12 hours per year (Equation 4):

$$h_c = 1.75H_e - 57.9(H_e^2 / gT_e^2) \qquad [4]$$

where:

$h_c$ = depth of closure relative to mean low water.

$H_e$ = nearshore significant wave height exceeded 12 hours per year.

$T_e$ = wave period corresponding to $H_e$.

g = acceleration of gravity constant, 32.2 ft/sec$^2$.

The offshore values of $H_e$ and $T_e$ are 11.2 feet and 8 seconds respectively, based on the 1980-1999 hindcast at WIS Station 132 (USACE, 2004). The Birkemeier depth of closure is calculated to be -15.5 feet (NAVD) (-16.1 feet, MLW). The average perpendicular distance from the 15.5-foot contour to the average shoreline location is approximately 7,000 feet, so the slope of the offshore profile (between –5 feet, NAVD and –15.5 feet, NAVD) is approximately 1V:670H.

### 2.7.3 Cross-shore Redistribution of Sediment

#### 2.7.3.1 Storm Overwash / Relative Sea-level Rise

Observations of Louisiana barrier islands suggest that the islands must be rising close to the rate of sea-level rise or the island (beach and marsh) would drown in place. The process of storm overwash and relative sea-level rise combine to effectively compress the island footprint to allow it to keep pace with relative sea-level rise (Figure 19). Historic shoreline changes suggest that Shell Island maintained its width until breached during the passage of Hurricane Bob. The volume of overwash can be calculated by multiplying the relative sea-level rise rate by the width of the island element. The average width between the mean high water shoreline on the Gulf side and the mean high water line on the bay side is approximately 900 feet and the distance to the break in slope is 500 feet, for a total island element width of 1,400 feet. A total of 2.0 cubic yards/foot/year are therefore required to raise the island element by the rate of relative sea-level rise. Shell Island retreats an average of 8.4 feet/year to provide sufficient sediment for the rate of rise of the island element to match the relative sea-level rise rate.

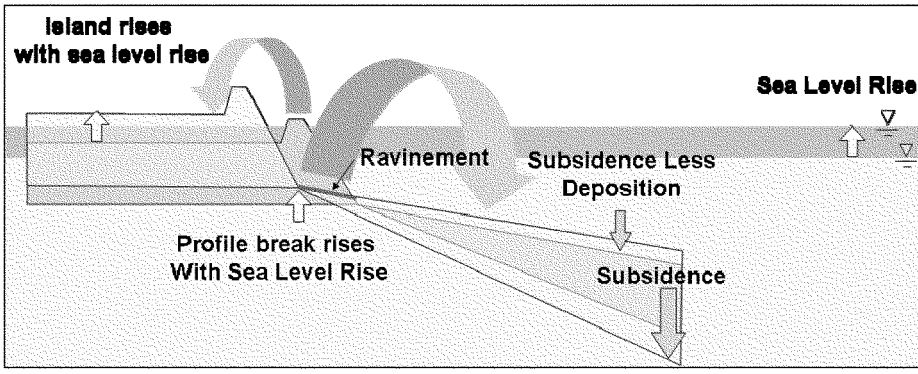



Figure 19. Schematic of Island Rising due to Relative Sea-level Rise

#### 2.7.3.2 Cross-shore Balance / Continuity

The model computes a mass balance for cross-shore sediment movement such that continuity is achieved when sufficient sediment is added to the offshore element so that the offshore slope intercepts the new break in slope location. The material that moves offshore from the island is primarily fine sediment that is exposed during storms and dislodged during wave action. The volume required to achieve continuity is approximately 2.2 cubic yards/foot/year. This corresponds to a shoreline retreat rate of 11.6 feet/year.

The total (historic) retreat due to cross-shore processes is therefore 20.0 feet/year. A sensitivity analysis on the dynamic morphosedimentary model is presented in Annex C-9.

### 2.7.4 Estimate of Sand Lost Longshore

The average shoreline recession between 1956 and 1973 was approximately 26 feet/year between USGS transects 68 and 81. The difference between the cross-shore component of retreat and the measured retreat is 6.0 feet/year. This difference is attributed to longshore loss. The active profile height (+4 feet, NAVD to –5 feet, NAVD) used when calculating longshore transport results in the longshore loss volume of 2.1 cubic yards/foot/year.

### 2.7.5 Littoral Transport Rates

The modeled section of Shell Island was approximately 22,355 feet long from the eastern end to the western end of the analyzed area. The top of the active profile for longshore transport is the top elevation of the island (+4 feet, NAVD). Given a 6.0 foot/year retreat rate for longshore loss and an active profile height of 9 feet, the total longshore littoral transport loss estimated by the model is approximately 46,300 cubic yards/year. The model does not give the distribution or direction of this sediment transport, only that 46,300 cubic yards/year were lost from the island by longshore processes.

## 2.8 SEDIMENT BUDGET DEVELOPMENT

A sediment budget was developed for each island to describe the movement of sediment into, out of, and within the project area. Volume changes provide the basis for tracking the movement of material.

A distinction is made between a sediment budget accounting for all material (sand, silts, and clays) and a sediment budget based on the available sand. From a coastal engineering perspective, it is the volume of sand within the system that is important as the sand provides protection from wave attack. When silt and clay are exposed, they are suspended in the water column and can be transported offshore. Therefore, a sand sediment budget was developed. This chapter discusses the development of a sand sediment budget.

The first step in development of a littoral budget is to calculate the total annual volume change within the system. The estimate of the volume change based on shoreline change was discussed in Section 2.6. The 1956 to 1973 shoreline history was used for the analysis because more recent time frames did not have a single cohesive island.

The second step is to estimate the volume loss due to relative sea-level rise and overwash. The dynamic morphosedimentary model suggested that the shoreline recession due to relative sea-level rise was 8.4 feet/year. The loss of material due to relative sea-level rise is calculated by multiplying the shoreline recession due to relative sea-level rise, the active profile height for calculating retreat (6.5 feet), and the width of the cell. It should be noted that "losses" due to relative sea-level rise are only a readjustment of the profile and not an actual volume loss. It is only termed a loss because it results in a shoreline recession.

The third step is to estimate the volume of silt lost in a cross-shore direction to the offshore element. It is assumed that silt/clay is lost cross-shore and that the sand component of the island is transported alongshore. The dynamic morphosedimentary model suggested that Shell Island was composed of 52% silt to obtain the observed shoreline recession rates. The available vibracores could not confirm or deny this assumption.

The conservation of sand principle was used to estimate the remaining volume lost in a longshore direction. The sand conservation equation allows the littoral transport for adjacent reaches to be estimated using Equation 5. Table 9 summarizes the components of volume change along Shell Island between 1956 and 1973.

$$LT_{out} = LT_{in} + \Delta V_{total} - V_{RSLR} - V_{offshore} \qquad [5]$$

where:

$LT_{out}$ = Littoral transport out of the reach

$LT_{in}$ = Littoral transport into the reach ($LT_{out}$ from updrift cell)

$\Delta V_{total}$ = Volume change calculated based on shoreline change

$V_{RSLR}$ = Volume associated with relative sea-level rise

$V_{offshore}$ = Offshore volume loss

Table 9. Development of Longshore Transport along Shell Island between 1956 and 1973

| USGS Transect Number | Shoreline based Volume Change (cy/yr) | Volume Correction for RSLR & Overwash (cy/yr) | Volume Correction for Cross-shore Volume Change (cy/yr) | Alongshore Volume Change (cy/yr) | Longshore Transport (cy/yr) |
|---|---|---|---|---|---|
| Empire Jetty | - | - | - | - | 0 |
| 81 | -13,000 | -2,800 | -5,300 | -4,900 | 4,900 |
| 80 | -6,000 | -2,300 | -1,900 | -1,800 | 6,700 |
| 79 | -10,000 | -2,600 | -3,800 | -3,600 | 10,300 |
| 78 | -9,600 | -2,700 | -3,500 | -3,400 | 13,700 |
| 77 | -11,500 | -3,400 | -4,200 | -3,900 | 17,600 |
| 76 | -12,100 | -4,300 | -4,000 | -3,800 | 21,400 |
| 75 | -14,000 | -4,300 | -5,000 | -4,700 | 26,100 |
| 74 | -12,300 | -3,700 | -4,400 | -4,200 | 30,300 |
| 73 | -10,100 | -3,100 | -3,600 | -3,400 | 33,700 |
| 72 | -8,800 | -3,100 | -2,900 | -2,800 | 36,500 |
| 71 | -11,100 | -3,400 | -4,000 | -3,700 | 40,200 |
| 70 | -9,800 | -3,500 | -3,200 | -3,100 | 43,300 |
| 69 | -7,400 | -3,300 | -2,100 | -2,000 | 45,300 |
| 68 | -4,900 | -2,900 | -1,000 | -1,000 | 46,300 |
| 67 | -2,300 | -2,400 | 0 | 100 | 46,200 |
| 66 | 4,800 | -2,600 | 3,800 | 3,600 | 42,600 |
| 65 | -3,100 | -1,600 | -700 | -800 | 43,400 |
| Total | -141,200 | -52,000 | -45,800 | -43,400 | - |

Note: East to West transport is denoted as a positive transport rate.

Figure 20 shows the sediment budget graphically, with the volume accounting for RSLR and overwash being transported to the north, the cross-shore transport of fines to the south (offshore), and the longshore transport to the east and west.

The net longshore transport rate along the island can be estimated by summing (integrating) the volume in a longshore direction (Equation 5). This model assumes that only sand is transported in the longshore direction and that clay and silt are transported offshore. The jetties were assumed to be a point of zero net sediment transport for the start of the calculation, as the jetties are sufficiently long to interrupt longshore transport.

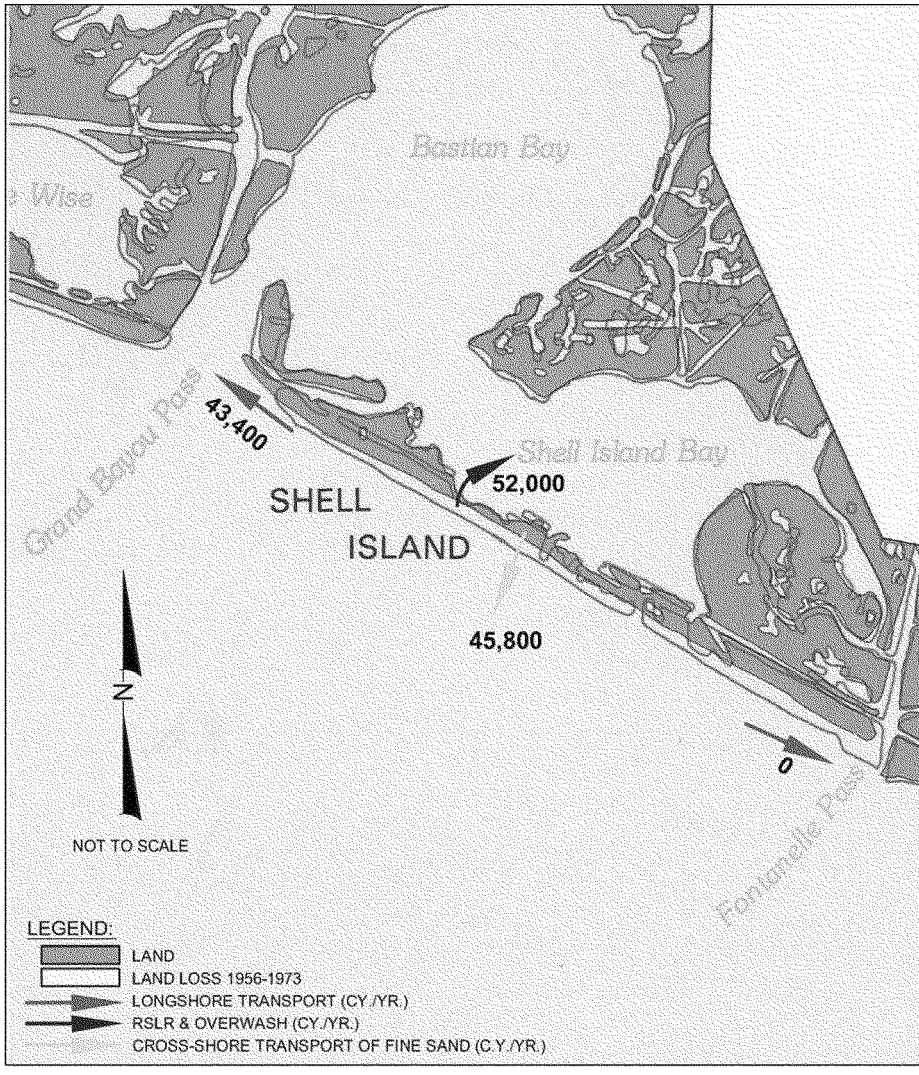



Figure 20. Sediment Budget for 1956-1973 Period

Table 9 and Figure 21 show that the net longshore transport rate estimated for the 1956 to 1973 time period increased to a maximum of approximately 46,300 cubic yards/year towards the western end of the project area (USGS transect number 68) before decreasing slightly to 43,400 cubic yards/year at the western end.

The development of the longshore transport curve along Shell Island allows for the prediction of sediment transport under a nourished, with project condition. The longshore transport can be applied to alternatives that are similar to the island conditions between 1956 and 1973. It should be recognized that this section only developed a net longshore transport rate that is composed of both east-to-west transport as well as west-to-east transport. Longshore losses for alternatives that comprise two separate islands with Coupe Bob in the middle will be higher than the longshore loss for a single island alternative.

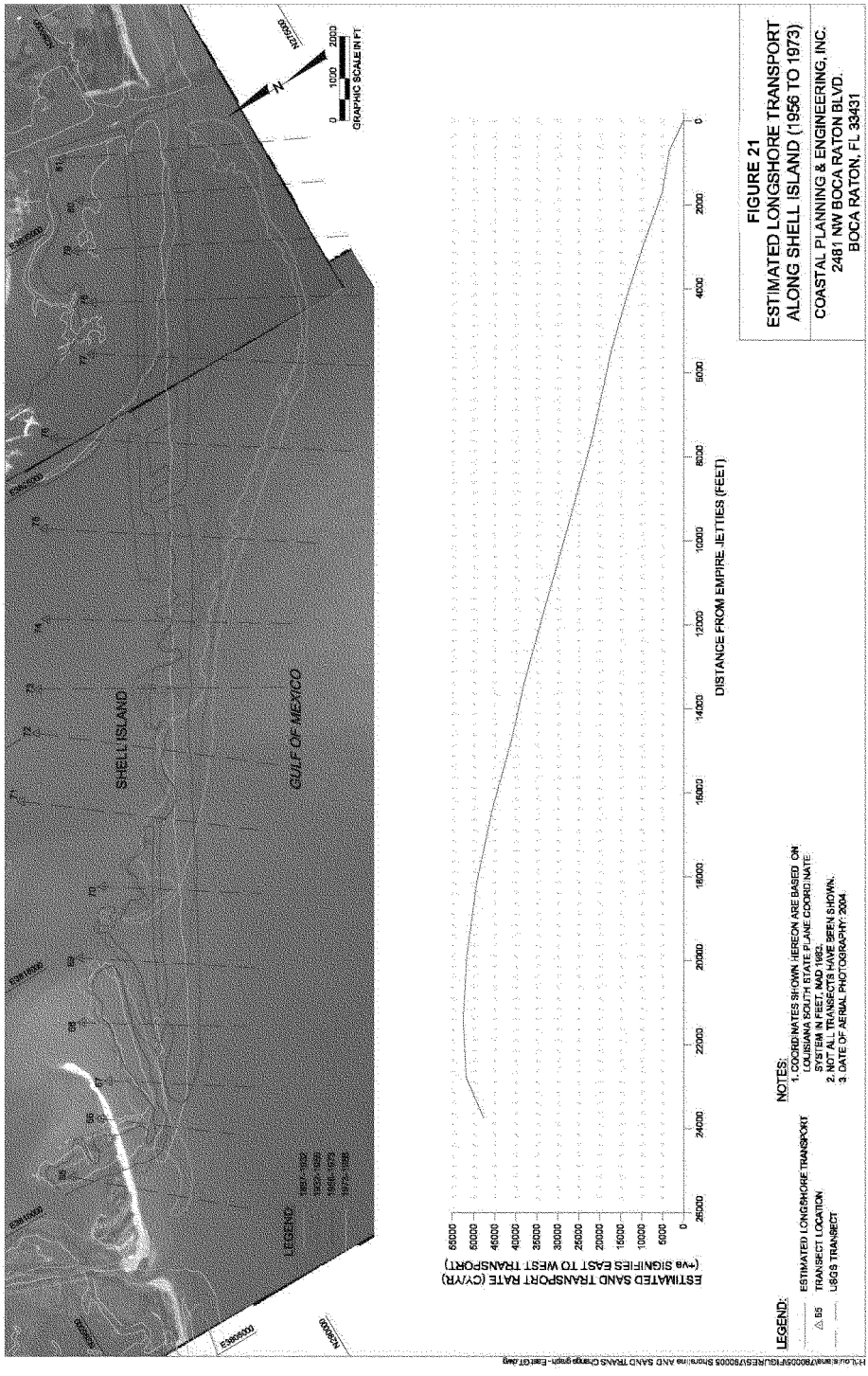



FIGURE 21
ESTIMATED LONGSHORE TRANSPORT
ALONG SHELL ISLAND (1956 TO 1973)

COASTAL PLANNING & ENGINEERING, INC.
2481 NW BOCA RATON BLVD.
BOCA RATON, FL 33431

## 2.9 BREACH ANALYSIS

A breach is a new opening in a narrow landmass, such as a barrier island, that allows water to flow between the water bodies on each side. A barrier island breach can increase erosion (as discussed in Section 2.4), expose the back bay or estuarine environment to Gulf waves and stronger currents, increase salinity and water levels in the back bay or estuarine environment, accelerate the destabilization of jetties, increase the costs of jetty repair and channel maintenance dredging, and reduce or impede navigability in adjacent inlets sharing the same water bodies as the breach. Identifying areas susceptible to potential breaching and implementing preventative measures is typically less costly than closing a breach.

Breaching can occur in two ways: by overtopping, and by seepage and liquefaction. Along the Gulf coast, incipient breaching typically occurs by overtopping from the Gulf side through a combination of storm surge and large waves that accompany tropical storms, hurricanes, and northeasters. Once the breach is initiated from the Gulf side, high water levels in the bay may open the breach quickly in ebbing (Kraus and Wamsley, 2003). The initiation and course of breaching depend on the cross section of the barrier island, surge hydrograph (or water level in the bay with respect to the Gulf in the case of breaching from the bay), wave height, longshore transport rate, hydraulic efficiency of the breach and its location, sedimentary composition, and the presence of barriers (Kraus, 2003). A breach may close naturally, but if the tidal exchange is strong and longshore sediment transport is weak, the breach can increase in size and become a new inlet.

Little quantitative information is available on the process of coastal barrier breaching (Kraus, 2003). The lack of a predictive capability required a quantitative analysis of previous breaches in Shell Island.

The breach in Shell Island known as Coupe Bob was formed during Hurricane Bob in 1979. This breach cut through the narrowest interior section of the island. The width of the barrier island prior to breaching, as measured from the 1973 mean high water shoreline presented in the Atlas of Shoreline Changes in Louisiana from 1853 to 1989 (Williams, Penland, and Sallenger, 1992), was approximately 300 feet. Similarly, the island breached between 1884 and 1932 at the narrowest interior section of the island. The width of the barrier island at this location prior to breaching was also approximately 300 feet. No new breaches were present when comparing the 1932 to 1956 and 1956 to 1973 shoreline data. The narrowest interior section of the island in 1932 and 1956 was greater than 400 feet or had a large land mass southeast of its location to provide sediment (sediment is transported northwesterly along this reach).

This analysis suggests that breaching of Shell Island historically occurs at the narrowest interior section of the island when its width is less than 300 feet and no updrift sediment source is available to close the breach. Therefore, breaching can be expected to occur at the narrowest interior section of Shell Island

when its width is less than 300 feet. Any single island alternative suggested to reconstruct Shell Island may be in danger of breaching if the island is not maintained at a width greater than 300 feet wide. The single island options, their renourishment intervals, and risk of breaching are discussed later in the report.

## 2.10 TIDAL PRISM AND EBB SHOAL FORMATION

The limited bathymetry in the vicinity of Coupe Bob does not currently show the presence of an ebb shoal. It is hypothesized that this is due to a lack of sandy sediment available to form the shoal. Construction of a two-island option, as proposed in the LCA, will provide sandy sediment to the system that could be reworked and moved offshore to form an ebb shoal. This section investigates the possibility of an ebb shoal forming at Coupe Bob and an estimate of the ebb shoal volume.

Several empirical relationships have been developed to determine the expected volume of an ebb shoal. Most of these are related to the inlet's tidal prism. As there is insufficient sandy sediment within the current system to build an ebb shoal, the current cross-section may not be representative of the equilibrium cross-section. Instead O'Brien's relationship (USACE, 2001a) was used to estimate the equilibrium cross-section of the inlet based on the tidal prism. O'Brien's relationship is shown in Equation 6.

$$A = 5.02 \times 10^{-4} P^{0.84} \qquad [6]$$

where:

A = equilibrium cross-section of the tidal inlet (feet$^2$)

P = tidal prism (feet$^3$)

The area of Bastian Bay was estimated to be 3,500 acres by outlining the area from the 2004 DOQQ's. The tidal prism could then be estimated considering a tidal range of 1.05 feet (mean low water to mean high water). The tidal prism for Bastian Bay is therefore $1.6 \times 10^8$ feet$^3$. It was assumed that the tidal prism for Shell Island Bay flowed in and out of Fontanelle Pass (Empire Waterway) and between the remanants of Shell Island East. This has not been included in the tidal prism volume for Bastian Bay.

SJB and CEC (2003) estimated that 39.8% of the tidal prism for Bay Joe Wise flowed through Coupe Bob while 19.7% flowed through Grand Bayou. The rest of the Bay Joe Wise tidal prism flowed through Pass Chaland. Assuming that Grand Bayou remains open and a tidal range of 1.05 feet, the tidal prism due to the 39.8% of the Bay Joe Wise tidal prism passing through Coupe Bob is $0.8 \times 10^8$ feet$^3$. If Grand Bayou

were to close, Coupe Bob would handle the additional 19.7% of the tidal prism flowing from Bay Joe Wise and through Grand Bayou for a total of $1.2 \times 10^8$ feet$^3$.

The total tidal prism that could flow through Coupe Bob is $2.8 \times 10^8$ feet$^3$ (draining Bastian Bay and Bay Joe Wise). Equation 5 suggests that the equilibrium cross-section would be 6,300 feet$^2$.

Walton and Adams (1976) developed a relationship to predict the size of an ebb shoal based on the cross-sectional area. This is shown in Equation 7.

$$V = 45.7\ A^{1.28} \qquad [7]$$

where:

V = Volume of the ebb shoal (cubic yards)

A = Cross-sectional area of the tidal inlet (feet$^2$)

This method suggests that Coupe Bob could form an ebb shoal containing 3.3M cubic yards of sandy sediment.

The *Shore Protection Manual* (USACE, 1984) provides a relationship between the volume of the ebb shoal and the tidal prism. This relationship, shown in Equation 8, is intended for use along the eastern Gulf of Mexico coast.

$$V = 1.38 \times 10^{-4}\ P^{1.23} \qquad [8]$$

where:

V = Volume of the ebb shoal (cubic yards)

P = Tidal Prism (feet$^3$)

This method suggests that the Coupe Bob ebb shoal will grow to 3.4M cubic yards.

The ebb shoal volume estimates are conservative given the 50-year project life. The following items have not been incorporated into the tidal prism estimate but would increase the tidal prism and ebb shoal volumes:

1. SJB and CEC (2003) estimated that the tidal range in Bay Joe Wise was approximately 1.5 feet based on measured data. A smaller tidal range (1.05 feet) has been used in the above calculations based on NOAA data measured at the Grand Isle tidal station.

2. Subsidence within Bastian Bay may cause an increase in the size of the bay over the project life. Barras *et al.* (1994) estimates a 0.9% loss of wetlands per year for Barataria Basin. This equates to 57% increase in Bastian Bay over the 50-year project life.

3. The influx of fresh water into Bastian Bay may increase the volume of water flowing through Coupe Bob.

4. The smaller bays north of Bastian Bay have not been included in the calculation.

The 2005 bathymetry does not show the presence of an existing ebb shoal at Coupe Bob. Coupe Bob most closely resembles an old transitional tidal inlet using Levin's (1993) classification, with remanants of a shoal/island in the throat. Levin states that growth of the ebb shoal with time can be expected due to subsidence and wave induced erosion. However, formation of the Coupe Bob ebb shoal appears to be limited by a lack of available sandy sediment in the current system.

The stability of an inlet can be evaluated by comparing the tidal prism to the gross longshore transport (USACE, 2001a). Based on sediment transport modeling and the sediment budget developed in previous sections, the gross longshore transport is approximately 75,000 cubic yards/year. This gives a tidal prism to net transport ratio of approximately 140. This ratio implies that the inlet stability would be fair to good and suggests that an offshore bar will form in a two-island scenario.

Under the one-island scenario (Alternatives 3 through 8) Coupe Bob is closed and the tidal flow would be redirected towards other inlets. The closest inlets are Grand Bayou and Empire Waterway. It is unlikely that new inlets will form as restoration projects are planned for the islands and headlands adjacent to the project area. Pelican Island is awaiting final permits and funds have been allocated to construct the project with an expected start date in late 2008. The Bay Joe Wise Headland Restoration project has been awarded (May 2008) and is about to start construction, and the Chaland Headland restoration was completed in March 2007. Restoration of Scofield Island is in the design phase.

It is expected that Grand Bayou would increase in size to accommodate a portion of the tidal prism flowing currently flowing through Coupe Bob. It has been estimated that it will grow and be similar to over 2,000 feet as previously observed prior to the formation of Coupe Bob (Figure 21). The Empire Waterway will accommodate the other portion of the flow though it is difficult to determine without a

more comprehensive modeling effort whether the cross-section will increase given that it has been dredged for navigation purposes. The additional cross-section due to dredging may be sufficient to handle the increased tidal flow. There is also a 2,000-foot gap between the northwest end of the jetty and the eastern end of Shell Island that can allow tidal exchange. Given the distance and shallow depths within the back bays, it is not expected that Scofield Pass, Pass Chaland or Bay Coquette (the area east of Scofield Island) will capture any of the Bastian Bay tidal prism.

Observations at Grand Bayou indicate that there is a small ebb shoal associated with the inlet. Under a single island alternative, this ebb shoal would likely increase in size. The assumed tidal prism for Coupe Bob will be similar to the tidal prism accommodated by Grand Bayou so an ebb shoal size of 3.4M cubic yards has been approximated.

## 3.0 SAND RESOURCES (GEOLOGY)

This section of the report provides a brief overview of the sediment sources available for the restoration of Shell Island. More detailed information about offshore sand sources, marine sediment resources, and sands from the Mississippi River are contained in Annex C-2. The Shell Island restoration project requires sediment sources for restoration and construction of the beach-dune system and back barrier marsh construction. Beach-dune sediment sources should be primarily comprised by sand whereas marshes may contain mixed sediment (*i.e.* admixtures of sand, silt, and clay).

Previous and ongoing investigations near the study area were conducted by Kindinger *et al.* (2001), Suter *et al.* (1991), CPE (2003-2004), Tulane University (2003), and CEC (2004). Recent investigations (CPE 2004a, 2005a) indicate that the Mississippi River is a source of high-quality sand that would be potentially suitable for this project, pending the results of detailed investigations.

Sequential offshore sand search investigations have not as yet confirmed the presence of sand deposits in the vicinity of Shell Island. Offshore mixed-sediment deposits could be readily used for marsh construction. This feasibility study is developed on the assumption that Mississippi River sand will be used as a sand source for beach-dune construction and that the offshore mixed-sediment borrow area at Empire will be exploited for marsh construction.

Summary data associated with the Mississippi River sand borrow areas, offshore sand borrow areas, and offshore mixed sediment borrow areas are briefly described in the following paragraphs. Refer to Annex C-2 for detailed description of the characteristic of these deposits and the process leading to their definition.

### 3.1 MISSISSIPPI RIVER SAND SOURCES

Due to large volume requirements and geographic location of the project area (8 to 15 miles from the Mississippi River), renewable sand deposits on the riverbed have potential to supply sediments for restoration of Shell Island. CPE (2004) performed an assessment of sand resources and indicated that significant volumes of sand may be available in the lower section of the river to restore the barrier islands of the Plaquemines Shoreline (Shell Island, Pelican Island, and Scofield Island).

The main findings of CPE's (2004) study of Mississippi River sand resources indicate three primary potential deposits near Shell Island (P1, P2, and P3). Of these, P1 has been confirmed by historical

geophysical and geotechnical investigations as a large sand deposit in a point bar located near Nairn (Figure 22). This deposit is located 2 to 4 miles upriver from Empire between mile marker (MM) 32 and MM 34, and about 11 miles from the center of Shell Island (direct route). This area is geographically best suited for use on Shell Island.

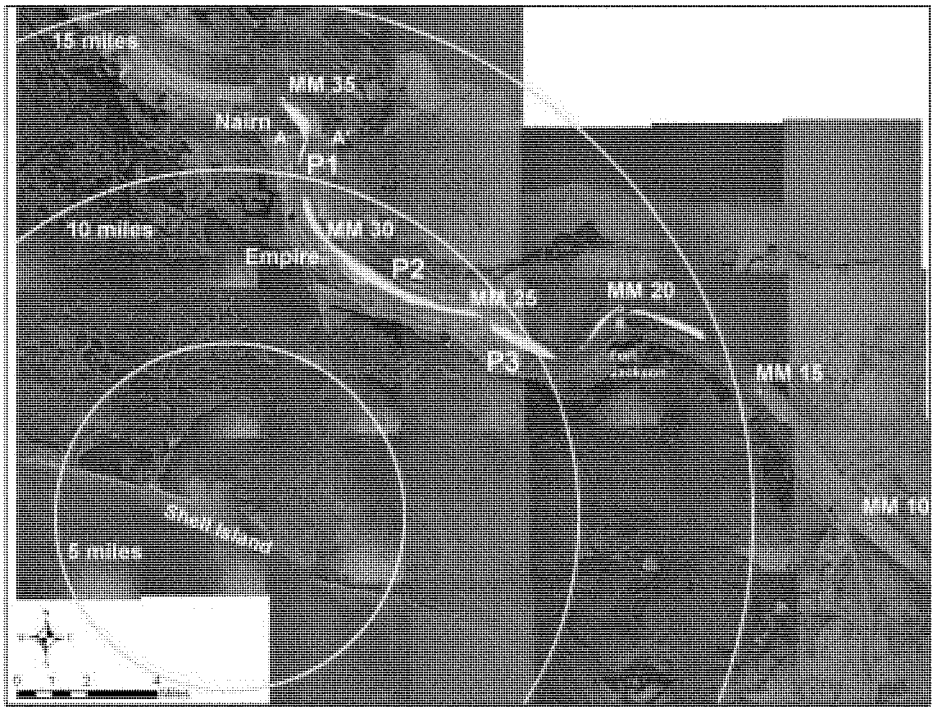



Figure 22. Location of Potential Mississippi River Sand Sources for Shell Island

P1 is located in a river meander where greater sediment thickness may be anticipated due to the presence of relict (vertically stacked) sand bars. McClelland (1988) stated that previous USACE boring data for this point bar indicated sand may extend to depths of at least -90 feet (NGVD). Based on 36 samples obtained from 16 vibracores collected in the Nairn point bar, an average (composite) grain size of 0.17 mm with 0.92 phi sorting was calculated by McClelland (1988).

P2 is located along a gentle river bend on the eastern side of the river (Figure 22). Surface samples obtained in this area identify a mean grain size of 0.17 mm to 0.28 mm (Allison and Nittrouer, 2004).

Surface sand waves are about 6 feet thick, but underlying sands may increase the total thickness of sand deposits (CPE 2004).

P3 occurs along the western riverbank about 6 miles downriver from Empire (Figure 22) and 2 miles upriver from the Fort Jackson River meander. The two-mile long target is limited upriver and downriver by riverbank revetments (CPE 2004).

The primary potential deposits P1, P2 and P3 and secondary area S1, identified by CPE (2004), were further investigated in 2005 (CPE, 2005a). During the 2005 investigation, thirteen (13) vibracores and twenty-three (23) line-miles of geophysical survey data were obtained in the Lower Mississippi River between MM 35 and MM 15. Investigation results of the primary potential deposit areas are briefly described below.

Three (3) vibracores and approximately 7.6 miles of geophysical data were collected from the Nairn point bar (P1). Results of the 2005 investigations along the Nairn point bar confirm prior reports that indicated silty and clayey layers commonly overlie sand in shallow water near the river banks (low flow areas) whereas sand predominates in deeper water (higher flow areas). Seismic data shows a slope break that occurs at approximately -30 feet (NGVD) which roughly corresponds to the bottom of this overburden layer based on both seismic data core data (CPE, 2005a). Although vibracore data collected in 2005 extends to -72.4 feet (NGVD), a study of the seismic record shows that the sand deposit extends below the vibracores.

A borrow area was delineated within the P1 deposit (Borrow Area MR A) and was estimated to contain 2.8 M cubic yards of sand based on a cut depth to -70.0 feet (NGVD) (CPE, 2005a). This volume estimate is very conservative as the boundary of Borrow Area MR A completely avoids the overburden area identified by core MRVC-05-02 and is limited by coverage of the 2005 vibracores (Figure 23). Seismic data and historic cores indicate potential for additional sand resources available within the entire deposit. Using an average bottom elevation of -30.0 feet (NGVD) for the overburden and a cut elevation of -80.0 feet (NGVD) (based on the seismic data), the potential sand deposit within P1 is estimated to be 10.5 M cubic yards with approximately 400,000 cubic yards of overburden (Figure 23). Much of the additional volume is found within the 50-foot thick sand deposit that underlies the overburden avoided in Borrow Area MR A. These volumes are approximations that will need to be refined based on final design-level investigations that include collection of core borings on a maximum 1,000 foot spacing that have recovery to the cut depth; and cultural resource level geophysical investigations. The estimated volume of sand within deposits may increase or decrease, sometimes significantly, based on the results of detailed investigations.

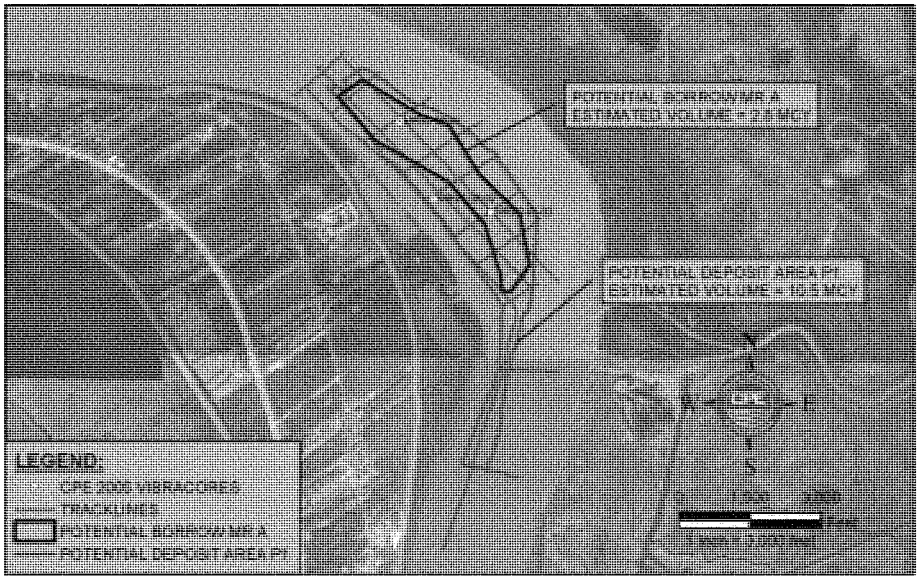



Figure 23. Primary Potential Deposit P1 and Potential Borrow Area MR A.

A total of four (4) vibracores and 7.2 line miles of geophysical data were collected from potential deposit P2 (CPE, 2005a). The vibracores contained mostly sand with less than 2% fines with intercalated layers of sand and clay found in shallow water. The sand layer appears to extend beyond the recovery length of the vibracores based on the seismic data. Because the deposit is segmented by pipelines it was refined into three borrow areas (MR B, MR C, and MR D). The extractable amount of sand in these borrow areas is approximately 16.5 M cubic yards (CPE, 2005a). This volume is based on limited vibracore and seismic data and a cut elevation of -70.0 feet (NGVD). Additional final design level investigations including collection of core borings on a maximum 1,000 foot spacing that have recovery to the cut depth and cultural resource level geophysical investigations will be needed to further refine this deposit.

Two (2) cores and 6.4 line miles of geophysical data were collected from potential deposit P3. Both cores recovered about 15 feet of sand having less than 5% fines. In this area the seismic data indicates that the sand layer extends below the recovered length of the cores and may have a thickness of between 50 and 80 feet. The deposit was refined based on the limited vibracore and seismic data into borrow area MR E. Based on and a cut elevation of -70 feet (NGVD), MR E was estimated to contain 6.3 M cubic yards of sand (CPE, 2005a). As with the other potential deposits, additional design level investigations including collection of core borings on a maximum 1,000 foot spacing that have recovery to the cut depth; and cultural resource level geophysical investigations will be needed to further refine this deposit.

## 3.2 MIXED SEDIMENT SOURCE FOR MARSH RESTORATION

Two deposits southeast of Shell Island were investigated by CPE (2002) *viz.* Empire and Scofield. Vibracores obtained within the Empire deposits were re-evaluated to determine whether the borrow area contains sufficient volume of mixed sediments for marsh restoration. Annex C-2 contains additional details of the Empire and Scofield deposits. The Empire borrow area is located approximately 1.5 miles from the Empire jetties and about 3.5 miles from the center of Shell Island. The boundaries of this redesigned mixed sediment borrow area are shown in Figure 24. Water depths in the borrow area increase seaward from 16 feet to 20 feet, isobaths (bathymetric contours) are roughly parallel to the shore, and surface geomorphology is featureless. Vibracores from the area show irregular intercalation of sand, silt, and clay layering.

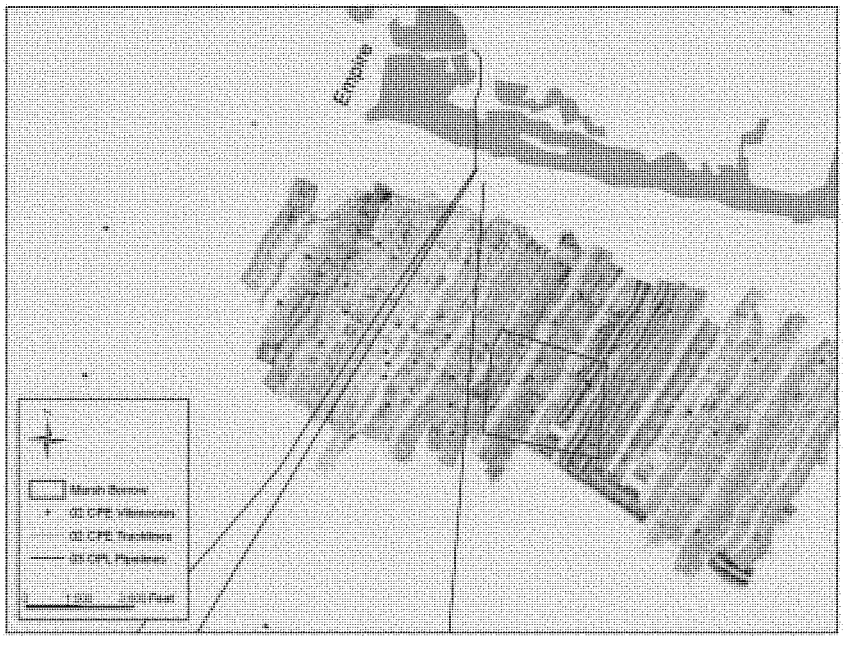



Figure 24. Boundaries of Proposed Marsh Fill Borrow Area

The borrow area occupies about 207 acres and total mixed sediment volumes range from 5.5 to 6.6 million cubic yards for 15 and 20-feet cut depths, respectively. Preliminary borrow area sedimentary characteristics indicate a mean grain size of 0.06 mm, a silt content of about 39%, a clay content about 22%, and sand contents that range from 37% to 38% (Table 10). Three pipelines are located west of this

deposit, as shown in Figure 24. The submerged pipeline would have to cross these pipelines to transport sediment to Shell Island.

Table 10. Empire Borrow Area Sediment Characteristics and Volumes

| Property | 15-foot Cut | 20-foot Cut |
|---|---|---|
| Area ($ft^2$) | 9,020,000 | 9,020,000 |
| Volume (cy) | 5,011,000 | 6,681,000 |
| Grain size (mm) | 0.06 | 0.06 |
| Sorting (phi) | 1.55 | 1.59 |
| % Sand | 38 | 37 |
| % Silt | 40 | 40 |
| % Clay | 22 | 23 |

The Pelican Island Restoration Project (BA-38-1) will require approximately 1.7M cubic yards of marsh fill. Assuming a cut to fill ratio of 2:1, this requires 3.4M cubic yards of marsh fill. This leaves 3.3M cubic yards of marsh fill for Shell Island. The Shell Island Alternatives include a 2.14M cubic yard marsh fill. Therefore additional investigations are required to expand the Empire borrow area in order to have sufficient sediment within the borrow area to proceed to construction with a cut to fill ratio of 2:1. A secondary borrow area is located approximately 0.5 miles to the east of the permitted Empire borrow area that could provide the remaining fill material.

## 3.3 OFFSHORE SAND SOURCES

Several researchers conducted geophysical and geotechnical investigations on the continental shelf adjacent to Shell Island in an effort to identify reconnaissance-level sand resources that could be used for barrier island restoration. These investigations included regional studies by Suter *et al.* (1991) and Kindinger *et al.* (2001), and more detailed studies by CPE (2002-2003) and CEC (2004). A brief summary is provided here with greater detail provided in Annex C-2.

### 3.3.1 Shell Island

Suter *et al.* (1991) and Kindinger *et al.* (2001) conducted regional sand resource assessments offshore of Shell Island. Based on interpretation of seismic data and limited sampling, Suter *et al.* (1991) identified many potential sand deposits nearby Shell Island that were associated with buried channels interpreted from seismic data and limited sampling (Figure 25). Kindinger *et al.* (2001) conducted additional seismic surveys and collected several cores along borrow areas located within the Barataria basin. The Kindinger

study, however, did not confirm sand sources near Shell Island that were suggested in the Suter study. Because Suter *et al.* (1991) suggested numerous potential sand borrow areas within 5 miles of Shell Island, it is recommended that offshore sand search investigations within a 5 mile radius of Shell Island be conducted. The volume of these potential deposits and quality of the material is unknown. There may not be sufficient sand volumes available to construct the initial project but a refined sand search investigation should be considered due to the potential cost savings.

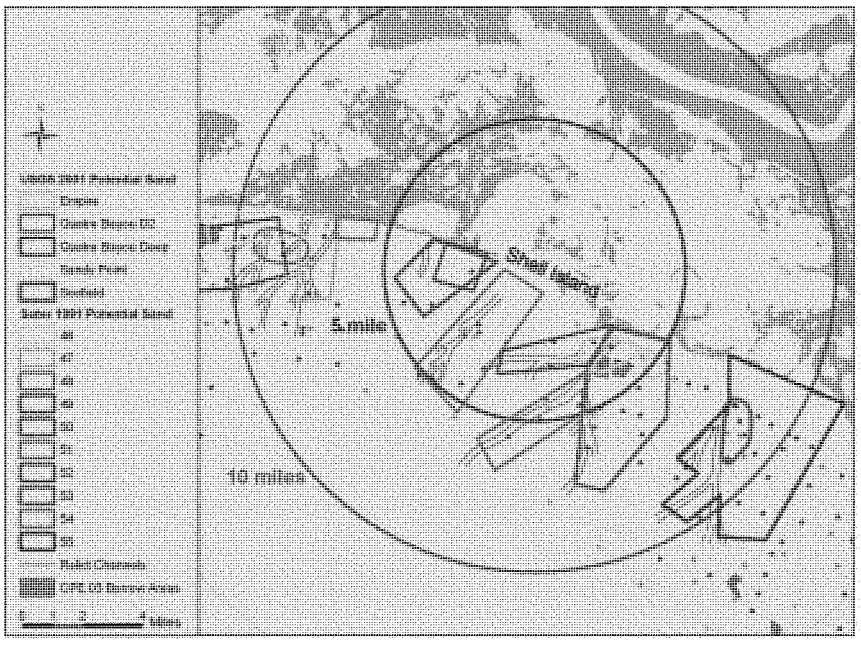



Figure 25. Potential Sand Deposits Identified by Suter *et al.* (1991)

The potential study areas that were identified by Suter *et al.* (1991) provide a general overview of the depositional systems that may store sand near Shell Island. Of particular interest are deposit areas #49, 50, 51, and 52 that are located within a 5 mile radius from Shell Island (Figure 25).

### 3.3.2 Quatre Bayou

The Quatre Bayou study area contains modern shoals and distributary channel environments in water depths that range from 11 to 20 feet. The deposit contains thin beds of surficial sands, a layer of fine sediments, and a subsurface layer of sand. The sand fraction ranges from 0.08 mm to 0.18 mm.

The Quatre Bayou borrow area was used for the restoration of Chaland Headland in 2006. Quatre Bayou Deep and Quatre Bayou D2 are deposits associated with buried distributary mouth bars or channel fill margins. These deposits, which contain laminated sands about 14 feet thick with no shell content, are covered by muddy sediments that range from 5 to 15 ft thick. A borrow area that extends from the southwest corner of Quatre Bayou to the offshore (about 12 miles from Shell Island) may be used for restoration of the shoreline segment in front of Bay Joe Wise. Additional sand resources may be available in these areas.

Detailed studies by CPE (2003) indicated that within the boundaries indicated by Kindinger *et al.* (2001), there is extensive variability in the continuity of the sand deposits of the Scofield and Empire borrow areas. These two borrow areas are thus more suitable as sources of mixed sediments for marsh restoration because most deposits contain less than 40% to 60% sand with some localized pockets of sand.

### 3.3.3 Sandy Point

Sandy Point, by far the largest deposit (220 to 294 million cubic yards of sand) identified by Kindinger *et al.* (2001), was reported to represent a distributary mouth bar environment. The deposit, consisting of interceded sands and clays, is located about 40 to 48 feet below mean sea-level with 8 to 13 feet of laminated clayey-silt overburden. CPE (2003) verified that this deposit is highly variable in both lateral and vertical contexts. Relict channels in this area are infilled by mostly fine-grained sediments and sands occurring as relatively thick channel margin deposits. Extensive oil infrastructure at Sandy Point may limit sand excavation. The western segment of Sandy Point occurs within 10 miles of Shell Island but was not investigated in detail by CPE (2003). Thus, sand reserves may be present in this area.

CPE (2003) defined sand borrow areas within the Sandy Point deposit (Figure 25) for the restoration of Pelican Island. The two deposit areas delimited by the infilled red polygons within the Sandy Point area in Figure 25, located about 12 to 16 miles from Shell Island, contain approximately 3.6M cubic yards of clean sand (about 4M cubic yards of sand and silt), with about 3M cubic yards of mud overburden. Grain sizes in these deposits average 0.11 mm and silt content varies around 10%.

The sand search investigations previously conducted on the continental shelf offshore Shell Island indicate limited volumes of marine sand resources. The most optimistic estimates are those of Suter *et al.* (1991). If 2% to 5% of the Suter *et al.* (1991) potential sand volumes are comprised of clean sand, these materials will provide enough fill for the Shell Island Restoration Project. The location of nearby sand resources (*i.e.* within 5 miles of the project area) would represent a significant savings (order of tens of millions of dollars) for the construction and implementation of the Shell Island Restoration Project. Because of the significant cost savings that would result from the identification of nearby offshore sand sources, additional (more detailed) investigations offshore of Shell Island are recommended in order to better ascertain the true potential for beach-compatible offshore sand sources along the areas where previous investigators indicated the potential occurrences of marine-deltaic sand deposits.

### 3.3.4 Ship Shoal

Ship Shoal, lying about 75 miles to the west of the study area, is described as a high-quality source of clean sand by both Suter *et al.* (1991) and Kindinger *et al.* (2001). This drowned barrier island contains twice the combined volume of the 9 sites identified in their study. Ship Shoal is estimated to contain 1.3 to 1.6 billion cubic yards of good quality sand deposits (80% to 100% sand, 0.25 mm to 0.07 mm) (not considering the presence of infrastructure). However, the distance to the project site makes this sand source more expensive than other known sand sources.

## 3.4 GRAIN SIZE COMPATIBILITY

The grain size and sorting of beach fill material can impact the performance of the project. Two methods to account for grain size and sorting include applying an overfill factor or using equilibrium profile theory (Gravens et al, 2001).

To determine an overfill factor the mean grain size and sorting values of the native and borrow source sediments are compared. However, determining the "grain size" of the native beach would be exceptionally difficult and probably not indicative of an equilibrium state due to the condition of the beach. The crest of the island has a high proportion of shells, which is indicative of an overly eroded profile that has migrated, concentrating the shells along the crest through overwash. Marsh outcrops are also visible along the island shoreface and removal of the upper foot of sand often exposes marsh. This marsh will likely become exposed during storm events. Given this range of sediment and the eroded profile, it was decided to apply the equilibrium profile theory.

Section 4.1.3 discusses the application of the equilibrium profile in the development of the template. The design was based on a mean grain size of 0.13mm because the grain sizes for the various borrow areas

ranges from 0.11mm to 0.28mm. Borrow area P1 contains 0.17mm, which provides a conservative estimate of project performance due to a slightly coarser grain size. Gravens, et al (2001) state that borrow material that is coarser than the native material will produce a beach that is at least as stable as a fill comprised of native fill. Given that the borrow material will likely be coarser than the native material, no overfill volume is required.

## 3.5 CUT TO FILL RATIOS

Losses are still expected during construction of the project that is not related to the overfill volume. A cut to fill ratio compares the volume of fill placed within the template to the volume of material removed from the borrow area.

Cut to fill ratios are typically based on similar types of constructed projects. Cut to fill ratios for Shell Island were based on other Louisiana shoreline protection projects including the Holly Beach Breakwater Enhancement and Sand Management Plan (CPE, 2003) and the Chaland Headland Barataria Barrier Island Restoration Project (BA-38-2) (CPE, 2008). Cut to pay ratios (the cut to fill ratio but clarifying that material placed outside of the template was not included in the fill portion) were 1.33 and 1.6 respectively for the beach portion of the project. Cut to fill ratios are lower than this. The silt content of these borrow areas were 14% and 25% respectively. Higher silt contents will increase the cut to fill ratio as it is assumed that the silt is lost and not placed within the template.

A cut to fill ratio of 1.5:1 was applied when determining whether sufficient beach fill sediment was available within the Mississippi River borrow areas. This was based on the Mississippi River borrow areas having a lower silt content than the comparison borrow areas. Borrow area P1 is estimated to contain 10.5M cubic yards of sand with a silt content less than 5% (including the overburden). Alternatives 4 through 6 require 5.6M cubic yards of material. This provides a cut to fill ratio of 1.87, which should be sufficient to construct the initial project.

A cut to fill ratio of 2 is typically estimated for marsh fill.

## 3.6 BORROW AREA IMPACT ANALYSIS

Dredging of material from the Empire, Scofield and/or Sandy Point borrow areas can alter the wave conditions behind the borrow areas, which can affect accretion and erosion patterns along the shoreline. A borrow area impact analysis was performed to investigate the extent of these impacts. It was assumed that each borrow area was completely dredged to the current permitted depth and that the final bathymetry matched the cut depths. Additional analyses are currently being performed in conjunction with

discussions with relevant agencies to increase the size of the borrow areas. The results of the borrow area impact analysis presented here should be reevaluated if there are changes to the borrow areas.

The Steady-State Spectral Wave Model – STWAVE (Smith *et al.*, 2002) wave transformation models was used to estimate the effect of dredging the borrow areas. STWAVE uses linear wave theory to evaluate spectral waves and predict the refracted wave height and wave angle. Inputs to the model include bathymetry, wave climate, and water levels. A complete discussion of the borrow area impact analysis is included in Annex C-3.

Waves during the average wave conditions govern long-term erosion and sediment transport. Five wave cases under typical conditions were modeled along with six storm cases including the 12-hour per year storm event, 5, 10, 20, and 100-year storm events, and the January 1999 storm.

The wave transformation analysis showed that the Empire Jetties have a sheltering effect along the eastern 1,500 feet of Shell Island. It also showed that the waves are depth limited during storm events with a several mile wide breaker zone.

The average wave propagates from the south-southeast and maintains its height until approaching the -15-foot contour. There is then a gradual change in the wave direction from south-southeast to south.

The wave transformation modeling suggested that there was no impact on the shoreline due to the complete dredging of Empire, Scofield, and Sandy Point borrow areas. There was deemed to be no impact when the change in wave height in the lee of the borrow area was less than the margin of error in the wave hindcast. The maximum dredging-related change in wave height is 0.5 feet at the 5-foot contour. In comparison, the wave height bias of the hindcast data is 0.66 feet (USACE, 2004). The dredging-related changes to the wave height were insignificant in the 11 modeled wave cases, since the changes were within the error margin of the wave hindcast.

The maximum dredging related change under typical wave conditions is 6, which is less than the error margin of 8 degrees. The maximum dredging-related change in incident wave angle during storm events is 13 degrees. However, the wave angle will typically vary by much greater amounts during the passage of the storm and dredging of the borrow areas is not expected to have any noticeable effect on the shoreline.

Figure 26 shows the STWAVE model result for a 20-year return period storm event. This figure shows that there is a decrease in wave height directly behind the borrow areas, with the Sandy Point borrow area having the largest effect, but that there is little difference along the -5-foot (NAVD) reference contour.

Plots of the wave height and wave angle along the -5-foot (NAVD) reference contour line are presented in Annex C-3 for each of the modeled wave cases.

Modeling should also be performed to evaluate potential impacts due to dredging of the Mississippi River. A hydrodynamic model such as Delft 3D or Mike21 would be suitable for modeling any effects. Bathymetric data of the river approximately 5 miles updrift and downdrift of the borrow site would be required for this analysis along with current and water level data. Impacts due to dredging in the river are unlikely, as there is presently no need for maintenance dredging in the areas discussed. Dredging of the point bar is not expected to impact the navigation channel. However, the Mississippi River Commission may require modeling as part of the permitting process.

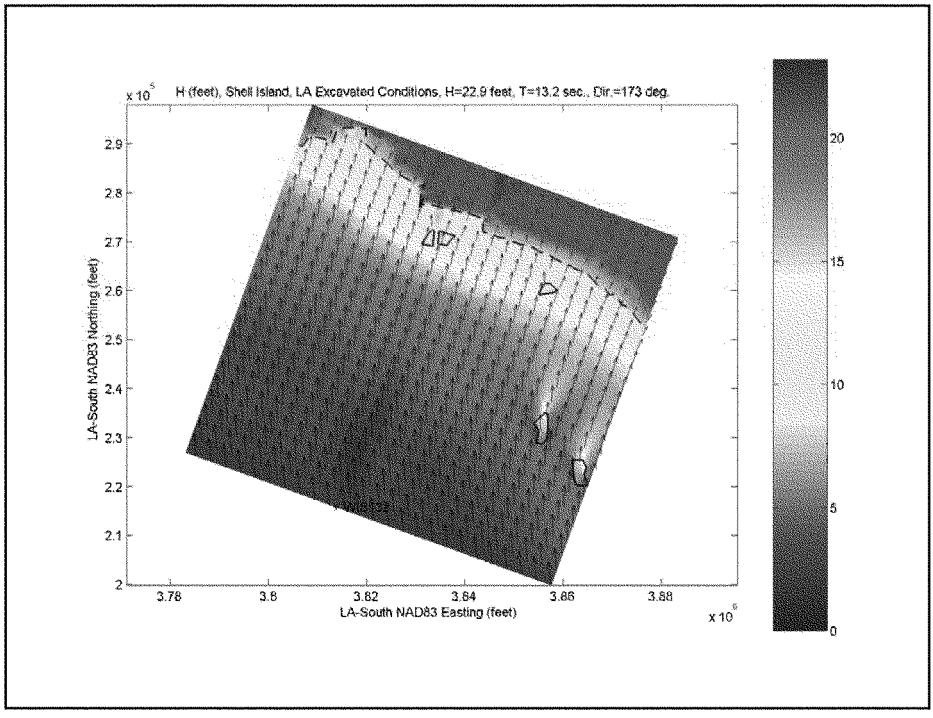



Figure 26. STWAVE Model Result for the 20-year Storm Event

# 4.0 PROJECT DESIGN

## 4.1 BEACH FILL CROSS-SECTION

This section discusses the development of the construction cross-section and the equilibrated cross-section. The concept of a design cross-section is also discussed.

### 4.1.1 Construction Template

The construction cross-section was based on construction templates used for previously constructed projects. The following design details were incorporated:

1. Gulfward Slope of Dune: 1V:45H
2. Bayward Slope of Dune: 1V:45H.
3. Dune Elevation: +6.0 feet (NAVD).

A 1V:45H construction slope was adopted for the Gulf face based on the constructed profile slope measured at the Holly Beach, Louisiana nourishment project (CPE, 2003c). The borrow source at Holly Beach had a grain size of approximately 0.13 mm (CPE, 2003c) and a silt content of 13%. The Chaland Headland Restoration Project started with a 1V:45H construction slope that was altered during construction to a 1V:30H slope above +1 feet, NAVD and 1V:90H below +1 feet, NAVD. There appears to be a threshold of about 20% silt within the borrow area above which flatter slopes may be required during construction. This report will discuss several potential borrow sources but the grain sizes are typically in this range, apart from the Mississippi River sand, which has grain sizes of approximately 0.17 mm (CPE, 2004) and a low silt content. The construction slopes should be reevaluated once the final borrow area is identified.

Other barrier island projects in Louisiana have used a steeper construction slope (1V:30H) on the bayward (landward) side, as the island provides a means of fill retention and thus steeper slopes can be constructed. Most of Shell Island will be constructed in open water or scattered island remnants. Therefore, the slopes on the front and back of the island are proposed to be 1V:45H. No steps are proposed in the construction template, as this increases the cost of construction and does not provide any added benefits compared to the single slope. The material will be reworked into a natural profile by wave and wind action.

The constructed dune elevation was set to +6.0 feet (NAVD). The +6.0 feet (NAVD) dune elevation is above the 20-year return period surge elevation (+5.9 feet, NAVD). Again this follows typical construction of Louisiana barrier islands.

The crest width of the dune is a function of the purpose of the individual alternatives. The dune width for Alternative 1 is based on a cost and target acreage goals that dictate the volume and cross-section width. Alternatives 2 through 8 will be based on a design width plus various advanced nourishment widths. Specific dune widths for the various alternatives will be discussed later.

### 4.1.2 Construction Template Positioning

The Louisiana Coastal Area (LCA) Study (USACE, 2004) discussed the positioning of beach fill templates. The location of the beach fill template can affect the volume of beach fill required to construct the template as well as the project performance. Constructing the beach fill on top of the existing island so that the seaward construction slope intercepts the existing beach face reduces the volume of beach fill required to construct the project. This was termed a "retreat" design in the LCA. A template that was constructed in front of the existing island was termed a "stabilized" design (LCA, Appendix D). The benefit of a stabilized design compared to the retreat design is that the body of the island, which contains a high silt content, does not become exposed. Thus, a stabilized design has lower shoreline retreat rate. However, the retreat design has a lower initial construction volume requirement.

The stabilized design was chosen for two primary reasons. First, the LCA estimated that the volume requirements over the project life were lower for a stabilized design. The stabilized design required more volume for initial construction (180 cubic yards/foot for stabilized vs 111.7 cubic yards/foot for the retreat) but that the renourishment volume was less (39 cubic yards/foot vs 61.7 cubic yards/foot). Thus, the stabilized design provides a volumetric savings of 13.5 cubic yards/foot over the project life.

The second reason was that under the retreat design shoreline recession rates continue to be very high. By placing a sand cap, there should be some reduction in shoreline recession but there is less available engineering design guidance for this concept. Under the retreat design, an estimate must be made as to when the underlying marsh will be exposed and how quickly it will erode. With a stabilized design, it is assumed that the marsh is not exposed during profile retreat allowing for better engineering design basis. Therefore, the risk and uncertainty associated with a retreat design is much higher than for a stabilized design.

### 4.1.3 Post-Construction Profile Equilibration

While the constructed beach slope is 1V:45H from the dune crest to the construction toe of fill, it is expected that the beach will readjust to an equilibrium beach profile in the year following construction. The expected equilibrium beach profile is based on Dean's (1987) equilibration profile below the mean high water line (Equation 3) and horizontal profile translation above the mean high water line.

The beach profile equilibration process assumes that there is only cross-shore redistribution of sediment and that sand volume is conserved. It is estimated that the mean high water shoreline will retreat approximately 20 feet due to profile equilibration. The June 2005 profile, typical construction template and post-construction equilibrium profile for profile line 49 are shown in Figure 27. Note that the volume of the construction template and the volume within the equilibrium profile following construction are the same. A mean grain size of 0.13 mm was used to determine the equilibrium beach profile, as this is typical of existing Louisiana barrier island mean grain size (CPE, 2005b).

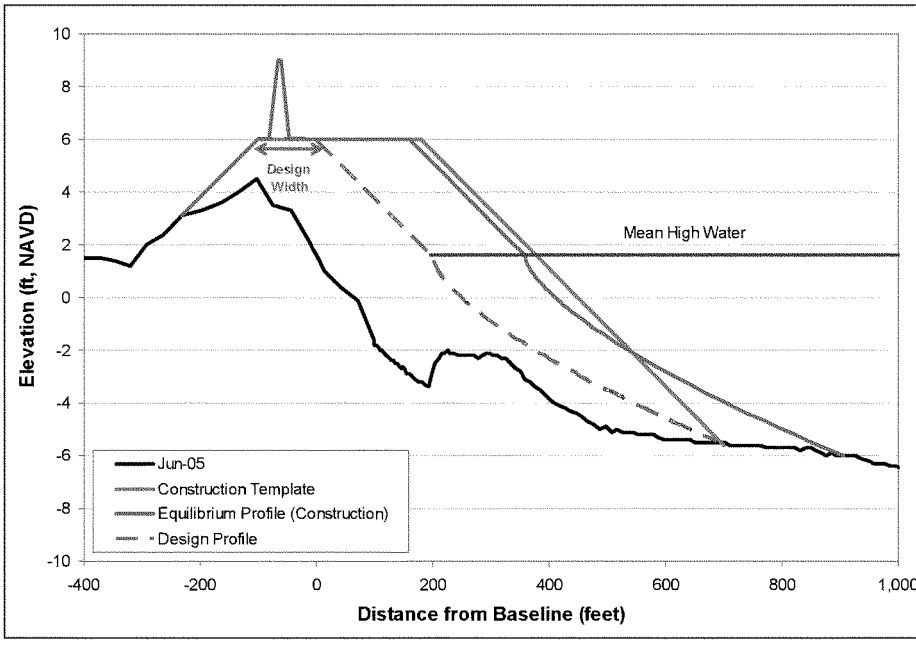



Figure 27. Post-construction Profile Equilibrium

Observations at Grand Isle and Holly Beach suggest that the input of fine sand into a system allows for increased aeolian transport than can increase the island elevation. Construction of sand fencing and planting of vegetation along the dune will promote additional elevation growth of the dune by holding the blowing sand. At Holly Beach, 4-foot high sand fences were quickly inundated with sand and increased the beach elevation by several feet (Figure 28). A 5-foot wide, +9 feet (NAVD) additional dune element was added to the top of the construction template to simulate this increase in dune elevation. Side slopes of 1V:5H were assumed based on surveys by John Chance (2005). It was assumed that this additional dune feature would take approximately 1 year to form. The elevated dune features are caused by a redistribution of sediment along the horizontal section of the construction template. The growth of these dunes may cause a small (a few tenths of a foot) decrease in the elevation of the flat section of the dune.

Figure 28. Photograph of Inundated Sand Fencing at Holly Beach (JCLS, 2005)

## 4.2 DESIGN CROSS-SECTION

A beach nourishment cross-section typically consists of two primary components:

1. The design section, which is the fill volume required at TY50 to meet applicable project goals.

2. Advanced nourishment, which is the sacrificial portion of the fill that will erode over the 50-year project life. Sufficient advanced nourishment can be added during construction or replaced periodically during renourishment projects.

This two-section design is in accordance with the National Research Council (1995) recommendations.

Cross-shore modeling (SBEACH) was used to evaluate the performance of the cross-sections with respect to overtopping and post-storm dune elevation. While a detailed discussion of the cross-shore modeling is provided in Annex C-4, a summary is presented here.

The goal of the analysis was to determine a cross-section that would resist breaching and maintain a sufficient dune elevation to prevent overtopping by more frequent storm events. A post-storm dune elevation of +4 feet (NAVD) in TY20 was determined to be a realistic goal for the East West Grand Terre Restoration Project (CPE, 2005b). This elevation was chosen as a minimum acceptable average post-storm dune elevation for the Shell Island design cross-section. The modeling suggested that a 100-foot design dune crest was needed to achieve a +4 feet (NAVD) post-storm crest elevation under the worst-case scenario. This critical storm event was a 20-year storm event occurring in TY50, following a 50-year storm event. Figure 29 shows the SBEACH output for Shell Island under this storm event.

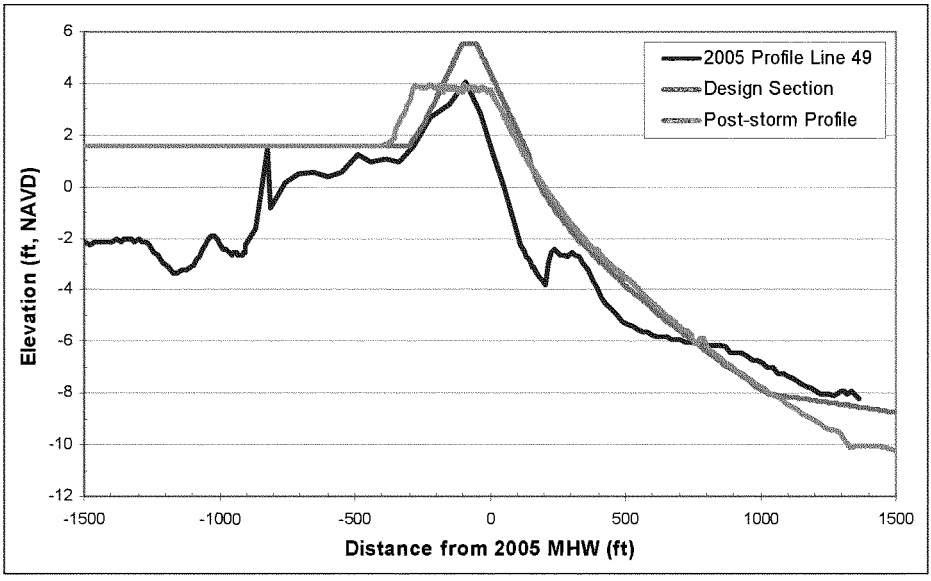



Figure 29. SBEACH Output showing Pre-construction, Design Section, and Post-storm Profile for Shell Island under a 20-year Storm Event at TY50

Note that the offshore portion of the design cross-section was lowered by 2.2 feet from the 2005 survey to account for subsidence. The dune crest was lowered by 0.43 feet to account for subsidence of the emergent island section. This was based on the assumption that the design section would be renourished at 10-year time intervals and that the design was at the end of a nourishment cycle. Therefore, the profile had experienced 10-years of subsidence. The equilibrium profile was also started at the TY50 mean high water line (2.26 feet, NAVD).

The maximum estimated overtopping rate (the movement of water over the dune crest) during the project life for the 100-foot design berm on Shell Island is 0.6 cubic feet per foot per second. The overtopping rate was based on output from the SBEACH model. The USACE (2001) estimated that island breaching occurs when the overtopping rate exceeds 1.7 cubic feet/foot/second. Therefore, breaching is not anticipated given that the overtopping rate is lower than 1.7 cubic feet/foot/second.

Breaching of the island is also dependent on factors such as island width, the height of the dune, density of the sand, root structure of vegetation, etc.

As discussed in the previous section, it is expected that the dune will grow in elevation due to the construction of sand fencing and vegetation planting. While the cross-shore modeling showed that this was effective in reducing overtopping up to a 10-year storm event, the increased dune elevation had a minimal effect during the 20 and 5-year storm events (Annex C-4).

## 4.3 BEACH FILL PLANFORM

Beach fill planforms were developed for the eight alternatives. These alternatives are summarized in the following table (Table 11).

Table 11. Summary of Alternatives 1 through 8

| Alternative | Island Description | Initial Advanced Fill Volume (years) | Beach Renourishment Interval (years) |
|---|---|---|---|
| 1 | Two Islands | 9 | No Renourishment |
| 2 | Two Islands | 10 | 10 |
| 3 | Single Island | 10 | No Renourishment |
| 4 | Single Island | 10 | 25 |
| 5 | Single Island | 10 | 20 |
| 6 | Single Island | 10 | 10 |
| 7 | Single Island | 20 | 20 |
| 8 | Single Island | 25 | 25 |

While the eight alternatives were developed from a different conceptual basis (LCA cost, LCA acreage, and single island option), each alternative can be broken into a design section and advanced fill section. The 100-foot wide design section is placed uniformly so that the design section is present everywhere along the shoreline following construction. The advanced fill is placed non-uniformly to account for diffusion losses, longshore losses, and tidal inlet losses, that vary along the project length. Plan view drawings of the proposed alternatives are contained in Figures 30 through 34.

LEGEND:
NOTES:
BERTRAM BAY
GULF OF MEXICO
Figure 50. Plan View for Alternative 1.

Figure 31. Plan View for Alternative 3.

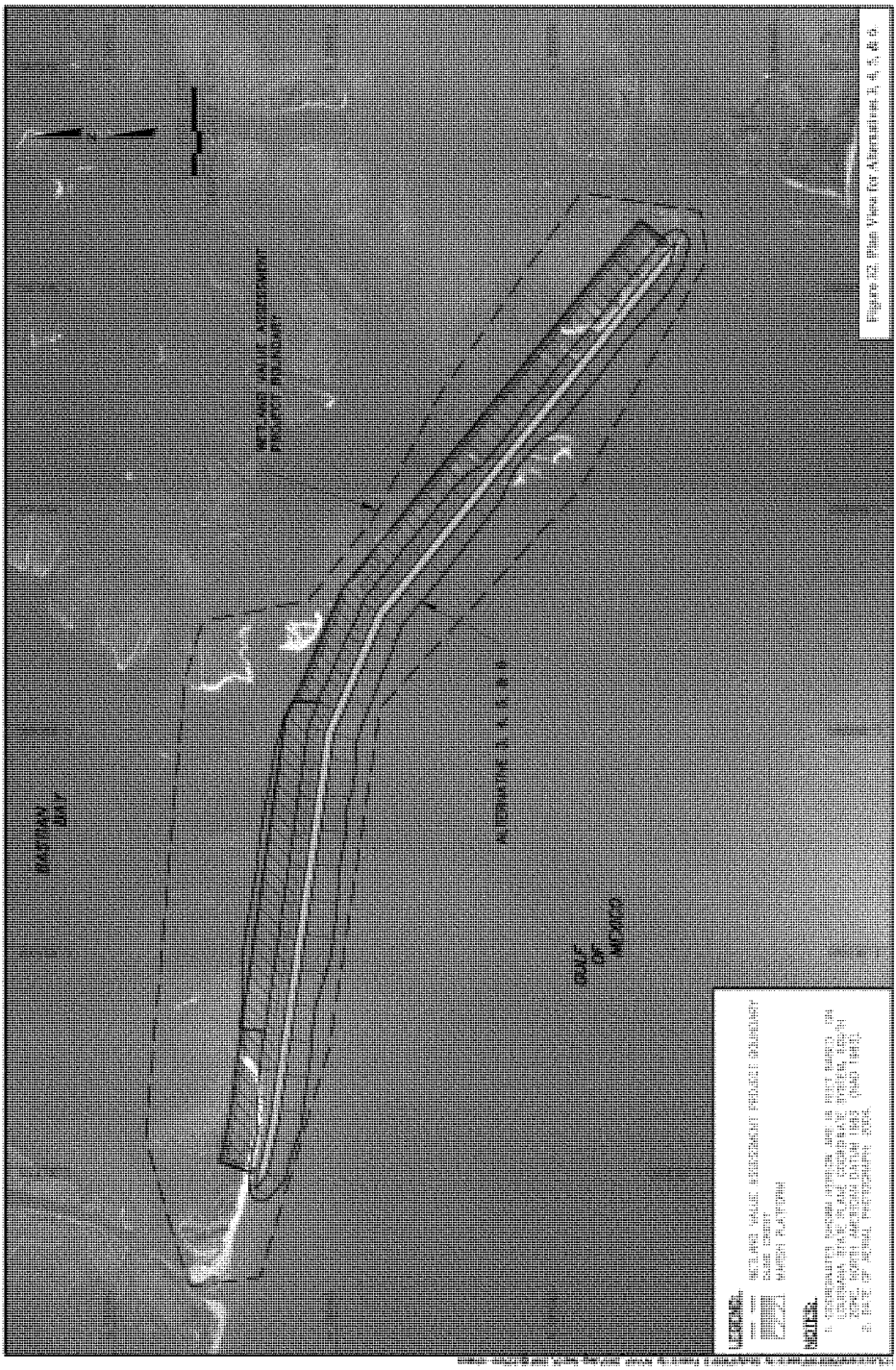



Figure 12. Plan View for Alternatives 3, 4, 5, & 6

LEGEND
NOTES
Figure 33: Plan View for Alternative 7

Figure 14. Plan View for Alternative II

The Generalized Model for Simulating Shoreline Change (GENESIS) (Hanson and Kraus, 1989) is a numerical model for determining long-term shoreline change on an open coast in response to spatial and temporal differences in longshore transport. It can be used to model shoreline changes and sediment transport quantities, with and without project improvements. GENESIS modeling, along with the sediment budget, was used to distribute the advanced nourishment volume to improve project performance. Further refinement of the fill plan layout may be required in the final design. A complete discussion of the GENESIS modeling is contained in Annex C-5.

### 4.3.1 Alternative 1 – Two Islands with No Renourishment

The initial LCA cost contained a construction cost of $45,000,000 for Alternative 1. This was increased to a $76,800,000 at the start of the feasibility design development based on a review by the Louisiana Department of Natural Resources and the U.S. Army Corps of Engineers (*personal correspondence*, Beau Tate, 2005). There has been a further increase in the expected construction cost due to market forces. The LCA proposed the construction of two islands (Shell Island East and Shell Island West), each having a beach and marsh component. Shell Island East had a target of 223 acres of dune/berm and 191 acres of marsh following construction while Shell Island West will have 139 acres of dune and 74 acres of marsh following construction. The dune/berm acreage for Shell Island West was revised upwards to 158 acres (*personal correspondence*, Catherine Grouchy, 2005) from that presented in the LCA plan.

The proposed layout for Alternative 1 is shown in Figure 30. The layout was based on the outline shown in the LCA with some modifications. While the total acreage of beach/dune and marsh is satisfied with the proposed plan, additional beach acreage was incorporated at the loss of some marsh acreage. Table 12 summarizes the LCA acreages and the acreages proposed in Alternative 1.

Table 12. Summary of Alternative 1 Construction Acreage

| | LCA Plan Acreage | | | Alternative 1 Acreage | | |
|---|---|---|---|---|---|---|
| | Beach | Marsh | Sub-Total | Beach | Marsh | Sub-Total |
| Shell Island East | 223 | 191 | 414 | 232 | 206 | 437 |
| Shell Island West | 158 | 74 | 232 | 100 | 145 | 246 |
| Total | 381 | 265 | 646 | 332 | 351 | 683 |

Notes:
1. Beach acreage is defined as the area of sand placement above +2 feet NAVD.
2. Marsh acreage is defined as the area of marsh placement above 0' NAVD.
3. Constructed elevation was not used to distinguish habitat in this table.

The beach/dune width is approximately 281 feet wide and is uniform along the length of the 15,400-foot long dune on Shell Island East. The landward dune crest for the eastern island of Alternative 1 was located along the approximate mean high water line of the remaining islands. This results in the majority of the sand fill being placed in front of the existing island. While volume savings could be realized by constructing the beach section on top of and behind the existing island, sand would only be added to the upper portion of the island profile. By constructing in front of the island, the entire active profile height is armored with sand. This is advantageous based on dynamic morphosedimentary model principles because this prevents the exposure of mixed sediment within the body of the existing island, which causes the high retreat rates. Instead, only sand is exposed during island retreat and the retreat rates will be lower than a mixed sediment system.

On Shell Island West, the proposed beach fill extends partially into Coupe Bob, extending the length of the current islands. The dune width has also been increased on the east end to 688 feet compared to 196 feet on the west end, to account for west to east sediment transport, sediment transport along the east side of the marsh fill, and offshore losses to the ebb shoal. It is recommended that a three-dimensional morphological model be performed to optimize the fill placement.

The marsh on Shell Island West follows the outline of the LCA plan, which has a triangular shape. The marsh on Shell Island East is an average of 525 feet wide but it widens in the northernmost 2,400 feet where it increases in width to just over 1,200 feet wide. Constructing the marshes on the shallow bay side of the islands helps reduce the volume of marsh fill required for construction.

While the WVA uses +2.0 as the upper elevation of the bay intertidal range, the post-construction marsh areas are calculated based on the post-construction position of the +2.5-foot contour. Settlement of the marsh material will lower the marsh elevation to the bay intertidal range within one year. Marsh elevations and a discussion of the WVA classifications are included later in the report (Section 4.4).

Dikes are proposed to contain the marsh fill material during construction. The material for dike construction will be dredged from within the footprint of the marsh so that the excavated area is filled during construction. The dike volume is included within the marsh fill volume.

Alternative 1 includes 4,130,000 cubic yards of beach fill and 1,876,500 cubic yards of marsh fill. The beach and marsh volumes were optimized based on available funding for construction. Table 13 provides a breakdown of beach fill and marsh fill volumes for each island.

Table 13. Summary of Alternative 1 Construction Volumes

| | Beach Fill (cy) | Marsh Fill (cy) |
|---|---|---|
| Shell Island East | 2,872,700 | 1,129,100 |
| Shell Island West | 1,257,300 | 747,400 |
| Total | 4,130,000 | 1,876,500 |

The volume estimates for Alternative 1 are based on comparisons of three dimensional surfaces, which were developed in Eagle Point (2003). The emergent islands were not well represented by the 2005 survey so "dummy" points were added based on the site visit and 2004 DOQQ's. Dummy points were also added in the back bay areas assuming a depth of -2 feet (NAVD). It is recommended that additional survey work be conducted to develop a better estimate of the construction volume.

### 4.3.2 Alternative 2 – Two Islands with Renourishment

Alternative 1 meets the cost and target acreage goals provided for this project. However, Alternative 1 also assumes that there is no maintenance (renourishment of the project) and that the island simply erodes away over time. Alternative 2 includes periodic nourishment using the Alternative 1 fill plan as the starting point. Therefore, a direct comparison of the costs and benefits of renourishment can be developed.

Alternative 2 has a similar beach and marsh fill layout as Alternative 1 (Figure 30), but with different dune crest widths for each island. The width of the dune crest on Shell Island West has been increased Gulfward by 82 feet, providing an additional 16 acres of dune acreage and additional advanced fill to last through the first renourishment project in 10 years. The width of the Shell Island East dune crest has been reduced 3 feet to 278 feet wide, decreasing the dune acreage by 1 acre. Optimization of the renourishment interval is discussed later in the report. Another difference between Alternatives 1 and 2 is the construction elevation of the marsh fill. Alternative 1 has a constructed marsh elevation of +2.5 feet (NAVD) while Alternative 2 has a constructed marsh elevation of +2.0 feet (NAVD). Marsh fill elevations are discussed in the next section. Table 14 provides the construction acreage and fill volumes for Alternative 2.

Table 14. Summary of Alternative 2 Construction Volumes and Acreages

| | Fill Volumes | | Acreage | | |
|---|---|---|---|---|---|
| | Beach Fill (cy) | Marsh Fill (cy) | Beach/Dune (ac) | Marsh (ac) | Sub-total |
| Shell Island East | 2,881,500 | 969,400 | 228 | 206 | 434 |
| Shell Island West | 1,429,300 | 646,300 | 111 | 145 | 256 |
| Total | 4,310,800 | 1,615,700 | 339 | 351 | 690 |

Notes:

1. Beach/dune acreage is based on the beach fill area above +2 feet, NAVD.
2. Marsh acreage is based on area of marsh fill above 0 feet, NAVD.

### 4.3.3 Alternative 3 – Single Island with No Renourishment

The remaining alternatives are based on constructing a single island with the goal of restoring Shell Island to a form similar to its pre-Hurricane Bob condition (Figure 32). The single island option has the following advantages over the two-island option:

1. Losses to the ebb shoal are reduced. There are no losses to Coupe Bob as this inlet will be closed. There will be continued losses to the Grand Bayou ebb shoal.

2. There is a significant decrease in longshore sediment transport losses, as the only longshore losses are to the west into Grand Bayou. Temporary reversals in littoral transport simply move sand back along the island. Under the two-island option, reversals in longshore transports result in losses off both ends of Shell Island West.

3. The one island option will eliminate wave energy entering Bastian Bay through Coupe Bob. The two-island option will have a 7,000-foot gap that allows propagation of wave energy into the bay.

The disadvantage of the one-island option is that the initial construction cost and present worth annualized costs are higher. Costs are discussed later in the report (Section 7.0).

The landward dune crest of Alternative 3 is located in front of the existing shoreline, as with Alternatives 1 and 2. However, the west end of Alternative 3 is terminated approximately 0.5 miles before Grand Bayou and 1,650 feet east of Alternatives 1 and 2. The closure of Coupe Bob is expected to return the tidal prism to its pre-1979 path of flowing through Grand Bayou and it is expected that Grand Bayou will increase in size. The increase in size of Grand Bayou will likely cause the existing west end of Shell

Island to erode and therefore the beach fill is terminated further east than Alternatives 1 and 2. The west end terminus of Alternative 3 is close to the western limit of the 1973 shoreline location of Shell Island in anticipation that Grand Bayou will start to widen.

The proposed island follows the shortest and shallowest route across Coupe Bob. The east end of the island then follows the remnants of Shell Island East but has a concave shape, rather than the convex shape of Alternatives 1 and 2. The eastern end of the island is located in the same location as Alternatives 1 and 2.

The construction dune crest is a uniform 189 feet wide along the length of the island. The 189-foot dune width is based on 10-years of advanced nourishment. Alternatives 4 through 6 have also been designed with the same 189-foot dune width, but each alternative has a different renourishment interval. The third alternative will not be renourished. This will be discussed further in the performance and cost sections of this report.

Advanced fill placement should be optimized when developing plans and specifications. The sediment budget and GENESIS modeling suggests that there will be greater transport along the eastern end and deposition in the center (in the current vicinity of Coupe Bob). Therefore, optimization of the advanced fill may require more fill placed on the eastern section with less in the center while still avoiding any risk of breaching. However, the greatest breach potential is in the location of Coupe Bob. These contradicting requirements require additional modeling, which is beyond the scope of this work. A uniform dune width is proposed for the feasibility stage. Adaptive management techniques should be incorporated into the project to analyze the performance of the fill and distribute advanced fill at future nourishment intervals.

Louisiana barrier islands have typical widths in the region of 1,000 to 1,500 feet wide from the Gulf shoreline to the bayward limit of the marsh. A uniform marsh width of 735 feet was chosen to construct an island that is approximately 1,240 feet wide following equilibration of the beach fill. The fill source for dike construction was located within the marsh fill footprint where the existing bathymetry is relatively shallow (less than -2 feet, NAVD).

However, in deeper water (bathymetry below -3 feet, NAVD) it is not feasible to construct the marsh section with only marsh sediments, as the marsh will settle too rapidly and non-uniformly to perform its intended purpose effectively. Instead it is recommended to construct a sand base across Coupe Bob at -3 feet (NAVD), using beach fill material. The marsh can then be constructed on top of this base, which will reduce settlement of the marsh material.

The contractor will construct a containment dike for marsh construction. The contractor could construct a dike by dredging muds within the marsh footprint, as will be done for the rest of the dike. However, in the middle of Coupe Bob where the sand base has been constructed, the contractor would likely have to transport the muds from the shallow bay areas. This could be time consuming and expensive. A second option is to install a geotextile tube for containment of the marsh fill where the -3 feet (NAVD) sand base is constructed. The geotextile tube could be filled with sand from the sand base. This option is shown in the plans. A third option could be to construct the dike with sand fill but this would require a wide crest as the sand dike will be exposed to waves coming from the north across Bastian Bay. The marsh would be filled to a higher level than the tide and precipitate failure of the sand dike. Mud dikes are relatively impermeable and would not have this problem. The method of marsh containment within the Coupe Bob section should be left up to the contractor's discretion.

It is estimated that 5,611,700 cubic yards of beach fill will be required to construct 317 acres of beach/dune area (area above +2 feet, NAVD). Approximately 2,138,500 cubic yards of marsh fill will be required to construct 466 acres of marsh.

### 4.3.4 Alternatives 4 through 6 – Single Island with Renourishment

Alternatives 4 through 6 have an identical construction template as Alternative 3. The difference between Alternatives 3 through 6 is the renourishment intervals. Each alternative is designed to be renourished at different time periods, which will lead to a difference in project performance and a difference in total cost. Alternatives 4 through 6 will initially be constructed with 10 years of advanced nourishment, requiring 5,611,700 cubic yards of beach fill, which will create 317 acres of beach/dune area (area above +2 feet, NAVD).

Alternative 4 will be renourished 25 years after initial construction to the original construction template of 317 acres of beach/dune area. The marsh fill for Alternative 4 will also be renourished at this time. Alternative 5 will be renourished 20 and 40 years after initial construction, and Alternative 6 will have renourishment events every 10 years. For Alternatives 5 and 6 the marsh fill will be renourished to its original construction template at 20 and 40 years after construction.

### 4.3.5 Alternative 7 – Single Island with Renourishment

Alternative 7 is also a single island design with the same marsh fill and containment dike as Alternatives 3 though 6. However, the beach fill for Alternative 7 has 20 years of advanced nourishment, requiring a uniform construction dune crest width of 280 feet. The Alternative 7 plan view is shown in Figure 33. The beach fill and marsh fill for Alternative 7 will be renourished every 20 years after initial construction.

It is estimated that 6,435,700 cubic yards of beach fill will be required to construct 361 acres of beach/dune area (area above +2 feet, NAVD). Approximately 2,138,500 cubic yards of marsh fill will be required to construct 466 acres of marsh.

### 4.3.6 Alternative 8 – Single Island with Renourishment

Alternative 8 employs the same one island design as Alternatives 3 through 7, but has a construction berm crest width of 343 feet, to account for 25 years of advanced nourishment. The beach and marsh fill for Alternative 8 will have one renourishment event 25 years after the initial construction.

It is estimated that 6,888,700 cubic yards of beach fill will be required to construct 395 acres of beach/dune area (area above +2 feet, NAVD). Approximately 2,138,500 cubic yards of marsh fill will be required to construct 466 acres of marsh.

## 4.4 MARSH FILL DESIGN

This section discusses the development of the marsh design. The proposed construction elevations were based on developing and intertidal marsh over the life of the 50 year project, considering the rate of relative sea-level rise, and consolidation of placed and subgrade sediments. Geotechnical analysis of the marsh fill material and underlying soils are based upon information presented by McClellan (1988) and more recent investigations at East Grand Terre (CPE, 2005b).

### 4.4.1 Marsh Design Elements

The average elevation of the existing marsh platform on Shell Island was determined to be approximately +1.1 feet (NAVD) based on JCLS 2005 survey data taken along Profile 49. This elevation is comparable to other marsh platforms in the area such as East Grand Terre, Chaland Headland, and Pelican Island. The current (2005) mean high water and mean low water elevations are +1.63 feet and +0.58 feet (NAVD) respectively, suggesting that the existing marsh is inundated during most of the tidal cycle.

One element of the marsh design is to maximize the time period that the marsh platform has an elevation in the bay intertidal zone for the wetland value assessment (WVA). The bay intertidal zone, as defined for the WVA, is between 0.0 feet (NAVD) and 2.0 feet (NAVD). Previous marsh creation projects (CPE, 2003 and CPE, 2005b) have developed a marsh elevation based on maximizing the time period that the marsh platform is between mean high water and mean low water. Over the 50-year project life, with an assumed start date of 2009, the mean high water and mean low water elevations will rise from +1.64 to

+2.29 feet (NAVD) and +0.58 feet to +1.23 feet (NAVD), respectively. This is due to an average eustatic sea-level rise of 0.013 feet/year. Therefore, the marsh was designed to obtain a marsh elevation above +1.2 feet (NAVD) at TY50. In order to achieve this, the marsh platform will have to be renourished periodically over the life of the project so that it remains within the tidal zone.

The loss in elevation of the marsh platform (relative to NAVD) is a function of three processes:

1. Geologic subsidence of the region (estimated at 0.0292 feet/year, Section 2.3).
2. Consolidation of the fill marsh material.
3. Consolidation of the underlying soils due to the load of the marsh fill.

The geologic subsidence and eustatic sea-level rise are independent of the project and will occur under both the without project condition and with project condition. For the purposes of design and analysis, the rate of subsidence and relative sea-level rise are considered to be constant at 0.0292 feet/year and 0.043 feet/year, respectively over the 50-year project life.

The extent of marsh fill consolidation will be a function of the properties of the borrow material (sand, silt, clay & organic content), the thickness of the lift and the placement techniques (*i.e.* dredge pipe discharge velocity and flow, containment, and cell capacity). Consolidation of the marsh fill for the three alternatives was estimated using the USACE's Primary Consolidation, Secondary Compression and Desiccation of Dredge Fill Program (PSDDF) (USACE, 1996) and Empire borrow area sediment data. The analysis neglected secondary compression, desiccation, and evaporation of the fill material over time.

The soil underlying the marsh fill will consolidate due to the addition of an overburden (the constructed marsh and beach fill). Settlement of the underlying soils is a function of the consolidation properties of the underlying soils, the area of the applied load and the amount of fill above the water table (surcharge load). The amount of consolidation of the underlying soils will also vary due to the varying lift thicknesses, properties of the marsh fill and project footprint. Settlement analysis of the consolidation of the underlying soils for the three alternatives were estimated using Ensoft, Inc.'s SETOFF, version 2.0 (Fenske, 1999) and soil boring information from McClelland (1988).

Marsh platform accretion due to annual vegetative dieback and regrowth (detritus) was also included in the marsh design. Fitzgerald (2003) projected detritus accretions on the order of 3 – 9 mm/year for salt marshes. A conservative detritus accretion rate of 0.0098 ft/year (3 mm/year) was used in this analysis beginning one year after 100% vegetative coverage was achieved. Assuming construction takes one year for Alternatives 1 and 2 and two years for Alternatives 3 through 8 and a 100% vegetation occurs within 3

years following construction, benefits from detritus will begin at TY5 (2014) for Alternatives 1 and 2, and TY6 (2015) for Alternatives 3 through 8.

The SBEACH modeling (Annex C-4) suggested that sand overwash was restricted to 200 feet from the landward dune crest. Therefore, overwash of beach fill material into the marsh was not included in marsh platfrom accretion.

Borrow material used to construct the marsh planform (marsh fill) will be taken from the upper 15 to 20 feet of the Empire borrow area. Based on 32 samples taken from 7 vibracores spaced 600 to 1900 feet apart, the overburden material is classified overall as a sandy silt (ML) with clay. The average sand/silt/clay percentages are 38/40/22, respectively. Dynamic morposedimentary principles suggest that island longevity is increased with increased percentages of sand in the marsh. The marsh fill in the Empire borrow area is similar to the composition of Louisiana barrier island marshes and is suitable for marsh fill. Organic content tests were not performed; however, organic content is anticipated to be low due to the depth of the water, approximately –20 feet (NAVD).

### 4.4.2 Alternative 1 – Two Islands with No Renourishment

Alternative 1 will create 293 acres of additional marsh behind Shell Island East and Shell Island West under one construction event (no renourishment). A plan view of the proposed marsh fill is shown in Figure 30. The proposed containment dikes will enclose approximately 40 acres of existing marsh based on the 2004 DOQQ's (LDNR, 2005). These 40 acres will be enhanced by increasing the existing elevation, so a total of 351 acres will be created or enhanced.

Settlement curves were developed for varying marsh construction elevations, assuming that marsh fill would be constructed using material dredged from the Empire borrow area. The fill will be a sandy silt. The average bottom elevation within the marsh fill areas is approximately -1.0 feet (NAVD). Figure 35 shows the expected marsh elevation with time, for a constructed marsh elevation of +2.5 feet (NAVD). A ±0.5 feet range has been placed on the marsh elevation shown in Figure 35 to represent a possible range of the marsh elevation due to construction tolerances, sorting of the material during construction, variations in borrow material percentages (sand or silt pockets), varying lift heights effecting primary consolidation, and variations in underlying soils. The marsh elevation range is not absolute and it should be recognized that undulations could be greater than those presented. While the timeline and elevations presented in the following paragraph are specific, variation in these values should be expected.

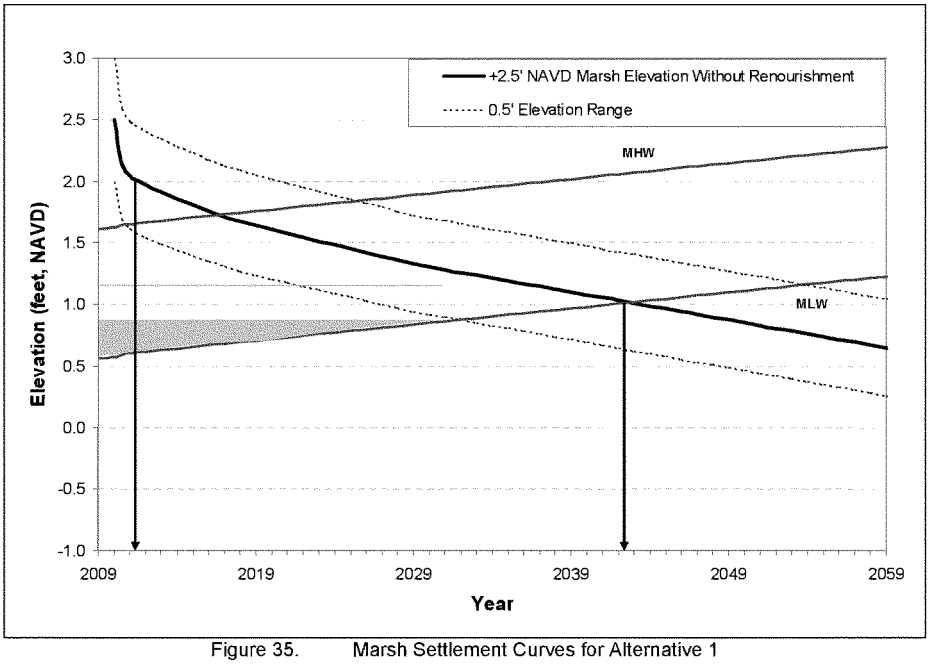



Figure 35. Marsh Settlement Curves for Alternative 1

Figure 35 shows that constructing the marsh elevation at an elevation of +2.5 feet (NAVD) will result in a marsh that will become bay intertidal (<2.0 feet, NAVD) during 2011 (TY2) and remain bay intertidal throughout 2059 (TY50). A construction elevation of +2.5 feet (NAVD) provides the greatest time period that the marsh is defined as bay intertidal for WVA calculations. The marsh will be continually submerged (average elevation below mean low water) after 2043 (TY34).

The marsh volume required during construction is 1,876,500 cubic yards. This volume includes the volume of marsh fill and the volume required to construct the marsh containment dikes.

### 4.4.3 Alternative 2 – Two Islands with Renourishment

Alternative 2 has a similar marsh footprint to Alternative 1 but incorporates a renourishment component to the marsh. The renourishment will allow the marsh platform to be constructed so that the average marsh elevation is between mean high water and mean low water for the majority of the 50-year project life and bay intertidal for the entire project life.

Since Alternative 2 is being renourished it is possible to use a different marsh construction elevation than was used for Alternative 1 to maximize the time period that the marsh is within the WVA bay intertidal zone, as well as within the mean high water to mean low water range. The recommended construction elevation is +2.0 feet (NAVD) for Alternative 2 compared to +2.5 feet (NAVD) for Alternative 1. Figure 36 shows the expected marsh elevation with time for Alternative 2 incorporating a marsh renourishment every 20 years. The marsh is renourished to re-establish the +2.0 feet (NAVD) marsh elevation at each nourishment interval.

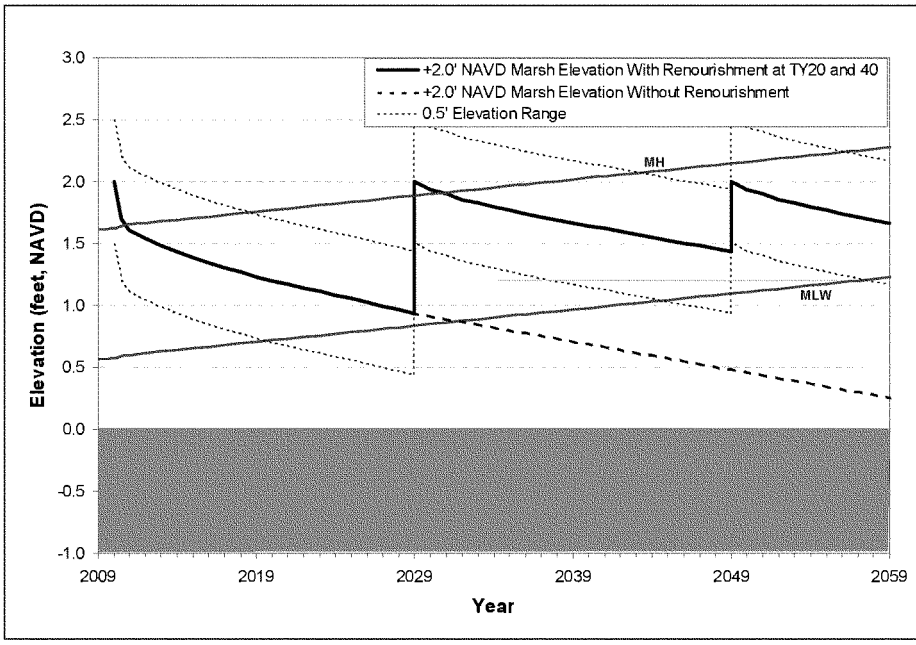



Figure 36. Marsh Settlement Curves With and Without Renourishment for Alternative 2

The volume of marsh fill required to initially construct Alternative 2 is 1,615,700 cubic yards and includes the volume required to construct the containment dikes. This is lower than the construction volume for Alternative 1 due to the lower marsh construction elevation. The volume of marsh fill required for the first renourishment is approximately 699,900 cubic yards while the volume for the second renourishment is 350,000 cubic yards. The first renourishment requires less volume than the initial marsh construction volume because consolidation of the marsh material placed originally has already occurred and detritus reduces the total subsidence. The second renourishment project requires less volume than the first renourishment because of the shorter lift height.

The affect of the lift height during marsh renourishment should be considered with respect to the impact on the existing vegetation. Lift heights over 1 foot may smother the vegetation. Shorter renourishment periods would reduce the lift height due to less time for marsh settlement. Alternatively, replanting vegetation could be included as part of the renourishment program.

### 4.4.4 Alternatives 3 to 8 – Single Island

Alternatives 3 to 8 are each single island designs with the same constructed marsh acreage of approximately 466 acres. The single island options cross Coupe Bob with depths approaching -10 feet (NAVD) in the main channel. To construct a marsh at +2 or +3 feet (NAVD) would require lift heights that are 12 or 13 feet high. This large thickness will result in differential settlements across the island and settlements of 2 to 3 feet over 20 years. This settlement can lead to severe plant stress and reduced growth (Reed, 2002) that is unacceptable when trying to construct a healthy marsh. Instead, it is proposed to construct a sand platform base up to -3 feet (NAVD) and construct the marsh on top of this base. Contractors indicated that they can construct a submerged platform but require 3 to 4 feet of water depth to float equipment. The top elevation of -3 feet (NAVD) for the sand platform was therefore based on constructability.

The settlement of the single island marsh fill for Alternatives 3 to 8 occurs in 3 different ways according to marsh renourishment intervals. The first being Alternative 3, which will have no renourishment of the marsh fill. The marsh renourishment interval for Alternatives 5, 6, and 7 is 20 years. The third settlement pattern would be for the options with a marsh renourishment interval of 25 years (Alternatives 4 and 8).

The elevation of the constructed marsh platform for Alternatives 3 though 8 is +2.0 feet (NAVD). This is similar to the marsh platform recommended for Alternative 2. The marsh elevation for each option will be between mean high water and mean low water from 2010 to 2027 (Figures 37 and 38). It is estimated that construction of Alternatives 3 to 8 will take two years to complete so Figures 37 and 38 and show marsh subsidence starting in TY2 (2011).

For Alternative 3 (+2.0 feet, NAVD marsh elevation without renourishment) Figure 37 shows that the marsh will submerged (below MLW) by 2027 (TY18) and will remain submerged unless a renourishment interval is implemented. The marsh fill should be considered intertidal all the way through 2059 (TY50).

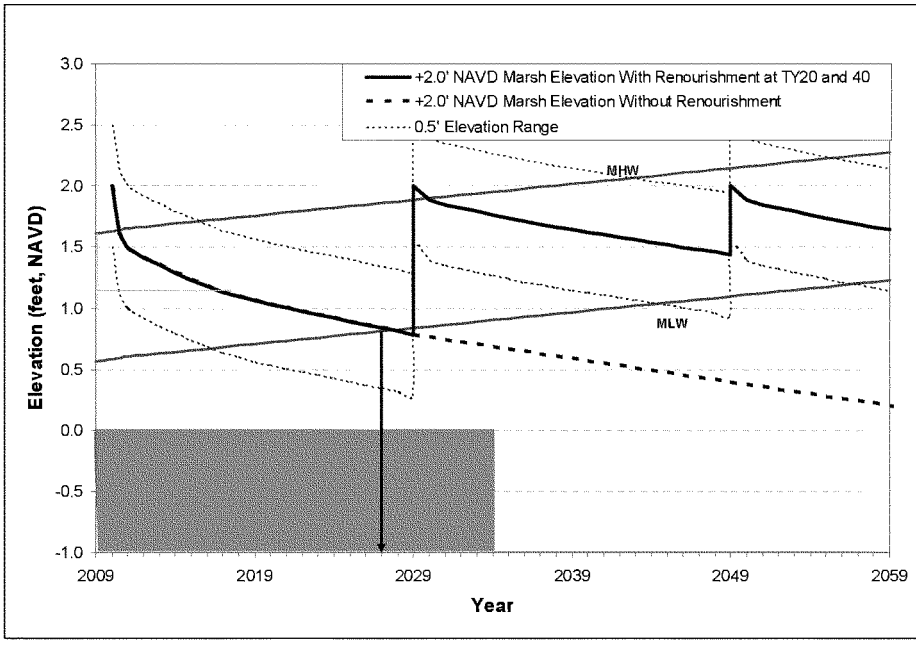



Figure 37. Marsh Settlement Curves for Alternatives 3, 5, 6, and 7

For Alternatives 5, 6, and 7 the marsh is renourishment back to an elevation of +2.0 feet (NAVD) every 20 years, which allows the marsh elevation to be between mean high water and mean low water over the majority of the 50-year project life (Figure 37). The volume of marsh fill required for the first renourishment is approximately 907,200 cubic yards while the volume for the second renourishment is 643,600 cubic yards.

Alternatives 4 and 8 will have a marsh renourishment 25 years after initial construction. This means that the marsh elevation will be below the MLW from 2027 to 2034 (Figure 38) before returning to its original elevation of +2.0 feet (NAVD) after TY25. The volume of marsh fill required for the renourishment at TY25 is approximately 1,103,700 cubic yards.

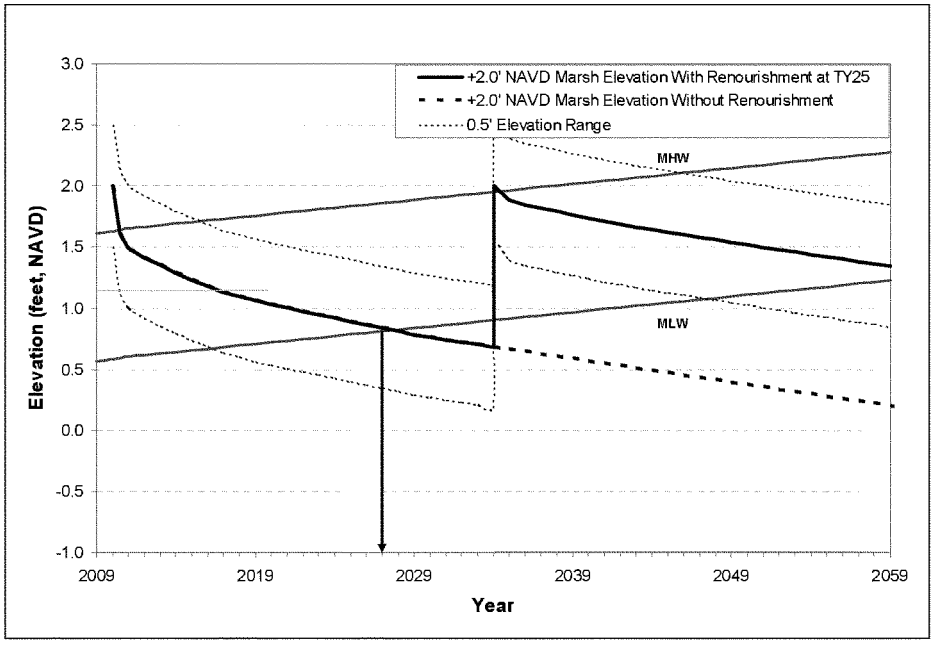



Figure 38. Marsh Settlement Curves for Alternatives 3, 4, and 8

Additional analyses should be performed on the Empire borrow area material and subsurface soils at Shell Island during the final design stage to determine the final construction marsh elevation.

### 4.4.5 Temporary Containment Dikes

All eight alternatives include the use of temporary containment dikes along the bay side to retain the marsh fill material. The north side of the beach dune will be used to contain the south edge of the marsh fill. Borrow material for the dikes will be excavated from within the fill footprint so that the excavated area is refilled during construction.

The temporary containment dike cross-section may be determined by the contractor in the field but shall have side slopes no steeper than 1V:4H, a minimum crest width of 5 feet and a minimum crest elevation of +4.5 feet (NAVD). The contractor may elect to flatten the side slopes, increase the crest width, and/or increase the crest elevation depending on the size and capacity of the dredge in order to reduce dike maintenance during construction. Dike maintenance is expected to be moderate to high since the bayside is unprotected from wave action within Bastian Bay, especially during the winter and fall months.

Alternatives 3 to 8 also include a geotextile tube for containment of the marsh fill where the -3 feet (NAVD) sand base is constructed, since there is no mud for dike construction easily accessible at this location. It could be possible to construct the dike with sand fill but this would require a wide crest as the sand dike will be exposed to waves coming from the north across Bastian Bay. The temporary mud dikes can better withstand the bay chop for the limited construction duration compared to a sand dike due to the cohesive nature of the sediment. The contractor will also have the option to transport dike fill from within the marsh footprint. The volume for construction of the containment dikes is included in the marsh fill.

### 4.4.6 Bayside Erosion

McBride and Byrnes (1997) stated that Grand Bayou Pass and adjacent shorelines have a bayside shoreline retreat of 0.7 feet/year (0.2m/yr). This retreat rate appears to be low given the possible wave growth across the Bastian Bay reach. McBride and Byrnes also present a bayside recession rate of 6.7 feet/year along other Plaquemines barrier islands. The average of these bayside recession values is 3.6 feet/year, and this was used to estimate future bayside marsh recession.

### 4.4.7 Outfall/Weir Design

The outfalls will be directed into areas of existing marsh wherever possible to reduce impacts of high turbidity on habitats and oyster leases. Outfalls directed into open water or bays will be surrounded with turbidity curtains. The location and number of outfall/weirs should be left to the Contractor except where there is a specific restriction (for example an adjacent oyster lease). This can be finalized in the construction plans and specifications.

## 4.5 STRUCTURAL OPTIONS

Coastal engineers sometimes employ structures to hold a fixed shoreline position, minimize erosional losses, or stabilize an inlet in a particular location, such as constructing the Empire Jetties to maintain a navigable channel. At Shell Island, there is no infrastructure that must be protected in the immediate vicinity of the project, so there is not a pressing need for a structural solution to sediment loss. However, this section discusses the potential for a structural solution that could minimize erosional losses.

A terminal structure at the east end of Shell Island East (for any of the Alternatives) could limit losses to the Empire Waterway. The terminal structure could extend from the northern end of the western jetty or simply be constructed at the east end of the island, leaving a gap. A terminal structure would also limit shoaling within the navigation channel.

While such a structure could limit volumetric loss into the navigation channel, the cost of the structure must be balanced against the cost of simply placing additional sand to offset this loss. Quantifying the loss of sediment into the waterway due to tidal flows would require additional work beyond the scope of this study. However, based on GENESIS modeling it is unlikely that this loss will be greater than a few thousand cubic yards per year. This would suggest that a structure is not a cost effective solution, as structures can cost tens of thousands of dollars per foot. The bathymetric survey shows that the water depth exceeds 12 feet between the existing jetty and the east end of the fill plan. The base of a structure that crosses this gap would be more than 70 feet wide if the structure extends 3 feet above mean high water, has 1V:2H side slopes, and a crest width of 10 feet.

It is unlikely that the navigation channel will shoal due to the increased tidal flow through Empire Waterway that can be expected with Alternatives 3 to 8. The 2005 bathymetric survey showed the presence of scour holes around the north end of the jetty so the tidal flows should be sufficient to keep the channel clear even with the construction of Alternatives 1 and 2. It is difficult to state this with certainty without additional tidal circulation data and modeling.

Terminal structures could also be constructed adjacent to Coupe Bob as part of Alternatives 1 and 2 for both Shell Island East and West. While this would limit volumetric losses into Coupe Bob in the short term, a fillet would soon fill and losses into the ebb shoal would continue. Given the cost of a structural solution, it would be better to invest these funds in additional sediment and allow nature to craft the island to a more natural state.

While the eight alternatives presented in this report will slow retreat of Shell Island, there is the possibility that any structures will be stranded, similar to the western Empire jetty, as the island continues its bayward retreat.

Without the requirement to protect vital infrastructure within the immediate project area, it is recommended that further analysis be conducted prior to the inclusion of structural elements into the Shell Island plan. The analysis at this feasibility stage does not suggest that a structural solution is warranted.

It is recommended that a dock be constructed during the initial construction. A channel and dock located on the north side of the island would provide an access during construction and for future maintenance work and monitoring. The LDNR has constructed similar structures on other barrier islands as part of the initial project construction.

## 5.0 PROJECT PERFORMANCE

Proposed barrier island shoreline projects are evaluated for environmental benefits using quantitative projections of plan form performance. This section discusses the performance of each alternative, including the no action alternative. Performance is discussed with respect to the project goals outlined in Section 1.6, and quantified based on habitat acreage descriptions for the wetland value assessment (WVA). The total acreage in the project boundary changes over the target years as project site conditions change. GENESIS modeling and the sediment budget are used to quantify barrier island shoreline changes and thus acreage values.

Shell Island habitat acreages were calculated using the Barrier Island Community Model in accordance with guidelines prepared by William and Sweeney (2005). The range of various habitat elevations and associated descriptions are defined in Table 15.

Table 15. Habitat Description (after Williams and Sweeney, 2005)

| Habitat | Description |
|---|---|
| Dune | ≥ +5 feet, NAVD<br>The portions of the dune platform anticipated to be within the elevation range. |
| Supratidal | ≥ +2 feet to <5 feet, NAVD<br>Beach berms and portions of the fore and back slope of the dune within elevation the elevation range. Also includes primary retention/ containment dikes for the period anticipated to remain in the elevation range. Generally includes major portion of the marsh platform until the time dewatering and consolidation reduce the elevation to intertidal. |
| Gulf Intertidal | ≥ 0 feet to < +2.0 feet, NAVD<br>Gulf side beach slope / shallow open water. |
| Bay Intertidal | ≥ 0 feet to < +2.0 feet, NAVD<br>Bayside elevations including vegetated wetlands, flats and bayside open water areas. |
| Subtidal | ≥ -1.5 feet to < 0.0 feet, NAVD or 1,000 feet bayward of the 0.0 feet contour<br>Shallow Open water bayside area only. |

The project boundary for the WVA calculations is shown in Figures 30 through 34. The project boundaries were defined based on the outer edges of the landmasses digitized from the 2004 DOQQ's. The west end of Shell Island West was included within the project boundary as it was anticipated that this area could be affected by construction of any alternative. Existing Shell Island remnants were included within the boundary to incorporate the without project conditions.

The following assumptions were made to develop the WVA acreages for each alternative:

1. Subsidence is uniform and there is no differential settlement due to fill height differences or variations in the constructed elevation.

2. The dune, supratidal, and Gulf intertidal contours are parallel and retreat at the same rate (no change in cross-shore profile) following cross-shore profile equilibration.

3. There is no subsidence of the dune, (sand fill) supratidal, or Gulf intertidal areas due to dynamic morphosedimentary principles. The volume to counterbalance subsidence is included in the shoreline recession rate.

4. Subsidence of the (marsh fill) supratidal and bay intertidal areas incorporate regional subsidence, primary and secondary consolidation, dewatering, and detritus to develop total subsidence rates. Marsh elevations were based on the marsh settlement curves presented in the previous section.

5. The bayside perimeter of the dike recedes at 3.6 feet/year due to wave action. Once the dike recedes past the +2.0' (NAVD) contour, the marsh perimeter begins to recede at 3.6 feet/year.

6. Dike and marsh material lost due to bayside recession is assumed to remain in suspension and settle outside of the project boundaries.

7. The boundary between Gulfside and bayside intertidal areas was assumed to be the point where the outer edge of the dike intersects the dune.

8. The areas for the without project condition that lie outside of the construction template are included in acreage estimates for all three alternatives. No change in recession or subsidence rates is applied to the areas outside the construction footprint.

9. Island rollover/overwash does not impact the elevation or the width of the island.

## 5.1 NO ACTION ALTERNATIVE

An estimate of existing (2005) acreages was developed based on the 2004 DOQQ's, 2005 JCLS survey, and the July 18, 2005 site visit. Due to a lack of recent onshore survey data for the project area, the acreages for the current conditions within the project boundary were derived from digitizing the visible

shorelines of the 2004 DOQQ's in AutoCAD. These shorelines were assumed to be the +0.6 feet (NAVD) contour (mean low water).

The 2-foot contour was identified on Shell Island West using profile line 49 from the 2005 JCLS survey. This contour was assumed to parallel the shoreline. There was no dune acreage on Shell Island West based on the JCLS survey. For Shell Island East, the DOQQ's and site visit suggested that there were no measurable supratidal or dune acreages on any of the remaining island and shoal land masses.

Gulfside shoreline recession rates were assumed to be 36 feet/year, while bayside recession rates were assumed to be 3.6 feet/year. Volume lost due to wave action was assumed to be transported outside of the project boundaries. Table 16 shows the habitat acreages for the no action alternative at various target years.

Table 16. Planform Performance Projection for the "No Action Alternative"

| Target Year | Habitat (acres) | | | | | Total |
|---|---|---|---|---|---|---|
| | Dune | Supratidal | Intertidal (Gulfside) | Intertidal (Bayside) | Subtidal (Bayside) | |
| TY0 | 0 | 6 | 50 | 89 | 240 | 386 |
| TY1 | 0 | 2 | 42 | 83 | 234 | 361 |
| TY2 | 0 | 0 | 37 | 79 | 229 | 346 |
| TY3 | 0 | 0 | 32 | 78 | 225 | 335 |
| TY5 | 0 | 0 | 27 | 80 | 218 | 325 |
| TY10 | 0 | 0 | 21 | 22 | 181 | 224 |
| TY20 | 0 | 0 | 13 | 5 | 139 | 157 |
| TY50 | 0 | 0 | 0 | 0 | 105 | 105 |

This analysis suggests that the remnants of Shell Island will be below 0 feet (NAVD) shortly after TY20 (2029). Penland *et al.* (2003) estimated that Shell Island would disappear between 2005 and 2039 depending on whether long-term or short-term data is used.

## 5.2 ALTERNATIVE 1 - TWO ISLANDS WITH NO RENOURISHMENT

The GENESIS model suggests that Shell Island West will recede an average of 1,215 feet over the 50-year project life. This equates to an average shoreline recession rate of 24.3 feet/year. A plan view of the GENESIS predicted shorelines are shown in Figure 39.

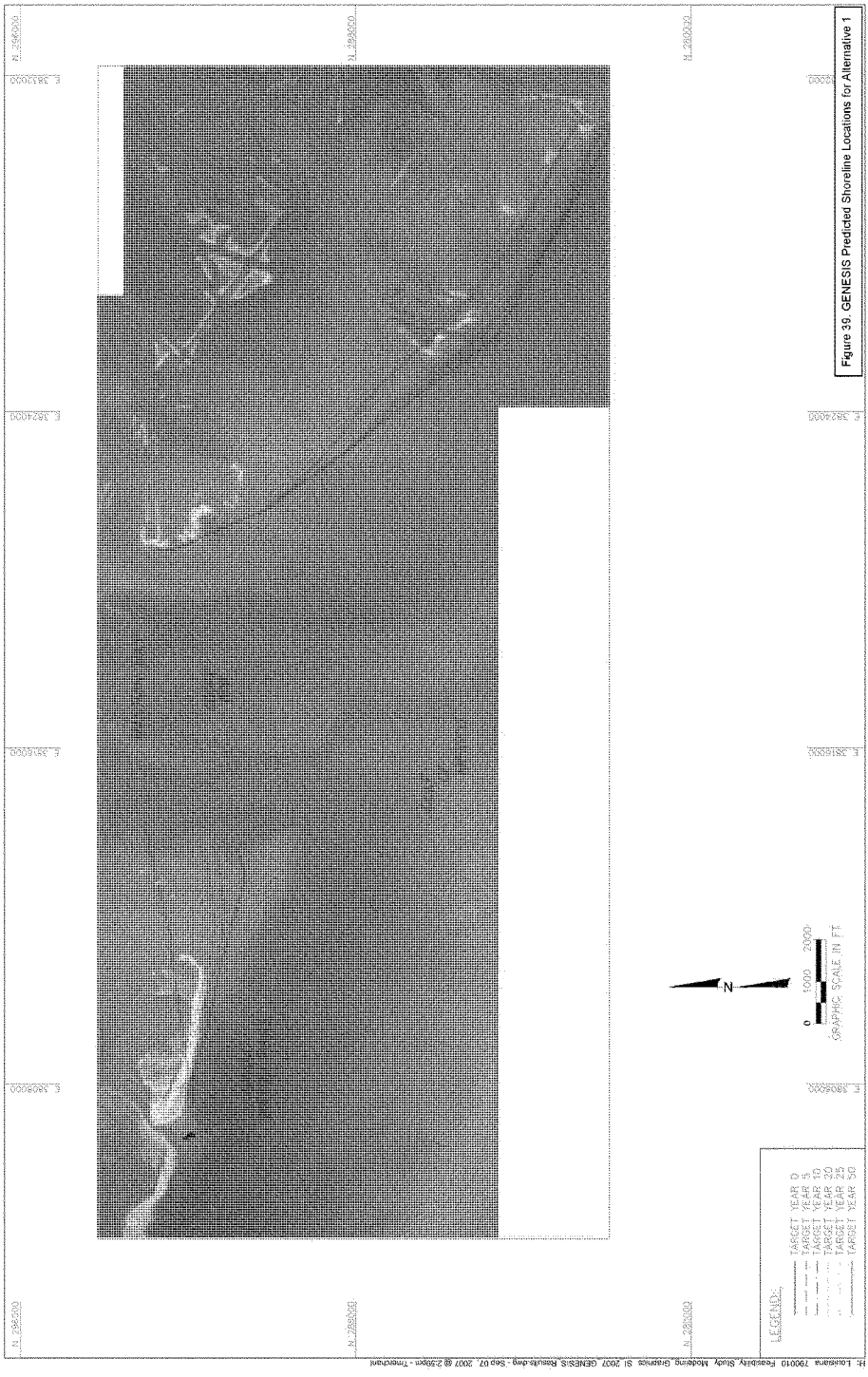



Figure 39. GENESIS Predicted Shoreline Locations for Alternative 1

Figure 39 shows that the island is expected to undergo a rotation such that the east end of the island recedes while the western end of the island is stable to accretional. The west end of Shell Island West is partially stabilized by the presence of the Bay Joe Wise headland. If Bay Joe Wise continues to recede, recession of the west end of Shell Island West would be highly likely. This highlights the need for a regional analysis, as retreat of the Bay Joe Wise headland will affect recession on Shell Island, and vice versa. The impact of construction of a nourishment project along Bay Joe Wise was not included in the analysis.

Shell Island East is predicted to recede over 1,110 feet in some areas Figure 40 shows that the center and southeast end of Shell Island East will experience the majority of the shoreline retreat while the northwest end may actually advance. This is due to the net transport of sediment to the west.

The higher and wider constructed beach elevation will limit the amount of island overtopping and thus restrict nourishing of the marshes in the back. The beach section will maintain its elevation due to the natural processes of island building while the marsh will sink. The shoreline recession due to relative sea-level rise can then be calculated based on the dynamic morphosedimentary model principles. Shoreline recession was calculated based on the 50-year project average for relative sea-level rise rate of 0.043 feet/year, an active profile height of 11 feet, and a beach width of 956 feet for Shell Island East and 953 feet for Shell Island West. The shoreline retreat rate due to relative sea-level rise was calculated to be 3.7 feet/year for Shell Island East and 3.6 feet/year for Shell Island West. Figure 40 includes the shoreline retreat rates due to relative sea-level rise.

The predicted shorelines must be carefully interpreted when using GENESIS, as it is not designed to model shoreline changes in the vicinity of inlets. However, GENESIS does provide the theoretical longshore transport based on shoreline orientation and wave climate. The GENESIS model was calibrated to the 1956 to 1973 longshore transport rates, which should give an accurate assessment of longshore transport rates for the modeled alternatives. Figure 40 shows the longshore transport rates for Alternative 1.

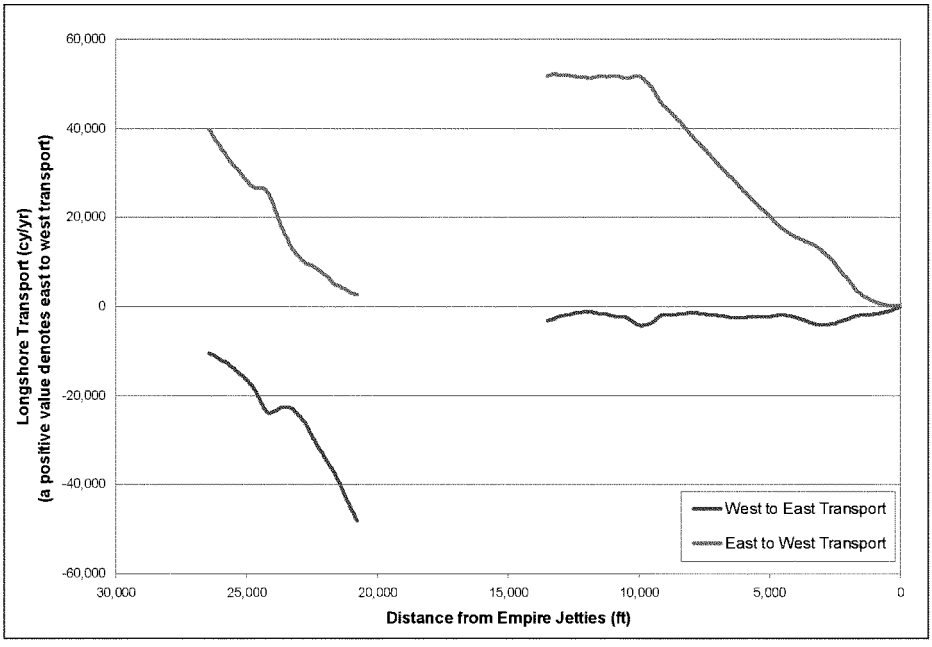



Figure 40. GENESIS Predicted Longshore Transport Rates

Figure 40 shows that the expected loss due to east-to-west longshore transport from the west end of Shell Island East is approximately cubic yards/year. This equates to an average shoreline recession of 8.6 feet/year using an active profile height of 11 feet. Including an additional 3.7 feet/year for relative sea-level rise gives a total average shoreline recession of 12.4 feet/year for Shell Island East.

The west to east longshore loss from Shell Island West into Coupe Bob is approximately 49,000 cubic yards/year. Under a two-island option the GENESIS model suggests that 40,000 cubic yards/year will be lost to Grand Bayou due to east-to-west transport. However, construction of such a large project and injection of sediment into the system may cause Grand Bayou to close. If this were to happen the loss from Shell Island West would be moderated by west to east transport of 10,000 cubic yards/year for a net transport of 30,000 cubic yards/year in a westerly direction. Therefore, the total longshore loss of sediment from Shell Island West would be 79,000 cubic yards/year. Figure 41 shows the sediment budget for Alternative 1.

Given an island length of 6,200 feet for Shell Island West, this is equivalent to a shoreline recession of 31 feet/year. The total shoreline recession is therefore 34.9 feet/year, after including losses due to relative sea-level rise, which is similar to the 1988 to 2004 shoreline recession rates. The volumetric change due to relative sea level rise is approximately 9,100 cubic yards/year. The total volumetric loss from Shell Island West is thus 88,100 cubic yards/year. At this rate, all of the beach and marsh fill placed during construction of Shell Island West will have eroded in 23 years (TY25), leaving pre-construction conditions. The acreage calculations were based on these volumetric loss rates (34.9 feet/year) rather than the GENESIS predicted shoreline change rate (24.3 feet/year).

The volume of sand that could be lost into Coupe Bob every year from the two-island option is approximately 101,000 cubic yards. At this rate it would take Coupe Bob approximately 33 years to reach its accommodation volume of 3.3M cubic yards. It is unlikely that Coupe Bob will reach its accommodation volume given that the total volume of sand fill placed in Alternative 1 is 4,130,000 cubic yards but it does suggest that little natural bypassing of sand should be expected across Coupe Bob.

The existing tidal prism in Bastian Bay flows across portions of the Alternative 1 project footprint. Construction will redirect the tidal flow through Grand Bayou, Coupe Bob, and Empire Waterway but it is expected that these inlets will accommodate the increased tidal flow, given their previous capacity. No impacts are expected to the project performance due to redirection of the tidal flow.

Table 17 provides the acreages for the wetland value assessment. Construction is expected to begin in 2009 (TY0) and take 1 year to construct. Post-construction acreages are therefore presented as TY1.

Table 17. Planform Performance Projection for Alternative 1

| Target Year | Habitat (acres) | | | | | Total |
|---|---|---|---|---|---|---|
| | Dune | Supratidal | Intertidal (Gulfside) | Intertidal (Bayside) | Subtidal (Bayside) | |
| TY0 | 0 | 6 | 50 | 89 | 240 | 386 |
| TY1 | 177 | 489 | 51 | 17 | 168 | 902 |
| TY2 | 158 | 487 | 41 | 16 | 168 | 871 |
| TY3 | 149 | 151 | 41 | 349 | 168 | 859 |
| TY5 | 131 | 147 | 41 | 347 | 168 | 835 |
| TY10 | 80 | 113 | 41 | 324 | 163 | 722 |
| TY20 | 36 | 100 | 41 | 287 | 153 | 618 |
| TY25 | 0 | 42 | 41 | 254 | 148 | 486 |
| TY35 | 0 | 0 | 41 | 187 | 138 | 367 |
| TY42 | 0 | 0 | 0 | 136 | 131 | 267 |
| TY50 | 0 | 0 | 0 | 0 | 213 | 213 |

Table 17 shows that the loss in dune and Gulf intertidal acreage between TY1 and TY2 is higher than in following years, which is due to profile equilibration. There is no change in the supratidal acreage on the gulfside due to equilibration or shoreline recession as the +2-foot and +5-foot contours retreat uniformly. The reduction in supratidal acreage is due to erosion of the dikes. However, once the shoreline recedes through the dune crest and there is no more dune acreage (TY10 for Shell Island West and TY25 for Shell Island East) supratidal acreage will start to be lost. Since the shoreline recession rate is higher on Shell Island West this occurs earlier than along Shell Island East.

By TY25 Shell Island West has receded to the point where there is no supratidal acreage. This type of low elevation island will be similar to the current remnants of Shell Island East. It is likely that because there is a marsh behind the island, rollover processes maintain a slightly higher island but for purposes of the acreage calculation model it was assumed that there was no supratidal acreage.

Once the supratidal acreage is lost, it was assumed that the marsh would be exposed to wave action from the Gulf and that the marsh would recede at the Gulf retreat rate. The intertidal acreage was assumed to be constant based on the reformation of a sand face. Note that once the marsh is exposed, the shoreline recession rates may actually increase, but this was not included in the acreage calculation model. Once the marsh has been destroyed, the Gulf intertidal acreage was then eroded (TY42 on Shell Island West).

There is a significant conversion of habitat acreage from supratidal acreage to bay intertidal acreage between TY2 and TY3. This is due to the marsh elevation crossing the 2-foot contour threshold between the two habitat definitions. Approximately 336 acres that were considered supratidal acreage are now considered to be bay intertidal acres. While this change does not occur as suddenly as presented here, it is based on the assumption that the marsh is constructed at a uniform elevation and that the marsh consolidates uniformly. Similarly, in TY48, the marsh sinks below 0.0 feet (NAVD) and is considered sub-tidal.

The subtidal acreage decreases following construction because parts of the subtidal acreage are located within the construction footprint. Therefore, the subtidal acres are converted to other habitat types.

## 5.3 ALTERNATIVE 2 – TWO ISLANDS WITH RENOURISHMENT

Alternative 2 has a similar layout to Alternative 1 except that the dune crest on Shell Island West is 82 feet wider, the dune crest on Shell Island East is 3 feet narrower, and the marsh construction elevation is +2.0 feet (NAVD) compared to +2.5 feet (NAVD) for Alternative 1. The initial performance of Alternatives 1 and 2 are similar because the project plan forms are similar. The GENESIS model shows the shoreline recession for Alternatives 2 (Figure 42) through TY10 at which point the beach fill is

renourished. The difference between the sediment budgets of Alternative 1 and 2 are the cross shore volumetric losses. The dune crest width for Alternative 2 Shell Island West is 332 feet, creating a total beach width of 1,007 feet (from the average Gulf side toe of dune to the point where the marsh fill intersects the bayside of the dune). The larger beach width creates a slightly higher shoreline recession rate due to relative sea level rise of 3.9 feet/year.

Including the overtopping component, the total cross shore volumetric loss for Shell Island West is 9,900 cubic yards/year. The cross shore losses for Shell Island East are slightly smaller than for Alternative 1 due to the slightly smaller dune crest width. The Gulfside shoreline recession rates for Alternative 2 are therefore 35.2 feet/year for Shell Island West and 12.3 feet/year for Shell Island East. The sediment budget for Alternative 2 can be seen in Figure 43.

The redirection of the tidal prism that previously crossed the footprint of Alternative 2 will be redirected through Grand Bayou, Coupe Bob, and Empire Waterway. As with Alternative 1, no impacts are expected on project performance because these three available inlets can accommodate the increased tidal flow. This is based on the observation that Coupe Bob is fairly shallow and wide, while Grand Bayou is closing. This indicates that both of these inlets could increase in cross-sectional area without affecting the proposed project.

The increased dune width on Shell Island West, compared to Alternative 1, increases the post-construction dune acreage by 16 acres (Table 18). The +2.0 feet (NAVD) construction marsh elevation results in the marsh being considered bay intertidal habitat in TY1 rather than supratidal habitat. Therefore, the TY1 bay intertidal acreage is greater than the supratidal acreage.

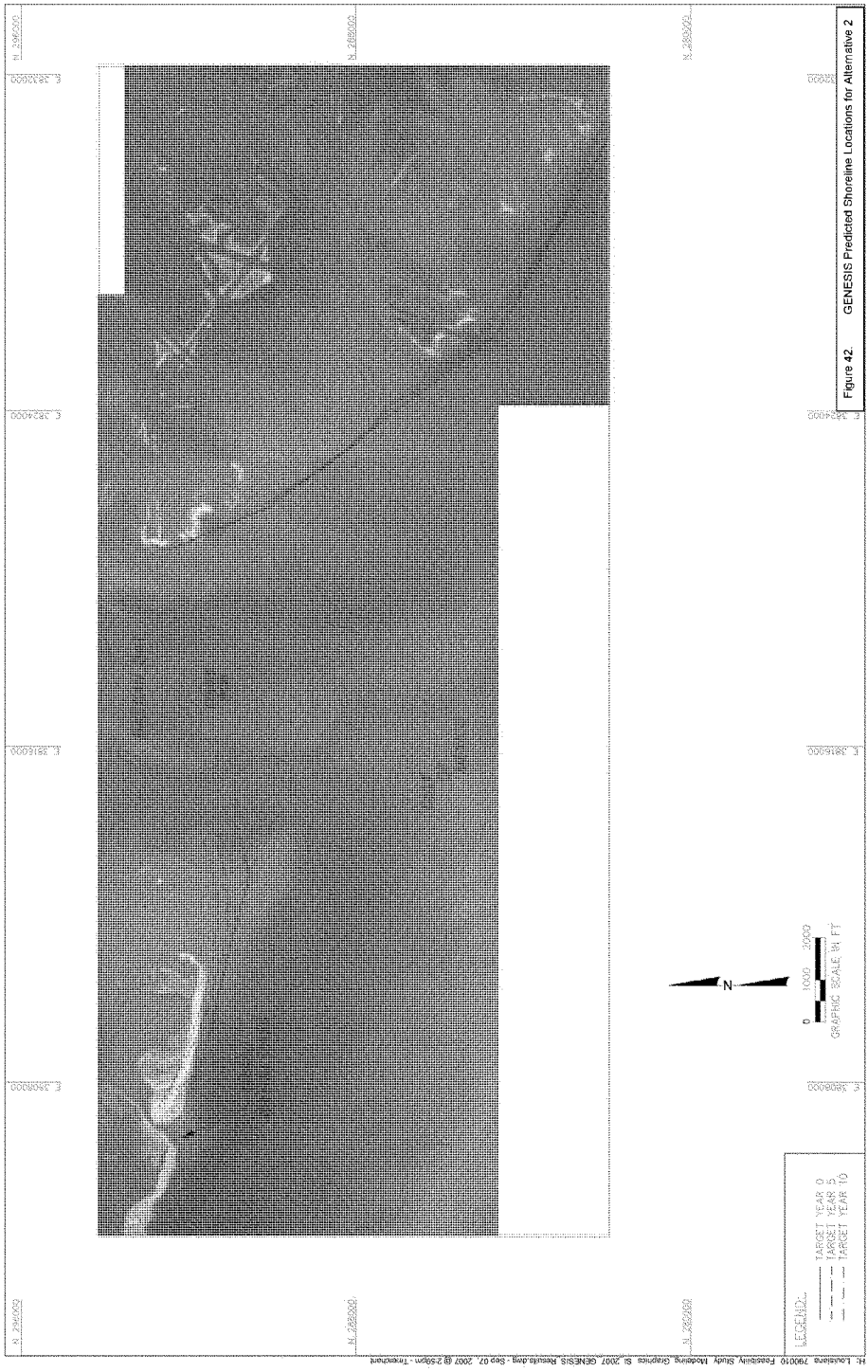



Figure 42. GENESIS Predicted Shoreline Locations for Alternative 2

Table 18. Planform Performance Projection for Alternative 2

| Target Year | Habitat (acres) | | | | | Total |
|---|---|---|---|---|---|---|
| | Dune | Supratidal | Intertidal (Gulfside) | Intertidal (Bayside) | Subtidal (Bayside) | |
| TY0 | 0 | 6 | 50 | 89 | 240 | 386 |
| TY1 | 193 | 147 | 50 | 351 | 168 | 909 |
| TY2 | 174 | 145 | 41 | 350 | 168 | 877 |
| TY3 | 165 | 143 | 41 | 349 | 168 | 865 |
| TY5 | 146 | 139 | 41 | 347 | 168 | 841 |
| TY10 | 101 | 139 | 41 | 324 | 165 | 769 |
| TY11 | 193 | 139 | 50 | 322 | 164 | 868 |
| TY12 | 174 | 139 | 41 | 320 | 163 | 837 |
| TY13 | 165 | 139 | 41 | 318 | 162 | 824 |
| TY15 | 146 | 139 | 41 | 314 | 160 | 800 |
| TY20 | 101 | 139 | 41 | 304 | 155 | 740 |
| TY21 | 193 | 147 | 50 | 341 | 156 | 887 |
| TY22 | 174 | 145 | 41 | 341 | 155 | 855 |
| TY23 | 165 | 143 | 41 | 341 | 154 | 843 |
| TY25 | 146 | 139 | 41 | 341 | 152 | 819 |
| TY30 | 101 | 139 | 41 | 324 | 147 | 752 |
| TY31 | 164 | 139 | 50 | 322 | 146 | 821 |
| TY32 | 145 | 139 | 41 | 320 | 145 | 790 |
| TY33 | 136 | 139 | 41 | 318 | 144 | 778 |
| TY35 | 129 | 139 | 41 | 314 | 142 | 765 |
| TY40 | 111 | 139 | 41 | 304 | 137 | 733 |
| TY41 | 135 | 147 | 50 | 341 | 139 | 811 |
| TY42 | 121 | 145 | 41 | 341 | 138 | 785 |
| TY43 | 118 | 143 | 41 | 341 | 137 | 779 |
| TY45 | 114 | 139 | 41 | 341 | 136 | 770 |
| TY50 | 100 | 139 | 41 | 324 | 132 | 735 |

Alternative 2 includes a renourishment program. The optimum renourishment interval for the beach is 10 years, with the marsh being renourished every 20 years. This is discussed later in the report (Section 7.4). The first renourishment project will occur in TY10 and the shoreline will be returned to its TY1 (immediate post-construction) condition. Therefore, the TY1 post-construction acreage will be regenerated in TY11, except for the additional acreage provided by the marsh dikes (which are not rebuilt in the first renourishment). Acreage loss due to profile equilibration is anticipated to occur after each nourishment project. The supratidal and bayside intertidal acreages are not increased during TY10 and TY30 because the losses associated with these areas occur only on the bayside, and are not regenerated until the marsh fill is renourished. The TY1 bayside intertidal acreage includes existing sediment outside of the construction template which is lost by TY11. When the marsh fill is renourished in TY 20 and 40,

the bayside intertidal acreage does not return to 351 aeres, but rather 341 acres, to account for the lost intertidal bayside acreage outside the construction footprint.

It is estimated that the Coupe Bob ebb shoal will grow by 101,000 cubic yards/year and require 33 years to reach its accommodation volume. As Coupe Bob approaches its accommodation volume, more sand will be bypassed across the inlet. As the net longshore drift is east to west, the sand transported longshore from Shell Island East will no longer be lost to the ebb shoal, but instead be transported across the inlet. The GENESIS model does not account for this change in coastal processes due to infilling of the ebb shoal. The USACE Reservoir Model (Kraus, 2002) can be used to estimate the volume of infilling and bypassing but it was beyond the scope of this feasibility level work. Instead, it was assumed the longshore losses on Shell Island East were reduced to 10,000 cubic yards/year (from 52,000 cubic yards/year) at TY35 and that longshore losses from Shell Island West were reduced to approximately 18,500 cubic yards/year (from 79,000 cubic yards/year). Coupe Bob is capable of reaching its accommodation volume because of the sand volume added to the project area during the renourishment projects.

After TY35, the shoreline recession rates are anticipated to decrease from 35.2 feet/year to 11.8 feet/year on Shell Island West and from 12.3 feet/year to 5.4 feet/year on Shell Island East. As discussed in the paragraph above, this will actually be a more gradual change but for the purposes of this feasibility report is assumed to occur at a specific time. Ten years of advanced fill at TY30 will require less fill than at TY10 and TY20 because the recession rates will decrease five years after TY30 construction. TY40 will require an even smaller renourishment volume because longshore losses will occur at the smaller rate from TY40 to TY50. Renourishment volumes for the TY30 renourishment will be 1,128,000 cubic yards while TY40 is estimated to require a renourishment volume of 623,000 cubic yards, compared to 1,633,000 cubic yards for the TY10 and TY20 renourishment projects. This is also reflected in the WVA for Alternative 2 (Table 18), where the dune acreages for TY11 and TY21 are 193 acres, whereas it is 164 acres in TY31 and only 135 acres in TY41.

Marsh recession (3.6 feet/year) and subsidence rates remain the same as for Alternative 1 except that the marsh is periodically renourished.

## 5.4 ALTERNATIVE 3 – ONE ISLAND WITH NO RENOURISHMENT

The single island options of Alternatives 3 to 8 better meet the listed goals of re-establishing a barrier between the Gulf of Mexico and Bastian Bay, reducing wave energy transmission into the back bay and promoting the re-establishment of the historic longshore sediment transport pattern along the Gulf shoreline.

The GENESIS model suggests that the eastern end of Shell Island will recede and that the center of the island will be relatively stable (Figure 44). The Empire Waterway was the edge of the model grid and no losses into the Empire Waterway were incorporated into the model. Additional recession of the eastern end of the island could therefore be expected. A terminal structure could be added to the eastern end of the island to eliminate losses to the Empire Waterway but this is not likely to be cost effective. With the redirected tidal prism flowing through the Empire Waterway, it is unlikely that construction of Alternative 3 will cause shoaling in the navigation channel. Tidal flow between the island and the northern end of the west jetty could increase shoreline erosion. A circulation model would provide greater insight into tidal flow in the area and the benefits or disadvantages of structural options, such as extending the jetties back to the island, constructing a terminal structure (but leaving a gap between the existing jetty and the end of the terminal structure), or removal of the existing jetties.

The western end of the island will recede, as the constructed shape has a headland type shape. However, the GENESIS model cannot predict the effect of Grand Bayou on the western end of the island. It is anticipated that Grand Bayou will reopen to its pre-Hurricane Bob width. This is expected as the tidal flow currently passing through Coupe Bob will be redirected towards Grand Bayou and Empire Waterway. Prior to breaching and the formation of Coupe Bob, Grand Bayou and Empire Waterway were the main channels for tidal exchange and it is expected for these to regain the previous tidal flows.

Figure 45 shows the expected sediment paths and volumes for Alternative 3. With the closure of Coupe Bob, the longshore transport losses are mainly to Grand Bayou at 44,000 cubic yards/year. Losses to Fontanelle Pass are expected to be small (approximately 1,000 cubic yards/year) due to the alignment of the east end and the sheltering provided by the Empire Jetties. Longshore losses are matched by losses due to relative sea level rise and overwash, which are estimated to be equivalent to 32,200 cubic yards/year. With an island length of 23,400 feet and an active profile height of 11 feet, the recession rate due to longshore losses was calculated to be 4.6 feet/year for Alternatives 3 through 8. The recession rate due to relative sea level rise for Alternatives 3 through 6 based on a beach width of 864 feet was calculated to be 3.4 feet/year, creating a total Gulf side recession rate of 7.9 feet/year.

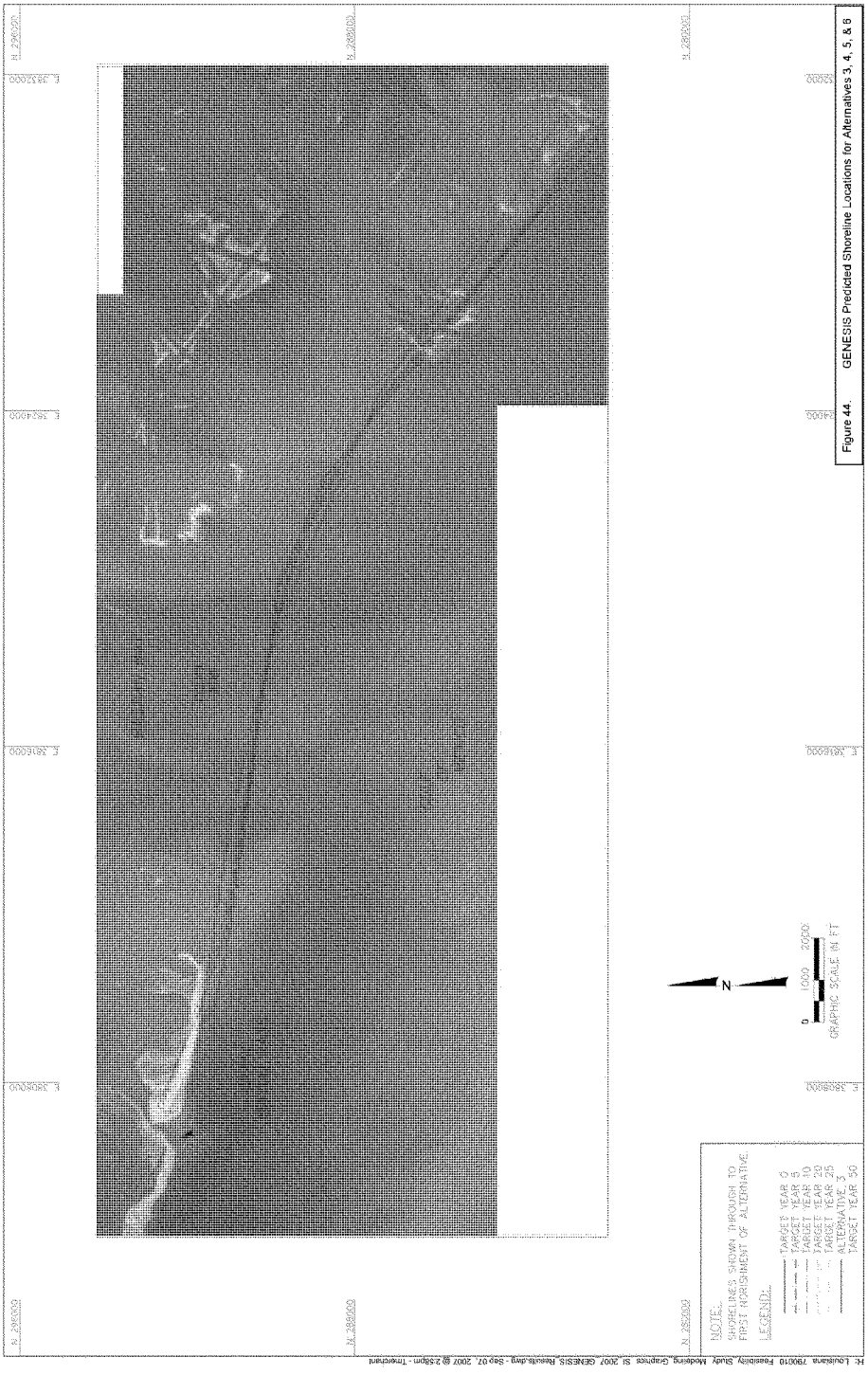



Figure 44. GENESIS Predicted Shoreline Locations for Alternatives 3, 4, 5, & 6

The construction of Alternative 3 will result in increased flow through Grand Bayou and Fontanelle Pass, as the tidal prism is redirected due to the closure of Coupe Bob. While Fontanelle Pass has been dredged for navigation purposes and may accommodate the additional tidal prism flow without altering the channel significantly, additional studies should be conducted to model water circulation and current velocities in the back bays and inlets due to the closure of Coupe Bob and the construction of the tidal diversion channel. It is expected that the increased flow through Grand Bayou will start to reopen the pass and it could expand to its pre-1979 size. The western end of Shell Island West would likely be eroded and the sediment transported to the Grand Bayou ebb shoal. It is assumed that the erosion of the west end of Shell Island West will occur within 10 years of construction. Hydrodynamic modeling of the project area would assist in developing a more accurate assessment of acreage changes and the associated timeline.

Alternative 3 is the only single island option that does not include renourishment of the dune or the marsh fill. Because Alternative 3 has no scheduled renourishment, it will have a higher risk of breaching than the other alternatives. As discussed in Section 2.9, Shell Island is expected to breach when the island width (from the beach fill MHW on the Gulf side to the marsh MHW on the bay side) is less than 300 feet. A breach analysis was conducted on Alternative 3 to assess its breaching potential. The following assumptions were made to determine when the island will be susceptible to breaching:

A. Breaching can be expected to occur after the interior width is less than 300 feet.

B. The initial width of the beach and marsh following construction will be 585 and 370 feet respectively, yielding an initial island width of 955 feet.

C. Equilibration of the beach, which is expected to occur during the first year following construction, will decrease the beach width by 20 feet.

D. The Gulf side of the beach will retreat at a rate of 7.9 feet per year.

E. The Bay side of the marsh will retreat at a rate of 3.6 feet per year until the marsh subsides below mean low water, which is expected to occur after TY19.

F. After the marsh subsides below mean low water, the Bay side of the beach will retreat at a rate of 3.4 feet per year.

A model was developed, using the aforementioned assumptions, to determine the width of Shell Island throughout the project lifetime. The model results, shown in Figure 46, indicate that Shell Island will be susceptible to breaching around TY30.

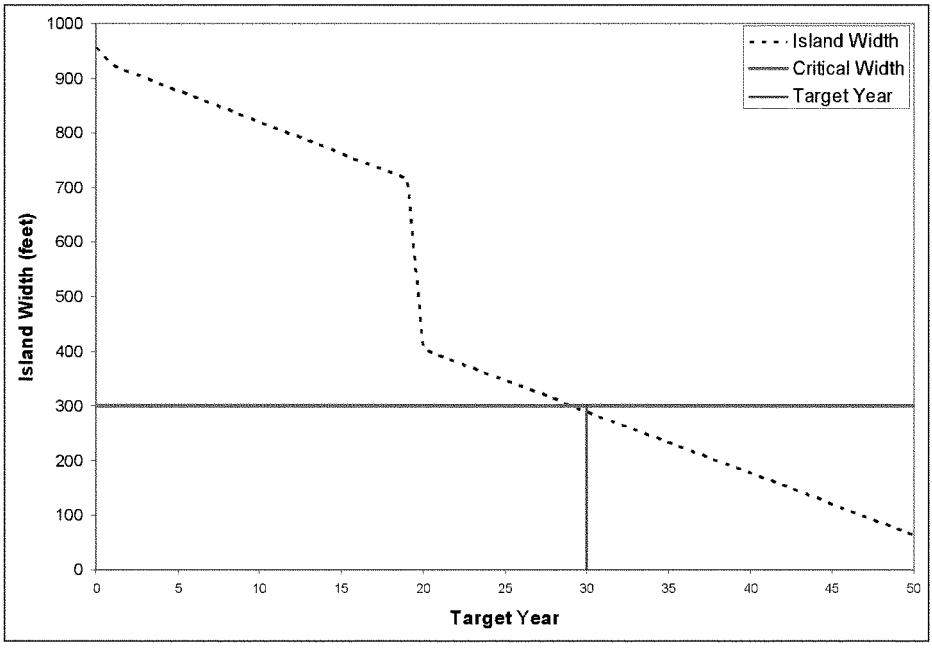



Figure 46. Shell Island Breach Analysis Model Results.

Although the model results indicate that Shell Island has the potential to breach around TY30, a couple of events could occur which would change the model results: (1) a severe hurricane may breach the island before the island recedes to a width less than 300 feet or (2) overwash events could stabilize the marsh platform which could potentially eliminate marsh subsidence below mean low water resulting in the island receding to a width of 300 feet after TY55.

The breaching of the island at TY30 produces an extra erosion loss factor to be included in the WVA assessment, which is not present in the assessments of the other alternatives. It was assumed that the Alternative 3 island breach would widen at a similar rate as the Coupe Bob breach after the 1979 Hurricane Bob. To calculate a breach formation rate, a relationship between time and breach width was developed by measuring the width of Coupe Bob at three known times; 1978 before Coupe Bob opened, 1989 when Coupe Bob was 5,590 feet wide, and 2004 when Coupe Bob was approximately 8,400 feet

wide (Figure 47). Breach formation rates, which cause a recession of the total island length, were calculated for each year from TY31 to TY50 based on the curve shown in Figure 47. The recession rate of the total island length due to breaching is 631 feet/year at TY31 and slowly decreases every year to a rate of 397 feet/year by TY50. It should be noted that the simple calculated rates based on the three known Coupe Bob widths will underestimate the actual breach formation rate at the beginning, when the breach is first formed, and will overestimate the formation rate by TY50.

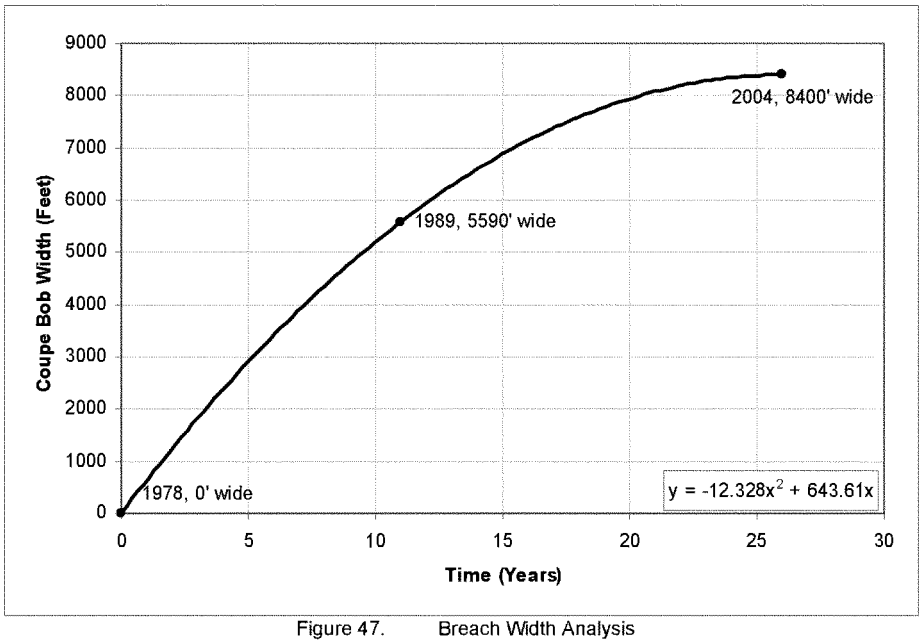



Figure 47. Breach Width Analysis

It was assumed in the WVA for Alternative 3 that breaching occurs at TY30, with the breaching effects beginning at TY31. Alternative 3 will initially create approximately 318 acres of supratidal and dune acreage and approximately 466 acres of bay intertidal (marsh) acreage (Table 19). Alternative 3 has more than 100 additional acres of bay intertidal acreage as a single island compared to the two island Alternative 2.

Table 19. Planform Performance Projection for Alternative 3

| Target Year | Habitat (acres) | | | | | Total |
|---|---|---|---|---|---|---|
| | Dune | Supratidal | Intertidal (Gulfside) | Intertidal (Bayside) | Subtidal (Bayside) | |
| TY0 | 0 | 6 | 50 | 89 | 240 | 386 |
| TY1 | 153 | 165 | 59 | 466 | 149 | 991 |
| TY2 | 137 | 162 | 46 | 455 | 149 | 949 |
| TY3 | 133 | 159 | 44 | 445 | 149 | 930 |
| TY5 | 124 | 154 | 42 | 429 | 149 | 898 |
| TY10 | 102 | 154 | 42 | 393 | 144 | 835 |
| TY11 | 98 | 154 | 42 | 390 | 143 | 827 |
| TY12 | 93 | 154 | 42 | 388 | 142 | 819 |
| TY13 | 89 | 154 | 42 | 386 | 141 | 812 |
| TY15 | 80 | 154 | 42 | 382 | 139 | 797 |
| TY20 | 58 | 154 | 42 | 371 | 134 | 759 |
| TY21 | 53 | 154 | 42 | 368 | 124 | 741 |
| TY22 | 49 | 154 | 42 | 366 | 121 | 732 |
| TY23 | 45 | 154 | 42 | 364 | 120 | 725 |
| TY25 | 36 | 154 | 42 | 359 | 118 | 709 |
| TY26 | 31 | 154 | 42 | 357 | 117 | 702 |
| TY27 | 27 | 154 | 42 | 355 | 116 | 694 |
| TY30 | 14 | 154 | 42 | 350 | 114 | 675 |
| TY31 | 9 | 150 | 41 | 340 | 110 | 650 |
| TY32 | 4 | 146 | 40 | 329 | 106 | 626 |
| TY33 | 0 | 142 | 39 | 319 | 103 | 603 |
| TY35 | 0 | 127 | 37 | 299 | 95 | 558 |
| TY37 | 0 | 113 | 35 | 280 | 88 | 516 |
| TY40 | 0 | 94 | 32 | 254 | 78 | 458 |
| TY41 | 0 | 88 | 31 | 246 | 66 | 431 |
| TY42 | 0 | 82 | 30 | 238 | 63 | 414 |
| TY43 | 0 | 76 | 29 | 230 | 61 | 397 |
| TY45 | 0 | 66 | 28 | 216 | 55 | 365 |
| TY47 | 0 | 57 | 26 | 202 | 50 | 335 |
| TY50 | 0 | 45 | 24 | 183 | 43 | 295 |

The decrease in total island length due to the breach formation will cause each acreage section to decrease starting at TY31. By TY50 the breach width is estimated to be 7,940 feet wide, and only 183 acres of marsh fill will be left after starting with 466 acres. Of the single island options, Alternative 3 has the smallest amount of wetland acres at TY50 with 295 acres.

The constructed marsh elevation for Alternatives 3 through 8 is +2.0 feet (NAVD). The constructed marsh is thus considered bay intertidal upon construction. No benefit has been included for the construction of the geotextile tube on the bay side of Alternatives 3 through 8, as this is a construction option available to the contractor and may not necessarily be constructed. Ignoring erosion protection

provided by the geotextile tube also provides a conservative acreage assessment. A bayside recession rate of 3.6 feet/year was assumed for Alternative 3 to 8.

## 5.5 ALTERNATIVE 4 – ONE ISLAND WITH RENOURISHMENT (TY25)

Alternative 4 has the same construction template as Alternative 3, however the beach and marsh fill are both renourished 25 years after construction. The GENESIS model results up to TY25 were the same for Alternative 4 as Alternative 3 (see Figure 44). Alternative 4 creates the same initial supratidal and dune acreage (318 acres) and bay intertidal acreage (466 acres) as Alternative 3 (Table 20).

Table 20. Planform Performance Projection for Alternative 4

| Target Year | Habitat (acres) | | | | | Total |
|---|---|---|---|---|---|---|
| | Dune | Supratidal | Intertidal (Gulfside) | Intertidal (Bayside) | Subtidal (Bayside) | |
| TY0 | 0 | 6 | 50 | 89 | 240 | 386 |
| TY1 | 153 | 165 | 59 | 466 | 149 | 991 |
| TY2 | 137 | 162 | 46 | 455 | 149 | 949 |
| TY3 | 133 | 159 | 44 | 445 | 149 | 930 |
| TY5 | 124 | 154 | 42 | 429 | 149 | 898 |
| TY10 | 102 | 154 | 42 | 393 | 144 | 835 |
| TY11 | 98 | 154 | 42 | 390 | 143 | 827 |
| TY12 | 93 | 154 | 42 | 388 | 142 | 819 |
| TY13 | 89 | 154 | 42 | 386 | 141 | 812 |
| TY15 | 80 | 154 | 42 | 382 | 139 | 797 |
| TY20 | 58 | 154 | 42 | 371 | 134 | 759 |
| TY21 | 53 | 154 | 42 | 368 | 124 | 741 |
| TY22 | 49 | 154 | 42 | 366 | 121 | 732 |
| TY23 | 45 | 154 | 42 | 364 | 120 | 725 |
| TY25 | 36 | 154 | 42 | 359 | 118 | 709 |
| TY26 | 153 | 163 | 52 | 410 | 120 | 898 |
| TY27 | 137 | 161 | 42 | 410 | 119 | 869 |
| TY30 | 124 | 154 | 42 | 410 | 117 | 847 |
| TY31 | 120 | 154 | 42 | 405 | 116 | 837 |
| TY32 | 115 | 154 | 42 | 399 | 115 | 825 |
| TY33 | 111 | 154 | 42 | 396 | 114 | 817 |
| TY35 | 102 | 154 | 42 | 392 | 112 | 802 |
| TY37 | 93 | 154 | 42 | 388 | 110 | 787 |
| TY40 | 80 | 154 | 42 | 381 | 107 | 764 |
| TY41 | 75 | 154 | 42 | 379 | 97 | 747 |
| TY42 | 71 | 154 | 42 | 377 | 96 | 740 |
| TY43 | 67 | 154 | 42 | 375 | 95 | 732 |
| TY45 | 58 | 154 | 42 | 370 | 93 | 717 |
| TY47 | 49 | 154 | 42 | 366 | 91 | 702 |
| TY50 | 36 | 154 | 42 | 359 | 88 | 679 |

Alternative 4 beach and marsh fill is renourished 25 years after construction, therefore at TY26 the acreages have been increased to reflect the renourishment. It should be noted that the acreages for TY26 are not the same as TY1 because TY1 includes existing sediment within the project boundary which would subside gradually and is not affected by the renourishment. With a construction template including 10 years of advanced nourishment and a beach and marsh renourishment at TY25, Alternative 4 has 679 acres remaining after 50 years.

## 5.6 ALTERNATIVE 5 – ONE ISLAND WITH RENOURISHMENT (TY20 & 40)

Alternative 5 is again designed to have the same construction template as Alternatives 3 through 6 though Alternative 5 has a renourishment interval of 20 years. Both the beach and marsh fill will be renourished at TY20 and TY40, meaning the GENESIS model results in Figure 44 up to TY20 apply to Alternative 5. Alternative 5 creates the same initial acreages as Alternatives 3 to 6 but a total of 699 acres remain after 50 years (Table 21). Since only 10 years of advanced fill will be added at the TY40 renourishment, the design section will be exposed at TY50.

## 5.7 ALTERNATIVE 6 – ONE ISLAND WITH RENOURISHMENT (TY10, 20, 30, & 40)

Alternative 6 is the single island option that incorporates renourishment projects in order to maintain the design section over the 50-year project life. Alternative 6 has the same renourishment schedule as Alternative 2 with the beach fill being renourished every 10 years, and the marsh fill renourished every 20 years. Alternative 6 is the preferred alternative because the beach fill is replenished prior to the design section being eroded.

Table 21. Planform Performance Projection for Alternative 5

| Target Year | Habitat (acres) | | | | | Total |
|---|---|---|---|---|---|---|
| | Dune | Supratidal | Intertidal (Gulfside) | Intertidal (Bayside) | Subtidal (Bayside) | |
| TY0 | 0 | 6 | 50 | 89 | 240 | 386 |
| TY1 | 153 | 165 | 59 | 466 | 149 | 991 |
| TY2 | 137 | 162 | 46 | 455 | 149 | 949 |
| TY3 | 133 | 159 | 44 | 445 | 149 | 930 |
| TY5 | 124 | 155 | 42 | 429 | 149 | 899 |
| TY10 | 102 | 155 | 42 | 393 | 144 | 835 |
| TY11 | 98 | 155 | 42 | 390 | 143 | 827 |
| TY12 | 93 | 155 | 42 | 388 | 142 | 820 |
| TY13 | 89 | 155 | 42 | 386 | 141 | 812 |
| TY15 | 80 | 155 | 42 | 382 | 139 | 797 |
| TY20 | 58 | 155 | 42 | 371 | 134 | 759 |
| TY21 | 153 | 163 | 52 | 410 | 135 | 913 |
| TY22 | 137 | 161 | 42 | 410 | 133 | 883 |
| TY23 | 133 | 159 | 42 | 410 | 132 | 875 |
| TY25 | 124 | 154 | 42 | 410 | 131 | 861 |
| TY26 | 120 | 154 | 42 | 405 | 130 | 851 |
| TY27 | 115 | 154 | 42 | 401 | 129 | 841 |
| TY30 | 102 | 154 | 42 | 392 | 127 | 817 |
| TY31 | 98 | 154 | 42 | 390 | 126 | 809 |
| TY32 | 93 | 154 | 42 | 388 | 125 | 802 |
| TY33 | 89 | 154 | 42 | 386 | 124 | 794 |
| TY35 | 80 | 154 | 42 | 381 | 122 | 779 |
| TY37 | 71 | 154 | 42 | 377 | 120 | 764 |
| TY40 | 58 | 154 | 42 | 370 | 117 | 741 |
| TY41 | 153 | 163 | 52 | 410 | 118 | 896 |
| TY42 | 137 | 161 | 42 | 410 | 117 | 867 |
| TY43 | 133 | 159 | 42 | 410 | 116 | 859 |
| TY45 | 124 | 154 | 42 | 410 | 114 | 844 |
| TY47 | 115 | 154 | 42 | 401 | 112 | 824 |
| TY50 | 102 | 154 | 42 | 392 | 109 | 799 |

Alternative 6 creates the same initial acreages as Alternatives 3 to 6 but is left with a total of 100 acres more fill than Alternative 5 after 50 years (Table 22). The GENESIS model results in Figure 44 apply to Alternative 6 through TY10. The sediment budget shown in Figure 45 also applies to Alternative 6.

Table 22. Planform Performance Projection for Alternative 6

| Target Year | Habitat (acres) | | | | | Total |
|---|---|---|---|---|---|---|
| | Dune | Supratidal | Intertidal (Gulfside) | Intertidal (Bayside) | Subtidal (Bayside) | |
| TY0 | 0 | 6 | 50 | 89 | 240 | 386 |
| TY1 | 153 | 165 | 59 | 466 | 149 | 991 |
| TY2 | 137 | 162 | 46 | 455 | 149 | 949 |
| TY3 | 133 | 159 | 44 | 445 | 149 | 930 |
| TY5 | 124 | 155 | 42 | 429 | 149 | 899 |
| TY10 | 102 | 155 | 42 | 393 | 144 | 835 |
| TY11 | 153 | 155 | 52 | 390 | 143 | 893 |
| TY12 | 137 | 155 | 42 | 388 | 142 | 864 |
| TY13 | 133 | 155 | 42 | 386 | 141 | 856 |
| TY15 | 124 | 155 | 42 | 382 | 139 | 841 |
| TY20 | 102 | 155 | 42 | 371 | 134 | 803 |
| TY21 | 153 | 163 | 52 | 410 | 135 | 913 |
| TY22 | 137 | 161 | 42 | 410 | 133 | 883 |
| TY23 | 133 | 159 | 42 | 410 | 132 | 875 |
| TY25 | 124 | 154 | 42 | 410 | 131 | 861 |
| TY26 | 120 | 154 | 42 | 405 | 130 | 851 |
| TY27 | 115 | 154 | 42 | 401 | 129 | 841 |
| TY30 | 102 | 154 | 42 | 392 | 126 | 816 |
| TY31 | 153 | 154 | 52 | 390 | 125 | 874 |
| TY32 | 137 | 154 | 42 | 388 | 124 | 845 |
| TY33 | 133 | 154 | 42 | 386 | 123 | 837 |
| TY35 | 124 | 154 | 42 | 381 | 121 | 822 |
| TY37 | 115 | 154 | 42 | 377 | 119 | 807 |
| TY40 | 102 | 154 | 42 | 370 | 116 | 784 |
| TY41 | 153 | 163 | 52 | 410 | 117 | 895 |
| TY42 | 137 | 161 | 42 | 410 | 116 | 866 |
| TY43 | 133 | 159 | 42 | 410 | 115 | 858 |
| TY45 | 124 | 154 | 42 | 410 | 113 | 843 |
| TY47 | 115 | 154 | 42 | 401 | 111 | 823 |
| TY50 | 102 | 154 | 42 | 392 | 108 | 798 |

As with Alternative 2, the dune acreage will return to its TY1 acreage every 10 years following each beach renourishment. The supratidal and bayside intertidal acreages are not increased in TY10 and TY30 because the losses associated with these areas occur only on the bayside, and are not regenerated until the marsh is renourished in TY20 and TY40. It should also be noted that with each renourishment, the acreages do not all return to the exact TY1 values, because these values include areas of existing sediment which within the project limits, but outside the construction template. This extra area is not renourished along with original construction template. Every ten years Alternative 6 will require a beach renourishment volume of 756,000 cubic yards.

## 5.8 ALTERNATIVE 7 – ONE ISLAND WITH RENOURISHMENT (TY20 & 40)

Alternative 7 is another single island option, but with a larger dune crest width than Alternatives 3 to 6, as it includes 20 years of advanced nourishment rather than 10 years for the previous single island options. The sediment budget for Alternative 7 (Figure 49) has the same longshore losses as the previous single island options, but the cross-shore losses due to relative sea level rise have increased. A dune crest width of 270 feet creates a beach width of 955 feet. The recession rate due to relative sea level rise was calculated to be 3.7 feet/year based on an active profile height of 11 feet, a width of 955 feet, and a relative sea level rise rate of 0.043 feet/year. This equates to a cross-shore volumetric loss of 35,600 cubic yards/year. The GENESIS model results, which include these recession rates, can be found in Figure 48.

The Gulf side recession rate used for the wetland value assessment below includes 4.6 feet/year due to longshore losses, and 3.7 feet/year due to relative sea level rise, creating a total recession rate of 8.3 feet/year. The bayside recession rate remains the same as all previous alternatives at 3.6 feet/year.

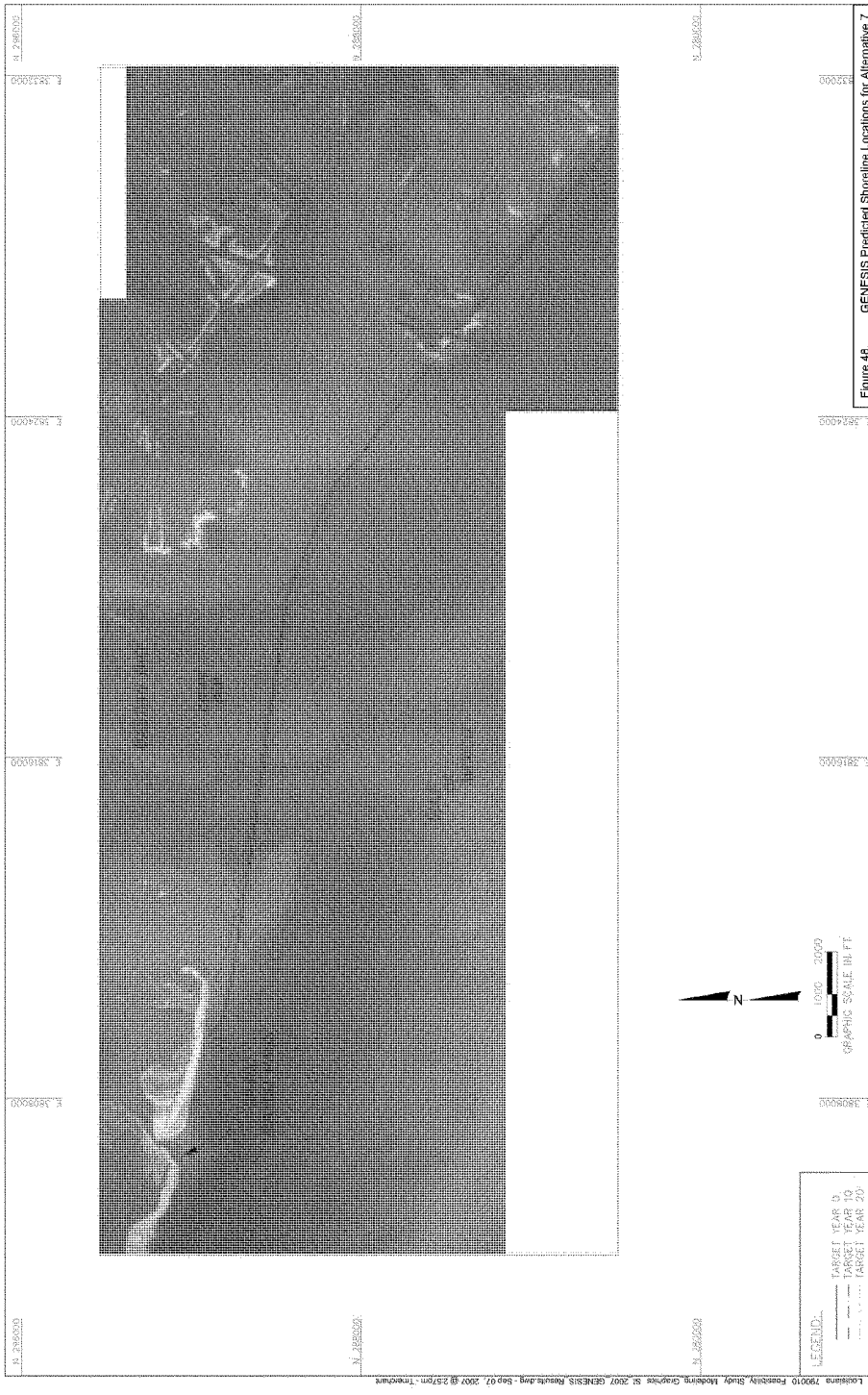



Figure 48. GENESIS Predicted Shoreline Locations for Alternative 7

Both the beach fill and the marsh fill for Alternative 7 are renourished every 20 years, which is the same renourishment schedule as Alternative 5. Alternative 7 will create approximately 362 acres of supratidal and dune acreage and approximately 469 acres of bay intertidal (marsh) acreage (Table 23). Alternative 7 has more than 44 additional dune and supratidal acres in TY1, and 43 more total acres remain in TY50 compared to Alternative 5.

Table 23. Planform Performance Projection for Alternative 7

| Target Year | Habitat (acres) | | | | | Total |
|---|---|---|---|---|---|---|
| | Dune | Supratidal | Intertidal (Gulfside) | Intertidal (Bayside) | Subtidal (Bayside) | |
| TY0 | 0 | 6 | 50 | 89 | 240 | 386 |
| TY1 | 197 | 165 | 59 | 466 | 149 | 1035 |
| TY2 | 181 | 162 | 46 | 455 | 149 | 993 |
| TY3 | 176 | 159 | 44 | 445 | 149 | 973 |
| TY5 | 167 | 155 | 41 | 429 | 149 | 942 |
| TY10 | 144 | 155 | 41 | 393 | 144 | 877 |
| TY11 | 139 | 155 | 41 | 390 | 143 | 869 |
| TY12 | 135 | 155 | 41 | 388 | 142 | 861 |
| TY13 | 130 | 155 | 41 | 386 | 141 | 853 |
| TY15 | 121 | 155 | 41 | 382 | 139 | 838 |
| TY20 | 98 | 155 | 41 | 371 | 134 | 798 |
| TY21 | 197 | 163 | 52 | 410 | 135 | 957 |
| TY22 | 181 | 161 | 41 | 410 | 133 | 926 |
| TY23 | 176 | 159 | 41 | 410 | 132 | 918 |
| TY25 | 167 | 154 | 41 | 410 | 131 | 903 |
| TY26 | 162 | 154 | 41 | 405 | 130 | 893 |
| TY27 | 158 | 154 | 41 | 401 | 129 | 883 |
| TY30 | 144 | 154 | 41 | 392 | 126 | 858 |
| TY31 | 139 | 154 | 41 | 390 | 125 | 850 |
| TY32 | 135 | 154 | 41 | 388 | 124 | 842 |
| TY33 | 130 | 154 | 41 | 386 | 123 | 834 |
| TY35 | 121 | 154 | 41 | 381 | 121 | 818 |
| TY37 | 111 | 154 | 41 | 377 | 119 | 803 |
| TY40 | 98 | 154 | 41 | 370 | 116 | 779 |
| TY41 | 197 | 163 | 52 | 410 | 117 | 939 |
| TY42 | 181 | 161 | 41 | 410 | 116 | 909 |
| TY43 | 176 | 159 | 41 | 410 | 115 | 902 |
| TY45 | 167 | 154 | 41 | 410 | 113 | 886 |
| TY47 | 158 | 154 | 41 | 401 | 111 | 866 |
| TY50 | 144 | 154 | 41 | 392 | 108 | 840 |

## 5.9 ALTERNATIVE 8 – ONE ISLAND WITH RENOURISHMENT (TY25)

Alternative 8 is the last single island option, with the difference being that this alternative has 25 years of advanced nourishment, and is only renourished in TY 25. The sediment budget for Alternative 8 is again slightly different from the previous alternatives because of the increase of loss due to relative sea level rise. The recession due to relative sea level rise for Alternative 8 is 4.0 feet/year, creating a total cross-shore volumetric loss of 37,900 cubic yards/year (Figure 51). The GENESIS model results for Alternative 8, which include these recession rates, are shown in Figure 50.

The Gulf side recession rate used for the wetland value assessment below totals 8.5 feet/year, and the bayside recession rate remains the same as all previous alternatives at 3.6 feet/year.

Alternative 8 has the same renourishment intervals as Alternative 4, with the beach and marsh fill renourished 25 years after construction. Alternative 8 will create approximately 396 acres of supratidal and dune acreage and approximately 469 acres of bay intertidal (marsh) acreage (Table 24). In comparison to Alternative 4, Alternative 8 has 151 additional dune and supratidal acres in TY1, and 77 more total acres remaining in TY50.

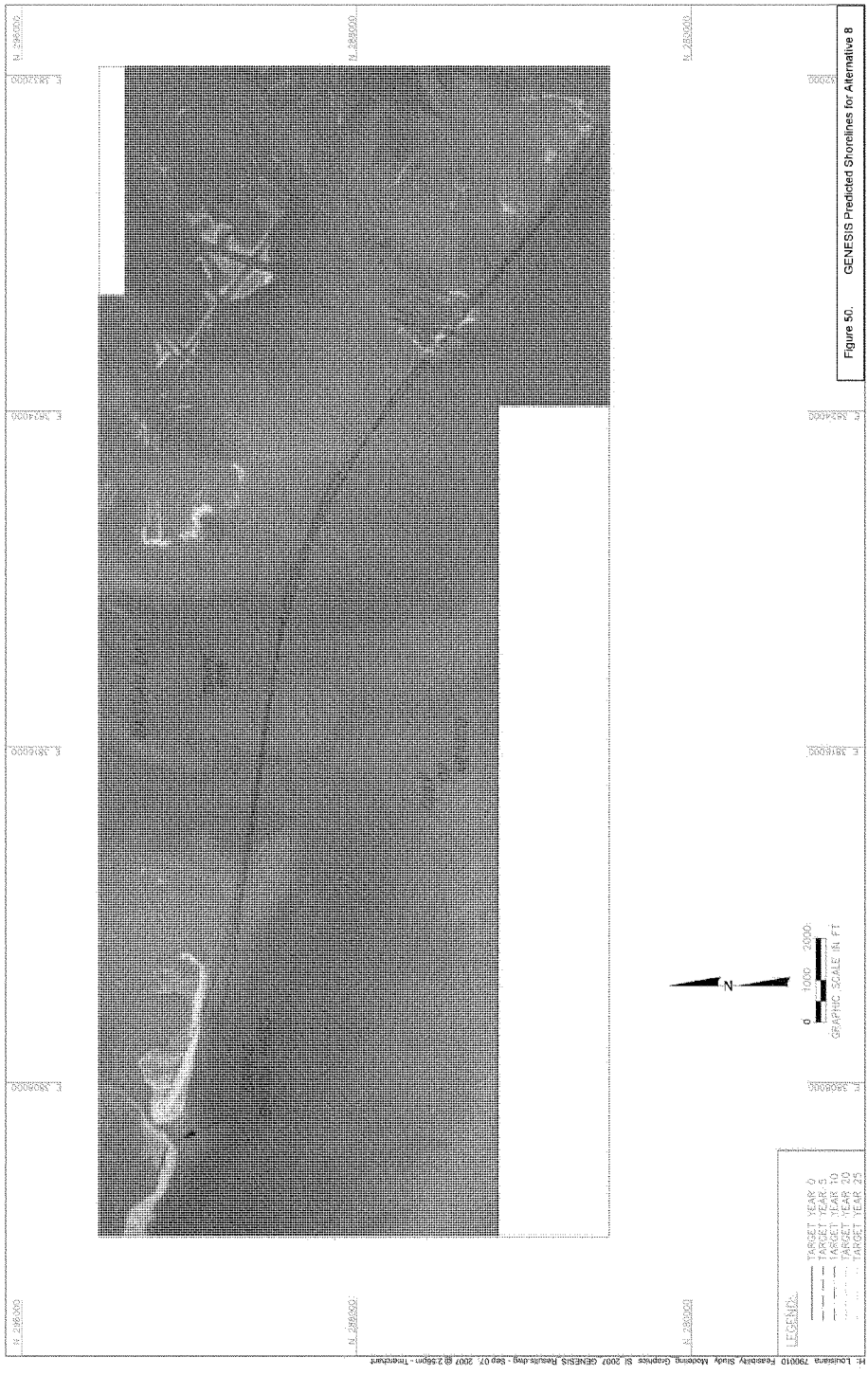



Figure 50. GENESIS Predicted Shorelines for Alternative 8

Table 24. Planform Performance Projection for Alternative 8

| Target Year | Habitat (acres) | | | | | Total |
|---|---|---|---|---|---|---|
| | Dune | Supratidal | Intertidal (Gulfside) | Intertidal (Bayside) | Subtidal (Bayside) | |
| TY0 | 0 | 6 | 50 | 89 | 240 | 386 |
| TY1 | 231 | 164 | 59 | 466 | 149 | 1069 |
| TY2 | 215 | 162 | 46 | 455 | 149 | 1027 |
| TY3 | 210 | 159 | 44 | 445 | 149 | 1007 |
| TY5 | 201 | 154 | 41 | 429 | 149 | 975 |
| TY10 | 177 | 154 | 41 | 393 | 144 | 909 |
| TY11 | 172 | 154 | 41 | 390 | 143 | 901 |
| TY12 | 168 | 154 | 41 | 388 | 142 | 893 |
| TY13 | 163 | 154 | 41 | 386 | 141 | 885 |
| TY15 | 153 | 154 | 41 | 382 | 139 | 870 |
| TY20 | 130 | 154 | 41 | 371 | 134 | 830 |
| TY21 | 125 | 154 | 41 | 368 | 124 | 812 |
| TY22 | 120 | 154 | 41 | 366 | 121 | 803 |
| TY23 | 116 | 154 | 41 | 364 | 120 | 795 |
| TY25 | 106 | 154 | 41 | 359 | 118 | 779 |
| TY26 | 231 | 163 | 52 | 410 | 120 | 976 |
| TY27 | 215 | 161 | 41 | 410 | 119 | 946 |
| TY30 | 201 | 154 | 41 | 410 | 117 | 923 |
| TY31 | 196 | 154 | 41 | 405 | 116 | 913 |
| TY32 | 191 | 154 | 41 | 399 | 115 | 900 |
| TY33 | 187 | 154 | 41 | 396 | 114 | 892 |
| TY35 | 177 | 154 | 41 | 392 | 112 | 876 |
| TY37 | 168 | 154 | 41 | 388 | 110 | 861 |
| TY40 | 153 | 154 | 41 | 381 | 107 | 837 |
| TY41 | 149 | 154 | 41 | 379 | 97 | 820 |
| TY42 | 144 | 154 | 41 | 377 | 96 | 812 |
| TY43 | 139 | 154 | 41 | 375 | 95 | 804 |
| TY45 | 130 | 154 | 41 | 370 | 93 | 788 |
| TY47 | 120 | 154 | 41 | 366 | 91 | 772 |
| TY50 | 106 | 154 | 41 | 359 | 88 | 748 |

## 5.10 PROJECT PERFORMANCE SUMMARY

In order to summarize the project performance of each alternative the following tables have been created. Table 25 includes the different dune crest widths, beach volumes, beach acreages created, and renourishment intervals. Table 26 summarizes the marsh elevations, volumes, and acres created, as well as the total remaining beach and marsh acres at TY50, as well as cost estimates, which are explained in more detailed in Section 7.0.

Table 25. Summary of Beach Wetland Value Assessments

| Alternative Number | + 6 ft, NAVD Dune Width (feet) | Beach/Dune Length (feet) | Beach/Dune Fill Volume (cubic yards) | Beach Acres Created (acres) | Dune Acres Created (acres) | Beach Renourishment Interval (years) | Beach Renourishment Volume (cubic yards) |
|---|---|---|---|---|---|---|---|
| 1 | W = 250, E = 281 | W = 5,900, E = 15,400 | 4,130,000 | 332 | W = 51, E = 126 | None | None |
| 2 | W = 332, E = 278 | W = 5,900, E = 15,400 | 4,308,600 | 339 | W = 67, E = 125 | 10 Yrs | TY10, 20 = 1,633,000<br>TY30 = 1,128,000<br>TY40 = 623,000 |
| 3 | 189 | 24,300 | 5,611,700 | 317 | 153 | None | None |
| 4 | 189 | 24,300 | 5,611,700 | 317 | 153 | 25 Yrs | 1,890,000 |
| 5 | 189 | 24,300 | 5,611,700 | 317 | 153 | 20 Yrs | 1,512,000 |
| 6 | 189 | 24,300 | 5,611,700 | 317 | 153 | 10 Yrs | 756,000 |
| 7 | 280 | 24,300 | 6,435,700 | 361 | 197 | 20 Yrs | 1,580,000 |
| 8 | 343 | 24,300 | 6,888,700 | 395 | 231 | 25 Yrs | 2,033,000 |

Table 26. Summary of Marsh Wetland Value Assessments

| Alternative Number | Marsh Elevation (feet, NAVD) | Marsh Fill Volume (cubic yards) | Marsh Acres Created/ Enhanced (acres) | Marsh Renourishment Interval (years) | Marsh Renourishment Volume (cubic yards) | Net Acres at TY50 (acres) | Total Cost |
|---|---|---|---|---|---|---|---|
| 1 | 2.5 | 1,876,500 | 351 | None | None | 213 | 135,475,100 |
| 2 | 2 | 1,615,700 | 351 | 20 | TY20 = 699,900<br>TY40 = 451,400 | 735 | 214,105,000 |
| 3 | 2 | 2,138,500 | 466 | None | None | 295 | 180,900,000 |
| 4 | 2 | 2,138,500 | 466 | 25 | TY25 = 1,103,700 | 679 | 217,650,200 |
| 5 | 2 | 2,138,500 | 466 | 20 | TY20 = 907,200<br>TY40 = 604,700 | 799 | 226,486,400 |
| 6 | 2 | 2,138,500 | 466 | 20 | TY20 = 907,200<br>TY40 = 604,700 | 798 | 243,996,000 |
| 7 | 2 | 2,138,500 | 466 | 20 | TY20 = 907,200<br>TY40 = 604,700 | 840 | 251,609,700 |
| 8 | 2 | 2,138,500 | 466 | 25 | TY25 = 1,103,700 | 748 | 260,036,800 |

## 5.11 BENEFITS OF BEACH AND DUNE FEATURES

Louisiana barrier islands typically have very low elevations with a narrow sand beach face. As described by the dynamic morphosedimentary model, this narrow sand face is overwashed and removed longshore during large storm events exposing mixed sediments to Gulf waves. The mixed sediment system is then rapidly eroded during average wave conditions resulting in large shoreline retreat rates. By restoring Shell Island with a sandy beach, the shoreline retreat rates will be lower than if a mixed sediment system was used on the seaward face of the island.

Beach and dune features are implied to be composed of sandy sediments that can withstand the average wave conditions with limited losses. The eight alternatives presented in this report are based on having beach and dune features in place. The average retreat rates vary on the specific alternatives from 7.9 feet/year to 35.2 feet/year. The single-island alternatives have lower retreat rates while the two island alternatives have higher retreat rates. The higher retreat rates are driven by longshore losses into Coupe Bob and Grand Bayou. For comparison purposes and to avoid inlet effects, the single island alternatives were considered and a shoreline retreat rate of 7.9 feet/year used to represent a sandy beach and dune feature system.

The dynamic morphosedimentary model was used to predict shoreline retreat rates if Shell Island was restored using a mixed sediment system. Historic conditions suggest that the average shoreline retreat prior to the formation of Coupe Bob was 26 feet/year (as measured for the time period 1956 to 1973 and between USGS transects 68 and 81). This is three times the predicted shoreline retreat rate for Alternatives 3 through 8. To achieve continuity within the dynamic morphosedimentary model, the historic sand percentage within the island was approximated to be 48%. If the restoration project was to be constructed using similar fill, then a retreat rate of 26 feet/year could also be expected.

As the percentage of sand within the fill is increased above 48% the shoreline retreat rate will decrease and conversely as the percentage of sand decreases, the shoreline retreat rate will increase. Increasing the sand percentage by 25% will result in a shoreline retreat rate of 20 feet/year. Decreasing the sand percentage by 25% will result in a shoreline retreat rate of 36 feet/year. If a mixed sediment system is constructed, the WVA acreages will need to be reassessed.

Some simplifying assumptions were made in the application of this model. First, it was assumed that the shoreline retreat rate required to compensate for relative sea level rise would remain similar to the sandy configuration. This may be an over simplification as the silty material will consolidate more overtime than sandy sediment. A greater volume of silt will therefore be required to obtain the same rise in island elevation compared to sand, requiring greater shoreline recession to provide this sediment. However, this

was considered to be a small compared to the overall shoreline retreat rate and was ignored. Second, it was also assumed that the shoreline retreat rate due to longshore losses was the same for the mixed sediment and sand fill configurations. It was assumed that the mixed sediment would recreate the sand face allowing the longshore components to be similar.

The influx of sand into the system will likely create a higher dune system, especially given that sand fencing is incorporated into the design. The sand fence will trap aeolian transported sand increasing the elevation of the dune. This could reduce overtopping during storm events once the waves are not breaking directly against the dune and the storm surge is above +6 feet, NAVD. SBEACH modeling was performed with and without sand fencing and shows the benefits of having the additional dune feature in place (Appendix C-4).

Consideration must also be given to the constructability of the beach if there is a high silt content within the fill. Section 4.1.1 discusses the impact of silt content on the construction slope when the silt content approaches 20%. However, at 50% silt in the beach fill, closed cells would be needed for construction increasing the project cost. Settlement of the project would also be significant and hamper long term project performance. Therefore, a sandy beach fill is recommended for this project.

The mean grain size of the beach fill will affect performance with coarser grain sizes being more resistant to erosion. The analysis throughout this report has assumed that the grain size will match the grain size of a typical Louisiana barrier island (~0.11 mm to 0.15 mm). Borrow Area P1 has a mean grain size of approximately 0.17 mm, the mean grain size in borrow area P2 ranges from 0.19 mm to 0.28 mm, in Sandy Point the mean grain size is 0.11 mm, and Ship Shoal ranges from 0.07 mm to 0.25 mm. Based on grain size, borrow area P2 is the preferred sand source to maximize project performance.

The most immediate impact of using a borrow area with a coarser grain size than 0.13 mm is that the construction slope can be made steeper than 1V:45H. Projects with grain sizes greater than 0.20 mm and silt contents less than 5% have been constructed using construction berm slopes of 1V:15H to 1V:10H. The steeper slope will allow for a wider dune crest and thus increase the dune acreage. The increase in the dune width between a 1V:45H berm slope and a 1V:15H slope is approximately 180 feet, assuming the same volume and the depth of toe being -6 feet, NAVD. The total habitat acreage would remain the same but the dune acreage would increase with a matched reduction in the supratidal and intertidal acreage.

The second impact on performance would be to equilibration. It was anticipated that the decrease in island width above 0 feet, NAVD would be approximately 20 feet due to equilibration, assuming a 1V:45H construction slope. There would be no loss due to equilibration with sand dredged from borrow

area P2 if a 1V:45H slope was constructed. Therefore, acreage estimates would increase. Assuming a finer grain size provides a conservative estimate of the acreage.

The third potential effect of a coarser grain size than was applied in the analysis, is that the sediment transport rate is lower than estimated and thus the longshore losses are decreased. A coarser grain size will thus result in the acreage amount being greater than estimated. Applying Kamphuis' equation (1991) for sediment transport that directly includes grain size suggests that the longshore transport rate would be approximately 18% lower for 0.25 mm grain size compared to a beach with a grains size of 0.13 mm, all other variables being the same. This suggests again that if borrow area P2 was used for construction that the acreage assessments provided in this report will be conservative.

## 5.12 SECONDARY BENEFITS

Secondary benefits of the project are the benefits to marsh areas that are not included within the WVA boundary, such as the marsh along the western and northern rim of Bastian Bay. Based on comparison of the 1998 and 2004 shorelines, digitized from rectified aerial images, approximately 1.9 acres of marsh are lost each year from around the rim of Bastian Bay (Figure 52). Construction of the project will provide additional protection from wave action to these marshes and should reduce the recession rates of the marsh. Annex C-8 provides details of the secondary benefit modeling.

The survival of a salt marsh is regulated by a variety of factors, including wave climate. Roland and Douglass (2005) suggested that there was a threshold criterion for marsh erosion based on wave height. When the median ($50^{th}$ percentile) wave height exceeded 0.33 feet or the $80^{th}$ percentile wave exceeded 0.66 feet then the marsh receded. When the wave climate was below this critical threshold, marshes were stable. The MIKE 21 NSW wave transformation model was used to determine the wave heights along the rim of Bastian Bay under the various alternatives and the future without project conditions.

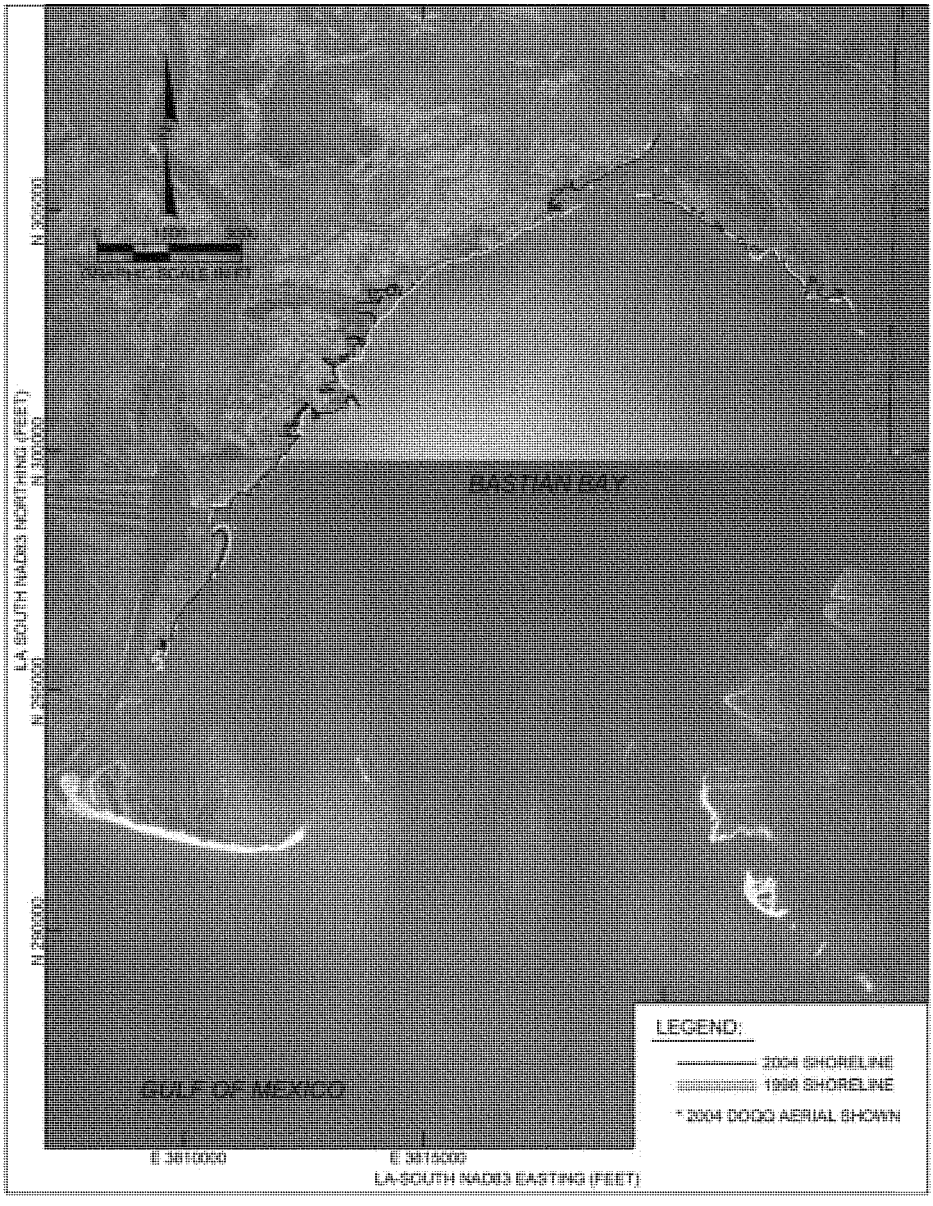



Figure 52. 1998 and 2004 Digitized Shorelines of Bastian Bay

Figure 53 shows the wave conditions within Bastian Bay during existing conditions and a median significant wave height. The color bar has been set so that there is a distinct change in color at the threshold wave height of 0.33 feet. This figure shows that the most of the rim of Bastian Bay experiences mean wave heights that are above the threshold wave height and therefore, marsh recession should be expected. Approximately 16,500 feet of marsh shoreline experience median wave heights greater than the 0.33-foot threshold wave height.

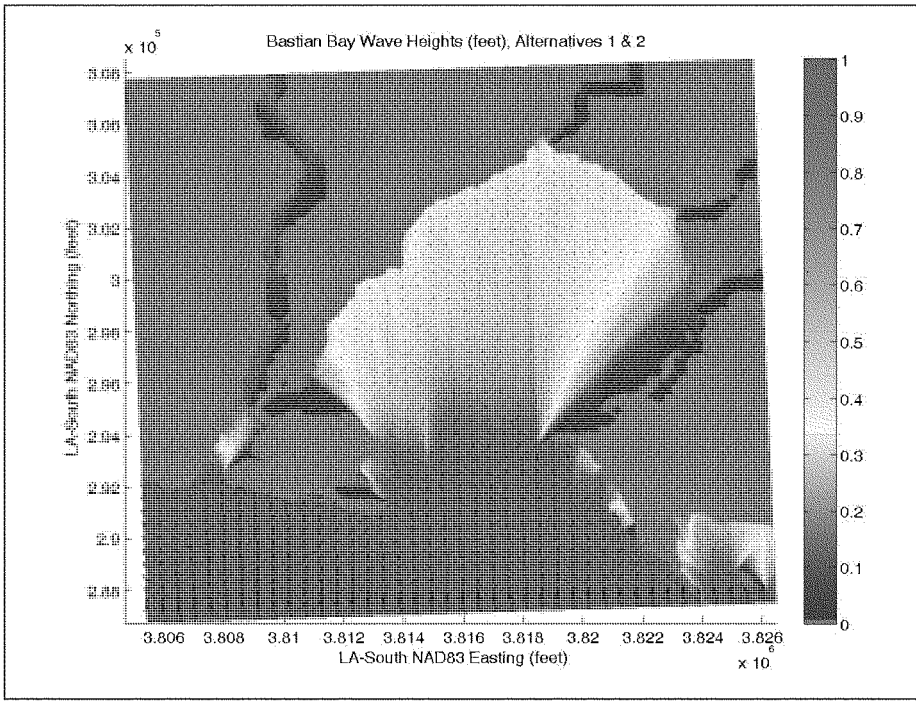



Figure 53. MIKE 21 Output for Existing Conditions under the median Wave Conditions

The construction of either of the alternatives will result in reduced marsh recession rates around the rim of Bastian Bay compared to the future without project condition. This is considered a secondary benefit of constructing the project. The existing marsh is losing approximately 1.9 acres/year. Under the future without project conditions, it is expected that Coupe Bob will continue to expand and that more of the marsh surrounding Bastian Bay will be exposed to wave action from the Gulf of Mexico. The average marsh recession in the future is expected to increase to 3.0 acres/year under future without project conditions. This is based on 26,000 feet of marsh shoreline being exposed to median waves greater than the threshold.

Alternatives 1 and 2 are similar to the existing condition so it is expected that Alternatives 1 and 2 will maintain the existing marsh loss rate of 1.9 acres/year. However, benefits from Alternative 2 will likely be higher than Alternative 1 because a larger ebb shoal will form with Alternative 2, which will limit wave propagation through Coupe Bob.

Alternatives 3 to 8 will almost eliminate the propagation of waves from the Gulf entering Bastian Bay and the marsh recession rate is expected to be reduced to 0.1 acres/year.

## 5.13 ADAPTIVE MANAGEMENT

Adaptive management techniques are typically employed for projects that are to be renourished/maintained. While Alternative 1 does not incorporate a renourishment project at this time, possibilities to invest additional funds to maximize project benefits could arise in the future. Monitoring Alternative 1 would also be useful for the design of other projects.

Adaptive management involves monitoring the evolution of the project and updating the project design to incorporate the additional data. It is recommended that annual surveys be conducted of the project area. This includes surveys of the beach and marsh, as well as hydrographic surveys of the offshore, back bay and tidal inlet areas. This will allow for the development of an accurate sediment budget by which sediment transport in the area can be tracked. This will be especially important for Alternative 2 where the rate of growth of the Coupe Bob ebb shoal could impact the renourishment interval. The surveys will provide a basis for distributing advanced fill along the project length.

Monitoring is also recommended for the single island alternatives. Since Alternative 3 only has the single nourishment, monitoring will only be used for scientific purposes though if sufficient benefit is observed from the project this could be changed and the monitoring data would be useful. Alternative 4 may require more careful monitoring than the other alternatives as it has the least amount of advanced fill with the longest renourishment interval. It therefore has the highest likelihood of breaching. It will be less expensive to renourish a single island than to close the breach.

Monitoring of the project will also indicate the performance of the island elevation. This will indicate whether future renourishment projects should be constructed at higher or lower elevations. The limited geotechnical data available makes adaptive management more important for this project, especially with regard to the marsh elevation.

# 6.0 CONSTRUCTION

## 6.1 CONSTRUCTION METHODS

Project construction will require the hydraulic placement of both beach and marsh fill within the project area. The previous section discussed possible marsh and beach fill sediment sources. This section discusses transport of the material to the project site and project specific construction items.

Construction of the beach and marsh fill will require the use of heavy machinery to manage the pipeline and construct containment dikes. Shell Island West provides a sufficient base for equipment deployment with placed fill used to supplement existing material for containment. However, the contractor will have to construct a beachhead on Shell Island East as the island remnants immediately adjacent to the Empire Waterway are not large enough to support equipment. To start a 2002 beach restoration project at Holly Beach, for example, the contractor placed the end of the dredge pipe on a pontoon and pumped a beachhead without an initial need for heavy equipment (Figure 54). A landing craft, or a barge and crane, could be used to deploy equipment, or the contractor may elect to construct a dock.

Figure 54. Beachhead construction at Holly Beach

The contractor will be required to construct dikes to control the placement of marsh fill. The bayward side of the beach fill will act as a dike to control fill on the south (Gulfward) side of the marsh. Dike construction on the bayward side of the marsh will require the use of a barge mounted bucket or similar equipment. The material used to construct the dikes will be taken from within the footprint of the marsh fill. The excavated ditch would also act as a temporary access canal for the barge. For Alternatives 3 to 8, the contractor may elect to construct a geotextile tube in the 9,000-foot long section of Coupe Bob, instead of transporting silt/clay for dike construction. The geotextile tube could be filled using material from the sand base but within the marsh footprint. The contractor could also choose to construct the dike using sand fill but this option may be more expensive. The method of marsh fill containment should be left to the discretion of the contractor. Excavation for dike construction will not be permitted within 50 feet of any pipelines. The location of secondary dikes or water control structures will be at the discretion of the contractor.

Alternatives 3 to 8 require the closure of Coupe Bob. Attempting to close Coupe Bob by the placement of sand in the inlet will increase tidal velocities in the constricted channel. These higher velocities will increase erosion losses at the fill ends bordering the channel. Dredging Grand Bayou and the tidal diversion channel prior to attempting to close Coupe Bob would create a more hydraulically efficient path for the tidal prism, which would assist in the closure of Coupe Bob. The contractor will likely wait for the first or last quarter moon when the tide range is lowest to attempt final closure of the inlet. Possible methods for closure of Coupe Bob include, but are not limited to:

1. Stockpiling material at the sides of the inlet and then bulldozing it into the gap.

2. Bringing a second dredge to the site to increase production rates. This dredge could excavate sand pockets shown by the McLelland cores or dredge sand fill that has been stockpiled or placed along the rest of the island.

3. Sink barges in the gap that can be refloated and removed at a later date, once the beach fill is in place behind or in front of the barge.

4. Drive temporary sheet piling over a short section of the gap. A review of the pipeline databases suggests that there are no pipelines in the vicinity of Coupe Bob that could be endangered by pile driving.

## 6.2 MISSISSIPPI SAND SOURCE DELIVERY

Construction of any of the proposed alternatives will involve the dredging of significant quantities (at least 4M cubic yards) of beach fill. Several potential sand sources have been discussed. This section discusses the options and feasibility of transporting sand from the Mississippi River borrow sources to the project site.

Several options are available to dredge and transport sand from the Mississippi River to Shell Island. The difficulty posed by dredging Mississippi River sand is that the pumping distance approaches 14 miles to dredge borrow area P1 and the pipe may have to cross various obstacles including private property, existing oil pipelines, roadways, the Mississippi River dike, shallow water, marshes, and navigation channels. Several options are discussed in "The Technical Assessment of Riverine Sand Mining to Support Scofield Island Restoration" (CPE, 2004). Some of these options are summarized here.

### 6.2.1 Cutterhead Dredge (River Source)

The use of the potential sand source P1 near Mile Marker 34 may stretch the capabilities of current dredge equipment. The distance from sand source P2 to the east end of Shell Island is 9 miles, which makes dredging this borrow source closer than dredging P1 but requires transporting the fill across the river. Pumping from the two primary sand sources will require between 2 and 5 booster pumps with an average of 5,000 hp each when using a 10,000-11,000 hp cutterhead dredge. The length of the pipeline and the addition of booster pumps make the project more complex, with each booster decreasing daily productivity by approximately 10% (1.5 hours). Three cutterhead dredge alternatives are considered, one for each sand source.

Route PL-1 and PL-4 from Sand Source P2: The shortest distance to the project area by way of the Empire Waterway uses sand source P2, which is across the river from the waterway river entrance (Figure 55). The maximum pipeline distance is approximately 16 miles as summarized in Table 27. The pipeline route runs under the river between the sand source the waterway entrance (PL-4), and then down pipeline route PL-1 described earlier.

Table 27. Summary of Pipeline Distances for Two Mississippi River Sand Borrow Sources

| Dredge Type | Hydraulic Cutterhead | | Hopper Combination |
|---|---|---|---|
| Borrow Area | P1 | P2 | P2 |
| Pipeline Routes | PL1 & PL3 | PL1 & PL4 | PL1 |
| Floating Line (miles) | 1 | 1 | 0.5 |
| Fixed Line (miles) | 13.5 | 9.75 | 9.25 |
| Maximum Shore Pipe (miles) | 5 | 5 | 5 |
| Maximum Pipe Length (miles) | 19.5 | 15.75 | 14.75 |

There is some difficulty/risk in maintaining a dredge pipe across the river. The currents within the river will attempt to push the dredge pipe downstream, so the pipeline will have to be anchored securely. Also, if there is an equipment failure and the dredge pump stops, the sand will sink to the bottom and plug the dredge pipe. Clearing this plug will likely require refloating the dredge pipe. The weight of the sand within the pipe will make this difficult and mechanical assistance may be required. Ship traffic within the Mississippi River will complicate the removal of the dredge pipe.

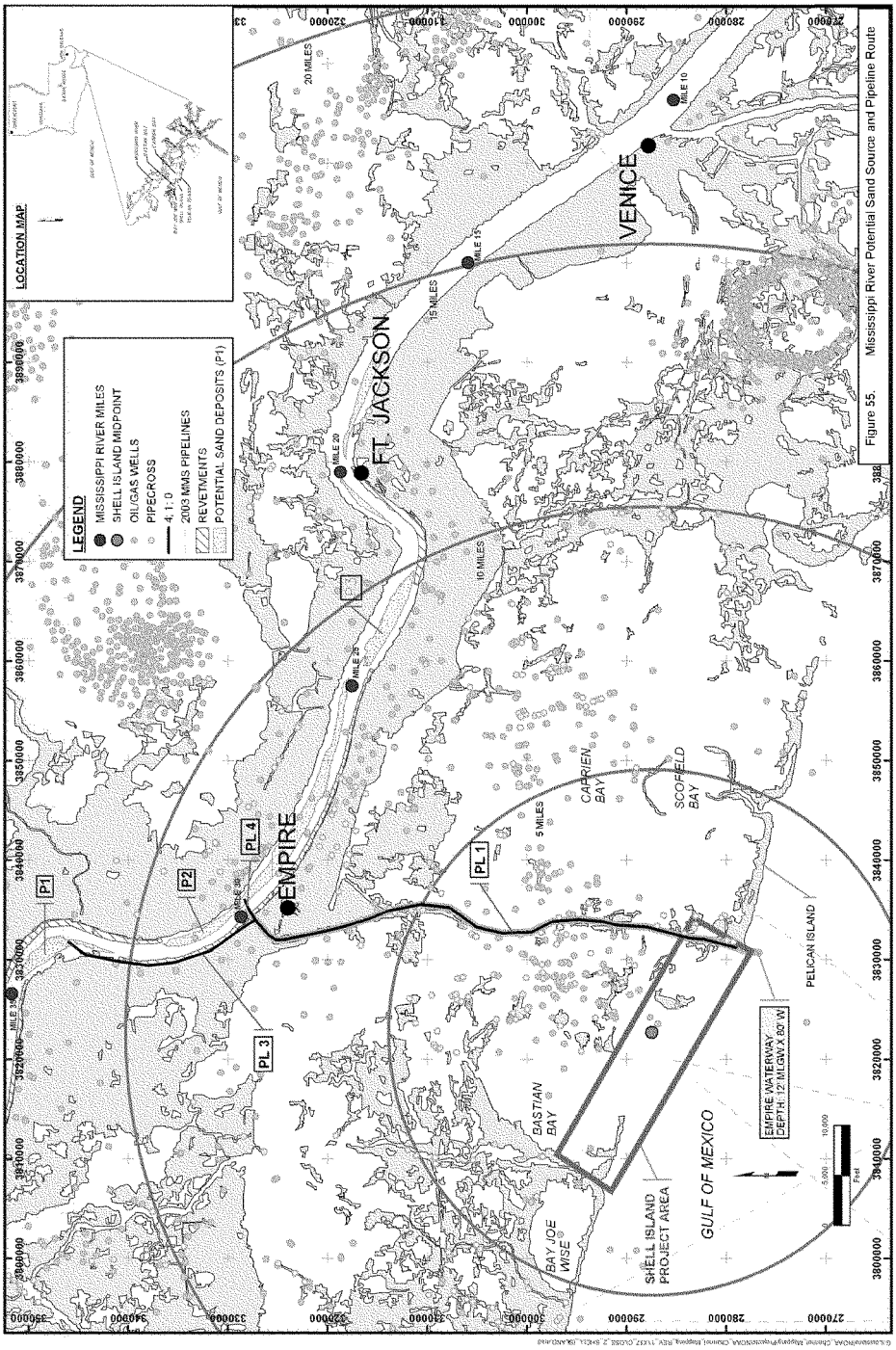



Figure 55. Mississippi River Potential Sand Source and Pipeline Route

Route PL-1 and PL-3 from Sand Source P1: The risk in pumping across the river can be alleviated by going alongshore from the Empire Waterway entrance to the P1 sand source located near Mile Marker 34. This option will increase the pumping distance by approximately 4 miles. The maximum pumping distance using the P3 and P1 route is 19.5 miles (Table 27) and it may exceed the practical limit for a cutterhead/booster pipeline combination. The practical distance limit is primarily the cost at which another method becomes more attractive. That alternative method is a combination of dredge and small scows which will be discussed later.

### 6.2.2 Hopper Dredge with Pipeline Combination (River Source)

A hopper dredge alternative using sand source P2 may be the more feasible method using the Empire Waterway. This method is advantageous because it can bring the mined sand to the entrance of the Empire Waterway, thereby keeping the pumping distance limited to that between Empire and the project area. The hopper dredge is also advantageous because it could move to where the potential sand sources are in the river, mining the sands, and then returning it to the pumpout location without worrying about obstacles inherent to a completely cutterhead/pipeline operation. The potential sand source located across the river from Empire is readily accessible to a hopper dredge which can easily avoid navigation and other obstacles. The sailing distance between the dredged area P2 and the pumpout location is very short. The drawback to a hopper dredge is that it would require at least one additional booster over a cutterhead for similar distance, since the onboard pumps are generally weaker for a hopper dredge. In addition, hopper dredging is slightly more expensive compared to a comparable cutterhead project.

The hopper pumpout can take a number of forms. The first method would directly hook up the hopper to the pipeline. Generally, a booster would be placed near this location, and a hydraulic dredge can be modified to act as a booster. This method is inefficient since the system must be started up and cleaned out for each hopper load, which may double the pumpout time. Although technically feasible, the use of a hopper with a long pipeline in this way is not a common practice. An alternative hopper method, which uses the strengths of both dredge types, would use a hopper dredge to transport the material from the borrow area and then bottom dump it in a stockpile. The cutterhead would then dredge the stockpiled material and pump it down the pipeline. This method allows each dredge to work to its strengths while avoiding their incompatibilities. This method has been used successfully on a beach project in Florida. The hopper will have a higher production rate compared to the cutterhead using pipeline route PL-1 and sand source P2, allowing it to keep the stockpile full. A second dredge replaces the need for an additional two booster pumps. A riverine temporary stockpile location would need to be specially designed, with consideration for the shoreline revetment system at Empire.

### 6.2.3 Pipeline with Scow Combination (River Source)

As the distance and number of booster pumps increases, the use of a pipeline only transport system becomes less desirable. Under these circumstances, the movement of the sand by scows becomes more advantageous. The Empire Waterway can only accommodate small scows. Small scows will need navigation depths of between 8 to 12 feet for transport. Deeper depths are required where the unloader is employed to transfer the material from the scows to the beach. The method of loading the scows would require a cutterhead dredge mining the sand and then pumping it through a pipeline to a system, such as a spider barge, that would load the barges. The barges would then be towed down the waterway to the project site where they would be offloaded.

The movement of small scows through the waterway may require dredging of the waterway. The preparation of an offloading site near the Shell Island complex may also be required. The unloader used to move the sand from the scows to the beach needs approximately 12 feet of water and would need to be relatively close to the end of the beach. The use of scows would be advantageous when the pumping distance and complexity of pipeline/booster use gets expensive, which may occur in the range of pipeline lengths proposed. Scows with the capability to bottom dump could also be used to fill sections of Coupe Bob.

## 6.3 GULF OF MEXICO FILL SOURCE

Offshore borrow sources were discussed previously in this report. The Empire borrow area is not conducive for use as a pure beach fill source as the sand is located in fingers that cannot be economically dredged. However, this borrow area provides an excellent opportunity to create a mixed sediment marsh. The marsh construction on Pelican Island will use the Empire borrow area as a fill source but remaining material could be used as marsh fill for Shell Island. The Empire borrow area could also be expanded as a potential marsh fill source. The Empire borrow area would be a preferable marsh fill source as it is close to Shell Island and could be dredged using a cutterhead and pipeline.

Ship Shoal and Sandy Point would be dredged using hopper dredges due to the distance from the project area. Ship Shoal has sufficient sand to construct the project but is over 60 miles away, which would result in a high unit cost. Sandy Point does not currently have sufficient sediment to construct Alternative 1. Additional studies are currently being performed to increase the depth of the Sandy Point borrow area, though much of this sand may be used to construct the Pelican Island (BA-38-1) Restoration Project.

## 6.4 CONSTRUCTION SEQUENCE

The construction sequence will be at the discretion of the contractor. However, this section presents a construction scenario to evaluate the feasibility of the project.

The construction sequence assumes that the contractor constructs all, or at least a portion, of the beach section prior to constructing the marsh, as the beach acts as the southern containment dike for the marsh fill.

Assuming that the contractor uses sand mined from the Mississippi River, the pipeline or scows could be brought to the east end of Shell Island for any of the alternatives. The offloader for the scows could be located in the deep section of the Empire Waterway. For the two-island option, the contractor would likely build Shell Island East first and then submerge the pipeline to cross Coupe Bob, in order to build Shell Island West. The possibility of placing the pipeline across Shell Island Bay should be investigated as this would shorten the pipeline distance to Shell Island West.

If an offshore borrow source was used (Sandy Point or Ship Shoal), the submerged line could be brought ashore at any location. However, the submerged line will have to cross oil pipelines and a magnetometer survey and/or jet probes should confirm whether these lines are buried and determine their depth.

Marsh fill containment dikes within Shell Bay would be constructed concurrently with the beach fill. Once the eastern marsh fill containment system is complete (beach fill and back bay containment dikes), overburden from the Empire borrow area can be dredged and pumped into the marsh containment area.

## 6.5 CONSTRUCTION TIMELINE

This construction timeline is based on the assumption that borrow area P1 is used as the beach fill source and that the Empire borrow area is used as the marsh fill source. Previous CPE construction timelines for Louisiana barrier island restoration projects have been based on production rates of 20,000 cubic yards/day for beach fill and 30,000 cubic yards/day for marsh fill.

At Holly Beach, beach fill production rates in excess of 30,000 cubic yards/day were recorded for the dustpan dredge *Beach Builder*, but the average production rate, including all downtime, was 11,970 cubic yards/day. This project experienced greater downtime than would typically be expected for a beach construction project because the dredge had to be removed from the project site twice due to the passage of Hurricanes Lili and Isidore, the submerged pipeline had to be fixed on numerous occasions, and the

dustpan had to be cleared of clay frequently (at least twice daily). The maximum pumping distance at Holly Beach was approximately 8 miles and one booster was utilized in the pipeline.

Similar production rates may be expected for the Shell Island project compared to the Holly Beach project. The increased pumping distance to Shell Island will be offset by the unusual delays experienced at Holly Beach. Furthermore, the borrow source and submerged line are within the Mississippi River and a sheltered bay, so the project should not be impacted from as many weather delays as compared to dredging in the Gulf of Mexico.

The USACE cost estimation spreadsheet (Annex C-7) suggests that production rates to dredge sand from the Mississippi River borrow source P1 will be approximately 8,880 cubic yards/day. Averaging the observed pumping rate at Holly Beach and the pumping rate suggested by the USACE cost estimation spreadsheet gives an estimated production rate of 10,400 cubic yards/day for beach fill. Given this pumping rate and assuming a loss of 30%, Alternatives 1, 2, 3 through 6, 7, and 8 will require 516, 560, 715, 805, and 861 days respectively to construct the beach section of the project.

Construction of the sand fencing can be required concurrently with construction of the beach. The Chaland Headland construction specifications require that sand fencing be constructed within one week of acceptance of the beach section. At Holly Beach the sand fencing was constructed following removal of the shore pipe. One four-person crew installed approximately 450 feet of sand fencing per day.

The marsh fill production rate is expected to be similar to that for the Chaland Headland Barrier Island Restoration Project (BA-38-2). Production rates in the order of 48,000 cubic yards/day were observed at Chaland Headland (CPE, 2007, in print). The marsh component will require 51, 44, and 58 days of pumping to construct the marsh for Alternative 1, 2 and 3 through 8 respectively. Marsh construction can occur concurrently with beach fill construction but it was assumed that half of the marsh will be constructed following completion of the beach fill.

A mobilization time of 2 months is expected to allow the contractor to gather and layout sufficient pipe to transport material from the Mississippi River to Shell Island. Demobilization will likely require 1 month. Therefore, Alternative 1 will require a total of 632 days to construct, Alternative 2 will require 672 days, Alternatives 3 through 6 will require 834 days, Alternative 7 will require 924 days, and Alternative 8 will require 980 days.

## 7.0 COST ESTIMATE

There are several possible borrow areas that could be dredged during construction of the project. The previous section provided methodologies to construct the project. This section provides cost estimates of dredging these borrow areas and constructing the project as described. Tables 28 to 32 provide the cost estimate, using 2007 dollars, for the initial construction of Alternatives 1, 2, 3 through 6, 7, and 8, respectively. The cost of the renourishment projects, proposed as an integral part of Alternatives 2, and 4 through 8, are presented later in this section and Annex C-6.

Table 28. Construction Cost Estimate for Alternative 1

| Description | Quantity | Unit | Unit cost | Subtotal | 20% Contingency | Total |
|---|---|---|---|---|---|---|
| Mob/demob | 1 | L.S. | $7,600,000 | $7,600,000 | $1,520,000 | $9,120,000 |
| Beach fill | 4,130,000 | c.y. | $20.16 | $83,260,800 | $16,652,160 | $99,912,960 |
| Marsh Fill | 1,876,500 | c.y. | $5.92 | $11,108,880 | $2,221,776 | $13,330,656 |
| Primary Marsh Dikes | 22,738 | L.F. | $50.00 | $1,136,920 | $227,384 | $1,364,304 |
| Single Row of Sand Fencing | 20,000 | L.F. | $16.00 | $320,000 | $64,000 | $384,000 |
| Settlement Plates | 10 | Unit | $3,500.00 | $35,000 | $7,000 | $42,000 |
| Pre-construction Survey | 1 | L.S. | $200,000 | $200,000 | $40,000 | $240,000 |
| Post-Construction Survey | 1 | L.S. | $240,000 | $240,000 | $48,000 | $288,000 |
| Vegetative Plantings | 1 | L.S. | $2,008,000 | $2,008,000 | $401,600 | $2,409,600 |
| Total | | | | $105,909,600 | $21,181,920 | **$127,091,500** |



Table 29. Construction Cost Estimate for Alternative 2

| Description | Quantity | Unit | Unit cost | Subtotal | 20% Contingency | Total |
|---|---|---|---|---|---|---|
| Mob/demob | 1 | L.S. | $7,600,000 | $7,600,000 | $1,520,000 | $9,120,000 |
| Beach fill | 4,310,800 | c.y. | $20.16 | $86,905,728 | $17,381,146 | $104,286,874 |
| Marsh Fill | 1,615,700 | c.y. | $5.92 | $9,564,944 | $1,912,989 | $11,477,933 |
| Primary Marsh Dikes | 22,738 | L.F. | $45.00 | $1,023,228 | $204,646 | $1,227,874 |
| Single Row of Sand Fencing | 20,000 | L.F. | $16.00 | $320,000 | $64,000 | $384,000 |
| Settlement Plates | 10 | Unit | $3,500.00 | $35,000 | $7,000 | $42,000 |
| Pre-construction Survey | 1 | L.S. | $200,000 | $200,000 | $40,000 | $240,000 |
| Post-Construction Survey | 1 | L.S. | $240,000 | $240,000 | $48,000 | $288,000 |
| Vegetative Plantings | 1 | L.S. | $2,056,000 | $2,056,000 | $411,200 | $2,467,200 |
| Total | | | | $107,944,900 | $21,588,980 | **$129,533,880** |

Table 30. Construction Cost Estimate for Alternatives 3, 4, 5, & 6

| Description | Quantity | Unit | Unit cost | Subtotal | 20% Contingency | Total |
|---|---|---|---|---|---|---|
| Mob/demob | 1 | L.S. | $7,600,000 | $7,600,000 | $1,520,000 | $9,120,000 |
| Beach fill | 5,611,700 | c.y. | $20.16 | $113,131,872 | $22,626,374 | $135,758,246 |
| Marsh Fill | 2,138,500 | c.y. | $5.92 | $12,659,920 | $2,531,984 | $15,191,904 |
| Primary Marsh Dikes | 16,000 | L.F. | $50.00 | $800,000 | $160,000 | $960,000 |
| Geotextile Tube Containment | 1 | L.S. | $500,000 | $500,000 | $100,000 | $600,000 |
| Single Row of Sand Fencing | 23,800 | L.F. | $16.00 | $380,800 | $76,160 | $456,960 |
| Breach Closure | 1 | L.S. | $500,000 | $500,000 | $100,000 | $600,000 |
| Settlement Plates | 10 | Unit | $3,500.00 | $35,000 | $7,000 | $42,000 |
| Pre-construction Survey | 1 | L.S. | $238,000 | $238,000 | $47,600 | $285,600 |
| Post-Construction Survey | 1 | L.S. | $286,000 | $286,000 | $57,200 | $343,200 |
| Vegetative Plantings | 1 | L.S. | $2,218,000 | $2,218,000 | $443,600 | $2,661,600 |
| Total | | | | $138,349,592 | $27,669,918 | **$166,019,500** |

Table 31. Construction Cost Estimate for Alternative 7

| Description | Quantity | Unit | Unit cost | Subtotal | 20% Contingency | Total |
|---|---|---|---|---|---|---|
| Mob/demob | 1 | L.S. | $7,600,000 | $7,600,000 | $1,520,000 | $9,120,000 |
| Beach fill | 6,435,700 | c.y. | $20.16 | $129,743,712 | $25,948,742 | $155,692,454 |
| Marsh Fill | 2,138,500 | c.y. | $5.92 | $12,659,920 | $2,531,984 | $15,191,904 |
| Primary Marsh Dikes | 16,000 | L.F. | $50.00 | $800,000 | $160,000 | $960,000 |
| Geotextile Tube Containment | 1 | L.S. | $500,000 | $500,000 | $100,000 | $600,000 |
| Single Row of Sand Fencing | 23,800 | L.F. | $16.00 | $380,800 | $76,160 | $456,960 |
| Breach Closure | 1 | L.S. | $500,000 | $500,000 | $100,000 | $600,000 |
| Settlement Plates | 10 | Unit | $3,500.00 | $35,000 | $7,000 | $42,000 |
| Pre-construction Survey | 1 | L.S. | $238,000 | $238,000 | $47,600 | $285,600 |
| Post-Construction Survey | 1 | L.S. | $286,000 | $286,000 | $57,200 | $343,200 |
| Vegetative Plantings | 1 | L.S. | $2,218,000 | $2,218,000 | $443,600 | $2,661,600 |
| Total | | | | $154,961,432 | $30,992,286 | **$185,953,700** |

Table 32. Construction Cost Estimate for Alternative 8

| Description | Quantity | Unit | Unit cost | Subtotal | 20% Contingency | Total |
|---|---|---|---|---|---|---|
| Mob/demob | 1 | L.S. | $7,600,000 | $7,600,000 | $1,520,000 | $9,120,000 |
| Beach fill | 6,888,700 | c.y. | $20.16 | $138,876,192 | $27,775,238 | $166,651,430 |
| Marsh Fill | 2,138,500 | c.y. | $5.92 | $12,659,920 | $2,531,984 | $15,191,904 |
| Primary Marsh Dikes | 16,000 | L.F. | $50.00 | $800,000 | $160,000 | $960,000 |
| Geotextile Tube Containment | 1 | L.S. | $500,000 | $500,000 | $100,000 | $600,000 |
| Single Row of Sand Fencing | 23,800 | L.F. | $16.00 | $380,800 | $76,160 | $456,960 |
| Breach Closure | 1 | L.S. | $500,000 | $500,000 | $100,000 | $600,000 |
| Settlement Plates | 10 | Unit | $3,500.00 | $35,000 | $7,000 | $42,000 |
| Pre-construction Survey | 1 | L.S. | $238,000 | $238,000 | $47,600 | $285,600 |
| Post-Construction Survey | 1 | L.S. | $286,000 | $286,000 | $57,200 | $343,200 |
| Vegetative Plantings | 1 | L.S. | $2,218,000 | $2,218,000 | $443,600 | $2,661,600 |
| Total | | | | $164,093,912 | $32,818,782 | **$196,912,700** |

## 7.1 MOBILIZATION COST

Mobilization and demobilization expenses include the cost to prepare and transport all equipment to and from the job site. For a hydraulic dredge this includes towing the dredge and transporting other support vessels, transporting and installing several miles of pipeline, and bringing personnel and land based equipment to the job site. The USACE cost estimation spreadsheets (Annex C-7) suggests that four to six booster pumps may be required to transport sand from the Mississippi River depending on which borrow area is used and assuming a 30 inch cutterhead is used for construction. The contractor may elect to construct a dock or provide other means of loading/unloading equipment and crew to the site. Mobilization costs can be minimized by bidding in advance of when the work is to be completed, and being flexible with the contractor as to when they must begin the work. A mobilization cost of $7.6M was estimated for initial construction and for renourishment projects where both the beach and marsh were renourished (Table 33). The mobilization cost was reduced to $6.0M when only the beach was being renourished.

Table 33. Cost Estimate to Dredge Borrow Area P1

| | Unit | Unit Price | Quantity | Total Price |
|---|---|---|---|---|
| Dredge | L.S. | $4,000,000 | 1 | $4,000,000 |
| Booster | L.S. | $275,000 | 6 | $1,650,000 |
| Pipeline | mile | $80,000 | 20 | $1,600,000 |
| Quarters Barge | L.S. | $350,000 | 1 | $350,000 |
| | | | | **$7,600,000** |

## 7.2 DREDGING UNIT COST

Unit costs for dredging sand from the Mississippi River borrow areas P1 and P2, Sandy Point, and Ship Shoal were developed using the USACE cost estimation spreadsheets. The unit cost for dredging marsh material from the Empire borrow area was also estimated using these spreadsheets. The unit costs for dredging these borrow areas are presented in Table 34 while the summary page of the USACE cost spreadsheets are included in Annex C-7.

Table 34. Summary of Unit Dredge Costs

| Borrow Area | Estimated Unit Dredge Cost ($/cy) |
|---|---|
| Empire | $5.92 |
| Mississippi River - P1 | $20.16 |
| Mississippi River - P2 | $19.14 |
| Mississippi River - P2 (hopper combo) | $21.58 (5.98 + 15.6) |
| Sandy Point | $18.71 |
| Ship Shoal | $68.50 |

It was assumed that a 30" cutterhead dredge would be used to construct the beach and marsh from the Mississippi River sand sources and Empire borrow area due to the large construction volumes. Six booster pumps may be required to transport the dredged material from borrow area P1 and four booster pumps if dredging P2. A medium sized hopper dredge (RN Weeks or Liberty Island Class hopper dredge) with an effective capacity of 2,000 cubic yards was used to estimate the cost to dredge Sandy Point and Ship Shoal. The pumpout for the hopper dredges was assumed to be at the -24 feet (NAVD) contour (-24.5 MLW), which is approximately 15,000 feet offshore. Two booster pumps would be required to transport the material ashore and then along the beach in this scenario.

Non-pay loss was assumed to be the percentage of silt in the borrow area plus 20%. Losses were increased to 100% for the hopper dredging portion of dredging borrow area P2 because currents within the river may cause sediment loss when bottom dumping.

Pipeline distances for the Mississippi River sand source were based on placing the dredge pipe within the Empire Waterway. The pipe would come ashore at the east end of East Shell Island. Shore pipe distance was assumed to follow the dune crests of Alternatives 3 to 8. Cutterhead dredges were assumed to require 1 mile of floating pipe.

The number of boosters required was based on optimizing the unit cost within the spreadsheet.

"Other production factors" were generally set at 0.9, except for the dredging of borrow area P2 by cutterhead. The production factor was reduced to 0.7 to incorporate the difficulty of maintaining a submerged dredge pipe across the Mississippi River. The production factor was set to 0.8 for the cutterhead dredge portion of the combined hopper/curtterhead dredging of P2 because of possible dredge restrictions imposed by the river revetment.

Monthly costs were set at $200,000 to maintain equipment and account for the difficulty of accessing the site.

The spreadsheet estimates were quasi-calibrated to recent construction bid amounts. However, the unit costs shown here represent an opinion and are subject to market forces, such as the availability of equipment, the increasing cost of fuel, *etc.*

Two contractors provided price estimates for dredging the Mississippi River borrow areas using the cutterhead/pipeline combination (CPE, 2004). Dredge contractors estimated that the mobilization cost could range from $2M to $5M and the unit price of sand could range from $5 to $12. The contractors indicated that 3 or 4 boosters would be required. These unit costs have since increased due primarily to the impacts of Hurricane Katrina and the increase in the price of fuel. Unit costs were developed using the USACE dredge cost estimation spreadsheets (Annex C-7) with corrections made for the increase in the price of fuel from 2005 to 2008.

A beach fill unit cost of $20.16/cubic yard was used in the development of the construction cost. This provides a conservative cost and should allow for the dredging of either P1 or P2. While possible sand sources may be located off of Shell Island, the Mississippi River provides a known source of sediment with sufficient quantities to construct any alternative. The analysis suggests that dredging Sandy Point is more expensive than using Mississippi River sand and the volume of available sand within the currently permitted Sandy Point borrow area is insufficient to construct the Pelican Island and Shell Island projects. Sandy Point is also being used as a borrow source to construct the Pelican Island Restoration Project, which will further decrease the volume of available sand.

A marsh fill unit cost of $5.92/cubic yard was used to estimate the construction cost of the marsh, based on the cost estimating spreadsheets. This unit cost is higher than the low bid unit cost for the marsh component of the Chaland Headland Restoration Project, which was $3.05/cubic yard. However, it is lower than the marsh fill cost for the Pass Chaland to Grand Bayou Pass Barrier Shoreline Restoration Project, which was $7.05/cubic yard. The pumping distance was slightly shorter for the Chaland Headland Project but longer for the Pass Chaland to Grand Bayou Pass project.

## 7.3 OTHER COSTS

The unit cost for the marsh containment dikes, sand fencing, settlement plates, and surveys are based on costs for similar projects that have been bid by dredge contractors, and most specifically the Pass Chaland to Grand Bayou Pass project.

Alternatives 3 to 8 have several additional line items compared to Alternatives 1 and 2. It is proposed that a geotextile tube will act as a containment dike for marsh construction. The contractor may elect to use alternative dike methodologies so this line item simply represents a possible cost for dike containment. A line item has also been included in the construction cost estimate for closure of Coupe Bob. This line item addresses the possibility that the contractor may elect to bring additional equipment to the site to assist in the closure of Coupe Bob.

## 7.4 RENOURISHMENT INTERVAL

Alternatives 2, and 4 through 8, include renourishment of the beach and marsh fill components. To determine the optimum renourishment interval, the annualized project cost for various intervals was calculated for Alternatives 2 and 6. The costs include the initial construction cost, as outlined in the previous section, plus the mobilization, fill, engineering and design, and supervision and administration costs for each subsequent renourishment project. The future construction costs and contingencies are based on their current values. The costs of each renourishment construction are then equated to their present value based on the current interest rate of 5.75%. These costs are then summed with the cost of the initial construction, which includes an interest cost during construction based on a predicted time, cost of construction, and the current interest rate. This sum is then annualized over the project life.

The annualized cost was developed for 5, 10, 15, 20, and 25 year renourishment intervals. The fill volumes for each interval were determined based on the expected volume losses (discussed previously) multiplied by the length of the interval. For the 15 year interval, the last renourishment (at TY45) is planned with only enough sand to last the final five years of the project life.

A renourishment interval of 10 years for the beach and 20 years for the marsh was chosen based on the lowest annualized cost. Table 35 and Figure 56 summarize the annualized costs for Alternative 2 and Alternative 6 though detailed cost tables are shown in Annex C-6.

Table 35. Renourishment Interval Optimization for Alternatives 2 and 6

| Renourishment Interval (years) | Annualized Cost | |
|---|---|---|
| | Alternative 2 | Alternative 6 |
| 5 | 14,577,100 | 15,943,000 |
| 10 | 13,112,100 | 14,942,600 |
| 15 | 14,060,100 | 15,064,700 |
| 20 | 14,979,800 | 15,408,900 |
| 25 | 15,885,300 | 15,938,600 |

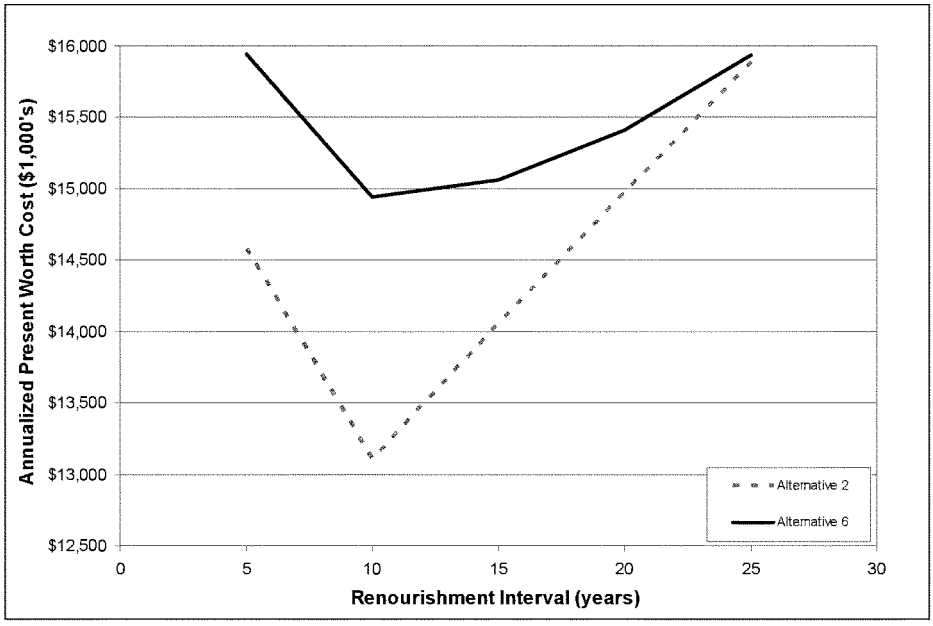



Figure 56. Renourishment Interval Optimization for Alternatives 2 and 6

## 7.5 COST PROJECTION TIMELINE

The planning process requires a projection of the construction costs, including actual construction costs, contingency, engineering and design, supervision and administration, and operation and maintenance. Tables 36 through 43 summarize the future expected costs for each alternative.

Table 36. Cost Project Timeline for Alternative 1

| | | 2009 |
|---|---|---|
| Construction Cost | $ | 105,909,600 |
| Contingency | $ | 21,181,920 |
| E & D (Engineering & Design) | $ | 6,354,576 |
| S & A (Supervision & Administration) | $ | 6,354,576 |
| O & M (Operations and Maintenance) | $ | - |

Table 37. Cost Project Timeline for Alternative 2

| - | 2009 | 2019 | 2029 | 2039 | 2049 |
|---|---|---|---|---|---|
| Construction Cost | $ 107,944,900 | $ 42,795,508 | $ 48,539,508 | $ 33,663,028 | $ 28,202,548 |
| Contingency | $ 21,589,000 | $ 8,559,000 | $ 9,708,000 | $ 6,733,000 | $ 5,641,000 |
| E & D (Engineering & Design) | $ 6,476,695 | $ 2,567,725 | $ 2,912,375 | $ 2,019,801 | $ 1,692,177 |
| S & A (Supervision & Administration) | $ 6,476,695 | $ 2,567,725 | $ 2,912,375 | $ 2,019,801 | $ 1,692,177 |
| O & M (Operations and Maintenance) | $ - | $ - | $ - | $ - | $ - |

Table 38. Cost Project Timeline for Alternative 3

| - | 2009 |
|---|---|
| Construction Cost | $ 138,349,592 |
| Contingency | $ 27,670,000 |
| E & D (Engineering & Design) | $ 8,300,980 |
| S & A (Supervision & Administration) | $ 8,300,980 |
| O & M (Operations and Maintenance) | $ - |

Table 39. Cost Project Timeline for Alternative 4

| - | 2009 | 2034 |
|---|---|---|
| Construction Cost | $ 138,349,592 | $ 57,194,104 |
| Contingency | $ 27,669,918 | $ 11,438,821 |
| E & D (Engineering & Design) | $ 8,300,976 | $ 3,431,646 |
| S & A (Supervision & Administration) | $ 8,300,976 | $ 3,431,646 |
| O & M (Operations and Maintenance) | $ - | $ - |

Table 40. Cost Project Timeline for Alternative 5

| - | 2009 | 2029 | 2049 |
|---|---|---|---|
| Construction Cost | $ 138,349,592 | $ 48,410,344 | $ 46,849,832 |
| Contingency | $ 27,669,918 | $ 9,682,069 | $ 9,369,966 |
| E & D (Engineering & Design) | $ 8,300,976 | $ 2,904,621 | $ 2,810,990 |
| S & A (Supervision & Administration) | $ 8,300,976 | $ 2,904,621 | $ 2,810,990 |
| O & M (Operations and Maintenance) | $ - | $ - | $ - |

Table 41. Cost Project Timeline for Alternative 6

| - | 2009 | 2019 | 2029 | 2039 | 2049 |
|---|---|---|---|---|---|
| Construction Cost | $ 138,349,592 | $ 26,198,760 | $ 33,169,384 | $ 26,198,760 | $ 31,608,872 |
| Contingency | $ 27,670,000 | $ 5,240,000 | $ 6,634,000 | $ 5,240,000 | $ 6,322,000 |
| E & D (Engineering & Design) | $ 8,300,980 | $ 1,571,938 | $ 1,990,169 | $ 1,571,938 | $ 1,896,544 |
| S & A (Supervision & Administration) | $ 8,300,980 | $ 1,571,938 | $ 1,990,169 | $ 1,571,938 | $ 1,896,544 |
| O & M (Operations and Maintenance) | $ - | $ - | $ - | $ - | $ - |

Table 42. Cost Project Timeline for Alternative 7

| - | 2009 | 2029 | 2049 |
|---|---|---|---|
| Construction Cost | $ 154,961,432 | $ 49,781,224 | $ 32,294,312 |
| Contingency | $ 30,992,286 | $ 9,956,245 | $ 6,458,862 |
| E & D (Engineering & Design) | $ 9,297,686 | $ 2,986,873 | $ 1,937,659 |
| S & A (Supervision & Administration) | $ 9,297,686 | $ 2,986,873 | $ 1,937,659 |
| O & M (Operations and Maintenance) | $ - | $ - | $ - |

Table 43. Cost Project Timeline for Alternative 8

| | | 2009 | | 2029 |
|---|---|---|---|---|
| Construction Cost | $ | 164,093,912 | $ | 60,076,984 |
| Contingency | $ | 32,818,782 | $ | 12,015,397 |
| E & D (Engineering & Design) | $ | 9,845,635 | $ | 3,604,619 |
| S & A (Supervision & Administration) | $ | 9,845,635 | $ | 3,604,619 |
| O & M (Operations and Maintenance) | $ | - | $ | - |

## 7.6 PRESENT WORTH COST

The previous section optimized the renourishment interval using an annualized cost. This annualized cost was converted to a present worth cost to allow comparison of the eight alternatives. Table 44 shows the present worth cost of the eight alternatives.

Table 44. Present Worth of Alternatives 1 through 8

| Alternative | Present Worth Cost | Annualized Cost |
|---|---|---|
| 1 | $135,475,100 | $8,237,700 |
| 2 | $214,105,000 | $13,112,100 |
| 3 | $180,900,000 | $10,999,900 |
| 4 | $217,650,200 | $13,329,200 |
| 5 | $226,486,400 | $13,870,300 |
| 6 | $243,996,000 | $14,942,600 |
| 7 | $251,609,700 | $15,408,900 |
| 8 | $260,036,800 | $15,925,000 |

## 7.7 PAYMENT CONSIDERATIONS

Payment for construction of the island can either be based on the volume of material measured in place or the volume of material removed from the borrow area. The industry standard is to structure payment based on the goal of the project. For a dredge navigation project with beneficial disposal, the standard is to base payment on a post-construction survey of the navigation channel. For an island restoration project, such as proposed for Shell Island, payment is typically based on the volume of material placed within the construction template.

Basing payment on the volume placed within the template is the most effective method to ensure that the project is constructed as designed. Directly measuring the post-construction profile is also more accurate than measuring the volume removed from the borrow area. Comparisons of the volume removed from a

borrow area and the volume measured on the beach (including material placed outside of the pay template) often shows that the volume of material removed is larger than the volume of material measured in place. This discrepancy is often attributed to losses during handling, loss of fines, and placement of material outside of the surveyed limits. Handling losses can occur due to leaks in the submerged line, double handling of dredge material at a secondary location, overflow of scows and hoppers, etc. Loss of fines can occur due to overflow of a hopper dredge (especially if there is a high pereentage of fines in the sand fill) and the material not falling back within the borrow area. Loss of fines also occurs at the beach discharge location as the fine sediment is suspended in the slurry and washed offshore. The loss of fines by suspension can be associated with material placed outside of the measured but typically this refers to more coarse material (sand) that is transported alongshore or cross-shore beyond the limits of the survey. Payment based on the measured volume within the template transfers the risk and cost of these losses to the Contractor and thus typically results in a higher unit cost to the Government. However, it also provides greater ineentive for the Contractor to limit these losses.

Payment based on the comparison of pre and post-construction surveys of the borrow area assumes that only dredge operations are responsible for removal of material from the borrow area. While this is a fair assessment in a quiescent area such as a back bay in Louisiana, it may not be accurate when dredging within the Mississippi River or dredging offshore sources. The Mississippi River has a large bed and suspended sediment load, which will likely result in in-filling of the borrow area. Offshore borrow sources in Louisiana have also experienced in-filling, such as at the Peveto Channel borrow area, dredged during construction of the Holly Beach Sand Management Project. This borrow area had approximately 20 feet of material deposited within its limits within 2 years following construction.

The advantage of surveying the borrow area for payment purposes is that it is easier to survey the borrow area than to survey the marsh. The borrow area can be surveyed by standard hydrographic techniques whereas surveying the marsh will require an airboat. Again, the goal of the project must be considered when determining the payment methodology. Vegetation to be planted within the marsh is sensitive to marsh elevation and so payment should be structured to provide incentive (or disincentive) for the Contractor to construct the project as designed.

## 7.8 PROJECT COST REDUCTION CONCEPTS

There are several options that could potentially reduce the unit cost for construction of the project. These options have not been specifically included within the development of the unit cost because they are a departure from the typical method of contracting an island restoration project. However, given the size of this job and the high construction cost, some consideration may be given to alternative concepts.

One option is to decouple the dredging of sand from the Mississippi River and the construction of the island. It may be possible to develop a contract to supply a given volume of sand to a temporary storage area rather than having to pump it all the way to the island and place it within the template. The potential advantage of this concept is that a contractor may have equipment available to perform the dredging work but not the island reworking or capability to pump the entire distance. By creating a separate holding area, one contractor could supply the sand from the river while the other accesses the material from the storage area. Alternatively, the same contractor could perform the work but might not have the equipment available at a given time to meet payment requirements. By paying for dredging and island construction separately, cost savings may be realized.

A follow-on to the concept discussed in the previous paragraph is to have a dedicated long-distance pipeline extending from the Mississippi River to a holding site. The dredging of Mississippi River sand can be structured to occur whenever a Contractor has available equipment and time to perform work. The mobilization time should be short because there is a dedicated pipeline. Rather than having the dredge sit idle, an open ended contract could be developed so that a Contractor could pump sand through this pipeline from the Mississippi River to the temporary storage area on the Contractor's schedule. Releasing the Contractor from any minimum requirements of volume and dredging on their schedule could result in a significant discount of the unit cost. Then when the project is ready for renourishment there is a source of sand readily available and close to the project site. The temporary storage area could be a previously dredged marsh fill borrow area that has already been cleared for dredge use.

A second option is to group construction projects within the area to minimize mobilization costs. Adjacent projects include the Pass Chaland to Grand Bayou Pass Barrier Shoreline Restoration (BA-35), Pelican Island Restoration (BA-38-1) CWPPRA Project, and the Riverine Sand Mining/Scofield Island Restoration Project (BA-40). While these projects have different funding sources and construction time frames, which may not lend themselves to grouping with the Shell Island Restoration, any synergies that could be recognized between these projects should be explored.

Adding a year or two to the anticipated construction window could be considered for a project of this size with the option for temporary cessation of work. Lower unit costs could be realized by allowing Contractors a large construction window and the ability to temporarily demobilize equipment to another construction site. Flexibility in the start time of the project could allow Contractors to plan far in advance for this project, while still having flexibility to react to other work, could result in a lower unit cost.

## 8.0 FUTURE STUDIES

This report provides analyses at a feasibility design level. Throughout the report, the assumptions upon which the analyses were based have been defined. Additional work would provide information that would be useful to enhance project design. This section briefly outlines several items that would enhance the project design.

A more detailed survey of the project area would provide a better estimate of the volume contained within the construction template. Now that there is a planform for the project more closely spaced survey lines can be performed. A bathymetric survey within Bastian Bay would allow a more accurate assessment of secondary benefits and the dredge volumes for the tidal diversion channel.

A more detailed geotechnical investigation offshore of Shell Island might locate a borrow source closer to the project that would significantly lower project costs. Previous analyses suggest that there may be sand deposits within 5 miles of Shell Island. Modern equipment and expertise gained from previous projects could help identify larger quantities of sand that were not realized previously. It would likely take approximately 6 months to review historic data for the area, perform exploratory and detailed seismic lines, collect vibracores and jet probes and define a borrow area.

A hydrodynamic model, such as Mike21 or Delft 3D would provide a better understanding of the interaction of waves, tidal currents and sediment transport in the project area. A hydrodynamic model could assist in optimizing the placement of advanced fill, predicting the growth of the Coupe Bob or Grand Bayou ebb shoals, and better define shoreline changes. While GENESIS has been applied to this area, it is not as suited as a full 3-dimensional morphodynamic model to predicting shoreline changes adjacent to inlets and accounting for mixed sediments. Inputs to a hydrodynamic model would be updated bathymetry for Bastian Bay and Shell Island Bays, current measurements in Grand Bayou, Coupe Bob, and Empire Waterway, and tide measurements in the Gulf and back bay areas. The field and office work would likely take 6 months to complete.

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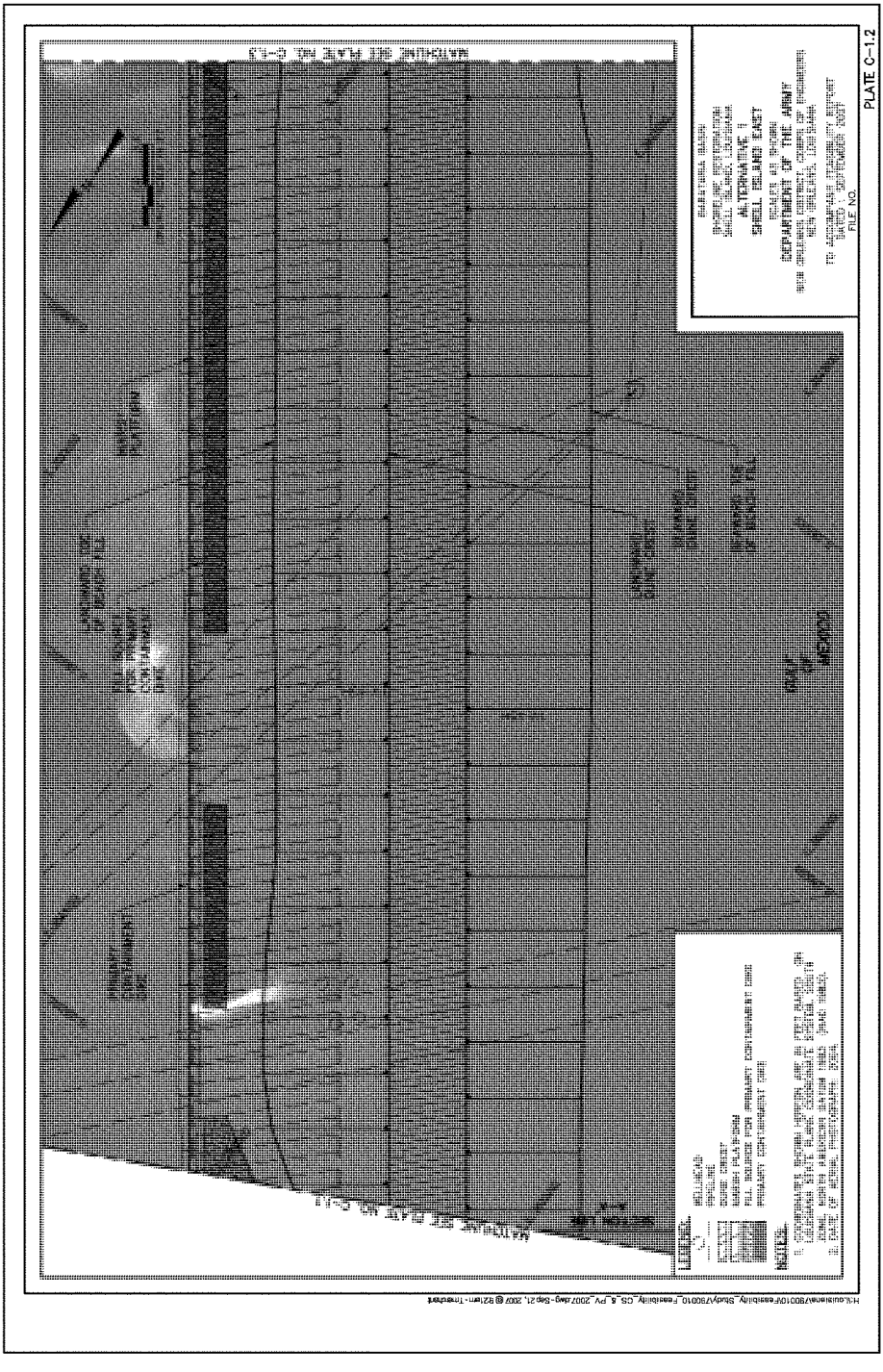
# ANNEX C-1
# PROJECT PLATES

PLATE C-1.1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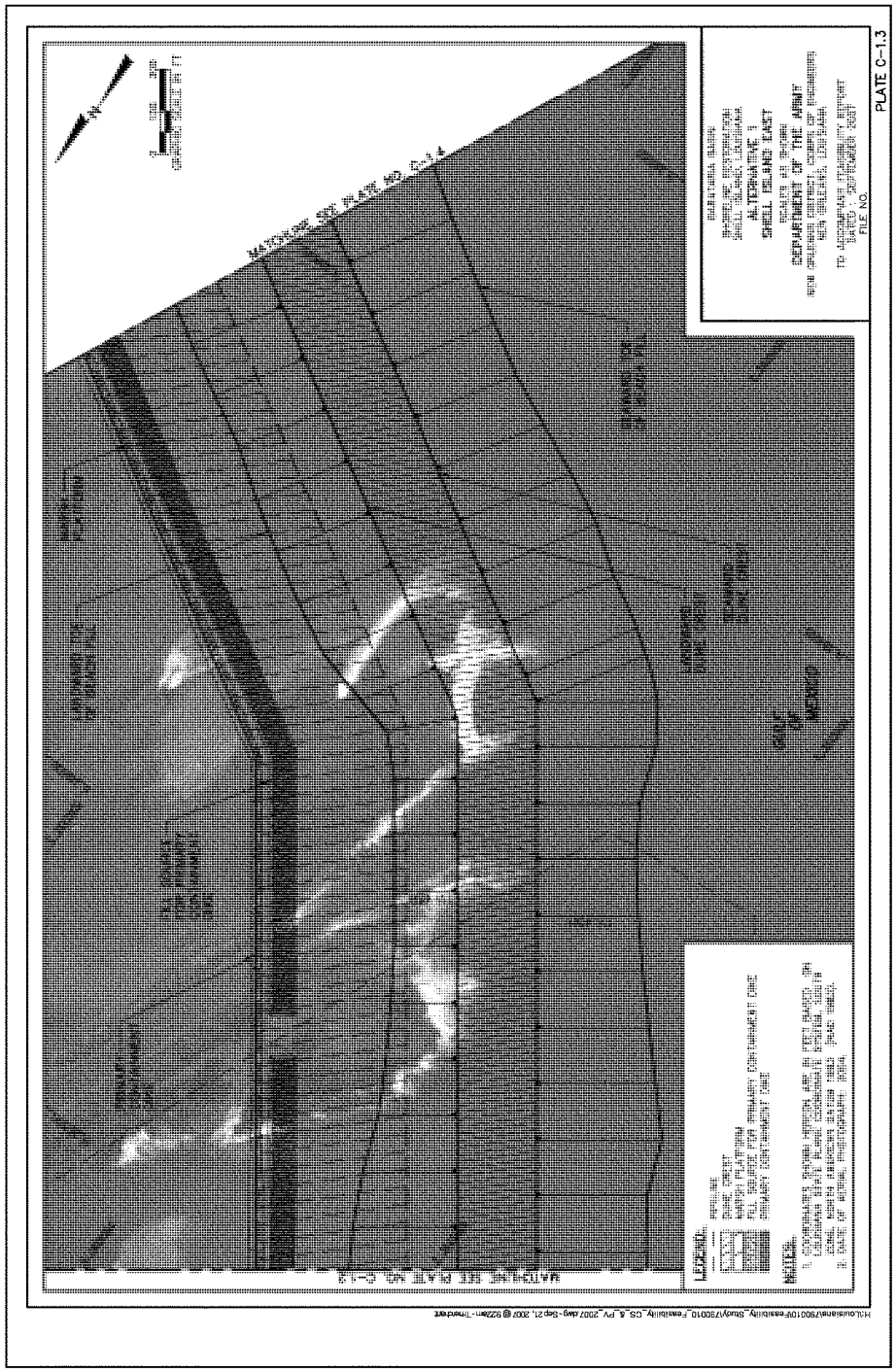


PLATE C-1.3

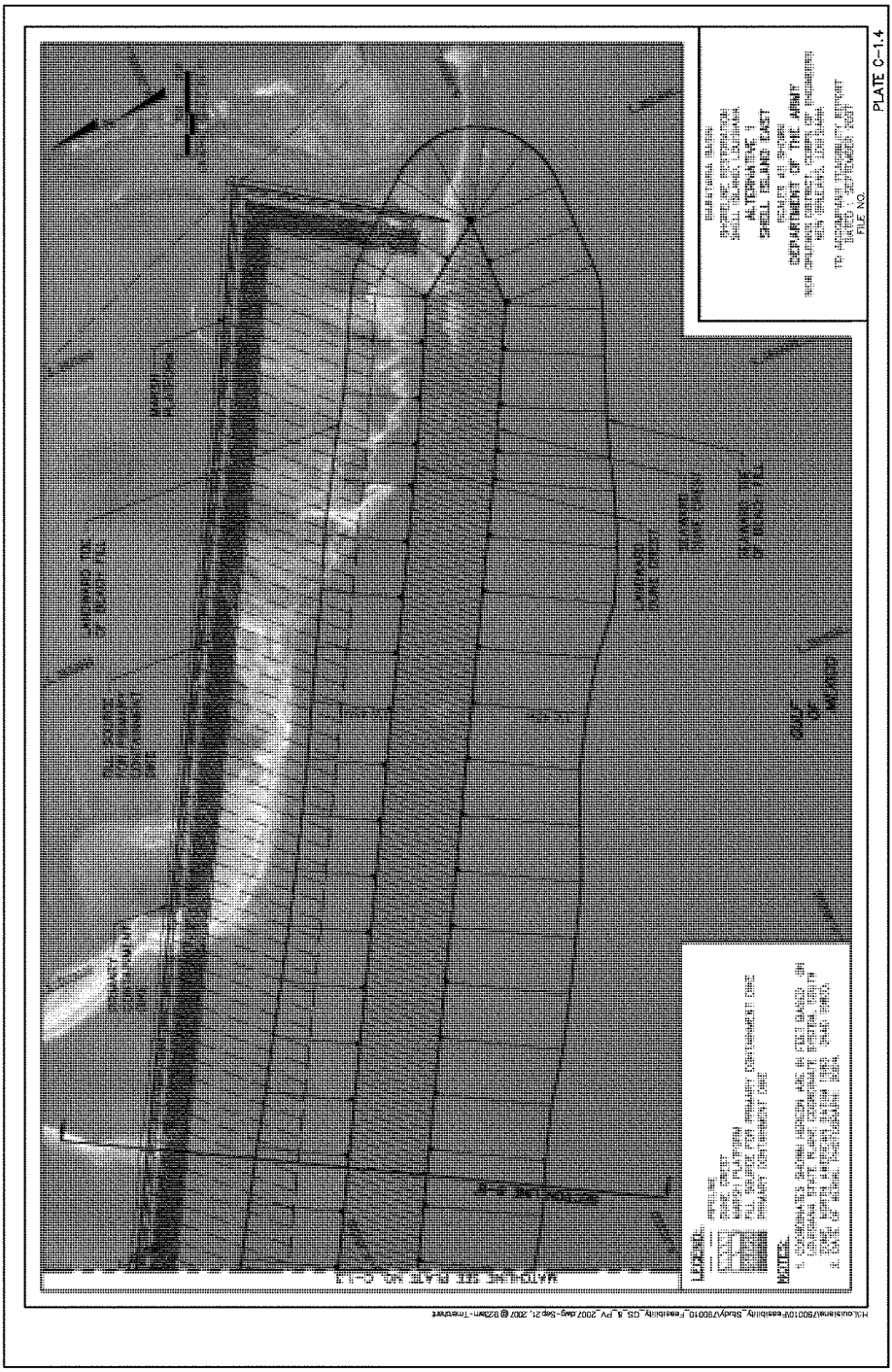
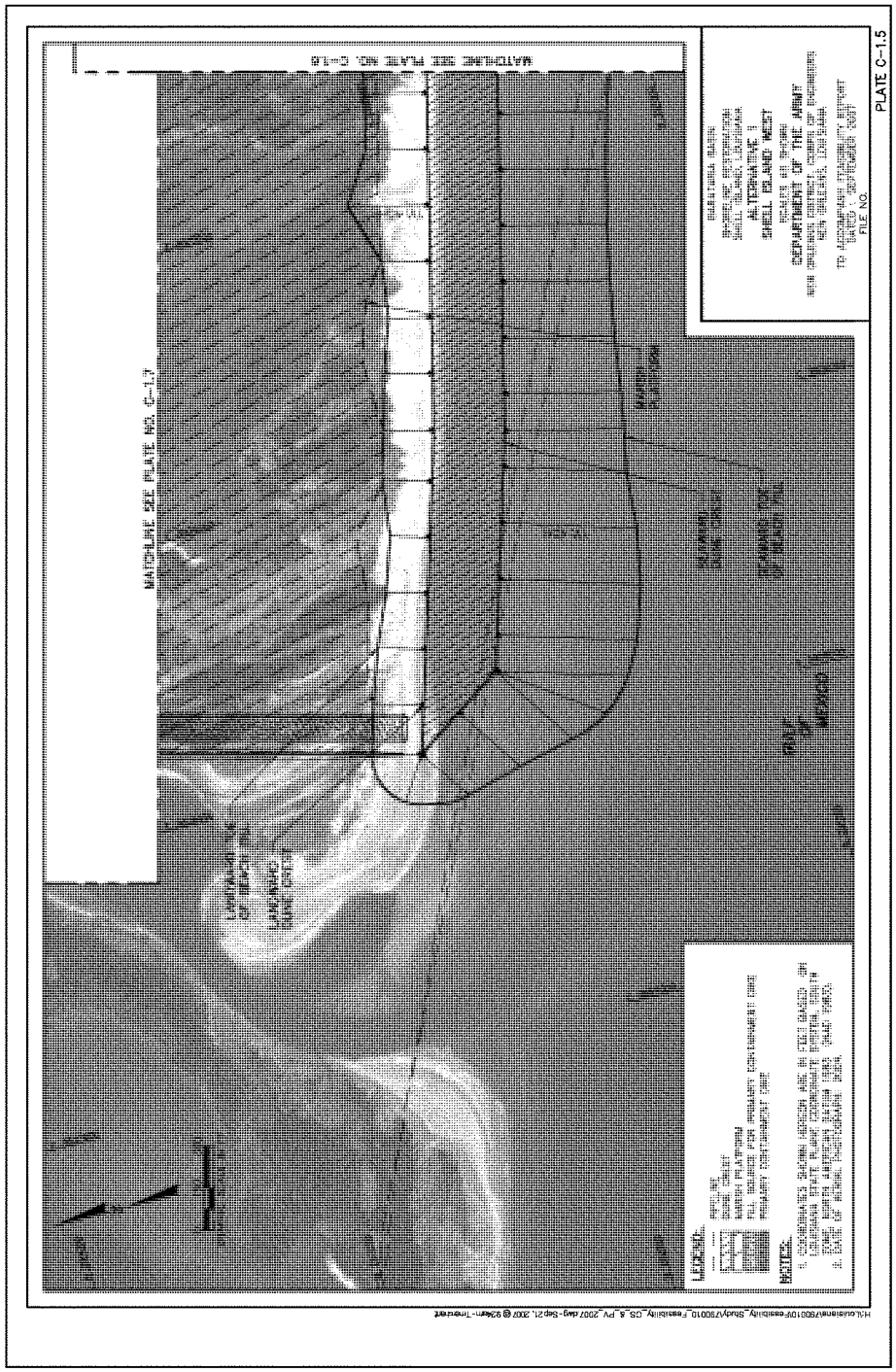


PLATE C-1.4
ALTERNATIVE 1
SHELL ISLAND EAST
DEPARTMENT OF THE ARMY
FILE NO.
LEGEND:
NOTES:
MATCHLINE SEE PLATE NO. C-1.3
GULF OF MEXICO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DEPARTMENT OF THE ARMY
SHELL ISLAND WEST
ALTERNATIVE 1
PLATE C-1.5

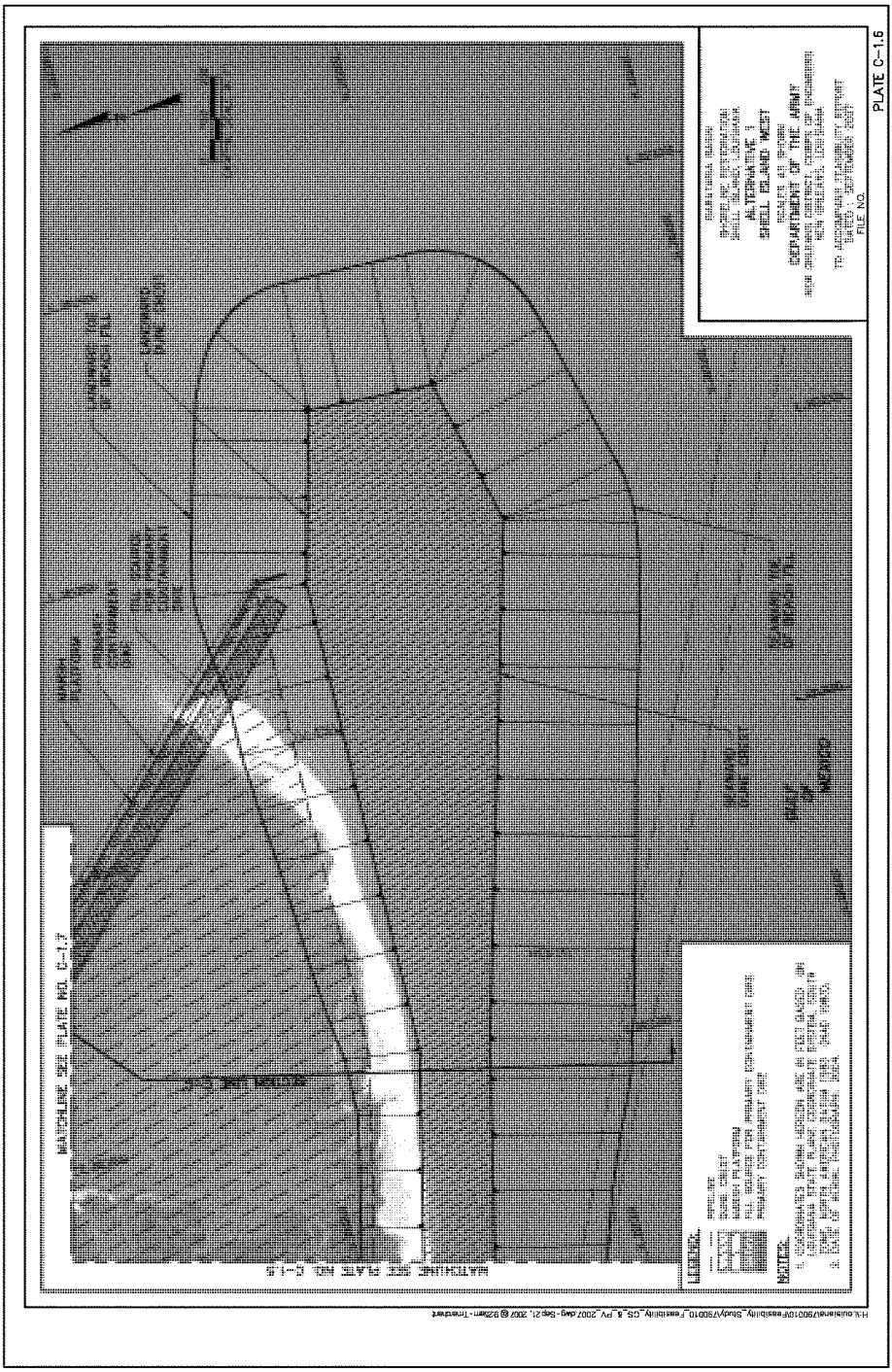
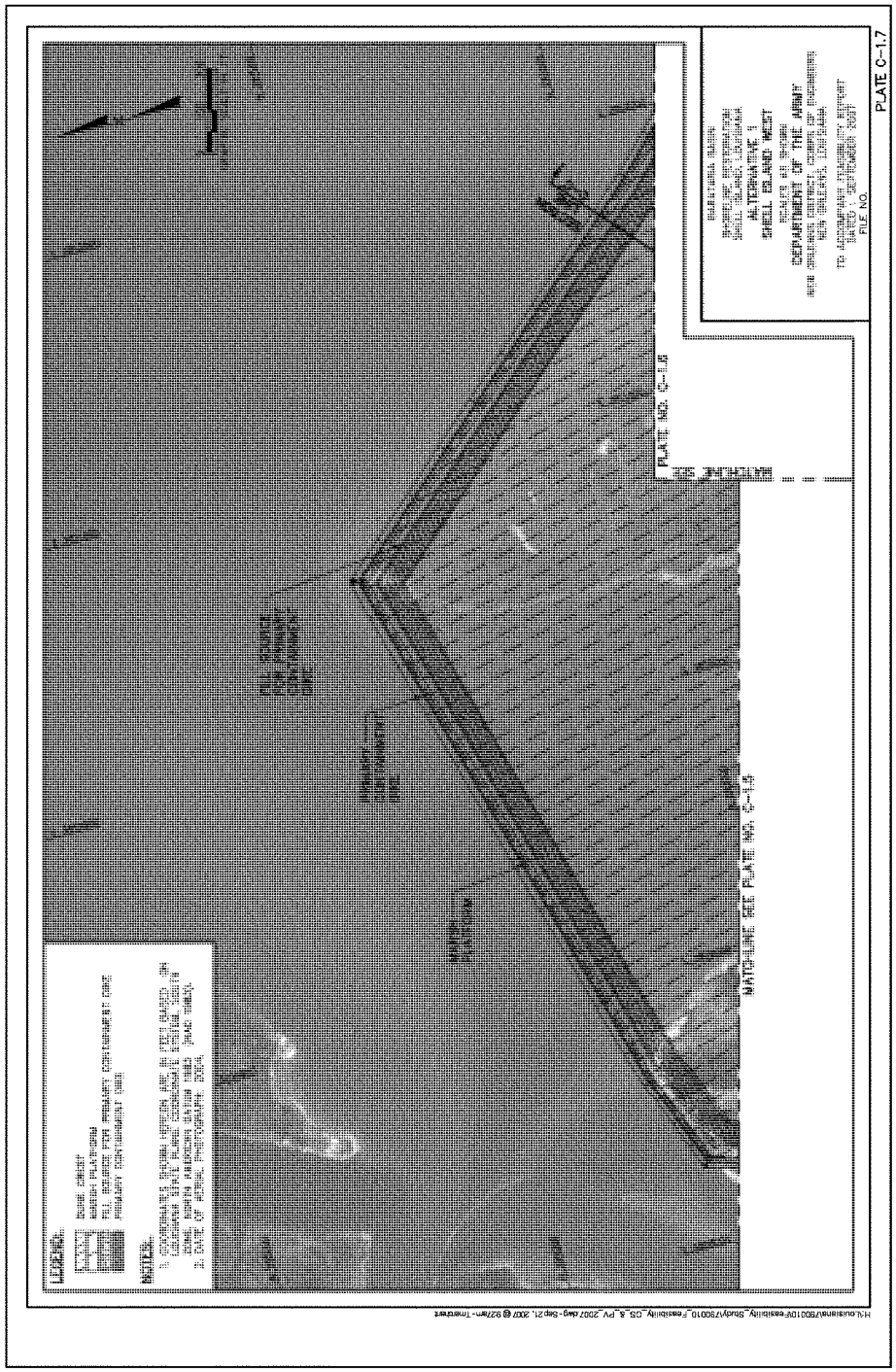


PLATE C-1.6
SHELL ISLAND WEST
ALTERNATIVE 1
DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA
WATERLINE SEE PLATE NO. C-1.5
WATERLINE SEE PLATE NO. C-1.7
NOTES:
LEGEND: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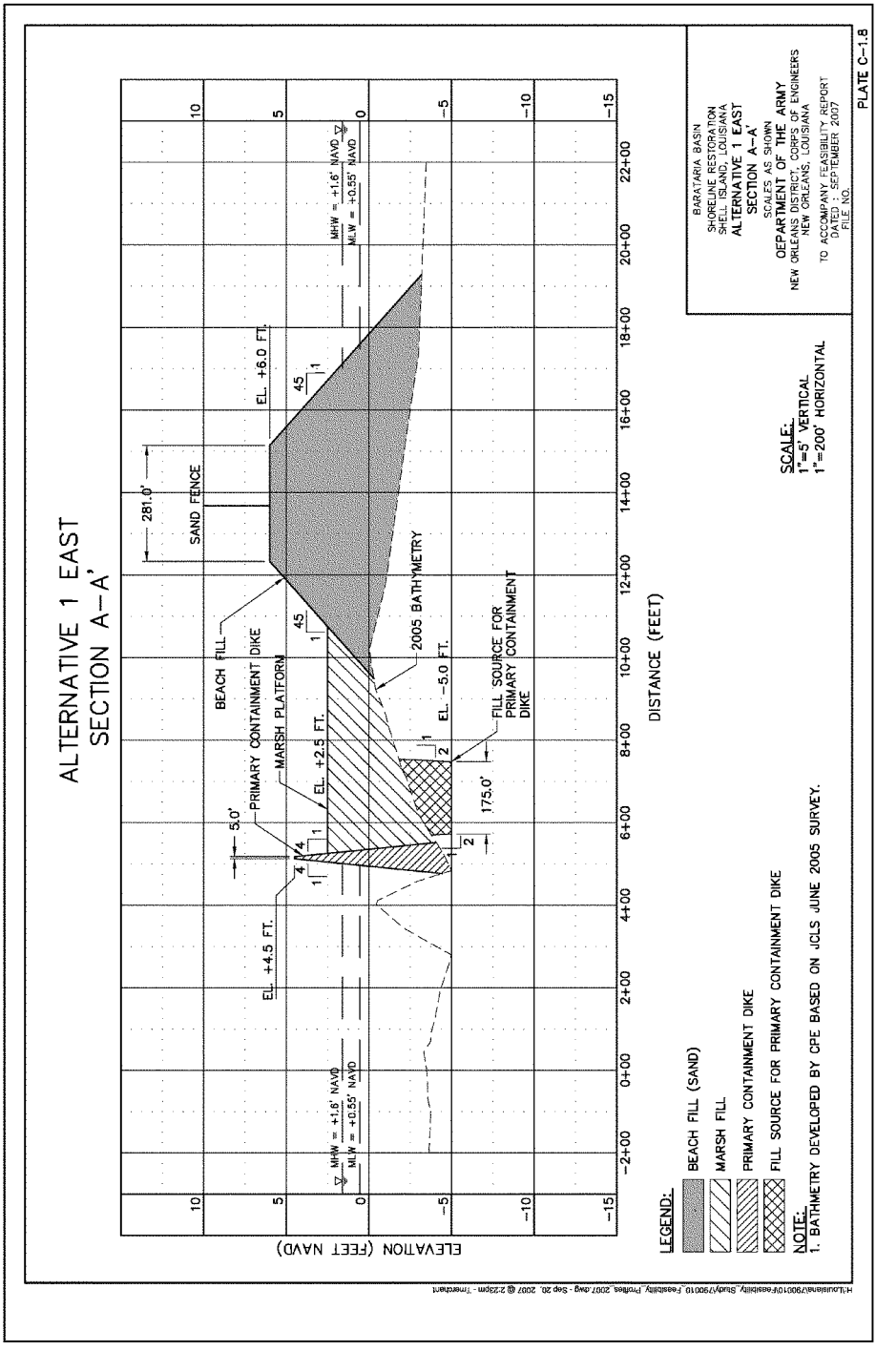
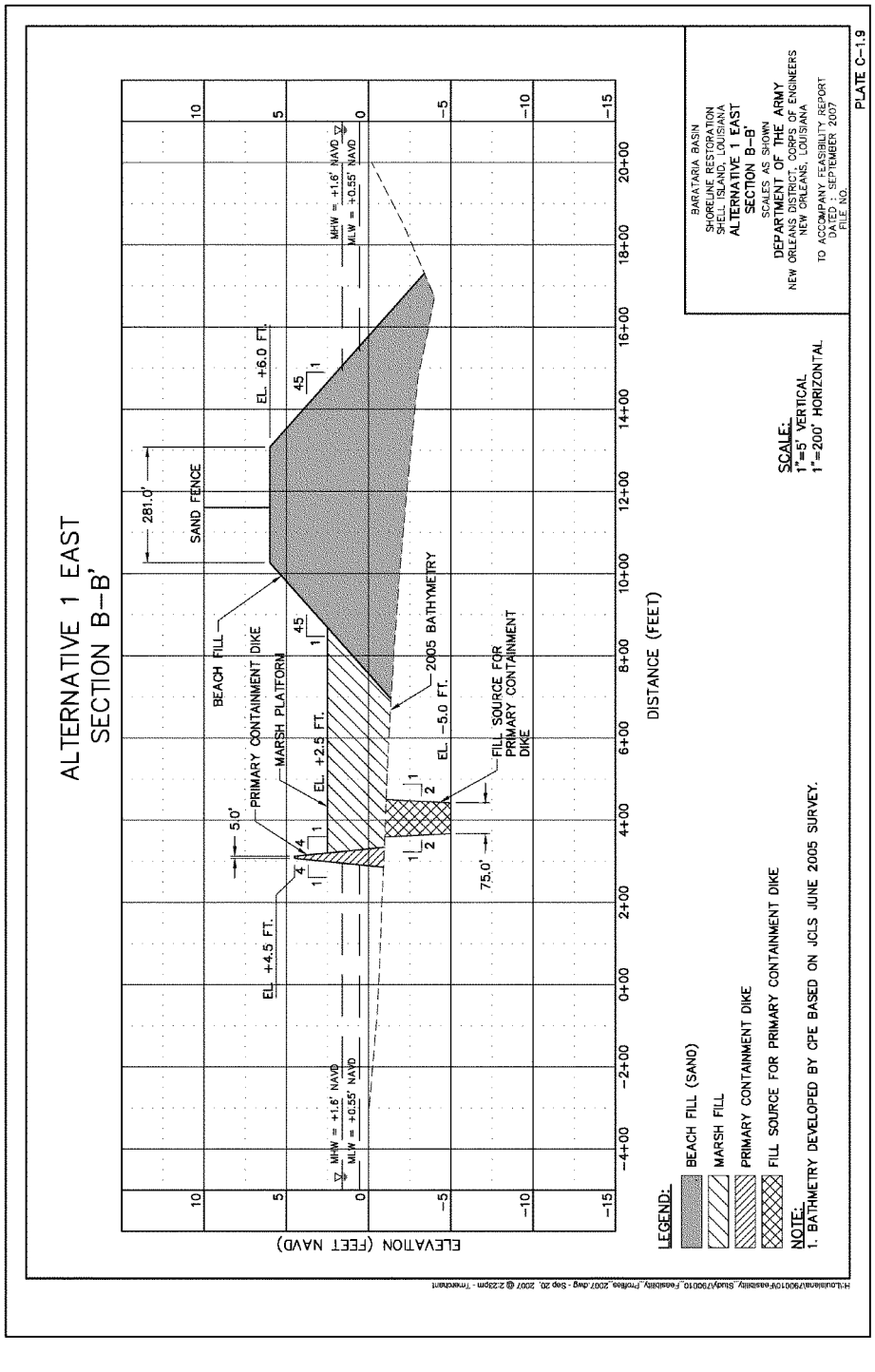
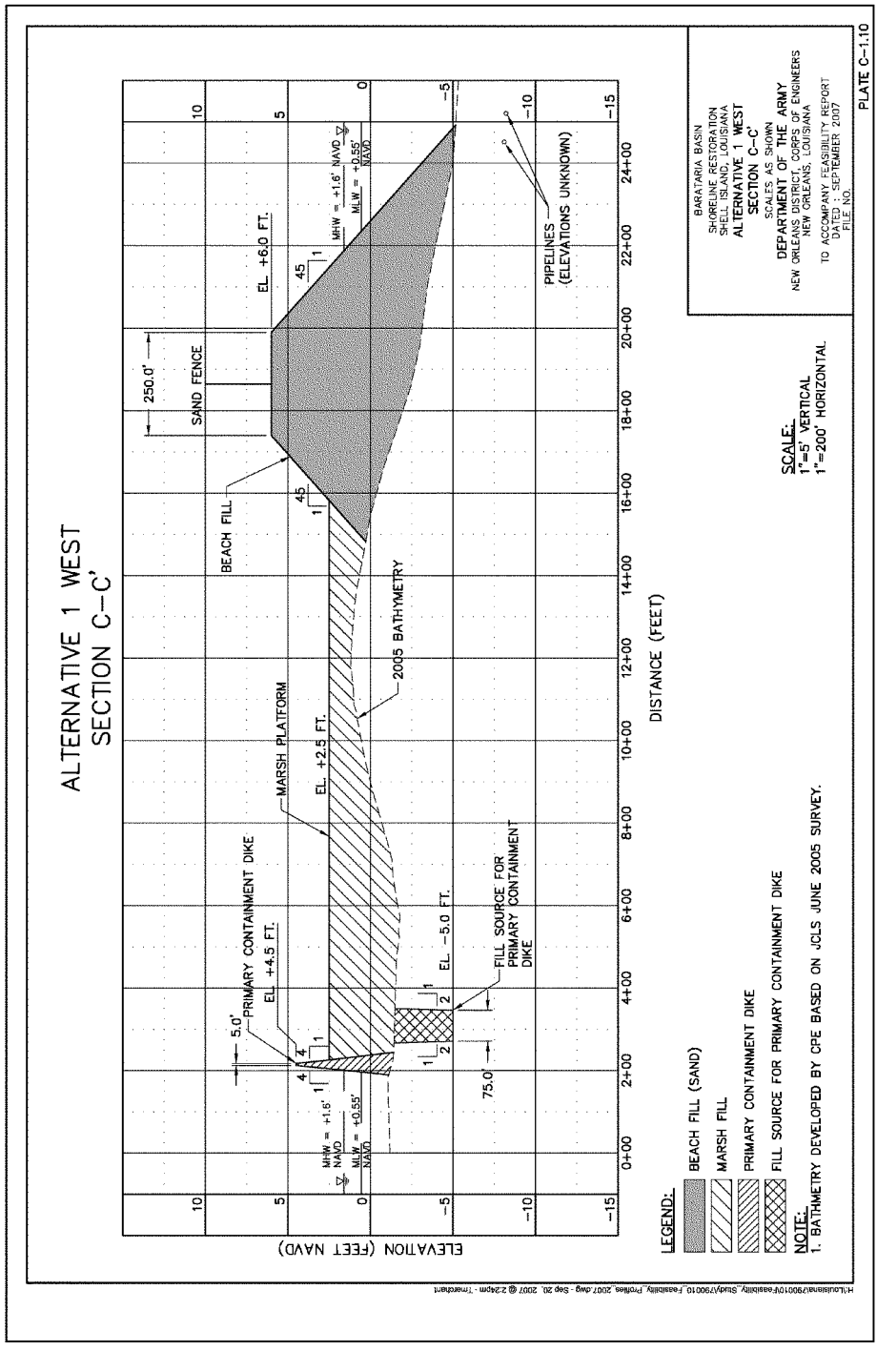

ALTERNATIVE 1 EAST
SECTION A–A'
ELEVATION (FEET NAVD)
DISTANCE (FEET)
SAND FENCE
281.0'
BEACH FILL
PRIMARY CONTAINMENT DIKE
MARSH PLATFORM
EL. +6.0 FT.
EL. +4.5 FT.
EL. +2.5 FT.
EL. -5.0 FT.
5.0'
175.0'
2005 BATHYMETRY
FILL SOURCE FOR PRIMARY CONTAINMENT DIKE
MHW = +1.6' NAVD
MLW = +0.55' NAVD
LEGEND:
BEACH FILL (SAND)
MARSH FILL
PRIMARY CONTAINMENT DIKE
FILL SOURCE FOR PRIMARY CONTAINMENT DIKE
NOTE:
1. BATHYMETRY DEVELOPED BY CPE BASED ON JCLS JUNE 2005 SURVEY.
SCALE:
1"=5' VERTICAL
1"=200' HORIZONTAL
BARATARIA BASIN
SHORELINE RESTORATION
SHELL ISLAND, LOUISIANA
ALTERNATIVE 1 EAST
SECTION A–A'
SCALES AS SHOWN
DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA
TO ACCOMPANY FEASIBILITY REPORT
DATED SEPTEMBER 2007
FILE NO.
PLATE C-1.8


ALTERNATIVE 1 EAST
SECTION B-B'
ELEVATION (FEET NAVD)
DISTANCE (FEET)
SAND FENCE
281.0'
BEACH FILL
PRIMARY CONTAINMENT DIKE
MARSH PLATFORM
EL +6.0 FT.
EL +4.5 FT.
EL +2.5 FT.
EL -5.0 FT.
2005 BATHYMETRY
FILL SOURCE FOR PRIMARY CONTAINMENT DIKE
5.0'
75.0'
MHW = +1.6' NAVD
MLW = +0.55' NAVD
LEGEND:
BEACH FILL (SAND)
MARSH FILL
PRIMARY CONTAINMENT DIKE
FILL SOURCE FOR PRIMARY CONTAINMENT DIKE
NOTE:
1. BATHYMETRY DEVELOPED BY CPE BASED ON JCLS JUNE 2005 SURVEY.
SCALE:
1"=5' VERTICAL
1"=200' HORIZONTAL
BARATARIA BASIN
SHORELINE RESTORATION
SHELL ISLAND, LOUISIANA
ALTERNATIVE 1 EAST
SECTION B-B'
SCALES AS SHOWN
DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA
TO ACCOMPANY FEASIBILITY REPORT
DATED : SEPTEMBER 2007
FILE NO.
PLATE C-1.9


ALTERNATIVE 1 WEST
SECTION C–C'
ELEVATION (FEET NAVD)
DISTANCE (FEET)
BEACH FILL
SAND FENCE
250.0'
EL +6.0 FT.
MARSH PLATFORM
EL +2.5 FT.
2005 BATHYMETRY
PRIMARY CONTAINMENT DIKE
EL +4.5 FT.
5.0'
FILL SOURCE FOR PRIMARY CONTAINMENT DIKE
EL. -5.0 FT.
75.0'
PIPELINES (ELEVATIONS UNKNOWN)
MHW = +1.6' NAVD
MLW = +0.55' NAVD
LEGEND:
BEACH FILL (SAND)
MARSH FILL
PRIMARY CONTAINMENT DIKE
FILL SOURCE FOR PRIMARY CONTAINMENT DIKE
NOTE:
1. BATHYMETRY DEVELOPED BY CPE BASED ON JCLS JUNE 2005 SURVEY.
SCALE:
1"=5' VERTICAL
1"=200' HORIZONTAL
BARATARIA BASIN
SHORELINE RESTORATION
SHELL ISLAND, LOUISIANA
ALTERNATIVE 1 WEST
SECTION C–C'
SCALES AS SHOWN
DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA
TO ACCOMPANY FEASIBILITY REPORT
DATED: SEPTEMBER 2007
FILE NO.
PLATE C-1.10

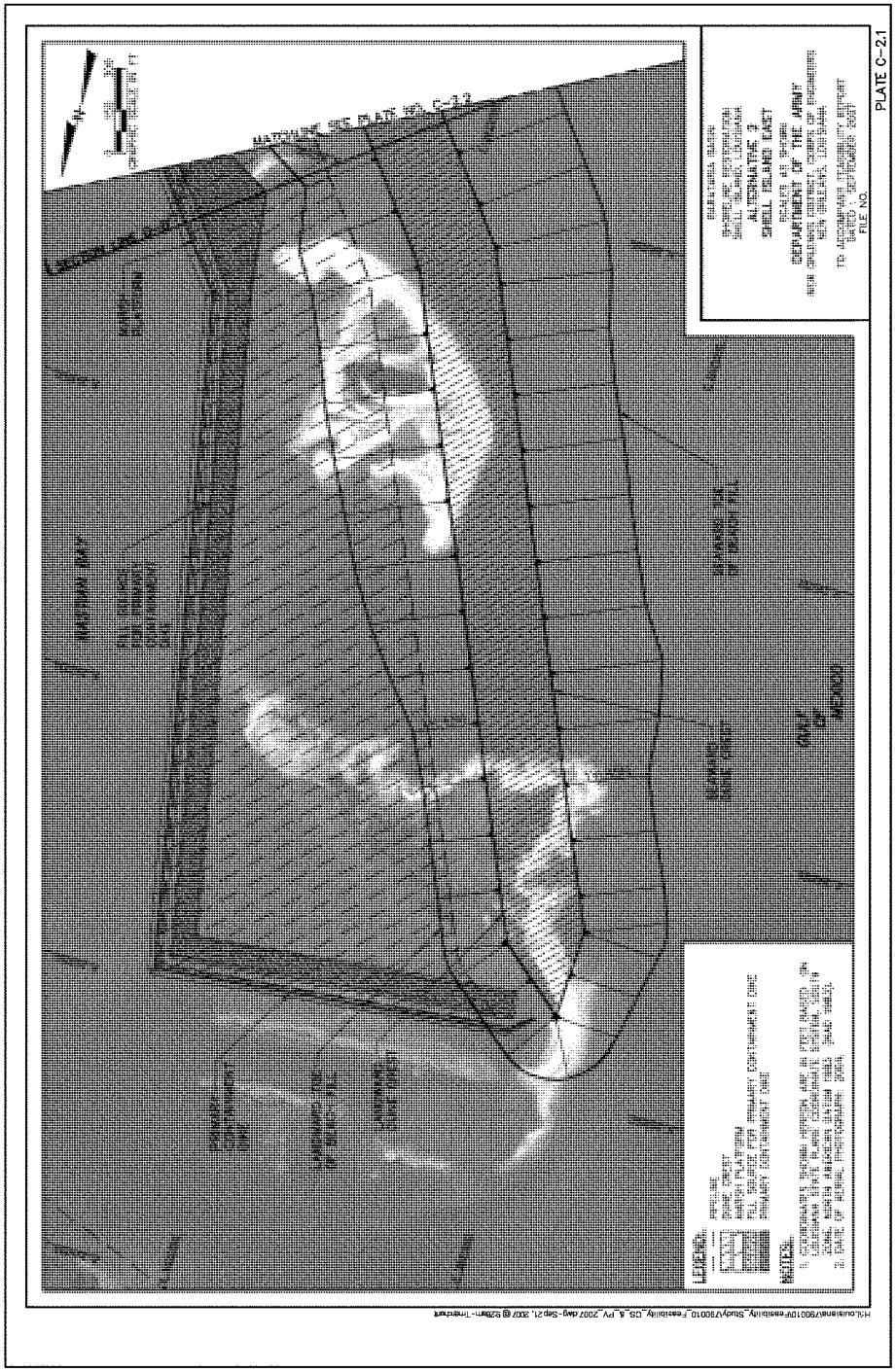


PLATE C-2.1

PLATE C-2.2

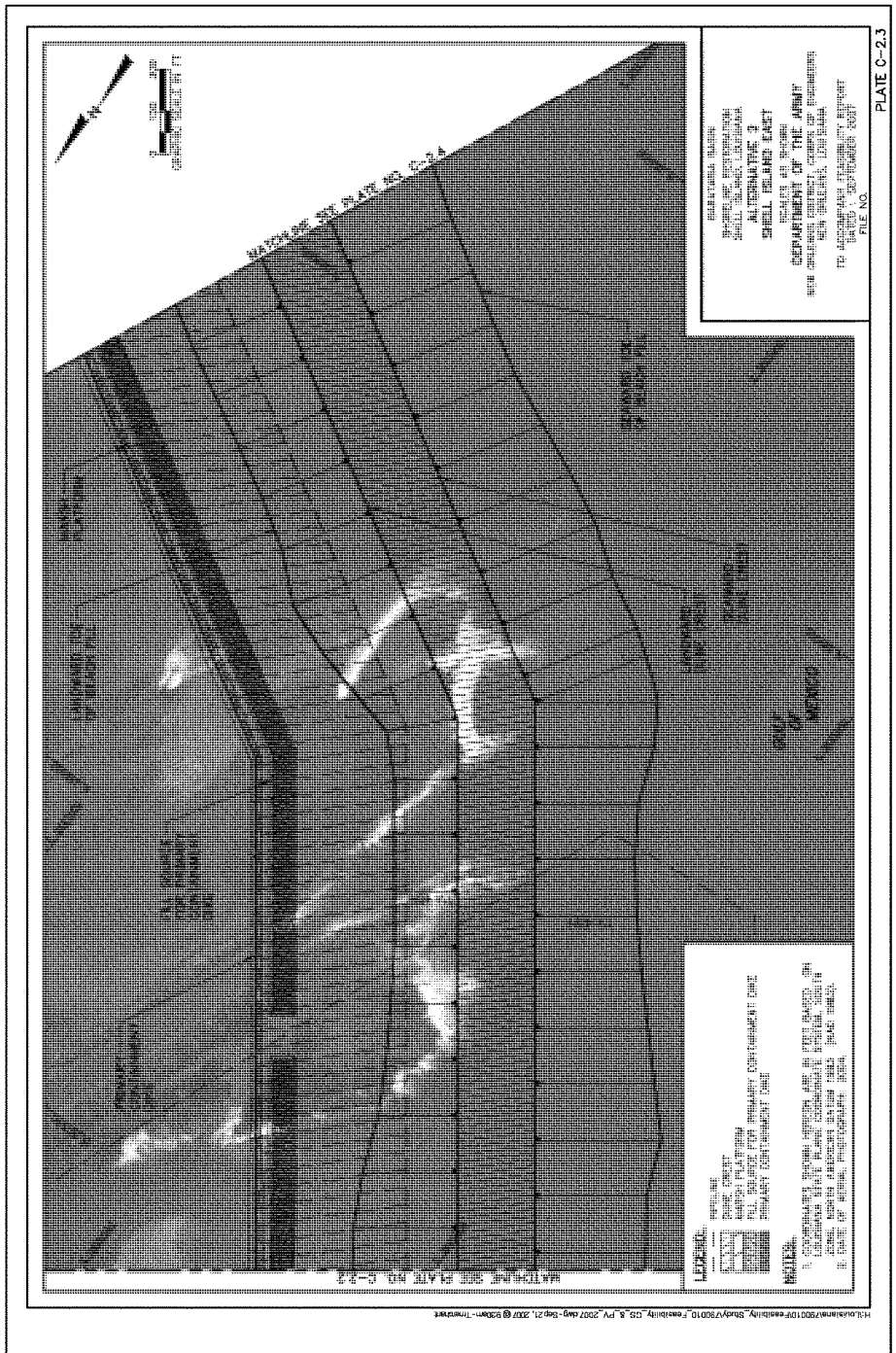


PLATE C-2.3
DEPARTMENT OF THE ARMY
SHELL ISLAND EAST
ALTERNATIVE 3
MATERIAL PLACEMENT PLAN NO. C-2.4
LEGEND:
NOTES:

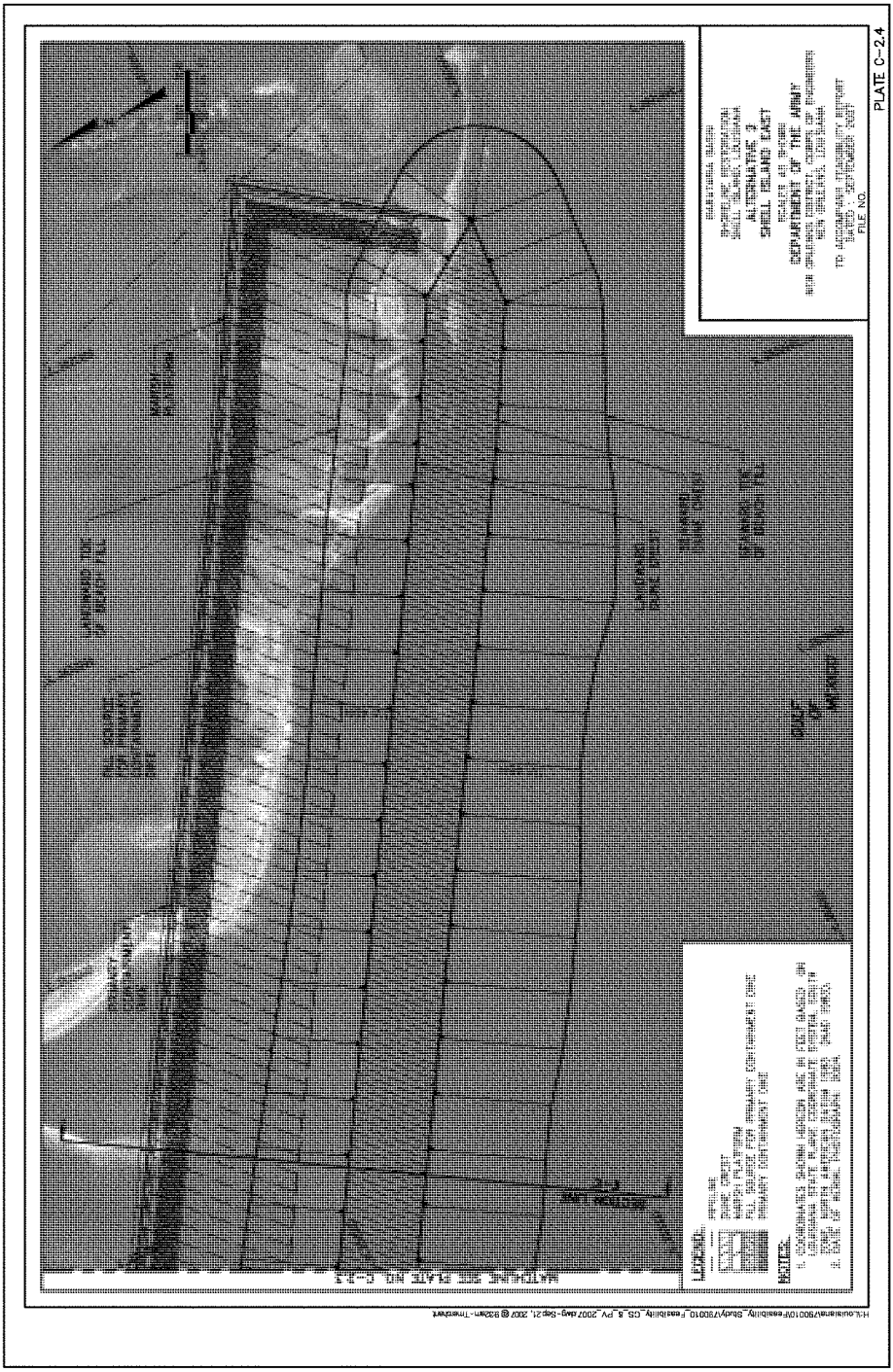


PLATE C-2.4
ALTERNATIVE 2
SHELL ISLAND EAST
DEPARTMENT OF THE ARMY
FILE NO.
LEGEND:
NOTES:
MATCHLINE SEE PLATE NO. C-2.3
GULF OF MEXICO

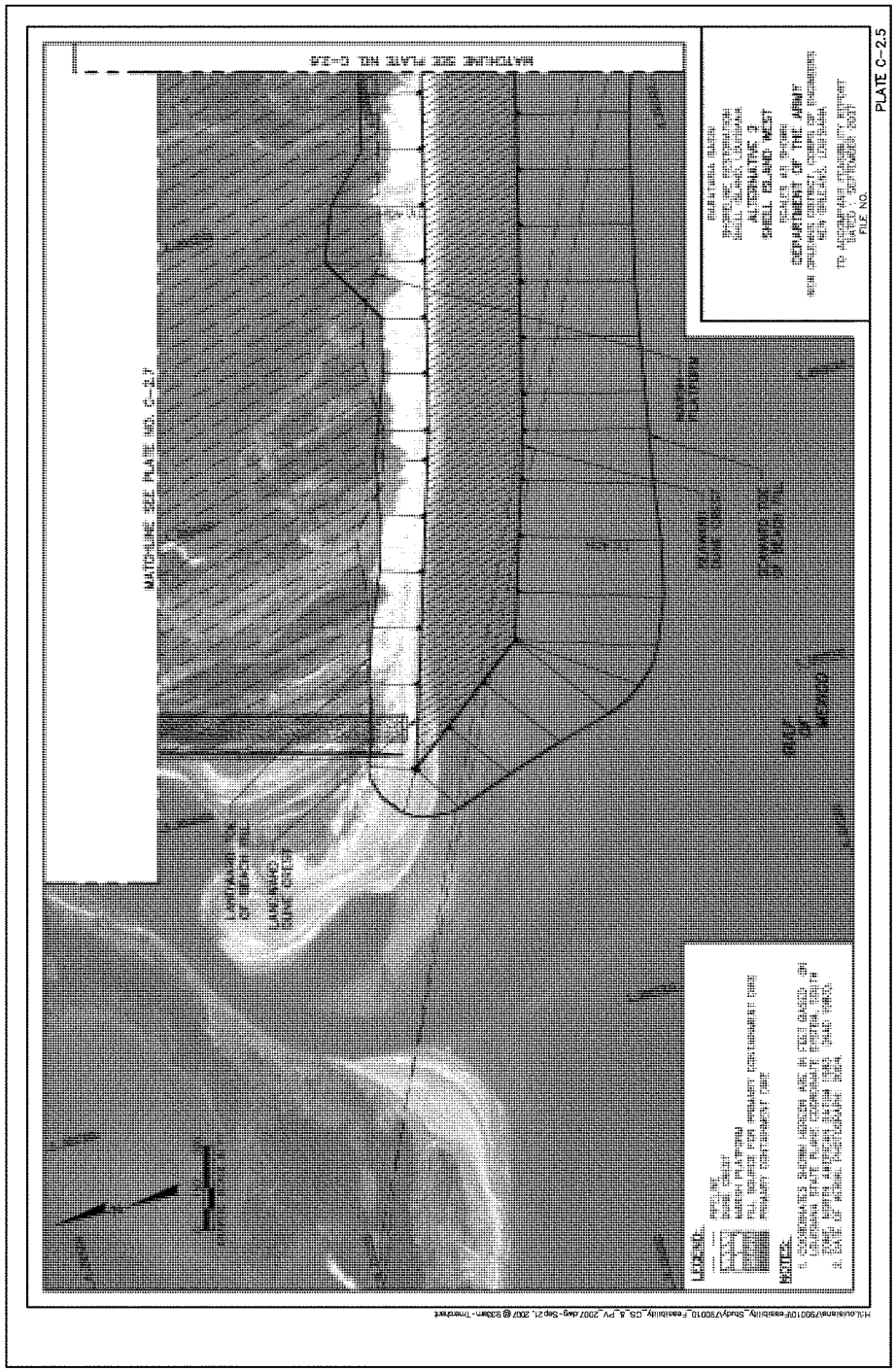
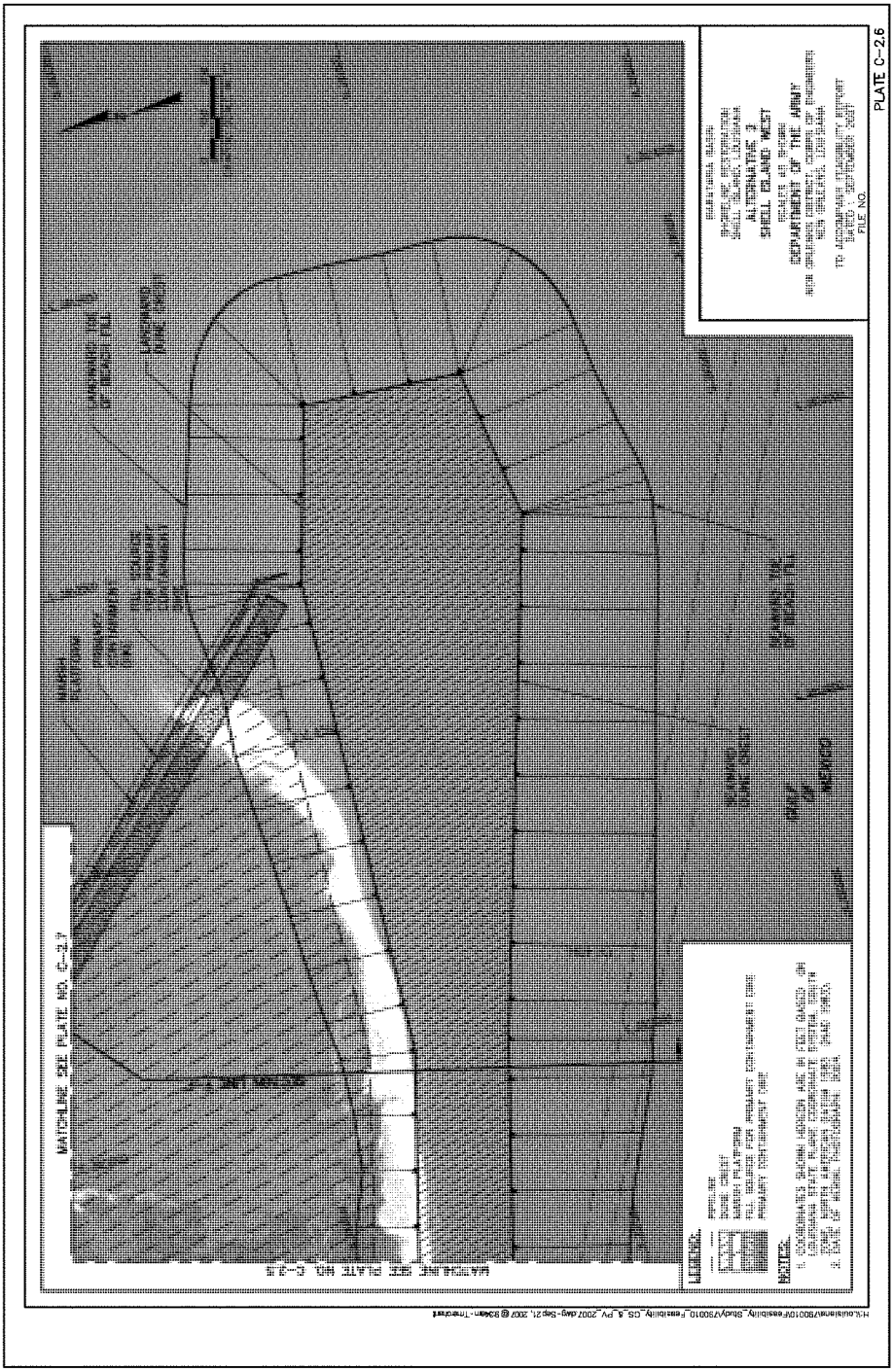


PLATE C-2.5
MATCHLINE SEE PLATE NO. C-2.7
MATCHLINE SEE PLATE NO. C-2.6
LANDWARD TOE OF BEACH FILL
LANDWARD DUNE CREST
SEAWARD DUNE CREST
SEAWARD TOE OF BEACH FILL
GULF OF MEXICO
ALTERNATIVE 3
SHELL ISLAND WEST
DEPARTMENT OF THE ARMY
FILE NO.
LEGEND:
NOTES: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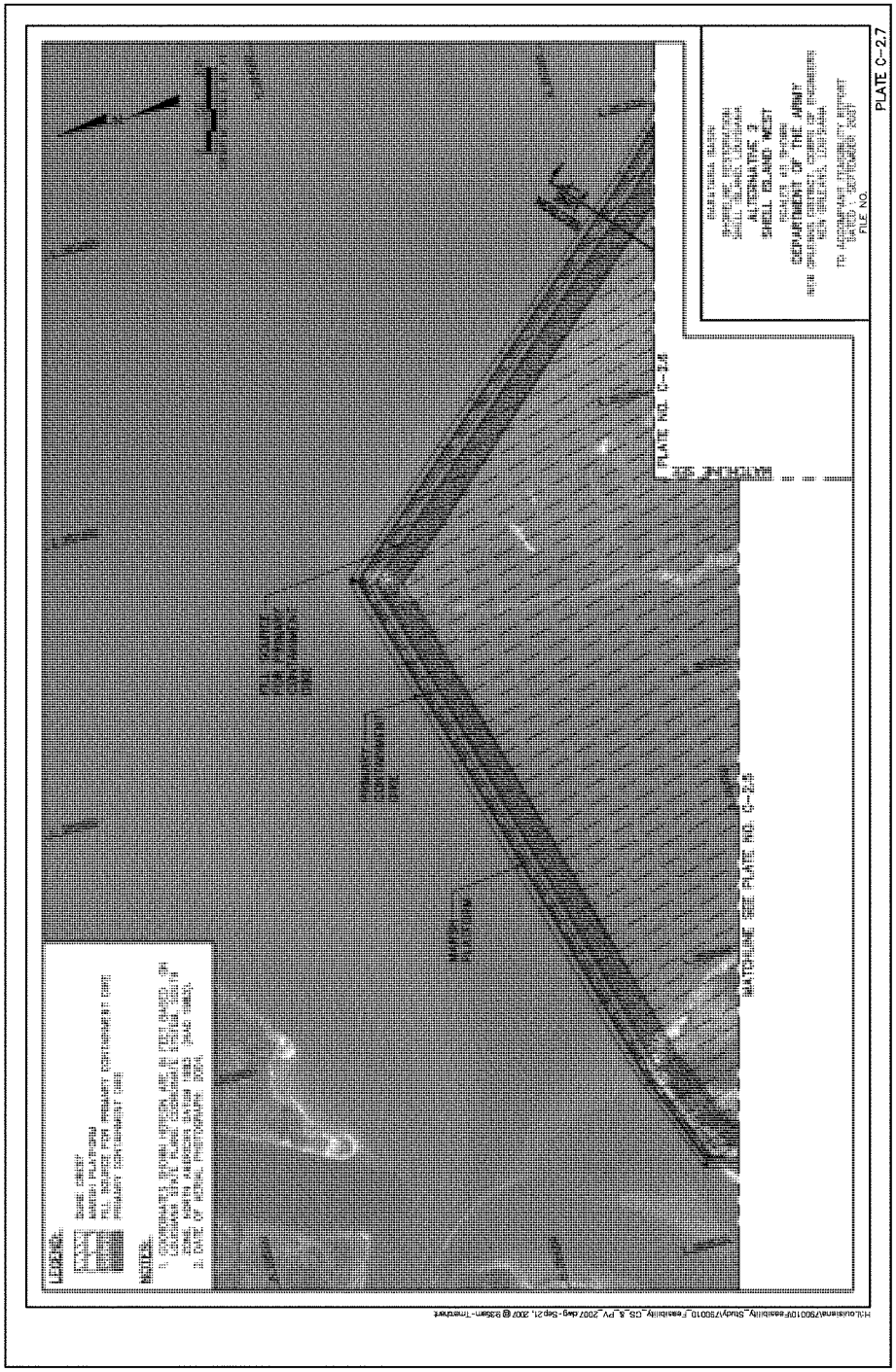
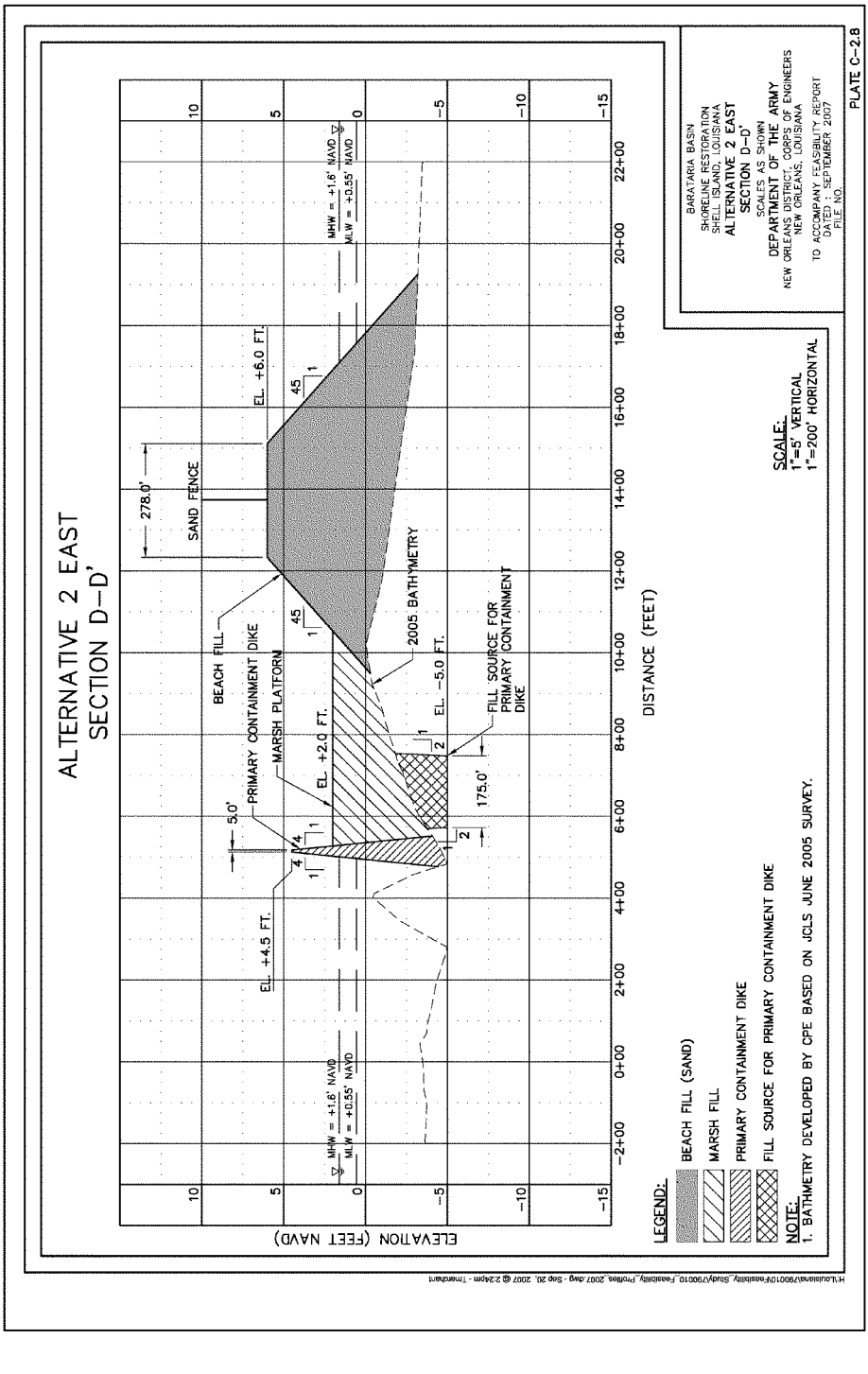
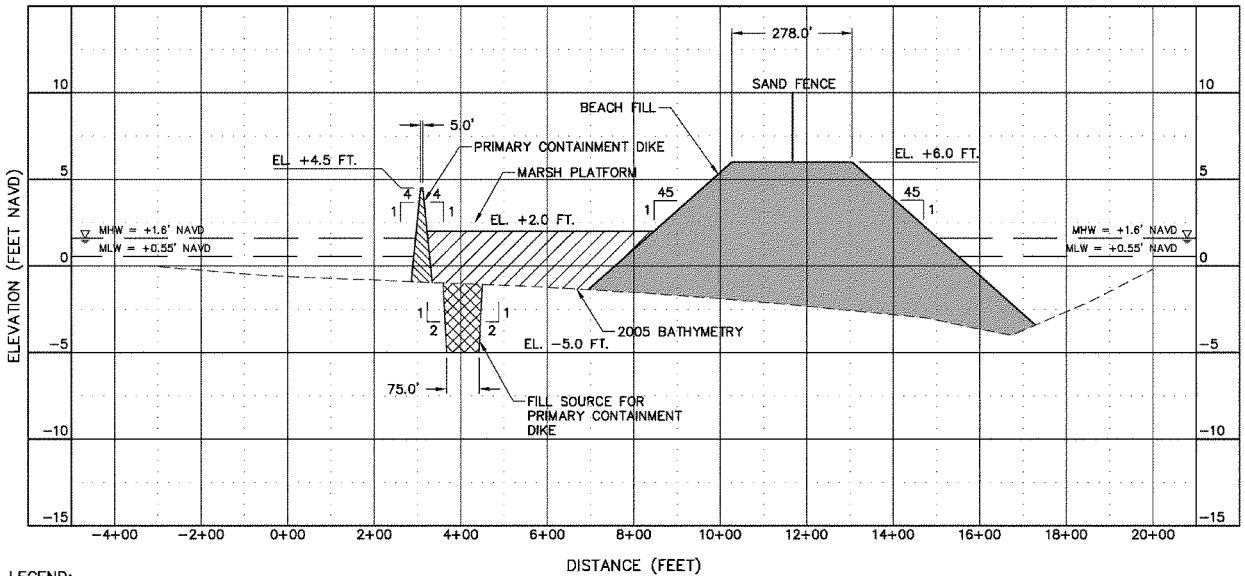

LEGEND:
NOTES:
BATHYLINE SEE PLATE NO. C-2.5
PLATE NO. C-2.6
DEPARTMENT OF THE ARMY
SHELL ISLAND WEST
ALTERNATIVE 3
PLATE NO.
PLATE C-2.7


ALTERNATIVE 2 EAST
SECTION D–D'
ELEVATION (FEET NAVD)
DISTANCE (FEET)
BEACH FILL
PRIMARY CONTAINMENT DIKE
MARSH PLATFORM
SAND FENCE
278.0'
EL. +6.0 FT.
EL. +4.5 FT.
EL. +2.0 FT.
EL. -5.0 FT.
5.0'
175.0'
2005 BATHYMETRY
FILL SOURCE FOR PRIMARY CONTAINMENT DIKE
MHW = +1.6' NAVD
MLW = +0.55' NAVD
LEGEND:
BEACH FILL (SAND)
MARSH FILL
PRIMARY CONTAINMENT DIKE
FILL SOURCE FOR PRIMARY CONTAINMENT DIKE
NOTE:
1. BATHYMETRY DEVELOPED BY CPE BASED ON JCLS JUNE 2005 SURVEY.
SCALE:
1"=5' VERTICAL
1"=200' HORIZONTAL
BARATARIA BASIN
SHORELINE RESTORATION
SHELL ISLAND, LOUISIANA
ALTERNATIVE 2 EAST
SECTION D–D'
SCALES AS SHOWN
DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA
TO ACCOMPANY FEASIBILITY REPORT
DATED SEPTEMBER 2007
FILE NO.
PLATE C-2.8

# ALTERNATIVE 2 EAST
## SECTION E–E'




LEGEND:

- BEACH FILL (SAND)
- MARSH FILL
- PRIMARY CONTAINMENT DIKE
- FILL SOURCE FOR PRIMARY CONTAINMENT DIKE

NOTE:
1. BATHMETRY DEVELOPED BY CPE BASED ON JCLS JUNE 2005 SURVEY.

SCALE:
1"=5' VERTICAL
1"=200' HORIZONTAL

BARATARIA BASIN
SHORELINE RESTORATION
SHELL ISLAND, LOUISIANA
ALTERNATIVE 2 EAST
SECTION E–E'
SCALES AS SHOWN
DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

TO ACCOMPANY FEASIBILITY REPORT
DATED : SEPTEMBER 2007
FILE NO.

PLATE C–2.9

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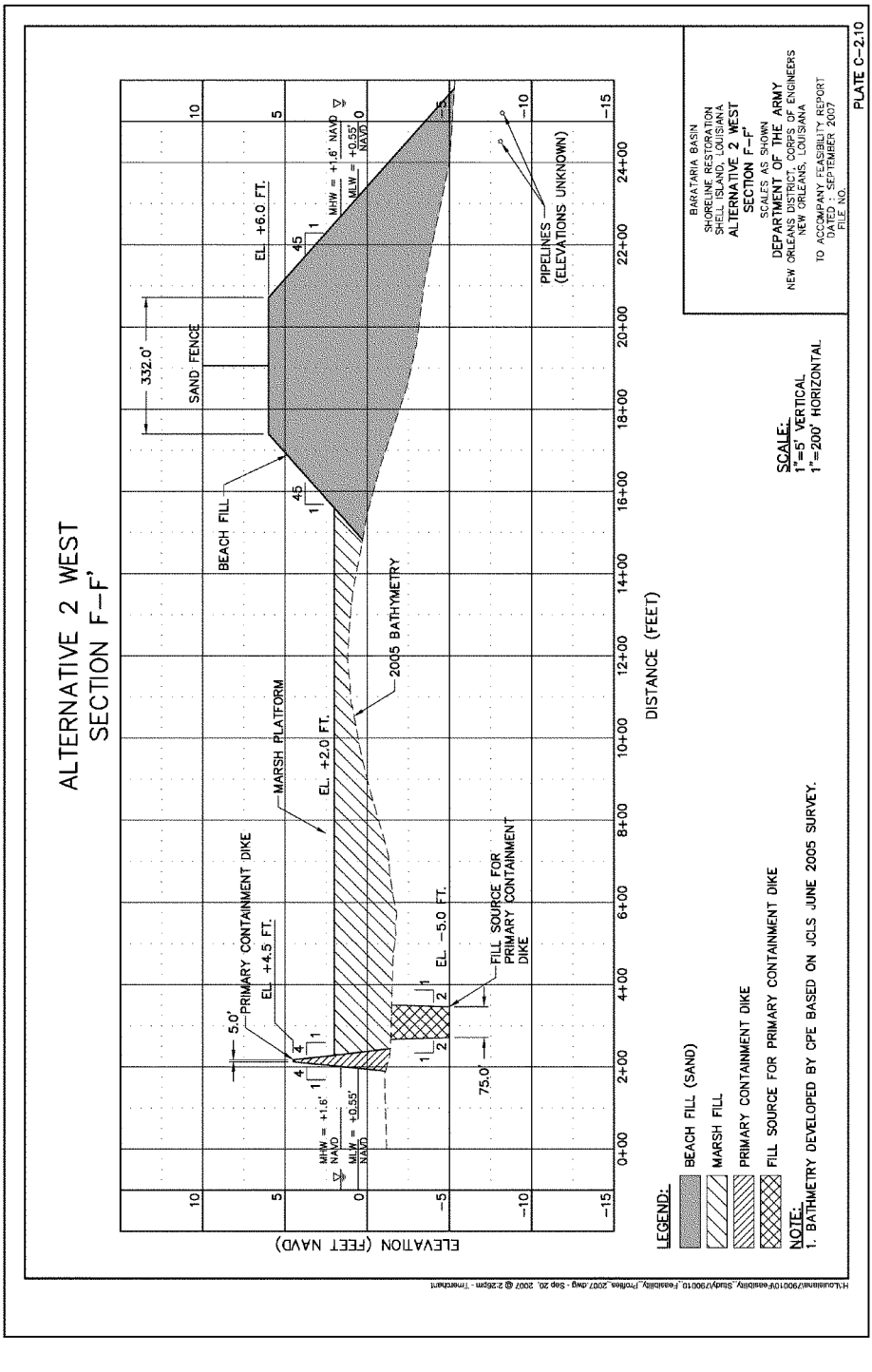
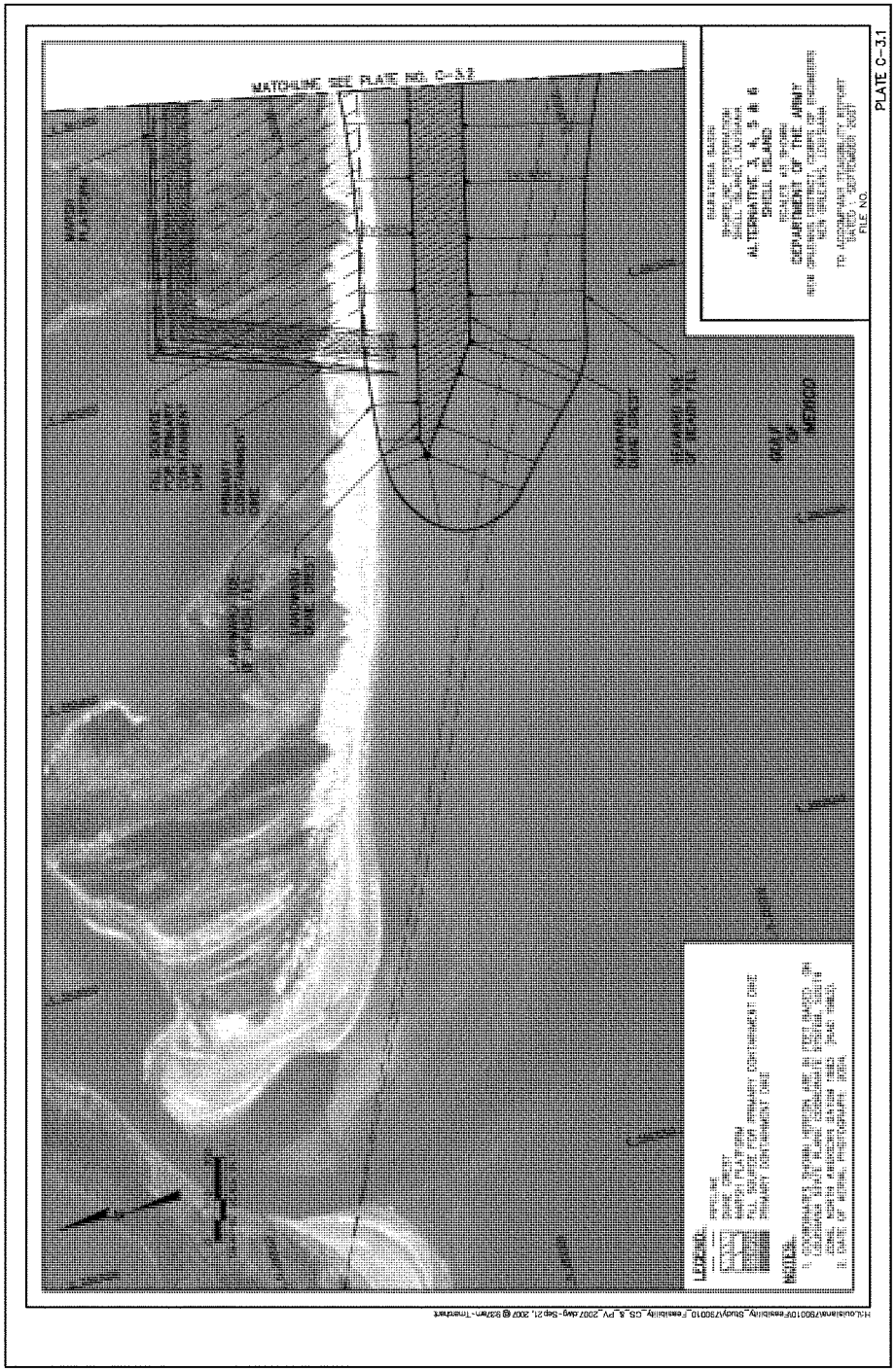

ALTERNATIVE 2 WEST
SECTION F–F'
ELEVATION (FEET NAVD)
DISTANCE (FEET)
BEACH FILL
SAND FENCE
332.0'
EL. +6.0 FT.
MARSH PLATFORM
EL. +2.0 FT.
2005 BATHYMETRY
PRIMARY CONTAINMENT DIKE
EL. +4.5 FT.
5.0'
EL. –5.0 FT.
FILL SOURCE FOR PRIMARY CONTAINMENT DIKE
75.0'
PIPELINES (ELEVATIONS UNKNOWN)
MHW = +1.6' NAVD
MLW = +0.55' NAVD
LEGEND:
BEACH FILL (SAND)
MARSH FILL
PRIMARY CONTAINMENT DIKE
FILL SOURCE FOR PRIMARY CONTAINMENT DIKE
NOTE:
1. BATHYMETRY DEVELOPED BY CPE BASED ON JCLS JUNE 2005 SURVEY.
SCALE:
1"=5' VERTICAL
1"=200' HORIZONTAL
BARATARIA BASIN
SHORELINE RESTORATION
SHELL ISLAND, LOUISIANA
ALTERNATIVE 2 WEST
SECTION F–F'
SCALES AS SHOWN
DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA
TO ACCOMPANY FEASIBILITY REPORT
DATED SEPTEMBER 2007
FILE NO.
PLATE C-2.10


MATCHLINE SEE PLATE NO. C-3.2
LEGEND:
NOTES:
ALTERNATIVE 3, 4, 5 & 6
SHELL ISLAND
DEPARTMENT OF THE ARMY
PLATE C-3.1

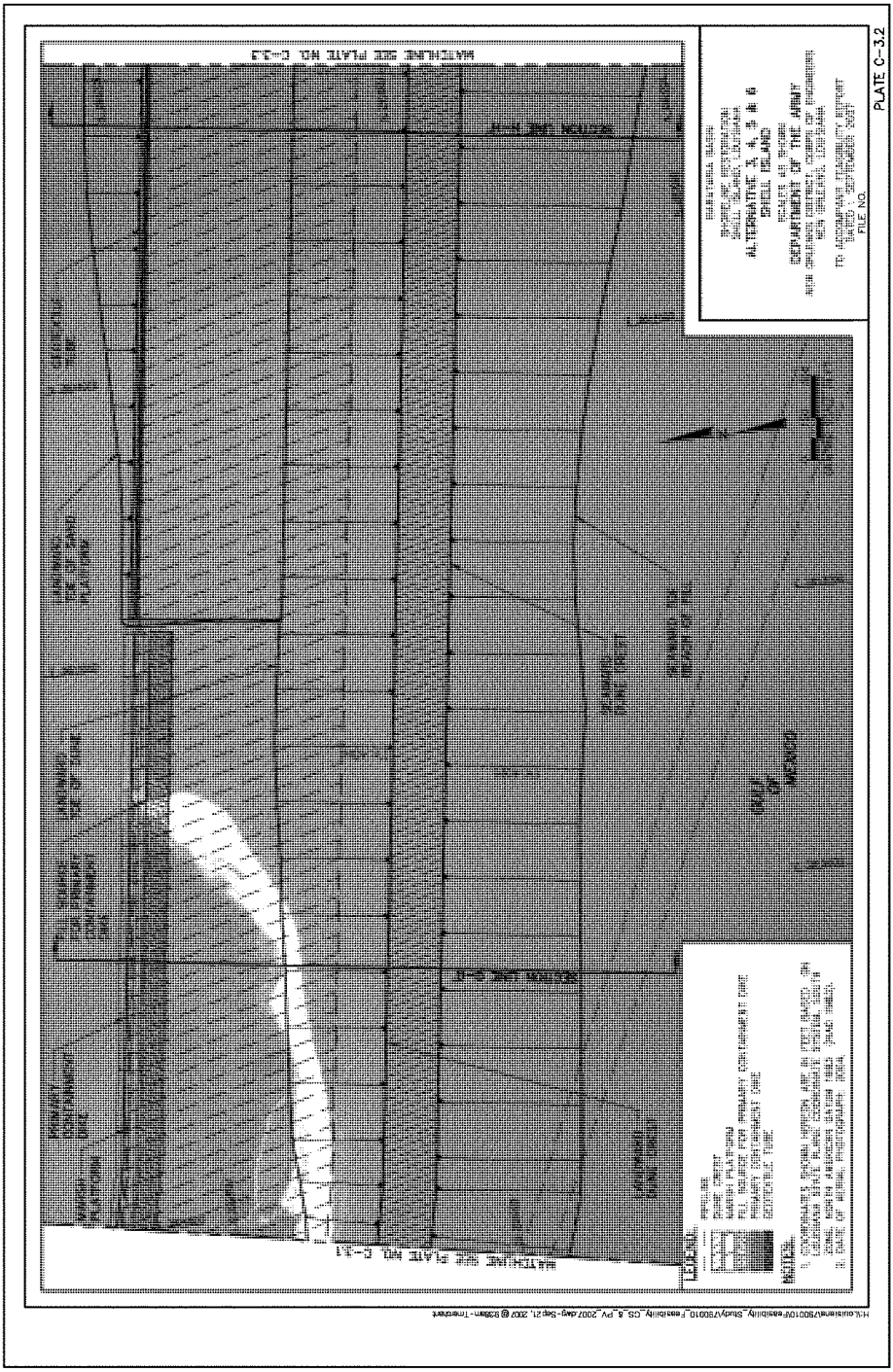


PLATE C-3.2
MATCHLINE SEE PLATE NO. C-3.3
MATCHLINE SEE PLATE NO. C-3.1
SECTION LINE N-N
SECTION LINE O-O
GULF OF MEXICO
LEGEND
NOTES
ALTERNATIVE 3, 4, 5 & 6
SHELL ISLAND
DEPARTMENT OF THE ARMY
FILE NO.

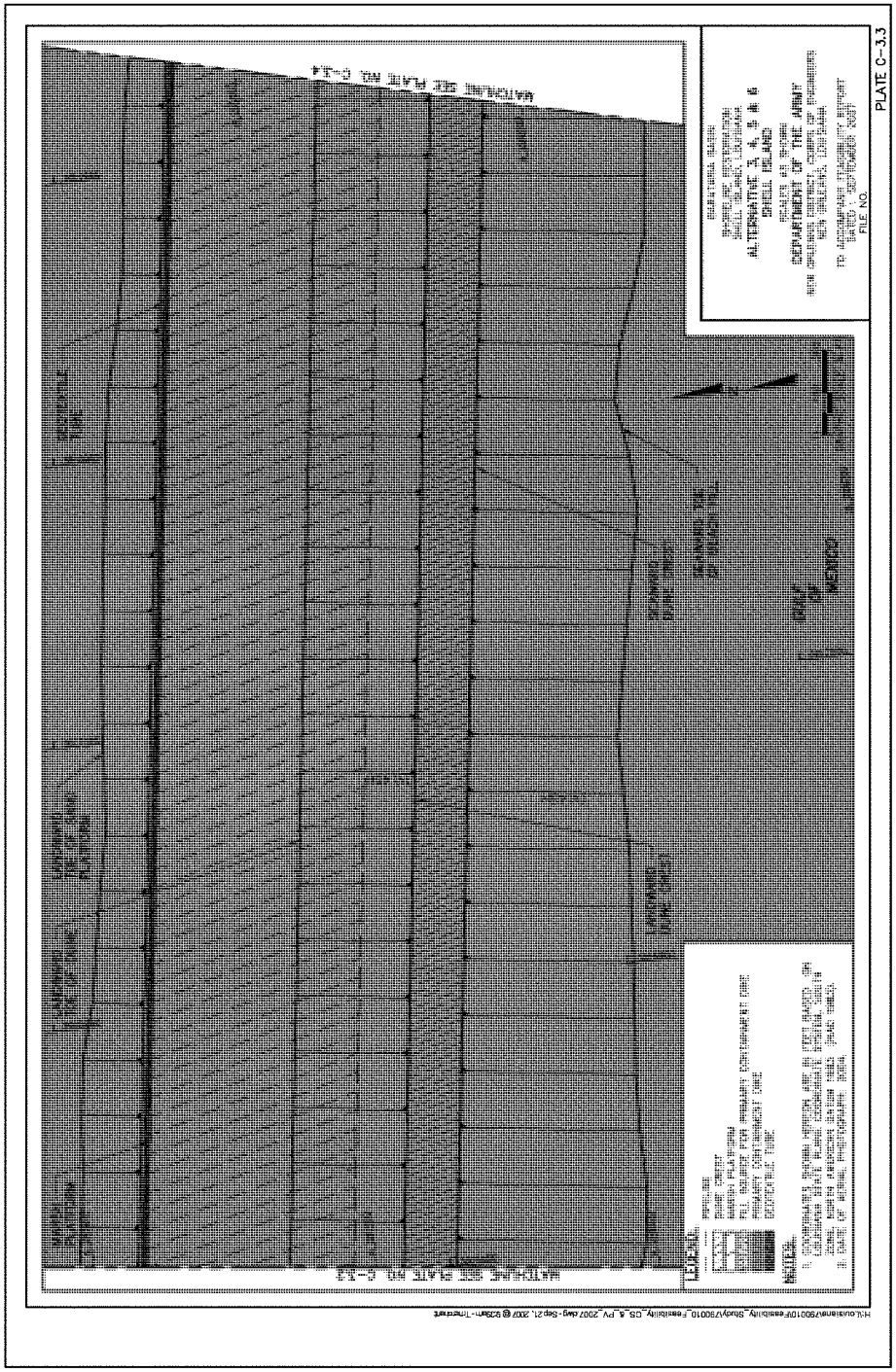


PLATE C-3.3

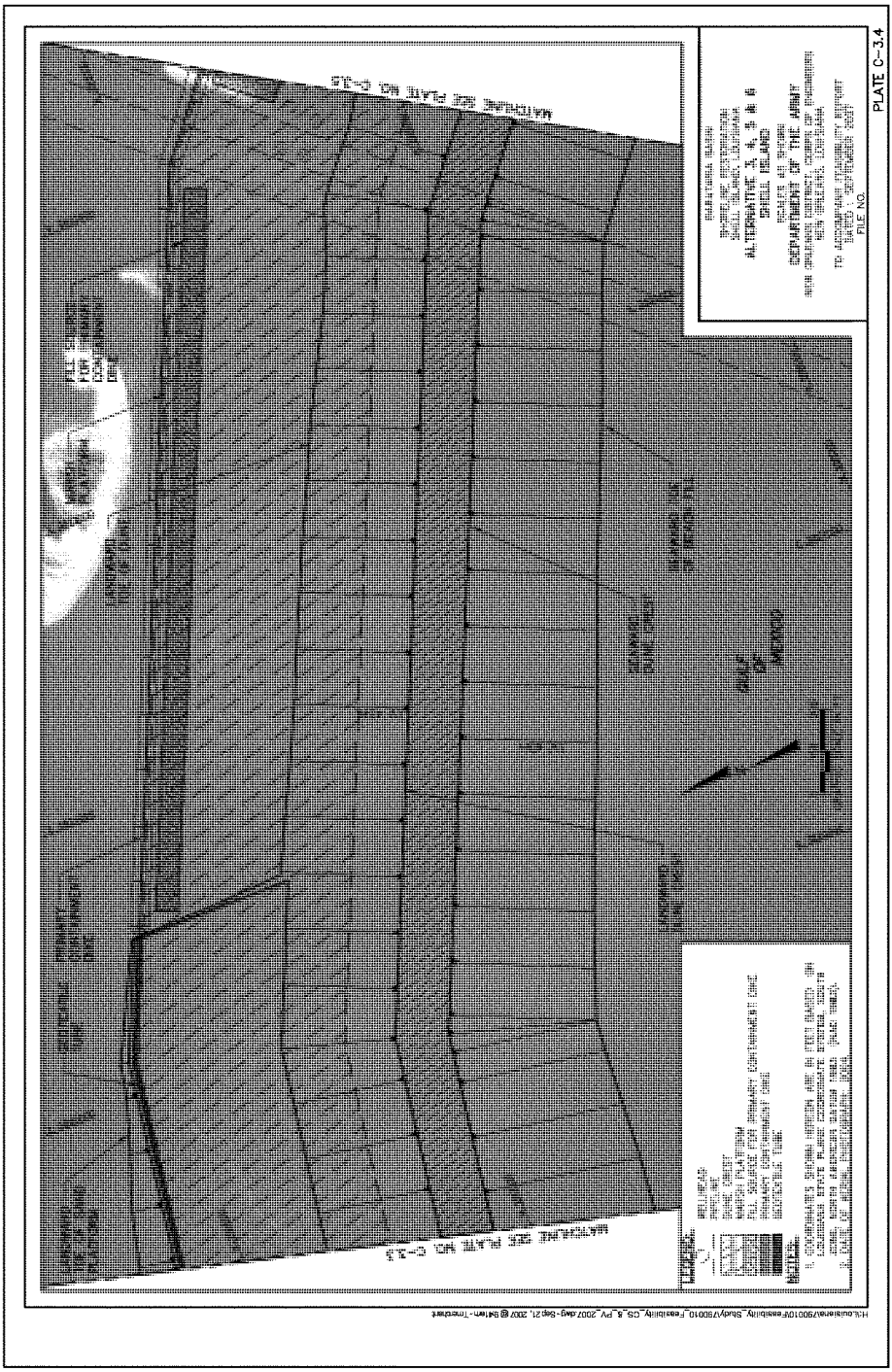


PLATE C-3.4

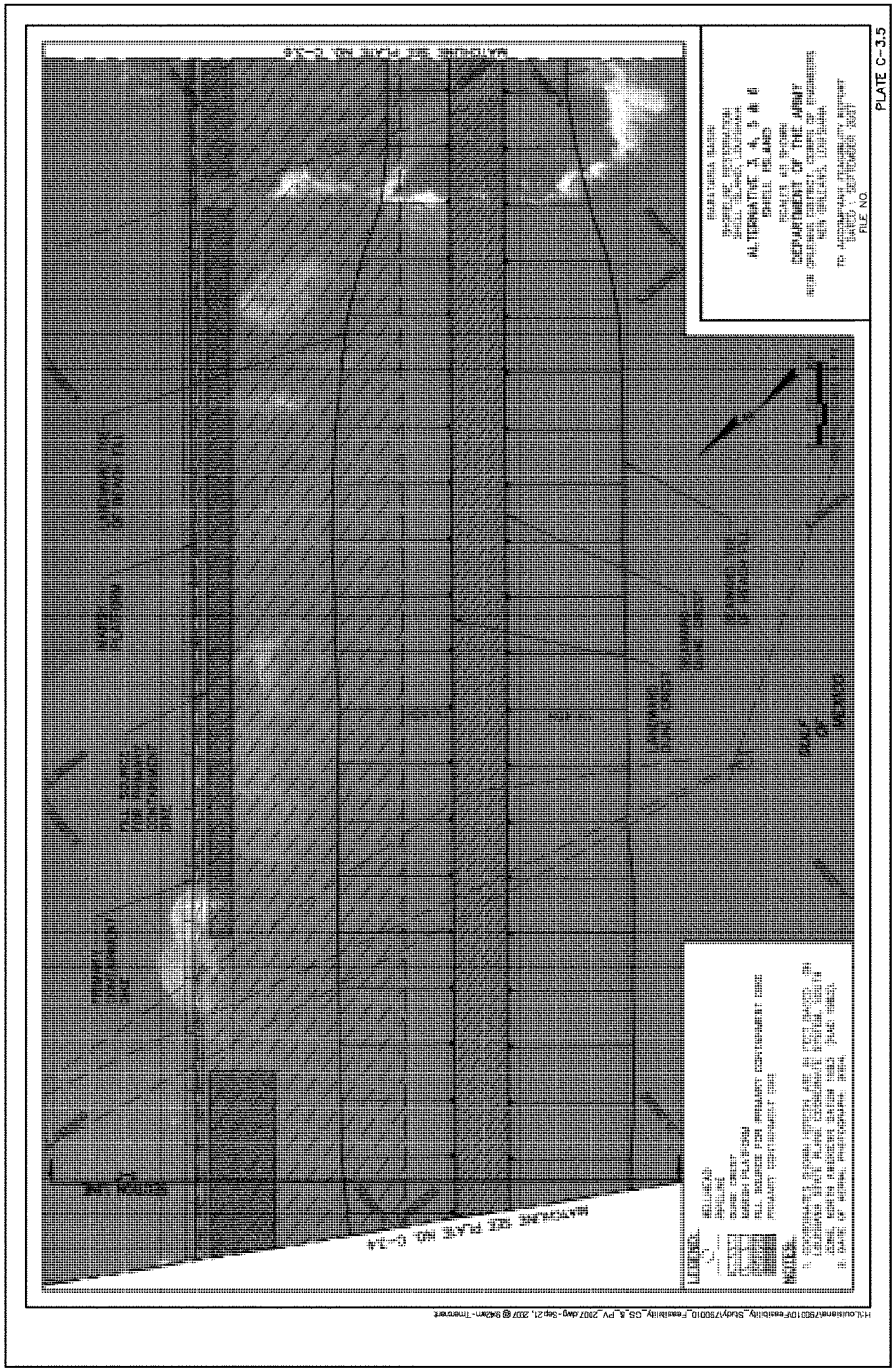


PLATE C-3.5

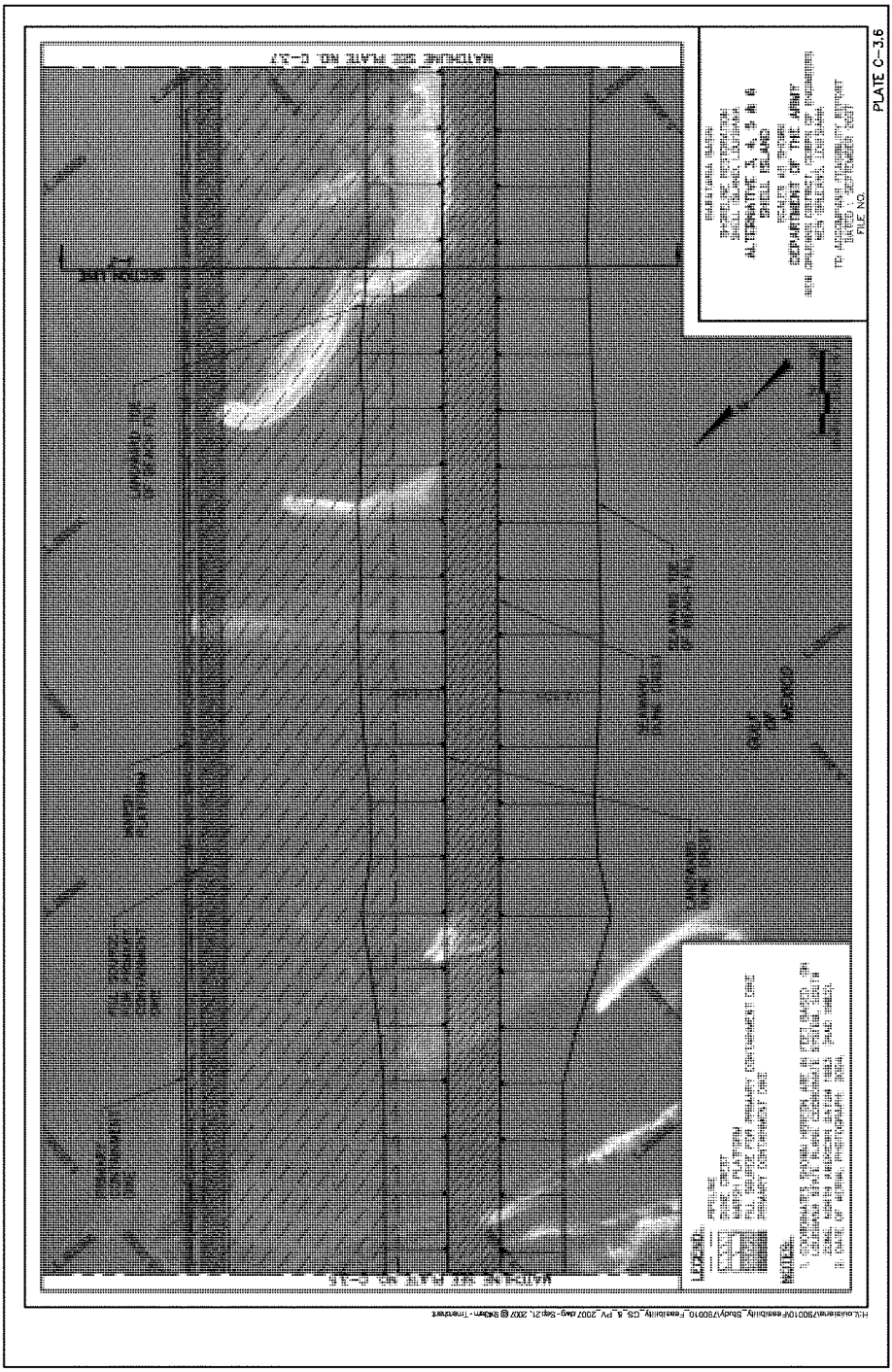


PLATE C-3.6

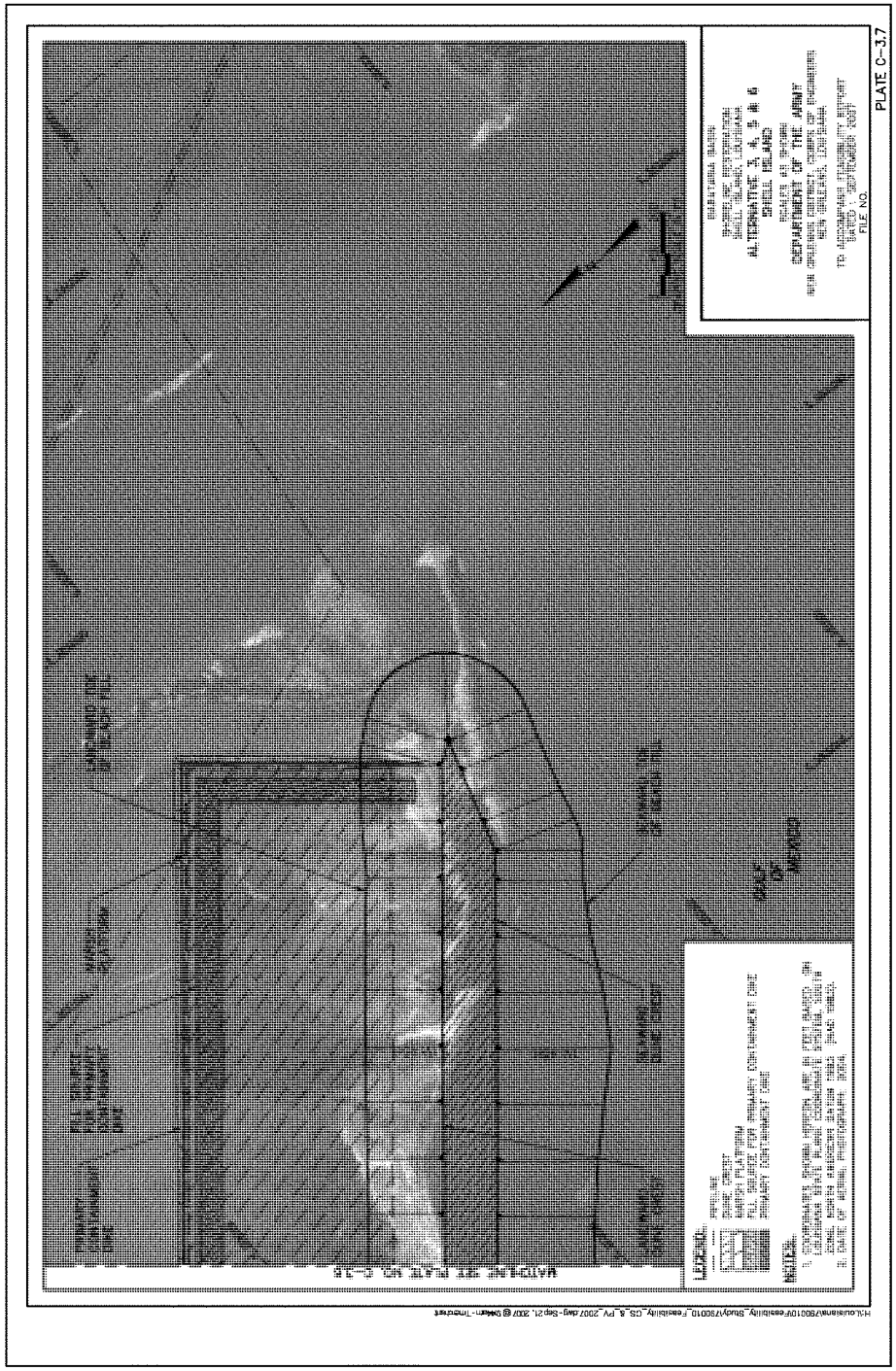
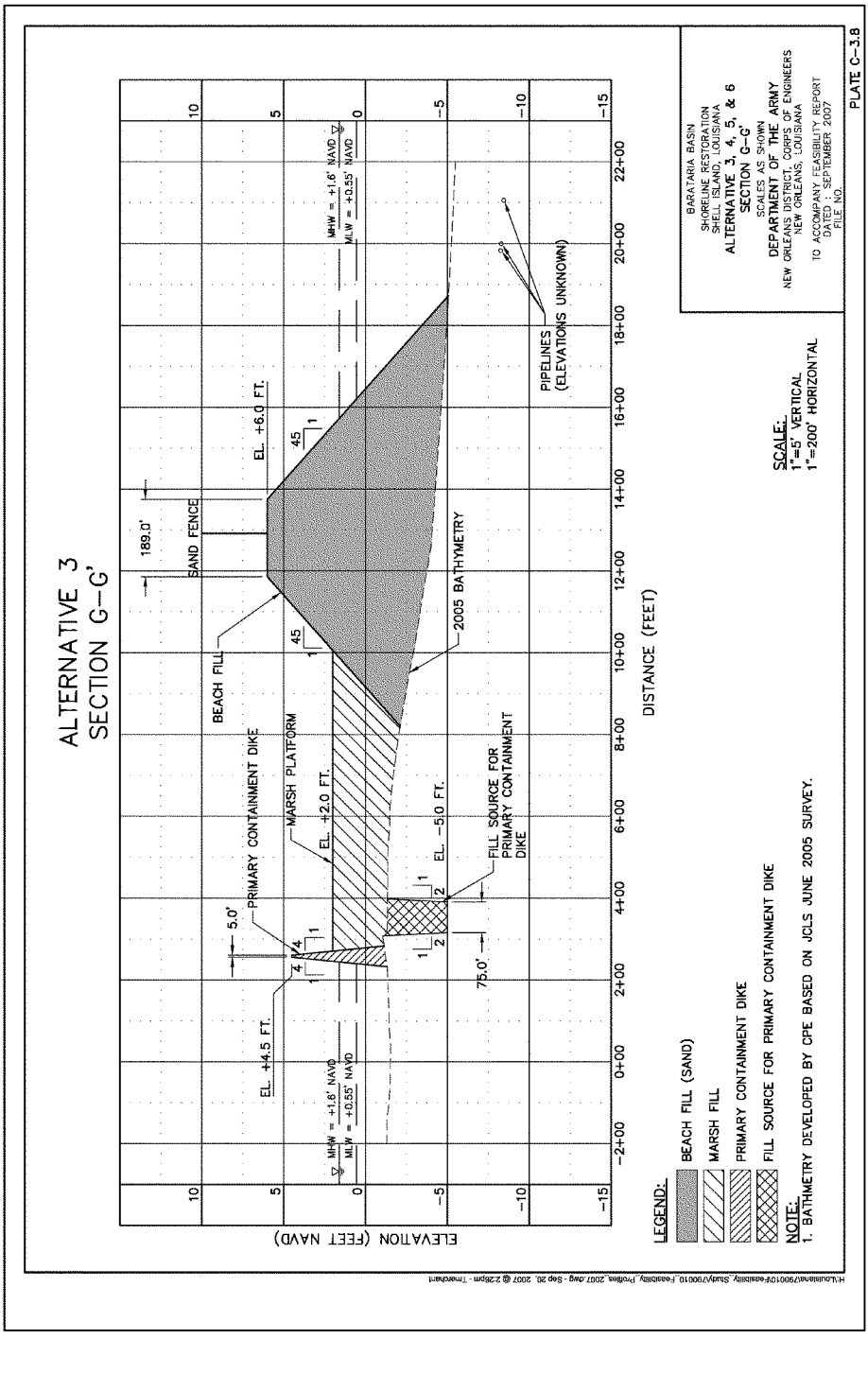
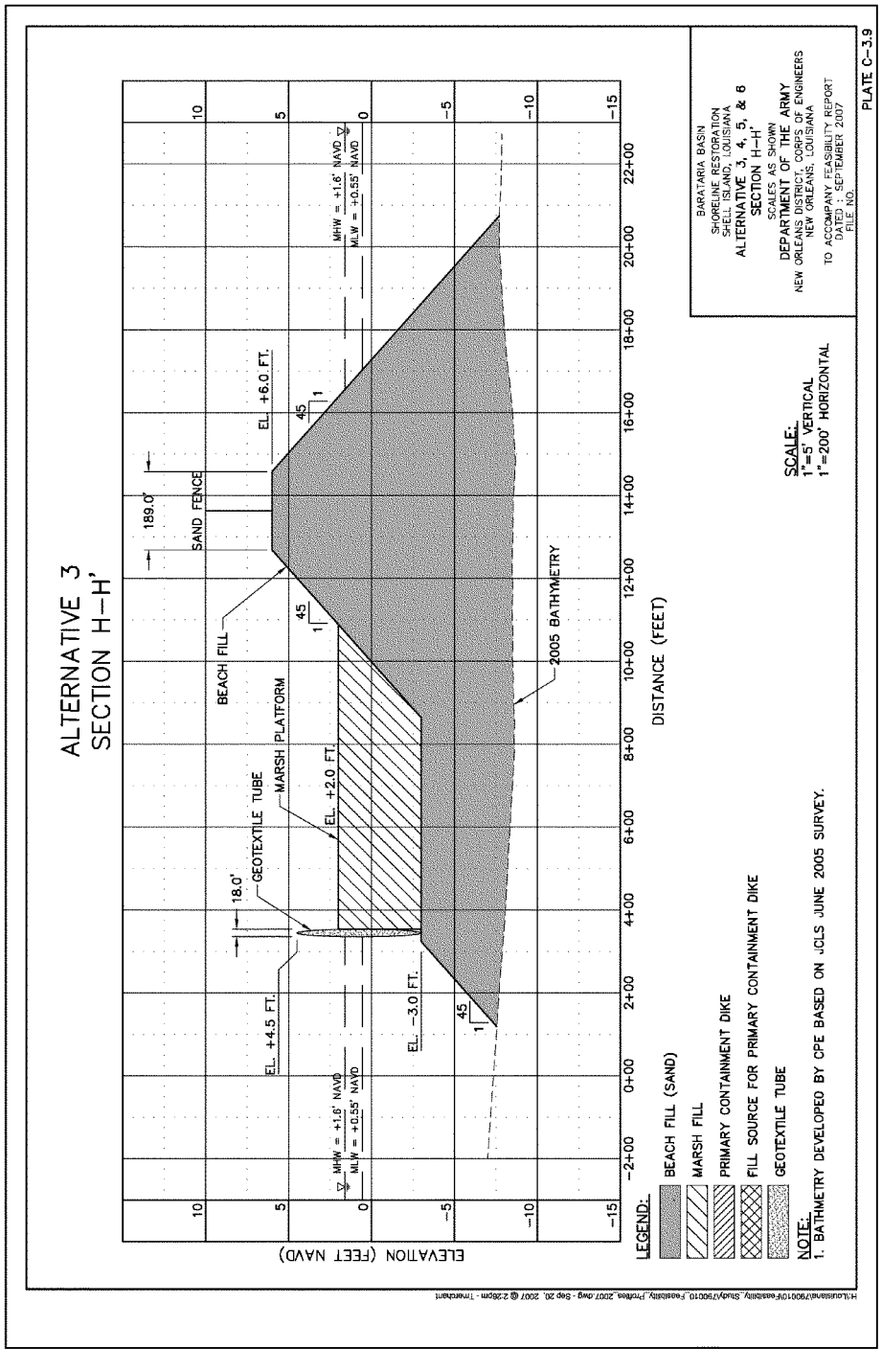
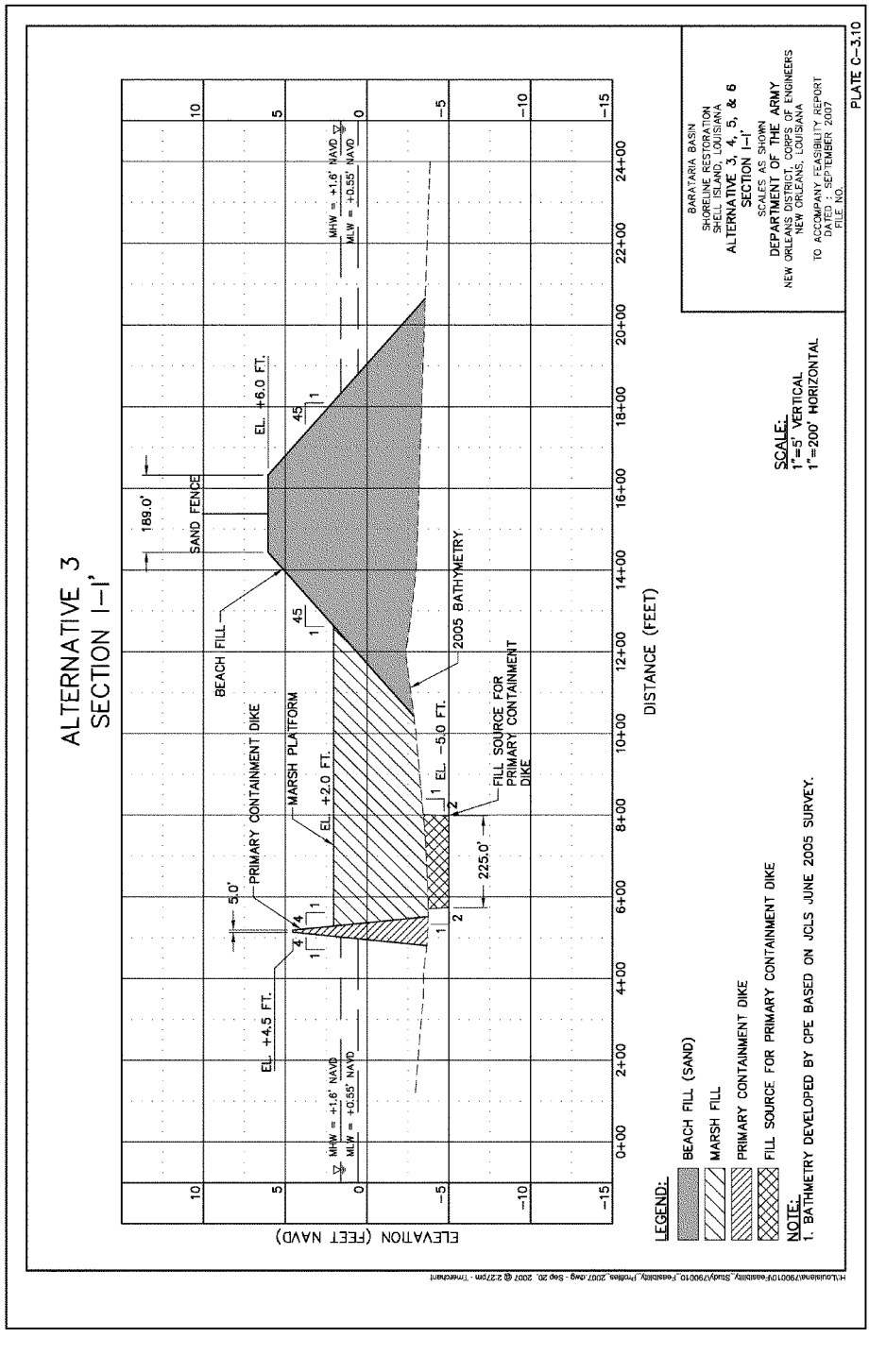
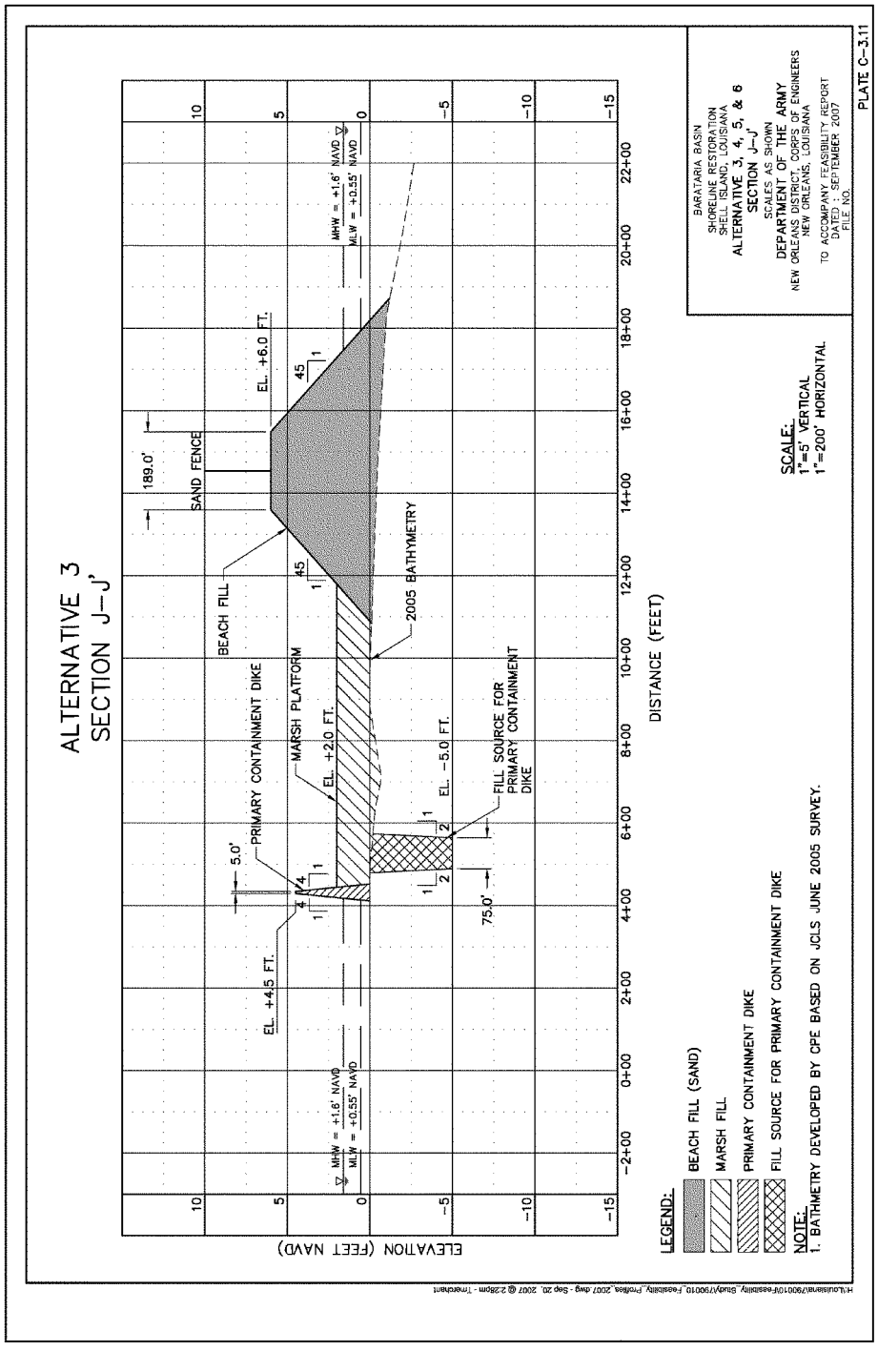


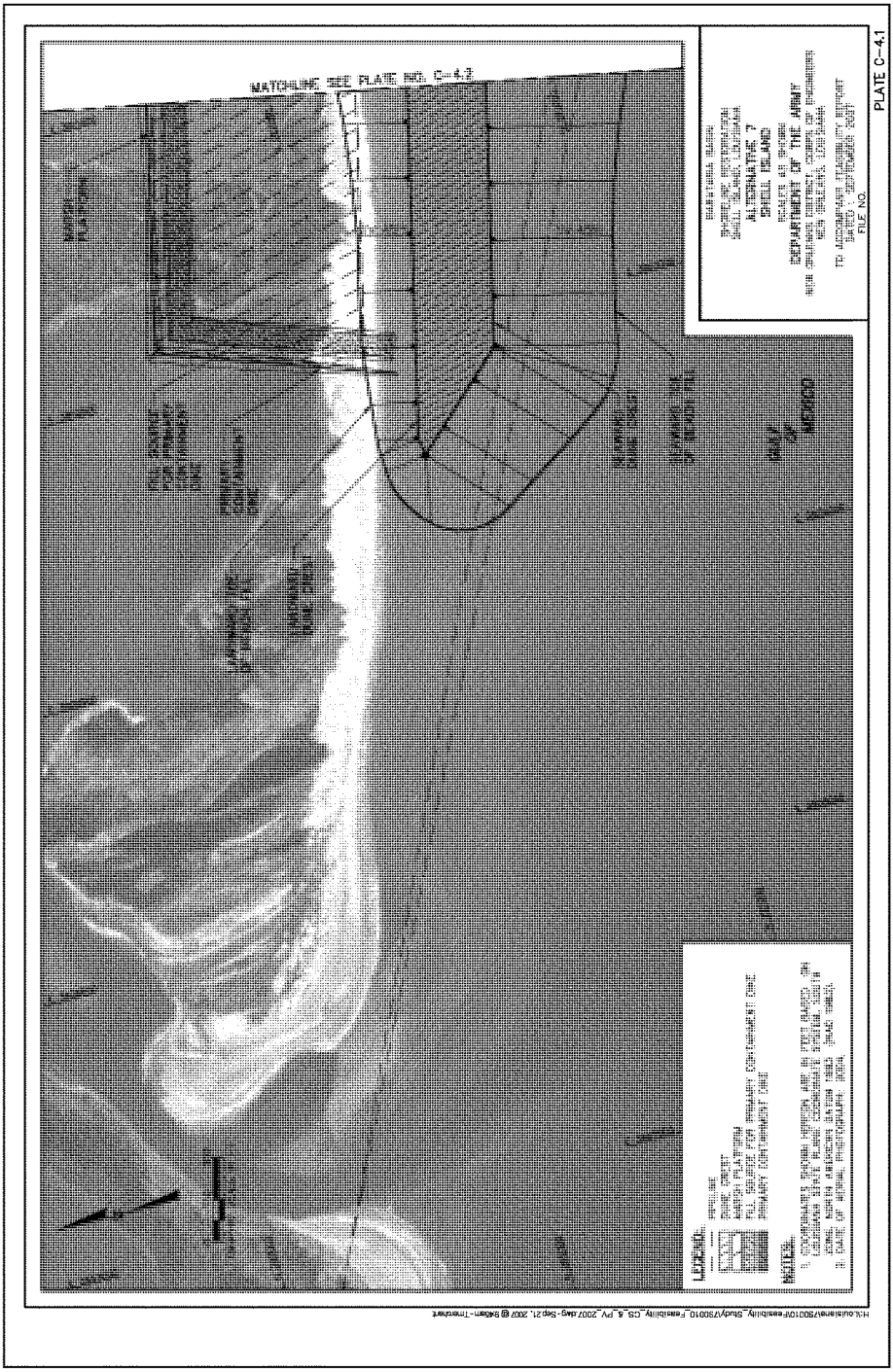
PLATE C-3.7


ALTERNATIVE 3
SECTION G–G'
ELEVATION (FEET NAVD)
DISTANCE (FEET)
BEACH FILL
SAND FENCE
189.0'
EL. +6.0 FT.
45
1
MHW = +1.6' NAVD
MLW = +0.55' NAVD
PRIMARY CONTAINMENT DIKE
5.0'
MARSH PLATFORM
EL. +2.0 FT.
EL. +4.5 FT.
EL. -5.0 FT.
FILL SOURCE FOR PRIMARY CONTAINMENT DIKE
75.0'
2005 BATHYMETRY
PIPELINES (ELEVATIONS UNKNOWN)
LEGEND:
BEACH FILL (SAND)
MARSH FILL
PRIMARY CONTAINMENT DIKE
FILL SOURCE FOR PRIMARY CONTAINMENT DIKE
NOTE:
1. BATHIMETRY DEVELOPED BY CPE BASED ON JCLS JUNE 2005 SURVEY.
SCALE:
1"=5' VERTICAL
1"=200' HORIZONTAL
BARATARIA BASIN
SHORELINE RESTORATION
SHELL ISLAND, LOUISIANA
ALTERNATIVE 3, 4, 5, & 6
SECTION G–G'
SCALES AS SHOWN
DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA
TO ACCOMPANY FEASIBILITY REPORT
DATED SEPTEMBER 2007
FILE NO.
PLATE C-3.8


ALTERNATIVE 3
SECTION H–H'
ELEVATION (FEET NAVD)
DISTANCE (FEET)
BEACH FILL
SAND FENCE
189.0'
EL. +6.0 FT.
45
1
MHW = +1.6' NAVD
MLW = +0.55' NAVD
18.0'
GEOTEXTILE TUBE
MARSH PLATFORM
EL. +2.0 FT.
EL. +4.5 FT.
EL. –3.0 FT.
2005 BATHYMETRY
LEGEND:
BEACH FILL (SAND)
MARSH FILL
PRIMARY CONTAINMENT DIKE
FILL SOURCE FOR PRIMARY CONTAINMENT DIKE
GEOTEXTILE TUBE
NOTE:
1. BATHYMETRY DEVELOPED BY CPE BASED ON JCLS JUNE 2005 SURVEY.
SCALE:
1"=5' VERTICAL
1"=200' HORIZONTAL
BARATARIA BASIN
SHORELINE RESTORATION
SHELL ISLAND, LOUISIANA
ALTERNATIVE 3, 4, 5, & 6
SECTION H–H'
SCALES AS SHOWN
DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA
TO ACCOMPANY FEASIBILITY REPORT
DATED : SEPTEMBER 2007
FILE NO.
PLATE C-3.9


ALTERNATIVE 3
SECTION I–I'
ELEVATION (FEET NAVD)
DISTANCE (FEET)
BEACH FILL
SAND FENCE
189.0'
EL. +6.0 FT.
MHW = +1.6' NAVD
MLW = +0.55' NAVD
PRIMARY CONTAINMENT DIKE
5.0'
MARSH PLATFORM
EL. +2.0 FT.
EL. +4.5 FT.
EL. -5.0 FT.
2005 BATHYMETRY
FILL SOURCE FOR PRIMARY CONTAINMENT DIKE
225.0'
LEGEND:
BEACH FILL (SAND)
MARSH FILL
PRIMARY CONTAINMENT DIKE
FILL SOURCE FOR PRIMARY CONTAINMENT DIKE
NOTE:
1. BATHYMETRY DEVELOPED BY CPE BASED ON JCLS JUNE 2005 SURVEY.
SCALE:
1"=5' VERTICAL
1"=200' HORIZONTAL
BARATARIA BASIN
SHORELINE RESTORATION
SHELL ISLAND, LOUISIANA
ALTERNATIVE 3, 4, 5, & 6
SECTION I–I'
SCALES AS SHOWN
DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA
TO ACCOMPANY FEASIBILITY REPORT
DATED SEPTEMBER 2007
FILE NO.
PLATE C-3.10


ALTERNATIVE 3
SECTION J–J'
ELEVATION (FEET NAVD)
DISTANCE (FEET)
BEACH FILL
SAND FENCE
189.0'
EL. +6.0 FT.
PRIMARY CONTAINMENT DIKE
5.0'
EL. +4.5 FT.
MARSH PLATFORM
EL. +2.0 FT.
2005 BATHYMETRY
FILL SOURCE FOR PRIMARY CONTAINMENT DIKE
EL. -5.0 FT.
75.0'
MHW = +1.6' NAVD
MLW = +0.55' NAVD
LEGEND:
BEACH FILL (SAND)
MARSH FILL
PRIMARY CONTAINMENT DIKE
FILL SOURCE FOR PRIMARY CONTAINMENT DIKE
NOTE:
1. BATHYMETRY DEVELOPED BY CPE BASED ON JCLS JUNE 2005 SURVEY.
SCALE:
1"=5' VERTICAL
1"=200' HORIZONTAL
BARATARIA BASIN
SHORELINE RESTORATION
SHELL ISLAND, LOUISIANA
ALTERNATIVE 3, 4, 5, & 6
SECTION J–J'
SCALES AS SHOWN
DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA
TO ACCOMPANY FEASIBILITY REPORT
DATED : SEPTEMBER 2007
FILE NO.
PLATE C-3.11


MATCHLINE SEE PLATE NO. C-4.2
LEGEND:
NOTES:
PLATE C-4.1

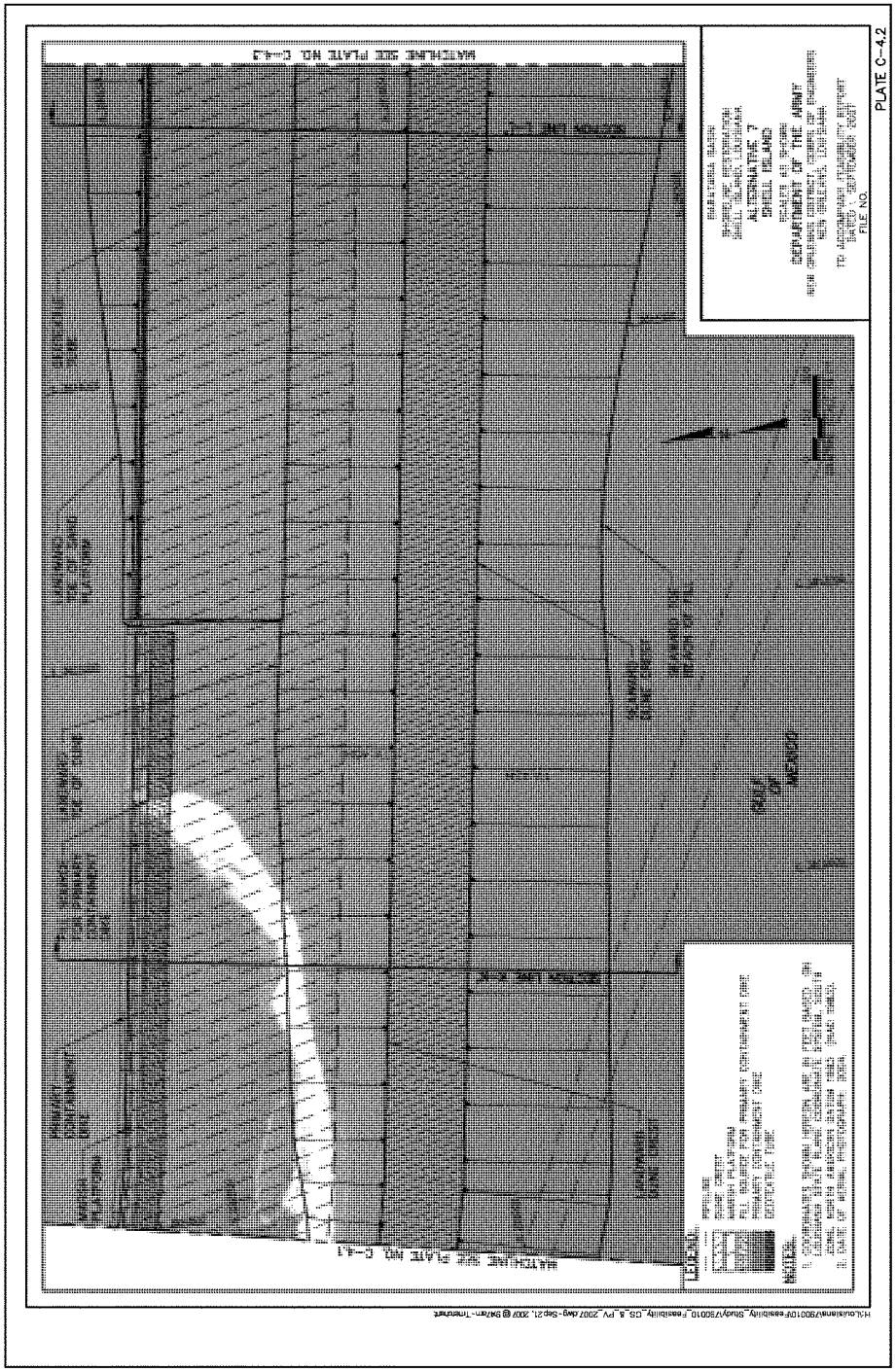


PLATE C-4.2
DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA
MATCHLINE SEE PLATE NO. C-4.1
MATCHLINE SEE PLATE NO. C-4.3
LEGEND
NOTES:

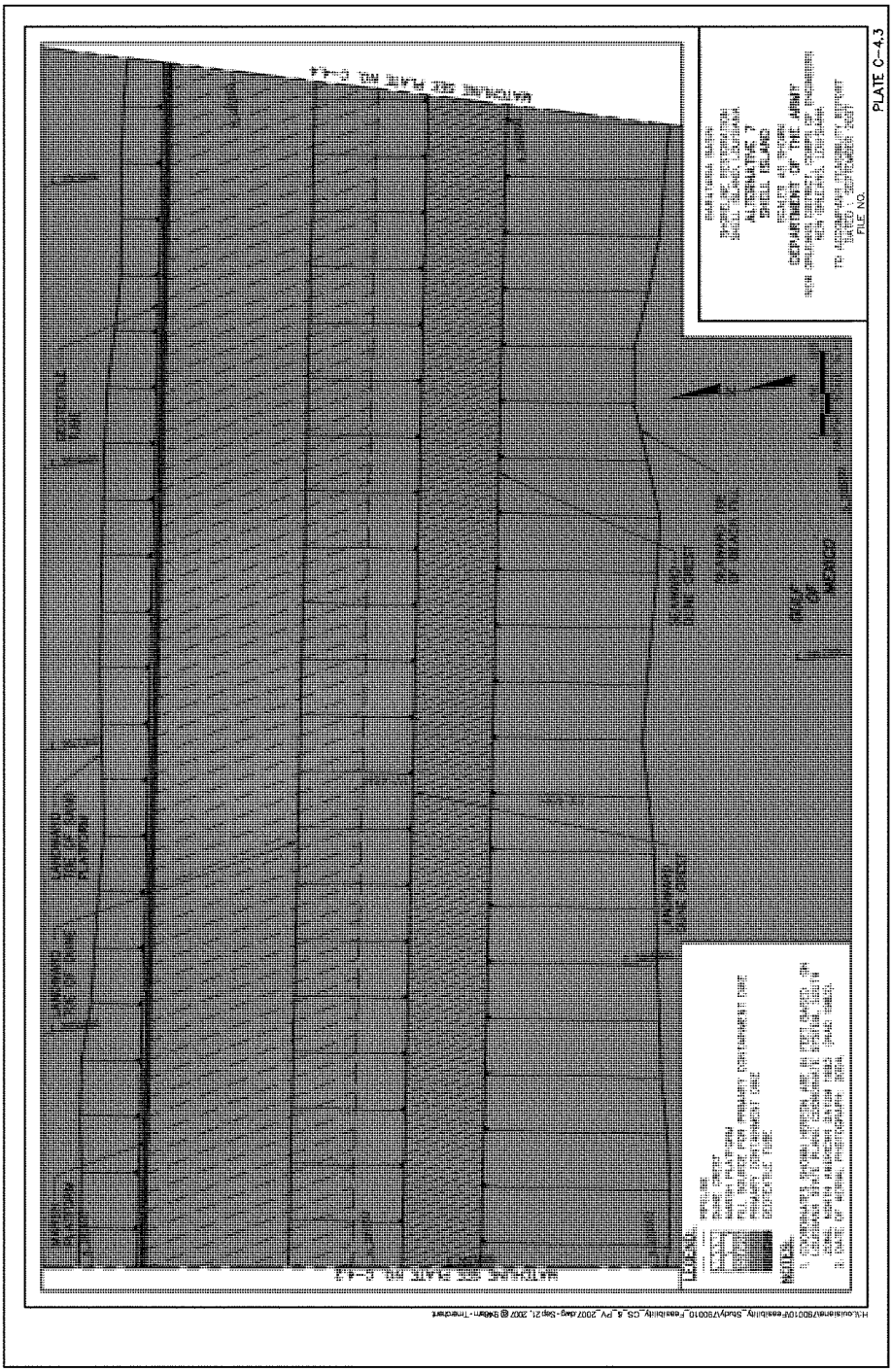


PLATE C-4.3

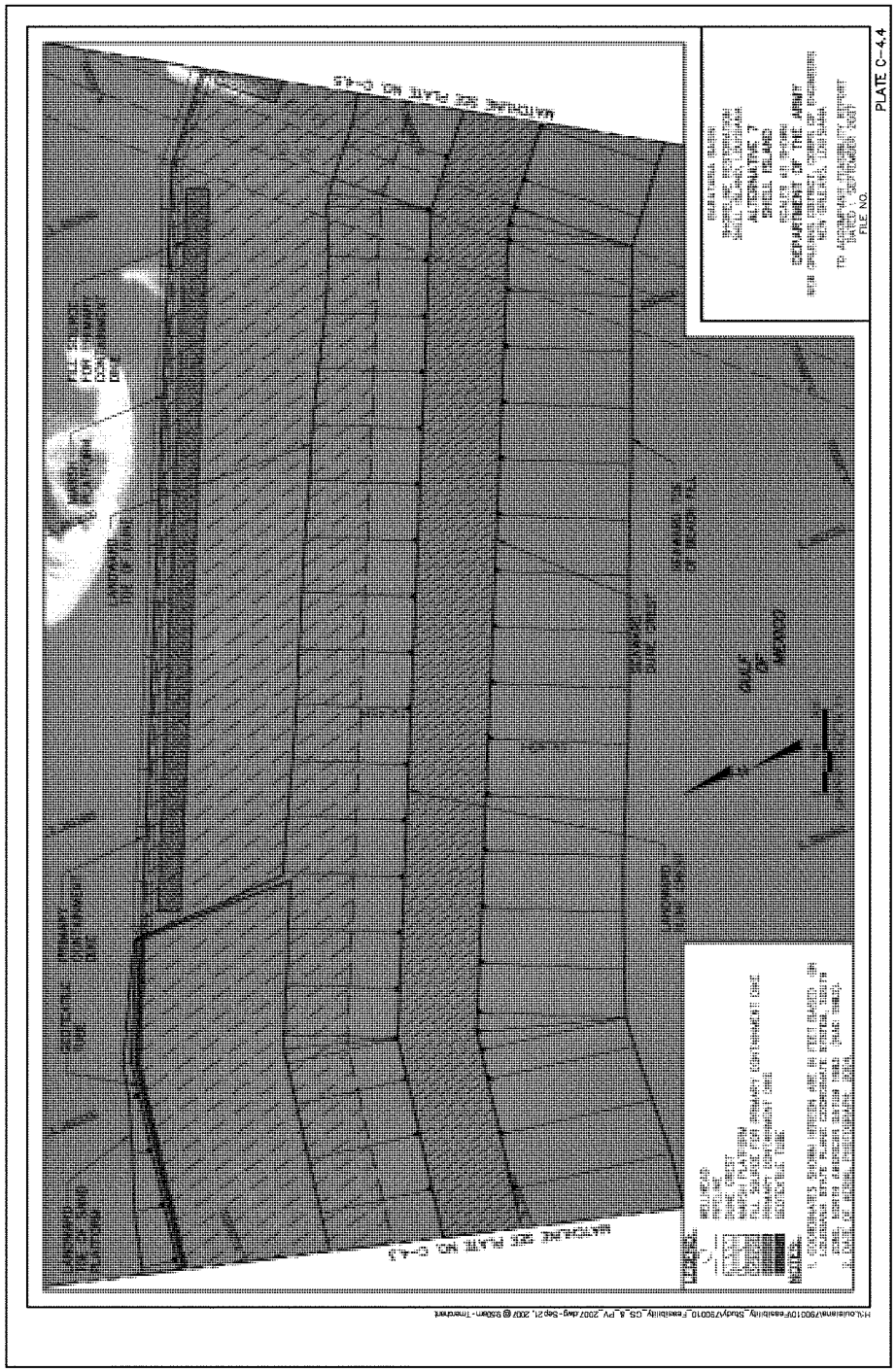


PLATE C-4.4

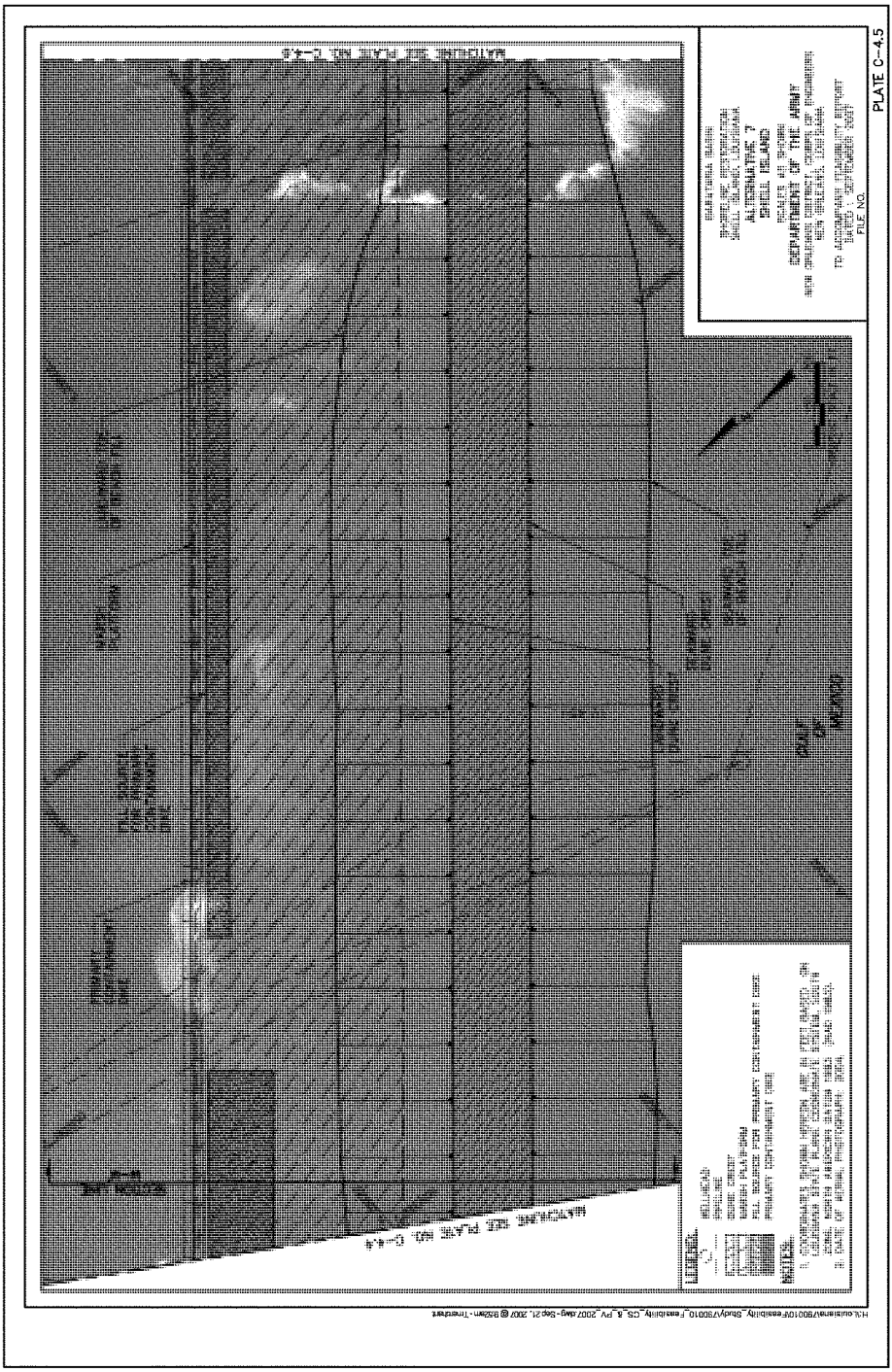


PLATE C-4.5

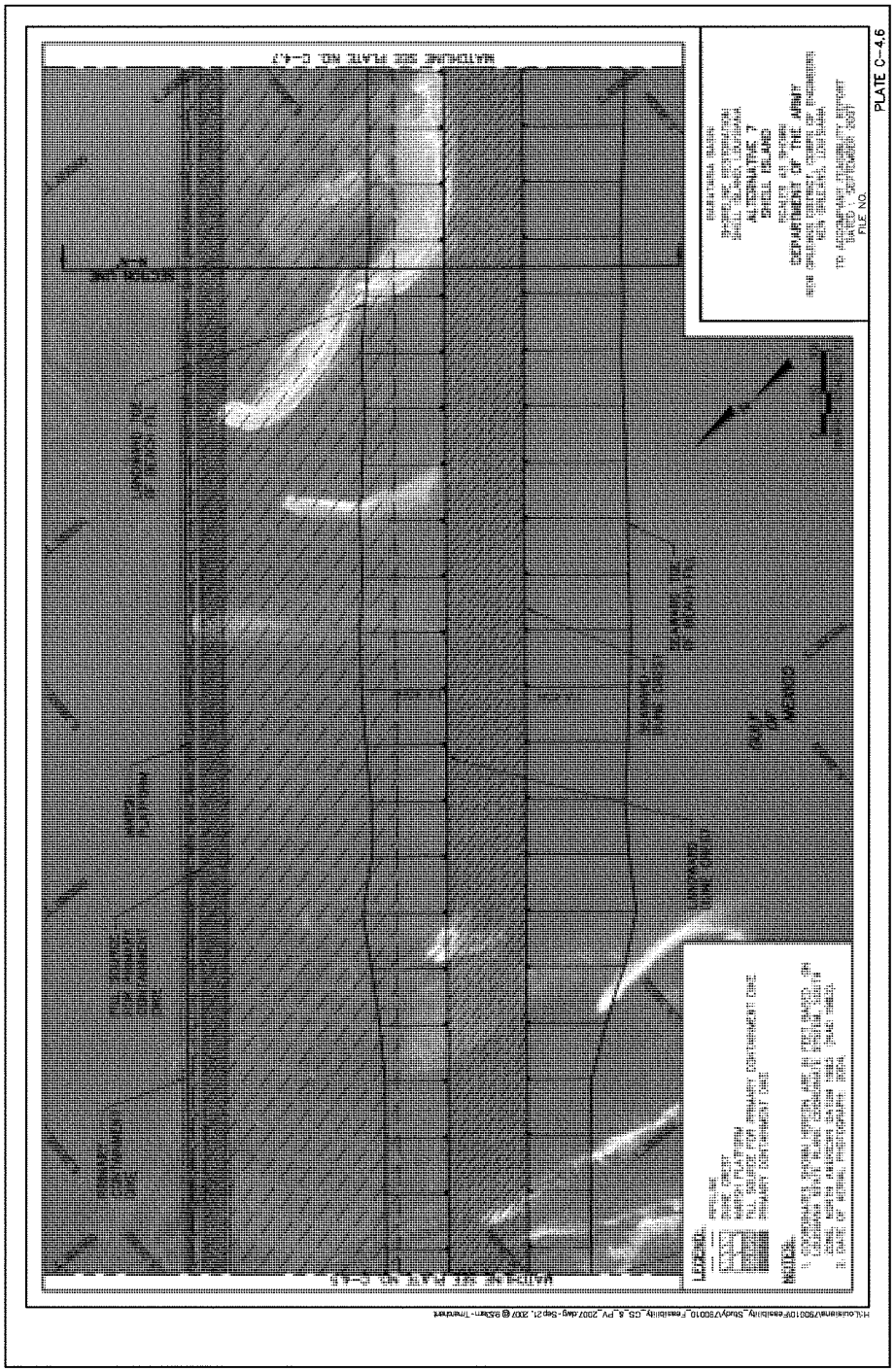
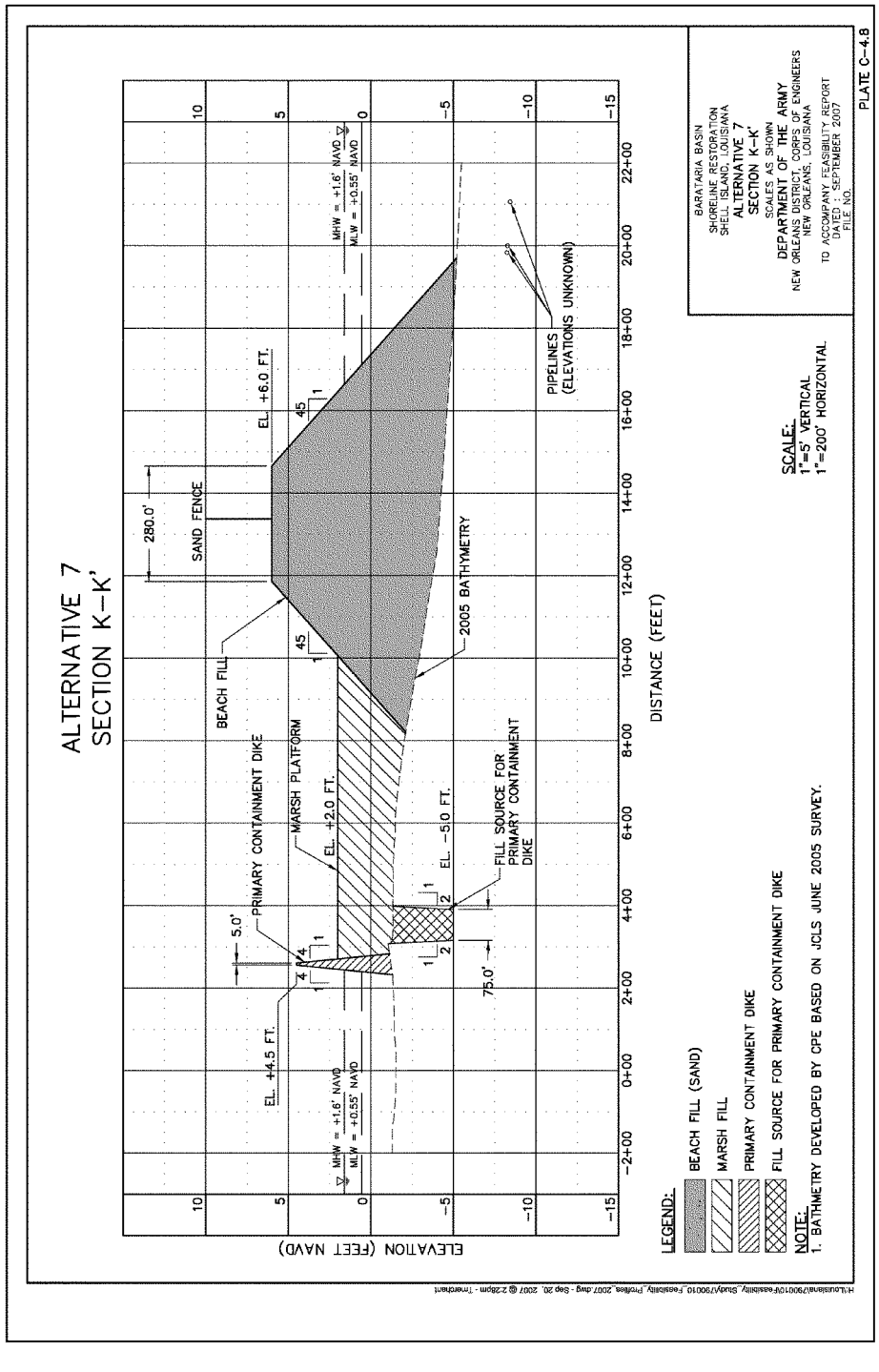


PLATE C-4.6
ALTERNATIVE 7
SHELL ISLAND
DEPARTMENT OF THE ARMY
FILE NO.
MATCHLINE SEE PLATE NO. C-4.7
MATCHLINE SEE PLATE NO. C-4.5
GULF OF MEXICO
LEGEND:
NOTES:

PLATE C-4.7


ALTERNATIVE 7
SECTION K–K'
BEACH FILL
SAND FENCE
280.0'
EL. +6.0 FT.
45
1
MHW = +1.6' NAVD
MLW = +0.55' NAVD
PIPELINES
(ELEVATIONS UNKNOWN)
2005 BATHYMETRY
PRIMARY CONTAINMENT DIKE
MARSH PLATFORM
EL. +2.0 FT.
EL. +4.5 FT.
5.0'
4
1
EL. -5.0 FT.
FILL SOURCE FOR PRIMARY CONTAINMENT DIKE
75.0'
2
ELEVATION (FEET NAVD)
DISTANCE (FEET)
10
5
0
-5
-10
-15
-2+00
0+00
2+00
4+00
6+00
8+00
10+00
12+00
14+00
16+00
18+00
20+00
22+00
LEGEND:
BEACH FILL (SAND)
MARSH FILL
PRIMARY CONTAINMENT DIKE
FILL SOURCE FOR PRIMARY CONTAINMENT DIKE
NOTE:
1. BATHIMETRY DEVELOPED BY CPE BASED ON JCLS JUNE 2005 SURVEY.
SCALE:
1"=5' VERTICAL
1"=200' HORIZONTAL
BARATARIA BASIN
SHORELINE RESTORATION
SHELL ISLAND, LOUISIANA
ALTERNATIVE 7
SECTION K–K'
SCALES AS SHOWN
DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA
TO ACCOMPANY FEASIBILITY REPORT
DATED : SEPTEMBER 2007
FILE NO.
PLATE C-4.8
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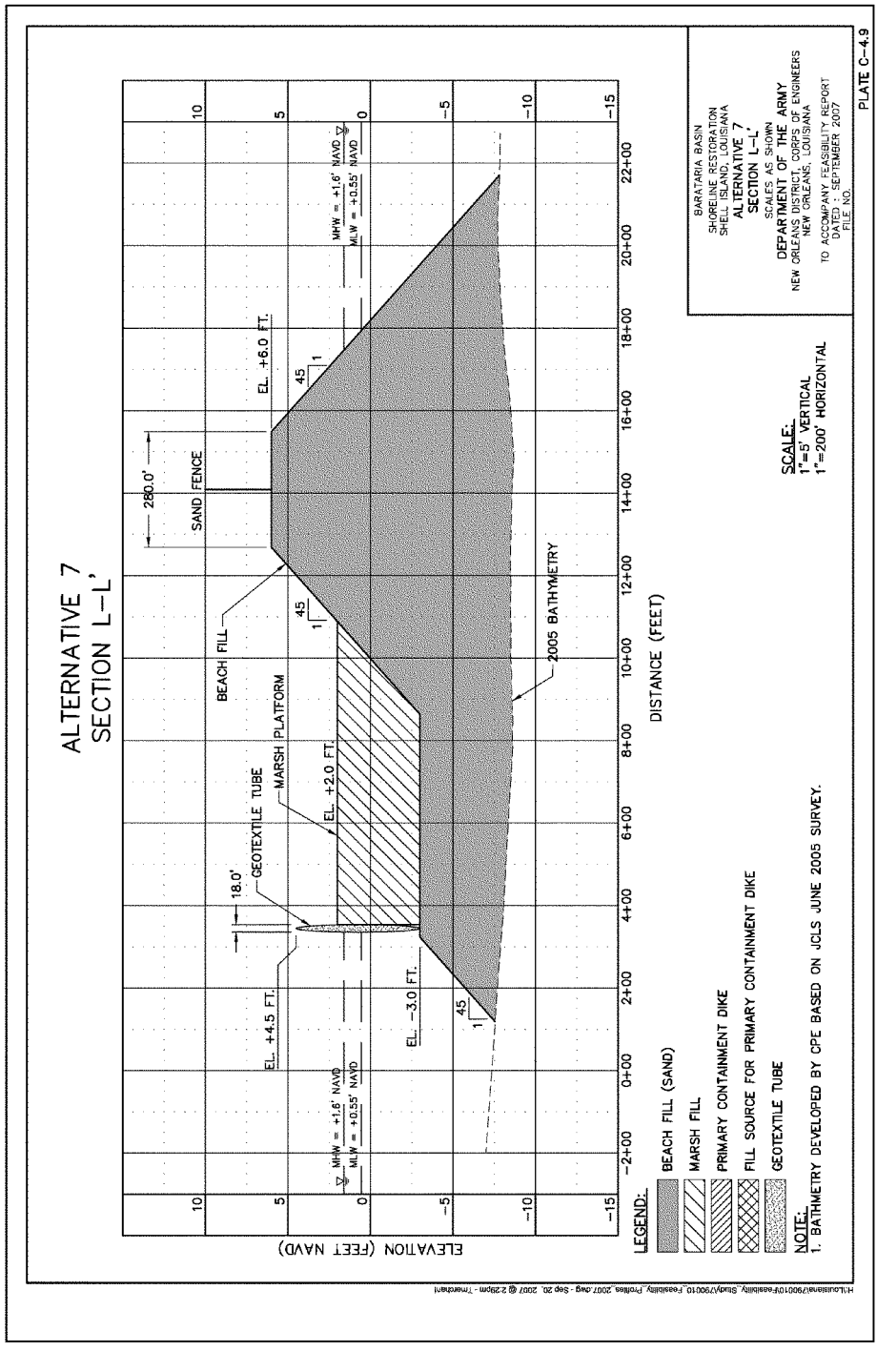
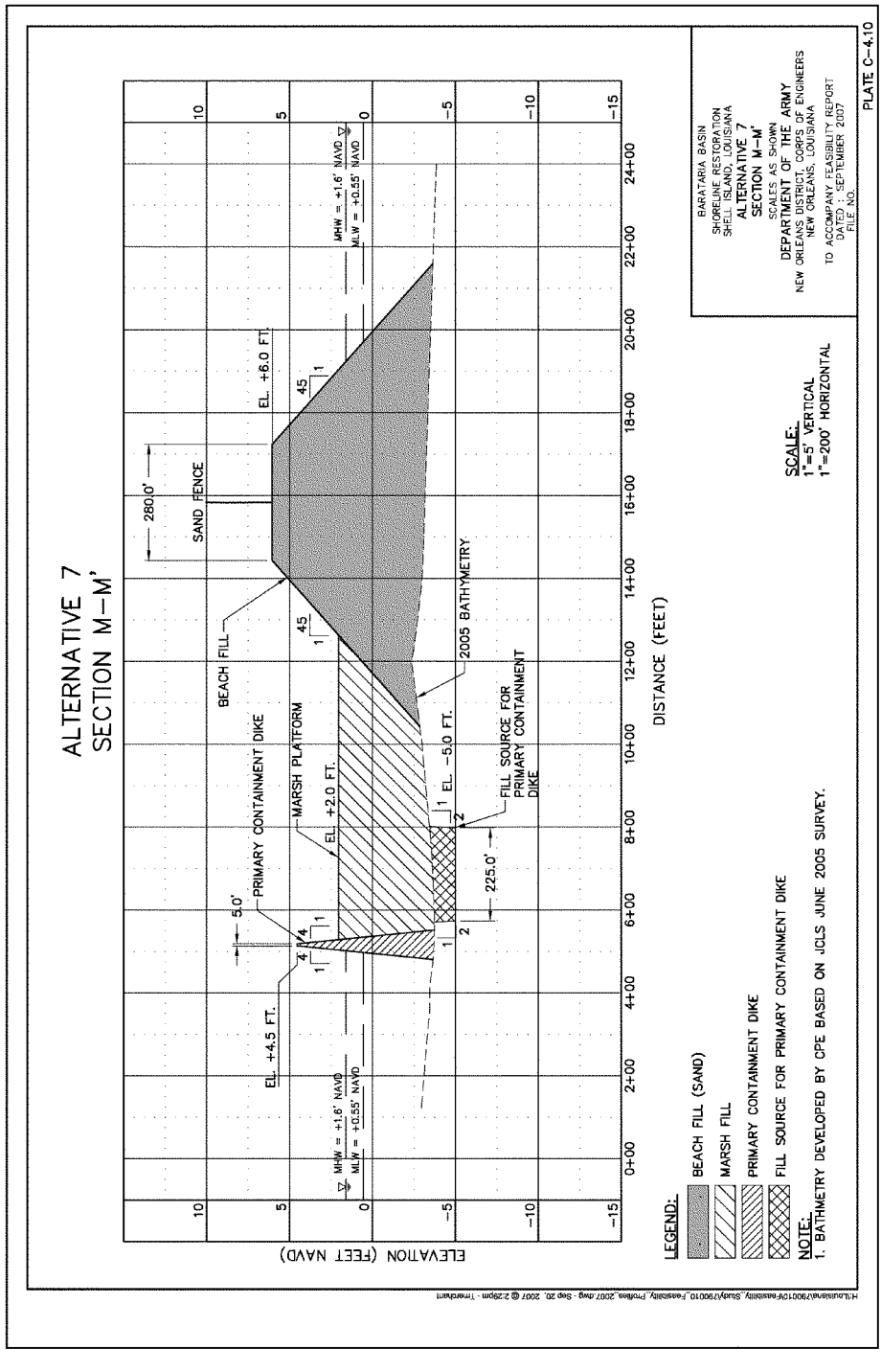

ALTERNATIVE 7
SECTION L-L'
ELEVATION (FEET NAVD)
DISTANCE (FEET)
BEACH FILL
SAND FENCE
280.0'
EL. +6.0 FT.
45
1
MHW = +1.6' NAVD
MLW = +0.55' NAVD
18.0'
GEOTEXTILE TUBE
MARSH PLATFORM
EL. +2.0 FT.
EL. +4.5 FT.
EL. -3.0 FT.
2005 BATHYMETRY
LEGEND:
BEACH FILL (SAND)
MARSH FILL
PRIMARY CONTAINMENT DIKE
FILL SOURCE FOR PRIMARY CONTAINMENT DIKE
GEOTEXTILE TUBE
NOTE:
1. BATHYMETRY DEVELOPED BY CPE BASED ON JCLS JUNE 2005 SURVEY.
SCALE:
1"=5' VERTICAL
1"=200' HORIZONTAL
BARATARIA BASIN
SHORELINE RESTORATION
SHELL ISLAND, LOUISIANA
ALTERNATIVE 7
SECTION L-L'
SCALES AS SHOWN
DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA
TO ACCOMPANY FEASIBILITY REPORT
DATED SEPTEMBER 2007
FILE NO.
PLATE C-4.9


ALTERNATIVE 7
SECTION M–M'
ELEVATION (FEET NAVD)
DISTANCE (FEET)
BEACH FILL
SAND FENCE
280.0'
EL. +6.0 FT.
MHW = +1.6' NAVD
MLW = +0.55' NAVD
45
1
PRIMARY CONTAINMENT DIKE
5.0'
MARSH PLATFORM
EL. +2.0 FT.
EL. +4.5 FT.
4
1
2
225.0'
EL. -5.0 FT.
2005 BATHYMETRY
FILL SOURCE FOR PRIMARY CONTAINMENT DIKE
0+00
2+00
4+00
6+00
8+00
10+00
12+00
14+00
16+00
18+00
20+00
22+00
24+00
10
5
0
-5
-10
-15
LEGEND:
BEACH FILL (SAND)
MARSH FILL
PRIMARY CONTAINMENT DIKE
FILL SOURCE FOR PRIMARY CONTAINMENT DIKE
NOTE:
1. BATHYMETRY DEVELOPED BY CPE BASED ON JCLS JUNE 2005 SURVEY.
SCALE:
1"=5' VERTICAL
1"=200' HORIZONTAL
BARATARIA BASIN
SHORELINE RESTORATION
SHELL ISLAND, LOUISIANA
ALTERNATIVE 7
SECTION M–M'
SCALES AS SHOWN
DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA
TO ACCOMPANY FEASIBILITY REPORT
DATED : SEPTEMBER 2007
FILE NO.
PLATE C-4.10
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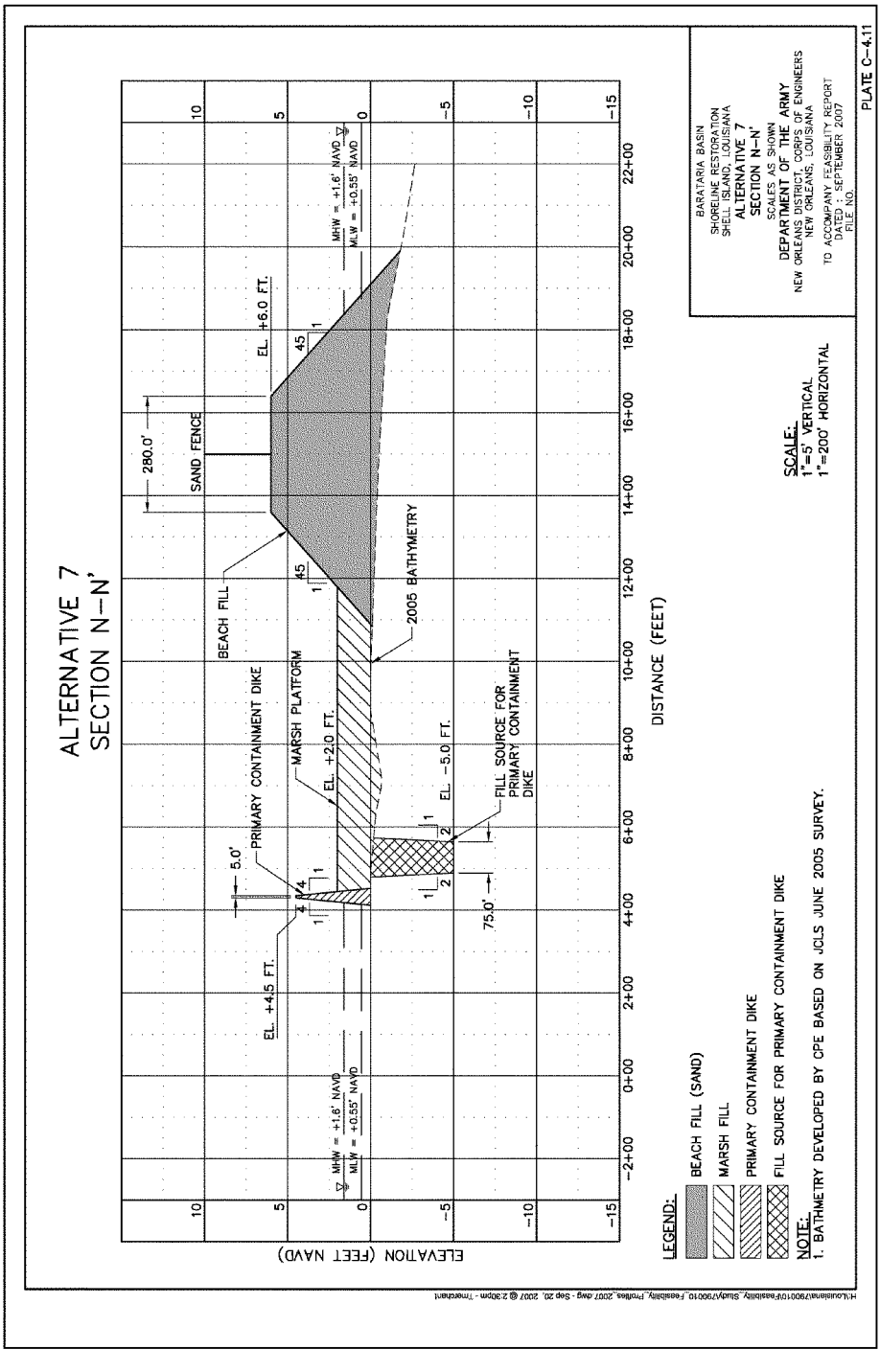

ALTERNATIVE 7
SECTION N-N'
ELEVATION (FEET NAVD)
DISTANCE (FEET)
BEACH FILL
SAND FENCE
280.0'
EL. +6.0 FT.
MHW = +1.6' NAVD
MLW = +0.55' NAVD
2005 BATHYMETRY
MARSH PLATFORM
EL. +2.0 FT.
PRIMARY CONTAINMENT DIKE
5.0'
EL. +4.5 FT.
FILL SOURCE FOR PRIMARY CONTAINMENT DIKE
EL. -5.0 FT.
75.0'
LEGEND:
BEACH FILL (SAND)
MARSH FILL
PRIMARY CONTAINMENT DIKE
FILL SOURCE FOR PRIMARY CONTAINMENT DIKE
NOTE:
1. BATHYMETRY DEVELOPED BY CPE BASED ON JCLS JUNE 2005 SURVEY.
SCALE:
1"=5' VERTICAL
1"=200' HORIZONTAL
BARATARIA BASIN
SHORELINE RESTORATION
SHELL ISLAND, LOUISIANA
ALTERNATIVE 7
SECTION N-N'
SCALES AS SHOWN
DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA
TO ACCOMPANY FEASIBILITY REPORT
DATED SEPTEMBER 2007
FILE NO.
PLATE C-4.11

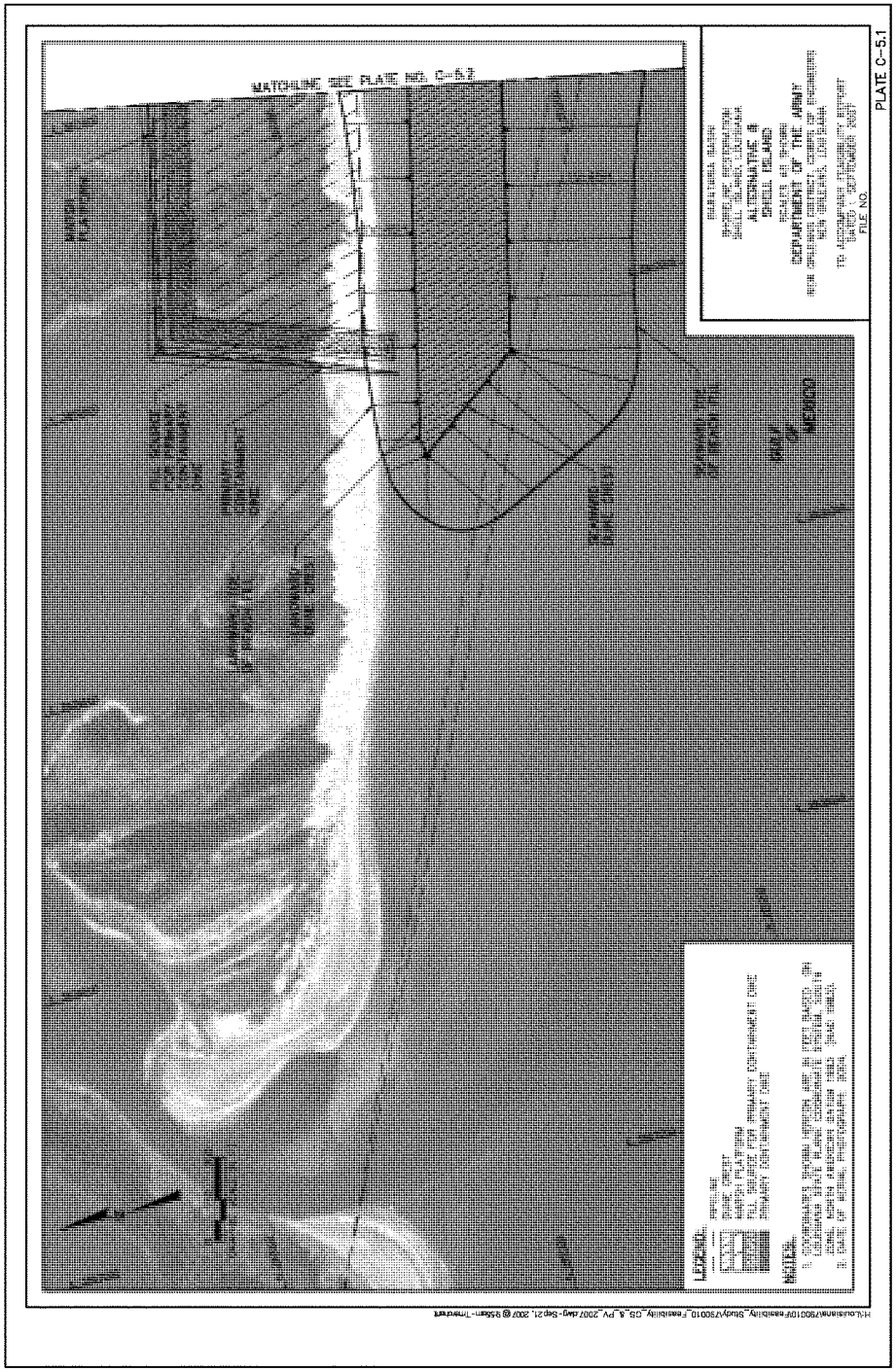

MATCHLINE SEE PLATE NO. C-5.2
LEGEND:
NOTES:
DEPARTMENT OF THE ARMY
PLATE C-5.1

PLATE C–5.2
FILE NO.

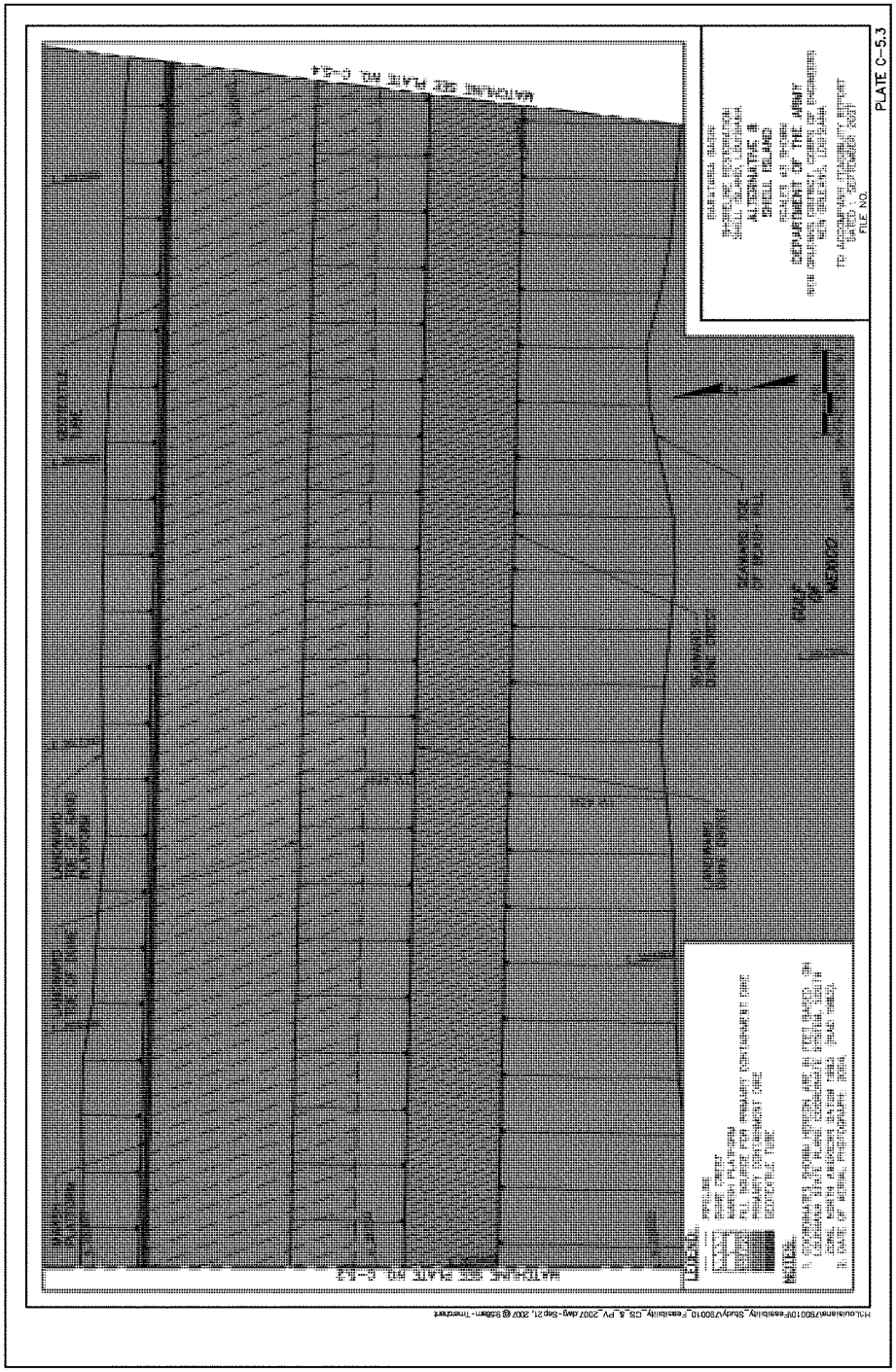


PLATE C-5.3

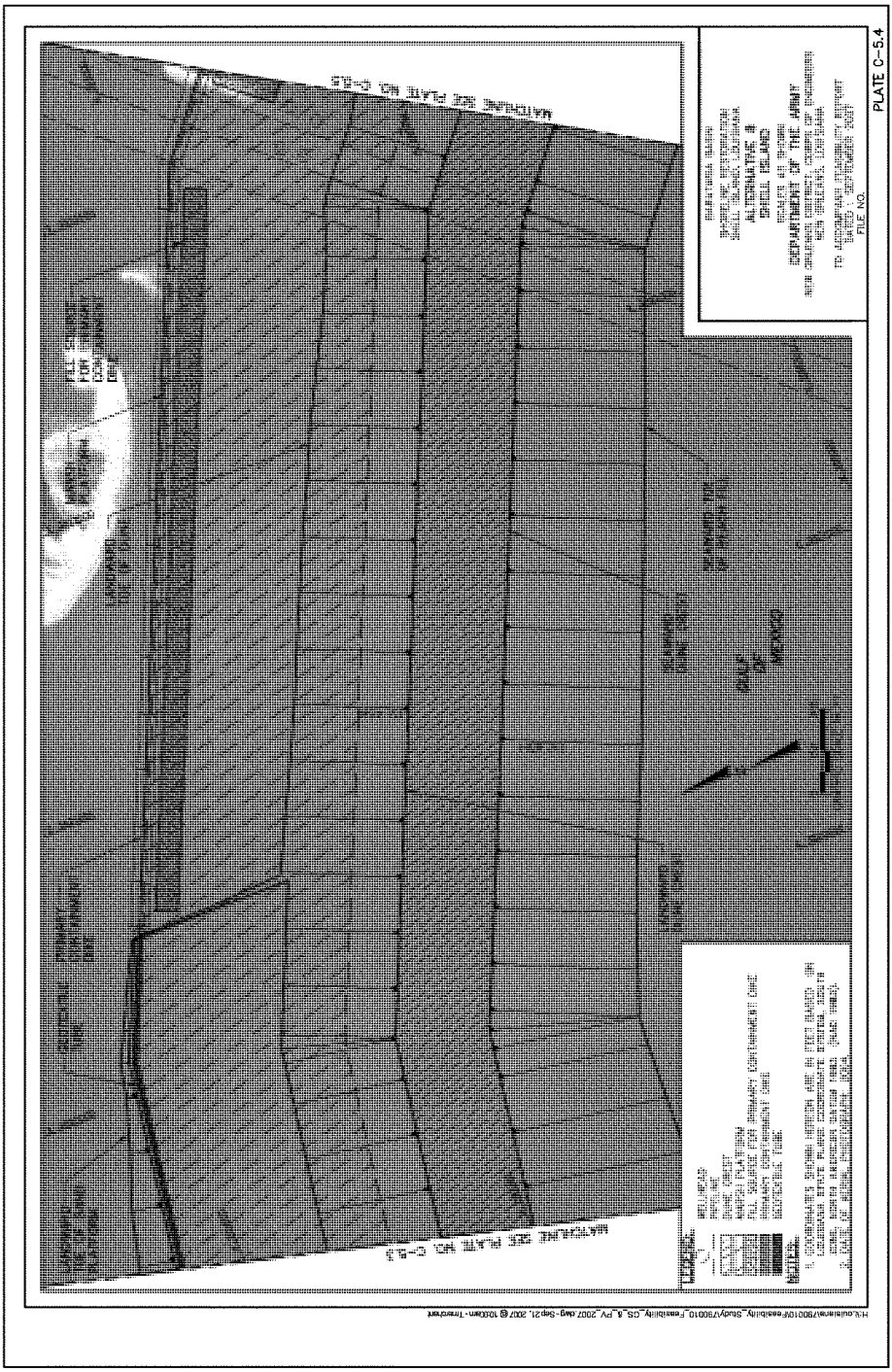


PLATE C-5.4

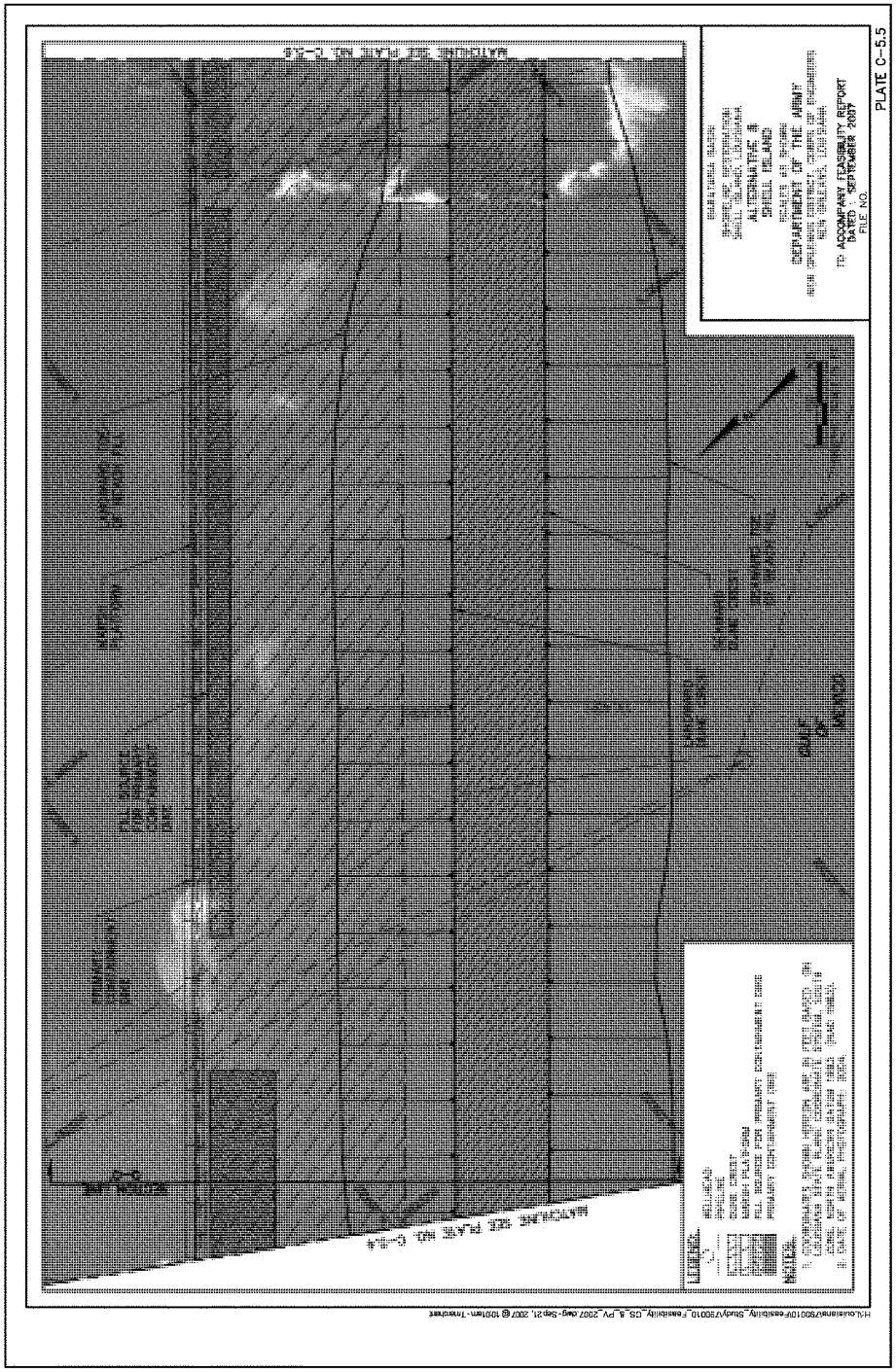


PLATE C-5.5

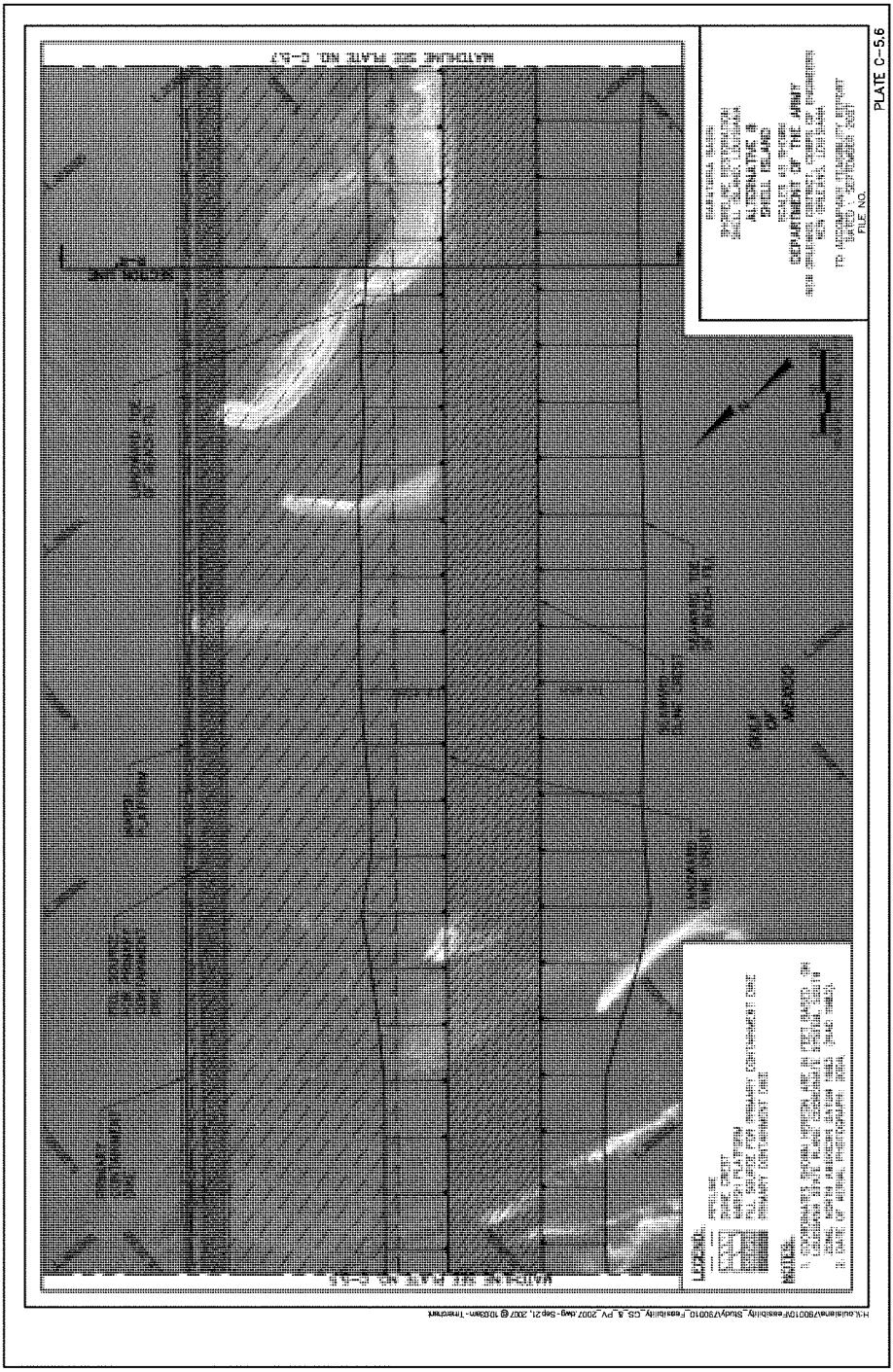


PLATE C-5.6

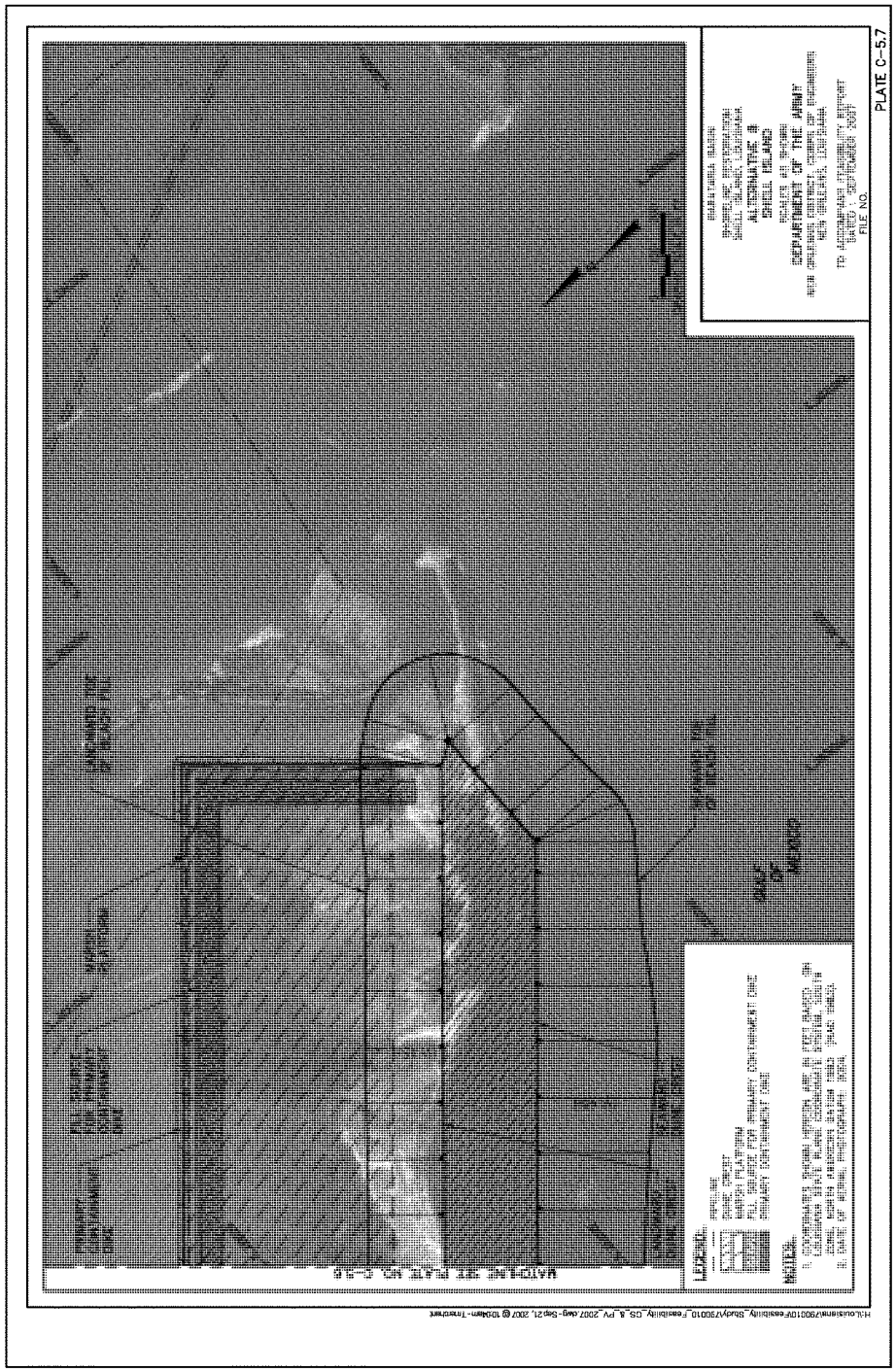
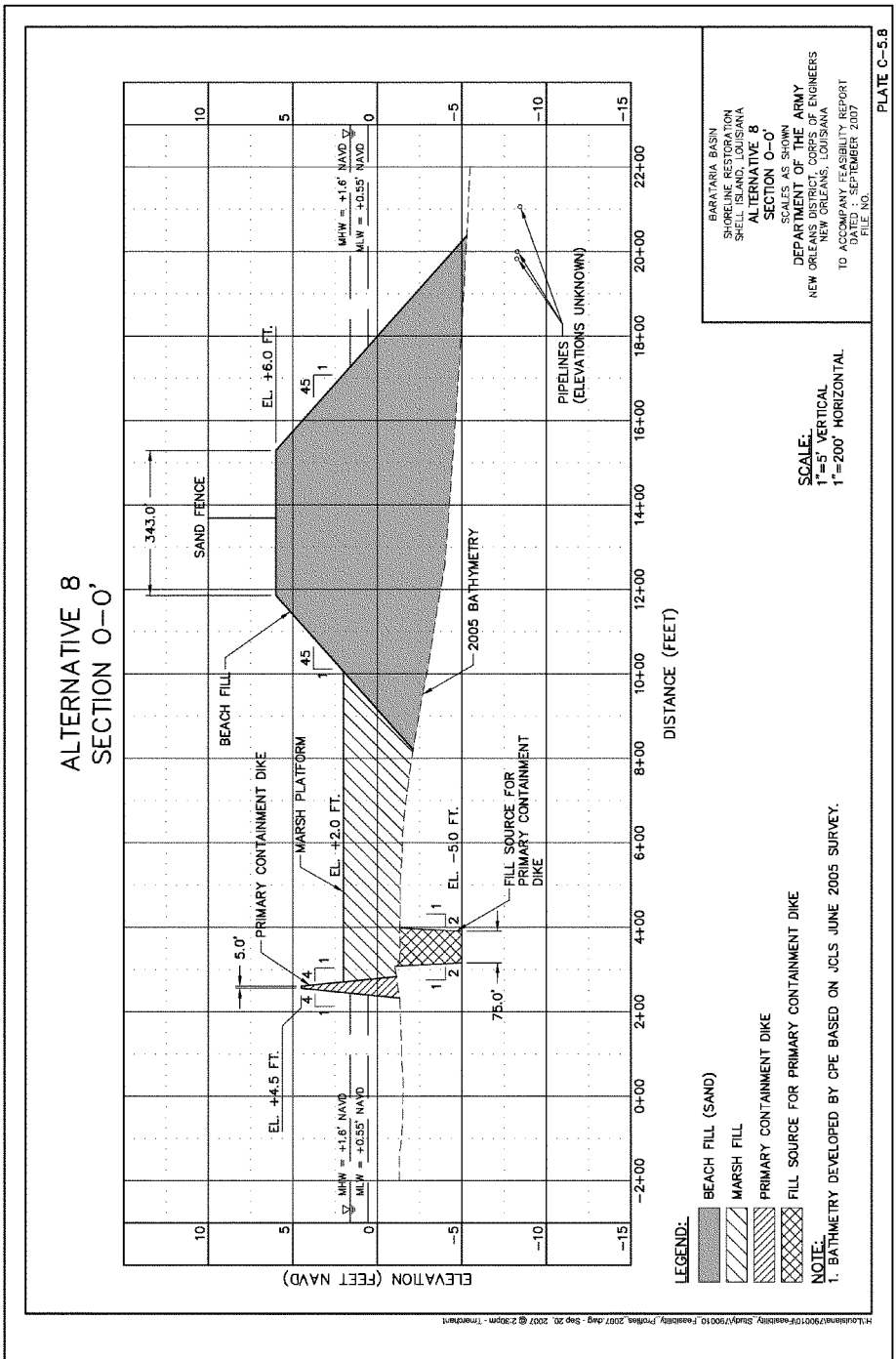
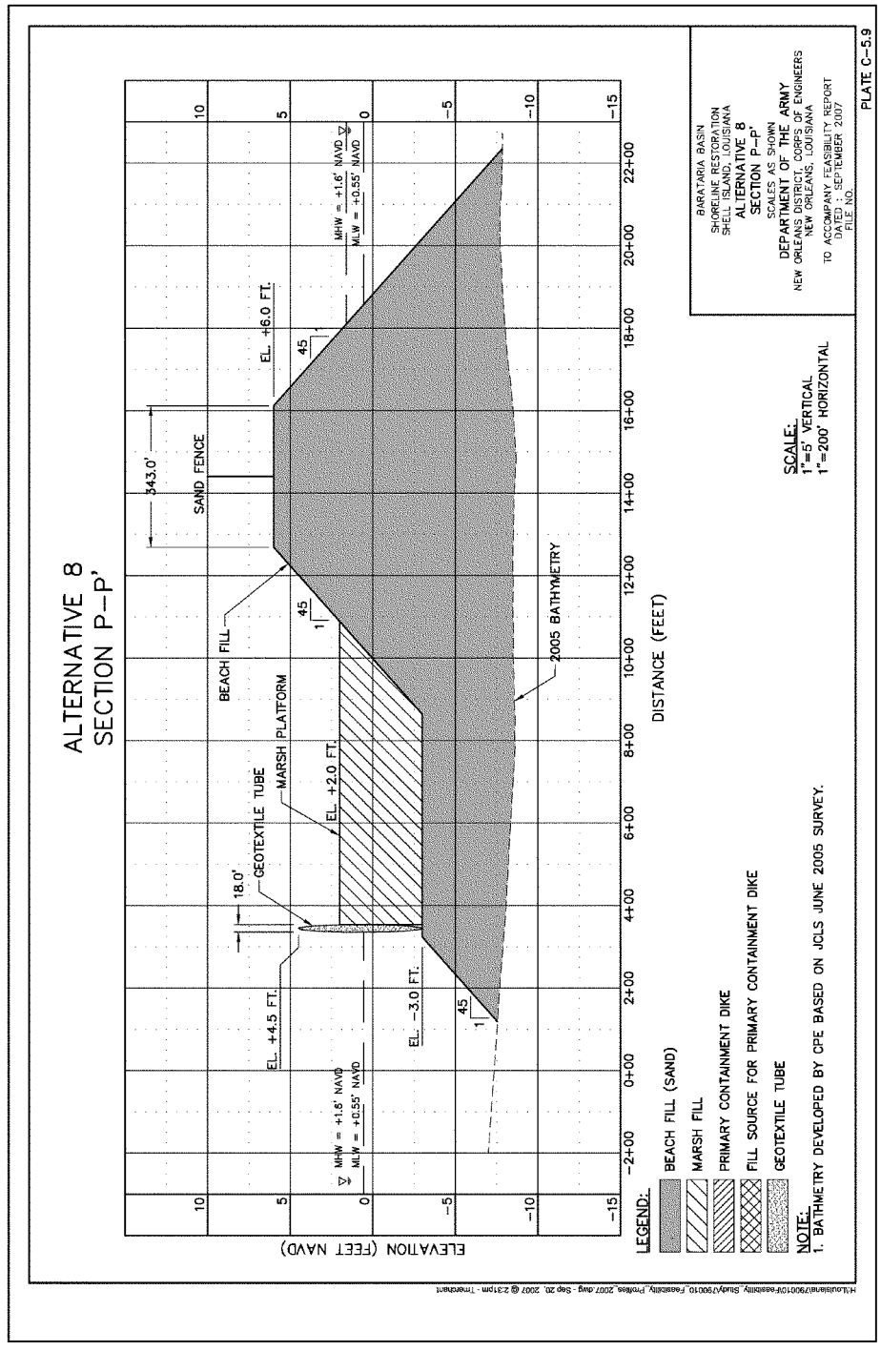
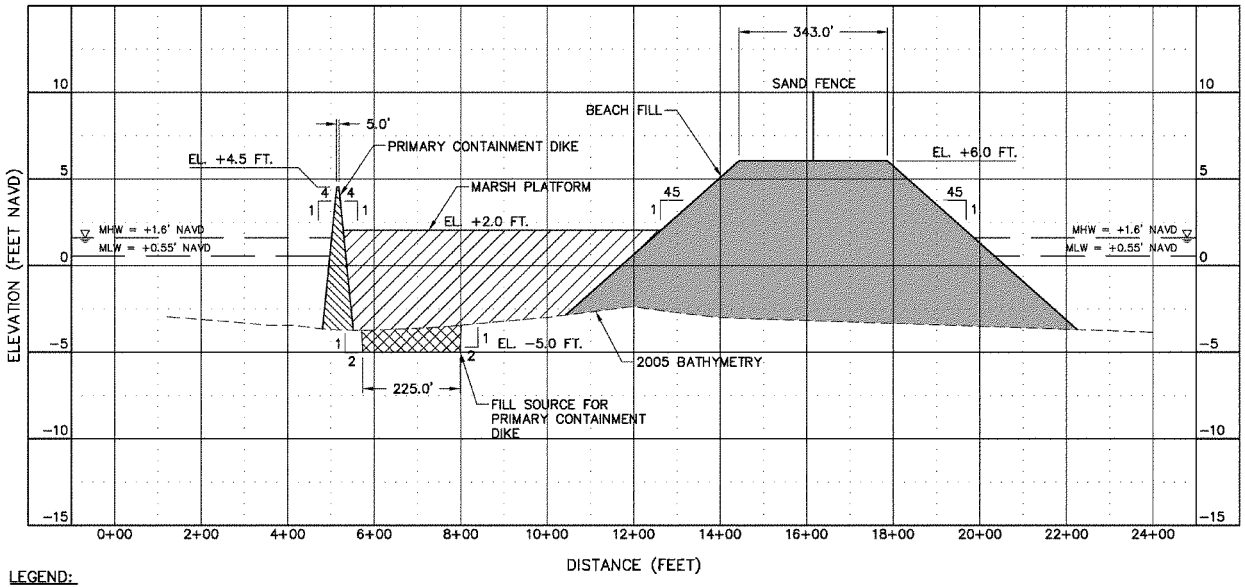


PLATE C-5.7


ALTERNATIVE 8
SECTION 0-0'
ELEVATION (FEET NAVD)
DISTANCE (FEET)
BEACH FILL
SAND FENCE
343.0'
EL. +6.0 FT.
PRIMARY CONTAINMENT DIKE
MARSH PLATFORM
EL. +2.0 FT.
EL. -5.0 FT.
FILL SOURCE FOR PRIMARY CONTAINMENT DIKE
2005 BATHYMETRY
PIPELINES (ELEVATIONS UNKNOWN)
EL. +4.5 FT.
5.0'
75.0'
MHW = +1.6' NAVD
MLW = +0.55' NAVD
LEGEND:
BEACH FILL (SAND)
MARSH FILL
PRIMARY CONTAINMENT DIKE
FILL SOURCE FOR PRIMARY CONTAINMENT DIKE
NOTE:
1. BATHYMETRY DEVELOPED BY CPE BASED ON JCLS JUNE 2005 SURVEY.
SCALE:
1"=5' VERTICAL
1"=200' HORIZONTAL
BARATARIA BASIN
SHORELINE RESTORATION
SHELL ISLAND, LOUISIANA
ALTERNATIVE 8
SECTION 0-0'
SCALES AS SHOWN
DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA
TO ACCOMPANY FEASIBILITY REPORT
DATED SEPTEMBER 2007
FILE NO.
PLATE C-5.8


ALTERNATIVE 8
SECTION P-P'
ELEVATION (FEET NAVD)
DISTANCE (FEET)
BEACH FILL
SAND FENCE
343.0'
EL. +6.0 FT.
45
1
MHW = +1.6' NAVD
MLW = +0.55' NAVD
18.0'
GEOTEXTILE TUBE
MARSH PLATFORM
EL. +2.0 FT.
EL. +4.5 FT.
EL. -3.0 FT.
2005 BATHYMETRY
LEGEND:
BEACH FILL (SAND)
MARSH FILL
PRIMARY CONTAINMENT DIKE
FILL SOURCE FOR PRIMARY CONTAINMENT DIKE
GEOTEXTILE TUBE
NOTE:
1. BATHYMETRY DEVELOPED BY CPE BASED ON JCLS JUNE 2005 SURVEY.
SCALE:
1"=5' VERTICAL
1"=200' HORIZONTAL
BARATARIA BASIN
SHORELINE RESTORATION
SHELL ISLAND, LOUISIANA
ALTERNATIVE 8
SECTION P-P'
SCALES AS SHOWN
DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA
TO ACCOMPANY FEASIBILITY REPORT
DATED : SEPTEMBER 2007
FILE NO.
PLATE C-5.9

# ALTERNATIVE 8
## SECTION Q–Q'




LEGEND:

- BEACH FILL (SAND)
- MARSH FILL
- PRIMARY CONTAINMENT DIKE
- FILL SOURCE FOR PRIMARY CONTAINMENT DIKE

NOTE:
1. BATHMETRY DEVELOPED BY CPE BASED ON JCLS JUNE 2005 SURVEY.

SCALE:
1"=5' VERTICAL
1"=200' HORIZONTAL

BARATARIA BASIN
SHORELINE RESTORATION
SHELL ISLAND, LOUISIANA
ALTERNATIVE 8
SECTION Q–Q'
SCALES AS SHOWN
DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

TO ACCOMPANY FEASIBILITY REPORT
DATED : SEPTEMBER 2007
FILE NO.

PLATE C–5.10

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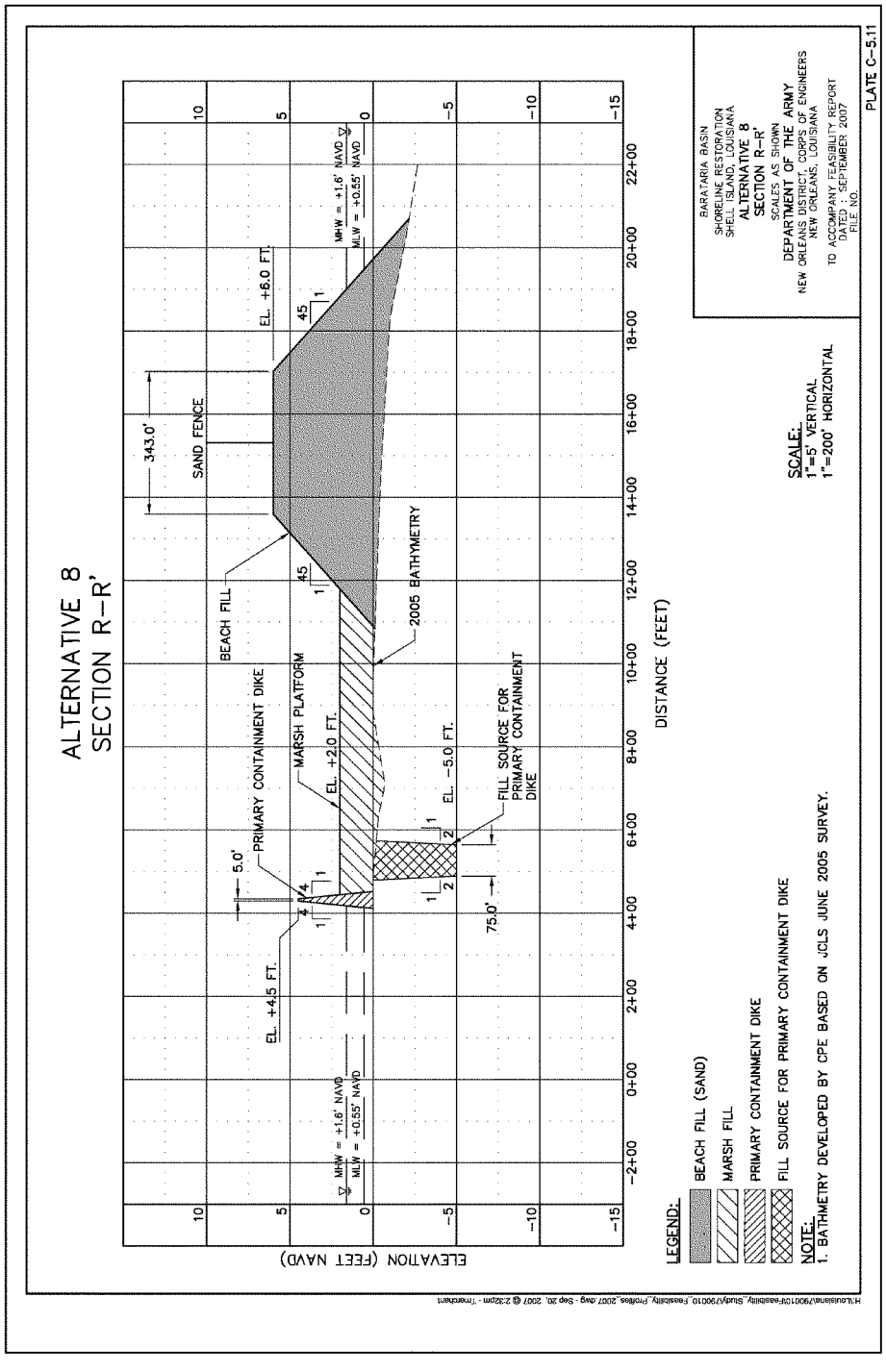
ALTERNATIVE 8
SECTION R-R'
ELEVATION (FEET NAVD)
DISTANCE (FEET)
BEACH FILL
PRIMARY CONTAINMENT DIKE
MARSH PLATFORM
EL. +2.0 FT.
EL. +4.5 FT.
EL. +6.0 FT.
EL. -5.0 FT.
5.0'
75.0'
343.0'
SAND FENCE
2005 BATHYMETRY
FILL SOURCE FOR PRIMARY CONTAINMENT DIKE
MHW = +1.6' NAVD
MLW = +0.55' NAVD
LEGEND:
BEACH FILL (SAND)
MARSH FILL
PRIMARY CONTAINMENT DIKE
FILL SOURCE FOR PRIMARY CONTAINMENT DIKE
NOTE:
1. BATHIMETRY DEVELOPED BY CPE BASED ON JCLS JUNE 2005 SURVEY.
SCALE:
1"=5' VERTICAL
1"=200' HORIZONTAL
BARATARIA BASIN
SHORELINE RESTORATION
SHELL ISLAND, LOUISIANA
ALTERNATIVE 8
SECTION R-R'
SCALES AS SHOWN
DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA
TO ACCOMPANY FEASIBILITY REPORT
DATED : SEPTEMBER 2007
FILE NO.
PLATE C-5.11

# ANNEX C- 2

# SAND RESOURCES

## C-2.0 POTENTIAL SOURCES OF SAND AND MIXED SEDIMENTS FOR THE RESTORATION OF SHELL ISLAND

This review of potential sand resources for Shell Island considers sedimentary deposits in the Mississippi River channel as well as offshore depositional environments associated with deltaic systems. The project area, Shell Island, is part of the Plaquemines shoreline complex that is characterized by a series of barrier islands (beaches, dunes, and salt marsh) and back bays. Shell Island formerly occupied the entire area located between Pelican Island/Empire Jetties and Bay Joe Wise, in the southeast segment of the Barataria/Plaquemines barrier shoreline (Figure 1). Because of its geographic location, offshore sediment borrow areas from Quatre Bayou to the east and Sandy Point to the west as well as the Mississippi River may serve as sediment resources for the restoration of Shell Island.

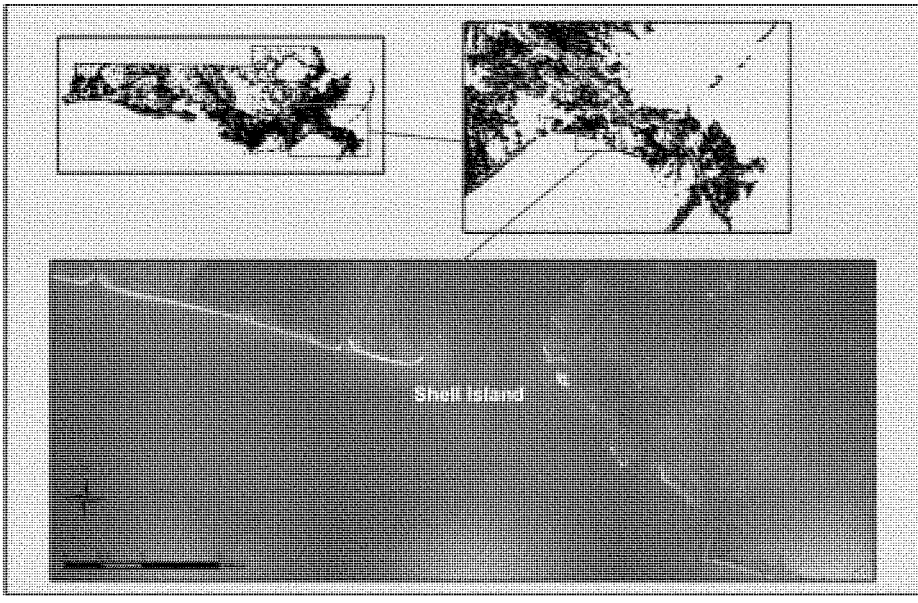


Figure 1. Geographic location of Shell Island

Studies of Mississippi River sediments were investigated by Coastal Planning & Engineering (CPE, 2004a , and CPE 2005) as potential renewable sand sources for Shell Island. These fluvial point bar sand deposits contain large volumes of sand that constitute a known supply of sediment for island restoration. Offshore sand sources in deltaic environments, investigated in reconnaissance surveys (*e.g.* Suter *et al.*

1991; Kindinger *et al.*, 2001) that identified potential source areas, are re-assessed here in terms of distance from Shell Island, grain size, and volume. This re-evaluation of offshore deposits indicates a need for additional more detailed surveys to ascertain compositional and stratigraphic continuity of potential deposits. Summaries of Mississippi River sands and offshore deposits are provided in the following sections.

## C-2.1 ASSESSMENT OF MISSISSIPPI RIVER SAND RESOURCES

Due to large volume requirements and geographic location (8 to 15 miles from the Mississippi River), renewable sand deposits in the river have potential to supply sediments for restoration of Shell Island. CPE (2004a) performed an assessment of sand resources in the Mississippi River based on a study of river geomorphology (potamological interpretation of fluvial forms, bathymetry, sedimentary deposits, and hydrology), and the analysis of historical data. Results of that study (CPE, 2004a) indicated that large volumes of good quality sand may be available in the Empire-Fort Jackson section of the river (Figure 2) to restore barrier islands on the Plaquemines Shoreline (Shell Island, Pelican, Scofield). The main findings of the CPE (2004a) study related to Mississippi River sand reserves are summarized below.

Three primary potential sand targets (P1, P2 and P3, see Figure 2) are identified between MM 35 and MM 22 (CPE, 2004a). P1 is located 2 to 4 miles upriver from Empire between MM 32 and MM 34, near the City of Nairn. P2 is located near Empire between MM 31 and MM 25. P3 is located near Fort Jackson between MM 24 and MM 22. A secondary potential sand target (S1) is identified between MM 20 and MM 18 at the Fort Jackson river bend (Figure 2).

These targets were found to have the potential to contain significant volumes of sand. Surface bedforms (mega ripples) were estimated to range in thickness from 3 to 9 ft. in the study area (Allison, 2004, *personal communication*), and USACE core borings indicate that sandy point bar deposits may extend to at least -90 ft. NGVD (McClelland, 1988).

Of these three deposits, P1 is located in a river meander where greater sediment thickness may be anticipated due to the presence of relict (vertically stacked) sand bars. A hypothetical cross section of this deposit (A-A', see Figure 2 for location) is presented in Figure 3.

P2 is located along a gentle river bend on the eastern side of the river. Surface samples obtained in this area identify a mean grain size of 0.17 mm to 0.28 mm (Allison and Nittrouer, 2004). Surface sand waves here are about 6 ft. thick, but underlying sands may locally increase the total thickness of sand deposits.

P3 occurs along the western riverbank about 6 miles downriver from Empire (Figure 2) and 2 miles upriver from the Fort Jackson river meander. The two-mile long target is limited upriver and downriver by rubble mound revetments.

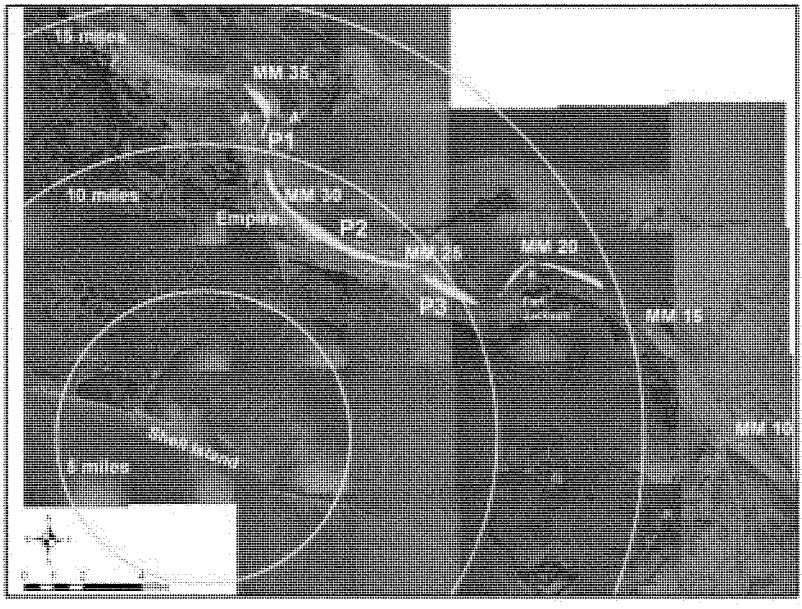


Figure 2. Aerial photo mosaic of the CPE study area showing three primary study areas and one secondary study area in relation to Shell Island.

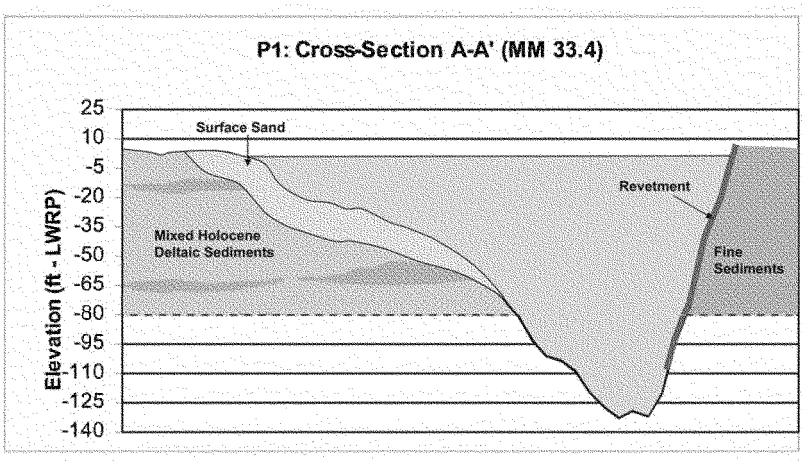


Figure 3. Schematic cross-section of the Mississippi River at MM 33.4 showing bathymetry and sedimentary deposits. Stratigraphy is approximated from broad scale geological studies and does not represent actual measured conditions at the site (after CPE, 2004a).

The secondary sand target mapped along the Fort Jackson meander may be morphologically and compositionally similar to P1 because it is located in a similar hydro-geomorphological setting (river meander-point bar). Rick Smith (*personal communication*), from Weeks Marine, Inc., reported that they constantly dredge large quantities of "sandy" sediments from this area (secondary target S1) on their Mississippi River maintenance dredging projects.

Sediment data, supplied by Allison and Nittrouer (2004), indicates that grain sizes in the active river sand sheet are relatively coarse (0.17 mm to 0.28 mm) compared to those on Louisiana's native barrier beaches (generally from 0.10 mm to 0.14 mm). According to this data, the downstream trend (from MM 86 to MM 0) in grain size shows downriver fining (*i.e.* decrease in mean grain size) that is related to decreased flow velocities.

The primary potential deposits P1, P2 and P3 and secondary area S1, identified by CPE (2004a), were further investigated in 2005 (CPE, 2005). During this investigation, thirteen (13) vibracores and twenty-three (23) line-miles of geophysical survey data were obtained in the Lower Mississippi River between MM 35 and MM 15. Investigation results of the primary potential deposit areas are briefly described below.

Three (3) vibracores and approximately 7.6 miles of geophysical data were collected from the Nairn point bar (P1). Results of the 2005 investigations along the Nairn point bar confirm prior reports that indicated silty and clayey layers commonly overlie sand in shallow water near the river banks (lower flow areas) whereas sand predominates in deeper water (higher flow areas). Seismic data shows a slope break at approximately -30 ft. (NGVD) that roughly corresponds to the bottom of overburden layer seen on both seismic and core data (CPE, 2005). Although vibracore data collected in 2005 extends to -72.4 ft. (NGVD), a study of the seismic record shows that the sand deposit extends below the vibracores.

A borrow area was delineated within the P1 deposit (Borrow Area MR A) and was estimated to contain 2.8 M cubic yards of sand based on a cut depth to -70.0 feet (NGVD) (CPE, 2005). This volume estimate is very conservative as the boundary of Borrow Area MR A completely avoids the overburden area identified by core MRVC-05-02 and is limited by coverage of the 2005 vibracores (Figure 4). Seismic data and historic cores indicate potential for additional sand resources available within the entire deposit. Using an average bottom elevation of -30.0 feet (NGVD) for the overburden and a cut elevation of -80.0 feet (NGVD) (based on the seismic data), the potential sand deposit within P1 is estimated to be 10.5 M cubic yards with approximately 400,000 cubic yards of overburden (Figure 4). Much of the additional volume is found within the 50-foot thick sand deposit that underlies the overburden avoided in Borrow Area MR A. These volumes are approximations that will need to be refined based on final design-level investigations that include collection of core borings on a maximum 1,000 foot spacing that have recovery to the cut depth; and cultural resource level geophysical investigations. The estimated volume of sand within deposits may increase or decrease, sometimes significantly, based on the results of detailed investigations.

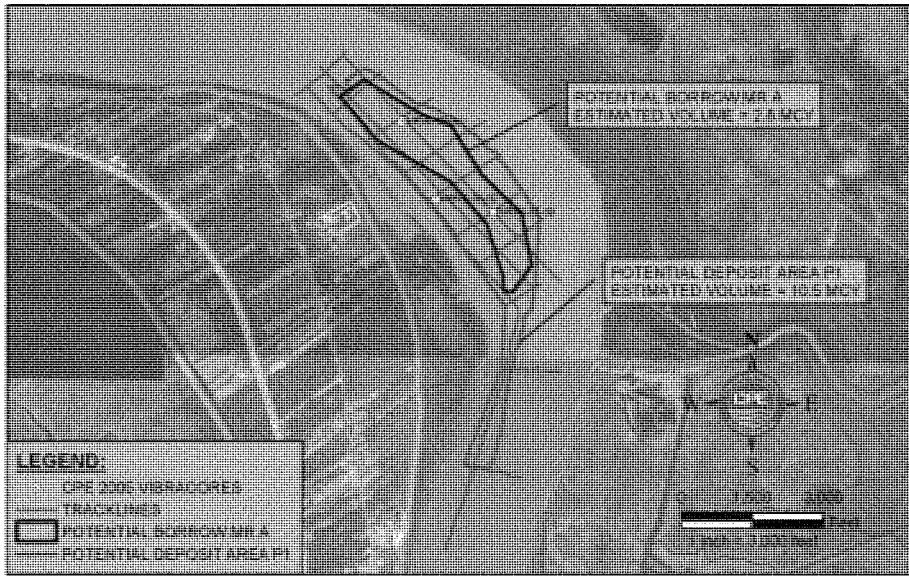


Figure 4. Primary Potential Deposit P1 and Potential Borrow Area MR A.

A total of four (4) vibracores and 7.2 line miles of geophysical data were collected from potential deposit P2 (CPE, 2005). The vibracores contained mostly sand with less than 2% fines with intercalated layers of sand and clay found in shallow water. The sand layer appears to extend beyond the recovery length of the vibracores based on the seismic data. Because the deposit is segmented by pipelines it was refined into three borrow areas (MR B, MR C and MR D). The extractable amount of sand within these borrow areas is approximately 16.5 M cubic yards (CPE, 2005). This volume is based on limited vibracore and seismic data and a cut elevation of -70.0 ft. (NGVD). Additional design level investigations including collection of core borings on a maximum 1000 ft. spacing that have recovery to the cut depth; and cultural resource level geophysical investigations will be needed to further refine this deposit.

Two (2) cores and 6.4 line miles of geophysical data were collected from potential deposit P3. Both cores recovered about 15 ft. of sand having less than 5% fines. In this area the seismic data indicates that the sand layer extends below the recovered length of the cores and may have a thickness of between 50 and 80 ft. The deposit was refined

based on the limited vibracore and seismic data into borrow area MR E. Based on a cut elevation of -70 ft. (NGVD), MR E was estimated to contain 6.3 M cubic yards of sand (CPE, 2005). As with the other potential deposits, additional design level investigations including collection of core borings on a maximum 1000 ft. spacing that have recovery to the cut depth; and cultural resource level geophysical investigations will be needed to further refine this deposit.

## C-2.2 McCLELLAND 1988 STUDIES – NAIRN POINT BAR

McClelland Engineers and John Chance Land Surveys, Inc. under contract to Brown & Root, conducted geotechnical and geophysical investigations in the Mississippi River meander corresponding to CPE potential deposit P1. This meander displays stratigraphic relationships that are similar to models described in the literature for meander point bars, where grain sizes become coarser with increasing distance from the river banks (increased channelward flow velocity) and with increasing depth (fining upward sequence).

These reports indicate that previous USACE boring data for this point bar may extend to an elevation of at least -90 ft. NGVD. This point bar is described as having two major sedimentary units: (1) a featureless (flat) mudbottom from the river bank to about 25 ft. water depth and (2) a sand bottom with surface waves (mega-ripples) from 25 ft. to their survey depth limit (Figure 5). Sand composition is described as being fairly homogenous with a slight coarsening downward (fining upward) trend. This meander deposit is shown in seismic image of Figure 5. These reports indicate, based on 36 samples obtained from 16 vibracores in the Nairn point bar, an average (composite) grain size of 0.17 mm with 0.92 phi sorting. These results verify the presence of large volumes of fluvial sands that can be used for future restoration of Shell Island and other Plaquemines barrier islands.

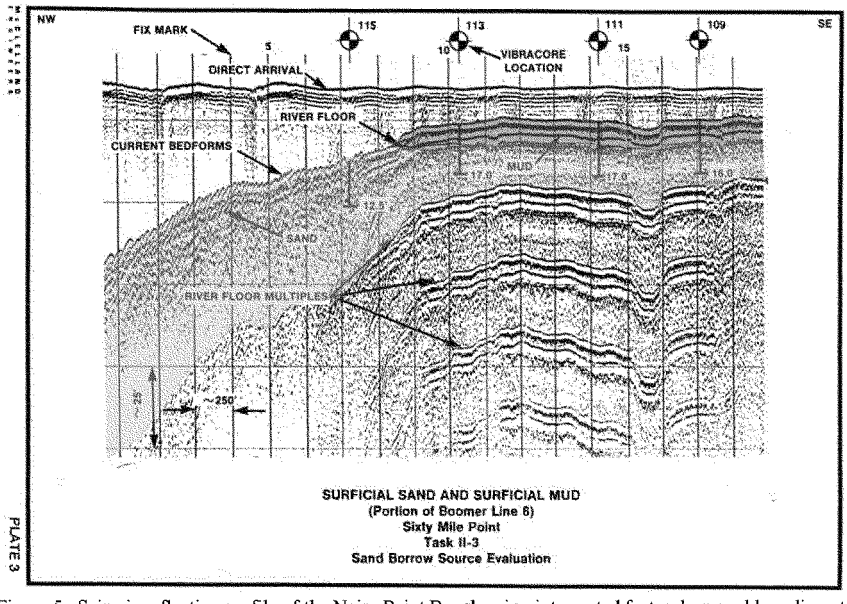


Figure 5. Seismic reflection profile of the Nairn Point Bar showing interpreted featureless muddy sediments in red and interpreted sand deposits in green (modified from McClelland, 1988).

## C-2.3 REGIONAL OFFSHORE SAND SEARCH STUDIES

Suter *et al.* (1991) and Kindinger *et al.* (2001) conducted regional sand resource assessments that concerned offshore areas in the vicinity of Shell Island. The potential sand targets they identified are associated with a range of depositional systems that include spit platforms, delta sheet sands, ebb-tidal deltas, distributary mouth bars, and distributary-channel fills, and inner shelf shoals. The subsequent Kindinger study did not confirm, however, sand sources near Shell Island that were suggested in the Suter study.

CPE (2003), using high resolution Chirp Seismic Data in Scofield, discovered that sand deposits were often located adjacent to relict-channels (channel margin bars) whereas the channels themselves were mostly infilled with fine-grained sediments. Stratigraphically, channel fill deposits usually exhibit fining upward sequences. Although channel forms are recognized in seismic profiles, a distinction between muddy and sandy facies that fill these channels is virtually impossible from most seismic records (Kindinger *et al.*, 2001). Sea-truthing to verify particle-size grading of channel fill deposits is therefore necessary. Smaller distributary channels of abandoned deltaic systems often contain sand deposits that are covered by up to 20 ft. of muddy overburden, as described by Kindinger *et al.* (2001) and CPE (2000).

Because of their importance to this project, the regional studies of Kindinger *et al.* (2001) and Suter *et al.* (1991) are briefly summarized here. Salient findings from detailed sand searches conducted by CPE (2003, 2004b) and CEC (2003) are also discussed.

## C-2.4 OFFSHORE SAND SOURCES NEAR SHELL ISLAND (AS INDICATED BY SUTER *et al.* 1991)

This study was conducted by Louisiana Geological Survey (LGS) personnel (*i.e.* J.R. Suter, S. Penland, and E.R. Ramsey) to compile pre-existing information and collect new field data from Marsh Island to Sandy Point in order to identify areas of potential sand deposits on the inner continental shelf.

The study was based on 4,785 miles of seismic profiles using a uniboom seismic profiler and 162 vibracores over a long stretch of coastline. Suter *et al.* (1991) identified fifty-five (55) prospective areas that represented depositional environments such as recurved spit and spit platform deposits, tidal channel fills, distributary channel fills, shoreface deposits, ebb- and flood-tidal deltas, and inner shelf shoals. Between Belle Pass and Sandy Point, adjacent to the Barataria Basin, about eighty percent (80%) of the total sand volume identified occurs as channel fill (tidal channel fills and distributary channel fills).

From the fifty-five (55) sand deposits identified by Suter *et al.* (1991), twenty-one (21) are located in or adjacent to the Barataria/Plaquemines Barrier Shoreline (between Belle Pass and Sandy Point, areas 34 to 55; Figure 6). Twelve (12) potential sand sources are located east of Quatre Bayou Pass, closer to Shell Island (areas 43 to 55). Although the results of Suter *et al.* (1991) appear promising, these deposits must be more critically assessed by detailed field investigations because about 80% of the sediments are channel fill complexes (as opposed to large individual channels) that were mapped using widely spaced

seismic tracklines for regional investigations. In order to obtain volume estimates for potential target areas, Suter *et al.* (1991) multiplied the surface area of a deposit by its thickness. Volume calculations were based on the following assumptions (Suter *et al.*, 1991): (1) channel-fill deposits are covered by 6.6 ft. of muddy overburden, (2) channel fill deposits contain on average at least 75% sand, and (3) channels represent 50% of the delimited seabed area. The presence of pipelines or petroleum industry infrastructure was not considered by Suter *et al.* (1991).

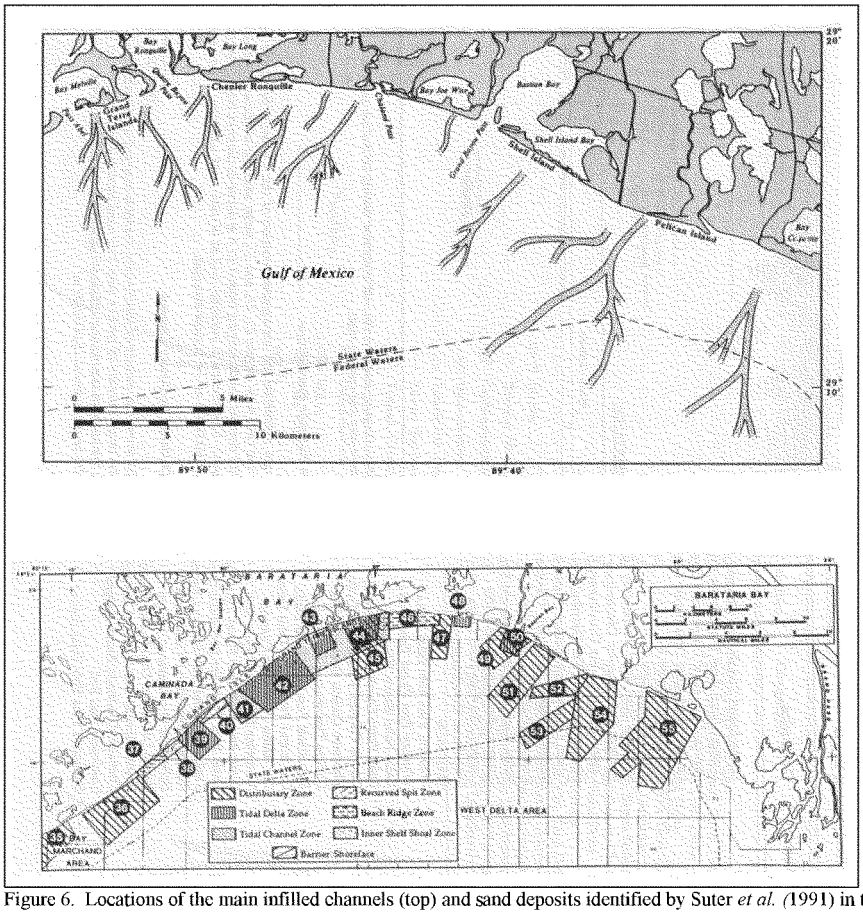


Figure 6. Locations of the main infilled channels (top) and sand deposits identified by Suter *et al.* (1991) in the study area (bottom)

These potential study areas that were identified by Suter *et al.* (1991) provide a general overview of the depositional systems that may store sand near Shell Island. Of particular interest are deposit areas 49, 50 and 51 that are located within a 5 mile radius from Shell Island. Area 49 (Figure 6) was described as

containing channel-fill deposits that are part of the Grand Bayou Pass distributary channels. The deposits were estimated to contain an average thickness of 30 ft. of sandy sediments, providing about 41 M cubic yards of sandy material, with variable amounts of muddy overburden. Area 50, identified as the Grand Bayou Pass Ebb Tidal Delta, was delimited on the basis of seafloor geomorphology (bathymetry). The deposit, characterized by very fine grained ebb tidal shoal sands that occur on the surface (little or no overburden) with an average thickness of 5 ft., was estimated to contain about 7.8 M cubic yards of sandy material. Deposit 51 (Figure 6) lies directly offshore of Shell Island and was associated with the Shell Island Distributary Channel Complex by Suter *et al.* (1991). Sand content and muddy overburden were reported to show large variation in this deposit. Average sand thickness, estimated to be around 30 ft., provided a basis for estimating that the deposit contains about 73,000,000 $m^3$.

Collectively, these three potential depositional areas (49, 50, and 51) near Shell Island were estimated to potentially contain 121.8 M cubic yards of sandy sediments. If only 5% of that volume is comprised by clean sand, it would represent a significant savings (on order of tens of millions of dollars) for the construction and implementation of the Shell Island restoration project. Reconnaissance seismic and vibracore investigations are thus recommended in these areas in order to assess their sand resource potential. Actual volumes of beach compatible sand, free of restrictions due to infrastructure and large percentages of fine grained materials, can only be obtained by additional field verification and GIS analysis.

## C-2.5 KINDINGER et al., 2001. SAND RESOURCES, REGIONAL GEOLOGY AND COASTAL PROCESSES FOR THE RESTORATION OF THE BARATARIA BARRIER SHORELINE

A cooperative effort between the U.S. Geological Survey (USGS), the University of New Orleans (UNO, Coastal Institute), and the U.S. Army Corps of Engineers (USACE), consisted of 652.5 line miles of single channel seismic profiles using 'Boomer' and 'Chirp' sources and more than 200 vibracores and borings.

In order to be considered a 'potential sand resource' by Kindinger *et al.* (2001), deposits had to meet the following criteria: (1) contain more than 60% sand, (2) be more than 3 ft. thick for surficial deposits or more than 5 ft. thick for deposits covered by muddy layers, and (3) not lie in water depths exceeding 60 ft. No deposit directly offshore Shell Island met these criteria and thus the Suter *et al.* (1991) deposits (49, 50 and 51) were not classified as potential sand resources in the 2001 study. Even though these deposits did not meet the Kindinger *et al.* (2001) criteria, the possibility should not be excluded that sand suitable for barrier island restoration exists in the area. Potential sand deposits thus may occur offshore of Shell Island in areas not examined in reconnaissance surveys. A case in point is the detailed investigation on Sandy Point by CPE (2003) where a deposit previously identified by Suter *et al.* (1991) and Kindinger *et al.* (2001) was found to contain greater sand thickness adjacent to a relict-channel and on channel margins. The significance of this observation is that the channels *per se* did not contain sand but were infilled mostly by silt and clay. If vibracores were obtained by these previous investigators to target relict channel thalwegs, they would have recovered mostly fine sediments because sand deposits occurred adjacent to channel margins. Because of the significant cost savings that would result from the identification of nearby offshore sand sources, it is recommended that additional (more detailed) investigations be conducted offshore of Shell Island to ascertain the true potential of offshore sand sources or confirm that they in fact do not exist.

Nine (9) sand targets met the criteria of Kindinger *et al.* (2001), six (6) of which are of particular interest due to their closer proximity to Shell Island (Quatre Bayou Deep, Shallow, and D2; Empire, Scofield, and Sandy Point). Kindinger *et al.* (2001) defined these sand sources on the basis of the following criteria: (1) more than 60% sand; (2) minimal thickness of 3 ft. for surficial deposits or more than 5 ft. for deposits with overburden; (3) maximum depth of deposits not exceeding 60 ft. below mean sea level. The target deposits identified by Kindinger *et al.* (2001) are shown in Figure 7. The six targets of interest are briefly described below.

Quatre Bayou Shallow is an ebb-tidal deposit composed of fine-grained sand to silty sand with abundant shell material. The deposit, about 6.6 ft. thick, is exposed on the surface with no mud cover. A borrow area located at the intersection of this deposit with Quatre Bayou Deep will be used for the restoration of Chaland. Quatre Bayou Deep and Quatre Bayou D2 in deeper water offshore are deposits associated with buried distributary mouth bars or channel fill margins. These deposits, which contain massive to laminated sands about 14 ft. thick with no shell content, are covered by muddy sediments that range from

Figure 7. Sand deposits identified by Kindinger *et al.* (2001) in the Barataria Basin region (image from Kindinger *et al.*, 2001).

5 to 15 ft. thick. A borrow area that extends from the southwest corner of Quatre Bayou Deep to the offshore may be used for restoration of the shoreline segment in front of Bay Joe Wise.

Kindinger *et al.* (2001) identified three deposits from Pass Abel to Sandy Point *viz.* Empire, Scofield, and Sandy Point (Figure 7) collectively account for about 233 to 310 M cubic yards of massive to laminated sands and muddy sands. Detailed studies by CPE (2003) indicated, however, that these deposits have little lateral and vertical sand continuity and that further exploration is limited by the presence of infrastructure. Scofield and Empire, for most of their extent, contain mixed sediments (less than 40% to 60% sand) with some localized pockets of sand.

Sandy Point, by far the largest deposit (220 to 294 M cubic yards of sand) identified by Kindinger *et al.* (2001), was reported to represent a distributary mouth bar environment. The deposit, consisting of interbedded sands and clays, is located about 40 to 48 ft. below mean sea level with 8 to 13 ft. of laminated clayey-silt overburden. CPE (2003) verified that this deposit is highly variable in both lateral and vertical contexts. Relict channels in this area are infilled by mostly fine grained sediments and sands occurring as channel margin deposits. Extensive infrastrueture at Sandy Point limits sand exploration.

The deposits identified by Kindinger *et al.* (2001) in the Barataria Basin contain varying amounts of mud overburden (from 0 to 40 ft.) which might be economically critical for their exploration and exploitation. An analysis of ratios of mud thickness per unit sand thickness, condueted by CPE (2003) using the Kindinger *et al.*(2001) data, indicated that while inshore deposits and ebb-shoal deposits are economically attraetive sand sources, offshore sources can be expensive to develop and perhaps even problematic in the short term. In the example of the Quatre Bayou D2 borrow area, there is an average mud to sand ratio of 11:1, indicating that for every cubic yard of sand used, eleven cubic yards of muddy overburden must be removed.

In addition to the presence of muddy overburden that may induce economic restraints for development of some deposits, it must be recalled that the actual volumes of exploitable sand available in these deposits is significantly less than what was presented by Kindinger *et al.* (2001). Bearing in mind these limitations, the target areas (identified by Kindinger *et al.*, 2001), provide useful guidance for delimiting potential sand resource areas that require further investigation.

## C-2.6 SHIP SHOAL

Ship Shoal, lying to the west of the study area, was mentioned as a possible sand resource by Kindinger *et al.* (2001) because this drowned barrier island contains twice the combined volume of the 9 sites identified in their study. Ship Shoal is estimated to contain significant quantities of good quality sand deposits (80% to 100% sand, 0.25 mm to 0.07 mm).

The Ship Shoal system was characterized by Penland *et al.* (1988) and Suter *et al.* (1991) as a sandy submerged barrier island about 31 miles long with widths ranging from 3 to 4.3 miles in the central area

and between 5 and 7.4 miles in the eastern area. Relief varies from 16 to 22 ft. and water depths range from 9 ft. in the west to 25 ft. in the east. The entire transgressive sequence of the shoal averages 16 to 19 ft. thick throughout its whole extent. The landward oriented asymmetry of the shoal indicates that it is migrating landward.

The stratigraphic position of Ship Shoal indicates that it is a transgressive sand body that has migrated to its present position under conditions of sea-level rise, shoreface erosion, and submergence. Although Ship Shoal is a deposit with potential for restoration of Louisiana's eroding barrier islands, it is probably too far away from Shell Island to provide an economically feasible basis for exploration in the present context.

## C-2.7 DETAILED SAND SEARCH STUDIES NEAR SHELL ISLAND

### C-2.7.1 Sandy Point

CPE (2003) reviewed prior sand search investigations and collected additional geotechnical and geophysical data in the Sandy Point study area. The CPE study included a more comprehensive evaluation of incised paleovalleys on the southwestern flanks of the Mississippi River delta as part of an effort to locate suitable deposits for barrier island restoration. The original Sandy Point sand deposit was identified by Kindinger *et al.*, (2001) as part of a regional investigation of sand resources in the Barataria Basin where large sub-regional target areas were delimited on the basis of reconnaissance geotechnical (vibracore) and geophysical (seismic sub-bottom) surveys.

Sandy Point lies seaward of a mapped paleochannel system, identified by the Louisiana Geological Survey (Suter *et al.*, 1991) that occurs on the landward margin of the inner shelf. The incised paleovalleys were extended and re-interpreted from seismic data obtained by CPE (2003) as shown in Figure 8.

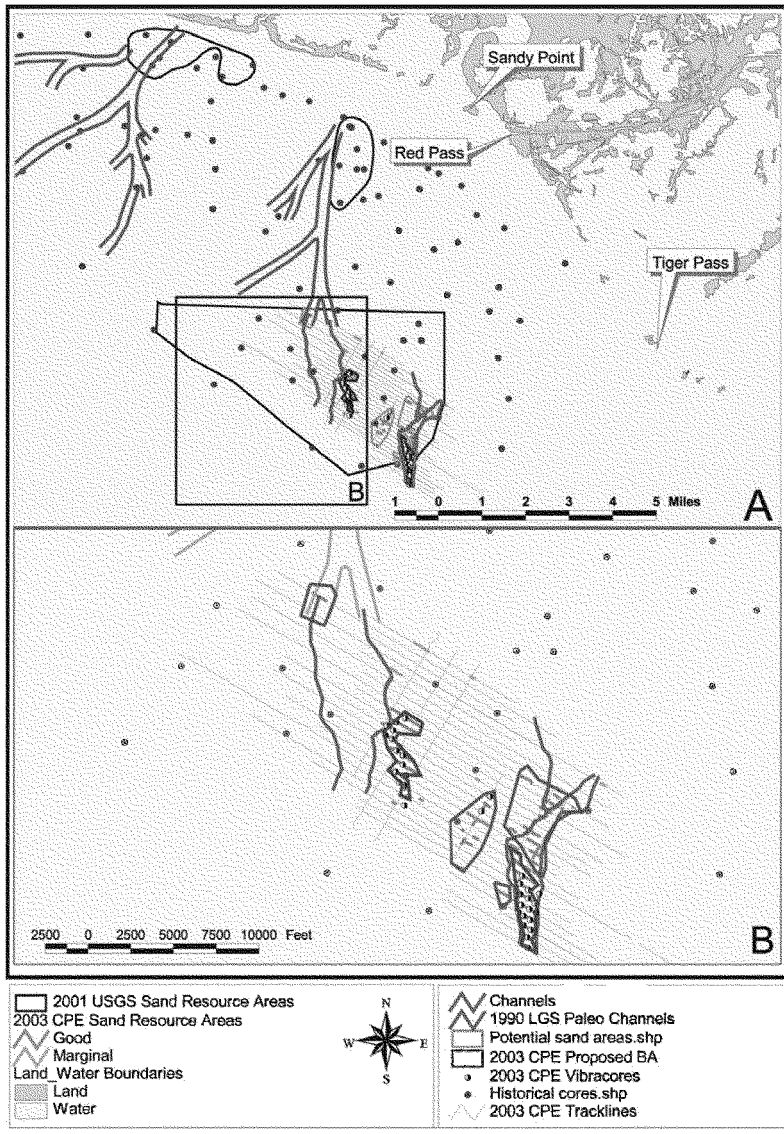


Figure 8. Relict channels and potential sand resource areas identified by CPE (2004b) along the Sandy Point depositional area.

The two deposit areas delimited by blue polygons in Figure 8 (2003 CPE proposed borrow area) contain approximately 3.6 M cubic yards of clean sand (about 4 M cubic yards of sand and silt), with about 3 M cubic yards of mud overburden. Grain sizes in these deposits average 0.11mm and silt content varies around 10%. Oil and gas pipelines limit areas that contain usable volumes of clean sandy sediments in the Sandy Point deposits. Restrictions related to the presence of oil and gas pipelines (*e.g.* dredging setbacks) may severely restrict or even prohibit exploration of the northeastern deposit.

The channels shown in Figure 8 (Suter *et al.* 1991) are channel fields and do not necessarily represent single channels or individual valleys. The mapping units, due to limitation of scale, thus represent approximate valley centerlines with a 200 ft. buffer zone. Because only major paleovalley trends are shown in Figure 8, numerous smaller incised valleys do not show at this scale.

The presence of sandy sediments is interpreted along seismic reflection profile lines that are calibrated from vibracore grain-size data (more or less than 60% sand content). Green-colored vibracore segments indicate sediments that contain more than 60% sand (Figure 9). The sediment distribution pattern shown in Figure 9 indicates that sandy sediments occur on the margins of channels rather than in the channels *per se*.

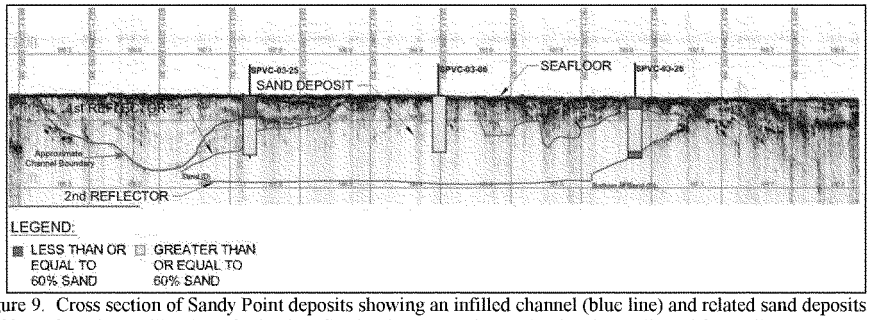


Figure 9. Cross section of Sandy Point deposits showing an infilled channel (blue line) and related sand deposits (red box), based on calibration of seismic reflection imagery using grain-size data collected from vibracores.

A part of the Sandy Point deposit, situated 12 to 16 miles from the Shell Island project site, is being considered for the restoration of Pelican Island. The Sandy Point depositional area is less attractive than the Mississippi River sands due to the presence of extensive oil and gas infrastructure, relatively thick layers of mud on top of sands (muddy overburden), and limited lateral and vertical extent of sand layers. Already considered for the restoration of Pelican Island is the most feasible segment of this deposit (in terms of sand versus thickness of mud overburden and dredging setbacks from oil/gas infrastructure), further restricting development of the potential borrow area. Despite these limitations, the area may still provide enough sediment to support restoration of Shell Island, pending results of additional geotechnical and geophysical investigations that are required for other segments of this deposit.

### C-2.7.2 Quatre Bayou (Shallow – Deep – D2) (CPE, 2003-2004b; CEC, 2004)

Kindinger *et al.* (2001) defined three sub-deposits within the Quatre Bayou depositional system (Shallow, Deep, and D2). CPE (2003) investigated the landward boundary of the Quatre Bayou Deep deposit and part of the Quatre Bayou Shallow with reconnaissance seismic reflection profile surveys. A smaller area (intersecting the two USGS boundaries) was later defined as a borrow area for the restoration of Chaland Island. CPE (2004b) investigated all Quatre Bayou Shallow deposits to define a borrow area for the restoration of East Grand Terre. An area just offshore the southwestern edge of the Quatre Bayou Deep deposit was investigated by CEC (2004) to define a borrow area for restoration of the barrier island segment in front of Bay Joe Wise. The main findings of these investigations, with emphasis on the availability of sand resources for Shell Island, are provided as follows.

The Quatre Bayou borrow area identified by CPE (2003) was located offshore of Quatre Bayou Pass and Pass Ronquille, west of Chaland Island. The borrow area is located in the northeast section of the USGS Quatre Bayou Deep deposit and partially overlies the southeast corner of Quatre Bayou Shallow (Figure 10). The Quatre Bayou study area contains modern shoals and distributary channel environments in water depths that range from 11 to 20 ft. Most cores obtained from water depths shallower than 14 ft. contained thin beds of surficial sands (recent ebb-shoal sedimentation), a layer of fine sediments, and a subsurface layer of sand. The sand fraction ranges from 0.08 mm to 0.18 mm. Sand depocenters (areas of greater sand thickness) are locally isolated and do not form a continuous sand body as previously described by Kindinger *et al.* (2001). The total volume that was estimated to occur in this borrow area was about 3.6 M cubic yards of sand for beach dune restoration and approximately 4 M cubic yards of mixed sediments for marsh restoration.

An additional borrow area within the Quatre Bayou depositional area was defined by CPE (2004b) for the restoration of East Grand Terre Island. This borrow area was located on the seaward boundary of the USGS Quatre Bayou Shallow deposit and almost touches the CPE (2003) borrow area in its southeast corner. The borrow area is located approximately 1 mile offshore Quatre Bayou Pass and parallels the coast. The investigated area is characterized by modern ebb-shoal sands that are texturally uniform; the area, however, contains vertically and laterally varying layers of sand, silty sand, and clay that are representative of channel, back barrier and marsh environments (especially in subsurface layers). The deposit, occurring in 8 to 12 ft. of water, contains about 2.8 M cubic yards of sand for beach dune restoration and about 3.6 M cubic yards of mixed sediments for marsh restoration. These materials may be extracted for the restoration of East Grand Terre Island.

CEC (2004) investigated the northwest corner of the Quatre Bayou Deep near a relict paleo-channel complex that was initially mapped by Suter *et al.* (1991). The CEC (2004) borrow area shown in Figure 10 contains about 2.5 M cubic yards of mixed sediments for marsh restoration and about 1.3 M cubic yards of fine sand for beach-dune restoration. The borrow area contains three distinct layers viz. a 6 to 8 foot thick layer of muddy overburden (to be removed and dumped in a disposal area), a 10 to 12 ft. thick layer of interbedded irregular sequences of clay, silt and sand (mixed sediments for a marsh cut), and a

layer of fine sand with an average thickness of 12 ft. The marsh cut contains an average grain size of 0.076 mm while the beach dune cut has an average grain size of 0.13 mm. Although silt content was not specifically indicated, a grain size frequency distribution curve for the beach dune borrow area shown in the CEC (2004) report indicates a silt content of about 22% within the borrow area.

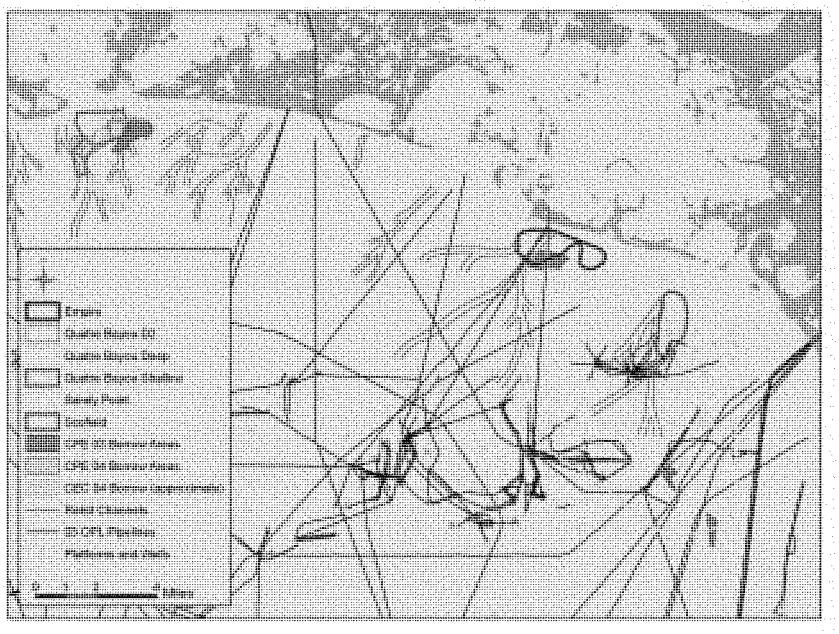

Figure 10. Previously mapped sand deposits along the Plaquemines shoreline in relation to oil and gas infrastructure. USGS sand deposits, mapped on the basis of regional investigations, are identified by hollow polygons whereas filled (solid color) polygons represent borrow areas that were mapped in detailed investigations conducted by CPE (2003, 2004b) and CEC (2004).

### C-2.7.3 Marsh Borrow Areas - Empire and Scofield

The Empire study area is located offshore the Empire Jetties and Pelican Island (see Figure 11). Previous geological studies (*e.g.* Kindinger *et al.*, 2001; Suter *et al.*, 1991) described the depositional environments in the area in terms of migrating (overlapping) fluvial and deltaic deposits where channels were filled by riverine and non-riverine sediments, both of which were subsequently covered by modern muds.

The Empire and Scofield area was investigated by CPE (2003) to search for sand deposits that would be suitable for beach dune restoration. Detailed geophysical and geotechnical studies conducted by CPE (2003) verified that sand deposition in the area was widespread but that it varied significantly in both lateral and vertical dimensions, contrary to what was previously indicated on the basis of reconnaissance surveys (Suter *et al.*, 1991; Kindinger *et al.*, 2001). Nonetheless, these two study areas may be able to provide sufficient volumes to support the marsh component of the Shell Island project.

Because of its close proximity to Shell Island, the Empire deposit was re-analyzed to determine whether there was enough sediment to support marsh restoration of Shell Island. The boundaries of this redesigned mixed sediment borrow area are shown in Figure 11.

The borrow area is located about 1 mile offshore Pelican Island and about 1.5 miles from the Empire Jetties. Water depths increase seaward from 16 ft. to 20 ft., isobaths (bathymetric contours) are roughly parallel to the shore, and surface geomorphology is featureless. Vibracores from the area show irregular intercalation of sand, silt and clay layering.

The borrow area occupies about 207 acres and total mixed sediment volumes range from 5.5 to 6.6 M cubic yards for 15 and 20 ft. cut depths, respectively (Table 1). Thirty-one (31) samples obtained from six (6) vibracores (spaced from 600 to 1900 ft. apart) were analyzed in order to determine selected sediment properties that characterize this borrow area. Because most samples were obtained below 15 ft. depth (but less than 20 ft.) the 20 ft. composite may be slightly biased. Additionally, the borrow area sedimentary composites were calculated using a direct arithmetic average that may induce additional bias. Preliminary borrow area sedimentary characteristics indicate a mean grain size of 0.06 mm, a silt content of about 39%, a clay content about 22%, and sand contents that range from 37% to 38% (Table 1). Three pipelines intersect the deposit as shown in Figure 11.

Table 1. Characteristics of the Empire mixed sediment borrow area.

| Marsh Borrow Area | 20 ft. Cut | 15 ft. Cut |
|---|---|---|
| Area ($ft^2$) | 9,019,962 | 9,019,962 |
| Volume(cubic yards) | 6,681,000 | 5,011,000 |
| Grain size (mm) | 0.06 | 0.06 |
| Sorting (phi) | 1.59 | 1.55 |
| % Silt | 39.77 | 39.57 |
| % Clay | 22.99 | 22.34 |
| % Sand | 37.24 | 38.10 |

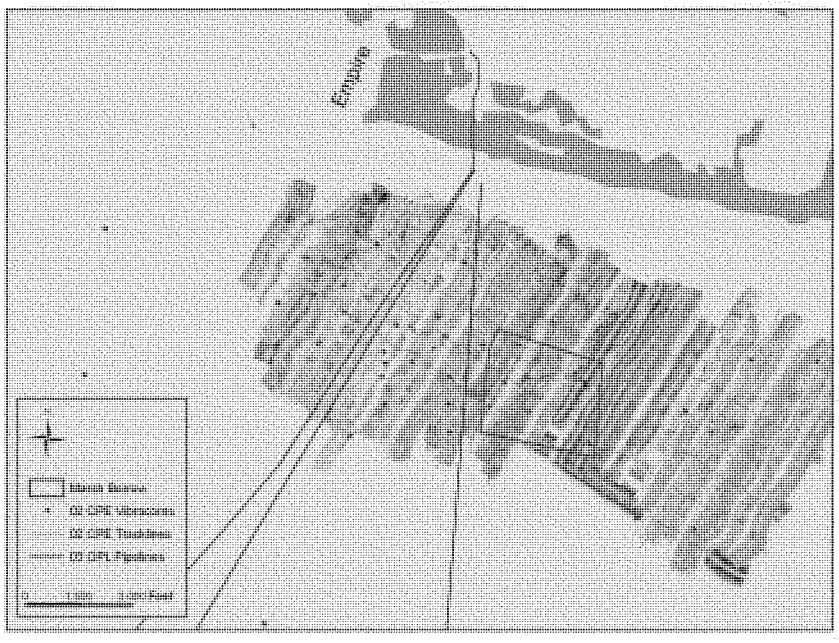


Figure 11. Boundaries of proposed mixed sediment borrow area for Shell Island.

### C-2.7.4 Final Considerations

Potential sand and mixed sediment borrow area sources for the restoration of Shell Island are described in this report. The Empire deposit does not contain enough mixed sediment to support the restoration of any of the design scenarios for Shell Island with a cut to fill ratio of 2:1. Additional material may be available by expanding the borrow area.

As for sand sources, there are a few options that require further evaluation with field investigations and dredging feasibility analyses. The Mississippi River point bar deposits at Nairn appear to be a promising sand resource due to the large volumes of clean sand (potentially renewable) available at that location. There still may be useful volumes of sand for beach dune restoration in Sandy Point and Quatre Bayou Deep deposits that need to be verified by field investigations and cleared from oil and gas infrastructure.

Suter *et al.* (1991) indicated the presence of large volumes of sandy sediments between Quatre Bayou Deep and Sandy Point (directly offshore of Shell Island). These deposits, associated with paleo-distributary channels and ebb-tidal shoals, were not subsequently verified by the regional investigations of Kindinger *et al.* (2001). Because of the significant cost savings that would result from the verification of nearby offshore sand sources, it is recommended that additional investigations be conducted offshore Grand Bayou Pass and Shell Island. Field investigations using the latest seismic survey technology and carefully targeted vibracores coupled with lessons learned from recent sand search efforts along Louisiana's deltaic coast may identify potential sand resources closer to the project area.

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# ANNEX C-3

# BORROW AREA IMPACT ANALYSIS

# C-3.0 BORROW AREA IMPACT ANALYSIS

## C-3.1.1 STWAVE MODEL

Wave transformation analysis for the study area utilized the STWAVE model (Smith, 2001). STWAVE is a spectral wave model that evaluates the transformation of the wave height and wave angle based on a spectrum of waves instead of a single, monochromatic wave. The model utilizes linear wave theory, neglects bottom friction, and assumes steady-state waves and winds. Inputs to the STWAVE model include bathymetry, incident wave spectra, wind velocities, and water levels. Water levels and wind velocities are assumed to be uniform over the model grid.

## C-3.1.2 BATHYMETRIC DATA

Bathymetric data for the wave transformation model was compiled from:

- The June 2005 survey of Shell Island by the Louisiana Department of Natural Resources.
- The September 2002 survey of Pelican Island by Coastal Planning & Engineering, Inc. (2003).
- The regional bathymetric grid compiled by NOAA (2005). This grid is an approximate representation of the 1981 conditions.

The area covered by the STWAVE model grid appears in Figure C-3.1. Elevations within the STWAVE model grid were taken from the regional NOAA (2005) grid, except within the areas surveyed in 2002 and 2005. To account for subsidence,

- Elevations at grid points representing the 1981 conditions were lowered 0.70 feet.
- Elevations at grid points within the 2002 Pelican Island survey area were lowered 0.08 feet.

The resulting bathymetric grid, which approximates the 2005 conditions, appears in Figure C-3.2. The size of the STWAVE grid is 14.3 miles in the cross-shore direction by 15 miles in the longshore direction.

Offshore contours generally form an elliptical arc, with the major axis running from west-northwest to east-southeast. The average distance between the Gulf shoreline and the -5 foot NAVD contour is about 0.4 miles. The average distance between the shoreline and the -15 foot NAVD contour is about 1.4 miles. Due south of the Empire Jetties, the contours protrude about 1 mile seaward. A similar protrusion is located near the eastern edge of the STWAVE model grid. At Shell Island itself, subsidence, long-term erosion, and breaching have removed much of the subaerial land. This loss of land has transformed Shell Island Bay and Bastian Bay into a large, 5 mile wide cove opening directly into the Gulf of Mexico.

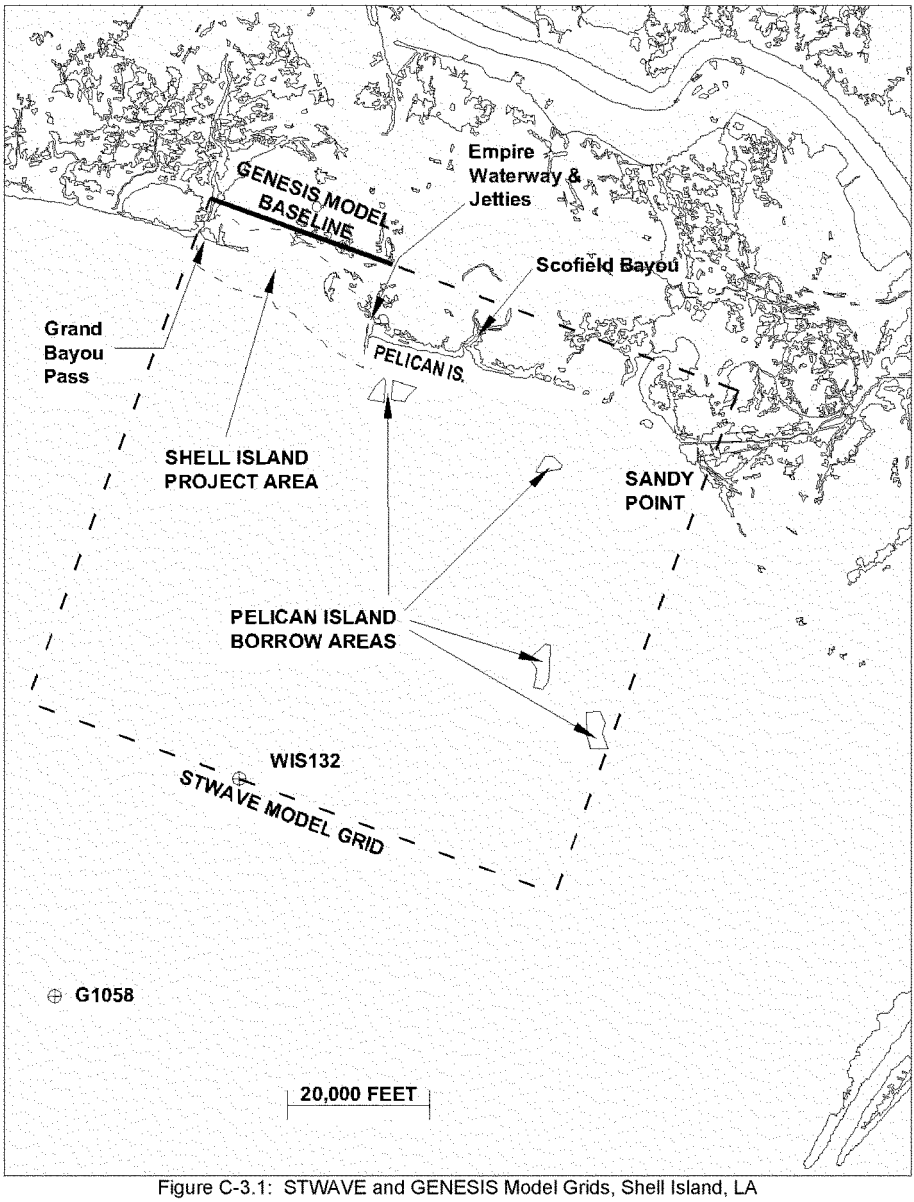


Figure C-3.1: STWAVE and GENESIS Model Grids, Shell Island, LA

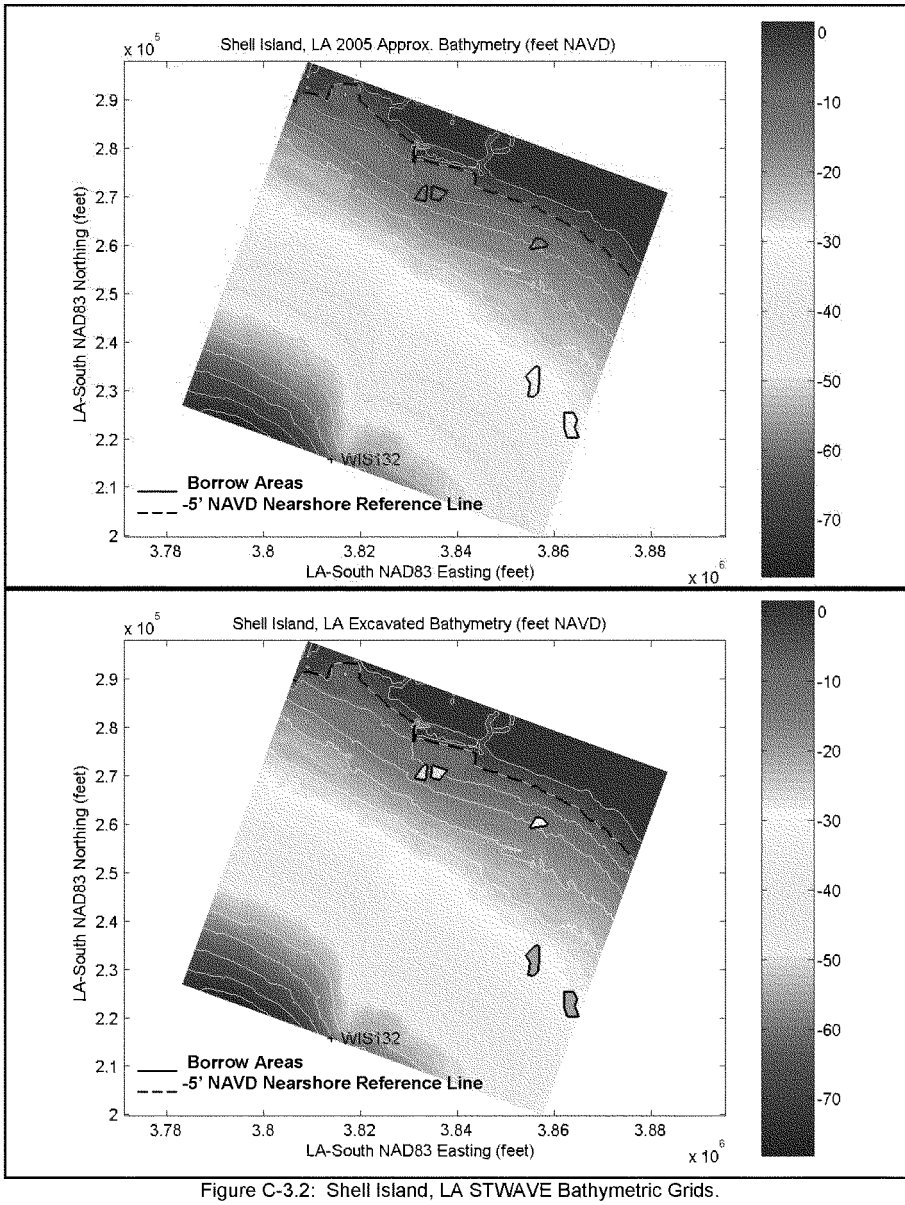


Figure C-3.2: Shell Island, LA STWAVE Bathymetric Grids.

The geotechnical investigations for the Pelican Island (CPE, 2003) and Shell Island restoration projects have mapped a number of borrow areas, which appear in Figures C-3.1 and C-3.2. The cut depths of these borrow areas range from -27 to -55 feet NAVD. The excavated conditions appear in Figure C-3.2, and assume that all borrow areas have been completely dredged.

### C-3.1.3 Wave Cases

Input wave cases appear in Table C-3.1. Water levels and winds were incorporated into the STWAVE model along with the incident waves. Wave cases under average conditions and annual cold fronts were based on the 1980-1999 wave hindcast at WIS Station 132 (Figures C-3.1 and C-3.2), along with the wind velocities. Water levels during average conditions were assumed to be equal to the mean tide level. Water levels during cold fronts were assumed to be equal to the mean high water elevation. Wave cases under severe storm conditions, such as hurricanes, were based on extremal wave statistics provided by USACE (2000) and presented in CPE (2003), along with the NOAA (2005b) WAVEWATCH forecast for Hurricane Katrina. Winds and water levels during Hurricane Katrina were measured by NOAA (2007) at Grand Isle, LA. For the remaining severe storm cases, water levels were based on the storm stages in CPE (2003) and the wind speeds from USACE (1985).

TABLE C-3.1 STWAVE Wave Cases, Shell Island, LA

| Wave Case | Height (feet) | Period (sec.) | Direction (deg.) | Water Level (feet NAVD) | Wind Velocity (mph) | Wind Velocity (deg.) |
|---|---|---|---|---|---|---|
| | | | ALL WAVES*: | | | |
| MEAN | 2.7 | 4.1 | 144 | 1.06 | 14 | 144 |
| + 1 σ | 2.7 | 4.1 | 185 | 1.06 | 13 | 185 |
| | | | ONSHORE WAVES ONLY*: | | | |
| - 1 σ | 2.8 | 4.3 | 126 | 1.06 | 14 | 126 |
| MEAN | 2.8 | 4.3 | 167 | 1.06 | 14 | 167 |
| + 1 σ | 2.8 | 4.3 | 208 | 1.06 | 12 | 208 |
| | | | COLD FRONTS*: | | | |
| March 1993 Storm | 10.3 | 9.1 | 144 | 1.58 | 30 | 125 |
| January 1999 Storm | 15.4 | 11.1 | 176 | 1.58 | 37 | 170 |
| | | | SEVERE STORM CONDITIONS** | | | |
| He, Te | 17.4 | 11.0 | 177 | 1.58 | 47 | 177 |
| 5-YEAR | 18.0 | 11.7 | 173 | 4.00 | 47 | 173 |
| 10-YEAR | 20.5 | 12.4 | 173 | 5.90 | 61 | 173 |
| 20-YEAR | 22.9 | 13.2 | 173 | 7.70 | 75 | 173 |
| Hur. Katrina (2005) | 36.9 | 15.0 | 147 | 6.12 | 65 | 86 |

NOTES: * Waves and Winds - WIS Station 132 (29°5' N, 89°40' W, depth 62 feet).
** Waves - CPE (2003), USACE (2000), NOAA (2005b); Winds - USACE (1985), NOAA (2007).

Waves during the average conditions govern long-term erosion and sediment transport. To evaluate the dredging-related impacts on the average wave conditions, 5 cases were considered. These cases include the average wave and the average onshore wave, both of which fall within the two most common direction bands, southeast and south-southeast. Four of the 5 average wave cases examine dredging-related impacts to the prevailing longshore sediment transport from east to west. The 208° wave case examines dredging-related impacts to the wave climate during sediment transport reversals, which often occur during the summer months.

Waves during annual cold fronts govern storm erosion and the associated sediment transport during the winter season, when a majority of the sediment transport occurs. To evaluate dredging-related changes to the wave conditions during cold fronts, two cases were examined:

- The March 1993 Storm. This large, extratropical system resulted in high winds and waves from the southern United States to New England. During this storm, the prevailing waves were from the southeast.

- The January 1999 storm. This storm resulted in the highest wave outside hurricane season between 1980 and 1999. During this storm, the prevailing waves from the south-southeast.

During both storms, the longshore sediment transport was generally from east to west.

Waves during severe storm conditions govern cross-shore sediment transport processes that result in overwash, breaching, and large losses of subaerial land. These cases are based on extremal wave statistics provided by CPE (2003) and USACE (2000) at WIS Station G1058 (29°0' N, 89°45' W, depth 12 feet), located 20 miles south-southwest of Shell Island. The He, Te case represents the wave height exceeded 12 hours per year. This case governs the depth of closure, below which sediment motion is negligible (Birkemeier, 1985). The other cases represent the 5, 10, and 20 year storm conditions most commonly experienced during hurricane season, along with Hurricane Katrina (2005), which caused extensive erosion and flooding in the region.

### C-3.1.4 Existing Conditions

STWAVE results given the existing conditions appear in Figures C-3.3 to C-3.24. Wave heights over the entire grid appear in Figures C-3.3 to C-3.14. Wave heights at the -5 foot NAVD contour appear in Figures C-3.14 to C-3.26.

During average conditions, the nearshore wave heights are heavily influenced by the sheltering of the Empire Waterway jetties, the mouth of Scofield Bayou, and the various banks that constitute the remains of Shell Island. During severe storm conditions, elevated water levels allow for the propagation of waves over the low-lying land areas in Figure C-3.1. Nevertheless, waves during severe storms are depth limited except near the Empire Waterway jetties.

#### C-3.1.4.1 Mean Wave

The average wave propagates from the south-southeast (144°) and maintains its height and direction until approaching the -15 foot NAVD contour. At that location, the bottom depth begins to govern the wavelength, resulting in a gradual change in wave direction from south-southeast to south as the waves approach the shoreline. Accompanying this change in direction is a reduction in wave height. Along the -5 foot NAVD contour (Figure C-3.14), the wave height ranges from 1.2 to 2.1 feet, except near the Empire Waterway west jetty. Nearshore waves are highest near the west end of Pelican Island. The nearshore waves are lowest near the Empire Waterway west jetty, the eastern end of Pelican Island, and the middle-western quarter of the Shell Island banks, where deeper gaps lie between the shoal areas.

#### C-3.1.4.2 Mean Wave + 1 Standard Deviation of Wave Direction

Average-sized waves from the south (185°) maintain their height and direction until approaching the -45 foot NAVD contour. At that location, the wave height gradually drops to approximately 2.5 feet as the waves approach the -15 foot NAVD contour. At that location, the waves assume a more south-southwesterly direction (190-200°). At the -5 foot NAVD contour, the wave heights vary from 1.5 to 2.5 feet, except near the Empire Waterway west jetty. Nearshore waves are highest near the west end of Pelican Island and the west end of the Shell Island banks. The lowest nearshore waves occur near the Empire Waterway west jetty, the eastern end of Pelican Island, a small area near the west end of the Shell Island banks, and the middle-western quarter of the Shell Island banks.

#### C-3.1.4.3 Mean Onshore Wave - 1 Standard Deviation of Wave Direction

Average-sized waves from the southeast (128°) maintain their height and direction until approaching the -35 foot NAVD contour. At that location, the wave height gradually drops to approximately 2 feet as the waves approach the -15 foot NAVD contour. At that location, the waves assume a more south-southeasterly direction (170-180°). At the -5 foot NAVD contour, the wave heights vary from 1 to 2 feet, except near the Empire Waterway west jetty. Nearshore waves are highest near the west end of Pelican Island and the eastern bank of Scofield Bayou (13,000 feet east of the Empire Waterway). Nearshore waves are lowest near the Empire Waterway west jetty, the eastern end of Pelican Island, and the middle-western quarter of the Shell Island banks.

#### C-3.1.4.4 Mean Onshore Wave

The average onshore wave propagates from the south-southeast (167°) and maintains its height and direction until approaching the -40 foot NAVD contour. Between that location and the -15 feet NAVD contour, the wave height drops to approximately 2.2 feet. At the -5 foot NAVD contour, wave heights vary from 1.5 to 2 feet, except near the Empire Waterway west jetty. Nearshore waves are highest near the west end of Pelican Island, the eastern bank of Scofield Bayou, and the western end of the Shell Island banks. Nearshore waves are lowest near the Empire Waterway west jetty, the eastern end of Pelican Island, and the middle-western quarter of the Shell Island banks.

### C-3.1.4.5 Mean Onshore Wave + 1 Standard Deviation of Wave Direction

Average-sized waves from the south-southwest (208°) maintain their height and direction until approaching the -40 foot NAVD contour. Between that location and the -10 feet NAVD contour, the wave height drops to approximately 2.2 feet. At the -5 foot NAVD contour, the wave heights vary from 1.5 to 2.6 feet, except near the Empire Waterway west jetty. Nearshore waves are highest near the western end of the Shell Island banks and the eastern bank of Scofield Bayou. Nearshore waves are lowest near the Empire Waterway west jetty, the eastern end of Pelican Island, and the western half of the Shell Island banks.

### C-3.1.4.6 March 1992 Storm

Bathymetry during the March 1993 storm is not available. Rather, Figures C-3.8 and C-3.20 show the wave conditions that would occur if a similar storm struck the project area today. Between the -60 and -20 foot NAVD contours, the wave height drops from 10 to 7 feet, with a change in wave direction from southeast (144°) to south-southwest. Wave breaking occurs near the -10 foot NAVD contour. At the -5 foot NAVD contour, wave heights are controlled by the depth and the location of the major inlets. Areas of reduced wave energy occur near Scofield Bayou, the Empire Waterway west jetty, and the middle-western quarter of the Shell Island banks. Along the rest of the study area, the nearshore waves are depth limited, exhibiting a height of approximately 4 feet.

### C-3.1.4.7 January 1999 Storm

Bathymetry during the January 1999 storm is not available. Rather, Figures C-3.9 and C-3.21 show the wave conditions that would occur if a similar storm struck the project area today. Between the -60 and -15 foot NAVD contour, the wave height drops from 15 to 9 feet, with a change in wave direction from south (176°) to south-southwest. Wave breaking occurs near the -15 foot NAVD contour. At the -5 foot NAVD contour, wave heights are generally depth limited, except near the Empire Waterway west jetty and the middle-western quarter of the Shell Island banks. The influence of Scofield Bayou on the nearshore wave height is negligible.

### C-3.1.4.8 Wave Exceeded 12 Hours per Year (He, Te)

The offshore wave exceeded 12 hours per year is somewhat higher than the January 1999 storm waves. However, the wave propagation patterns are similar. At the -5 foot NAVD contour, the waves are generally depth limited and exhibit a variation similar to the January 1999 storm.

### C-3.1.4.9 5, 10, and 20 Year Waves

Wave propagation patterns during the 5, 10, and 20 year storms appear in Figures C-3.11 to C-3.13 and C-3.23 to C-3.25. During these storms, the wave direction gradually changes from south to south-southwest between the -60 and -15 foot NAVD contours. Near the -15 foot NAVD contour, wave breaking occurs. At the -5 foot NAVD contour, wave heights are controlled by the depth and the location

of the major inlets. Areas of reduced wave energy occur near Scofield Bayou, the Empire Waterway west jetty, and the middle-western quarter of the Shell Island banks. Along the rest of the study area, the nearshore waves are depth limited.

During the 5, 10, and 20 year storms, storm surge results in the inundation of the land areas bordering the Gulf. Wave propagation over these areas depends on the storm stage relative to the land elevation. The 20 year wave can reach heights 2 to 4 feet over the inundated land areas.

#### C-3.1.4.10 Hurricane Katrina (2005)

Hurricane Katrina is the Storm of the Century for the project area. The estimated wave patterns during the peak of Hurricane Katrina appear in Figures C-3.14 and C-3.26. Although Katrina had highest wave height at WIS Station 132, estimated wave heights within most of the model grid were lower than the 20 year storm. This result was due to the observed water level at Grand Isle, which was 1.6 feet lower than the 20 year storm stage. Because the Grand Isle station was located to the west of the eye, the storm surge at Grand Isle was much smaller than the surge experienced at the project site. Within 2-3 miles of the southern grid boundary, the estimated wave height decreased from 37 to 25 feet. Between the southern grid boundary and the -20 foot NAVD contour, the estimated wave direction gradually changed from south-southeast (147°) to south (180°). Between the -15 and -5 foot NAVD contours, wave breaking occurred. Along the -5 foot NAVD contour, the estimated wave heights were controlled by the depth and the locations of the major inlets. Areas of reduced wave energy occurred near Scofield Bayou, the Empire Waterway west jetty, and the middle-western quarter of the Shell Island banks. Along the rest of the study area, the nearshore waves were depth limited. Estimated wave directions along the -5 foot NAVD contour generally ranged from 185 to 205 degrees, except at the locations of the major inlets.

### C-3.1.5 Excavated Conditions

STWAVE results given the existing conditions appear in Figures C-3.3 to C-3.26. Determination of significant, dredging-related impacts is based on the error margin of the 1980-1999 hindcast (USACE, 2004). Once the dredging-related change in wave height is less than the margin of error of the input wave height, it is deemed that there is no impact due to dredging of the borrow area.

The maximum dredging-related change in wave height is 0.5 feet (Figure C-3.16). In comparison, the wave height bias of the 1980-1999 hindcast is +0.66 feet (USACE, 2004). In all 12 cases, dredging-related changes to the wave height are insignificant, since they fall within the error margin of the wave hindcast.

Under average wave conditions, the dredging-related change in wave angle is 6 degrees. In comparison, the wave angle bias of the 1980-1999 hindcast offshore of Biloxi, MS, is 8 degrees, based on directional wave measurements from NOAA Buoy 42007 (NOAA, 2005a). Thus, dredging related changes to the nearshore wave angle during average conditions are also insignificant, since they fall within the error margin of the wave hindcast. As noted before, dredging-related changes to the wave height under average

conditions are insignificant. Accordingly, the impact of dredging on the erosional patterns during average conditions will be negligible.

During cold fronts, tropical storms, and hurricanes (Figures C-3.19 to C-3.24), the maximum change in wave angle is 13 degrees. This change is larger than the wave angle bias of the 1980-1999 hindcast, but smaller than the root-mean square error value of 42 degrees. However, the wave angle will typically vary by much greater amounts during a storm event, and dredging of the borrow areas are not expected to have a noticeable effect on the shoreline.

## C-3.2 REFERENCES

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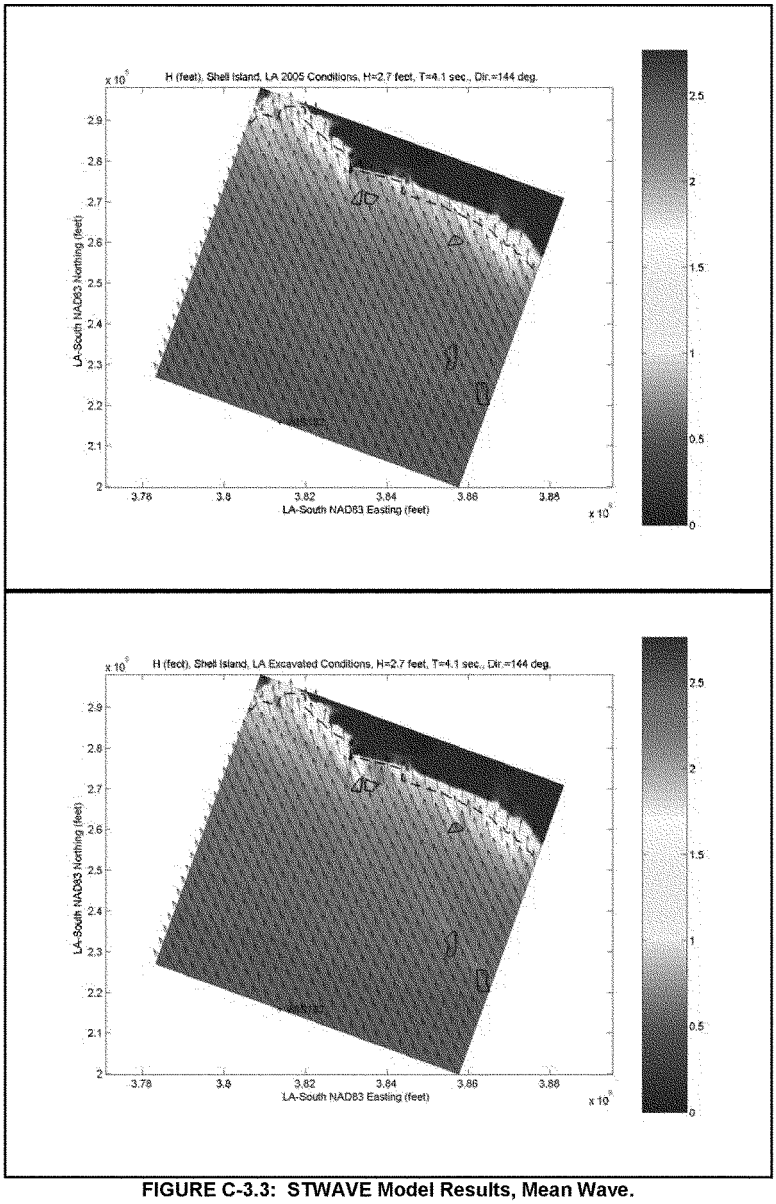


**FIGURE C-3.3: STWAVE Model Results, Mean Wave.**

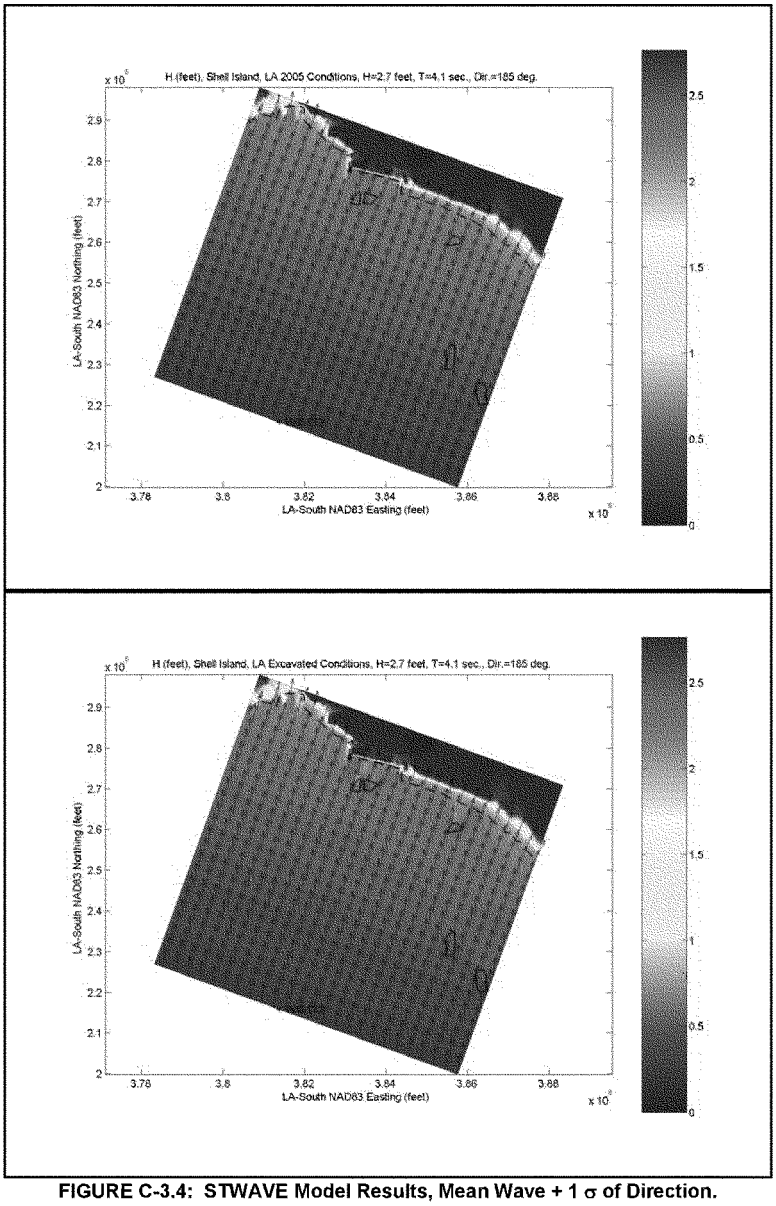


**FIGURE C-3.4: STWAVE Model Results, Mean Wave + 1 σ of Direction.**

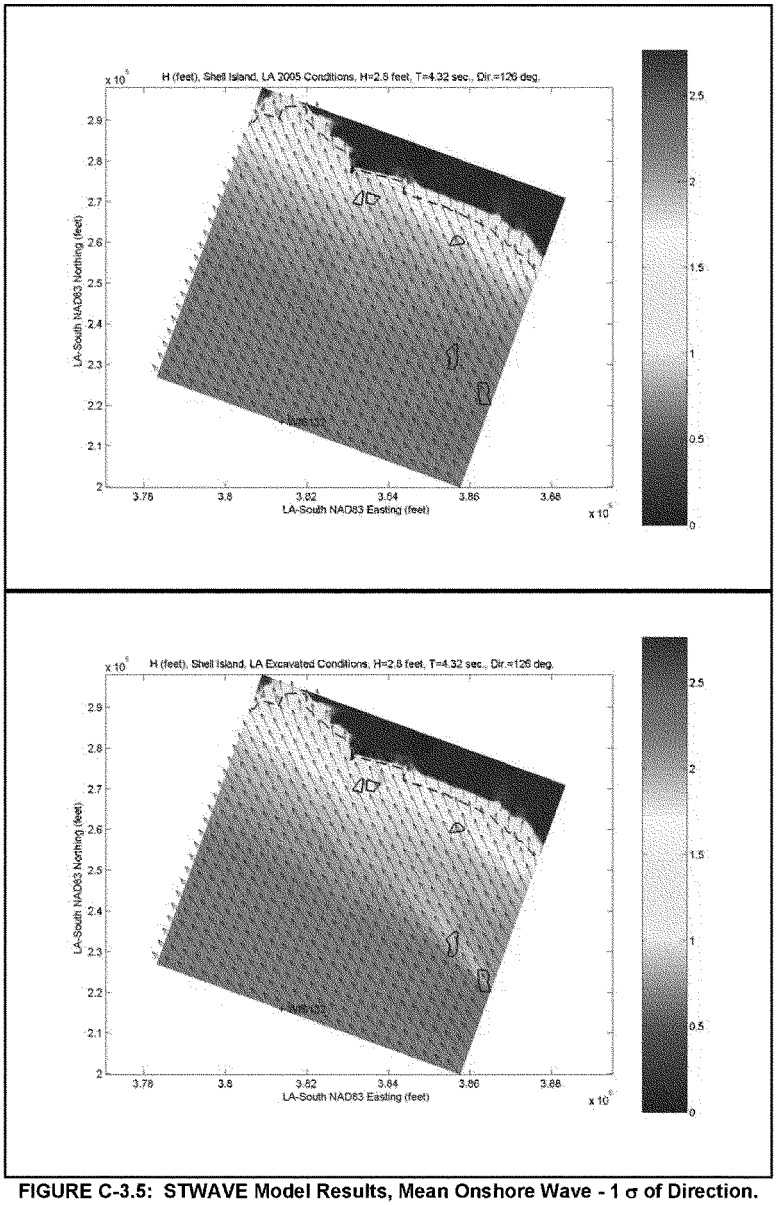


**FIGURE C-3.5: STWAVE Model Results, Mean Onshore Wave - 1 σ of Direction.**

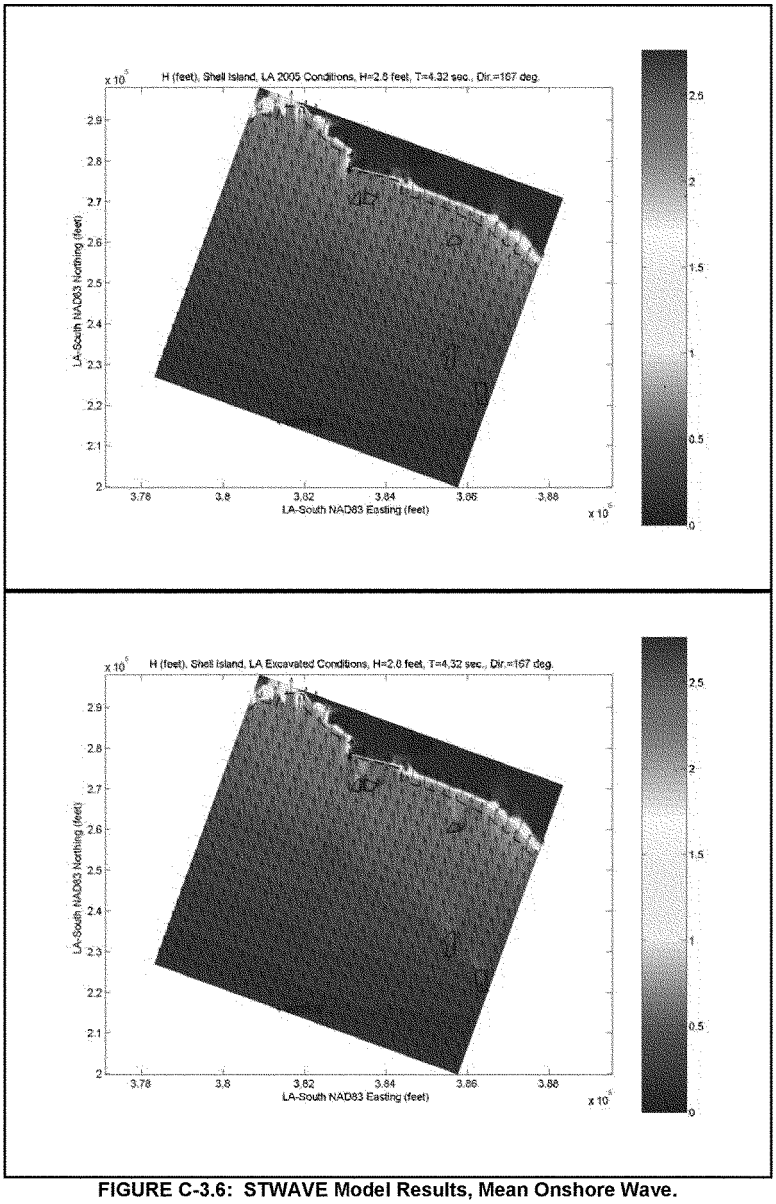


**FIGURE C-3.6: STWAVE Model Results, Mean Onshore Wave.**

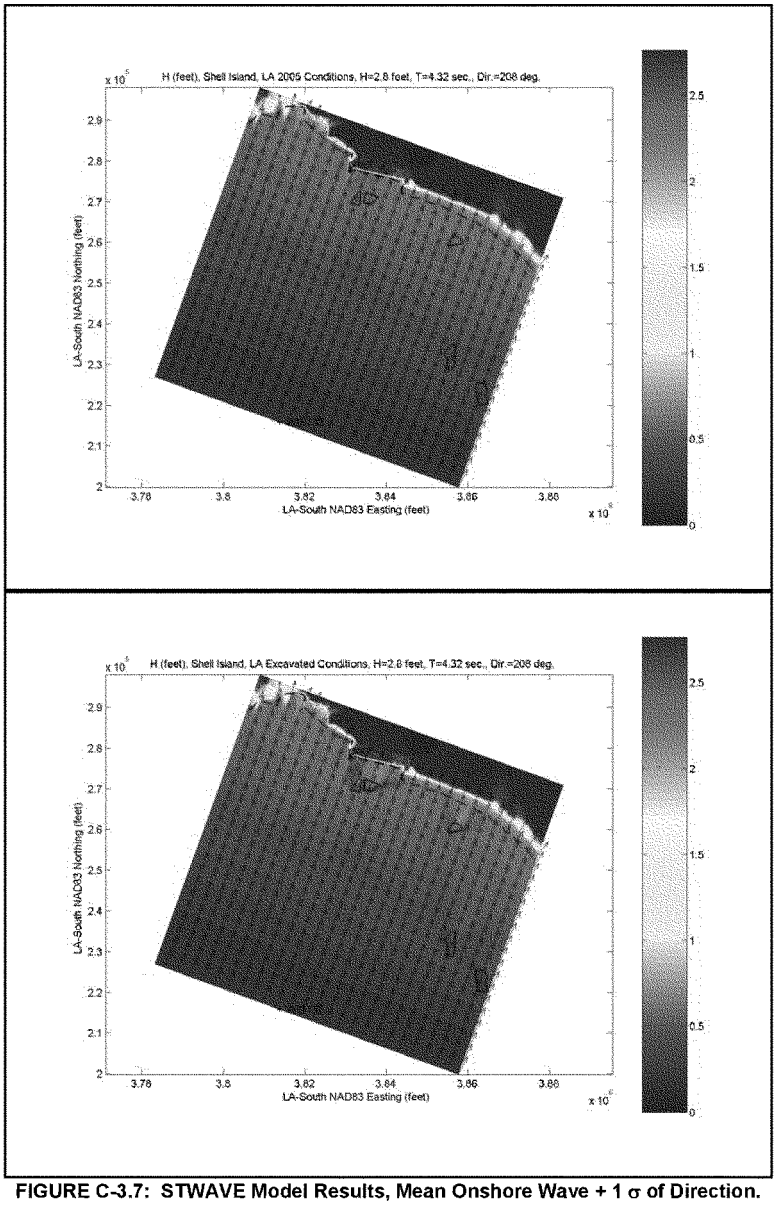


**FIGURE C-3.7: STWAVE Model Results, Mean Onshore Wave + 1 σ of Direction.**

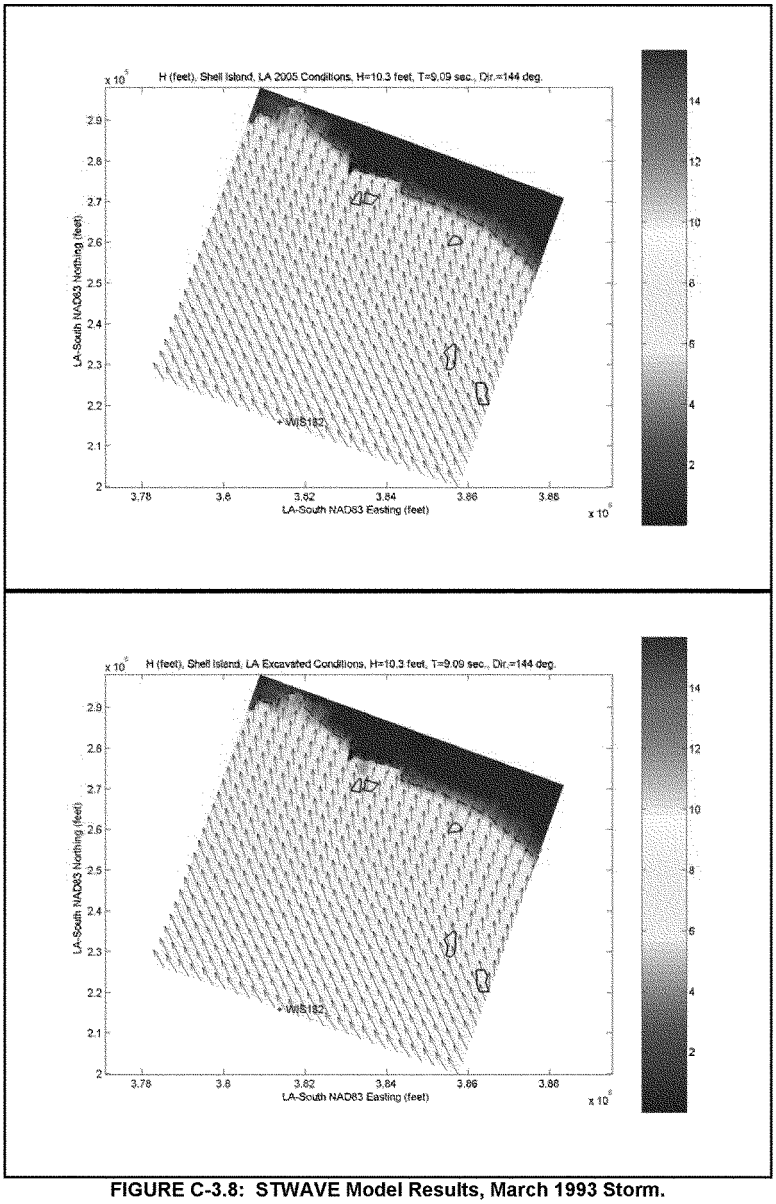


**FIGURE C-3.8: STWAVE Model Results, March 1993 Storm.**

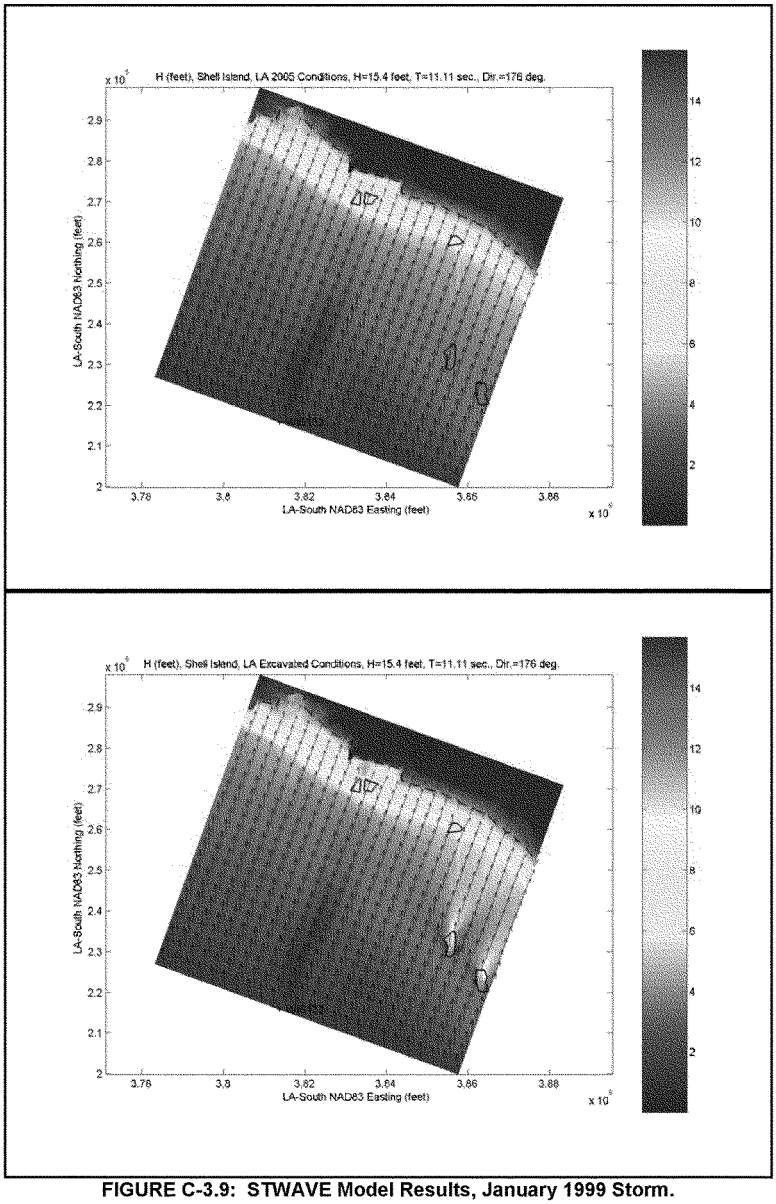


**FIGURE C-3.9: STWAVE Model Results, January 1999 Storm.**

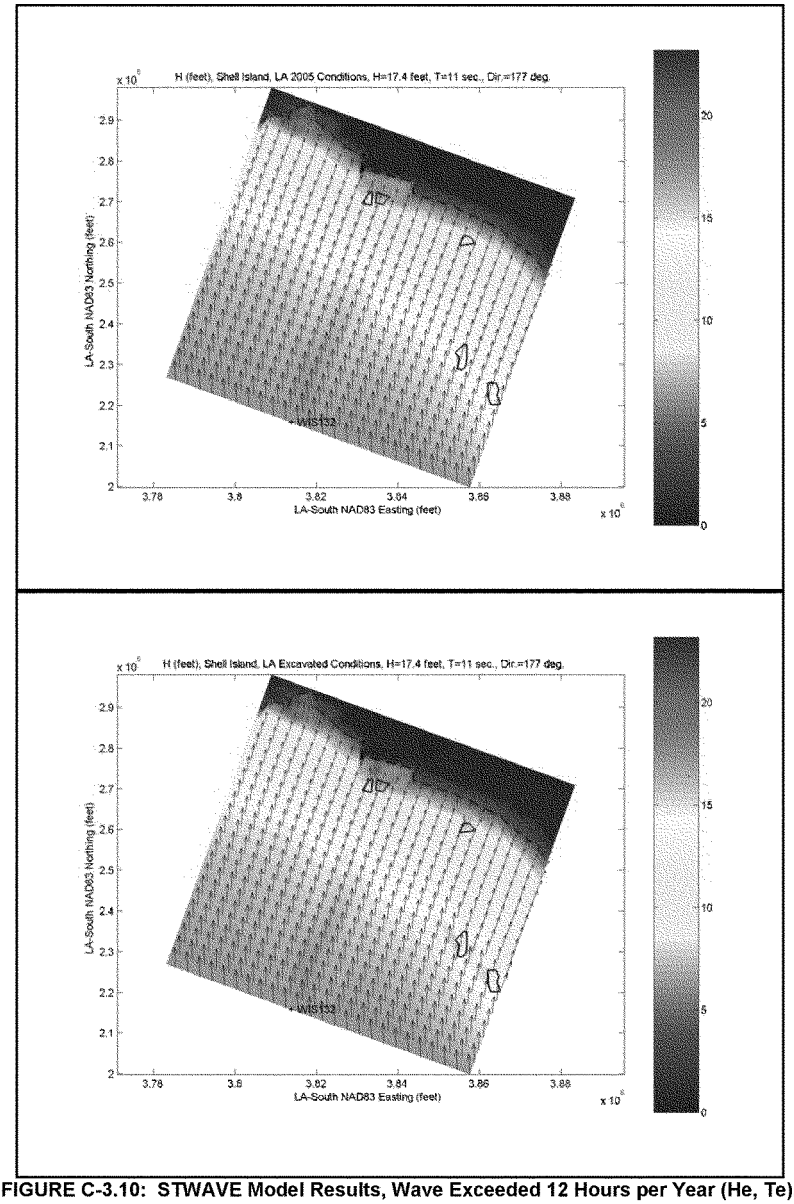


**FIGURE C-3.10: STWAVE Model Results, Wave Exceeded 12 Hours per Year (He, Te).**

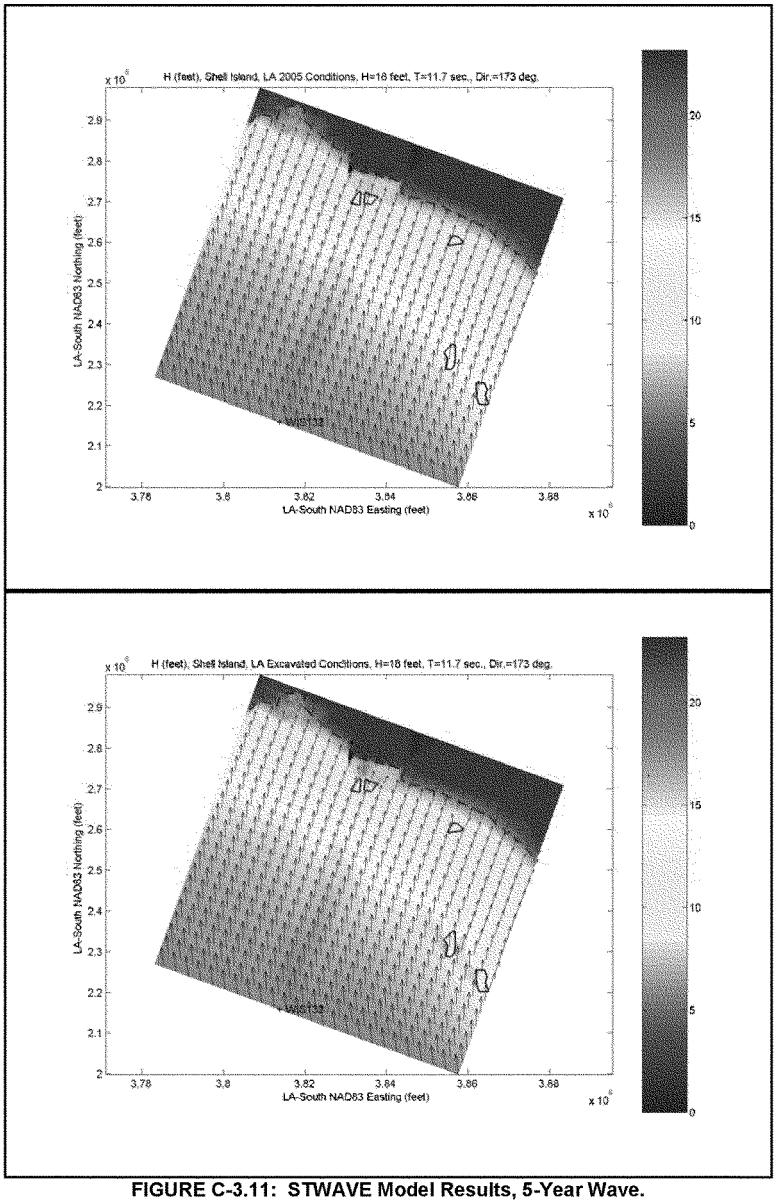


**FIGURE C-3.11: STWAVE Model Results, 5-Year Wave.**

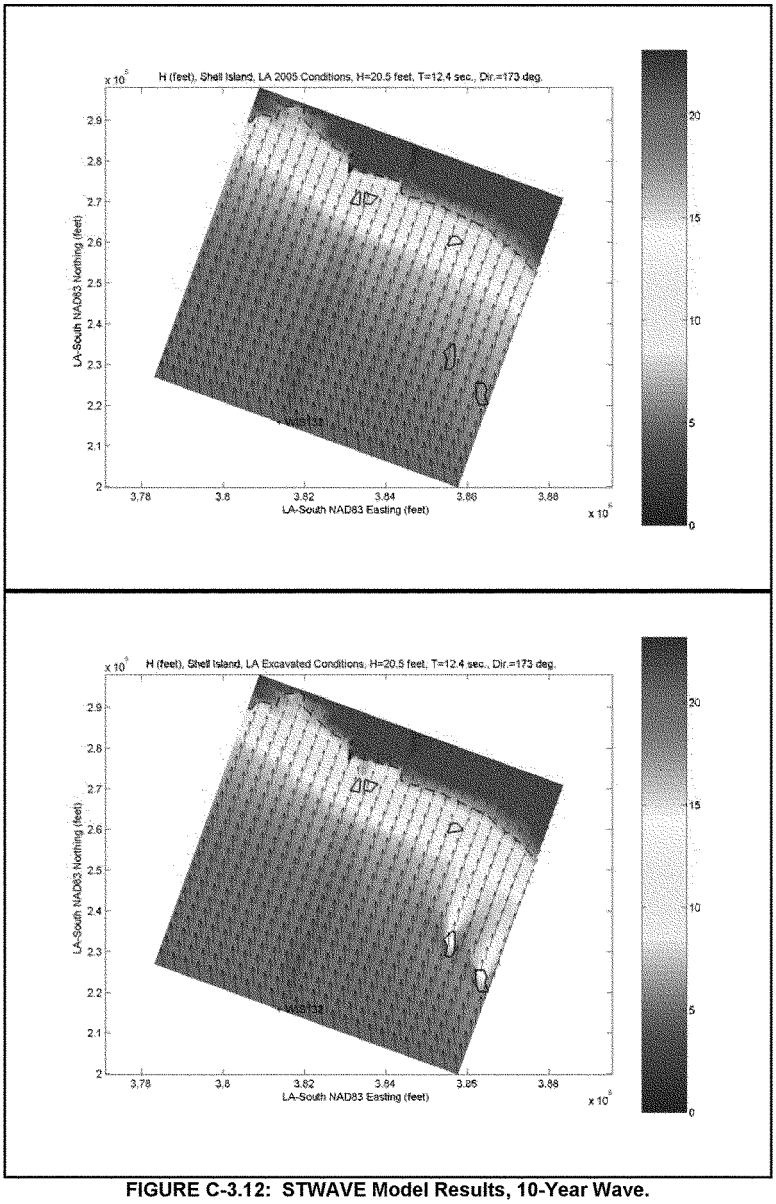


**FIGURE C-3.12: STWAVE Model Results, 10-Year Wave.**

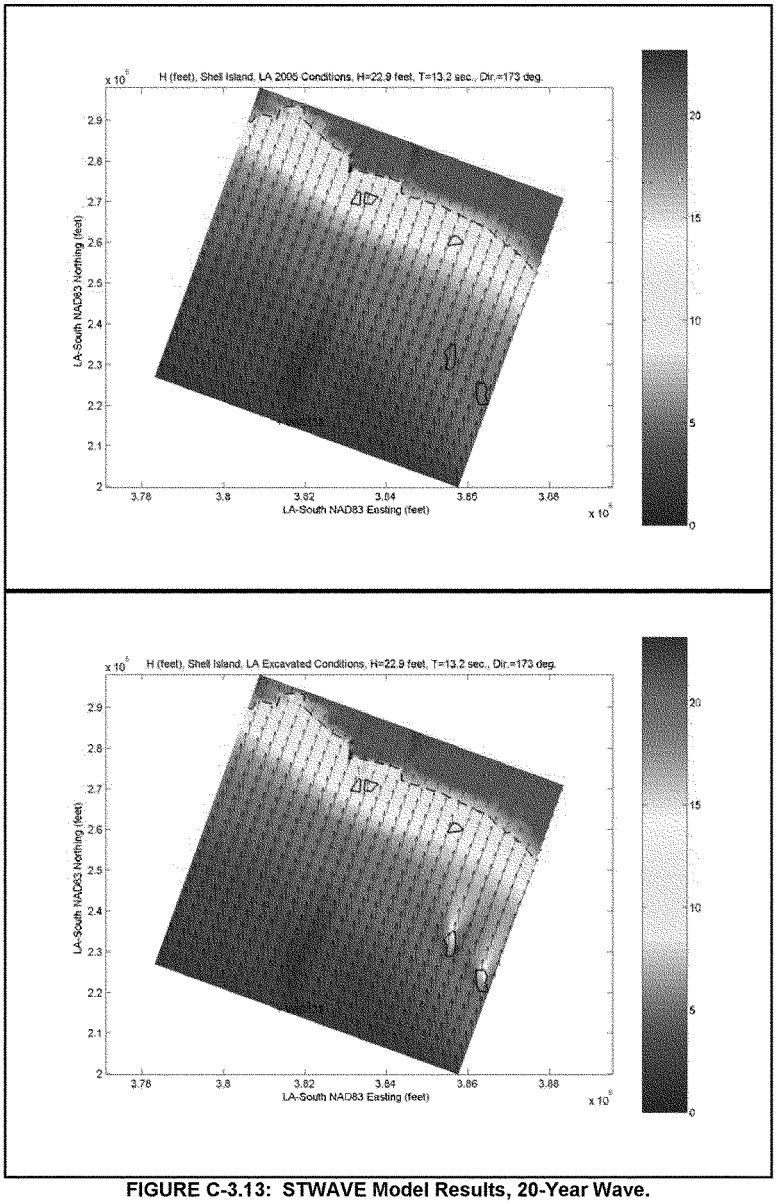


**FIGURE C-3.13: STWAVE Model Results, 20-Year Wave.**

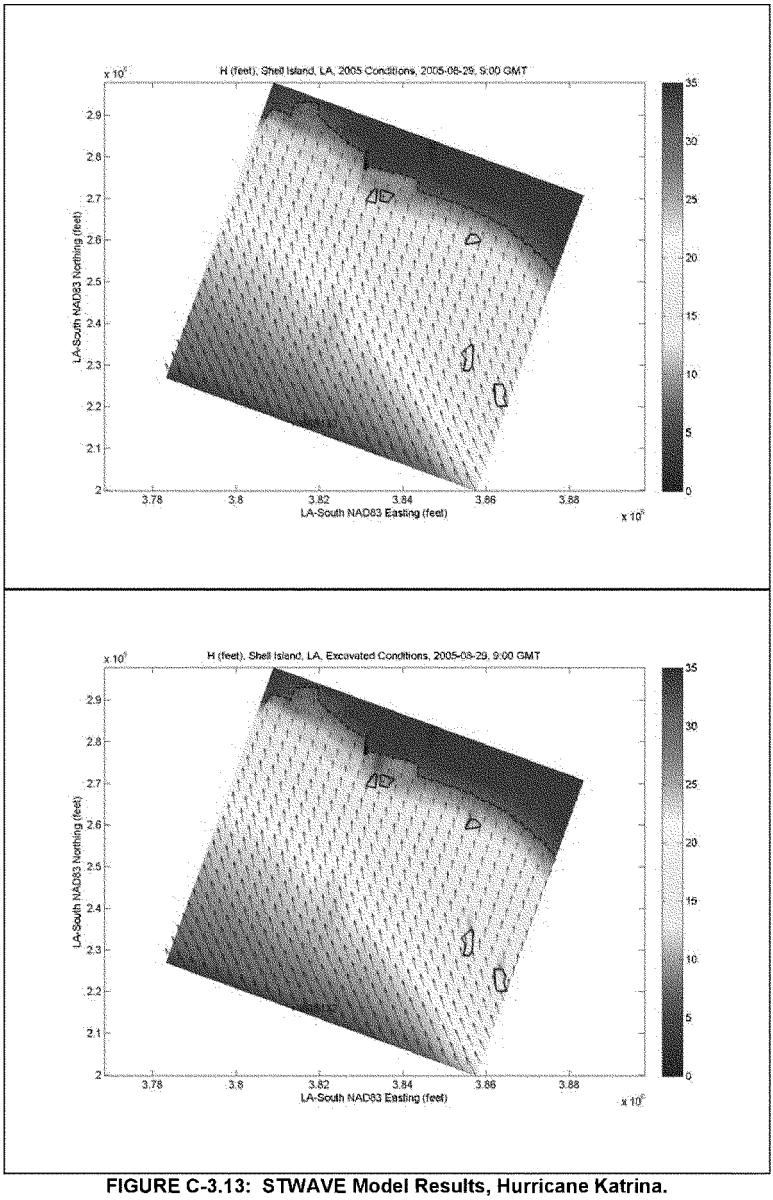


**FIGURE C-3.13: STWAVE Model Results, Hurricane Katrina.**

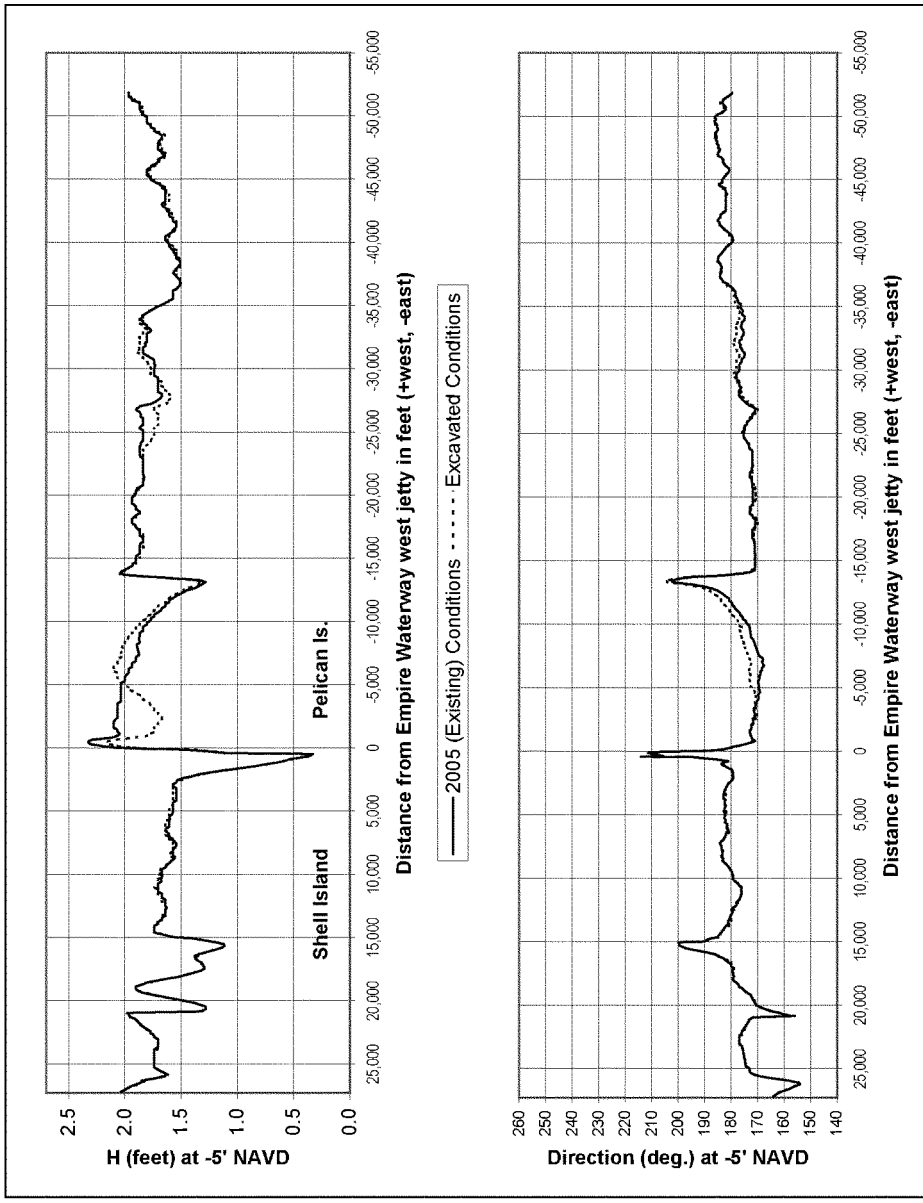


**FIGURE C-3-15: Nearshore Wave Results, Mean Wave, H = 2.7', T = 4.1 sec., Direction = 144 deg.**

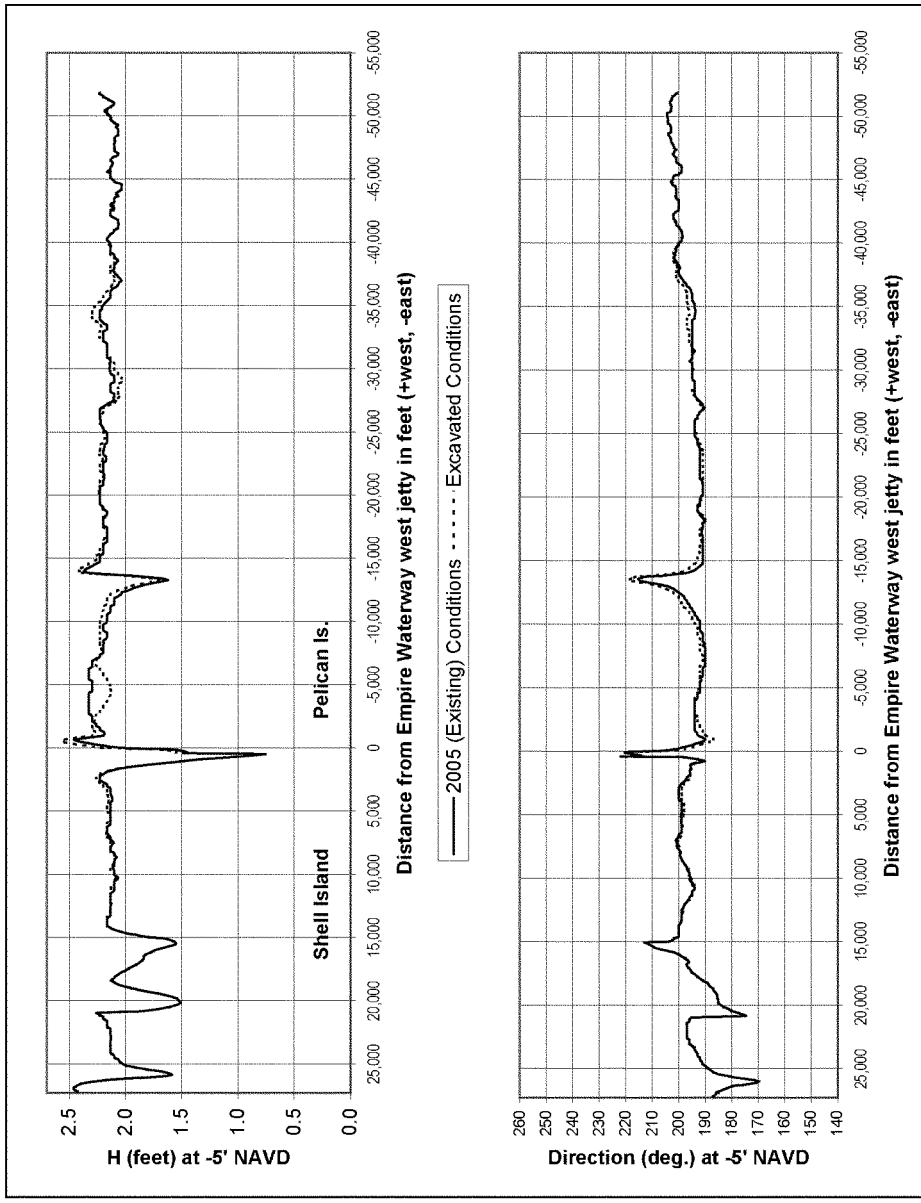


**FIGURE C-3-16: Nearshore Wave Results, Mean Wave + 1 Std. of Direction, H = 2.7', T = 4.1 sec., Direction = 185 deg.**

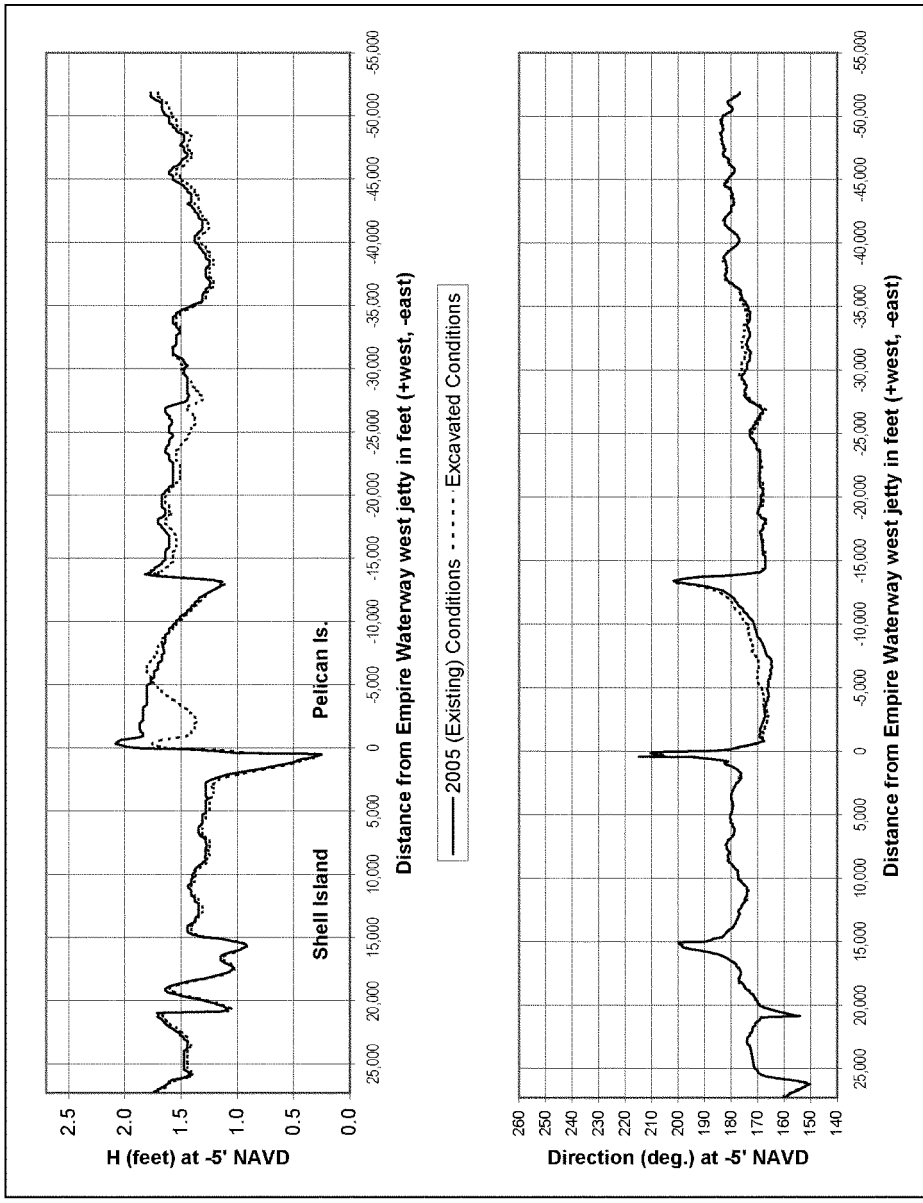


**FIGURE C-3-17: Nearshore Wave Results, Mean Onshore Wave - 1 Std. of Direction, H = 2.8', T = 4.3 sec., Direction = 126 deg.**

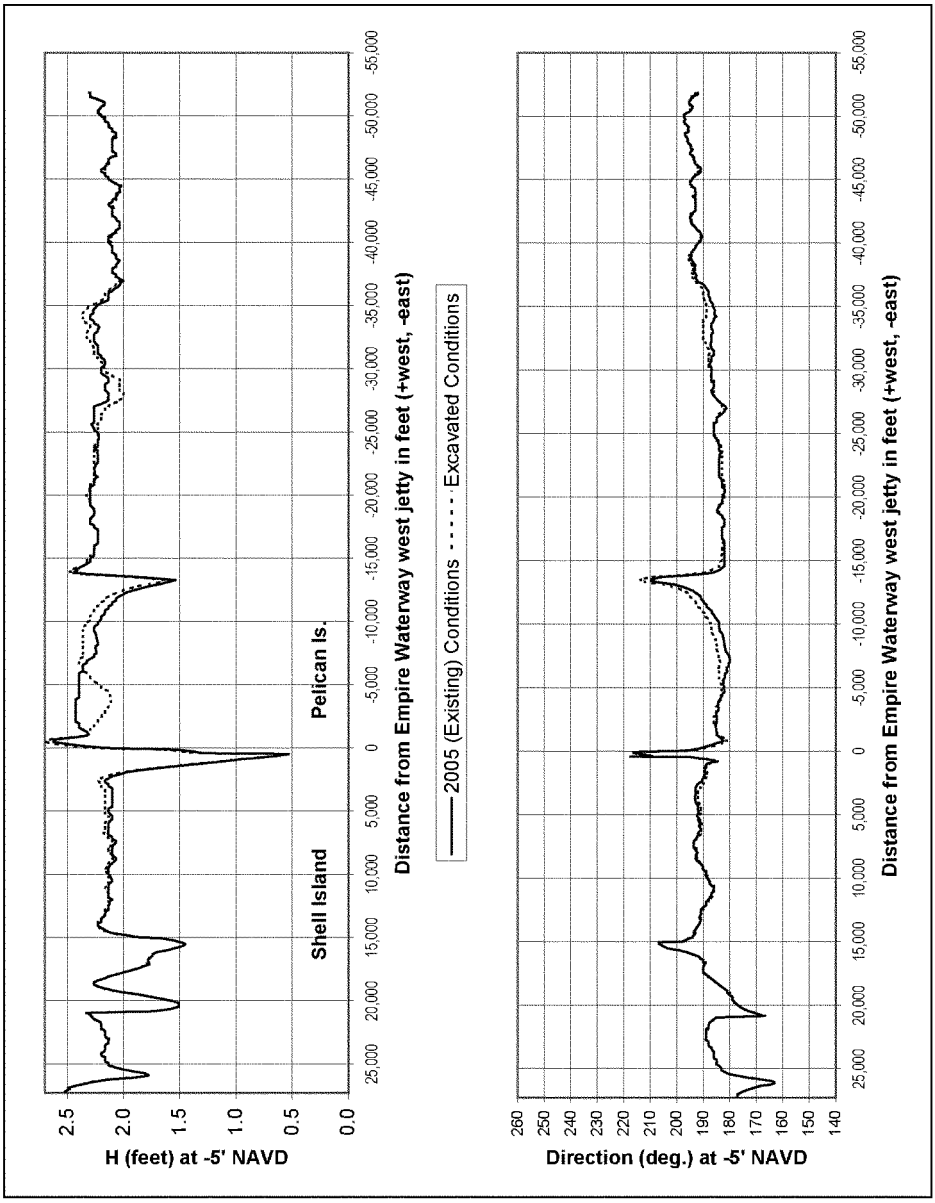


**FIGURE C-3-18: Nearshore Wave Results, Mean Onshore Wave, H = 2.8', T = 4.3 sec., Direction = 167 deg.**

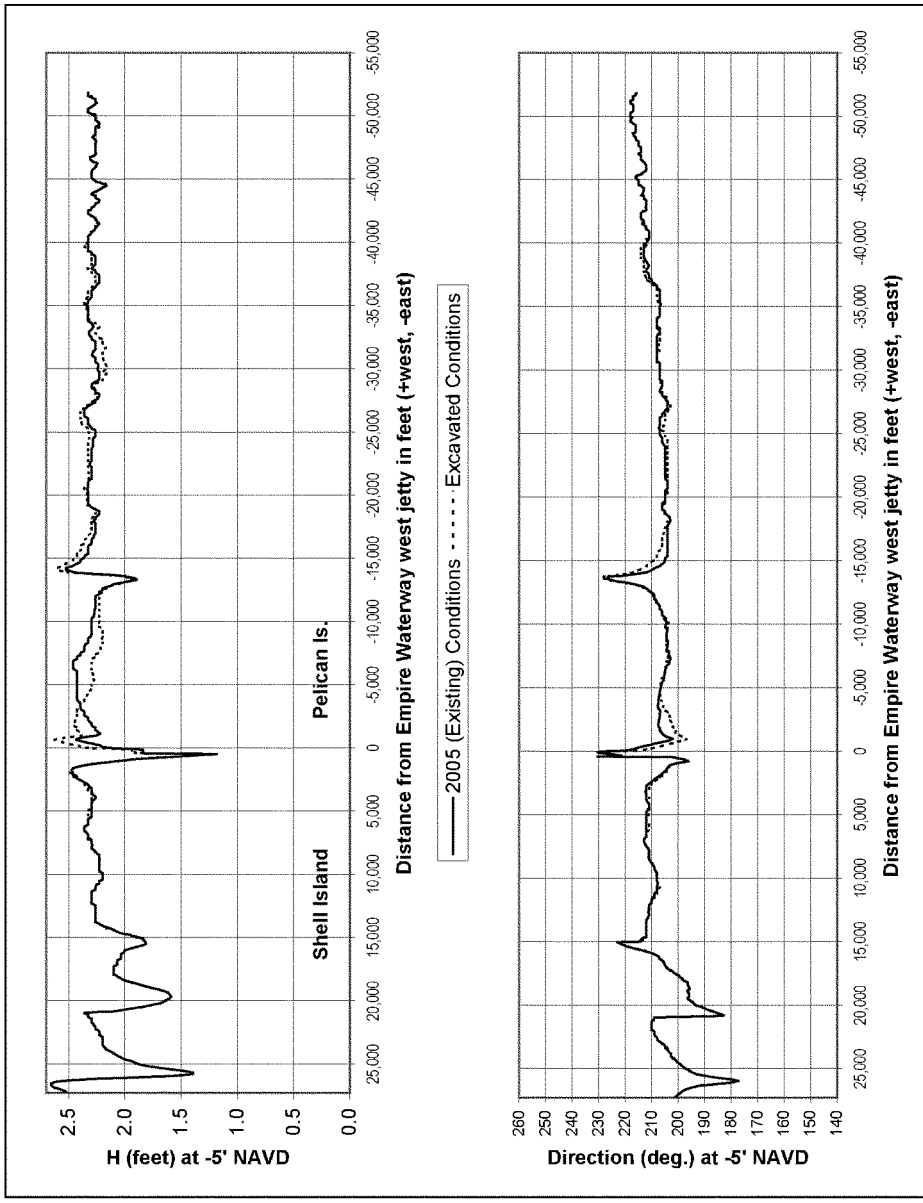


**FIGURE C-3-19: Nearshore Wave Results, Mean Onshore Wave + 1 Std. of Direction, H = 2.8', T = 4.3 sec., Direction = 208 deg.**

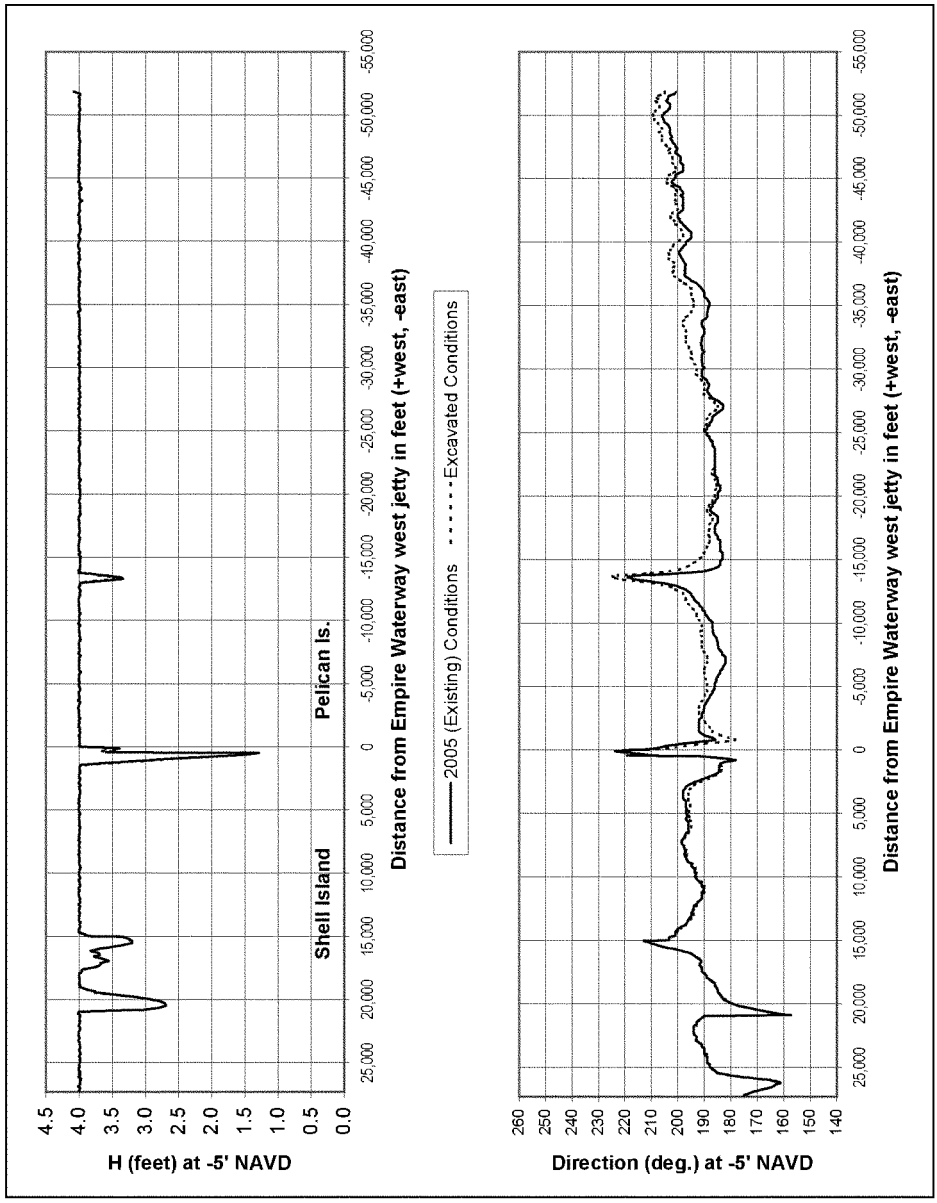


**FIGURE C-3-20: Nearshore Wave Results, March 1993 Storm, H = 10.3', T = 9.1 sec., Direction = 144 deg.**

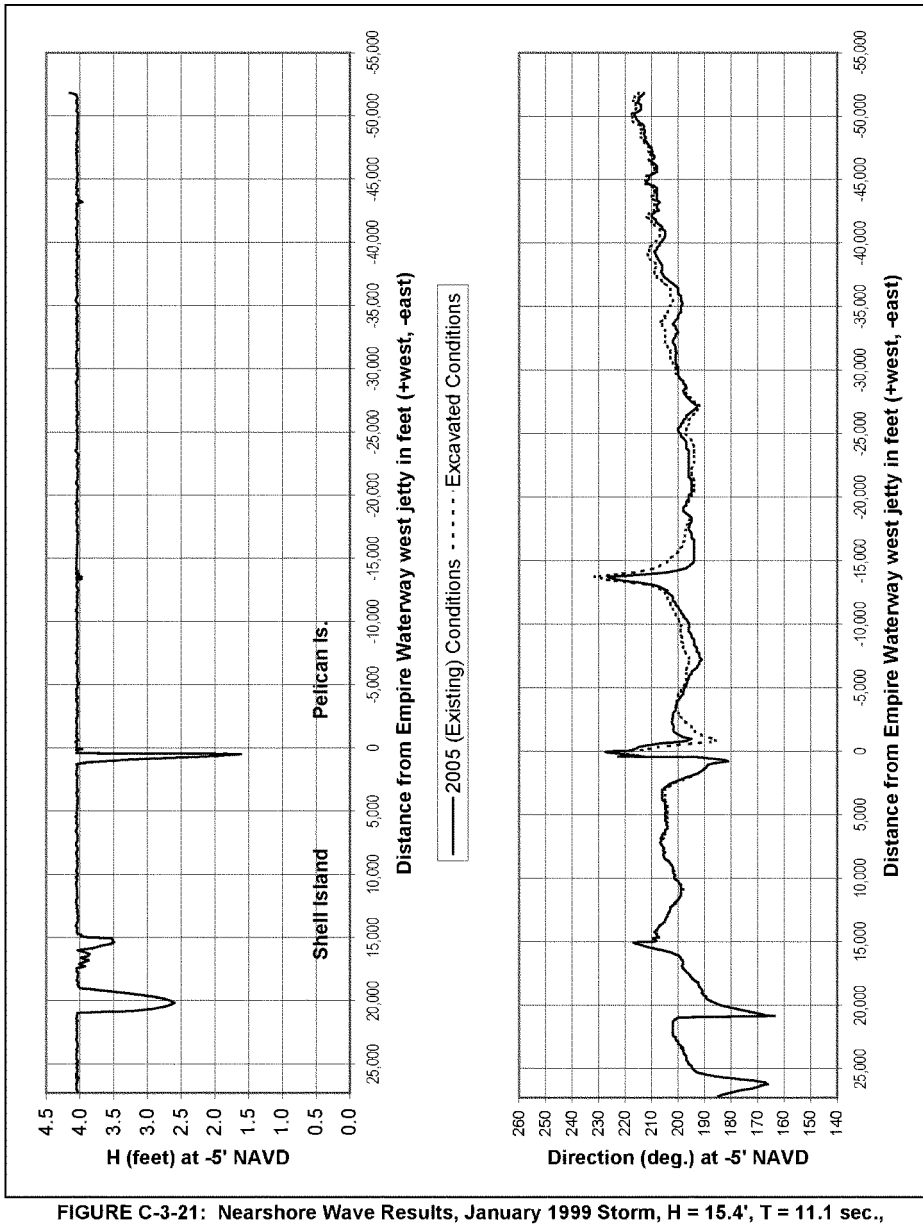


**FIGURE C-3-21: Nearshore Wave Results, January 1999 Storm, H = 15.4', T = 11.1 sec., Direction = 176 deg.**

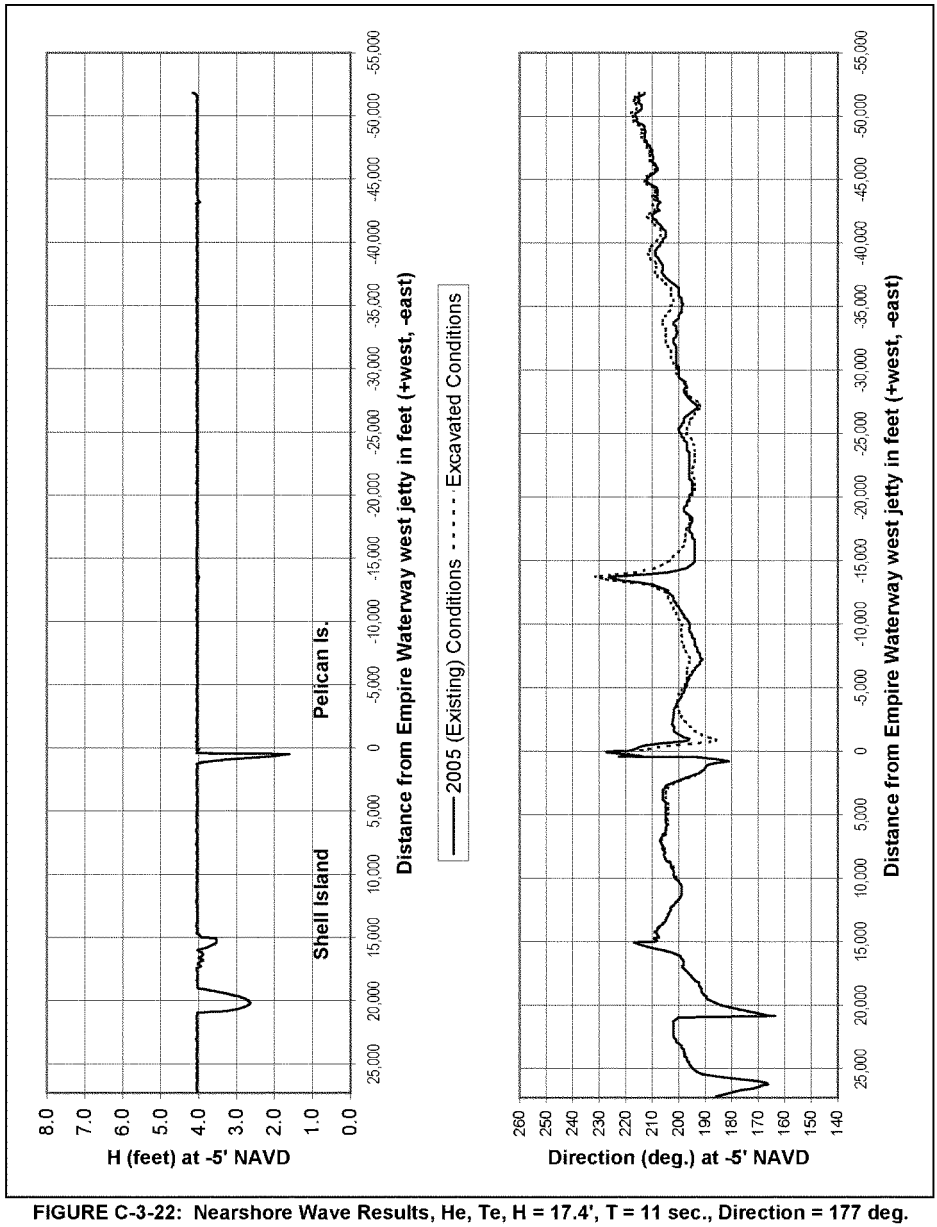


**FIGURE C-3-22: Nearshore Wave Results, He, Te, H = 17.4', T = 11 sec., Direction = 177 deg.**

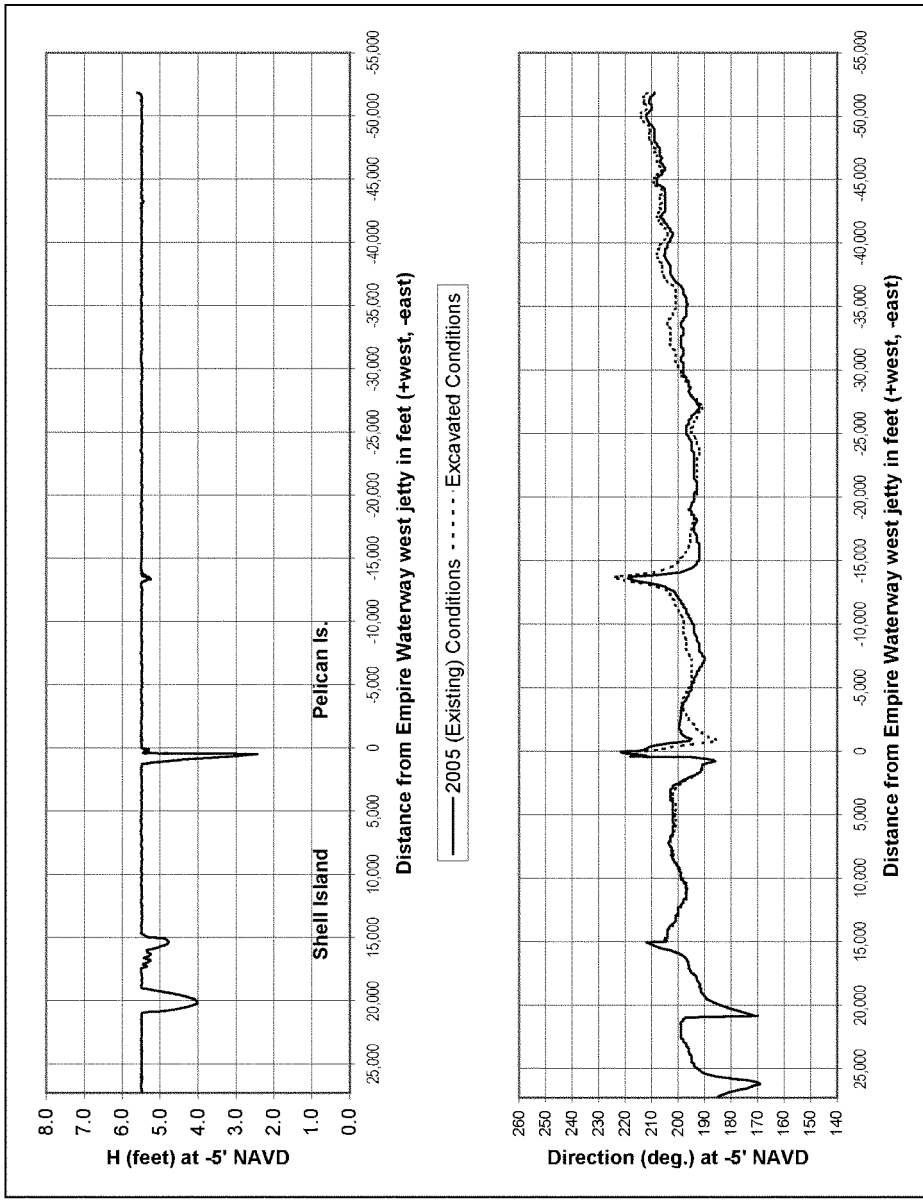


**FIGURE C-3-23: Nearshore Wave Results, 5-Year Wave, H = 18', T = 11.7 sec., Direction = 173 deg.**

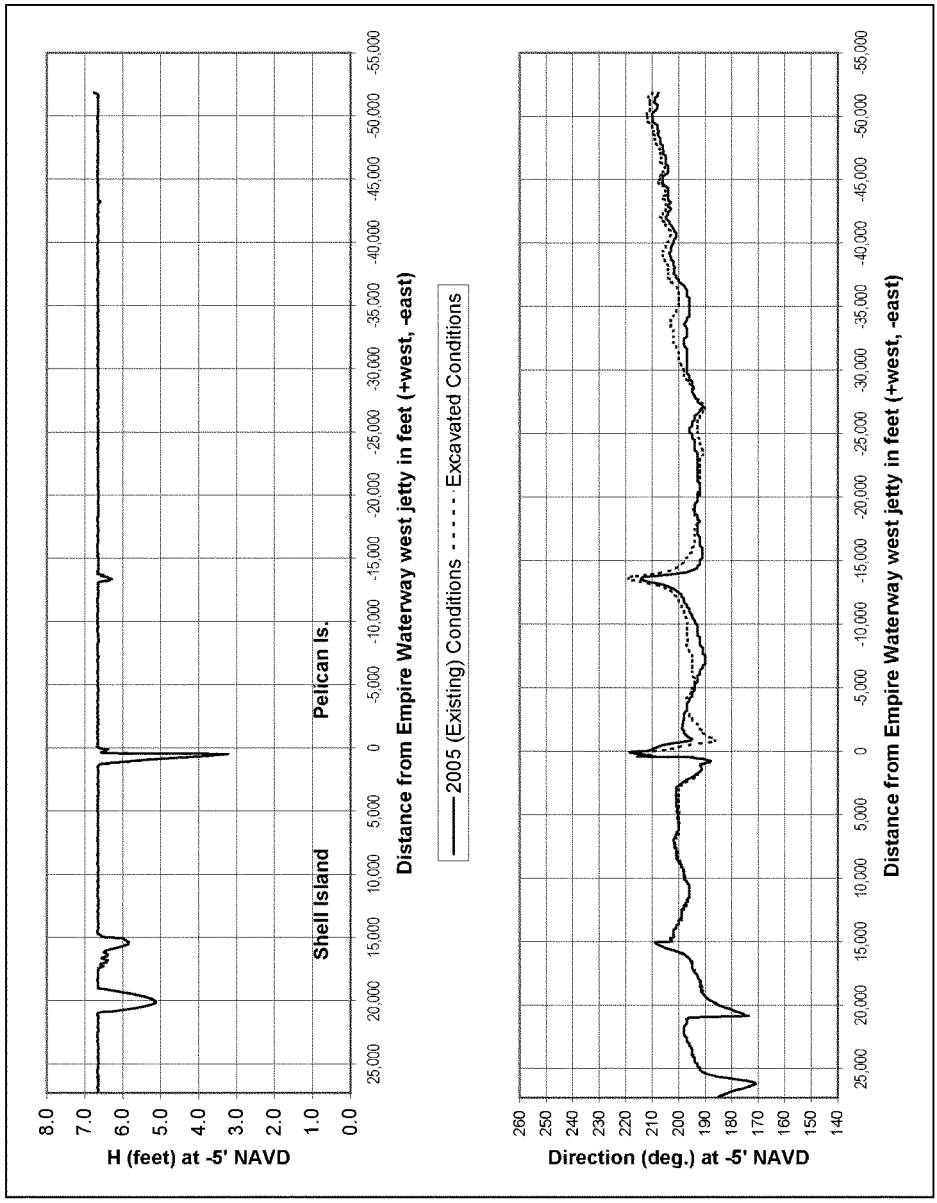


**FIGURE C-3-24: Nearshore Wave Results, 10-Year Wave, H = 20.5', T = 12.4 sec., Direction = 173 deg.**

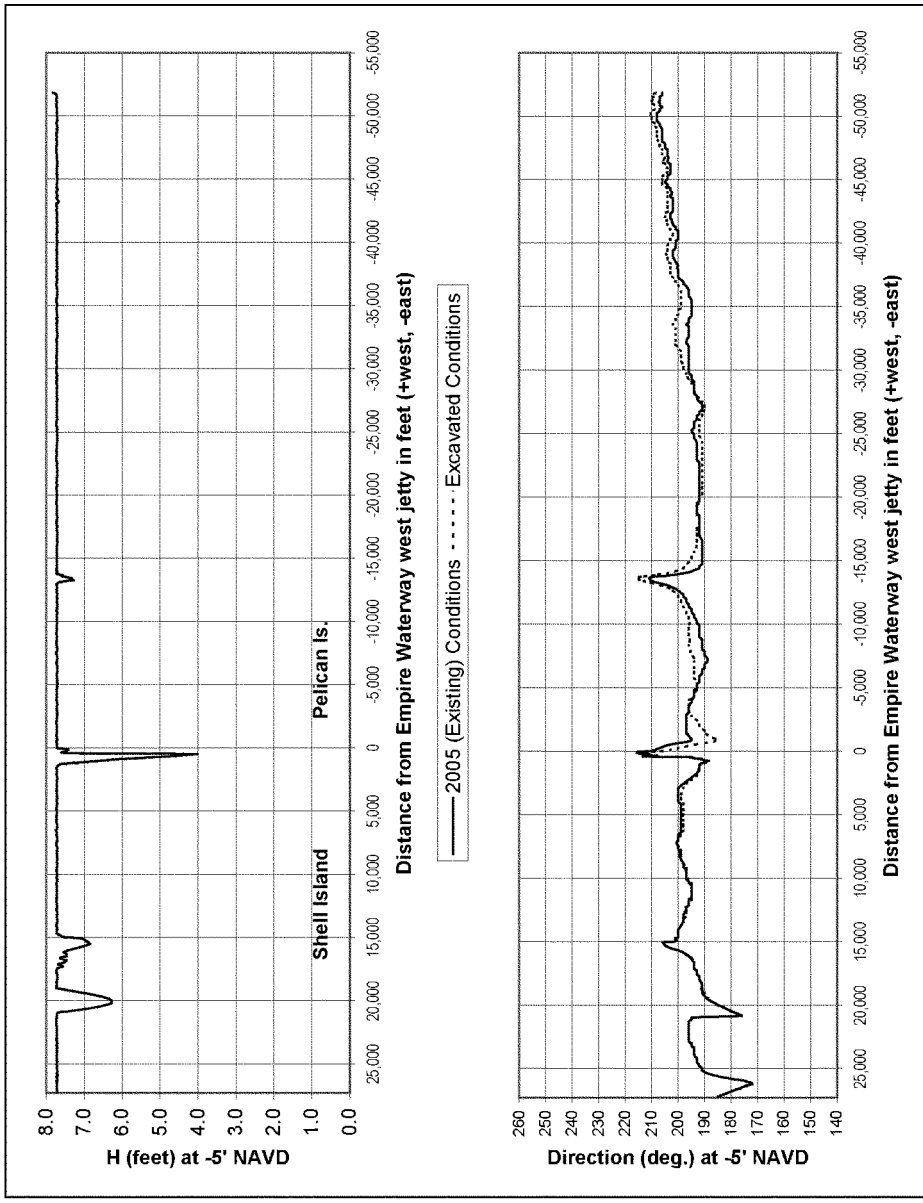


**FIGURE C-3-25: Nearshore Wave Results, 20-Year Wave, H = 22.9', T = 13.2 sec., Direction = 173 deg.**

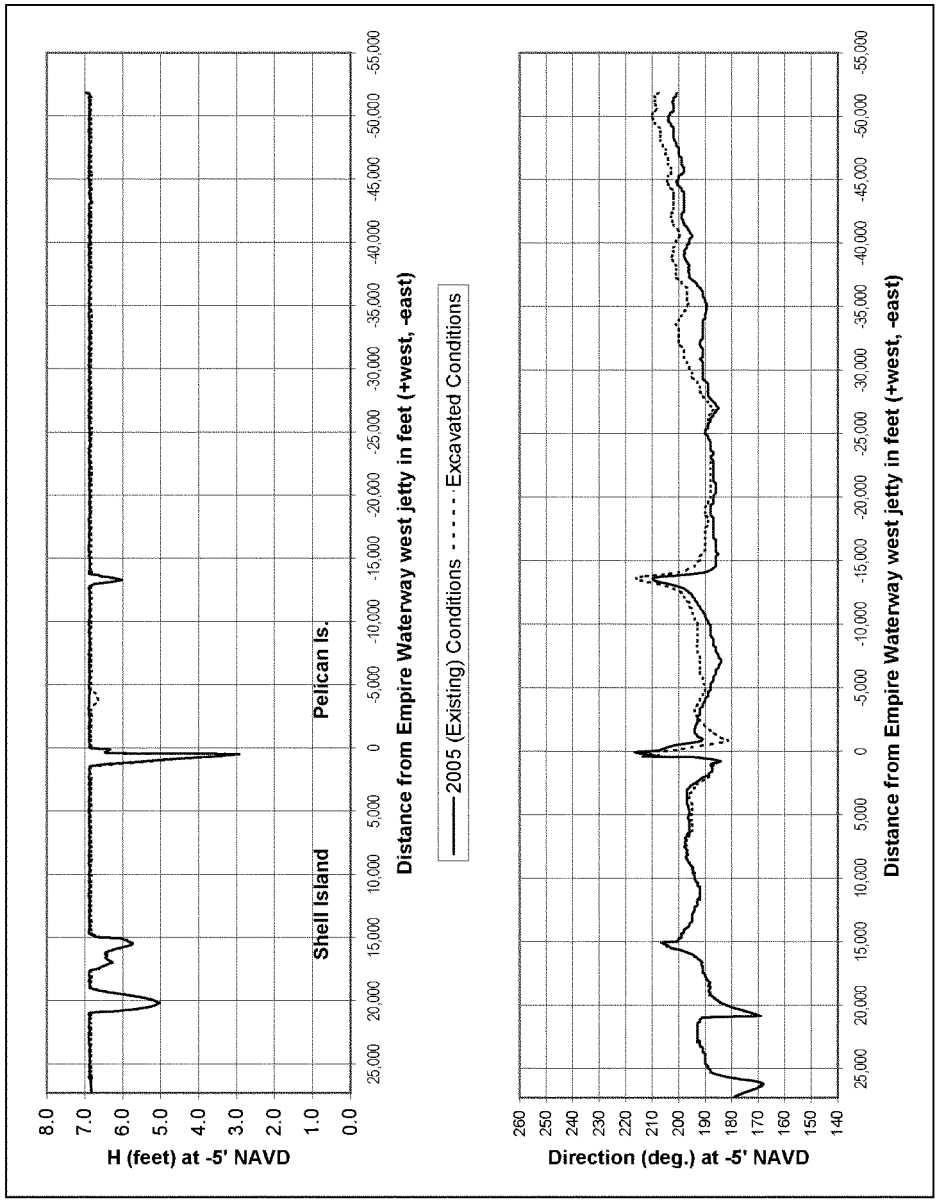


**FIGURE C-3-26: Nearshore Wave Results, Hurricane Katrina, H = 36.9', T = 15 sec., Direction = 147 deg.**

# ANNEX C-4

# ISLAND CROSS-SHORE PERFORMANCE (SBEACH MODELING)

## C-4.0 BACKGROUND

Significant beach erosion and shoreline recession often occurs during storm events as a result of cross-shore sediment transport processes. These storm impacts must be taken into account in the design of the restoration project. Cross-shore storm impact evaluations for the project areas were conducted using the Storm Induced Beach Change Model (SBEACH, Larson and Kraus, 1989).

The goal of this analysis is to:

1. Determine the elevation of the design dune cross-section.
2. To determine the minimum volume of sand necessary to meet the project goals.
3. Determine cross-shore response of the island.

The design life for this project is 50 years. Therefore, the response to the beach/dune profile was modeled for storms with a 50-year return period and higher frequency events.

These main goals focus on the response of the beach/dune profile to any given storm event at any point within the 50-year project life. A post-storm dune elevation of +4.0 feet NAVD was deemed sufficient, based on requirements for the East Grand Terre Island Restoration Project (CPE, 2005). A constructed dune elevation of +6 feet NAVD was chosen based on construction templates of similar island restorations.

The final design will include a sand fencing component on top of the dune, which can trap wind blown sand and raise the dune elevation. The higher dune elevation may limit wave overtopping. For this analysis, the effect of wind blown sand captured by the sand fence is compared using a 100-foot wide dune crest with and without a 3-foot high triangular aeolian-born additional dune peak. The peak of the dune was located 25 feet from the landward edge of the main dune crest and has a 30 foot base. The dimensions of the dune peak were based on surveys of the Holly Beach Sand Management Project (JCLS, 2005). These two profiles were subjected to the 20-year and 50-year return period storm events at TY0.

## C-4.1 SBEACH MODEL

## C-4.2 MODEL BACKGROUND

SBEACH simulates beach profile changes that result from varying storm waves and water levels. These profile changes include the formation and movement of morphological features such as longshore bars, troughs, berms, and dunes. SBEACH is a one-dimensional model which assumes that the simulated profile changes are produced only by cross-shore processes. Longshore sediment transport processes are neglected. SBEACH is an empirically based numerical model, formulated using both field data and the results of large-scale physical model tests. Input data required by SBEACH includes the beach and marsh cross-section, the median sediment grain size, several calibration parameters, and the time histories of the waves, winds, and water elevations. SBEACH calculates the cross-shore variation in wave height and wave setup at discrete points along the profile from the offshore zone to the landward survey limit.

The following basic assumptions underlie the SBEACH model:

- Breaking waves and variations in water level are the major causes of sand transport and profile change.
- The median sediment grain diameter on the profile is reasonably uniform across shore. A mean grain size of 0.12mm was used in this analysis.
- The influence of structures blocking longshore transport is small, and the shoreline is straight (i.e., longshore effects are negligible during the term of simulation).
- Linear wave theory is applicable everywhere along the beach profile.

## C-4.3 MODEL CALIBRATION

Calibration of the SBEACH model was previously performed for nearby projects (Chaland Headland and Pelican Island). This calibration was based on surveyed profiles before and after the passage of Hurricanes Isidore and Lili (CPE, 2003a). As these parameters were calibrated against actual measured storm events and beach profile changes, the following calibration parameters were adopted for use in this analysis.

- The transport rate coefficient (K = 2.50 x $10^{-7}$ $m^4$/N), equal to the ratio between the cross-shore transport rate and the wave energy dissipation rate.

- The slope dependent coefficient ($\varepsilon$ = 0.0001 $m^2$/s), which governs the influence of the profile slope on the cross-shore transport.

- The transport rate decay coefficient ($\kappa$ = 0.3 $ft^{-1}$), which governs the reduction in the wave height over the beach profile due to wave breaking.

## C-4.4 STORM DATA

Four storms were used in this cross-shore assessment. The 5-year, 10-year, 20-year, and 50-year storm events were determined based on WIS data from 1980-1999. They were modified for use in this analysis by scaling the hydrographs to match the peak values for the 5, 10, 20, and 50-year return periods identified in the main text. Wave heights, wave periods, and storm stages used in the model appear in Figures C-4.1 through C-4.4. Storm erosion simulations were run assuming target year 0 and target year 50 conditions. To account for sea level rise, the year 50 hydrographs were elevated by 0.62 feet as shown in Figure C-4.4. To account for subsidence, the near-shore profiles for target year 50 were lowered 0.43 feet as shown in Figure C-4.11. This assumes that the design profile is renourished every 10 years and the last renourishment takes place at TY 40. The offshore profile was lowered 2.24 feet to account for subsidence between 2005 (the latest offshore survey) and 2059 (TY 50). Altering the water elevation and lowering the profile more accurately simulates the conditions in target year 50.

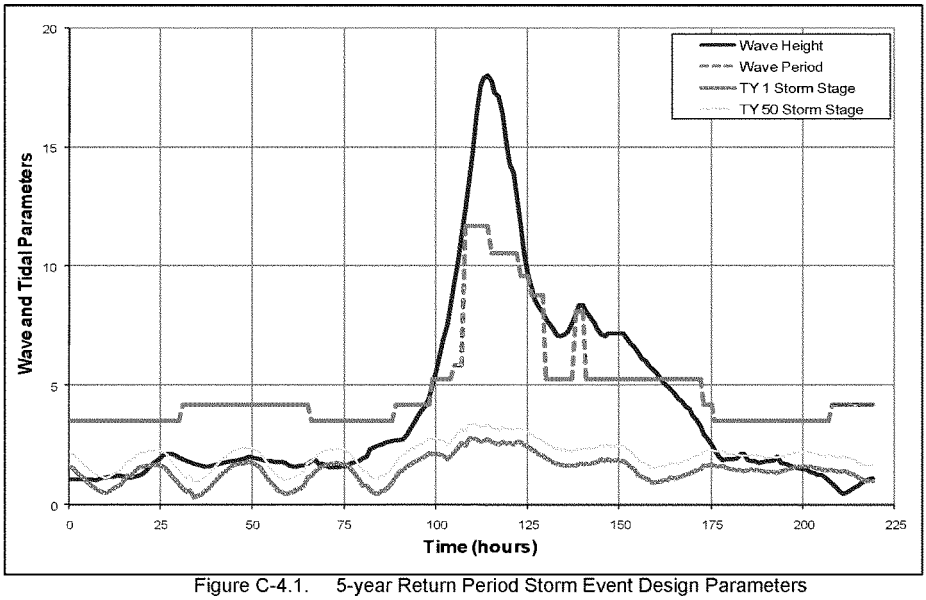


Figure C-4.1. 5-year Return Period Storm Event Design Parameters

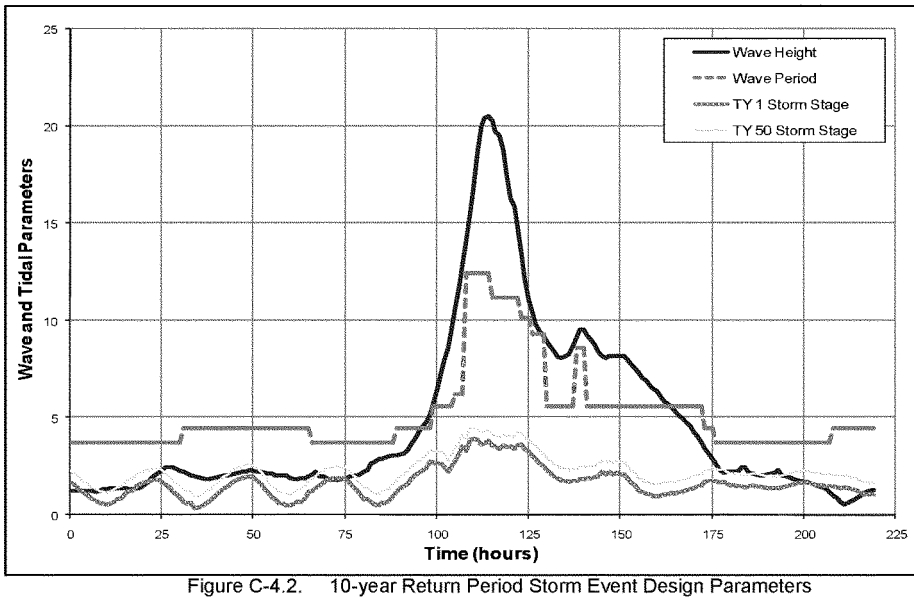


Figure C-4.2. 10-year Return Period Storm Event Design Parameters

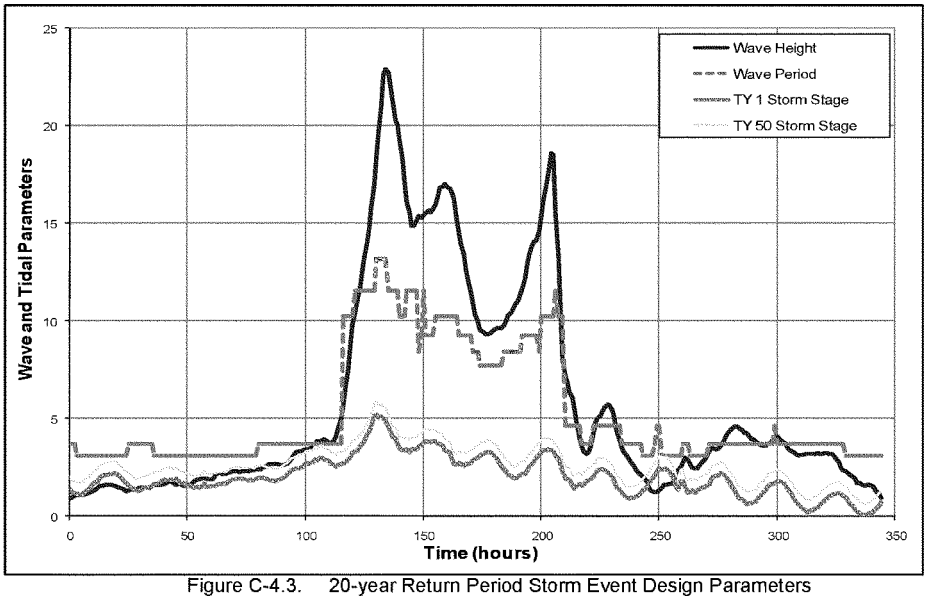


Figure C-4.3. 20-year Return Period Storm Event Design Parameters

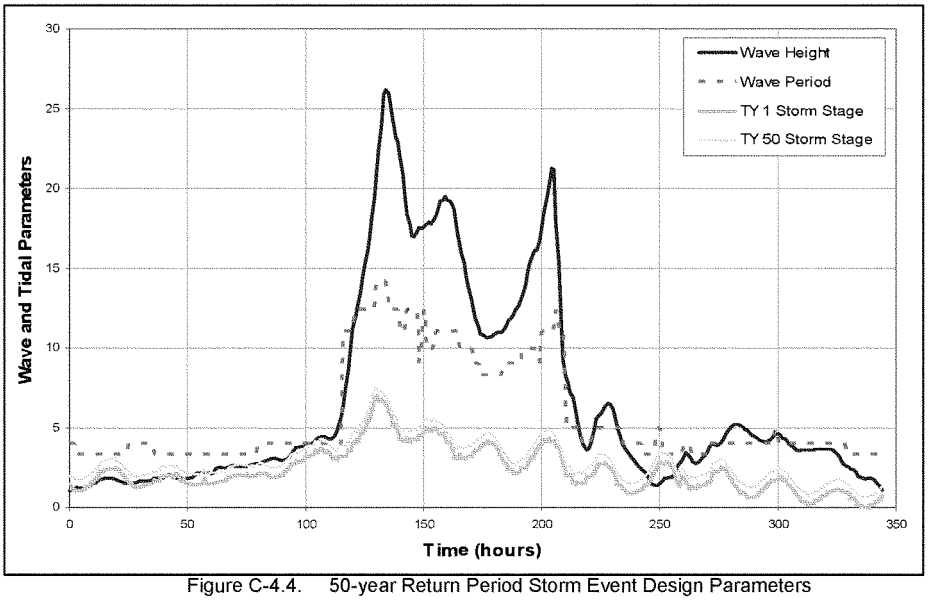


Figure C-4.4. 50-year Return Period Storm Event Design Parameters

## C-4.5 REPRESENTATIVE PROFILE

One representative profile was chosen for use in the model: profile line 49 (JCLS 2005 line A-A') on Shell Island West. This profile was chosen for assessment of the existing island because it is the only profile that crosses the island. It also has a sandy face that is similar to the proposed design section.

The bayward and offshore construction slopes of the cross-section were both set to 1V:45H. These were based on the attained profile slope measured at the Holly Beach nourishment project (CPE, 2003). The dune elevation was set to +6.0 feet NAVD, which is above the 20-year return period surge elevation estimated for target year 50 of +5.9 feet NAVD (includes relative sea level rise over the life of the project).

## C-4.6 WITHOUT PROJECT PERFORMANCE

The without project conditions were modeled in TY1 and TY50 for Shell Island (Figures C-4.5 through C-4.6). The model suggests overtopping rates do not exceed 1.7 feet$^3$/second/foot for any case modeled (as shown in Table C2), which is the threshhold for island breaching. Although the model indicates breaching will not occur during a storm event, the post-storm dune elevation of +3 feet NAVD may not be sufficient to prevent the island from breaching following another storm event. Without placement of fill material, breaching of Shell Island West can be expected at some point during the 50-year project life based on SBEACH Modeling.

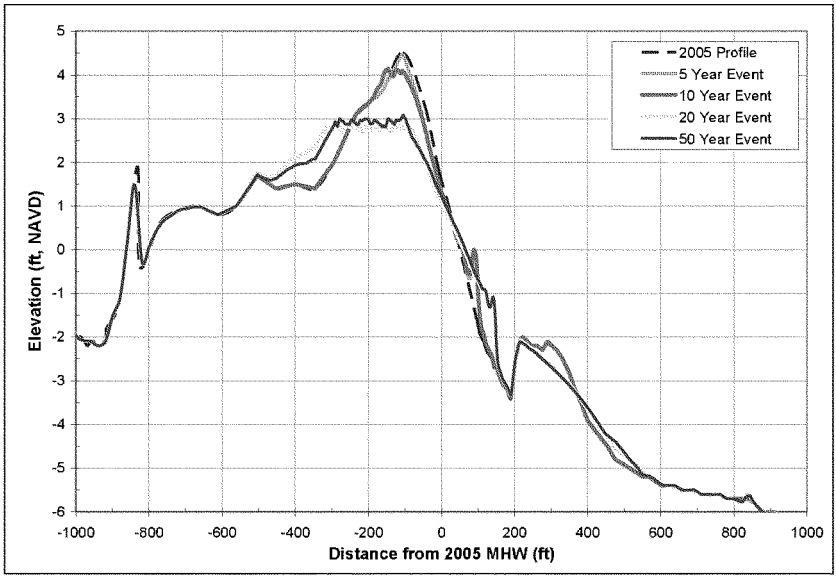


Figure C-4.5. Profile Line 49 Performance without Project Under Target Year 1 Conditions

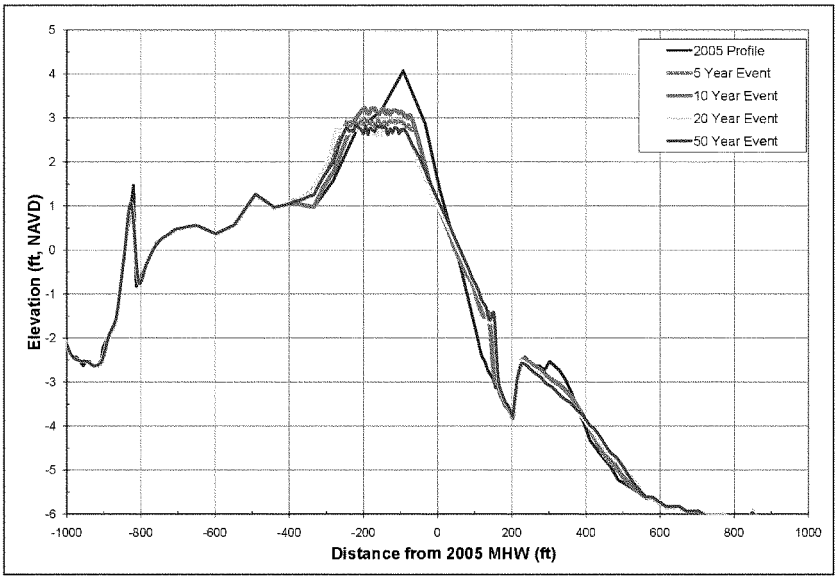


Figure C-4.6. Profile Line 49 Performance without Project Under Target Year 50 Conditions

## C-4.7 DESIGN STORM

Various construction cross-sections were modeled for the following storm events to determine the required design berm width to protect the island over the 50-year design life:

Table C-4.1. Selected Storm and Project Year Conditions

| | |
|---|---|
| 5 Year Event, TY 1 Conditions | 5 Year Event, TY 50 Conditions |
| 10 Year Event, TY 1 Conditions | 10 Year Event, TY 50 Conditions |
| 20 Year Event, TY 1 Conditions | 20 Year Event, TY 50 Conditions |
| 50 Year Event, TY 1 Conditions | 50 Year Event, TY 50 Conditions |

The target year 1 and target year 50 cases were modeled as individual storm events and as a series of events, e.g. a 20-year event followed by a 50-year event. It was found that the single 50-year event caused as great an impact to the dune system as any of the series of events for target year 1. For target year 50, the 50-year event caused more damage if it followed a 20-year event than if it occurred on an unimpacted design beach.

Under the various design project scenarios, the 50-year event occurring in target year 1 and the 50-year event following a 20-year event occurring in target year 50 were the events driving the design. The peak values of these storms are as follows.

The 50-year event modeled under TY 1 conditions:

- Offshore wave height = 26 feet
- Wave period = 14 seconds
- Storm stage = +6.9 feet NAVD

The 50-year event following a 20-year event modeled under TY50 conditions:

- Offshore wave height = 26 feet
- Wave period = 14 seconds
- Storm stage = +7.5 feet NAVD

These two storm events are the critical events driving the design due to their impacts on the constructed dune heights. The storm impacts are greatest when the storm stage is near the constructed dune elevation and the wave action is concentrated at the dune crest. The model results indicate that during these events there is a significant reduction in dune elevation accompanied by a bayward dune migration. When water levels exceed the dune crest elevation during the highest water levels at the peak of the storm event (such as during a 50-year event occurring in TY50), less sediment is transported bayward because wave energy now passes over the island resulting in minimal cross-shore transport. When water levels are lower than the grade of the dune (such as the 5 and 10-year events occurring in TY0), the model indicates that the waves do not significantly lower the dune elevation or decrease the crest width. In these instances, most of the eroded material is transported in the offshore direction.

## C-4.8 DESIGN SECTION

This section discusses the development of the construction cross-section and the equilibrated cross-section. The concept of a design cross-section is also discussed.

## C-4.9 CONSTRUCTION TEMPLATE

The construction cross-section was based on construction templates used for previously constructed projects. The following design details were incorporated:

A. Gulfward Slope of Dune: 1V:45H

B. Bayward Slope of Dune: 1V:45H.

C. Dune Elevation: +6.0 feet, NAVD

A 1V:45H construction slope was adopted for the gulf face based on the constructed profile slope measured at the Holly Beach, Louisiana nourishment project (CPE, 2003b). The borrow source at Holly Beach had a grain size of approximately 0.13mm (CPE, 2003b). Annex C-2 discusses several potential borrow sources. The grain sizes are typically in this range, apart from the Mississippi River sand, which has grain sizes of approximately 0.17mm (McClelland, 1988). The construction slopes should be reevaluated once the final borrow area is identified.

Other barrier island projects in Louisiana have used a steeper construction slope (1V:30H) on the bayward (landward) side, as the island provides a means of fill retention and thus steeper slopes can be constructed. Most of Shell Island will be constructed in open water or scattered island remnants. Therefore, the slopes on the front and back of the island are proposed to be 1V:45H. No steps are proposed in the construction template, as this increases the cost of construction and does not provide any added benefits compared to the single slope. The material will be reworked into a natural profile by wave action.

The constructed dune elevation was set to +6.0 feet, NAVD. The +6.0 feet, NAVD dune elevation is above the 20-year return period surge elevation (+5.9 feet, NAVD). Again this follows typical construction of Louisiana barrier islands.

The crest width of the dune is a function of the purpose of the individual alternatives. The dune width for Alternative 1 is based on a cost and target acreage goals that dictate the volume and cross-section width. Alternatives 3 through 8 will be based on a design width plus advanced nourishment width. Specific dune widths for the various alternatives will be discussed later.

## C-4.10 POST-CONSTRUCTION PROFILE EQUILIBRATION

While the constructed beach slope is 1V:45H from the dune crest to the construction toe of fill, it is expected that the beach will readjust to an equilibrium beach profile in the year following construction. The expected equilibrium beach profile is based on Dean's (1987) equilibration profile below the mean high water line (equation 2) and horizontal profile translation above the mean high water line.

The beach profile equilibration process assumes that there is only cross-shore redistribution of sediment and that sand volume is conserved. It is estimated that the mean high water shoreline will retreat approximately 20 feet due to profile equilibration. The June 2005 profile, typical construction template and post-construction equilibrium profile for profile line 49 are shown in Figure C-4.7. Note that the volume of the construction template and the volume within the equilibrium profile following construction are the same.

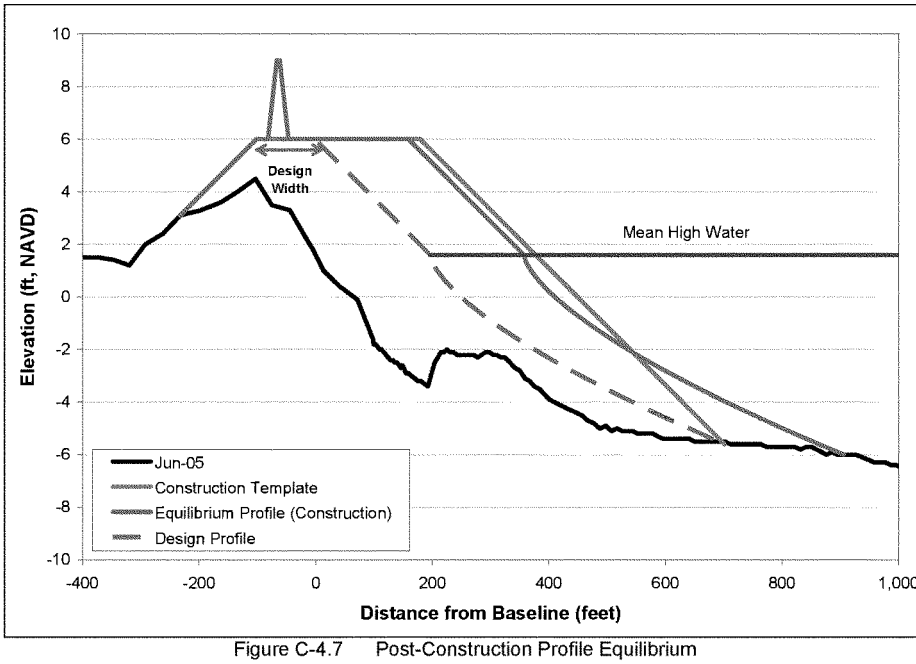


Figure C-4.7 Post-Construction Profile Equilibrium

Observations at Grand Isle and Holly Beach suggest that the input of sand into a system allows for increased aeolian transport that can increase the island elevation. Construction of sand fencing and planting of vegetation along the dune will promote additional elevation growth of the dune by holding the blowing sand. At Holly Beach, 4-foot high sand fences were quickly inundated with sand and increased the beach elevation by several feet (Figure C-4.8). A 5-foot wide, +9 feet NAVD additional dune element was added to the top of the construction template to simulate this increase in dune elevation. Side slopes of 1V:5H were assumed based on surveys by John Chance (2005). It was assumed that this additional dune feature would take approximately 1 year to form. The elevated dune features are caused by a redistribution of sediment along the horizontal section of the construction template. The growth of these dunes may cause a small (a few tenths) decrease in the flat section of the dune.

Figure C-4.8. Photograph of Inundated Sand Fencing at Holly Beach (JCLS, 2005)

## C-4.11 DESIGN CROSS-SECTION

A beach nourishment cross-section typically consists of two primary components:

A. The design section, which is the fill volume required at TY50 to meet applicable project goals.

B. Advanced nourishment, which is the sacrificial portion of the fill that will erode over the 50-year project life. Sufficient advanced nourishment can be added during construction or replaced periodically during renourishment projects.

This two-section design is in accordance with the National Research Council (1995) recommendations.

Cross-shore modeling (SBEACH) was used to evaluate the performance of the cross-sections with respect to overtopping and post-storm dune elevation.

The goal of the analysis was to determine a cross-section that would resist breaching and maintain a sufficient dune elevation to prevent overtopping by more frequent storm events. A post-storm dune elevation of +4 feet, NAVD in TY20 was determined to be a realistic goal for the East West Grand Terre Restoration Project (CPE, 2005). This elevation was chosen as a minimum acceptable average post-storm dune elevation for the Shell Island design cross-section. The modeling suggested that a 100-foot design dune crest was needed to achieve a +4 feet, NAVD post-storm crest elevation under the worst-case scenario. As discussed in the previous section, the critical storm event was a 20-year storm event occurring in TY50, following a 50-year storm event. Figure C-4.9 shows the SBEACH output for Shell Island under this storm event.

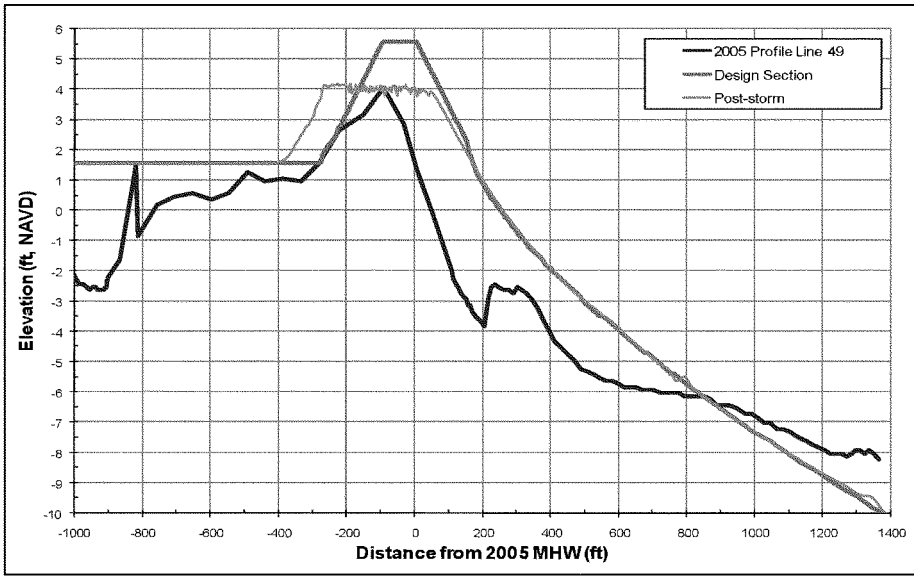


Figure C-4.9. SBEACH Output showing Pre-construction, Design Section, and Post-storm Profile for Shell Island under a 20-year Storm Event at TY50

Note that the offshore portion of the design cross-section was lowered by 2.2 feet from the 2005 survey to account for subsidence. The dune crest was lowered by 0.43 feet to account for subsidence of the emergent island section. This was based on the assumption that the design section would be renourished

at 10-year time intervals and that the design was at the end of a nourishment cycle. Therefore, the profile had experienced 10-years of subsidence. The equilibrium profile was also started at the TY50 mean high water line (2.26 feet, NAVD).

The maximum estimated overtopping rate (the movement of water over the dune crest) during the project life for the 100-foot design berm on Shell Island is 0.6 cubic feet per second. The USACE (2001) estimated that island breaching occurs when the overtopping rate exceeds 1.7 cubic feet/foot/second. Therefore, breaching is not anticipated given that the overtopping rate is lower than 1.7 cubic feet/foot/second.

## C-4.12 PERFORMANCE ANALYSIS

Two criteria were established to evaluate the performance of the cross-sections: overtopping and post-storm dune elevation.

## C-4.13 OVERTOPPING

Overtopping is equal to the discharge of water over the dune crest per linear foot of shoreline. The damage threshold used in the evaluation was breaching of the island, which occurs at 1.7 $feet^3$/second/foot (USACE, 2001a).

Overtopping rates were calculated using the formula of Hancock and Kobayashi (1994):

$$Q = (gH^3)^{0.5}\, 3.35x10^{-4}\exp[2.82(R_{2\%}-H_c)/H] \qquad [1]$$

where:

Q = Overtopping, $feet^3$/second/foot

g = 32.2 $feet/second^2$

H = Wave height, assumed to be equal to the breaking wave height (feet)

$R_{2\%}$ = Theoretical wave runup relative to the storm stage (feet)

$H_c$ = Freeboard (Dune elevation – Storm stage) (feet)

Overtopping rates for the existing and design cross-sections evaluated appear in the attached Table C-4.2. Overtopping will occur in both cases evaluated; however, the impact is not sufficient to suggest that breaching of the island will occur because overtopping rates do not exceed 1.7 $feet^3$/second/foot.

## C-4.14 POST-STORM DUNE ELEVATION

The maximum existing dune elevation is +4.5 feet NAVD at profile 49. In order to maintain this elevation relative to sea level rise, the required post-storm dune elevation in target year 50 is +5.16 feet NAVD. However, an elevation of +4.0 feet NAVD was adopted as the minimum allowable post-storm dune elevation in this report.

The post-storm dune elevations for the cross-section evaluated appear in Table C-4. For Shell Island the minimum required constructed dune width to maintain a dune elevation of +4.0 ft NAVD in target year 50 is 100 feet. This is the design width. Based on this design beach width, Shell Island will require approximately 2,677,800 cubic yards of design fill for Alternatives 1 and 2, and 4,855,700 cubic yards of design fill for alternatives 3 through 8. The average design fill density is 128 cubic yards/foot for Alternatives 1 and 2 and 204 cubic yards/foot for Alternatives 3 through 8.

The SBEACH results of the 100 foot design dune for Shell Island are shown in Figures C-4.10 and C-4.11 below.

## C-4.15 BENEFITS OF SAND FENCING

The SBEACH model comparison results for a 100 foot berm width with and without the benefit of an aeolian-born dune are shown in Figures C-4.12 and C-4.13 below. The shape of the additional dune crest, created with the assistance of sand fencing and dune vegetation is based on the post construction survey of Holly Beach, LA (JCLS, 2005). The results indicate that the sand trapped by the fencing plays a significant role in preventing the overtopping of the island during the 20 year event at target year 1.

Table C-4.2. SBEACH Modeled Runup and Overtopping at Profile Line 49

| Profile | Storm | NAVD Stage (ft) | | Breaking Wave Hb (ft) | Design Dune Elev (ft NAVD) | | Post-Storm Dune Elev (FT NAVD) | | Overtopping, Q (cfs/foot) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | TY 1 | TY 50 | | TY 1 | TY 50 | TY 1 | TY 50 | TY 1 | TY 50 |
| Without Project | 5 year | 2.8 | 3.4 | 24.2 | 4.5 | 4.1 | 4.5 | 2.9 | 0.2 | 0.4 |
| 100' Dune | 5 year | 2.8 | 3.4 | 24.2 | 6.0 | 5.6 | 6.0 | 5.7 | 0.2 | 0.2 |
| Without Project | 10 year | 3.9 | 4.5 | 27.5 | 4.5 | 4.1 | 4.1 | 3.1 | 0.3 | 0.4 |
| 100' Dune | 10 year | 3.9 | 4.5 | 27.5 | 6.0 | 5.6 | 6.1 | 4.8 | 0.3 | 0.3 |
| Without Project | 20 year | 5.2 | 5.8 | 30.9 | 4.5 | 4.1 | 2.8 | 2.7 | 0.5 | 0.5 |
| 100' Dune | 20 year | 5.2 | 5.8 | 30.9 | 6.0 | 5.6 | 5.5 | 4.4 | 0.4 | 0.5 |
| Without Project | 50 year | 6.9 | 7.5 | 35.5 | 4.5 | 4.1 | 2.9 | 2.7 | 0.6 | 0.6 |
| 100' Dune | 50 year | 6.9 | 7.5 | 35.5 | 6.0 | 5.6 | 5.1 | 4.4 | 0.6 | 0.6 |
| 100' Dune - Post 20 year | 50 year | 6.9 | 7.5 | 35.5 | 5.2 | 4.0 | 4.9 | 4.2 | 0.5 | 0.6 |
| 100' Dune - Post 50 year | 20 year | 5.2 | 5.8 | 30.9 | 4.7 | 4.1 | 5.0 | 4.0 | 0.4 | 0.5 |

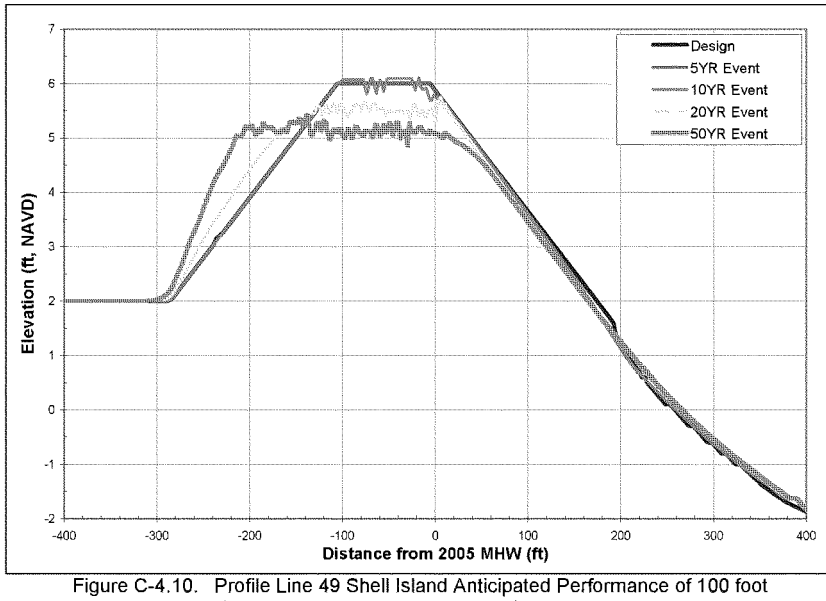


Figure C-4.10. Profile Line 49 Shell Island Anticipated Performance of 100 foot Design Dune Under Target Year 1 Conditions

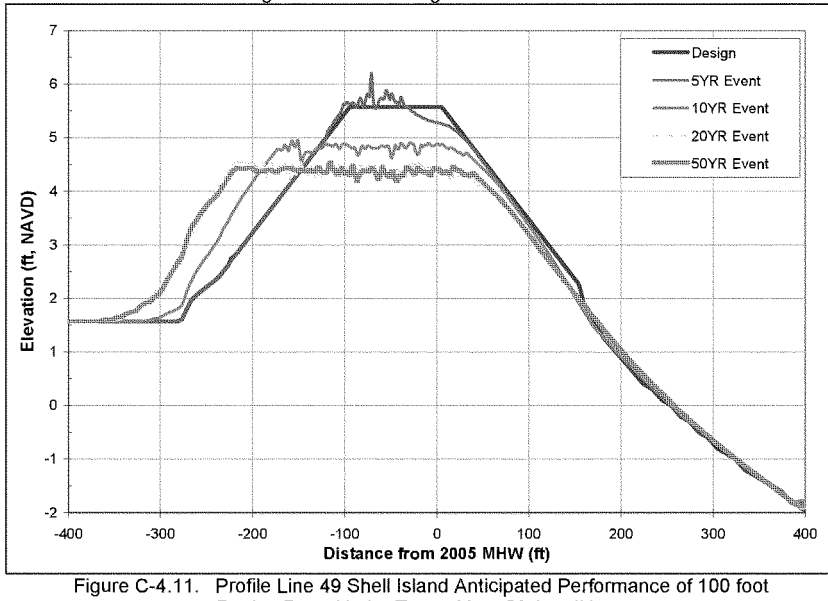


Figure C-4.11. Profile Line 49 Shell Island Anticipated Performance of 100 foot Design Dune Under Target Year 50 Conditions

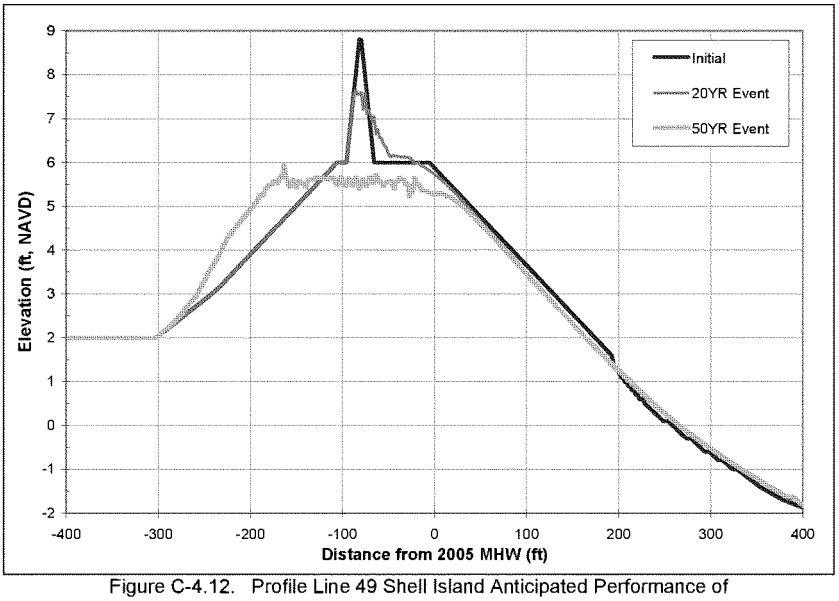


Figure C-4.12. Profile Line 49 Shell Island Anticipated Performance of 100 foot Design Dune with Sand Fencing Under Target Year 1 Conditions

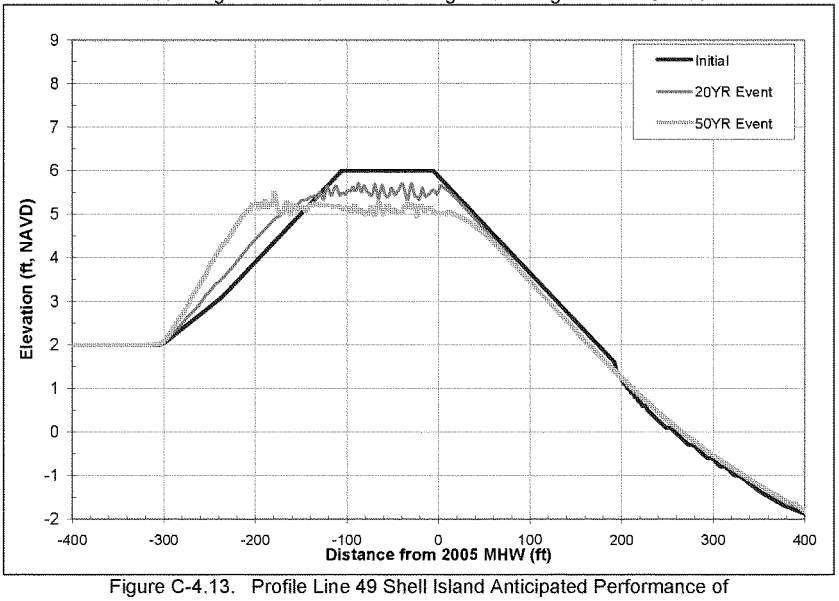


Figure C-4.13. Profile Line 49 Shell Island Anticipated Performance of 100 foot Design Dune without Sand Fencing Under Target Year 1 Conditions

## C-4.16 SENSITIVITY ANALYSIS

A model sensitivity analysis was performed on the SBEACH input parameters to examine the stability and sensitivity of the model. The following parameters were considered: grain size, transport rate coefficient, slope dependent coefficient, transport rate decay, landward surf zone depth, and maximum slope prior to avalanching. The equilibrated 100 foot wide design beach at profile 49 was modeled using a 20-year storm event under Year 0 and Year 50 conditions with one input parameter changed each time. The resulting post-storm dune elevation and overtopping rates were recorded and compared to the original calibration results, to evaluate the model sensitivity.

Table C-4.3 below summarizes some of the parameters from the final calibration which were not affected by changing the input parameters during the sensitivity analysis. These values were used in calculating the maximum runup elevations and the overtopping rates presented at the end of the analysis.

Table C-4.3. SBEACH Sensitivity Analysis Constant Model Outputs for 20 Year Storm

| Constant Model Outputs | Stage (feet, NAVD) | | Breaking Wave Hb (feet) | Design Dune Elevation (feet, NAVD) | |
|---|---|---|---|---|---|
| | Year 0 | Year 50 | | Year 0 | Year 50 |
| Final Calibration | 5.2 | 5.8 | 30.9 | 6.0 | 5.6 |

The first parameter examined in the sensitivity analysis was the grain size. The model originally used a grain size of 0.11mm, however, the potential borrow area grain sizes range from 0.06 mm to 0.28 mm. SBEACH limits the grain sizes used in the model to be between 0.1 mm and 1 mm, therefore, only the 0.28 mm grain size was examined. As expected, the model predicts very similar results when increasing the grain size, but the post-storm dune elevation is higher because of a more stable beach (see Figure C-4.14).

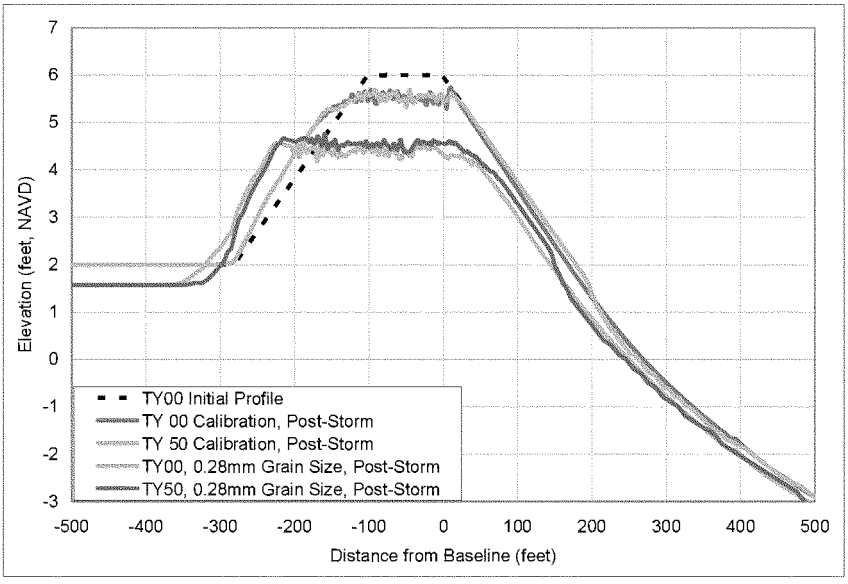


Figure C-4.14. Sensitivity Analysis Results, Grain Size

The transport rate coefficient used in the original modeling was 2.5 x $10^{-7}$ $m^4$/N, which is the minimum transport rate coefficient allowed by the SBEACH model. The maximum coefficient is 2.5 x $10^{-6}$ $m^4$/N, which was examined in this sensitivity analysis. The larger transport rate coefficient greatly affected the output results, predicting a much lower post-storm dune elevation and an increase in overtopping rates, especially for the TY50 conditions. The dune elevation after the 20 year storm was approximately 2 feet lower for both the TY00 and TY50 with the maximum transport rate coefficient of 2.5 x $10^{-6}$ $m^4$/N compared to the minimum coefficient of 2.5 x $10^{-7}$ $m^4$/N. Figure C-4.15 shows the model was also less stable with the larger transport rate coefficient, indicated by an irregular cross-shore profile with large peaks and dips.

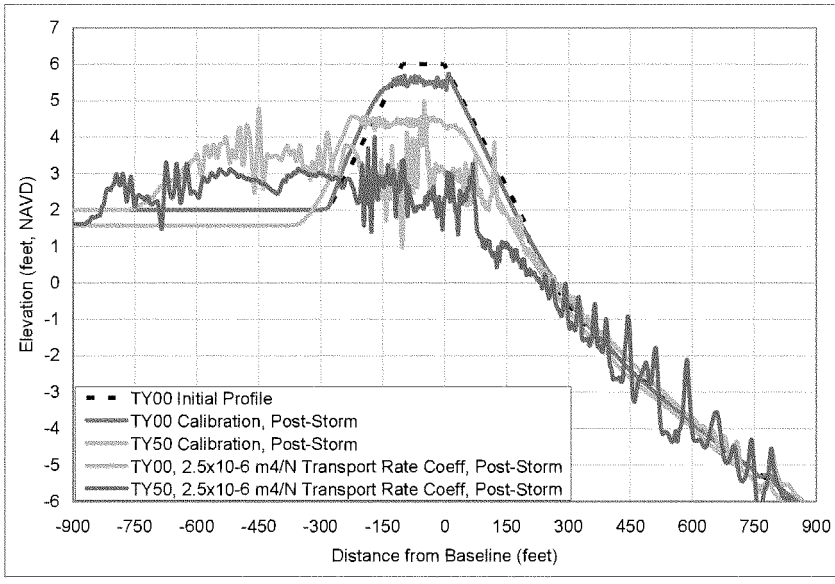


Figure C-4.15. Sensitivity Analysis Results, Transport Rate Coefficient

The minimum slope dependent coefficient of 0.0001 $m^2/s$ was used in the original SBEACH modeling, so the influence of the maximum slope dependent coefficient of 0.005 $m^2/s$ was evaluated in the sensitivity analysis. The difference in the output profile, post-storm dune elevation, and overtopping rate between the two slope dependent coefficients was negligible for both the TY0 and TY50 conditions (Figure C-4.16).

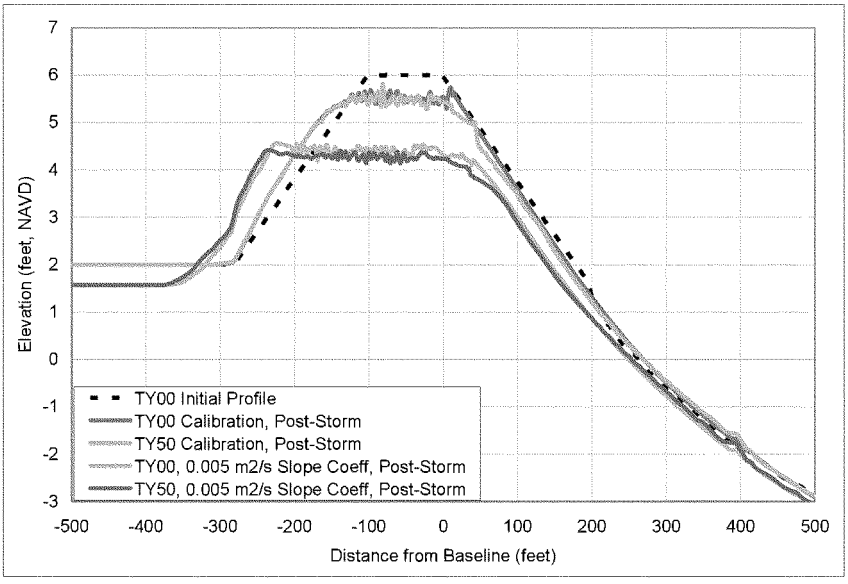


Figure C-4.16. Sensitivity Analysis Results, Slope Dependent Coefficient

A transport rate decay of 0.3 was used in the SBEACH model, therefore the minimum and maximum values of 0.1 and 0.5 were examined in the sensitivity analysis. The difference in the model results using the various transport rate decay values was insignificant in terms of the post-storm dune elevation and overtopping rate. However, the model appeared to be less stable using the transport rate decay values of 0.1 and 0.5, as the results showed abnormalities in the along the post-storm dune crest (Figures C-4.17 and C-4.18).

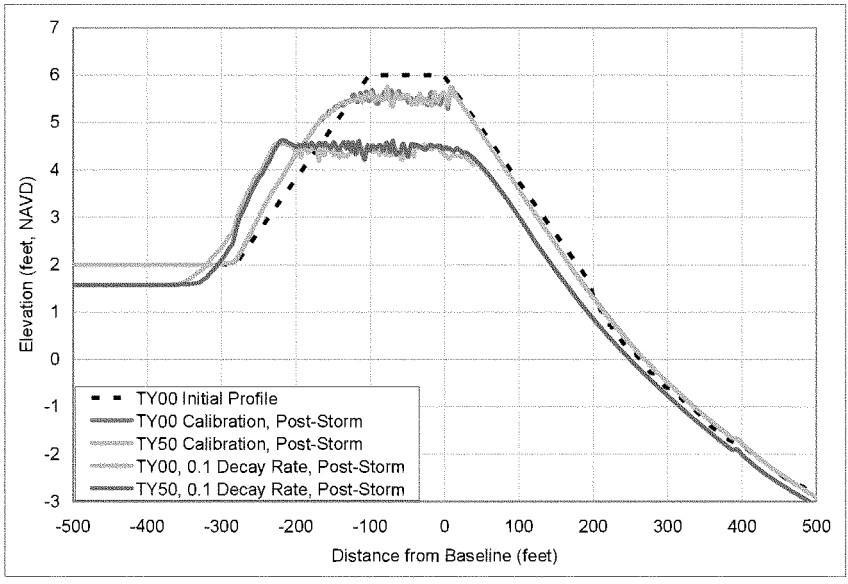


Figure C-4.17. Sensitivity Analysis Results, Minimum Decay Rate

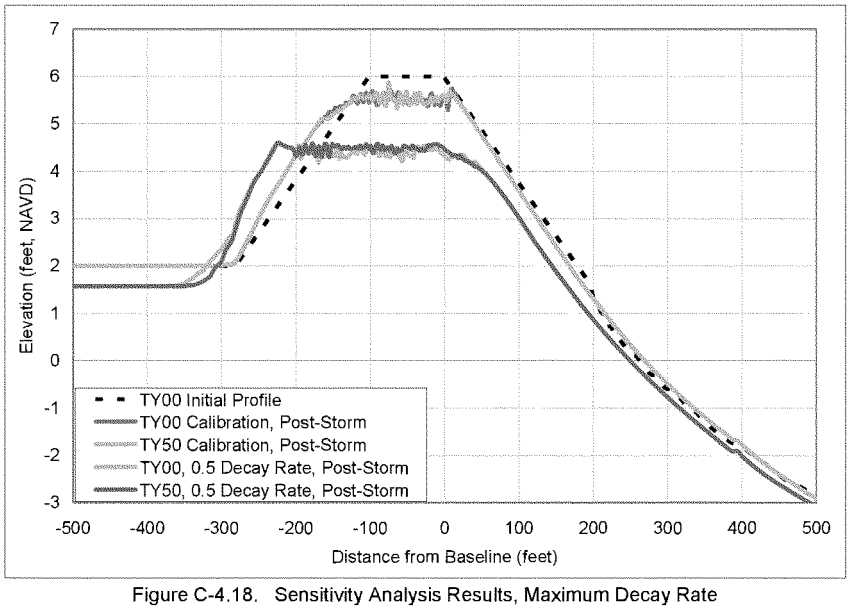


Figure C-4.18. Sensitivity Analysis Results, Maximum Decay Rate

The minimum landward surf zone depth of 0.5 m was used in the original model, therefore the maximum depth of 1.6 m was examined in the sensitivity analysis. Significant differences in the model output were observed when using the greater surf zone depth. The model appears unstable with large spikes along the output cross-section. A large amount of erosion can be seen above the mean high water in comparison to the calibration output with a landward surf zone depth of 0.5 m. The TY50 post-storm dune crest is also significantly lower and wider, with the width increasing in the landward direction due to an increase in overtopping. The post-storm dune elevations were 0.6 feet lower for TY0 conditions and 1.4 feet lower for TY50 conditions compared to the landward surf zone depth value used in the original SBEACH modeling.

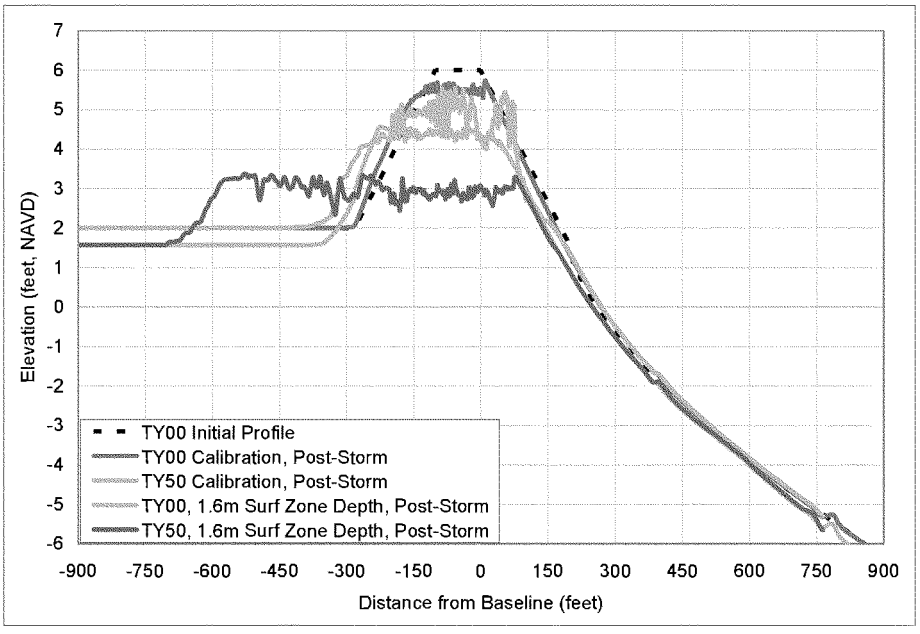


Figure C-4.19. Sensitivity Analysis Results, Surf Zone Depth

The maximum slope prior to avalanching was 30° in the original model, and the sensitivity analysis examined a slope of 45°. The model showed a negligible difference in post-storm dune elevations, cross-sections, and overtopping rates with a different maximum slope prior to avalanching.

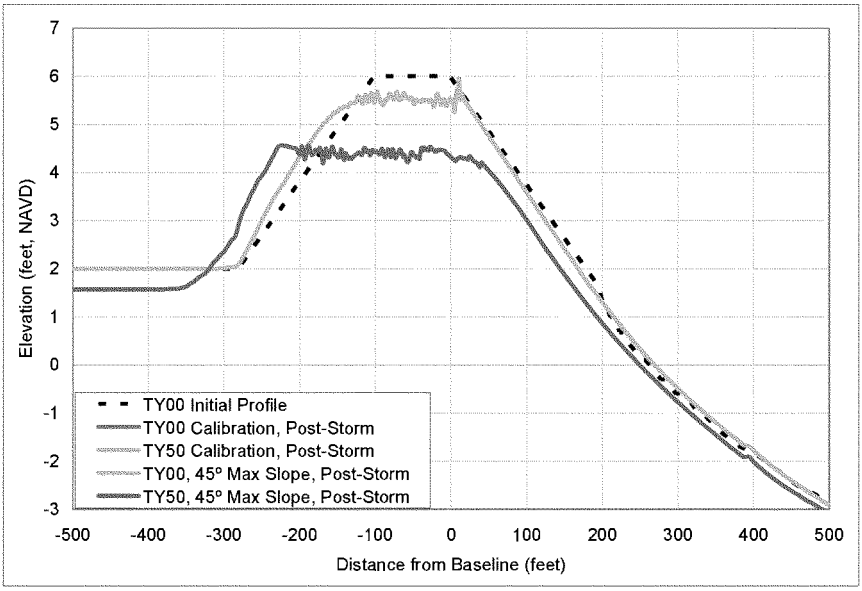


Figure C-4.20. Sensitivity Analysis Results, Maximum Slope Prior to Overtopping

In summary, the post-storm dune elevation and overtopping results were least sensitive to the maximum slope prior to avalanching and the slope dependent coefficient. The SBEACH model was most sensitive to the landward surf zone depth and the transport rate coefficient. Varying the transport decay rate produced a physically similar post-dune elevation as the calibrated decay rate, except that the crest of the dune was uneven with large peaks and dips. Table C-4.3 summarizes the maximum runup, post-storm dune elevation, and overtopping of both the final calibration results and the sensitivity analysis runs.

Table C-4.4. SBEACH Sensitivity Analysis Summary

| Modified Model Inputs | Max Runup (feet, NAVD) | | Post-Storm Dune Elevation (feet, NAVD) | | Overtopping (cfs/foot) | |
|---|---|---|---|---|---|---|
| | Year 0 | Year 50 | Year 0 | Year 50 | Year 0 | Year 50 |
| Final Calibration | 7.9 | 8.2 | 5.5 | 4.4 | 0.4 | 0.5 |
| Grain Size = 0.28 mm | 8.0 | 8.1 | 5.5 | 4.5 | 0.4 | 0.5 |
| Transport Rate Coefficient, K ($m^4/N$) = 2.5 x 10-6 (max) | 8.0 | 9.2 | 3.1 | 2.6 | 0.5 | 0.6 |
| Slope Dependent Coefficient, e ($m^2/s$) = 0.0003 (max) | 8.0 | 8.3 | 5.5 | 4.4 | 0.4 | 0.5 |
| Transport Rate Decay, k = 0.1 (min) | 7.9 | 8.2 | 5.5 | 4.5 | 0.4 | 0.5 |
| Transport Rate Decay, k = 0.5 (max) | 7.9 | 8.0 | 5.5 | 4.5 | 0.4 | 0.5 |
| Landward Surf Zone Depth = 1.6 m | 7.9 | 8.0 | 4.9 | 3.0 | 0.4 | 0.5 |
| Max slope prior to avalanching = 45 ° | 7.9 | 8.2 | 5.5 | 4.4 | 0.4 | 0.5 |

## C-4.16 CONCLUSIONS

The required design cross-section, which is the fill required in TY50 to meet the project goals, includes a 100 foot wide dune with a +6 feet, NAVD elevation and a Gulf side offshore slope of 1V:45H. The +6 feet, NAVD dune is higher than the 20-year return period surge elevation, and it maintains a post-storm dune elevation above +4 feet, NAVD after a 20-year return period storm. This design cross-section will require approximately 2,677,800 cubic yards of fill for Alternatives 1 and 2, and approximately 4,855,700 cubic yards for Alternatives 3 and 8.

## C-4.17 REFERENCES

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# ANNEX C-5

# LONGSHORE MODELING (GENESIS)

# C-5.0 ISLAND SHORELINE PERFORMANCE

## C-5.1 BACKGROUND

Future shoreline projections for Shell Island utilize the Generalized Model for Simulating Shoreline Change (GENESIS) (Gravens et al., 1991). This model can incorporate seawalls, groins, breakwaters, beach fills, artificial sand transport, and offshore bathymetry. Changes due to relative sea level rise are incorporated by estimated annual shoreline recession outside the model. Inputs to the model include shoreline locations, structure locations, a time series of offshore waves, shoreline recession to account for relative sea level rise, and a set of wave refraction coefficients and refracted wave angles.

The GENESIS model determines shoreline changes relative to a fixed baseline based on the wave-driven, longshore sediment transport. Transport rates are calculated using the USACE (1989) formula (CERC Equation), with an additional term to account for longshore variations in the breaking wave height. To calibrate the model, two longshore transport coefficients are determined. Coefficient K1 governs the transport resulting from changes in the shoreline orientation. Coefficient K2 governs the transport resulting from variations in the breaking wave height (Gravens et al., 1991).

## C-5.2 MODEL BASELINE

The Shell Island GENESIS model covers 5.2 miles of shoreline between the Empire Waterway and Grand Bayou Pass. The orientation of the model baseline is 110°/290° (Figure C-5.1).

## C-5.3 CALIBRATION

In most cases, the GENESIS model is calibrated based on the most recent shoreline changes. However, in the case of Shell Island, this approach is not possible. First, shoreline changes along Shell Island depend not only on longshore transport, but also sea level rise, subsidence, overwash, breaching, cross-shore tidal currents, and mud transport. GENESIS cannot simulate these other processes. Second, the morphology of the project area will be considerably different from the existing morphology once the restoration project has been constructed. Under the restored conditions, the project area will consist of one or two continuous islands rather than a set of low islands and intertidal shoals. Also, the active beach face will consist primarily of sand rather than a mixture of mud and sand.

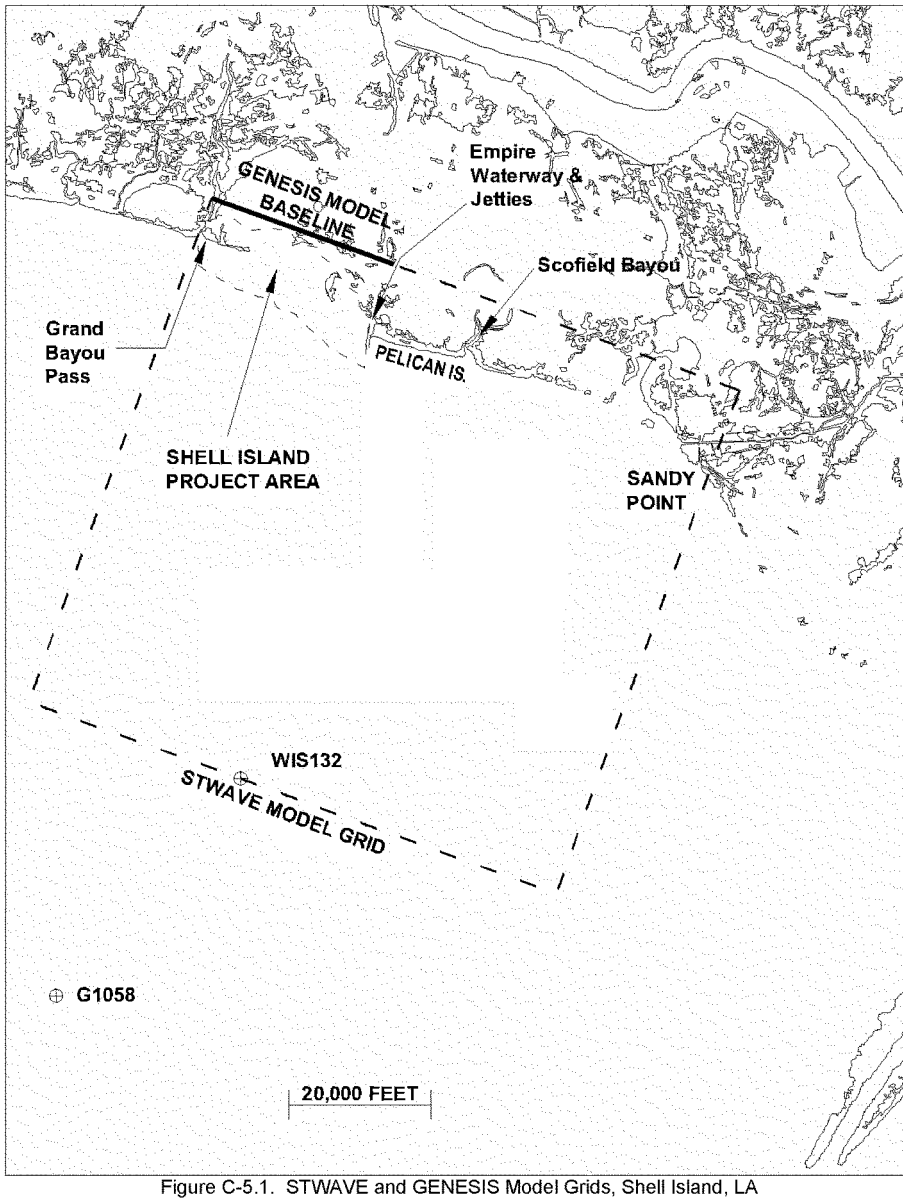



Figure C-5.1. STWAVE and GENESIS Model Grids, Shell Island, LA

To better simulate the restored conditions, calibration of the model was performed using the 1956-1973 sand transport rates. The 1956-1973 sand transport rates are discussed with the main report's sediment budget and appear in Figure C-5.2. These transport rates are representative of a continuous barrier island extending from the Empire Waterway to Grand Bayou Pass.

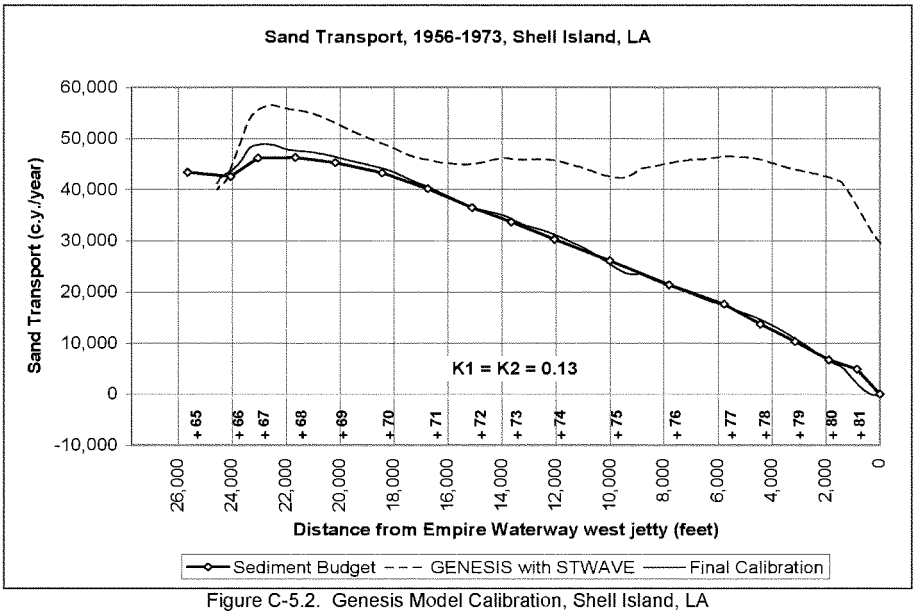


Figure C-5.2. Genesis Model Calibration, Shell Island, LA

To calibrate the model, the 1956 shoreline (Williams, et al., 1992) was utilized as the initial condition. The 1980 to 1999 hindcast at WIS Station 132 (Figure C-5.1) provided the offshore waves. To determine the nearshore waves, 39 wave angle and wave period bands were identified from the hindcast. Each band was assigned a wave height of 1 meter (3.3 feet) and given a corresponding wave spectrum using CEDAS-NEMOS 3.06 (Veri-Tech, 2004). The 1 meter (3.3 foot) waves were then refracted to -5 feet NAVD using STWAVE (Smith, 2001). From the STWAVE results, the refraction coefficients were determined by dividing the nearshore wave heights by the offshore wave height (1 meter = 3.3 feet).

To determine K1 and K2, several simulations of the 1956-1973 sand transport rates were conducted using GENESIS with the STWAVE results. The values of K1 and K2 were estimated to be K1 = K2 = 0.13. These values were on the same order as the Pelican Island and Chaland Headland GENESIS models (CPE, 2003). To further refine the calibration, refraction coefficients were adjusted to match the simulated sand transport

rates to the sediment budget's transport rates. The resulting calibration appears in Figure C-5.2. Agreement between the simulated sand transport and the sediment budget is excellent.

## C-5.4 VERIFICATION

To verify the model, sand transport rates between 1932 and 1956 were simulated. The 1932 shoreline was used as the initial condition. Sand transport rates based on the observed 1932-1956 shoreline changes were estimated using the same assumptions as the 1956-1973 sediment budget:

- An active profile height of 6.5 feet.
- A retreat component of 8.4 feet per year due to sea level rise.
- A 48% ratio of longshore to cross-shore transport.

The resulting sand transport rates appear in Figure C-5.3, along with the estimated transport rates from the GENESIS model. In general, the model overpredicts sand transport. This indicates that as a shoreline change model, GENESIS could overestimate the amount of shoreline retreat. Overall, projections of future shoreline change based on the GENESIS model will be conservative.

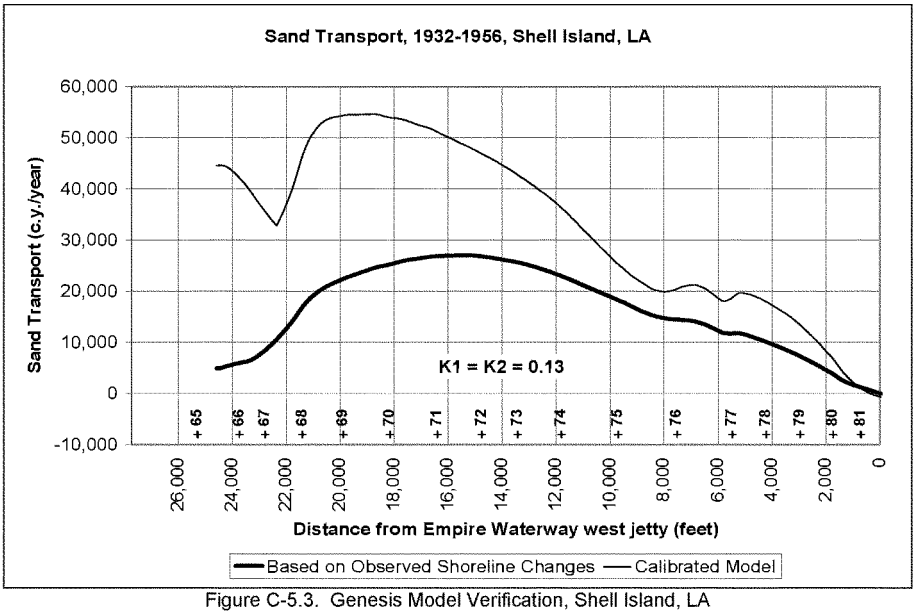



Figure C-5.3. Genesis Model Verification, Shell Island, LA

## C-5.5 WITHOUT PROJECT FUTURE CONDITIONS

If no project is constructed, the existing land areas will likely disappear over the next 5-10 years. The processes governing these changes cannot be simulated in the GENESIS model. For these reasons, the without-project scenario was not simulated using GENESIS.

### C-5.5.1 Alternative 1

Alternative 1 constructs two islands. The western island will be an expansion of the existing island adjacent to Grand Bayou Pass. The eastern island will cover the remnant islands and shoals between the midpoint of the GENESIS baseline and the Empire Waterway. Alternative 1 will have a project life of 50 years, with no renourishment following initial construction. Future shoreline changes given Alternative 1 appear in Table C-5.1 and in Figures C-5.4 – C-5.5.

Over the next 50 years, the western island will retreat an average of 1,215 feet. Retreat rates will be greatest at the eastern end of the island. As a result, the island could experience a change in orientation as the eastern end retreats and the western end accretes or remains stable. The resulting shoreline shape will be similar to the present shape until Year 25.

Table C-5.1 Average Shoreline and Volume Changes Alternative 1
Shell Island, LA

| | Shoreline Length (feet) | Shoreline Change (feet) from Year 0 to Year ... | | | | | |
|---|---|---|---|---|---|---|---|
| | | 5 | 10 | 15 | 20 | 25 | 50 |
| East Island Project Area | 11,400 | -95 | -161 | -231 | -313 | -396 | -731 |
| West Island Project Area | 5,760 | -285 | -463 | -636 | -807 | -942 | -1,215 |

| | Shoreline Length (feet) | Volume Change (c.y.) from Year 0 to Year ... | | | | | |
|---|---|---|---|---|---|---|---|
| | | 5 | 10 | 15 | 20 | 25 | 50 |
| East Island Project Area | 11,400 | -441,000 | -750,000 | -1,071,000 | -1,453,000 | -1,839,000 | -3,397,000 |
| West Island Project Area | 5,760 | -669,000 | -1,087,000 | -1,491,000 | -1,893,000 | -2,210,000 | -2,851,000 |

Notes: Design Berm Elevation = +6 feet NAVD
Assumed Depth of Closure = -5 feet NAVD

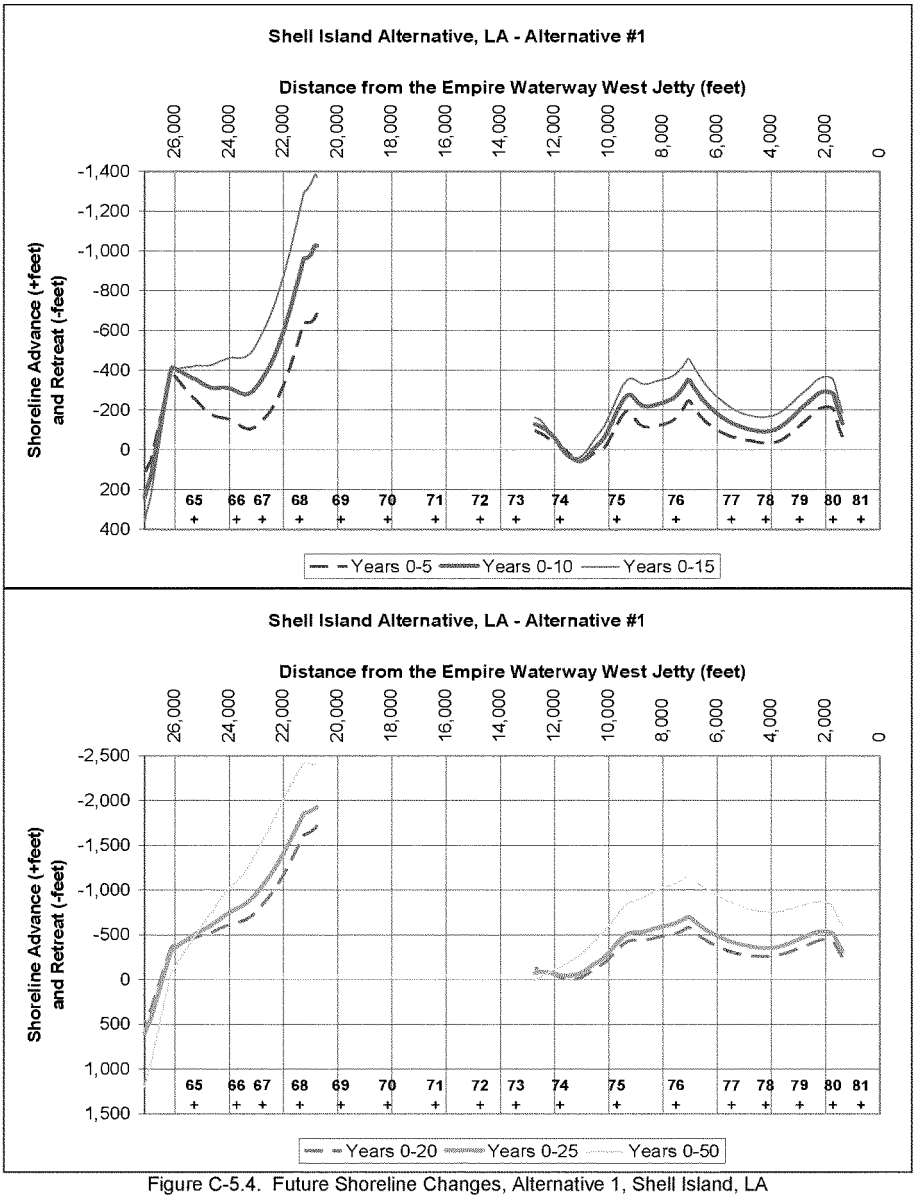



Figure C-5.4. Future Shoreline Changes, Alternative 1, Shell Island, LA

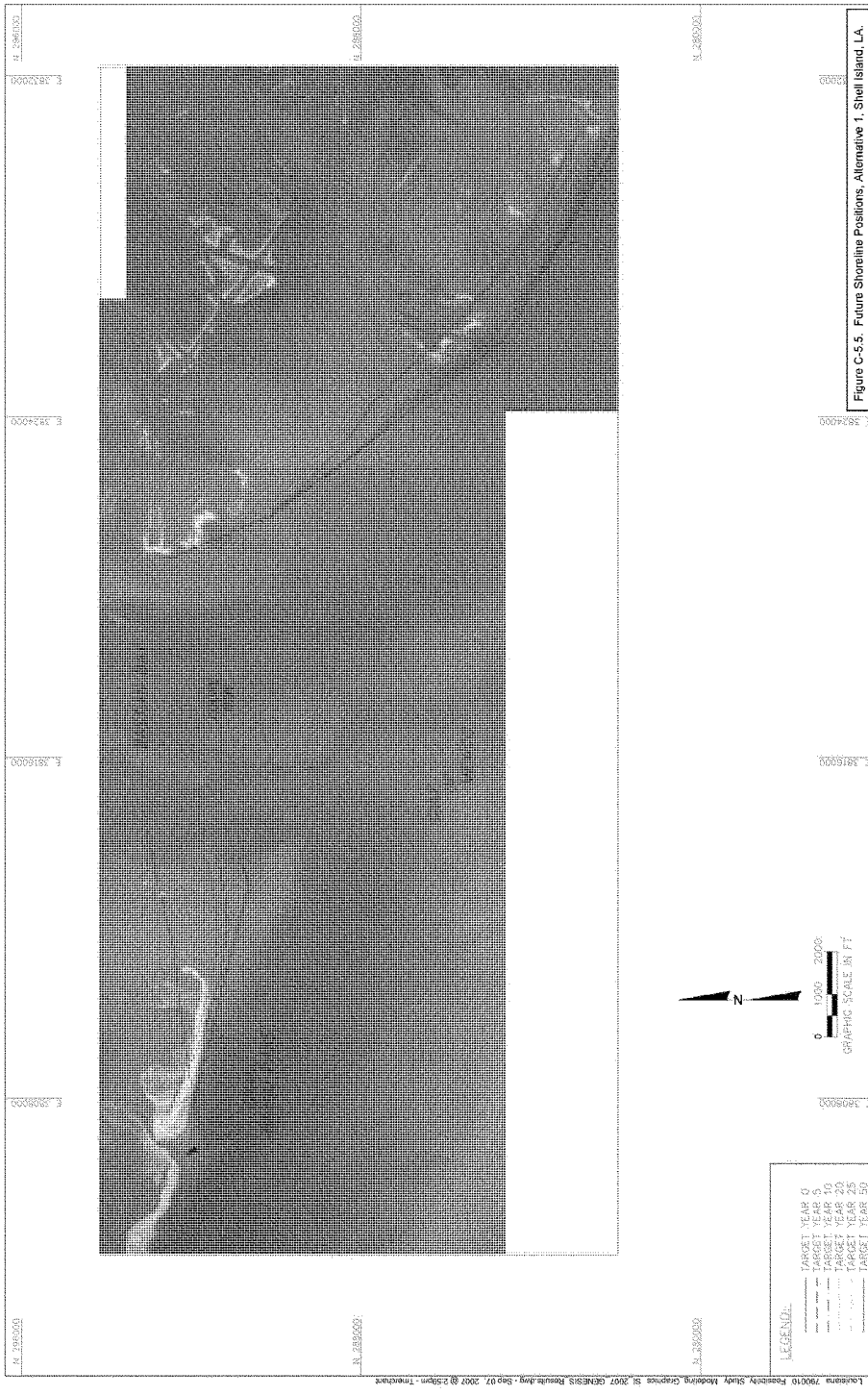



Figure C-5.5. Future Shoreline Positions, Alternative 1, Shell Island, LA.

The eastern island will retreat an average of 731 feet over the next 50 years. Except near Lines 74-75, the shorelines will retreat. The greatest retreat will occur near the midpoint of the island at Line 76. These patterns reflect the influence of the Empire Waterway jetties and the predominant sediment transport, which is from east to west. Over the 50 year project life, the shoreline will transition from a curved shape at Year 0 to a relatively straight alignment at Years 25 and 50.

### C-5.5.2 Alternative 2

Alternative 2 is similar to Alternative 1. However, Alternative 2 will be renourished every 10 years. Between TY0 and TY10, the western island will retreat 476 feet, and the eastern island will retreat 161 feet. Estimated volumes required for renourishment at TY10 will be 1,129,000 cubic yards along the western island and at least 746,000 cubic yards along the eastern island. Future shoreline changes given Alternative 2 appear in Table C-5.2 and in Figures C-5.6 and C-5.7.

Table C-5.2 Average Shoreline Changes Alternative 2
Shell Island, LA

| | Shoreline Length (feet) | Shoreline Change (feet) from Year 0 to Year ... | |
|---|---|---|---|
| | | 5 | 10 |
| East Island Project Area | 11,400 | -95 | -161 |
| West Island Project Area | 5,820 | -293 | -476 |
| | **Shoreline Length (feet)** | **Volume Change (c.y.) from Year 0 to Year ...** | |
| | | 5 | 10 |
| East Island Project Area | 11,400 | -440,000 | -746,000 |
| West Island Project Area | 5,820 | -694,000 | -1,129,000 |

Notes: Design Berm Elevation = +6 feet NAVD
Assumed Depth of Closure = -5 feet NAVD

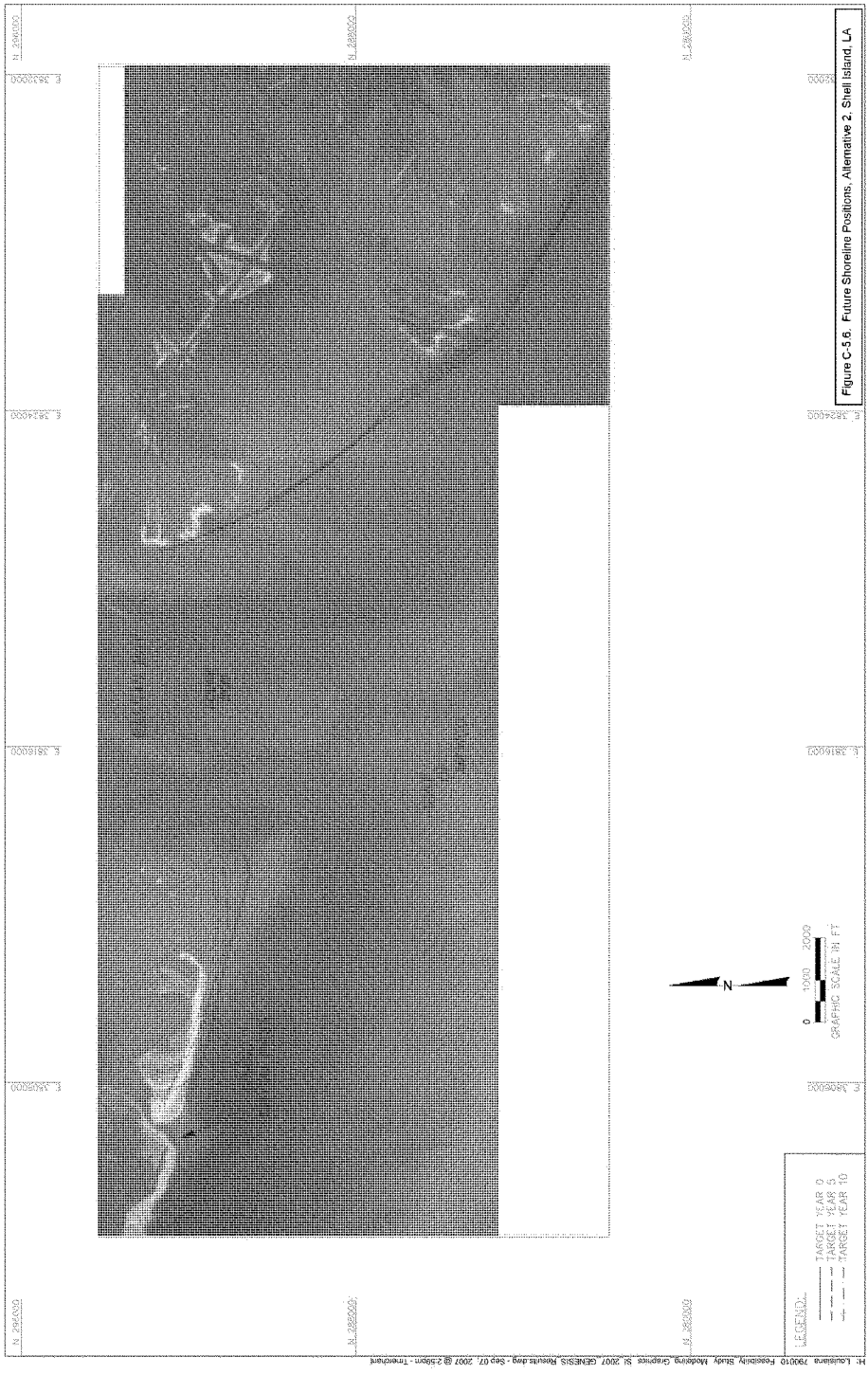



Figure C-5.6. Future Shoreline Positions, Alternative 2, Shell Island, LA

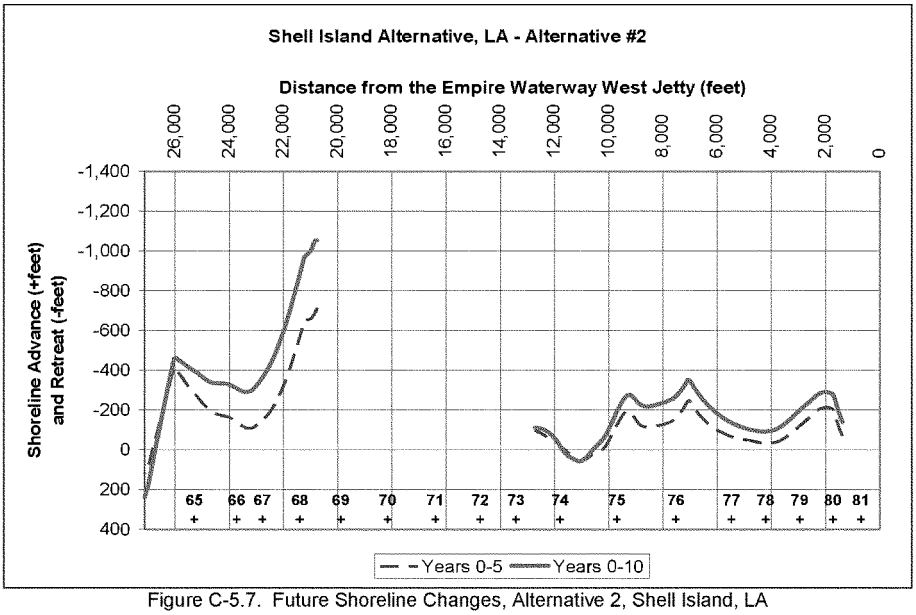



Figure C-5.7. Future Shoreline Changes, Alternative 2, Shell Island, LA

### C-5.5.3 Alternatives 3-6

Alternatives 3-6 construct a single island extending from Grand Bayou Pass to the Empire Waterway. The shoreline positions of Alternatives 3-6 are identical at Year 0. However, each features a different renourishment cycle:

- Alternative 3 – No renourishment.
- Alternative 4 – Renourishment at Year 25.
- Alternative 5 – Renourishment at Years 20 and 40
- Alternative 6 – Renourishment at Years 10, 20, 30, and 40

The performance of Alternatives 3-6 is summarized in Table C-5.3, Figure C-5.8, and Figure C-5.9. The tables and figures are illustrative of the time to renourishment. Following renourishment, the island will be restored to the initial, post-construction conditions.

Table C-5.3 Average Shoreline Changes Alternatives 3-6
Shell Island, LA

| | Shoreline Length (feet) | Shoreline Change (feet) from Year 0 to Year ... | | | | | |
|---|---|---|---|---|---|---|---|
| | | 5 | 10 | 15 | 20 | 25 | 50 |
| | | | | Alts. 3-5 only | Alts. 3-5 only | Alts. 3-4 only | Alt. 3 only |
| Eastern Section (65-70) | 9,300 | -81 | -133 | -186 | -239 | -293 | -509 |
| Middle Section (71-74) | 6,480 | 78 | 112 | 143 | 179 | 202 | 231 |
| Western Section (75-81) | 7,560 | -101 | -161 | -213 | -256 | -283 | -291 |

| | Shoreline Length (feet) | Volume Change (c.y.) from Year 0 to Year ... | | | | | |
|---|---|---|---|---|---|---|---|
| | | 5 | 10 | 15 | 20 | 25 | 50 |
| | | | | Alts. 3-5 only | Alts. 3-5 only | Alts. 3-4 only | Alt. 3 only |
| Eastern Section (65-70) | 9,300 | -308,000 | -506,000 | -704,000 | -905,000 | -1,110,000 | -1,930,000 |
| Middle Section (71-74) | 6,480 | 205,000 | 296,000 | 376,000 | 472,000 | 534,000 | 611,000 |
| Western Section (75-81) | 7,560 | -311,000 | -496,000 | -655,000 | -788,000 | -872,000 | -897,000 |

Notes: Design Berm Elevation = +6 feet NAVD
Assumed Depth of Closure = -5 feet NAVD

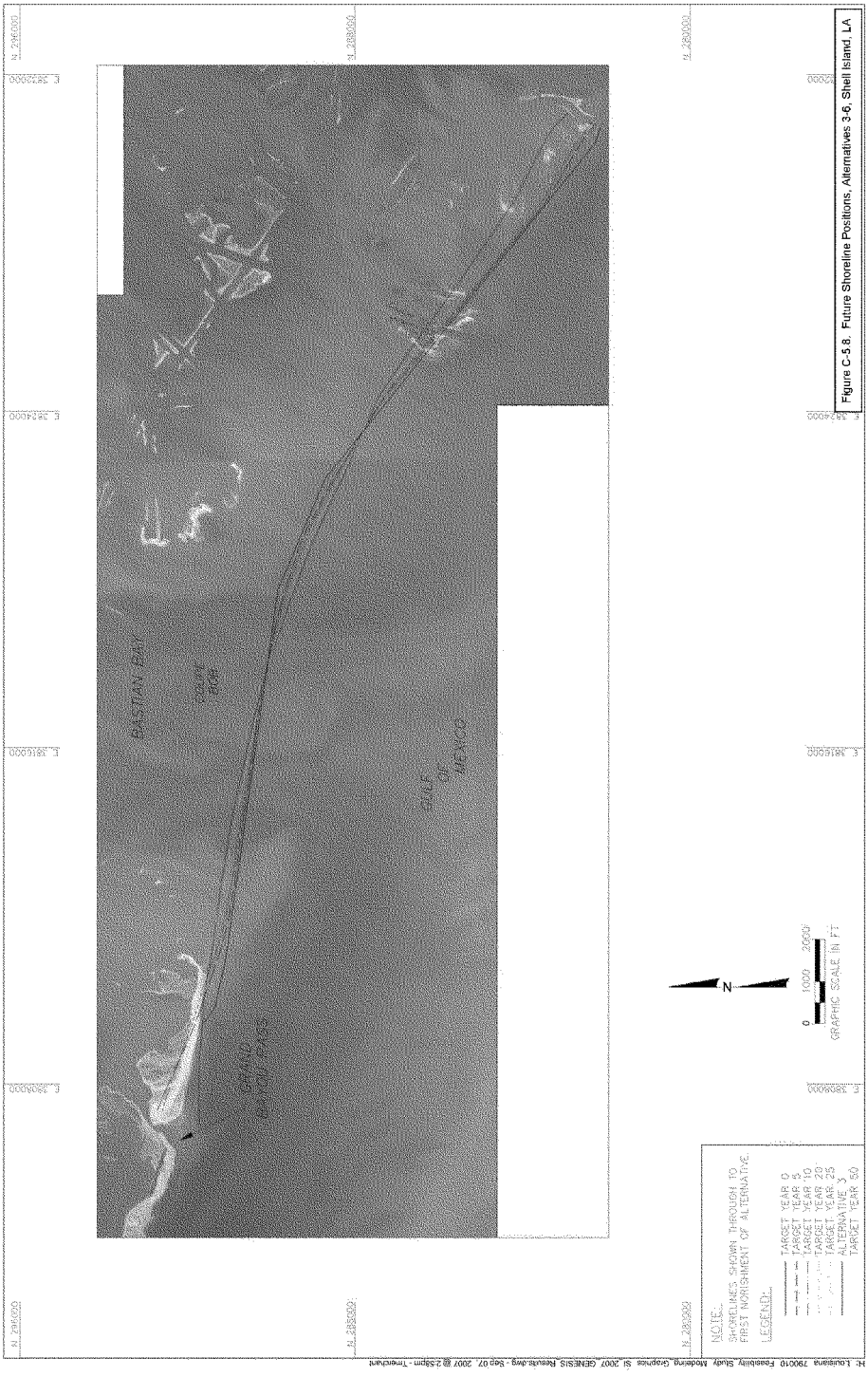



Figure C-5.8. Future Shoreline Positions, Alternatives 3-6, Shell Island, LA

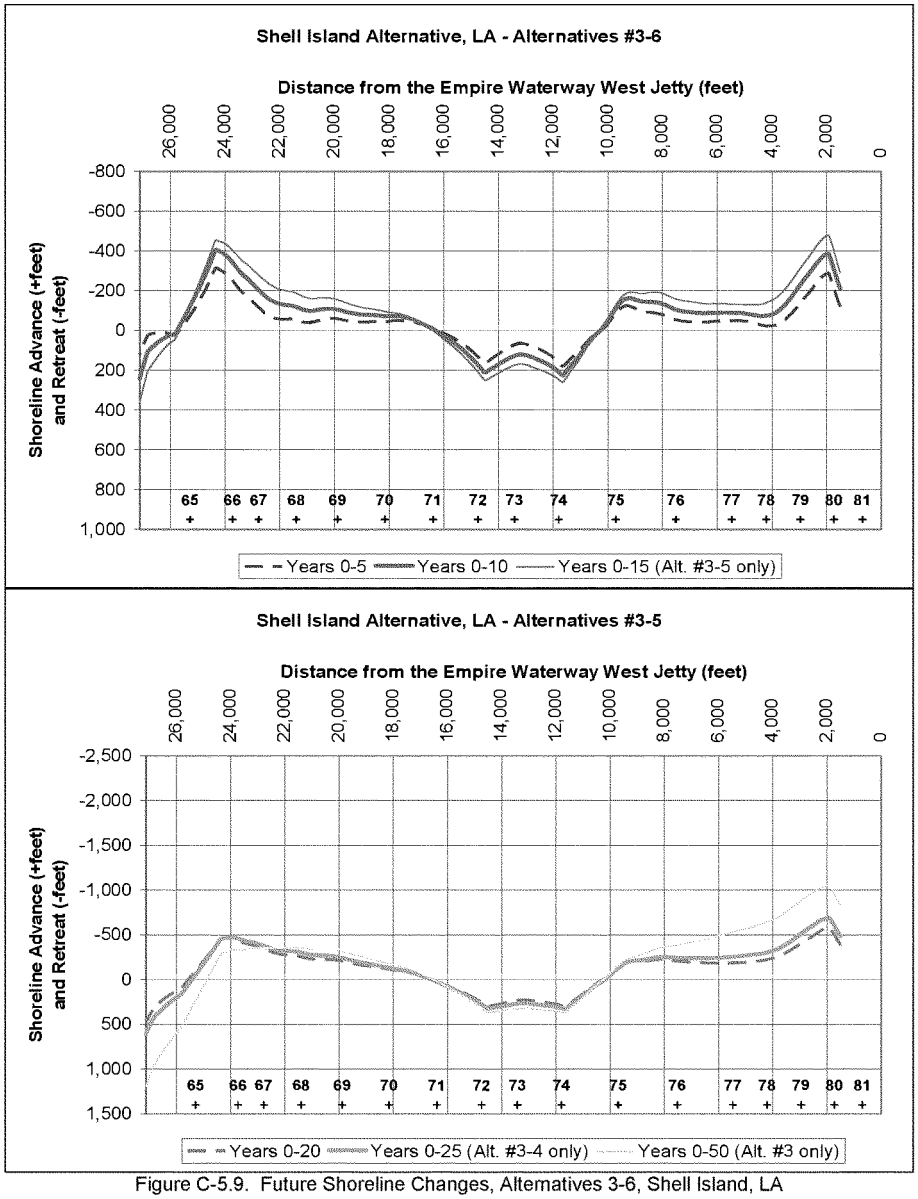



Figure C-5.9. Future Shoreline Changes, Alternatives 3-6, Shell Island, LA

Between Year 0 and Year 10, the net loss from the project area will be 706,000 cubic yards. The eastern end of the island will retreat 133 feet, and the western end will retreat 161 feet. However the middle section will advance 112 feet. The combined erosion in these two areas will be 1,002,000 cubic yards. These shoreline change patterns are generally due to a reduction in the curvature of the shoreline. If the renourishment of Alternative 6 is based on the overall performance of the project through Year 10, the fill requirement will be 706,000 cubic yards. If the renourishment of Alternative 6 is based on the eroding shorelines only, the fill requirement will be 1,002,000 cubic yards.

Between Year 0 and Year 20, the net loss from the project area as a whole will be 1,221,000 cubic yards. The eastern end of the island will retreat 239 feet, and the western end will retreat 256 feet. The combined erosion in these two areas will be 1,693,000 cubic yards. Partial deposition of the eroded material will occur along the middle of the island, resulting in a 179 foot shoreline advance. If the renourishment of Alternative 5 is based on the overall performance of the project through Year 20, the fill requirement will be 1,221,000 cubic yards. If the renourishment of Alternative 5 is based on the eroding shorelines only, the fill requirement will be 1,693,000 cubic yards.

Between Year 0 and Year 25, the net loss from the project area as a whole will be 1,448,000 cubic yards. The eastern end of the island will retreat 293 feet, and the western end will retreat 283 feet. The combined erosion in these two areas will be 1,982,000 cubic yards. Partial deposition of the eroded material will occur along the middle of the island, resulting in a 202 foot shoreline advance. If the renourishment of Alternative 4 is based on the overall performance of the project through Year 25, the fill requirement will be 1,448,000 cubic yards. If the renourishment of Alternative 4 is based on the eroding shorelines only, the fill requirement will be 1,982,000 cubic yards.

Between Year 0 and Year 50, the net loss from the project area as a whole will be 2,216,000 cubic yards. The eastern end of the island will retreat 509 feet, and the western end will retreat 291 feet. The combined erosion in these two areas will be 2,827,000 cubic yards. Partial deposition of the eroded material will occur along the middle of the island, resulting in a 231 foot shoreline advance. In general, the larger retreat on the eastern section of the island is due to the influence of the Empire Waterway jetties and the changes in shoreline orientation. On the western end of the project area, changes in shoreline orientation are relatively small after Year 25. However, on the eastern end, the shoreline orientation is still transitioning from a northwest / southeast direction to a west-northwest / east-southeast direction. For this reason, erosion rates are larger on the eastern end of the island than the western end. The probability of breaching through Alternative 6 is low. However, if it occurs, it is likely to happen near the east end of the island.

### C-5.5.4 Alternative 7

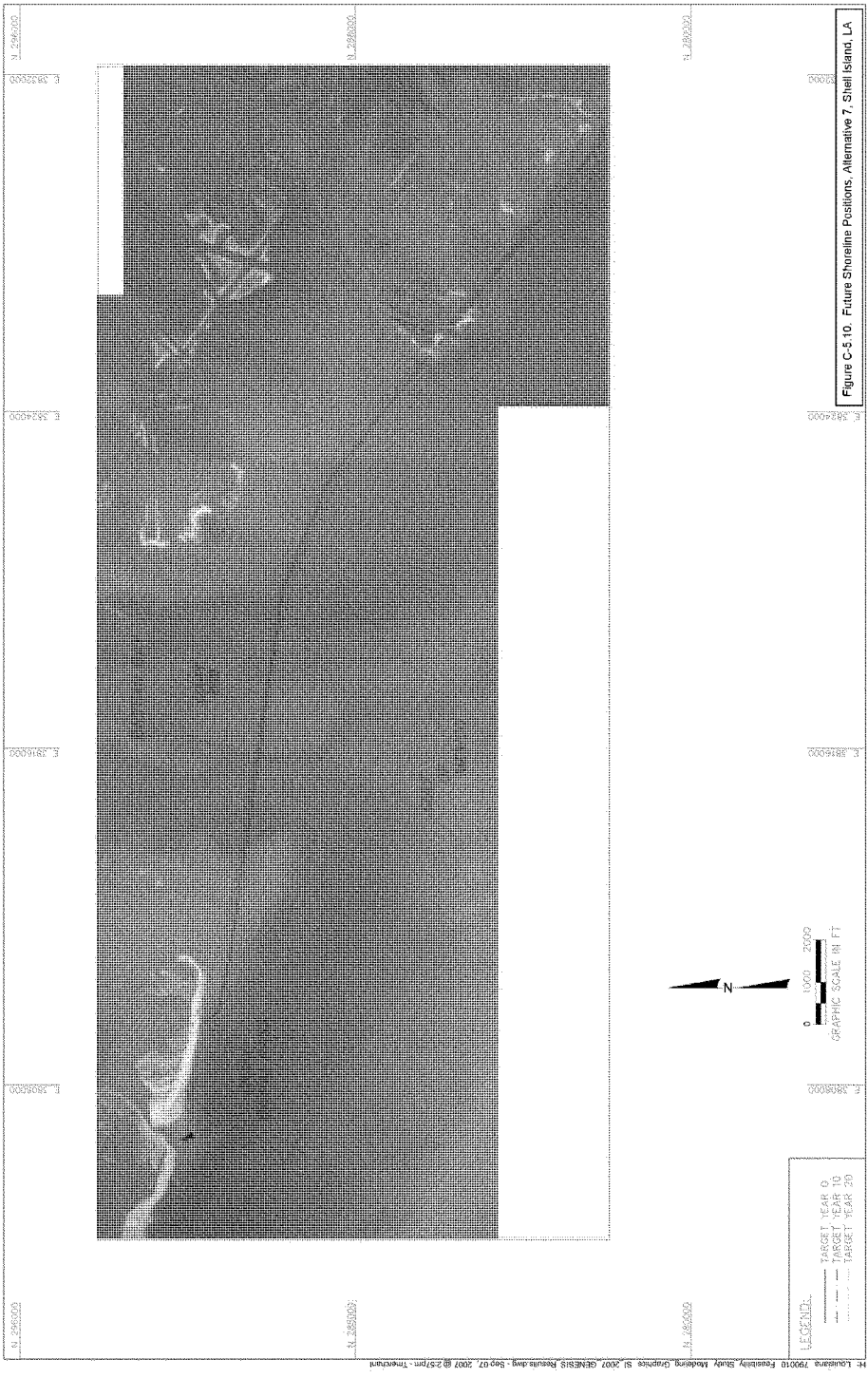
Alternative 7 is similar to Alternative 5. It consists of a single island, with renourishment at Years 20 and 40. However, the initial construction places more advance fill. The performance of Alternative 7 is summarized in Table C-5.4, Figure C-5.10, and Figure C-15.11.

Table C-5.4 Average Shoreline and Volume Changes Alternative 7
Shell Island, LA

| | Shoreline Length (feet) | Shoreline Change (feet) from Year 0 to Year ... 5 | 10 | 15 | 20 |
|---|---|---|---|---|---|
| Eastern Section (65-70) | 9,300 | -84 | -137 | -190 | -244 |
| Middle Section (71-74) | 6,480 | 78 | 113 | 143 | 179 |
| Western Section (75-81) | 7,560 | -111 | -174 | -228 | -274 |
| | **Shoreline Length (feet)** | **Volume Change (c.y.) from Year 0 to Year ... 5** | **10** | **15** | **20** |
| Eastern Section (65-70) | 9,300 | -317,000 | -518,000 | -718,000 | -923,000 |
| Middle Section (71-74) | 6,480 | 205,000 | 297,000 | 378,000 | 473,000 |
| Western Section (75-81) | 7,560 | -341,000 | -535,000 | -702,000 | -843,000 |

Notes: Design Berm Elevation = +6 feet NAVD
Assumed Depth of Closure = -5 feet NAVD

Between Year 0 and Year 20, the net loss from the project area as a whole will be 1,293,000 cubic yards. The eastern end of the island will retreat 244 feet, and the western end will retreat 274 feet. The combined erosion in these two areas will be 1,766,000 cubic yards. Partial deposition of the eroded material will occur along the middle of the island, resulting in a 179 foot shoreline advance. If the renourishment of Alternative 7 is based on the overall performance of the project through Year 20, the fill requirement will be 1,293,000 cubic yards. If the renourishment of Alternative 7 is based on the eroding shorelines only, the fill requirement will be 1,766,000 cubic yards.


LEGEND:
TARGET YEAR 0
TARGET YEAR 10
TARGET YEAR 20
N
0
1000
2000
GRAPHIC SCALE IN FT
Figure C-5.10. Future Shoreline Positions, Alternative 7, Shell Island, LA

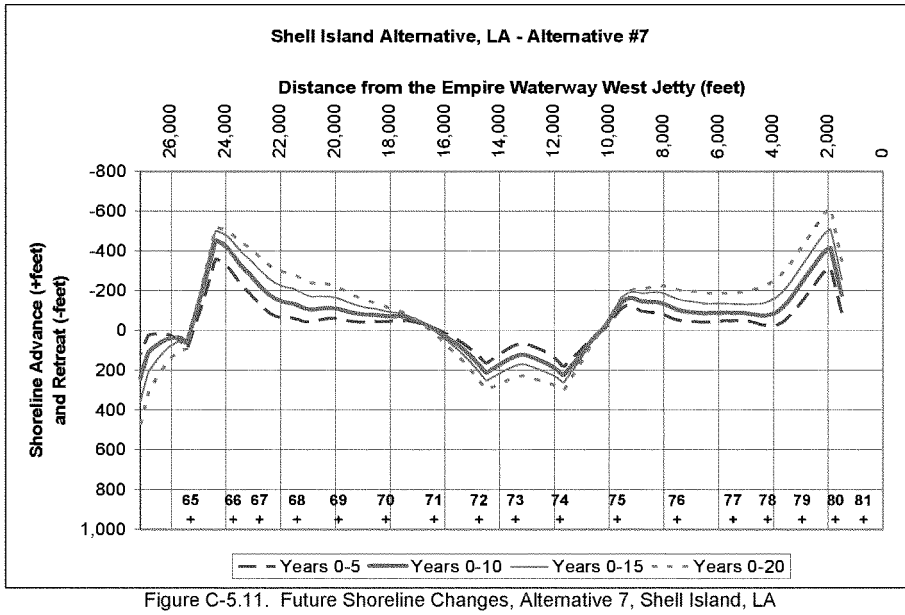



Figure C-5.11. Future Shoreline Changes, Alternative 7, Shell Island, LA

### C-5.5.5 Alternative 8

Alternative 8 is also similar to Alternative 5. It consists of a single island, with renourishment at Year 25. However, the initial construction places more advance fill than Alternative 5. The performance of Alternative 8 is summarized in Table C-5.6, Figure C-5.12, and Figure C-15.13.

Between Year 0 and Year 25, the net loss from the project area will be 1,595,000 cubic yards. The eastern end of the island will retreat 303 feet, and the western end will retreat 319 feet. The combined erosion in these two areas will be 2,130,000 cubic yards. Partial deposition of the eroded material will occur along the middle of the island, resulting in a 179 foot shoreline advance. If the renourishment of Alternative 8 is based on the overall performance of the project through Year 25, the fill requirement will be 1,595,000 cubic yards. If the renourishment of Alternative 8 is based on the eroding shorelines only, the fill requirement will be 2,130,000 cubic yards.

Table C-5.6 Average Shoreline and Volume Changes Alternative 8
Shell Island, LA

| | Shoreline Length (feet) | Shoreline Change (feet) from Year 0 to Year ... | | | | |
|---|---|---|---|---|---|---|
| | | 5 | 10 | 15 | 20 | 25 |
| Eastern Section (65-70) | 9,300 | -86 | -139 | -193 | -247 | -303 |
| Middle Section (71-74) | 6,480 | 78 | 113 | 143 | 179 | 202 |
| Western Section (75-81) | 7,560 | -117 | -182 | -239 | -287 | -319 |

| | Shoreline Length (feet) | Volume Change (c.y.) from Year 0 to Year ... | | | | |
|---|---|---|---|---|---|---|
| | | 5 | 10 | 15 | 20 | 25 |
| Eastern Section (65-70) | 9,300 | -325,000 | -527,000 | -730,000 | -937,000 | -1,147,000 |
| Middle Section (71-74) | 6,480 | 206,000 | 298,000 | 379,000 | 474,000 | 535,000 |
| Western Section (75-81) | 7,560 | -362,000 | -562,000 | -735,000 | -884,000 | -983,000 |

Notes: Design Berm Elevation = +6 feet NAVD
Assumed Depth of Closure = -5 feet NAVD

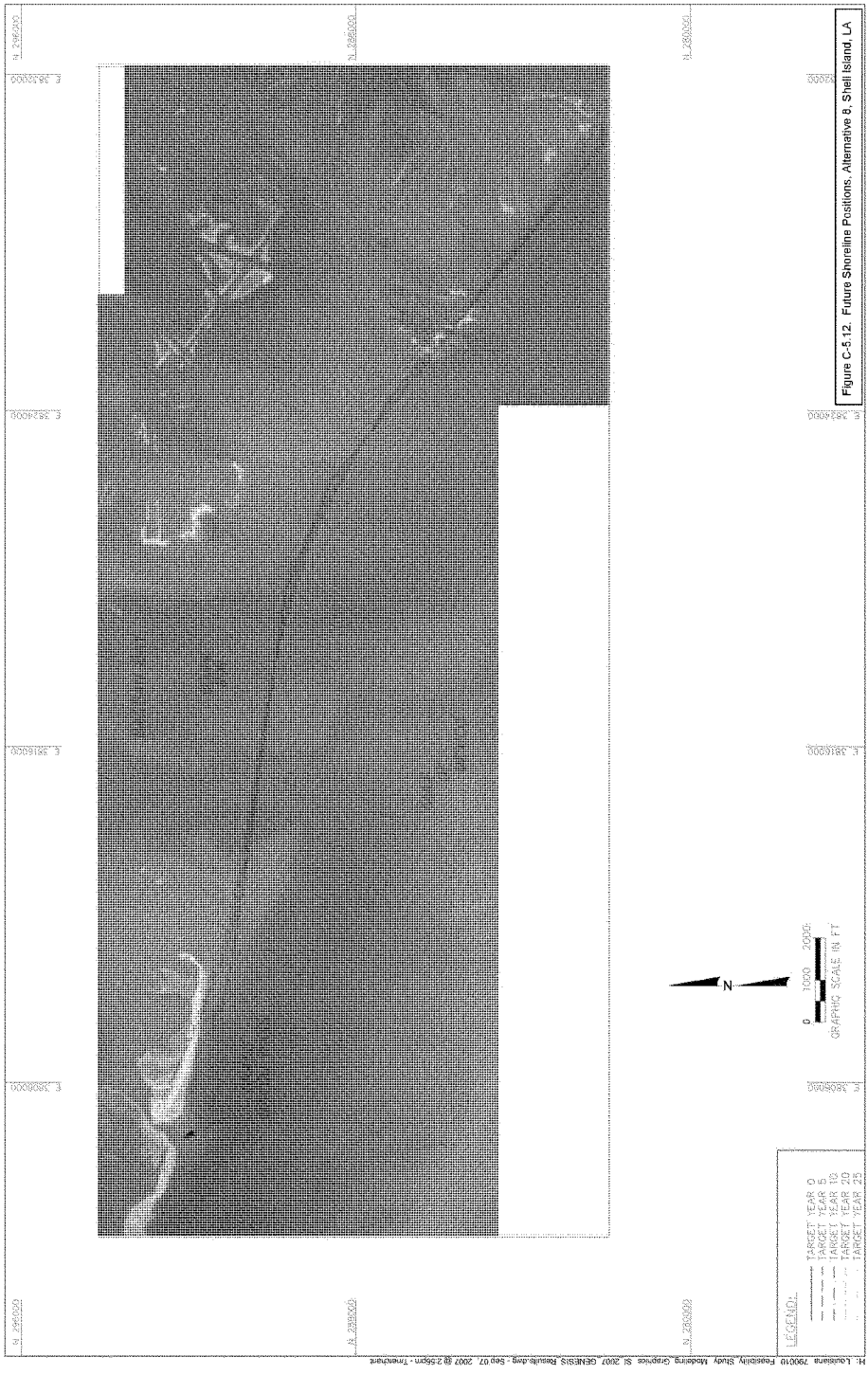



Figure C-5.12. Future Shoreline Positions, Alternative 8, Shell Island, LA

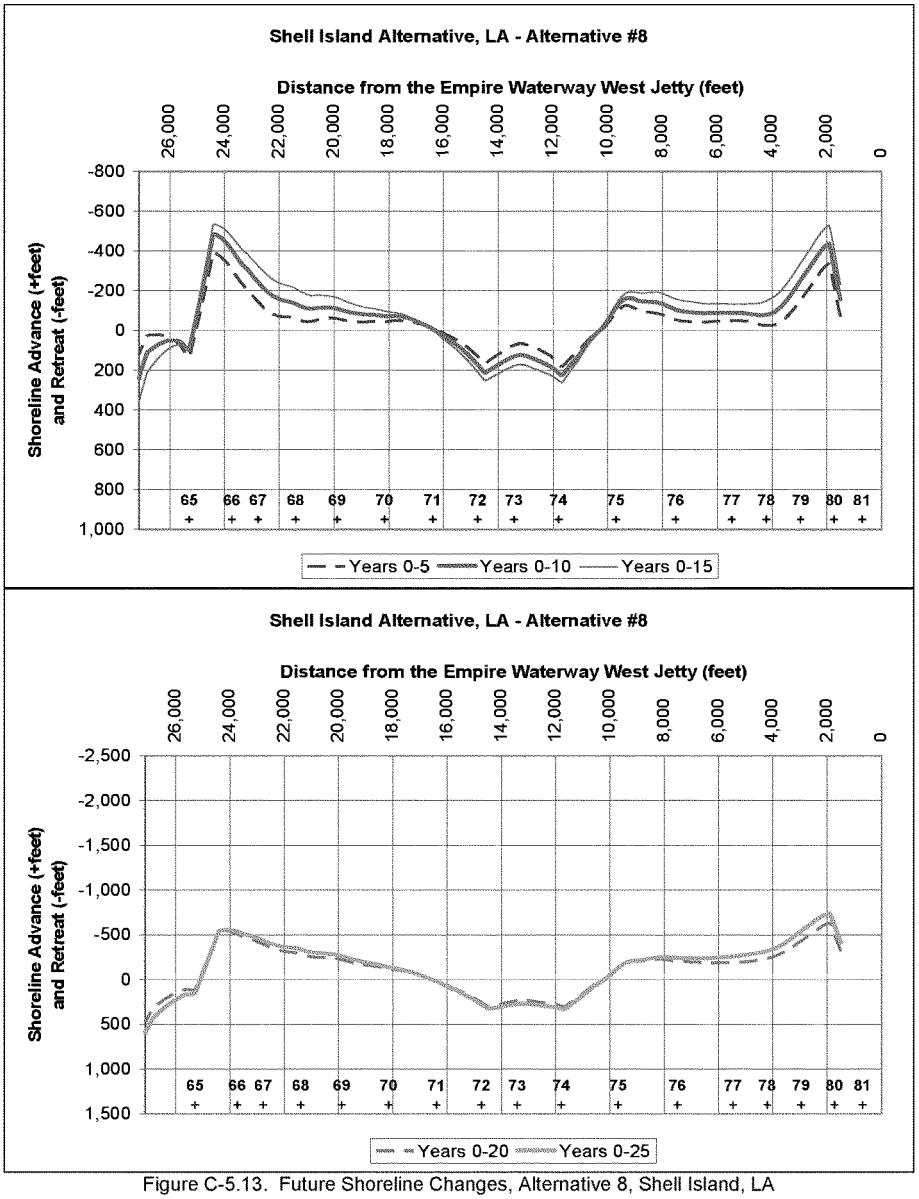



Figure C-5.13. Future Shoreline Changes, Alternative 8, Shell Island, LA

## C-5.6 SEDIMENT TRANSPORT

### C.5.6.1 Alternative 1

The 50-year, average sand transport given Alternative 1 appears in Figure C-5.14. In general, the sand transport is directed into Coupe Bob (the gap between the two islands) at a rate of approximately 93,000 c.y./year. Along the eastern island, the net sand transport will be from east to west. Transport in the opposite direction will be very small. The large jetties at the Empire Waterway will act as a total barrier to longshore transport. Between the Empire Waterway and Line 74, the net transport increases from 0 to 51,000 c.y./year. Between Line 74 and Coupe Bob, the net transport decreases from 51,000 to 38,000 c.y./year. Along the western island, the net sand transport will be from west to east. Transport from east to west will be about 2/3 of the total transport from west to east. Between Grand Bayou Pass and Line 65, the net transport decreases from 12,000 to 6,000 c.y./year. Between Line 65 and Coupe Bob, the net transport increases from 6,000 to 55,000 c.y./year. The variation in sand transport along the western island is responsible for the curvature that appears in Figure C-5.5.

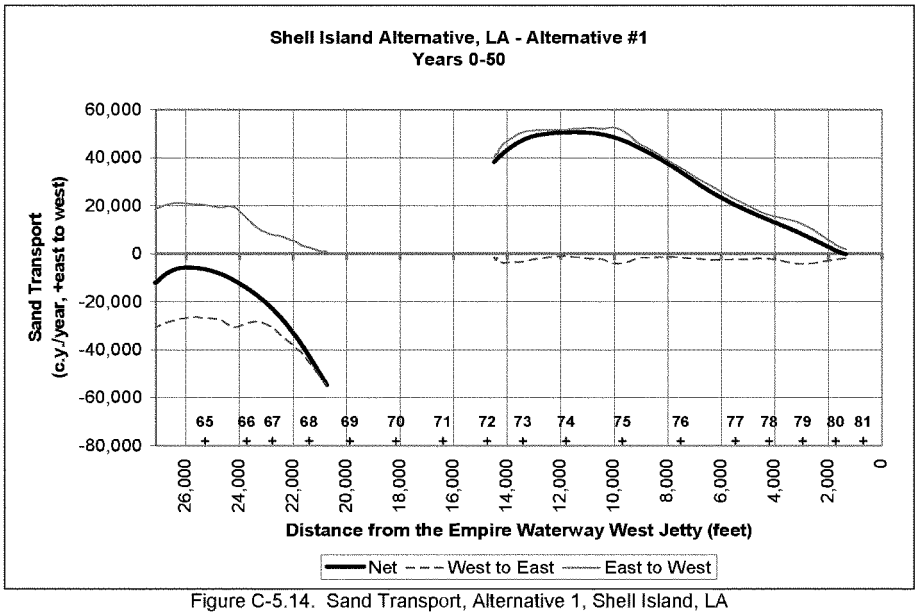



Figure C-5.14. Sand Transport, Alternative 1, Shell Island, LA

### C.5.6.2 Alternative 2

The 10-year, average sand transport given Alternative 2 appears in Figure C-5.15. Given the similarity between Alternatives 1 and 2, these results can also represent the sand transport for Alternative 1 between Years 0 and 10. In general, the sand transport is directed into Coupe Bob (the gap between the two islands) at a rate of approximately 96,000 c.y./year. Along the eastern island, the net sand transport will be from east to west, except near the east end of the island. Transport from west to east will be very small. The large jetties at the Empire Waterway will act as a total barrier to longshore transport. Between the Empire Waterway and Line 75, the net transport increases from 0 to 55,000 c.y./year. Between Lines 75 and 73, the net transport exhibits a small degree of variation near the range of 50,000 c.y./year. Between Line 75 and Coupe Bob, the net transport decreases to 42,000 c.y./year. Along the western island, the net sand transport is from west to east on the eastern third of the island and from east to west elsewhere. A nodal point is located near Line 67. Between the nodal point and Coupe Bob, the transport towards Coupe Bob increases to 54,000 c.y./year. Between the nodal point and Grand Bayou Pass, the transport from east to west increases to 47,000 c.y./year.

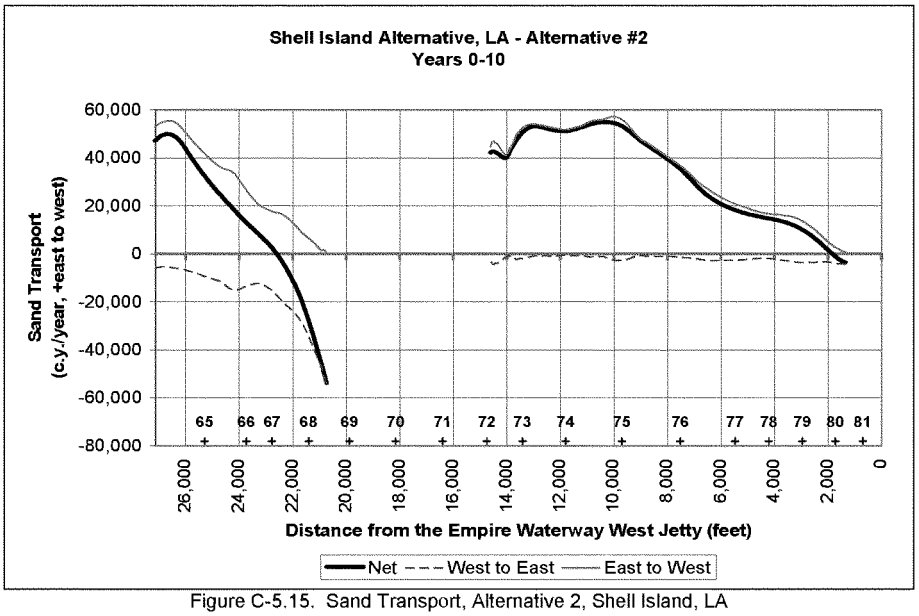



Figure C-5.15. Sand Transport, Alternative 2, Shell Island, LA

### C.5.6.3 Alternatives 3-6

Sediment transport rates for Alternatives 3-6 appear in Figures C-5.16 and C-5.17. Three time periods are shown: the 50 year average for Alternative 3, the 20 year average for Alternatives 3-5, and the 10 year average for Alternatives 3-6.

Over a 10 year period, the net sand transport given Alternatives 3-6 will be from east to west, except near Lines 69-72. In this section of island, the net transport will be from west to east. This transport pattern is responsible for the accreting beaches in the middle of the island and the reduction of its curvature. On the eastern and western thirds of the island, the net transport is directed towards the middle third. Between the Empire Waterway and Line 75, the net transport increases from 0 to 38,000 c.y./year. Along this segment, the transport in the opposite, west to east direction is low. Between Lines 75 and 72, the net transport decreases back to zero. Near Line 69, transport from east to west resumes, increasing to 37,000 c.y./year at Line 65. Between Line 65 and Grand Bayou Pass, the net sand transport decreases to 31,000 c.y./year.

Over a 20 year period, the net sand transport given Alternatives 3-5 will exhibit characteristics similar to the 10 year pattern. However, on the eastern and western sections of the island, the net transport values will be 12 to 32 percent lower. The lower transport rates reflect the changes in the island's curvature, which are expected to slow down over time.

Over a 50 year period, the net transport sand transport given Alternative 3 will be from east to west along the entire project area. Net transport from west to east will only occur next to Grand Bayou Pass. Between the Empire Waterway and Line 75, the net transport will increase from 0 to 28,000 c.y.year. Along this segment, the transport in the opposite, west to east direction is relatively low. Between Lines 75 and 70, the net transport will decrease from 28,000 to 4,000 c.y./year. Net transport rates will exhibit a small increase between Lines 70 and 66, with a decrease towards zero between Line 66 and Grand Bayou Pass. West of Line 75, the transport in the opposite, west to east direction is approximately 60 to 80 percent of the transport in the east to west direction. Overall, the net transport rates over a 50 year period are 27 to 73 percent lower than the 10 year averages.

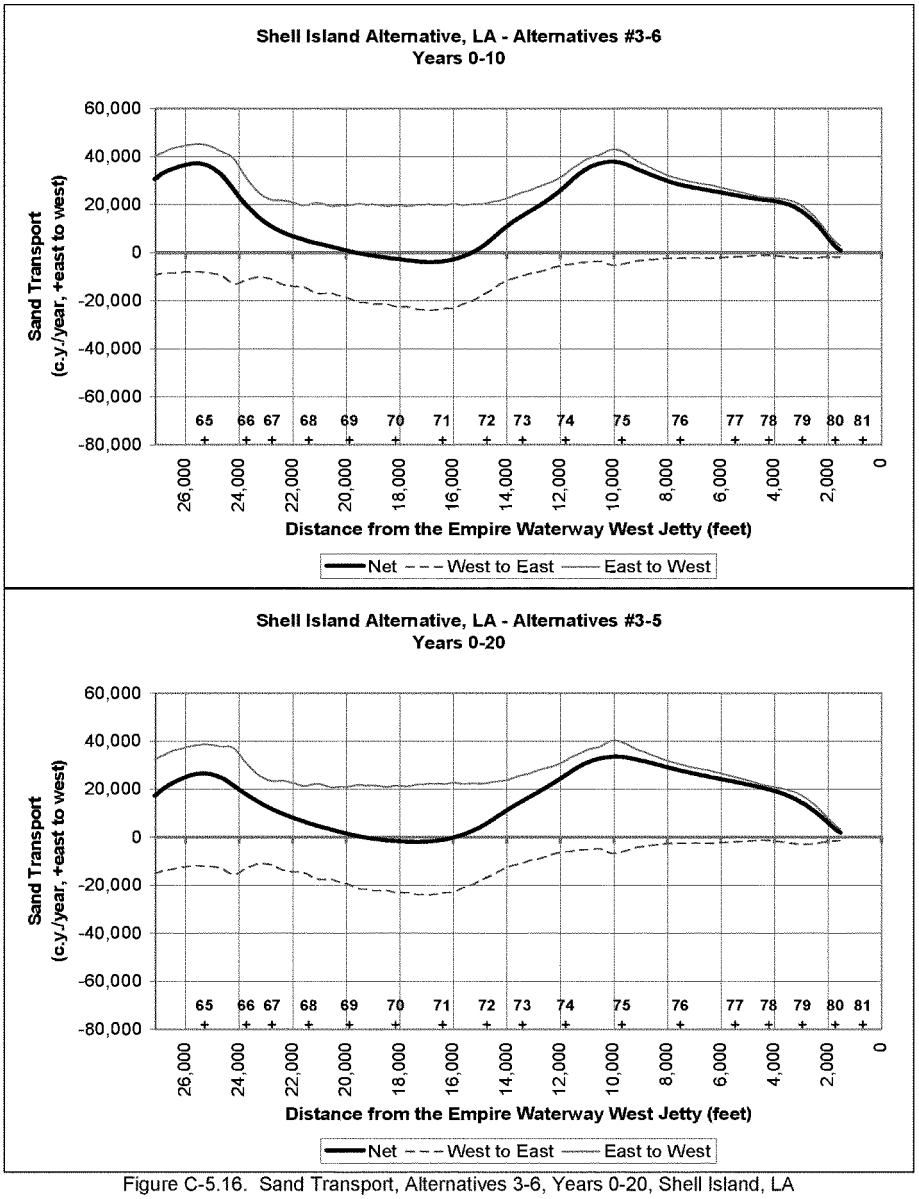



Figure C-5.16. Sand Transport, Alternatives 3-6, Years 0-20, Shell Island, LA

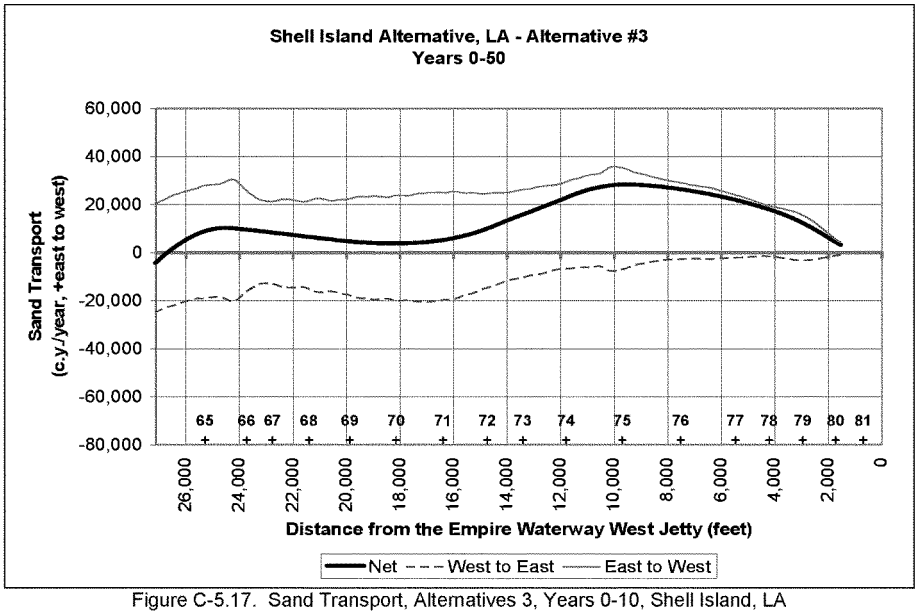



Figure C-5.17. Sand Transport, Alternatives 3, Years 0-10, Shell Island, LA

## C-5.7 SENSITIVITY ANALYSIS OF THE GENESIS MODEL

To assess the uncertainty of the model, a sensitivity analysis was conducted for Alternatives 2 and 3. The following parameters were considered: grain size, berm elevation, depth of closure, K2, K1, and the wave refraction pattern.

### C-5.7.1 Parameters Examined

The GENESIS model utilizes the grain size to estimate a theoretical wave-breaking slope (Gravens et al, 1991). In the model's code, grain size determines the value of Dean's A factor, which then dictates the wave-breaking slope. Wave breaking is then calculated based on the refracted wave at the depth of closure or an arbitrary, nearshore reference line. The previously discussed model results assume a grain size of 0.11 mm. However, grain sizes in the potential borrow areas range from 0.06 mm to 0.28 mm. The sensitivity of the model to grain size is based on 10 year results given a mean grain size of 0.06, 0.11, and 0.28 mm.

The berm elevation and the depth of closure determine the active profile height and the proportionality factor between shoreline and volume change in GENESIS. Natural berm elevations range from 0.7 to 5.7 feet NAVD based on the most recent surveys. The calibration and verification runs assume a berm height of +4

feet NAVD. The model runs for Alternatives 1-8 assume the design berm height of +6 feet NAVD. The sensitivity of the model to berm elevation is based on 10 year results given a berm elevation of 0.7 feet NAVD and the design berm elevation of +6 feet NAVD.

The depth of closure governs both the active profile height and wave breaking in GENESIS. This depth can be estimated based on wave data or survey data. The depth of closure values based on wave data is -15.5 feet NAVD. However, this value is not consistent with recent surveys. Where the 2000 and 2005 beach profiles exhibit closure, the closure point varies from -4 to -8 feet NAVD. The sediment budget in the main report assumes a depth of closure near -5 feet NAVD, which lies between these values. The previously discussed model results assume a -5 feet NAVD depth of closure. The sensitivity of the model to the depth of closure is based on 10 year results given values of -4, -5, and-8 feet NAVD.

Coefficients K1 and K2 governed the magnitude of the sediment transport given equal values of the other model inputs. The selected values of K1 and K2 from the calibration run were K1 = K2 = 0.13. However, during the verification run, the hindcast sediment transport was approximately 2.2 times the value based on observed shoreline changes. Accordingly, the sensitivity of the model to the value of K1 was based on the 10 year results given K1 values of 0.06, 0.13, and 0.29. Recommended values of K2 ranged from 0 to K2 = K1. The sensitivity of the model to the value of K2 waves based on 10 year results given K2 values of 0 and K2 = 0.13.

Waves were the primary forcing in the GENESIS model. Wave transformation between WIS Station 132 and the project area was estimated using STWAVE and subsequently modified to improve the calibration results. Both methods had weaknesses, such as the lack of friction in the STWAVE model and the neglect of bathymetric changes offshore. The model runs for Alternatives 1-8 utilized in modified wave transformation results. The sensitivity of the model to wave transformation patterns was based on the 10 year results given the raw STWAVE output and the modified wave transformation patterns.

### C-5.7.2 Alternative 2

The first parameter examined by the Alternative 2 sensitivity analysis was grain size (Figure C-5.18). To examine the sensitivity of the model to grain size, two additional simulations were conducted using grain sizes of 0.06 and 0.28 mm. The other model inputs were identical to those of the final calibration. Reducing the grain size to 0.06 mm raised the erosion rates by 3 percent on the eastern island and 10 percent on the western island. The largest increase in the erosion rates given the smaller grain size occurred on the eastern half of the western island near Coupe Bob. Increasing the grain size to 0.28 mm lowered the erosion rates by 12 percent on the eastern island and 2 percent on the western island. However, on the eastern island, most of the changes to the erosion rates occurred near its western end. Elsewhere, changes to the erosion rate were

very small. In general, reducing the grain size from 0.11 mm produced noticeable changes to the erosion rates. However, in most locations, increasing the grain size did not.

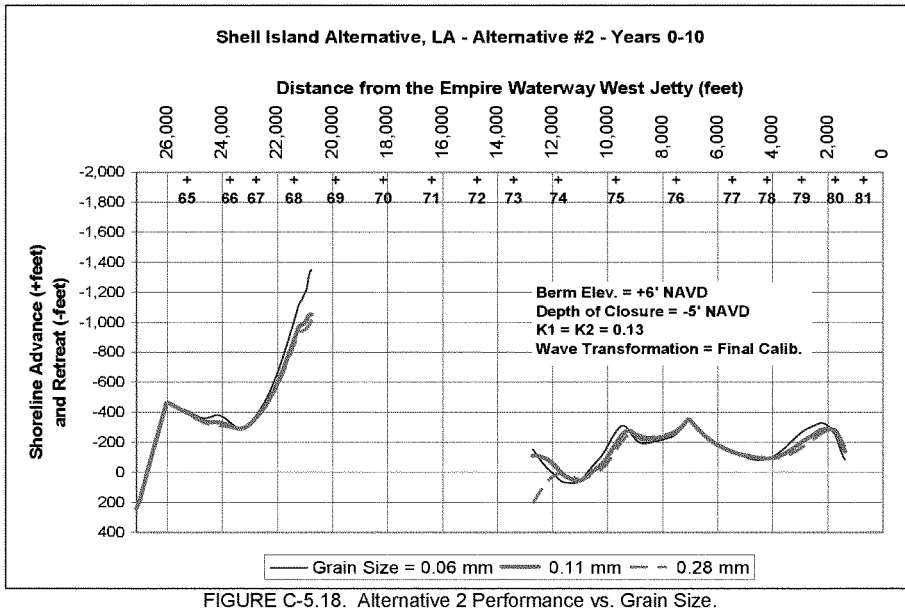



FIGURE C-5.18. Alternative 2 Performance vs. Grain Size.

The second parameter examined by the Alternative 2 sensitivity analysis was the berm elevation (Figure C-5.19). To examine the sensitivity of the model to berm elevation, an additional simulation was conducted using a berm elevation of +0.7' NAVD. The other model inputs were identical to those of the final calibration. The change in berm elevation reduced the active profile height from 11 to 5.7 feet. Lowering the berm elevation to +0.7' NAVD increased the erosion rates by 45 percent on the eastern island and 71 percent on the western island. While these changes were substantial, they were considerably less than a 92 percent increase based on an 11 to 5.7 ratio. The shoreline positions resulting from the higher erosion rates modified the sediment transport, thereby reducing the effect of a smaller active profile height.

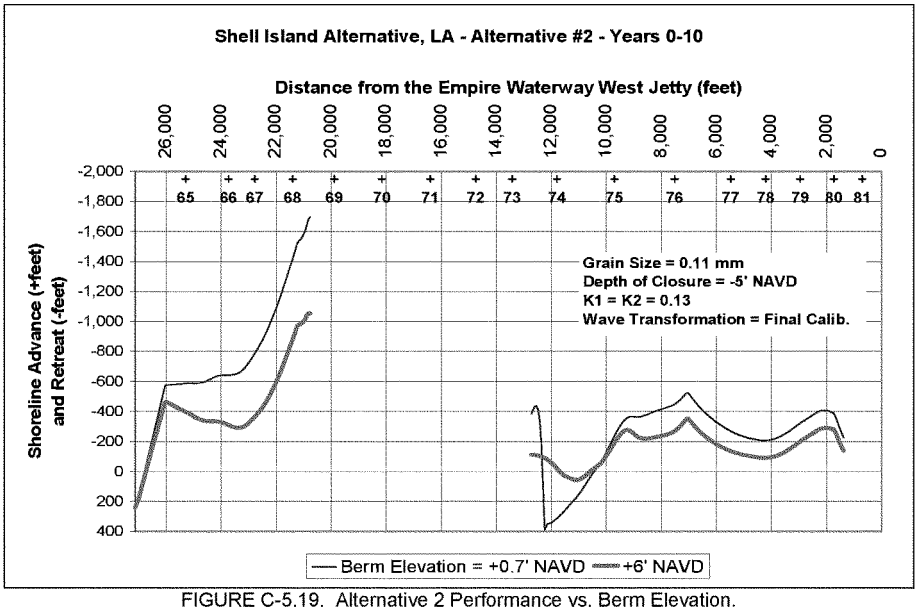



FIGURE C-5.19. Alternative 2 Performance vs. Berm Elevation.

The third parameter examined by the Alternative 2 sensitivity analysis was the depth of closure (Figure C-5.20). To examine the sensitivity of the model to the depth of closure, two additional simulations were conducted using values of -4 and -8 feet NAVD. The other model inputs were identical to those of the final calibration. Modifying the depth of closure changed the active profile height from 11 feet to either 10 or 14 feet. Raising the depth of closure to -4 feet NAVD increased the erosion rates 7 percent on the eastern island and 8 percent on the western island. Lowering the depth of closure to -8 feet NAVD decreased the erosion rates by 15 percent on the eastern island and 18 percent on the western island. In both cases, changes to the erosion rates were less than the ratios between the various active profile heights. The reason for this result was similar to the previous test involving the berm elevation.

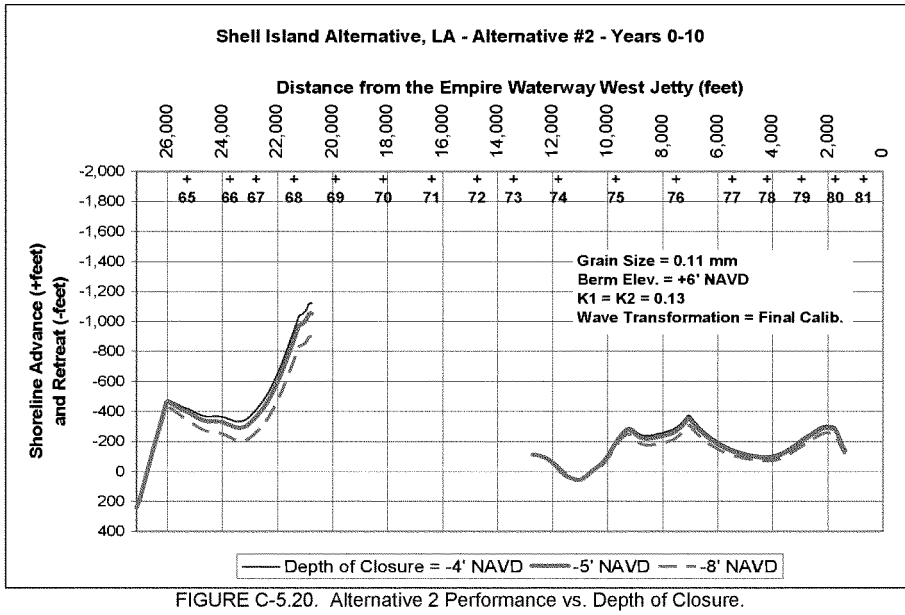



FIGURE C-5.20. Alternative 2 Performance vs. Depth of Closure.

The fourth parameter examined by the Alternative 2 sensitivity analysis was the sediment transport coefficient K1 (Figure C-5.21). To examine the sensitivity of the model to K1, two additional simulations were conducted using K1 = K2 = 0.06 and K1 = K2 = 0.28. The other model inputs were identical to those of the final calibration. Decreasing the values of K1 and K2 by 54 percent lowered the erosion rates by 39 percent on the eastern island and 46 percent on the western island. Increasing the values of K1 and K2 by a factor of 2.15 raised the erosion rates by 68 percent on the eastern island and 88 percent on the western island. In general, changes to the erosion rates did not match the ratios to the original K1 and K2 value of 0.13. The shoreline positions resulting from the altered erosion rates modified the sediment transport, thereby reducing the effect of a larger or smaller value of K1 and K2.

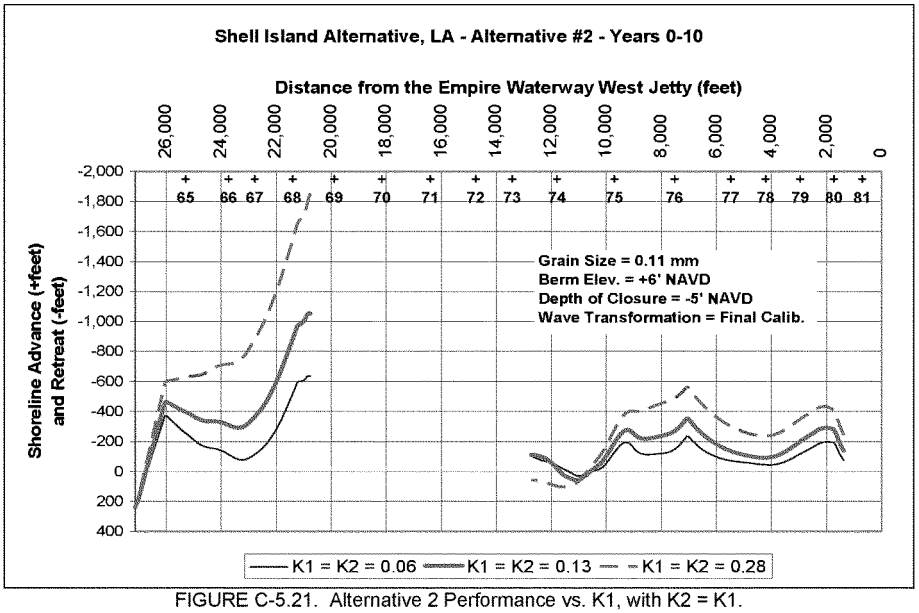



FIGURE C-5.21. Alternative 2 Performance vs. K1, with K2 = K1.

The fifth parameter examined by the Alternative 2 sensitivity analysis was the sediment transport coefficient K2 (Figures C-5.22 and C-5.23). To examine the sensitivity of the model to K2, an additional simulation was conducted using K2 = 0 with K1 = 0.13. The other model inputs were identical to those of the final calibration. In most locations, changing the value of K2 to zero had little impact on the model's results. However, near Lines 73, 74, and 75, the erosion rates differed substantially from those estimated using K2 = K1. Due to the steep angle between the shoreline and the GENESIS baseline, the model was unable to properly calculate the sediment transport without a high K2 value. Setting K2 equal to K1 stabilized the sediment transport calculation, providing a more realistic shoreline position near Lines 73, 74, and 75.

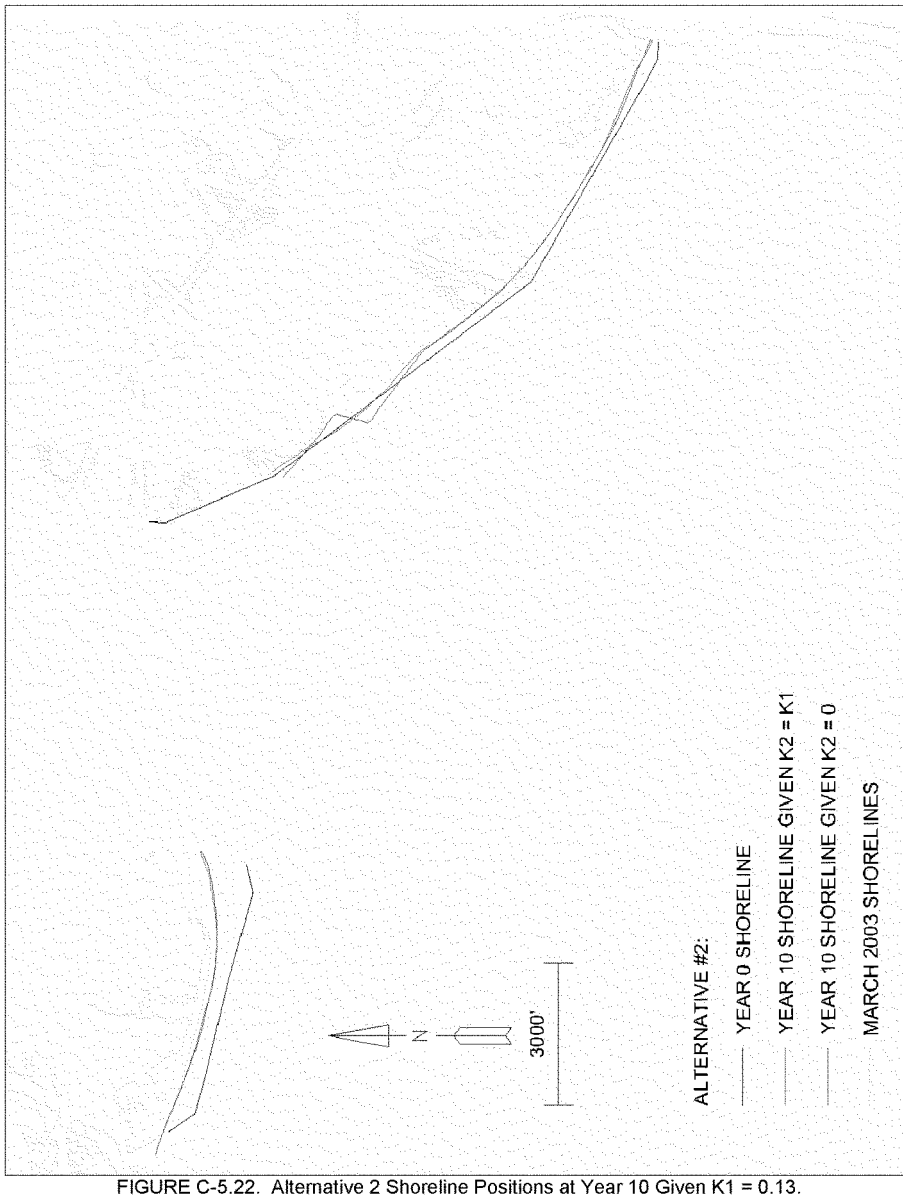



FIGURE C-5.22. Alternative 2 Shoreline Positions at Year 10 Given K1 = 0.13.

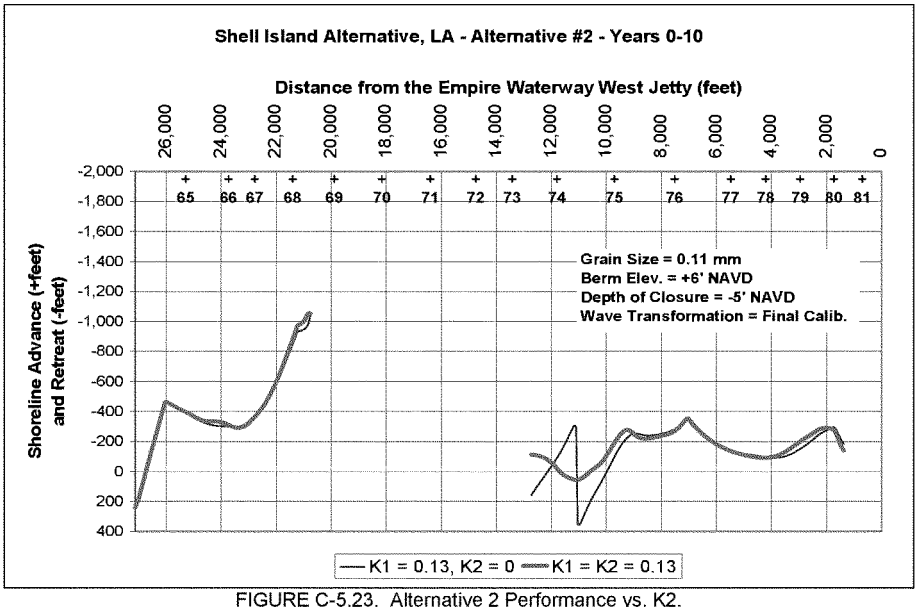



FIGURE C-5.23. Alternative 2 Performance vs. K2.

The final parameter examined by the Alternative 2 sensitivity analysis was the wave transformation pattern (Figures C-5.24). To examine the sensitivity of this input, an additional simulation was conducted using original refraction coefficients from STWAVE. The other model inputs were identical to those of the final calibration. Switching to the STWAVE refraction coefficients decreased the erosion rates by 15 percent on the eastern island and increased them by 14 percent on the western island. In most locations, the erosion patterns were credible. However, at Lines 73-76, the shoreline orientation induced a breakdown in the sediment transport estimate, in a manner similar to Figure C-5.22. The modified refraction coefficients stabilized the sediment transport calculation, providing a more realistic shoreline position at Lines 73-76.

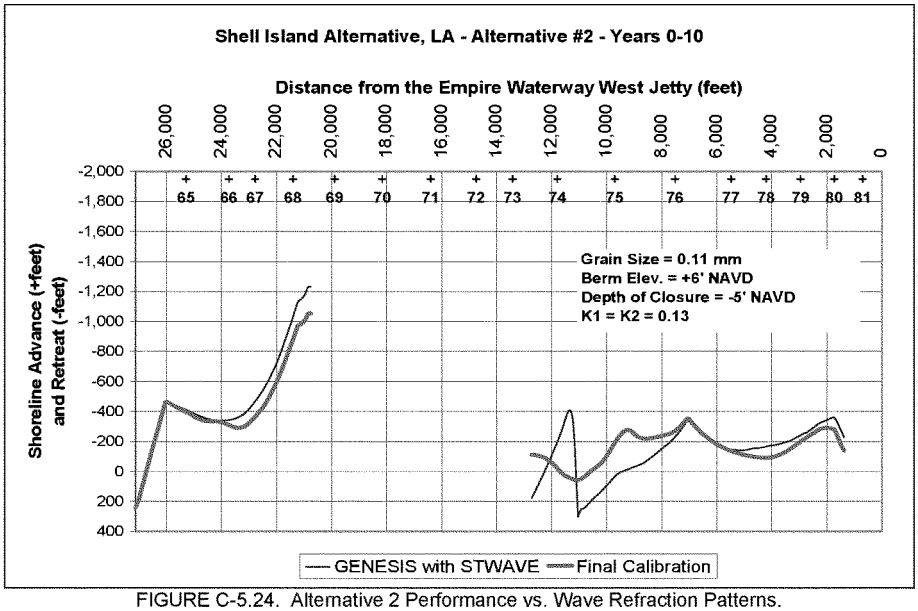



FIGURE C-5.24. Alternative 2 Performance vs. Wave Refraction Patterns.

### C-5.7.3 Alternative 3

The first parameter examined by the Alternative 3 sensitivity analysis was grain size (Figure C-5.25). To examine the sensitivity of the model to grain size, two additional simulations were conducted using grain sizes of 0.06 and 0.28 mm. The other model inputs were identical to those of the final calibration. Reducing the grain size to 0.06 mm raised the erosion rates by 8 percent on the eastern third of the island. Increasing the grain size to 0.28 mm lowered the erosion rates by 4 percent on the eastern third of the island. Elsewhere, changing the grain size had only a minor impact on the erosion or accretion rates.

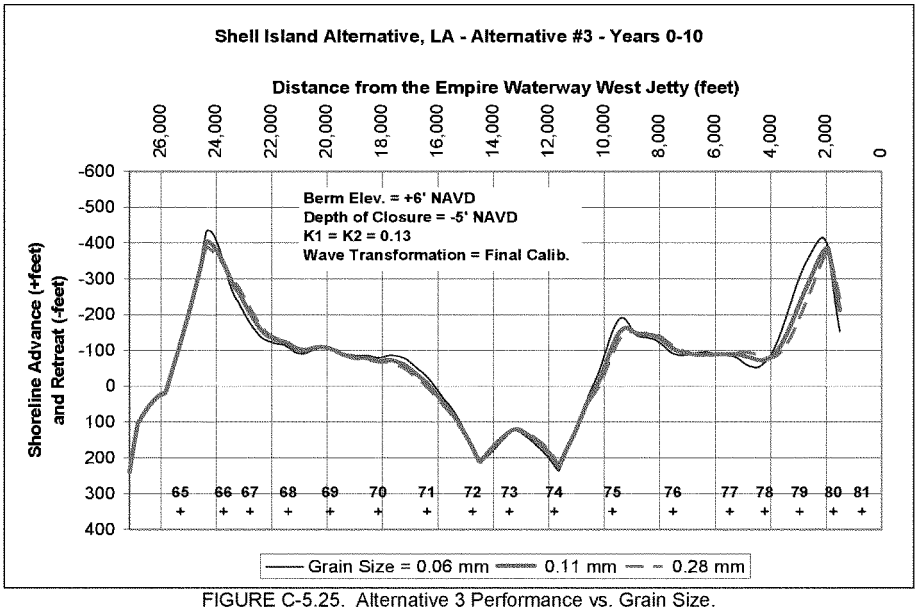



FIGURE C-5.25. Alternative 3 Performance vs. Grain Size.

The second parameter examined by the Alternative 3 sensitivity analysis was the berm elevation (Figure C-5.26). To examine the sensitivity of the model to berm elevation, an additional simulation was conducted using a berm elevation of +0.7' NAVD. The other model inputs were identical to those of the final calibration. Lowering the berm elevation to +0.7' NAVD increased the erosion rates by 47 percent on the eastern third of the island and 43 percent on the western third. In the center of the island, the accretion rate increased by 84 percent. Similar to the Alternative 2 analysis, changes to the accretion and erosion rates were substantial, but less than the ratio between the larger and smaller active profile height. This finding was most applicable in the eroding areas.

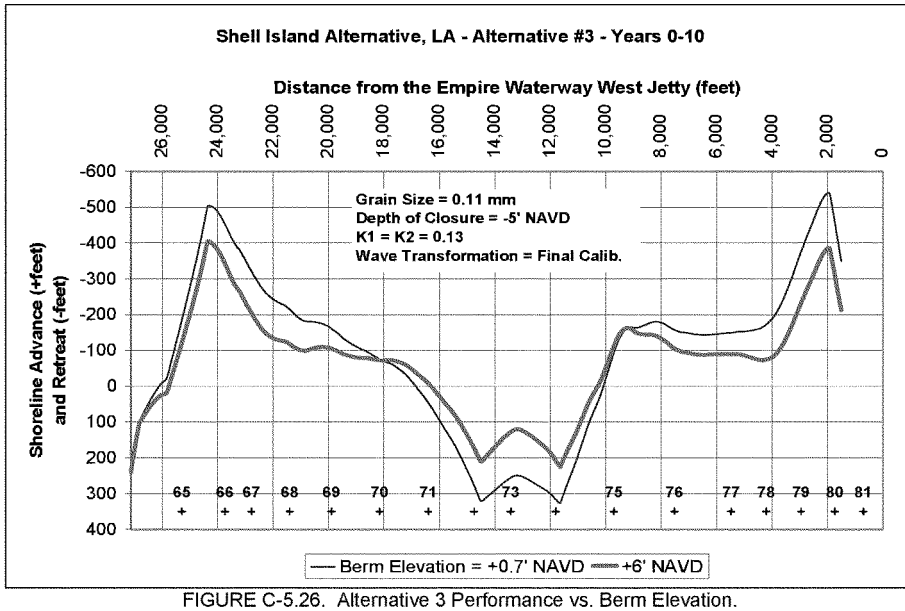



FIGURE C-5.26. Alternative 3 Performance vs. Berm Elevation.

The third parameter examined by the Alternative 3 sensitivity analysis was the depth of closure (Figure C-5.27). To examine the sensitivity of the model to the depth of closure, two additional simulations were conducted using values of -4 and -8 feet NAVD. The other model inputs were identical to those of the final calibration. Raising the depth of closure to -4 feet NAVD increased the erosion rates 6 percent on the eastern third of the island and 5 percent on the western third. In the center of the island, the accretion rate increased 11 percent. Lowering the depth of closure to -8 feet NAVD decreased the erosion rates by 13 percent on the eastern and western thirds of the island. In the center of the island, the accretion rate decreased 24 percent. In the accreting areas, changes to the accretion rate were similar to the various ratios between the active profile heights. In the eroding areas, they tended to be smaller.

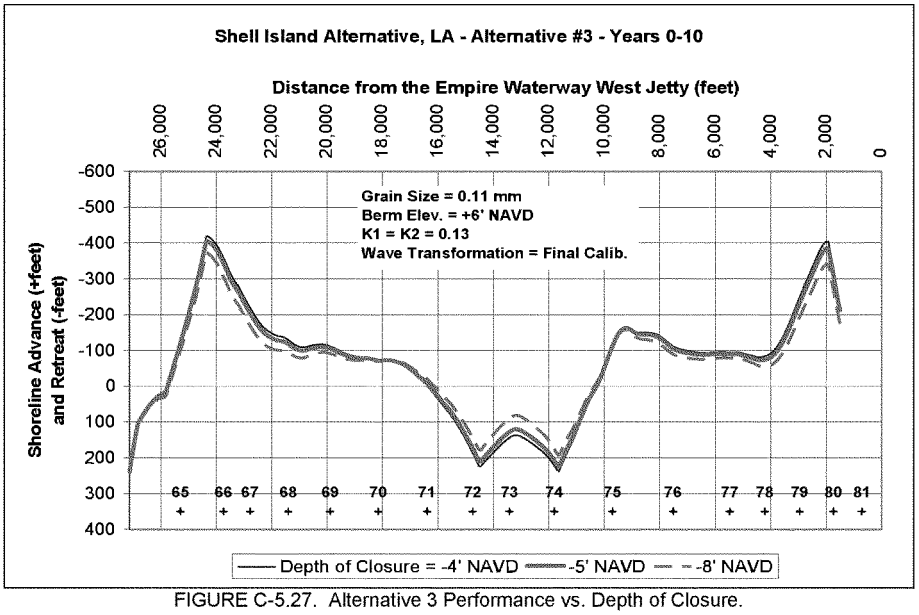



FIGURE C-5.27. Alternative 3 Performance vs. Depth of Closure.

The fourth parameter examined by the Alternative 3 sensitivity analysis was the sediment transport coefficient K1 (Figure C-5.28). To examine the sensitivity of the model to K1, two additional simulations were conducted using K1 = K2 = 0.06 and K1 = K2 = 0.28. The other model inputs were identical to those of the final calibration. Decreasing the values of K1 and K2 by 54 percent lowered the erosion rates by 33 to 34 percent on the eastern and western thirds of the island. In the middle section, the accretion rate decreased by 64 percent. Increasing the values of K1 and K2 by a factor of 2.15 raised the erosion rates by 58 percent on the eastern third of the island and 51 percent on the western third. In the middle section, the accretion rate doubled. In the accreting areas, changes to the accretion rate were similar to the various ratios between the K1 values. However, in the eroding areas, they tended to be smaller. This finding was similar to the berm and depth of closure result.

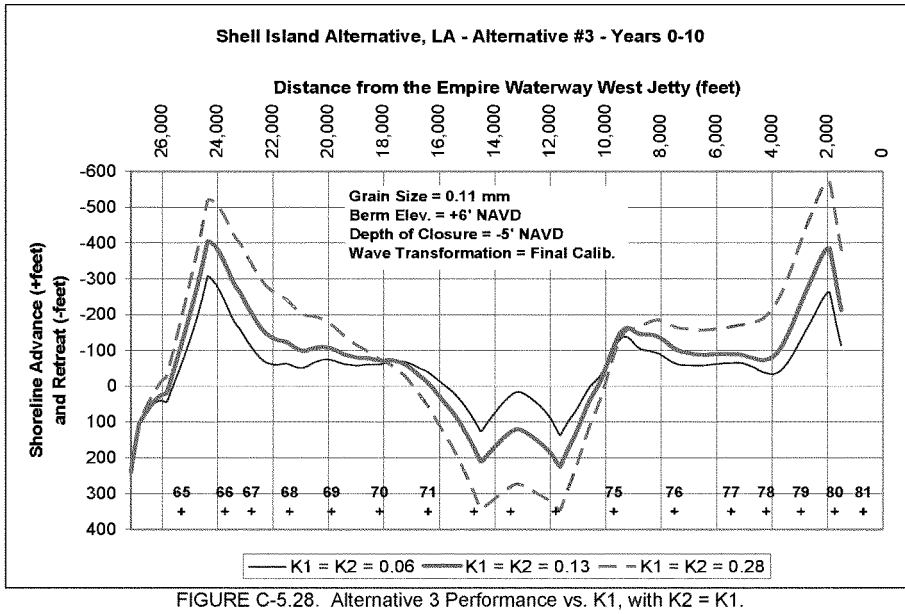



FIGURE C-5.28. Alternative 3 Performance vs. K1, with K2 = K1.

The fifth parameter examined by the Alternative 3 sensitivity analysis was the sediment transport coefficient K2 (Figure C-5.29). To examine the sensitivity of the model to K2, an additional simulations was conducted using K2 = 0 with K1 = 0.13. The other model inputs were identical to those of the final calibration. Setting K2 equal to zero lowered the erosion rates by 6 percent on the eastern third of the island. Elsewhere, changing the K2 value had only a minor impact on the erosion or accretion rates. The differences between the orientations of the shoreline and the model baseline were considerably smaller than Alternative 2. This allowed a valid sediment transport estimate at all locations given a K2 value of zero.

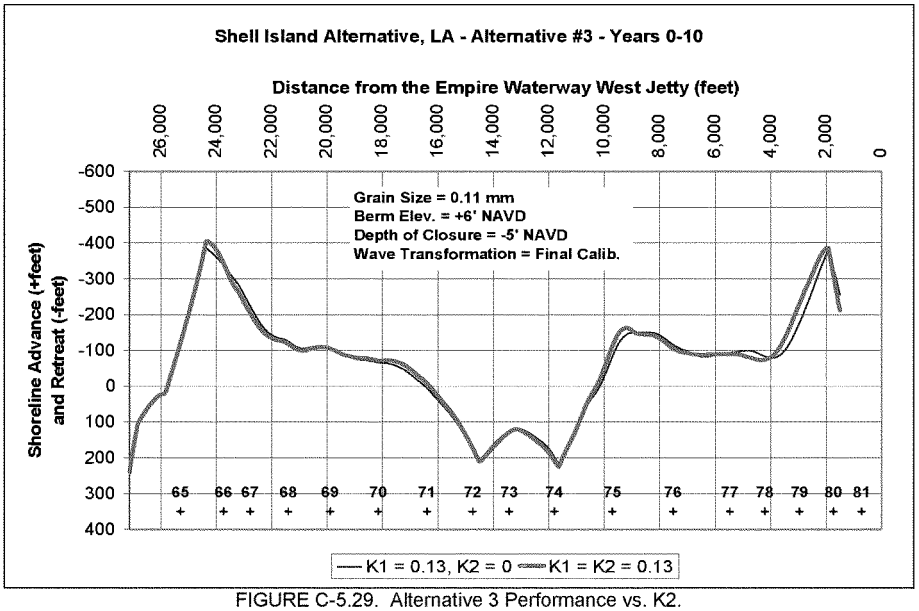



FIGURE C-5.29. Alternative 3 Performance vs. K2.

The final parameter examined by the Alternative 3 sensitivity analysis was the wave transformation pattern (Figures C-5.30). To examine the sensitivity of this input, an additional simulation was conducted using original refraction coefficients from STWAVE. The other model inputs were identical to those of the final calibration. Switching to the STWAVE refraction coefficients decreased the erosion rates by 34 percent on the eastern third of the island, and increased them by 5 percent on the western third. In the middle of the island, the accretion rate increased by 49 percent. Similar to the K2 analysis, differences between the orientations of the shoreline and the model baseline were small enough to allow a valid sediment transport estimate at all locations. However, the stable shoreline at Lines 75-77 was contrary to the observed erosion between 1956 and 1988 (see main text). As shown in Figure C-5.2, running GENESIS with STWAVE produced a relatively uniform sand transport rate between Lines 75 and 77. On the other hand, the sediment budget produced variable transport rate in this area, increasing from east to west. In summary, the results in Figure C-5.30 confirmed that it was necessary to modify the refraction coefficients in order to achieve a realistic erosion projection for the single-island Alternatives 3-8.

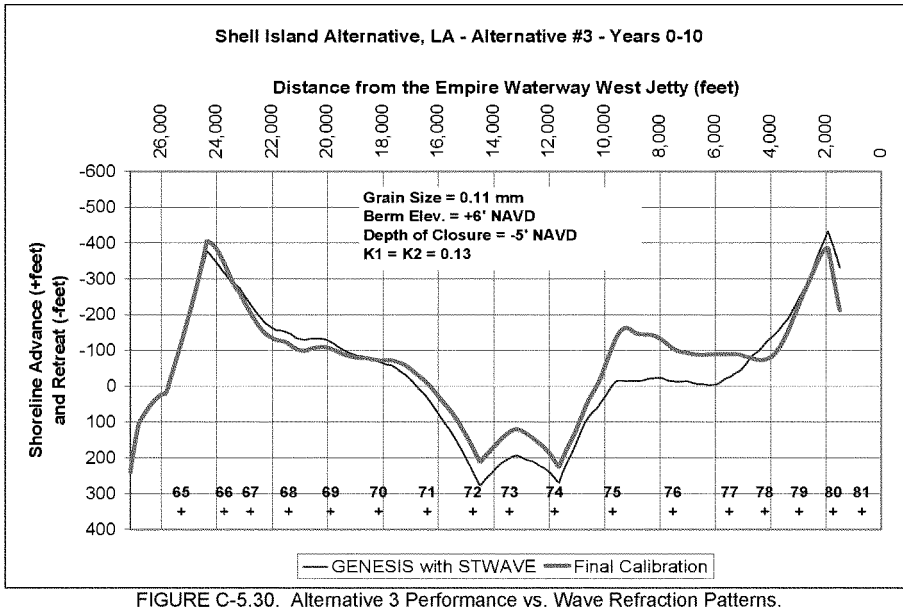



FIGURE C-5.30. Alternative 3 Performance vs. Wave Refraction Patterns.

### C-5.7.4 Summary of Sensitivity Analysis

The GENESIS sensitivity analysis provides useful information regarding the stability of the model and the reliability of its results. For the two island simulations (Alternatives 1-2) to remain stable, it is necessary to use a high K2 value (i.e. K2 = K1) and the modified wave refraction pattern. The single island simulations (Alternatives 3-8) will remain stable for any reasonable combination of the model inputs. However, they also require the modified wave refraction pattern to provide realistic erosion values along Shell Island. The model inputs with the most influence on the results are the K1 values, the berm elevation, the depth of closure, and the wave refraction pattern. The influence of grain size on the model results is minor, and has less of an effect in the 0.11 to 0.28 mm range. For the two island alternatives, the uncertainty limit based on the sensitivity analysis is 35 percent on the eastern island and 42 percent on the western island (Table C-5.7). For the single island alternatives, the uncertainty limit based on the sensitivity analysis is 41 percent on the eastern third of the island, 52 percent in the middle, and 38 percent in the western third (Table C-5.8).

Table C.5.7
Alternative 2 GENESIS Model Sensitivity Analysis

| Modified Model Inputs | Average Shoreline Change (feet), Years 0 to 10 | |
|---|---|---|
| | East Island Project Area | West Island Project Area |
| **Final Calibration (see below)** | **-161** | **-476** |
| Grain Size = 0.06 mm | -166 | -524 |
| Grain Size = 0.28 mm | -141 | -464 |
| Berm Elevation = +0.7' NAVD | -233 | -816 |
| Depth of Closure = -4' NAVD | -172 | -515 |
| Depth of Closure = -8' NAVD | -136 | -391 |
| K1 = K2 = 0.06 | -98 | -256 |
| K1 = K2 = 0.28 | -269 | -893 |
| K2 = 0 | Unstable | -463 |
| STWAVE Refraction Coefficients | Unstable | -543 |
| RMS Difference from Final Calibration | 56 | 198 |
| | 35% | 42% |
| Shoreline Length (feet) | 11,400 | 5,820 |

| Final Calibration Parameters: | |
|---|---|
| Grain Size (mm) | 0.11 |
| Depth of Closure (feet NAVD) | -5 |
| Berm Elevation (feet NAVD) | +4 (Existing Conditions)<br>+6 (Design Cross-Section) |
| K1 | 0.13 |
| K2 | 0.13 |
| Wave Refraction Coefficients | Modified |

Table C.5.8
Alternative 3 GENESIS Model Sensitivity Analysis

| Modified Model Inputs | Average Shoreline Change (feet), Years 0 to 10 | | |
|---|---|---|---|
| | Eastern Section (65-70) | Middle Section (71-74) | Western Section (75-81) |
| **Final Calibration (see below)** | **-133** | **112** | **-161** |
| Grain Size = 0.06 mm | -144 | 112 | -160 |
| Grain Size = 0.28 mm | -128 | 113 | -161 |
| Berm Elevation = +0.7' NAVD | -197 | 207 | -231 |
| Depth of Closure = -4' NAVD | -141 | 124 | -170 |
| Depth of Closure = -8' NAVD | -117 | 85 | -141 |
| K1 = K2 = 0.06 | -89 | 40 | -106 |
| K1 = K2 = 0.28 | -211 | 226 | -244 |
| K2 = 0 | -126 | 113 | -162 |
| STWAVE Refraction Coefficients | -88 | 167 | -168 |
| RMS Difference from Final Calibration | 54 | 58 | 62 |
| | 41% | 52% | 38% |
| Shoreline Length (feet) | 9,300 | 6,480 | 7,560 |

| Final Calibration Parameters: | | |
|---|---|---|
| | Grain Size (mm) | 0.11 |
| | Depth of Closure (feet NAVD) | -5 |
| | Berm Elevation (feet NAVD) | +4 (Existing Conditions)<br>+6 (Design Cross-Section) |
| | K1 | 0.13 |
| | K2 | 0.13 |
| | Wave Refraction Coefficients | Modified |

## C-5.8 REFERENCES

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# ANNEX C-6

# RENOURISHMENT OPTIMIZATION COSTS

**Alternative 2 – Renourishment Interval Cost Summaries**

| Renourishment Cycle Length | | | 5 | years |
|---|---|---|---|---|
| Cost estimate used in LRR | Unit cost | Volumes | | |
| | | Design | Annual Loss | |
| | | | TY0-TY35 | TY35-TY50 |
| Mob/demob | $7,600,000 | | | |
| Sand | $20.16 | 4,310,800 | 163,300 | 72,700 |
| Marsh | $5.92 | 1,615,700 | 36,600 | 35,000 |
| Interest rate | 5.750% | | | |
| Contingency | 20% | | | |
| | | | | |
| Monthly dredge volume | 300000 | | | |

| Item | Year of Project | Borrow Area | Unit | Quantity | Unit cost | 2009 | 2014 | 2019 | 2024 | 2029 | 2034 | 2039 | 2044 | 2049 | 2054 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mobilization | | | Lump Sum | 1 | $7,600,000 | $7,600 | $6,000 | $6,000 | $6,000 | $7,600 | $6,000 | $6,000 | $6,000 | $7,600 | $6,000 |
| Other construction | 2009 | | Lump Sum | 1 | $3,874,228 | $3,874 | $3,874 | $3,874 | $3,874 | $3,874 | $3,874 | $3,874 | $3,874 | $3,874 | $3,874 |
| Beach Fill (Design) | 2009 | Riverine | C.Y. | 2,858,655 | $20.16 | $57,630 | | | | | | | | | |
| Beach Fill (Advanced) | 2009 | Riverine | C.Y. | 816,500 | $20.16 | $16,461 | | | | | | | | | |
| Beach Fill | 2014 | Riverine | C.Y. | 816,500 | $20.16 | | $16,461 | | | | | | | | |
| | 2019 | Riverine | C.Y. | 816,500 | $20.16 | | | $16,461 | | | | | | | |
| | 2024 | Riverine | C.Y. | 816,500 | $20.16 | | | | $16,461 | | | | | | |
| | 2029 | Riverine | C.Y. | 816,500 | $20.16 | | | | | $16,461 | | | | | |
| | 2034 | Riverine | C.Y. | 816,500 | $20.16 | | | | | | $16,461 | | | | |
| | 2039 | Riverine | C.Y. | 816,500 | $20.16 | | | | | | | $16,461 | | | |
| | 2044 | Riverine | C.Y. | 363,500 | $20.16 | | | | | | | | $7,328 | | |
| | 2049 | Riverine | C.Y. | 363,500 | $20.16 | | | | | | | | | $7,328 | |
| | 2054 | Riverine | C.Y. | 363,500 | $20.16 | | | | | | | | | | $7,328 |
| Marsh Fill | 2009 | Offshore | C.Y. | 1,615,700 | $5.92 | $9,565 | | | | | | | | | |
| | 2029 | Offshore | C.Y. | 2,928,000 | $5.92 | | | | | $17,334 | | | | | |
| | 2049 | Offshore | C.Y. | 366,000 | $5.92 | | | | | | | | | $2,167 | |
| Subtotal | | | | | | $95,130 | $26,335 | $26,335 | $26,335 | $45,269 | $26,335 | $26,335 | $17,202 | $20,969 | $17,202 |
| Contingency (20%) | | | | | | $19,026 | $5,267 | $5,267 | $5,267 | $9,054 | $5,267 | $5,267 | $3,440 | $4,194 | $3,440 |
| Contract Cost | | | | | | $114,156 | $31,602 | $31,602 | $31,602 | $54,323 | $31,602 | $31,602 | $20,642 | $25,163 | $20,642 |
| E&D + S&A (10%) | | | | | | $11,416 | $3,160 | $3,160 | $3,160 | $5,432 | $3,160 | $3,160 | $2,064 | $2,516 | $2,064 |
| **Total Construction Cost** | | | | | | **$125,572** | **$34,762** | **$34,762** | **$34,762** | **$59,755** | **$34,762** | **$34,762** | **$22,706** | **$27,679** | **$22,706** |

**Summary-Investment and Annual Costs for 5-year Renourishment Cycle**

| Item | Year of Renourishment Project (amount in $1,000's) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2009 | 2014 | 2019 | 2024 | 2029 | 2034 | 2039 | 2044 | 2049 | 2054 |
| Construction Cost | $125,572 | $34,762 | $34,762 | $34,762 | $59,755 | $34,762 | $34,762 | $22,706 | $27,679 | $22,706 |
| Interest During Construction | $8,646 | $ | $ | $ | $ | $ | $ | $ | $ | $ |
| Total Investment Cost | $134,218 | $34,762 | $34,762 | $34,762 | $59,755 | $34,762 | $34,762 | $22,706 | $27,679 | $22,706 |
| Present Worth of Each Construction | $134,218 | $26,285 | $19,875 | $15,028 | $19,533 | $8,592 | $6,497 | $3,209 | $2,958 | $1,835 |
| **Total Present Worth** | **$238,028** | | | | | | | | | |

| Renourishment Cycle Length | | 10 | years |
|---|---|---|---|
| **Cost estimate used in LRR** | **Unit cost** | **Volumes** | |
| | | **Design** | **Annual Loss** |
| Mob/demob | $7,600,000 | | **TY0-TY35** **TY35-TY50** |
| Sand | $20.16 | 2,677,800 | 163,300 72,700 |
| Marsh | $5.92 | 1,615,700 | 35,000 35,000 |
| Interest rate | 5.750% | | |
| Contingency | 20% | | |
| Monthly dredge volume | 300000 | | |

| Item | Year of Project | Borrow Area | Unit | Quantity | Unit cost | Year of Renourishment Project (amount in $1,000's) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 2009 | 2019 | 2029 | 2039 | 2049 |
| Mobilization | | | Lump Sum | 1 | $7,600,000 | $7,600 | $6,000 | $7,600 | $6,000 | $7,600 |
| Other construction | 2009 | | Lump Sum | 1 | $3,874,228 | $3,874 | $3,874 | $3,874 | $3,874 | $3,874 |
| Beach Fill (Design) | 2009 | Riverine | C.Y. | 2,677,800 | $20.16 | $53,984 | | | | |
| Beach Fill (Advanced) | 2009 | Riverine | C.Y. | 1,633,000 | $20.16 | $32,921 | | | | |
| Beach Fill | 2019 | Riverine | C.Y. | 1,633,000 | $20.16 | | $32,921 | | | |
| | 2029 | Riverine | C.Y. | 1,633,000 | $20.16 | | | $32,921 | | |
| | 2039 | Riverine | C.Y. | 1,180,000 | $20.16 | | | | $23,789 | |
| | 2049 | Riverine | C.Y. | 727,000 | $20.16 | | | | | $14,656 |
| Marsh Fill | 2009 | Offshore | C.Y. | 1,615,700 | $5.92 | $9,565 | | | | |
| | 2029 | Offshore | C.Y. | 700,000 | $5.92 | | | $4,144 | | |
| | 2049 | Offshore | C.Y. | 350,000 | $5.92 | | | | | $2,072 |
| Subtotal | | | | | | $107,945 | $42,796 | $48,540 | $33,663 | $28,203 |
| Contingency (20%) (25% for LERR) | | | | | | $21,589 | $8,559 | $9,708 | $6,733 | $5,641 |
| Contract Cost | | | | | | $129,534 | $51,355 | $58,248 | $40,396 | $33,844 |
| E&D + S&A (10%) | | | | | | $12,953 | $5,135 | $5,825 | $4,040 | $3,384 |
| **Total Construction Cost** | | | | | | **$142,487** | **$56,490** | **$64,073** | **$44,436** | **$37,228** |

**Summary-Investment and Annual Costs for 10-year Renourishment Cycle**

| Item | Year of Renourishment Project (amount in $1,000's) | | | | |
|---|---|---|---|---|---|
| | 2009 | 2019 | 2029 | 2039 | 2049 |
| Construction Cost | $142,487 | $56,490 | $64,073 | $44,436 | $37,228 |
| Interest During Construction | $6,094 | $ | $ | $ | $ |
| Total Investment Cost | $148,581 | $56,490 | $64,073 | $44,436 | $37,228 |
| Present Worth of Each Construction | $148,581 | $32,297 | $20,944 | $8,305 | $3,978 |
| **Total Present Worth** | **$214,105** | | | | |

| Renourishment Cycle Length | | | 15 | years |
|---|---|---|---|---|
| Cost estimate used in LRR | Unit cost | Volumes | | |
| | | Design | Annual Loss | |
| Mob/demob | $7,600,000 | | TY0-TY35 | TY35-TY50 |
| Sand | $20.16 | 4,310,800 | 163,300 | 72,700 |
| Marsh | $5.92 | 1,615,700 | 35,000 | 35,000 |
| Interest rate | 5.750% | | | |
| Contingency | 20% | | | |
| Monthly dredge volume | 300000 | | | |

| Item | Year of Project | Borrow Area | Unit | Quantity | Unit cost | Year of Renourishment Project (amount in $1,000's) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 2009 | 2024 | 2039 | 2054 |
| Mobilization | | | Lump Sum | 1 | $7,600,000 | $7,600 | $7,600 | $6,000 | $6,000 |
| Other construction | 2009 | | Lump Sum | 1 | $3,874,228 | $3,874 | $3,874 | $3,874 | $3,874 |
| Beach Fill (Design) | 2009 | Riverine | C.Y. | 2,858,655 | $20.16 | $57,630 | | | |
| Beach Fill (Advanced) | 2009 | Riverine | C.Y. | 2,449,500 | $20.16 | $49,382 | | | |
| Beach Fill | 2024 | Riverine | C.Y. | 2,449,500 | $20.16 | | $49,382 | | |
| | 2039 | Riverine | C.Y. | 727,075 | $20.16 | | | $14,658 | |
| | 2054 | Riverine | C.Y. | 363,500 | $20.16 | | | | $7,328 |
| Marsh Fill | 2009 | Offshore | C.Y. | 1,615,700 | $5.92 | $9,565 | | | |
| | 2024 | Offshore | C.Y. | 1,050,000 | $5.92 | | $6,216 | | |
| | 2054 | Offshore | C.Y. | 105,000 | $5.92 | | | | $622 |
| Subtotal | | | | | | $128,052 | $67,072 | $24,532 | $17,824 |
| Contingency (20%) (25% for LERR) | | | | | | $25,610 | $13,414 | $4,906 | $3,565 |
| Contract Cost | | | | | | $153,662 | $80,486 | $29,438 | $21,389 |
| E&D + S&A (10%) | | | | | | $15,366 | $8,049 | $2,944 | $2,139 |
| **Total Construction Cost** | | | | | | **$169,028** | **$88,535** | **$32,382** | **$23,528** |

**Summary-Investment and Annual Costs for 15-year Renourishment Cycle**

| Item | Year of Renourishment Project (amount in $1,000's) | | | |
|---|---|---|---|---|
| | 2009 | 2024 | 2039 | 2054 |
| Construction Cost | $169,028 | $88,535 | $32,382 | $23,528 |
| Interest During Construction | $14,331 | $ | $ | $ |
| Total Investment Cost | $183,358 | $88,535 | $32,382 | $23,528 |
| Present Worth of Each Construction | $183,358 | $38,275 | $6,052 | $1,901 |
| **Total Present Worth** | **$229,586** | | | |

| Renourishment Cycle Length | | | 20 | years |
|---|---|---|---|---|
| Cost estimate used in LRR | Unit cost | Volumes | | |
| | | Design | Annual Loss | |
| Mob/demob | $7,600,000 | | TY0-TY35 | TY35-TY50 |
| Sand | $20.16 | 4,310,800 | 163,300 | 72,700 |
| Marsh | $5.92 | 1,615,700 | 35,000 | 35,000 |
| Interest rate | 5.750% | | | |
| Contingency | 20% | | | |
| Monthly dredge volume | 300000 | | | |

| Item | Year of Project | Borrow Area | Unit | Quantity | Unit cost | Year of Renourishment Project (amount in $1,000's) | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | 2009 | 2029 | 2049 |
| Mobilization | | | Lump Sum | 1 | $7,600,000 | $7,600 | $7,600 | $7,600 |
| Other construction | 2009 | | Lump Sum | 1 | $3,874,228 | $3,874 | $3,874 | $3,874 |
| Beach Fill (Design) | 2009 | Riverine | C.Y. | 2,858,655 | $20.16 | $57,630 | | |
| Beach Fill (Advanced) | 2009 | Riverine | C.Y. | 3,266,000 | $20.16 | $65,843 | | |
| | 2029 | Riverine | C.Y. | 2,813,000 | $20.16 | | $56,710 | |
| | 2049 | Riverine | C.Y. | 727,000 | $20.16 | | | $14,656 |
| Marsh Fill | 2009 | Offshore | C.Y. | 1,615,700 | $5.92 | $9,565 | | |
| | 2029 | Offshore | C.Y. | 700,000 | $5.92 | | $4,144 | |
| | 2049 | Offshore | C.Y. | 350,000 | $5.92 | | | $2,072 |
| Subtotal | | | | | | $144,512 | $72,328 | $28,203 |
| Contingency (20%) (25% for LERR) | | | | | | $28,902 | $14,466 | $5,641 |
| Contract Cost | | | | | | $173,414 | $86,794 | $33,844 |
| E&D + S&A (10%) | | | | | | $17,341 | $8,679 | $3,384 |
| **Total Construction Cost** | | | | | | **$190,755** | **$95,473** | **$37,228** |

**Summary-Investment and Annual Costs for 20-year Renourishment Cycle**

| Item | Year of Renourishment Project (amount in $1,000's) | | |
|---|---|---|---|
| | 2009 | 2029 | 2049 |
| Construction Cost | $190,755 | $95,473 | $37,228 |
| Interest During Construction | $18,661 | $ | $ |
| Total Investment Cost | $209,416 | $95,473 | $37,228 |
| Present Worth of Each Construction | $209,416 | $31,209 | $3,978 |
| **Total Present Worth** | **$244,602** | | |

| Renourishment Cycle Length | | | 25 | years | | | |
|---|---|---|---|---|---|---|---|
| Cost estimate used in LRR | Unit cost | Volumes | | | | | |
| | | Design | Annual Loss | | | | |
| Mob/demob | $7,600,000 | | TY0-TY35 | TY35-TY50 | | | |
| Sand | $20.16 | 4,310,800 | 163,300 | 72,700 | | | |
| Marsh | $5.92 | 1,615,700 | 35,000 | 35,000 | | | |
| Interest rate | 5.750% | | | | | | |
| Contingency | 20% | | | | | | |
| | | | | | | | |
| Monthly dredge volume | 300000 | | | | | | |

| Item | Year of Project | Borrow Area | Unit | Quantity | Unit cost | Year of Renourishment Project (amount in $1,000's) | |
|---|---|---|---|---|---|---|---|
| | | | | | | 2009 | 2034 |
| Mobilization | | | Lump Sum | 1 | $7,600,000 | $7,600 | $7,600 |
| Other construction | 2009 | | Lump Sum | 1 | $3,874,228 | $3,874 | $3,874 |
| Beach Fill (Design) | 2009 | Riverine | C.Y. | 2,858,655 | $20.16 | $57,630 | |
| Beach Fill (Advanced) | 2009 | Riverine | C.Y. | 4,082,500 | $20.16 | $82,303 | |
| | 2034 | Riverine | C.Y. | 2,723,500 | $20.16 | | $54,906 |
| Marsh Fill | 2009 | Offshore | C.Y. | 1,615,700 | $5.92 | $9,565 | |
| | 2034 | Offshore | C.Y. | 875,000 | $5.92 | | $5,180 |
| Subtotal | | | | | | $160,973 | $71,560 |
| Contingency (20%) (25% for LERR) | | | | | | $32,195 | $14,312 |
| Contract Cost | | | | | | $193,168 | $85,872 |
| E&D + S&A (10%) | | | | | | $19,317 | $8,587 |
| **Total Construction Cost** | | | | | | **$212,485** | **$94,459** |

**Summary-Investment and Annual Costs for 25-year Renourishment Cycle**

| Item | Year of Renourishment Project (amount in $1,000's) | |
|---|---|---|
| | 2009 | 2034 |
| Construction Cost | $212,485 | $94,459 |
| Interest During Construction | $23,557 | $ |
| Total Investment Cost | $236,042 | $94,459 |
| Present Worth of Each Construction | $236,042 | $23,347 |
| **Total Present Worth** | **$259,389** | |

**Alternatives 6 –Renourishment Interval Cost Summaries**

| Renourishment Cycle Length | | | 5 | years |
|---|---|---|---|---|
| Cost estimate used in LRR | Unit cost | Volumes | | |
| | | Design | Annual Loss | |
| Mob/demob | $7,600,000 | | | |
| Sand | $20.16 | 4,855,700 | 75,000 | |
| Marsh | $5.92 | 2,138,500 | 45,360 | |
| Interest rate | 5.750% | | | |
| Contingency | 20% | | | |
| Monthly dredge volume | 300000 | | | |

| Item | Year of Project | Borrow Area | Unit | Quantity | Unit cost | 2009 | 2014 | 2019 | 2024 | 2029 | 2034 | 2039 | 2044 | 2049 | 2054 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mobilization | | | Lump Sum | 1 | $7,600,000 | $7,600 | $6,000 | $6,000 | $6,000 | $7,600 | $6,000 | $6,000 | $6,000 | $7,600 | $6,000 |
| Other construction | 2009 | | Lump Sum | 1 | $4,957,800 | $4,958 | $4,958 | $4,958 | $4,958 | $4,958 | $4,958 | $4,958 | $4,958 | $4,958 | $4,958 |
| Beach Fill (Design) | 2009 | Riverine | C.Y. | 4,855,700 | $20.16 | $97,891 | | | | | | | | | |
| Beach Fill (Advanced) | 2009 | Riverine | C.Y. | 375,000 | $20.16 | $7,560 | | | | | | | | | |
| Beach Fill | 2014 | Riverine | C.Y. | 375,000 | $20.16 | | $7,560 | | | | | | | | |
| | 2019 | Riverine | C.Y. | 375,000 | $20.16 | | | $7,560 | | | | | | | |
| | 2024 | Riverine | C.Y. | 375,000 | $20.16 | | | | $7,560 | | | | | | |
| | 2029 | Riverine | C.Y. | 375,000 | $20.16 | | | | | $7,560 | | | | | |
| | 2034 | Riverine | C.Y. | 375,000 | $20.16 | | | | | | $7,560 | | | | |
| | 2039 | Riverine | C.Y. | 375,000 | $20.16 | | | | | | | $7,560 | | | |
| | 2044 | Riverine | C.Y. | 375,000 | $20.16 | | | | | | | | $7,560 | | |
| | 2049 | Riverine | C.Y. | 375,000 | $20.16 | | | | | | | | | $7,560 | |
| | 2054 | Riverine | C.Y. | 375,000 | $20.16 | | | | | | | | | | $7,560 |
| Marsh Fill | 2009 | Offshore | C.Y. | 2,138,500 | $5.92 | $12,660 | | | | | | | | | |
| | 2029 | Offshore | C.Y. | 907,200 | $5.92 | | | | | $5,371 | | | | | |
| | 2049 | Offshore | C.Y. | 643,600 | $5.92 | | | | | | | | | $3,810 | |
| Subtotal | | | | | | $130,669 | $18,518 | $18,518 | $18,518 | $25,488 | $18,518 | $18,518 | $18,518 | $23,928 | $18,518 |
| Contingency (20%) | | | | | | $26,134 | $3,704 | $3,704 | $3,704 | $5,098 | $3,704 | $3,704 | $3,704 | $4,786 | $3,704 |
| Contract Cost | | | | | | $156,803 | $22,222 | $22,222 | $22,222 | $30,586 | $22,222 | $22,222 | $22,222 | $28,714 | $22,222 |
| E&D + S&A (10%) | | | | | | $15,680 | $2,222 | $2,222 | $2,222 | $3,059 | $2,222 | $2,222 | $2,222 | $2,871 | $2,222 |
| **Total Construction Cost** | | | | | | **$172,483** | **$24,444** | **$24,444** | **$24,444** | **$33,645** | **$24,444** | **$24,444** | **$24,444** | **$31,585** | **$24,444** |

**Summary-Investment and Annual Costs for 5-year Renourishment Cycle**

| Item | Year of Renourishment Project (amount in $1,000's) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2009 | 2014 | 2019 | 2024 | 2029 | 2034 | 2039 | 2044 | 2049 | 2054 |
| Construction Cost | $172,483 | $24,444 | $24,444 | $24,444 | $33,645 | $24,444 | $24,444 | $24,444 | $31,585 | $24,444 |
| Interest During Construction | $14,410 | $ | $ | $ | $ | $ | $ | $ | $ | $ |
| Total Investment Cost | $186,893 | $24,444 | $24,444 | $24,444 | $33,645 | $24,444 | $24,444 | $24,444 | $31,585 | $24,444 |
| Present Worth of Each Construction | $186,893 | $18,483 | $13,975 | $10,567 | $10,998 | $6,042 | $4,568 | $3,454 | $3,375 | $1,975 |
| **Total Present Worth** | **$260,331** | | | | | | | | | |

| Renourishment Cycle Length | | | 10 | years |
|---|---|---|---|---|
| Cost estimate used in LRR | Unit cost | Volumes | | |
| | | Design | Annual Loss | |
| Mob/demob | $7,600,000 | | | |
| Sand | $20.16 | 4,855,700 | 75,600 | |
| Marsh | $5.92 | 2,138,500 | 45,360 | |
| Interest rate | 5.750% | | | |
| Contingency | 20% | | | |
| Monthly dredge volume | 300000 | | | |

| Item | Year of Project | Borrow Area | Unit | Quantity | Unit cost | Year of Renourishment Project (amount in $1,000's) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 2009 | 2019 | 2029 | 2039 | 2049 |
| Mobilization | | | Lump Sum | 1 | $7,600,000 | $7,600 | $6,000 | $7,600 | $6,000 | $7,600 |
| Other construction | 2009 | | Lump Sum | 1 | $4,957,800 | $4,958 | $4,958 | $4,958 | $4,958 | $4,958 |
| Beach Fill (Design) | 2009 | Riverine | C.Y. | 4,855,700 | $20.16 | $97,891 | | | | |
| Beach Fill (Advanced) | 2009 | Riverine | C.Y. | 756,000 | $20.16 | $15,241 | | | | |
| Beach Fill | 2019 | Riverine | C.Y. | 756,000 | $20.16 | | $15,241 | | | |
| | 2029 | Riverine | C.Y. | 756,000 | $20.16 | | | $15,241 | | |
| | 2039 | Riverine | C.Y. | 756,000 | $20.16 | | | | $15,241 | |
| | 2049 | Riverine | C.Y. | 756,000 | $20.16 | | | | | $15,241 |
| Marsh Fill | 2009 | Offshore | C.Y. | 2,138,500 | $5.92 | $12,660 | | | | |
| | 2029 | Offshore | C.Y. | 907,200 | $5.92 | | | $5,371 | | |
| | 2049 | Offshore | C.Y. | 643,600 | $5.92 | | | | | $3,810 |
| Subtotal | | | | | | $138,350 | $26,199 | $33,169 | $26,199 | $31,609 |
| Contingency (20%) (25% for LERR) | | | | | | $27,670 | $5,240 | $6,634 | $5,240 | $6,322 |
| Contract Cost | | | | | | $166,020 | $31,439 | $39,803 | $31,439 | $37,931 |
| E&D + S&A (10%) | | | | | | $16,602 | $3,144 | $3,980 | $3,144 | $3,793 |
| **Total Construction Cost** | | | | | | **$182,622** | **$34,583** | **$43,783** | **$34,583** | **$41,724** |

**Summary-Investment and Annual Costs for 10-year Renourishment Cycle**

| Item | Year of Renourishment Project (amount in $1,000's) | | | | |
|---|---|---|---|---|---|
| | 2009 | 2019 | 2029 | 2039 | 2049 |
| Construction Cost | $182,622 | $34,583 | $43,783 | $34,583 | $41,724 |
| Interest During Construction | $16,369 | $ | $ | $ | $ |
| Total Investment Cost | $198,990 | $34,583 | $43,783 | $34,583 | $41,724 |
| Present Worth of Each Construction | $198,990 | $19,772 | $14,312 | $6,463 | $4,458 |
| **Total Present Worth** | **$243,996** | | | | |

| Renourishment Cycle Length | | | 15 | years |
|---|---|---|---|---|
| Cost estimate used in LRR | Unit cost | Volumes | | |
| | | Design | Annual Loss | |
| Mob/demob | $7,600,000 | | | |
| Sand | $20.16 | 4,855,700 | 77,300 | |
| Marsh | $5.92 | 2,138,500 | 45,360 | |
| Interest rate | 5.750% | | | |
| Contingency | 20% | | | |
| Monthly dredge volume | 300000 | | | |

| Item | Year of Project | Borrow Area | Unit | Quantity | Unit cost | Year of Renourishment Project (amount in $1,000's) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 2009 | 2024 | 2039 | 2054 |
| Mobilization | | | Lump Sum | 1 | $7,600,000 | $7,600 | $7,600 | $6,000 | $7,600 |
| Other construction | 2009 | | Lump Sum | 1 | $4,957,800 | $4,958 | $4,958 | $4,958 | $4,958 |
| Beach Fill (Design) | 2009 | Riverine | C.Y. | 4,855,700 | $20.16 | $97,891 | | | |
| Beach Fill (Advanced) | 2009 | Riverine | C.Y. | 1,159,500 | $20.16 | $23,376 | | | |
| Beach Fill | 2024 | Riverine | C.Y. | 1,159,500 | $20.16 | | $23,376 | | |
| | 2039 | Riverine | C.Y. | 1,159,500 | $20.16 | | | $23,376 | |
| | 2054 | Riverine | C.Y. | 386,500 | $20.16 | | | | $7,792 |
| Marsh Fill | 2009 | Offshore | C.Y. | 2,138,500 | $5.92 | $12,660 | | | |
| | 2024 | Offshore | C.Y. | 680,400 | $5.92 | | $4,028 | | |
| | 2054 | Offshore | C.Y. | 965,400 | $5.92 | | | | $5,715 |
| Subtotal | | | | | | $146,484 | $39,961 | $34,333 | $26,065 |
| Contingency (20%) (25% for LERR) | | | | | | $29,297 | $7,992 | $6,867 | $5,213 |
| Contract Cost | | | | | | $175,781 | $47,953 | $41,200 | $31,278 |
| E&D + S&A (10%) | | | | | | $17,578 | $4,795 | $4,120 | $3,128 |
| **Total Construction Cost** | | | | | | **$193,359** | **$52,748** | **$45,320** | **$34,406** |

**Summary-Investment and Annual Costs for 15-year Renourishment Cycle**

| Item | Year of Renourishment Project (amount in $1,000's) | | | |
|---|---|---|---|---|
| | 2009 | 2024 | 2039 | 2054 |
| Construction Cost | $193,359 | $52,748 | $45,320 | $34,406 |
| Interest During Construction | $18,577 | $ | $ | $ |
| Total Investment Cost | $211,936 | $52,748 | $45,320 | $34,406 |
| Present Worth of Each Construction | $211,936 | $22,804 | $8,470 | $2,780 |
| **Total Present Worth** | **$245,990** | | | |

| Renourishment Cycle Length | 20 | years |
|---|---|---|

| Cost estimate used in LRR | Unit cost | Volumes | |
|---|---|---|---|
| | | Design | Annual Loss |
| Mob/demob | $7,600,000 | | |
| Sand | $20.16 | 4,855,700 | 79,000 |
| Marsh | $5.92 | 2,138,500 | 45,360 |
| Interest rate | 5.750% | | |
| Contingency | 20% | | |
| Monthly dredge volume | 300000 | | |

| Item | Year of Project | Borrow Area | Unit | Quantity | Unit cost | Year of Renourishment Project (amount in $1,000's) | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | 2009 | 2029 | 2049 |
| Mobilization | | | Lump Sum | 1 | $7,600,000 | $7,600 | $7,600 | $7,600 |
| Other construction | 2009 | | Lump Sum | 1 | $4,957,800 | $4,958 | $4,958 | $4,958 |
| Beach Fill (Design) | 2009 | Riverine | C.Y. | 4,855,700 | $20.16 | $97,891 | | |
| Beach Fill (Advanced) | 2009 | Riverine | C.Y. | 1,580,000 | $20.16 | $31,853 | | |
| | 2029 | Riverine | C.Y. | 1,580,000 | $20.16 | | $31,853 | |
| | 2049 | Riverine | C.Y. | 790,000 | $20.16 | | | $15,926 |
| Marsh Fill | 2009 | Offshore | C.Y. | 2,138,500 | $5.92 | $12,660 | | |
| | 2029 | Offshore | C.Y. | 907,200 | $5.92 | | $5,371 | |
| | 2049 | Offshore | C.Y. | 643,600 | $5.92 | | | $3,810 |
| Subtotal | | | | | | $154,961 | $49,781 | $32,294 |
| Contingency (20%) (25% for LERR) | | | | | | $30,992 | $9,956 | $6,459 |
| Contract Cost | | | | | | $185,953 | $59,737 | $38,753 |
| E&D + S&A (10%) | | | | | | $18,595 | $5,974 | $3,875 |
| **Total Construction Cost** | | | | | | **$204,548** | **$65,711** | **$42,628** |

**Summary-Investment and Annual Costs for 20-year Renourishment Cycle**

| Item | Year of Renourishment Project (amount in $1,000's) | | |
|---|---|---|---|
| | 2009 | 2029 | 2049 |
| Construction Cost | $204,548 | $65,711 | $42,628 |
| Interest During Construction | $21,026 | $ | $ |
| Total Investment Cost | $225,574 | $65,711 | $42,628 |
| Present Worth of Each Construction | $225,574 | $21,480 | $4,555 |
| **Total Present Worth** | **$251,609** | | |

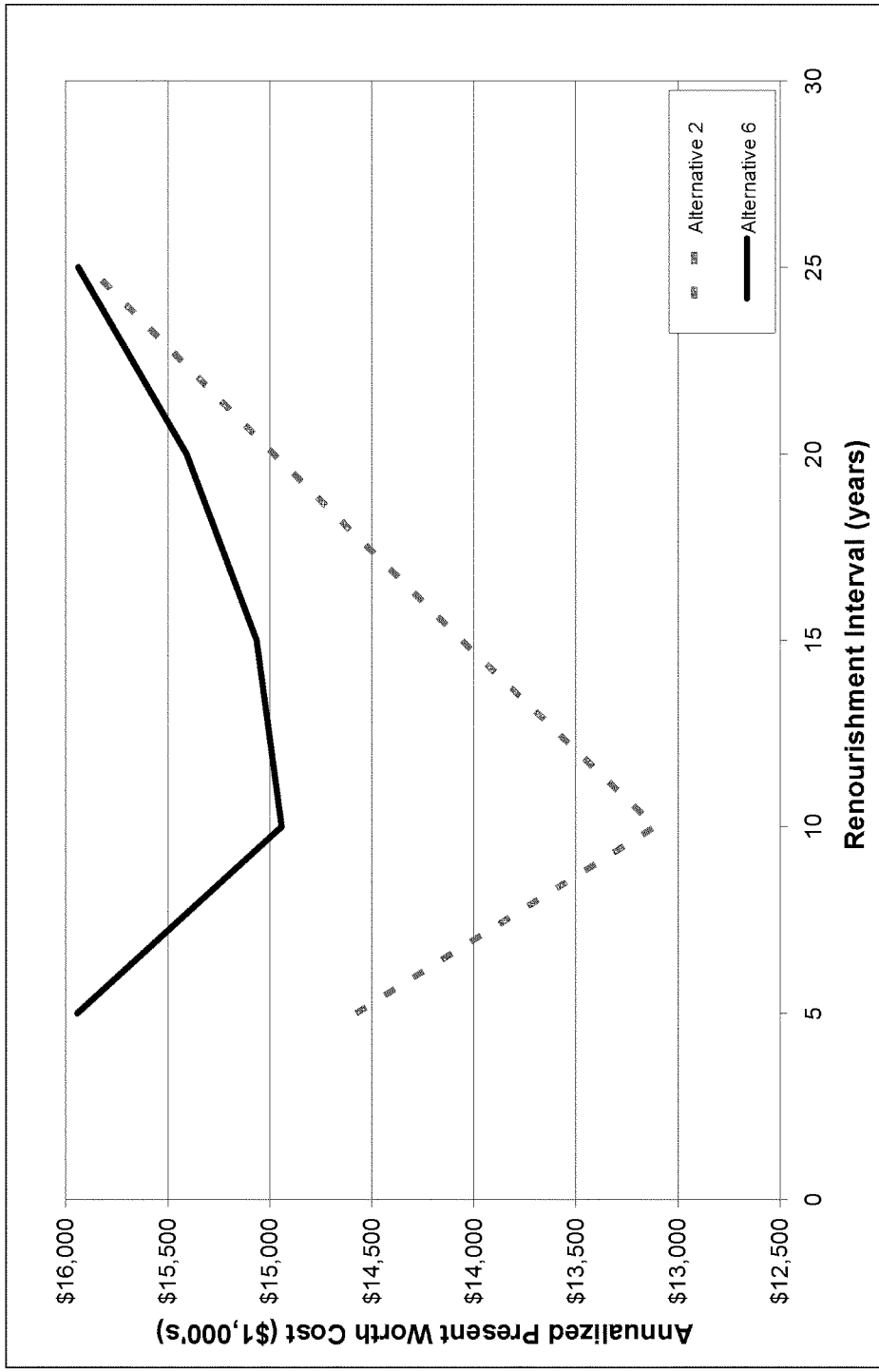
| Renourishment Cycle Length | | | 25 | years |
|---|---|---|---|---|
| Cost estimate used in LRR | Unit cost | Volumes | | |
| | | Design | Annual Loss | |
| Mob/demob | $7,600,000 | | | |
| Sand | $20.16 | 4,855,700 | 81,320 | |
| Marsh | $5.92 | 2,138,500 | 45,360 | |
| Interest rate | 5.750% | | | |
| Contingency | 20% | | | |
| Monthly dredge volume | 300000 | | | |

| Item | Year of Project | Borrow Area | Unit | Quantity | Unit cost | Year of Renourishment Project (amount in $1,000's) | |
|---|---|---|---|---|---|---|---|
| | | | | | | 2009 | 2034 |
| Mobilization | | | Lump Sum | 1 | $7,600,000 | $7,600 | $7,600 |
| Other construction | 2009 | | Lump Sum | 1 | $4,957,800 | $4,958 | $4,958 |
| Beach Fill (Design) | 2009 | Riverine | C.Y. | 4,855,700 | $20.16 | $97,891 | |
| Beach Fill (Advanced) | 2009 | Riverine | C.Y. | 2,033,000 | $20.16 | $40,985 | |
| | 2034 | Riverine | C.Y. | 2,033,000 | $20.16 | | $40,985 |
| Marsh Fill | 2009 | Offshore | C.Y. | 2,138,500 | $5.92 | $12,660 | |
| | 2034 | Offshore | C.Y. | 1,218,900 | $5.92 | | $7,216 |
| Subtotal | | | | | | $164,094 | $60,759 |
| Contingency (20%) (25% for LERR) | | | | | | $32,819 | $12,152 |
| Contract Cost | | | | | | $196,913 | $72,911 |
| E&D + S&A (10%) | | | | | | $19,691 | $7,291 |
| **Total Construction Cost** | | | | | | **$216,604** | **$80,202** |

**Summary-Investment and Annual Costs for 25-year Renourishment Cycle**

| Item | Year of Renourishment Project (amount in $1,000's) | |
|---|---|---|
| | 2009 | 2034 |
| Construction Cost | $216,604 | $80,202 |
| Interest During Construction | $23,832 | $ |
| Total Investment Cost | $240,436 | $80,202 |
| Present Worth of Each Construction | $240,436 | $19,823 |
| **Total Present Worth** | **$260,260** | |

**Renourishment Interval Optimization Cost Chart**


Annualized Present Worth Cost ($1,000's)
$16,000
$15,500
$15,000
$14,500
$14,000
$13,500
$13,000
$12,500
0
5
10
15
20
25
30
Renourishment Interval (years)
Alternative 2
Alternative 6

**Alternative 4 – Renourishment Interval Cost Summary**

**Renourishment Cycle Length** 25 years

| Cost estimate used in LRR | Unit cost | Volumes | |
|---|---|---|---|
| | | Design | Annual Loss |
| Mob/demob | $7,600,000 | | |
| Sand | $20.16 | 4,855,700 | 75,600 |
| Marsh | $5.92 | 2,138,500 | 44,148 |
| Interest rate | 5.750% | | |
| Contingency | 20% | | |
| Monthly dredge volume | 300000 | | |

10 years of advanced fill placed during initial construction

Rebuilding the initial construction template in year 25. Need to add 25 years of advanced fill to account for erosion, not the future nourishment need.

Note: Annual marsh loss is based on an average subsidence rate over 25 years

| Item | Year of Project | Borrow Area | Unit | Quantity | Unit cost | Year of Renourishment Project (amount in $1,000's) | |
|---|---|---|---|---|---|---|---|
| | | | | | | 2009 | 2034 |
| Mobilization | | | Lump Sum | 1 | $7,600,000 | $7,600 | $7,600 |
| Other construction | 2009 | | Lump Sum | 1 | $4,957,800 | $4,958 | $4,958 |
| Beach Fill (Design) | 2009 | Riverine | C.Y. | 4,855,700 | $20.16 | $97,891 | |
| Beach Fill (Advanced) | 2009 | Riverine | C.Y. | 756,000 | $20.16 | $15,241 | |
| Beach Fill | 2034 | Riverine | C.Y. | 1,890,000 | $20.16 | | $38,102 |
| Marsh Fill | 2009 | Offshore | C.Y. | 2,138,500 | $5.92 | $12,660 | |
| | 2034 | Offshore | C.Y. | 1,103,700 | $5.92 | | $6,534 |
| Subtotal | | | | | | $138,350 | $57,194 |
| Contingency (20%) (25% for LERR) | | | | | | $27,670 | $11,439 |
| Contract Cost | | | | | | $166,020 | $68,633 |
| E&D + S&A (10%) | | | | | | $16,602 | $6,863 |
| **Total Construction Cost** | | | | | | **$182,622** | **$75,496** |

**Summary-Investment and Annual Costs for 25-year Renourishment Cycle**

| Item | Year of Renourishment Project (amount in $1,000's) | |
|---|---|---|
| | 2009 | 2034 |
| Construction Cost | $182,622 | $75,496 |
| Interest During Construction | $16,369 | |
| Total Investment Cost | $198,990 | $75,496 |
| Present Worth of Each Construction | $198,990 | $18,660 |
| **Total Present Worth** | **$217,650** | |

**Alternative 5 –Renourishment Interval Cost Summary**

**Renourishment Cycle Length** 20 years

| Cost estimate used in LRR | Unit cost | Volumes | |
|---|---|---|---|
| | | Design | Annual Loss |
| Mob/demob | $7,600,000 | | |
| Sand | $20.16 | 4,855,700 | 75,600 |
| Marsh | $5.92 | 2,138,500 | 45,360 |

| | |
|---|---|
| Interest rate | 5.750% |
| Contingency | 20% |
| Monthly dredge volume | 300000 |

10 years of advanced fill placed during initial construction

Rebuilding the initial construction tempalte in year 20. Need to add 20 years of advanced fill to account for erosion, not the future nourishment need.

Note: Annual marsh loss is based on an average subsidence rate over 20 years

| Item | Year of Project | Borrow Area | Unit | Quantity | Unit cost | Year of Renourishment Project (amount in $1,000's) | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | 2009 | 2029 | 2049 |
| Mobilization | | | Lump Sum | 1 | $7,600,000 | $7,600 | $7,600 | $7,600 |
| Other construction | 2009 | | Lump Sum | 1 | $4,957,800 | $4,958 | $4,958 | $4,958 |
| Beach Fill (Design) | 2009 | Riverine | C.Y. | 4,855,700 | $20.16 | $97,891 | | |
| Beach Fill (Advanced) | 2009 | Riverine | C.Y. | 756,000 | $20.16 | $15,241 | | |
| Beach Fill | 2029 | Riverine | C.Y. | 1,512,000 | $20.16 | | $30,482 | |
| | 2049 | Riverine | C.Y. | 1,512,000 | $20.16 | | | $30,482 |
| Marsh Fill | 2009 | Offshore | C.Y. | 2,138,500 | $5.92 | $12,660 | | |
| | 2029 | Offshore | C.Y. | 907,200 | $5.92 | | $5,371 | |
| | 2049 | Offshore | C.Y. | 643,600 | $5.92 | | | $3,810 |
| Subtotal | | | | | | $138,350 | $48,410 | $46,850 |
| Contingency (20%) (25% for LERR) | | | | | | $27,670 | $9,682 | $9,370 |
| Contract Cost | | | | | | $166,020 | $58,092 | $56,220 |
| E&D + S&A (10%) | | | | | | $16,602 | $5,809 | $5,622 |
| **Total Construction Cost** | | | | | | **$182,622** | **$63,901** | **$61,842** |

**Summary-Investment and Annual Costs for 20-year Renourishment Cycle**

| Item | Year of Renourishment Project (amount in $1,000's) | | |
|---|---|---|---|
| | 2009 | 2029 | 2049 |
| Construction Cost | $182,622 | $63,901 | $61,842 |
| Interest During Construction | $16,369 | $ | $ |
| Total Investment Cost | $198,990 | $63,901 | $61,842 |
| Present Worth of Each Construction | $198,990 | $20,888 | $6,608 |
| **Total Present Worth** | **$226,486** | | |

**Alternative 7 –Renourishment Interval Cost Summary**

**Renourishment Cycle Length** 20 years

| Cost estimate used in LRR | Unit cost | Volumes | |
|---|---|---|---|
| | | Design | Annual Loss |
| Mob/demob | $7,600,000 | | |
| Sand | $20.16 | 4,855,700 | 79,000 |
| Marsh | $5.92 | 2,138,500 | 45,360 |

| | |
|---|---|
| Interest rate | 5.750% |
| Contingency | 20% |
| Monthly dredge volume | 300000 |

20 years of advanced fill placed during intitial construction

Rebuilding the initial construction tempalte in year 20. Need to add 20 years of advanced fill to account for erosion, not the future nourishment need.

Note: Annual marsh loss is based on an average subsidence rate over 20 years

| Item | Year of Project | Borrow Area | Unit | Quantity | Unit cost | Year of Renourishment Project (amount in $1,000's) | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | 2009 | 2029 | 2049 |
| Mobilization | | | Lump Sum | 1 | $7,600,000 | $7,600 | $7,600 | $7,600 |
| Other construction | 2009 | | Lump Sum | 1 | $4,957,800 | $4,958 | $4,958 | $4,958 |
| Beach Fill (Design) | 2009 | Riverine | C.Y. | 4,855,700 | $20.16 | $97,891 | | |
| Beach Fill (Advanced) | 2009 | Riverine | C.Y. | 1,580,000 | $20.16 | $31,853 | | |
| Beach Fill | 2029 | Riverine | C.Y. | 1,580,000 | $20.16 | | $31,853 | |
| | 2049 | Riverine | C.Y. | 790,000 | $20.16 | | | $15,926 |
| Marsh Fill | 2009 | Offshore | C.Y. | 2,138,500 | $5.92 | $12,660 | | |
| | 2029 | Offshore | C.Y. | 907,200 | $5.92 | | $5,371 | |
| | 2049 | Offshore | C.Y. | 643,600 | $5.92 | | | $3,810 |
| Subtotal | | | | | | $154,961 | $49,781 | $32,294 |
| Contingency (20%) (25% for LERR) | | | | | | $30,992 | $9,956 | $6,459 |
| Contract Cost | | | | | | $185,953 | $59,737 | $38,753 |
| E&D + S&A (10%) | | | | | | $18,595 | $5,974 | $3,875 |
| **Total Construction Cost** | | | | | | **$204,548** | **$65,711** | **$42,628** |

**Summary-Investment and Annual Costs for 20-year Renourishment Cycle**

| Item | Year of Renourishment Project (amount in $1,000's) | | |
|---|---|---|---|
| | 2009 | 2029 | 2049 |
| Construction Cost | $204,548 | $65,711 | $42,628 |
| Interest During Construction | $21,026 | $ | $ |
| Total Investment Cost | $225,574 | $65,711 | $42,628 |
| Present Worth of Each Construction | $225,574 | $21,480 | $4,555 |
| **Total Present Worth** | **$251,609** | | |

**Alternative 8 –Renourishment Interval Cost Summary**

**Renourishment Cycle Length** 25 years

| Cost estimate used in LRR | Unit cost | Volumes | |
|---|---|---|---|
| | | Design | Annual Loss |
| Mob/demob | $7,600,000 | | |
| Sand | $20.16 | 4,855,700 | 81,320 |
| Marsh | $5.92 | 2,138,500 | 44,148 |
| Interest rate | 5.750% | | |
| Contingency | 20% | | |
| Monthly dredge volume | 300000 | | |

25 years of advanced fill placed during intitial construction

Rebuilding the initial construction tempalte in year 25. Need to add 25 years of advanced fill to account for erosion, not the future nourishment need.

Note: Annual marsh loss is based on an average subsidence rate over 25 years

| Item | Year of Project | Borrow Area | Unit | Quantity | Unit cost | Year of Renourishment Project (amount in $1,000's) | |
|---|---|---|---|---|---|---|---|
| | | | | | | 2009 | 2034 |
| Mobilization | | | Lump Sum | 1 | $7,600,000 | $7,600 | $7,600 |
| Other construction | 2009 | | Lump Sum | 1 | $4,957,800 | $4,958 | $4,958 |
| Beach Fill (Design) | 2009 | Riverine | C.Y. | 4,855,700 | $20.16 | $97,891 | |
| Beach Fill (Advanced) | 2009 | Riverine | C.Y. | 2,033,000 | $20.16 | $40,985 | |
| Beach Fill | 2034 | Riverine | C.Y. | 2,033,000 | $20.16 | | $40,985 |
| Marsh Fill | 2009 | Offshore | C.Y. | 2,138,500 | $5.92 | $12,660 | |
| | 2034 | Offshore | C.Y. | 1,103,700 | $5.92 | | $6,534 |
| Subtotal | | | | | | $164,094 | $60,077 |
| Contingency (20%) (25% for LERR) | | | | | | $32,819 | $12,015 |
| Contract Cost | | | | | | $196,913 | $72,092 |
| E&D + S&A (10%) | | | | | | $19,691 | $7,209 |
| **Total Construction Cost** | | | | | | **$216,604** | **$79,301** |

**Summary-Investment and Annual Costs for 25-year Renourishment Cycle**

| Item | Year of Renourishment Project (amount in $1,000's) | |
|---|---|---|
| | 2009 | 2034 |
| Construction Cost | $216,604 | $79,301 |
| Interest During Construction | $23,832 | |
| Total Investment Cost | $240,436 | $79,301 |
| Present Worth of Each Construction | $240,436 | $19,601 |
| **Total Present Worth** | **$260,037** | |

# ANNEX C-7

# UNIT DREDGE COST ESTIMATES

**Unit Cost to Dredge Marsh Fill From Empire East Borrow Area - $5.92**

| | | | | |
|---|---|---|---|---|
| 419,799 pay c.y. per month | UNIT COST.. | $5.92 | PER C.Y. | Select Dredge |
| 2,152 cy per hour | EXCAV. COST | $11,108,880 | | 30" Cutter-Suction |
| 30" Cutter-Suction Dredge | TIME..... | 4.47 | MONTHS | |

PROJECT TITLES: PG 1 of 11

| | |
|---|---|
| Project Name..... | Shell Island Feasibility Report |
| Project Location..... | Offshore Borrow Area - Empire East |
| Invit. or Contr. No..... | Planning Estimate |
| Date of Estimate..... | April 11, 2008 |
| Estimator..... | Gordon Thomson |
| Checked by..... | |

Ver. 1.0

(Input Project Descriptions on Sheet A) **Goto Sheet A**

Mobilization Bid Item..... 1

Excavation Bid Item..... 2 Goto Area Factors

TYPE OF ESTIMATE PG 2 of 11

Type of Estimate..... 1 Planning Estimate

(1) Planning, (2) Bid, or (3) Mod **Estimate Descriptions**

INDIRECT COSTS:

| | | |
|---|---|---|
| Contractor's Overhead... | 12.8 | Percent of contract |
| Contractor's Profit..... | 10.0 | Percent of contract |
| Contractor's Bond..... | 0.8 | Percent of contract |

ESTIMATED DREDGING QUANTITY: PG 3 of 11

Non-Pay Computation Method: 3

(1) Surface Area, (2) % of Pay O.D., (3) % of Net Pay, (4) % of Gross

BANK HEIGHT: 15.0 FT.

DREDGING PRISM:

| | | | | |
|---|---|---|---|---|
| Required.... | 1,876,500 | C.Y. | | |
| + Pay O.D.... | 0 | C.Y. | | |
| Bid Quantity | 1,876,500 | C.Y. | | |
| - Not Dug.. | 0 | C.Y. | LOSSES: | |
| Net Pay | 1,876,500 | C.Y. | @ | |
| + Non-Pay | 1,595,000 | C.Y. | 85.0 | % of Net Pay |
| Gross Volume | 3,471,500 | C.Y. | 15.0 | FT. BANK HT. |

MATERIAL FACTORS: PG 4 of 11

Additional Information

| DESCRIPTION | FACTOR | PERCENTAGE | |
|---|---|---|---|
| MUD & SILT | 3 | 65 | % |
| MUD & SILT | 2.5 | 0 | % |
| MUD & SILT | 2 | 0 | % |
| LOOSE SAND | 1.1 | 35 | % |
| LOOSE SAND | 1 | 0 | % |
| COMP. SAND | 0.9 | 0 | % |
| STIFF CLAY | 0.6 | 0 | % |
| COMP. SHELL | 0.5 | 0 | % |
| SOFT ROCK | 0.4 | 0 | % |
| BLAST. ROCK | 0.25 | 0 | % |

DIRECT ENTRY FACTOR= 0.00

RESULTANT MATERIAL FACTOR= 1.87

PIPELINE CONSIDERATIONS: PG 5 of 11

MAXIMUM PIPELINE REQUIRED:

| | | |
|---|---|---|
| Floating Pipeline..... | 5,280 | Feet |
| Submerged Pipeline..... | 14,100 | Feet |
| Shore Pipeline..... | 26,000 | Feet |
| Total Pipeline on Job: | 45,380 | Feet |

Ave Pumping Distance.... 32,380 Feet of Pipelin =Floating + Subline + (0.5)Total Shorepip

Pipeline Cost Category..... 1 MUD

(0) Computed from Material Factor,
(1) Mud, (2) Sand, or (3) Rock

Equivalent Pipe..... 0 Feet (Theoretical)

Description.....

Basis of Production: 32,380 Feet (Ave + Equiv)

PRODUCTION ANALYSIS: PG 6 of 11

1 BOOSTER(S) 46,468 L.F. POSSIBLE based on 14200 Tot. H.P.
32,380 Ft Ave Pumping Distance
45,380 L.F. Max. on jobsite

55.0 % X 730 HRS/MO = EWT OF (without Boosters) 402 HRS/MO

Goto HP Adjustments

X 0.90 Booster Factor

49.5 % X 730 HRS/MO = EWT OF (with Boosters) 361 HRS/MO

OTHER PRODUCTION FACTORS: PG 7 of 11

CURRENT DREDGE SELECTED: 30" Cutter-Suction Dredge

Bank Factor for 15.0 ft of Bank ----> 1.10 (From Chart)

Bank Factor Override.... 0 1.10 (Used)

Description..... >

Other Factor..... 0.9

Description..... Navigation issues

Cleanup Dredging..... 2 Percent Additional Time (Cleanup Factor = 0.98)

HISTORICAL PRODUCTION OVERRIDES: PG 8 of 11

(In order to use this screen, Overrides must be entered for all three categories.)

| | Override | Computed | Used |
|---|---|---|---|
| Production (Cy/Hr)..... | 0 | 2152 | 2,152 |
| Operating Time (Hrs/Mo). | 0 | 361 | 361 |
| Number of Boosters..... | 0 | 1 | 1 |

OTHER PRICING ADJUSTMENTS: PG 9 of 11

Other Monthly Costs:

| | | |
|---|---|---|
| 1st Input..... | $50,000 | Per Month |
| Description..... | Shore Equipment & Transport | |
| (For Additional Inputs Go to Sheet D\4) | Goto Sheet D\4 | |

Fixed Costs:

| | | |
|---|---|---|
| 1st Input..... | | Lump Sum |
| Description..... | | |
| (For Additional Inputs Go to Sheet E) | Goto Sheet E | |
| (To Adjust Labor Go To Sheet DB_L) | Goto Sheet DB_L | |
| (To Adjust Equipment Go To Sheet DB_E) | Goto Sheet DB_E | |

**The Factors below normally will not change for every estimate.**

LOCAL AREA FACTORS: PG 10 of 11

| | | | |
|---|---|---|---|
| Present Year..... | 2008 | (Equipment Calculations) | |
| Economic Index..... | 7667 | (EP-1110-1-8, APP E) | 2009 Marine Equipment |
| Labor Adjustment Factor. | 0.830 | (EP-1110-1-8, APP B) | Southeast Region - 2007 |
| Full Cost of Money Rate. | 5.75 | Percent per Year | |
| Dates for Money Rate.... | July to December 2007 | | Return |
| Annual Months Available for Dredging: | | | |
| Pipeline.... | 10 | Months per Year | |
| Bucket..... | 10 | Months per Year | |
| Hopper..... | 10 | Months per Year | |
| Current Fuel Price..... | $3.75 | Per Gallon | |

HP & BOOSTER FACTOR ADJUSTMENTS: PG 11 of 11

| | Override | Database | Used |
|---|---|---|---|
| Total Available Pump Horsepower..... | 0 | 9,000 | 9,000 |
| Booster Pump HP..... | | 5,200 | 5,200 |

Return

| % Loss per booster, when job lasts: | | | |
|---|---|---|---|
| Less than 1 month (%) | 0 | 15% | 15% |
| More than 1 month (%) | 0 | 10% | 10% |

Without Booster Losses, this job would last 4.02 months, therefore, the 10% figure will be used.

**Unit Cost to Dredge Beach Fill From Sandy Point SE Borrow Area - $18.71**

| | | | | |
|---|---|---|---|---|
| 124,360 pay c.y. per month | UNIT COST.. | $18.71 | PER C.Y. | Select Dredge |
| 265 c.y. per hour | EXCAV. COST | $77,272,300 | | GENERIC MEDIUM |
| 2.9 Loads/Day | TIME..... | 33.21 | MONTHS | |

PROJECT TITLES: PG 1 of 12

| | | |
|---|---|---|
| Project Name..... | Shell Island Restoration, LA | Ver. 1.0 |
| Project Location..... | Offshore Borrow Area - Sandy Point SE | For Information, Call: |
| Invit. or Contr. No..... | Planning Estimate | Julie Davin |
| Date of Estimate..... | April 11, 2008 | Ph: 509-527-7514 |
| Estimator..... | Gordon Thomson | |
| Checked by..... | | |
| (Input Project Descriptions on Sheet A) | Goto Sheet A | |
| Mobilization Bid Item..... | 1 | |
| Excavation Bid Item..... | 2 | Goto Area Factors |

TYPE OF ESTIMATE PG 2 of 12

| | | |
|---|---|---|
| Type of Estimate..... | 1 | Planning Estimate |
| (1) Planning, (2) Bid, or (3) Mod | | Estimate Descriptions |

INDIRECT COSTS:

| | | |
|---|---|---|
| Contractor's Overhead... | 12.0 | Percent of contract |
| Contractor's Profit..... | 10.0 | Percent of contract |
| Contractor's Bond..... | 0.8 | Percent of contract |

ESTIMATED DREDGING QUANTITY: PG 3 of 12

Non-Pay Computation Method: 3

(1) Surface Area, (2) % of Pay O.D., (3) % of Net Pay, (4) % of Gross

BANK HEIGHT: 20 FT.

DREDGING PRISM:

| | | | | | |
|---|---|---|---|---|---|
| Required.... | 4,130,000 | C.Y. | | | |
| + Pay O.D.... | 0 | C.Y. | | | |
| Bid Quantity | 4,130,000 | C.Y. | | | |
| - Not Dug.. | 0 | C.Y. | | LOSSES: | |
| Net Pay | 4,130,000 | C.Y. | | | |
| + Non-Pay | 1,652,000 | C.Y. | @ | 40.0 | % of Net Pay |
| Gross Volume | 5,782,000 | C.Y. | | 20.0 | FT. BANK HT. |

PRODUCTION WORKSHEET: part 1 of 3 PG 4 of 12

| | | |
|---|---|---|
| Material Classification: | 20 | % MUD |
| | 80 | % SAND |
| | 0 | % GRAVEL |
| Volume of Hopper (cyds)..... | 3,800 | (From Database) |
| Max Safe Load (cyds of Sand).... | 2,500 | (From Database) |

| | Override | Calculated | Used |
|---|---|---|---|
| Effect Capacity (cyds).. | 2,000 | 1,748 | 2,000 |
| Excavation Rate (cy/hr) using 2 Dragheads..... | 0 | 1,370 | 1,370 |
| | | Database | |
| Dragheads Used (ea)..... | 2 | 2 | 2 |
| Excavation based upon 2.0 Dragheads. (cy/hr)..... | | | 1,370 |

(Excavation Time per Cycle = 88 min)

PRODUCTION WORKSHEET: part 2 of 3 PG 5 of 12

| | | |
|---|---|---|
| Turns/Cycle..... | 1 | Each |
| Time Per Turn..... | 6 | Minutes |
| (Turning Time per Cycle = 6 min) | | |
| One-Way Haul Distance..... | 14 | Miles (Statute) |
| Speed to Disposal Area..... | 5 | mph |
| Max Speed Loaded..... | 11.5 | mph |
| Speed Used to D/A..... | 5 | mph |
| (Hauling Time to D/A per Cycle = 168 min) | | |
| Speed from Disp Area..... | 10 | mph |
| Max Speed Light..... | 12.7 | mph |
| Speed Used from D/A..... | 10 | mph |
| (Hauling Time from D/A per Cycle = 84 min) | | |
| (Total Haul Time = 252 min) | | |

PRODUCTION WORKSHEET: part 3 of 3 PG 6 of 12

| | | | |
|---|---|---|---|
| Will Pumpout be Used?..... | 1 | YES (0=NO) | |
| | Override | Database | Used |
| Pumpout Rate (cy/hr).... | 2400 | 1800 | 2400 |
| Pipeline Used..... | 28000 | lf | |
| Max Pipe without using a Booster..... 6,000 lf | | | |
| (Pumpout Time per Cycle = 50 min) | | | |
| Connect & Disconnect.... | 15 | Minutes per Cycle | |
| Cleanup Dredging..... | 10 | % Additional Time | |
| Time Efficiency..... | 90.0 | % of Effective Working Time | |
| | | 657 Hours Per Month | |

PLANT OWNERSHIP AND OPERATING: part 1 of 2 PG 7 of 12

| DREDGE | Override | Database | Used |
|---|---|---|---|
| Dredge Acquisition..... | $0 | $16,600,000 | $ 16,600,000 |
| Capital Improvements %.. | 0 | % 10% | 10% |
| REQUIRED PLANT (Monthly Costs) | | | |
| Dredge Propulsion Tug... | $0 | self prop. | self prop. |
| Survey Vessel..... | $30,000 | $0 | $30,000 |

Goto Oper Adj Factors

PLANT OWNERSHIP AND OPERATING: part 2 of 2 PG 8 of 12

| OPTIONAL PLANT (Monthly Costs) | | | | |
|---|---|---|---|---|
| Booster..... .....Include? | 1 | YES (0=NO) | $100,000 | <--Database |
| .....Override> | $300,000 | | $300,000 | <--Used |
| Crane Barge..... .....Include? | 0 | NO (1=YES) | $7,000 | <--Database |
| .....Override> | $0 | | $0 | <--Used |
| Tender Tug..... .....Include? | 0 | NO (1=YES) | $0 | <--Database |
| .....Override> | $1,500 | | $0 | <--Used |
| Other Marine..... | $0 | | | |
| Shore Equip..... | $0 | | | |

OTHER PRICING ADJUSTMENTS: PG 9 of 12

Other Monthly Costs: Goto Travel & Provisions

| | | |
|---|---|---|
| 1st Input..... | $200,000 | Per Month |
| Description..... | Shore Equipment & Transport | |
| (For Additional Inputs Go to Sheet D\3) | Goto Sheet D/3 | |

Fixed Costs:

| | | |
|---|---|---|
| 1st Input..... | $0 | Lump Sum |
| Description..... | > | |
| (For Additional Inputs Go to Sheet E) | Goto Sheet E | |
| (To Adjust Labor Go To Sheet DB_L) | Goto Sheet DB_L | |
| (To Adjust Equipment Go to Sheet DB_E) | Goto Sheet DB_E | |

**The Factors below normally will not change for every estimate.**

LOCAL AREA FACTORS: PG 10 of 12

| | | |
|---|---|---|
| Present Year..... | 2008 | (Equipment Calculations) |
| Economic Index..... | 7667 | (EP-1110-1-8, APP E) |
| Labor Adjustment Factor. | 0.830 | (EP-1110-1-8, APP B) |
| Full Cost of Money Rate. | 5.75 | Percent per Year |
| Dates for Money Rate.... | July to December 2007 | |
| Annual Months Available for Dredging: | | |
| Pipeline.... | 10 | Months per Year |
| Bucket..... | 10 | Months per Year |
| Hopper..... | 10 | Months per Year |
| Current Fuel Price..... | $3.75 | Per Gallon |

Return

DREDGE OPERATING ADJUSTMENT FACTORS (OPTIONAL): PG 11 of 12

| | Overide | | Assumed | Used |
|---|---|---|---|---|
| Pump Load Factor..... | 0 | % | 50% | 50% |
| Adj to Exist Repair Cost... (Range .80 to 1.20) | 0.00 | | 1.00 | 1.00 |
| Jet Pump Useage..... | 0 | % | 100% | 100% |

| | Overide | Calculated | Used |
|---|---|---|---|
| Fuel Usage (Gal/Day).... | 0 | 3,665 | 3,665 |

Return

TRAVEL & PROVISIONS: PG 12 of 12

TRAVEL FOR DREDGE CREW:

| | | |
|---|---|---|
| Frequency Of Travel..... | 28 | days |
| Cost of Ticket..... | $400 | per Round Trip |

Return

EXTRA MEALS PROVIDED:

| | | |
|---|---|---|
| Gov Personnel On Dredge. | 3 | <- |
| Prov & Supplies..... | $15.00 | /Man-Day |

**Unit Cost to Dredge Beach Fill From Ship Shoal Borrow Area - $68.50**

| | | | | |
|---|---|---|---|---|
| 31,840 pay c.y. per month | UNIT COST.. | $68.50 | PER C.Y. | **Select Dredge** |
| 63 c.y. per hour | EXCAV. COST | $282,905,000 | | GENERIC MEDIUM |
| 0.7 Loads/Day | TIME..... | 129.71 | MONTHS | |

PROJECT TITLES: PG 1 of 12

| | |
|---|---|
| Project Name..... | Shell Island Restoration, LA |
| Project Location..... | Offshore Borrow Area - Ship Shoal |
| Invit. or Contr. No..... | Planning Estimate |
| Date of Estimate..... | April 11, 2008 |
| Estimator..... | Gordon Thomson |
| Checked by..... | |

Ver. 1.0
For Information, Call:
Julie Davin
Ph: 509-527-7514

(Input Project Descriptions on Sheet A) Goto Sheet A

Mobilization Bid Item..... 1

Excavation Bid Item..... 2 Goto Area Factors

TYPE OF ESTIMATE PG 2 of 12

Type of Estimate..... 1 Planning Estimate
(1) Planning, (2) Bid, or (3) Mod Estimate Descriptions

INDIRECT COSTS:

| | | |
|---|---|---|
| Contractor's Overhead... | 12.0 | Percent of contract |
| Contractor's Profit..... | 10.0 | Percent of contract |
| Contractor's Bond..... | 0.8 | Percent of contract |

ESTIMATED DREDGING QUANTITY: PG 3 of 12

Non-Pay Computation Method: 3
(1) Surface Area, (2) % of Pay O.D., (3) % of Net Pay, (4) % of Gross

BANK HEIGHT: 9 FT.

DREDGING PRISM:

| | | | | |
|---|---|---|---|---|
| Required.... | 4,130,000 | C.Y. | | |
| + Pay O.D.... | 0 | C.Y. | | |
| Bid Quantity | 4,130,000 | C.Y. | | |
| - Not Dug.. | 0 | C.Y. | LOSSES: | |
| Net Pay | 4,130,000 | C.Y. | | |
| + Non-Pay | 1,239,000 | C.Y. | @ 30.0 | % of Net Pay |
| Gross Volume | 5,369,000 | C.Y. | 9.0 | FT. BANK HT. |

PRODUCTION WORKSHEET: part 1 of 3 PG 4 of 12

| | | |
|---|---|---|
| Material Classification: | 5 | % MUD |
| | 95 | % SAND |
| | 0 | % GRAVEL |

Volume of Hopper (cyds)..... 3,800 (From Database)
Max Safe Load (cyds of Sand).... 2,500 (From Database)

| | Override | Calculated | Used |
|---|---|---|---|
| Effect Capacity (cyds).. | 2,000 | 1,862 | 2,000 |
| Excavation Rate (cy/hr) using 2 Dragheads..... | | 1,286 | 1,286 |
| | | Database | |
| Dragheads Used (ea)..... | 2 | 2 | 2 |
| Excavation based upon 2.0 Dragheads. (cy/hr)..... | | | 1,286 |

(Excavation Time per Cycle = 93 min)

PRODUCTION WORKSHEET: part 2 of 3 PG 5 of 12

| | | |
|---|---|---|
| Turns/Cycle..... | 0 | Each |
| Time Per Turn..... | 2 | Minutes |
| (Turning Time per Cycle = 0 min) | | |
| One-Way Haul Distance..... | 87 | Miles (Statute) |
| Speed to Disposal Area..... | 5 | mph |
| Max Speed Loaded..... | 11.5 | mph |
| Speed Used to D/A..... | 5 | mph |
| (Hauling Time to D/A per Cycle = 1044 min) | | |
| Speed from Disp Area..... | 10 | mph |
| Max Speed Light..... | 12.7 | mph |
| Speed Used from D/A..... | 10 | mph |
| (Hauling Time from D/A per Cycle = 522 min) | | |
| (Total Haul Time = 1566 min) | | |

PRODUCTION WORKSHEET: part 3 of 3 PG 6 of 12

| | | | |
|---|---|---|---|
| Will Pumpout be Used?..... | 1 | YES (0=NO) | |
| | Override | Database | Used |
| Pumpout Rate (cy/hr).... | 2400 | 1800 | 2400 |
| Pipeline Used..... | 28000 | lf | |
| Max Pipe without using a Booster..... 6,000 lf | | | |
| (Pumpout Time per Cycle = 50 min) | | | |
| Connect & Disconnect.... | 15 | Minutes per Cycle | |
| Cleanup Dredging..... | 10 | % Additional Time | |
| Time Efficiency..... | 90.0 | % of Effective Working Time | |
| | | 657 Hours Per Month | |

PLANT OWNERSHIP AND OPERATING: part 1 of 2 PG 7 of 12

| DREDGE | Override | Database | Used |
|---|---|---|---|
| Dredge Acquisition..... | $0 | $16,600,000 | $ 16,600,000 |
| Capital Improvements %.. | 0 % | 10% | 10% |
| REQUIRED PLANT (Monthly Costs) | | | |
| Dredge Propulsion Tug... | $0 | self prop. | self prop. |
| Survey Vessel..... | $30,000 | $0 | $30,000 |

Goto Oper Adj Factors

PLANT OWNERSHIP AND OPERATING: part 2 of 2 PG 8 of 12

| OPTIONAL PLANT (Monthly Costs) | | | | |
|---|---|---|---|---|
| Booster..... .....Include? | 1 | YES (0=NO) | $100,000 | <--Database |
| .....Override> | $300,000 | | $300,000 | <--Used |
| Crane Barge..... .....Include? | 0 | NO (1=YES) | $7,000 | <--Database |
| .....Override> | $0 | | $0 | <--Used |
| Tender Tug..... .....Include? | 0 | NO (1=YES) | $0 | <--Database |
| .....Override> | $1,500 | | $0 | <--Used |
| Other Marine..... | $0 | | | |
| Shore Equip..... | $0 | | | |

OTHER PRICING ADJUSTMENTS: PG 9 of 12

Other Monthly Costs: Goto Travel & Provisions

| | | |
|---|---|---|
| 1st Input..... | $200,000 | Per Month |
| Description..... | Shore Equipment and Transport | |
| (For Additional Inputs Go to Sheet D\3) | | **Goto Sheet D/3** |

Fixed Costs:

| | | |
|---|---|---|
| 1st Input..... | $0 | Lump Sum |
| Description..... | > | |
| (For Additional Inputs Go to Sheet E) | | **Goto Sheet E** |
| (To Adjust Labor Go To Sheet DB_L) | | Goto Sheet DB_L |
| (To Adjust Equipment Go to Sheet DB_E) | | Goto Sheet DB_E |

**The Factors below normally will not change for every estimate.**

LOCAL AREA FACTORS: PG 10 of 12

| | | |
|---|---|---|
| Present Year..... | 2008 | (Equipment Calculations) |
| Economic Index..... | 7667 | (EP-1110-1-8, APP E) |
| Labor Adjustment Factor. | 0.830 | (EP-1110-1-8, APP B) |
| Full Cost of Money Rate. | 5.75 | Percent per Year |
| Dates for Money Rate.... | Jan to June 2007 | |
| Annual Months Available for Dredging: | | |
| Pipeline.... | 9 | Months per Year |
| Bucket..... | 10 | Months per Year |
| Hopper..... | 10 | Months per Year |
| Current Fuel Price..... | $3.75 | Per Gallon |

Return

DREDGE OPERATING ADJUSTMENT FACTORS (OPTIONAL): PG 11 of 12

| | Overide | | Assumed | Used |
|---|---|---|---|---|
| Pump Load Factor..... | 0 | % | 50% | 50% |
| Adj to Exist Repair Cost... (Range .80 to 1.20) | 0.00 | | 1.00 | 1.00 |
| Jet Pump Useage..... | 0 | % | 100% | 100% |

| | Overide | Calculated | Used |
|---|---|---|---|
| Fuel Usage (Gal/Day).... | 0 | 3,754 | 3,754 |

Return

TRAVEL & PROVISIONS: PG 12 of 12

TRAVEL FOR DREDGE CREW:

| | | |
|---|---|---|
| Frequency Of Travel..... | 28 | days |
| Cost of Ticket..... | $400 | per Round Trip |

Return

EXTRA MEALS PROVIDED:

| | | |
|---|---|---|
| Gov Personnel On Dredge. | 3 | <- |
| Prov & Supplies..... | $15.00 | /Man-Day |

**Unit Cost to Dredge Beach Fill From Mississippi Borrow Area P1 - $20.16**

| | | | | |
|---|---|---|---|---|
| 203,850 pay c.y. per month | UNIT COST.. | $20.16 | PER C.Y. | Select Dredge |
| 1,292 cy per hour | EXCAV. COST | $83,260,800 | | 30" Cutter-Suction |
| 30" Cutter-Suction Dredge | TIME..... | 20.26 | MONTHS | |

PROJECT TITLES: PG 1 of 11

| | |
|---|---|
| Project Name..... | Shell Island Feasibility Report |
| Project Location..... | Mississippi River Borrow Area - P1 |
| Invit. or Contr. No..... | Planning Estimate |
| Date of Estimate..... | April 11, 2008 |
| Estimator..... | Gordon Thomson |
| Checked by..... | |

Ver. 1.0

(Input Project Descriptions on Sheet A) **Goto Sheet A**

Mobilization Bid Item..... 1

Excavation Bid Item..... 2 Goto Area Factors

TYPE OF ESTIMATE PG 2 of 11

Type of Estimate..... 1 Planning Estimate

(1) Planning, (2) Bid, or (3) Mod **Estimate Descriptions**

INDIRECT COSTS:

| | | |
|---|---|---|
| Contractor's Overhead... | 12.8 | Percent of contract |
| Contractor's Profit..... | 10.0 | Percent of contract |
| Contractor's Bond..... | 0.8 | Percent of contract |

ESTIMATED DREDGING QUANTITY: PG 3 of 11

Non-Pay Computation Method: 3

(1) Surface Area, (2) % of Pay O.D., (3) % of Net Pay, (4) % of Gross

BANK HEIGHT: 20.0 FT.

DREDGING PRISM:

| | | | | |
|---|---|---|---|---|
| Required.... | 4,130,000 | C.Y. | | |
| + Pay O.D.... | | C.Y. | | |
| Bid Quantity | 4,130,000 | C.Y. | | |
| - Not Dug.. | 0 | C.Y. | LOSSES: | |
| Net Pay | 4,130,000 | C.Y. | @ | |
| + Non-Pay | 1,445,500 | C.Y. | 35.0 | % of Net Pay |
| Gross Volume | 5,575,500 | C.Y. | 20.0 | FT. BANK HT. |

MATERIAL FACTORS: PG 4 of 11

Additional Information

| DESCRIPTION | FACTOR | PERCENTAGE | |
|---|---|---|---|
| MUD & SILT | 3 | 0 | % |
| MUD & SILT | 2.5 | 0 | % |
| MUD & SILT | 2 | 10 | % DIRECT ENTRY |
| LOOSE SAND | 1.1 | 45 | % FACTOR= 0.00 |
| LOOSE SAND | 1 | 45 | % |
| COMP. SAND | 0.9 | 0 | % |
| STIFF CLAY | 0.6 | 0 | % |
| COMP. SHELL | 0.5 | 0 | % RESULTANT MATERIAL |
| SOFT ROCK | 0.4 | 0 | % FACTOR= 1.10 |
| BLAST. ROCK | 0.25 | 0 | % |

PIPELINE CONSIDERATIONS: PG 5 of 11

MAXIMUM PIPELINE REQUIRED:

| | | |
|---|---|---|
| Floating Pipeline..... | 5,280 | Feet |
| Submerged Pipeline..... | 71,280 | Feet |
| Shore Pipeline..... | 26,400 | Feet |
| Total Pipeline on Job: | 102,960 | Feet |

Additional Information

Ave Pumping Distance.... 89,760 Feet of Pipelin =Floating + Subline + (0.5)Total Shorepipe

Pipeline Cost Category..... 0 SAND

(0) Computed from Material Factor,
(1) Mud, (2) Sand, or (3) Rock

Equivalent Pipe..... 0 Feet (Theoretical)

Description.....

Basis of Production: 89,760 Feet (Ave + Equiv)

PRODUCTION ANALYSIS: PG 6 of 11

6 BOOSTER(S) 131,463 L.F. POSSIBLE based on 40200 Tot. H.P.

89,760 Ft Ave Pumping Distance

102,960 L.F. Max. on jobsite

55.0 % X 730 HRS/MO = EWT OF 402 HRS/MO (without Boosters)

Goto HP Adjustments

X 0.53 Booster Factor

29.2 % X 730 HRS/MO = EWT OF 213 HRS/MO (with Boosters)

OTHER PRODUCTION FACTORS: PG 7 of 11

CURRENT DREDGE SELECTED: 30" Cutter-Suction Dredge

Bank Factor for 20.0 ft of Bank ---> 1.10 (From Chart)

Bank Factor Override.... 0 1.10 (Used)

Description..... >

Other Factor..... 0.9

Description..... Navigation issues

Cleanup Dredging..... 2 Percent Additional Time (Cleanup Factor = 0.98)

HISTORICAL PRODUCTION OVERRIDES: PG 8 of 11

(In order to use this screen, Overrides must be entered for all three categories.)

| | Override | Computed | Used |
|---|---|---|---|
| Production (Cy/Hr)..... | 0 | 1292 | 1,292 |
| Operating Time (Hrs/Mo). | 0 | 213 | 213 |
| Number of Boosters..... | 0 | 6 | 6 |

OTHER PRICING ADJUSTMENTS: PG 9 of 11

Other Monthly Costs:

| | | |
|---|---|---|
| 1st Input..... | $200,000 | Per Month |
| Description..... | Shore Equipment & Transport | |
| (For Additional Inputs Go to Sheet D\4) | Goto Sheet D\4 | |

Fixed Costs:

| | | |
|---|---|---|
| 1st Input..... | | Lump Sum |
| Description..... | | |
| (For Additional Inputs Go to Sheet E) | Goto Sheet E | |
| (To Adjust Labor Go To Sheet DB_L) | Goto Sheet DB_L | |
| (To Adjust Equipment Go To Sheet DB_E) | Goto Sheet DB_E | |

**The Factors below normally will not change for every estimate.**

LOCAL AREA FACTORS: PG 10 of 11

| | | | |
|---|---|---|---|
| Present Year..... | 2008 | (Equipment Calculations) | |
| Economic Index..... | 7667 | (EP-1110-1-8, APP E) | 2005 Marine Equipment |
| Labor Adjustment Factor. | 0.830 | (EP-1110-1-8, APP B) | Southeast Region - 2003 |
| Full Cost of Money Rate. | 5.75 | Percent per Year | |
| Dates for Money Rate.... | July to December 2007 | | Return |
| Annual Months Available for Dredging: | | | |
| Pipeline.... | 11 | Months per Year | |
| Bucket..... | 10 | Months per Year | |
| Hopper..... | 11 | Months per Year | |
| Current Fuel Price..... | $3.75 | Per Gallon | |

HP & BOOSTER FACTOR ADJUSTMENTS: PG 11 of 11

| | Override | Database | Used |
|---|---|---|---|
| Total Available Pump Horsepower..... | 0 | 9,000 | 9,000 |
| Booster Pump HP..... | | 5,200 | 5,200 |
| % Loss per booster, when job lasts: | | | |
| Less than 1 month (%) | 0 | 15% | 15% |
| More than 1 month (%) | 0 | 10% | 10% |

Return

Without Booster Losses, this job would last 10.75 months, therefore, the 10% figure will be used.

**Unit Cost to Dredge Beach Fill From Mississippi River Borrow Area P2 - $19.14**

202,948 pay c.y. per month
1,113 cy per hour
30" Cutter-Suction Dredge

UNIT COST.. $19.14 PER C.Y.
EXCAV. COST $79,048,200
TIME..... 20.35 MONTHS

Select Dredge: 30" Cutter-Suction

PROJECT TITLES: PG 1 of 11

Ver. 1.0

| | |
|---|---|
| Project Name | Shell Island Feasibility Report |
| Project Location | Mississippi Borrow Area - P2 |
| Invit. or Contr. No | Planning Estimate |
| Date of Estimate | April 11, 2008 |
| Estimator | Gordon Thomson |
| Checked by | |

(Input Project Descriptions on Sheet A) **Goto Sheet A**

Mobilization Bid Item: 1
Excavation Bid Item: 2
Goto Area Factors

TYPE OF ESTIMATE PG 2 of 11

Type of Estimate..... 1 Planning Estimate
(1) Planning, (2) Bid, or (3) Mod **Estimate Descriptions**

INDIRECT COSTS:

| | | |
|---|---|---|
| Contractor's Overhead... | 12.8 | Percent of contract |
| Contractor's Profit..... | 10.0 | Percent of contract |
| Contractor's Bond..... | 0.8 | Percent of contract |

ESTIMATED DREDGING QUANTITY: PG 3 of 11

Non-Pay Computation Method: 3
(1) Surface Area, (2) % of Pay O.D., (3) % of Net Pay, (4) % of Gross

BANK HEIGHT: 10.0 FT.

DREDGING PRISM:

| | | | | |
|---|---|---|---|---|
| Required.... | 4,130,000 | C.Y. | | |
| + Pay O.D.... | 0 | C.Y. | | |
| Bid Quantity | 4,130,000 | C.Y. | | |
| - Not Dug.. | 0 | C.Y. | LOSSES: | |
| Net Pay | 4,130,000 | C.Y. | @ | |
| + Non-Pay | 1,239,000 | C.Y. | 30.0 | % of Net Pay |
| Gross Volume | 5,369,000 | C.Y. | 10.0 | FT. BANK HT. |

MATERIAL FACTORS: PG 4 of 11

| DESCRIPTION | FACTOR | PERCENTAGE | |
|---|---|---|---|
| MUD & SILT | 3 | 0 | % |
| MUD & SILT | 2.5 | 0 | % |
| MUD & SILT | 2 | 10 | % |
| LOOSE SAND | 1.1 | 45 | % |
| LOOSE SAND | 1 | 45 | % |
| COMP. SAND | 0.9 | 0 | % |
| STIFF CLAY | 0.6 | 0 | % |
| COMP. SHELL | 0.5 | 0 | % |
| SOFT ROCK | 0.4 | 0 | % |
| BLAST. ROCK | 0.25 | 0 | % |

Additional Information

DIRECT ENTRY
FACTOR= 0.00

RESULTANT MATERIAL
FACTOR= 1.10

PIPELINE CONSIDERATIONS: PG 5 of 11

MAXIMUM PIPELINE REQUIRED:

| | | |
|---|---|---|
| Floating Pipeline..... | 5,280 | Feet |
| Submerged Pipeline..... | 51,500 | Feet |
| Shore Pipeline..... | 26,000 | Feet |
| Total Pipeline on Job: | 82,780 | Feet |

Additional Information

Ave Pumping Distance.... 69,780 Feet of Pipelin =Floating + Subline + (0.5)Total Shorepipe

Pipeline Cost Category..... 0 SAND

(0) Computed from Material Factor,
(1) Mud, (2) Sand, or (3) Rock

Equivalent Pipe..... 0 Feet (Theoretical)

Description.....

Basis of Production: 69,780 Feet (Ave + Equiv)

PRODUCTION ANALYSIS: PG 6 of 11

5 BOOSTER(S) 114,405 L.F. POSSIBLE based on 35000 Tot. H.P.

69,780 Ft Ave Pumping Distance

82,780 L.F. Max. on jobsite

55.0 % X 730 HRS/MO = EWT OF (without Boosters) 402 HRS/MO

Goto HP Adjustments

X 0.59 Booster Factor

32.5 % X 730 HRS/MO = EWT OF (with Boosters) 237 HRS/MO

OTHER PRODUCTION FACTORS: PG 7 of 11

CURRENT DREDGE SELECTED: 30" Cutter-Suction Dredge

Bank Factor for 10.0 ft of Bank ----> 1.10 (From Chart)

Bank Factor Override.... 0 1.10 (Used)

Description.....

Other Factor..... 0.7

Description..... Navigation issues / crossing river

Cleanup Dredging..... 2 Percent Additional Time (Cleanup Factor = 0.98)

HISTORICAL PRODUCTION OVERRIDES: PG 8 of 11

(In order to use this screen, Overrides must be entered for all three categories.)

| | Override | Computed | Used |
|---|---|---|---|
| Production (Cy/Hr)..... | 0 | 1113 | 1,113 |
| Operating Time (Hrs/Mo). | 0 | 237 | 237 |
| Number of Boosters..... | 0 | 5 | 5 |

OTHER PRICING ADJUSTMENTS: PG 9 of 11

Other Monthly Costs:

| | | |
|---|---|---|
| 1st Input..... | $200,000 | Per Month |
| Description..... | Shore Equipment & Transport | |
| (For Additional Inputs Go to Sheet D\4) | Goto Sheet D\4 | |

Fixed Costs:

| | | |
|---|---|---|
| 1st Input..... | | Lump Sum |
| Description..... | | |
| (For Additional Inputs Go to Sheet E) | Goto Sheet E | |
| (To Adjust Labor Go To Sheet DB_L) | Goto Sheet DB_L | |
| (To Adjust Equipment Go To Sheet DB_E) | Goto Sheet DB_E | |

**The Factors below normally will not change for every estimate.**

LOCAL AREA FACTORS: PG 10 of 11

| | | | |
|---|---|---|---|
| Present Year..... | 2008 | (Equipment Calculations) | |
| Economic Index..... | 7667 | (EP-1110-1-8, APP E) | 2005 Marine Equipment |
| Labor Adjustment Factor. | 0.830 | (EP-1110-1-8, APP B) | Southeast Region - 2003 |
| Full Cost of Money Rate. | 5.75 | Percent per Year | |
| Dates for Money Rate.... | July to December 2008 | | Return |
| Annual Months Available for Dredging: | | | |
| Pipeline.... | 11 | Months per Year | |
| Bucket..... | 10 | Months per Year | |
| Hopper..... | 11 | Months per Year | |
| Current Fuel Price..... | $3.75 | Per Gallon | |

HP & BOOSTER FACTOR ADJUSTMENTS: PG 11 of 11

| | Override | Database | Used |
|---|---|---|---|
| Total Available Pump Horsepower..... | 0 | 9,000 | 9,000 |
| Booster Pump HP..... | | 5,200 | 5,200 |
| % Loss per booster, when job lasts: | | | |
| Less than 1 month (%) | 0 | 15% | 15% |
| More than 1 month (%) | 0 | 10% | 10% |

Return

Without Booster Losses, this job would last 12.01 months, therefore, the 10% figure will be used.

# ANNEX C-8
# SECONDARY BENEFITS ANALYSIS

# C-8.0 SECONDARY BENEFITS ANALYSIS

## C-8.1 INTRODUCTION

Secondary benefits of the project are the benefits to marsh areas that are not included within the WVA boundary, such as the marsh along the western and northern rim of Bastian Bay. Construction of the project may provide additional protection from wave action to these marshes. The survival of a salt marsh is regulated by a variety of factors, including wave climate (Roland and Douglass, 2005). This section discusses the modeling effort that estimated the wave climate for the without project condition and the three design alternatives. The benefit (reduced marsh recession) is then quantified to derive a secondary benefit compared to the without project condition.

Roland and Douglass (2005) determined that marsh stability was partially dependent on wave climate, based on observations of salt marshes in Alabama. Marshes where the median significant wave height was less than approximately 0.33 feet and a corresponding $80^{th}$ percentile significant wave height of roughly 0.66 feet or less were stable. Marshes with a wave climate exceeding this threshold were retreating. Based on site observations and a comparison of the 1998 and 2004 shoreline (digitized from georectified aerials), the current marsh is retreating at an average rate of 8 feet/year. The MIKE 21 NSW wave model was used to determine if the design alternatives would reduce the wave heights and thereby reduce marsh recession rates.

## C-8.2 BACKGROUND MARSH RECESSION RATES

The edge of the marsh surrounding Bastian Bay was digitized from 1998 and 2004 rectified aerials (Figure C-8.1). The marsh is healthier and the edge of the marsh is more defined along the west and northwest sides of Bastian Bay. The east side of Bastian Bay/Shell Island Bay is composed of several small patches of marsh and small islands.

The measured area of marsh lost between 1998 and 2004, based on the digitized shorelines, was 28 acres. This equates to a marsh loss rate of approximately 5 acres/year. The shoreline length within this area was roughly 53,000 feet. An average marsh shoreline recession of 8 feet/year was calculated based on these measurements.

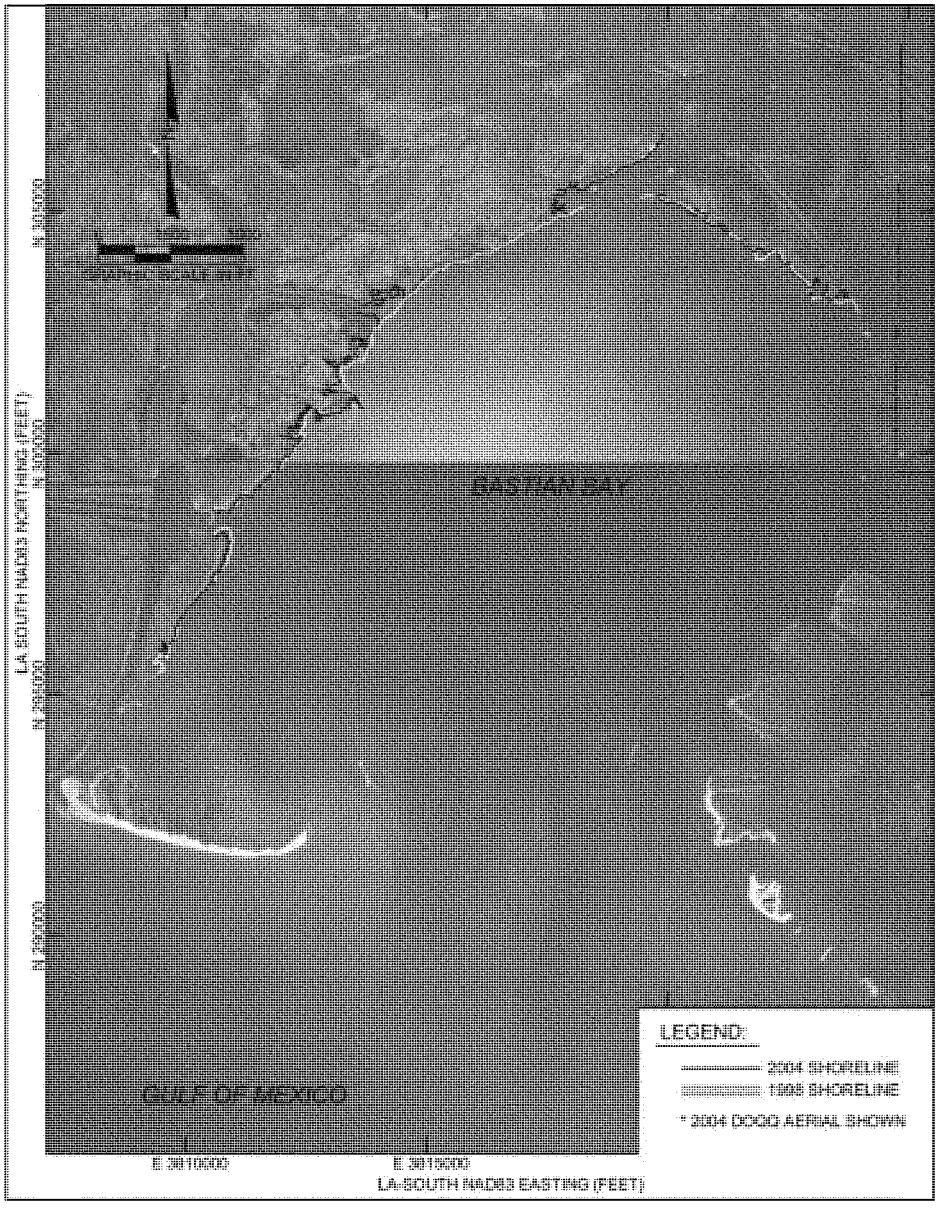



Figure C-8.1 The 1998 and 2004 limits of marsh extent based on aerial digitization

## C-8.3 MIKE 21 MODEL

Wave transformation analysis for the study area utilized the MIKE 21 Nearshore Spectral Wind-Wave (NSW) model. MIKE 21 NSW is a wind-wave model that describes the propagation, growth and decay of short-crested waves in nearshore areas. MIKE 21 NSW uses spectral waves instead of a single monochromatic wave though a single-peaked frequency spectrum is assumed, which means that mixed seas (e.g. wind waves and swell) cannot be simulated. The model includes the effects of refraction and shoaling due to varying depth, wave generation due to wind, and energy dissipation due to bottom friction and wave breaking. Inputs to the MIKE 21 model include bathymetry, incident wave spectra, wind velocities, and water levels. MIKE 21 was used for the secondary benefits analysis instead of STWAVE because Bastian Bay is very shallow and friction is one of the most important factors when modeling wave transformation across muddy, shallow bays.

### C-8.3.1 Bathymetric Data

Bathymetric data for the wave transformation model was compiled from:

- The June 2005 survey of Shell Island by the Louisiana Department of Natural Resources.
- The September 2002 survey of Pelican Island by Coastal Planning & Engineering, Inc. (2003).
- The regional bathymetric grid compiled by NOAA (2005). This grid is an approximate representation of the 1981 conditions.

The area covered by the MIKE 21 model grid appears in Figure C-8.2. Elevations within the MIKE 21 model grid were taken from the regional NOAA (2005) grid, except within the areas surveyed in 2002 and 2005. The 1981 elevation data was lowered 0.98 feet to account for subsidence and eustatic sea level change, which is based on a relative sea level rise rate of 0.039 feet/year. The resulting bathymetric grid, which approximates the 2005 conditions, appears in Figure C-8.2. The size of the MIKE 21 grid is roughly 4.0 miles in an east-west direction by 4.0 miles in a north-south direction.

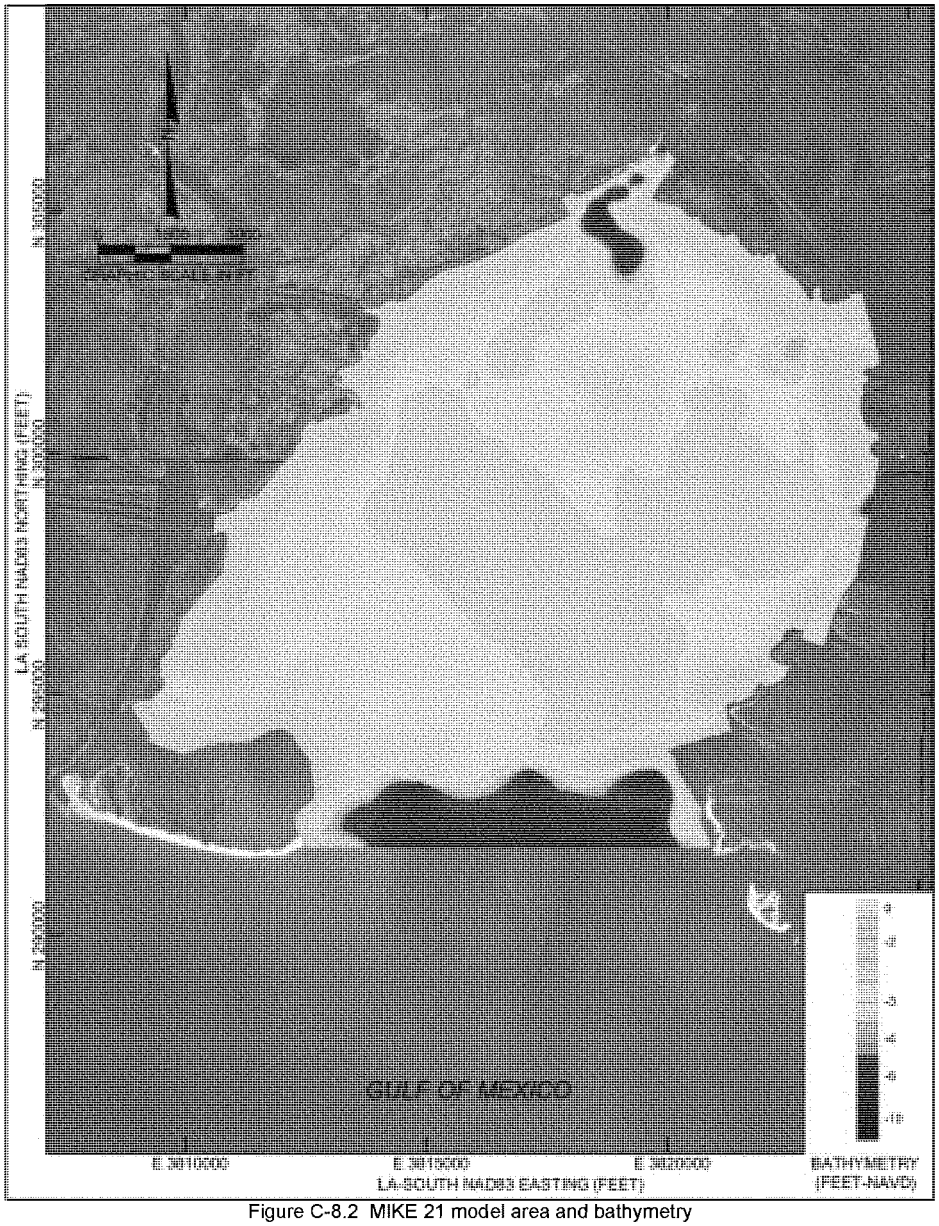



Figure C-8.2 MIKE 21 model area and bathymetry

### C-8.3.2 Wave Cases

Based on the study performed by Roland and Douglass (2005), the upper limit of wave energy for (noneroding) salt marsh existence is a median significant wave height of about 0.33 feet and a corresponding 80$^{th}$ percentile significant wave height of 0.66 feet. Using the hindcast wave data between 1980 and 1999 from WIS station 132, which is located in 62 feet of water, the median offshore significant wave height was found to be 5.7 feet and the 80$^{th}$ percentile offshore significant wave height was found to be 7.3 feet. The nearshore significant wave height used for model input was calculated by transforming the offshore waves to a water depth of 13 feet. Nearshore environmental conditions input into the MIKE 21 model for each wave case are shown in Table 1. Water levels were assumed to be equal to the mean tide level (1.06 feet, NAVD).

Table C-8.1 MIKE 21 NSW Model Input Wave Conditions

| Percentile | Nearshore HS (feet) | Average Period (sec.) | Wave Direction (deg.) | Wind Speed (mph) | Wind Direction (deg.) |
|---|---|---|---|---|---|
| 50 | 5.3 | 4.0 | 165.0 | 18.3 | 160.0 |
| 80 | 6.9 | 5.0 | 170.0 | 23.2 | 155.0 |

### C-8.3.3 Model Calibration

The model was calibrated by assuming that the median significant wave heights along the western and northern rim of Bastian Bay were greater than the threshold of 0.33 feet but less than 1 foot. This was based on the interpretation of aerial photographs and site observations, which showed that there is a marsh around Bastian Bay but that it is retreating. MIKE 21 NSW default inputs were used except for the wave friction coefficient, wave breaking parameters, and wind generation formula. The wave friction coefficient assumed a Nikuradse roughness parameter of 0.002. The model was run using Battjes and Janssen's (1978) wave breaking criterion, not the default values used in MIKE21 that were suggested by Holthuijsen *et al.*(1989). The wind generation formula used in the model calibration for fetch-limited sea states was based on expressions derived from the Shore Protection Manual (USACE, 1984).

Figure C-8.3 shows the wave conditions within Bastian Bay during existing conditions and a median significant wave height. The color bar has been set so that there is a distinct change in color at the threshold wave height of 0.33 feet. The arrows show the direction of wave propagation with the arrow size being related to the wave height. This figure shows that the most of the rim of Bastian Bay experiences mean wave heights that are above the threshold wave height and therefore, marsh recession should be expected. Approximately 16,500 linear feet of marsh shoreline exceeded the 0.33-foot threshold.

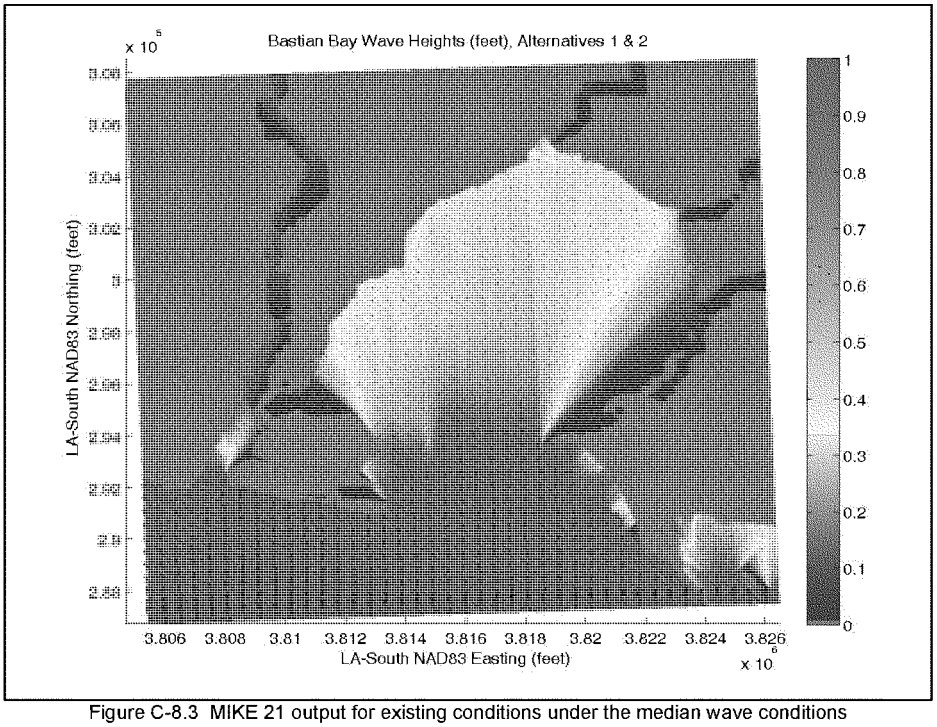



Figure C-8.3 MIKE 21 output for existing conditions under the median wave conditions

Figure C-8.4 shows the wave conditions within Bastian Bay under the 80$^{th}$ percentile wave condition. This figure shows that along the bordering marsh of Bastian Bay the wave height does not exceed the 0.66-foot threshold for recession developed by Roland and Douglass (2005). As with Figure C-8.3, there is a distinct break in the color scheme at the threshold wave height. The reduction in wave height as waves propagate into Bastian Bay is greater than anticipated but recent bathymetric survey data is not available for Bastian Bay and measured wave data is not available to fully calibrate the model. This should be considered when evaluating the accuracy of the secondary benefit acreage.

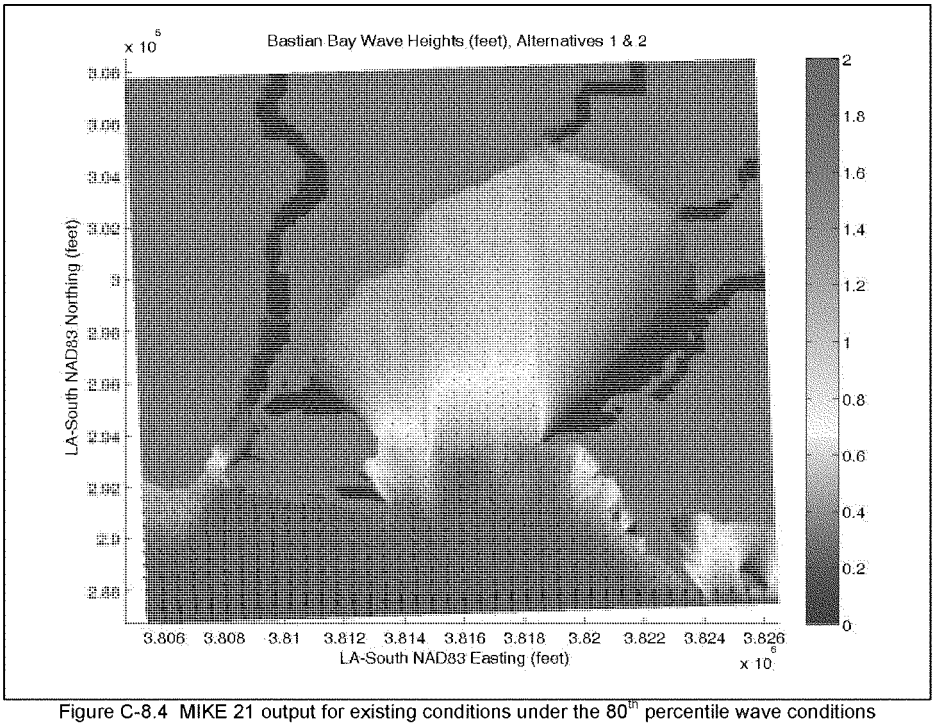



Figure C-8.4 MIKE 21 output for existing conditions under the 80th percentile wave conditions

### C-8.3.4 Future Without Project

The future without project conditions assumed that Shell Island West will be eroded exposing more of Bastian Bay to waves propagating from the Gulf of Mexico. It was assumed that the recession rate will remain the same as between 1998 and 2004, except that the length of marsh exposed will increase. The average annual loss of marsh acreage for the future without project conditions is 3.0 acres/year.

The average wave height along the rim of Bastian Bay is 0.49 feet. The length of shoreline experiencing wave heights greater than the threshold wave height of 0.33 feet is 16,500 feet.

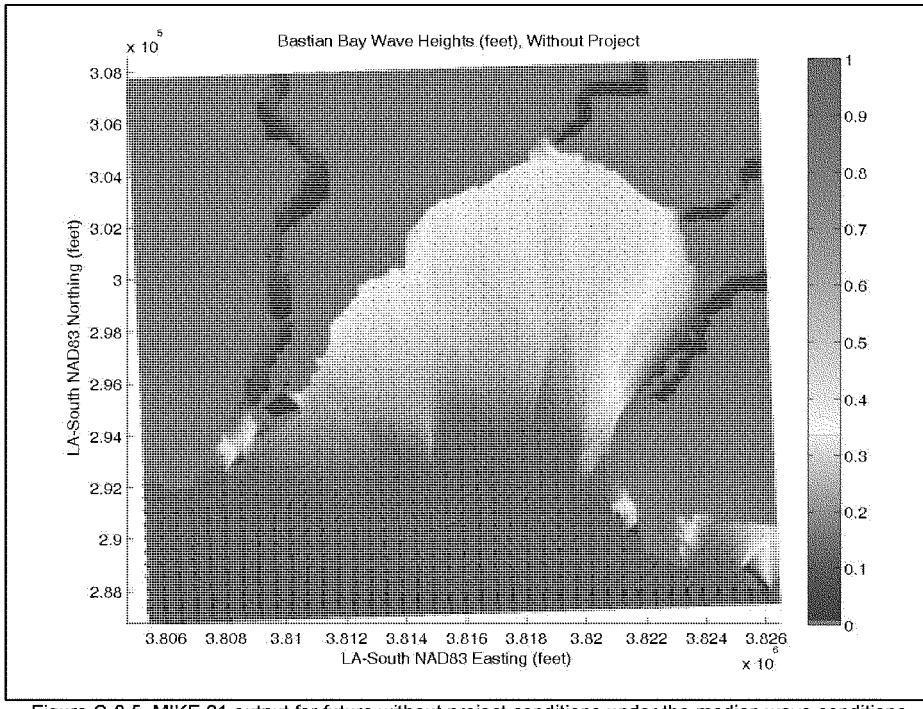



Figure C-8.5 MIKE 21 output for future without project conditions under the median wave conditions

### C-8.3.5 Alternatives 1 and 2

Since the existing conditions are similar to the proposed footprint of Alternatives 1 and 2, the existing marsh recession rate is applicable to Alternatives 1 and 2. Figures C-8.3 and C-8.4 represent the wave conditions for Bastian Bay following construction. Therefore, it is expected that the secondary benefits for Alternatives 1 and 2 will be identical to the benefits for the without project condition in the initial years. The secondary benefits for the construction of either Alternative 1 or 2 will therefore be 1.9 acres/year.

However, the reconstruction of East Shell Island and West Shell Island should provide greater benefits than the without project condition in future years. Alternatives 1 and 2 will help to stabilize Coupe Bob at its current width and thus the wave energy entering Bastian Bay compared to the without project condition will be lower than in TY50. Furthermore, the construction of either Alternative 1 or 2 will likely result in the formation of an ebb and flood shoal across Coupe Bob. This will decrease the wave energy propagating into Coupe Bob by breaking waves as they propagate through the inlet. The renourishment projects included in Alternative 2 will result in a larger and more stable ebb shoal

compared to Alternative 1. Therefore, over the 50-year project life, Alternative 2 will allow less energy into Bastian Bay and will have higher secondary benefits than Alternative 1, which will have higher secondary benefits than the without project alternative. However, a more detailed model study would be required to quantify the difference in secondary benefits between Alternatives 1 and 2.

### C-8.3.6 Alternatives 3 to 8

Alternatives 3 to 8 will close Coupe Bob and thus almost eliminate wave propagation into Bastian Bay from the Gulf of Mexico. Wave propagation through the opening of Grand Bayou could be expected but will likely be small compared to Coupe Bob. However, winds blowing across the bay will generate waves. Figure C-8.6 shows Mike 21 NSW model output of average significant wave height generated by wind blowing across Bastian Bay. This figure shows that the length of shoreline experiencing wave heights above the threshold for marsh recession is shorter than for the without project, Alternative 1, and Alternative 2 conditions. The average wave height impacting the marsh is 0.16 feet for Alternatives 3 to 8 compared to 0.49 feet. The length of marsh impacted by wave heights greater than the threshold wave height is 400 feet compared to 16,500 feet. The expected average annual loss of marsh acreage is 0.1 acres/year for Alternatives 3 to 8 compared to 3.0 acres/year under the No Action Alternative.

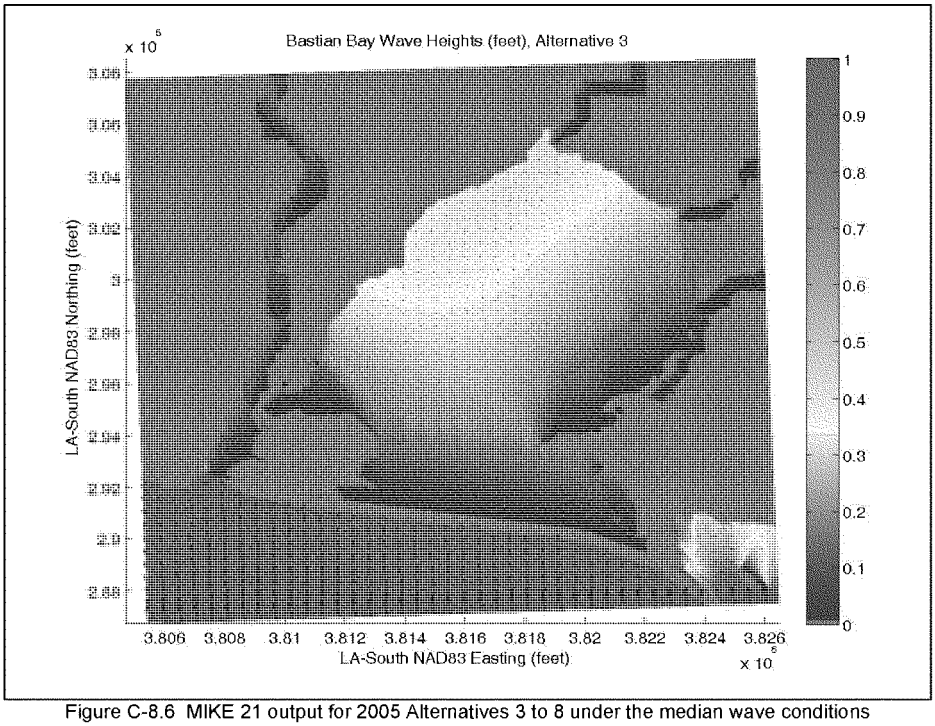



Figure C-8.6 MIKE 21 output for 2005 Alternatives 3 to 8 under the median wave conditions

## C-8.4 SUMMARY

The construction of either Alternative will result in reduced marsh recession rates around the rim of Bastian Bay compared to the without project condition. This is considered a secondary benefit of constructing the project. The existing marsh is losing approximately 1.9 acres/year. Under the without project conditions, it is expected that Coupe Bob will continue to expand and that more of the marsh surrounding Bastian Bay will be exposed to wave action from the Gulf of Mexico. The average marsh recession in the future is expected to increase to 3.0 acres/year under future without project conditions. Alternatives 1 and 2 will maintain the existing marsh loss rate of 1.9 acres/year though benefits from Alternative 2 will likely be higher. Alternatives 3 to 8 will almost eliminate the propagation of waves from the Gulf entering Bastian Bay and the marsh recession rate is expected to be reduced to 0.1 acres/year.

## C-8.5 REFERENCES

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# ANNEX C-9

# DYNAMIC MORPHOSEDIMENTARY MODEL SENSITIVITY ANALYSIS

# C-9.0 DYNAMIC MORPHOSEDIMENTARY MODEL

## C-9.1 BACKGROUND

Louisiana's barrier islands typically have a Gulfside face that is composed of sand while the main body of the island is composed both of sand and fine sediment (Figure C-9.1). As the island retreats, the material from the main body of the island is exposed and the fine sediment is suspended and moved offshore while the sand concentrates at the front face of the island. Sand is then removed from the face of the island by both longshore and cross-shore transport.

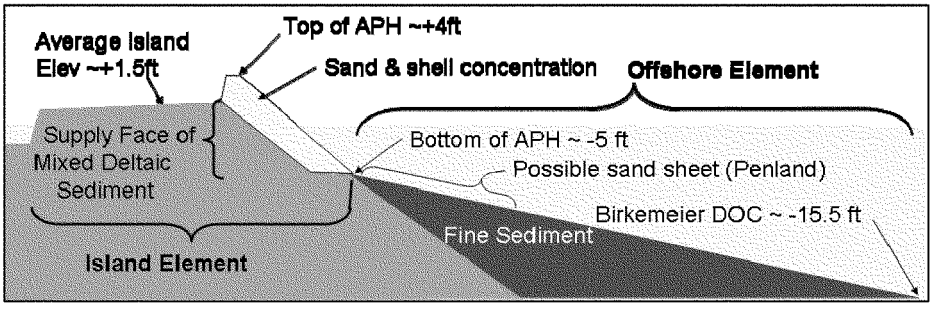


Figure C-9.1. Schematic of Cross-shore Profile for a Barrier Island

A dynamic morphosedimentary model (Campbell, 2005) was used to estimate the total longshore and cross-shore sediment transport for Shell Island and the island retreat rate due to these processes. The model output provides a relationship between cross-shore, longshore losses, and losses due to relative sea level rise. The model accounts for a mixed sediment system, such as Louisiana's barrier islands.

The model is based on the following data that can either be measured, or directly calculated:

1. Shoreline retreat rate.
2. Rate of relative sea-level rise (subsidence plus eustatic sea level rise).
3. Elevation of the break in the profile slope.
4. Birkemeier's (1985) depth of closure.
5. Elevation of the marsh platform.
6. Width of the island.

7. Distance to Birkemeier's depth of closure.

The Dynamic Morphosedimentary Model was developed considering islands with uniform shoreline retreat rates. It cannot account for sediment losses due to tidal flow. Tidal currents through a breach such as Coupe Bob can increase the shoreline retreat rates non-uniformly, so the model was applied in the pre-Hurricane Bob time period. The model was initially developed using the 1956 to 1973 time period, as it was after the construction of the Empire Jetties but prior to the formation of Coupe Bob in 1979. The model can then be applied to any of the stated alternatives since Coupe Bob will either be closed Alternatives 3 through 8) or assumed to be in a stable state (Alternatives 1 and 2).

## C-9.2 BASELINE VALUES

A measured shoreline retreat rate was used within the initial development of the model. The measured shoreline retreat was estimated to be 25.7 feet/year for the 1956 to 1973 analysis period between USGS transects 68 and 81.

The rate of relative sea level rise was assumed to be 0.039 feet/year for the initial calibration period of 1956 to 1973. This was calculated based on back-calculating the relative sea level rise rate using the NRC methodology.

The elevation of the break in slope was taken as -5 feet, NAVD (see section 2.6 of the main report) and was located 500 feet offshore. The elevation of the marsh platform was taken as 1.5 feet, NAVD. Therefore, the height of the eroding island element is 6.5 feet (it is assumed that the dune cap maintains elevation during retreat so the eroding portion only extends to 1.5 feet, NAVD). The width of the island element was averaged to be 1,400 feet (-5 foot contour on the gulf side to Mean Low Water on the bayside).

Birkemeier's depth of closure was taken as -15.5 feet, NAVD, which is located approximately 7,000 feet offshore.

The model suggests that given these baseline values the following shoreline retreat rates are needed to meet the continuity requirements of the model: the longshore sediment transport losses requires a shoreline retreat rate of 6.0 feet/year, a shoreline retreat rate of 11.3 feet/year is required to achieve cross-shore continuity on the island and achieve continuity with the offshore element, and for the island to respond to relative sea level rise requires a shoreline retreat of 8.4 feet/year.

## C-9.3 SENSITIVITY ANALYSIS RESULTS

A model sensitivity analysis was performed on the various input parameters. The percentage of longshore transport was altered to achieve mass balance and continuity within the model once the given variable was altered.

Increasing the shoreline retreat rate by 25% to 32.1 feet/year resulted in the required longshore transport rate increasing to 11.2 feet/year, an increase of 87%. The shoreline retreat rate to account for RSLR did not change though the shoreline retreat need to account for cross-shore continuity increased to 12.5 feet/year (an 11% increase). It was not possible to reduce the shoreline retreat rate by more than 25% because the shoreline retreat rate was too low to reach an equilibrium state. When the total shoreline retreat rate was reduced by 25% to 19.7 feet/year, the longshore loss decreased by 83% while the loss required to achieve cross-shore continuity reduced by 13%. Again the shoreline retreat required to account for RSLR did not change. The input values and subsequent shoreline retreat rates needed to satisfy continuity are summarized in Table C-9-1.

Relative sea level rise is composed of two parts, subsidence and eustatic sea level rise. These were analyzed for sensitivity separately. Increasing the subsidence rate by 25% to -0.0365 feet/year reduced the shoreline retreat for longshore transport by 57% to 2.6 feet/year. The shoreline retreat required to achieve cross-shore continuity increased to 13.1 feet/year, a 19% increase. The shoreline retreat required to account for relative sea level rise increased by 16% to 10.0 feet/year. Reducing the subsidence rate by 25% increased the retreat rate due to longshore transport by 47% to 8.8 feet/year. The shoreline retreat required to achieve cross-shore continuity decreased to 10.1 feet/year, a 19% decrease while the shoreline retreat required to account for relative sea level rise decreased by 19% to 6.8 feet/year.

Increasing the eustatic sea level rise rate by 25% to 0.0123 feet/year decreased the shoreline retreat for longshore transport by 18% to 4.9 feet/year. The shoreline retreat required to achieve cross-shore continuity increased to 12.0 feet/year, a 6% increase. The shoreline retreat required to account for relative sea level rise also increased by 6% to 8.9 feet/year. Reducing the eustatic sea level rise rate by 25% to 0.00735 feet/year increased the retreat rate due to longshore transport by 10% to 6.6 feet/year. The shoreline retreat required to achieve cross-shore continuity decreased to 11.2 feet/year, a 1% decrease while the shoreline retreat required to account for relative sea level rise decreased by 6% to 7.9 feet/year.

Table C-9-1. Sensitivity Analysis Results for the Dynamic Morphosedimentary Model

| Variable | | | | | | | | Shoreline Retreat to Account For: | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Shoreline Retreat Rate (feet/year)** | **Subsidence (feet/year)** | **Eustatic SLR (feet/year)** | **El. of Break in Slope (feet, NAVD)** | **El. of Marsh Platform (feet, NAVD)** | **Island Width (feet)** | **Birkemeier's Depth of Closure (feet, NAVD)** | **Distance to Depth of Closure (feet)** | **Longshore Loss** | **Cross-shore Continuity** | **RSLR** |
| 25.7 | -0.0292 | 0.0098 | -5.0 | 1.5 | 1,400 | -15.5 | 7,000 | 6.0 | 11.3 | 8.4 |
| **32.1** | -0.0292 | 0.0098 | -5.0 | 1.5 | 1,400 | -15.5 | 7,000 | 11.2 | 12.5 | 8.4 |
| **19.3** | -0.0292 | 0.0098 | -5.0 | 1.5 | 1,400 | -15.5 | 7,000 | 1.1 | 9.8 | 8.4 |
| 25.7 | **-0.0365** | 0.0098 | -5.0 | 1.5 | 1,400 | -15.5 | 7,000 | 2.6 | 13.1 | 10.0 |
| 25.7 | **-0.0219** | 0.0098 | -5.0 | 1.5 | 1,400 | -15.5 | 7,000 | 8.8 | 10.1 | 6.8 |
| 25.7 | -0.0292 | **0.0123** | -5.0 | 1.5 | 1,400 | -15.5 | 7,000 | 4.9 | 12.0 | 8.9 |
| 25.7 | -0.0292 | **0.00735** | -5.0 | 1.5 | 1,400 | -15.5 | 7,000 | 6.6 | 11.2 | 7.9 |
| 25.7 | -0.0292 | 0.0098 | **-3.8** | 1.5 | 1,400 | -15.5 | 7,000 | 5.6 | 9.8 | 10.3 |
| 25.7 | -0.0292 | 0.0098 | **-6.3** | 1.5 | 1,400 | -15.5 | 7,000 | 5.6 | 13.1 | 7.0 |
| 25.7 | -0.0292 | 0.0098 | -5.0 | **1.9** | 1,400 | -15.5 | 7,000 | 6.1 | 11.6 | 7.9 |
| 25.7 | -0.0292 | 0.0098 | -5.0 | **1.1** | 1,400 | -15.5 | 7,000 | 5.3 | 11.4 | 9.0 |
| 25.7 | -0.0292 | 0.0098 | -5.0 | 1.5 | **1,750** | -15.5 | 7,000 | 5.1 | 10.1 | 10.5 |
| 25.7 | -0.0292 | 0.0098 | -5.0 | 1.5 | **1,050** | -15.5 | 7,000 | 6.5 | 12.9 | 6.3 |
| 25.7 | -0.0292 | 0.0098 | -5.0 | 1.5 | 1,400 | **-19.4** | 7,000 | 9.0 | 8.3 | 8.4 |
| 25.7 | -0.0292 | 0.0098 | -5.0 | 1.5 | 1,400 | **-11.6** | 7,000 | 0.8 | 16.5 | 8.4 |
| 25.7 | -0.0292 | 0.0098 | -5.0 | 1.5 | 1,400 | -15.5 | **8,750** | 2.3 | 15.0 | 8.4 |
| 25.7 | -0.0292 | 0.0098 | -5.0 | 1.5 | 1,400 | -15.5 | **5,250** | 9.3 | 8.0 | 8.4 |

Increasing the elevation of the break in slope by 25% to -3.8 feet, NAVD decreased the shoreline retreat for longshore transport by 7% to 5.6 feet/year. The shoreline retreat required to achieve cross-shore continuity increased to 9.7 feet/year, a 13% increase. The shoreline retreat required to account for relative sea level rise increased by 23% to 10.3 feet/year. Reducing the elevation of the break in slope by 25% to -6.3 feet/year decreased the retreat rate due to longshore transport by 7% to 5.6 feet/year, similar to the decrease in the break in slope elevation. The shoreline retreat required to achieve cross-shore continuity increased to 13.1 feet/year, a 16% increase, while the shoreline retreat required to account for relative sea level rise decreased by 17% to 7.0 feet/year.

Increasing the elevation of the marsh elevation by 25% to 1.9 feet, NAVD increased the shoreline retreat for longshore transport by 2% to 6.1 feet/year. The shoreline retreat required to achieve cross-shore continuity increased to 11.6 feet/year, a 13% increase. The shoreline retreat required to account for relative sea level rise decreased by 6% to 7.9 feet/year. Reducing the elevation of the marsh by 25% to 1.1 feet/year decreased the retreat rate due to longshore transport by 12% to 5.3 feet/year. The shoreline retreat required to achieve cross-shore continuity increased to 11.4 feet/year, a 1% increase while the shoreline retreat required to account for relative sea level rise increased by 7% to 9.0 feet/year.

Increasing the island width by 25% to 1,750 feet decreased the shoreline retreat for longshore transport by 15% to 5.1 feet/year. The shoreline retreat required to achieve cross-shore continuity decreased to 10.1 feet/year, an 11% decrease. The shoreline retreat required to account for relative sea level rise increased by 25% to 10.5 feet/year. Reducing the island width by 25% to 1,050 feet increased the retreat rate due to longshore transport by 6% to 6.5 feet/year. The shoreline retreat required to achieve cross-shore continuity increased to 12.9 feet/year, a 14% increase while the shoreline retreat required to account for relative sea level rise decreased by 25% to 6.3 feet/year.

Increasing the depth of closure by 25% to -19.4 feet, NAVD increased the shoreline retreat for longshore transport by 50% to 9.0 feet/year. The shoreline retreat required to achieve cross-shore continuity decreased to 8.3 feet/year, a 27% decrease. The shoreline retreat required to account for relative sea level rise was unchanged. Reducing the depth of closure by 25% to -11.6 feet, NAVD decreased the retreat rate due to longshore transport by 87% to 0.8 feet/year. The shoreline retreat required to achieve cross-shore continuity increased to 16.5 feet/year, a 46% increase while the shoreline retreat required to account for relative sea level rise was unchanged.

Increasing the distance from the break in slope to the depth of closure by 25% (8,750) feet decreased the shoreline retreat for longshore transport by 62% to 2.3 feet/year. The shoreline retreat required to achieve cross-shore continuity increased to 15.0 feet/year, a 33% increase. The shoreline retreat required to account for relative sea level rise was unchanged. Reducing the distance from the break in slope to the

depth of closure by 25% to 5,250 feet increased the retreat rate due to longshore transport by 55% to 9.3 feet/year. The shoreline retreat required to achieve cross-shore continuity decreased to 8.0 feet/year, a 29% increase while the shoreline retreat required to account for relative sea level rise was unchanged.

## C-9.4 SENSITIVITY ANALYSIS DISCUSSION

The model suggests that a change in the measured shoreline retreat rate mostly alters the longshore transport. This is expected as larger or smaller transport rates would result in higher or lower shoreline retreat rates with little impact to cross-shore processes and no impact on effects relating to RSLR. The shoreline retreat rate is the only variable that will change the total shoreline retreat in the sensitivity analysis. All other variables will impact the ratio of shoreline retreat attributed to longshore loss, reforming the sand face on the island, and losses due to RSLR, but they do not change the total shoreline retreat within the model. The longshore transport component is most sensitive to changes in the shoreline retreat rate.

The first element calculated within the model is losses due to RSLR. Subsidence and eustatic sea level rise are both critical aspects of RSLR and in increase in either one will increase RSLR. Increasing subsidence or eustatic sea level rise results in an increase in shoreline retreat to account for the increased RSLR. Cross-shore processes also need to increase in response to RSLR. Since these values are increasing but the total retreat rate is constant, a decrease in the longshore component is required. The longshore component is inversely related to RSLR. Lastly, since subsidence has a larger magnitude than eustatic sea level rise, subsidence will have a greater effect on the output for a similar percentage change in the baseline value.

The elevation of the break in slope affects the height of the eroding section of the island element. As the break in slope becomes shallower, there is less material provided for island processes for each foot of shoreline retreat, and vice versa. Since RSLR requirements have not changed, a shorter eroding section of the island element requires greater the retreat to satisfy RSLR requirements. Thus, the required shoreline retreat increases to provide material for RSLR with a shallower break in slope and there is less material available for other cross-shore and longshore processes. Conversely, if the slope in break deepens, less shoreline retreat is required to provide the same volume for RSLR and the longshore and cross-shore components increase.

Similar to the break in slope, a decrease in the marsh elevation decreases the volume of sediment released for each foot that the shoreline retreats. When developing the model, this first impacts the needs for RSLR and then longshore loss and cross-shore sand reformation process. Since the magnitude of the marsh elevation is small (1.5 feet), a 25% change in the marsh elevation has the least impact on the magnitude of changes from the baseline condition.

The volume necessary for the island to maintain its elevation relative to sea level is estimated by the width of the island multiplied by the RSLR. The model assumes that there is a direct correlation between island width and volumetric needs. Therefore, a 25% increase or decrease in island width will result in a 25% increase or decrease in shoreline retreat needed to supply material to sustain island elevation. The volume to satisfy the RSLR needs is calculated within the model first and the remaining volume is then divided between the cross-shore and longshore processes, with both inversely related to the change in RSLR requirements. The change in shoreline retreat to meet RSLR needs is most sensitive to the change in island width within the dynamic morphosedimentary model.

The depth of closure and distance to the depth of closure have no impact upon the volume needed to maintain the elevation of the island. However, as the depth of closure increases or the distance to the depth of closure decreases, the nearshore slope becomes steeper. This reduces the volume of material needed in a cross-shore direction and increases the longshore component. Conversely, as the depth of closure becomes shallower or the distance offshore increases, the offshore slope becomes flatter and the volume requirement in a cross-shore direction becomes greater and the longshore component reduces. A 25% change in the baseline value creates more than a 25% change in both the longshore loss and sand reformation values though the longshore component experiences a greater percentage change because it has a smaller baseline magnitude. Following the total shoreline retreat, the model is most sensitive to changes related to the depth of closure and its distance offshore.

## C-9.5 CONCLUSION

The sensitivity analysis shows that the dynamic morphosedimentary model is most sensitive to changes in the shoreline retreat rate followed by the depth and distance to the depth of closure. The model is least sensitive to the elevation of the break in slope of the profile and the marsh elevation.

## C-9.6 REFERENCES

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Campbell, T.C. 2005. Development of a Conceptual Morphosedimentary Model for Design of Coastal Restoration Projects along the Louisiana Coast. *Journal of Coastal Research*. S.I. No 44, pp 234 – 244. The Coastal Education and Research Foundation, West Palm Beach, FL and Louisiana Department of Natural Resources, Baton Rouge, LA.

**Annex 3: Barataria Basin Shoreline Restoration Feasibility Study**
**-Additional Modeling and Engineering Information**

# ANNEX 3
# ADDITIONAL MODELING AND ENGINEERING INFORMATION

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**Attachment 1 Design Premise for the Caminada Headland Preferred Template**

# ANNEX 3
# ADDITIONAL MODELING AND ENGINEERING INFORMATION

## GENERAL

This annex contains additional information on the modeling done for this study and its use in plan formulation and selection. More detailed information on the development of the preferred design template for Caminada is included as Attachment 1 to this Annex.

## MODEL ASSUMPTIONS

### *Shell Island*

SBEACH

For Shell Island the assumptions underlying the SBEACH model are briefly stated in Annex 2 of Appendix A. However a further list of assumptions taken from Rosati, et al. (1993) appears below.

1. **Breaking waves and changing water level are the major driving agents in SBEACH that produce sediment transport and beach profile change.**
   In general, aerial photographs of the Louisiana's barrier islands reveal numerous overwash fans, which form as material is eroded from the beach face during storms, transported over the crest of the beach and dune, and deposited on the landward side of the beach and dune crest. Breaking waves are the major cause of the erosion along the beach face that happens during this process, and elevated water levels allow the eroded material to be transported over the beach and dune crest. Thus, this fundamental assumption of the model is reasonable.

2. **Longshore wave, current, and sediment transport processes are omitted.**
   Over long-term time scales, longshore currents and sediment transport are significant processes governing erosion from the beach face. However, as illustrated in Thomson, et al, 2008, the longest model simulations were approximately two weeks. During storms such as Isidore, Lili, and the 5-50 year storms, processes such as overwash and the deflation of the beach profile as depicted in Annex 2 of Appendix A are largely governed by cross-shore sediment transport as described above. Given these considerations, the application of the SBEACH to examine beach face erosion and overwash during storm events is reasonable.

3. **SBEACH should not be used to examine profile change in the vicinity of jetties and similar structures that form barriers to longshore sand transport.**
   The only erosion control structure near the Shell Island project area is the Empire Waterway jetties towards the east end. Although the SBEACH model results would be questionable in this area, it should be noted that the Shell Island project area as a whole is very long (3 miles). Along a majority of the Shell Island project area, the beaches do not lie in close proximity to the Empire Waterway jetties or any other erosion control structure, and do not violate the caveat listed above.

4. **Neither should the model be used for long-term analysis of cross-shore transport, in which hydrodynamic forces other than for breaking waves and water level may be factors. SBEACH is intended to predict and analyze short-term, storm-induced erosion.**
   As noted earlier, the longest model simulations during the Shell Island study were approximately two weeks. Long-term analysis of cross-shore transport was not analyzed using SBEACH.

5. **SBEACH is an empirically based model that was developed for sandy beaches with uniform representative grain sizes in the range of 0.20 to 0.42 mm (2.32 to 1.25ϕ). However, Larson and Kraus (1989) state that "consideration is limited to sediment in the sand range of grain size (particle diameters in the range of 0.062 - 2.00 mm [-1 to 4ϕ])". The minimum grain size allowed by the model is 0.1 mm (3.32ϕ).**
   The native grain size assumed for Shell Island is 0.13 mm (2.94ϕ) see Annex 2 of Appendix A. This grain size is above the minimum value allowed by the model, and falls within the original range examined by Larson and Kraus (1989) during the development of the model (0.062 - 2.00 mm or -1 to 4ϕ).

GENESIS

The assumptions underlying the GENESIS model (Gravens, et al, 1991) are the following:

1. **That the beach profile moves landward and seaward while retaining the same shape.**
   Along the Shell Island project area, this assumption is difficult to validate due to rapid land losses. However, at the west end of the Shell Island project area, subaerial land was present during both the November 2000 and June 2005 surveys. Onshore and offshore slopes on Coast 2050 Profile 49, which was located along this area, were similar during both surveys.

2. **Sand is transported alongshore between two well-defined limiting elevations on the profile. The shoreward limit is located at the top of the active berm, and the seaward limit is located where no significant depth change occurs, the so-called depth of profile closure.**
   Along the western end of the Shell Island project area, the November 2000 and June 2005 surveys exhibit similar beach crest elevations on Coast 2050 Profile 49. Due to rapid subsidence and land loss, assessing the depth of closure is more difficult. For modeling purposes, the depth of closure was assumed to be -5 feet NAVD, which Thomson, et al. (2008) identified as the "depth at which there is a significant change in the offshore slope".

3. **The transport rate is taken to be a function of the breaking wave height and direction alongshore. The horizontal circulation in the nearshore, which actually moves the sand, is not directly considered.**

In the case of Shell Island, very little land is left along the project area. For this reason, morphological changes are presently governed by sea level rise, subsidence, overwash, breaching, cross-shore tidal currents, and mud transport, not just longshore transport. This is duly noted at the beginning of Annex 2 of Appendix A. All applications of the GENESIS model for Shell Island considered either past conditions (1932-1973), when a long barrier island beach was present, or improved conditions which construct a barrier island with a sandy beach along all or part of Shell Island's former location. For either of these scenarios (1932-1973 or improved conditions), the predominant sediment transport would have been in the longshore direction and governed, first and foremost, by breaking waves. Based on the assumption above, the application of the model was appropriate for the scenarios that were considered.

4. **The model must be applied where there is a long-term trend in shoreline behavior in order to separate and predict a clear signal of shoreline change from cyclical and random movement in the beach system produced by storms, seasonal changes in waves, and tidal fluctuations.**
As noted in Annex 2 of Appendix A, the model was calibrated over a relatively long period, 1956 to 1973. The calibration period was long enough so that the contributions of storms, seasonal changes in waves, and tidal fluctuations to the total shoreline changes would be relatively low. GENESIS was not able to simulate sea level rise, subsidence, overwash, breaching, cross-shore tidal currents, and mud transport. To account for sea level rise and subsidence, shoreline retreat rates due to these two factors were estimated using the Bruun Rule. The resulting retreat was added to the shoreline retreat predicted by the GENESIS model obtain the final results. The contributions of the other influences were assumed to be small in comparison to the shoreline changes due to wave-driven transport, sea level rise, and subsidence.

***Caminada***

SBEACH

General

The model does not take into account alongshore wave, current, and sediment transport processes and assumes all of the transport to be in the cross-shore direction. It accepts as input varying water levels as produced by storm surge and tide, varying wave heights and periods, and an arbitrary grain size in the fine-to-medium sand range.

Water level data were obtained from verified historical records at NOAA Station 8761724 located on Grand Isle just east of the Caminada Headland and were assumed to be comparable to the water levels that occurred during these storm events along the Headland.

Two transects were utilized in developing design alternatives. Variation in the transect profiles was assumed to represent the range of beach/dune profiles along the Headland.
Selection of the Design Storms

Storm Data

The primary extreme storm events experienced at the Caminada Headland are hurricanes and intense tropical storms. Design storm selection was based primarily on landfall location, but also on wave height and water level elevations associated with the storm. Landfall locations were obtained from the NOAA Coastal Services Historical Hurricane storm track data (http://hurricane.csc.noaa.gov/hurricanes/). The records were reviewed from 1985 to 2004. The major storms that approached within 175 miles of the Project area and designated as a hurricane (H1 through H5) since 1985 are listed in the following table. The table lists Year, Month, Days of Occurring Peak Wind Speed, Peak Wind Speed, and Storm Category (Engineering Appendix, Annex 1 Section C-3).

NOAA Historical Hurricane Tracks (1985-2004)

| STORM NAME | YEAR | MONTH | DAY | WIND SPEED (KNOTS) | CATEGORY |
|---|---|---|---|---|---|
| DANNY | 1985 | 8 | 15 | 80 | H1 |
| ELENA | 1985 | 9 | 2 | 105 | H3 |
| **JUAN** | **1985** | **10** | **29** | **75** | **H1** |
| BONNIE | 1986 | 6 | 26 | 70 | H1 |
| **ANDREW** | **1992** | **8** | **26** | **125** | **H4** |
| OPAL | 1995 | 10 | 4 | 130 | H4 |
| **DANNY** | **1997** | **7** | **19** | **70** | **H1** |
| EARL | 1998 | 9 | 2 | 85 | H2 |
| GEORGES | 1998 | 9 | 28 | 95 | H2 |
| **ISIDORE** | **2002** | **9** | **23** | **Not Available** | **TS** |
| **LILI** | **2002** | **10** | **3** | **125** | **H4** |
| IVAN | 2004 | 9 | 15 | 115 | H4 |

Rationale

The U.S. Army Corps of Engineers (USACE) completed a SBEACH model study in support of the Grand Island Shore Protection Project (USACE, 2004a). The rationale for selecting the design storms from the Grand Isle model study for use in the Caminada Headland SBEACH Model Program was four fold.

First, Grand Isle is immediately adjacent to the Caminada Headland and as such, experiences similar tropical storm and hurricane effects. Second, for two federal projects to be located adjacent to each other, the Project Delivery Team (PDT) decided that consistency between the two studies was important. Third, the USACE completed a Sediment Transport Parameter calibration for the Grand Isle model study and validated the results with measured data; and no post storm data was available for the Caminada Headland to perform a similar calibration at the time the Caminada Headland Model Program was completed.

Fourth, these storms, Juan, Andrew, Danny, Isidore, and Lili were the most severe storms within recent history leading up to the Model Program completed in 2005 (CEC & SJB, 2008) for which the necessary data were available such as wave, winds, and water levels. Subsequent to the completion of the Model Program, several major hurricanes impacted the Project area. The design storms selected for the modeling were compared to targeted recent storms. The comparison included the Grand Isle gage data for the hurricanes that were modeled including Hurricanes Isidore and Lili. The Grand Isle gage data that recorded the water levels in the project area during Hurricanes Gustav and Ike was recently obtained. The record for Hurricanes Isidore and Lili in 2002 depicted that the peak water levels were approximately 5.0 feet NAVD88 and 4.8 feet NAVD88, respectively. The record for Hurricanes Gustav and Ike depicted that the peak water levels were approximately 5.7 feet NAVD88 and 5.6 feet NAVD88, respectively. Thus the storm effects on water levels of the magnitude of Hurricanes Gustav and Ike were accounted for in the storm modeling. In addition to the water levels, wave heights recorded in the Gulf of Mexico during Hurricanes Gustav and Ike were obtained. The data were obtained from NOAA's NDBC Station 42001 located 200 miles south of Southwest Pass, LA. The STWAVE model was used to propagate the recorded wave heights to the Caminada Headland and compute the corresponding nearshore wave conditions. The results of the wave analysis yielded peak wave heights for Hurricanes Gustav and Ike on the order of 14.2 feet and 14.5 feet, respectively. For comparison, the peak nearshore wave heights for Hurricanes Juan, Andrew, Isidore and Lili were 14.5 feet, 13.3 feet, 12.6 feet, and 13.5 feet, respectively. Thus, the range of wave heights presented in the storm modeling included wave heights of the magnitude of Hurricanes Gustav and Ike.

Return Periods and Risk

The selected storms represent design storm events anticipated to impact the Project area within the renourishment interval outlined in the 2004 Louisiana Coastal Area Study (USACE, 2004b) equal to every 10 years. Thus these storms were representative of the magnitude that would affect the Headland between renourishment intervals.

With that said, it is recognized that more severe storms may affect the Project area within a given renourishment cycle. One possible risk of not including design storms ranging in magnitude from 20-year to 50-year design storms in the analysis and selection of the design fill template is that if such event does occur, the predicted storm damage reduction benefit provided by the restoration project would be overestimated. Another possible risk is the predicted net ecosystem restoration benefit equal to the difference between the FWP and FWOP may actually be underestimated. This is because both ecosystem restoration benefits for the Future With Project (FWP) and Future Without Project (FWOP) would be less if larger storms were accounted for.

To moderate the risk from not modeling more severe storms within Plan Formulation, the PDT relied upon the 100-year record of morphologic changes, well documented in the literature, to evolve the FWP and FWOP alternatives to derive the ecosystem restoration benefits for the 50-year period of analysis. The 100-year morphologic change record included the effects of shoreline erosion, overwash, Headland migration, compaction, settlement, sea level change, and impacts of storms including severe storms greater than 20-year return events.

GENESIS

The model assumes that the cross-shore profile is in equilibrium, so that morphological change can be represented by the change in shoreline position alone. It requires basic inputs including an initial shoreline position, the average height of the beach berm, the depth of closure, and the effective grain diameter which are used to define an equilibrium profile.

Pinned boundary conditions were assumed and imposed, which do not allow shoreline change at the model boundaries.

Offshore wave conditions were based on wave data at Station WIS-130 between January 1, 1995 and December 31, 1998 and were assumed to be representative of typical long-term wave climate.

## COMPARISON OF MODEL RESULTS TO FIELD OBSERVATIONS

### *Shell Island*

The SBEACH model was also applied to examine storm erosion along Chenier Ronquille and Chaland Headland (Thomson, et al, 2011). To verify whether SBEACH could be used for the Chenier Ronquille project, SBEACH versions 2.0 and 4.03 were applied to examine storm erosion and overwash during hurricanes Gustav and Ike. Pre-storm surveys and post-storm aerials were available along nearby Chaland Headland to locate the landward limit of overwash. SBEACH 4.03 was generally able to predict the landward limit of overwash when utilized with an overwash coefficient of 0.01 (Thomson, et al, 2011, pp. E-6 to E-7). Given the results at Chaland Headland, along with the considerations in Item 1 above, the model's assumptions are compatible with the application of the model along the Gulf shoreline of Plaquemines Parish.

### *Caminada*

As described above, the existing suite of storms was compared to recent hurricanes that impacted the Louisiana coastline. The analysis included comparing water levels and wave heights to the 2008 hurricanes, Gustav and Ike. The comparisons concluded that the storm effects on water levels and range of wave heights of the magnitude of Hurricanes Gustav and Ike were accounted for in the storm modeling.

For SBEACH, input parameters were based on survey data (input beach/dune transects), sediment samples (grain size), measured tide (input water level), and a wide range of historic storm events. The SBEACH model employed a validated model program (USACE, 2004a) from the adjacent barrier shoreline, Grand Isle; and the results were compared to field observations and post-storm data, e.g. Katrina (2005) and Gustav/Ike (2008), and were in reasonable agreement. For GENESIS, input parameters were based on survey data (input shoreline, berm height, depth of closure), and sediment samples (grain size). The GENESIS results were compared to historical shoreline change data and were in good to excellent agreement, indicating the results are reasonable.

## USE OF MODELS IN PLAN FORMULATION AND ANALYSIS

The two models were employed for specific purposes in Step 3 of the Planning Process, "Formulating Alternative Plans." More details of this process can be found in the Main Report. The use of both models is considered standard practice both in the United States and internationally as evidenced by the many documented applications in professional journals and conference proceedings. GENESIS is a longshore sediment transport model utilized for predicting long-term platform evolution of a beach in response to imposed wave conditions as well as simulating beach fill diffusion and response to coastal structures. It was employed in the analysis of alternatives as part of the screening of structural complements. SBEACH is a cross-shore sediment transport model utilized for predicting storm-induced beach and dune erosion. It was employed in the evaluation of different fill templates as well as screening of structural complements. These applications are consistent with the industry standard for model use. Both model program results were compared with historical and / or measured data and demonstrated reasonable agreement validating the use of these two models. The range and combination of forcing was sufficient for the specific purposes that the models were employed.

## MODELING UNCERTAINTIES

### *Shell Island*

For Shell Island, the GENESIS model was calibrated based on observed shoreline change during periods (i.e. 1956-1973) in which its use have been appropriate. The SBEACH model could not be specifically calibrated for Shell Island due to the lack of a pre-storm survey and post-storm survey during a recent storm. Given the lack of data required for the calibration of an SBEACH model at Shell Island, the model calibration at two nearby projects – Chaland Headland and Pelican Island was used by reference.

The model results were primarily employed in the analysis of alternatives to evaluate fill template options and as part of the evaluation and screening of structural measures. These applications are consistent with the industry standard for model use. The model results were compared to field observations. The comparisons demonstrated reasonable agreement validating the use of these models for the purposes specified herein.

### *Caminada*

While the GENESIS model was not specifically calibrated, that is, a detailed sensitivity analysis of the sediment transport coefficients was not completed; the model results were validated through comparison of the model results to measured short-term and long-term shoreline changes, which is presented in the Engineering Appendix (Annex 1 Section C-3). The average shoreline change predicted in the GENESIS simulation of approximately 138 feet of erosion over the 4-year simulation period (equivalent to 34.5 feet of erosion per year) is in excellent agreement with the short-term shoreline change rate of 36 feet of erosion per year (Engineering Appendix, Annex 1 Section C-2) and is in good agreement with the long-term shoreline change rate of 45 feet per year. Based on the historic shoreline measurements, the existing breakwaters reduce erosion in the lee of the breakwaters by approximately 33% which is in fair agreement

with the shoreline erosion rate reduction of 55% predicted by GENESIS (Engineering Appendix, Annex 1 Section C-5).

An SBEACH study including model validation was completed by the USACE for Grand Isle. The storm events modeled included Hurricane Juan (1985), Andrew (1992), Danny (1997), Lili (2002), and Tropical Storm Isidore (2002). These five storms "... were judged to be the most severe from an erosion standpoint due to their high peak water levels, storm duration, and wave characteristics." The input storm wave conditions for Hurricane Lili also include the data from Tropical Storm Isidore, which occurred approximately two weeks before Lili, and were treated as a single storm event. It was concluded from the verification attempt that the default coefficients in SBEACH are reasonable for use in performing beach fill analysis on Grand Isle, and that no changes to the defaults were justifiable (USACE, 2004a).

Because the sediment transport parameter calibration was determined for Grand Isle and because post-storm profile data were not available for the Caminada Headland, the PDT used engineering judgment to run SBEACH with the coefficients from the Grand Isle report for the same five storms for the Caminada Headland model program. The PDT validated the results by comparing them to post-storm observations and comparisons of pre- and post-storm (e.g., post Katrina-2005 and post Gustav and Ike-2008) aerial photographs. The comparisons indicated the model results were reasonable.

The purpose of the GENESIS model program was two-fold. First, the model was applied during Step 3, "Formulating Alternative Plans" to investigate the effect of breakwaters off Caminada Headland on long-term shoreline change in the area. As stated in the Engineering Appendix (Annex 1 Section C-5), it was concluded that the breakwaters protect the shoreline by reducing erosion in the lee of the breakwaters and it was recommended the existing breakwaters remain. The results were also utilized to qualitatively assess the addition of breakwaters along the Headland as a structural complement to the restoration plans. As stated in Annex 1 Section C-5, construction of breakwaters along the majority of the Headland could result in downdrift impacts to Grand Isle and West Belle Pass; thus this measure was screened out. The results of this modeling study were not used in designing project alternatives or in computing habitat benefit acres which are the measure of project performance. Thus the assessment of uncertainty on project performance and alternatives is not applicable for this model study.

Second, after selection of the recommended plan in Step 6, "Selecting a Plan" the model was utilized to assess the performance of the renourishment plan, that being maintenance dredging of Belle Pass and construction of feeder beaches. The GENESIS model was applied to examine alongshore diffusion of the feeder beaches for use in the computing the evolution of habitat acres over time in the Wetland Value Assessment. As stated in the Engineering Appendix (Annex 1A), it was concluded that the feeder beach will benefit the Headland both to the east and west as longshore transport nourishes the beach face profile and adds width to the shoreline. This model study recommended in the PED phase that the modeling program be refined through additional model calibration and verification to improve quantifying the benefits from the feeder beach. During this, an analysis shall be included that will cover the implications of uncertainty in model results and how that uncertainty affects the evaluation of the feeder beach benefits.

Model uncertainty may be a result of various components including variation in modeled transects, storm events, and wave conditions, among others. The SBEACH model was applied to two typical transects representing the Caminada Headland. Four historic hurricanes of different magnitudes and return intervals and their respective wave parameters were considered. Taking all these into account resulted in a large array of possible scenarios from which project alternatives were developed.

The model results were primarily employed in the analysis of alternatives to evaluate fill template options and as part of the evaluation and screening of structural measures. These applications are consistent with the industry standard for model use. The model results were compared to field observations. The comparisons demonstrated reasonable agreement validating the use of these models for the purposes specified herein.

## DESIGN APPROACHES AND ALTERNATIVE SELECTION

### *System Comparison*

The two systems (Caminada Headland and Shell Island) are different in that Caminada Headland has a significant backing marsh with limited concern about breaching with large tidal flows to keep the breach open. Shell Island has a substantial waterbody on the north side of the island and a history that shows that the single island present as early as the 1950's breached and there was sufficient tidal flow, to not only maintain the breach but have the breach be the dominant factor in subsequent evolution of the system.

As such, the two systems need a different design approach, as outlined in the engineering document.

> The diversity and selection in restoration designs is based upon the two separate Barataria Basin barrier system components-headland and barrier island-that are proposed to be restored. Restoration design and rationale is based upon review of US Geological Survey Williams et al. (1992) "Atlas of Shoreline Changes in Louisiana from 1853 to 1989" and Ritchie et al. (1990) Coastal Sand Dunes of Louisiana: the Plaquemines Shoreline; and (1995) Coastal Sand Dunes of Louisiana: the Bayou Lafourche Barrier Shoreline. The Caminada Headland is characterized as an erosional or retreating headland of the Bayou Lafourche distributary of the Mississippi River that was active until 300 years ago. In contrast Shell Island is a barrier island that is part of the Plaquemines barrier shoreline system. Although these barrier components are part of the Barataria Basin barrier system, they are quite different geomorphologic features. As such they exhibit different variations in height, slope, and other geomorphic attributes. Hence, the rationale for restoration template design is based upon these differences as documented in the referenced literature.
>
> Within each specific system, the barrier headland system (Caminada) and the barrier island system (Shell), the models were applied equally for their specific alternatives. Because the Wetland Value Assessment (WVA) outputs AAHU's on an equivalent basis, the combination of alternatives from the two different systems can be combined to find the Best Buy. The WVA model requires acreage inputs for various elevation ranges at various periods (target years) following construction. While some morphologic responses may necessitate additional performance output at different years, the WVA accounts for the 50-year period of project

evaluation. For example, a narrower island on Shell Island may breach requiring that acreage outputs be developed for the first few years after the breach. A two island option would not require that these identical years be modeled. However, the WVA accounts for the different years that have been modeled and provides a single output value for the 50-year project evaluation period.

***Shell Island***

For Shell Island, adaptive management techniques were employed from other barrier island projects constructed throughout Louisiana, including Chaland Headland (CPE, 2003b), Holly Beach (CPE, 2000 and CPE 2003c), Timbalier Island, East Timbalier Island, East Grand Terre (CPE, 2005b), and Pass La Mer to Grand Bayou Pass (CPE, 2004). Lessons learned during the ongoing design of other projects such as Pelican Island (CPE, 2003b), West Belle Pass Barrier Headland, West Grand Terre (CPE, 2003b) and Scofield Island (SJB & CEC, 2010) were also included.

The elevation for Shell Island was primarily driven through environmental concerns that historical elevations of Louisiana's barrier islands are typically less than 6 to 8 feet. Therefore, an ecosystem restoration project should employ a similar elevation to the natural system. Dune widths were based on cross-shore modeling to determine the design width, following National Research Council design guidance. Advanced fill volume was then added in front of the design template and an economic analysis performed to determine the optimum renourishment interval. The advanced fill volume was then added to the design section to provide the dune width.

The dune on Shell Island for the two island option was located to maximize the existing island remnants and shallower sections within the project area in order to reduce fill volumes. The single island option was located similarly.

***Caminada***

The preferred template for the Caminada Headland segment was selected based upon modeling results, engineering judgment, experience, and discussions among the PDT for balancing the desire to have storm damage reduction benefits while creating and sustaining the habitat zones for the beach, dune, and marsh components defined by the geomorphic history of the Headland. Further, the design criteria selected for development of the fill template alternatives were based on long-term geomorphic trend data, and were very conservative, resulting in a very conservative estimate of the project's ecosystem restoration benefits.

The Caminada Headland has a substantial backing marsh area without a tidally connected bay, so breaching was factored in the design approach. Because Shell Island has a limited marsh platform to catch and contain the material before it overwashes the island, the design approach did not factor in WVA benefits, as material deposits in the area overwash into deeper water where no WVA benefits are recognized. The difference between the spreadsheets used for the WVA is described in Section 3.6.1 (Benefits Analysis) of the Main Report.

The purpose of the study was to evaluate alternatives to restore the barrier shoreline through shoreline and marsh restoration to address this severe erosion and land loss, and to ensure continuing geomorphic and hydrologic form and function. The barrier shoreline is typically low lying and comprised of three physical features, the beach, dune, and back barrier marsh. It acts as

a buffer to reduce the full force and effects of wave action, saltwater intrusion, storm surge, and tidal currents on associated estuaries and wetlands. To restore its geomorphic form and provide this buffer involves reinforcing the shoreline through dune and supratidal (beach) habitat restoration. In addition, it includes providing a marsh platform to capture overwash sediments during episodic events; sediment that would otherwise be carried into back bay areas to form shoals or be lost into deeper waters. The marsh also serves as a roll over platform as the headland migrates landward.

Restoration of hydrologic function includes vegetating both the restored dune and back barrier marsh platform with native plants, to provide wetland habitat for a diverse number of plant and animal species and to help retain sediment. This approach is supported by the WVA Model, which was the model selected for this study to evaluate the ecosystem restoration project benefits.

In order to provide geomorphic form and hydrologic function, the beach, dune, and marsh components must exhibit certain physical characteristics. These characteristics were defined through analysis of historical planforms, elevations, and geomorphic trends that are well documented in the literature.

For the Caminada Headland, the range of dimensions for the dune and supratidal features were defined through analysis of existing profile data and historical data extracted from the literature sources referenced herein. Mendelssohn (1982) reported that Louisiana barrier shorelines have poorly-developed dunes because of the limited volume if aeolian sand and the high frequency of storm overwash, stating that "Most of Louisiana's barrier islands and beaches have only one primary dune line which is relatively low in profile and only moderately vegetated." Ritchie and Penland (1989) studied coastal erosion and washover along the Caminada Headland and reached a number of relevant conclusions. The coastline is dominated by storm events, the vast majority being winter cold-fronts that elevate water level up to 3 feet on a cycle of 10 to 30 per year and produce waves as high as 9 feet. Tropical storms occur less frequently (~4 to 5 year interval) but elevate sea level from 6 feet to over 20 feet. While the coastal sediment is fine grained sand that can be readily formed into dunes by aeolian transport, the high frequency of overwash events prevents formation and stabilization of high dunes.

The average healthy marsh elevation is defined as the target elevation for the marsh platform, and is typically within +/- 0.1 feet of MHW. MHW for the Project area is approximately 1.6 feet NAVD and was defined as the design criteria for the marsh platform elevation. Marsh fill compaction (a combination of foundation settlement and fill consolidation) was compensated for in the design.

**USE OF EXISTING PROJECTS AND DESIGN WORK**

Previous experience of the State on constructing barrier island restoration projects such as Chaland Headland (CPE, 2003b), Holly Beach (CPE, 2000 and CPE 2003c), Timbalier Island, East Timbalier Island, East Grand Terre (CPE, 2005b), Pass La Mer to Grand Bayou Pass (CPE, 2004) was applied to the development of the report. Lessons learned during the ongoing design of other projects such as Pelican Island (CPE, 2003b), West Belle Pass Barrier Headland (CPE,

2010), West Grand Terre (CPE, 2003b) and Scofield Island (SJB & CEC, 2010) were also included.

Lessons learned from previous construction projects that have been discussed and included in the report include:

1. Beach construction slopes: The proposed construction slopes for the seaward and bayward beach slopes is considerably flatter than used elsewhere in the country. A 1V:45H slope for Shell Island was applied based on experience from the Holly Beach Sand Management Project (CS-01) (CPE, 2003).
2. Dune Elevations: The dune elevation is based on previous experience with barrier islands and the Wetland Value Assessment methodology. The environmentally preferred elevation for dune in Louisiana was determined to be approximately 6 feet, NAVD.
3. Inclusion of Marsh Consolidation Rates: Marsh consolidation rates used for Pelican Island Restoration Project (BA-38-1) and Chaland Headland Restoration Project (BA-38-2) were used to develop target marsh elevations and settlement curves. Lessons learned from previous projects also highlighted that a sand base may be needed to avoid excessive settlement of the marsh fill within the deepest section of Coupe Bob.
4. Primary Dike Construction: The construction of primary dikes (appropriate size and shape) was taken from previous barrier island restoration projects, including Chaland Headland Restoration and Pass La Mer to Grand Bayou Restoration. Placing the fill source within the marsh fill footprint was found to be beneficial at the Chaland Headland project from a performance perspective. Lastly, previous experience highlighted that a geotextile tube may be required for marsh containment along portions of the perimeter.
5. Dynamic Morphosedimentary Model (DMSM): The DMSM was developed by CPE based on observations from previous projects and the application of traditional coastal engineering principles. This model explains the high retreat rates of the Louisiana barrier islands and provides guidance on how to anticipate future shoreline retreat rates when the beach face has a higher sand percentage.
6. Sand Fencing: Previous projects have illustrated the benefit of constructing sand fence to increase barrier island elevation. However, during large storm events the dune built up against the sand fence does not appear to provide additional resistance against overtopping. Therefore, the benefit of sand fencing was excluded from the model and project performance analysis. Despite the previous statements, sand fencing is still considered beneficial from a short term environmental perspective.
7. Renourishment Rates: For Shell Island, renourishment rates were based on project performance criteria using a standard coastal engineering design approach recommended by the National Research Council of a design section and advanced fill section. Renourishment is proposed once the advanced fill is lost in order to protect the design section. A variety of renourishment intervals were evaluated to develop the most cost-effective interval of approximately 10 years. This agrees well with optimum renourishment intervals observed on beach nourishment projects around the country.
8. Based on multiple marsh creation projects it has been observed that tidal creeks, ponds, and pools naturally form due to the variability in settlement, compaction, consolidation, and borrow area sediment characteristics. Thus, marsh creation designs do not have to include

pre-excavation of such hydrological desired features. As an example, the created marsh for the Pass Chaland to Grand Bayou Pass Restoration Project (BA-35) construction in 2009 was not sculpted to facilitate tidal circulation (CEC, 2010). Based on recent observation, the marsh created for BA-35 is progressing as anticipated as the marsh fill continues to compact and settle to its target elevation.

9. Design of containment dike systems with access channel and floatation may be constrained by available equipment versus design criteria. As such the slope stability analysis should strive for minimal factors of safety. For example most local contractors use bucket dredges with a 100 to 120 foot maximum reach for dike construction. If overly conservative factors of safety are employed, this will increase costs significantly due to requirement of having to double handle the borrow sediments to construct the dikes.
10. Sand fencing should follow beach and dune construction as closely as possible to take advantage of wind and aeolian sand transport.

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## Annex 4: Water Quality Report

# CAMINADA HEADLANDS AND SHELL ISLAND RESTORATION PROJECTS

# WATER QUALITY ASSESSMENT REPORT

## LOUISIANA DEPARTMENT OF NATURAL RESOURCES CONTRACT NO. 2503-05-51

**MAY 2007**

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## EXECUTIVE SUMMARY

This project addresses the water quality assessment associated with the restoration of the Caminada Headland and Shell Island barrier island shoreline reaches of the Barataria Basin. The project area (see **Figure 1**) consisted of four potential borrow source areas and two restoration sites (Caminada Headlands and Shell Island). The three potential borrow source areas for the Shell Island restoration are the Empire borrow source, the Sandy Point borrow source, and the Mississippi River at Nairn borrow source area. The single potential borrow source area under consideration for the Caminada Headlands restoration is the South Pelto borrow source area, which is part of Ship Shoal.

Providence Engineering and Environmental Group LLC (Providence) divided data collection into two steps. The first step was the assimilation and evaluation of relevant existing data. The second step of the data collection process involved field collection and laboratory analyses of samples from each of the potential borrow areas and the restoration areas.

No existing sediment or elutriate data for the parameters designated for evaluation are available for the potential borrow areas or restoration sites. Due to the limited availability of existing, relevant data, all sites were determined to have insufficient data for adequate assessment, and it was concluded that site-specific sampling and laboratory analyses were necessary to obtain representative data for evaluation. Upon approval from the Louisiana Department of Natural Resources (LDNR), Providence developed a field sampling and laboratory analysis plan (S&A Plan) that addressed the additional data needs for the project.

The elutriate results generally indicate a potential for mobilization of metals from the sediments to the water column during the construction phase of these projects. For all of the metals, with the possible exception of mercury, the temporary increases in concentration do not represent adverse impacts to water quality and the aquatic environment when evaluated in the context of the potential for significant exceedances of the applicable numerical criteria of the Louisiana Surface Water Quality Standards (LA WQS) and/or United States Environmental Protection Agency's Section 304(a) criteria (USEPA WQC).

The overall assessment of the sediment sample results for samples collected from the two proposed restoration project areas and four potential borrow source areas is that no significant anthropogenic contamination is indicated that would have potential for long-term, adverse impacts to water quality or the aquatic environment in the vicinity of the project and potential borrow areas. As discussed in the comparison of elutriate results versus ambient water results in Section 2.3.2, there is a potential for mobilization of metals from the sediments to the water column during the construction phase of these projects, but the temporary increases in metals concentrations that are likely do not represent adverse impacts to water quality and the aquatic environment when evaluated in the context of the potential for significant exceedances of the applicable numerical criteria of the LA WQS and/or USEPA WQC. Potential for mobilization of mercury from sediments to result in more substantially elevated, but temporary, water column concentrations is more significant and may require further evaluation.

The increased concentrations of Total Suspended Solids (TSS), higher turbidity, potentially increased metals and mercury concentrations, and mobilization of nutrients from sediments would occur in close proximity to the construction activities with concentrations decreasing with distance away from the placement areas and borrow sources. The increased concentrations of TSS and turbidity would result in short-term disruption and some temporary displacement of aquatic communities in the restoration areas during the construction phase of the project.

Methods for mitigating impacts during construction should include best management practices for reducing sediment dispersion at the placement sites using temporary barriers to control placement and minimize migration from the placement sites. Methods to reduce sediment dispersion in open water areas (*i.e.* the borrow sources) resulting from construction activities may include silt/turbidity screens or other devices.

The proposed Caminada Headlands and Shell Island Restoration Projects are not expected to have long-term construction impacts on the project area. Short-term impacts to water quality and natural communities as noted are expected to occur during the construction phase of the project. Mitigation methods should be evaluated during the final design stage to reduce the construction impacts.

## 1.0 BACKGROUND

This project addresses the restoration of the Caminada Headland and Shell Island barrier island shoreline reaches of the Barataria Basin. These landforms are in need of restoration due to a combination of natural and anthropogenic forces. Subsidence—a natural phenomenon—has been exacerbated by a general sea level rise as well as a loss of replenishing sediments. Sediment loss can be attributed to natural cycles, dredging activities, and the channelization and levee system of the lower Mississippi River, which discharges the vast majority of its sediment off the continental shelf into deep water.

Restoration of these landforms will help protect and restore important habitats that are crucial to the viability of migratory birds, commercial and recreational fisheries, and a great variety of terrestrial and aquatic species. These landforms also contribute to maintenance of water quality in the region by reducing suspended sediment and nutrient loading in the aquatic environment. In addition, they reduce the impacts of flooding and storm surges on infrastructures in the coastal region, including highways, oil and gas production facilities, pipelines, and navigation features, such as ports and channels.

The project area (see **Figure 1**) consists of four potential borrow source areas and two restoration sites (Caminada Headlands and Shell Island). The three potential borrow source areas for the Shell Island Restoration are the Empire borrow source, the Sandy Point borrow source, and the Mississippi River at Nairn borrow source. The single potential borrow source for Caminada Headlands restoration is the South Pelto borrow source area, which is part of Ship Shoal.

Providence divided data collection into two steps. The first step was the compilation and evaluation of relevant existing data. Numerous federal and state agencies were contacted, as well as academic institutions. No existing sources of relevant data for the parameters designated for evaluation were discovered for the potential borrow source areas and restoration areas for this project. This is discussed in more detail in Section 2.1.

The second step of the data collection process involved sampling of both the potential borrow sources and the restoration areas. Field sampling and laboratory analyses of the water column, water bottom sediments, and sediment elutriate were undertaken at all sites to obtain quantitative data representative of the project area. Quantitative data have been used to assess the potential for environmental water quality impacts due to the proposed projects. Assessment of the potential for water quality impacts was based on the analysis of the data obtained through field sampling and laboratory analyses. Additional data collection through field sampling and laboratory analyses is discussed in more detail in Section 2.2.

## 2.0 WATER QUALITY DATA COLLECTION

### 2.1 Existing Water, Elutriate, and Sediment Quality Data

Providence compiled data for the four potential borrow source areas and the two restoration sites (Caminada Headlands and Shell Island). First, the availability of existing data (water quality, sediment, and elutriate data) was researched through a literature search and inquiries concerning relevant data availability made to various federal and state agencies.

The following sources were searched for data applicable to the borrow and restoration sites:

- U.S. Environmental Protection Agency (USEPA) STORET database and others
- U.S. Army Corps of Engineers (USACE)
- U.S. Department of the Interior (DOI)
  - Minerals Management Service (MMS)
  - U.S. Fish & Wildlife Service (USFWS)
  - U.S. Geological Survey (USGS)
- U. S. Department of Commerce
  - National Oceanic and Atmospheric Administration (NOAA)
  - National Marine Fisheries Service (NMFS)
- Louisiana Department of Natural Resources (LDNR)
- Louisiana Department of Environmental Quality (LDEQ)
- Louisiana Department of Wildlife and Fisheries (LDWF)
- Louisiana Universities Marine Consortium (LUMCON)
- University of New Orleans (UNO)
- Louisiana State University (LSU)
- Louisiana Department of Health and Hospitals (DHH)
- *Limnology and Oceanography* (scientific journal)

Parameters designated for evaluation for which water quality, elutriate, and sediment data were sought from the above sources include the following:

- Total suspended solids (TSS) and turbidity (ambient surface water)
- Total volatile solids and grain size distribution for sediments
- Total dissolved solids (TDS), salinity, and conductivity (ambient surface water and elutriate)
- pH (ambient surface water and elutriate)
- Metals - including but not necessarily limited to the USEPA/Clean Water Act (CWA) Section 307 priority pollutant metals (ambient water, elutriate, and sediments)
- Nitrate–nitrite nitrogen (ambient water, elutriate, and sediments)

- Total organic nitrogen (TON) and ammonia (ambient water, elutriate, and sediments)
- Total phosphorus, organic phosphorus, and orthophosphate (ambient water, elutriate, and sediments)
- Sulfides, sulfites, and sulfates (ambient water, elutriate, and sediments)
- Total organic carbon (TOC), particulate organic carbon (POC), and dissolved organic carbon (DOC) (ambient surface water and elutriate)
- Dissolved oxygen (DO) (ambient surface water)
- Environmentally-persistent and bioaccumulative toxic organic chemicals including, but not necessarily limited to, certain CWA Section 307 priority pollutant organic compounds (ambient water, elutriate, and sediments)

Generally, no sediment or elutriate data for the above parameters are available for the potential borrow source areas or restoration sites. **Table 1** provides a summary of available data from each agency or source investigated. The USACE maintains some sediment data for the Mississippi River. Salinity and dissolved oxygen water quality data are available through several sources for the potential borrow source areas and restoration areas. LDEQ maintains ambient water quality monitoring stations in the Gulf of Mexico south of Belle Pass (Station 0927) and at South Pass at head of passes (Station 1093). At the time of this report, the LDEQ data are unavailable.

## 2.2 Additional Data Collection

Due to the limited available relevant data, all sites were determined to have insufficient data for adequate assessment, and it was concluded that site-specific sampling and laboratory analyses would be required. Upon approval from the LDNR, Providence developed a field Sampling and Laboratory Analysis Plan (S&A Plan) that addressed the additional data needs for the project. A copy of the S&A Plan is included in **Appendix A**.

Composite samples were collected at each potential borrow source area and restoration area for laboratory analyses. The number of collection points (subsample collection locations) for each composite depended on the size of the area; however, at least three subsamples were collected at each potential borrow source and restoration area to make up composite samples. **Table 2** provides a summary of the sampling efforts at the borrow and restoration areas.

Water quality samples were collected within the water column. Sediment samples were collected from the surficial bed material (upper 15 centimeters or six inches) settled on the bottom of the water body (*i.e.*

Mississippi River or Gulf of Mexico) using a Petit Ponar™ bottom sampler. Additional sediment composite samples were collected for sediment elutriate analysis. The elutriate samples were prepared for analysis in the laboratory in accordance with the USACE standard procedures.

The elutriate test is a simplified simulation of the dredging and disposal process wherein predetermined amounts of dredging site water and sediment are mixed together to approximate a dredged material slurry. The test provides an indication of the chemical constituents likely to be released to the water column during dredging and deposition/filling operations. Sediment elutriate was prepared by the analytical laboratory for testing by thoroughly mixing one part (by volume) of sediment with four parts (by volume) of site water. Following the prescribed mixing, the water in the mixture was decanted and centrifuged to settle out the suspended solids. The elutriate water was then filtered or preserved (depending upon the required parameter) and analyzed.

### *2.2.1 Overview of Field Sampling and Analytical Requirements*

At each sampling site, *in situ* field measurements were made and recorded for pH, water temperature, conductivity, salinity, dissolved oxygen, and water depth. The field water quality parameters and monitoring methods are summarized on **Table 3**. Visual observations for the presence of any sheen of possible petrogenic origin (*i.e.* oil and grease) and weather conditions were made and recorded for each location. Field data were recorded at the time of sample collection on field data forms in a logbook. Specific field procedures are detailed in the S&A Plan (**Appendix A**).

Water, sediment, and elutriate samples collected from a sampling site are intended to be representative of that project site. For the purpose of this project, representative samples consisted of the following for each respective medium: (1) a composite sample comprised of a minimum of three grab "subsamples" collected at one-half the total depth of the water column (for ambient water analyses); (2) a composite sample comprised of a minimum of three grab subsamples of sediment (for whole sediment analyses); and (3) a composite sample comprised of a minimum of three grab subsamples of sediment and 16 liters of ambient site water (collected at mid-depth in the water column) for subsequent preparation of elutriate samples in the laboratory. Sample containers used for this program were provided by the contract analytical laboratory and certified as USEPA Level 1 cleaned containers.

Three different sampling events were required to successfully sample all required areas. These sampling events were conducted on February 8, 2006 (Sandy Point and Empire potential borrow source areas, and Shell Island Restoration Area); February 13, 2006 (Caminada Headlands Restoration Area and South Pelto potential borrow source area); and February 16, 2006 (Mississippi River potential borrow source areas).

The S&A Plan (**Appendix A**) was followed to the maximum extent practicable, with no significant deviations. All relevant field activities were noted on the "Field Sampling Information Form," copies of which Providence has maintained on file.

### *2.2.2 Overview of Laboratory Analytical Requirements*

Field personnel collected water quality, sediment, and elutriate samples using appropriate sampling methods and containers for laboratory analyses. The samples were delivered using appropriate chain-of-custody procedures and documentation to the designated contract laboratory for required analyses within the specified holding times. The analytical laboratory contracted for this project was Severn Trent Laboratories, Inc. (Severn Trent), which is certified under the Louisiana Environmental Laboratory Accreditation Program (LELAP). The laboratory analytical requirements for water and elutriate samples, including recommended USEPA-approved methods and required analytical method detection limits (MDLs), are summarized on **Table 4**. The laboratory analytical requirements for sediment samples, including recommended USEPA-approved methods and required analytical MDLs, are summarized on **Table 5**.

## 2.3 Data Assessment Summary

**Tables 6** and **7** present the laboratory analytical results for all of the ambient water and elutriate samples collected from the Caminada Headlands and Shell Island proposed project restoration areas and the four potential borrow source areas. In **Table 6**, the concentrations for metals in ambient waters are reported as dissolved metals concentrations. In **Table 7**, the concentrations for metals in elutriate samples are reported as total recoverable metal concentrations (total metals).

In **Tables 6** and **7**, the ambient water and elutriate analytical results for specific, potentially toxic substances are compared to (1) the corresponding numerical criteria established in the Louisiana Surface Water Quality Standards (LA WQS) as set forth in the Louisiana Administrative Code (LAC) at LAC 33:IX.1113.C.6, Table 1, or (2) the

USEPA's Section 304(a) criteria (USEPA WQC) for priority toxic pollutants (40 CFR 131.36) for those metals and organic compounds for which no numerical criteria have been promulgated in the LA WQS. For parameters that have LA WQS numerical criteria established, the LA WQS values are enforceable regulatory standards and have precedence over the corresponding USEPA WQC. The USEPA WQC, which have no regulatory standing applicable to waters of the State of Louisiana, are included in **Table 6** and **7** only for screening and comparison purposes. The USEPA WQC at 40 CFR 131.36 are established to apply as regulatory standards only in certain states whose water quality standards regulations do not comply with Section 303(a) of the Federal Clean Water Act (CWA). For states such as Louisiana that have established water quality standards regulations that are approved by the USEPA and are in compliance with CWA Section 303(a), the USEPA WQC are typically used as guidance or suggested criteria for those parameters for which the state has not yet promulgated numerical criteria into the state water quality standards regulations.

**Table 8** presents the laboratory analytical results for the sediment samples collected from the Caminada Headlands and Shell Island proposed project restoration areas and the four potential borrow source areas. To assess the collected sediment data, sediment analytical results are compared in **Table 8** to the respective marine sediment "threshold effects levels" (TELs) developed by the National Oceanographic and Atmospheric Administration (NOAA) and set forth in NOAA's Screening Quick Reference Tables[1] (SQuiRTs). The NOAA TELs are not regulatory standards. The TEL values are intended for screening purposes only to assess or predict potential for possible adverse environmental effects.

The SQuiRTs reference information states the following concerning the use and interpretation of sediment data compared with the SQuiRT TEL values.

- "Screening with conservative lower-threshold values (*e.g.,* TELs) ensures, with a high degree of confidence, that any contaminant sources eliminated from future consideration pose no potential threat. Conversely, it does not necessarily predict toxicity."

- "The TEL is calculated as the geometric mean of the lower 15$^{th}$ percentile concentration of the toxic effects data set; as such, it represents the concentration below which adverse effects are expected to occur only rarely."

[1] Buchman, M. F., 1999. NOAA Screening Quick Reference Tables, NOAA, HAZMAT Report 99-1, Seattle, WA, Coastal Protection and Restoration Division, National Oceanic and Atmospheric Administration, 12 pages.

In using the TEL values, Providence has interpreted a TEL value for a given contaminant to be the lower threshold concentration at which adverse effects may be measurable using bioassay techniques and appropriate test organisms. The sediment analytical results presented in **Table 8** indicate that the observed sediment concentrations are less than the respective TELs for all potential contaminant parameters evaluated for which TELs have been developed by NOAA.

Additionally, sediment analytical results are also compared in **Table 8** to the LDEQ's Risk Evaluation/Corrective Action Program[2] (RECAP) Limiting Soil Screening Standards (LSS) applied, which values are the lower of either the respective Soil Protective of Groundwater Screening Standards ($Soil_{SSGW}$) or the respective Industrial Soil Screening Standards ($Soil_{SSI}$) provided in Table 1 of RECAP 2003. The LDEQ does apply the LSS when screening potentially contaminated sediments for projects and at sites under their regulatory jurisdiction. All the observed sediment concentrations are less than the respective LSS for all potential contaminant parameters evaluated.

### *2.3.1 Ambient Water Analytical Results*

As shown on **Table 6,** the "priority pollutant" volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), chlorinated pesticides (insecticides or herbicides), and polychlorinated biphenyls (PCBs) were not present at or above the respective analytical MDLs in the ambient water samples collected from the Caminada Headlands and Shell Island proposed project restoration areas and the four potential borrow source areas. One exception was a reported concentration of 16 micrograms per liter (µg/L or parts per billion) for the SVOC, bis(2-chloroethoxy)methane, in the Sandy 01 sample collected in the water column at the Sandy Point borrow source area. There is no plausible explanation for this result nor is there a known source for this compound at this location in open waters of the Gulf of Mexico. Bis(2-chloroethoxy)methane was not detected in the other water sample, Sandy 02, from this potential borrow area. The analytical result of 16 µg/L for bis(2-chloroethoxy)methane in the Sandy 01 water sample is considered anomalous.

Certain metals, analyzed as the dissolved fractions, were detected at low concentrations in ambient water samples, including arsenic, beryllium, cadmium, copper, mercury, nickel, thallium, and zinc.

[2] LDEQ, 2003. *Louisiana Department of Environment Quality Risk Evaluation/Corrective Action Program (RECAP)*, version dated October 20, 2003 adopted pursuant to LAC Title 33, Part I, Chapter 13.

Dissolved arsenic was detected in samples from the marine locations (Caminada Headlands and Shell Island proposed project restoration areas, and the Empire, Sandy Point, and South Pelto potential borrow source areas) at concentrations ranging from 1.4 µg/L to 1.8 µg/L. This range of arsenic concentrations is less than the marine numerical criteria for protection of aquatic life (acute toxicity criterion of 69 µg/L and chronic toxicity criterion of 36 µg/L) established for arsenic in the LA WQS[3]. The ambient water sample (MS RIV01) from the Mississippi River borrow source area exhibited a dissolved arsenic concentration of 1.1 µg/L, which is less than the freshwater numerical criteria (acute toxicity criterion of 339.8 µg/L and chronic toxicity criterion of 150 µg/L) established for arsenic in the LA WQS. The LA WQS numerical criterion for protection of human health against potential toxicity associated with consumption of drinking water and aquatic organisms is 50 µg/L for waters designated for public water supply. No arsenic numerical criterion for protection of human health against potential toxicity associated with consumption of aquatic organisms only (applicable to marine waters and freshwaters not designated for public water supply) has been established in the LA WQS. The USEPA WQC suggested arsenic numerical criterion for protection of human health (consumption of aquatic organisms only) is 0.14 µg/L. At this writing, the LDEQ has not accepted the USEPA WQC suggested numerical criterion for protection of human health (consumption of aquatic organisms only).

Dissolved beryllium was detected in only one ambient water sample (Shell 01 from the Shell Island restoration area) at 0.16 µg/L. This value is only marginally above the MDL of 0.15 µg/L for beryllium. Dissolved cadmium was detected in ambient water samples from three locations and only marginally above the MDL (0.1 µg/L) for cadmium. Concentrations of 0.17 µg/L (at the MDL), 0.11 µg/L, and 0.1 µg/L, respectively, were reported for the samples from the Shell Island restoration area (Shell 01), South Pelto potential borrow source area (SPELTO 01), and from the Empire potential borrow source area (Empire 01). No numerical criteria for beryllium are established by either the LA WQS or USEPA WQC. The concentrations reported for cadmium are less than the LA WQS marine numerical criteria for protection of aquatic life established for cadmium (acute toxicity criterion of 45.35 µg/L and chronic toxicity criterion of 10.0 µg/L). The LA WQS cadmium numerical

[3] The numerical criteria established by the LA WQS for all metals are expressed as dissolved metal concentrations (LAC 33:IX.1113.C.6.d). The USEPA WQC numerical criteria for metals are also expressed as dissolved metals concentrations, except for antimony, beryllium, thallium, and the aquatic life protection criteria (only) for selenium, which are expressed as total recoverable metal concentrations [40 CFR 131.36(c)(4)(iii)].

criterion for protection of human health (consumption of drinking water and aquatic organisms) is 10.0 µg/L in freshwaters designated as public water supply. Neither the LA WQS nor the USEPA WQC establish cadmium numerical criteria for protection of human health applicable to marine waters. The reported concentrations for beryllium and cadmium are considered unremarkable and do not indicate anthropogenic contamination.

Dissolved copper was reported in samples from all of the ambient water sampling locations at concentrations ranging from 0.50 µg/L to 2.2 µg/L, all of which are less than the LA WQS marine numerical criteria for protection of aquatic life established for copper (acute toxicity criterion and chronic toxicity criterion are both 3.63 µg/L). For copper, the LA WQS freshwater (hardness dependent) numerical criteria for protection of aquatic life calculated for the Mississippi River are 27.6 µg/L (acute criterion) and 17.7 µg/L (chronic criterion). Neither the LA WQS nor the USEPA WQC establish copper numerical criteria for protection of human health applicable to marine waters. The LA WQS numerical criterion for protection of human health in freshwaters designated for public water supply is 1.0 milligram per liter (mg/L) or 1,000 µg/L.

Dissolved mercury[4] (as inorganic mercury not methylmercury) was detected at only one ambient water sampling location, the Mississippi River borrow source area (sample number MS Riv 01), at a concentration of 0.000093 mg/L or 0.093 µg/L. The detected concentration of mercury is less than both the LA WQS freshwater and marine numerical criteria for mercury established for the protection of aquatic life against acute toxicity (freshwater acute criterion of 2.04 µg/L and marine acute criterion of 2.0 µg/L). However, the detected concentration for mercury exceeds both the LA WQS freshwater and marine numerical criteria for mercury established for the protection of aquatic life against chronic toxicity (freshwater chronic criterion of 0.012 µg/L and marine chronic criterion of 0.025 µg/L).
The LDEQ has recognized an issue with dissolved mercury concentrations in a number of watersheds in Louisiana, including coastal waters. As a result, the LDEQ included a number of water bodies throughout Louisiana on the state's list of impaired water

[4] The analyses for mercury were performed using USEPA Method 245.1 (water and elutriate) and USEPA Method 7471A (sediments) the results from which include inorganic mercury and mercury oxidized to ionic mercury from organomercury compounds such as methylmercury. The analytical concentration results for mercury in any medium (water, elutriate, or sediment) evaluated in this report should not be construed to be equivalent to concentrations of methylmercury but may include mercury oxidized from methylmercury if present in the sample medium.

bodies that is required pursuant to Section 303(d) of the CWA. The many mercury total maximum daily load (TMDL) reports prepared to date not only for Louisiana but also for other states in the eastern United States have indicated that by far the primary source of mercury entering the aquatic environment is atmospheric deposition and resulting storm water runoff. The USEPA has estimated that from 98.5% to greater than 99% of the mercury mass loading to aquatic systems in the southeastern United States, is from atmospheric dispersion and deposition[5].

In June 2005, a TMDL for mercury in fish tissue for coastal bays and gulf waters of Louisiana[6] was prepared for the LDEQ and USEPA. The report included the project area comprised of the Terrebonne River Basin Coastal Bays (Coastal Segment 120806) and Barataria Basin Coastal Bays (Coastal Segment 021102).The TMDL report identifies atmospheric deposition as the primary source of mercury and notes that likely avenues of input to coastal areas, besides direct deposition, include rivers, storm water runoff, and release from sediments. There are no known point-source wastewater discharges of mercury in the vicinity of the Mississippi River borrow source area.

Dissolved nickel was reported in samples collected at each of the ambient water sampling locations, except the Mississippi River borrow source area, at concentrations ranging from 0.57 µg/L to 1.5 µg/L, all of which are less than the LA WQS marine numerical criteria for protection of aquatic life established for nickel (acute toxicity criterion of 74 µg/L and chronic toxicity criterion of 8.2 µg/L). No nickel numerical criteria for protection of human health are established by the LA WQS. The USEPA WQC marine (saltwater) numerical criterion for protection of human health established for nickel is 4,600 µg/L.

Dissolved thallium was detected at low concentrations in the ambient water samples collected from the Shell Island restoration area (Shell 01) and the Mississippi River borrow source area (MS Riv 01). The concentrations detected (0.39 µg/L in Shell 01 and 0.31 µg/L in MS Riv 01) are only marginally higher than the MDL of 0.25 µg/L for thallium. The reported thallium concentrations are well

[5] Schurtz, M.H. and P. A. Guelfo, 2001. "A Comparative Analysis of Technical Approaches for Mercury TMDL Development." Presentation at the National Petrochemical and Refiners Association 9th Annual Environmental Conference, September 2001, Austin, Texas.

[6] Frederick, January, 2005. *TMDLs for Mercury in Fish Tissue for Coastal Bays and Gulf of Mexico Waters of Louisiana*. Prepared by Parsons for the USEPA, Region 6, Dallas, Texas and the Office of Environmental Assessment, LDEQ, Contract No. 68-C-02-111.

less than the USEPA WQC marine water numerical criterion (6.3 µg/L) for protection of human health (consumption of aquatic organisms). Neither the LA WQS nor the USEPA WQC establish thallium numerical criteria for the protection of aquatic life. The reported concentrations for thallium are unremarkable and do not indicate contamination.

Dissolved zinc was detected in samples from all of the ambient water sampling locations at concentrations ranging from 4.7 µg/L (MS Riv 01) to 16 µg/L (Shell 01 and Empire 01). The concentration range for the marine locations (13 µg/L to 16 µg/L) is less than the LA WQS marine numerical criteria for protection of aquatic life established for zinc (acute toxicity criterion of 90 µg/L and chronic toxicity criterion of 81 µg/L). The concentration of 4.7 µg/L reported for the ambient water sample from the Mississippi River borrow source area (MS Riv 01) is less than the LA WQS freshwater (hardness dependent) numerical criteria for protection of aquatic life calculated for zinc applicable to the Mississippi River: 164.7 µg/L (acute criterion) and 150.4 µg/L (chronic criterion). The zinc concentration at the Mississippi River borrow source area is less than the LA WQS numerical criterion of 5.0 µg/L for protection of human health (consumption of drinking water and organisms).

The laboratory analytical reports for the ambient surface water samples collected are provided in **Appendices B, C, and D.**

### *2.3.2 Elutriate Analytical Results*

As shown on **Table 7,** the "priority pollutant" VOCs, SVOCs, chlorinated pesticides (insecticides or herbicides), and PCBs were not present at or above the respective analytical MDLs in the elutriate water samples collected from the Caminada Headlands and Shell Island proposed project restoration areas and the four potential borrow source areas. Two exceptions were reported, methylene chloride and bis(2-ethylhexyl)phthalate. Concentrations of the VOC methylene chloride were reported in samples collected at Caminada Headlands proposed project restoration area (CH 02), the Shell Island proposed restoration area (Shell 01), the Sandy Point borrow source area (Sandy 01 and Sandy 02), and the South Pelto borrow source area (SPELTO 01), ranging from 2.4 µg/L to 14 µg/L. A concentration of 4.7 µg/L for the SVOC, bis(2-ethylhexyl)phthalate, was reported in the CH 01 sample collected at the Caminada Headlands restoration area. There are no known sources for these compounds in the vicinity of these locations. Although methylene chloride was detected in samples from five separate locations, the presence of this compound at the

concentrations reported is believed to be from laboratory contamination. Methylene chloride was not detected in the ambient water samples or sediment samples collected from these locations. Methylene chloride is a common solvent used in environmental laboratories for the extraction of SVOCs. The reported results are considered to be laboratory analytical artifacts. Bis(2-ethylhexyl) phthalate was not detected in any other elutriate samples and was not detected in the ambient water sample or the sediment sample collected from the Caminada Headlands restoration area. The analytical result of 4.7 µg/L in the CH 01 elutriate sample is considered to be a sampling artifact. The various phthalate esters listed by the USEPA as "priority pollutants" are used as plasticizers in many plastic products and are common environmental sample artifact contaminants.

Certain metals, analyzed as total recoverable metals (total metals), were detected at low concentrations in elutriate samples, including arsenic, beryllium, cadmium, chromium, copper, lead, nickel, selenium, thallium, zinc, and mercury.

Total arsenic concentrations were reported for the elutriate samples from all locations at levels ranging from 1.5 µg/L to 7.8 µg/L. This range of arsenic concentrations is less than the marine numerical criteria for protection of aquatic life (acute toxicity criterion of 69 µg/L and chronic toxicity criterion of 36 µg/L) and less than the freshwater numerical criteria (acute toxicity criterion of 339.8 µg/L and chronic toxicity criterion of 150 µg/L) established for arsenic in the LA WQS[7]. The LA WQS freshwater numerical criterion for protection of human health (consumption of drinking water and aquatic organisms) is 50 µg/L for waters designated for public water supply. No arsenic numerical criterion for protection of human health (consumption of aquatic organisms only) has been established in the LA WQS. However, the USEPA WQC suggested arsenic numerical criterion for protection of human health (consumption of aquatic organisms only) is 0.14 µg/L. At this writing, the LDEQ has not accepted the USEPA WQC suggested

[7]It is again noted that the numerical criteria for all metals established by the LA WQS and most of the numerical criteria of the USEPA WQC are expressed as dissolved metal concentrations, except for antimony, beryllium, thallium, and the aquatic life protection criteria (only) for selenium, which are expressed as total recoverable metal concentrations [LAC 33:IX.1113.C.6.d and 40 CFR 131.36(c)(4)(iii), respectively]. Metals concentrations in the elutriate samples were analyzed and reported as total metals. The comparison of metals concentrations reported as total metals with the LA WQS and the USEPA WQC numerical criteria, which apply to dissolved metals concentrations, is conservative since only a portion of the total concentration reported for a metal is actually dissolved. Total metal analyses were performed on elutriate samples to provide data for evaluation of the significance of the metals fractions adsorbed to suspended sediment. The total metals concentration results include both the metals fractions adsorbed to sediments and other particulates and the dissolved fractions.

numerical criterion for protection of human health (consumption of aquatic organisms).

A total beryllium concentration was reported for only one elutriate sample (MS Riv 01 from the Mississippi River potential borrow source) at 1.0 µg/L. This value is only marginally above the MDL of 0.6 µg/L for beryllium. Total cadmium concentrations were reported for the elutriate samples from five locations, which ranged from 0.12 µg/L to 0.43 µg/L for the samples from the Shell Island restoration area (Shell 01 and Shell 02), Empire potential borrow source area (Empire 01), Sandy Point potential borrow source (Sandy 01), and Mississippi River potential borrow source (MS Riv 01). No numerical criteria for beryllium are established by either the LA WQS or USEPA WQC. The concentrations reported for cadmium are less than the LA WQS marine numerical criteria for protection of aquatic life established for cadmium (acute toxicity criterion of 45.35 µg/L and chronic toxicity criterion of 10.0 µg/L) and less than the LA WQS freshwater (hardness dependent) numerical criteria (acute toxicity criterion of 50.7 µg/L and chronic toxicity criterion of 1.42 µg/L) calculated for cadmium as applicable to the Mississippi River. The concentrations reported for cadmium are less than the LA WQS drinking water supply numerical criteria for protection of human health (10 µg/L) as applicable to the Mississippi River. Neither the LA WQS nor the USEPA WQC establish cadmium numerical criteria for protection of human health applicable to marine waters. The reported concentrations for beryllium and cadmium in elutriate samples are unremarkable and do not indicate contamination.

Total chromium concentrations were reported for the elutriate samples from six sample locations including the Shell Island restoration area (samples Shell 01 and Shell 02), the Empire potential borrow source (Empire 01), the Mississippi River potential borrow source (MS Riv 01), and the Sandy Point potential borrow source (samples Sandy 01 and Sandy 02). The concentrations detected ranged from 2.1 µg/L (Empire 01) to 23 µg/L (MS Riv 01). All of the elutriate sample concentrations for chromium are less than the LA WQS marine numerical criteria for protection of aquatic life established for chromium (acute toxicity criterion of 515 µg/L and chronic toxicity criterion of 103 µg/L) and less than the LA WQS freshwater (hardness dependent) numerical criteria for protection of aquatic life (acute toxicity criterion of 780.3 µg/L and chronic toxicity criterion of 253.1 µg/L) calculated for chromium as applicable to the Mississippi River. The concentrations reported for chromium are less than the LA WQS drinking water supply

numerical criteria for protection of human health (50 µg/L) as applicable to the Mississippi River.

Total copper concentrations were reported for the elutriate samples from all sampling locations at levels ranging from 0.94 µg/L to 19 µg/L. The copper concentrations in the elutriate samples from all of the marine locations are less than the LA WQS marine numerical criteria numerical criteria for protection of aquatic life established for copper (acute toxicity criterion and chronic toxicity criterion are both 3.63 µg/L). The elutriate concentration of 19 µg/L reported for the sample from the Mississippi River potential borrow source area is less than the LA WQS freshwater (hardness dependent) acute toxicity numerical criteria for protection of aquatic life of 27.6 µg/L calculated for the Mississippi River, but exceeds the LA WQS freshwater (hardness dependent) chronic toxicity numerical criterion for protection of aquatic life of 17.7 µg/L calculated for the Mississippi River. It is noted that the comparison of the elutriate results reported as total copper concentrations with the LA WQS numerical criteria for copper, which are expressed as dissolved concentrations, is conservative. Neither the LA WQS nor the USEPA WQC establish copper numerical criteria for protection of human health applicable to marine waters. The LA WQS numerical criterion for protection of human health in freshwaters designated for public water supply is 1.0 milligram per liter (mg/L) or 1,000 µg/L.

Total lead concentrations were reported for the elutriate samples from all sampling locations with the exception of the South Pelto potential borrow source area. The reported concentrations ranged from 0.51 µg/L to 19 µg/L. The lead concentrations in the elutriate samples from all of the marine locations are less than the LA WQS marine numerical criteria numerical criteria for protection of aquatic life established for lead acute toxicity criterion of 209 µg/L and chronic toxicity criterion of 8.08 µg/L. The elutriate concentration of 19 µg/L reported for the sample from the Mississippi River potential borrow source area is less than the LA WQS freshwater (hardness dependent) acute toxicity numerical criteria for protection of aquatic life of 102.8 µg/L calculated for the Mississippi River, but exceeds the LA WQS freshwater (hardness dependent) chronic toxicity numerical criterion for protection of aquatic life of 4.00 µg/L calculated for the Mississippi River. Again, it is noted that the comparison of the elutriate results reported as total lead concentrations with the LA WQS numerical criteria for lead, which are expressed as dissolved concentrations, is conservative. The LA WQS do not establish a numerical criterion for lead for the protection of human health (consumption of aquatic organisms

only) applicable to marine waters; however, the LA WQS numerical criterion for protection of human health (consumption of drinking water and aquatic organisms) for freshwaters designated for public water supply is 50.0 µg/L.

Total mercury concentrations were reported for the elutriate samples from three locations: two locations at the Caminada Headlands restoration area (CH 01 and CH 02) and one location at the South Pelto potential borrow source area (SPELTO 01). The elutriate sample concentrations of mercury range from 0.18 µg/L to 0.24 µg/L. The detected concentrations of mercury are less than both the LA WQS marine numerical criteria for mercury established for the protection of aquatic life against acute toxicity (acute criterion of 2.0 µg/L). However, the detected concentrations for mercury exceed the LA WQS marine numerical criterion for mercury established for the protection of aquatic life against chronic toxicity (marine chronic criterion of 0.025 µg/L).

Total nickel concentrations were reported for the elutriate samples from all sampling locations, with the levels ranging from 1.0 µg/L to 7.2 µg/L at the marine locations. A concentration of 22 µg/L was reported for the Mississippi River potential borrow source area. All of the reported concentrations for the marine locations are less than the LA WQS marine acute numerical criteria for protection of aquatic life established for nickel (acute toxicity criterion of 74 µg/L and chronic toxicity criterion of 8.2 µg/L). The nickel concentration of 22 µg/L for the Mississippi River potential borrow source elutriate sample is less than the LA WQS freshwater (hardness dependent) numerical criteria for protection of aquatic life (acute toxicity criterion of 2,036 µg/L and chronic toxicity criterion of 226.1 µg/L) calculated for nickel as applicable to the Mississippi River. No nickel numerical criteria for protection of human health are established by the LA WQS. The USEPA WQC marine (saltwater) numerical criterion for protection of human health established for nickel is 4,600 µg/L, and the freshwater numerical criterion for protection of human health (consumption of drinking water and aquatic organisms) is 610 µg/L for water bodies designated as a public water supply (*e.g.,* the Mississippi River).

Total selenium was reported at a low concentration in one elutriate sample collected from the Shell Island restoration area (Shell 01). The concentration reported (2.3 µg/L) is only marginally higher than the MDL of 2.0 µg/L for selenium. No numerical criteria (for either aquatic life or human health protection) are established for selenium in the LA WQS. The USEPA WQC marine (saltwater) numerical criteria for the protection of aquatic life are 290 µg/L

(acute toxicity criterion) and 71 µg/L (chronic toxicity criterion). The USEPA WQC do not establish selenium numerical criteria for protection of human health. The reported concentration for selenium is unremarkable and does not indicate contamination.

Total thallium concentrations were reported in the two elutriate samples collected from the Sandy Point potential borrow source (Sandy 01 and Sandy 02). The low concentrations detected (0.46 µg/L in Sandy 01 and 0.35 µg/L in Sandy 02) are only marginally higher than the MDL of 0.25 µg/L for thallium. The reported thallium concentrations are less than the USEPA WQC marine (saltwater) numerical criterion of 6.3 µg/L for protection of human health (consumption of aquatic organisms only). Neither the LA WQS nor the USEPA WQC establish thallium numerical criteria for the protection of aquatic life. The reported concentrations for thallium are unremarkable and do not indicate contamination.

Total zinc concentrations were reported in elutriate samples from all locations monitored at concentrations ranging from 15 µg/L at several locations to 72 µg/L (MS Riv 01). The concentration range (15 µg/L to 39 µg/L) for the marine locations is less than the LA WQS marine numerical criteria for protection of aquatic life established for zinc (acute toxicity criterion of 90 µg/L and chronic toxicity criterion of 81 µg/L). The concentration of 72 µg/L reported for the elutriate sample from the Mississippi River borrow source area is less than the LA WQS freshwater (hardness dependent) numerical criteria for protection of aquatic life calculated for zinc applicable to the Mississippi River: 164.7 µg/L (acute criterion) and 150.4 µg/L (chronic criterion). The zinc concentration reported for the elutriate sample from the Mississippi River borrow source area exceeds the LA WQS freshwater numerical criterion of 5.0 µg/L for protection of human health (consumption of drinking water and organisms).

The table below summarizes the analytical results for the metals concentrations in the elutriate samples in comparison with the ambient water analytical results. Generally, the elutriate concentrations are somewhat higher than the corresponding ambient water concentrations for a given location. The differences in concentrations may be a reflection of the difference in the analytical basis of total metals concentrations in elutriate samples versus dissolved fraction concentrations only for the ambient water samples. However, the results for the Mississippi River potential borrow source area (MS Riv 01) indicate a more substantial difference between elutriate concentrations and ambient water concentrations for beryllium, cadmium, chromium, copper, lead,

nickel, and zinc. This observation may reflect a higher potential for mobilization of these metals from sediments to freshwater. The comparison of elutriate samples versus ambient water sample concentrations for these metals at the marine locations (brackish waters exhibiting salinities distinctly higher than freshwater) does not indicate an increase of comparable magnitude in concentration in elutriate versus ambient water.

With regard to mercury, a more substantial (an order of magnitude) increase in concentration is indicated for both samples from the Caminada Headlands restoration area (CH 01 and CH 02) and one of the samples (SPELTO 01) from the South Pelto potential borrow source area, but an increase in mercury concentration from ambient to elutriate is not indicated for the freshwater of the Mississippi River (MS Riv 01).

| Metals (µg/L) | CH 01 | CH 02 | Shell 01 | Shell 02 | Empire 01 | MSRiv 01 | Sandy 01 | Sandy 02 | SPELTO 01 | SPELTO 02 |
|---|---|---|---|---|---|---|---|---|---|---|
| Arsenic (1) | 1.4 | NS | 1.8 | NS | 1.7 | 1.1 | 1.7 | NS | 1.7 | NS |
| Arsenic (2) | 5.6 | 3.6 | 6 | 3.5 | 2.1 | 7.8 | 3.2 | 2.3 | 1.5 | 2.1 |
| Beryllium (1) | <0.15 | NS | 0.16 | NS | <0.15 | <0.15 | <0.15 | NS | <0.15 | NS |
| Beryllium (2) | <0.6 | <0.6 | <0.6 | <0.6 | <0.6 | 1. | <0.6 | <0.6 | <0.6 | <0.6 |
| Cadmium (1) | <0.1 | NS | 0.17 | NS | 0.1 | <0.1 | <0.1 | NS | 0.11 | NS |
| Cadmium (2) | <0.1 | <0.1 | 0.18 | 0.12 | 0.14 | 0.43 | 0.2 | <0.1 | <0.1 | <0.1 |
| Chromium (1) | <1.5 | NS | <1.5 | NS | <1.5 | <1.5 | <1.5 | NS | <1.5 | NS |
| Chromium(2) | <1.5 | <1.5 | 4.7 | 3.2 | 2.1 | 23 | 5.1 | 3.3 | <1.5 | <1.5 |
| Copper (1) | 0.69 | NS | 1.3 | NS | 0.54 | 2.2 | 0.5 | NS | 0.9 | NS |
| Copper (2) | 0.99 | 1.5 | 2.3 | 2.1 | 1.6 | 19 | 3.4 | 3 | 1 | 0.94 |
| Lead (1) | <0.5 | NS | <0.5 | NS | <0.5 | <0.5 | <0.5 | NS | <0.5 | NS |
| Lead (2) | 0.72 | 0.85 | 1.7 | 3.7 | 0.51 | 19 | 1.9 | 1.4 | <0.5 | <0.5 |
| Mercury (1) | <0.078 | NS | <0.078 | NS | <0.078 | 0.093 | <0.078 | NS | <0.078 | NS |
| Mercury(2) | 0.19 | 0.18 | <0.078 | <0.078 | <0.078 | <0.078 | <0.078 | <0.078 | 0.24 | <0.078 |
| Nickel (1) | 1.3 | NS | 1.5 | NS | 0.99 | <0.15 | 0.57 | NS | 0.94 | NS |
| Nickel (2) | 1.6 | 2.4 | 2.9 | 7.2 | 2.5 | 22 | 4.5 | 3.7 | 1.1 | 1 |
| Selenium (1) | <2 | NS | <2 | NS | <2 | <2 | <2 | NS | <2 | NS |
| Selenium (2) | <2 | <2 | 2.3 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Thallium (1) | <0.25 | NS | 0.39 | NS | <0.25 | <0.25 | 0.31 | NS | <0.25 | NS |
| Thallium (2) | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | 0.46 | 0.35 | <0.25 | <0.25 |
| Zinc (1) | 13 | NS | 15 | NS | 16 | 4.7 | 14 | NS | 15 | NS |
| Zinc (2) | 15 | 17 | 23 | 32 | 17 | 72 | 15 | 15 | 39 | 15 |

(1) ambient water result
(2) elutriate result
NS – not sampled

Although the elutriate results generally indicate a potential for mobilization of metals from the sediments to the water column during the construction phase of these projects, for all of the metals, with the possible exception of mercury, the temporary increases in concentration do not represent adverse impacts to water quality and the aquatic environment when evaluated in the context of the potential for significant exceedances of the applicable numerical criteria of the LA WQS and/or USEPA WQC.

The laboratory analytical reports for the elutriate samples collected are provided in **Appendices B, C, and D.**

### *2.3.3 Sediment Analytical Results*

As shown on **Table 8,** the "priority pollutant" VOCs, chlorinated pesticides (insecticides or herbicides), and PCBs were not present at or above the respective analytical MDLs in the sediment samples collected from the Caminada Headlands and Shell Island proposed project restoration areas and the four potential borrow source areas.

Generally, the SVOCs analyzed in samples from the restoration and potential borrow areas were not present at or above the respective analytical MDLs in the sediment samples. Certain exceptions are discussed below.

The polycyclic aromatic hydrocarbon (PAH), pyrene, was reported at concentrations of 2.7 micrograms per kilogram (µg/Kg or parts per billion) in one of the sediment samples from the Caminada Headlands restoration area (CH 01), 2.1 µg/Kg in one of the sediment samples from the Shell Island restoration area (Shell 01), and 2.8 µg/Kg in one of the sediment samples from the Sandy Point potential borrow source area (Sandy 01). The PAH fluoranthene was reported at a concentration of 2.2 µg/Kg in one of the samples from the Sandy Point potential borrow source area (Sandy 01). The detected concentrations of pyrene and fluoranthene are only marginally above the respective MDLs in the sediment samples from the above sites. The detected concentrations of pyrene and fluoranthene in sediment samples from the above locations are less than the respective NOAA TELs for these compounds.

The sediment composite sample from the Mississippi River potential borrow source area (MS Riv 01) exhibited detectable levels of the following PAHs at the concentrations noted below.

- benzo[b]fluoranthene – 66 µg/Kg
- benzo[g,h,i]perylene – 34 µg/Kg
- benzo[k]fluoranthene – 19 µg/Kg
- chrysene – 80 µg/Kg
- fluoranthene – 83 µg/Kg
- fluorene – 6.4 µg/Kg
- indeno[1,2,3-cd]pyrene – 26 µg/Kg
- naphthalene – 8.8 µg/Kg
- phenanthrene – 47 µg/Kg
- pyrene - 94 µg/Kg

In addition, six other SVOCs were reported in the sediment sample from the Mississippi River potential borrow source area (MS Riv 01). These compounds and their respective concentrations are listed below.

- hexachlorobenzene – 15 µg/Kg
- hexachlorobutadiene – 12 µg/Kg
- hexachlororcyclopentadiene – 10 µg/Kg
- hexachloroethane – 13 µg/Kg
- isophorone – 15 µg/Kg
- nitrobenzene – 12 µg/Kg

None of the SVOC concentrations detected in the sediments from the Mississippi River potential borrow source area are above the respective NOAA TELs (if established) or the LDEQ RECAP LSS.

Certain metals, analyzed as total metals and reported in milligrams per kilogram (mg/Kg or parts per million), were detected at low concentrations in sediment samples, including arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, and zinc.

Arsenic was detected in the sediment samples from all locations at concentrations ranging from 1.9 mg/Kg (Shell 02 and SPELTO 01) to 5.5 mg/Kg (MS Riv 01). This range of arsenic concentrations is less than the NOAA TEL (7.24 mg/Kg) and LDEQ RECAP LSS concentration (12 mg/Kg).

Beryllium was detected in the sediment samples at all locations at concentrations ranging from 0.083 mg/Kg (SPELTO 01) to 0.56 mg/Kg (MS Riv 01). This range of beryllium concentrations is less than the LDEQ RECAP LSS concentration (8 mg/Kg). NOAA has not established a TEL value in for beryllium.

Cadmium was detected in all of the sediment samples with the exception of the samples from the South Pelto potential borrow source (SPELTO 01 and SPELTO 02). The concentrations ranged from 0.028 mg/Kg (Shell 02) to 0.39 mg/Kg (MS Riv 01). This range of cadmium concentrations is less than the NOAA TEL (0.676 mg/Kg) and LDEQ RECAP LSS concentration (3.9 mg/Kg).

Chromium was detected in the sediment samples at all locations at concentrations ranging from 3.2 mg/Kg (SPELTO 01) to 15 mg/Kg (MS Riv 01). This range of chromium concentrations is less than the NOAA TEL (52.30 mg/Kg) and LDEQ RECAP LSS concentration (23 mg/Kg).

Copper was detected in the sediment samples at all locations at concentrations ranging from 0.72 mg/Kg (SPELTO 01) to 12 mg/Kg (MS Riv 01). This range of copper concentrations is less than the NOAA TEL (18.70 mg/Kg) and LDEQ RECAP LSS concentration (310 mg/Kg).

Lead was detected in the sediment samples at all locations at concentrations ranging from 1.8 mg/Kg (SPELTO 01) to 15 mg/Kg (MS Riv 01). This range of lead concentrations is less than the NOAA TEL (30.24 mg/Kg) and LDEQ RECAP LSS concentration (100 mg/Kg).

Concentrations of mercury were detected in the sediment samples at all locations with the exception of SPELTO 01. The mercury concentrations ranged from 0.0089 mg/Kg (SPELTO 02) to 0.041 mg/Kg (MS Riv 01). This range of mercury concentrations is less than the NOAA TEL (0.130 mg/Kg) and LDEQ RECAP LSS concentration (2.3 mg/Kg).

Nickel was detected in the sediment samples at all locations at concentrations ranging from 4.2 mg/Kg (SPELTO 01) to 16 mg/Kg (MS Riv 01). With the exception of the MS Riv 01 sediment concentration of 16 mg/Kg, the range of nickel concentrations is less than the NOAA TEL (15.90 mg/Kg) and LDEQ RECAP LSS concentration (160 mg/Kg).

Selenium was detected in the sediment samples at five locations including the Caminada Headlands restoration area (CH 01), Shell Island restoration area (Shell 01), Mississippi River potential borrow source area (MS Riv 01), and both sampling locations at the Sandy Point potential borrow source area (Sandy 01 and Sandy 02). The detected concentrations ranged from 0.14 mg/Kg (Sandy 02) to 0.32 mg/Kg (MS Riv 01). This range of selenium concentrations is

less than the LDEQ RECAP LSS concentration (20 mg/Kg). NOAA has not established a TEL value for selenium.

Silver was detected in the sediment samples at three locations including the Sandy Point potential borrow source (Sandy 01 and Sandy 02) and the Shell Island restoration area (Shell 01). The detected concentrations ranged from 0.049 mg/Kg (Sandy 02) to 0.068 mg/Kg (Shell 01). This range of silver concentrations is less than the NOAA TEL (0.730 mg/Kg) and LDEQ RECAP LSS concentration (39 mg/Kg).

Thallium was detected in the sediment samples at five locations including the Shell Island restoration area (Shell 01), Empire potential borrow area (Empire 01), Mississippi River potential borrow source area (MS Riv 01), and both of the sampling locations at the Sandy Point potential borrow source area (Sandy 01 and Sandy 02). The detected concentrations ranged from 0.12 mg/Kg (at Shell 01) to 0.18 mg/Kg (at Sandy 01). This range of thallium concentrations is less than LDEQ RECAP LSS concentration (0.55 mg/kg). NOAA has not established a TEL value for thallium.

Zinc was detected in the sediment samples at all locations at concentrations ranging from 12 mg/Kg (SPELTO 01) to 58 mg/Kg (MS Riv 01). This range of zinc concentrations is less than the NOAA TEL (124.00 mg/Kg) and LDEQ RECAP LSS concentration (2,300 mg/Kg).

The overall assessment of the sediment sample results for samples collected from the two proposed restoration project areas and four potential borrow source areas is that no significant anthropogenic contamination is indicated that would have potential for long-term adverse impacts to water quality or the aquatic environment in the vicinity of the project and potential borrow areas. As discussed in the comparison of elutriate results versus ambient water results in Section 2.3.2 above, there is a potential for mobilization of metals from the sediments to the water column during the construction phase of these projects but the temporary increases in metals concentrations that are likely do not represent adverse impacts to water quality and the aquatic environment when evaluated in the context of the potential for significant exceedances of the applicable numerical criteria of the LA WQS and/or USEPA WQC. Potential for mobilization of mercury from sediments to result in more substantially elevated, but temporary, water column concentrations is more significant and may require further evaluation.

The laboratory analytical reports for the sediment samples collected are provided in **Appendices B, C, and D.**

## 3.0 IMPACT ASSESSMENT OF PROPOSED PROJECTS

The environmental impacts and potential mitigation associated with the proposed project are discussed below.

### 3.1 Land Use

The proposed project would not change the current land uses. These projects would restore land area at the restoration sites that has been lost through erosion and subsidence. No adverse impacts to land use would occur at the restoration sites. An objective of the project is to restore and enhance the extent of beach on the seaward side of the barrier island landscapes.

### 3.2 Water Quality

The proposed projects would have no long-term impacts to surface water quality in the potential borrow sources and restoration areas. Long-term impacts to current salinity levels are anticipated in the restoration areas and are discussed in Section 3.6. Short-term impacts associated with the construction activities are discussed in Section 3.7.

### 3.3 Natural Communities

The proposed projects would have no long-term impacts to existing vegetation, wildlife, or aquatic communities. Construction activities would result in the relocation, at least temporarily, of these species that inhabit the restoration areas and, to a lesser degree, in localized zones within the borrow areas during active dredging. Short-term impacts associated with the construction activities are discussed in Section 3.7.

### 3.4 Wetlands

The proposed Caminada Headland Restoration Project would restore appropriate substrate for the re-establishment of coastal wetland associations that previously existed in greater areal extent in the inland side of the barrier island landscapes. The proposed project would provide protection against further erosion of wetlands in the project area.

## 3.5 Floodplains

The proposed project sites lie within the 100-year floodplain. Fill sections associated with the projects will not affect the 100-year surface ponding elevation.

## 3.6 Salinity

According to the Louisiana Gulf Shoreline Restoration Report[8] [Louisiana Coastal Area (LCA) 2004 Study], the presence of barrier islands at the mouth of a bay restricts water exchange with the shelf, provides storm surge protection to wetlands and human infrastructure from the islands, and modifies currents and salinity within the bay system. The LCA study notes that, at present, a comprehensive model that can evaluate the spatial and temporal links that barrier islands have with the interior bays and coastal marshes is unavailable.

The LCA 2004 Study has shown that the hydrodynamics of the mixing zone are influenced by the location of the barrier islands; however, the hydraulic conveyance of the embayment and the marsh are probably more important. The more open water and conveyance channels in the marshes resulting from subsidence and other factors, the greater will be the penetration of tidal energy into the marsh. Open water and channelization represents an increase in the hydraulic conveyance of the marsh. The mixing zone of fresh and saltwater will thus move landward as the flow capacity of the marsh increases.

Another aspect of barrier island location is that fetch between the islands and the marsh increases with the distance between the barrier islands and the marsh. This fetch determines the wind energy that can be transferred to the embayment and the wave energy that is available for shore processes. In addition, the barrier islands provide a local wake or shadow zone that is sheltered from onshore winds and tidal currents. As barrier islands moved closer to shore, substantial changes occur in the durations of salinity and flooding. This, in turn, influences the marshes in the upper estuary. The salinity mixing zone moves towards the shore, as barrier island position prevents saltwater from mixing into the estuary by limiting the tidal prism and thus the exchange with the offshore zone.

The proposed projects will have a positive effect (reduction) on the salinity of the water on the landward side of the proposed restoration sites. The Shell Island restoration will have a greater impact on area salinity than the Caminada Headland Restoration Project.

[8] Reyes, Enrique, Loannis Georgiou, Alex McCorquodale, and Denise Reed; "Chapter D.5 Using Models to Evaluate the Effect of Barrier Islands on Estuarine Hydrodynamics and Habitats: A Numerical Experiment," Louisiana Gulf Shoreline Restoration Report, November 2004.

## 3.7 Construction Impacts

Short-term impacts to the water quality and natural communities are anticipated during the construction activities. Construction impacts to water quality would result from increased concentrations of TSS, greater turbidity, potential increases in ambient surface water concentrations of mercury and other metals, and mobilization of nutrient parameters based upon elutriate results. The impacts to water quality could vary spatially and temporally depending on the dredging and material placement methods.

The increased concentrations of TSS, higher turbidity, and potentially increased mercury and other metal concentrations would occur in close proximity to the construction activities, with concentrations decreasing with distance away from the construction activities. Mitigation methods may include controlling sediment dispersion near the construction site or providing a barrier for outside activities. Methods to reduce sediment dispersion in open water areas resulting from construction activities may include silt/turbidity screens or other devices.

The increased concentrations of TSS and turbidity would result in short-term disruption and some temporary displacement of aquatic communities in the restoration areas during the construction phase of the project. No adverse impacts from TSS or turbidity are expected to persist beyond the construction phase. The release of nitrogen and phosphorus forms from sediments will result in short-term increased availability of nutrient parameters in the water column in the near vicinity of the active dredging sites within the borrow areas, and in the vicinity of active deposition at the restoration sites.

The likely release and mobilization of mercury from sediments in dissolved fractions and fractions adsorbed to fine particles (silt/clay) will result in the short-term increase in ambient concentrations in the water column at and near the construction (deposition) areas. The form of mercury that can potentially affect aquatic organisms is methylmercury. Oxidation of some portion of the methylmercury to forms with less potential to affect aquatic organisms will occur in connection with the turbulence associated with sediment dredging, transport, and deposition. The mobilization of methylmercury into the water column from sediments has the potential for increased exposure to aquatic organisms through direct bioaccumulation from the water column and through food web bioaccumulation. The increased potential for exposure to aquatic organisms will be localized and of short duration.

The scale of the predicted impacts are not anticipated to differ significantly from those that would occur in connection with natural disturbances, such as tropical storms and hurricanes.

## 3.8 Permitting

**Ocean Dumping**

Ocean dumping of material is regulated under 40 CFR 220 and 228, specifically, the dumping of material into portions of the territorial sea which are subject to the jurisdiction of any state within their respective regions, and in those portions of the contiguous zone immediately adjacent to such parts of the territorial sea; and in the oceans with respect to the approved waste disposal sites designated pursuant to Part 228 of Subchapter H. Potential exceptions to these requirements are for the construction of any fixed structure or artificial island or the intentional placement of any device in ocean waters or on or in the submerged land beneath such waters, for a purpose other than disposal, when such construction or such placement is otherwise regulated by federal or state law or occurs pursuant to an authorized federal or state program. The project will still be regulated for any material that is replaced on the ocean floor of the dredge site or is discharged from the barge or vessel transporting dredged material from the dredge sites to the placement sites.

**USACE 404(b)(1) Guidelines Evaluation**

A Section 404(b)(1) Guideline Evaluation Example for the implementation of the Caminada Headlands and Shell Island Restoration projects is included in **Appendix E**. The Section 404(b)(1) Guideline Evaluation was based on the 40 CFR 230, Section 404(b)(1): Guidelines for Specification of Disposal Sites for Dredged or Fill Material regulations. The regulations implement Sections 404(b) and 501(a) of the Clean Water Act, which govern the disposal of dredged and fill material inside the territorial sea baseline [§230.2(b)]. The Section 404(b)(1) evaluation is presented in a format that addresses all required elements of the evaluation. A copy of the USACE 404(b)(1) short form evaluation completed the relevant sections to the water quality analysis is included in **Appendix F**.

## 4.0 CONCLUSIONS

The proposed Caminada Headlands and Shell Island restoration projects are not expected to have long-term water quality impacts on the project area. Short-term impacts to water quality and natural communities may occur during the construction phase of the project. Mitigation methods should be evaluated during the final design stage to reduce the potential construction impacts.

# TABLE 1

# SUMMARY OF AVAILABLE DATA

**TABLE 1**
**SUMMARY OF AVAILABLE DATA**

| Agency | Results |
|---|---|
| USEPA STORET | • No available data for the potential sediment borrow areas or project restoration sites. Some water quality data available for Mississippi River area. |
| USACE | • Some Mississippi River sediment data are available from USACE.<br>• No data are available for remaining potential borrow areas or project restoration sites.<br>• Some water and sediment quality data available for Mississippi River area. |
| MMS | • Data available for sand levels in the coastal region, but no water quality, sediment, or elutriate chemical data available. |
| USFWS | • No available data for the potential sediment borrow areas or project restoration sites. |
| USGS | • No available data for the potential sediment borrow areas or project restoration sites.<br>• Some water quality data available for Mississippi River area. All water quality data are prior to 2000. Only Station 73745550 (USACE Mississippi River at Venice) maintains data from prior to 1988. |
| NOAA | • Remote sensing data available (satellite) for sea surface temperatures, but no relevant data available for the potential sediment borrow areas or project restoration sites. |
| NMFS | • No available data for the potential sediment borrow areas or project restoration sites. |
| LDNR | • Database provides access to numerous coastal projects, but no relevant data available for the potential sediment borrow areas or project restoration sites. |
| LDEQ | • No available data for the potential sediment borrow areas or project restoration sites. Water quality data available for Mississippi River area and area near Caminada. LDEQ maintains ambient water quality monitoring stations in the Gulf of Mexico south of Belle Pass (Station 0927) and at South Pass at head of passes (Station 1093). |
| LDWF | • No available data for the potential sediment borrow areas or project restoration sites. |
| LSU | • LSU has water quality and sediment data for the Ship Shoal borrow area. The water quality data are for temperature, salinity, and dissolved oxygen. The sediment is for grain size, percent organic carbon, percent shell, and percent shell carbon. |
| LUMCON | • LUMCON has no data available for the potential sediment borrow areas or the project restoration sites. |
| UNO | • No available data at this time for the potential sediment borrow areas or project restoration sites.<br>• UNO may have additional data; however, their website is down due to Hurricane Katrina. |
| DHH | • Information on water quality at oyster leases, but no relevant data for the potential sediment borrow areas or project restoration sites. |
| *LIMNOLOGY AND OCEANOGRAPHY* | • Total organic carbon ($g/cm^3$) data derived from core samples taken at known lateral transects from sample sites near the proposed Caminada Headlands site were presented in an article published in 1983. (Hatton, R. S., R. D. DeLaune, and W. H. Patrick, Jr. 1983. "Sedimentation, Accretion, and Subsidence in Marshes of Barataria Basin, Louisiana." *Limnology and Oceanography*. 28: 494-502.). |

# TABLE 2

# SUMMARY OF FIELD SAMPLING EFFORTS

**TABLE 2**
**SUMMARY OF FIELD SAMPLING EFFORTS**

| Location | Potential Borrow Sources | | | | Restoration Areas | |
|---|---|---|---|---|---|---|
| | Mississippi River (Nairn) | Empire | Sandy Point | South Pelto | Caminada Headlands | Shell Island |
| Number of Sample Locations | 1 | 1 | 2 | 2 | 2 | 2 |
| Medium<br>*Sediment*<br>*Elutriate*<br>*Water* | <br>1 Composite<br>1 Composite<br>1 Composite | <br>1 Composite<br>1 Composite<br>1 Composite | <br>2 Composite<br>2 Composite<br>1 Composite | <br>2 Composite<br>2 Composite<br>1 Composite | <br>2 Composite<br>2 Composite<br>1 Composite | <br>2 Composite<br>2 Composite<br>1 Composite |
| Total Number of Samples | 3 | 3 | 5 | 5 | 5 | 5 |
| Analytes at Each Location | Field Parameters<br><br>Priority Pollutants (metals and organics)<br><br>Nitrogen and Phosphorus species | Field Parameters<br><br>Priority Pollutants (metals and organics)<br><br>Nitrogen and Phosphorus species | Field Parameters<br><br>Priority Pollutants (metals and organics)<br><br>Nitrogen and Phosphorus species | Field Parameters<br><br>Priority Pollutants (metals and organics)<br><br>Nitrogen and Phosphorus species | Field Parameters<br><br>Priority Pollutants (metals and organics)<br><br>Nitrogen and Phosphorus species | Field Parameters<br><br>Priority Pollutants (metals and organics)<br><br>Nitrogen and Phosphorus species |

# TABLE 3

# FIELD WATER QUALITY PARAMETERS AND MONITORING METHODS

## TABLE 3

## FIELD WATER QUALITY PARAMETERS AND MONITORING METHODS

| PARAMETER | METHOD | REFERENCE |
|---|---|---|
| Conductivity | Portable Meter | Method 120.1 [1]<br>ASTM Standards D 1125-91(A) |
| Salinity[3] | Portable Meter | Method 120.1 [1]<br>Method 2520B [2] |
| pH | Portable Meter | Method 150.1 [1]<br>ASTM Standards D1293-84(90)(A or B)<br>Method 4500-$H^+$ B [2] |
| Temperature | Portable Meter or Thermometer | Method 170.1 [1]<br>Method 2550 B [2] |
| Oxygen, Dissolved | Portable Meter with Membrane Electrode | Method 360.1 [1]<br>Method 4500-0 G [2]<br>Manufacturer's Operation Manual |
| Oxygen, Dissolved/ Percent Saturation | Portable Meter with Membrane Electrode | Method 360.1 [1]<br>Method 4500-0 G [2]<br>Manufacturer's Operation Manual |

[1] U.S. Environmental Protection Agency (USEPA), Methods for Chemical Analysis of Water and Wastes, USEPA Publication Number EPA-600/4-79-020

[2] Standard Methods for the Examination of Water and Wastewater, 18th Edition (1992), 19th Edition (1995), or 20th Edition (1998)

[3] YSI 556 Portable Meter was not calibrated properly for conductivity (specific conductance is used to calibrate for conductivity and salinity) when calibrated to the 47.6 mS/cm standard on 02/08/06. The YSI 556 was calibrated in the field directly before taking field readings on 02/08/06. This miscalibration was either a user error or due to a compromised standard. The conductivity (mS/cm) and salinity (ppt) readings for the sampling date of 02/08/06 appear to be higher than normal, and should therefore be considered suspect. On the afternoon of 02/08/06, the YSI 556 was recalibrated using a 1.0 mS/cm standard, and the unit calibrated properly. The conductivity and salinity field readings taken on 02/13/06 were taken based on the calibration standard 1.0 mS/cm. The conductivity and salinity readings appear to be within the normal range for the sampling date of 02/13/06. The YSI unit was un-calibrated for conductivity (reset to the factory's default setting) on the date of 02/14/06. The unit was then calibrated to the 1.0 mS/cm standard. The unit calibrated properly.

# TABLE 4

# WATER AND ELUTRIATE SAMPLE LABORATORY ANALYTICAL REQUIREMENTS

## TABLE 4
## WATER AND ELUTRIATE SAMPLE LABORATORY ANALYTICAL REQUIREMENTS
## Page 1 of 4

| Parameter | CAS Number | Recommended Analytical Method 40 CFR 136 [1] | Required MDL [2] µg/L [3] |
|---|---|---|---|
| **NUTRIENT PARAMETERS** | | | |
| Phosphorous (as P), Total | 7723-14-0 | 365.2 | 10 |
| Nitrate-Nitrite Nitrogen | 7727-37-9 | 353.2 | 100 |
| Nitrogen, Total Organic | --- | See Footnote [4] | See Footnote [4] |
| Total Kjeldahl Nitrogen (TKN) | E-10264 | 351.4 | 30 |
| Ammonia (As N) | 7664-41-7 | 350.1 or 350.2 | 10 or 1000 |
| **PRIORITY POLLUTANT ORGANIC COMPOUNDS** | | | |
| **VOLATILE ORGANIC COMPOUNDS** | | | |
| Acrolein (2-Propenal) | 107-02-8 | 603 or 624 | 0.7 or nd [5] |
| Acrylonitrile (2-Propenenitrile) | 107-13-1 | 603 or 624 | 0.5 or nd [5] |
| Benzene | 71-43-2 | 602 or 624 | 0.2 or 4.4 |
| Bromoform (Tribromomethane) | 75-25-2 | 601 or 624 | 0.20 or 4.7 |
| Carbon tetrachloride | 56-23-5 | 601 or 624 | 0.12 or 2.8 |
| Chlorobenzene | 108-90-7 | 601 or 624 | 0.25 or 6.0 |
| Chlorodibromomethane (Dibromochloromethane) | 124-48-1 | 601 or 624 | 0.09 or 3.1 |
| Chloroethane | 75-00-3 | 601 or 624 | 0.52 or nd [5] |
| 2-Chloroethylvinyl ether | 110-75-8 | 601 or 624 | 0.13 or nd [5] |
| Chloroform (Trichloromethane) | 67-66-3 | 601 or 624 | 0.05 or 1.6 |
| Dichlorobromomethane (Bromodichloromethane) | 75-27-4 | 601 or 624 | 0.10 or 2.2 |
| 1,1-Dichloroethane | 75-34-3 | 601 or 624 | 0.07 or 4.7 |
| 1,2-Dichloroethane [Ethylene Dichloride (EDC)] | 107-06-02 | 601 or 624 | 0.03 or 2.8 |
| 1,1-Dichloroethylene (1,1-Dichloroethene) | 75-35-4 | 601 or 624 | 0.13 or 2.8 |
| 1,2-Dichloropropane | 78-87-5 | 601 or 624 | 0.04 or 6.0 |
| 1,3-Dichloropropylene (1,3-Dichloropropene) | 542-75-6 | 601 or 624 | 0.34 or 5.0 |
| Ethylbenzene | 100-41-4 | 602 or 624 | 0.2 or 7.2 |
| Methyl bromide (Bromomethane) | 74-83-9 | 601 or 624 | 1.18 or nd [5] |
| Methyl chloride (Chloromethane) | 74-87-3 | 601 or 624 | 0.08 or nd [5] |
| Methylene chloride (Dichloromethane) | 75-09-2 | 601 or 624 | 0.25 or 2.8 |
| 1,1,2,2-Tetrachloroethane | 79-34-5 | 601 or 624 | 0.03 or 6.9 |
| Tetrachloroethylene (Tetrachloroethene) (Perchloroethylene) | 127-18-4 | 601 or 624 | 0.03 or 4.1 |
| Toluene | 108-88-3 | 602 or 624 | 0.2 or 6.0 |
| trans-1,2-Dichloroethylene (trans-1,2-Dichloroethene) | 156-60-5 | 601 or 624 | 0.10 or 1.6 |
| 1,1,1-Trichloroethane (Methyl chloroform) | 71-55-6 | 601 or 624 | 0.03 or 3.8 |
| 1,1,2-Trichloroethane | 79-00-5 | 601 or 624 | 0.02 or 5.0 |
| Trichloroethylene (Trichloroethene) | 79-01-6 | 601 or 624 | 0.12 or 1.9 |
| Vinyl chloride (Chloroethene) | 75-01-4 | 601 or 624 | 0.18 or nd [5] |
| **ACID EXTRACTABLE SEMIVOLATILE ORGANIC COMPOUNDS** | | | |
| 2-Chlorophenol (*o*-Chlorophenol) | 95-57-8 | 625 | 3.3 |
| 2,4-Dichlorophenol | 120-83-2 | 625 | 2.7 |

## TABLE 4
## WATER AND ELUTRIATE SAMPLE LABORATORY ANALYTICAL REQUIREMENTS
## Page 2 of 4

| Parameter | CAS Number | Recommended Analytical Method 40 CFR 136 [1] | Required MDL [2] µg/L [3] |
|---|---|---|---|
| 2,4-Dimethylphenol | 105-67-9 | 625 | 2.7 |
| 4,6-Dinitro-*o*-cresol (4,6-Dinitro-2-methylphenol) | 534-52-1 | 625 | 24 |
| 2,4-Dinitrophenol | 51-28-5 | 625 | 42 |
| 2-Nitrophenol (*o*-Nitrophenol) | 88-75-5 | 625 | 3.6 |
| 4-Nitrophenol (*p*-Nitrophenol) | 100-02-7 | 625 | 3.6 |
| *p*-chloro-*m*-cresol (4-Chloro-3-methylphenol) | 59-50-7 | 625 | 3.0 |
| Pentachlorophenol | 87-86-5 | 625 | 3.6 |
| Phenol | 108-95-2 | 625 | 1.5 |
| 2,4,6-Trichlorophenol | 88-06-2 | 625 | 2.7 |
| **BASE/NEUTRAL EXTRACTABLE SEMIVOLATILE ORGANIC COMPOUNDS** | | | |
| Acenaphthene | 83-32-9 | 625 | 1.9 |
| Acenaphthylene | 208-96-8 | 625 | 3.5 |
| Anthracene | 120-12-7 | 625 | 1.9 |
| Benzidine | 92-87-5 | 625 | 44 |
| Benz (a)anthracene | 56-55-3 | 625 | 7.8 |
| Benzo(a)pyrene | 50-32-8 | 625 | 2.5 |
| 3,4-Benzofluoranthene (Benzo(b)fluoranthene) | 205-99-2 | 625 | 4.8 |
| Benzo(g,h,i)perylene | 191-24-2 | 625 | 4.1 |
| Benzo(k)fluoranthene | 207-08-9 | 625 | 2.5 |
| Bis(2-chloroethoxy)methane | 111-91-1 | 625 | 5.3 |
| Bis(2-chloroethyl)ether | 111-44-4 | 625 | 5.7 |
| Bis(2-chloroisopropyl)ether [2,2'-Oxybis(1-chloropropane)] | 108-60-1 | 625 | 5.7 |
| Bis(2-ethylhexyl)phthalate | 117-81-7 | 625 | 2.5 |
| 4-Bromophenyl phenyl ether | 101-55-3 | 625 | 1.9 |
| Butylbenzyl phthalate | 85-68-7 | 625 | 2.5 |
| 2-Chloronaphthalene | 91-58-7 | 625 | 1.9 |
| 4-Chlorophenyl phenyl ether | 7005-72-3 | 625 | 4.2 |
| Chrysene | 218-01-9 | 625 | 2.5 |
| Dibenzo(a,h)anthracene | 53-70-3 | 625 | 2.5 |
| 1,2-Dichlorobenzene (*o*-Dichlorobenzene) | 95-50-1 | 625 | 1.9 |
| 1,3-Dichlorobenzene (*m*-Dichlorobenzene) | 541-73-1 | 625 | 1.9 |
| 1,4-Dichlorobenzene (*p*-Dichlorobenzene) | 106-46-7 | 625 | 4.4 |
| 3,3'-Dichlorobenzidine | 91-94-1 | 625 | 16.5 |
| Diethyl phthalate | 84-66-2 | 625 | 1.9 |
| Dimethyl phthalate | 131-11-3 | 625 | 1.6 |
| Di-n-butyl phthalate | 84-74-2 | 625 | 2.5 |
| 2,4-Dinitrotoluene | 121-14-2 | 625 | 5.7 |
| 2,6-Dinitrotoluene | 606-20-2 | 625 | 1.9 |
| Di-n-octyl phthalate | 117-84-0 | 625 | 2.5 |
| 1,2-Diphenylhydrazine (as Azobenzene) | 122-66-7 | 625 | nd [5] |
| Fluoranthene | 206-44-0 | 625 | 2.2 |
| Fluorene | 86-73-7 | 625 | 1.9 |

**TABLE 4**
**WATER AND ELUTRIATE SAMPLE LABORATORY ANALYTICAL REQUIREMENTS**
**Page 3 of 4**

| Parameter | CAS Number | Recommended Analytical Method 40 CFR 136 [1] | Required MDL [2] µg/L [3] |
|---|---|---|---|
| Hexachlorobenzene | 118-74-1 | 625 | 0.9 |
| Hexachlorobutadiene | 87-68-3 | 625 | 1.9 |
| Hexachlorocyclopentadiene | 77-47-4 | 625 | nd [5] |
| Hexachloroethane | 67-72-1 | 625 | 1.6 |
| Indeno(1,2,3-cd)pyrene | 193-39-5 | 625 | 3.7 |
| Isophorone | 78-59-1 | 625 | 2.2 |
| Naphthalene | 91-20-3 | 625 | 1.6 |
| Nitrobenzene | 98-95-3 | 625 | 1.9 |
| N-nitrosodimethylamine | 62-75-9 | 625 | nd [5] |
| N-nitrosodi-n-propylamine | 621-64-7 | 625 | nd [5] |
| N-nitrosodiphenylamine (Diphenylamine) | 86-30-6 | 625 | 1.9 |
| Phenanthrene | 85-01-8 | 625 | 5.4 |
| Pyrene | 129-00-0 | 625 | 1.9 |
| 1,2,4-Trichlorobenzene | 120-82-1 | 625 | 1.9 |
| **PESTICIDES, HERBICIDES, AND POLYCHLORINATED BIPHENYLS (PCBs)** | | | |
| Aldrin | 309-00-2 | 608 | 0.004 |
| alpha-BHC | 319-84-6 | 608 | 0.003 |
| beta-BHC | 319-85-7 | 608 | 0.006 |
| delta-BHC | 319-86-8 | 608 | 0.009 |
| gamma-BHC (Hexachlorocyclohexane) (Lindane) | 58-89-9 | 608 | 0.004 |
| Chlordane | 57-74-9 | 608 | 0.014 |
| 4,4-DDT | 50-29-3 | 608 | 0.012 |
| 4,4-DDE | 72-55-9 | 608 | 0.004 |
| 4,4-DD | 72-54-8 | 608 | 0.011 |
| Dieldrin | 60-57-1 | 608 | 0.002 |
| Alpha-Endosulfan (Endosulfan I) | 959-98-8 | 608 | 0.014 |
| Beta-Endosulfan (Endosulfan II) | 33213-65-9 | 608 | 0.004 |
| Endosulfan sulfate | 1031-07-8 | 608 | 0.066 |
| Endrin | 72-20-8 | 608 | 0.006 |
| Endrin aldehyde | 7421-93-4 | 608 | 0.023 |
| Heptachlor | 76-44-8 | 608 | 0.003 |
| Heptachlor Epoxide | 1024-57-3 | 608 | 0.003 |
| Toxaphene | 8001-35-2 | 608 | 0.24 |
| PCB-1016 | 12674-11-2 | 608 | nd [5] |
| PCB-1221 | 11104-28-2 | 608 | nd [5] |
| PCB-1232 | 11141-16-5 | 608 | nd [5] |
| PCB-1242 | 53469-21-9 | 608 | 0.065 |
| PCB-1248 | 12672-29-6 | 608 | nd [5] |
| PCB-1254 | 11097-69-1 | 608 | nd [5] |
| PCB-1260 | 11096-82-5 | 608 | nd [5] |

**TABLE 4**
**WATER AND ELUTRIATE SAMPLE LABORATORY ANALYTICAL REQUIREMENTS**
**Page 4 of 4**

| Parameter | CAS Number | Recommended Analytical Method 40 CFR 136 [1] | Required MDL [2] µg/L [3] |
|---|---|---|---|
| **PRIORITY POLLUTANT METALS [6]** | | | |
| Antimony, Dissolved for ambient water | 7440-36-0 | 200.8 | 3 |
| Arsenic, Dissolved | 7440-38-2 | 200.8 | 1 |
| Beryllium, Dissolved | 7440-41-7 | 200.8 | 0.2 |
| Cadmium, Dissolved | 7440-43-9 | 200.8 | 0.1 |
| Chromium, Dissolved | 7440-47-3 | 200.8 | 1 |
| Copper, Dissolved | 7440-50-8 | 200.8 | 1 |
| Lead, Dissolved | 7439-92-1 | 200.8 | 1 |
| Mercury, Dissolved | 7439-97-6 | 245.1 | 0.2 |
| Nickel, Dissolved (Freshwater or Marine) | 7440-02-0 | 200.8 | 1 |
| Selenium, Dissolved | 7782-49-2 | 200.8 | 2 |
| Silver, Dissolved | 7440-22-4 | 200.8 | 0.2 |
| Thallium, Dissolved | 7440-28-0 | 200.8 | 1 |
| Zinc, Dissolved | 7440-66-6 | 200.8 | 0.05 |

(1) Per the regulatory requirements at 40 Code of Federal Regulations (CFR) at 40 CFR 136, USEPA Guidelines Establishing Test Procedures for the Analysis of Pollutants, with methods from the documents (1) Methods for Chemical Analysis of Water and Wastes, USEPA Publication Number EPA-600/4-79-020 and/or (2) Standard Methods for the Examination of Water and Wastewater, 18th Edition (1992), 19th Edition (1995), or 20th Edition (1998)

(2) MDL = Method Detection Limit

(3) µg/L = micrograms per liter

(4) Total Organic Nitrogen is determined by subtracting the Ammonia (as N) value (as determined by an approved method) from the Total Kjeldahl Nitrogen value (as determined by an approved method).

(5) nd = not determined

(6) For ambient water samples, metal concentrations were analyzed and reported as the dissolved fraction; for elutriate samples, concentrations were analyzed and reported as total recoverable metals (total metals).

# TABLE 5

# SEDIMENT SAMPLE LABORATORY ANALYTICAL REQUIREMENTS

## TABLE 5
## SEDIMENT SAMPLE LABORATORY ANALYTICAL REQUIREMENTS
**Page 1 of 4**

| Parameter | CAS Number | Recommended Analytical Method SW 846 [1] | Required MDL [2] µg/Kg [3] |
|---|---|---|---|
| **NUTRIENT PARAMETERS** | | | |
| Phosphorous (as P), Total | 7723-14-0 | 3050/6010 | 600 |
| Nitrate-Nitrite Nitrogen | 7727-37-9 | 353.2 | 480 |
| Nitrogen, Total Organic | --- | See Footnote [4] | See Footnote [4] |
| Total Kjeldahl Nitrogen (TKN) | E-10264 | 351.4 | 3000 |
| Ammonia (As N) | 7664-41-7 | I-6522-90 [5] | 140 |
| **PRIORITY POLLUTANT ORGANIC COMPOUNDS** | | | |
| **VOLATILE ORGANIC COMPOUNDS** | | | |
| Acrolein (2-Propenal) | 107-02-8 | 8260 | 28.0 |
| Acrylonitrile (2-Propenenitrile) | 107-13-1 | 8260 | 6.2 |
| Benzene | 71-43-2 | 8240A | 5 |
| Bromoform (Tribromomethane) | 75-25-2 | 8240A | 5 |
| Carbon tetrachloride | 56-23-5 | 8240A | 5 |
| Chlorobenzene | 108-90-7 | 8240A | 5 |
| Chlorodibromomethane (Dibromochloromethane) | 124-48-1 | 8240A | 5 |
| Chloroethane | 75-00-3 | 8240A | 10 |
| 2-Chloroethylvinyl ether | 110-75-8 | 8260 | 17.0 |
| Chloroform (Trichloromethane) | 67-66-3 | 8240A | 5 |
| Dichlorobromomethane (Bromodichloromethane) | 75-27-4 | 8240A | 5 |
| 1,1-Dichloroethane | 75-34-3 | 8240A | 5 |
| 1,2-Dichloroethane [Ethylene Dichloride (EDC)] | 107-06-02 | 8240A | 5 |
| 1,1-Dichloroethylene (1,1-Dichloroethene) | 75-35-4 | 8260 | 1.30 |
| 1,2-Dichloropropane | 78-87-5 | 8240A | 5 |
| 1,3-Dichloropropylene (1,3-Dichloropropene) | 542-75-6 | 8240A | 5 |
| Ethylbenzene | 100-41-4 | 8240A | 5 |
| Methyl bromide (Bromomethane) | 74-83-9 | 8240A | 10 |
| Methyl chloride (Chloromethane) | 74-87-3 | 8240A | 10 |
| Methylene chloride (Dichloromethane) | 75-09-2 | 8240A | 5 |
| 1,1,2,2-Tetrachloroethane | 79-34-5 | 8240A | 5 |
| Tetrachloroethylene (Tetrachloroethene) (Perchloroethylene) | 127-18-4 | 8240A | 5 |
| Toluene | 108-88-3 | 8240A | 5 |
| trans-1,2-Dichloroethylene (trans-1,2-Dichloroethene) | 156-60-5 | 8240A | 5 |
| 1,1,1-Trichloroethane (Methyl chloroform) | 71-55-6 | 8240A | 5 |
| 1,1,2-Trichloroethane | 79-00-5 | 8240A | 5 |
| Trichloroethylene (Trichloroethene) | 79-01-6 | 8240A | 5 |
| Vinyl chloride (Chloroethene) | 75-01-4 | 8240A | 10 |

## TABLE 5
## SEDIMENT SAMPLE LABORATORY ANALYTICAL REQUIREMENTS
**Page 2 of 4**

| Parameter | CAS Number | Recommended Analytical Method SW 846 [1] | Required MDL [2] µg/Kg [3] |
|---|---|---|---|
| **ACID EXTRACTABLE SEMIVOLATILE ORGANIC COMPOUNDS** | | | |
| 2-Chlorophenol (*o*-Chlorophenol) | 95-57-8 | 8270 | 660 |
| 2,4-Dichlorophenol | 120-83-2 | 8270 | 660 |
| 2,4-Dimethylphenol | 105-67-9 | 8270 | 660 |
| 4,6-Dinitro-*o*-cresol (4,6-Dinitro-2-methylphenol) | 534-52-1 | 8270 | 78 |
| 2,4-Dinitrophenol | 51-28-5 | 8270 | 3300 |
| 2-Nitrophenol (*o*-Nitrophenol) | 88-75-5 | 8270 | 660 |
| 4-Nitrophenol (*p*-Nitrophenol) | 100-02-7 | 8270 | 3300 |
| *p*-chloro-*m*-cresol (4-Chloro-3-methylphenol) | 59-50-7 | 8270 | 1300 |
| Pentachlorophenol | 87-86-5 | 8270 | 3300 |
| Phenol | 108-95-2 | 8270 | 660 |
| 2,4,6-Trichlorophenol | 88-06-2 | 8270 | 660 |
| **BASE/NEUTRAL EXTRACTABLE SEMIVOLATILE ORGANIC COMPOUNDS** | | | |
| Acenaphthene | 83-32-9 | 8270 | 660 |
| Acenaphthylene | 208-96-8 | 8270 | 660 |
| Anthracene | 120-12-7 | 8270 | 660 |
| Benzidine | 92-87-5 | 8270 | nd [6] |
| Benz(a)anthracene | 56-55-3 | 8270 | 660 |
| Benzo(a)pyrene | 50-32-8 | 8270 | 660 |
| 3,4-Benzofluoranthene (Benzo(b)fluoranthene) | 205-99-2 | 8270 | 660 |
| Benzo(g,h,i)perylene | 191-24-2 | 8270 | 660 |
| Benzo(k)fluoranthene | 207-08-9 | 8270 | 660 |
| Bis(2-chloroethoxy)methane | 111-91-1 | 8270 | 660 |
| Bis(2-chloroethyl)ether | 111-44-4 | 8270 | 660 |
| Bis(2-chloroisopropyl)ether [2,2'-Oxybis(1-chloropropane)] | 108-60-1 | 8270 | 660 |
| Bis(2-ethylhexyl)phthalate | 117-81-7 | 8270 | 660 |
| 4-Bromophenyl phenyl ether | 101-55-3 | 8270 | 660 |
| Butylbenzyl phthalate | 85-68-7 | 8270 | 660 |
| 2-Chloronaphthalene | 91-58-7 | 8270 | 660 |
| 4-Chlorophenyl phenyl ether | 7005-72-3 | 8270 | 660 |
| Chrysene | 218-01-9 | 8270 | 660 |
| Dibenzo(a,h)anthracene | 53-70-3 | 8270 | 660 |
| 1,2-Dichlorobenzene (*o*-Dichlorobenzene) | 95-50-1 | 8270 | 660 |
| 1,3-Dichlorobenzene (*m*-Dichlorobenzene) | 541-73-1 | 8270 | 660 |
| 1,4-Dichlorobenzene (*p*-Dichlorobenzene) | 106-46-7 | 8270 | 660 |
| 3,3'-Dichlorobenzidine | 91-94-1 | 8270 | 70 |
| Diethyl phthalate | 84-66-2 | 8270 | 660 |
| Dimethyl phthalate | 131-11-3 | 8270 | 660 |
| Di-n-butyl phthalate | 84-74-2 | 8270 | 9 |
| 2,4-Dinitrotoluene | 121-14-2 | 8270 | 660 |
| 2,6-Dinitrotoluene | 606-20-2 | 8270 | 660 |
| Di-n-octyl phthalate | 117-84-0 | 8270 | 660 |

## TABLE 5
## SEDIMENT SAMPLE LABORATORY ANALYTICAL REQUIREMENTS
**Page 3 of 4**

| Parameter | CAS Number | Recommended Analytical Method SW 846 [1] | Required MDL [2] µg/Kg [3] |
|---|---|---|---|
| 1,2-Diphenylhydrazine (as Azobenzene) | 122-66-7 | 8270 | 35 |
| Fluoranthene | 206-44-0 | 8270 | 660 |
| Fluorene | 86-73-7 | 8270 | 660 |
| Hexachlorobenzene | 118-74-1 | 8270 | 660 |
| Hexachlorobutadiene | 87-68-3 | 8270 | 660 |
| Hexachlorocyclopentadiene | 77-47-4 | 8270 | 660 |
| Hexachloroethane | 67-72-1 | 8270 | 660 |
| Indeno(1,2,3-cd)pyrene | 193-39-5 | 8270 | 660 |
| Isophorone | 78-59-1 | 8270 | 660 |
| Naphthalene | 91-20-3 | 8270 | 660 |
| Nitrobenzene | 98-95-3 | 8270 | 660 |
| N-nitrosodimethylamine | 62-75-9 | 8270 | nd [6] |
| N-nitrosodi-n-propylamine | 621-64-7 | 8270 | 660 |
| N-nitrosodiphenylamine (Diphenylamine) | 86-30-6 | 8270 | 660 |
| Phenanthrene | 85-01-8 | 8270 | 660 |
| Pyrene | 129-00-0 | 8270 | 660 |
| 1,2,4-Trichlorobenzene | 120-82-1 | 8270 | 660 |
| **PESTICIDES, HERBICIDES, AND POLYCHLORINATED BIPHENYLS (PCBs)** | | | |
| Aldrin | 309-00-2 | 8081 | 3 |
| PCB-1016 | 12674-11-2 | 8082 | 33 |
| PCB-1221 | 11104-28-2 | 8082 | 67 |
| PCB-1232 | 11141-16-5 | 8082 | 33 |
| PCB-1242 | 53469-21-9 | 8082 | 33 |
| PCB-1248 | 12672-29-6 | 8082 | 33 |
| PCB-1254 | 11097-69-1 | 8082 | 33 |
| PCB-1260 | 11096-82-5 | 8082 | 33 |
| alpha-BHC | 319-84-6 | 8081 | 2 |
| beta-BHC | 319-85-7 | 8081 | 4 |
| delta-BHC | 319-86-8 | 8081 | 6 |
| gamma-BHC (Hexachlorocyclohexane) (Lindane) | 58-89-9 | 8081 | 3 |
| Chlordane | 57-74-9 | 8081 | 9 |
| 4,4-DDT | 50-29-3 | 8081 | 8 |
| 4,4-DDE | 72-55-9 | 8081 | 3 |
| 4,4-DDD | 72-54-8 | 8081 | 7 |
| Dieldrin | 60-57-1 | 8081 | 2 |
| Alpha-Endosulfan (Endosulfan I) | 959-98-8 | 8081 | 9 |
| Beta-Endosulfan (Endosulfan II) | 33213-65-9 | 8081 | 3 |
| Endosulfan sulfate | 1031-07-8 | 8081 | 45 |
| Endrin | 72-20-8 | 8081 | 4 |
| Endrin aldehyde | 7421-93-4 | 8081 | 16 |

## TABLE 5
## SEDIMENT SAMPLE LABORATORY ANALYTICAL REQUIREMENTS
**Page 4 of 4**

| Parameter | CAS Number | Recommended Analytical Method SW 846 [1] | Required MDL [2] µg/Kg [3] |
|---|---|---|---|
| Heptachlor | 76-44-8 | 8081 | 2 |
| Heptachlor Epoxide | 1024-57-3 | 8081 | 56 |
| Toxaphene | 8001-35-2 | 8081 | 161 |
| **PRIORITY POLLUTANT METALS** | | | |
| Antimony, Total | 7440-36-0 | 6020 | 500 |
| Arsenic, Total | 7440-38-2 | 6020 | 500 |
| Beryllium, Total | 7440-41-7 | 6020 | 100 |
| Cadmium, Total | 7440-43-9 | 6020 | 100 |
| Chromium, Total | 7440-47-3 | 6020 | 1000 |
| Copper, Total | 7440-50-8 | 6020 | 500 |
| Lead, Total | 7439-92-1 | 6020 | 300 |
| Mercury, Total | 7439-97-6 | 7471 | 20 |
| Nickel, Total (Freshwater or Marine) | 7440-02-0 | 6020 | 200 |
| Selenium, Total | 7782-49-2 | 6020 | 500 |
| Silver, Total | 7440-22-4 | 6020 | 200 |
| Thallium, Total | 7440-28-0 | 6020 | 200 |
| Zinc, Total | 7440-66-6 | 6020 | 4000 |

(1) SW 846 = USEPA Test Methods for Evaluating Solid Waste, Physical/Chemical Methods. Also, some methods from Methods for Chemical Analysis of Water and Wastes, USEPA Publication Number EPA-600/4-79-020.

(2) MDL = Method Detection Limit

(3) µg/Kg = micrograms per kilogram

(4) Total Organic Nitrogen is determined by subtracting the Ammonia (as N) value (as determined by an approved method) from the Total Kjeldahl Nitrogen value (as determined by an approved method).

(5) This method is not from SW 846, but rather from M.J. Fishman, 1993, Methods of Analysis by the U.S. Geological Survey National Water Quality Laboratory--Determination of Inorganic and Organic Constituents in Water and Fluvial Sediments: U.S. Geological Survey Open-File Report 93-125.

(6) nd = not determined

# TABLE 6

# AMBIENT SURFACE WATER ANALYTICAL RESULTS

TABLE 6
AMBIENT SURFACE WATER ANALYTICAL RESULTS
Pages 1 of 5

| | Marine Water Numerical Criteria for Protection of Aquatic Life | | Marine Water Numerical Criteria for Protection of Human Health (consumption of organisms) | CH01 | Shell 01 | Empire 01 | MS Riv 01 | Sandy 01 | SPELTO 01 |
|---|---|---|---|---|---|---|---|---|---|
| | Acute | Chronic | | Avg | Avg | Avg | Avg | Avg | Avg |
| VOLATILE ORGANIC COMPOUNDS (VOCs) | | | | | | | | | |
| | µg/L | | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L |
| 1,1,1-Trichloroethane | 3,120 | 1,560 | -- | < 0.19 | < 0.19 | < 0.19 | < 0.19 | < 0.19 | < 0.19 |
| 1,1,2,2-Tetrachloroethane | 902 | 451 | 1.8 | < 0.25 | < 0.25 | < 0.25 | < 0.25 | < 0.25 | < 0.25 |
| 1,1,2-Trichloroethane | -- | -- | 6.9 | < 0.31 | < 0.31 | < 0.31 | < 0.31 | < 0.31 | < 0.31 |
| 1,1-Dichloroethane | -- | -- | -- | < 0.14 | < 0.14 | < 0.14 | < 0.14 | < 0.14 | < 0.14 |
| 1,1-Dichloroethene | 22,400 | 11,200 | 0.58 | < 0.38 | < 0.38 | < 0.38 | < 0.38 | < 0.38 | < 0.38 |
| 1,2-Dichloroethane | 11,300 | 5,650 | 99 | < 0.15 | < 0.15 | < 0.15 | < 0.15 | < 0.15 | < 0.15 |
| 1,2-Dichloropropane | -- | -- | 1700 | < 0.15 | < 0.15 | < 0.15 | < 0.15 | < 0.15 | < 0.15 |
| 1,3-Dichloropropane | -- | -- | -- | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 |
| 2-Chloroethyl vinyl ether | -- | -- | -- | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 |
| Acrolein | -- | -- | 780 | < 9.6 | < 9.6 | < 9.6 | < 9.6 | < 9.6 | < 9.6 |
| Acrylonitrile | -- | -- | 0.66 | < 0.67 | < 0.67 | < 0.67 | < 0.67 | < 0.67 | < 0.67 |
| Benzene | 2,700 | 1,350 | 12.5 | < 0.12 | < 0.12 | < 0.12 | < 0.12 | < 0.12 | < 0.12 |
| Bromoform | 1,790 | 895 | 34.7 | < 0.18 | < 0.18 | < 0.18 | < 0.18 | < 0.18 | < 0.18 |
| Bromomethane | -- | -- | -- | < 0.8 | < 0.8 | < 0.8 | < 0.8 | < 0.8 | < 0.8 |
| Carbon tetrachloride | 15,000 | 7,500 | 4.4 | < 0.56 | < 0.56 | < 0.56 | < 0.56 | < 0.56 | < 0.56 |
| Chlorobenzene | -- | -- | 21,000 | < 0.17 | < 0.17 | < 0.17 | < 0.17 | < 0.17 | < 0.17 |
| Chlorodibromomethane | -- | -- | 34 | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 |
| Chloroethane | -- | -- | -- | < 0.84 | < 0.84 | < 0.84 | < 0.84 | < 0.84 | < 0.84 |
| Chloroform | 8,150 | 4,075 | 70 | < 0.18 | < 0.18 | < 0.18 | < 0.18 | < 0.18 | < 0.18 |
| Chloromethane | 27,000 | 13,500 | -- | < 0.15 | < 0.15 | < 0.15 | < 0.15 | < 0.15 | < 0.15 |
| Dichlorobromomethane | -- | -- | 5.08 | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 |
| Ethylbenzene | 8,760 | 4,380 | 0.0081 | < 0.56 | < 0.56 | < 0.56 | < 0.56 | < 0.56 | < 0.56 |
| Methylene Chloride | 25,600 | 12,800 | 87 | < 0.45 | < 0.45 | < 0.45 | < 0.45 | < 0.45 | < 0.45 |
| Tetrachloroethene | 1,020 | 510 | 2.5 | < 0.2 | < 0.2 | < 0.2 | < 0.2 | < 0.2 | < 0.2 |
| Toluene | 950 | 475 | 0.0462 | < 0.19 | < 0.19 | < 0.19 | < 0.19 | < 0.19 | < 0.19 |
| trans-1,2-Dichloroethene | -- | -- | -- | < 0.24 | < 0.24 | < 0.24 | < 0.24 | < 0.24 | < 0.24 |
| Trichloroethene | 200 | 100 | 21 | < 0.29 | < 0.29 | < 0.29 | < 0.29 | < 0.29 | < 0.29 |
| Vinyl chloride | -- | -- | 35.8 | < 0.22 | < 0.22 | < 0.22 | < 0.22 | < 0.22 | < 0.22 |

TABLE 6
AMBIENT SURFACE WATER ANALYTICAL RESULTS
Pages 2 of 5

| | Marine Water Numerical Criteria for Protection of Aquatic Life | | Marine Water Numerical Criteria for Protection of Human Health (consumption of organisms) | CH01 | Shell 01 | Empire 01 | MS Riv 01 | Sandy 01 | SPELTO 01 |
|---|---|---|---|---|---|---|---|---|---|
| | Acute | Chronic | | Avg | Avg | Avg | Avg | Avg | Avg |
| **SEMIVOLATILE ORGANIC COMPOUNDS (SVOCs)** | | | | | | | | | |
| | µg/L | | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L |
| 1,2-Dichlorobenzene | -- | -- | 17,000 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 |
| 1,2-Diphenylhydrazine | -- | -- | 0.54 | < 4 | < 4 | < 4 | < 4 | < 4 | < 4 |
| 1,3-Dichlorobenzene | -- | -- | 2,600 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 |
| 1,4-Dichlorobenzene | -- | -- | 2,600 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 |
| 2,2'-oxybis(2-chloropropane) | -- | -- | -- | < 1.3 | < 1.3 | < 1.3 | < 1.3 | < 1.3 | < 1.3 |
| 2,4,6-Trichlorophenol | -- | -- | 6.5 | < 2.4 | < 2.4 | < 2.4 | < 2.4 | < 2.4 | < 2.4 |
| 2,4-Dichlorophenol | -- | -- | 232.6 | < 1.2 | < 1.2 | < 1.2 | < 1.2 | < 1.2 | < 1.2 |
| 2,4-Dimethylphenol | -- | -- | -- | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 |
| 2,4-Dinitrophenol | -- | -- | -- | < 2.3 | < 2.3 | < 2.3 | < 2.3 | < 2.3 | < 2.3 |
| 2,4-Dinitrotoluene | -- | -- | 9.1 | < 2.2 | < 2.2 | < 2.2 | < 2.2 | < 2.2 | < 2.2 |
| 2,6-Dinitrotoluene | -- | -- | -- | < 2.4 | < 2.4 | < 2.4 | < 2.4 | < 2.4 | < 2.4 |
| 2-Chloronaphthalene | -- | -- | 14,000 | < 1.7 | < 1.7 | < 1.7 | < 1.7 | < 1.7 | < 1.7 |
| 2-Chlorophenol | -- | -- | 126.4 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 |
| 2-Nitrophenol | -- | -- | -- | < 1.3 | < 1.3 | < 1.3 | < 1.3 | < 1.3 | < 1.3 |
| 3,3'-Dichlorobenzidine | -- | -- | 0.077 | < 7.1 | < 7.1 | < 7.1 | < 7.1 | < 7.1 | < 7.1 |
| 4,6-Dinitro-2-methylphenol | -- | -- | -- | < 2.1 | < 2.1 | < 2.1 | < 2.1 | < 2.1 | < 2.1 |
| 4-Bromophenyl phenyl ether | -- | -- | -- | < 1.7 | < 1.7 | < 1.7 | < 1.7 | < 1.7 | < 1.7 |
| 4-Chloro-3-methylphenol | -- | -- | -- | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 |
| 4-Chlorophenyl phenyl ether | -- | -- | -- | < 1.5 | < 1.5 | < 1.5 | < 1.5 | < 1.5 | < 1.5 |
| 4-Nitrophenol | -- | -- | -- | < 3.6 | < 3.6 | < 3.6 | < 3.6 | < 3.6 | < 3.6 |
| Acenaphthene | -- | -- | -- | < 1.3 | < 1.3 | < 1.3 | < 1.3 | < 1.3 | < 1.3 |
| Acenaphthylene | -- | -- | -- | < 2.4 | < 2.4 | < 2.4 | < 2.4 | < 2.4 | < 2.4 |
| Anthracene | -- | -- | 110,000 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 |
| Benzidine | -- | -- | 0.00054 | < 8.4 | < 8.4 | < 8.4 | < 8.4 | < 8.4 | < 8.4 |
| Benz(a)anthracene | -- | -- | 0.031 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 |
| Benzo(a)pyrene | -- | -- | 0.031 | < 5.6 | < 5.6 | < 5.6 | < 5.6 | < 5.6 | < 5.6 |
| Benzo(b()Foranthene | -- | -- | 0.031 | < 9.5 | < 9.5 | < 9.5 | < 9.5 | < 9.5 | < 9.5 |
| Benzo(g,h,i)perylene | -- | -- | -- | < 5.4 | < 5.4 | < 5.4 | < 5.4 | < 5.4 | < 5.4 |
| Benzo(k)fluoranthene | -- | -- | 0.031 | < 9 | < 9 | < 9 | < 9 | < 9 | < 9 |
| Bis(2-chloroethoxy)methane | -- | -- | -- | < 5.4 | < 5.4 | < 5.4 | < 5.4 | 16 | < 5.4 |
| Bis(2-chloroethyl)ether | -- | -- | 1.4 | < 3 | < 3 | < 3 | < 3 | < 3 | < 3 |
| Bis(2-ethylhexyl) phthalate | -- | -- | 5.9 | < 3.3 | < 3.3 | < 3.3 | < 3.3 | < 3.3 | < 3.3 |
| Butyl benzyl phthalate | -- | -- | -- | < 2.8 | < 2.8 | < 2.8 | < 2.8 | < 2.8 | < 2.8 |
| Chrysene | -- | -- | 0.031 | < 2.3 | < 2.3 | < 2.3 | < 2.3 | < 2.3 | < 2.3 |

TABLE 6
AMBIENT SURFACE WATER ANALYTICAL RESULTS
Pages 3 of 5

| | Marine Water Numerical Criteria for Protection of Aquatic Life | | Marine Water Numerical Criteria for Protection of Human Health (consumption of organisms) | CH01 | Shell 01 | Empire 01 | MS Riv 01 | Sandy 01 | SPELTO 01 |
|---|---|---|---|---|---|---|---|---|---|
| | Acute | Chronic | | Avg | Avg | Avg | Avg | Avg | Avg |
| **SEMIVOLATILE ORGANIC COMPOUNDS (SVOCs) Continued** | | | | | | | | | |
| | µg/L | | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L |
| Dimethyl phthalate | | | 2,900,000 | < 1.2 | < 1.2 | < 1.2 | < 1.2 | < 1.2 | < 1.2 |
| Di-n-butyl phthalate | -- | -- | 12,000 | < 1.2 | < 1.2 | < 1.2 | < 1.2 | < 1.2 | < 1.2 |
| Di-n-octyl phthalate | -- | -- | -- | < 1.8 | < 1.8 | < 1.8 | < 1.8 | < 1.8 | < 1.8 |
| Fluoranthene | -- | -- | 370 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 |
| Fluorene | -- | -- | 14,000 | < 1.5 | < 1.5 | < 1.5 | < 1.5 | < 1.5 | < 1.5 |
| Hexachlorobenzene | -- | -- | 0.00077 | < 1.7 | < 1.7 | < 1.7 | < 1.7 | < 1.7 | < 1.7 |
| Hexachlorobutadiene | 1.6 | 0.32 | 50 | < 1.4 | < 1.4 | < 1.4 | < 1.4 | < 1.4 | < 1.4 |
| Hexachlorocyclopentadiene | -- | -- | 17000 | < 1.8 | < 1.8 | < 1.8 | < 1.8 | < 1.8 | < 1.8 |
| Hexachloroethane | -- | -- | 8.9 | < 1.3 | < 1.3 | < 1.3 | < 1.3 | < 1.3 | < 1.3 |
| Indeno[1,2,3-cd]pyrene | -- | -- | 0.031 | < 2.9 | < 2.9 | < 2.9 | < 2.9 | < 2.9 | < 2.9 |
| Isophorone | -- | -- | 600 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 |
| Naphthalene | -- | -- | -- | < 1.2 | < 1.2 | < 1.2 | < 1.2 | < 1.2 | < 1.2 |
| Nitrobenzene | -- | -- | 1,900 | < 1.4 | < 1.4 | < 1.4 | < 1.4 | < 1.4 | < 1.4 |
| N-Nitrosodimethylamine | -- | -- | 8.1 | < 2.2 | < 2.2 | < 2.2 | < 2.2 | < 2.2 | < 2.2 |
| N-Nitrosodi-n-propylamine | -- | -- | -- | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 |
| N-Nitrosodiphenylamine | -- | -- | 16 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 |
| Pentachlorophenol | -- | -- | 8.2 | < 2.1 | < 2.1 | < 2.1 | < 2.1 | < 2.1 | < 2.1 |
| Phenanthrene | -- | -- | -- | < 1.2 | < 1.2 | < 1.2 | < 1.2 | < 1.2 | < 1.2 |
| Phenol | 580 | 290 | 4,600,000 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 |
| Pyrene | -- | -- | 11,000 | < 2.2 | < 2.2 | < 2.2 | < 2.2 | < 2.2 | < 2.2 |

TABLE 6
AMBIENT SURFACE WATER ANALYTICAL RESULTS
Pages 4 of 5

| | Marine Water Numerical Criteria for Protection of Aquatic Life | | Marine Water Numerical Criteria for Protection of Human Health (consumption of organisms) | CH01 | Shell 01 | Empire 01 | MS Riv 01 | Sandy 01 | SPELTO 01 |
|---|---|---|---|---|---|---|---|---|---|
| | Acute | Chronic | | Avg | Avg | Avg | Avg | Avg | Avg |
| **PESTICIDES, HERBICIDES, AND POLYCHLORINATED BIOPHENYLS** | | | | | | | | | |
| | µg/L | | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L |
| 4,4'-DDD | 1.25 | 0.25 | 0.00027 | < 0.0076 | < 0.0076 | < 0.0076 | < 0.0076 | < 0.0076 | < 0.0076 |
| 4,4'-DDE | 0.7 | 0.14 | 0.00019 | < 0.0064 | < 0.0064 | < 0.0064 | < 0.0064 | < 0.0064 | < 0.0064 |
| 4,4'-DDT | 0.13 | 0.001 | 0.00019 | < 0.0084 | < 0.0084 | < 0.0084 | < 0.0084 | < 0.0084 | < 0.0084 |
| Aldrin | 1.3 | -- | 0.00004 | < 0.0045 | < 0.0045 | < 0.0045 | < 0.0045 | < 0.0045 | < 0.0045 |
| alpha-BHC | -- | -- | 0.013 | < 0.0056 | < 0.0056 | < 0.0056 | < 0.0056 | < 0.0056 | < 0.0056 |
| beta-BHC | -- | -- | 0.046 | < 0.0036 | < 0.0036 | < 0.0036 | < 0.0036 | < 0.0036 | < 0.0036 |
| Chlordane (technical) | 0.09 | 0.004 | 0.00019 | < 0.032 | < 0.032 | < 0.032 | < 0.032 | < 0.032 | < 0.032 |
| delta-BHC | -- | -- | -- | < 0.01 | < 0.01 | < 0.01 | < 0.01 | < 0.01 | < 0.01 |
| Dieldrin | 0.71 | 0.0019 | 0.00005 | < 0.0074 | < 0.0074 | < 0.0074 | < 0.0074 | < 0.0074 | < 0.0074 |
| Endosulfan I | 0.034 | 0.0087 | 2 | < 0.0044 | < 0.0044 | < 0.0044 | < 0.0044 | < 0.0044 | < 0.0044 |
| Endosulfan II | -- | -- | 2 | < 0.0047 | < 0.0047 | < 0.0047 | < 0.0047 | < 0.0047 | < 0.0047 |
| Endosulfan sulfate | -- | -- | 2 | < 0.009 | < 0.009 | < 0.009 | < 0.009 | < 0.009 | < 0.009 |
| Endrin | 0.037 | 0.0023 | 0.26 | < 0.0067 | < 0.0067 | < 0.0067 | < 0.0067 | < 0.0067 | < 0.0067 |
| Endrin aldehyde | -- | -- | 0.81 | < 0.0069 | < 0.0069 | < 0.0069 | < 0.0069 | < 0.0069 | < 0.0069 |
| gamma-BHC (Lindane) | 0.16 | -- | 0.063 | < 0.0049 | < 0.0049 | < 0.0049 | < 0.0049 | < 0.0049 | < 0.0049 |
| Heptachlor | 0.053 | 0.0036 | 0.00007 | < 0.0037 | < 0.0037 | < 0.0037 | < 0.0037 | < 0.0037 | < 0.0037 |
| Heptachlor epoxide | -- | -- | 0.00011 | < 0.0039 | < 0.0039 | < 0.0039 | < 0.0039 | < 0.0039 | < 0.0039 |
| Toxaphene | 0.21 | 0.002 | 0.00024 | < 0.31 | < 0.31 | < 0.31 | < 0.11 | < 0.31 | < 0.31 |
| PCB-1016 | 10 | 0.03 | -- | < 0.11 | < 0.11 | < 0.11 | < 0.17 | < 0.11 | < 0.11 |
| PCB-1221 | 10 | 0.03 | -- | < 0.17 | < 0.17 | < 0.17 | < 0.31 | < 0.17 | < 0.17 |
| PCB-1232 | 10 | 0.03 | -- | < 0.13 | < 0.13 | < 0.13 | < 0.14 | < 0.13 | < 0.13 |
| PCB-1242 | 10 | 0.03 | -- | < 0.18 | < 0.18 | < 0.18 | < 0.12 | < 0.18 | < 0.18 |
| PCB-1248 | 10 | 0.03 | -- | < 0.14 | < 0.14 | < 0.14 | < 0.12 | < 0.14 | < 0.14 |
| PCB-1254 | 10 | 0.03 | -- | < 0.12 | < 0.12 | < 0.12 | < 0.13 | < 0.12 | < 0.12 |
| PCB-1260 | 10 | 0.03 | -- | < 0.12 | < 0.12 | < 0.12 | < 0.18 | < 0.12 | < 0.12 |

**TABLE 6**
**AMBIENT SURFACE WATER ANALYTICAL RESULTS**
**Pages 5 of 5**

| | Marine Water Numerical Criteria for Protection of Aquatic Life | | Marine Water Numerical Criteria for Protection of Human Health (consumption of organisms) | CH01 | Shell 01 | Empire 01 | MS Riv 01 | Sandy 01 | SPELTO 01 |
|---|---|---|---|---|---|---|---|---|---|
| | Acute | Chronic | | Avg | Avg | Avg | Avg | Avg | Avg |
| **METALS** | | | | | | | | | |
| | µg/L | | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L |
| Antimony | | | 4,300 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 |
| Arsenic | 69 | 36 | 0.14 | 1.4 | 1.8 | 1.7 | 1.1 | 1.7 | 1.7 |
| Beryllium | -- | -- | -- | < 0.15 | 0.16 | < 0.15 | < 0.15 | < 0.15 | < 0.15 |
| Cadmium | 45.35 | 10 | -- | < 0.1 | 0.17 | 0.1 | < 0.1 | < 0.1 | 0.11 |
| Chromium | -- | -- | -- | < 1.5 | < 1.5 | < 1.5 | < 1.5 | < 1.5 | < 1.5 |
| Copper | 3.63 | 3.63 | -- | 0.69 | 1.3 | 0.54 | 2.2 | 0.5 | 0.9 |
| Lead | 209 | 8.08 | 0.15 | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 |
| Nickel | 74 | 8.2 | -- | 1.3 | 1.5 | 0.99 | < 0.15 | 0.57 | 0.94 |
| Selenium | -- | -- | -- | < 2 | < 2 | < 2 | < 2 | < 2 | < 2 |
| Silver | -- | -- | -- | < 0.25 | < 0.25 | < 0.25 | < 0.25 | < 0.25 | < 0.25 |
| Thallium | -- | -- | 6.3 | < 0.25 | 0.39 | < 0.25 | < 0.25 | 0.31 | < 0.25 |
| Zinc | -- | -- | -- | 13 | 15 | 16 | 4.7 | 14 | 15 |
| | mg/L | | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L |
| Mercury | 0.002 | 0.000025 | 0.00015 | < 0.000078 | < 0.000078 | < 0.000078 | 0.000093 | < 0.000078 | < 0.000078 |
| **GENERAL CHEMISTRY** | | | | | | | | | |
| | mg/L | | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L |
| Ammonia | -- | -- | -- | < 0.007 | 0.83 | 0.47 | 0.035 | 0.79 | 0.014 |
| Nitrogen, Organic | -- | -- | -- | 1.2 | < 0.03 | < 0.03 | < 0.03 | < 0.03 | 0.14 |
| Nitrogen, Kjeldahl | -- | -- | -- | < 0.15 | < 0.15 | < 0.15 | < 0.15 | < 0.15 | < 0.15 |
| Nitrogen, Nitrate Nitrite | -- | -- | -- | 48 | 870 | 950 | 370 | 760 | 83 |
| Phosphorus, Total | -- | -- | -- | 2.7 | 0.11 | 0.075 | 0.22 | 0.062 | 0.25 |

Notes:
-- denotes that no numerical criteria have been established for a parameter by the LDEQ or USEPA.

# TABLE 7

# ELUTRIATE ANALYTICAL RESULTS

TABLE 7
ELUTRIATE ANALYTICAL RESULTS
Page 1 of 4

| | Marine Water Numerical Criteria for Protection of Aquatic Life | | Marine Water Numerical Criteria for Protection of Human Health (consumption of organisms) | CH 01 | CH 02 | Shell 01 | Shell 02 | Empire 01 | MSRiv 01 | Sandy 01 | Sandy 02 | SPELTO 01 | SPELTO 02 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Acute | Chronic | | | | | | | | | | | |
| **VOLATILE ORGANIC COMPOUNDS (VOCs)** | | | | | | | | | | | | | |
| | µg/L | | ug/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L |
| 1,1,2,2-Tetrachloroethane | 902 | 451 | 1.8 | < 0.25 | < 0.25 | < 0.25 | < 0.25 | < 0.25 | < 0.25 | < 0.25 | < 0.25 | < 0.25 | < 0.25 |
| 1,1,2-Trichloroethane | -- | -- | 6.9 | < 0.31 | < 0.31 | < 0.31 | < 0.31 | < 0.31 | < 0.31 | < 0.31 | < 0.31 | < 0.31 | < 0.31 |
| 1,1-Dichloroethane | -- | -- | -- | < 0.14 | < 0.14 | < 0.14 | < 0.14 | < 0.14 | < 0.14 | < 0.14 | < 0.14 | < 0.14 | < 0.14 |
| 1,1-Dichloroethene | 22,400 | 11,200 | 0.58 | < 0.38 | < 0.38 | < 0.38 | < 0.38 | < 0.38 | < 0.38 | < 0.38 | < 0.38 | < 0.38 | < 0.38 |
| 1,2-Dichloroethane | 11,300 | 5,650 | 99 | < 0.15 | < 0.15 | < 0.15 | < 0.15 | < 0.15 | < 0.15 | < 0.15 | < 0.22 | < 0.15 | < 0.15 |
| 1,2-Dichloropropane | -- | -- | 1,700 | < 0.15 | < 0.15 | < 0.15 | < 0.15 | < 0.15 | < 0.15 | < 0.15 | < 0.15 | < 0.15 | < 0.15 |
| 1,3-Dichloropropane | -- | -- | -- | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 |
| 2-Chloroethyl vinyl ether | -- | -- | -- | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 |
| Acrolein | -- | -- | 780 | < 9.6 | < 9.6 | < 9.6 | < 9.6 | < 9.6 | < 9.6 | < 9.6 | < 9.6 | < 9.6 | < 9.6 |
| Acrylonitrile | -- | -- | 0.66 | < 0.67 | < 0.67 | < 0.67 | < 0.67 | < 0.67 | < 0.67 | < 0.67 | < 0.67 | < 0.67 | < 0.67 |
| Benzene | 2,700 | 1,350 | 12.5 | < 0.12 | < 0.12 | < 0.12 | < 0.12 | < 0.12 | < 0.12 | < 0.12 | < 0.12 | < 0.12 | < 0.12 |
| Bromoform | 1,790 | 895 | 34.7 | < 0.18 | < 0.18 | < 0.18 | < 0.18 | < 0.18 | < 0.18 | < 0.18 | < 0.18 | < 0.18 | < 0.18 |
| Bromomethane | -- | -- | -- | < 0.8 | < 0.8 | < 0.8 | < 0.8 | < 0.8 | < 0.8 | < 0.8 | < 0.8 | < 0.8 | < 0.8 |
| Carbon tetrachloride | 15,000 | 7,500 | 4.4 | < 0.56 | < 0.56 | < 0.56 | < 0.56 | < 0.56 | < 0.56 | < 0.56 | < 0.56 | < 0.56 | < 0.56 |
| Chlorobenzene | -- | -- | 21,000 | < 0.17 | < 0.17 | < 0.17 | < 0.17 | < 0.17 | < 0.17 | < 0.17 | < 0.17 | < 0.17 | < 0.17 |
| Chlorodibromomethane | -- | -- | 34 | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 |
| Chloroethane | -- | -- | -- | < 0.84 | < 0.84 | < 0.84 | < 0.84 | < 0.84 | < 0.84 | < 0.84 | < 0.84 | < 0.84 | < 0.84 |
| Chloroform | 8,150 | 4,075 | 70 | < 0.18 | < 0.18 | < 0.18 | < 0.18 | < 0.18 | < 0.18 | < 0.18 | < 0.18 | < 0.18 | < 0.18 |
| Chloromethane | 27,000 | 13,500 | -- | < 0.15 | < 0.15 | < 0.15 | < 0.15 | < 0.15 | < 0.15 | < 0.15 | < 0.15 | < 0.15 | < 0.15 |
| Dichlorobromomethane | -- | -- | 5.08 | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 |
| Ethylbenzene | 8,760 | 4,380 | 0.0081 | < 0.56 | < 0.56 | < 0.56 | < 0.56 | < 0.56 | < 0.56 | < 0.56 | < 0.56 | < 0.56 | < 0.56 |
| Methylene Chloride | 25,600 | 12,800 | 87 | < 0.45 | 6.4 | 2.4 | < 0.45 | < 0.45 | < 0.45 | 14 | 4.9 | 9.2 | < 0.45 |
| Tetrachloroethene | 1,020 | 510 | 2.5 | < 0.2 | < 0.2 | < 0.2 | < 0.2 | < 0.2 | < 0.2 | < 0.2 | < 0.2 | < 0.2 | < 0.2 |
| Toluene | 950 | 475 | 0.0462 | < 0.19 | < 0.19 | < 0.19 | < 0.19 | < 0.19 | < 0.19 | < 0.19 | < 0.19 | < 0.19 | < 0.19 |
| trans-1,2-Dichloroethene | -- | -- | -- | < 0.24 | < 0.24 | < 0.24 | < 0.24 | < 0.24 | < 0.24 | < 0.24 | < 0.24 | < 0.24 | < 0.24 |
| Trichloroethene | 200 | 100 | 21 | < 0.29 | < 0.29 | < 0.29 | < 0.29 | < 0.29 | < 0.29 | < 0.29 | < 0.29 | < 0.29 | < 0.29 |
| Vinyl chloride | -- | -- | 35.8 | < 0.22 | < 0.22 | < 0.22 | < 0.22 | < 0.22 | < 0.22 | < 0.22 | < 0.22 | < 0.22 | < 0.22 |
| **SEMIVOLATILE ORGANIC COMPOUNDS (SOVCs)** | | | | | | | | | | | | | |
| | µg/L | | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L |
| 1,2-Diphenylhydrazine | -- | -- | 0.54 | < 4 | < 4 | < 4 | < 4 | < 4 | < 4 | < 4 | < 4 | < 4 | < 4 |
| 1,3-Dichlorobenzene | -- | -- | 2,600 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 |
| 1,4-Dichlorobenzene | -- | -- | 2,600 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 |
| 2,2'-oxybis(2-chloropropane) | -- | -- | -- | < 1.3 | < 1.3 | < 1.3 | < 1.3 | < 1.3 | < 1.3 | < 1.3 | < 1.3 | < 1.3 | < 1.3 |
| 2,4,6-Trichlorophenol | -- | -- | 6.5 | < 2.4 | < 2.4 | < 2.4 | < 2.4 | < 2.4 | < 2.4 | < 2.4 | < 2.4 | < 2.4 | < 2.4 |
| 2,4-Dichlorophenol | -- | -- | 232.6 | < 1.2 | < 1.2 | < 1.2 | < 1.2 | < 1.2 | < 1.2 | < 1.2 | < 1.2 | < 1.2 | < 1.2 |
| 2,4-Dimethylphenol | -- | -- | -- | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 |
| 2,4-Dinitrophenol | -- | -- | -- | < 2.3 | < 2.3 | < 2.3 | < 2.3 | < 2.3 | < 2.3 | < 2.3 | < 2.3 | < 2.3 | < 2.3 |
| 2,4-Dinitrotoluene | -- | -- | 9.1 | < 2.2 | < 2.2 | < 2.2 | < 2.2 | < 2.2 | < 2.2 | < 2.2 | < 2.2 | < 2.2 | < 2.2 |
| 2,6-Dinitrotoluene | -- | -- | -- | < 2.4 | < 2.4 | < 2.4 | < 2.4 | < 2.4 | < 2.4 | < 2.4 | < 2.4 | < 2.4 | < 2.4 |
| 2-Chloronaphthalene | -- | -- | 14,000 | < 1.7 | < 1.7 | < 1.7 | < 1.7 | < 1.7 | < 1.7 | < 1.7 | < 1.7 | < 1.7 | < 1.7 |
| 2-Chlorophenol | -- | -- | 126.4 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 |
| 2-Nitrophenol | -- | -- | -- | < 1.3 | < 1.3 | < 1.3 | < 1.3 | < 1.3 | < 1.3 | < 1.3 | < 1.3 | < 1.3 | < 1.3 |

TABLE 7
ELUTRIATE ANALYTICAL RESULTS
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| | Marine Water Numerical Criteria for Protection of Aquatic Life | | Marine Water Numerical Criteria for Protection of Human Health (consumption of organisms) | CH 01 | CH 02 | Shell 01 | Shell 02 | Empire 01 | MSRiv 01 | Sandy 01 | Sandy 02 | SPELTO 01 | SPELTO 02 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Acute | Chronic | | | | | | | | | | | |
| **SEMIVOLATILE ORGANIC COMPOUNDS (SOVCs) - Continued** | | | | | | | | | | | | | |
| | µg/L | | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L |
| 3,3'-Dichlorobenzidine | -- | -- | 0.077 | < 7.1 | < 7.1 | < 7.1 | < 7.1 | < 7.1 | < 7.1 | < 7.1 | < 7.1 | < 7.1 | < 7.1 |
| 4,6-Dinitro-2-methylphenol | -- | -- | -- | < 2.1 | < 2.1 | < 2.1 | < 2.1 | < 2.1 | < 2.1 | < 2.1 | < 2.1 | < 2.1 | < 2.1 |
| 4-Chloro-3-methylphenol | -- | -- | -- | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 |
| 4-Chlorophenyl phenyl ether | -- | -- | -- | < 1.5 | < 1.5 | < 1.5 | < 1.5 | < 1.5 | < 1.5 | < 1.5 | < 1.5 | < 1.5 | < 1.5 |
| 4-Nitrophenol | -- | -- | -- | < 3.6 | < 3.6 | < 3.6 | < 3.6 | < 3.6 | < 3.6 | < 3.6 | < 3.6 | < 3.6 | < 3.6 |
| Acenaphthene | -- | -- | -- | < 1.3 | < 1.3 | < 1.3 | < 1.3 | < 1.3 | < 1.3 | < 1.3 | < 1.3 | < 1.3 | < 1.3 |
| Acenaphthylene | -- | -- | -- | < 2.4 | < 2.4 | < 2.4 | < 2.4 | < 2.4 | < 2.4 | < 2.4 | < 2.4 | < 2.4 | < 2.4 |
| Anthracene | -- | -- | 110,000 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 |
| Benzidine | -- | -- | 0.00054 | < 8.4 | < 8.4 | < 8.4 | < 8.4 | < 8.4 | < 8.4 | < 8.4 | < 8.4 | < 8.4 | < 8.4 |
| Benzo[a]anthracene | -- | -- | 0.031 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 |
| Benzo[a]pyrene | -- | -- | 0.031 | < 5.6 | < 5.6 | < 5.6 | < 5.6 | < 5.6 | < 5.6 | < 5.6 | < 5.6 | < 5.6 | < 5.6 |
| Benzo[b]fluoranthene | -- | -- | 0.031 | < 9.5 | < 9.5 | < 9.5 | < 9.5 | < 9.5 | < 9.5 | < 9.5 | < 9.5 | < 9.5 | < 9.5 |
| Benzo[g,h,i]perylene | -- | -- | -- | < 5.4 | < 5.4 | < 5.4 | < 5.4 | < 5.4 | < 5.4 | < 5.4 | < 5.4 | < 5.4 | < 5.4 |
| Benzo[k]fluoranthene | -- | -- | 0.031 | < 9 | < 9 | < 9 | < 9 | < 9 | < 9 | < 9 | < 9 | < 9 | < 9 |
| Bis(2-chloroethoxy)methane | -- | -- | -- | < 5.4 | < 5.4 | < 5.4 | < 5.4 | < 5.4 | < 5.4 | < 5.4 | < 5.4 | < 5.4 | < 5.4 |
| Bis(2-chloroethyl)ether | -- | -- | 1.4 | < 3 | < 3 | < 3 | < 3 | < 3 | < 3 | < 3 | < 3 | < 3 | < 3 |
| Bis(2-ethylhexyl) phthalate | -- | -- | 5.9 | 4.7 | < 3.3 | < 3.3 | < 3.3 | < 3.3 | < 3.3 | < 3.3 | < 3.3 | < 3.3 | < 3.3 |
| Butyl benzyl phthalate | -- | -- | -- | < 2.8 | < 2.8 | < 2.8 | < 2.8 | < 2.8 | < 2.8 | < 2.8 | < 2.8 | < 2.8 | < 2.8 |
| Chrysene | -- | -- | 0.031 | < 2.3 | < 2.3 | < 2.3 | < 2.3 | < 2.3 | < 2.3 | < 2.3 | < 2.3 | < 2.3 | < 2.3 |
| Dibenz(a,h)anthracene | -- | -- | 0.031 | < 9.5 | < 9.5 | < 9.5 | < 9.5 | < 9.5 | < 9.5 | < 9.5 | < 9.5 | < 9.5 | < 9.5 |
| Diethyl phthalate | -- | -- | 120,000 | < 1.7 | < 1.7 | < 1.7 | < 1.7 | < 1.7 | < 1.7 | < 1.7 | < 1.7 | < 1.7 | < 1.7 |
| Dimethyl phthalate | -- | -- | 2,900,000 | < 1.2 | < 1.2 | < 1.2 | < 1.2 | < 1.2 | < 1.2 | < 1.2 | < 1.2 | < 1.2 | < 1.2 |
| Di-n-butyl phthalate | -- | -- | 12,000 | < 1.2 | < 1.2 | < 1.2 | < 1.2 | < 1.2 | < 1.2 | < 1.2 | < 1.2 | < 1.2 | < 1.2 |
| Di-n-octyl phthalate | -- | -- | -- | < 1.8 | < 1.8 | < 1.8 | < 1.8 | < 1.8 | < 1.8 | < 1.8 | < 1.8 | < 1.8 | < 1.8 |
| Fluoranthene | -- | -- | 370 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 |
| Fluorene | -- | -- | 14,000 | < 1.5 | < 1.5 | < 1.5 | < 1.5 | < 1.5 | < 1.5 | < 1.5 | < 1.5 | < 1.5 | < 1.5 |
| Hexachlorobenzene | -- | -- | 0.00077 | < 1.7 | < 1.7 | < 1.7 | < 1.7 | < 1.7 | < 1.7 | < 1.7 | < 1.7 | < 1.7 | < 1.7 |
| Hexachlorobutadiene | 1.6 | 0.32 | 50 | < 1.4 | < 1.4 | < 1.4 | < 1.4 | < 1.4 | < 1.4 | < 1.4 | < 1.4 | < 1.4 | < 1.4 |
| Hexachlorocyclopentadiene | -- | -- | 17,000 | < 1.8 | < 1.8 | < 1.8 | < 1.8 | < 1.8 | < 1.8 | < 1.8 | < 1.8 | < 1.8 | < 1.8 |
| Hexachloroethane | -- | -- | 8.9 | < 1.3 | < 1.3 | < 1.3 | < 1.3 | < 1.3 | < 1.3 | < 1.3 | < 1.3 | < 1.3 | < 1.3 |
| Indeno[1,2,3-cd]pyrene | -- | -- | 0.031 | < 2.9 | < 2.9 | < 2.9 | < 2.9 | < 2.9 | < 2.9 | < 2.9 | < 2.9 | < 2.9 | < 2.9 |
| Isophorone | -- | -- | 600 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 |
| Naphthalene | -- | -- | -- | < 1.2 | < 1.2 | < 1.2 | < 1.2 | < 1.2 | < 1.2 | < 1.2 | < 1.2 | < 1.2 | < 1.2 |
| Nitrobenzene | -- | -- | 1,900 | < 1.4 | < 1.4 | < 1.4 | < 1.4 | < 1.4 | < 1.4 | < 1.4 | < 1.4 | < 1.4 | < 1.4 |
| N-Nitrosodimethylamine | -- | -- | 8.1 | < 2.2 | < 2.2 | < 2.2 | < 2.2 | < 2.2 | < 2.2 | < 2.2 | < 2.2 | < 2.2 | < 2.2 |
| N-Nitrosodi-n-propylamine | -- | -- | -- | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 |
| N-Nitrosodiphenylamine | -- | -- | 16 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 |
| Pentachlorophenol | -- | -- | 8.2 | < 2.1 | < 2.1 | < 2.1 | < 2.1 | < 2.1 | < 2.1 | < 2.1 | < 2.1 | < 2.1 | < 2.1 |
| Phenanthrene | -- | -- | -- | < 1.2 | < 1.2 | < 1.2 | < 1.2 | < 1.2 | < 1.2 | < 1.2 | < 1.2 | < 1.2 | < 1.2 |
| Phenol | 580 | 290 | 4,600,000 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 |
| Pyrene | -- | -- | 11,000 | < 2.2 | < 2.2 | < 2.2 | < 2.2 | < 2.2 | < 2.2 | < 2.2 | < 2.2 | < 2.2 | < 2.2 |

**TABLE 7**
**ELUTRIATE ANALYTICAL RESULTS**
**Page 3 of 4**

| | Marine Water Numerical Criteria for Protection of Aquatic Life | | Marine Water Numerical Criteria for Protection of Human Health (consumption of organisms) | CH 01 | CH 02 | Shell 01 | Shell 02 | Empire 01 | MSRiv 01 | Sandy 01 | Sandy 02 | SPELTO 01 | SPELTO 02 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Acute | Chronic | | | | | | | | | | | |
| **PESTICIDES, HERBICIDES, AND POLYCHLORINATED BIPHENYLS (PCBs)** | | | | | | | | | | | | | |
| | µg/L | | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L |
| 4,4'-DDD | 1.25 | 0.25 | 0.00027 | < 0.0076 | < 0.0076 | < 0.0076 | < 0.0076 | < 0.0076 | < 0.0076 | < 0.0076 | < 0.0076 | < 0.0076 | < 0.0076 |
| 4,4'-DDE | 0.7 | 0.14 | 0.00019 | < 0.0064 | < 0.0064 | < 0.0064 | < 0.0064 | < 0.0064 | < 0.0064 | < 0.0064 | < 0.0064 | < 0.0064 | < 0.0064 |
| 4,4'-DDT | 0.13 | 0.001 | 0.00019 | < 0.0084 | < 0.0084 | < 0.0084 | < 0.0084 | < 0.0084 | < 0.0084 | < 0.0084 | < 0.0084 | < 0.0084 | < 0.0084 |
| Aldrin | 1.3 | -- | 0.00004 | < 0.0045 | < 0.0045 | < 0.0045 | < 0.0045 | < 0.0045 | < 0.0045 | < 0.0045 | < 0.0045 | < 0.0045 | < 0.0045 |
| alpha-BHC | -- | -- | 0.013 | < 0.0056 | < 0.0056 | < 0.0056 | < 0.0056 | < 0.0056 | < 0.0056 | < 0.0056 | < 0.0056 | < 0.0056 | < 0.0056 |
| beta-BHC | -- | -- | 0.046 | < 0.0036 | < 0.0036 | < 0.0036 | < 0.0036 | < 0.0036 | < 0.0036 | < 0.0036 | < 0.0036 | < 0.0036 | < 0.0036 |
| Chlordane (technical) | 0.09 | 0.004 | 0.00019 | < 0.032 | < 0.032 | < 0.032 | < 0.032 | < 0.032 | < 0.032 | < 0.032 | < 0.032 | < 0.032 | < 0.032 |
| delta-BHC | -- | -- | -- | < 0.01 | < 0.01 | < 0.01 | < 0.01 | < 0.01 | < 0.01 | < 0.01 | < 0.01 | < 0.01 | < 0.01 |
| Dieldrin | 0.71 | 0.0019 | 0.00005 | < 0.0074 | < 0.0074 | < 0.0074 | < 0.0074 | < 0.0074 | < 0.0074 | < 0.0074 | < 0.0074 | < 0.0074 | < 0.0074 |
| Endosulfan I | 0.034 | 0.0087 | 2 | < 0.0044 | < 0.0044 | < 0.0044 | < 0.0044 | < 0.0044 | < 0.0044 | < 0.0044 | < 0.0044 | < 0.0044 | < 0.0044 |
| Endosulfan II | -- | -- | 2 | < 0.0047 | < 0.0047 | < 0.0047 | < 0.0047 | < 0.0047 | < 0.0047 | < 0.0047 | < 0.0047 | < 0.0047 | < 0.0047 |
| Endosulfan sulfate | -- | -- | 2 | < 0.009 | < 0.009 | < 0.009 | < 0.009 | < 0.009 | < 0.009 | < 0.009 | < 0.009 | < 0.009 | < 0.009 |
| Endrin | 0.037 | 0.0023 | 0.81 | < 0.0067 | < 0.0067 | < 0.0067 | < 0.0067 | < 0.0067 | < 0.0067 | < 0.0067 | < 0.0067 | < 0.0067 | < 0.0067 |
| Endrin aldehyde | -- | -- | 0.26 | < 0.0069 | < 0.0069 | < 0.0069 | < 0.0069 | < 0.0069 | < 0.0069 | < 0.0069 | < 0.0069 | < 0.0069 | < 0.0069 |
| gamma-BHC (Lindane) | 0.16 | -- | 0.063 | < 0.0049 | < 0.0049 | < 0.0049 | < 0.0049 | < 0.0049 | < 0.0049 | < 0.0049 | < 0.0049 | < 0.0049 | < 0.0049 |
| Heptachlor | 0.053 | 0.0036 | 0.00007 | < 0.0037 | < 0.0037 | < 0.0037 | < 0.0037 | < 0.0037 | < 0.0037 | < 0.0037 | < 0.0037 | < 0.0037 | < 0.0037 |
| Heptachlor epoxide | -- | -- | 0.00011 | < 0.0039 | < 0.0039 | < 0.0039 | < 0.0039 | < 0.0039 | < 0.0039 | < 0.0039 | < 0.0039 | < 0.0039 | < 0.0039 |
| Toxaphene | 0.21 | 0.0002 | 0.00024 | < 0.31 | < 0.31 | < 0.31 | < 0.31 | < 0.31 | < 0.31 | < 0.31 | < 0.31 | < 0.31 | < 0.31 |
| PCB-1016 | 10 | 0.03 | -- | < 0.11 | < 0.11 | < 0.11 | < 0.11 | < 0.11 | < 0.11 | < 0.11 | < 0.11 | < 0.11 | < 0.11 |
| PCB-1221 | 10 | 0.03 | -- | < 0.17 | < 0.17 | < 0.17 | < 0.17 | < 0.17 | < 0.17 | < 0.17 | < 0.17 | < 0.17 | < 0.17 |
| PCB-1232 | 10 | 0.03 | -- | < 0.13 | < 0.13 | < 0.13 | < 0.13 | < 0.13 | < 0.13 | < 0.13 | < 0.13 | < 0.13 | < 0.13 |
| PCB-1242 | 10 | 0.03 | -- | < 0.18 | < 0.18 | < 0.18 | < 0.18 | < 0.18 | < 0.18 | < 0.18 | < 0.18 | < 0.18 | < 0.18 |
| PCB-1248 | 10 | 0.03 | -- | < 0.14 | < 0.14 | < 0.14 | < 0.14 | < 0.14 | < 0.14 | < 0.14 | < 0.14 | < 0.14 | < 0.14 |
| PCB-1254 | 10 | 0.03 | -- | < 0.12 | < 0.12 | < 0.12 | < 0.12 | < 0.12 | < 0.12 | < 0.12 | < 0.12 | < 0.12 | < 0.12 |
| PCB-1260 | 10 | 0.03 | -- | < 0.12 | < 0.12 | < 0.12 | < 0.12 | < 0.12 | < 0.12 | < 0.12 | < 0.12 | < 0.12 | < 0.12 |
| **METALS** | | | | | | | | | | | | | |
| | µg/L | | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L | µg/L |
| Antimony | -- | -- | 4,300 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 |
| Arsenic | 69 | 36 | 0.14 | **5.6** | **3.6** | **6** | **3.5** | 2.1 | **7.8** | **3.2** | 2.3 | 1.5 | 2.1 |
| Beryllium | -- | -- | -- | < 0.6 | < 0.6 | < 0.6 | < 0.6 | < 0.6 | 1 | < 0.6 | < 0.6 | < 0.6 | < 0.6 |
| Cadmium | 45.35 | 10 | -- | < 0.1 | < 0.1 | 0.18 | 0.12 | 0.14 | 0.43 | 0.2 | < 0.1 | < 0.1 | < 0.1 |
| Chromium | -- | -- | -- | < 1.5 | < 1.5 | 4.7 | 3.2 | 2.1 | | **5.1** | 3.3 | < 1.5 | < 1.5 |
| Copper | 3.63 | 3.63 | -- | 0.99 | 1.5 | 2.3 | 2.1 | 1.6 | **19** | **3.4** | 3 | 1 | **0.94** |
| Lead | 209 | 8.08 | 0.15 | 0.72 | 0.85 | **1.7** | **3.7** | 0.51 | **19** | **1.9** | 1.4 | < 0.5 | < 0.5 |
| Nickel | 74 | 8.2 | -- | **1.6** | **2.4** | **2.9** | **7.2** | **2.5** | **22** | **4.5** | **3.7** | **1.1** | 1 |
| Selenium | -- | -- | -- | < 2 | < 2 | 2.3 | < 2 | < 2 | < 2 | < 2 | < 2 | < 2 | < 2 |
| Silver | -- | -- | -- | < 0.25 | < 0.25 | < 0.25 | < 0.25 | < 0.25 | < 0.25 | < 0.25 | < 0.25 | < 0.25 | < 0.25 |
| Thallium | -- | -- | 6.3 | < 0.25 | < 0.25 | < 0.25 | < 0.25 | < 0.25 | < 0.25 | 0.46 | 0.35 | < 0.25 | < 0.25 |
| Zinc | -- | -- | -- | 15 | 17 | **23** | **32** | 17 | **72** | 15 | 15 | **39** | 15 |
| | mg/L | | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L |
| Mercury | 2 | 0.025 | 4,600 | **0.00019** | **0.00018** | < 0.000078 | < 0.000078 | < 0.000078 | < 0.000078 | < 0.000078 | < 0.000078 | **0.00024** | < 0.000078 |

TABLE 7
ELUTRIATE ANALYTICAL RESULTS
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| | Marine Water Numerical Criteria for Protection of Aquatic Life | | Marine Water Numerical Criteria for Protection of Human Health (consumption of organisms) | CH 01 | CH 02 | Shell 01 | Shell 02 | Empire 01 | MSRiv 01 | Sandy 01 | Sandy 02 | SPELTO 01 | SPELTO 02 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Acute | Chronic | | | | | | | | | | | |
| **GENERAL CHEMISTRY** | | | | | | | | | | | | | |
| | mg/L | | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L |
| Ammonia | -- | -- | -- | 0.18 | 0.33 | < 0.007 | 0.044 | < 0.007 | 0.47 | 0.022 | 0.12 | 0.019 | 0.027 |
| Nitrogen, Kjeldahl | -- | -- | -- | 0.97 | 1.8 | 4.7 | 0.97 | 1 | 1.9 | 0.81 | 1.2 | 0.2 | 0.3 |
| Nitrogen, Nitrate Nitrite | -- | -- | -- | 0.45 | 0.52 | 0.47 | 0.49 | 0.56 | 2 | 1.7 | 1.7 | 0.49 | 0.61 |
| Phosphorus, Total | -- | -- | -- | 0.2 | 0.32 | 0.47 | 0.27 | 0.34 | 0.82 | 0.2 | 0.15 | 0.19 | 0.13 |
| Nitrogen, Organic | -- | -- | -- | 0.79 | 1.5 | 0.86 | 0.93 | 1 | 1.4 | 0.79 | 1.1 | 0.18 | 0.28 |

Notes:
-- denotes that no numerical criteria have been established for a parameter by the LDEQ or USEPA.

# TABLE 8

# SEDIMENT ANALYTICAL RESULTS

**TABLE 8**
**SEDIMENT ANALYTICAL RESULTS**
**Page 1 of 4**

| | LSS | CH 01 | CH02 | Shell 01 | Shell 02 | Empire 01 | MSRiv 01 | Sandy 01 | Sandy 02 | SPELTO 01 | SPELTO 02 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **VOLATILE ORGANIC COMPOUNDS (VOCs)** | | | | | | | | | | | |
| | µg/Kg | µg/Kg | µg/Kg | µg/Kg | µg/Kg | µg/Kg | µg/Kg | µg/Kg | µg/Kg | µg/Kg | µg/Kg |
| 1,1,2,2-Tetrachloroethane | 6 | < 1.6 | < 1.6 | < 1.6 | < 1.6 | < 1.6 | < 2.8 | < 1.7 | < 1.7 | < 1.7 | < 1.7 |
| 1,1,2-Trichloroethane | 58 | < 1.1 | < 1.1 | < 1.2 | < 1.2 | < 1.2 | < 2 | < 1.2 | < 1.2 | < 1.2 | < 1.2 |
| 1,1-Dichloroethane | 7,500 | < 0.95 | < 0.96 | < 0.96 | < 0.98 | < 0.97 | < 1.6 | < 0.98 | < 0.98 | < 0.98 | < 0.97 |
| 1,1-Dichloroethene | 85 | < 1.2 | < 1.2 | < 1.2 | < 1.3 | < 1.3 | < 2.1 | < 1.3 | < 1.3 | < 1.3 | < 1.3 |
| 1,2-Dichloroethane | 35 | < 1.9 | < 1.9 | < 1.9 | < 2 | < 1.9 | < 3.3 | < 2 | < 2 | < 2 | < 1.9 |
| 1,2-Dichloropropane | 42 | < 1.1 | < 1.1 | < 1.1 | < 1.2 | < 1.2 | < 2 | < 1.2 | < 1.2 | < 1.2 | < 1.2 |
| 1,3-Dichloropropene, Total | 40 | < 1.4 | < 1.4 | < 1.4 | < 1.5 | < 1.4 | < 2.5 | < 1.5 | < 1.5 | < 1.5 | < 1.5 |
| 2-Chloroethyl vinyl ether | -- | < 16 | < 16 | < 16 | < 17 | < 16 | < 28 | < 17 | < 17 | < 17 | < 17 |
| Acrolein | -- | < 27 | < 27 | < 27 | < 28 | < 27 | < 46 | < 28 | < 28 | < 28 | < 27 |
| Acrylonitrile | -- | < 59 | < 59 | < 59 | < 61 | < 60 | < 100 | < 61 | < 61 | < 61 | < 60 |
| Benzene | 51 | < 1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.8 | < 1.1 | < 1.1 | < 1.1 | < 1.1 |
| Bromoform | 1,800 | < 1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.8 | < 1.1 | < 1.1 | < 1.1 | < 1.1 |
| Bromomethane | 40 | < 3.4 | < 3.4 | < 3.4 | < 3.5 | < 3.5 | < 5.9 | < 3.5 | < 3.5 | < 3.5 | < 3.5 |
| Carbon tetrachloride | 110 | < 1.3 | < 1.3 | < 1.3 | < 1.4 | < 1.4 | < 2.3 | < 1.4 | < 1.4 | < 1.4 | < 1.4 |
| Chlorobenzene | 3,000 | < 1 | < 1 | < 1.1 | < 1.1 | < 1.1 | < 1.8 | < 1.1 | < 1.1 | < 1.1 | < 1.1 |
| Chlorodibromomethane | 920 | < 1.1 | < 1.1 | < 1.1 | < 1.2 | < 1.2 | < 2 | < 1.2 | < 1.2 | < 1.2 | < 1.2 |
| Chloroethane | 35 | < 1.4 | < 1.4 | < 1.4 | < 1.5 | < 1.5 | < 2.5 | < 1.5 | < 1.5 | < 1.5 | < 1.5 |
| Chloroform | 44 | < 0.78 | < 0.79 | < 0.78 | < 0.81 | < 0.79 | < 1.4 | < 0.8 | < 0.81 | < 0.81 | < 0.8 |
| Chloromethane | 100 | < 2.2 | < 2.2 | < 2.2 | < 2.3 | < 2.2 | < 3.8 | < 2.3 | < 2.3 | < 2.3 | < 2.2 |
| Dichlorobromomethane | 1,000 | < 1.1 | < 1.1 | < 1.1 | < 1.2 | < 1.2 | < 2 | < 1.2 | < 1.2 | < 1.2 | < 1.2 |
| Ethylbenzene | 19,000 | < 1.7 | < 1.7 | < 1.7 | < 1.8 | < 1.7 | < 3 | < 1.8 | < 1.8 | < 1.8 | < 1.7 |
| Methylene Chloride | 17 | < 1.5 | < 1.5 | < 1.5 | < 1.6 | < 1.5 | < 2.6 | < 1.6 | < 1.6 | < 1.6 | < 1.6 |
| Tetrachloroethene | 180 | < 0.85 | < 0.86 | < 0.86 | < 0.89 | < 0.87 | < 1.5 | < 0.88 | < 0.89 | < 0.88 | < 0.87 |
| Toluene | 20,000 | < 0.95 | < 0.96 | < 0.96 | < 0.98 | < 0.97 | < 1.6 | < 0.98 | < 0.98 | < 0.98 | < 0.97 |
| trans-1,2-Dichloroethene | 770 | < 0.94 | < 0.95 | < 0.95 | < 0.97 | < 0.96 | < 1.6 | < 0.97 | < 0.97 | < 0.97 | < 0.96 |
| Trichloroethene | 73 | < 0.85 | < 0.86 | < 0.86 | < 0.89 | < 0.87 | < 1.5 | < 0.88 | < 0.89 | < 0.88 | < 8.7 |
| Vinyl chloride | 13 | < 1.5 | < 1.5 | < 1.5 | < 1.6 | < 1.5 | < 2.6 | < 1.6 | < 1.6 | < 1.6 | < 1.6 |
| Xylenes, Total | 18,000 | NR | NR | < 1.2 | < 1.3 | < 1.3 | NR | < 1.3 | < 1.3 | NR | NR |
| **SEMIVOLATIE ORGANIC COMPOUNDS (SVOCs)** | | | | | | | | | | | |
| | µg/Kg | µg/Kg | µg/Kg | µg/Kg | µg/Kg | µg/Kg | µg/Kg | µg/Kg | µg/Kg | µg/Kg | µg/Kg |
| 1,2,4-Trichlorobenzene | 14000 | < 5 | < 5 | < 5 | < 5 | < 5 | < 14 | < 5 | < 5 | < 5 | < 5 |
| 1,2-Dichlorobenzene | 29000 | < 5.4 | < 5.4 | < 5.4 | < 5.4 | < 5.4 | < 15 | < 5.4 | < 5.4 | < 5.4 | < 5.4 |
| 1,2-Diphenylhydrazine | -- | < 4.2 | < 4.2 | < 4.2 | < 4.2 | < 4.2 | < 12 | < 4.2 | < 4.2 | < 4.2 | < 4.2 |
| 1,3-Dichlorobenzene | 2,100 | < 6.2 | < 6.2 | < 6.2 | < 6.2 | < 6.2 | < 18 | < 6.2 | < 6.2 | < 6.2 | < 6.2 |
| 1,4-Dichlorobenzene | 5,700 | < 4.2 | < 4.2 | < 4.2 | < 4.2 | < 4.2 | < 12 | < 4.2 | < 4.2 | < 4.2 | < 4.2 |
| 2,2'-oxybis(2-chloropropane) | -- | < 7.2 | < 7.2 | < 7.2 | < 7.2 | < 7.2 | < 21 | < 7.2 | < 7.2 | < 7.2 | < 7.2 |
| 2,4,6-Trichlorophenol | 1,300 | < 4.7 | < 4.7 | < 4.7 | < 4.7 | < 4.7 | < 13 | < 4.7 | < 4.7 | < 4.7 | < 4.7 |
| 2,4-Dichlorophenol | 12,000 | < 4.3 | < 4.3 | < 4.3 | < 4.3 | < 4.3 | < 12 | < 4.3 | < 4.3 | < 4.3 | < 4.3 |
| 2,4-Dimethylphenol | 20,000 | < 4.6 | < 4.6 | < 4.6 | < 4.6 | < 4.6 | < 13 | < 4.6 | < 4.6 | < 4.6 | < 4.6 |
| 2,4-Dinitrophenol | 1,700 | < 5.2 | < 5.2 | < 5.2 | < 5.2 | < 5.2 | < 15 | < 5.2 | < 5.2 | < 5.2 | < 5.2 |
| 2,4-Dinitrotoluene | 1,000 | < 4.3 | < 4.3 | < 4.3 | < 4.3 | < 4.3 | < 12 | < 4.3 | < 4.3 | < 4.3 | < 4.3 |

**TABLE 8**
**SEDIMENT ANALYTICAL RESULTS**
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| | LSS | CH 01 | CH02 | Shell 01 | Shell 02 | Empire 01 | MSRiv 01 | Sandy 01 | Sandy 02 | SPELTO 01 | SPELTO 02 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **SEMIVOLATIE ORGANIC COMPOUNDS (SVOCs) - Continued** | | | | | | | | | | | |
| | µg/Kg | µg/Kg | µg/Kg | µg/Kg | µg/Kg | µg/Kg | µg/Kg | µg/Kg | µg/Kg | µg/Kg | µg/Kg |
| 2,6-Dinitrotoluene | 390 | < 5.3 | < 5.3 | < 5.3 | < 5.3 | < 5.3 | < 15 | < 5.3 | < 5.3 | < 5.3 | < 5.3 |
| 2-Chloronaphthalene | 500,000 | < 5 | < 5 | < 5 | < 5 | < 5 | < 14 | < 5 | < 5 | < 5 | < 5 |
| 2-Chlorophenol | 1,400 | < 5 | < 5 | < 5 | < 5 | < 5 | < 14 | < 5 | < 5 | < 5 | < 5 |
| 2-Nitrophenol | -- | < 4.3 | < 4.3 | < 4.3 | < 4.3 | < 4.3 | < 12 | < 4.3 | < 4.3 | < 4.3 | < 4.3 |
| 3,3'-Dichlorobenzidine | 970 | < 8.4 | < 8.4 | < 8.4 | < 8.4 | < 8.4 | < 24 | < 8.4 | < 8.4 | < 8.4 | < 8.4 |
| 4,6-Dinitro-2-methylphenol | -- | < 9.4 | < 9.4 | < 9.4 | < 9.4 | < 9.4 | < 27 | < 9.4 | < 9.4 | < 9.4 | < 9.4 |
| 4-Bromophenyl phenyl ether | -- | < 5 | < 5 | < 5 | < 5 | < 5 | < 14 | < 5 | < 5 | < 5 | < 5 |
| 4-Chloro-3-methylphenol | -- | < 4.9 | < 4.9 | < 4.9 | < 4.9 | < 4.9 | < 14 | < 4.9 | < 4.9 | < 4.9 | < 4.9 |
| 4-Chlorophenyl phenyl ether | -- | < 4.6 | < 4.6 | < 4.6 | < 4.6 | < 4.6 | < 13 | < 4.6 | < 4.6 | < 4.6 | < 4.6 |
| 4-Nitrophenol | 2,300 | < 9.2 | < 9.2 | < 9.2 | < 9.2 | < 9.2 | < 26 | < 9.2 | < 9.2 | < 9.2 | < 9.2 |
| Acenaphthene | 220,000 | < 2.1 | < 2.1 | < 2.1 | < 2.1 | < 2.1 | < 6 | < 2.1 | < 2.1 | < 2.1 | < 2.1 |
| Acenaphthylene | 88,000 | < 1.2 | < 1.2 | < 1.2 | < 1.2 | < 1.2 | 5.1 | < 1.2 | < 1.2 | < 1.2 | < 1.2 |
| Anthracene | 120,000 | < 2.6 | < 2.6 | < 2.6 | < 2.6 | < 2.6 | 21 | < 2.6 | < 2.6 | < 2.6 | < 2.6 |
| Benzidine | -- | < 26 | < 26 | < 26 | < 26 | < 26 | < 26 | < 26 | < 26 | < 26 | < 26 |
| Benzo[a]anthracene | 620 | < 1.3 | < 1.3 | < 1.3 | < 1.3 | < 1.3 | 45 | < 1.3 | < 1.3 | < 1.3 | < 1.3 |
| Benzo[a]pyrene | 330 | < 1.2 | < 1.2 | < 1.2 | < 1.2 | < 1.2 | 43 | < 1.2 | < 1.2 | < 1.2 | < 1.2 |
| Benzo[b]fluoranthene | 620 | < 3.7 | < 3.7 | < 3.7 | < 3.7 | < 3.7 | 66 | < 3.7 | < 3.7 | < 3.7 | < 3.7 |
| Benzo[g,h,i]perylene | -- | < 1.8 | < 1.8 | < 1.8 | < 1.8 | < 1.8 | 34 | < 1.8 | < 1.8 | < 1.8 | < 1.8 |
| Benzo[k]fluoranthene | 6,200 | < 2.6 | < 2.6 | < 2.6 | < 2.6 | < 2.6 | 19 | < 2.6 | < 2.6 | < 2.6 | < 2.6 |
| Bis(2-chloroethoxy)methane | -- | < 4.7 | < 4.7 | < 4.7 | < 4.7 | < 4.7 | < 13 | < 4.7 | < 4.7 | < 4.7 | < 4.7 |
| Bis(2-chloroethyl)ether | 330 | < 5 | < 5 | < 5 | < 5 | < 5 | < 14 | < 5 | < 5 | < 5 | < 5 |
| Bis(2-ethylhexyl) phthalate | 35,000 | < 4.4 | < 4.4 | < 4.4 | < 4.4 | < 4.4 | < 13 | < 4.4 | < 4.4 | < 4.4 | < 4.4 |
| Butyl benzyl phthalate | 220,000 | < 5.9 | < 5.9 | < 5.9 | < 5.9 | < 5.9 | < 17 | < 5.9 | < 5.9 | < 5.9 | < 5.9 |
| Chrysene | 62,000 | < 1.4 | < 1.4 | < 1.4 | < 1.4 | < 1.4 | 80 | < 1.4 | < 1.4 | < 1.4 | < 1.4 |
| Dibenz(a,h)anthracene | 330 | < 4.2 | < 4.2 | < 4.2 | < 4.2 | < 4.2 | < 12 | < 4.2 | < 4.2 | < 4.2 | < 4.2 |
| Diethyl phthalate | 360,000 | < 4.7 | < 4.7 | < 4.7 | < 4.7 | < 4.7 | < 13 | < 4.7 | < 4.7 | < 4.7 | < 4.7 |
| Dimethyl phthalate | 1,500,000 | < 4.9 | < 4.9 | NR | NR | NR | < 14 | NR | NR | < 4.9 | < 4.9 |
| Di-n-butyl phthalate | -- | < 5 | < 5 | < 5 | < 5 | < 5 | < 14 | < 5 | < 5 | < 5 | < 5 |
| Di-n-octyl phthalate | 240,000 | < 4.1 | < 4.1 | < 4.1 | < 4.1 | < 4.1 | < 12 | < 4.1 | < 4.1 | < 4.1 | < 4.1 |
| Fluoranthene | 220,000 | < 2.1 | < 2.1 | < 2.1 | < 2.1 | < 2.1 | 83 | 2.2 | < 2.1 | < 2.1 | < 2.1 |
| Fluorene | 220,000 | < 1.7 | < 1.7 | < 1.7 | < 1.7 | < 1.7 | 6.4 | < 1.7 | < 1.7 | < 1.7 | < 1.7 |
| Hexachlorobenzene | 340 | < 5.4 | < 5.4 | < 5.4 | < 5.4 | < 5.4 | 15 | < 5.4 | < 5.4 | < 5.4 | < 5.4 |
| Hexachlorobutadiene | 820 | < 4.1 | < 4.1 | < 4.1 | < 4.1 | < 4.1 | 12 | < 4.1 | < 4.1 | < 4.1 | < 4.1 |
| Hexachlorocyclopentadiene | 1,400 | < 3.6 | < 3.6 | < 3.6 | < 3.6 | < 3.6 | 10 | < 3.6 | < 3.6 | < 3.6 | < 3.6 |
| Hexachloroethane | 2,200 | < 4.6 | < 4.6 | < 4.6 | < 4.6 | < 4.6 | 13 | < 4.6 | < 4.6 | < 4.6 | < 4.6 |
| Indeno[1,2,3-cd]pyrene | 620 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | 26 | < 1.1 | < 1.1 | < 1.1 | < 1.1 |
| Isophorone | 560 | < 4.3 | < 4.3 | < 4.3 | < 4.3 | < 4.3 | 15 | < 4.3 | < 4.3 | < 4.3 | < 4.3 |
| Naphthalene | 1,500 | < 2 | < 2 | < 2 | < 2 | < 2 | 8.8 | < 2 | < 2 | < 2 | < 2 |
| Nitrobenzene | 330 | < 4.3 | < 4.3 | < 4.3 | < 4.3 | < 4.3 | 12 | < 4.3 | < 4.3 | < 4.3 | < 4.3 |
| N-Nitrosodimethylamine | -- | < 20 | < 20 | < 20 | < 20 | < 20 | < 57 | < 20 | < 20 | < 20 | < 20 |

**TABLE 8**
**SEDIMENT ANALYTICAL RESULTS**
**Page 3 of 4**

| | LSS | CH 01 | CH02 | Shell 01 | Shell 02 | Empire 01 | MSRiv 01 | Sandy 01 | Sandy 02 | SPELTO 01 | SPELTO 02 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **SEMIVOLATIE ORGANIC COMPOUNDS (SVOCs) - Continued** | | | | | | | | | | | |
| | µg/Kg | µg/Kg | µg/Kg | µg/Kg | µg/Kg | µg/Kg | µg/Kg | µg/Kg | µg/Kg | µg/Kg | µg/Kg |
| N-Nitrosodi-n-propylamine | 330 | < 4.7 | < 4.7 | < 4.7 | < 4.7 | < 4.7 | < 13 | < 4.7 | < 4.7 | < 4.7 | < 4.7 |
| N-Nitrosodiphenylamine | 2,100 | < 5.4 | < 5.4 | < 5.4 | < 5.4 | < 5.4 | < 15 | < 5.4 | < 5.4 | < 5.4 | < 5.4 |
| Pentachlorophenol | 1,700 | < 4.3 | < 4.3 | < 4.3 | < 4.3 | < 4.3 | < 12 | < 4.3 | < 4.3 | < 4.3 | < 4.3 |
| Phenanthrene | 660,000 | < 2.3 | < 2.3 | < 2.3 | < 2.3 | < 2.3 | 47 | < 2.3 | < 2.3 | < 2.3 | < 2.3 |
| Phenol | 11,000 | < 4.3 | < 4.3 | < 4.3 | < 4.3 | < 4.3 | < 12 | < 4.3 | < 4.3 | < 4.3 | < 4.3 |
| Pyrene | 230,000 | 2.7 | < 1 | 2.1 | < 1 | < 1 | 94 | 2.8 | < 1 | < 1 | < 1 |
| **PESTICIDES, HERBICIDES, AND POLYCHLORINATED BIPHENYLS** | | | | | | | | | | | |
| | µg/Kg | µg/Kg | µg/Kg | µg/Kg | µg/Kg | µg/Kg | µg/Kg | µg/Kg | µg/Kg | µg/Kg | µg/Kg |
| 4,4'-DDD | 1,500 | < 0.2 | < 0.2 | < 0.2 | < 0.2 | < 0.2 | < 0.35 | < 0.2 | < 0.2 | < 0.2 | < 0.2 |
| 4,4'-DDE | 1,700 | < 0.18 | < 0.18 | < 0.18 | < 0.18 | < 0.18 | < 0.31 | < 0.18 | < 0.18 | < 0.18 | < 0.18 |
| 4,4'-DDT | 1,700 | < 0.32 | < 0.32 | < 0.32 | < 0.32 | < 0.32 | < 0.56 | < 0.32 | < 0.32 | < 0.32 | < 0.32 |
| Aldrin | 28 | < 0.17 | < 0.17 | < 0.17 | < 0.17 | < 0.17 | < 0.3 | < 0.17 | < 0.17 | < 0.17 | < 0.17 |
| alpha-BHC | 6.4 | < 0.072 | < 0.072 | < 0.072 | < 0.072 | < 0.072 | < 0.12 | < 0.072 | < 0.072 | < 0.072 | < 0.072 |
| beta-BHC | 16 | < 0.072 | < 0.072 | < 0.072 | < 0.072 | < 0.072 | < 0.12 | < 0.072 | < 0.072 | < 0.072 | < 0.072 |
| Chlordane (technical) | 1,600 | < 0.9 | < 0.9 | < 0.9 | < 0.9 | < 0.9 | < 1.5 | < 0.9 | < 0.9 | < 0.9 | < 0.9 |
| delta-BHC | -- | < 0.15 | < 0.15 | < 0.15 | < 0.15 | < 0.15 | < 0.26 | < 0.15 | < 0.15 | < 0.15 | < 0.15 |
| Dieldrin | 30 | < 0.16 | < 0.16 | < 0.16 | < 0.16 | < 0.16 | < 0.27 | < 0.16 | < 0.16 | < 0.16 | < 0.16 |
| Endosulfan I | 34,000 | < 0.072 | < 0.072 | < 0.072 | < 0.072 | < 0.072 | < 0.12 | < 0.072 | < 0.072 | < 0.072 | < 0.072 |
| Endosulfan II | 34,000 | < 0.23 | < 0.23 | < 0.23 | < 0.23 | < 0.23 | < 0.4 | < 0.23 | < 0.23 | < 0.23 | < 0.23 |
| Endosulfan sulfate | -- | < 0.2 | < 0.2 | < 0.2 | < 0.2 | < 0.2 | < 0.35 | < 0.2 | < 0.2 | < 0.2 | < 0.2 |
| Endrin | 1,800 | < 0.23 | < 0.23 | < 0.23 | < 0.23 | < 0.23 | < 0.39 | < 0.23 | < 0.23 | < 0.23 | < 0.23 |
| Endrin aldehyde | -- | < 0.23 | < 0.23 | < 0.23 | < 0.23 | < 0.23 | < 0.39 | < 0.23 | < 0.23 | < 0.23 | < 0.23 |
| gamma-BHC (Lindane) | 33 | < 0.066 | < 0.066 | < 0.066 | < 0.066 | < 0.066 | < 0.11 | < 0.066 | < 0.066 | < 0.066 | < 0.066 |
| Heptachlor | 16 | < 0.11 | < 0.11 | < 0.11 | < 0.11 | < 0.11 | < 0.2 | < 0.11 | < 0.11 | < 0.11 | < 0.11 |
| Heptachlor epoxide | 53 | < 0.078 | < 0.078 | < 0.078 | < 0.078 | < 0.078 | < 0.13 | < 0.078 | < 0.078 | < 0.078 | < 0.078 |
| Toxaphene | 440 | < 6.6 | < 6.6 | < 6.6 | < 6.6 | < 6.6 | < 11 | < 6.6 | < 6.6 | < 6.6 | < 6.6 |
| PCB-1016 | 110 | < 1.8 | < 1.8 | < 1.8 | < 1.8 | < 1.8 | < 3.1 | < 1.8 | < 1.8 | < 1.8 | < 1.8 |
| PCB-1221 | 110 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.1 | < 1.9 | < 1.1 | < 1.1 | < 1.1 | < 1.1 |
| PCB-1232 | 110 | < 2.2 | < 2.2 | < 2.2 | < 2.2 | < 2.2 | < 3.8 | < 2.2 | < 2.2 | < 2.2 | < 2.2 |
| PCB-1242 | 110 | < 1.7 | < 1.7 | < 1.7 | < 1.7 | < 1.7 | < 2.9 | < 1.7 | < 1.7 | < 1.7 | < 1.7 |
| PCB-1248 | 110 | < 2.6 | < 2.6 | < 2.6 | < 2.6 | < 2.6 | < 4.4 | < 2.6 | < 2.6 | < 2.6 | < 2.6 |
| PCB-1254 | 110 | < 1.9 | < 1.9 | < 1.9 | < 1.9 | < 1.9 | < 3.2 | < 1.9 | < 1.9 | < 1.9 | < 1.9 |
| PCB-1260 | 110 | < 1.6 | < 1.6 | < 1.6 | < 1.6 | < 1.6 | < 2.7 | < 1.6 | < 1.6 | < 1.6 | < 1.6 |

**TABLE 8**
**SEDIMENT ANALYTICAL RESULTS**
**Page 4 of 4**

| | LSS | CH 01 | CH02 | Shell 01 | Shell 02 | Empire 01 | MSRiv 01 | Sandy 01 | Sandy 02 | SPELTO 01 | SPELTO 02 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **METALS** | | | | | | | | | | | |
| | **mg/Kg** | **mg/Kg** | **mg/Kg** | **mg/Kg** | **mg/Kg** | **mg/Kg** | **mg/Kg** | **mg/Kg** | **mg/Kg** | **mg/Kg** | **mg/Kg** |
| Antimony | 3.1 | < 0.19 | < 0.18 | < 0.19 | < 0.18 | < 0.19 | < 0.32 | < 0.18 | < 0.18 | < 0.18 | < 0.19 |
| Arsenic | 12 | 3.6 | 2.1 | 3.7 | 1.9 | 2.1 | 5.5 | < 0.11 | 3.5 | 1.9 | 2.3 |
| Beryllium | 8.0 | 0.3 | 0.14 | 0.37 | 0.12 | 0.14 | 0.56 | < 0.27 | 0.3 | 0.083 | 0.098 |
| Cadmium | 3.9 | 0.11 | 0.037 | 0.15 | 0.028 | 0.094 | 0.39 | < 0.018 | 0.074 | < 0.018 | < 0.019 |
| Chromium | 23 | 7.8 | 4 | 9.8 | 3.8 | 5.1 | 15 | < 0.27 | 8.2 | 3.2 | 3.4 |
| Copper | 31 | 6.8 | 2.1 | 8.6 | 1.1 | 1.5 | 12 | < 0.035 | 6.1 | 0.72 | 0.98 |
| Lead | 100 | 5.7 | 2.9 | 8 | 2.5 | 3.1 | 15 | < 0.091 | 6 | 1.8 | 1.9 |
| Nickel | 160 | 7.8 | 5.6 | 8.3 | 5 | 6.2 | 16 | 9 | 7.6 | 4.2 | 5.3 |
| Selenium | 2.0 | 0.21 | < 0.09 | 0 0.28 | < 0.092 | < 0.94 | 0.32 | < 0.091 | 0.14 | < 0.091 | < 0.095 |
| Silver | 39 | < 0.046 | < 0.045 | 0.068 | < 0.046 | < 0.047 | < 0.081 | < 0.045 | 0.049 | < 0.045 | < 0.048 |
| Thallium | 0.55 | < 0.082 | < 0.045 | 0.12 | < 0.046 | 0.058 | 0.14 | < 0.045 | 0.14 | < 0.045 | < 0.048 |
| Zinc | 2300 | 29 | 15 | 31 | 15 | 17 | 58 | < 0.25 | 28 | 12 | 13 |
| Mercury | 2.3 | 0.013 | 0.017 | 0.03 | 0.012 | 0.012 | 0.041 | 0.022 | 0.011 | < 0.0059 | 0.0089 |
| **GENERAL CHEMISTRY** | | | | | | | | | | | |
| | | **%** | **%** | **%** | **%** | **%** | **%** | **%** | **%** | **%** | **%** |
| Percent Moisture | -- | 58 | 31 | 58 | 25 | 25 | 42 | 38 | 46 | 16 | 19 |
| Percent Solids | -- | 42 | 69 | 42 | 75 | 75 | 58 | 62 | 54 | 84 | 81 |
| | **mg/Kg** | **mg/Kg** | **mg/Kg** | **mg/Kg** | **mg/Kg** | **mg/Kg** | **mg/Kg** | **mg/Kg** | **mg/Kg** | **mg/Kg** | **mg/Kg** |
| Ammonia | -- | 0.18 | 0.25 | 13 | 8.1 | 4.3 | 31 | 4.1 | 5.7 | < 0.14 | 0.25 |
| TKN | -- | 1000 | 130 | 580 | 160 | 210 | 260 | 140 | 540 | 130 | 80 |
| Nitrogen, Nitrate Nitrite | 13,000 | 3.3 | 1 | 3.8 | 2.9 | 2.5 | < 4.3 | 4.1 | 2.7 | 2 | 1.3 |
| Phosphorus, Total | -- | 460 | 390 | 260 | 390 | 380 | 230 | 140 | 310 | 290 | 250 |
| Nitrogen, Total | -- | 1000 | 130 | 590 | 170 | 210 | | 150 | 550 | 130 | 81 |

Notes:
-- denotes that no numerical criteria have been established for a parameter by the LDEQ or USEPA.
LSS - LDEQ RECAP Limiting Screening Standards; LSS applied are the lower of the Non-Industrial Soil and the Soil Protective of Groundwater Screening Standards provided in Table 1 of RECAP (LDEQ 2003).
NR = Not reported

# FIGURE 1

# FIELD SAMPLING LOCATIONS FOR RESTORATION AND POTENTIAL BORROW SOURCES

Field Sampling Locations for Restoration and Borrow Areas
Legislative Department of Natural Resources
PROVIDENCE

# APPENDIX A

# FIELD SAMPLING AND LABORATORY ANALYSIS PLAN

# WATER QUALITY ASSESSMENT AND REPORTING FOR CAMINADA HEADLAND AND SHELL ISLAND RESTORATION PROJECTS

# FIELD SAMPLING AND LABORATORY ANALYSIS PLAN

# LOUISIANA DEPARTMENT OF NATURAL RESOURCES CONTRACT NO. 2503-05-51

## JANUARY 2006

Providence Engineering and Environmental Group LLC
Project No. 227-002

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**APPENDIX**

A Field Sampling Information Form

## 1.0 INTRODUCTION

This field sampling and laboratory analysis plan (S&A Plan) is in support of the Barataria Basin Barrier Shoreline, Caminada Headland, Shell Island Restoration Project Feasibility Study (Feasibility Study). This restoration project was identified by the US Army Corps of Engineers (USACE) as a critical near-term restoration project for coastal Louisiana. The Louisiana Department of Natural Resources (LDNR) is working in cooperation with the USACE to oversee the Feasibility Study. The Caminada Headland and Shell Island restoration areas are shown on **Figure 1**.

The overall project addresses the restoration of the Caminada Headland and Shell Island barrier island shoreline reaches of the Barataria Basin. The Feasibility Study will also identify and assess sources of borrow material for shoreline and marsh creation and nourishment, including riverine sources (*e.g.*, Mississippi River at Nairn) and offshore sites (*e.g.*, Ship Shoal, South Pelto, and Sandy Point), and would assess impacts of dredging at these locations.

Restoration of these landforms will help protect and restore unique habitats that are crucial to the viability of migratory birds, commercial and recreational fisheries, and a great variety of terrestrial and aquatic species. These landforms also contribute to maintenance of water quality in the region by reducing suspended sediment and nutrient loading in the aquatic environment. In addition, they reduce the impacts of flooding and storm surges on infrastructures in the coastal region, including highways, oil and gas production facilities, pipelines, and navigation features, such as ports and channels.

Providence Engineering and Environmental Group LLC (Providence Engineering) is responsible for water quality assessment and reporting for the Caminada Headland and Shell Island restoration projects. This assessment and reporting will provide water quality, sediment, and elutriate data which will identify existing conditions and environmental consequences associated with the project.

In order to establish a baseline of existing conditions, Providence Engineering researched and compiled existing water quality, sediment, and elutriate data from various public sources. Providence Engineering compiled data for the proposed four borrow areas (Mississippi River at Nairn, Empire, Sandy Point, and South Pelto) and the two restoration sites (Caminada Headlands and Shell Island). Existing data (water quality, sediment, and elutriate data) were compiled through a literature search, and sites with insufficient data (data gap analysis) were identified. On December 19, 2005, Providence Engineering submitted a summary of this information to the LDNR in a document titled "Data Gap Analysis Section."

The goal of the field sampling and laboratory analysis of water column, water bottom sediments, and sediment elutriate is to obtain quantitative data for all sites representative of the project sites and use the data to discern environmental impacts of the proposed project. Impact decisions are based on data analysis. To provide data to support environmental impact decisions, data collection will occur

for all parameters before the commencement of restoration activities. The one-time sampling event at each specified location will provide a data set of measurements for all parameters. Providence Engineering personnel will conduct all field sampling activities. Field sampling and laboratory analyses will be conducted in accordance with the Quality Assurance Project Plan (QAPP) which was prepared for this project.

This S&A Plan addresses the additional data needs for the project. Data will be collected systematically to obtain water quality, sediment, and elutriate data representative of the sediment borrow areas and the restoration project sites. This S&A Plan describes the sampling locations; specific methods and protocols for collecting the water, sediment, and elutriate field samples; the field and laboratory analytical procedures and parameters of interest; the field and laboratory Quality Assurance/Quality Control (QA/QC) protocols that will be followed; and the estimated schedule to complete the proposed field sampling activities.

## 2.0 SAMPLING LOCATIONS AND MEDIA

**Figure 1** shows the sampling project area consisting of the proposed four borrow areas (Mississippi River at Nairn, Empire, Sandy Point, and South Pelto) and the two restoration sites (Caminada Headlands and Shell Island).

Due to the large area to be sampled, composite samples will be collected at each borrow and restoration area for laboratory analyses. The number of collection points (subsamples) for each composite will depend on the size of the area, but at least three subsamples will be collected at each. **Table 1** provides a summary of the sampling effort at the borrow and restoration areas.

Water quality samples are collected within the water column. Sediment samples are collected from the materials settled on the bottom of a water body. Sediment elutriate is decanted water from the sediment mixed with site water. Using sediment elutriate water is an attempt to simulate conditions in the water column over the sediments due to bottom disturbances induced by wind and surface and internal wave actions. The elutriate test is a simplified simulation of the dredging and disposal process wherein predetermined amounts of dredging site water and sediment are mixed together to approximate a dredged material slurry. The test provides an indication of the chemical constituents likely to be released to the water column during a dredging disposal/filling operation. Sediment elutriate water is prepared by the analytical laboratory for testing by mixing one part of sediment with four parts of site water. The water in the mixture is decanted or poured off and then centrifuged to settle out the suspended solids. The elutriate water may then be filtered or preserved (depending upon the required parameter) and then analyzed.

## 3.0 SPECIAL TRAINING REQUIREMENTS

Providence Engineering personnel will receive training on proper sampling techniques and performing *in situ* measurements. Training will address (1) sample collection, handling, labeling, preservation, chain-of-custody, delivery, and holding time requirements; (2) operation, maintenance, and calibration of electronic instruments used for *in situ* measurements; (3) boat safety; and (4) hazardous waste awareness.

## 4.0 OVERVIEW OF FIELD ANALYTICAL REQUIREMENTS

At each sampling site, the sample collectors will take *in situ* measurements (**Table 2**) for pH, water temperature, conductivity, salinity, dissolved oxygen, and water depth. The sample collectors will also record visual observations for the presence of any sheen of possible petrogenic origin (*i.e.* oil and grease) and weather conditions. Field data will be recorded at the time of sample collection on field data forms and/or in a logbook. Specific field procedures are detailed in the remainder of this S&A Plan.

## 5.0 OVERVIEW OF LABORATORY ANALYTICAL REQUIREMENTS

Field personnel will collect water quality, sediment, and elutriate samples using appropriate sampling methods and containers for laboratory analyses (**Tables 3** and **4**). The samples will be delivered using appropriate chain-of-custody procedures and documentation to the designated contract laboratory for required analyses within the specified holding times. The analytical laboratory contracted for this project is Severn Trent Laboratories, which is certified under the Louisiana Environmental Laboratory Accreditation Program (LELAP).

Water, sediment, and elutriate samples collected from a sampling site are intended to be representative of that project site. For the purpose of this project, representative samples consist of (1) a composite sample comprised of a minimum of three grab "subsamples" collected at one-half the total depth of the water column (for water), (2) a composite sample comprised of a minimum of three grab subsamples of sediment (for sediment), and (3) a composite sample comprised of a minimum of three grab subsamples of sediment mixed with ambient site water for elutriate. Sample containers used for the purposes of this program are provided by the contract analytical laboratory and certified as U.S. Environmental Protection Agency (USEPA) Level 1 cleaned containers.

Situations could develop that would render the sample collection or analysis invalid. Samples may leak, be dropped or lost, or otherwise not be adequately collected. Sufficient time is allocated within the data collection schedule to allow for resampling. After reviewing the data, the Project Manager may decide that resampling is required of all parameters, or only those parameters for which the sample collection and/or analysis has been compromised.

Specific procedures are detailed in the remainder of this S&A Plan.

## 6.0 SPECIFIC FIELD PROCEDURES

The specific methods that will be followed for the collection of water, sediment, and elutriate samples are summarized in the following sections.

### 6.1 Field Preparation Procedures

Equipment coordination will be conducted in advance of sampling and/or on the day of sampling, as appropriate. Sample containers obtained from the analytical laboratory will be inventoried to ensure that all required analyses will be conducted.

All field equipment used in the project will be inspected for acceptable working order prior to embarking upon a data-gathering event. Electronic equipment that has not been recently operated (in storage) will undergo an operational check according to manufacturer specifications prior to use by Providence Engineering.

All field instruments used for this sampling program shall be properly calibrated at the outset of each field sampling event. Calibration procedures will be accomplished and based on manufacturers' protocols and standard practice for the type of instrument and parameter. Acceptance limits for field operations are ±0.2 standard units (S.U.) for pH, 0.2 milligrams per liter (mg/L) for dissolved oxygen, 1.0 % of the actual reading for conductivity, and ±0.10 degrees Celsius ($^{o}$C) for temperature.

All calibration events shall be documented in a field logbook, and the documentation shall include:

- Instrument type, manufacturer, and model number [*e.g.*, such as a Hydrolab™ or Yellow Springs Instruments (YSI™) Model 556 multi-parameter field water quality analyzer or equivalent]
- The parameter(s) for which calibration is undertaken
- The value(s) to which calibration was adjusted, the procedure used, and the temperature at which calibration was made [*e.g.*, for pH: calibrated to pH of 7.0 S.U. and pH of 10.0 S.U. using standard buffered solutions of 7.0 S.U. and 10.0 S.U. at a temperature of 25.0$^{o}$C, or for dissolved oxygen: calibrated to 8.3 mg/L using air calibration procedure at a temperature of 25.0$^{o}$C in accordance with manufacturer's directions)
- The date and time of calibration event
- The name of the person performing the calibration

Equipment will be recalibrated as necessary during sampling activities, and calibration results will be recorded in the field log forms and/or logbooks. All non-disposable sampling equipment will be decontaminated prior to beginning the first sample, between sample locations, and at the

end of the day. Field equipment decontamination procedures are further described in Sections 6.3 and 6.4.

## 6.2 Field *In Situ* Analyses and Observations

At each sampling site, the sample collectors will take *in situ* measurements (**Table 2**) of water quality parameters, measure water depth, and document general weather and water conditions.

At all sampling locations, field water quality readings will be made at one-half the total depth of the water column. The *in situ* readings will be made using a multi-parameter field analyzer (YSI™ Model 556 or equivalent analyzer). Water depth is to be measured by a weighted line or other similar method. Field measurements will be taken using the multi-parameter field analyzer for pH, water temperature, conductivity, salinity, dissolved oxygen, and water depth. All measurements will be recorded on field water quality sample information forms (shown in **Appendix A**) and/or a logbook.

In the event of instrument problems with the multi-parameter field analyzer, samples for field water quality measurements will be collected as grab samples mid-depth in the water column using an acrylic Van Dorn water sampler. When collection of mid-depth samples is not possible without disturbing bottom sediments because of total water depths that are too shallow, the water samples will be collected immediately beneath the surface of the water. Field measurements will be performed immediately on the grab samples using appropriate field titration kits for dissolved oxygen (Azide modification of the Winkler titration) and parameter-specific instrumentation for conductivity, pH, and temperature.

The sample collectors will also record a visual observation for the presence/absence of any sheen of possible petrogenic origin. Field observations will be made and recorded concerning wind direction and cloud cover. Observations should also be made and recorded concerning other pertinent conditions such as algal blooms, surface films, scum, *etc.* This information will be recorded on the field data forms and/or in a logbook.

## 6.3 Field Collection of Water Samples for Laboratory Analyses

At each sampling location, after the *in situ* field water quality analyses have been conducted, water samples will be collected for laboratory analyses of required parameters (see **Table 3**). Composite samples will be collected at the locations for laboratory analyses as outlined in **Table 1**. The number of collection points (subsamples) for each composite will depend on the borrow or restoration area size, but at least three subsamples will be collected for each composite sample (see **Figure 1**). The location of each subsample collection point will be documented using a global positioning

system (GPS) and will be recorded on the field data forms and/or in a logbook.

Latex gloves will be worn during the collection of each sample. Care will be taken to ensure that samples are not inadvertently contaminated by contact with anything other than the designated containers. All field activities must be recorded on the field forms and/or field logbook.

Prior to collecting water samples, field decontamination procedures to remove contaminants from the acrylic Van Dorn water sampler or stainless steel wastewater sampler will consist of thoroughly rinsing the sampler with ambient site water. Other water sampling equipment may require decontamination using Alconox™ laboratory detergent, triple-rinsing with deionized water, and rinsing again with ambient site water collected from a depth of one meter below the surface (to avoid surface film or sheen contaminants).

The water grab samples will be collected using a decontaminated acrylic Van Dorn water sampler or stainless steel wastewater sampler at mid-depth within the water column, with care taken not to disturb the bottom sediments at each sample location site. When collection of mid-depth samples is not possible without disturbing bottom sediments because of total water depths that are too shallow, the water samples will be collected immediately beneath the surface of the water.

Water grab samples for dissolved metals analysis will be collected from the Van Dorn water sampler by using a peristaltic pump. The metals samples will be filtered in the field through a 5-micron metals-free encapsulated filter prior to preservation.

Sample containers used for the purposes of this program are certified as USEPA Level 1 cleaned containers. To the extent practicable, in filling sample containers, headspace will be eliminated on all, but this is most critical with containers for volatile organic compound (VOC) samples. When a sample is transferred to the appropriate containers for shipment to the laboratory, care must be taken to ensure that the sample is uniform and homogenous.

For each composite sample at the four borrow areas and two restoration areas, the subsamples will be collected as grab samples as described and then combined in equal volumes to form a composite sample (in chemically-clean laboratory- provided sample containers). Sample volume will be sufficient to supply the needs of all required parameter analyses. Immediately following preparation of a composite sample, the water sample will be divided and transferred to separate, appropriate laboratory-supplied sample containers for laboratory analyses for the respective, required testing parameters. Each sample container will be analyzed for

specified parameters, which are grouped according to sample container type (*i.e.* glass or plastic) and preservative requirements.

VOC samples cannot be composited in the field, so separate aliquots must be collected at each subsample collection point and combined by the analytical laboratory in equal proportions to form a single composite sample for analysis for each of the sample locations.

Water samples for analyses of organic compounds [such as VOCs, base neutral and acid extractable semivolatile organic compounds (semivolatiles)] will be collected by lowering a stainless steel Solinst® point source bailer-type sampler to approximately mid-depth within the water column. As the bailer is lowered through the water column, ball-check valves on top and bottom are open allowing flow-through of water. When the bailer has reached the desired depth, the check valves close with the upward movement of the apparatus. After collection of the sample, the bailer can be emptied through the bottom valve directly into the appropriate sample container.

Discrete samples must be carefully collected for VOC analysis in two 40-milliliter (mL) septum vials (*i.e.* collected at least in duplicate). The VOC vials must be filled just to overflowing to form a meniscus. Special consideration must be used to avoid losing the preservative contained in the VOC vials. If the flow from the bailer is too great to prevent loss of the preservative, a chemically-clean sample collection container (glass) will be used for each sampling event to collect and transfer the sample to each of the two vials. The lid on each vial must be placed securely to prevent air entrapment. The VOC vial must be checked for air bubbles by turning it upside down. If bubbles are present, more sample volume must be added to the vial and the above procedure repeated. The vial should not be emptied and refilled because the preservative will be lost.

The proper preservation of water samples collected in the field is necessary to ensure the samples do not undergo significant changes before being analyzed in the laboratory. Field preservation techniques are generally limited to pH control, chemical addition to form species that resist change, and refrigeration. Samples kept in an ice chest will maintain a temperature of less than 4 °C as long as the samples are completely surrounded by ice and/or in an ice water bath. Any required preservatives will be added to the containers by the contract laboratory prior to use in the field. Field personnel will be responsible for ensuring the correct preservative has been used. When filling a container, care will be taken to avoid loss of preservatives and injury to personnel due to contact with the preservatives.

## 6.4 Field Collection of Sediment and Elutriate Samples for Laboratory Analyses

At each sampling location, after the field water samples have been collected, sediment and elutriate samples will be collected for laboratory analyses of required parameters (see **Table 3** and **4**).

Latex gloves should be worn during the collection of each sample. Care must be taken to ensure that samples are not inadvertently contaminated by contact with anything other than the designated containers. All field activities must be recorded in a field logbook.

Elutriate samples will be collected in the same manner in the field as the sediment samples; thus, the sediment samples will be collected in duplicate at each location. Additionally, site water must be collected in chemically-clean containers (at least one liter) at each subsample location (and subsequently combined in equal proportions to form a composite) for the laboratory to prepare the elutriate samples. This site water should be collected from one meter below the water surface before the sediment samples are collected. The contract analytical laboratory will prepare the elutriate samples from one of the sets of sediment samples using standard USEPA protocols. For elutriate samples, the required analytical methods are the same as for the water samples (see **Table 3**).

Wide-mouth jars (chemically-clean) provided by the analytical laboratory will be used for sediment samples. For each location to be represented by composite sediment and composite elutriate samples, two large wide-mouth jars should be filled with composite sediment, one labeled for sediment analyses and one for elutriate analyses.

Sediment samples will be collected either by use of a Petite Ponar™ sampler or an Ekman dredge. The sampler will be slowly lowered to the bottom of the water column, and allowed to gently penetrate the sediments, so as to not disturb the sediments. Once pulled from the water, excess water will be allowed to drain. Because compositing of grab samples is required at all locations, the grab subsamples will be combined in equal proportions and thoroughly mixed in chemically-clean, stainless steel trays. Composite samples for laboratory chemical analyses will be transferred to chemically-clean wide-mouth jars (at least one liter) using a stainless steel spatula or large stainless steel serving spoon. The composite whole sediment samples and elutriate samples must be of sufficient volume for the laboratory to perform all required analyses.

Sediment samples for VOC analyses will be combined to form a composite by removing an appropriate amount from each separate sediment grab (before mixing occurs in the stainless steel tray) using a stainless steel spatula. Care must be taken in gently removing each sediment aliquot and placing them in the designated wide-mouth jar.

Containers will be filled to the lip, and headspace must be eliminated to the maximum extent possible, using ambient water as necessary.

All composite samples will immediately be placed in an ice chest and covered with ice for shipment to the laboratory. Samples for whole sediment and elutriate analyses are not preserved with chemical additives but rather are chilled to less than 4 °C.

Prior to the initial sample collection and between sample location stations, all equipment (*e.g.*, Petit Ponar™ grab sampler, stainless steel trays, and utensils) used for sediment sampling and handling activities will be decontaminated using Alconox™ laboratory detergent, triple-rinsed with deionized water, and rinsed again with ambient site water collected from a depth of one meter below the surface (to avoid surface film or sheen contaminants). This decontamination is not required between subsamples at a single sampling location since the subsamples are combined to form the composite.

## 6.5 Sample Labels

Each sample container for water, sediment, and elutriate (separate water and sediment to be mixed in the laboratory) analyses will receive a discrete identification number. All sample containers used will be properly labeled. Sample labels will be completed immediately upon sample collection, and the following information will be included on each sample label:

- unique sample identification number (may include the sample location number)
- sample source/location
- sample medium for analyses (*e.g.*, surface water, whole sediment, water for elutriate, sediment for elutriate)
- VOC aliquot number (as applicable)
- time and date of sample collection
- initials of the sample collector
- contract laboratory
- testing parameters/analyses to be performed
- preservative used (if required)

## 6.6 Chain-of-Custody Procedures

Providence Engineering's field sampling personnel will be responsible for the samples throughout the sampling period. All samples will be properly packaged in ice chests (on wet ice at a temperature not to exceed 4°C) for transportation to the contract laboratory. Samples will be delivered to the designated contract laboratory so that all samples may be analyzed within the specified holding times. Appropriate chain-of-custody forms detailing

the analytical requirements will be filled out by the designated sampling personnel and will accompany the samples to the contract laboratory.

When transferring possession of samples, for each change of possession, the transferor and the recipient will sign and record the date and time on the chain-of-custody form. A standardized chain-of-custody form will be used that is designated to "prompt" the user(s) to complete all required sample collection and transport information, including the following:

- Sample type and number of containers
- Sample description or identification number
- Preservative used (if any)
- Full name of person collecting the samples
- Date and time of collection for each sample
- Laboratory analysis required/requested
- Full name and signature of each transferor and recipient, along with date and time for every custody transfer from sample collection through receipt by laboratory

The Providence Engineering sampling team will attach copies of **Tables 3** and **4**, as applicable, to all chain-of custody forms. **Tables 3** and **4** list all of the required testing parameters by media (water or sediment). Providing the tables with the chain-of-custody forms will ensure that all of the testing parameters required for each set of samples for each sample location are clearly provided in writing to the laboratory at the time of sample delivery.

## 7.0 LABORATORY ANALYTICAL PROCEDURES

The laboratory must use approved methods with appropriate analytical method detection limits for sample analysis, as listed in **Tables 3** and **4**. The laboratory is expected to report at or below the listed analytical method detection limit for each parameter.

Sample handling, preservation, and analysis for sediment samples to be analyzed for required parameters will be conducted by the contract laboratory in accordance with the most current edition of Test Methods for Evaluating Solid Waste Physical/Chemical Methods, USEPA publication number SW-846. Water and elutriate sample handling, preservation, and analysis will meet the requirements of Methods for Chemical Analysis of Water and Waste, USEPA publication number EPA-600/4-79-020 and/or Standard Methods for the Examination of Water and Wastewater, 18$^{th}$ Edition (1992), 19$^{th}$ Edition, or 20$^{th}$ Edition (American Public Health Association, American Water Works Association, and Water Environment Federation).

## 8.0 SCHEDULE

Sampling activities will be initiated immediately upon receipt of LDNR approval of this S&A Plan. In order to collect one set of water, sediment, and elutriate

samples at each of the four borrow areas and two restoration area sampling locations, three days in the field are estimated to be required to complete the sampling efforts (excluding unforeseen contingencies - sampling activities may be delayed or prolonged in the event of severe weather conditions or equipment failure). It is anticipated that the field activities will be completed within one month after LDNR approval of this S&A Plan.

# TABLE 1

# OVERVIEW OF SAMPLING EFFORTS

**TABLE 1**
**OVERVIEW OF SAMPLING EFFORTS**

| Location | Borrow Areas | | | | Restoration Areas | |
|---|---|---|---|---|---|---|
| | Mississippi River (Naim) | Empire | Sandy Point | South Pelto | Caminada Headlands | Shell Island |
| Number of Sample Locations | 1 (composite) | 1 (composite) | 2 (composite) | 2 (composite) | 2 (composite) | 2 (composite) |
| Medium<br>*Sediment*<br>*Elutriate*<br>*Water* | <br>1<br>1<br>1 | <br>1<br>1<br>1 | <br>2<br>2<br>1 | <br>2<br>2<br>1 | <br>2<br>2<br>1 | <br>2<br>2<br>1 |
| Total Number of Samples | 3 | 3 | 5 | 5 | 5 | 5 |
| Analytes at Each Location | Field Parameters<br><br>Priority Pollutants (metals and organics)<br><br>Nitrogen and Phosphorus species | Field Parameters<br><br>Priority Pollutants (metals and organics)<br><br>Nitrogen and Phosphorus species | Field Parameters<br><br>Priority Pollutants (metals and organics)<br><br>Nitrogen and Phosphorus species | Field Parameters<br><br>Priority Pollutants (metals and organics)<br><br>Nitrogen and Phosphorus species | Field Parameters<br><br>Priority Pollutants (metals and organics)<br><br>Nitrogen and Phosphorus species | Field Parameters<br><br>Priority Pollutants (metals and organics)<br><br>Nitrogen and Phosphorus species |

# TABLE 2

# FIELD WATER QUALITY PARAMETERS AND MONITORING METHODS

## TABLE 2
## FIELD WATER QUALITY PARAMETERS AND MONITORING METHODS

| PARAMETER | METHOD | REFERENCE |
|---|---|---|
| Conductivity | Portable Meter | Method 120.1 [1]<br>ASTM Standards D 1125-91(A) |
| Salinity | Portable Meter | Method 120.1 [1]<br>Method 2520B [2] |
| pH | Portable Meter | Method 150.1 [1]<br>ASTM Standards D1293-84(90)(A or B)<br>Method 4500-$H^+$ B [2] |
| Temperature | Portable Meter or Thermometer | Method 170.1 [1]<br>Method 2550 B [2] |
| Oxygen, Dissolved | Portable Meter with Membrane Electrode | Method 360.1 [1]<br>Method 4500-0 G [2]<br>Manufacturer's Operation Manual |
| Oxygen, Dissolved/ Percent Saturation | Portable Meter with Membrane Electrode | Method 360.1 [1]<br>Method 4500-0 G [2]<br>Manufacturer's Operation Manual |

[1] U.S. Environmental Protection Agency (USEPA), Methods for Chemical Analysis of Water and Wastes, USEPA Publication Number EPA-600/4-79-020

[2] Standard Methods for the Examination of Water and Wastewater, 18th Edition (1992), 19th Edition (1995), or 20th Edition (1998)

# TABLE 3

# WATER AND ELUTRIATE SAMPLE LABORATORY ANALYTICAL REQUIREMENTS

## TABLE 3
## Water and Elutriate Sample Laboratory Analytical Requirements

| Parameter | CAS Number | Recommended Analytical Method 40 CFR 136 [1] | Required MDL [2] µg/L [3] |
|---|---|---|---|
| **MISCELLANEOUS PARAMETERS** | | | |
| Phosphorous (as P), Total | 7723-14-0 | 365.2 | 10 |
| Nitrate-Nitrite Nitrogen | 7727-37-9 | 353.2 | 100 |
| Nitrogen, Total Organic | --- | See Footnote [4] | See Footnote [4] |
| Total Kjeldahl Nitrogen (TKN) | E-10264 | 351.4 | 30 |
| Ammonia (As N) | 7664-41-7 | 350.1 or 350.2 | 10 or 1000 |
| **PRIORITY POLLUTANT ORGANIC COMPOUNDS** | | | |
| **VOLATILE ORGANIC COMPOUNDS** | | | |
| Acrolein (2-Propenal) | 107-02-8 | 603 or 624 | 0.7 or nd [5] |
| Acrylonitrile (2-Propenenitrile) | 107-13-1 | 603 or 624 | 0.5 or nd [5] |
| Benzene | 71-43-2 | 602 or 624 | 0.2 or 4.4 |
| Bromoform (Tribromomethane) | 75-25-2 | 601 or 624 | 0.20 or 4.7 |
| Carbon tetrachloride | 56-23-5 | 601 or 624 | 0.12 or 2.8 |
| Chlorobenzene | 108-90-7 | 601 or 624 | 0.25 or 6.0 |
| Chlorodibromomethane (Dibromochloromethane) | 124-48-1 | 601 or 624 | 0.09 or 3.1 |
| Chloroethane | 75-00-3 | 601 or 624 | 0.52 or nd [5] |
| 2-chloroethylvinyl ether | 110-75-8 | 601 or 624 | 0.13 or nd [5] |
| Chloroform (Trichloromethane) | 67-66-3 | 601 or 624 | 0.05 or 1.6 |
| Dichlorobromomethane (Bromodichloromethane) | 75-27-4 | 601 or 624 | 0.10 or 2.2 |
| 1,1-Dichloroethane | 75-34-3 | 601 or 624 | 0.07 or 4.7 |
| 1,2-Dichloroethane [Ethylene Dichloride (EDC)] | 107-06-02 | 601 or 624 | 0.03 or 2.8 |
| 1,1-Dichloroethylene (1,1-Dichloroethene) | 75-35-4 | 601 or 624 | 0.13 or 2.8 |
| 1,2-Dichloropropane | 78-87-5 | 601 or 624 | 0.04 or 6.0 |
| 1,3-Dichloropropylene (1,3-Dichloropropene) | 542-75-6 | 601 or 624 | 0.34 or 5.0 |
| Ethylbenzene | 100-41-4 | 602 or 624 | 0.2 or 7.2 |
| Methyl bromide (Bromomethane) | 74-83-9 | 601 or 624 | 1.18 or nd [5] |
| Methyl chloride (Chloromethane) | 74-87-3 | 601 or 624 | 0.08 or nd [5] |
| Methylene chloride (Dichloromethane) | 75-09-2 | 601 or 624 | 0.25 or 2.8 |
| 1,1,2,2-Tetrachloroethane | 79-34-5 | 601 or 624 | 0.03 or 6.9 |
| Tetrachloroethylene (Tetrachloroethene) (Perchloroethylene) | 127-18-4 | 601 or 624 | 0.03 or 4.1 |
| Toluene | 108-88-3 | 602 or 624 | 0.2 or 6.0 |
| trans-1,2-Dichloroethylene (trans-1,2-Dichloroethene) | 156-60-5 | 601 or 624 | 0.10 or 1.6 |
| 1,1,1-Trichloroethane (Methyl chloroform) | 71-55-6 | 601 or 624 | 0.03 or 3.8 |
| 1,1,2-Trichloroethane | 79-00-5 | 601 or 624 | 0.02 or 5.0 |
| Trichloroethylene (Trichloroethene) | 79-01-6 | 601 or 624 | 0.12 or 1.9 |
| Vinyl chloride (Chloroethene) | 75-01-4 | 601 or 624 | 0.18 or nd [5] |
| **ACID FRACTION COMPOUNDS** | | | |
| 2-Chlorophenol (o-Chlorophenol) | 95-57-8 | 625 | 3.3 |
| 2,4-Dichlorophenol | 120-83-2 | 625 | 2.7 |
| 2,4-Dimethylphenol | 105-67-9 | 625 | 2.7 |
| 4,6-Dinitro-o-cresol (4,6-Dinitro-2-methylphenol) | 534-52-1 | 625 | 24 |

**TABLE 3**
**Water and Elutriate Sample Laboratory Analytical Requirements**

| Parameter | CAS Number | Recommended Analytical Method 40 CFR 136 [1] | Required MDL [2] µg/L [3] |
|---|---|---|---|
| 2,4-Dinitrophenol | 51-28-5 | 625 | 42 |
| 2-Nitrophenol (o-Nitrophenol) | 88-75-5 | 625 | 3.6 |
| 4-Nitrophenol (p-Nitrophenol) | 100-02-7 | 625 | 3.6 |
| p-chloro-m-cresol (4-Chloro-3-methylphenol) | 59-50-7 | 625 | 3.0 |
| Pentachlorophenol | 87-86-5 | 625 | 3.6 |
| Phenol | 108-95-2 | 625 | 1.5 |
| 2,4,6-Trichlorophenol | 88-06-2 | 625 | 2.7 |
| **BASE/NEUTRAL COMPOUNDS** | | | |
| Acenaphthene | 83-32-9 | 625 | 1.9 |
| Acenaphthylene | 208-96-8 | 625 | 3.5 |
| Anthracene | 120-12-7 | 625 | 1.9 |
| Benzidine | 92-87-5 | 625 | 44 |
| Benzo(a)anthracene | 56-55-3 | 625 | 7.8 |
| Benzo(a)pyrene | 50-32-8 | 625 | 2.5 |
| 3,4-Benzofluoranthene (Benzo(b)fluoranthene) | 205-99-2 | 625 | 4.8 |
| Benzo(ghi)perylene | 191-24-2 | 625 | 4.1 |
| Benzo(k)fluoranthene | 207-08-9 | 625 | 2.5 |
| Bis(2-chloroethoxy)methane | 111-91-1 | 625 | 5.3 |
| Bis(2-chloroethyl)ether | 111-44-4 | 625 | 5.7 |
| Bis(2-chloroisopropyl)ether [2,2'-oxybis(1-Chloropropane)] | 108-60-1 | 625 | 5.7 |
| Bis(2-ethylhexyl)phthalate | 117-81-7 | 625 | 2.5 |
| 4-Bromophenyl phenyl ether | 101-55-3 | 625 | 1.9 |
| Butylbenzyl phthalate | 85-68-7 | 625 | 2.5 |
| 2-Chloronaphthalene | 91-58-7 | 625 | 1.9 |
| 4-Chlorophenyl phenyl ether | 7005-72-3 | 625 | 4.2 |
| Chrysene | 218-01-9 | 625 | 2.5 |
| Dibenzo(a,h)anthracene | 53-70-3 | 625 | 2.5 |
| 1,2-Dichlorobenzene (o-Dichlorobenzene) | 95-50-1 | 625 | 1.9 |
| 1,3-Dichlorobenzene (m-Dichlorobenzene) | 541-73-1 | 625 | 1.9 |
| 1,4-Dichlorobenzene (p-Dichlorobenzene) | 106-46-7 | 625 | 4.4 |
| 3,3'-Dichlorobenzidine | 91-94-1 | 625 | 16.5 |
| Diethyl phthalate | 84-66-2 | 625 | 1.9 |
| Dimethyl phthalate | 131-11-3 | 625 | 1.6 |
| Di-n-butyl phthalate | 84-74-2 | 625 | 2.5 |
| 2,4-Dinitrotoluene | 121-14-2 | 625 | 5.7 |
| 2,6-Dinitrotoluene | 606-20-2 | 625 | 1.9 |
| Di-n-octyl phthalate | 117-84-0 | 625 | 2.5 |
| 1,2-Diphenylhydrazine (as azobenzene) | 122-66-7 | 625 | nd [5] |
| Fluoranthene | 206-44-0 | 625 | 2.2 |
| Fluorene | 86-73-7 | 625 | 1.9 |
| Hexachlorobenzene | 118-74-1 | 625 | 0.9 |
| Hexachlorobutadiene | 87-68-3 | 625 | 1.9 |
| Hexachlorocyclopentadiene | 77-47-4 | 625 | nd [5] |

**TABLE 3**
**Water and Elutriate Sample Laboratory Analytical Requirements**

| Parameter | CAS Number | Recommended Analytical Method 40 CFR 136 [1] | Required MDL [2] µg/L [3] |
|---|---|---|---|
| Hexachloroethane | 67-72-1 | 625 | 1.6 |
| Indeno(1,2,3-cd)pyrene | 193-39-5 | 625 | 3.7 |
| Isophorone | 78-59-1 | 625 | 2.2 |
| Naphthalene | 91-20-3 | 625 | 1.6 |
| Nitrobenzene | 98-95-3 | 625 | 1.9 |
| N-nitrosodimethylamine | 62-75-9 | 625 | nd [5] |
| N-nitrosodi-n-propylamine | 621-64-7 | 625 | nd [5] |
| N-nitrosodiphenylamine (Diphenylamine) | 86-30-6 | 625 | 1.9 |
| Phenanthrene | 85-01-8 | 625 | 5.4 |
| Pyrene | 129-00-0 | 625 | 1.9 |
| 1,2,4-Trichlorobenzene | 120-82-1 | 625 | 1.9 |
| **PESTICIDES, HERBICIDES, AND PCBs** | | | |
| Aldrin | 309-00-2 | 608 | 0.004 |
| PCB-1016 | 12674-11-2 | 608 | nd [5] |
| PCB-1221 | 11104-28-2 | 608 | nd [5] |
| PCB-1232 | 11141-16-5 | 608 | nd [5] |
| PCB-1242 | 53469-21-9 | 608 | 0.065 |
| PCB-1248 | 12672-29-6 | 608 | nd [5] |
| PCB-1254 | 11097-69-1 | 608 | nd [5] |
| PCB-1260 | 11096-82-5 | 608 | nd [5] |
| alpha-BHC | 319-84-6 | 608 | 0.003 |
| beta-BHC | 319-85-7 | 608 | 0.006 |
| delta-BHC | 319-86-8 | 608 | 0.009 |
| gamma-BHC (Hexachlorocyclohexane) (Lindane) | 58-89-9 | 608 | 0.004 |
| Chlordane | 57-74-9 | 608 | 0.014 |
| 4,4'DDT | 50-29-3 | 608 | 0.012 |
| 4,4'DDE | 72-55-9 | 608 | 0.004 |
| 4,4'DDD | 72-54-8 | 608 | 0.011 |
| Dieldrin | 60-57-1 | 608 | 0.002 |
| Alpha-Endosulfan (Endosulfan I) | 959-98-8 | 608 | 0.014 |
| Beta-Endosulfan (Endosulfan II) | 33213-65-9 | 608 | 0.004 |
| Endosulfan sulfate | 1031-07-8 | 608 | 0.066 |
| Endrin | 72-20-8 | 608 | 0.006 |
| Endrin aldehyde | 7421-93-4 | 608 | 0.023 |
| Heptachlor | 76-44-8 | 608 | 0.003 |
| Heptachlor Epoxide | 1024-57-3 | 608 | 0.003 |
| Toxaphene | 8001-35-2 | 608 | 0.24 |
| **PRIORITY POLLUTANT METALS** | | | |
| Antimony, Dissolved | 7440-36-0 | 200.8 | 3 |
| Arsenic, Dissolved | 7440-38-2 | 200.8 | 1 |
| Beryllium, Dissolved | 7440-41-7 | 200.8 | 0.2 |
| Cadmium, Dissolved | 7440-43-9 | 200.8 | 0.1 |

**TABLE 3**
**Water and Elutriate Sample Laboratory Analytical Requirements**

| Parameter | CAS Number | Recommended Analytical Method 40 CFR 136 [1] | Required MDL [2] µg/L [3] |
|---|---|---|---|
| Chromium, Dissolved | 7440-47-3 | 200.8 | 1 |
| Copper, Dissolved | 7440-50-8 | 200.8 | 1 |
| Lead, Dissolved | 7439-92-1 | 200.8 | 1 |
| Mercury, Dissolved | 7439-97-6 | 245.1 | 0.2 |
| Nickel, Dissolved (Freshwater or Marine) | 7440-02-0 | 200.8 | 1 |
| Selenium, Dissolved | 7782-49-2 | 200.8 | 2 |
| Silver, Dissolved | 7440-22-4 | 200.8 | 0.2 |
| Thallium, Dissolved | 7440-28-0 | 200.8 | 1 |
| Zinc, Dissolved | 7440-66-6 | 200.8 | 0.05 |

[1] Per the regulatory requirements at 40 Code of Federal Regulations (CFR) at 40 CFR 136, USEPA Guidelines Establishing Test Procedures for the Analysis of Pollutants, with methods from the documents (1) Methods for Chemical Analysis of Water and Wastes, USEPA Publication Number EPA-600/4-79-020 and/or (2) Standard Methods for the Examination of Water and Wastewater, 18th Edition (1992), 19th Edition (1995), or 20th Edition (1998)
[2] MDL = Method Detection Limit
[3] µg/L = micrograms per liter
[4] Total Organic Nitrogen is determined by subtracting the Ammonia (as N) value (as determined by an approved method) from the Total Kjeldahl Nitrogen value (as determined by an approved method).
[5] nd = not determined

# TABLE 4

# SEDIMENT SAMPLE LABORATORY ANALYTICAL REQUIREMENTS

## TABLE 4
## Sediment Sample Laboratory Analytical Requirements

| Parameter | CAS Number | Recommended Analytical Method SW 846 [1] | Required MDL [2] µg/Kg [3] |
|---|---|---|---|
| **MISCELLANEOUS PARAMETERS** | | | |
| Phosphorous (as P), Total | 7723-14-0 | 3050/6010 | 600 |
| Nitrate-Nitrite Nitrogen | 7727-37-9 | 353.2 | 480 |
| Nitrogen, Total Organic | --- | See Footnote [4] | See Footnote [4] |
| Total Kjeldahl Nitrogen (TKN) | E-10264 | 351.4 | 3000 |
| Ammonia (As N) | 7664-41-7 | I-6522-90 [5] | 140 |
| **PRIORITY POLLUTANT ORGANIC COMPOUNDS** | | | |
| **VOLATILE ORGANIC COMPOUNDS** | | | |
| Acrolein (2-Propenal) | 107-02-8 | 8260 | 28.0 |
| Acrylonitrile (2-Propenenitrile) | 107-13-1 | 8260 | 6.2 |
| Benzene | 71-43-2 | 8240A | 5 |
| Bromoform (Tribromomethane) | 75-25-2 | 8240A | 5 |
| Carbon tetrachloride | 56-23-5 | 8240A | 5 |
| Chlorobenzene | 108-90-7 | 8240A | 5 |
| Chlorodibromomethane (Dibromochloromethane) | 124-48-1 | 8240A | 5 |
| Chloroethane | 75-00-3 | 8240A | 10 |
| 2-chloroethylvinyl ether | 110-75-8 | 8260 | 17.0 |
| Chloroform (Trichloromethane) | 67-66-3 | 8240A | 5 |
| Dichlorobromomethane (Bromodichloromethane) | 75-27-4 | 8240A | 5 |
| 1,1-Dichloroethane | 75-34-3 | 8240A | 5 |
| 1,2-Dichloroethane [Ethylene Dichloride (EDC)] | 107-06-02 | 8240A | 5 |
| 1,1-Dichloroethylene (1,1-Dichloroethene) | 75-35-4 | 8260 | 1.30 |
| 1,2-Dichloropropane | 78-87-5 | 8240A | 5 |
| 1,3-Dichloropropylene (1,3-Dichloropropene) | 542-75-6 | 8240A | 5 |
| Ethylbenzene | 100-41-4 | 8240A | 5 |
| Methyl bromide (Bromomethane) | 74-83-9 | 8240A | 10 |
| Methyl chloride (Chloromethane) | 74-87-3 | 8240A | 10 |
| Methylene chloride (Dichloromethane) | 75-09-2 | 8240A | 5 |
| 1,1,2,2-Tetrachloroethane | 79-34-5 | 8240A | 5 |
| Tetrachloroethylene (Tetrachloroethene) (Perchloroethylene) | 127-18-4 | 8240A | 5 |
| Toluene | 108-88-3 | 8240A | 5 |
| trans-1,2-Dichloroethylene (trans-1,2-Dichloroethene) | 156-60-5 | 8240A | 5 |
| 1,1,1-Trichloroethane (Methyl chloroform) | 71-55-6 | 8240A | 5 |
| 1,1,2-Trichloroethane | 79-00-5 | 8240A | 5 |
| Trichloroethylene (Trichloroethene) | 79-01-6 | 8240A | 5 |
| Vinyl chloride (Chloroethene) | 75-01-4 | 8240A | 10 |
| **ACID FRACTION COMPOUNDS** | | | |
| 2-Chlorophenol (o-Chlorophenol) | 95-57-8 | 8270 | 660 |
| 2,4-Dichlorophenol | 120-83-2 | 8270 | 660 |

**TABLE 4**
**Sediment Sample Laboratory Analytical Requirements**

| Parameter | CAS Number | Recommended Analytical Method SW 846 [1] | Required MDL [2] µg/Kg [3] |
|---|---|---|---|
| 2,4-Dimethylphenol | 105-67-9 | 8270 | 660 |
| 4,6-Dinitro-o-cresol (4,6-Dinitro-2-methylphenol) | 534-52-1 | 8270 | 78 |
| 2,4-Dinitrophenol | 51-28-5 | 8270 | 3300 |
| 2-Nitrophenol (o-Nitrophenol) | 88-75-5 | 8270 | 660 |
| 4-Nitrophenol (p-Nitrophenol) | 100-02-7 | 8270 | 3300 |
| p-chloro-m-cresol (4-Chloro-3-methylphenol) | 59-50-7 | 8270 | 1300 |
| Pentachlorophenol | 87-86-5 | 8270 | 3300 |
| Phenol | 108-95-2 | 8270 | 660 |
| 2,4,6-Trichlorophenol | 88-06-2 | 8270 | 660 |
| **BASE/NEUTRAL COMPOUNDS** | | | |
| Acenaphthene | 83-32-9 | 8270 | 660 |
| Acenaphthylene | 208-96-8 | 8270 | 660 |
| Anthracene | 120-12-7 | 8270 | 660 |
| Benzidine | 92-87-5 | 8270 | nd [6] |
| Benzo(a)anthracene | 56-55-3 | 8270 | 660 |
| Benzo(a)pyrene | 50-32-8 | 8270 | 660 |
| 3,4-Benzofluoranthene (Benzo(b)fluoranthene) | 205-99-2 | 8270 | 660 |
| Benzo(ghi)perylene | 191-24-2 | 8270 | 660 |
| Benzo(k)fluoranthene | 207-08-9 | 8270 | 660 |
| Bis(2-chloroethoxy)methane | 111-91-1 | 8270 | 660 |
| Bis(2-chloroethyl)ether | 111-44-4 | 8270 | 660 |
| Bis(2-chloroisopropyl)ether [2,2'-oxybis(1-Chloropropane)] | 108-60-1 | 8270 | 660 |
| Bis(2-ethylhexyl)phthalate | 117-81-7 | 8270 | 660 |
| 4-Bromophenyl phenyl ether | 101-55-3 | 8270 | 660 |
| Butylbenzyl phthalate | 85-68-7 | 8270 | 660 |
| 2-Chloronaphthalene | 91-58-7 | 8270 | 660 |
| 4-Chlorophenyl phenyl ether | 7005-72-3 | 8270 | 660 |
| Chrysene | 218-01-9 | 8270 | 660 |
| Dibenzo(a,h)anthracene | 53-70-3 | 8270 | 660 |
| 1,2-Dichlorobenzene (o-Dichlorobenzene) | 95-50-1 | 8270 | 660 |
| 1,3-Dichlorobenzene (m-Dichlorobenzene) | 541-73-1 | 8270 | 660 |
| 1,4-Dichlorobenzene (p-Dichlorobenzene) | 106-46-7 | 8270 | 660 |
| 3,3'-Dichlorobenzidine | 91-94-1 | 8270 | 70 |
| Diethyl phthalate | 84-66-2 | 8270 | 660 |
| Dimethyl phthalate | 131-11-3 | 8270 | 660 |
| Di-n-butyl phthalate | 84-74-2 | 8270 | 9 |
| 2,4-Dinitrotoluene | 121-14-2 | 8270 | 660 |
| 2,6-Dinitrotoluene | 606-20-2 | 8270 | 660 |
| Di-n-octyl phthalate | 117-84-0 | 8270 | 660 |
| 1,2-Diphenylhydrazine (as azobenzene) | 122-66-7 | 8270 | 35 |
| Fluoranthene | 206-44-0 | 8270 | 660 |
| Fluorene | 86-73-7 | 8270 | 660 |
| Hexachlorobenzene | 118-74-1 | 8270 | 660 |
| Hexachlorobutadiene | 87-68-3 | 8270 | 660 |

**TABLE 4**
**Sediment Sample Laboratory Analytical Requirements**

| Parameter | CAS Number | Recommended Analytical Method SW 846 [1] | Required MDL [2] µg/Kg [3] |
|---|---|---|---|
| Hexachlorocyclopentadiene | 77-47-4 | 8270 | 660 |
| Hexachloroethane | 67-72-1 | 8270 | 660 |
| Indeno(1,2,3-cd)pyrene | 193-39-5 | 8270 | 660 |
| Isophorone | 78-59-1 | 8270 | 660 |
| Naphthalene | 91-20-3 | 8270 | 660 |
| Nitrobenzene | 98-95-3 | 8270 | 660 |
| N-nitrosodimethylamine | 62-75-9 | 8270 | nd [6] |
| N-nitrosodi-n-propylamine | 621-64-7 | 8270 | 660 |
| N-nitrosodiphenylamine (Diphenylamine) | 86-30-6 | 8270 | 660 |
| Phenanthrene | 85-01-8 | 8270 | 660 |
| Pyrene | 129-00-0 | 8270 | 660 |
| 1,2,4-Trichlorobenzene | 120-82-1 | 8270 | 660 |
| **PESTICIDES, HERBICIDES, AND PCBs** | | | |
| Aldrin | 309-00-2 | 8081 | 3 |
| PCB-1016 | 12674-11-2 | 8082 | 33 |
| PCB-1221 | 11104-28-2 | 8082 | 67 |
| PCB-1232 | 11141-16-5 | 8082 | 33 |
| PCB-1242 | 53469-21-9 | 8082 | 33 |
| PCB-1248 | 12672-29-6 | 8082 | 33 |
| PCB-1254 | 11097-69-1 | 8082 | 33 |
| PCB-1260 | 11096-82-5 | 8082 | 33 |
| alpha-BHC | 319-84-6 | 8081 | 2 |
| beta-BHC | 319-85-7 | 8081 | 4 |
| delta-BHC | 319-86-8 | 8081 | 6 |
| gamma-BHC (Hexachlorocyclohexane) (Lindane) | 58-89-9 | 8081 | 3 |
| Chlordane | 57-74-9 | 8081 | 9 |
| 4,4'DDT | 50-29-3 | 8081 | 8 |
| 4,4'DDE | 72-55-9 | 8081 | 3 |
| 4,4'DDD | 72-54-8 | 8081 | 7 |
| Dieldrin | 60-57-1 | 8081 | 2 |
| Alpha-Endosulfan (Endosulfan I) | 959-98-8 | 8081 | 9 |
| Beta-Endosulfan (Endosulfan II) | 33213-65-9 | 8081 | 3 |
| Endosulfan sulfate | 1031-07-8 | 8081 | 45 |
| Endrin | 72-20-8 | 8081 | 4 |
| Endrin aldehyde | 7421-93-4 | 8081 | 16 |
| Heptachlor | 76-44-8 | 8081 | 2 |
| Heptachlor Epoxide | 1024-57-3 | 8081 | 56 |
| Toxaphene | 8001-35-2 | 8081 | 161 |
| **PRIORITY POLLUTANT METALS** | | | |
| Antimony, Total | 7440-36-0 | 6020 | 500 |
| Arsenic, Total | 7440-38-2 | 6020 | 500 |

## TABLE 4
## Sediment Sample Laboratory Analytical Requirements

| Parameter | CAS Number | Recommended Analytical Method SW 846 [1] | Required MDL [2] µg/Kg [3] |
|---|---|---|---|
| Beryllium, Total | 7440-41-7 | 6020 | 100 |
| Cadmium, Total | 7440-43-9 | 6020 | 100 |
| Chromium, Total | 7440-47-3 | 6020 | 1000 |
| Copper, Total | 7440-50-8 | 6020 | 500 |
| Lead, Total | 7439-92-1 | 6020 | 300 |
| Mercury, Total | 7439-97-6 | 7471 | 20 |
| Nickel, Total (Freshwater or Marine) | 7440-02-0 | 6020 | 200 |
| Selenium, Total | 7782-49-2 | 6020 | 500 |
| Silver, Total | 7440-22-4 | 6020 | 200 |
| Thallium, Total | 7440-28-0 | 6020 | 200 |
| Zinc, Total | 7440-66-6 | 6020 | 4000 |

[1] SW 846 = USEPA Test Methods for Evaluating Solid Waste, Physical/Chemical Methods. Also, some methods from Methods for Chemical Analysis of Water and Wastes, USEPA Publication Number EPA-600/4-79-020.
[2] MDL = Method Detection Limit
[3] µg/Kg = micrograms per kilogram
[4] Total Organic Nitrogen is determined by subtracting the Ammonia (as N) value (as determined by an approved method) from the Total Kjeldahl Nitrogen value (as determined by an approved method).
[5] This method is not from SW 846, but rather from M.J. Fishman, 1993, Methods of Analysis by the U.S. Geological Survey National Water Quality Laboratory--Determination of Inorganic and Organic Constituents in Water and Fluvial Sediments: U.S. Geological Survey Open-File Report 93-125
[6] nd = not determined

# FIGURE 1

# SAMPLING LOCATIONS

# APPENDIX A

# FIELD SAMPLING INFORMATION FORM

## FIELD SAMPLING INFORMATION FORM

| Sampling Location Information and Observations | | | |
|---|---|---|---|
| Sample Location: | | Survey Team: | |
| GPS Coordinates: | | | |
| | | | |
| Water Body: | | Date: | |
| Parish: | | Time (Inclusive): | |
| Water Depth (feet or meters): | | Weather Conditions: | |
| Air Temperature (°F or °C): | | Estimated Wind Speed (mph): | |
| Wind Direction: | | | |
| Observation of Water Conditions: | | | |

| Field Water Quality Readings | | | |
|---|---|---|---|
| Depth (feet or meters): | | Salinity (ppt): | |
| Temperature (°C): | | Dissolved Oxygen (% saturation): | |
| Conductivity (mS/cm) | | Dissolved Oxygen (mg/L): | |
| Battery: | | pH (S.U.): | |
| Instrumentation: | | | |

# APPENDIX B

# SEVERN TRENT LABORATORIES, INC. ANALYTICAL REPORT (FEBRUARY 8, 2006 SAMPLES)

# ANALYTICAL REPORT

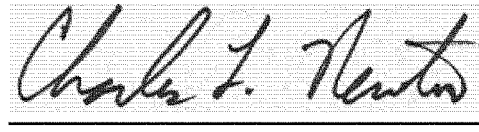
Job Number: 700-9680-1

Job Description: Providence Engineering & Envvironmental

For:

Providence Engineering & Environmental
6160 Perkins Road
Suite 100
Baton Rouge, LA 70808

Attention: Mr. Phillip Parker



Charles Newton
Project Manager I
cnewton@stl-inc.com
03/13/2006

## METHOD SUMMARY

Client: Providence Engineering & Environmental Job Number: 700-9680-1

| Description | Lab Location | Method | Preparation Method |
|---|---|---|---|
| **Matrix: Solid** | | | |
| Volatile Organic Compounds by GC/MS | STL-MOB | SW846 8260B | |
| Purge-and-Trap Low Level | STL-MOB | | SW846 5030B |
| Semivolatile Compounds by Gas Chromatography/Mass Spectrometry (GC/MS) | STL-MOB | SW846 8270C | |
| Ultrasonic Extraction | STL-MOB | | SW846 3550B |
| Semivolatile Organic Compounds by GCMS - Low Levels | STL-MOB | SW846 8270C | |
| Ultrasonic Extraction | STL-MOB | | SW846 3550B |
| Organochlorine Pesticides by Gas Chromatography | STL-MOB | SW846 8081A | |
| Ultrasonic Extraction | STL-MOB | | SW846 3550B |
| Polychlorinated Biphenyls (PCBs) by Gas Chromatography | STL-MOB | SW846 8082 | |
| Ultrasonic Extraction | STL-MOB | | SW846 3550B |
| Inductively Coupled Plasma - Mass Spectrometry | STL-SAV | SW846 6020 | |
| Acid Digestion of Sediments, Sludges, and Soils | STL-SAV | | SW846 3050B |
| Mercury in Solid or Semisolid Waste (Manual Cold Vapor Technique) | STL-MOB | SW846 7471A | |
| Mercury in Solid or Semi-Solid Waste (Manual | STL-MOB | | SW846 7471A |
| Nitrogen (Ammonia, Colorimetric, Automated Phenate) | STL-MOB | MCAWW 350.1 | |
| Deionized Water Leaching Procedure (Routine) | STL-MOB | | ASTM NONE |
| Nitrogen, Total Kjeldahl (Colorimetric, Semi-Automated Block Digester, AAII) | STL-MOB | MCAWW 351.2 | |
| Nitrogen, Total Kjeldahl (Colorimetric, | STL-MOB | | MCAWW 351.2 |
| Nitrogen, Nitrate-Nitrite (Colorimetric, Automated, Cadmium Reduction) | STL-MOB | MCAWW 353.2 | |
| Deionized Water Leaching Procedure (Routine) | STL-MOB | | ASTM NONE |
| Total Phosphorus | STL-MOB | EPA 365.4 | |
| Sample Digestion for Total Phosphorous | STL-MOB | | MCAWW 365.2/365.3 |
| Percent Moisture | STL-MOB | EPA 160.3 | |
| Total Nitrogen | STL-MOB | EPA Total Nitrogen | |
| **Matrix: Water** | | | |
| Purgeable Organic Compounds by GC/MS | STL-MOB | 40CFR136A 624 | |
| Base/Neutral and Acid Organics in Wastewater | STL-MOB | 40CFR136A 625 | |
| Continuous Liquid-Liquid Extraction | STL-MOB | | SW846 3520C |
| Organochlorine Pesticides/PCBs in Water | STL-MOB | 40CFR136A 608 | |
| Continuous LiqLiq Extractions for Clean Water Act | STL-MOB | | 40CFR136A |
| ICPMS Metals by 200.8 CWA | STL-SAV | EPA 200.8 | |

**STL Mobile**

## METHOD SUMMARY

Client: Providence Engineering & Environmental Job Number: 700-9680-1

| Matrix: Water | | | |
|---|---|---|---|
| ICPMS Metals by 200.8 CWA | STL-SAV | EPA 200.8 | |
| Total Recoverable Metals for 200.8 | STL-SAV | | MCAWW 4.1.4 |
| Sample Filtration performed in the Field | STL-SAV | | FIELD_FLTRD |
| Mercury in Water by CVAA | STL-MOB | EPA 245.1 | |
| Digestion for CVAA Mercury in Waters | STL-MOB | | EPA 245.1 |
| Nitrogen (Ammonia, Colorimetric, Automated Phenate) | STL-MOB | MCAWW 350.1 | |
| Nitrogen, Total Kjeldahl (Colorimetric, Semi-Automated Block Digester, AAII) | STL-MOB | MCAWW 351.2 | |
| Nitrogen, Total Kjeldahl (Colorimetric, | STL-MOB | | MCAWW 351.2 |
| Nitrogen, Nitrate-Nitrite (Colorimetric, Automated, Cadmium Reduction) | STL-MOB | MCAWW 353.2 | |
| Total Phosphorus | STL-MOB | EPA 365.4 | |
| Sample Digestion for Total Phosphorous | STL-MOB | | MCAWW 365.2/365.3 |
| Organic Nitrogen | STL-MOB | EPA Nitrogen,Org | |

### LAB REFERENCES:

STL-SAV = STL-Savannah
STL-MOB = STL-Mobile

### METHOD REFERENCES:

40CFR136A - "Methods for Organic Chemical Analysis of Municipal Industrial Wastewater", 40CFR, Part 136, Appendix A, October 26, 1984 and subsequent revisions.

EPA - US Environmental Protection Agency

MCAWW - "Methods For Chemical Analysis Of Water And Wastes", EPA-600/4-79-020, March 1983 And Subsequent Revisions.

SW846 - "Test Methods For Evaluating Solid Waste, Physical/Chemical Methods", Third Edition, November 1986 And Its Updates.

## METHOD / ANALYST SUMMARY

Client: Providence Engineering & Environmental Job Number: 700-9680-1

| Method | Analyst | Analyst ID |
|---|---|---|
| 40CFR136A 624 | Var, Kerry | KBV |
| SW846 8260B | Var, Kerry | KBV |
| 40CFR136A 625 | Huynh, HoangNam | HH |
| SW846 8270C | Huynh, HoangNam | HH |
| SW846 8270C | Nguyen, LanHuong | LN |
| 40CFR136A 608 | Nguyen, Khanh | KN |
| SW846 8081A | Nguyen, Khanh | KN |
| SW846 8082 | Nguyen, Khanh | KN |
| EPA 200.8 | Boyuk, Brian | BB |
| EPA 200.8 | Eaton, Cliff | CE |
| EPA 245.1 | Bruce, Timothy R | TRB |
| SW846 6020 | Eaton, Cliff | CE |
| SW846 7471A | Bruce, Timothy R | TRB |
| EPA 160.3 | Giang, My | MG |
| MCAWW 350.1 | Bradley, Katie | KB |
| MCAWW 351.2 | Flanagan, Mike | MF |
| MCAWW 353.2 | Bradley, Katie | KB |
| EPA 365.4 | Flanagan, Mike | MF |
| EPA Nitrogen,Org | Bradley, Katie | KB |
| EPA Total Nitrogen | Flanagan, Mike | MF |

## SAMPLE SUMMARY

Client: Providence Engineering & Environmental Job Number: 700-9680-1

| Lab Sample ID | Client Sample ID | Client Matrix | Date/Time Sampled | Date/Time Received |
|---|---|---|---|---|
| 700-9680-1 | Sandy 01 Water | Water | 02/08/2006 1010 | 02/10/2006 1040 |
| 700-9680-2 | Sandy 01 Sediment | Solid | 02/08/2006 1100 | 02/10/2006 1040 |
| 700-9680-3 | Sandy 01 Elutriate | Water | 02/08/2006 1100 | 02/10/2006 1040 |
| 700-9680-5 | Sandy 02 Sediment | Solid | 02/08/2006 1155 | 02/10/2006 1040 |
| 700-9680-6 | Sandy 02 Elutriate | Water | 02/08/2006 1155 | 02/10/2006 1040 |
| 700-9680-7 | Empire 01 Water | Water | 02/08/2006 1240 | 02/10/2006 1040 |
| 700-9680-8 | Empire 01 Sediment | Solid | 02/08/2006 1300 | 02/10/2006 1040 |
| 700-9680-9 | Empire 01 Elutriate | Water | 02/08/2006 1300 | 02/10/2006 1040 |
| 700-9680-10 | Shell 01 Water | Water | 02/08/2006 1430 | 02/10/2006 1040 |
| 700-9680-11 | Shell 01 Sediment | Solid | 02/08/2006 1440 | 02/10/2006 1040 |
| 700-9680-12 | Shell 01 Elutriate | Water | 02/08/2006 1430 | 02/10/2006 1040 |
| 700-9680-14 | Shell 02 Sediment | Solid | 02/08/2006 1615 | 02/10/2006 1040 |
| 700-9680-15 | Shell 02 Elutriate | Water | 02/08/2006 1615 | 02/10/2006 1040 |
| 700-9680-16 | Sandy 01A | Water | 02/08/2006 1010 | 02/10/2006 1040 |
| 700-9680-17 | Sandy 01B | Water | 02/08/2006 1010 | 02/10/2006 1040 |
| 700-9680-18 | Sandy 01C | Water | 02/08/2006 1010 | 02/10/2006 1040 |
| 700-9680-19 | Empire 01A | Water | 02/08/2006 1315 | 02/10/2006 1040 |
| 700-9680-20 | Empire 01B | Water | 02/08/2006 1320 | 02/10/2006 1040 |
| 700-9680-21 | Empire 01C | Water | 02/08/2006 1325 | 02/10/2006 1040 |
| 700-9680-22 | Shell 01A | Water | 02/08/2006 1430 | 02/10/2006 1040 |
| 700-9680-23 | Shell 01B | Water | 02/08/2006 1435 | 02/10/2006 1040 |
| 700-9680-24 | Shell 01C | Water | 02/08/2006 1440 | 02/10/2006 1040 |
| 700-9680-25TB | Trip Blank A | Water | 02/08/2006 0000 | 02/10/2006 1040 |
| 700-9680-26TB | Trip Blank B | Water | 02/08/2006 0000 | 02/10/2006 1040 |

# SAMPLE RESULTS

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9680-1

**Client Sample ID:** **Sandy 01 Elutriate**

Lab Sample ID: 700-9680-3 | Date Sampled: 02/08/2006 1100
Client Matrix: Water | Date Received: 02/10/2006 1040

**624 Purgeable Organic Compounds by GC/MS**

Method: 624 | Analysis Batch: 700-17450 | Instrument ID: VMG5973
Preparation: N/A | Lab File ID: G021617.D
Dilution: 1.0 | Initial Weight/Volume: 5 mL
Date Analyzed: 02/16/2006 1857 | Final Weight/Volume: 5 mL
Date Prepared: N/A

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| 1,1,1-Trichloroethane | ND | | 0.19 | 5.0 |
| 1,1,2,2-Tetrachloroethane | ND | | 0.25 | 5.0 |
| 1,1,2-Trichloroethane | ND | | 0.31 | 5.0 |
| 1,1-Dichloroethane | ND | | 0.14 | 5.0 |
| 1,1-Dichloroethene | ND | | 0.38 | 5.0 |
| 1,2-Dichloroethane | ND | | 0.15 | 5.0 |
| 1,2-Dichloropropane | ND | | 0.15 | 5.0 |
| 2-Chloroethyl vinyl ether | ND | | 0.50 | 50 |
| Acrolein | ND | | 9.6 | 100 |
| Acrylonitrile | ND | | 0.67 | 100 |
| Benzene | ND | | 0.12 | 5.0 |
| Bromoform | ND | | 0.18 | 5.0 |
| Bromomethane | ND | | 0.80 | 10 |
| Carbon tetrachloride | ND | | 0.56 | 5.0 |
| Chlorobenzene | ND | | 0.17 | 5.0 |
| Chlorodibromomethane | ND | | 0.50 | 5.0 |
| Chloroethane | ND | | 0.84 | 10 |
| Chloroform | ND | | 0.18 | 5.0 |
| Chloromethane | ND | | 0.15 | 10 |
| Dichlorobromomethane | ND | | 0.50 | 5.0 |
| Ethylbenzene | ND | | 0.56 | 5.0 |
| Methylene Chloride | 14 | | 0.45 | 5.0 |
| Tetrachloroethene | ND | | 0.20 | 5.0 |
| Toluene | ND | | 0.19 | 5.0 |
| trans-1,2-Dichloroethene | ND | | 0.24 | 5.0 |
| Trichloroethene | ND | | 0.29 | 5.0 |
| Vinyl chloride | ND | | 0.22 | 10 |
| 1,3-Dichloropropane | ND | | 0.50 | 5.0 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| Toluene-d8 | 109 | 77 - 116 |
| Dibromofluoromethane | 116 | 66 - 125 |
| 4-Bromofluorobenzene | 107 | 70 - 118 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID:** **Sandy 02 Elutriate**

Lab Sample ID: 700-9680-6 Date Sampled: 02/08/2006 1155
Client Matrix: Water Date Received: 02/10/2006 1040

**624 Purgeable Organic Compounds by GC/MS**

Method: 624 Analysis Batch: 700-17450 Instrument ID: VMG5973
Preparation: N/A Lab File ID: G021618.D
Dilution: 1.0 Initial Weight/Volume: 5 mL
Date Analyzed: 02/16/2006 1928 Final Weight/Volume: 5 mL
Date Prepared: N/A

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| 1,1,1-Trichloroethane | ND | | 0.19 | 5.0 |
| 1,1,2,2-Tetrachloroethane | ND | | 0.25 | 5.0 |
| 1,1,2-Trichloroethane | ND | | 0.31 | 5.0 |
| 1,1-Dichloroethane | ND | | 0.14 | 5.0 |
| 1,1-Dichloroethene | ND | | 0.38 | 5.0 |
| 1,2-Dichloroethane | 2.2 | J | 0.15 | 5.0 |
| 1,2-Dichloropropane | ND | | 0.15 | 5.0 |
| 2-Chloroethyl vinyl ether | ND | | 0.50 | 50 |
| Acrolein | ND | | 9.6 | 100 |
| Acrylonitrile | ND | | 0.67 | 100 |
| Benzene | ND | | 0.12 | 5.0 |
| Bromoform | ND | | 0.18 | 5.0 |
| Bromomethane | ND | | 0.80 | 10 |
| Carbon tetrachloride | ND | | 0.56 | 5.0 |
| Chlorobenzene | ND | | 0.17 | 5.0 |
| Chlorodibromomethane | ND | | 0.50 | 5.0 |
| Chloroethane | ND | | 0.84 | 10 |
| Chloroform | ND | | 0.18 | 5.0 |
| Chloromethane | ND | | 0.15 | 10 |
| Dichlorobromomethane | ND | | 0.50 | 5.0 |
| Ethylbenzene | ND | | 0.56 | 5.0 |
| Methylene Chloride | 4.9 | J | 0.45 | 5.0 |
| Tetrachloroethene | ND | | 0.20 | 5.0 |
| Toluene | ND | | 0.19 | 5.0 |
| trans-1,2-Dichloroethene | ND | | 0.24 | 5.0 |
| Trichloroethene | ND | | 0.29 | 5.0 |
| Vinyl chloride | ND | | 0.22 | 10 |
| 1,3-Dichloropropane | ND | | 0.50 | 5.0 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| Toluene-d8 | 109 | 77 - 116 |
| Dibromofluoromethane | 113 | 66 - 125 |
| 4-Bromofluorobenzene | 108 | 70 - 118 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9680-1

**Client Sample ID:** **Empire 01 Elutriate**

Lab Sample ID: 700-9680-9 | Date Sampled: 02/08/2006 1300
Client Matrix: Water | Date Received: 02/10/2006 1040

**624 Purgeable Organic Compounds by GC/MS**

Method: 624 | Analysis Batch: 700-17450 | Instrument ID: VMG5973
Preparation: N/A | Lab File ID: G021619.D
Dilution: 1.0 | Initial Weight/Volume: 5 mL
Date Analyzed: 02/17/2006 0813 | Final Weight/Volume: 5 mL
Date Prepared: N/A

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| 1,1,1-Trichloroethane | ND | | 0.19 | 5.0 |
| 1,1,2,2-Tetrachloroethane | ND | | 0.25 | 5.0 |
| 1,1,2-Trichloroethane | ND | | 0.31 | 5.0 |
| 1,1-Dichloroethane | ND | | 0.14 | 5.0 |
| 1,1-Dichloroethene | ND | | 0.38 | 5.0 |
| 1,2-Dichloroethane | ND | | 0.15 | 5.0 |
| 1,2-Dichloropropane | ND | | 0.15 | 5.0 |
| 2-Chloroethyl vinyl ether | ND | | 0.50 | 50 |
| Acrolein | ND | | 9.6 | 100 |
| Acrylonitrile | ND | | 0.67 | 100 |
| Benzene | ND | | 0.12 | 5.0 |
| Bromoform | ND | | 0.18 | 5.0 |
| Bromomethane | ND | | 0.80 | 10 |
| Carbon tetrachloride | ND | | 0.56 | 5.0 |
| Chlorobenzene | ND | | 0.17 | 5.0 |
| Chlorodibromomethane | ND | | 0.50 | 5.0 |
| Chloroethane | ND | | 0.84 | 10 |
| Chloroform | ND | | 0.18 | 5.0 |
| Chloromethane | ND | | 0.15 | 10 |
| Dichlorobromomethane | ND | | 0.50 | 5.0 |
| Ethylbenzene | ND | | 0.56 | 5.0 |
| Methylene Chloride | ND | | 0.45 | 5.0 |
| Tetrachloroethene | ND | | 0.20 | 5.0 |
| Toluene | ND | | 0.19 | 5.0 |
| trans-1,2-Dichloroethene | ND | | 0.24 | 5.0 |
| Trichloroethene | ND | | 0.29 | 5.0 |
| Vinyl chloride | ND | | 0.22 | 10 |
| 1,3-Dichloropropane | ND | | 0.50 | 5.0 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| Toluene-d8 | 109 | 77 - 116 |
| Dibromofluoromethane | 112 | 66 - 125 |
| 4-Bromofluorobenzene | 111 | 70 - 118 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID: Shell 01 Elutriate**

Lab Sample ID: 700-9680-12 Date Sampled: 02/08/2006 1430
Client Matrix: Water Date Received: 02/10/2006 1040

**624 Purgeable Organic Compounds by GC/MS**

Method: 624 Analysis Batch: 700-17450 Instrument ID: VMG5973
Preparation: N/A Lab File ID: G021620.D
Dilution: 1.0 Initial Weight/Volume: 5 mL
Date Analyzed: 02/17/2006 0844 Final Weight/Volume: 5 mL
Date Prepared: N/A

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| 1,1,1-Trichloroethane | ND | | 0.19 | 5.0 |
| 1,1,2,2-Tetrachloroethane | ND | | 0.25 | 5.0 |
| 1,1,2-Trichloroethane | ND | | 0.31 | 5.0 |
| 1,1-Dichloroethane | ND | | 0.14 | 5.0 |
| 1,1-Dichloroethene | ND | | 0.38 | 5.0 |
| 1,2-Dichloroethane | ND | | 0.15 | 5.0 |
| 1,2-Dichloropropane | ND | | 0.15 | 5.0 |
| 2-Chloroethyl vinyl ether | ND | | 0.50 | 50 |
| Acrolein | ND | | 9.6 | 100 |
| Acrylonitrile | ND | | 0.67 | 100 |
| Benzene | ND | | 0.12 | 5.0 |
| Bromoform | ND | | 0.18 | 5.0 |
| Bromomethane | ND | | 0.80 | 10 |
| Carbon tetrachloride | ND | | 0.56 | 5.0 |
| Chlorobenzene | ND | | 0.17 | 5.0 |
| Chlorodibromomethane | ND | | 0.50 | 5.0 |
| Chloroethane | ND | | 0.84 | 10 |
| Chloroform | ND | | 0.18 | 5.0 |
| Chloromethane | ND | | 0.15 | 10 |
| Dichlorobromomethane | ND | | 0.50 | 5.0 |
| Ethylbenzene | ND | | 0.56 | 5.0 |
| Methylene Chloride | 2.4 | J | 0.45 | 5.0 |
| Tetrachloroethene | ND | | 0.20 | 5.0 |
| Toluene | ND | | 0.19 | 5.0 |
| trans-1,2-Dichloroethene | ND | | 0.24 | 5.0 |
| Trichloroethene | ND | | 0.29 | 5.0 |
| Vinyl chloride | ND | | 0.22 | 10 |
| 1,3-Dichloropropane | ND | | 0.50 | 5.0 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| Toluene-d8 | 108 | 77 - 116 |
| Dibromofluoromethane | 113 | 66 - 125 |
| 4-Bromofluorobenzene | 108 | 70 - 118 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID:** **Shell 02 Elutriate**

Lab Sample ID: 700-9680-15 Date Sampled: 02/08/2006 1615
Client Matrix: Water Date Received: 02/10/2006 1040

**624 Purgeable Organic Compounds by GC/MS**

Method: 624 Analysis Batch: 700-17450 Instrument ID: VMG5973
Preparation: N/A Lab File ID: G021621.D
Dilution: 1.0 Initial Weight/Volume: 5 mL
Date Analyzed: 02/17/2006 0915 Final Weight/Volume: 5 mL
Date Prepared: N/A

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| 1,1,1-Trichloroethane | ND | | 0.19 | 5.0 |
| 1,1,2,2-Tetrachloroethane | ND | | 0.25 | 5.0 |
| 1,1,2-Trichloroethane | ND | | 0.31 | 5.0 |
| 1,1-Dichloroethane | ND | | 0.14 | 5.0 |
| 1,1-Dichloroethene | ND | | 0.38 | 5.0 |
| 1,2-Dichloroethane | ND | | 0.15 | 5.0 |
| 1,2-Dichloropropane | ND | | 0.15 | 5.0 |
| 2-Chloroethyl vinyl ether | ND | | 0.50 | 50 |
| Acrolein | ND | | 9.6 | 100 |
| Acrylonitrile | ND | | 0.67 | 100 |
| Benzene | ND | | 0.12 | 5.0 |
| Bromoform | ND | | 0.18 | 5.0 |
| Bromomethane | ND | | 0.80 | 10 |
| Carbon tetrachloride | ND | | 0.56 | 5.0 |
| Chlorobenzene | ND | | 0.17 | 5.0 |
| Chlorodibromomethane | ND | | 0.50 | 5.0 |
| Chloroethane | ND | | 0.84 | 10 |
| Chloroform | ND | | 0.18 | 5.0 |
| Chloromethane | ND | | 0.15 | 10 |
| Dichlorobromomethane | ND | | 0.50 | 5.0 |
| Ethylbenzene | ND | | 0.56 | 5.0 |
| Methylene Chloride | ND | | 0.45 | 5.0 |
| Tetrachloroethene | ND | | 0.20 | 5.0 |
| Toluene | ND | | 0.19 | 5.0 |
| trans-1,2-Dichloroethene | ND | | 0.24 | 5.0 |
| Trichloroethene | ND | | 0.29 | 5.0 |
| Vinyl chloride | ND | | 0.22 | 10 |
| 1,3-Dichloropropane | ND | | 0.50 | 5.0 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| Toluene-d8 | 109 | 77 - 116 |
| Dibromofluoromethane | 117 | 66 - 125 |
| 4-Bromofluorobenzene | 110 | 70 - 118 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9680-1

**Client Sample ID:** **Sandy 01A**

Lab Sample ID: 700-9680-16 | Date Sampled: 02/08/2006 1010
Client Matrix: Water | Date Received: 02/10/2006 1040

**624 Purgeable Organic Compounds by GC/MS**

Method: 624 | Analysis Batch: 700-17450 | Instrument ID: VMG5973
Preparation: N/A | Lab File ID: G021606.D
Dilution: 1.0 | Initial Weight/Volume: 5 mL
Date Analyzed: 02/16/2006 1231 | Final Weight/Volume: 5 mL
Date Prepared: N/A

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| 1,1,1-Trichloroethane | ND | | 0.19 | 5.0 |
| 1,1,2,2-Tetrachloroethane | ND | | 0.25 | 5.0 |
| 1,1,2-Trichloroethane | ND | | 0.31 | 5.0 |
| 1,1-Dichloroethane | ND | | 0.14 | 5.0 |
| 1,1-Dichloroethene | ND | | 0.38 | 5.0 |
| 1,2-Dichloroethane | ND | | 0.15 | 5.0 |
| 1,2-Dichloropropane | ND | | 0.15 | 5.0 |
| 2-Chloroethyl vinyl ether | ND | | 0.50 | 50 |
| Acrolein | ND | | 9.6 | 100 |
| Acrylonitrile | ND | | 0.67 | 100 |
| Benzene | ND | | 0.12 | 5.0 |
| Bromoform | ND | | 0.18 | 5.0 |
| Bromomethane | ND | | 0.80 | 10 |
| Carbon tetrachloride | ND | | 0.56 | 5.0 |
| Chlorobenzene | ND | | 0.17 | 5.0 |
| Chlorodibromomethane | ND | | 0.50 | 5.0 |
| Chloroethane | ND | | 0.84 | 10 |
| Chloroform | ND | | 0.18 | 5.0 |
| Chloromethane | ND | | 0.15 | 10 |
| Dichlorobromomethane | ND | | 0.50 | 5.0 |
| Ethylbenzene | ND | | 0.56 | 5.0 |
| Methylene Chloride | ND | | 0.45 | 5.0 |
| Tetrachloroethene | ND | | 0.20 | 5.0 |
| Toluene | ND | | 0.19 | 5.0 |
| trans-1,2-Dichloroethene | ND | | 0.24 | 5.0 |
| Trichloroethene | ND | | 0.29 | 5.0 |
| Vinyl chloride | ND | | 0.22 | 10 |
| 1,3-Dichloropropane | ND | | 0.50 | 5.0 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| Toluene-d8 | 113 | 77 - 116 |
| Dibromofluoromethane | 115 | 66 - 125 |
| 4-Bromofluorobenzene | 109 | 70 - 118 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID:** **Sandy 01B**

Lab Sample ID: 700-9680-17 Date Sampled: 02/08/2006 1010
Client Matrix: Water Date Received: 02/10/2006 1040

**624 Purgeable Organic Compounds by GC/MS**

Method: 624 Analysis Batch: 700-17450 Instrument ID: VMG5973
Preparation: N/A Lab File ID: G021607.D
Dilution: 1.0 Initial Weight/Volume: 5 mL
Date Analyzed: 02/16/2006 1301 Final Weight/Volume: 5 mL
Date Prepared: N/A

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| 1,1,1-Trichloroethane | ND | | 0.19 | 5.0 |
| 1,1,2,2-Tetrachloroethane | ND | | 0.25 | 5.0 |
| 1,1,2-Trichloroethane | ND | | 0.31 | 5.0 |
| 1,1-Dichloroethane | ND | | 0.14 | 5.0 |
| 1,1-Dichloroethene | ND | | 0.38 | 5.0 |
| 1,2-Dichloroethane | ND | | 0.15 | 5.0 |
| 1,2-Dichloropropane | ND | | 0.15 | 5.0 |
| 2-Chloroethyl vinyl ether | ND | | 0.50 | 50 |
| Acrolein | ND | | 9.6 | 100 |
| Acrylonitrile | ND | | 0.67 | 100 |
| Benzene | ND | | 0.12 | 5.0 |
| Bromoform | ND | | 0.18 | 5.0 |
| Bromomethane | ND | | 0.80 | 10 |
| Carbon tetrachloride | ND | | 0.56 | 5.0 |
| Chlorobenzene | ND | | 0.17 | 5.0 |
| Chlorodibromomethane | ND | | 0.50 | 5.0 |
| Chloroethane | ND | | 0.84 | 10 |
| Chloroform | ND | | 0.18 | 5.0 |
| Chloromethane | ND | | 0.15 | 10 |
| Dichlorobromomethane | ND | | 0.50 | 5.0 |
| Ethylbenzene | ND | | 0.56 | 5.0 |
| Methylene Chloride | ND | | 0.45 | 5.0 |
| Tetrachloroethene | ND | | 0.20 | 5.0 |
| Toluene | ND | | 0.19 | 5.0 |
| trans-1,2-Dichloroethene | ND | | 0.24 | 5.0 |
| Trichloroethene | ND | | 0.29 | 5.0 |
| Vinyl chloride | ND | | 0.22 | 10 |
| 1,3-Dichloropropane | ND | | 0.50 | 5.0 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| Toluene-d8 | 109 | 77 - 116 |
| Dibromofluoromethane | 116 | 66 - 125 |
| 4-Bromofluorobenzene | 109 | 70 - 118 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID: Sandy 01C**

Lab Sample ID: 700-9680-18 Date Sampled: 02/08/2006 1010
Client Matrix: Water Date Received: 02/10/2006 1040

**624 Purgeable Organic Compounds by GC/MS**

Method: 624 Analysis Batch: 700-17450 Instrument ID: VMG5973
Preparation: N/A Lab File ID: G021608.D
Dilution: 1.0 Initial Weight/Volume: 5 mL
Date Analyzed: 02/16/2006 1332 Final Weight/Volume: 5 mL
Date Prepared: N/A

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| 1,1,1-Trichloroethane | ND | | 0.19 | 5.0 |
| 1,1,2,2-Tetrachloroethane | ND | | 0.25 | 5.0 |
| 1,1,2-Trichloroethane | ND | | 0.31 | 5.0 |
| 1,1-Dichloroethane | ND | | 0.14 | 5.0 |
| 1,1-Dichloroethene | ND | | 0.38 | 5.0 |
| 1,2-Dichloroethane | ND | | 0.15 | 5.0 |
| 1,2-Dichloropropane | ND | | 0.15 | 5.0 |
| 2-Chloroethyl vinyl ether | ND | | 0.50 | 50 |
| Acrolein | ND | | 9.6 | 100 |
| Acrylonitrile | ND | | 0.67 | 100 |
| Benzene | ND | | 0.12 | 5.0 |
| Bromoform | ND | | 0.18 | 5.0 |
| Bromomethane | ND | | 0.80 | 10 |
| Carbon tetrachloride | ND | | 0.56 | 5.0 |
| Chlorobenzene | ND | | 0.17 | 5.0 |
| Chlorodibromomethane | ND | | 0.50 | 5.0 |
| Chloroethane | ND | | 0.84 | 10 |
| Chloroform | ND | | 0.18 | 5.0 |
| Chloromethane | ND | | 0.15 | 10 |
| Dichlorobromomethane | ND | | 0.50 | 5.0 |
| Ethylbenzene | ND | | 0.56 | 5.0 |
| Methylene Chloride | ND | | 0.45 | 5.0 |
| Tetrachloroethene | ND | | 0.20 | 5.0 |
| Toluene | ND | | 0.19 | 5.0 |
| trans-1,2-Dichloroethene | ND | | 0.24 | 5.0 |
| Trichloroethene | ND | | 0.29 | 5.0 |
| Vinyl chloride | ND | | 0.22 | 10 |
| 1,3-Dichloropropane | ND | | 0.50 | 5.0 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| Toluene-d8 | 113 | 77 - 116 |
| Dibromofluoromethane | 118 | 66 - 125 |
| 4-Bromofluorobenzene | 109 | 70 - 118 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9680-1

**Client Sample ID:** **Empire 01A**

Lab Sample ID: 700-9680-19 | Date Sampled: 02/08/2006 1315
Client Matrix: Water | Date Received: 02/10/2006 1040

**624 Purgeable Organic Compounds by GC/MS**

Method: 624 | Analysis Batch: 700-17450 | Instrument ID: VMG5973
Preparation: N/A | Lab File ID: G021609.D
Dilution: 1.0 | Initial Weight/Volume: 5 mL
Date Analyzed: 02/16/2006 1403 | Final Weight/Volume: 5 mL
Date Prepared: N/A

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| 1,1,1-Trichloroethane | ND | | 0.19 | 5.0 |
| 1,1,2,2-Tetrachloroethane | ND | | 0.25 | 5.0 |
| 1,1,2-Trichloroethane | ND | | 0.31 | 5.0 |
| 1,1-Dichloroethane | ND | | 0.14 | 5.0 |
| 1,1-Dichloroethene | ND | | 0.38 | 5.0 |
| 1,2-Dichloroethane | ND | | 0.15 | 5.0 |
| 1,2-Dichloropropane | ND | | 0.15 | 5.0 |
| 2-Chloroethyl vinyl ether | ND | | 0.50 | 50 |
| Acrolein | ND | | 9.6 | 100 |
| Acrylonitrile | ND | | 0.67 | 100 |
| Benzene | ND | | 0.12 | 5.0 |
| Bromoform | ND | | 0.18 | 5.0 |
| Bromomethane | ND | | 0.80 | 10 |
| Carbon tetrachloride | ND | | 0.56 | 5.0 |
| Chlorobenzene | ND | | 0.17 | 5.0 |
| Chlorodibromomethane | ND | | 0.50 | 5.0 |
| Chloroethane | ND | | 0.84 | 10 |
| Chloroform | ND | | 0.18 | 5.0 |
| Chloromethane | ND | | 0.15 | 10 |
| Dichlorobromomethane | ND | | 0.50 | 5.0 |
| Ethylbenzene | ND | | 0.56 | 5.0 |
| Methylene Chloride | ND | | 0.45 | 5.0 |
| Tetrachloroethene | ND | | 0.20 | 5.0 |
| Toluene | ND | | 0.19 | 5.0 |
| trans-1,2-Dichloroethene | ND | | 0.24 | 5.0 |
| Trichloroethene | ND | | 0.29 | 5.0 |
| Vinyl chloride | ND | | 0.22 | 10 |
| 1,3-Dichloropropane | ND | | 0.50 | 5.0 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| Toluene-d8 | 108 | 77 - 116 |
| Dibromofluoromethane | 118 | 66 - 125 |
| 4-Bromofluorobenzene | 110 | 70 - 118 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID: Empire 01B**

Lab Sample ID: 700-9680-20 Date Sampled: 02/08/2006 1320
Client Matrix: Water Date Received: 02/10/2006 1040

**624 Purgeable Organic Compounds by GC/MS**

Method: 624 Analysis Batch: 700-17450 Instrument ID: VMG5973
Preparation: N/A Lab File ID: G021610.D
Dilution: 1.0 Initial Weight/Volume: 5 mL
Date Analyzed: 02/16/2006 1434 Final Weight/Volume: 5 mL
Date Prepared: N/A

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| 1,1,1-Trichloroethane | ND | | 0.19 | 5.0 |
| 1,1,2,2-Tetrachloroethane | ND | | 0.25 | 5.0 |
| 1,1,2-Trichloroethane | ND | | 0.31 | 5.0 |
| 1,1-Dichloroethane | ND | | 0.14 | 5.0 |
| 1,1-Dichloroethene | ND | | 0.38 | 5.0 |
| 1,2-Dichloroethane | ND | | 0.15 | 5.0 |
| 1,2-Dichloropropane | ND | | 0.15 | 5.0 |
| 2-Chloroethyl vinyl ether | ND | | 0.50 | 50 |
| Acrolein | ND | | 9.6 | 100 |
| Acrylonitrile | ND | | 0.67 | 100 |
| Benzene | ND | | 0.12 | 5.0 |
| Bromoform | ND | | 0.18 | 5.0 |
| Bromomethane | ND | | 0.80 | 10 |
| Carbon tetrachloride | ND | | 0.56 | 5.0 |
| Chlorobenzene | ND | | 0.17 | 5.0 |
| Chlorodibromomethane | ND | | 0.50 | 5.0 |
| Chloroethane | ND | | 0.84 | 10 |
| Chloroform | ND | | 0.18 | 5.0 |
| Chloromethane | ND | | 0.15 | 10 |
| Dichlorobromomethane | ND | | 0.50 | 5.0 |
| Ethylbenzene | ND | | 0.56 | 5.0 |
| Methylene Chloride | ND | | 0.45 | 5.0 |
| Tetrachloroethene | ND | | 0.20 | 5.0 |
| Toluene | ND | | 0.19 | 5.0 |
| trans-1,2-Dichloroethene | ND | | 0.24 | 5.0 |
| Trichloroethene | ND | | 0.29 | 5.0 |
| Vinyl chloride | ND | | 0.22 | 10 |
| 1,3-Dichloropropane | ND | | 0.50 | 5.0 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| Toluene-d8 | 112 | 77 - 116 |
| Dibromofluoromethane | 116 | 66 - 125 |
| 4-Bromofluorobenzene | 110 | 70 - 118 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID:** **Empire 01C**

Lab Sample ID: 700-9680-21 Date Sampled: 02/08/2006 1325
Client Matrix: Water Date Received: 02/10/2006 1040

**624 Purgeable Organic Compounds by GC/MS**

Method: 624 Analysis Batch: 700-17450 Instrument ID: VMG5973
Preparation: N/A Lab File ID: G021611.D
Dilution: 1.0 Initial Weight/Volume: 5 mL
Date Analyzed: 02/16/2006 1504 Final Weight/Volume: 5 mL
Date Prepared: N/A

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| 1,1,1-Trichloroethane | ND | | 0.19 | 5.0 |
| 1,1,2,2-Tetrachloroethane | ND | | 0.25 | 5.0 |
| 1,1,2-Trichloroethane | ND | | 0.31 | 5.0 |
| 1,1-Dichloroethane | ND | | 0.14 | 5.0 |
| 1,1-Dichloroethene | ND | | 0.38 | 5.0 |
| 1,2-Dichloroethane | ND | | 0.15 | 5.0 |
| 1,2-Dichloropropane | ND | | 0.15 | 5.0 |
| 2-Chloroethyl vinyl ether | ND | | 0.50 | 50 |
| Acrolein | ND | | 9.6 | 100 |
| Acrylonitrile | ND | | 0.67 | 100 |
| Benzene | ND | | 0.12 | 5.0 |
| Bromoform | ND | | 0.18 | 5.0 |
| Bromomethane | ND | | 0.80 | 10 |
| Carbon tetrachloride | ND | | 0.56 | 5.0 |
| Chlorobenzene | ND | | 0.17 | 5.0 |
| Chlorodibromomethane | ND | | 0.50 | 5.0 |
| Chloroethane | ND | | 0.84 | 10 |
| Chloroform | ND | | 0.18 | 5.0 |
| Chloromethane | ND | | 0.15 | 10 |
| Dichlorobromomethane | ND | | 0.50 | 5.0 |
| Ethylbenzene | ND | | 0.56 | 5.0 |
| Methylene Chloride | ND | | 0.45 | 5.0 |
| Tetrachloroethene | ND | | 0.20 | 5.0 |
| Toluene | ND | | 0.19 | 5.0 |
| trans-1,2-Dichloroethene | ND | | 0.24 | 5.0 |
| Trichloroethene | ND | | 0.29 | 5.0 |
| Vinyl chloride | ND | | 0.22 | 10 |
| 1,3-Dichloropropane | ND | | 0.50 | 5.0 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| Toluene-d8 | 109 | 77 - 116 |
| Dibromofluoromethane | 111 | 66 - 125 |
| 4-Bromofluorobenzene | 107 | 70 - 118 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID: Shell 01A**

Lab Sample ID: 700-9680-22 Date Sampled: 02/08/2006 1430
Client Matrix: Water Date Received: 02/10/2006 1040

**624 Purgeable Organic Compounds by GC/MS**

Method: 624 Analysis Batch: 700-17450 Instrument ID: VMG5973
Preparation: N/A Lab File ID: G021612.D
Dilution: 1.0 Initial Weight/Volume: 5 mL
Date Analyzed: 02/16/2006 1624 Final Weight/Volume: 5 mL
Date Prepared: N/A

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| 1,1,1-Trichloroethane | ND | | 0.19 | 5.0 |
| 1,1,2,2-Tetrachloroethane | ND | | 0.25 | 5.0 |
| 1,1,2-Trichloroethane | ND | | 0.31 | 5.0 |
| 1,1-Dichloroethane | ND | | 0.14 | 5.0 |
| 1,1-Dichloroethene | ND | | 0.38 | 5.0 |
| 1,2-Dichloroethane | ND | | 0.15 | 5.0 |
| 1,2-Dichloropropane | ND | | 0.15 | 5.0 |
| 2-Chloroethyl vinyl ether | ND | | 0.50 | 50 |
| Acrolein | ND | | 9.6 | 100 |
| Acrylonitrile | ND | | 0.67 | 100 |
| Benzene | ND | | 0.12 | 5.0 |
| Bromoform | ND | | 0.18 | 5.0 |
| Bromomethane | ND | | 0.80 | 10 |
| Carbon tetrachloride | ND | | 0.56 | 5.0 |
| Chlorobenzene | ND | | 0.17 | 5.0 |
| Chlorodibromomethane | ND | | 0.50 | 5.0 |
| Chloroethane | ND | | 0.84 | 10 |
| Chloroform | ND | | 0.18 | 5.0 |
| Chloromethane | ND | | 0.15 | 10 |
| Dichlorobromomethane | ND | | 0.50 | 5.0 |
| Ethylbenzene | ND | | 0.56 | 5.0 |
| Methylene Chloride | ND | | 0.45 | 5.0 |
| Tetrachloroethene | ND | | 0.20 | 5.0 |
| Toluene | ND | | 0.19 | 5.0 |
| trans-1,2-Dichloroethene | ND | | 0.24 | 5.0 |
| Trichloroethene | ND | | 0.29 | 5.0 |
| Vinyl chloride | ND | | 0.22 | 10 |
| 1,3-Dichloropropane | ND | | 0.50 | 5.0 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| Toluene-d8 | 110 | 77 - 116 |
| Dibromofluoromethane | 118 | 66 - 125 |
| 4-Bromofluorobenzene | 110 | 70 - 118 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID: Shell 01B**

Lab Sample ID: 700-9680-23 Date Sampled: 02/08/2006 1435
Client Matrix: Water Date Received: 02/10/2006 1040

**624 Purgeable Organic Compounds by GC/MS**

Method: 624 Analysis Batch: 700-17450 Instrument ID: VMG5973
Preparation: N/A Lab File ID: G021613.D
Dilution: 1.0 Initial Weight/Volume: 5 mL
Date Analyzed: 02/16/2006 1655 Final Weight/Volume: 5 mL
Date Prepared: N/A

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| 1,1,1-Trichloroethane | ND | | 0.19 | 5.0 |
| 1,1,2,2-Tetrachloroethane | ND | | 0.25 | 5.0 |
| 1,1,2-Trichloroethane | ND | | 0.31 | 5.0 |
| 1,1-Dichloroethane | ND | | 0.14 | 5.0 |
| 1,1-Dichloroethene | ND | | 0.38 | 5.0 |
| 1,2-Dichloroethane | ND | | 0.15 | 5.0 |
| 1,2-Dichloropropane | ND | | 0.15 | 5.0 |
| 2-Chloroethyl vinyl ether | ND | | 0.50 | 50 |
| Acrolein | ND | | 9.6 | 100 |
| Acrylonitrile | ND | | 0.67 | 100 |
| Benzene | ND | | 0.12 | 5.0 |
| Bromoform | ND | | 0.18 | 5.0 |
| Bromomethane | ND | | 0.80 | 10 |
| Carbon tetrachloride | ND | | 0.56 | 5.0 |
| Chlorobenzene | ND | | 0.17 | 5.0 |
| Chlorodibromomethane | ND | | 0.50 | 5.0 |
| Chloroethane | ND | | 0.84 | 10 |
| Chloroform | ND | | 0.18 | 5.0 |
| Chloromethane | ND | | 0.15 | 10 |
| Dichlorobromomethane | ND | | 0.50 | 5.0 |
| Ethylbenzene | ND | | 0.56 | 5.0 |
| Methylene Chloride | ND | | 0.45 | 5.0 |
| Tetrachloroethene | ND | | 0.20 | 5.0 |
| Toluene | ND | | 0.19 | 5.0 |
| trans-1,2-Dichloroethene | ND | | 0.24 | 5.0 |
| Trichloroethene | ND | | 0.29 | 5.0 |
| Vinyl chloride | ND | | 0.22 | 10 |
| 1,3-Dichloropropane | ND | | 0.50 | 5.0 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| Toluene-d8 | 110 | 77 - 116 |
| Dibromofluoromethane | 119 | 66 - 125 |
| 4-Bromofluorobenzene | 108 | 70 - 118 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID:** **Shell 01C**

Lab Sample ID: 700-9680-24 Date Sampled: 02/08/2006 1440
Client Matrix: Water Date Received: 02/10/2006 1040

**624 Purgeable Organic Compounds by GC/MS**

Method: 624 Analysis Batch: 700-17450 Instrument ID: VMG5973
Preparation: N/A Lab File ID: G021614.D
Dilution: 1.0 Initial Weight/Volume: 5 mL
Date Analyzed: 02/16/2006 1725 Final Weight/Volume: 5 mL
Date Prepared: N/A

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| 1,1,1-Trichloroethane | ND | | 0.19 | 5.0 |
| 1,1,2,2-Tetrachloroethane | ND | | 0.25 | 5.0 |
| 1,1,2-Trichloroethane | ND | | 0.31 | 5.0 |
| 1,1-Dichloroethane | ND | | 0.14 | 5.0 |
| 1,1-Dichloroethene | ND | | 0.38 | 5.0 |
| 1,2-Dichloroethane | ND | | 0.15 | 5.0 |
| 1,2-Dichloropropane | ND | | 0.15 | 5.0 |
| 2-Chloroethyl vinyl ether | ND | | 0.50 | 50 |
| Acrolein | ND | | 9.6 | 100 |
| Acrylonitrile | ND | | 0.67 | 100 |
| Benzene | ND | | 0.12 | 5.0 |
| Bromoform | ND | | 0.18 | 5.0 |
| Bromomethane | ND | | 0.80 | 10 |
| Carbon tetrachloride | ND | | 0.56 | 5.0 |
| Chlorobenzene | ND | | 0.17 | 5.0 |
| Chlorodibromomethane | ND | | 0.50 | 5.0 |
| Chloroethane | ND | | 0.84 | 10 |
| Chloroform | ND | | 0.18 | 5.0 |
| Chloromethane | ND | | 0.15 | 10 |
| Dichlorobromomethane | ND | | 0.50 | 5.0 |
| Ethylbenzene | ND | | 0.56 | 5.0 |
| Methylene Chloride | ND | | 0.45 | 5.0 |
| Tetrachloroethene | ND | | 0.20 | 5.0 |
| Toluene | ND | | 0.19 | 5.0 |
| trans-1,2-Dichloroethene | ND | | 0.24 | 5.0 |
| Trichloroethene | ND | | 0.29 | 5.0 |
| Vinyl chloride | ND | | 0.22 | 10 |
| 1,3-Dichloropropane | ND | | 0.50 | 5.0 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| Toluene-d8 | 110 | 77 - 116 |
| Dibromofluoromethane | 114 | 66 - 125 |
| 4-Bromofluorobenzene | 110 | 70 - 118 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9680-1

**Client Sample ID:** **Trip Blank A**

Lab Sample ID: 700-9680-25TB | Date Sampled: 02/08/2006 0000
Client Matrix: Water | Date Received: 02/10/2006 1040

**624 Purgeable Organic Compounds by GC/MS**

Method: 624 | Analysis Batch: 700-17450 | Instrument ID: VMG5973
Preparation: N/A | Lab File ID: G021615.D
Dilution: 1.0 | Initial Weight/Volume: 5 mL
Date Analyzed: 02/16/2006 1756 | Final Weight/Volume: 5 mL
Date Prepared: N/A

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| 1,1,1-Trichloroethane | ND | | 0.19 | 5.0 |
| 1,1,2,2-Tetrachloroethane | ND | | 0.25 | 5.0 |
| 1,1,2-Trichloroethane | ND | | 0.31 | 5.0 |
| 1,1-Dichloroethane | ND | | 0.14 | 5.0 |
| 1,1-Dichloroethene | ND | | 0.38 | 5.0 |
| 1,2-Dichloroethane | ND | | 0.15 | 5.0 |
| 1,2-Dichloropropane | ND | | 0.15 | 5.0 |
| 2-Chloroethyl vinyl ether | ND | | 0.50 | 50 |
| Acrolein | ND | | 9.6 | 100 |
| Acrylonitrile | ND | | 0.67 | 100 |
| Benzene | ND | | 0.12 | 5.0 |
| Bromoform | ND | | 0.18 | 5.0 |
| Bromomethane | ND | | 0.80 | 10 |
| Carbon tetrachloride | ND | | 0.56 | 5.0 |
| Chlorobenzene | ND | | 0.17 | 5.0 |
| Chlorodibromomethane | ND | | 0.50 | 5.0 |
| Chloroethane | ND | | 0.84 | 10 |
| Chloroform | ND | | 0.18 | 5.0 |
| Chloromethane | ND | | 0.15 | 10 |
| Dichlorobromomethane | ND | | 0.50 | 5.0 |
| Ethylbenzene | ND | | 0.56 | 5.0 |
| Methylene Chloride | ND | | 0.45 | 5.0 |
| Tetrachloroethene | ND | | 0.20 | 5.0 |
| Toluene | ND | | 0.19 | 5.0 |
| trans-1,2-Dichloroethene | ND | | 0.24 | 5.0 |
| Trichloroethene | ND | | 0.29 | 5.0 |
| Vinyl chloride | ND | | 0.22 | 10 |
| 1,3-Dichloropropane | ND | | 0.50 | 5.0 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| Toluene-d8 | 111 | 77 - 116 |
| Dibromofluoromethane | 115 | 66 - 125 |
| 4-Bromofluorobenzene | 112 | 70 - 118 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID:** **Trip Blank B**

Lab Sample ID: 700-9680-26TB Date Sampled: 02/08/2006 0000
Client Matrix: Water Date Received: 02/10/2006 1040

**624 Purgeable Organic Compounds by GC/MS**

Method: 624 Analysis Batch: 700-17450 Instrument ID: VMG5973
Preparation: N/A Lab File ID: G021616.D
Dilution: 1.0 Initial Weight/Volume: 5 mL
Date Analyzed: 02/16/2006 1827 Final Weight/Volume: 5 mL
Date Prepared: N/A

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| 1,1,1-Trichloroethane | ND | | 0.19 | 5.0 |
| 1,1,2,2-Tetrachloroethane | ND | | 0.25 | 5.0 |
| 1,1,2-Trichloroethane | ND | | 0.31 | 5.0 |
| 1,1-Dichloroethane | ND | | 0.14 | 5.0 |
| 1,1-Dichloroethene | ND | | 0.38 | 5.0 |
| 1,2-Dichloroethane | ND | | 0.15 | 5.0 |
| 1,2-Dichloropropane | ND | | 0.15 | 5.0 |
| 2-Chloroethyl vinyl ether | ND | | 0.50 | 50 |
| Acrolein | ND | | 9.6 | 100 |
| Acrylonitrile | ND | | 0.67 | 100 |
| Benzene | ND | | 0.12 | 5.0 |
| Bromoform | ND | | 0.18 | 5.0 |
| Bromomethane | ND | | 0.80 | 10 |
| Carbon tetrachloride | ND | | 0.56 | 5.0 |
| Chlorobenzene | ND | | 0.17 | 5.0 |
| Chlorodibromomethane | ND | | 0.50 | 5.0 |
| Chloroethane | ND | | 0.84 | 10 |
| Chloroform | ND | | 0.18 | 5.0 |
| Chloromethane | ND | | 0.15 | 10 |
| Dichlorobromomethane | ND | | 0.50 | 5.0 |
| Ethylbenzene | ND | | 0.56 | 5.0 |
| Methylene Chloride | ND | | 0.45 | 5.0 |
| Tetrachloroethene | ND | | 0.20 | 5.0 |
| Toluene | ND | | 0.19 | 5.0 |
| trans-1,2-Dichloroethene | ND | | 0.24 | 5.0 |
| Trichloroethene | ND | | 0.29 | 5.0 |
| Vinyl chloride | ND | | 0.22 | 10 |
| 1,3-Dichloropropane | ND | | 0.50 | 5.0 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| Toluene-d8 | 111 | 77 - 116 |
| Dibromofluoromethane | 119 | 66 - 125 |
| 4-Bromofluorobenzene | 108 | 70 - 118 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID:** **Sandy 01 Sediment**

Lab Sample ID: 700-9680-2 Date Sampled: 02/08/2006 1100
Client Matrix: Solid Date Received: 02/10/2006 1040

**8260B Volatile Organic Compounds by GC/MS**

Method: 8260B Analysis Batch: 700-17500 Instrument ID: VMG5973
Preparation: 5030B Lab File ID: G021713.D
Dilution: 1.0 Initial Weight/Volume: 5.08 g
Date Analyzed: 02/17/2006 2015 Final Weight/Volume: 5 mL
Date Prepared: 02/17/2006 2015

| Analyte | DryWt Corrected: N | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| 1,1,2,2-Tetrachloroethane | | ND | | 1.7 | 4.9 |
| 1,1,1-Trichloroethane | | ND | | 1.5 | 4.9 |
| 1,1,2-Trichloroethane | | ND | | 1.2 | 4.9 |
| Toluene | | ND | | 0.98 | 4.9 |
| 1,1-Dichloroethane | | ND | | 0.98 | 4.9 |
| 1,1-Dichloroethene | | ND | | 1.3 | 4.9 |
| 1,2-Dichloroethane | | ND | | 2.0 | 4.9 |
| 1,2-Dichloropropane | | ND | | 1.2 | 4.9 |
| Benzene | | ND | | 1.1 | 4.9 |
| Bromoform | | ND | | 1.1 | 4.9 |
| Bromomethane | | ND | | 3.5 | 9.8 |
| Carbon tetrachloride | | ND | | 1.4 | 4.9 |
| Chlorobenzene | | ND | | 1.1 | 4.9 |
| Chlorodibromomethane | | ND | | 1.2 | 4.9 |
| Chloroethane | | ND | | 1.5 | 9.8 |
| Chloromethane | | ND | | 2.3 | 9.8 |
| Chloroform | | ND | | 0.81 | 4.9 |
| 1,3-Dichloropropene, Total | | ND | | 1.5 | 9.8 |
| Dichlorobromomethane | | ND | | 1.2 | 4.9 |
| Ethylbenzene | | ND | | 1.8 | 4.9 |
| Methylene Chloride | | ND | | 1.6 | 4.9 |
| 2-Chloroethyl vinyl ether | | ND | | 17 | 49 |
| Xylenes, Total | | ND | | 1.3 | 9.8 |
| Acrolein | | ND | | 28 | 98 |
| Acrylonitrile | | ND | | 61 | 98 |
| Trichloroethene | | ND | | 0.89 | 4.9 |
| Vinyl chloride | | ND | | 1.6 | 9.8 |
| trans-1,2-Dichloroethene | | ND | | 0.97 | 4.9 |
| Tetrachloroethene | | ND | | 0.89 | 4.9 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| Dibromofluoromethane | 122 | 59 - 132 |
| Toluene-d8 | 111 | 61 - 131 |
| 4-Bromofluorobenzene | 94 | 55 - 131 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID:** **Sandy 02 Sediment**

Lab Sample ID: 700-9680-5 Date Sampled: 02/08/2006 1155
Client Matrix: Solid Date Received: 02/10/2006 1040

**8260B Volatile Organic Compounds by GC/MS**

Method: 8260B Analysis Batch: 700-17500 Instrument ID: VMG5973
Preparation: 5030B Lab File ID: G021714.D
Dilution: 1.0 Initial Weight/Volume: 5.10 g
Date Analyzed: 02/17/2006 2046 Final Weight/Volume: 5 mL
Date Prepared: 02/17/2006 2046

| Analyte | DryWt Corrected: N | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| 1,1,2,2-Tetrachloroethane | | ND | | 1.7 | 4.9 |
| 1,1,1-Trichloroethane | | ND | | 1.5 | 4.9 |
| 1,1,2-Trichloroethane | | ND | | 1.2 | 4.9 |
| Toluene | | ND | | 0.98 | 4.9 |
| 1,1-Dichloroethane | | ND | | 0.98 | 4.9 |
| 1,1-Dichloroethene | | ND | | 1.3 | 4.9 |
| 1,2-Dichloroethane | | ND | | 2.0 | 4.9 |
| 1,2-Dichloropropane | | ND | | 1.2 | 4.9 |
| Benzene | | ND | | 1.1 | 4.9 |
| Bromoform | | ND | | 1.1 | 4.9 |
| Bromomethane | | ND | | 3.5 | 9.8 |
| Carbon tetrachloride | | ND | | 1.4 | 4.9 |
| Chlorobenzene | | ND | | 1.1 | 4.9 |
| Chlorodibromomethane | | ND | | 1.2 | 4.9 |
| Chloroethane | | ND | | 1.5 | 9.8 |
| Chloromethane | | ND | | 2.3 | 9.8 |
| Chloroform | | ND | | 0.80 | 4.9 |
| Dichlorobromomethane | | ND | | 1.2 | 4.9 |
| 1,3-Dichloropropene, Total | | ND | | 1.5 | 9.8 |
| Ethylbenzene | | ND | | 1.8 | 4.9 |
| Methylene Chloride | | ND | | 1.6 | 4.9 |
| 2-Chloroethyl vinyl ether | | ND | | 17 | 49 |
| Xylenes, Total | | ND | | 1.3 | 9.8 |
| Acrolein | | ND | | 27 | 98 |
| Acrylonitrile | | ND | | 61 | 98 |
| Trichloroethene | | ND | | 0.88 | 4.9 |
| Vinyl chloride | | ND | | 1.6 | 9.8 |
| trans-1,2-Dichloroethene | | ND | | 0.97 | 4.9 |
| Tetrachloroethene | | ND | | 0.88 | 4.9 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| Dibromofluoromethane | 118 | 59 - 132 |
| Toluene-d8 | 99 | 61 - 131 |
| 4-Bromofluorobenzene | 84 | 55 - 131 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID:** **Empire 01 Sediment**

Lab Sample ID: 700-9680-8 Date Sampled: 02/08/2006 1300
Client Matrix: Solid Date Received: 02/10/2006 1040

**8260B Volatile Organic Compounds by GC/MS**

Method: 8260B Analysis Batch: 700-17500 Instrument ID: VMG5973
Preparation: 5030B Lab File ID: G021715.D
Dilution: 1.0 Initial Weight/Volume: 5.18 g
Date Analyzed: 02/17/2006 2117 Final Weight/Volume: 5 mL
Date Prepared: 02/17/2006 2117

| Analyte | DryWt Corrected: N | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| 1,1,2,2-Tetrachloroethane | | ND | | 1.6 | 4.8 |
| 1,1,1-Trichloroethane | | ND | | 1.4 | 4.8 |
| 1,1,2-Trichloroethane | | ND | | 1.2 | 4.8 |
| Toluene | | ND | | 0.97 | 4.8 |
| 1,1-Dichloroethane | | ND | | 0.97 | 4.8 |
| 1,1-Dichloroethene | | ND | | 1.3 | 4.8 |
| 1,2-Dichloroethane | | ND | | 1.9 | 4.8 |
| 1,2-Dichloropropane | | ND | | 1.2 | 4.8 |
| Benzene | | ND | | 1.1 | 4.8 |
| Bromoform | | ND | | 1.1 | 4.8 |
| Bromomethane | | ND | | 3.5 | 9.7 |
| Carbon tetrachloride | | ND | | 1.4 | 4.8 |
| Chlorobenzene | | ND | | 1.1 | 4.8 |
| Chlorodibromomethane | | ND | | 1.2 | 4.8 |
| Chloroethane | | ND | | 1.4 | 9.7 |
| Chloromethane | | ND | | 2.2 | 9.7 |
| Chloroform | | ND | | 0.79 | 4.8 |
| 1,3-Dichloropropene, Total | | ND | | 1.4 | 9.7 |
| Dichlorobromomethane | | ND | | 1.2 | 4.8 |
| Ethylbenzene | | ND | | 1.7 | 4.8 |
| Methylene Chloride | | ND | | 1.5 | 4.8 |
| 2-Chloroethyl vinyl ether | | ND | | 16 | 48 |
| Xylenes, Total | | ND | | 1.3 | 9.7 |
| Acrolein | | ND | | 27 | 97 |
| Acrylonitrile | | ND | | 60 | 97 |
| Trichloroethene | | ND | | 0.87 | 4.8 |
| Vinyl chloride | | ND | | 1.5 | 9.7 |
| trans-1,2-Dichloroethene | | ND | | 0.96 | 4.8 |
| Tetrachloroethene | | ND | | 0.87 | 4.8 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| Dibromofluoromethane | 109 | 59 - 132 |
| Toluene-d8 | 88 | 61 - 131 |
| 4-Bromofluorobenzene | 82 | 55 - 131 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID: Shell 01 Sediment**

Lab Sample ID: 700-9680-11 Date Sampled: 02/08/2006 1440
Client Matrix: Solid Date Received: 02/10/2006 1040

**8260B Volatile Organic Compounds by GC/MS**

Method: 8260B Analysis Batch: 700-17500 Instrument ID: VMG5973
Preparation: 5030B Lab File ID: G021716.D
Dilution: 1.0 Initial Weight/Volume: 5.23 g
Date Analyzed: 02/17/2006 2148 Final Weight/Volume: 5 mL
Date Prepared: 02/17/2006 2148

| Analyte | DryWt Corrected: N | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| 1,1,2,2-Tetrachloroethane | | ND | | 1.6 | 4.8 |
| 1,1,1-Trichloroethane | | ND | | 1.4 | 4.8 |
| 1,1,2-Trichloroethane | | ND | | 1.1 | 4.8 |
| Toluene | | ND | | 0.96 | 4.8 |
| 1,1-Dichloroethane | | ND | | 0.96 | 4.8 |
| 1,1-Dichloroethene | | ND | | 1.2 | 4.8 |
| 1,2-Dichloroethane | | ND | | 1.9 | 4.8 |
| 1,2-Dichloropropane | | ND | | 1.1 | 4.8 |
| Benzene | | ND | | 1.1 | 4.8 |
| Bromoform | | ND | | 1.1 | 4.8 |
| Bromomethane | | ND | | 3.4 | 9.6 |
| Carbon tetrachloride | | ND | | 1.3 | 4.8 |
| Chlorobenzene | | ND | | 1.1 | 4.8 |
| Chlorodibromomethane | | ND | | 1.1 | 4.8 |
| Chloroethane | | ND | | 1.4 | 9.6 |
| Chloromethane | | ND | | 2.2 | 9.6 |
| Chloroform | | ND | | 0.78 | 4.8 |
| 1,3-Dichloropropene, Total | | ND | | 1.4 | 9.6 |
| Dichlorobromomethane | | ND | | 1.1 | 4.8 |
| Ethylbenzene | | ND | | 1.7 | 4.8 |
| Methylene Chloride | | ND | | 1.5 | 4.8 |
| 2-Chloroethyl vinyl ether | | ND | | 16 | 48 |
| Xylenes, Total | | ND | | 1.2 | 9.6 |
| Acrolein | | ND | | 27 | 96 |
| Acrylonitrile | | ND | | 59 | 96 |
| Trichloroethene | | ND | | 0.86 | 4.8 |
| Vinyl chloride | | ND | | 1.5 | 9.6 |
| trans-1,2-Dichloroethene | | ND | | 0.95 | 4.8 |
| Tetrachloroethene | | ND | | 0.86 | 4.8 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| Dibromofluoromethane | 110 | 59 - 132 |
| Toluene-d8 | 93 | 61 - 131 |
| 4-Bromofluorobenzene | 80 | 55 - 131 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9680-1

**Client Sample ID:** **Shell 02 Sediment**

Lab Sample ID: 700-9680-14 | Date Sampled: 02/08/2006 1615
Client Matrix: Solid | Date Received: 02/10/2006 1040

**8260B Volatile Organic Compounds by GC/MS**

Method: 8260B | Analysis Batch: 700-17500 | Instrument ID: VMG5973
Preparation: 5030B | Lab File ID: G021717.D
Dilution: 1.0 | Initial Weight/Volume: 5.18 g
Date Analyzed: 02/17/2006 2219 | Final Weight/Volume: 5 mL
Date Prepared: 02/17/2006 2219

| Analyte | DryWt Corrected: N | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| 1,1,2,2-Tetrachloroethane | | ND | | 1.6 | 4.8 |
| 1,1,1-Trichloroethane | | ND | | 1.4 | 4.8 |
| 1,1,2-Trichloroethane | | ND | | 1.2 | 4.8 |
| Toluene | | ND | | 0.97 | 4.8 |
| 1,1-Dichloroethane | | ND | | 0.97 | 4.8 |
| 1,1-Dichloroethene | | ND | | 1.3 | 4.8 |
| 1,2-Dichloroethane | | ND | | 1.9 | 4.8 |
| 1,2-Dichloropropane | | ND | | 1.2 | 4.8 |
| Benzene | | ND | | 1.1 | 4.8 |
| Bromoform | | ND | | 1.1 | 4.8 |
| Bromomethane | | ND | | 3.5 | 9.7 |
| Carbon tetrachloride | | ND | | 1.4 | 4.8 |
| Chlorobenzene | | ND | | 1.1 | 4.8 |
| Chlorodibromomethane | | ND | | 1.2 | 4.8 |
| Chloroethane | | ND | | 1.4 | 9.7 |
| Chloromethane | | ND | | 2.2 | 9.7 |
| Chloroform | | ND | | 0.79 | 4.8 |
| Dichlorobromomethane | | ND | | 1.2 | 4.8 |
| 1,3-Dichloropropene, Total | | ND | | 1.4 | 9.7 |
| Ethylbenzene | | ND | | 1.7 | 4.8 |
| Methylene Chloride | | ND | | 1.5 | 4.8 |
| 2-Chloroethyl vinyl ether | | ND | | 16 | 48 |
| Xylenes, Total | | ND | | 1.3 | 9.7 |
| Acrolein | | ND | | 27 | 97 |
| Acrylonitrile | | ND | | 60 | 97 |
| Trichloroethene | | ND | | 0.87 | 4.8 |
| Vinyl chloride | | ND | | 1.5 | 9.7 |
| trans-1,2-Dichloroethene | | ND | | 0.96 | 4.8 |
| Tetrachloroethene | | ND | | 0.87 | 4.8 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| Dibromofluoromethane | 113 | 59 - 132 |
| Toluene-d8 | 95 | 61 - 131 |
| 4-Bromofluorobenzene | 96 | 55 - 131 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID:** **Sandy 01 Water**

Lab Sample ID: 700-9680-1 Date Sampled: 02/08/2006 1010
Client Matrix: Water Date Received: 02/10/2006 1040

**625 Base/Neutral and Acid Organics in Wastewater**

Method: 625 Analysis Batch: 700-17512 Instrument ID: SMC5973
Preparation: 3520C Prep Batch: 700-17307 Lab File ID: C021714.D
Dilution: 5.0 Initial Weight/Volume: 1000 mL
Date Analyzed: 02/17/2006 1648 Final Weight/Volume: 1.0 mL
Date Prepared: 02/15/2006 1108 Injection Volume:

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| 1,2,4-Trichlorobenzene | ND | | 1.2 | 10 |
| 1,2-Dichlorobenzene | ND | | 1.1 | 10 |
| 1,2-Diphenylhydrazine | ND | | 4.0 | 10 |
| 1,3-Dichlorobenzene | ND | | 1.1 | 10 |
| 1,4-Dichlorobenzene | ND | | 1.1 | 10 |
| 2,2'-oxybis(2-chloropropane) | ND | | 1.3 | 10 |
| 2,4,6-Trichlorophenol | ND | | 2.4 | 10 |
| 2,4-Dichlorophenol | ND | | 1.2 | 10 |
| 2,4-Dimethylphenol | ND | | 1.1 | 10 |
| 2,4-Dinitrophenol | ND | | 2.3 | 50 |
| 2,4-Dinitrotoluene | ND | | 2.2 | 10 |
| 2,6-Dinitrotoluene | ND | | 2.4 | 10 |
| 2-Chloronaphthalene | ND | | 1.7 | 10 |
| 2-Chlorophenol | ND | | 1.0 | 10 |
| 2-Nitrophenol | ND | | 1.3 | 10 |
| 3,3'-Dichlorobenzidine | ND | | 7.1 | 20 |
| 4,6-Dinitro-2-methylphenol | ND | | 2.1 | 50 |
| 4-Bromophenyl phenyl ether | ND | | 1.7 | 10 |
| 4-Chloro-3-methylphenol | ND | | 1.0 | 10 |
| 4-Chlorophenyl phenyl ether | ND | | 1.5 | 10 |
| 4-Nitrophenol | ND | | 3.6 | 50 |
| Acenaphthene | ND | | 1.3 | 10 |
| Acenaphthylene | ND | | 2.4 | 10 |
| Anthracene | ND | | 1.0 | 10 |
| Benzidine | ND | | 8.4 | 80 |
| Benzo[a]anthracene | ND | | 1.0 | 10 |
| Benzo[a]pyrene | ND | | 5.6 | 10 |
| Benzo[b]fluoranthene | ND | | 9.5 | 10 |
| Benzo[g,h,i]perylene | ND | | 5.4 | 10 |
| Benzo[k]fluoranthene | ND | | 9.0 | 10 |
| Bis(2-chloroethoxy)methane | 16 | | 5.4 | 10 |
| Bis(2-chloroethyl)ether | ND | | 3.0 | 10 |
| Bis(2-ethylhexyl) phthalate | ND | | 3.3 | 10 |
| Butyl benzyl phthalate | ND | | 2.8 | 10 |
| Chrysene | ND | | 2.3 | 10 |
| Dibenz(a,h)anthracene | ND | | 9.5 | 10 |
| Diethyl phthalate | ND | | 1.7 | 10 |
| Dimethyl phthalate | ND | | 1.2 | 10 |
| Di-n-butyl phthalate | ND | | 1.2 | 10 |
| Di-n-octyl phthalate | ND | | 1.8 | 10 |
| Fluoranthene | ND | | 1.0 | 10 |
| Fluorene | ND | | 1.5 | 10 |
| Hexachlorobenzene | ND | | 1.7 | 10 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9680-1

**Client Sample ID:** **Sandy 01 Water**

Lab Sample ID: 700-9680-1 | Date Sampled: 02/08/2006 1010
Client Matrix: Water | Date Received: 02/10/2006 1040

**625 Base/Neutral and Acid Organics in Wastewater**

| | | | |
|---|---|---|---|
| Method: | 625 | Analysis Batch: 700-17512 | Instrument ID: SMC5973 |
| Preparation: | 3520C | Prep Batch: 700-17307 | Lab File ID: C021714.D |
| Dilution: | 5.0 | | Initial Weight/Volume: 1000 mL |
| Date Analyzed: | 02/17/2006 1648 | | Final Weight/Volume: 1.0 mL |
| Date Prepared: | 02/15/2006 1108 | | Injection Volume: |

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Hexachlorobutadiene | ND | | 1.4 | 10 |
| Hexachlorocyclopentadiene | ND | | 1.8 | 10 |
| Hexachloroethane | ND | | 1.3 | 10 |
| Indeno[1,2,3-cd]pyrene | ND | | 2.9 | 10 |
| Isophorone | ND | | 1.1 | 10 |
| Naphthalene | ND | | 1.2 | 10 |
| Nitrobenzene | ND | | 1.4 | 10 |
| N-Nitrosodimethylamine | ND | | 2.2 | 10 |
| N-Nitrosodi-n-propylamine | ND | | 1.0 | 10 |
| N-Nitrosodiphenylamine | ND | | 10 | 10 |
| Pentachlorophenol | ND | | 2.1 | 50 |
| Phenanthrene | ND | | 1.2 | 10 |
| Phenol | ND | | 1.1 | 10 |
| Pyrene | ND | | 2.2 | 10 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| 2,4,6-Tribromophenol | 73 | 14 - 93 |
| 2-Fluorobiphenyl | 80 | 34 - 118 |
| 2-Fluorophenol | 60 | 25 - 102 |
| Nitrobenzene-d5 | 81 | 39 - 133 |
| Phenol-d5 | 58 | 21 - 95 |
| Terphenyl-d14 | 73 | 16 - 158 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID: Sandy 01 Elutriate**

Lab Sample ID: 700-9680-3 Date Sampled: 02/08/2006 1100
Client Matrix: Water Date Received: 02/10/2006 1040

**625 Base/Neutral and Acid Organics in Wastewater**

Method: 625 Analysis Batch: 700-17512 Instrument ID: SMC5973
Preparation: 3520C Prep Batch: 700-17307 Lab File ID: C021719.D
Dilution: 5.0 Initial Weight/Volume: 1000 mL
Date Analyzed: 02/17/2006 1942 Final Weight/Volume: 1.0 mL
Date Prepared: 02/15/2006 1108 Injection Volume:

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| 1,2,4-Trichlorobenzene | ND | | 1.2 | 10 |
| 1,2-Dichlorobenzene | ND | | 1.1 | 10 |
| 1,2-Diphenylhydrazine | ND | | 4.0 | 10 |
| 1,3-Dichlorobenzene | ND | | 1.1 | 10 |
| 1,4-Dichlorobenzene | ND | | 1.1 | 10 |
| 2,2'-oxybis(2-chloropropane) | ND | | 1.3 | 10 |
| 2,4,6-Trichlorophenol | ND | | 2.4 | 10 |
| 2,4-Dichlorophenol | ND | | 1.2 | 10 |
| 2,4-Dimethylphenol | ND | | 1.1 | 10 |
| 2,4-Dinitrophenol | ND | | 2.3 | 50 |
| 2,4-Dinitrotoluene | ND | | 2.2 | 10 |
| 2,6-Dinitrotoluene | ND | | 2.4 | 10 |
| 2-Chloronaphthalene | ND | | 1.7 | 10 |
| 2-Chlorophenol | ND | | 1.0 | 10 |
| 2-Nitrophenol | ND | | 1.3 | 10 |
| 3,3'-Dichlorobenzidine | ND | | 7.1 | 20 |
| 4,6-Dinitro-2-methylphenol | ND | | 2.1 | 50 |
| 4-Bromophenyl phenyl ether | ND | | 1.7 | 10 |
| 4-Chloro-3-methylphenol | ND | | 1.0 | 10 |
| 4-Chlorophenyl phenyl ether | ND | | 1.5 | 10 |
| 4-Nitrophenol | ND | | 3.6 | 50 |
| Acenaphthene | ND | | 1.3 | 10 |
| Acenaphthylene | ND | | 2.4 | 10 |
| Anthracene | ND | | 1.0 | 10 |
| Benzidine | ND | | 8.4 | 80 |
| Benzo[a]anthracene | ND | | 1.0 | 10 |
| Benzo[a]pyrene | ND | | 5.6 | 10 |
| Benzo[b]fluoranthene | ND | | 9.5 | 10 |
| Benzo[g,h,i]perylene | ND | | 5.4 | 10 |
| Benzo[k]fluoranthene | ND | | 9.0 | 10 |
| Bis(2-chloroethoxy)methane | ND | | 5.4 | 10 |
| Bis(2-chloroethyl)ether | ND | | 3.0 | 10 |
| Bis(2-ethylhexyl) phthalate | ND | | 3.3 | 10 |
| Butyl benzyl phthalate | ND | | 2.8 | 10 |
| Chrysene | ND | | 2.3 | 10 |
| Dibenz(a,h)anthracene | ND | | 9.5 | 10 |
| Diethyl phthalate | ND | | 1.7 | 10 |
| Dimethyl phthalate | ND | | 1.2 | 10 |
| Di-n-butyl phthalate | ND | | 1.2 | 10 |
| Di-n-octyl phthalate | ND | | 1.8 | 10 |
| Fluoranthene | ND | | 1.0 | 10 |
| Fluorene | ND | | 1.5 | 10 |
| Hexachlorobenzene | ND | | 1.7 | 10 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9680-1

**Client Sample ID:** **Sandy 01 Elutriate**

Lab Sample ID: 700-9680-3 | Date Sampled: 02/08/2006 1100
Client Matrix: Water | Date Received: 02/10/2006 1040

**625 Base/Neutral and Acid Organics in Wastewater**

| | | | | | |
|---|---|---|---|---|---|
| Method: | 625 | Analysis Batch: 700-17512 | Instrument ID: | SMC5973 | |
| Preparation: | 3520C | Prep Batch: 700-17307 | Lab File ID: | C021719.D | |
| Dilution: | 5.0 | | Initial Weight/Volume: | 1000 | mL |
| Date Analyzed: | 02/17/2006 1942 | | Final Weight/Volume: | 1.0 | mL |
| Date Prepared: | 02/15/2006 1108 | | Injection Volume: | | |

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Hexachlorobutadiene | ND | | 1.4 | 10 |
| Hexachlorocyclopentadiene | ND | | 1.8 | 10 |
| Hexachloroethane | ND | | 1.3 | 10 |
| Indeno[1,2,3-cd]pyrene | ND | | 2.9 | 10 |
| Isophorone | ND | | 1.1 | 10 |
| Naphthalene | ND | | 1.2 | 10 |
| Nitrobenzene | ND | | 1.4 | 10 |
| N-Nitrosodimethylamine | ND | | 2.2 | 10 |
| N-Nitrosodi-n-propylamine | ND | | 1.0 | 10 |
| N-Nitrosodiphenylamine | ND | | 10 | 10 |
| Pentachlorophenol | ND | | 2.1 | 50 |
| Phenanthrene | ND | | 1.2 | 10 |
| Phenol | ND | | 1.1 | 10 |
| Pyrene | ND | | 2.2 | 10 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| 2,4,6-Tribromophenol | 70 | 14 - 93 |
| 2-Fluorobiphenyl | 83 | 34 - 118 |
| 2-Fluorophenol | 68 | 25 - 102 |
| Nitrobenzene-d5 | 88 | 39 - 133 |
| Phenol-d5 | 62 | 21 - 95 |
| Terphenyl-d14 | 54 | 16 - 158 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9680-1

**Client Sample ID:** **Sandy 02 Elutriate**

Lab Sample ID: 700-9680-6 | Date Sampled: 02/08/2006 1155
Client Matrix: Water | Date Received: 02/10/2006 1040

**625 Base/Neutral and Acid Organics in Wastewater**

Method: 625 | Analysis Batch: 700-17512 | Instrument ID: SMC5973
Preparation: 3520C | Prep Batch: 700-17307 | Lab File ID: C021720.D
Dilution: 5.0 | Initial Weight/Volume: 1000 mL
Date Analyzed: 02/17/2006 2017 | Final Weight/Volume: 1.0 mL
Date Prepared: 02/15/2006 1108 | Injection Volume:

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| 1,2,4-Trichlorobenzene | ND | | 1.2 | 10 |
| 1,2-Dichlorobenzene | ND | | 1.1 | 10 |
| 1,2-Diphenylhydrazine | ND | | 4.0 | 10 |
| 1,3-Dichlorobenzene | ND | | 1.1 | 10 |
| 1,4-Dichlorobenzene | ND | | 1.1 | 10 |
| 2,2'-oxybis(2-chloropropane) | ND | | 1.3 | 10 |
| 2,4,6-Trichlorophenol | ND | | 2.4 | 10 |
| 2,4-Dichlorophenol | ND | | 1.2 | 10 |
| 2,4-Dimethylphenol | ND | | 1.1 | 10 |
| 2,4-Dinitrophenol | ND | | 2.3 | 50 |
| 2,4-Dinitrotoluene | ND | | 2.2 | 10 |
| 2,6-Dinitrotoluene | ND | | 2.4 | 10 |
| 2-Chloronaphthalene | ND | | 1.7 | 10 |
| 2-Chlorophenol | ND | | 1.0 | 10 |
| 2-Nitrophenol | ND | | 1.3 | 10 |
| 3,3'-Dichlorobenzidine | ND | | 7.1 | 20 |
| 4,6-Dinitro-2-methylphenol | ND | | 2.1 | 50 |
| 4-Bromophenyl phenyl ether | ND | | 1.7 | 10 |
| 4-Chloro-3-methylphenol | ND | | 1.0 | 10 |
| 4-Chlorophenyl phenyl ether | ND | | 1.5 | 10 |
| 4-Nitrophenol | ND | | 3.6 | 50 |
| Acenaphthene | ND | | 1.3 | 10 |
| Acenaphthylene | ND | | 2.4 | 10 |
| Anthracene | ND | | 1.0 | 10 |
| Benzidine | ND | | 8.4 | 80 |
| Benzo[a]anthracene | ND | | 1.0 | 10 |
| Benzo[a]pyrene | ND | | 5.6 | 10 |
| Benzo[b]fluoranthene | ND | | 9.5 | 10 |
| Benzo[g,h,i]perylene | ND | | 5.4 | 10 |
| Benzo[k]fluoranthene | ND | | 9.0 | 10 |
| Bis(2-chloroethoxy)methane | ND | | 5.4 | 10 |
| Bis(2-chloroethyl)ether | ND | | 3.0 | 10 |
| Bis(2-ethylhexyl) phthalate | ND | | 3.3 | 10 |
| Butyl benzyl phthalate | ND | | 2.8 | 10 |
| Chrysene | ND | | 2.3 | 10 |
| Dibenz(a,h)anthracene | ND | | 9.5 | 10 |
| Diethyl phthalate | ND | | 1.7 | 10 |
| Dimethyl phthalate | ND | | 1.2 | 10 |
| Di-n-butyl phthalate | ND | | 1.2 | 10 |
| Di-n-octyl phthalate | ND | | 1.8 | 10 |
| Fluoranthene | ND | | 1.0 | 10 |
| Fluorene | ND | | 1.5 | 10 |
| Hexachlorobenzene | ND | | 1.7 | 10 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID:** **Sandy 02 Elutriate**

Lab Sample ID: 700-9680-6 Date Sampled: 02/08/2006 1155
Client Matrix: Water Date Received: 02/10/2006 1040

**625 Base/Neutral and Acid Organics in Wastewater**

Method: 625 Analysis Batch: 700-17512 Instrument ID: SMC5973
Preparation: 3520C Prep Batch: 700-17307 Lab File ID: C021720.D
Dilution: 5.0 Initial Weight/Volume: 1000 mL
Date Analyzed: 02/17/2006 2017 Final Weight/Volume: 1.0 mL
Date Prepared: 02/15/2006 1108 Injection Volume:

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Hexachlorobutadiene | ND | | 1.4 | 10 |
| Hexachlorocyclopentadiene | ND | | 1.8 | 10 |
| Hexachloroethane | ND | | 1.3 | 10 |
| Indeno[1,2,3-cd]pyrene | ND | | 2.9 | 10 |
| Isophorone | ND | | 1.1 | 10 |
| Naphthalene | ND | | 1.2 | 10 |
| Nitrobenzene | ND | | 1.4 | 10 |
| N-Nitrosodimethylamine | ND | | 2.2 | 10 |
| N-Nitrosodi-n-propylamine | ND | | 1.0 | 10 |
| N-Nitrosodiphenylamine | ND | | 10 | 10 |
| Pentachlorophenol | ND | | 2.1 | 50 |
| Phenanthrene | ND | | 1.2 | 10 |
| Phenol | ND | | 1.1 | 10 |
| Pyrene | ND | | 2.2 | 10 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| 2,4,6-Tribromophenol | 60 | 14 - 93 |
| 2-Fluorobiphenyl | 71 | 34 - 118 |
| 2-Fluorophenol | 39 | 25 - 102 |
| Nitrobenzene-d5 | 69 | 39 - 133 |
| Phenol-d5 | 41 | 21 - 95 |
| Terphenyl-d14 | 69 | 16 - 158 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID: Empire 01 Water**

Lab Sample ID: 700-9680-7 Date Sampled: 02/08/2006 1240
Client Matrix: Water Date Received: 02/10/2006 1040

**625 Base/Neutral and Acid Organics in Wastewater**

Method: 625 Analysis Batch: 700-17512 Instrument ID: SMC5973
Preparation: 3520C Prep Batch: 700-17307 Lab File ID: C021716.D
Dilution: 5.0 Initial Weight/Volume: 1000 mL
Date Analyzed: 02/17/2006 1758 Final Weight/Volume: 1.0 mL
Date Prepared: 02/15/2006 1108 Injection Volume:

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| 1,2,4-Trichlorobenzene | ND | | 1.2 | 10 |
| 1,2-Dichlorobenzene | ND | | 1.1 | 10 |
| 1,2-Diphenylhydrazine | ND | | 4.0 | 10 |
| 1,3-Dichlorobenzene | ND | | 1.1 | 10 |
| 1,4-Dichlorobenzene | ND | | 1.1 | 10 |
| 2,2'-oxybis(2-chloropropane) | ND | | 1.3 | 10 |
| 2,4,6-Trichlorophenol | ND | | 2.4 | 10 |
| 2,4-Dichlorophenol | ND | | 1.2 | 10 |
| 2,4-Dimethylphenol | ND | | 1.1 | 10 |
| 2,4-Dinitrophenol | ND | | 2.3 | 50 |
| 2,4-Dinitrotoluene | ND | | 2.2 | 10 |
| 2,6-Dinitrotoluene | ND | | 2.4 | 10 |
| 2-Chloronaphthalene | ND | | 1.7 | 10 |
| 2-Chlorophenol | ND | | 1.0 | 10 |
| 2-Nitrophenol | ND | | 1.3 | 10 |
| 3,3'-Dichlorobenzidine | ND | | 7.1 | 20 |
| 4,6-Dinitro-2-methylphenol | ND | | 2.1 | 50 |
| 4-Bromophenyl phenyl ether | ND | | 1.7 | 10 |
| 4-Chloro-3-methylphenol | ND | | 1.0 | 10 |
| 4-Chlorophenyl phenyl ether | ND | | 1.5 | 10 |
| 4-Nitrophenol | ND | | 3.6 | 50 |
| Acenaphthene | ND | | 1.3 | 10 |
| Acenaphthylene | ND | | 2.4 | 10 |
| Anthracene | ND | | 1.0 | 10 |
| Benzidine | ND | | 8.4 | 80 |
| Benzo[a]anthracene | ND | | 1.0 | 10 |
| Benzo[a]pyrene | ND | | 5.6 | 10 |
| Benzo[b]fluoranthene | ND | | 9.5 | 10 |
| Benzo[g,h,i]perylene | ND | | 5.4 | 10 |
| Benzo[k]fluoranthene | ND | | 9.0 | 10 |
| Bis(2-chloroethoxy)methane | ND | | 5.4 | 10 |
| Bis(2-chloroethyl)ether | ND | | 3.0 | 10 |
| Bis(2-ethylhexyl) phthalate | ND | | 3.3 | 10 |
| Butyl benzyl phthalate | ND | | 2.8 | 10 |
| Chrysene | ND | | 2.3 | 10 |
| Dibenz(a,h)anthracene | ND | | 9.5 | 10 |
| Diethyl phthalate | ND | | 1.7 | 10 |
| Dimethyl phthalate | ND | | 1.2 | 10 |
| Di-n-butyl phthalate | ND | | 1.2 | 10 |
| Di-n-octyl phthalate | ND | | 1.8 | 10 |
| Fluoranthene | ND | | 1.0 | 10 |
| Fluorene | ND | | 1.5 | 10 |
| Hexachlorobenzene | ND | | 1.7 | 10 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9680-1

**Client Sample ID:** **Empire 01 Water**

Lab Sample ID: 700-9680-7 | Date Sampled: 02/08/2006 1240
Client Matrix: Water | Date Received: 02/10/2006 1040

**625 Base/Neutral and Acid Organics in Wastewater**

| | | | | | |
|---|---|---|---|---|---|
| Method: | 625 | Analysis Batch: 700-17512 | Instrument ID: | SMC5973 | |
| Preparation: | 3520C | Prep Batch: 700-17307 | Lab File ID: | C021716.D | |
| Dilution: | 5.0 | | Initial Weight/Volume: | 1000 | mL |
| Date Analyzed: | 02/17/2006 1758 | | Final Weight/Volume: | 1.0 | mL |
| Date Prepared: | 02/15/2006 1108 | | Injection Volume: | | |

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Hexachlorobutadiene | ND | | 1.4 | 10 |
| Hexachlorocyclopentadiene | ND | | 1.8 | 10 |
| Hexachloroethane | ND | | 1.3 | 10 |
| Indeno[1,2,3-cd]pyrene | ND | | 2.9 | 10 |
| Isophorone | ND | | 1.1 | 10 |
| Naphthalene | ND | | 1.2 | 10 |
| Nitrobenzene | ND | | 1.4 | 10 |
| N-Nitrosodimethylamine | ND | | 2.2 | 10 |
| N-Nitrosodi-n-propylamine | ND | | 1.0 | 10 |
| N-Nitrosodiphenylamine | ND | | 10 | 10 |
| Pentachlorophenol | ND | | 2.1 | 50 |
| Phenanthrene | ND | | 1.2 | 10 |
| Phenol | ND | | 1.1 | 10 |
| Pyrene | ND | | 2.2 | 10 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| 2,4,6-Tribromophenol | 76 | 14 - 93 |
| 2-Fluorobiphenyl | 81 | 34 - 118 |
| 2-Fluorophenol | 65 | 25 - 102 |
| Nitrobenzene-d5 | 83 | 39 - 133 |
| Phenol-d5 | 65 | 21 - 95 |
| Terphenyl-d14 | 85 | 16 - 158 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9680-1

**Client Sample ID:** **Empire 01 Elutriate**

Lab Sample ID: 700-9680-9 | Date Sampled: 02/08/2006 1300
Client Matrix: Water | Date Received: 02/10/2006 1040

**625 Base/Neutral and Acid Organics in Wastewater**

Method: 625 | Analysis Batch: 700-17512 | Instrument ID: SMC5973
Preparation: 3520C | Prep Batch: 700-17307 | Lab File ID: C021721.D
Dilution: 5.0 | Initial Weight/Volume: 1000 mL
Date Analyzed: 02/17/2006 2052 | Final Weight/Volume: 1.0 mL
Date Prepared: 02/15/2006 1108 | Injection Volume:

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| 1,2,4-Trichlorobenzene | ND | | 1.2 | 10 |
| 1,2-Dichlorobenzene | ND | | 1.1 | 10 |
| 1,2-Diphenylhydrazine | ND | | 4.0 | 10 |
| 1,3-Dichlorobenzene | ND | | 1.1 | 10 |
| 1,4-Dichlorobenzene | ND | | 1.1 | 10 |
| 2,2'-oxybis(2-chloropropane) | ND | | 1.3 | 10 |
| 2,4,6-Trichlorophenol | ND | | 2.4 | 10 |
| 2,4-Dichlorophenol | ND | | 1.2 | 10 |
| 2,4-Dimethylphenol | ND | | 1.1 | 10 |
| 2,4-Dinitrophenol | ND | | 2.3 | 50 |
| 2,4-Dinitrotoluene | ND | | 2.2 | 10 |
| 2,6-Dinitrotoluene | ND | | 2.4 | 10 |
| 2-Chloronaphthalene | ND | | 1.7 | 10 |
| 2-Chlorophenol | ND | | 1.0 | 10 |
| 2-Nitrophenol | ND | | 1.3 | 10 |
| 3,3'-Dichlorobenzidine | ND | | 7.1 | 20 |
| 4,6-Dinitro-2-methylphenol | ND | | 2.1 | 50 |
| 4-Bromophenyl phenyl ether | ND | | 1.7 | 10 |
| 4-Chloro-3-methylphenol | ND | | 1.0 | 10 |
| 4-Chlorophenyl phenyl ether | ND | | 1.5 | 10 |
| 4-Nitrophenol | ND | | 3.6 | 50 |
| Acenaphthene | ND | | 1.3 | 10 |
| Acenaphthylene | ND | | 2.4 | 10 |
| Anthracene | ND | | 1.0 | 10 |
| Benzidine | ND | | 8.4 | 80 |
| Benzo[a]anthracene | ND | | 1.0 | 10 |
| Benzo[a]pyrene | ND | | 5.6 | 10 |
| Benzo[b]fluoranthene | ND | | 9.5 | 10 |
| Benzo[g,h,i]perylene | ND | | 5.4 | 10 |
| Benzo[k]fluoranthene | ND | | 9.0 | 10 |
| Bis(2-chloroethoxy)methane | ND | | 5.4 | 10 |
| Bis(2-chloroethyl)ether | ND | | 3.0 | 10 |
| Bis(2-ethylhexyl) phthalate | ND | | 3.3 | 10 |
| Butyl benzyl phthalate | ND | | 2.8 | 10 |
| Chrysene | ND | | 2.3 | 10 |
| Dibenz(a,h)anthracene | ND | | 9.5 | 10 |
| Diethyl phthalate | ND | | 1.7 | 10 |
| Dimethyl phthalate | ND | | 1.2 | 10 |
| Di-n-butyl phthalate | ND | | 1.2 | 10 |
| Di-n-octyl phthalate | ND | | 1.8 | 10 |
| Fluoranthene | ND | | 1.0 | 10 |
| Fluorene | ND | | 1.5 | 10 |
| Hexachlorobenzene | ND | | 1.7 | 10 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID:** **Empire 01 Elutriate**

Lab Sample ID: 700-9680-9 Date Sampled: 02/08/2006 1300
Client Matrix: Water Date Received: 02/10/2006 1040

**625 Base/Neutral and Acid Organics in Wastewater**

| | | | |
|---|---|---|---|
| Method: | 625 | Analysis Batch: 700-17512 | Instrument ID: SMC5973 |
| Preparation: | 3520C | Prep Batch: 700-17307 | Lab File ID: C021721.D |
| Dilution: | 5.0 | | Initial Weight/Volume: 1000 mL |
| Date Analyzed: | 02/17/2006 2052 | | Final Weight/Volume: 1.0 mL |
| Date Prepared: | 02/15/2006 1108 | | Injection Volume: |

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Hexachlorobutadiene | ND | | 1.4 | 10 |
| Hexachlorocyclopentadiene | ND | | 1.8 | 10 |
| Hexachloroethane | ND | | 1.3 | 10 |
| Indeno[1,2,3-cd]pyrene | ND | | 2.9 | 10 |
| Isophorone | ND | | 1.1 | 10 |
| Naphthalene | ND | | 1.2 | 10 |
| Nitrobenzene | ND | | 1.4 | 10 |
| N-Nitrosodimethylamine | ND | | 2.2 | 10 |
| N-Nitrosodi-n-propylamine | ND | | 1.0 | 10 |
| N-Nitrosodiphenylamine | ND | | 10 | 10 |
| Pentachlorophenol | ND | | 2.1 | 50 |
| Phenanthrene | ND | | 1.2 | 10 |
| Phenol | ND | | 1.1 | 10 |
| Pyrene | ND | | 2.2 | 10 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| 2,4,6-Tribromophenol | 71 | 14 - 93 |
| 2-Fluorobiphenyl | 80 | 34 - 118 |
| 2-Fluorophenol | 62 | 25 - 102 |
| Nitrobenzene-d5 | 81 | 39 - 133 |
| Phenol-d5 | 60 | 21 - 95 |
| Terphenyl-d14 | 75 | 16 - 158 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9680-1

**Client Sample ID:** **Shell 01 Water**

Lab Sample ID: 700-9680-10 | Date Sampled: 02/08/2006 1430
Client Matrix: Water | Date Received: 02/10/2006 1040

**625 Base/Neutral and Acid Organics in Wastewater**

Method: 625 | Analysis Batch: 700-17512 | Instrument ID: SMC5973
Preparation: 3520C | Prep Batch: 700-17307 | Lab File ID: C021715.D
Dilution: 5.0 | Initial Weight/Volume: 1000 mL
Date Analyzed: 02/17/2006 1723 | Final Weight/Volume: 1.0 mL
Date Prepared: 02/15/2006 1108 | Injection Volume:

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| 1,2,4-Trichlorobenzene | ND | | 1.2 | 10 |
| 1,2-Dichlorobenzene | ND | | 1.1 | 10 |
| 1,2-Diphenylhydrazine | ND | | 4.0 | 10 |
| 1,3-Dichlorobenzene | ND | | 1.1 | 10 |
| 1,4-Dichlorobenzene | ND | | 1.1 | 10 |
| 2,2'-oxybis(2-chloropropane) | ND | | 1.3 | 10 |
| 2,4,6-Trichlorophenol | ND | | 2.4 | 10 |
| 2,4-Dichlorophenol | ND | | 1.2 | 10 |
| 2,4-Dimethylphenol | ND | | 1.1 | 10 |
| 2,4-Dinitrophenol | ND | | 2.3 | 50 |
| 2,4-Dinitrotoluene | ND | | 2.2 | 10 |
| 2,6-Dinitrotoluene | ND | | 2.4 | 10 |
| 2-Chloronaphthalene | ND | | 1.7 | 10 |
| 2-Chlorophenol | ND | | 1.0 | 10 |
| 2-Nitrophenol | ND | | 1.3 | 10 |
| 3,3'-Dichlorobenzidine | ND | | 7.1 | 20 |
| 4,6-Dinitro-2-methylphenol | ND | | 2.1 | 50 |
| 4-Bromophenyl phenyl ether | ND | | 1.7 | 10 |
| 4-Chloro-3-methylphenol | ND | | 1.0 | 10 |
| 4-Chlorophenyl phenyl ether | ND | | 1.5 | 10 |
| 4-Nitrophenol | ND | | 3.6 | 50 |
| Acenaphthene | ND | | 1.3 | 10 |
| Acenaphthylene | ND | | 2.4 | 10 |
| Anthracene | ND | | 1.0 | 10 |
| Benzidine | ND | | 8.4 | 80 |
| Benzo[a]anthracene | ND | | 1.0 | 10 |
| Benzo[a]pyrene | ND | | 5.6 | 10 |
| Benzo[b]fluoranthene | ND | | 9.5 | 10 |
| Benzo[g,h,i]perylene | ND | | 5.4 | 10 |
| Benzo[k]fluoranthene | ND | | 9.0 | 10 |
| Bis(2-chloroethoxy)methane | ND | | 5.4 | 10 |
| Bis(2-chloroethyl)ether | ND | | 3.0 | 10 |
| Bis(2-ethylhexyl) phthalate | ND | | 3.3 | 10 |
| Butyl benzyl phthalate | ND | | 2.8 | 10 |
| Chrysene | ND | | 2.3 | 10 |
| Dibenz(a,h)anthracene | ND | | 9.5 | 10 |
| Diethyl phthalate | ND | | 1.7 | 10 |
| Dimethyl phthalate | ND | | 1.2 | 10 |
| Di-n-butyl phthalate | ND | | 1.2 | 10 |
| Di-n-octyl phthalate | ND | | 1.8 | 10 |
| Fluoranthene | ND | | 1.0 | 10 |
| Fluorene | ND | | 1.5 | 10 |
| Hexachlorobenzene | ND | | 1.7 | 10 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9680-1

**Client Sample ID:** **Shell 01 Water**

Lab Sample ID: 700-9680-10 | Date Sampled: 02/08/2006 1430
Client Matrix: Water | Date Received: 02/10/2006 1040

**625 Base/Neutral and Acid Organics in Wastewater**

| | | | | | |
|---|---|---|---|---|---|
| Method: | 625 | Analysis Batch: 700-17512 | Instrument ID: | SMC5973 | |
| Preparation: | 3520C | Prep Batch: 700-17307 | Lab File ID: | C021715.D | |
| Dilution: | 5.0 | | Initial Weight/Volume: | 1000 | mL |
| Date Analyzed: | 02/17/2006 1723 | | Final Weight/Volume: | 1.0 | mL |
| Date Prepared: | 02/15/2006 1108 | | Injection Volume: | | |

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Hexachlorobutadiene | ND | | 1.4 | 10 |
| Hexachlorocyclopentadiene | ND | | 1.8 | 10 |
| Hexachloroethane | ND | | 1.3 | 10 |
| Indeno[1,2,3-cd]pyrene | ND | | 2.9 | 10 |
| Isophorone | ND | | 1.1 | 10 |
| Naphthalene | ND | | 1.2 | 10 |
| Nitrobenzene | ND | | 1.4 | 10 |
| N-Nitrosodimethylamine | ND | | 2.2 | 10 |
| N-Nitrosodi-n-propylamine | ND | | 1.0 | 10 |
| N-Nitrosodiphenylamine | ND | | 10 | 10 |
| Pentachlorophenol | ND | | 2.1 | 50 |
| Phenanthrene | ND | | 1.2 | 10 |
| Phenol | ND | | 1.1 | 10 |
| Pyrene | ND | | 2.2 | 10 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| 2,4,6-Tribromophenol | 62 | 14 - 93 |
| 2-Fluorobiphenyl | 79 | 34 - 118 |
| 2-Fluorophenol | 62 | 25 - 102 |
| Nitrobenzene-d5 | 82 | 39 - 133 |
| Phenol-d5 | 62 | 21 - 95 |
| Terphenyl-d14 | 81 | 16 - 158 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID:** **Shell 01 Elutriate**

Lab Sample ID: 700-9680-12 Date Sampled: 02/08/2006 1430
Client Matrix: Water Date Received: 02/10/2006 1040

**625 Base/Neutral and Acid Organics in Wastewater**

Method: 625 Analysis Batch: 700-17512 Instrument ID: SMC5973
Preparation: 3520C Prep Batch: 700-17307 Lab File ID: C021722.D
Dilution: 5.0 Initial Weight/Volume: 1000 mL
Date Analyzed: 02/17/2006 2127 Final Weight/Volume: 1.0 mL
Date Prepared: 02/15/2006 1108 Injection Volume:

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| 1,2,4-Trichlorobenzene | ND | | 1.2 | 10 |
| 1,2-Dichlorobenzene | ND | | 1.1 | 10 |
| 1,2-Diphenylhydrazine | ND | | 4.0 | 10 |
| 1,3-Dichlorobenzene | ND | | 1.1 | 10 |
| 1,4-Dichlorobenzene | ND | | 1.1 | 10 |
| 2,2'-oxybis(2-chloropropane) | ND | | 1.3 | 10 |
| 2,4,6-Trichlorophenol | ND | | 2.4 | 10 |
| 2,4-Dichlorophenol | ND | | 1.2 | 10 |
| 2,4-Dimethylphenol | ND | | 1.1 | 10 |
| 2,4-Dinitrophenol | ND | | 2.3 | 50 |
| 2,4-Dinitrotoluene | ND | | 2.2 | 10 |
| 2,6-Dinitrotoluene | ND | | 2.4 | 10 |
| 2-Chloronaphthalene | ND | | 1.7 | 10 |
| 2-Chlorophenol | ND | | 1.0 | 10 |
| 2-Nitrophenol | ND | | 1.3 | 10 |
| 3,3'-Dichlorobenzidine | ND | | 7.1 | 20 |
| 4,6-Dinitro-2-methylphenol | ND | | 2.1 | 50 |
| 4-Bromophenyl phenyl ether | ND | | 1.7 | 10 |
| 4-Chloro-3-methylphenol | ND | | 1.0 | 10 |
| 4-Chlorophenyl phenyl ether | ND | | 1.5 | 10 |
| 4-Nitrophenol | ND | | 3.6 | 50 |
| Acenaphthene | ND | | 1.3 | 10 |
| Acenaphthylene | ND | | 2.4 | 10 |
| Anthracene | ND | | 1.0 | 10 |
| Benzidine | ND | | 8.4 | 80 |
| Benzo[a]anthracene | ND | | 1.0 | 10 |
| Benzo[a]pyrene | ND | | 5.6 | 10 |
| Benzo[b]fluoranthene | ND | | 9.5 | 10 |
| Benzo[g,h,i]perylene | ND | | 5.4 | 10 |
| Benzo[k]fluoranthene | ND | | 9.0 | 10 |
| Bis(2-chloroethoxy)methane | ND | | 5.4 | 10 |
| Bis(2-chloroethyl)ether | ND | | 3.0 | 10 |
| Bis(2-ethylhexyl) phthalate | ND | | 3.3 | 10 |
| Butyl benzyl phthalate | ND | | 2.8 | 10 |
| Chrysene | ND | | 2.3 | 10 |
| Dibenz(a,h)anthracene | ND | | 9.5 | 10 |
| Diethyl phthalate | ND | | 1.7 | 10 |
| Dimethyl phthalate | ND | | 1.2 | 10 |
| Di-n-butyl phthalate | ND | | 1.2 | 10 |
| Di-n-octyl phthalate | ND | | 1.8 | 10 |
| Fluoranthene | ND | | 1.0 | 10 |
| Fluorene | ND | | 1.5 | 10 |
| Hexachlorobenzene | ND | | 1.7 | 10 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID:** **Shell 01 Elutriate**

Lab Sample ID: 700-9680-12 Date Sampled: 02/08/2006 1430
Client Matrix: Water Date Received: 02/10/2006 1040

**625 Base/Neutral and Acid Organics in Wastewater**

| | | | | | |
|---|---|---|---|---|---|
| Method: | 625 | Analysis Batch: 700-17512 | Instrument ID: | SMC5973 | |
| Preparation: | 3520C | Prep Batch: 700-17307 | Lab File ID: | C021722.D | |
| Dilution: | 5.0 | | Initial Weight/Volume: | 1000 | mL |
| Date Analyzed: | 02/17/2006 2127 | | Final Weight/Volume: | 1.0 | mL |
| Date Prepared: | 02/15/2006 1108 | | Injection Volume: | | |

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Hexachlorobutadiene | ND | | 1.4 | 10 |
| Hexachlorocyclopentadiene | ND | | 1.8 | 10 |
| Hexachloroethane | ND | | 1.3 | 10 |
| Indeno[1,2,3-cd]pyrene | ND | | 2.9 | 10 |
| Isophorone | ND | | 1.1 | 10 |
| Naphthalene | ND | | 1.2 | 10 |
| Nitrobenzene | ND | | 1.4 | 10 |
| N-Nitrosodimethylamine | ND | | 2.2 | 10 |
| N-Nitrosodi-n-propylamine | ND | | 1.0 | 10 |
| N-Nitrosodiphenylamine | ND | | 10 | 10 |
| Pentachlorophenol | ND | | 2.1 | 50 |
| Phenanthrene | ND | | 1.2 | 10 |
| Phenol | ND | | 1.1 | 10 |
| Pyrene | ND | | 2.2 | 10 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| 2,4,6-Tribromophenol | 59 | 14 - 93 |
| 2-Fluorobiphenyl | 71 | 34 - 118 |
| 2-Fluorophenol | 53 | 25 - 102 |
| Nitrobenzene-d5 | 70 | 39 - 133 |
| Phenol-d5 | 47 | 21 - 95 |
| Terphenyl-d14 | 48 | 16 - 158 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9680-1

**Client Sample ID:** **Shell 02 Elutriate**

Lab Sample ID: 700-9680-15 | Date Sampled: 02/08/2006 1615
Client Matrix: Water | Date Received: 02/10/2006 1040

**625 Base/Neutral and Acid Organics in Wastewater**

Method: 625 | Analysis Batch: 700-17512 | Instrument ID: SMC5973
Preparation: 3520C | Prep Batch: 700-17307 | Lab File ID: C021723.D
Dilution: 5.0 | Initial Weight/Volume: 1000 mL
Date Analyzed: 02/17/2006 2202 | Final Weight/Volume: 1.0 mL
Date Prepared: 02/15/2006 1108 | Injection Volume:

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| 1,2,4-Trichlorobenzene | ND | | 1.2 | 10 |
| 1,2-Dichlorobenzene | ND | | 1.1 | 10 |
| 1,2-Diphenylhydrazine | ND | | 4.0 | 10 |
| 1,3-Dichlorobenzene | ND | | 1.1 | 10 |
| 1,4-Dichlorobenzene | ND | | 1.1 | 10 |
| 2,2'-oxybis(2-chloropropane) | ND | | 1.3 | 10 |
| 2,4,6-Trichlorophenol | ND | | 2.4 | 10 |
| 2,4-Dichlorophenol | ND | | 1.2 | 10 |
| 2,4-Dimethylphenol | ND | | 1.1 | 10 |
| 2,4-Dinitrophenol | ND | | 2.3 | 50 |
| 2,4-Dinitrotoluene | ND | | 2.2 | 10 |
| 2,6-Dinitrotoluene | ND | | 2.4 | 10 |
| 2-Chloronaphthalene | ND | | 1.7 | 10 |
| 2-Chlorophenol | ND | | 1.0 | 10 |
| 2-Nitrophenol | ND | | 1.3 | 10 |
| 3,3'-Dichlorobenzidine | ND | | 7.1 | 20 |
| 4,6-Dinitro-2-methylphenol | ND | | 2.1 | 50 |
| 4-Bromophenyl phenyl ether | ND | | 1.7 | 10 |
| 4-Chloro-3-methylphenol | ND | | 1.0 | 10 |
| 4-Chlorophenyl phenyl ether | ND | | 1.5 | 10 |
| 4-Nitrophenol | ND | | 3.6 | 50 |
| Acenaphthene | ND | | 1.3 | 10 |
| Acenaphthylene | ND | | 2.4 | 10 |
| Anthracene | ND | | 1.0 | 10 |
| Benzidine | ND | | 8.4 | 80 |
| Benzo[a]anthracene | ND | | 1.0 | 10 |
| Benzo[a]pyrene | ND | | 5.6 | 10 |
| Benzo[b]fluoranthene | ND | | 9.5 | 10 |
| Benzo[g,h,i]perylene | ND | | 5.4 | 10 |
| Benzo[k]fluoranthene | ND | | 9.0 | 10 |
| Bis(2-chloroethoxy)methane | ND | | 5.4 | 10 |
| Bis(2-chloroethyl)ether | ND | | 3.0 | 10 |
| Bis(2-ethylhexyl) phthalate | ND | | 3.3 | 10 |
| Butyl benzyl phthalate | ND | | 2.8 | 10 |
| Chrysene | ND | | 2.3 | 10 |
| Dibenz(a,h)anthracene | ND | | 9.5 | 10 |
| Diethyl phthalate | ND | | 1.7 | 10 |
| Dimethyl phthalate | ND | | 1.2 | 10 |
| Di-n-butyl phthalate | ND | | 1.2 | 10 |
| Di-n-octyl phthalate | ND | | 1.8 | 10 |
| Fluoranthene | ND | | 1.0 | 10 |
| Fluorene | ND | | 1.5 | 10 |
| Hexachlorobenzene | ND | | 1.7 | 10 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID:** **Shell 02 Elutriate**

Lab Sample ID: 700-9680-15 Date Sampled: 02/08/2006 1615
Client Matrix: Water Date Received: 02/10/2006 1040

**625 Base/Neutral and Acid Organics in Wastewater**

Method: 625 Analysis Batch: 700-17512 Instrument ID: SMC5973
Preparation: 3520C Prep Batch: 700-17307 Lab File ID: C021723.D
Dilution: 5.0 Initial Weight/Volume: 1000 mL
Date Analyzed: 02/17/2006 2202 Final Weight/Volume: 1.0 mL
Date Prepared: 02/15/2006 1108 Injection Volume:

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Hexachlorobutadiene | ND | | 1.4 | 10 |
| Hexachlorocyclopentadiene | ND | | 1.8 | 10 |
| Hexachloroethane | ND | | 1.3 | 10 |
| Indeno[1,2,3-cd]pyrene | ND | | 2.9 | 10 |
| Isophorone | ND | | 1.1 | 10 |
| Naphthalene | ND | | 1.2 | 10 |
| Nitrobenzene | ND | | 1.4 | 10 |
| N-Nitrosodimethylamine | ND | | 2.2 | 10 |
| N-Nitrosodi-n-propylamine | ND | | 1.0 | 10 |
| N-Nitrosodiphenylamine | ND | | 10 | 10 |
| Pentachlorophenol | ND | | 2.1 | 50 |
| Phenanthrene | ND | | 1.2 | 10 |
| Phenol | ND | | 1.1 | 10 |
| Pyrene | ND | | 2.2 | 10 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| 2,4,6-Tribromophenol | 63 | 14 - 93 |
| 2-Fluorobiphenyl | 66 | 34 - 118 |
| 2-Fluorophenol | 50 | 25 - 102 |
| Nitrobenzene-d5 | 71 | 39 - 133 |
| Phenol-d5 | 47 | 21 - 95 |
| Terphenyl-d14 | 56 | 16 - 158 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID:** **Sandy 01 Sediment**

Lab Sample ID: 700-9680-2 Date Sampled: 02/08/2006 1100
Client Matrix: Solid Date Received: 02/10/2006 1040

**8270C Semivolatile Organic Compounds by GCMS - Low Levels**

Method: 8270C Analysis Batch: 700-17635 Instrument ID: Agilent GC/MS 5973
Preparation: 3550B Prep Batch: 700-17433 Lab File ID: D022009.D
Dilution: 1.0 Initial Weight/Volume: 50.0 g
Date Analyzed: 02/20/2006 1720 Final Weight/Volume: 1.0 mL
Date Prepared: 02/17/2006 0900 Injection Volume:

| Analyte | DryWt Corrected: N | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| Acenaphthene | | ND | | 2.1 | 4.0 |
| Pyrene | | 2.8 | J | 1.0 | 4.0 |
| Acenaphthylene | | ND | | 1.2 | 4.0 |
| Anthracene | | ND | | 2.6 | 4.0 |
| Benzo[a]pyrene | | ND | | 1.2 | 4.0 |
| Benzo[b]fluoranthene | | ND | | 3.7 | 4.0 |
| Benzo[a]anthracene | | ND | | 1.3 | 4.0 |
| Benzo[g,h,i]perylene | | ND | | 1.8 | 4.0 |
| Benzo[k]fluoranthene | | ND | | 2.6 | 4.0 |
| Fluoranthene | | 2.2 | J | 2.1 | 4.0 |
| Fluorene | | ND | | 1.7 | 4.0 |
| Indeno[1,2,3-cd]pyrene | | ND | | 1.1 | 4.0 |
| Naphthalene | | ND | | 2.0 | 4.0 |
| Phenanthrene | | ND | | 2.3 | 4.0 |
| Chrysene | | ND | | 1.4 | 4.0 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| 2,4,6-Tribromophenol | 68 | 5.0 - 106 |
| 2-Fluorobiphenyl | 58 | 31 - 118 |
| 2-Fluorophenol | 51 | 10 - 128 |
| Nitrobenzene-d5 | 55 | 35 - 122 |
| Phenol-d5 | 49 | 29 - 113 |
| Terphenyl-d14 | 83 | 37 - 149 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9680-1

**Client Sample ID:** **Sandy 01 Sediment**

Lab Sample ID: 700-9680-2 | Date Sampled: 02/08/2006 1100
Client Matrix: Solid | Date Received: 02/10/2006 1040

**8270C Semivolatile Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)**

Method: 8270C | Analysis Batch: 700-17742 | Instrument ID: SMC5973
Preparation: 3550B | Prep Batch: 700-17431 | Lab File ID: C022009.D
Dilution: 1.0 | Initial Weight/Volume: 50.0 g
Date Analyzed: 02/20/2006 1711 | Final Weight/Volume: 1.0 mL
Date Prepared: 02/17/2006 0900 | Injection Volume:

| Analyte | DryWt Corrected: N | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| 1,2,4-Trichlorobenzene | | ND | | 5.0 | 40 |
| 1,2-Dichlorobenzene | | ND | | 5.4 | 40 |
| 1,2-Diphenylhydrazine | | ND | | 4.2 | 40 |
| 1,3-Dichlorobenzene | | ND | | 6.2 | 40 |
| 1,4-Dichlorobenzene | | ND | | 4.2 | 40 |
| 2,2'-oxybis(2-chloropropane) | | ND | | 7.2 | 40 |
| 2,4,6-Trichlorophenol | | ND | | 4.7 | 40 |
| 2,4-Dichlorophenol | | ND | | 4.3 | 40 |
| 2,4-Dimethylphenol | | ND | | 4.6 | 40 |
| 2,4-Dinitrophenol | | ND | | 5.2 | 200 |
| 2,4-Dinitrotoluene | | ND | | 4.3 | 40 |
| 2,6-Dinitrotoluene | | ND | | 5.3 | 40 |
| 2-Chloronaphthalene | | ND | | 5.0 | 40 |
| 2-Chlorophenol | | ND | | 5.0 | 40 |
| 2-Nitrophenol | | ND | | 4.3 | 40 |
| 3,3'-Dichlorobenzidine | | ND | | 8.4 | 79 |
| 4,6-Dinitro-2-methylphenol | | ND | | 9.4 | 200 |
| 4-Bromophenyl phenyl ether | | ND | | 5.0 | 40 |
| 4-Chloro-3-methylphenol | | ND | | 4.9 | 40 |
| 4-Chlorophenyl phenyl ether | | ND | | 4.6 | 40 |
| 4-Nitrophenol | | ND | | 9.2 | 200 |
| Benzidine | | ND | | 26 | 320 |
| Bis(2-chloroethoxy)methane | | ND | | 4.7 | 40 |
| Bis(2-chloroethyl)ether | | ND | | 5.0 | 40 |
| Bis(2-ethylhexyl) phthalate | | ND | | 4.4 | 40 |
| Butyl benzyl phthalate | | ND | | 5.9 | 40 |
| Dibenz(a,h)anthracene | | ND | | 4.2 | 40 |
| Diethyl phthalate | | ND | | 4.7 | 40 |
| Di-n-butyl phthalate | | ND | | 5.0 | 40 |
| Di-n-octyl phthalate | | ND | | 4.1 | 40 |
| Hexachlorobenzene | | ND | | 5.4 | 40 |
| Hexachlorobutadiene | | ND | | 4.1 | 40 |
| Hexachlorocyclopentadiene | | ND | | 3.6 | 40 |
| Hexachloroethane | | ND | | 4.6 | 40 |
| Isophorone | | ND | | 5.4 | 40 |
| Nitrobenzene | | ND | | 4.3 | 40 |
| N-Nitrosodimethylamine | | ND | | 20 | 40 |
| N-Nitrosodi-n-propylamine | | ND | | 4.7 | 40 |
| N-Nitrosodiphenylamine | | ND | | 5.4 | 40 |
| Pentachlorophenol | | ND | | 4.3 | 200 |
| Phenol | | ND | | 4.3 | 40 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| 2,4,6-Tribromophenol | 92 | 5.0 - 106 |



**STL Mobile**

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9680-1

**Client Sample ID:** **Sandy 01 Sediment**

Lab Sample ID: 700-9680-2 | Date Sampled: 02/08/2006 1100
Client Matrix: Solid | Date Received: 02/10/2006 1040

**8270C Semivolatile Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)**

| | | | | | |
|---|---|---|---|---|---|
| Method: | 8270C | Analysis Batch: 700-17742 | Instrument ID: | SMC5973 | |
| Preparation: | 3550B | Prep Batch: 700-17431 | Lab File ID: | C022009.D | |
| Dilution: | 1.0 | | Initial Weight/Volume: | 50.0 | g |
| Date Analyzed: | 02/20/2006 1711 | | Final Weight/Volume: | 1.0 | mL |
| Date Prepared: | 02/17/2006 0900 | | Injection Volume: | | |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| 2-Fluorobiphenyl | 67 | 31 - 118 |
| 2-Fluorophenol | 55 | 10 - 128 |
| Nitrobenzene-d5 | 66 | 35 - 122 |
| Phenol-d5 | 58 | 29 - 113 |
| Terphenyl-d14 | 81 | 37 - 149 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID:** **Sandy 02 Sediment**

Lab Sample ID: 700-9680-5 Date Sampled: 02/08/2006 1155
Client Matrix: Solid Date Received: 02/10/2006 1040

**8270C Semivolatile Organic Compounds by GCMS - Low Levels**

Method: 8270C Analysis Batch: 700-17635 Instrument ID: Agilent GC/MS 5973
Preparation: 3550B Prep Batch: 700-17433 Lab File ID: D022010.D
Dilution: 1.0 Initial Weight/Volume: 50.0 g
Date Analyzed: 02/20/2006 1755 Final Weight/Volume: 1.0 mL
Date Prepared: 02/17/2006 0900 Injection Volume:

| Analyte | DryWt Corrected: N | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| Acenaphthene | | ND | | 2.1 | 4.0 |
| Pyrene | | ND | | 1.0 | 4.0 |
| Acenaphthylene | | ND | | 1.2 | 4.0 |
| Anthracene | | ND | | 2.6 | 4.0 |
| Benzo[a]pyrene | | ND | | 1.2 | 4.0 |
| Benzo[b]fluoranthene | | ND | | 3.7 | 4.0 |
| Benzo[a]anthracene | | ND | | 1.3 | 4.0 |
| Benzo[g,h,i]perylene | | ND | | 1.8 | 4.0 |
| Benzo[k]fluoranthene | | ND | | 2.6 | 4.0 |
| Fluoranthene | | ND | | 2.1 | 4.0 |
| Fluorene | | ND | | 1.7 | 4.0 |
| Indeno[1,2,3-cd]pyrene | | ND | | 1.1 | 4.0 |
| Naphthalene | | ND | | 2.0 | 4.0 |
| Phenanthrene | | ND | | 2.3 | 4.0 |
| Chrysene | | ND | | 1.4 | 4.0 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| 2,4,6-Tribromophenol | 66 | 5.0 - 106 |
| 2-Fluorobiphenyl | 54 | 31 - 118 |
| 2-Fluorophenol | 49 | 10 - 128 |
| Nitrobenzene-d5 | 52 | 35 - 122 |
| Phenol-d5 | 47 | 29 - 113 |
| Terphenyl-d14 | 82 | 37 - 149 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID:** **Sandy 02 Sediment**

Lab Sample ID: 700-9680-5 Date Sampled: 02/08/2006 1155
Client Matrix: Solid Date Received: 02/10/2006 1040

**8270C Semivolatile Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)**

Method: 8270C Analysis Batch: 700-17742 Instrument ID: SMC5973
Preparation: 3550B Prep Batch: 700-17431 Lab File ID: C022010.D
Dilution: 1.0 Initial Weight/Volume: 50.0 g
Date Analyzed: 02/20/2006 1746 Final Weight/Volume: 1.0 mL
Date Prepared: 02/17/2006 0900 Injection Volume:

| Analyte | DryWt Corrected: N | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| 1,2,4-Trichlorobenzene | | ND | | 5.0 | 40 |
| 1,2-Dichlorobenzene | | ND | | 5.4 | 40 |
| 1,2-Diphenylhydrazine | | ND | | 4.2 | 40 |
| 1,3-Dichlorobenzene | | ND | | 6.2 | 40 |
| 1,4-Dichlorobenzene | | ND | | 4.2 | 40 |
| 2,2'-oxybis(2-chloropropane) | | ND | | 7.2 | 40 |
| 2,4,6-Trichlorophenol | | ND | | 4.7 | 40 |
| 2,4-Dichlorophenol | | ND | | 4.3 | 40 |
| 2,4-Dimethylphenol | | ND | | 4.6 | 40 |
| 2,4-Dinitrophenol | | ND | | 5.2 | 200 |
| 2,4-Dinitrotoluene | | ND | | 4.3 | 40 |
| 2,6-Dinitrotoluene | | ND | | 5.3 | 40 |
| 2-Chloronaphthalene | | ND | | 5.0 | 40 |
| 2-Chlorophenol | | ND | | 5.0 | 40 |
| 2-Nitrophenol | | ND | | 4.3 | 40 |
| 3,3'-Dichlorobenzidine | | ND | | 8.4 | 79 |
| 4,6-Dinitro-2-methylphenol | | ND | | 9.4 | 200 |
| 4-Bromophenyl phenyl ether | | ND | | 5.0 | 40 |
| 4-Chloro-3-methylphenol | | ND | | 4.9 | 40 |
| 4-Chlorophenyl phenyl ether | | ND | | 4.6 | 40 |
| 4-Nitrophenol | | ND | | 9.2 | 200 |
| Benzidine | | ND | | 26 | 320 |
| Bis(2-chloroethoxy)methane | | ND | | 4.7 | 40 |
| Bis(2-chloroethyl)ether | | ND | | 5.0 | 40 |
| Bis(2-ethylhexyl) phthalate | | ND | | 4.4 | 40 |
| Butyl benzyl phthalate | | ND | | 5.9 | 40 |
| Dibenz(a,h)anthracene | | ND | | 4.2 | 40 |
| Diethyl phthalate | | ND | | 4.7 | 40 |
| Di-n-butyl phthalate | | ND | | 5.0 | 40 |
| Di-n-octyl phthalate | | ND | | 4.1 | 40 |
| Hexachlorobenzene | | ND | | 5.4 | 40 |
| Hexachlorobutadiene | | ND | | 4.1 | 40 |
| Hexachlorocyclopentadiene | | ND | | 3.6 | 40 |
| Hexachloroethane | | ND | | 4.6 | 40 |
| Isophorone | | ND | | 5.4 | 40 |
| Nitrobenzene | | ND | | 4.3 | 40 |
| N-Nitrosodimethylamine | | ND | | 20 | 40 |
| N-Nitrosodi-n-propylamine | | ND | | 4.7 | 40 |
| N-Nitrosodiphenylamine | | ND | | 5.4 | 40 |
| Pentachlorophenol | | ND | | 4.3 | 200 |
| Phenol | | ND | | 4.3 | 40 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| 2,4,6-Tribromophenol | 91 | 5.0 - 106 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9680-1

**Client Sample ID:** **Sandy 02 Sediment**

Lab Sample ID: 700-9680-5 | Date Sampled: 02/08/2006 1155
Client Matrix: Solid | Date Received: 02/10/2006 1040

**8270C Semivolatile Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)**

Method: 8270C | Analysis Batch: 700-17742 | Instrument ID: SMC5973
Preparation: 3550B | Prep Batch: 700-17431 | Lab File ID: C022010.D
Dilution: 1.0 | Initial Weight/Volume: 50.0 g
Date Analyzed: 02/20/2006 1746 | Final Weight/Volume: 1.0 mL
Date Prepared: 02/17/2006 0900 | Injection Volume:

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| 2-Fluorobiphenyl | 63 | 31 - 118 |
| 2-Fluorophenol | 52 | 10 - 128 |
| Nitrobenzene-d5 | 63 | 35 - 122 |
| Phenol-d5 | 54 | 29 - 113 |
| Terphenyl-d14 | 79 | 37 - 149 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID:** **Empire 01 Sediment**

Lab Sample ID: 700-9680-8 Date Sampled: 02/08/2006 1300
Client Matrix: Solid Date Received: 02/10/2006 1040

**8270C Semivolatile Organic Compounds by GCMS - Low Levels**

Method: 8270C Analysis Batch: 700-17635 Instrument ID: Agilent GC/MS 5973
Preparation: 3550B Prep Batch: 700-17433 Lab File ID: D022011.D
Dilution: 1.0 Initial Weight/Volume: 50.0 g
Date Analyzed: 02/20/2006 1830 Final Weight/Volume: 1.0 mL
Date Prepared: 02/17/2006 0900 Injection Volume:

| Analyte | DryWt Corrected: N | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| Acenaphthene | | ND | | 2.1 | 4.0 |
| Pyrene | | ND | | 1.0 | 4.0 |
| Acenaphthylene | | ND | | 1.2 | 4.0 |
| Anthracene | | ND | | 2.6 | 4.0 |
| Benzo[a]pyrene | | ND | | 1.2 | 4.0 |
| Benzo[b]fluoranthene | | ND | | 3.7 | 4.0 |
| Benzo[a]anthracene | | ND | | 1.3 | 4.0 |
| Benzo[g,h,i]perylene | | ND | | 1.8 | 4.0 |
| Benzo[k]fluoranthene | | ND | | 2.6 | 4.0 |
| Fluoranthene | | ND | | 2.1 | 4.0 |
| Fluorene | | ND | | 1.7 | 4.0 |
| Indeno[1,2,3-cd]pyrene | | ND | | 1.1 | 4.0 |
| Naphthalene | | ND | | 2.0 | 4.0 |
| Phenanthrene | | ND | | 2.3 | 4.0 |
| Chrysene | | ND | | 1.4 | 4.0 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| 2,4,6-Tribromophenol | 64 | 5.0 - 106 |
| 2-Fluorobiphenyl | 56 | 31 - 118 |
| 2-Fluorophenol | 52 | 10 - 128 |
| Nitrobenzene-d5 | 54 | 35 - 122 |
| Phenol-d5 | 47 | 29 - 113 |
| Terphenyl-d14 | 77 | 37 - 149 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID:** **Empire 01 Sediment**

Lab Sample ID: 700-9680-8 Date Sampled: 02/08/2006 1300
Client Matrix: Solid Date Received: 02/10/2006 1040

**8270C Semivolatile Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)**

Method: 8270C Analysis Batch: 700-17742 Instrument ID: SMC5973
Preparation: 3550B Prep Batch: 700-17431 Lab File ID: C022011.D
Dilution: 1.0 Initial Weight/Volume: 50.0 g
Date Analyzed: 02/20/2006 1822 Final Weight/Volume: 1.0 mL
Date Prepared: 02/17/2006 0900 Injection Volume:

| Analyte | DryWt Corrected: N | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| 1,2,4-Trichlorobenzene | | ND | | 5.0 | 40 |
| 1,2-Dichlorobenzene | | ND | | 5.4 | 40 |
| 1,2-Diphenylhydrazine | | ND | | 4.2 | 40 |
| 1,3-Dichlorobenzene | | ND | | 6.2 | 40 |
| 1,4-Dichlorobenzene | | ND | | 4.2 | 40 |
| 2,2'-oxybis(2-chloropropane) | | ND | | 7.2 | 40 |
| 2,4,6-Trichlorophenol | | ND | | 4.7 | 40 |
| 2,4-Dichlorophenol | | ND | | 4.3 | 40 |
| 2,4-Dimethylphenol | | ND | | 4.6 | 40 |
| 2,4-Dinitrophenol | | ND | | 5.2 | 200 |
| 2,4-Dinitrotoluene | | ND | | 4.3 | 40 |
| 2,6-Dinitrotoluene | | ND | | 5.3 | 40 |
| 2-Chloronaphthalene | | ND | | 5.0 | 40 |
| 2-Chlorophenol | | ND | | 5.0 | 40 |
| 2-Nitrophenol | | ND | | 4.3 | 40 |
| 3,3'-Dichlorobenzidine | | ND | | 8.4 | 79 |
| 4,6-Dinitro-2-methylphenol | | ND | | 9.4 | 200 |
| 4-Bromophenyl phenyl ether | | ND | | 5.0 | 40 |
| 4-Chloro-3-methylphenol | | ND | | 4.9 | 40 |
| 4-Chlorophenyl phenyl ether | | ND | | 4.6 | 40 |
| 4-Nitrophenol | | ND | | 9.2 | 200 |
| Benzidine | | ND | | 26 | 320 |
| Bis(2-chloroethoxy)methane | | ND | | 4.7 | 40 |
| Bis(2-chloroethyl)ether | | ND | | 5.0 | 40 |
| Bis(2-ethylhexyl) phthalate | | ND | | 4.4 | 40 |
| Butyl benzyl phthalate | | ND | | 5.9 | 40 |
| Dibenz(a,h)anthracene | | ND | | 4.2 | 40 |
| Diethyl phthalate | | ND | | 4.7 | 40 |
| Di-n-butyl phthalate | | ND | | 5.0 | 40 |
| Di-n-octyl phthalate | | ND | | 4.1 | 40 |
| Hexachlorobenzene | | ND | | 5.4 | 40 |
| Hexachlorobutadiene | | ND | | 4.1 | 40 |
| Hexachlorocyclopentadiene | | ND | | 3.6 | 40 |
| Hexachloroethane | | ND | | 4.6 | 40 |
| Isophorone | | ND | | 5.4 | 40 |
| Nitrobenzene | | ND | | 4.3 | 40 |
| N-Nitrosodimethylamine | | ND | | 20 | 40 |
| N-Nitrosodi-n-propylamine | | ND | | 4.7 | 40 |
| N-Nitrosodiphenylamine | | ND | | 5.4 | 40 |
| Pentachlorophenol | | ND | | 4.3 | 200 |
| Phenol | | ND | | 4.3 | 40 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| 2,4,6-Tribromophenol | 86 | 5.0 - 106 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9680-1

**Client Sample ID:** **Empire 01 Sediment**

Lab Sample ID: 700-9680-8 | Date Sampled: 02/08/2006 1300
Client Matrix: Solid | Date Received: 02/10/2006 1040

**8270C Semivolatile Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)**

| | | | | | |
|---|---|---|---|---|---|
| Method: | 8270C | Analysis Batch: 700-17742 | Instrument ID: | SMC5973 | |
| Preparation: | 3550B | Prep Batch: 700-17431 | Lab File ID: | C022011.D | |
| Dilution: | 1.0 | | Initial Weight/Volume: | 50.0 | g |
| Date Analyzed: | 02/20/2006 1822 | | Final Weight/Volume: | 1.0 | mL |
| Date Prepared: | 02/17/2006 0900 | | Injection Volume: | | |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| 2-Fluorobiphenyl | 67 | 31 - 118 |
| 2-Fluorophenol | 57 | 10 - 128 |
| Nitrobenzene-d5 | 67 | 35 - 122 |
| Phenol-d5 | 59 | 29 - 113 |
| Terphenyl-d14 | 80 | 37 - 149 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9680-1

**Client Sample ID:** **Shell 01 Sediment**

Lab Sample ID: 700-9680-11 | Date Sampled: 02/08/2006 1440
Client Matrix: Solid | Date Received: 02/10/2006 1040

**8270C Semivolatile Organic Compounds by GCMS - Low Levels**

Method: 8270C | Analysis Batch: 700-17635 | Instrument ID: Agilent GC/MS 5973
Preparation: 3550B | Prep Batch: 700-17433 | Lab File ID: D022012.D
Dilution: 1.0 | Initial Weight/Volume: 50.0 g
Date Analyzed: 02/20/2006 1904 | Final Weight/Volume: 1.0 mL
Date Prepared: 02/17/2006 0900 | Injection Volume:

| Analyte | DryWt Corrected: N | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| Acenaphthene | | ND | | 2.1 | 4.0 |
| Pyrene | | 2.1 | J | 1.0 | 4.0 |
| Acenaphthylene | | ND | | 1.2 | 4.0 |
| Anthracene | | ND | | 2.6 | 4.0 |
| Benzo[a]pyrene | | ND | | 1.2 | 4.0 |
| Benzo[b]fluoranthene | | ND | | 3.7 | 4.0 |
| Benzo[a]anthracene | | ND | | 1.3 | 4.0 |
| Benzo[g,h,i]perylene | | ND | | 1.8 | 4.0 |
| Benzo[k]fluoranthene | | ND | | 2.6 | 4.0 |
| Fluoranthene | | ND | | 2.1 | 4.0 |
| Fluorene | | ND | | 1.7 | 4.0 |
| Indeno[1,2,3-cd]pyrene | | ND | | 1.1 | 4.0 |
| Naphthalene | | ND | | 2.0 | 4.0 |
| Phenanthrene | | ND | | 2.3 | 4.0 |
| Chrysene | | ND | | 1.4 | 4.0 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| 2,4,6-Tribromophenol | 67 | 5.0 - 106 |
| 2-Fluorobiphenyl | 59 | 31 - 118 |
| 2-Fluorophenol | 52 | 10 - 128 |
| Nitrobenzene-d5 | 57 | 35 - 122 |
| Phenol-d5 | 50 | 29 - 113 |
| Terphenyl-d14 | 73 | 37 - 149 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID:** **Shell 01 Sediment**

Lab Sample ID: 700-9680-11 Date Sampled: 02/08/2006 1440
Client Matrix: Solid Date Received: 02/10/2006 1040

**8270C Semivolatile Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)**

Method: 8270C Analysis Batch: 700-17742 Instrument ID: SMC5973
Preparation: 3550B Prep Batch: 700-17431 Lab File ID: C022012.D
Dilution: 1.0 Initial Weight/Volume: 50.0 g
Date Analyzed: 02/20/2006 1857 Final Weight/Volume: 1.0 mL
Date Prepared: 02/17/2006 0900 Injection Volume:

| Analyte | DryWt Corrected: N | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| 1,2,4-Trichlorobenzene | | ND | | 5.0 | 40 |
| 1,2-Dichlorobenzene | | ND | | 5.4 | 40 |
| 1,2-Diphenylhydrazine | | ND | | 4.2 | 40 |
| 1,3-Dichlorobenzene | | ND | | 6.2 | 40 |
| 1,4-Dichlorobenzene | | ND | | 4.2 | 40 |
| 2,2'-oxybis(2-chloropropane) | | ND | | 7.2 | 40 |
| 2,4,6-Trichlorophenol | | ND | | 4.7 | 40 |
| 2,4-Dichlorophenol | | ND | | 4.3 | 40 |
| 2,4-Dimethylphenol | | ND | | 4.6 | 40 |
| 2,4-Dinitrophenol | | ND | | 5.2 | 200 |
| 2,4-Dinitrotoluene | | ND | | 4.3 | 40 |
| 2,6-Dinitrotoluene | | ND | | 5.3 | 40 |
| 2-Chloronaphthalene | | ND | | 5.0 | 40 |
| 2-Chlorophenol | | ND | | 5.0 | 40 |
| 2-Nitrophenol | | ND | | 4.3 | 40 |
| 3,3'-Dichlorobenzidine | | ND | | 8.4 | 79 |
| 4,6-Dinitro-2-methylphenol | | ND | | 9.4 | 200 |
| 4-Bromophenyl phenyl ether | | ND | | 5.0 | 40 |
| 4-Chloro-3-methylphenol | | ND | | 4.9 | 40 |
| 4-Chlorophenyl phenyl ether | | ND | | 4.6 | 40 |
| 4-Nitrophenol | | ND | | 9.2 | 200 |
| Benzidine | | ND | | 26 | 320 |
| Bis(2-chloroethoxy)methane | | ND | | 4.7 | 40 |
| Bis(2-chloroethyl)ether | | ND | | 5.0 | 40 |
| Bis(2-ethylhexyl) phthalate | | ND | | 4.4 | 40 |
| Butyl benzyl phthalate | | ND | | 5.9 | 40 |
| Dibenz(a,h)anthracene | | ND | | 4.2 | 40 |
| Diethyl phthalate | | ND | | 4.7 | 40 |
| Di-n-butyl phthalate | | ND | | 5.0 | 40 |
| Di-n-octyl phthalate | | ND | | 4.1 | 40 |
| Hexachlorobenzene | | ND | | 5.4 | 40 |
| Hexachlorobutadiene | | ND | | 4.1 | 40 |
| Hexachlorocyclopentadiene | | ND | | 3.6 | 40 |
| Hexachloroethane | | ND | | 4.6 | 40 |
| Isophorone | | ND | | 5.4 | 40 |
| Nitrobenzene | | ND | | 4.3 | 40 |
| N-Nitrosodimethylamine | | ND | | 20 | 40 |
| N-Nitrosodi-n-propylamine | | ND | | 4.7 | 40 |
| N-Nitrosodiphenylamine | | ND | | 5.4 | 40 |
| Pentachlorophenol | | ND | | 4.3 | 200 |
| Phenol | | ND | | 4.3 | 40 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| 2,4,6-Tribromophenol | 91 | 5.0 - 106 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9680-1

**Client Sample ID:** **Shell 01 Sediment**

Lab Sample ID: 700-9680-11 | Date Sampled: 02/08/2006 1440
Client Matrix: Solid | Date Received: 02/10/2006 1040

**8270C Semivolatile Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)**

| | | | | | |
|---|---|---|---|---|---|
| Method: | 8270C | Analysis Batch: 700-17742 | Instrument ID: | SMC5973 | |
| Preparation: | 3550B | Prep Batch: 700-17431 | Lab File ID: | C022012.D | |
| Dilution: | 1.0 | | Initial Weight/Volume: | 50.0 | g |
| Date Analyzed: | 02/20/2006 1857 | | Final Weight/Volume: | 1.0 | mL |
| Date Prepared: | 02/17/2006 0900 | | Injection Volume: | | |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| 2-Fluorobiphenyl | 68 | 31 - 118 |
| 2-Fluorophenol | 61 | 10 - 128 |
| Nitrobenzene-d5 | 71 | 35 - 122 |
| Phenol-d5 | 63 | 29 - 113 |
| Terphenyl-d14 | 69 | 37 - 149 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID:** **Shell 02 Sediment**

Lab Sample ID: 700-9680-14 Date Sampled: 02/08/2006 1615
Client Matrix: Solid Date Received: 02/10/2006 1040

**8270C Semivolatile Organic Compounds by GCMS - Low Levels**

Method: 8270C Analysis Batch: 700-17635 Instrument ID: Agilent GC/MS 5973
Preparation: 3550B Prep Batch: 700-17433 Lab File ID: D022013.D
Dilution: 1.0 Initial Weight/Volume: 50.0 g
Date Analyzed: 02/20/2006 1938 Final Weight/Volume: 1.0 mL
Date Prepared: 02/17/2006 0900 Injection Volume:

| Analyte | DryWt Corrected: N | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| Acenaphthene | | ND | | 2.1 | 4.0 |
| Pyrene | | ND | | 1.0 | 4.0 |
| Acenaphthylene | | ND | | 1.2 | 4.0 |
| Anthracene | | ND | | 2.6 | 4.0 |
| Benzo[a]pyrene | | ND | | 1.2 | 4.0 |
| Benzo[b]fluoranthene | | ND | | 3.7 | 4.0 |
| Benzo[a]anthracene | | ND | | 1.3 | 4.0 |
| Benzo[g,h,i]perylene | | ND | | 1.8 | 4.0 |
| Benzo[k]fluoranthene | | ND | | 2.6 | 4.0 |
| Fluoranthene | | ND | | 2.1 | 4.0 |
| Fluorene | | ND | | 1.7 | 4.0 |
| Indeno[1,2,3-cd]pyrene | | ND | | 1.1 | 4.0 |
| Naphthalene | | ND | | 2.0 | 4.0 |
| Phenanthrene | | ND | | 2.3 | 4.0 |
| Chrysene | | ND | | 1.4 | 4.0 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| 2,4,6-Tribromophenol | 67 | 5.0 - 106 |
| 2-Fluorobiphenyl | 59 | 31 - 118 |
| 2-Fluorophenol | 55 | 10 - 128 |
| Nitrobenzene-d5 | 55 | 35 - 122 |
| Phenol-d5 | 48 | 29 - 113 |
| Terphenyl-d14 | 69 | 37 - 149 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID:** **Shell 02 Sediment**

Lab Sample ID: 700-9680-14 Date Sampled: 02/08/2006 1615
Client Matrix: Solid Date Received: 02/10/2006 1040

**8270C Semivolatile Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)**

Method: 8270C Analysis Batch: 700-17742 Instrument ID: SMC5973
Preparation: 3550B Prep Batch: 700-17431 Lab File ID: C022013.D
Dilution: 1.0 Initial Weight/Volume: 50.0 g
Date Analyzed: 02/20/2006 1933 Final Weight/Volume: 1.0 mL
Date Prepared: 02/17/2006 0900 Injection Volume:

| Analyte | DryWt Corrected: N | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| 1,2,4-Trichlorobenzene | | ND | | 5.0 | 40 |
| 1,2-Dichlorobenzene | | ND | | 5.4 | 40 |
| 1,2-Diphenylhydrazine | | ND | | 4.2 | 40 |
| 1,3-Dichlorobenzene | | ND | | 6.2 | 40 |
| 1,4-Dichlorobenzene | | ND | | 4.2 | 40 |
| 2,2'-oxybis(2-chloropropane) | | ND | | 7.2 | 40 |
| 2,4,6-Trichlorophenol | | ND | | 4.7 | 40 |
| 2,4-Dichlorophenol | | ND | | 4.3 | 40 |
| 2,4-Dimethylphenol | | ND | | 4.6 | 40 |
| 2,4-Dinitrophenol | | ND | | 5.2 | 200 |
| 2,4-Dinitrotoluene | | ND | | 4.3 | 40 |
| 2,6-Dinitrotoluene | | ND | | 5.3 | 40 |
| 2-Chloronaphthalene | | ND | | 5.0 | 40 |
| 2-Chlorophenol | | ND | | 5.0 | 40 |
| 2-Nitrophenol | | ND | | 4.3 | 40 |
| 3,3'-Dichlorobenzidine | | ND | | 8.4 | 79 |
| 4,6-Dinitro-2-methylphenol | | ND | | 9.4 | 200 |
| 4-Bromophenyl phenyl ether | | ND | | 5.0 | 40 |
| 4-Chloro-3-methylphenol | | ND | | 4.9 | 40 |
| 4-Chlorophenyl phenyl ether | | ND | | 4.6 | 40 |
| 4-Nitrophenol | | ND | | 9.2 | 200 |
| Benzidine | | ND | | 26 | 320 |
| Bis(2-chloroethoxy)methane | | ND | | 4.7 | 40 |
| Bis(2-chloroethyl)ether | | ND | | 5.0 | 40 |
| Bis(2-ethylhexyl) phthalate | | ND | | 4.4 | 40 |
| Butyl benzyl phthalate | | ND | | 5.9 | 40 |
| Dibenz(a,h)anthracene | | ND | | 4.2 | 40 |
| Diethyl phthalate | | ND | | 4.7 | 40 |
| Di-n-butyl phthalate | | ND | | 5.0 | 40 |
| Di-n-octyl phthalate | | ND | | 4.1 | 40 |
| Hexachlorobenzene | | ND | | 5.4 | 40 |
| Hexachlorobutadiene | | ND | | 4.1 | 40 |
| Hexachlorocyclopentadiene | | ND | | 3.6 | 40 |
| Hexachloroethane | | ND | | 4.6 | 40 |
| Isophorone | | ND | | 5.4 | 40 |
| Nitrobenzene | | ND | | 4.3 | 40 |
| N-Nitrosodimethylamine | | ND | | 20 | 40 |
| N-Nitrosodi-n-propylamine | | ND | | 4.7 | 40 |
| N-Nitrosodiphenylamine | | ND | | 5.4 | 40 |
| Pentachlorophenol | | ND | | 4.3 | 200 |
| Phenol | | ND | | 4.3 | 40 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| 2,4,6-Tribromophenol | 86 | 5.0 - 106 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9680-1

**Client Sample ID:** **Shell 02 Sediment**

Lab Sample ID: 700-9680-14 | Date Sampled: 02/08/2006 1615
Client Matrix: Solid | Date Received: 02/10/2006 1040

**8270C Semivolatile Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)**

| | | | | | |
|---|---|---|---|---|---|
| Method: | 8270C | Analysis Batch: 700-17742 | Instrument ID: | SMC5973 | |
| Preparation: | 3550B | Prep Batch: 700-17431 | Lab File ID: | C022013.D | |
| Dilution: | 1.0 | | Initial Weight/Volume: | 50.0 | g |
| Date Analyzed: | 02/20/2006 1933 | | Final Weight/Volume: | 1.0 | mL |
| Date Prepared: | 02/17/2006 0900 | | Injection Volume: | | |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| 2-Fluorobiphenyl | 67 | 31 - 118 |
| 2-Fluorophenol | 55 | 10 - 128 |
| Nitrobenzene-d5 | 67 | 35 - 122 |
| Phenol-d5 | 57 | 29 - 113 |
| Terphenyl-d14 | 76 | 37 - 149 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9680-1

**Client Sample ID:** **Sandy 01 Water**

Lab Sample ID: 700-9680-1 | Date Sampled: 02/08/2006 1010
Client Matrix: Water | Date Received: 02/10/2006 1040

**608 Organochlorine Pesticides/PCBs in Water**

Method: 608 | Analysis Batch: 700-17493 | Instrument ID: MSGY
Preparation: CWA_Prep_CLLE | Prep Batch: 700-17324 | Lab File ID: Y021820.D
Dilution: 1.0 | Initial Weight/Volume: 1000 mL
Date Analyzed: 02/18/2006 1856 | Final Weight/Volume: 5.0 mL
Date Prepared: 02/15/2006 1515 | Injection Volume:
Column ID: PRIMARY

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Aldrin | ND | | 0.0045 | 0.050 |
| alpha-BHC | ND | | 0.0056 | 0.050 |
| beta-BHC | ND | | 0.0036 | 0.050 |
| Chlordane (technical) | ND | | 0.032 | 0.50 |
| 4,4'-DDD | ND | | 0.0076 | 0.10 |
| 4,4'-DDE | ND | | 0.0064 | 0.10 |
| 4,4'-DDT | ND | | 0.0084 | 0.10 |
| delta-BHC | ND | | 0.010 | 0.050 |
| Dieldrin | ND | | 0.0074 | 0.10 |
| Endosulfan I | ND | | 0.0044 | 0.050 |
| Endosulfan II | ND | | 0.0047 | 0.10 |
| Endosulfan sulfate | ND | | 0.0090 | 0.10 |
| Endrin | ND | | 0.0067 | 0.10 |
| Endrin aldehyde | ND | | 0.0069 | 0.10 |
| gamma-BHC (Lindane) | ND | | 0.0049 | 0.050 |
| Heptachlor | ND | | 0.0037 | 0.050 |
| Heptachlor epoxide | ND | | 0.0039 | 0.050 |
| PCB-1221 | ND | | 0.17 | 2.0 |
| PCB-1248 | ND | | 0.14 | 1.0 |
| PCB-1232 | ND | | 0.13 | 1.0 |
| PCB-1254 | ND | | 0.12 | 1.0 |
| PCB-1242 | ND | | 0.18 | 1.0 |
| PCB-1260 | ND | | 0.12 | 1.0 |
| PCB-1016 | ND | | 0.11 | 1.0 |
| Toxaphene | ND | | 0.31 | 5.0 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| DCB Decachlorobiphenyl | 33 | 30 - 150 |
| Tetrachloro-m-xylene | 56 | 30 - 150 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9680-1

**Client Sample ID:** **Sandy 01 Elutriate**

Lab Sample ID: 700-9680-3 | Date Sampled: 02/08/2006 1100
Client Matrix: Water | Date Received: 02/10/2006 1040

**608 Organochlorine Pesticides/PCBs in Water**

Method: 608 | Analysis Batch: 700-17493 | Instrument ID: MSGY
Preparation: CWA_Prep_CLLE | Prep Batch: 700-17324 | Lab File ID: Y021825.D
Dilution: 1.0 | Initial Weight/Volume: 1000 mL
Date Analyzed: 02/18/2006 2130 | Final Weight/Volume: 5.0 mL
Date Prepared: 02/15/2006 1515 | Injection Volume:
Column ID: PRIMARY

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Aldrin | ND | | 0.0045 | 0.050 |
| alpha-BHC | ND | | 0.0056 | 0.050 |
| beta-BHC | ND | | 0.0036 | 0.050 |
| Chlordane (technical) | ND | | 0.032 | 0.50 |
| 4,4'-DDD | ND | | 0.0076 | 0.10 |
| 4,4'-DDE | ND | | 0.0064 | 0.10 |
| 4,4'-DDT | ND | | 0.0084 | 0.10 |
| delta-BHC | ND | | 0.010 | 0.050 |
| Dieldrin | ND | | 0.0074 | 0.10 |
| Endosulfan I | ND | | 0.0044 | 0.050 |
| Endosulfan II | ND | | 0.0047 | 0.10 |
| Endosulfan sulfate | ND | | 0.0090 | 0.10 |
| Endrin | ND | | 0.0067 | 0.10 |
| Endrin aldehyde | ND | | 0.0069 | 0.10 |
| gamma-BHC (Lindane) | ND | | 0.0049 | 0.050 |
| Heptachlor | ND | | 0.0037 | 0.050 |
| Heptachlor epoxide | ND | | 0.0039 | 0.050 |
| PCB-1016 | ND | | 0.11 | 1.0 |
| PCB-1221 | ND | | 0.17 | 2.0 |
| PCB-1248 | ND | | 0.14 | 1.0 |
| PCB-1232 | ND | | 0.13 | 1.0 |
| PCB-1254 | ND | | 0.12 | 1.0 |
| PCB-1242 | ND | | 0.18 | 1.0 |
| PCB-1260 | ND | | 0.12 | 1.0 |
| Toxaphene | ND | | 0.31 | 5.0 |

| Surrogate | %Rec | | Acceptance Limits |
|---|---|---|---|
| DCB Decachlorobiphenyl | 14 | * | 30 - 150 |
| Tetrachloro-m-xylene | 43 | | 30 - 150 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9680-1

**Client Sample ID:** **Sandy 02 Elutriate**

Lab Sample ID: 700-9680-6 | Date Sampled: 02/08/2006 1155
Client Matrix: Water | Date Received: 02/10/2006 1040

**608 Organochlorine Pesticides/PCBs in Water**

Method: 608 | Analysis Batch: 700-17493 | Instrument ID: MSGY
Preparation: CWA_Prep_CLLE | Prep Batch: 700-17324 | Lab File ID: Y021826.D
Dilution: 1.0 | Initial Weight/Volume: 1000 mL
Date Analyzed: 02/18/2006 2200 | Final Weight/Volume: 5.0 mL
Date Prepared: 02/15/2006 1515 | Injection Volume:
Column ID: PRIMARY

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Aldrin | ND | | 0.0045 | 0.050 |
| alpha-BHC | ND | | 0.0056 | 0.050 |
| beta-BHC | ND | | 0.0036 | 0.050 |
| Chlordane (technical) | ND | | 0.032 | 0.50 |
| 4,4'-DDD | ND | | 0.0076 | 0.10 |
| 4,4'-DDE | ND | | 0.0064 | 0.10 |
| 4,4'-DDT | ND | | 0.0084 | 0.10 |
| delta-BHC | ND | | 0.010 | 0.050 |
| Dieldrin | ND | | 0.0074 | 0.10 |
| Endosulfan I | ND | | 0.0044 | 0.050 |
| Endosulfan II | ND | | 0.0047 | 0.10 |
| Endosulfan sulfate | ND | | 0.0090 | 0.10 |
| Endrin | ND | | 0.0067 | 0.10 |
| Endrin aldehyde | ND | | 0.0069 | 0.10 |
| gamma-BHC (Lindane) | ND | | 0.0049 | 0.050 |
| Heptachlor | ND | | 0.0037 | 0.050 |
| Heptachlor epoxide | ND | | 0.0039 | 0.050 |
| PCB-1016 | ND | | 0.11 | 1.0 |
| PCB-1221 | ND | | 0.17 | 2.0 |
| PCB-1248 | ND | | 0.14 | 1.0 |
| PCB-1232 | ND | | 0.13 | 1.0 |
| PCB-1254 | ND | | 0.12 | 1.0 |
| PCB-1242 | ND | | 0.18 | 1.0 |
| PCB-1260 | ND | | 0.12 | 1.0 |
| Toxaphene | ND | | 0.31 | 5.0 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| DCB Decachlorobiphenyl | 15 | 30 - 150 |
| Tetrachloro-m-xylene | 45 | 30 - 150 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID:** **Empire 01 Water**

Lab Sample ID: 700-9680-7 Date Sampled: 02/08/2006 1240
Client Matrix: Water Date Received: 02/10/2006 1040

**608 Organochlorine Pesticides/PCBs in Water**

Method: 608 Analysis Batch: 700-17493 Instrument ID: MSGY
Preparation: CWA_Prep_CLLE Prep Batch: 700-17324 Lab File ID: Y021821.D
Dilution: 1.0 Initial Weight/Volume: 1000 mL
Date Analyzed: 02/18/2006 1927 Final Weight/Volume: 5.0 mL
Date Prepared: 02/15/2006 1515 Injection Volume:
Column ID: PRIMARY

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Aldrin | ND | | 0.0045 | 0.050 |
| alpha-BHC | ND | | 0.0056 | 0.050 |
| beta-BHC | ND | | 0.0036 | 0.050 |
| Chlordane (technical) | ND | | 0.032 | 0.50 |
| 4,4'-DDD | ND | | 0.0076 | 0.10 |
| 4,4'-DDE | ND | | 0.0064 | 0.10 |
| 4,4'-DDT | ND | | 0.0084 | 0.10 |
| delta-BHC | ND | | 0.010 | 0.050 |
| Dieldrin | ND | | 0.0074 | 0.10 |
| Endosulfan I | ND | | 0.0044 | 0.050 |
| Endosulfan II | ND | | 0.0047 | 0.10 |
| Endosulfan sulfate | ND | | 0.0090 | 0.10 |
| Endrin | ND | | 0.0067 | 0.10 |
| Endrin aldehyde | ND | | 0.0069 | 0.10 |
| gamma-BHC (Lindane) | ND | | 0.0049 | 0.050 |
| Heptachlor | ND | | 0.0037 | 0.050 |
| Heptachlor epoxide | ND | | 0.0039 | 0.050 |
| PCB-1260 | ND | | 0.12 | 1.0 |
| PCB-1016 | ND | | 0.11 | 1.0 |
| PCB-1221 | ND | | 0.17 | 2.0 |
| PCB-1248 | ND | | 0.14 | 1.0 |
| PCB-1232 | ND | | 0.13 | 1.0 |
| PCB-1254 | ND | | 0.12 | 1.0 |
| PCB-1242 | ND | | 0.18 | 1.0 |
| Toxaphene | ND | | 0.31 | 5.0 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| DCB Decachlorobiphenyl | 34 | 30 - 150 |
| Tetrachloro-m-xylene | 54 | 30 - 150 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID:** **Empire 01 Elutriate**

Lab Sample ID: 700-9680-9 Date Sampled: 02/08/2006 1300
Client Matrix: Water Date Received: 02/10/2006 1040

**608 Organochlorine Pesticides/PCBs in Water**

Method: 608 Analysis Batch: 700-17493 Instrument ID: MSGY
Preparation: CWA_Prep_CLLE Prep Batch: 700-17324 Lab File ID: Y021827.D
Dilution: 1.0 Initial Weight/Volume: 1000 mL
Date Analyzed: 02/18/2006 2231 Final Weight/Volume: 5.0 mL
Date Prepared: 02/15/2006 1515 Injection Volume:
Column ID: PRIMARY

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Aldrin | ND | | 0.0045 | 0.050 |
| alpha-BHC | ND | | 0.0056 | 0.050 |
| beta-BHC | ND | | 0.0036 | 0.050 |
| Chlordane (technical) | ND | | 0.032 | 0.50 |
| 4,4'-DDD | ND | | 0.0076 | 0.10 |
| 4,4'-DDE | ND | | 0.0064 | 0.10 |
| 4,4'-DDT | ND | | 0.0084 | 0.10 |
| delta-BHC | ND | | 0.010 | 0.050 |
| Dieldrin | ND | | 0.0074 | 0.10 |
| Endosulfan I | ND | | 0.0044 | 0.050 |
| Endosulfan II | ND | | 0.0047 | 0.10 |
| Endosulfan sulfate | ND | | 0.0090 | 0.10 |
| Endrin | ND | | 0.0067 | 0.10 |
| Endrin aldehyde | ND | | 0.0069 | 0.10 |
| gamma-BHC (Lindane) | ND | | 0.0049 | 0.050 |
| Heptachlor | ND | | 0.0037 | 0.050 |
| Heptachlor epoxide | ND | | 0.0039 | 0.050 |
| PCB-1248 | ND | | 0.14 | 1.0 |
| PCB-1232 | ND | | 0.13 | 1.0 |
| PCB-1254 | ND | | 0.12 | 1.0 |
| PCB-1242 | ND | | 0.18 | 1.0 |
| PCB-1260 | ND | | 0.12 | 1.0 |
| PCB-1016 | ND | | 0.11 | 1.0 |
| PCB-1221 | ND | | 0.17 | 2.0 |
| Toxaphene | ND | | 0.31 | 5.0 |

| Surrogate | %Rec | | Acceptance Limits |
|---|---|---|---|
| DCB Decachlorobiphenyl | 24 | * | 30 - 150 |
| Tetrachloro-m-xylene | 52 | | 30 - 150 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID:** **Shell 01 Water**

Lab Sample ID: 700-9680-10 Date Sampled: 02/08/2006 1430
Client Matrix: Water Date Received: 02/10/2006 1040

**608 Organochlorine Pesticides/PCBs in Water**

Method: 608 Analysis Batch: 700-17493 Instrument ID: MSGY
Preparation: CWA_Prep_CLLE Prep Batch: 700-17324 Lab File ID: Y021822.D
Dilution: 1.0 Initial Weight/Volume: 1000 mL
Date Analyzed: 02/18/2006 1958 Final Weight/Volume: 5.0 mL
Date Prepared: 02/15/2006 1515 Injection Volume:
Column ID: PRIMARY

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Aldrin | ND | | 0.0045 | 0.050 |
| alpha-BHC | ND | | 0.0056 | 0.050 |
| beta-BHC | ND | | 0.0036 | 0.050 |
| Chlordane (technical) | ND | | 0.032 | 0.50 |
| 4,4'-DDD | ND | | 0.0076 | 0.10 |
| 4,4'-DDE | ND | | 0.0064 | 0.10 |
| 4,4'-DDT | ND | | 0.0084 | 0.10 |
| delta-BHC | ND | | 0.010 | 0.050 |
| Dieldrin | ND | | 0.0074 | 0.10 |
| Endosulfan I | ND | | 0.0044 | 0.050 |
| Endosulfan II | ND | | 0.0047 | 0.10 |
| Endosulfan sulfate | ND | | 0.0090 | 0.10 |
| Endrin | ND | | 0.0067 | 0.10 |
| Endrin aldehyde | ND | | 0.0069 | 0.10 |
| gamma-BHC (Lindane) | ND | | 0.0049 | 0.050 |
| Heptachlor | ND | | 0.0037 | 0.050 |
| Heptachlor epoxide | ND | | 0.0039 | 0.050 |
| PCB-1016 | ND | | 0.11 | 1.0 |
| PCB-1221 | ND | | 0.17 | 2.0 |
| PCB-1248 | ND | | 0.14 | 1.0 |
| PCB-1232 | ND | | 0.13 | 1.0 |
| PCB-1254 | ND | | 0.12 | 1.0 |
| PCB-1242 | ND | | 0.18 | 1.0 |
| PCB-1260 | ND | | 0.12 | 1.0 |
| Toxaphene | ND | | 0.31 | 5.0 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| DCB Decachlorobiphenyl | 30 | 30 - 150 |
| Tetrachloro-m-xylene | 59 | 30 - 150 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID:** **Shell 01 Elutriate**

Lab Sample ID: 700-9680-12 Date Sampled: 02/08/2006 1430
Client Matrix: Water Date Received: 02/10/2006 1040

**608 Organochlorine Pesticides/PCBs in Water**

Method: 608 Analysis Batch: 700-17493 Instrument ID: MSGY
Preparation: CWA_Prep_CLLE Prep Batch: 700-17324 Lab File ID: Y021828.D
Dilution: 1.0 Initial Weight/Volume: 1000 mL
Date Analyzed: 02/18/2006 2302 Final Weight/Volume: 5.0 mL
Date Prepared: 02/15/2006 1515 Injection Volume:
Column ID: PRIMARY

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Aldrin | ND | | 0.0045 | 0.050 |
| alpha-BHC | ND | | 0.0056 | 0.050 |
| beta-BHC | ND | | 0.0036 | 0.050 |
| Chlordane (technical) | ND | | 0.032 | 0.50 |
| 4,4'-DDD | ND | | 0.0076 | 0.10 |
| 4,4'-DDE | ND | | 0.0064 | 0.10 |
| 4,4'-DDT | ND | | 0.0084 | 0.10 |
| delta-BHC | ND | | 0.010 | 0.050 |
| Dieldrin | ND | | 0.0074 | 0.10 |
| Endosulfan I | ND | | 0.0044 | 0.050 |
| Endosulfan II | ND | | 0.0047 | 0.10 |
| Endosulfan sulfate | ND | | 0.0090 | 0.10 |
| Endrin | ND | | 0.0067 | 0.10 |
| Endrin aldehyde | ND | | 0.0069 | 0.10 |
| gamma-BHC (Lindane) | ND | | 0.0049 | 0.050 |
| Heptachlor | ND | | 0.0037 | 0.050 |
| Heptachlor epoxide | ND | | 0.0039 | 0.050 |
| PCB-1016 | ND | | 0.11 | 1.0 |
| PCB-1221 | ND | | 0.17 | 2.0 |
| PCB-1248 | ND | | 0.14 | 1.0 |
| PCB-1232 | ND | | 0.13 | 1.0 |
| PCB-1254 | ND | | 0.12 | 1.0 |
| PCB-1242 | ND | | 0.18 | 1.0 |
| PCB-1260 | ND | | 0.12 | 1.0 |
| Toxaphene | ND | | 0.31 | 5.0 |

| Surrogate | %Rec | | Acceptance Limits |
|---|---|---|---|
| DCB Decachlorobiphenyl | 20 | * | 30 - 150 |
| Tetrachloro-m-xylene | 43 | | 30 - 150 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID:** **Shell 02 Elutriate**

Lab Sample ID: 700-9680-15 Date Sampled: 02/08/2006 1615
Client Matrix: Water Date Received: 02/10/2006 1040

**608 Organochlorine Pesticides/PCBs in Water**

Method: 608 Analysis Batch: 700-17493 Instrument ID: MSGY
Preparation: CWA_Prep_CLLE Prep Batch: 700-17324 Lab File ID: Y021829.D
Dilution: 1.0 Initial Weight/Volume: 1000 mL
Date Analyzed: 02/18/2006 2332 Final Weight/Volume: 5.0 mL
Date Prepared: 02/15/2006 1515 Injection Volume:
Column ID: PRIMARY

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Aldrin | ND | | 0.0045 | 0.050 |
| alpha-BHC | ND | | 0.0056 | 0.050 |
| beta-BHC | ND | | 0.0036 | 0.050 |
| Chlordane (technical) | ND | | 0.032 | 0.50 |
| 4,4'-DDD | ND | | 0.0076 | 0.10 |
| 4,4'-DDE | ND | | 0.0064 | 0.10 |
| 4,4'-DDT | ND | | 0.0084 | 0.10 |
| delta-BHC | ND | | 0.010 | 0.050 |
| Dieldrin | ND | | 0.0074 | 0.10 |
| Endosulfan I | ND | | 0.0044 | 0.050 |
| Endosulfan II | ND | | 0.0047 | 0.10 |
| Endosulfan sulfate | ND | | 0.0090 | 0.10 |
| Endrin | ND | | 0.0067 | 0.10 |
| Endrin aldehyde | ND | | 0.0069 | 0.10 |
| gamma-BHC (Lindane) | ND | | 0.0049 | 0.050 |
| Heptachlor | ND | | 0.0037 | 0.050 |
| Heptachlor epoxide | ND | | 0.0039 | 0.050 |
| PCB-1221 | ND | | 0.17 | 2.0 |
| PCB-1248 | ND | | 0.14 | 1.0 |
| PCB-1232 | ND | | 0.13 | 1.0 |
| PCB-1254 | ND | | 0.12 | 1.0 |
| PCB-1242 | ND | | 0.18 | 1.0 |
| PCB-1260 | ND | | 0.12 | 1.0 |
| PCB-1016 | ND | | 0.11 | 1.0 |
| Toxaphene | ND | | 0.31 | 5.0 |

| Surrogate | %Rec | | Acceptance Limits |
|---|---|---|---|
| DCB Decachlorobiphenyl | 21 | * | 30 - 150 |
| Tetrachloro-m-xylene | 46 | | 30 - 150 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID:** **Sandy 01 Sediment**

Lab Sample ID: 700-9680-2 Date Sampled: 02/08/2006 1100
Client Matrix: Solid Date Received: 02/10/2006 1040

**8081A Organochlorine Pesticides by Gas Chromatography**

Method: 8081A Analysis Batch: 700-17870 Instrument ID: MSGY
Preparation: 3550B Prep Batch: 700-17522 Lab File ID: Y022510.D
Dilution: 1.0 Initial Weight/Volume: 50.0 g
Date Analyzed: 02/25/2006 1348 Final Weight/Volume: 5.0 mL
Date Prepared: 02/20/2006 0900 Injection Volume:
Column ID: PRIMARY

| Analyte | DryWt Corrected: N | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| Aldrin | | ND | | 0.17 | 1.0 |
| alpha-BHC | | ND | | 0.072 | 1.0 |
| beta-BHC | | ND | | 0.072 | 1.0 |
| Chlordane (technical) | | ND | | 0.90 | 10 |
| 4,4'-DDD | | ND | | 0.20 | 2.0 |
| 4,4'-DDE | | ND | | 0.18 | 2.0 |
| 4,4'-DDT | | ND | | 0.32 | 2.0 |
| delta-BHC | | ND | | 0.15 | 1.0 |
| Dieldrin | | ND | | 0.16 | 2.0 |
| Endosulfan I | | ND | | 0.072 | 1.0 |
| Endosulfan II | | ND | | 0.23 | 2.0 |
| Endosulfan sulfate | | ND | | 0.20 | 2.0 |
| Endrin | | ND | | 0.23 | 2.0 |
| Endrin aldehyde | | ND | * | 0.23 | 2.0 |
| gamma-BHC (Lindane) | | ND | | 0.066 | 1.0 |
| Heptachlor | | ND | | 0.11 | 1.0 |
| Heptachlor epoxide | | ND | | 0.078 | 1.0 |
| Toxaphene | | ND | | 6.6 | 100 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| DCB Decachlorobiphenyl | 64 | 30 - 150 |
| Tetrachloro-m-xylene | 48 | 30 - 150 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID:** **Sandy 02 Sediment**

Lab Sample ID: 700-9680-5 Date Sampled: 02/08/2006 1155
Client Matrix: Solid Date Received: 02/10/2006 1040

**8081A Organochlorine Pesticides by Gas Chromatography**

Method: 8081A Analysis Batch: 700-17870 Instrument ID: MSGY
Preparation: 3550B Prep Batch: 700-17522 Lab File ID: Y022511.D
Dilution: 1.0 Initial Weight/Volume: 50.0 g
Date Analyzed: 02/25/2006 1419 Final Weight/Volume: 5.0 mL
Date Prepared: 02/20/2006 0900 Injection Volume:
Column ID: PRIMARY

| Analyte | DryWt Corrected: N | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| Aldrin | | ND | | 0.17 | 1.0 |
| alpha-BHC | | ND | | 0.072 | 1.0 |
| beta-BHC | | ND | | 0.072 | 1.0 |
| Chlordane (technical) | | ND | | 0.90 | 10 |
| 4,4'-DDD | | ND | | 0.20 | 2.0 |
| 4,4'-DDE | | ND | | 0.18 | 2.0 |
| 4,4'-DDT | | ND | | 0.32 | 2.0 |
| delta-BHC | | ND | | 0.15 | 1.0 |
| Dieldrin | | ND | | 0.16 | 2.0 |
| Endosulfan I | | ND | | 0.072 | 1.0 |
| Endosulfan II | | ND | | 0.23 | 2.0 |
| Endosulfan sulfate | | ND | | 0.20 | 2.0 |
| Endrin | | ND | | 0.23 | 2.0 |
| Endrin aldehyde | | ND | * | 0.23 | 2.0 |
| gamma-BHC (Lindane) | | ND | | 0.066 | 1.0 |
| Heptachlor | | ND | | 0.11 | 1.0 |
| Heptachlor epoxide | | ND | | 0.078 | 1.0 |
| Toxaphene | | ND | | 6.6 | 100 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| DCB Decachlorobiphenyl | 72 | 30 - 150 |
| Tetrachloro-m-xylene | 54 | 30 - 150 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9680-1

**Client Sample ID:** **Empire 01 Sediment**

Lab Sample ID: 700-9680-8 | Date Sampled: 02/08/2006 1300
Client Matrix: Solid | Date Received: 02/10/2006 1040

**8081A Organochlorine Pesticides by Gas Chromatography**

Method: 8081A | Analysis Batch: 700-17870 | Instrument ID: MSGY
Preparation: 3550B | Prep Batch: 700-17522 | Lab File ID: Y022512.D
Dilution: 1.0 | Initial Weight/Volume: 50.0 g
Date Analyzed: 02/25/2006 1450 | Final Weight/Volume: 5.0 mL
Date Prepared: 02/20/2006 0900 | Injection Volume:
Column ID: PRIMARY

| Analyte | DryWt Corrected: N | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| Aldrin | | ND | | 0.17 | 1.0 |
| alpha-BHC | | ND | | 0.072 | 1.0 |
| beta-BHC | | ND | | 0.072 | 1.0 |
| Chlordane (technical) | | ND | | 0.90 | 10 |
| 4,4'-DDD | | ND | | 0.20 | 2.0 |
| 4,4'-DDE | | ND | | 0.18 | 2.0 |
| 4,4'-DDT | | ND | | 0.32 | 2.0 |
| delta-BHC | | ND | | 0.15 | 1.0 |
| Dieldrin | | ND | | 0.16 | 2.0 |
| Endosulfan I | | ND | | 0.072 | 1.0 |
| Endosulfan II | | ND | | 0.23 | 2.0 |
| Endosulfan sulfate | | ND | | 0.20 | 2.0 |
| Endrin | | ND | | 0.23 | 2.0 |
| Endrin aldehyde | | ND | * | 0.23 | 2.0 |
| gamma-BHC (Lindane) | | ND | | 0.066 | 1.0 |
| Heptachlor | | ND | | 0.11 | 1.0 |
| Heptachlor epoxide | | ND | | 0.078 | 1.0 |
| Toxaphene | | ND | | 6.6 | 100 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| DCB Decachlorobiphenyl | 66 | 30 - 150 |
| Tetrachloro-m-xylene | 51 | 30 - 150 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID: Shell 01 Sediment**

Lab Sample ID: 700-9680-11 Date Sampled: 02/08/2006 1440
Client Matrix: Solid Date Received: 02/10/2006 1040

**8081A Organochlorine Pesticides by Gas Chromatography**

Method: 8081A Analysis Batch: 700-17870 Instrument ID: MSGY
Preparation: 3550B Prep Batch: 700-17522 Lab File ID: Y022513.D
Dilution: 1.0 Initial Weight/Volume: 50.0 g
Date Analyzed: 02/25/2006 1520 Final Weight/Volume: 5.0 mL
Date Prepared: 02/20/2006 0900 Injection Volume:
Column ID: PRIMARY

| Analyte | DryWt Corrected: N | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| Aldrin | | ND | | 0.17 | 1.0 |
| alpha-BHC | | ND | | 0.072 | 1.0 |
| beta-BHC | | ND | | 0.072 | 1.0 |
| Chlordane (technical) | | ND | | 0.90 | 10 |
| 4,4'-DDD | | ND | | 0.20 | 2.0 |
| 4,4'-DDE | | ND | | 0.18 | 2.0 |
| 4,4'-DDT | | ND | | 0.32 | 2.0 |
| delta-BHC | | ND | | 0.15 | 1.0 |
| Dieldrin | | ND | | 0.16 | 2.0 |
| Endosulfan I | | ND | | 0.072 | 1.0 |
| Endosulfan II | | ND | | 0.23 | 2.0 |
| Endosulfan sulfate | | ND | | 0.20 | 2.0 |
| Endrin | | ND | | 0.23 | 2.0 |
| Endrin aldehyde | | ND | * | 0.23 | 2.0 |
| gamma-BHC (Lindane) | | ND | | 0.066 | 1.0 |
| Heptachlor | | ND | | 0.11 | 1.0 |
| Heptachlor epoxide | | ND | | 0.078 | 1.0 |
| Toxaphene | | ND | | 6.6 | 100 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| DCB Decachlorobiphenyl | 68 | 30 - 150 |
| Tetrachloro-m-xylene | 51 | 30 - 150 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9680-1

**Client Sample ID:** **Shell 02 Sediment**

Lab Sample ID: 700-9680-14 | Date Sampled: 02/08/2006 1615
Client Matrix: Solid | Date Received: 02/10/2006 1040

**8081A Organochlorine Pesticides by Gas Chromatography**

Method: 8081A | Analysis Batch: 700-17870 | Instrument ID: MSGY
Preparation: 3550B | Prep Batch: 700-17522 | Lab File ID: Y022514.D
Dilution: 1.0 | Initial Weight/Volume: 50.0 g
Date Analyzed: 02/25/2006 1551 | Final Weight/Volume: 5.0 mL
Date Prepared: 02/20/2006 0900 | Injection Volume:
Column ID: PRIMARY

| Analyte | DryWt Corrected: N | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| Aldrin | | ND | | 0.17 | 1.0 |
| alpha-BHC | | ND | | 0.072 | 1.0 |
| beta-BHC | | ND | | 0.072 | 1.0 |
| Chlordane (technical) | | ND | | 0.90 | 10 |
| 4,4'-DDD | | ND | | 0.20 | 2.0 |
| 4,4'-DDE | | ND | | 0.18 | 2.0 |
| 4,4'-DDT | | ND | | 0.32 | 2.0 |
| delta-BHC | | ND | | 0.15 | 1.0 |
| Dieldrin | | ND | | 0.16 | 2.0 |
| Endosulfan I | | ND | | 0.072 | 1.0 |
| Endosulfan II | | ND | | 0.23 | 2.0 |
| Endosulfan sulfate | | ND | | 0.20 | 2.0 |
| Endrin | | ND | | 0.23 | 2.0 |
| Endrin aldehyde | | ND | * | 0.23 | 2.0 |
| gamma-BHC (Lindane) | | ND | | 0.066 | 1.0 |
| Heptachlor | | ND | | 0.11 | 1.0 |
| Heptachlor epoxide | | ND | | 0.078 | 1.0 |
| Toxaphene | | ND | | 6.6 | 100 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| DCB Decachlorobiphenyl | 70 | 30 - 150 |
| Tetrachloro-m-xylene | 54 | 30 - 150 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9680-1

**Client Sample ID:** **Sandy 01 Sediment**

Lab Sample ID: 700-9680-2 | Date Sampled: 02/08/2006 1100
Client Matrix: Solid | Date Received: 02/10/2006 1040

**8082 Polychlorinated Biphenyls (PCBs) by Gas Chromatography**

Method: 8082 | Analysis Batch: 700-17870 | Instrument ID: MSGY
Preparation: 3550B | Prep Batch: 700-17524 | Lab File ID: Y022510pcb.D
Dilution: 1.0 | Initial Weight/Volume: 50.0 g
Date Analyzed: 02/25/2006 1348 | Final Weight/Volume: 5.0 mL
Date Prepared: 02/20/2006 0900 | Injection Volume:
Column ID: PRIMARY

| Analyte | DryWt Corrected: N | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| PCB-1016 | | ND | | 1.8 | 20 |
| PCB-1221 | | ND | | 1.1 | 40 |
| PCB-1232 | | ND | | 2.2 | 20 |
| PCB-1242 | | ND | | 1.7 | 20 |
| PCB-1248 | | ND | | 2.6 | 20 |
| PCB-1254 | | ND | | 1.9 | 20 |
| PCB-1260 | | ND | * | 1.6 | 20 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| DCB Decachlorobiphenyl | 63 | 30 - 150 |
| Tetrachloro-m-xylene | 41 | 30 - 150 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9680-1

**Client Sample ID:** **Sandy 02 Sediment**

Lab Sample ID: 700-9680-5 | Date Sampled: 02/08/2006 1155
Client Matrix: Solid | Date Received: 02/10/2006 1040

**8082 Polychlorinated Biphenyls (PCBs) by Gas Chromatography**

Method: 8082 | Analysis Batch: 700-17870 | Instrument ID: MSGY
Preparation: 3550B | Prep Batch: 700-17524 | Lab File ID: Y022511pcb.D
Dilution: 1.0 | Initial Weight/Volume: 50.0 g
Date Analyzed: 02/25/2006 1419 | Final Weight/Volume: 5.0 mL
Date Prepared: 02/20/2006 0900 | Injection Volume:
Column ID: PRIMARY

| Analyte | DryWt Corrected: N | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| PCB-1016 | | ND | | 1.8 | 20 |
| PCB-1221 | | ND | | 1.1 | 40 |
| PCB-1232 | | ND | | 2.2 | 20 |
| PCB-1242 | | ND | | 1.7 | 20 |
| PCB-1248 | | ND | | 2.6 | 20 |
| PCB-1254 | | 31 | | 1.9 | 20 |
| PCB-1260 | | ND | * | 1.6 | 20 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| DCB Decachlorobiphenyl | 72 | 30 - 150 |
| Tetrachloro-m-xylene | 46 | 30 - 150 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9680-1

**Client Sample ID:** **Empire 01 Sediment**

Lab Sample ID: 700-9680-8 | Date Sampled: 02/08/2006 1300
Client Matrix: Solid | Date Received: 02/10/2006 1040

**8082 Polychlorinated Biphenyls (PCBs) by Gas Chromatography**

Method: 8082 | Analysis Batch: 700-17870 | Instrument ID: MSGY
Preparation: 3550B | Prep Batch: 700-17524 | Lab File ID: Y022512pcb.D
Dilution: 1.0 | Initial Weight/Volume: 50.0 g
Date Analyzed: 02/25/2006 1450 | Final Weight/Volume: 5.0 mL
Date Prepared: 02/20/2006 0900 | Injection Volume:
Column ID: PRIMARY

| Analyte | DryWt Corrected: N | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| PCB-1016 | | ND | | 1.8 | 20 |
| PCB-1221 | | ND | | 1.1 | 40 |
| PCB-1232 | | ND | | 2.2 | 20 |
| PCB-1242 | | ND | | 1.7 | 20 |
| PCB-1248 | | ND | | 2.6 | 20 |
| PCB-1254 | | ND | | 1.9 | 20 |
| PCB-1260 | | ND | * | 1.6 | 20 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| DCB Decachlorobiphenyl | 66 | 30 - 150 |
| Tetrachloro-m-xylene | 44 | 30 - 150 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9680-1

**Client Sample ID:** **Shell 01 Sediment**

Lab Sample ID: 700-9680-11 | Date Sampled: 02/08/2006 1440
Client Matrix: Solid | Date Received: 02/10/2006 1040

**8082 Polychlorinated Biphenyls (PCBs) by Gas Chromatography**

Method: 8082 | Analysis Batch: 700-17870 | Instrument ID: MSGY
Preparation: 3550B | Prep Batch: 700-17524 | Lab File ID: Y022513pcb.D
Dilution: 1.0 | Initial Weight/Volume: 50.0 g
Date Analyzed: 02/25/2006 1520 | Final Weight/Volume: 5.0 mL
Date Prepared: 02/20/2006 0900 | Injection Volume:
Column ID: PRIMARY

| Analyte | DryWt Corrected: N | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| PCB-1016 | | ND | | 1.8 | 20 |
| PCB-1221 | | ND | | 1.1 | 40 |
| PCB-1232 | | ND | | 2.2 | 20 |
| PCB-1242 | | ND | | 1.7 | 20 |
| PCB-1248 | | ND | | 2.6 | 20 |
| PCB-1254 | | ND | | 1.9 | 20 |
| PCB-1260 | | ND | * | 1.6 | 20 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| DCB Decachlorobiphenyl | 67 | 30 - 150 |
| Tetrachloro-m-xylene | 43 | 30 - 150 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9680-1

**Client Sample ID:** **Shell 02 Sediment**

Lab Sample ID: 700-9680-14 | Date Sampled: 02/08/2006 1615
Client Matrix: Solid | Date Received: 02/10/2006 1040

**8082 Polychlorinated Biphenyls (PCBs) by Gas Chromatography**

Method: 8082 | Analysis Batch: 700-17870 | Instrument ID: MSGY
Preparation: 3550B | Prep Batch: 700-17524 | Lab File ID: Y022514pcb.D
Dilution: 1.0 | Initial Weight/Volume: 50.0 g
Date Analyzed: 02/25/2006 1551 | Final Weight/Volume: 5.0 mL
Date Prepared: 02/20/2006 0900 | Injection Volume:
Column ID: PRIMARY

| Analyte | DryWt Corrected: N | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| PCB-1016 | | ND | | 1.8 | 20 |
| PCB-1221 | | ND | | 1.1 | 40 |
| PCB-1232 | | ND | | 2.2 | 20 |
| PCB-1242 | | ND | | 1.7 | 20 |
| PCB-1248 | | ND | | 2.6 | 20 |
| PCB-1254 | | ND | | 1.9 | 20 |
| PCB-1260 | | ND | * | 1.6 | 20 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| DCB Decachlorobiphenyl | 70 | 30 - 150 |
| Tetrachloro-m-xylene | 47 | 30 - 150 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID: Sandy 01 Water**

Lab Sample ID: 700-9680-1 Date Sampled: 02/08/2006 1010
Client Matrix: Water Date Received: 02/10/2006 1040

**200.8 ICPMS Metals by 200.8 CWA-Dissolved**

Method: 200.8 Analysis Batch: 680-37853 Instrument ID: ICP MS
Preparation: 4.1.4 Prep Batch: 680-37202 Lab File ID: N/A
Dilution: 1.0 Initial Weight/Volume: 50 mL
Date Analyzed: 02/25/2006 0604 Final Weight/Volume: 250 mL
Date Prepared: 02/23/2006 1624

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Antimony | ND | | 1.0 | 2.5 |
| Arsenic | 1.7 | J | 0.60 | 2.5 |
| Beryllium | ND | | 0.15 | 0.50 |
| Cadmium | ND | | 0.10 | 0.50 |
| Chromium | ND | | 1.5 | 5.0 |
| Copper | 0.50 | J | 0.39 | 2.5 |
| Lead | ND | | 0.50 | 1.5 |
| Nickel | 0.57 | J | 0.15 | 1.0 |
| Silver | ND | | 0.25 | 1.0 |
| Thallium | 0.31 | J | 0.25 | 1.0 |
| Zinc | 14 | J | 3.5 | 20 |

Method: 200.8 Analysis Batch: 680-37853 Instrument ID: ICP MS
Preparation: 4.1.4 Prep Batch: 680-37202 Lab File ID: N/A
Dilution: 4.0 Initial Weight/Volume: 50 mL
Date Analyzed: 03/01/2006 1834 Final Weight/Volume: 250 mL
Date Prepared: 02/23/2006 1624

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Selenium | ND | | 2.0 | 10 |

**245.1 Mercury in Water by CVAA**

Method: 245.1 Analysis Batch: 700-17272 Instrument ID: LEEMAN PS200
Preparation: 245.1 Prep Batch: 700-17199 Lab File ID: N/A
Dilution: 1.0 Initial Weight/Volume: 40 mL
Date Analyzed: 02/14/2006 1631 Final Weight/Volume: 40 mL
Date Prepared: 02/13/2006 1432

| Analyte | Result (mg/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Mercury | ND | | 0.000078 | 0.00020 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID: Sandy 01 Sediment**

Lab Sample ID: 700-9680-2 Date Sampled: 02/08/2006 1100
Client Matrix: Solid Date Received: 02/10/2006 1040

**6020 Inductively Coupled Plasma - Mass Spectrometry**

Method: 6020 Analysis Batch: 680-37413 Instrument ID: ICP MS
Preparation: 3050B Prep Batch: 680-37134 Lab File ID: N/A
Dilution: 1.0 Initial Weight/Volume: 1.10 g
Date Analyzed: 02/24/2006 2139 Final Weight/Volume: 1000 mL
Date Prepared: 02/23/2006 1049

| Analyte | DryWt Corrected: N | Result (mg/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| Antimony | | ND | | 0.18 | 0.45 |
| Arsenic | | 4.2 | | 0.11 | 0.45 |
| Beryllium | | 0.36 | | 0.027 | 0.091 |
| Cadmium | | 0.13 | | 0.018 | 0.091 |
| Chromium | | 8.9 | | 0.27 | 0.91 |
| Copper | | 5.5 | B | 0.035 | 0.45 |
| Lead | | 6.7 | | 0.091 | 0.27 |
| Selenium | | 0.18 | J | 0.091 | 0.45 |
| Silver | | 0.056 | J | 0.045 | 0.18 |
| Thallium | | 0.18 | J | 0.045 | 0.18 |
| Zinc | | 35 | B | 0.25 | 3.6 |

Method: 6020 Analysis Batch: 680-37413 Instrument ID: ICP MS
Preparation: 3050B Prep Batch: 680-37134 Lab File ID: N/A
Dilution: 1.0 Initial Weight/Volume: 1.10 g
Date Analyzed: 02/25/2006 2050 Final Weight/Volume: 1000 mL
Date Prepared: 02/23/2006 1049

| Analyte | DryWt Corrected: N | Result (mg/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| Nickel | | 9.0 | B | 0.027 | 0.18 |

**7471A Mercury in Solid or Semisolid Waste (Manual Cold Vapor Technique)**

Method: 7471A Analysis Batch: 700-17398 Instrument ID: LEEMAN PS200
Preparation: 7471A Prep Batch: 700-17349 Lab File ID: N/A
Dilution: 1.0 Initial Weight/Volume: 0.57 g
Date Analyzed: 02/16/2006 1121 Final Weight/Volume: 40.0 mL
Date Prepared: 02/15/2006 1700

| Analyte | DryWt Corrected: N | Result (mg/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| Mercury | | 0.022 | * | 0.0070 | 0.014 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID: Sandy 01 Elutriate**

Lab Sample ID: 700-9680-3 Date Sampled: 02/08/2006 1100
Client Matrix: Water Date Received: 02/10/2006 1040

**200.8 ICPMS Metals by 200.8 CWA-Total Recoverable**

Method: 200.8 Analysis Batch: 680-37851 Instrument ID: ICP MS
Preparation: 4.1.4 Prep Batch: 680-37205 Lab File ID: N/A
Dilution: 1.0 Initial Weight/Volume: 50 mL
Date Analyzed: 02/25/2006 0331 Final Weight/Volume: 250 mL
Date Prepared: 02/23/2006 1637

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Antimony | ND | | 1.0 | 2.5 |
| Arsenic | 3.2 | | 0.60 | 2.5 |
| Cadmium | 0.20 | J | 0.10 | 0.50 |
| Chromium | 5.1 | | 1.5 | 5.0 |
| Copper | 3.4 | | 0.39 | 2.5 |
| Lead | 1.9 | | 0.50 | 1.5 |
| Nickel | 4.2 | | 0.15 | 1.0 |
| Silver | ND | | 0.25 | 1.0 |
| Thallium | 0.46 | J | 0.25 | 1.0 |
| Zinc | 15 | J B | 3.5 | 20 |

Method: 200.8 Analysis Batch: 680-37851 Instrument ID: ICP MS
Preparation: 4.1.4 Prep Batch: 680-37205 Lab File ID: N/A
Dilution: 4.0 Initial Weight/Volume: 50 mL
Date Analyzed: 03/01/2006 2037 Final Weight/Volume: 250 mL
Date Prepared: 02/23/2006 1637

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Selenium | ND | | 2.0 | 10 |

Method: 200.8 Analysis Batch: 680-37851 Instrument ID: ICP MS
Preparation: 4.1.4 Prep Batch: 680-37205 Lab File ID: N/A
Dilution: 4.0 Initial Weight/Volume: 50 mL
Date Analyzed: 03/03/2006 0654 Final Weight/Volume: 250 mL
Date Prepared: 02/23/2006 1637

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Beryllium | ND | | 0.60 | 2.0 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID: Sandy 01 Elutriate**

| | | | |
|---|---|---|---|
| Lab Sample ID: | 700-9680-3 | Date Sampled: | 02/08/2006 1100 |
| Client Matrix: | Water | Date Received: | 02/10/2006 1040 |

**245.1 Mercury in Water by CVAA**

| | | | | | |
|---|---|---|---|---|---|
| Method: | 245.1 | Analysis Batch: 700-17622 | | Instrument ID: | LEEMAN PS200 |
| Preparation: | 245.1 | Prep Batch: 700-17565 | | Lab File ID: | N/A |
| Dilution: | 1.0 | | | Initial Weight/Volume: | 40.0 mL |
| Date Analyzed: | 02/22/2006 1047 | | | Final Weight/Volume: | 40.0 mL |
| Date Prepared: | 02/21/2006 1015 | | | | |

| Analyte | Result (mg/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Mercury | ND | | 0.000078 | 0.00020 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9680-1

**Client Sample ID: Sandy 02 Sediment**

Lab Sample ID: 700-9680-5 | Date Sampled: 02/08/2006 1155
Client Matrix: Solid | Date Received: 02/10/2006 1040

**6020 Inductively Coupled Plasma - Mass Spectrometry**

Method: 6020 | Analysis Batch: 680-37413 | Instrument ID: ICP MS
Preparation: 3050B | Prep Batch: 680-37134 | Lab File ID: N/A
Dilution: 1.0 | Initial Weight/Volume: 1.12 g
Date Analyzed: 02/24/2006 2216 | Final Weight/Volume: 1000 mL
Date Prepared: 02/23/2006 1049

| Analyte | DryWt Corrected: N | Result (mg/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| Antimony | | ND | | 0.18 | 0.45 |
| Arsenic | | 3.5 | | 0.11 | 0.45 |
| Beryllium | | 0.30 | | 0.027 | 0.089 |
| Cadmium | | 0.074 | J | 0.018 | 0.089 |
| Chromium | | 8.2 | | 0.27 | 0.89 |
| Copper | | 6.1 | B | 0.034 | 0.45 |
| Lead | | 6.0 | | 0.089 | 0.27 |
| Selenium | | 0.14 | J | 0.089 | 0.45 |
| Silver | | 0.049 | J | 0.045 | 0.18 |
| Thallium | | 0.14 | J | 0.045 | 0.18 |
| Zinc | | 28 | B | 0.24 | 3.6 |

Method: 6020 | Analysis Batch: 680-37413 | Instrument ID: ICP MS
Preparation: 3050B | Prep Batch: 680-37134 | Lab File ID: N/A
Dilution: 1.0 | Initial Weight/Volume: 1.12 g
Date Analyzed: 02/25/2006 2126 | Final Weight/Volume: 1000 mL
Date Prepared: 02/23/2006 1049

| Analyte | DryWt Corrected: N | Result (mg/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| Nickel | | 7.6 | B | 0.027 | 0.18 |

**7471A Mercury in Solid or Semisolid Waste (Manual Cold Vapor Technique)**

Method: 7471A | Analysis Batch: 700-17398 | Instrument ID: LEEMAN PS200
Preparation: 7471A | Prep Batch: 700-17349 | Lab File ID: N/A
Dilution: 1.0 | Initial Weight/Volume: 0.84 g
Date Analyzed: 02/16/2006 1125 | Final Weight/Volume: 40.0 mL
Date Prepared: 02/15/2006 1700

| Analyte | DryWt Corrected: N | Result (mg/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| Mercury | | 0.011 | * | 0.0048 | 0.0095 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID: Sandy 02 Elutriate**

Lab Sample ID: 700-9680-6 Date Sampled: 02/08/2006 1155
Client Matrix: Water Date Received: 02/10/2006 1040

**200.8 ICPMS Metals by 200.8 CWA-Total Recoverable**

Method: 200.8 Analysis Batch: 680-37851 Instrument ID: ICP MS
Preparation: 4.1.4 Prep Batch: 680-37205 Lab File ID: N/A
Dilution: 1.0 Initial Weight/Volume: 50 mL
Date Analyzed: 02/25/2006 0407 Final Weight/Volume: 250 mL
Date Prepared: 02/23/2006 1637

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Antimony | ND | | 1.0 | 2.5 |
| Arsenic | 2.3 | J | 0.60 | 2.5 |
| Cadmium | ND | | 0.10 | 0.50 |
| Chromium | 3.3 | J | 1.5 | 5.0 |
| Copper | 3.0 | | 0.39 | 2.5 |
| Lead | 1.4 | J | 0.50 | 1.5 |
| Nickel | 3.7 | | 0.15 | 1.0 |
| Silver | ND | | 0.25 | 1.0 |
| Thallium | 0.35 | J | 0.25 | 1.0 |
| Zinc | 15 | J B | 3.5 | 20 |

Method: 200.8 Analysis Batch: 680-37851 Instrument ID: ICP MS
Preparation: 4.1.4 Prep Batch: 680-37205 Lab File ID: N/A
Dilution: 4.0 Initial Weight/Volume: 50 mL
Date Analyzed: 03/01/2006 2114 Final Weight/Volume: 250 mL
Date Prepared: 02/23/2006 1637

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Selenium | ND | | 2.0 | 10 |

Method: 200.8 Analysis Batch: 680-37851 Instrument ID: ICP MS
Preparation: 4.1.4 Prep Batch: 680-37205 Lab File ID: N/A
Dilution: 4.0 Initial Weight/Volume: 50 mL
Date Analyzed: 03/03/2006 0730 Final Weight/Volume: 250 mL
Date Prepared: 02/23/2006 1637

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Beryllium | ND | | 0.60 | 2.0 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID: Sandy 02 Elutriate**

| | | | |
|---|---|---|---|
| Lab Sample ID: | 700-9680-6 | Date Sampled: | 02/08/2006 1155 |
| Client Matrix: | Water | Date Received: | 02/10/2006 1040 |

**245.1 Mercury in Water by CVAA**

| | | | | | |
|---|---|---|---|---|---|
| Method: | 245.1 | Analysis Batch: 700-17622 | Instrument ID: | LEEMAN PS200 | |
| Preparation: | 245.1 | Prep Batch: 700-17565 | Lab File ID: | N/A | |
| Dilution: | 1.0 | | Initial Weight/Volume: | 40.0 | mL |
| Date Analyzed: | 02/22/2006 1052 | | Final Weight/Volume: | 40.0 | mL |
| Date Prepared: | 02/21/2006 1015 | | | | |

| Analyte | Result (mg/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Mercury | ND | | 0.000078 | 0.00020 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID: Empire 01 Water**

Lab Sample ID: 700-9680-7 Date Sampled: 02/08/2006 1240
Client Matrix: Water Date Received: 02/10/2006 1040

**200.8 ICPMS Metals by 200.8 CWA-Dissolved**

Method: 200.8 Analysis Batch: 680-37853 Instrument ID: ICP MS
Preparation: 4.1.4 Prep Batch: 680-37202 Lab File ID: N/A
Dilution: 1.0 Initial Weight/Volume: 50 mL
Date Analyzed: 02/25/2006 0648 Final Weight/Volume: 250 mL
Date Prepared: 02/23/2006 1624

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Antimony | ND | | 1.0 | 2.5 |
| Arsenic | 1.7 | J | 0.60 | 2.5 |
| Beryllium | ND | | 0.15 | 0.50 |
| Cadmium | 0.10 | J | 0.10 | 0.50 |
| Chromium | ND | | 1.5 | 5.0 |
| Copper | 0.54 | J | 0.39 | 2.5 |
| Lead | ND | | 0.50 | 1.5 |
| Nickel | 0.99 | J | 0.15 | 1.0 |
| Silver | ND | | 0.25 | 1.0 |
| Thallium | ND | | 0.25 | 1.0 |
| Zinc | 16 | J | 3.5 | 20 |

Method: 200.8 Analysis Batch: 680-37853 Instrument ID: ICP MS
Preparation: 4.1.4 Prep Batch: 680-37202 Lab File ID: N/A
Dilution: 4.0 Initial Weight/Volume: 50 mL
Date Analyzed: 03/01/2006 1918 Final Weight/Volume: 250 mL
Date Prepared: 02/23/2006 1624

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Selenium | ND | | 2.0 | 10 |

**245.1 Mercury in Water by CVAA**

Method: 245.1 Analysis Batch: 700-17272 Instrument ID: LEEMAN PS200
Preparation: 245.1 Prep Batch: 700-17199 Lab File ID: N/A
Dilution: 1.0 Initial Weight/Volume: 40 mL
Date Analyzed: 02/14/2006 1633 Final Weight/Volume: 40 mL
Date Prepared: 02/13/2006 1432

| Analyte | Result (mg/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Mercury | ND | | 0.000078 | 0.00020 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9680-1

**Client Sample ID: Empire 01 Sediment**

Lab Sample ID: 700-9680-8 | Date Sampled: 02/08/2006 1300
Client Matrix: Solid | Date Received: 02/10/2006 1040

**6020 Inductively Coupled Plasma - Mass Spectrometry**

Method: 6020 | Analysis Batch: 680-37413 | Instrument ID: ICP MS
Preparation: 3050B | Prep Batch: 680-37134 | Lab File ID: N/A
Dilution: 1.0 | Initial Weight/Volume: 1.06 g
Date Analyzed: 02/24/2006 2223 | Final Weight/Volume: 1000 mL
Date Prepared: 02/23/2006 1049

| Analyte | DryWt Corrected: N | Result (mg/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| Antimony | | ND | | 0.19 | 0.47 |
| Arsenic | | 2.1 | | 0.11 | 0.47 |
| Beryllium | | 0.14 | | 0.028 | 0.094 |
| Cadmium | | 0.094 | J | 0.019 | 0.094 |
| Chromium | | 5.1 | | 0.28 | 0.94 |
| Copper | | 1.5 | B | 0.036 | 0.47 |
| Lead | | 3.1 | | 0.094 | 0.28 |
| Selenium | | ND | | 0.094 | 0.47 |
| Silver | | ND | | 0.047 | 0.19 |
| Thallium | | 0.058 | J | 0.047 | 0.19 |
| Zinc | | 17 | B | 0.25 | 3.8 |

Method: 6020 | Analysis Batch: 680-37413 | Instrument ID: ICP MS
Preparation: 3050B | Prep Batch: 680-37134 | Lab File ID: N/A
Dilution: 1.0 | Initial Weight/Volume: 1.06 g
Date Analyzed: 02/25/2006 2134 | Final Weight/Volume: 1000 mL
Date Prepared: 02/23/2006 1049

| Analyte | DryWt Corrected: N | Result (mg/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| Nickel | | 6.2 | B | 0.028 | 0.19 |

**7471A Mercury in Solid or Semisolid Waste (Manual Cold Vapor Technique)**

Method: 7471A | Analysis Batch: 700-17398 | Instrument ID: LEEMAN PS200
Preparation: 7471A | Prep Batch: 700-17349 | Lab File ID: N/A
Dilution: 1.0 | Initial Weight/Volume: 0.62 g
Date Analyzed: 02/16/2006 1126 | Final Weight/Volume: 40.0 mL
Date Prepared: 02/15/2006 1700

| Analyte | DryWt Corrected: N | Result (mg/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| Mercury | | 0.012 | J * | 0.0065 | 0.013 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID: Empire 01 Elutriate**

Lab Sample ID: 700-9680-9 Date Sampled: 02/08/2006 1300
Client Matrix: Water Date Received: 02/10/2006 1040

**200.8 ICPMS Metals by 200.8 CWA-Total Recoverable**

Method: 200.8 Analysis Batch: 680-37851 Instrument ID: ICP MS
Preparation: 4.1.4 Prep Batch: 680-37205 Lab File ID: N/A
Dilution: 1.0 Initial Weight/Volume: 50 mL
Date Analyzed: 02/25/2006 0414 Final Weight/Volume: 250 mL
Date Prepared: 02/23/2006 1637

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Antimony | ND | | 1.0 | 2.5 |
| Arsenic | 2.1 | J | 0.60 | 2.5 |
| Cadmium | 0.14 | J | 0.10 | 0.50 |
| Chromium | 2.1 | J | 1.5 | 5.0 |
| Copper | 1.6 | J | 0.39 | 2.5 |
| Lead | 0.51 | J | 0.50 | 1.5 |
| Nickel | 2.5 | | 0.15 | 1.0 |
| Silver | ND | | 0.25 | 1.0 |
| Thallium | ND | | 0.25 | 1.0 |
| Zinc | 17 | J B | 3.5 | 20 |

Method: 200.8 Analysis Batch: 680-37851 Instrument ID: ICP MS
Preparation: 4.1.4 Prep Batch: 680-37205 Lab File ID: N/A
Dilution: 4.0 Initial Weight/Volume: 50 mL
Date Analyzed: 03/01/2006 2121 Final Weight/Volume: 250 mL
Date Prepared: 02/23/2006 1637

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Selenium | ND | | 2.0 | 10 |

Method: 200.8 Analysis Batch: 680-37851 Instrument ID: ICP MS
Preparation: 4.1.4 Prep Batch: 680-37205 Lab File ID: N/A
Dilution: 4.0 Initial Weight/Volume: 50 mL
Date Analyzed: 03/03/2006 0737 Final Weight/Volume: 250 mL
Date Prepared: 02/23/2006 1637

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Beryllium | ND | | 0.60 | 2.0 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID: Empire 01 Elutriate**

| | | | |
|---|---|---|---|
| Lab Sample ID: | 700-9680-9 | Date Sampled: | 02/08/2006 1300 |
| Client Matrix: | Water | Date Received: | 02/10/2006 1040 |

**245.1 Mercury in Water by CVAA**

| | | | | | |
|---|---|---|---|---|---|
| Method: | 245.1 | Analysis Batch: 700-17622 | | Instrument ID: | LEEMAN PS200 |
| Preparation: | 245.1 | Prep Batch: 700-17565 | | Lab File ID: | N/A |
| Dilution: | 1.0 | | | Initial Weight/Volume: | 40.0 mL |
| Date Analyzed: | 02/22/2006 1054 | | | Final Weight/Volume: | 40.0 mL |
| Date Prepared: | 02/21/2006 1015 | | | | |

| Analyte | Result (mg/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Mercury | ND | | 0.000078 | 0.00020 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID: Shell 01 Water**

Lab Sample ID: 700-9680-10 Date Sampled: 02/08/2006 1430
Client Matrix: Water Date Received: 02/10/2006 1040

**200.8 ICPMS Metals by 200.8 CWA-Dissolved**

Method: 200.8 Analysis Batch: 680-37853 Instrument ID: ICP MS
Preparation: 4.1.4 Prep Batch: 680-37202 Lab File ID: N/A
Dilution: 1.0 Initial Weight/Volume: 50 mL
Date Analyzed: 02/25/2006 0640 Final Weight/Volume: 250 mL
Date Prepared: 02/23/2006 1624

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Antimony | ND | | 1.0 | 2.5 |
| Arsenic | 1.8 | J | 0.60 | 2.5 |
| Beryllium | 0.16 | J | 0.15 | 0.50 |
| Cadmium | 0.17 | J | 0.10 | 0.50 |
| Chromium | ND | | 1.5 | 5.0 |
| Copper | 1.3 | J | 0.39 | 2.5 |
| Lead | ND | | 0.50 | 1.5 |
| Nickel | 1.5 | | 0.15 | 1.0 |
| Silver | ND | | 0.25 | 1.0 |
| Thallium | 0.39 | J | 0.25 | 1.0 |
| Zinc | 15 | J | 3.5 | 20 |

Method: 200.8 Analysis Batch: 680-37853 Instrument ID: ICP MS
Preparation: 4.1.4 Prep Batch: 680-37202 Lab File ID: N/A
Dilution: 4.0 Initial Weight/Volume: 50 mL
Date Analyzed: 03/01/2006 1910 Final Weight/Volume: 250 mL
Date Prepared: 02/23/2006 1624

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Selenium | ND | | 2.0 | 10 |

**245.1 Mercury in Water by CVAA**

Method: 245.1 Analysis Batch: 700-17272 Instrument ID: LEEMAN PS200
Preparation: 245.1 Prep Batch: 700-17199 Lab File ID: N/A
Dilution: 1.0 Initial Weight/Volume: 40 mL
Date Analyzed: 02/14/2006 1634 Final Weight/Volume: 40 mL
Date Prepared: 02/13/2006 1432

| Analyte | Result (mg/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Mercury | ND | | 0.000078 | 0.00020 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID: Shell 01 Sediment**

Lab Sample ID: 700-9680-11 Date Sampled: 02/08/2006 1440
Client Matrix: Solid Date Received: 02/10/2006 1040

**6020 Inductively Coupled Plasma - Mass Spectrometry**

Method: 6020 Analysis Batch: 680-37413 Instrument ID: ICP MS
Preparation: 3050B Prep Batch: 680-37134 Lab File ID: N/A
Dilution: 1.0 Initial Weight/Volume: 1.04 g
Date Analyzed: 02/24/2006 2245 Final Weight/Volume: 1000 mL
Date Prepared: 02/23/2006 1049

| Analyte | DryWt Corrected: N | Result (mg/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| Antimony | | ND | | 0.19 | 0.48 |
| Arsenic | | 3.7 | | 0.12 | 0.48 |
| Beryllium | | 0.37 | | 0.029 | 0.096 |
| Cadmium | | 0.15 | | 0.019 | 0.096 |
| Chromium | | 9.8 | | 0.29 | 0.96 |
| Copper | | 8.6 | B | 0.037 | 0.48 |
| Lead | | 8.0 | | 0.096 | 0.29 |
| Selenium | | 0.28 | J | 0.096 | 0.48 |
| Silver | | 0.068 | J | 0.048 | 0.19 |
| Thallium | | 0.12 | J | 0.048 | 0.19 |
| Zinc | | 31 | B | 0.26 | 3.8 |

Method: 6020 Analysis Batch: 680-37413 Instrument ID: ICP MS
Preparation: 3050B Prep Batch: 680-37134 Lab File ID: N/A
Dilution: 1.0 Initial Weight/Volume: 1.04 g
Date Analyzed: 02/25/2006 2155 Final Weight/Volume: 1000 mL
Date Prepared: 02/23/2006 1049

| Analyte | DryWt Corrected: N | Result (mg/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| Nickel | | 8.3 | B | 0.029 | 0.19 |

**7471A Mercury in Solid or Semisolid Waste (Manual Cold Vapor Technique)**

Method: 7471A Analysis Batch: 700-17398 Instrument ID: LEEMAN PS200
Preparation: 7471A Prep Batch: 700-17349 Lab File ID: N/A
Dilution: 1.0 Initial Weight/Volume: 0.61 g
Date Analyzed: 02/16/2006 1128 Final Weight/Volume: 40.0 mL
Date Prepared: 02/15/2006 1700

| Analyte | DryWt Corrected: N | Result (mg/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| Mercury | | 0.030 | * | 0.0066 | 0.013 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID: Shell 01 Elutriate**

Lab Sample ID: 700-9680-12 Date Sampled: 02/08/2006 1430
Client Matrix: Water Date Received: 02/10/2006 1040

**200.8 ICPMS Metals by 200.8 CWA-Total Recoverable**

Method: 200.8 Analysis Batch: 680-37851 Instrument ID: ICP MS
Preparation: 4.1.4 Prep Batch: 680-37205 Lab File ID: N/A
Dilution: 1.0 Initial Weight/Volume: 50 mL
Date Analyzed: 02/25/2006 0436 Final Weight/Volume: 250 mL
Date Prepared: 02/23/2006 1637

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Antimony | ND | | 1.0 | 2.5 |
| Arsenic | 6.0 | | 0.60 | 2.5 |
| Cadmium | 0.18 | J | 0.10 | 0.50 |
| Chromium | 4.7 | J | 1.5 | 5.0 |
| Copper | 2.3 | J | 0.39 | 2.5 |
| Lead | 1.7 | | 0.50 | 1.5 |
| Nickel | 2.9 | | 0.15 | 1.0 |
| Silver | ND | | 0.25 | 1.0 |
| Thallium | ND | | 0.25 | 1.0 |
| Zinc | 23 | B | 3.5 | 20 |

Method: 200.8 Analysis Batch: 680-37851 Instrument ID: ICP MS
Preparation: 4.1.4 Prep Batch: 680-37205 Lab File ID: N/A
Dilution: 4.0 Initial Weight/Volume: 50 mL
Date Analyzed: 03/01/2006 2143 Final Weight/Volume: 250 mL
Date Prepared: 02/23/2006 1637

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Selenium | 2.3 | J | 2.0 | 10 |

Method: 200.8 Analysis Batch: 680-37851 Instrument ID: ICP MS
Preparation: 4.1.4 Prep Batch: 680-37205 Lab File ID: N/A
Dilution: 4.0 Initial Weight/Volume: 50 mL
Date Analyzed: 03/03/2006 1148 Final Weight/Volume: 250 mL
Date Prepared: 02/23/2006 1637

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Beryllium | ND | | 0.60 | 2.0 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID: Shell 01 Elutriate**

| | | | |
|---|---|---|---|
| Lab Sample ID: | 700-9680-12 | Date Sampled: | 02/08/2006 1430 |
| Client Matrix: | Water | Date Received: | 02/10/2006 1040 |

**245.1 Mercury in Water by CVAA**

| | | | | | |
|---|---|---|---|---|---|
| Method: | 245.1 | Analysis Batch: 700-17622 | | Instrument ID: | LEEMAN PS200 |
| Preparation: | 245.1 | Prep Batch: 700-17565 | | Lab File ID: | N/A |
| Dilution: | 1.0 | | | Initial Weight/Volume: | 40.0 mL |
| Date Analyzed: | 02/22/2006 1055 | | | Final Weight/Volume: | 40.0 mL |
| Date Prepared: | 02/21/2006 1015 | | | | |

| Analyte | Result (mg/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Mercury | ND | | 0.000078 | 0.00020 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9680-1

**Client Sample ID: Shell 02 Sediment**

| | | | |
|---|---|---|---|
| Lab Sample ID: | 700-9680-14 | Date Sampled: | 02/08/2006 1615 |
| Client Matrix: | Solid | Date Received: | 02/10/2006 1040 |

**6020 Inductively Coupled Plasma - Mass Spectrometry**

| | | | | | |
|---|---|---|---|---|---|
| Method: | 6020 | Analysis Batch: 680-37413 | | Instrument ID: | ICP MS |
| Preparation: | 3050B | Prep Batch: 680-37134 | | Lab File ID: | N/A |
| Dilution: | 1.0 | | | Initial Weight/Volume: | 1.09 g |
| Date Analyzed: | 02/24/2006 2252 | | | Final Weight/Volume: | 1000 mL |
| Date Prepared: | 02/23/2006 1049 | | | | |

| Analyte | DryWt Corrected: N | Result (mg/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| Antimony | | ND | | 0.18 | 0.46 |
| Arsenic | | 1.9 | | 0.11 | 0.46 |
| Beryllium | | 0.12 | | 0.028 | 0.092 |
| Cadmium | | 0.028 | J | 0.018 | 0.092 |
| Chromium | | 3.8 | | 0.28 | 0.92 |
| Copper | | 1.1 | B | 0.035 | 0.46 |
| Lead | | 2.5 | | 0.092 | 0.28 |
| Selenium | | ND | | 0.092 | 0.46 |
| Silver | | ND | | 0.046 | 0.18 |
| Thallium | | ND | | 0.046 | 0.18 |
| Zinc | | 15 | B | 0.25 | 3.7 |

| | | | | | |
|---|---|---|---|---|---|
| Method: | 6020 | Analysis Batch: 680-37413 | | Instrument ID: | ICP MS |
| Preparation: | 3050B | Prep Batch: 680-37134 | | Lab File ID: | N/A |
| Dilution: | 1.0 | | | Initial Weight/Volume: | 1.09 g |
| Date Analyzed: | 02/25/2006 2203 | | | Final Weight/Volume: | 1000 mL |
| Date Prepared: | 02/23/2006 1049 | | | | |

| Analyte | DryWt Corrected: N | Result (mg/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| Nickel | | 5.0 | B | 0.028 | 0.18 |

**7471A Mercury in Solid or Semisolid Waste (Manual Cold Vapor Technique)**

| | | | | | |
|---|---|---|---|---|---|
| Method: | 7471A | Analysis Batch: 700-17398 | | Instrument ID: | LEEMAN PS200 |
| Preparation: | 7471A | Prep Batch: 700-17349 | | Lab File ID: | N/A |
| Dilution: | 1.0 | | | Initial Weight/Volume: | 0.56 g |
| Date Analyzed: | 02/16/2006 1129 | | | Final Weight/Volume: | 40.0 mL |
| Date Prepared: | 02/15/2006 1700 | | | | |

| Analyte | DryWt Corrected: N | Result (mg/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| Mercury | | 0.012 | J * | 0.0071 | 0.014 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID: Shell 02 Elutriate**

Lab Sample ID: 700-9680-15 Date Sampled: 02/08/2006 1615
Client Matrix: Water Date Received: 02/10/2006 1040

**200.8 ICPMS Metals by 200.8 CWA-Total Recoverable**

Method: 200.8 Analysis Batch: 680-37851 Instrument ID: ICP MS
Preparation: 4.1.4 Prep Batch: 680-37205 Lab File ID: N/A
Dilution: 1.0 Initial Weight/Volume: 50 mL
Date Analyzed: 02/25/2006 0443 Final Weight/Volume: 250 mL
Date Prepared: 02/23/2006 1637

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Antimony | ND | | 1.0 | 2.5 |
| Arsenic | 3.5 | | 0.60 | 2.5 |
| Cadmium | 0.12 | J | 0.10 | 0.50 |
| Chromium | 3.2 | J | 1.5 | 5.0 |
| Copper | 2.1 | J | 0.39 | 2.5 |
| Lead | 3.7 | | 0.50 | 1.5 |
| Nickel | 7.2 | | 0.15 | 1.0 |
| Silver | ND | | 0.25 | 1.0 |
| Thallium | ND | | 0.25 | 1.0 |
| Zinc | 32 | B | 3.5 | 20 |

Method: 200.8 Analysis Batch: 680-37851 Instrument ID: ICP MS
Preparation: 4.1.4 Prep Batch: 680-37205 Lab File ID: N/A
Dilution: 4.0 Initial Weight/Volume: 50 mL
Date Analyzed: 03/01/2006 2150 Final Weight/Volume: 250 mL
Date Prepared: 02/23/2006 1637

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Selenium | ND | | 2.0 | 10 |

Method: 200.8 Analysis Batch: 680-37851 Instrument ID: ICP MS
Preparation: 4.1.4 Prep Batch: 680-37205 Lab File ID: N/A
Dilution: 4.0 Initial Weight/Volume: 50 mL
Date Analyzed: 03/03/2006 1155 Final Weight/Volume: 250 mL
Date Prepared: 02/23/2006 1637

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Beryllium | ND | | 0.60 | 2.0 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Client Sample ID: Shell 02 Elutriate**

| | | | |
|---|---|---|---|
| Lab Sample ID: | 700-9680-15 | Date Sampled: | 02/08/2006 1615 |
| Client Matrix: | Water | Date Received: | 02/10/2006 1040 |

**245.1 Mercury in Water by CVAA**

| | | | | | |
|---|---|---|---|---|---|
| Method: | 245.1 | Analysis Batch: 700-17622 | | Instrument ID: | LEEMAN PS200 |
| Preparation: | 245.1 | Prep Batch: 700-17565 | | Lab File ID: | N/A |
| Dilution: | 1.0 | | | Initial Weight/Volume: | 40.0 mL |
| Date Analyzed: | 02/22/2006 1056 | | | Final Weight/Volume: | 40.0 mL |
| Date Prepared: | 02/21/2006 1015 | | | | |

| Analyte | Result (mg/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Mercury | ND | | 0.000078 | 0.00020 |

**Analytical Data**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**General Chemistry**

**Client Sample ID:** **Sandy 01 Water**

Lab Sample ID: 700-9680-1
Client Matrix: Water

Date Sampled: 02/08/2006 1010
Date Received: 02/10/2006 1040

| Analyte | Result | Qual | Units | MDL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Ammonia | 0.79 | | mg/L | 0.0070 | 0.030 | 1.0 | 350.1 |
| | Anly Batch: 700-17513 | Date Analyzed | 02/20/2006 0856 | | | | |
| Nitrogen, Kjeldahl | ND | | mg/L | 0.15 | 0.20 | 1.0 | 351.2 |
| | Anly Batch: 700-17470 | Date Analyzed | 02/17/2006 1622 | | | | |
| | Prep Batch: 700-17446 | Date Prepared: | 02/16/2006 1800 | | | | |
| Nitrogen, Nitrate Nitrite | 760 | B | mg/L | 24 | 50 | 1000 | 353.2 |
| | Anly Batch: 700-17424 | Date Analyzed | 02/15/2006 1120 | | | | |
| Phosphorus, Total | 0.062 | J | mg/L | 0.000030 | 0.10 | 1.0 | 365.4 |
| | Anly Batch: 700-17469 | Date Analyzed | 02/17/2006 1622 | | | | |
| | Prep Batch: 700-17448 | Date Prepared: | 02/16/2006 1800 | | | | |

| Analyte | Result | Qual | Units | RL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Nitrogen, Organic | ND | | mg/L | 0.030 | 0.030 | 1.0 | Nitrogen,Org |
| | Anly Batch: 700-17859 | Date Analyzed | 02/17/2006 2021 | | | | |

**Analytical Data**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**General Chemistry**

**Client Sample ID:** **Sandy 01 Sediment**

Lab Sample ID: 700-9680-2
Client Matrix: Solid

Date Sampled: 02/08/2006 1100
Date Received: 02/10/2006 1040

| Analyte | Result | Qual | Units | MDL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Ammonia-Soluble | 4.1 | | mg/Kg | 0.14 | 0.49 | 1.0 | 350.1 |
| Anly Batch: 700-17558 | Date Analyzed | | 02/17/2006 1952 | | | DryWt Corrected: N | |
| TKN | 140 | | mg/Kg | 1.8 | 31 | 1.0 | 351.2 |
| Anly Batch: 700-17470 | Date Analyzed | | 02/17/2006 1623 | | | DryWt Corrected: N | |
| Prep Batch: 700-17446 | Date Prepared: | | 02/16/2006 1800 | | | | |
| Nitrogen, Nitrate Nitrite-Soluble | 4.1 | B | mg/Kg | 0.47 | 0.98 | 1.0 | 353.2 |
| Anly Batch: 700-17424 | Date Analyzed | | 02/15/2006 1101 | | | DryWt Corrected: N | |
| Phosphorus, Total | 140 | | mg/Kg | 0.37 | 15 | 1.0 | 365.4 |
| Anly Batch: 700-17469 | Date Analyzed | | 02/17/2006 1623 | | | DryWt Corrected: N | |
| Prep Batch: 700-17448 | Date Prepared: | | 02/16/2006 1800 | | | | |

| Analyte | Result | Qual | Units | RL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Percent Moisture | 38 | H | % | 0.10 | 0.10 | 1.0 | 160.3 |
| Anly Batch: 700-17490 | Date Analyzed | | 02/17/2006 1600 | | | | |
| Percent Solids | 62 | H | % | 0.10 | 0.10 | 1.0 | 160.3 |
| Anly Batch: 700-17490 | Date Analyzed | | 02/17/2006 1600 | | | | |
| Nitrogen, Total | 150 | | mg/Kg | 50 | 50 | 1.0 | Total Nitrogen |
| Anly Batch: 700-17831 | Date Analyzed | | 02/17/2006 1558 | | | DryWt Corrected: N | |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**General Chemistry**

**Client Sample ID:** **Sandy 01 Elutriate**

Lab Sample ID: 700-9680-3
Client Matrix: Water

Date Sampled: 02/08/2006 1100
Date Received: 02/10/2006 1040

| Analyte | Result | Qual | Units | MDL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Ammonia | 0.022 | J | mg/L | 0.0070 | 0.030 | 1.0 | 350.1 |
| Anly Batch: 700-17513 | Date Analyzed | | 02/20/2006 0856 | | | | |
| Nitrogen, Kjeldahl | 0.81 | | mg/L | 0.15 | 0.20 | 1.0 | 351.2 |
| Anly Batch: 700-17470 | Date Analyzed | | 02/17/2006 1624 | | | | |
| Prep Batch: 700-17446 | Date Prepared: | | 02/16/2006 1800 | | | | |
| Nitrogen, Nitrate Nitrite | 1.7 | | mg/L | 0.048 | 0.10 | 2.0 | 353.2 |
| Anly Batch: 700-17716 | Date Analyzed | | 02/23/2006 1643 | | | | |
| Phosphorus, Total | 0.20 | | mg/L | 0.000030 | 0.10 | 1.0 | 365.4 |
| Anly Batch: 700-17469 | Date Analyzed | | 02/17/2006 1624 | | | | |
| Prep Batch: 700-17448 | Date Prepared: | | 02/16/2006 1800 | | | | |

| Analyte | Result | Qual | Units | RL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Nitrogen, Organic | 0.79 | | mg/L | 0.030 | 0.030 | 1.0 | Nitrogen,Org |
| Anly Batch: 700-17859 | Date Analyzed | | 02/17/2006 2021 | | | | |

**Analytical Data**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**General Chemistry**

**Client Sample ID:** **Sandy 02 Sediment**

Lab Sample ID: 700-9680-5
Client Matrix: Solid

Date Sampled: 02/08/2006 1155
Date Received: 02/10/2006 1040

| Analyte | Result | Qual | Units | MDL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Ammonia-Soluble | 5.7 | | mg/Kg | 0.11 | 0.39 | 1.0 | 350.1 |
| Anly Batch: 700-17558 | Date Analyzed | | 02/17/2006 1952 | | | DryWt Corrected: N | |
| TKN | 540 | | mg/Kg | 2.9 | 49 | 1.0 | 351.2 |
| Anly Batch: 700-17470 | Date Analyzed | | 02/17/2006 1625 | | | DryWt Corrected: N | |
| Prep Batch: 700-17446 | Date Prepared: | | 02/16/2006 1800 | | | | |
| Nitrogen, Nitrate Nitrite-Soluble | 2.7 | B | mg/Kg | 0.37 | 0.77 | 1.0 | 353.2 |
| Anly Batch: 700-17424 | Date Analyzed | | 02/15/2006 1102 | | | DryWt Corrected: N | |
| Phosphorus, Total | 310 | | mg/Kg | 0.59 | 24 | 1.0 | 365.4 |
| Anly Batch: 700-17469 | Date Analyzed | | 02/17/2006 1625 | | | DryWt Corrected: N | |
| Prep Batch: 700-17448 | Date Prepared: | | 02/16/2006 1800 | | | | |

| Analyte | Result | Qual | Units | RL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Percent Moisture | 46 | H | % | 0.10 | 0.10 | 1.0 | 160.3 |
| Anly Batch: 700-17490 | Date Analyzed | | 02/17/2006 1600 | | | | |
| Percent Solids | 54 | H | % | 0.10 | 0.10 | 1.0 | 160.3 |
| Anly Batch: 700-17490 | Date Analyzed | | 02/17/2006 1600 | | | | |
| Nitrogen, Total | 550 | | mg/Kg | 50 | 50 | 1.0 | Total Nitrogen |
| Anly Batch: 700-17831 | Date Analyzed | | 02/17/2006 1558 | | | DryWt Corrected: N | |

**Analytical Data**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**General Chemistry**

**Client Sample ID:** **Sandy 02 Elutriate**

Lab Sample ID: 700-9680-6
Client Matrix: Water

Date Sampled: 02/08/2006 1155
Date Received: 02/10/2006 1040

| Analyte | Result | Qual | Units | MDL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Ammonia | 0.12 | | mg/L | 0.0070 | 0.030 | 1.0 | 350.1 |
| | Anly Batch: 700-17513 | Date Analyzed | 02/20/2006 0856 | | | | |
| Nitrogen, Kjeldahl | 1.2 | | mg/L | 0.15 | 0.20 | 1.0 | 351.2 |
| | Anly Batch: 700-17470 | Date Analyzed | 02/17/2006 1627 | | | | |
| | Prep Batch: 700-17446 | Date Prepared: | 02/16/2006 1800 | | | | |
| Nitrogen, Nitrate Nitrite | 1.7 | | mg/L | 0.024 | 0.050 | 1.0 | 353.2 |
| | Anly Batch: 700-17716 | Date Analyzed | 02/23/2006 1644 | | | | |
| Phosphorus, Total | 0.15 | | mg/L | 0.000030 | 0.10 | 1.0 | 365.4 |
| | Anly Batch: 700-17469 | Date Analyzed | 02/17/2006 1627 | | | | |
| | Prep Batch: 700-17448 | Date Prepared: | 02/16/2006 1800 | | | | |

| Analyte | Result | Qual | Units | RL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Nitrogen, Organic | 1.1 | | mg/L | 0.030 | 0.030 | 1.0 | Nitrogen,Org |
| | Anly Batch: 700-17859 | Date Analyzed | 02/17/2006 2021 | | | | |

**Analytical Data**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**General Chemistry**

**Client Sample ID:** **Empire 01 Water**

Lab Sample ID: 700-9680-7
Client Matrix: Water

Date Sampled: 02/08/2006 1240
Date Received: 02/10/2006 1040

| Analyte | Result | Qual | Units | MDL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Ammonia | 0.47 | | mg/L | 0.0070 | 0.030 | 1.0 | 350.1 |
| | Anly Batch: 700-17513 | Date Analyzed | | 02/20/2006 0856 | | | |
| Nitrogen, Kjeldahl | ND | | mg/L | 0.15 | 0.20 | 1.0 | 351.2 |
| | Anly Batch: 700-17470 | Date Analyzed | | 02/17/2006 1631 | | | |
| | Prep Batch: 700-17446 | Date Prepared: | | 02/16/2006 1800 | | | |
| Nitrogen, Nitrate Nitrite | 950 | B | mg/L | 12 | 25 | 500 | 353.2 |
| | Anly Batch: 700-17424 | Date Analyzed | | 02/15/2006 1058 | | | |
| Phosphorus, Total | 0.075 | J | mg/L | 0.000030 | 0.10 | 1.0 | 365.4 |
| | Anly Batch: 700-17469 | Date Analyzed | | 02/17/2006 1631 | | | |
| | Prep Batch: 700-17448 | Date Prepared: | | 02/16/2006 1800 | | | |

| Analyte | Result | Qual | Units | RL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Nitrogen, Organic | ND | | mg/L | 0.030 | 0.030 | 1.0 | Nitrogen,Org |
| | Anly Batch: 700-17859 | Date Analyzed | | 02/17/2006 2021 | | | |

**Analytical Data**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**General Chemistry**

**Client Sample ID:** **Empire 01 Sediment**

Lab Sample ID: 700-9680-8
Client Matrix: Solid

Date Sampled: 02/08/2006 1300
Date Received: 02/10/2006 1040

| Analyte | Result | Qual | Units | MDL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Ammonia-Soluble | 4.3 | | mg/Kg | 0.12 | 0.41 | 1.0 | 350.1 |
| | Anly Batch: 700-17558 | Date Analyzed | 02/17/2006 1952 | | | DryWt Corrected: N | |
| TKN | 210 | | mg/Kg | 2.3 | 38 | 1.0 | 351.2 |
| | Anly Batch: 700-17470 | Date Analyzed | 02/17/2006 1632 | | | DryWt Corrected: N | |
| | Prep Batch: 700-17446 | Date Prepared: | 02/16/2006 1800 | | | | |
| Nitrogen, Nitrate Nitrite-Soluble | 2.5 | B | mg/Kg | 0.40 | 0.83 | 1.0 | 353.2 |
| | Anly Batch: 700-17424 | Date Analyzed | 02/15/2006 1103 | | | DryWt Corrected: N | |
| Phosphorus, Total | 380 | | mg/Kg | 0.46 | 19 | 1.0 | 365.4 |
| | Anly Batch: 700-17469 | Date Analyzed | 02/17/2006 1632 | | | DryWt Corrected: N | |
| | Prep Batch: 700-17448 | Date Prepared: | 02/16/2006 1800 | | | | |

| Analyte | Result | Qual | Units | RL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Percent Moisture | 25 | H | % | 0.10 | 0.10 | 1.0 | 160.3 |
| | Anly Batch: 700-17490 | Date Analyzed | 02/17/2006 1600 | | | | |
| Percent Solids | 75 | H | % | 0.10 | 0.10 | 1.0 | 160.3 |
| | Anly Batch: 700-17490 | Date Analyzed | 02/17/2006 1600 | | | | |
| Nitrogen, Total | 210 | | mg/Kg | 50 | 50 | 1.0 | Total Nitrogen |
| | Anly Batch: 700-17831 | Date Analyzed | 02/17/2006 1558 | | | DryWt Corrected: N | |

**Analytical Data**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**General Chemistry**

**Client Sample ID:** **Empire 01 Elutriate**

Lab Sample ID: 700-9680-9
Client Matrix: Water

Date Sampled: 02/08/2006 1300
Date Received: 02/10/2006 1040

| Analyte | Result | Qual | Units | MDL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Ammonia | ND | | mg/L | 0.0070 | 0.030 | 1.0 | 350.1 |
| | Anly Batch: 700-17513 | Date Analyzed | | 02/20/2006 0856 | | | |
| Nitrogen, Kjeldahl | 1.0 | | mg/L | 0.15 | 0.20 | 1.0 | 351.2 |
| | Anly Batch: 700-17470 | Date Analyzed | | 02/17/2006 1633 | | | |
| | Prep Batch: 700-17446 | Date Prepared: | | 02/16/2006 1800 | | | |
| Nitrogen, Nitrate Nitrite | 0.56 | | mg/L | 0.024 | 0.050 | 1.0 | 353.2 |
| | Anly Batch: 700-17716 | Date Analyzed | | 02/23/2006 1645 | | | |
| Phosphorus, Total | 0.34 | | mg/L | 0.000030 | 0.10 | 1.0 | 365.4 |
| | Anly Batch: 700-17469 | Date Analyzed | | 02/17/2006 1633 | | | |
| | Prep Batch: 700-17448 | Date Prepared: | | 02/16/2006 1800 | | | |

| Analyte | Result | Qual | Units | RL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Nitrogen, Organic | 1.0 | | mg/L | 0.030 | 0.030 | 1.0 | Nitrogen,Org |
| | Anly Batch: 700-17859 | Date Analyzed | | 02/17/2006 2021 | | | |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**General Chemistry**

**Client Sample ID:** **Shell 01 Water**

Lab Sample ID: 700-9680-10
Client Matrix: Water

Date Sampled: 02/08/2006 1430
Date Received: 02/10/2006 1040

| Analyte | Result | Qual | Units | MDL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Ammonia | 0.83 | | mg/L | 0.0070 | 0.030 | 1.0 | 350.1 |
| | Anly Batch: 700-17513 | Date Analyzed | 02/20/2006 0856 | | | | |
| Nitrogen, Kjeldahl | ND | | mg/L | 0.15 | 0.20 | 1.0 | 351.2 |
| | Anly Batch: 700-17470 | Date Analyzed | 02/17/2006 1634 | | | | |
| | Prep Batch: 700-17446 | Date Prepared: | 02/16/2006 1800 | | | | |
| Nitrogen, Nitrate Nitrite | 870 | B | mg/L | 12 | 25 | 500 | 353.2 |
| | Anly Batch: 700-17424 | Date Analyzed | 02/15/2006 1100 | | | | |
| Phosphorus, Total | 0.11 | | mg/L | 0.000030 | 0.10 | 1.0 | 365.4 |
| | Anly Batch: 700-17469 | Date Analyzed | 02/17/2006 1634 | | | | |
| | Prep Batch: 700-17448 | Date Prepared: | 02/16/2006 1800 | | | | |

| Analyte | Result | Qual | Units | RL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Nitrogen, Organic | ND | | mg/L | 0.030 | 0.030 | 1.0 | Nitrogen,Org |
| | Anly Batch: 700-17859 | Date Analyzed | 02/17/2006 2021 | | | | |

**Analytical Data**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**General Chemistry**

**Client Sample ID:** **Shell 01 Sediment**

Lab Sample ID: 700-9680-11
Client Matrix: Solid

Date Sampled: 02/08/2006 1440
Date Received: 02/10/2006 1040

| Analyte | Result | Qual | Units | MDL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Ammonia-Soluble | 13 | | mg/Kg | 0.093 | 0.33 | 1.0 | 350.1 |
| Anly Batch: 700-17558 | Date Analyzed | | 02/17/2006 1952 | | | DryWt Corrected: N | |
| TKN | 580 | | mg/Kg | 2.8 | 47 | 1.0 | 351.2 |
| Anly Batch: 700-17470 | Date Analyzed | | 02/17/2006 1635 | | | DryWt Corrected: N | |
| Prep Batch: 700-17446 | Date Prepared: | | 02/16/2006 1800 | | | | |
| Nitrogen, Nitrate Nitrite-Soluble | 3.8 | B | mg/Kg | 0.32 | 0.66 | 1.0 | 353.2 |
| Anly Batch: 700-17424 | Date Analyzed | | 02/15/2006 1116 | | | DryWt Corrected: N | |
| Phosphorus, Total | 260 | | mg/Kg | 0.56 | 24 | 1.0 | 365.4 |
| Anly Batch: 700-17469 | Date Analyzed | | 02/17/2006 1635 | | | DryWt Corrected: N | |
| Prep Batch: 700-17448 | Date Prepared: | | 02/16/2006 1800 | | | | |

| Analyte | Result | Qual | Units | RL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Percent Moisture | 58 | H | % | 0.10 | 0.10 | 1.0 | 160.3 |
| Anly Batch: 700-17490 | Date Analyzed | | 02/17/2006 1600 | | | | |
| Percent Solids | 42 | H | % | 0.10 | 0.10 | 1.0 | 160.3 |
| Anly Batch: 700-17490 | Date Analyzed | | 02/17/2006 1600 | | | | |
| Nitrogen, Total | 590 | | mg/Kg | 50 | 50 | 1.0 | Total Nitrogen |
| Anly Batch: 700-17831 | Date Analyzed | | 02/17/2006 1558 | | | DryWt Corrected: N | |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**General Chemistry**

**Client Sample ID:** **Shell 01 Elutriate**

Lab Sample ID: 700-9680-12 Date Sampled: 02/08/2006 1430
Client Matrix: Water Date Received: 02/10/2006 1040

| Analyte | Result | Qual | Units | MDL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Ammonia | ND | | mg/L | 0.0070 | 0.030 | 1.0 | 350.1 |
| | Anly Batch: 700-17513 | Date Analyzed | 02/20/2006 0902 | | | | |
| Nitrogen, Kjeldahl | 4.7 | | mg/L | 0.15 | 0.20 | 1.0 | 351.2 |
| | Anly Batch: 700-17598 | Date Analyzed | 02/21/2006 1711 | | | | |
| | Prep Batch: 700-17595 | Date Prepared: | 02/20/2006 2206 | | | | |
| Nitrogen, Nitrate Nitrite | 0.47 | | mg/L | 0.024 | 0.050 | 1.0 | 353.2 |
| | Anly Batch: 700-17716 | Date Analyzed | 02/23/2006 1646 | | | | |
| Phosphorus, Total | 0.86 | | mg/L | 0.000030 | 0.10 | 1.0 | 365.4 |
| | Anly Batch: 700-17597 | Date Analyzed | 02/21/2006 1711 | | | | |
| | Prep Batch: 700-17596 | Date Prepared: | 02/20/2006 2206 | | | | |

| Analyte | Result | Qual | Units | RL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Nitrogen, Organic | 4.7 | | mg/L | 0.030 | 0.030 | 1.0 | Nitrogen,Org |
| | Anly Batch: 700-17859 | Date Analyzed | 02/17/2006 2021 | | | | |

**Analytical Data**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**General Chemistry**

**Client Sample ID:** **Shell 02 Sediment**

Lab Sample ID: 700-9680-14
Client Matrix: Solid

Date Sampled: 02/08/2006 1615
Date Received: 02/10/2006 1040

| Analyte | Result | Qual | Units | MDL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Ammonia-Soluble | 8.1 | | mg/Kg | 0.12 | 0.42 | 1.0 | 350.1 |
| Anly Batch: 700-17558 | Date Analyzed | | 02/17/2006 1952 | | | DryWt Corrected: N | |
| TKN | 160 | | mg/Kg | 2.2 | 36 | 1.0 | 351.2 |
| Anly Batch: 700-17598 | Date Analyzed | | 02/21/2006 1712 | | | DryWt Corrected: N | |
| Prep Batch: 700-17595 | Date Prepared: | | 02/20/2006 2206 | | | | |
| Nitrogen, Nitrate Nitrite-Soluble | 2.9 | B | mg/Kg | 0.40 | 0.84 | 1.0 | 353.2 |
| Anly Batch: 700-17424 | Date Analyzed | | 02/15/2006 1104 | | | DryWt Corrected: N | |
| Phosphorus, Total | 390 | | mg/Kg | 0.44 | 18 | 1.0 | 365.4 |
| Anly Batch: 700-17597 | Date Analyzed | | 02/21/2006 1712 | | | DryWt Corrected: N | |
| Prep Batch: 700-17596 | Date Prepared: | | 02/20/2006 2206 | | | | |

| Analyte | Result | Qual | Units | RL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Percent Moisture | 25 | H | % | 0.10 | 0.10 | 1.0 | 160.3 |
| Anly Batch: 700-17490 | Date Analyzed | | 02/17/2006 1600 | | | | |
| Percent Solids | 75 | H | % | 0.10 | 0.10 | 1.0 | 160.3 |
| Anly Batch: 700-17490 | Date Analyzed | | 02/17/2006 1600 | | | | |
| Nitrogen, Total | 170 | | mg/Kg | 50 | 50 | 1.0 | Total Nitrogen |
| Anly Batch: 700-17812 | Date Analyzed | | 02/21/2006 1657 | | | DryWt Corrected: N | |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**General Chemistry**

**Client Sample ID:** **Shell 02 Elutriate**

Lab Sample ID: 700-9680-15
Client Matrix: Water

Date Sampled: 02/08/2006 1615
Date Received: 02/10/2006 1040

| Analyte | Result | Qual | Units | MDL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Ammonia | 0.044 | | mg/L | 0.0070 | 0.030 | 1.0 | 350.1 |
| | Anly Batch: 700-17513 | Date Analyzed | 02/20/2006 0902 | | | | |
| Nitrogen, Kjeldahl | 0.97 | | mg/L | 0.15 | 0.20 | 1.0 | 351.2 |
| | Anly Batch: 700-17598 | Date Analyzed | 02/21/2006 1713 | | | | |
| | Prep Batch: 700-17595 | Date Prepared: | 02/20/2006 2206 | | | | |
| Nitrogen, Nitrate Nitrite | 0.49 | | mg/L | 0.024 | 0.050 | 1.0 | 353.2 |
| | Anly Batch: 700-17716 | Date Analyzed | 02/23/2006 1647 | | | | |
| Phosphorus, Total | 0.27 | | mg/L | 0.000030 | 0.10 | 1.0 | 365.4 |
| | Anly Batch: 700-17597 | Date Analyzed | 02/21/2006 1713 | | | | |
| | Prep Batch: 700-17596 | Date Prepared: | 02/20/2006 2206 | | | | |

| Analyte | Result | Qual | Units | RL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Nitrogen, Organic | 0.93 | | mg/L | 0.030 | 0.030 | 1.0 | Nitrogen,Org |
| | Anly Batch: 700-17859 | Date Analyzed | 02/17/2006 2021 | | | | |

## DATA REPORTING QUALIFIERS

Client: Providence Engineering & Environmental Job Number: 700-9680-1

| Lab Section | Qualifier | Description |
|---|---|---|
| GC/MS VOA | | |
| | J | Result is less than the RL but greater than or equal to the MDL and the concentration is an approximate value. |
| GC/MS Semi VOA | | |
| | J | Result is less than the RL but greater than or equal to the MDL and the concentration is an approximate value. |
| GC Semi VOA | | |
| | * | LCS, LCSD, MS, MSD, MD, or Surrogate exceeds the control limits |
| Metals | | |
| | B | Compound was found in the blank and sample. |
| | * | LCS, LCSD, MS, MSD, MD, or Surrogate exceeds the control limits |
| | J | Result is less than the RL but greater than or equal to the MDL and the concentration is an approximate value. |
| General Chemistry | | |
| | B | Compound was found in the blank and sample. |
| | J | Result is less than the RL but greater than or equal to the MDL and the concentration is an approximate value. |
| | H | Sample was prepped or analyzed beyond the specified holding time |

# QUALITY CONTROL RESULTS

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**Method Blank - Batch: 700-17450**

**Method: 624**
**Preparation: N/A**

Lab Sample ID: MB 700-17450/3
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/16/2006 1200
Date Prepared: N/A

Analysis Batch: 700-17450
Prep Batch: N/A
Units: ug/L

Instrument ID: VMG5973
Lab File ID: G021605.D
Initial Weight/Volume: 5 mL
Final Weight/Volume: 5 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| 1,1,1-Trichloroethane | ND | | 0.19 | 5.0 |
| 1,1,2,2-Tetrachloroethane | ND | | 0.25 | 5.0 |
| 1,1,2-Trichloroethane | ND | | 0.31 | 5.0 |
| 1,1-Dichloroethane | ND | | 0.14 | 5.0 |
| 1,1-Dichloroethene | ND | | 0.38 | 5.0 |
| 1,2-Dichloroethane | ND | | 0.15 | 5.0 |
| 1,2-Dichloropropane | ND | | 0.15 | 5.0 |
| 2-Chloroethyl vinyl ether | ND | | 0.50 | 50 |
| Acrolein | ND | | 9.6 | 100 |
| Acrylonitrile | ND | | 0.67 | 100 |
| Benzene | ND | | 0.12 | 5.0 |
| Bromoform | ND | | 0.18 | 5.0 |
| Bromomethane | ND | | 0.80 | 10 |
| Carbon tetrachloride | ND | | 0.56 | 5.0 |
| Chlorobenzene | ND | | 0.17 | 5.0 |
| Chlorodibromomethane | ND | | 0.50 | 5.0 |
| Chloroethane | ND | | 0.84 | 10 |
| Chloroform | ND | | 0.18 | 5.0 |
| Chloromethane | ND | | 0.15 | 10 |
| Dichlorobromomethane | ND | | 0.50 | 5.0 |
| Ethylbenzene | ND | | 0.56 | 5.0 |
| Methylene Chloride | ND | | 0.45 | 5.0 |
| Tetrachloroethene | ND | | 0.20 | 5.0 |
| Toluene | ND | | 0.19 | 5.0 |
| trans-1,2-Dichloroethene | ND | | 0.24 | 5.0 |
| Trichloroethene | ND | | 0.29 | 5.0 |
| Vinyl chloride | ND | | 0.22 | 10 |
| 1,3-Dichloropropane | ND | | 0.50 | 5.0 |

| Surrogate | % Rec | Acceptance Limits |
|---|---|---|
| Toluene-d8 | 111 | 77 - 116 |
| Dibromofluoromethane | 118 | 66 - 125 |
| 4-Bromofluorobenzene | 107 | 70 - 118 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17450**

**Method: 624**
**Preparation: N/A**

LCS Lab Sample ID: LCS 700-17450/1
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/16/2006 1028
Date Prepared: N/A

Analysis Batch: 700-17450
Prep Batch: N/A
Units: ug/L

Instrument ID: VMG5973
Lab File ID: G021602.D
Initial Weight/Volume: 5 mL
Final Weight/Volume: 5 mL

LCSD Lab Sample ID: LCSD 700-17450/2
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/16/2006 1059
Date Prepared: N/A

Analysis Batch: 700-17450
Prep Batch: N/A
Units: ug/L

Instrument ID: VMG5973
Lab File ID: G021603.D
Initial Weight/Volume: 5 mL
Final Weight/Volume: 5 mL

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| 1,1,1-Trichloroethane | 96 | 91 | 52 - 162 | 5 | 25 | | |
| 1,1,2,2-Tetrachloroethane | 95 | 104 | 46 - 157 | 9 | 25 | | |
| 1,1,2-Trichloroethane | 113 | 113 | 52 - 150 | 0 | 25 | | |
| 1,1-Dichloroethane | 102 | 99 | 59 - 155 | 3 | 40 | | |
| 1,1-Dichloroethene | 106 | 103 | 1 - 234 | 2 | 25 | | |
| 1,2-Dichloroethane | 92 | 91 | 49 - 155 | 1 | 26 | | |
| 1,2-Dichloropropane | 109 | 108 | 1 - 210 | 1 | 25 | | |
| 2-Chloroethyl vinyl ether | 123 | 126 | 1 - 305 | 3 | 40 | | |
| Acrolein | 123 | 136 | 54 - 145 | 10 | 74 | | |
| Acrylonitrile | 114 | 117 | 10 - 183 | 3 | 41 | | |
| Benzene | 99 | 97 | 37 - 151 | 2 | 31 | | |
| Bromoform | 105 | 109 | 45 - 169 | 3 | 30 | | |
| Bromomethane | 117 | 123 | 1 - 242 | 5 | 32 | | |
| Carbon tetrachloride | 96 | 89 | 50 - 150 | 8 | 25 | | |
| Chlorobenzene | 101 | 103 | 37 - 160 | 1 | 25 | | |
| Chlorodibromomethane | 101 | 101 | 37 - 151 | 0 | 40 | | |
| Chloroethane | 116 | 122 | 14 - 230 | 5 | 36 | | |
| Chloroform | 99 | 99 | 51 - 138 | 1 | 25 | | |
| Chloromethane | 89 | 94 | 1 - 273 | 5 | 40 | | |
| Dichlorobromomethane | 94 | 93 | 53 - 149 | 1 | 25 | | |
| Ethylbenzene | 103 | 100 | 37 - 162 | 3 | 25 | | |
| Methylene Chloride | 106 | 105 | 1 - 221 | 1 | 37 | | |
| Tetrachloroethene | 111 | 105 | 64 - 148 | 6 | 40 | | |
| Toluene | 122 | 116 | 47 - 150 | 5 | 25 | | |
| trans-1,2-Dichloroethene | 102 | 99 | 54 - 156 | 3 | 40 | | |
| Trichloroethene | 110 | 104 | 71 - 157 | 6 | 25 | | |
| Vinyl chloride | 103 | 109 | 1 - 251 | 6 | 40 | | |
| 1,3-Dichloropropane | 98 | 99 | 50 - 150 | 1 | 40 | | |

| Surrogate | LCS % Rec | LCSD % Rec | Acceptance Limits |
|---|---|---|---|
| Toluene-d8 | 111 | 108 | 77 - 116 |
| Dibromofluoromethane | 111 | 113 | 66 - 125 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17450**

**Method: 624**
**Preparation: N/A**

| | | | | | |
|---|---|---|---|---|---|
| LCS Lab Sample ID: | LCS 700-17450/1 | Analysis Batch: | 700-17450 | Instrument ID: | VMG5973 |
| Client Matrix: | Water | Prep Batch: | N/A | Lab File ID: | G021602.D |
| Dilution: | 1.0 | Units: | ug/L | Initial Weight/Volume: | 5 mL |
| Date Analyzed: | 02/16/2006 1028 | | | Final Weight/Volume: | 5 mL |
| Date Prepared: | N/A | | | | |

| | | | | | |
|---|---|---|---|---|---|
| LCSD Lab Sample ID: | LCSD 700-17450/2 | Analysis Batch: | 700-17450 | Instrument ID: | VMG5973 |
| Client Matrix: | Water | Prep Batch: | N/A | Lab File ID: | G021603.D |
| Dilution: | 1.0 | Units: | ug/L | Initial Weight/Volume: | 5 mL |
| Date Analyzed: | 02/16/2006 1059 | | | Final Weight/Volume: | 5 mL |
| Date Prepared: | N/A | | | | |

| Surrogate | LCS % Rec | LCSD % Rec | Acceptance Limits |
|---|---|---|---|
| 4-Bromofluorobenzene | 112 | 111 | 70 - 118 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**Method Blank - Batch: 700-17500**

**Method: 8260B**
**Preparation: 5030B**

Lab Sample ID: MB 700-17500/3
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/17/2006 1607
Date Prepared: 02/17/2006 1607

Analysis Batch: 700-17500
Prep Batch: N/A
Units: ug/Kg

Instrument ID: VMG5973
Lab File ID: G021705.D
Initial Weight/Volume: 5 mL
Final Weight/Volume: 5 g

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| 1,1,2,2-Tetrachloroethane | ND | | 1.7 | 5.0 |
| 1,1,1-Trichloroethane | ND | | 1.5 | 5.0 |
| 1,1,2-Trichloroethane | ND | | 1.2 | 5.0 |
| Toluene | ND | | 1.0 | 5.0 |
| 1,1-Dichloroethane | ND | | 1.0 | 5.0 |
| 1,1-Dichloroethene | ND | | 1.3 | 5.0 |
| 1,2-Dichloroethane | ND | | 2.0 | 5.0 |
| 1,2-Dichloropropane | ND | | 1.2 | 5.0 |
| Benzene | ND | | 1.1 | 5.0 |
| Bromoform | ND | | 1.1 | 5.0 |
| Bromomethane | ND | | 3.6 | 10 |
| Carbon tetrachloride | ND | | 1.4 | 5.0 |
| Chlorobenzene | ND | | 1.1 | 5.0 |
| Chlorodibromomethane | ND | | 1.2 | 5.0 |
| Chloroethane | ND | | 1.5 | 10 |
| Chloromethane | ND | | 2.3 | 10 |
| Chloroform | ND | | 0.82 | 5.0 |
| Dichlorobromomethane | ND | | 1.2 | 5.0 |
| 1,3-Dichloropropene, Total | ND | | 1.5 | 10 |
| Ethylbenzene | ND | | 1.8 | 5.0 |
| Methylene Chloride | ND | | 1.6 | 5.0 |
| 2-Chloroethyl vinyl ether | ND | | 17 | 50 |
| Xylenes, Total | ND | | 1.3 | 10 |
| Acrolein | ND | | 28 | 100 |
| Acrylonitrile | ND | | 62 | 100 |
| Trichloroethene | ND | | 0.90 | 5.0 |
| Vinyl chloride | ND | | 1.6 | 10 |
| trans-1,2-Dichloroethene | ND | | 0.99 | 5.0 |
| Tetrachloroethene | ND | | 0.90 | 5.0 |

| Surrogate | % Rec | Acceptance Limits |
|---|---|---|
| Dibromofluoromethane | 128 | 59 - 132 |
| Toluene-d8 | 118 | 61 - 131 |
| 4-Bromofluorobenzene | 117 | 55 - 131 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17500**

**Method: 8260B**
**Preparation: 5030B**

LCS Lab Sample ID: LCS 700-17500/1
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/17/2006 1504
Date Prepared: 02/17/2006 1504

Analysis Batch: 700-17500
Prep Batch: N/A
Units: ug/Kg

Instrument ID: VMG5973
Lab File ID: G021703.D
Initial Weight/Volume: 5 mL
Final Weight/Volume: 5 g

LCSD Lab Sample ID: LCSD 700-17500/2
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/17/2006 1535
Date Prepared: 02/17/2006 1535

Analysis Batch: 700-17500
Prep Batch: N/A
Units: ug/Kg

Instrument ID: VMG5973
Lab File ID: G021704.D
Initial Weight/Volume: 5 mL
Final Weight/Volume: 5 g

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| Toluene | 117 | 109 | 66 - 141 | 7 | 32 | | |
| 1,1-Dichloroethene | 128 | 119 | 48 - 154 | 7 | 46 | | |
| Benzene | 107 | 96 | 69 - 137 | 11 | 42 | | |
| Chlorobenzene | 111 | 101 | 70 - 138 | 10 | 34 | | |
| Trichloroethene | 123 | 111 | 68 - 138 | 10 | 34 | | |

| Surrogate | LCS % Rec | LCSD % Rec | Acceptance Limits |
|---|---|---|---|
| Dibromofluoromethane | 130 | 126 | 59 - 132 |
| Toluene-d8 | 118 | 112 | 61 - 131 |
| 4-Bromofluorobenzene | 120 | 110 | 55 - 131 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**Method Blank - Batch: 700-17307**

**Method: 625**
**Preparation: 3520C**

Lab Sample ID: MB 700-17307/1-A
Client Matrix: Water
Dilution: 5.0
Date Analyzed: 02/17/2006 1136
Date Prepared: 02/15/2006 1108

Analysis Batch: 700-17512
Prep Batch: 700-17307
Units: ug/L

Instrument ID: SMC5973
Lab File ID: C021705.D
Initial Weight/Volume: 1000 mL
Final Weight/Volume: 1.0 mL
Injection Volume:

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| 1,2,4-Trichlorobenzene | ND | | 1.2 | 10 |
| 1,2-Dichlorobenzene | ND | | 1.1 | 10 |
| 1,2-Diphenylhydrazine | ND | | 4.0 | 10 |
| 1,3-Dichlorobenzene | ND | | 1.1 | 10 |
| 1,4-Dichlorobenzene | ND | | 1.1 | 10 |
| 2,2'-oxybis(2-chloropropane) | ND | | 1.3 | 10 |
| 2,4,6-Trichlorophenol | ND | | 2.4 | 10 |
| 2,4-Dichlorophenol | ND | | 1.2 | 10 |
| 2,4-Dimethylphenol | ND | | 1.1 | 10 |
| 2,4-Dinitrophenol | ND | | 2.3 | 50 |
| 2,4-Dinitrotoluene | ND | | 2.2 | 10 |
| 2,6-Dinitrotoluene | ND | | 2.4 | 10 |
| 2-Chloronaphthalene | ND | | 1.7 | 10 |
| 2-Chlorophenol | ND | | 1.0 | 10 |
| 2-Nitrophenol | ND | | 1.3 | 10 |
| 3,3'-Dichlorobenzidine | ND | | 7.1 | 20 |
| 4,6-Dinitro-2-methylphenol | ND | | 2.1 | 50 |
| 4-Bromophenyl phenyl ether | ND | | 1.7 | 10 |
| 4-Chloro-3-methylphenol | ND | | 1.0 | 10 |
| 4-Chlorophenyl phenyl ether | ND | | 1.5 | 10 |
| 4-Nitrophenol | ND | | 3.6 | 50 |
| Acenaphthene | ND | | 1.3 | 10 |
| Acenaphthylene | ND | | 2.4 | 10 |
| Anthracene | ND | | 1.0 | 10 |
| Benzidine | ND | | 8.4 | 80 |
| Benzo[a]anthracene | ND | | 1.0 | 10 |
| Benzo[a]pyrene | ND | | 5.6 | 10 |
| Benzo[b]fluoranthene | ND | | 9.5 | 10 |
| Benzo[g,h,i]perylene | ND | | 5.4 | 10 |
| Benzo[k]fluoranthene | ND | | 9.0 | 10 |
| Bis(2-chloroethoxy)methane | ND | | 5.4 | 10 |
| Bis(2-chloroethyl)ether | ND | | 3.0 | 10 |
| Bis(2-ethylhexyl) phthalate | ND | | 3.3 | 10 |
| Butyl benzyl phthalate | ND | | 2.8 | 10 |
| Chrysene | ND | | 2.3 | 10 |
| Dibenz(a,h)anthracene | ND | | 9.5 | 10 |
| Diethyl phthalate | ND | | 1.7 | 10 |
| Dimethyl phthalate | ND | | 1.2 | 10 |
| Di-n-butyl phthalate | ND | | 1.2 | 10 |
| Di-n-octyl phthalate | ND | | 1.8 | 10 |
| Fluoranthene | ND | | 1.0 | 10 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**Method Blank - Batch: 700-17307**

**Method: 625**
**Preparation: 3520C**

Lab Sample ID: MB 700-17307/1-A
Client Matrix: Water
Dilution: 5.0
Date Analyzed: 02/17/2006 1136
Date Prepared: 02/15/2006 1108

Analysis Batch: 700-17512
Prep Batch: 700-17307
Units: ug/L

Instrument ID: SMC5973
Lab File ID: C021705.D
Initial Weight/Volume: 1000 mL
Final Weight/Volume: 1.0 mL
Injection Volume:

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Fluorene | ND | | 1.5 | 10 |
| Hexachlorobenzene | ND | | 1.7 | 10 |
| Hexachlorobutadiene | ND | | 1.4 | 10 |
| Hexachlorocyclopentadiene | ND | | 1.8 | 10 |
| Hexachloroethane | ND | | 1.3 | 10 |
| Indeno[1,2,3-cd]pyrene | ND | | 2.9 | 10 |
| Isophorone | ND | | 1.1 | 10 |
| Naphthalene | ND | | 1.2 | 10 |
| Nitrobenzene | ND | | 1.4 | 10 |
| N-Nitrosodimethylamine | ND | | 2.2 | 10 |
| N-Nitrosodi-n-propylamine | ND | | 1.0 | 10 |
| N-Nitrosodiphenylamine | ND | | 10 | 10 |
| Pentachlorophenol | ND | | 2.1 | 50 |
| Phenanthrene | ND | | 1.2 | 10 |
| Phenol | ND | | 1.1 | 10 |
| Pyrene | ND | | 2.2 | 10 |

| Surrogate | % Rec | Acceptance Limits |
|---|---|---|
| 2,4,6-Tribromophenol | 70 | 14 - 93 |
| 2-Fluorobiphenyl | 76 | 34 - 118 |
| 2-Fluorophenol | 60 | 25 - 102 |
| Nitrobenzene-d5 | 77 | 39 - 133 |
| Phenol-d5 | 62 | 21 - 95 |
| Terphenyl-d14 | 82 | 16 - 158 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17307**

**Method: 625**
**Preparation: 3520C**

LCS Lab Sample ID: LCS 700-17307/2-A
Client Matrix: Water
Dilution: 2.0
Date Analyzed: 02/17/2006 1210
Date Prepared: 02/15/2006 1108

Analysis Batch: 700-17512
Prep Batch: 700-17307
Units: ug/L

Instrument ID: SMC5973
Lab File ID: C021706.D
Initial Weight/Volume: 1000 mL
Final Weight/Volume: 1.0 mL
Injection Volume:

LCSD Lab Sample ID: LCSD 700-17307/3-A
Client Matrix: Water
Dilution: 2.0
Date Analyzed: 02/17/2006 1245
Date Prepared: 02/15/2006 1108

Analysis Batch: 700-17512
Prep Batch: 700-17307
Units: ug/L

Instrument ID: SMC5973
Lab File ID: C021707.D
Initial Weight/Volume: 1000 mL
Final Weight/Volume: 1.0 mL
Injection Volume:

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| 1,2,4-Trichlorobenzene | 67 | 73 | 34 - 103 | 8 | 28 | | |
| 1,2-Dichlorobenzene | 56 | 61 | 23 - 104 | 8 | 30 | | |
| 1,3-Dichlorobenzene | 52 | 56 | 19 - 101 | 8 | 31 | | |
| 1,4-Dichlorobenzene | 53 | 58 | 30 - 95 | 8 | 31 | | |
| 2,4,6-Trichlorophenol | 88 | 98 | 47 - 124 | 11 | 22 | | |
| 2,4-Dichlorophenol | 74 | 83 | 42 - 121 | 12 | 30 | | |
| 2,4-Dimethylphenol | 69 | 79 | 27 - 126 | 14 | 43 | | |
| 2,4-Dinitrophenol | 98 | 97 | 17 - 147 | 1 | 63 | | |
| 2,4-Dinitrotoluene | 99 | 106 | 36 - 129 | 7 | 32 | | |
| 2,6-Dinitrotoluene | 87 | 96 | 46 - 128 | 10 | 24 | | |
| 2-Chloronaphthalene | 83 | 91 | 43 - 115 | 9 | 22 | | |
| 2-Chlorophenol | 71 | 80 | 45 - 116 | 12 | 34 | | |
| 2-Nitrophenol | 82 | 91 | 38 - 121 | 10 | 24 | | |
| 3,3'-Dichlorobenzidine | 40 | 38 | 1.0 - 119 | 5 | 72 | | |
| 4,6-Dinitro-2-methylphenol | 92 | 96 | 42 - 135 | 4 | 33 | | |
| 4-Bromophenyl phenyl ether | 94 | 103 | 39 - 109 | 9 | 26 | | |
| 4-Chloro-3-methylphenol | 78 | 86 | 48 - 128 | 10 | 31 | | |
| 4-Chlorophenyl phenyl ether | 96 | 103 | 40 - 121 | 7 | 26 | | |
| 4-Nitrophenol | 85 | 81 | 20 - 144 | 4 | 44 | | |
| Acenaphthene | 87 | 97 | 34 - 134 | 10 | 35 | | |
| Acenaphthylene | 82 | 91 | 44 - 129 | 10 | 28 | | |
| Anthracene | 91 | 100 | 44 - 126 | 9 | 21 | | |
| Benzo[a]anthracene | 96 | 105 | 39 - 134 | 9 | 34 | | |
| Benzo[a]pyrene | 90 | 101 | 30 - 132 | 11 | 24 | | |
| Benzo[b]fluoranthene | 101 | 106 | 34 - 138 | 5 | 32 | | |
| Benzo[g,h,i]perylene | 107 | 115 | 32 - 133 | 7 | 39 | | |
| Benzo[k]fluoranthene | 99 | 106 | 30 - 147 | 7 | 34 | | |
| Bis(2-chloroethoxy)methane | 83 | 91 | 36 - 125 | 9 | 20 | | |
| Bis(2-chloroethyl)ether | 78 | 84 | 22 - 132 | 7 | 58 | | |
| Bis(2-ethylhexyl) phthalate | 97 | 107 | 43 - 130 | 9 | 26 | | |
| Butyl benzyl phthalate | 84 | 96 | 43 - 136 | 13 | 41 | | |
| Chrysene | 96 | 104 | 39 - 138 | 8 | 31 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17307**

**Method: 625**
**Preparation: 3520C**

LCS Lab Sample ID: LCS 700-17307/2-A
Client Matrix: Water
Dilution: 2.0
Date Analyzed: 02/17/2006 1210
Date Prepared: 02/15/2006 1108

Analysis Batch: 700-17512
Prep Batch: 700-17307
Units: ug/L

Instrument ID: SMC5973
Lab File ID: C021706.D
Initial Weight/Volume: 1000 mL
Final Weight/Volume: 1.0 mL
Injection Volume:

LCSD Lab Sample ID: LCSD 700-17307/3-A
Client Matrix: Water
Dilution: 2.0
Date Analyzed: 02/17/2006 1245
Date Prepared: 02/15/2006 1108

Analysis Batch: 700-17512
Prep Batch: 700-17307
Units: ug/L

Instrument ID: SMC5973
Lab File ID: C021707.D
Initial Weight/Volume: 1000 mL
Final Weight/Volume: 1.0 mL
Injection Volume:

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| Dibenz(a,h)anthracene | 118 | 124 | 32 - 134 | 5 | 35 | | |
| Diethyl phthalate | 94 | 104 | 48 - 128 | 10 | 49 | | |
| Dimethyl phthalate | 88 | 97 | 47 - 122 | 9 | 31 | | |
| Di-n-butyl phthalate | 98 | 108 | 43 - 133 | 9 | 29 | | |
| Di-n-octyl phthalate | 102 | 111 | 41 - 129 | 9 | 33 | | |
| Fluoranthene | 99 | 105 | 39 - 139 | 6 | 24 | | |
| Fluorene | 101 | 109 | 41 - 130 | 7 | 23 | | |
| Hexachlorobenzene | 94 | 105 | 33 - 124 | 11 | 31 | | |
| Hexachlorobutadiene | 63 | 69 | 26 - 104 | 9 | 30 | | |
| Hexachlorocyclopentadiene | 34 | 34 | 1.0 - 87 | 0 | 67 | | |
| Hexachloroethane | 51 | 56 | 21 - 94 | 8 | 35 | | |
| Indeno[1,2,3-cd]pyrene | 116 | 116 | 26 - 140 | 0 | 38 | | |
| Isophorone | 80 | 87 | 34 - 140 | 8 | 33 | | |
| Naphthalene | 71 | 77 | 26 - 121 | 8 | 33 | | |
| Nitrobenzene | 83 | 89 | 34 - 124 | 8 | 40 | | |
| N-Nitrosodiphenylamine | 78 | 88 | 30 - 130 | 12 | 50 | | |
| Pentachlorophenol | 72 | 73 | 34 - 133 | 1 | 33 | | |
| Phenanthrene | 98 | 107 | 45 - 129 | 9 | 20 | | |
| Phenol | 72 | 81 | 29 - 122 | 11 | 36 | | |
| Pyrene | 83 | 94 | 32 - 122 | 13 | 42 | | |

| Surrogate | LCS % Rec | LCSD % Rec | Acceptance Limits |
|---|---|---|---|
| 2,4,6-Tribromophenol | 93 | 93 | 14 - 93 |
| 2-Fluorobiphenyl | 85 | 90 | 34 - 118 |
| 2-Fluorophenol | 61 | 67 | 25 - 102 |
| Nitrobenzene-d5 | 88 | 90 | 39 - 133 |
| Phenol-d5 | 66 | 71 | 21 - 95 |
| Terphenyl-d14 | 85 | 100 | 16 - 158 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**Method Blank - Batch: 700-17431**

**Method: 8270C**
**Preparation: 3550B**

Lab Sample ID: MB 700-17431/1-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/20/2006 1342
Date Prepared: 02/17/2006 0900

Analysis Batch: 700-17742
Prep Batch: 700-17431
Units: ug/Kg

Instrument ID: SMC5973
Lab File ID: C022003.D
Initial Weight/Volume: 30.0 g
Final Weight/Volume: 1.0 mL
Injection Volume:

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| 1,2,4-Trichlorobenzene | ND | | 8.4 | 66 |
| 1,2-Dichlorobenzene | ND | | 9.0 | 66 |
| 1,2-Diphenylhydrazine | ND | | 7.0 | 66 |
| 1,3-Dichlorobenzene | ND | | 10 | 66 |
| 1,4-Dichlorobenzene | ND | | 7.0 | 66 |
| 2,2'-oxybis(2-chloropropane) | ND | | 12 | 66 |
| 2,4,6-Trichlorophenol | ND | | 7.8 | 66 |
| 2,4-Dichlorophenol | ND | | 7.2 | 66 |
| 2,4-Dimethylphenol | ND | | 7.6 | 66 |
| 2,4-Dinitrophenol | ND | | 8.6 | 340 |
| 2,4-Dinitrotoluene | ND | | 7.2 | 66 |
| 2,6-Dinitrotoluene | ND | | 8.8 | 66 |
| 2-Chloronaphthalene | ND | | 8.4 | 66 |
| 2-Chlorophenol | ND | | 8.4 | 66 |
| 2-Nitrophenol | ND | | 7.2 | 66 |
| 3,3'-Dichlorobenzidine | ND | | 14 | 130 |
| 4,6-Dinitro-2-methylphenol | ND | | 16 | 340 |
| 4-Bromophenyl phenyl ether | ND | | 8.4 | 66 |
| 4-Chloro-3-methylphenol | ND | | 8.2 | 66 |
| 4-Chlorophenyl phenyl ether | ND | | 7.6 | 66 |
| 4-Nitrophenol | ND | | 15 | 340 |
| Benzidine | ND | | 44 | 540 |
| Bis(2-chloroethoxy)methane | ND | | 7.8 | 66 |
| Bis(2-chloroethyl)ether | ND | | 8.4 | 66 |
| Bis(2-ethylhexyl) phthalate | ND | | 7.4 | 66 |
| Butyl benzyl phthalate | ND | | 9.8 | 66 |
| Dibenz(a,h)anthracene | ND | | 7.0 | 66 |
| Diethyl phthalate | ND | | 7.8 | 66 |
| Di-n-butyl phthalate | ND | | 8.4 | 66 |
| Di-n-octyl phthalate | ND | | 6.8 | 66 |
| Hexachlorobenzene | ND | | 9.0 | 66 |
| Hexachlorobutadiene | ND | | 6.8 | 66 |
| Hexachlorocyclopentadiene | ND | | 6.0 | 66 |
| Hexachloroethane | ND | | 7.6 | 66 |
| Isophorone | ND | | 9.0 | 66 |
| Nitrobenzene | ND | | 7.2 | 66 |
| N-Nitrosodimethylamine | ND | | 33 | 66 |
| N-Nitrosodi-n-propylamine | ND | | 7.8 | 66 |
| N-Nitrosodiphenylamine | ND | | 9.0 | 66 |
| Pentachlorophenol | ND | | 7.2 | 340 |
| Phenol | ND | | 7.2 | 66 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**Method Blank - Batch: 700-17431**

**Method: 8270C**
**Preparation: 3550B**

Lab Sample ID: MB 700-17431/1-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/20/2006 1342
Date Prepared: 02/17/2006 0900

Analysis Batch: 700-17742
Prep Batch: 700-17431
Units: ug/Kg

Instrument ID: SMC5973
Lab File ID: C022003.D
Initial Weight/Volume: 30.0 g
Final Weight/Volume: 1.0 mL
Injection Volume:

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|

| Surrogate | % Rec | Acceptance Limits |
|---|---|---|
| 2,4,6-Tribromophenol | 65 | 5.0 - 106 |
| 2-Fluorobiphenyl | 61 | 31 - 118 |
| 2-Fluorophenol | 51 | 10 - 128 |
| Nitrobenzene-d5 | 61 | 35 - 122 |
| Phenol-d5 | 52 | 29 - 113 |
| Terphenyl-d14 | 69 | 37 - 149 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17431**

**Method: 8270C**
**Preparation: 3550B**

LCS Lab Sample ID: LCS 700-17431/2-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/20/2006 1417
Date Prepared: 02/17/2006 0900

Analysis Batch: 700-17742
Prep Batch: 700-17431
Units: ug/Kg

Instrument ID: SMC5973
Lab File ID: C022004.D
Initial Weight/Volume: 30.0 g
Final Weight/Volume: 1.0 mL
Injection Volume:

LCSD Lab Sample ID: LCSD 700-17431/3-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/20/2006 1452
Date Prepared: 02/17/2006 0900

Analysis Batch: 700-17742
Prep Batch: 700-17431
Units: ug/Kg

Instrument ID: SMC5973
Lab File ID: C022005.D
Initial Weight/Volume: 30.0 g
Final Weight/Volume: 1.0 mL
Injection Volume:

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| 1,2,4-Trichlorobenzene | 68 | 71 | 34 - 103 | 4 | 22 | | |
| 1,4-Dichlorobenzene | 59 | 62 | 30 - 95 | 5 | 31 | | |
| 2,4-Dinitrotoluene | 75 | 81 | 26 - 115 | 7 | 37 | | |
| 2-Chlorophenol | 64 | 69 | 36 - 106 | 7 | 38 | | |
| 4-Chloro-3-methylphenol | 72 | 76 | 48 - 128 | 6 | 32 | | |
| 4-Nitrophenol | 76 | 80 | 20 - 144 | 5 | 57 | | |
| N-Nitrosodi-n-propylamine | 58 | 62 | 28 - 111 | 7 | 37 | | |
| Pentachlorophenol | 84 | 91 | 34 - 133 | 8 | 55 | | |
| Phenol | 62 | 67 | 32 - 107 | 7 | 39 | | |

| Surrogate | LCS % Rec | LCSD % Rec | Acceptance Limits |
|---|---|---|---|
| 2,4,6-Tribromophenol | 92 | 93 | 5.0 - 106 |
| 2-Fluorobiphenyl | 71 | 72 | 31 - 118 |
| 2-Fluorophenol | 58 | 60 | 10 - 128 |
| Nitrobenzene-d5 | 72 | 73 | 35 - 122 |
| Phenol-d5 | 60 | 62 | 29 - 113 |
| Terphenyl-d14 | 75 | 77 | 37 - 149 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**Method Blank - Batch: 700-17433**

**Method: 8270C**
**Preparation: 3550B**

Lab Sample ID: MB 700-17433/1-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/20/2006 1428
Date Prepared: 02/17/2006 0900

Analysis Batch: 700-17635
Prep Batch: 700-17433
Units: ug/Kg

Instrument ID: Agilent GC/MS 5973
Lab File ID: D022004.D
Initial Weight/Volume: 30.0 g
Final Weight/Volume: 1.0 mL
Injection Volume:

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Acenaphthene | ND | | 3.5 | 6.7 |
| Pyrene | ND | | 1.7 | 6.7 |
| Acenaphthylene | ND | | 2.0 | 6.7 |
| Anthracene | ND | | 4.4 | 6.7 |
| Benzo[a]pyrene | ND | | 2.0 | 6.7 |
| Benzo[b]fluoranthene | ND | | 6.2 | 6.7 |
| Benzo[a]anthracene | ND | | 2.1 | 6.7 |
| Benzo[g,h,i]perylene | ND | | 3.0 | 6.7 |
| Benzo[k]fluoranthene | ND | | 4.3 | 6.7 |
| Fluoranthene | ND | | 3.5 | 6.7 |
| Fluorene | ND | | 2.9 | 6.7 |
| Indeno[1,2,3-cd]pyrene | ND | | 1.9 | 6.7 |
| Naphthalene | ND | | 3.4 | 6.7 |
| Phenanthrene | ND | | 3.8 | 6.7 |
| Chrysene | ND | | 2.3 | 6.7 |

| Surrogate | % Rec | Acceptance Limits |
|---|---|---|
| 2,4,6-Tribromophenol | 58 | 5.0 - 106 |
| 2-Fluorobiphenyl | 58 | 31 - 118 |
| 2-Fluorophenol | 48 | 10 - 128 |
| Nitrobenzene-d5 | 55 | 35 - 122 |
| Phenol-d5 | 47 | 29 - 113 |
| Terphenyl-d14 | 68 | 37 - 149 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17433**

**Method: 8270C**
**Preparation: 3550B**

LCS Lab Sample ID: LCS 700-17433/2-A
Client Matrix: Solid
Dilution: 2.0
Date Analyzed: 02/20/2006 1502
Date Prepared: 02/17/2006 0900

Analysis Batch: 700-17635
Prep Batch: 700-17433
Units: ug/Kg

Instrument ID: Agilent GC/MS 5973
Lab File ID: D022005.D
Initial Weight/Volume: 30.0 g
Final Weight/Volume: 1.0 mL
Injection Volume:

LCSD Lab Sample ID: LCSD 700-17433/3-A
Client Matrix: Solid
Dilution: 2.0
Date Analyzed: 02/20/2006 1536
Date Prepared: 02/17/2006 0900

Analysis Batch: 700-17635
Prep Batch: 700-17433
Units: ug/Kg

Instrument ID: Agilent GC/MS 5973
Lab File ID: D022006.D
Initial Weight/Volume: 30.0 g
Final Weight/Volume: 1.0 mL
Injection Volume:

| Analyte | % Rec. LCS | LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| 1,2,4-Trichlorobenzene | 60 | 61 | 34 - 103 | 2 | 22 | | |
| 1,4-Dichlorobenzene | 52 | 53 | 30 - 95 | 2 | 31 | | |
| 2,4-Dinitrotoluene | 80 | 83 | 36 - 129 | 4 | 37 | | |
| 2-Chlorophenol | 60 | 61 | 45 - 116 | 2 | 38 | | |
| 4-Chloro-3-methylphenol | 71 | 74 | 48 - 128 | 5 | 32 | | |
| 4-Nitrophenol | 72 | 64 | 20 - 144 | 11 | 57 | | |
| Acenaphthene | 64 | 65 | 34 - 134 | 2 | 49 | | |
| N-Nitrosodi-n-propylamine | 69 | 71 | 30 - 130 | 4 | 37 | | |
| Pentachlorophenol | 71 | 73 | 34 - 133 | 3 | 55 | | |
| Phenol | 59 | 61 | 29 - 122 | 3 | 39 | | |
| Pyrene | 80 | 82 | 32 - 122 | 3 | 42 | | |

| Surrogate | LCS % Rec | LCSD % Rec | Acceptance Limits |
|---|---|---|---|
| 2,4,6-Tribromophenol | 77 | 76 | 5.0 - 106 |
| 2-Fluorobiphenyl | 67 | 66 | 31 - 118 |
| 2-Fluorophenol | 67 | 65 | 10 - 128 |
| Nitrobenzene-d5 | 61 | 60 | 35 - 122 |
| Phenol-d5 | 60 | 59 | 29 - 113 |
| Terphenyl-d14 | 86 | 85 | 37 - 149 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**Method Blank - Batch: 700-17324**

**Method: 608**
**Preparation: CWA_Prep_CLLE**

Lab Sample ID: MB 700-17324/1-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/18/2006 1826
Date Prepared: 02/15/2006 1515

Analysis Batch: 700-17493
Prep Batch: 700-17324
Units: ug/L

Instrument ID: MSGY
Lab File ID: Y021819.D
Initial Weight/Volume: 1000 mL
Final Weight/Volume: 5.0 mL
Injection Volume:
Column ID: PRIMARY

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Aldrin | ND | | 0.0045 | 0.050 |
| alpha-BHC | ND | | 0.0056 | 0.050 |
| beta-BHC | ND | | 0.0036 | 0.050 |
| Chlordane (technical) | ND | | 0.032 | 0.50 |
| 4,4'-DDD | ND | | 0.0076 | 0.10 |
| 4,4'-DDE | ND | | 0.0064 | 0.10 |
| 4,4'-DDT | ND | | 0.0084 | 0.10 |
| delta-BHC | ND | | 0.010 | 0.050 |
| Dieldrin | ND | | 0.0074 | 0.10 |
| Endosulfan I | ND | | 0.0044 | 0.050 |
| Endosulfan II | ND | | 0.0047 | 0.10 |
| Endosulfan sulfate | ND | | 0.0090 | 0.10 |
| Endrin | ND | | 0.0067 | 0.10 |
| Endrin aldehyde | ND | | 0.0069 | 0.10 |
| gamma-BHC (Lindane) | ND | | 0.0049 | 0.050 |
| Heptachlor | ND | | 0.0037 | 0.050 |
| Heptachlor epoxide | ND | | 0.0039 | 0.050 |
| PCB-1248 | ND | | 0.14 | 1.0 |
| PCB-1232 | ND | | 0.13 | 1.0 |
| PCB-1254 | ND | | 0.12 | 1.0 |
| PCB-1242 | ND | | 0.18 | 1.0 |
| PCB-1260 | ND | | 0.12 | 1.0 |
| PCB-1016 | ND | | 0.11 | 1.0 |
| PCB-1221 | ND | | 0.17 | 2.0 |
| Toxaphene | ND | | 0.31 | 5.0 |

| Surrogate | % Rec | Acceptance Limits |
|---|---|---|
| DCB Decachlorobiphenyl | 46 | 30 - 150 |
| Tetrachloro-m-xylene | 57 | 30 - 150 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17324**

**Method: 608**
**Preparation: CWA_Prep_CLLE**

LCS Lab Sample ID: LCS 700-17324/2-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/18/2006 1623
Date Prepared: 02/15/2006 1515

Analysis Batch: 700-17493
Prep Batch: 700-17324
Units: ug/L

Instrument ID: MSGY
Lab File ID: Y021815.D
Initial Weight/Volume: 1000 mL
Final Weight/Volume: 5.0 mL
Injection Volume:
Column ID: PRIMARY

LCSD Lab Sample ID: LCSD 700-17324/3-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/18/2006 1654
Date Prepared: 02/15/2006 1515

Analysis Batch: 700-17493
Prep Batch: 700-17324
Units: ug/L

Instrument ID: MSGY
Lab File ID: Y021816.D
Initial Weight/Volume: 1000 mL
Final Weight/Volume: 5.0 mL
Injection Volume:
Column ID: PRIMARY

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| Aldrin | 69 | 67 | 32 - 120 | 3 | 25 | | |
| alpha-BHC | 74 | 73 | 17 - 106 | 2 | 30 | | |
| beta-BHC | 79 | 78 | 34 - 136 | 2 | 35 | | |
| 4,4'-DDD | 78 | 78 | 49 - 140 | 0 | 39 | | |
| 4,4'-DDE | 79 | 80 | 44 - 115 | 1 | 18 | | |
| 4,4'-DDT | 76 | 84 | 37 - 150 | 10 | 27 | | |
| delta-BHC | 78 | 79 | 17 - 123 | 1 | 41 | | |
| Dieldrin | 70 | 71 | 40 - 142 | 1 | 42 | | |
| Endosulfan I | 60 | 55 | 24 - 147 | 8 | 24 | | |
| Endosulfan II | 63 | 61 | 45 - 145 | 3 | 22 | | |
| Endosulfan sulfate | 99 | 92 | 40 - 141 | 8 | 28 | | |
| Endrin | 78 | 76 | 36 - 137 | 3 | 25 | | |
| Endrin aldehyde | 83 | 80 | 52 - 148 | 3 | 34 | | |
| gamma-BHC (Lindane) | 76 | 75 | 24 - 118 | 1 | 26 | | |
| Heptachlor | 66 | 66 | 34 - 114 | 0 | 26 | | |
| Heptachlor epoxide | 71 | 71 | 37 - 130 | 1 | 31 | | |

| Surrogate | LCS % Rec | | LCSD % Rec | Acceptance Limits |
|---|---|---|---|---|
| DCB Decachlorobiphenyl | 19 | * | 50 | 30 - 150 |
| Tetrachloro-m-xylene | 59 | | 57 | 30 - 150 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**Method Blank - Batch: 700-17522**

**Method: 8081A**
**Preparation: 3550B**

Lab Sample ID: MB 700-17522/1-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/26/2006 0235
Date Prepared: 02/20/2006 0900

Analysis Batch: 700-17870
Prep Batch: 700-17522
Units: ug/Kg

Instrument ID: MSGY
Lab File ID: Y022535.D
Initial Weight/Volume: 30.0 g
Final Weight/Volume: 5.0 mL
Injection Volume:
Column ID: PRIMARY

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Aldrin | ND | | 0.29 | 1.7 |
| alpha-BHC | ND | | 0.12 | 1.7 |
| beta-BHC | ND | | 0.12 | 1.7 |
| Chlordane (technical) | ND | | 1.5 | 17 |
| 4,4'-DDD | ND | | 0.34 | 3.3 |
| 4,4'-DDE | ND | | 0.30 | 3.3 |
| 4,4'-DDT | ND | | 0.54 | 3.3 |
| delta-BHC | ND | | 0.25 | 1.7 |
| Dieldrin | ND | | 0.26 | 3.3 |
| Endosulfan I | ND | | 0.12 | 1.7 |
| Endosulfan II | ND | | 0.39 | 3.3 |
| Endosulfan sulfate | ND | | 0.34 | 3.3 |
| Endrin | ND | | 0.38 | 3.3 |
| Endrin aldehyde | ND | | 0.38 | 3.3 |
| gamma-BHC (Lindane) | ND | | 0.11 | 1.7 |
| Heptachlor | ND | | 0.19 | 1.7 |
| Heptachlor epoxide | ND | | 0.13 | 1.7 |
| Toxaphene | ND | | 11 | 170 |

| Surrogate | % Rec | Acceptance Limits |
|---|---|---|
| DCB Decachlorobiphenyl | 76 | 30 - 150 |
| Tetrachloro-m-xylene | 48 | 30 - 150 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17522**

**Method: 8081A**
**Preparation: 3550B**

| | | | |
|---|---|---|---|
| LCS Lab Sample ID: | LCS 700-17522/2-A | Analysis Batch: 700-17870 | Instrument ID: MSGY |
| Client Matrix: | Solid | Prep Batch: 700-17522 | Lab File ID: Y022531.D |
| Dilution: | 1.0 | Units: ug/Kg | Initial Weight/Volume: 30.0 g |
| Date Analyzed: | 02/26/2006 0033 | | Final Weight/Volume: 5.0 mL |
| Date Prepared: | 02/20/2006 0900 | | Injection Volume: |
| | | | Column ID: PRIMARY |

| | | | |
|---|---|---|---|
| LCSD Lab Sample ID: | LCSD 700-17522/3-A | Analysis Batch: 700-17870 | Instrument ID: MSGY |
| Client Matrix: | Solid | Prep Batch: 700-17522 | Lab File ID: Y022532.D |
| Dilution: | 1.0 | Units: ug/Kg | Initial Weight/Volume: 30.0 g |
| Date Analyzed: | 02/26/2006 0103 | | Final Weight/Volume: 5.0 mL |
| Date Prepared: | 02/20/2006 0900 | | Injection Volume: |
| | | | Column ID: PRIMARY |

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| Aldrin | 65 | 73 | 25 - 128 | 11 | 38 | | |
| 4,4'-DDT | 60 | 56 | 24 - 148 | 7 | 26 | | |
| Dieldrin | 71 | 73 | 22 - 145 | 3 | 30 | | |
| Endrin | 97 | 103 | 26 - 140 | 7 | 32 | | |
| gamma-BHC (Lindane) | 65 | 71 | 20 - 128 | 9 | 37 | | |
| Heptachlor | 46 | 48 | 19 - 139 | 3 | 38 | | |

| Surrogate | LCS % Rec | LCSD % Rec | Acceptance Limits |
|---|---|---|---|
| DCB Decachlorobiphenyl | 76 | 79 | 30 - 150 |
| Tetrachloro-m-xylene | 48 | 54 | 30 - 150 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**Method Blank - Batch: 700-17524**

**Method: 8082**
**Preparation: 3550B**

Lab Sample ID: MB 700-17524/1-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/26/2006 0235
Date Prepared: 02/20/2006 0900

Analysis Batch: 700-17870
Prep Batch: 700-17524
Units: ug/Kg

Instrument ID: MSGY
Lab File ID: Y022535pcb.D
Initial Weight/Volume: 30.0 g
Final Weight/Volume: 5.0 mL
Injection Volume:
Column ID: PRIMARY

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| PCB-1016 | ND | | 3.0 | 33 |
| PCB-1260 | ND | | 2.6 | 33 |

| Surrogate | % Rec | Acceptance Limits |
|---|---|---|
| DCB Decachlorobiphenyl | 76 | 30 - 150 |
| Tetrachloro-m-xylene | 41 | 30 - 150 |

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17524**

**Method: 8082**
**Preparation: 3550B**

LCS Lab Sample ID: LCS 700-17524/6-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/26/2006 0134
Date Prepared: 02/20/2006 0900

Analysis Batch: 700-17870
Prep Batch: 700-17524
Units: ug/Kg

Instrument ID: MSGY
Lab File ID: Y022533.D
Initial Weight/Volume: 30.0 g
Final Weight/Volume: 5.0 mL
Injection Volume:
Column ID: PRIMARY

LCSD Lab Sample ID: LCSD 700-17524/7-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/26/2006 0205
Date Prepared: 02/20/2006 0900

Analysis Batch: 700-17870
Prep Batch: 700-17524
Units: ug/Kg

Instrument ID: MSGY
Lab File ID: Y022534.D
Initial Weight/Volume: 30.0 g
Final Weight/Volume: 5.0 mL
Injection Volume:
Column ID: PRIMARY

| Surrogate | LCS % Rec | LCSD % Rec | Acceptance Limits |
|---|---|---|---|
| DCB Decachlorobiphenyl | 75 | 70 | 30 - 150 |
| Tetrachloro-m-xylene | 36 | 38 | 30 - 150 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**Method Blank - Batch: 680-37202**

**Method: 200.8**
**Preparation: 4.1.4**
**Dissolved**

Lab Sample ID: MB 680-37202/7-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/25/2006 0542
Date Prepared: 02/23/2006 1624

Analysis Batch: 680-37853
Prep Batch: 680-37202
Units: ug/L

Instrument ID: ICP MS
Lab File ID: N/A
Initial Weight/Volume: 50 mL
Final Weight/Volume: 250 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Antimony | ND | | 1.0 | 2.5 |
| Arsenic | ND | | 0.60 | 2.5 |
| Beryllium | ND | | 0.15 | 0.50 |
| Cadmium | ND | | 0.10 | 0.50 |
| Chromium | ND | | 1.5 | 5.0 |
| Copper | ND | | 0.39 | 2.5 |
| Lead | ND | | 0.50 | 1.5 |
| Nickel | ND | | 0.15 | 1.0 |
| Silver | ND | | 0.25 | 1.0 |
| Thallium | ND | | 0.25 | 1.0 |
| Zinc | ND | | 3.5 | 20 |

**Method Blank - Batch: 680-37202**

**Method: 200.8**
**Preparation: 4.1.4**
**Dissolved**

Lab Sample ID: MB 680-37202/7-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 03/01/2006 1812
Date Prepared: 02/23/2006 1624

Analysis Batch: 680-37853
Prep Batch: 680-37202
Units: ug/L

Instrument ID: ICP MS
Lab File ID: N/A
Initial Weight/Volume: 50 mL
Final Weight/Volume: 250 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Selenium | ND | | 0.50 | 2.5 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 680-37202**

**Method: 200.8**
**Preparation: 4.1.4**
**Dissolved**

LCS Lab Sample ID: LCS 680-37202/8-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/25/2006 0549
Date Prepared: 02/23/2006 1624

Analysis Batch: 680-37853
Prep Batch: 680-37202
Units: ug/L

Instrument ID: ICP MS
Lab File ID: N/A
Initial Weight/Volume: 50 mL
Final Weight/Volume: 250 mL

LCSD Lab Sample ID: LCSD 680-37202/9-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/25/2006 0557
Date Prepared: 02/23/2006 1624

Analysis Batch: 680-37853
Prep Batch: 680-37202
Units: ug/L

Instrument ID: ICP MS
Lab File ID: N/A
Initial Weight/Volume: 50 mL
Final Weight/Volume: 250 mL

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| Antimony | 94 | 96 | 85 - 115 | 1 | 20 | | |
| Arsenic | 98 | 93 | 85 - 115 | 5 | 20 | | |
| Beryllium | 93 | 96 | 85 - 115 | 2 | 20 | | |
| Cadmium | 93 | 95 | 85 - 115 | 2 | 20 | | |
| Chromium | 95 | 96 | 85 - 115 | 1 | 20 | | |
| Copper | 98 | 99 | 85 - 115 | 1 | 20 | | |
| Lead | 104 | 106 | 85 - 115 | 2 | 20 | | |
| Nickel | 97 | 98 | 85 - 115 | 1 | 20 | | |
| Silver | 98 | 99 | 85 - 115 | 1 | 20 | | |
| Thallium | 99 | 102 | 85 - 115 | 3 | 20 | | |
| Zinc | 97 | 97 | 85 - 115 | 0 | 20 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 680-37202**

**Method: 200.8**
**Preparation: 4.1.4**
**Dissolved**

LCS Lab Sample ID: LCS 680-37202/8-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 03/01/2006 1819
Date Prepared: 02/23/2006 1624

Analysis Batch: 680-37853
Prep Batch: 680-37202
Units: ug/L

Instrument ID: ICP MS
Lab File ID: N/A
Initial Weight/Volume: 50 mL
Final Weight/Volume: 250 mL

LCSD Lab Sample ID: LCSD 680-37202/9-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 03/01/2006 1826
Date Prepared: 02/23/2006 1624

Analysis Batch: 680-37853
Prep Batch: 680-37202
Units: ug/L

Instrument ID: ICP MS
Lab File ID: N/A
Initial Weight/Volume: 50 mL
Final Weight/Volume: 250 mL

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| Selenium | 103 | 105 | 85 - 115 | 2 | 20 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**Matrix Spike/**
**Matrix Spike Duplicate Recovery Report - Batch: 680-37202**

**Method: 200.8**
**Preparation: 4.1.4**
**Dissolved**

| | | | | | |
|---|---|---|---|---|---|
| MS Lab Sample ID: | 700-9680-1 | Analysis Batch: | 680-37853 | Instrument ID: | ICP MS |
| Client Matrix: | Water | Prep Batch: | 680-37202 | Lab File ID: | N/A |
| Dilution: | 1.0 | | | Initial Weight/Volume: | 50 mL |
| Date Analyzed: | 02/25/2006 0626 | | | Final Weight/Volume: | 250 mL |
| Date Prepared: | 02/23/2006 1624 | | | | |

| | | | | | |
|---|---|---|---|---|---|
| MSD Lab Sample ID: | 700-9680-1 | Analysis Batch: | 680-37853 | Instrument ID: | ICP MS |
| Client Matrix: | Water | Prep Batch: | 680-37202 | Lab File ID: | N/A |
| Dilution: | 1.0 | | | Initial Weight/Volume: | 50 mL |
| Date Analyzed: | 02/25/2006 0633 | | | Final Weight/Volume: | 250 mL |
| Date Prepared: | 02/23/2006 1624 | | | | |

| | % Rec. | | | | | | |
|---|---|---|---|---|---|---|---|
| Analyte | MS | MSD | Limit | RPD | RPD Limit | MS Qual | MSD Qual |
| Antimony | 103 | 96 | 75 - 125 | 7 | 20 | | |
| Arsenic | 101 | 96 | 75 - 125 | 5 | 20 | | |
| Beryllium | 103 | 98 | 75 - 125 | 6 | 20 | | |
| Cadmium | 92 | 88 | 75 - 125 | 5 | 20 | | |
| Chromium | 113 | 106 | 75 - 125 | 6 | 20 | | |
| Copper | 98 | 93 | 75 - 125 | 5 | 20 | | |
| Lead | 93 | 86 | 75 - 125 | 8 | 20 | | |
| Nickel | 100 | 95 | 75 - 125 | 5 | 20 | | |
| Silver | 93 | 90 | 75 - 125 | 4 | 20 | | |
| Thallium | 80 | 75 | 75 - 125 | 6 | 20 | | |
| Zinc | 92 | 85 | 75 - 125 | 8 | 20 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**Matrix Spike/**
**Matrix Spike Duplicate Recovery Report - Batch: 680-37202**

**Method: 200.8**
**Preparation: 4.1.4**
**Dissolved**

| | | | |
|---|---|---|---|
| MS Lab Sample ID: | 700-9680-1 | Analysis Batch: 680-37853 | Instrument ID: ICP MS |
| Client Matrix: | Water | Prep Batch: 680-37202 | Lab File ID: N/A |
| Dilution: | 4.0 | | Initial Weight/Volume: 50 mL |
| Date Analyzed: | 03/01/2006 1856 | | Final Weight/Volume: 250 mL |
| Date Prepared: | 02/23/2006 1624 | | |

| | | | |
|---|---|---|---|
| MSD Lab Sample ID: | 700-9680-1 | Analysis Batch: 680-37853 | Instrument ID: ICP MS |
| Client Matrix: | Water | Prep Batch: 680-37202 | Lab File ID: N/A |
| Dilution: | 4.0 | | Initial Weight/Volume: 50 mL |
| Date Analyzed: | 03/01/2006 1903 | | Final Weight/Volume: 250 mL |
| Date Prepared: | 02/23/2006 1624 | | |

| | % Rec. | | | | | | |
|---|---|---|---|---|---|---|---|
| Analyte | MS | MSD | Limit | RPD | RPD Limit | MS Qual | MSD Qual |
| Selenium | 103 | 101 | 75 - 125 | 2 | 20 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**Method Blank - Batch: 680-37205**

**Method: 200.8**
**Preparation: 4.1.4**
**Total Recoverable**

Lab Sample ID: MB 680-37205/7-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/25/2006 0309
Date Prepared: 02/23/2006 1637

Analysis Batch: 680-37851
Prep Batch: 680-37205
Units: ug/L

Instrument ID: ICP MS
Lab File ID: N/A
Initial Weight/Volume: 50 mL
Final Weight/Volume: 250 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Antimony | ND | | 1.0 | 2.5 |
| Arsenic | ND | | 0.60 | 2.5 |
| Cadmium | ND | | 0.10 | 0.50 |
| Chromium | ND | | 1.5 | 5.0 |
| Copper | ND | | 0.39 | 2.5 |
| Lead | ND | | 0.50 | 1.5 |
| Nickel | ND | | 0.15 | 1.0 |
| Silver | ND | | 0.25 | 1.0 |
| Thallium | ND | | 0.25 | 1.0 |
| Zinc | 4.3 | J | 3.5 | 20 |

**Method Blank - Batch: 680-37205**

**Method: 200.8**
**Preparation: 4.1.4**
**Total Recoverable**

Lab Sample ID: MB 680-37205/7-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 03/01/2006 2016
Date Prepared: 02/23/2006 1637

Analysis Batch: 680-37851
Prep Batch: 680-37205
Units: ug/L

Instrument ID: ICP MS
Lab File ID: N/A
Initial Weight/Volume: 50 mL
Final Weight/Volume: 250 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Selenium | ND | | 0.50 | 2.5 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**Method Blank - Batch: 680-37205**

**Method: 200.8**
**Preparation: 4.1.4**
**Total Recoverable**

Lab Sample ID: MB 680-37205/7-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 03/03/2006 0632
Date Prepared: 02/23/2006 1637

Analysis Batch: 680-37851
Prep Batch: 680-37205
Units: ug/L

Instrument ID: ICP MS
Lab File ID: N/A
Initial Weight/Volume: 50 mL
Final Weight/Volume: 250 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Beryllium | ND | | 0.15 | 0.50 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 680-37205**

**Method: 200.8**
**Preparation: 4.1.4**
**Total Recoverable**

LCS Lab Sample ID: LCS 680-37205/8-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/25/2006 0316
Date Prepared: 02/23/2006 1637

Analysis Batch: 680-37851
Prep Batch: 680-37205
Units: ug/L

Instrument ID: ICP MS
Lab File ID: N/A
Initial Weight/Volume: 50 mL
Final Weight/Volume: 250 mL

LCSD Lab Sample ID: LCSD 680-37205/9-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/25/2006 0323
Date Prepared: 02/23/2006 1637

Analysis Batch: 680-37851
Prep Batch: 680-37205
Units: ug/L

Instrument ID: ICP MS
Lab File ID: N/A
Initial Weight/Volume: 50 mL
Final Weight/Volume: 250 mL

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| Antimony | 100 | 94 | 85 - 115 | 6 | 20 | | |
| Arsenic | 109 | 97 | 85 - 115 | 12 | 20 | | |
| Cadmium | 101 | 93 | 85 - 115 | 8 | 20 | | |
| Chromium | 109 | 94 | 85 - 115 | 14 | 20 | | |
| Copper | 113 | 98 | 85 - 115 | 14 | 20 | | |
| Lead | 106 | 101 | 85 - 115 | 5 | 20 | | |
| Nickel | 111 | 97 | 85 - 115 | 13 | 20 | | |
| Silver | 103 | 99 | 85 - 115 | 4 | 20 | | |
| Thallium | 103 | 98 | 85 - 115 | 5 | 20 | | |
| Zinc | 103 | 97 | 85 - 115 | 6 | 20 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental Job Number: 700-9680-1

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 680-37205**

**Method: 200.8**
**Preparation: 4.1.4**
**Total Recoverable**

| | | | |
|---|---|---|---|
| LCS Lab Sample ID: | LCS 680-37205/8-A | Analysis Batch: 680-37851 | Instrument ID: ICP MS |
| Client Matrix: | Water | Prep Batch: 680-37205 | Lab File ID: N/A |
| Dilution: | 1.0 | Units: ug/L | Initial Weight/Volume: 50 mL |
| Date Analyzed: | 03/01/2006 2023 | | Final Weight/Volume: 250 mL |
| Date Prepared: | 02/23/2006 1637 | | |

| | | | |
|---|---|---|---|
| LCSD Lab Sample ID: | LCSD 680-37205/9-A | Analysis Batch: 680-37851 | Instrument ID: ICP MS |
| Client Matrix: | Water | Prep Batch: 680-37205 | Lab File ID: N/A |
| Dilution: | 1.0 | Units: ug/L | Initial Weight/Volume: 50 mL |
| Date Analyzed: | 03/01/2006 2030 | | Final Weight/Volume: 250 mL |
| Date Prepared: | 02/23/2006 1637 | | |

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| Selenium | 99 | 97 | 85 - 115 | 2 | 20 | | |

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 680-37205**

**Method: 200.8**
**Preparation: 4.1.4**
**Total Recoverable**

| | | | |
|---|---|---|---|
| LCS Lab Sample ID: | LCS 680-37205/8-A | Analysis Batch: 680-37851 | Instrument ID: ICP MS |
| Client Matrix: | Water | Prep Batch: 680-37205 | Lab File ID: N/A |
| Dilution: | 1.0 | Units: ug/L | Initial Weight/Volume: 50 mL |
| Date Analyzed: | 03/03/2006 0639 | | Final Weight/Volume: 250 mL |
| Date Prepared: | 02/23/2006 1637 | | |

| | | | |
|---|---|---|---|
| LCSD Lab Sample ID: | LCSD 680-37205/9-A | Analysis Batch: 680-37851 | Instrument ID: ICP MS |
| Client Matrix: | Water | Prep Batch: 680-37205 | Lab File ID: N/A |
| Dilution: | 1.0 | Units: ug/L | Initial Weight/Volume: 50 mL |
| Date Analyzed: | 03/03/2006 0646 | | Final Weight/Volume: 250 mL |
| Date Prepared: | 02/23/2006 1637 | | |

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| Beryllium | 98 | 98 | 85 - 115 | 0 | 20 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**Matrix Spike/**
**Matrix Spike Duplicate Recovery Report - Batch: 680-37205**

**Method: 200.8**
**Preparation: 4.1.4**
**Total Recoverable**

| | | | | | |
|---|---|---|---|---|---|
| MS Lab Sample ID: | 700-9680-3 | Analysis Batch: | 680-37851 | Instrument ID: | ICP MS |
| Client Matrix: | Water | Prep Batch: | 680-37205 | Lab File ID: | N/A |
| Dilution: | 1.0 | | | Initial Weight/Volume: | 50 mL |
| Date Analyzed: | 02/25/2006 0352 | | | Final Weight/Volume: | 250 mL |
| Date Prepared: | 02/23/2006 1637 | | | | |

| | | | | | |
|---|---|---|---|---|---|
| MSD Lab Sample ID: | 700-9680-3 | Analysis Batch: | 680-37851 | Instrument ID: | ICP MS |
| Client Matrix: | Water | Prep Batch: | 680-37205 | Lab File ID: | N/A |
| Dilution: | 1.0 | | | Initial Weight/Volume: | 50 mL |
| Date Analyzed: | 02/25/2006 0400 | | | Final Weight/Volume: | 250 mL |
| Date Prepared: | 02/23/2006 1637 | | | | |

| | % Rec. | | | | | | |
|---|---|---|---|---|---|---|---|
| Analyte | MS | MSD | Limit | RPD | RPD Limit | MS Qual | MSD Qual |
| Antimony | 99 | 100 | 75 - 125 | 1 | 20 | | |
| Arsenic | 97 | 98 | 75 - 125 | 2 | 20 | | |
| Cadmium | 91 | 92 | 75 - 125 | 1 | 20 | | |
| Chromium | 98 | 105 | 75 - 125 | 7 | 20 | | |
| Copper | 92 | 98 | 75 - 125 | 6 | 20 | | |
| Lead | 91 | 91 | 75 - 125 | 0 | 20 | | |
| Nickel | 92 | 98 | 75 - 125 | 5 | 20 | | |
| Silver | 84 | 93 | 75 - 125 | 10 | 20 | | |
| Thallium | 89 | 90 | 75 - 125 | 1 | 20 | | |
| Zinc | 92 | 92 | 75 - 125 | 0 | 20 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**Matrix Spike/**
**Matrix Spike Duplicate Recovery Report - Batch: 680-37205**

**Method: 200.8**
**Preparation: 4.1.4**
**Total Recoverable**

| | | | |
|---|---|---|---|
| MS Lab Sample ID: | 700-9680-3 | Analysis Batch: 680-37851 | Instrument ID: ICP MS |
| Client Matrix: | Water | Prep Batch: 680-37205 | Lab File ID: N/A |
| Dilution: | 4.0 | | Initial Weight/Volume: 50 mL |
| Date Analyzed: | 03/01/2006 2059 | | Final Weight/Volume: 250 mL |
| Date Prepared: | 02/23/2006 1637 | | |

| | | | |
|---|---|---|---|
| MSD Lab Sample ID: | 700-9680-3 | Analysis Batch: 680-37851 | Instrument ID: ICP MS |
| Client Matrix: | Water | Prep Batch: 680-37205 | Lab File ID: N/A |
| Dilution: | 4.0 | | Initial Weight/Volume: 50 mL |
| Date Analyzed: | 03/01/2006 2106 | | Final Weight/Volume: 250 mL |
| Date Prepared: | 02/23/2006 1637 | | |

| | % Rec. | | | | | |
|---|---|---|---|---|---|---|
| Analyte | MS | MSD | Limit | RPD | RPD Limit | MS Qual MSD Qual |
| Selenium | 96 | 97 | 75 - 125 | 0 | 20 | |

**Matrix Spike/**
**Matrix Spike Duplicate Recovery Report - Batch: 680-37205**

**Method: 200.8**
**Preparation: 4.1.4**
**Total Recoverable**

| | | | |
|---|---|---|---|
| MS Lab Sample ID: | 700-9680-3 | Analysis Batch: 680-37851 | Instrument ID: ICP MS |
| Client Matrix: | Water | Prep Batch: 680-37205 | Lab File ID: N/A |
| Dilution: | 4.0 | | Initial Weight/Volume: 50 mL |
| Date Analyzed: | 03/03/2006 0716 | | Final Weight/Volume: 250 mL |
| Date Prepared: | 02/23/2006 1637 | | |

| | | | |
|---|---|---|---|
| MSD Lab Sample ID: | 700-9680-3 | Analysis Batch: 680-37851 | Instrument ID: ICP MS |
| Client Matrix: | Water | Prep Batch: 680-37205 | Lab File ID: N/A |
| Dilution: | 4.0 | | Initial Weight/Volume: 50 mL |
| Date Analyzed: | 03/03/2006 0723 | | Final Weight/Volume: 250 mL |
| Date Prepared: | 02/23/2006 1637 | | |

| | % Rec. | | | | | |
|---|---|---|---|---|---|---|
| Analyte | MS | MSD | Limit | RPD | RPD Limit | MS Qual MSD Qual |
| Beryllium | 100 | 98 | 75 - 125 | 3 | 20 | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**Method Blank - Batch: 700-17199**

**Method: 245.1**
**Preparation: 245.1**

Lab Sample ID: MB 700-17199/1-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/14/2006 1622
Date Prepared: 02/13/2006 1432

Analysis Batch: 700-17272
Prep Batch: 700-17199
Units: mg/L

Instrument ID: LEEMAN PS200
Lab File ID: N/A
Initial Weight/Volume: 40 mL
Final Weight/Volume: 40 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Mercury | ND | | 0.000078 | 0.00020 |

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17199**

**Method: 245.1**
**Preparation: 245.1**

LCS Lab Sample ID: LCS 700-17199/2-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/14/2006 1623
Date Prepared: 02/13/2006 1432

Analysis Batch: 700-17272
Prep Batch: 700-17199
Units: mg/L

Instrument ID: LEEMAN PS200
Lab File ID: N/A
Initial Weight/Volume: 40 mL
Final Weight/Volume: 40 mL

LCSD Lab Sample ID: LCSD 700-17199/3-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/14/2006 1625
Date Prepared: 02/13/2006 1432

Analysis Batch: 700-17272
Prep Batch: 700-17199
Units: mg/L

Instrument ID: LEEMAN PS200
Lab File ID: N/A
Initial Weight/Volume: 40 mL
Final Weight/Volume: 40 mL

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| Mercury | 97 | 94 | 80 - 120 | 3 | 20 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**Method Blank - Batch: 700-17565**

**Method: 245.1**
**Preparation: 245.1**

Lab Sample ID: MB 700-17565/1-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/22/2006 1043
Date Prepared: 02/21/2006 1015

Analysis Batch: 700-17622
Prep Batch: 700-17565
Units: mg/L

Instrument ID: LEEMAN PS200
Lab File ID: N/A
Initial Weight/Volume: 40.0 mL
Final Weight/Volume: 40.0 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Mercury | ND | | 0.000078 | 0.00020 |

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17565**

**Method: 245.1**
**Preparation: 245.1**

LCS Lab Sample ID: LCS 700-17565/2-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/22/2006 1045
Date Prepared: 02/21/2006 1015

Analysis Batch: 700-17622
Prep Batch: 700-17565
Units: mg/L

Instrument ID: LEEMAN PS200
Lab File ID: N/A
Initial Weight/Volume: 40.0 mL
Final Weight/Volume: 40.0 mL

LCSD Lab Sample ID: LCSD 700-17565/3-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/22/2006 1046
Date Prepared: 02/21/2006 1015

Analysis Batch: 700-17622
Prep Batch: 700-17565
Units: mg/L

Instrument ID: LEEMAN PS200
Lab File ID: N/A
Initial Weight/Volume: 40.0 mL
Final Weight/Volume: 40.0 mL

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| Mercury | 114 | 113 | 80 - 120 | 2 | 20 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**Matrix Spike/**
**Matrix Spike Duplicate Recovery Report - Batch: 700-17565**

**Method: 245.1**
**Preparation: 245.1**

| | | | | | |
|---|---|---|---|---|---|
| MS Lab Sample ID: | 700-9680-3 | Analysis Batch: | 700-17622 | Instrument ID: | LEEMAN PS200 |
| Client Matrix: | Water | Prep Batch: | 700-17565 | Lab File ID: | N/A |
| Dilution: | 1.0 | | | Initial Weight/Volume: | 40.0 mL |
| Date Analyzed: | 02/22/2006 1049 | | | Final Weight/Volume: | 40.0 mL |
| Date Prepared: | 02/21/2006 1015 | | | | |

| | | | | | |
|---|---|---|---|---|---|
| MSD Lab Sample ID: | 700-9680-3 | Analysis Batch: | 700-17622 | Instrument ID: | LEEMAN PS200 |
| Client Matrix: | Water | Prep Batch: | 700-17565 | Lab File ID: | N/A |
| Dilution: | 1.0 | | | Initial Weight/Volume: | 40.0 mL |
| Date Analyzed: | 02/22/2006 1051 | | | Final Weight/Volume: | 40.0 mL |
| Date Prepared: | 02/21/2006 1015 | | | | |

| | % Rec. | | | | | | |
|---|---|---|---|---|---|---|---|
| Analyte | MS | MSD | Limit | RPD | RPD Limit | MS Qual | MSD Qual |
| Mercury | 110 | 103 | 80 - 120 | 6 | 20 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**Method Blank - Batch: 680-37134**

**Method: 6020**
**Preparation: 3050B**

Lab Sample ID: MB 680-37134/11-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/24/2006 2117
Date Prepared: 02/23/2006 1049

Analysis Batch: 680-37413
Prep Batch: 680-37134
Units: mg/Kg

Instrument ID: ICP MS
Lab File ID: N/A
Initial Weight/Volume: 1.00 g
Final Weight/Volume: 1000 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Antimony | ND | | 0.20 | 0.50 |
| Arsenic | ND | | 0.12 | 0.50 |
| Beryllium | ND | | 0.030 | 0.10 |
| Cadmium | ND | | 0.020 | 0.10 |
| Chromium | ND | | 0.30 | 1.0 |
| Copper | 0.085 | J | 0.038 | 0.50 |
| Lead | ND | | 0.10 | 0.30 |
| Selenium | ND | | 0.10 | 0.50 |
| Silver | ND | | 0.050 | 0.20 |
| Thallium | ND | | 0.050 | 0.20 |
| Zinc | 0.31 | J | 0.27 | 4.0 |

**Method Blank - Batch: 680-37134**

**Method: 6020**
**Preparation: 3050B**

Lab Sample ID: MB 680-37134/11-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/25/2006 2028
Date Prepared: 02/23/2006 1049

Analysis Batch: 680-37413
Prep Batch: 680-37134
Units: mg/Kg

Instrument ID: ICP MS
Lab File ID: N/A
Initial Weight/Volume: 1.00 g
Final Weight/Volume: 1000 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Nickel | 0.051 | J | 0.030 | 0.20 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 680-37134**

**Method: 6020**
**Preparation: 3050B**

LCS Lab Sample ID: LCS 680-37134/12-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/24/2006 2125
Date Prepared: 02/23/2006 1049

Analysis Batch: 680-37413
Prep Batch: 680-37134
Units: mg/Kg

Instrument ID: ICP MS
Lab File ID: N/A
Initial Weight/Volume: 1.00 g
Final Weight/Volume: 1000 mL

LCSD Lab Sample ID: LCSD 680-37134/13-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/24/2006 2132
Date Prepared: 02/23/2006 1049

Analysis Batch: 680-37413
Prep Batch: 680-37134
Units: mg/Kg

Instrument ID: ICP MS
Lab File ID: N/A
Initial Weight/Volume: 1.00 g
Final Weight/Volume: 1000 mL

| | % Rec. | | | | | | |
|---|---|---|---|---|---|---|---|
| Analyte | LCS | LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
| Antimony | 95 | 93 | 75 - 125 | 2 | 20 | | |
| Arsenic | 97 | 95 | 75 - 125 | 1 | 20 | | |
| Beryllium | 94 | 91 | 75 - 125 | 3 | 20 | | |
| Cadmium | 94 | 91 | 75 - 125 | 3 | 20 | | |
| Chromium | 95 | 96 | 75 - 125 | 2 | 20 | | |
| Copper | 107 | 99 | 75 - 125 | 8 | 20 | | |
| Lead | 100 | 100 | 75 - 125 | 0 | 20 | | |
| Selenium | 93 | 93 | 75 - 125 | 0 | 20 | | |
| Silver | 102 | 99 | 75 - 125 | 3 | 20 | | |
| Thallium | 95 | 97 | 75 - 125 | 2 | 20 | | |
| Zinc | 97 | 95 | 75 - 125 | 3 | 20 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 680-37134**

**Method: 6020**
**Preparation: 3050B**

LCS Lab Sample ID: LCS 680-37134/12-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/25/2006 2035
Date Prepared: 02/23/2006 1049

Analysis Batch: 680-37413
Prep Batch: 680-37134
Units: mg/Kg

Instrument ID: ICP MS
Lab File ID: N/A
Initial Weight/Volume: 1.00 g
Final Weight/Volume: 1000 mL

LCSD Lab Sample ID: LCSD 680-37134/13-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/25/2006 2043
Date Prepared: 02/23/2006 1049

Analysis Batch: 680-37413
Prep Batch: 680-37134
Units: mg/Kg

Instrument ID: ICP MS
Lab File ID: N/A
Initial Weight/Volume: 1.00 g
Final Weight/Volume: 1000 mL

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| Nickel | 101 | 99 | 75 - 125 | 3 | 20 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**Matrix Spike/**
**Matrix Spike Duplicate Recovery Report - Batch: 680-37134**

**Method: 6020**
**Preparation: 3050B**

| | | | | | |
|---|---|---|---|---|---|
| MS Lab Sample ID: | 700-9680-2 | Analysis Batch: | 680-37413 | Instrument ID: | ICP MS |
| Client Matrix: | Solid | Prep Batch: | 680-37134 | Lab File ID: | N/A |
| Dilution: | 1.0 | | | Initial Weight/Volume: | 1.10 g |
| Date Analyzed: | 02/24/2006 2201 | | | Final Weight/Volume: | 1000 mL |
| Date Prepared: | 02/23/2006 1049 | | | | |

| | | | | | |
|---|---|---|---|---|---|
| MSD Lab Sample ID: | 700-9680-2 | Analysis Batch: | 680-37413 | Instrument ID: | ICP MS |
| Client Matrix: | Solid | Prep Batch: | 680-37134 | Lab File ID: | N/A |
| Dilution: | 1.0 | | | Initial Weight/Volume: | 1.10 g |
| Date Analyzed: | 02/24/2006 2208 | | | Final Weight/Volume: | 1000 mL |
| Date Prepared: | 02/23/2006 1049 | | | | |

| | % Rec. | | | | | | |
|---|---|---|---|---|---|---|---|
| Analyte | MS | MSD | Limit | RPD | RPD Limit | MS Qual | MSD Qual |
| Antimony | 93 | 93 | 75 - 125 | 0 | 20 | | |
| Arsenic | 97 | 103 | 75 - 125 | 3 | 20 | | |
| Beryllium | 106 | 102 | 75 - 125 | 3 | 20 | | |
| Cadmium | 101 | 100 | 75 - 125 | 1 | 20 | | |
| Chromium | 104 | 105 | 75 - 125 | 0 | 20 | | |
| Copper | 106 | 106 | 75 - 125 | 0 | 20 | B | B |
| Lead | 93 | 97 | 75 - 125 | 2 | 20 | | |
| Selenium | 102 | 101 | 75 - 125 | 1 | 20 | | |
| Silver | 108 | 106 | 75 - 125 | 2 | 20 | | |
| Thallium | 103 | 103 | 75 - 125 | 0 | 20 | | |
| Zinc | 91 | 94 | 75 - 125 | 1 | 20 | B | B |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**Matrix Spike/**
**Matrix Spike Duplicate Recovery Report - Batch: 680-37134**

**Method: 6020**
**Preparation: 3050B**

| | | | |
|---|---|---|---|
| MS Lab Sample ID: | 700-9680-2 | Analysis Batch: 680-37413 | Instrument ID: ICP MS |
| Client Matrix: | Solid | Prep Batch: 680-37134 | Lab File ID: N/A |
| Dilution: | 1.0 | | Initial Weight/Volume: 1.10 g |
| Date Analyzed: | 02/25/2006 2112 | | Final Weight/Volume: 1000 mL |
| Date Prepared: | 02/23/2006 1049 | | |

| | | | |
|---|---|---|---|
| MSD Lab Sample ID: | 700-9680-2 | Analysis Batch: 680-37413 | Instrument ID: ICP MS |
| Client Matrix: | Solid | Prep Batch: 680-37134 | Lab File ID: N/A |
| Dilution: | 1.0 | | Initial Weight/Volume: 1.10 g |
| Date Analyzed: | 02/25/2006 2119 | | Final Weight/Volume: 1000 mL |
| Date Prepared: | 02/23/2006 1049 | | |

| | % Rec. | | | | | | |
|---|---|---|---|---|---|---|---|
| Analyte | MS | MSD | Limit | RPD | RPD Limit | MS Qual | MSD Qual |
| Nickel | 85 | 85 | 75 - 125 | 0 | 20 | B | B |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**Method Blank - Batch: 700-17349**

**Method: 7471A**
**Preparation: 7471A**

Lab Sample ID: MB 700-17349/1-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/16/2006 1116
Date Prepared: 02/15/2006 1700

Analysis Batch: 700-17398
Prep Batch: 700-17349
Units: mg/Kg

Instrument ID: LEEMAN PS200
Lab File ID: N/A
Initial Weight/Volume: 0.40 g
Final Weight/Volume: 40.0 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Mercury | ND | | 0.010 | 0.020 |

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17349**

**Method: 7471A**
**Preparation: 7471A**

LCS Lab Sample ID: LCS 700-17349/2-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/16/2006 1117
Date Prepared: 02/15/2006 1700

Analysis Batch: 700-17398
Prep Batch: 700-17349
Units: mg/Kg

Instrument ID: LEEMAN PS200
Lab File ID: N/A
Initial Weight/Volume: 0.40 g
Final Weight/Volume: 40.0 mL

LCSD Lab Sample ID: LCSD 700-17349/3-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/16/2006 1118
Date Prepared: 02/15/2006 1700

Analysis Batch: 700-17398
Prep Batch: 700-17349
Units: mg/Kg

Instrument ID: LEEMAN PS200
Lab File ID: N/A
Initial Weight/Volume: 0.40 g
Final Weight/Volume: 40.0 mL

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| Mercury | 116 | 105 | 80 - 120 | 22 | 20 | | * |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**Matrix Spike/**
**Matrix Spike Duplicate Recovery Report - Batch: 700-17349**

**Method: 7471A**
**Preparation: 7471A**

| | | | | | |
|---|---|---|---|---|---|
| MS Lab Sample ID: | 700-9680-2 | Analysis Batch: | 700-17398 | Instrument ID: | LEEMAN PS200 |
| Client Matrix: | Solid | Prep Batch: | 700-17349 | Lab File ID: | N/A |
| Dilution: | 1.0 | | | Initial Weight/Volume: | 0.51 g |
| Date Analyzed: | 02/16/2006 1122 | | | Final Weight/Volume: | 40.0 mL |
| Date Prepared: | 02/15/2006 1700 | | | | |

| | | | | | |
|---|---|---|---|---|---|
| MSD Lab Sample ID: | 700-9680-2 | Analysis Batch: | 700-17398 | Instrument ID: | LEEMAN PS200 |
| Client Matrix: | Solid | Prep Batch: | 700-17349 | Lab File ID: | N/A |
| Dilution: | 1.0 | | | Initial Weight/Volume: | 0.50 g |
| Date Analyzed: | 02/16/2006 1123 | | | Final Weight/Volume: | 40.0 mL |
| Date Prepared: | 02/15/2006 1700 | | | | |

| | % Rec. | | | | | | |
|---|---|---|---|---|---|---|---|
| Analyte | MS | MSD | Limit | RPD | RPD Limit | MS Qual | MSD Qual |
| Mercury | 99 | 96 | 80 - 120 | 1 | 20 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**Method Blank - Batch: 700-17513**

**Method: 350.1**
**Preparation: N/A**

Lab Sample ID: MB 700-17513/1
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/17/2006 1952
Date Prepared: N/A

Analysis Batch: 700-17513
Prep Batch: N/A
Units: mg/Kg

Instrument ID: KONELAB AUTOANALYZE
Lab File ID: N/A
Initial Weight/Volume: 10 mL
Final Weight/Volume: 10 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Ammonia-Soluble | ND | | 0.0070 | 0.025 |

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17513**

**Method: 350.1**
**Preparation: N/A**

LCS Lab Sample ID: LCS 700-17513/29
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/17/2006 2011
Date Prepared: N/A

Analysis Batch: 700-17513
Prep Batch: N/A
Units: mg/Kg

Instrument ID: KONELAB AUTOANALYZE
Lab File ID: N/A
Initial Weight/Volume: 10 mL
Final Weight/Volume: 10 mL

LCSD Lab Sample ID: LCSD 700-17513/30
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/17/2006 2011
Date Prepared: N/A

Analysis Batch: 700-17513
Prep Batch: N/A
Units: mg/Kg

Instrument ID: KONELAB AUTOANALY
Lab File ID: N/A
Initial Weight/Volume: 10 mL
Final Weight/Volume: 10 mL

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| Ammonia-Soluble | 102 | | 75 - 125 | | | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**Method Blank - Batch: 700-17558**

**Method: 350.1**
**Preparation: N/A**

Lab Sample ID: MB 700-17558/1
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/17/2006 1952
Date Prepared: N/A

Analysis Batch: 700-17558
Prep Batch: N/A
Units: mg/Kg

Instrument ID: No Equipment Assigned
Lab File ID: N/A
Initial Weight/Volume: 10 mL
Final Weight/Volume: 10 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Ammonia-Soluble | ND | | 0.0070 | 0.025 |

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17558**

**Method: 350.1**
**Preparation: N/A**

LCS Lab Sample ID: LCS 700-17558/2
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/17/2006 1952
Date Prepared: N/A

Analysis Batch: 700-17558
Prep Batch: N/A
Units: mg/Kg

Instrument ID: No Equipment Assigned
Lab File ID: N/A
Initial Weight/Volume: 10 mL
Final Weight/Volume: 10 mL

LCSD Lab Sample ID: LCSD 700-17558/3
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/17/2006 1952
Date Prepared: N/A

Analysis Batch: 700-17558
Prep Batch: N/A
Units: mg/Kg

Instrument ID: No Equipment Assigned
Lab File ID: N/A
Initial Weight/Volume: 10 mL
Final Weight/Volume: 10 mL

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| Ammonia-Soluble | 100 | 100 | 75 - 125 | 0 | 30 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**Method Blank - Batch: 700-17446**

**Method: 351.2**
**Preparation: 351.2**

Lab Sample ID: MB 700-17446/1-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/17/2006 1604
Date Prepared: 02/16/2006 1800

Analysis Batch: 700-17470
Prep Batch: 700-17446
Units: mg/L

Instrument ID: QUICKCHEM 8000
Lab File ID: 0217TKTP.FDT
Initial Weight/Volume: 20 mL
Final Weight/Volume: 20 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Nitrogen, Kjeldahl | ND | | 0.15 | 0.20 |

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17446**

**Method: 351.2**
**Preparation: 351.2**

LCS Lab Sample ID: LCS 700-17446/2-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/17/2006 1605
Date Prepared: 02/16/2006 1800

Analysis Batch: 700-17470
Prep Batch: 700-17446
Units: mg/L

Instrument ID: QUICKCHEM 8000
Lab File ID: 0217TKTP.FDT
Initial Weight/Volume: 20 mL
Final Weight/Volume: 20 mL

LCSD Lab Sample ID: LCSD 700-17446/3-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/17/2006 1606
Date Prepared: 02/16/2006 1800

Analysis Batch: 700-17470
Prep Batch: 700-17446
Units: mg/L

Instrument ID: QUICKCHEM 8000
Lab File ID: 0217TKTP.FDT
Initial Weight/Volume: 20 mL
Final Weight/Volume: 20 mL

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| Nitrogen, Kjeldahl | 98 | 102 | 75 - 125 | 4 | 40 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**Method Blank - Batch: 700-17595**

**Method: 351.2**
**Preparation: 351.2**

Lab Sample ID: MB 700-17595/1-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/21/2006 1703
Date Prepared: 02/20/2006 2206

Analysis Batch: 700-17598
Prep Batch: 700-17595
Units: mg/L

Instrument ID: QUICKCHEM 8000
Lab File ID: TPTK0221.FDT
Initial Weight/Volume: 20 mL
Final Weight/Volume: 20 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Nitrogen, Kjeldahl | ND | | 0.15 | 0.20 |

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17595**

**Method: 351.2**
**Preparation: 351.2**

LCS Lab Sample ID: LCS 700-17595/2-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/21/2006 1704
Date Prepared: 02/20/2006 2206

Analysis Batch: 700-17598
Prep Batch: 700-17595
Units: mg/L

Instrument ID: QUICKCHEM 8000
Lab File ID: TPTK0221.FDT
Initial Weight/Volume: 20 mL
Final Weight/Volume: 20 mL

LCSD Lab Sample ID: LCSD 700-17595/3-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/21/2006 1705
Date Prepared: 02/20/2006 2206

Analysis Batch: 700-17598
Prep Batch: 700-17595
Units: mg/L

Instrument ID: QUICKCHEM 8000
Lab File ID: TPTK0221.FDT
Initial Weight/Volume: 20 mL
Final Weight/Volume: 20 mL

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| Nitrogen, Kjeldahl | 94 | 82 | 75 - 125 | 14 | 40 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**Method Blank - Batch: 700-17424**

**Method: 353.2**
**Preparation: N/A**

Lab Sample ID: MB 700-17424/2
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/15/2006 1054
Date Prepared: N/A

Analysis Batch: 700-17424
Prep Batch: N/A
Units: mg/L

Instrument ID: QUICKCHEM 8000
Lab File ID: NO30215B.FDT
Initial Weight/Volume: 10 mL
Final Weight/Volume: 10 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Nitrogen, Nitrate Nitrite | 0.044 | J | 0.024 | 0.050 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**Method Blank - Batch: 700-17716**

**Method: 353.2**
**Preparation: N/A**

Lab Sample ID: MB 700-17716/2
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/23/2006 1632
Date Prepared: N/A

Analysis Batch: 700-17716
Prep Batch: N/A
Units: mg/L

Instrument ID: QUICKCHEM 8000
Lab File ID: NO30223.FDT
Initial Weight/Volume: 10 mL
Final Weight/Volume: 10 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Nitrogen, Nitrate Nitrite | ND | | 0.024 | 0.050 |

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17716**

**Method: 353.2**
**Preparation: N/A**

LCS Lab Sample ID: LCS 700-17716/4
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/23/2006 1635
Date Prepared: N/A

Analysis Batch: 700-17716
Prep Batch: N/A
Units: mg/L

Instrument ID: QUICKCHEM 8000
Lab File ID: NO30223.FDT
Initial Weight/Volume: 10 mL
Final Weight/Volume: 10 mL

LCSD Lab Sample ID: LCSD 700-17716/5
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/23/2006 1636
Date Prepared: N/A

Analysis Batch: 700-17716
Prep Batch: N/A
Units: mg/L

Instrument ID: QUICKCHEM 8000
Lab File ID: NO30223.FDT
Initial Weight/Volume: 10 mL
Final Weight/Volume: 10 mL

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| Nitrogen, Nitrate Nitrite | 89 | 90 | 80 - 120 | 1.2 | 30.0 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**Method Blank - Batch: 700-17448**

**Method: 365.4**
**Preparation: 365.2/365.3**

Lab Sample ID: MB 700-17448/1-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/17/2006 1603
Date Prepared: 02/16/2006 1800

Analysis Batch: 700-17469
Prep Batch: 700-17448
Units: mg/Kg

Instrument ID: QUICKCHEM 8000
Lab File ID: 0217TKTP.FDT
Initial Weight/Volume: 20 mL
Final Weight/Volume: 20 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Phosphorus, Total | 0.086 | | 0.0015 | 0.063 |

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17448**

**Method: 365.4**
**Preparation: 365.2/365.3**

LCS Lab Sample ID: LCS 700-17448/2-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/17/2006 1605
Date Prepared: 02/16/2006 1800

Analysis Batch: 700-17469
Prep Batch: 700-17448
Units: mg/Kg

Instrument ID: QUICKCHEM 8000
Lab File ID: 0217TKTP.FDT
Initial Weight/Volume: 20 mL
Final Weight/Volume: 20 mL

LCSD Lab Sample ID: LCSD 700-17448/3-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/17/2006 1606
Date Prepared: 02/16/2006 1800

Analysis Batch: 700-17469
Prep Batch: 700-17448
Units: mg/Kg

Instrument ID: QUICKCHEM 8000
Lab File ID: 0217TKTP.FDT
Initial Weight/Volume: 20 mL
Final Weight/Volume: 20 mL

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| Phosphorus, Total | 108 | 112 | 60 - 140 | 3.1 | 40.0 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9680-1

**Method Blank - Batch: 700-17596**

**Method: 365.4**
**Preparation: 365.2/365.3**

Lab Sample ID: MB 700-17596/1-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/21/2006 1703
Date Prepared: 02/20/2006 2206

Analysis Batch: 700-17597
Prep Batch: 700-17596
Units: mg/L

Instrument ID: QUICKCHEM 8000
Lab File ID: TPTK0221.FDT
Initial Weight/Volume: 20 mL
Final Weight/Volume: 20 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Phosphorus, Total | ND | | 0.000030 | 0.10 |

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17596**

**Method: 365.4**
**Preparation: 365.2/365.3**

LCS Lab Sample ID: LCS 700-17596/2-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/21/2006 1704
Date Prepared: 02/20/2006 2206

Analysis Batch: 700-17597
Prep Batch: 700-17596
Units: mg/L

Instrument ID: QUICKCHEM 8000
Lab File ID: TPTK0221.FDT
Initial Weight/Volume: 20 mL
Final Weight/Volume: 20 mL

LCSD Lab Sample ID: LCSD 700-17596/3-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/21/2006 1705
Date Prepared: 02/20/2006 2206

Analysis Batch: 700-17597
Prep Batch: 700-17596
Units: mg/L

Instrument ID: QUICKCHEM 8000
Lab File ID: TPTK0221.FDT
Initial Weight/Volume: 20 mL
Final Weight/Volume: 20 mL

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| Phosphorus, Total | 91 | 81 | 60 - 140 | 13 | 40 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

# APPENDIX C

# SEVERN TRENT LABORATORIES, INC. ANALYTICAL REPORT (FEBRUARY 13, 2006 SAMPLES)

# ANALYTICAL REPORT

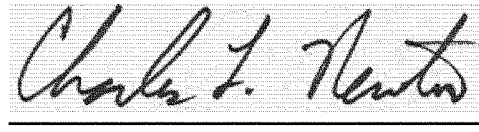
Job Number: 700-9790-1

Job Description: Providence Engineering & Envvironmental

For:

Providence Engineering & Environmental
6160 Perkins Road
Suite 100
Baton Rouge, LA 70808

Attention: Mr. Phillip Parker



Charles Newton
Project Manager I
cnewton@stl-inc.com
03/13/2006

**Severn Trent Laboratories, Inc.**
STL Mobile 900 Lakeside Drive, Mobile, AL 36693
Tel 251-666-6633 Fax 251-666-6696 www.stl-inc.com

## METHOD SUMMARY

Client: Providence Engineering & Environmental Job Number: 700-9790-1

| Description | Lab Location | Method | Preparation Method |
|---|---|---|---|
| **Matrix: Solid** | | | |
| Volatile Organic Compounds by GC/MS | STL-MOB | SW846 8260B | |
| Purge-and-Trap Low Level | STL-MOB | | SW846 5030B |
| Semivolatile Compounds by Gas Chromatography/Mass Spectrometry (GC/MS) | STL-MOB | SW846 8270C | |
| Ultrasonic Extraction | STL-MOB | | SW846 3550B |
| Semivolatile Organic Compounds by GCMS - Low Levels | STL-MOB | SW846 8270C | |
| Ultrasonic Extraction | STL-MOB | | SW846 3550B |
| Organochlorine Pesticides by Gas Chromatography | STL-MOB | SW846 8081A | |
| Ultrasonic Extraction | STL-MOB | | SW846 3550B |
| Polychlorinated Biphenyls (PCBs) by Gas Chromatography | STL-MOB | SW846 8082 | |
| Ultrasonic Extraction | STL-MOB | | SW846 3550B |
| Inductively Coupled Plasma - Mass Spectrometry | STL-SAV | SW846 6020 | |
| Acid Digestion of Sediments, Sludges, and Soils | STL-SAV | | SW846 3050B |
| Mercury in Solid or Semisolid Waste (Manual Cold Vapor Technique) | STL-MOB | SW846 7471A | |
| Mercury in Solid or Semi-Solid Waste (Manual | STL-MOB | | SW846 7471A |
| Nitrogen (Ammonia, Colorimetric, Automated Phenate) | STL-MOB | MCAWW 350.1 | |
| Deionized Water Leaching Procedure (Routine) | STL-MOB | | ASTM NONE |
| Nitrogen, Total Kjeldahl (Colorimetric, Semi-Automated Block Digester, AAII) | STL-MOB | MCAWW 351.2 | |
| Nitrogen, Total Kjeldahl (Colorimetric, | STL-MOB | | MCAWW 351.2 |
| Nitrogen, Nitrate-Nitrite (Colorimetric, Automated, Cadmium Reduction) | STL-MOB | MCAWW 353.2 | |
| Deionized Water Leaching Procedure (Routine) | STL-MOB | | ASTM NONE |
| Total Phosphorus | STL-MOB | EPA 365.4 | |
| Sample Digestion for Total Phosphorous | STL-MOB | | MCAWW 365.2/365.3 |
| Percent Moisture | STL-MOB | EPA 160.3 | |
| Total Nitrogen | STL-MOB | EPA Total Nitrogen | |
| **Matrix: Water** | | | |
| Purgeable Organic Compounds by GC/MS | STL-MOB | 40CFR136A 624 | |
| Base/Neutral and Acid Organics in Wastewater | STL-MOB | 40CFR136A 625 | |
| Continuous Liquid-Liquid Extraction | STL-MOB | | SW846 3520C |
| Organochlorine Pesticides/PCBs in Water | STL-MOB | 40CFR136A 608 | |
| Continuous LiqLiq Extractions for Clean Water Act | STL-MOB | | 40CFR136A |
| ICPMS Metals by 200.8 CWA | STL-SAV | EPA 200.8 | |

## METHOD SUMMARY

Client: Providence Engineering & Environmental Job Number: 700-9790-1

| Matrix: Water | | | |
|---|---|---|---|
| ICPMS Metals by 200.8 CWA | STL-SAV | EPA 200.8 | |
| Total Recoverable Metals for 200.8 | STL-SAV | | MCAWW 4.1.4 |
| Sample Filtration performed in the Field | STL-SAV | | FIELD_FLTRD |
| Mercury in Water by CVAA | STL-MOB | EPA 245.1 | |
| Digestion for CVAA Mercury in Waters | STL-MOB | | EPA 245.1 |
| Nitrogen (Ammonia, Colorimetric, Automated Phenate) | STL-MOB | MCAWW 350.1 | |
| Nitrogen, Total Kjeldahl (Colorimetric, Semi-Automated Block Digester, AAII) | STL-MOB | MCAWW 351.2 | |
| Nitrogen, Total Kjeldahl (Colorimetric, | STL-MOB | | MCAWW 351.2 |
| Nitrogen, Nitrate-Nitrite (Colorimetric, Automated, Cadmium Reduction) | STL-MOB | MCAWW 353.2 | |
| Total Phosphorus | STL-MOB | EPA 365.4 | |
| Sample Digestion for Total Phosphorous | STL-MOB | | MCAWW 365.2/365.3 |
| Organic Nitrogen | STL-MOB | EPA Nitrogen,Org | |

### LAB REFERENCES:

STL-SAV = STL-Savannah
STL-MOB = STL-Mobile

### METHOD REFERENCES:

40CFR136A - "Methods for Organic Chemical Analysis of Municipal Industrial Wastewater", 40CFR, Part 136, Appendix A, October 26, 1984 and subsequent revisions.

EPA - US Environmental Protection Agency

MCAWW - "Methods For Chemical Analysis Of Water And Wastes", EPA-600/4-79-020, March 1983 And Subsequent Revisions.

SW846 - "Test Methods For Evaluating Solid Waste, Physical/Chemical Methods", Third Edition, November 1986 And Its Updates.

## METHOD / ANALYST SUMMARY

Client: Providence Engineering & Environmental Job Number: 700-9790-1

| Method | Analyst | Analyst ID |
|---|---|---|
| 40CFR136A 624 | Var, Kerry | KBV |
| SW846 8260B | Var, Kerry | KBV |
| 40CFR136A 625 | Huynh, HoangNam | HH |
| SW846 8270C | Huynh, HoangNam | HH |
| SW846 8270C | Nguyen, LanHuong | LN |
| 40CFR136A 608 | Nguyen, Khanh | KN |
| SW846 8081A | Nguyen, Khanh | KN |
| SW846 8082 | Nguyen, Khanh | KN |
| EPA 200.8 | Boyuk, Brian | BB |
| EPA 200.8 | Eaton, Cliff | CE |
| EPA 245.1 | Bruce, Timothy R | TRB |
| SW846 6020 | Eaton, Cliff | CE |
| SW846 7471A | Bruce, Timothy R | TRB |
| EPA 160.3 | Giang, My | MG |
| MCAWW 350.1 | Bradley, Katie | KB |
| MCAWW 351.2 | Flanagan, Mike | MF |
| MCAWW 353.2 | Bradley, Katie | KB |
| EPA 365.4 | Flanagan, Mike | MF |
| EPA Nitrogen,Org | Bradley, Katie | KB |
| EPA Total Nitrogen | Flanagan, Mike | MF |

## SAMPLE SUMMARY

Client: Providence Engineering & Environmental Job Number: 700-9790-1

| Lab Sample ID | Client Sample ID | Client Matrix | Date/Time Sampled | Date/Time Received |
|---|---|---|---|---|
| 700-9790-1 | CH01 Water | Water | 02/13/2006 0935 | 02/15/2006 0903 |
| 700-9790-2 | CH01 Elutriate | Water | 02/13/2006 0920 | 02/15/2006 0903 |
| 700-9790-3 | CH01 Sediment | Solid | 02/13/2006 0920 | 02/15/2006 0903 |
| 700-9790-6 | CH02 Elutriate | Water | 02/13/2006 1200 | 02/15/2006 0903 |
| 700-9790-7 | CH02 Sediment | Solid | 02/13/2006 1200 | 02/15/2006 0903 |
| 700-9790-8 | SPELTO 01 Water | Water | 02/13/2006 1415 | 02/15/2006 0903 |
| 700-9790-9 | SPELTO 01 Elutriate | Water | 02/13/2006 1420 | 02/15/2006 0903 |
| 700-9790-11 | SPELTO 01 Sediment | Solid | 02/13/2006 1420 | 02/15/2006 0903 |
| 700-9790-13 | SPELTO 02 Elutriate | Water | 02/13/2006 1540 | 02/15/2006 0903 |
| 700-9790-14 | SPELTO 02 Sediment | Solid | 02/13/2006 1540 | 02/15/2006 0903 |
| 700-9790-15 | CH01A | Water | 02/13/2006 0945 | 02/15/2006 0903 |
| 700-9790-16 | CH01B | Water | 02/13/2006 0950 | 02/15/2006 0903 |
| 700-9790-17 | CH01C | Water | 02/13/2006 0955 | 02/15/2006 0903 |
| 700-9790-18 | SPELTO 01A | Water | 02/13/2006 1415 | 02/15/2006 0903 |
| 700-9790-19 | SPELTO 01B | Water | 02/13/2006 1420 | 02/15/2006 0903 |
| 700-9790-20 | SPELTO 01C | Water | 02/13/2006 1425 | 02/15/2006 0903 |

# SAMPLE RESULTS

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9790-1

**Client Sample ID:** **CH01 Elutriate**

Lab Sample ID: 700-9790-2 Date Sampled: 02/13/2006 0920
Client Matrix: Water Date Received: 02/15/2006 0903

**624 Purgeable Organic Compounds by GC/MS**

Method: 624 Analysis Batch: 700-17632 Instrument ID: VMG5973
Preparation: N/A Lab File ID: G022128.D
Dilution: 1.0 Initial Weight/Volume: 5 mL
Date Analyzed: 02/21/2006 2213 Final Weight/Volume: 5 mL
Date Prepared: N/A

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| 1,1,1-Trichloroethane | ND | | 0.19 | 5.0 |
| 1,1,2,2-Tetrachloroethane | ND | | 0.25 | 5.0 |
| 1,1,2-Trichloroethane | ND | | 0.31 | 5.0 |
| 1,1-Dichloroethane | ND | | 0.14 | 5.0 |
| 1,1-Dichloroethene | ND | | 0.38 | 5.0 |
| 1,2-Dichloroethane | ND | | 0.15 | 5.0 |
| 1,2-Dichloropropane | ND | | 0.15 | 5.0 |
| 2-Chloroethyl vinyl ether | ND | | 0.50 | 50 |
| Acrolein | ND | * | 9.6 | 100 |
| Acrylonitrile | ND | | 0.67 | 100 |
| Benzene | ND | | 0.12 | 5.0 |
| Bromoform | ND | | 0.18 | 5.0 |
| Bromomethane | ND | | 0.80 | 10 |
| Carbon tetrachloride | ND | | 0.56 | 5.0 |
| Chlorobenzene | ND | | 0.17 | 5.0 |
| Chlorodibromomethane | ND | | 0.50 | 5.0 |
| Chloroethane | ND | | 0.84 | 10 |
| Chloroform | ND | | 0.18 | 5.0 |
| Chloromethane | ND | | 0.15 | 10 |
| Dichlorobromomethane | ND | | 0.50 | 5.0 |
| Ethylbenzene | ND | | 0.56 | 5.0 |
| Methylene Chloride | ND | | 0.45 | 5.0 |
| Tetrachloroethene | ND | | 0.20 | 5.0 |
| Toluene | ND | | 0.19 | 5.0 |
| trans-1,2-Dichloroethene | ND | | 0.24 | 5.0 |
| Trichloroethene | ND | | 0.29 | 5.0 |
| Vinyl chloride | ND | | 0.22 | 10 |
| 1,3-Dichloropropane | ND | | 0.50 | 5.0 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| Toluene-d8 | 111 | 77 - 116 |
| Dibromofluoromethane | 115 | 66 - 125 |
| 4-Bromofluorobenzene | 111 | 70 - 118 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9790-1

**Client Sample ID:** **CH02 Elutriate**

Lab Sample ID: 700-9790-6 Date Sampled: 02/13/2006 1200
Client Matrix: Water Date Received: 02/15/2006 0903

**624 Purgeable Organic Compounds by GC/MS**

Method: 624 Analysis Batch: 700-17632 Instrument ID: VMG5973
Preparation: N/A Lab File ID: G022129.D
Dilution: 1.0 Initial Weight/Volume: 5 mL
Date Analyzed: 02/21/2006 2243 Final Weight/Volume: 5 mL
Date Prepared: N/A

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| 1,1,1-Trichloroethane | ND | | 0.19 | 5.0 |
| 1,1,2,2-Tetrachloroethane | ND | | 0.25 | 5.0 |
| 1,1,2-Trichloroethane | ND | | 0.31 | 5.0 |
| 1,1-Dichloroethane | ND | | 0.14 | 5.0 |
| 1,1-Dichloroethene | ND | | 0.38 | 5.0 |
| 1,2-Dichloroethane | ND | | 0.15 | 5.0 |
| 1,2-Dichloropropane | ND | | 0.15 | 5.0 |
| 2-Chloroethyl vinyl ether | ND | | 0.50 | 50 |
| Acrolein | ND | * | 9.6 | 100 |
| Acrylonitrile | ND | | 0.67 | 100 |
| Benzene | ND | | 0.12 | 5.0 |
| Bromoform | ND | | 0.18 | 5.0 |
| Bromomethane | ND | | 0.80 | 10 |
| Carbon tetrachloride | ND | | 0.56 | 5.0 |
| Chlorobenzene | ND | | 0.17 | 5.0 |
| Chlorodibromomethane | ND | | 0.50 | 5.0 |
| Chloroethane | ND | | 0.84 | 10 |
| Chloroform | ND | | 0.18 | 5.0 |
| Chloromethane | ND | | 0.15 | 10 |
| Dichlorobromomethane | ND | | 0.50 | 5.0 |
| Ethylbenzene | ND | | 0.56 | 5.0 |
| Methylene Chloride | 6.4 | | 0.45 | 5.0 |
| Tetrachloroethene | ND | | 0.20 | 5.0 |
| Toluene | ND | | 0.19 | 5.0 |
| trans-1,2-Dichloroethene | ND | | 0.24 | 5.0 |
| Trichloroethene | ND | | 0.29 | 5.0 |
| Vinyl chloride | ND | | 0.22 | 10 |
| 1,3-Dichloropropane | ND | | 0.50 | 5.0 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| Toluene-d8 | 108 | 77 - 116 |
| Dibromofluoromethane | 115 | 66 - 125 |
| 4-Bromofluorobenzene | 108 | 70 - 118 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9790-1

**Client Sample ID:** **SPELTO 01 Elutriate**

Lab Sample ID: 700-9790-9 | Date Sampled: 02/13/2006 1420
Client Matrix: Water | Date Received: 02/15/2006 0903

**624 Purgeable Organic Compounds by GC/MS**

Method: 624 | Analysis Batch: 700-17632 | Instrument ID: VMG5973
Preparation: N/A | Lab File ID: G022130.D
Dilution: 1.0 | Initial Weight/Volume: 5 mL
Date Analyzed: 02/21/2006 2314 | Final Weight/Volume: 5 mL
Date Prepared: N/A

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| 1,1,1-Trichloroethane | ND | | 0.19 | 5.0 |
| 1,1,2,2-Tetrachloroethane | ND | | 0.25 | 5.0 |
| 1,1,2-Trichloroethane | ND | | 0.31 | 5.0 |
| 1,1-Dichloroethane | ND | | 0.14 | 5.0 |
| 1,1-Dichloroethene | ND | | 0.38 | 5.0 |
| 1,2-Dichloroethane | ND | | 0.15 | 5.0 |
| 1,2-Dichloropropane | ND | | 0.15 | 5.0 |
| 2-Chloroethyl vinyl ether | ND | | 0.50 | 50 |
| Acrolein | ND | * | 9.6 | 100 |
| Acrylonitrile | ND | | 0.67 | 100 |
| Benzene | ND | | 0.12 | 5.0 |
| Bromoform | ND | | 0.18 | 5.0 |
| Bromomethane | ND | | 0.80 | 10 |
| Carbon tetrachloride | ND | | 0.56 | 5.0 |
| Chlorobenzene | ND | | 0.17 | 5.0 |
| Chlorodibromomethane | ND | | 0.50 | 5.0 |
| Chloroethane | ND | | 0.84 | 10 |
| Chloroform | ND | | 0.18 | 5.0 |
| Chloromethane | ND | | 0.15 | 10 |
| Dichlorobromomethane | ND | | 0.50 | 5.0 |
| Ethylbenzene | ND | | 0.56 | 5.0 |
| Methylene Chloride | 9.2 | | 0.45 | 5.0 |
| Tetrachloroethene | ND | | 0.20 | 5.0 |
| Toluene | ND | | 0.19 | 5.0 |
| trans-1,2-Dichloroethene | ND | | 0.24 | 5.0 |
| Trichloroethene | ND | | 0.29 | 5.0 |
| Vinyl chloride | ND | | 0.22 | 10 |
| 1,3-Dichloropropane | ND | | 0.50 | 5.0 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| Toluene-d8 | 109 | 77 - 116 |
| Dibromofluoromethane | 120 | 66 - 125 |
| 4-Bromofluorobenzene | 111 | 70 - 118 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9790-1

**Client Sample ID:** **SPELTO 02 Elutriate**

Lab Sample ID: 700-9790-13 Date Sampled: 02/13/2006 1540
Client Matrix: Water Date Received: 02/15/2006 0903

**624 Purgeable Organic Compounds by GC/MS**

Method: 624 Analysis Batch: 700-17632 Instrument ID: VMG5973
Preparation: N/A Lab File ID: G022131.D
Dilution: 1.0 Initial Weight/Volume: 5 mL
Date Analyzed: 02/21/2006 2344 Final Weight/Volume: 5 mL
Date Prepared: N/A

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| 1,1,1-Trichloroethane | ND | | 0.19 | 5.0 |
| 1,1,2,2-Tetrachloroethane | ND | | 0.25 | 5.0 |
| 1,1,2-Trichloroethane | ND | | 0.31 | 5.0 |
| 1,1-Dichloroethane | ND | | 0.14 | 5.0 |
| 1,1-Dichloroethene | ND | | 0.38 | 5.0 |
| 1,2-Dichloroethane | ND | | 0.15 | 5.0 |
| 1,2-Dichloropropane | ND | | 0.15 | 5.0 |
| 2-Chloroethyl vinyl ether | ND | | 0.50 | 50 |
| Acrolein | ND | * | 9.6 | 100 |
| Acrylonitrile | ND | | 0.67 | 100 |
| Benzene | ND | | 0.12 | 5.0 |
| Bromoform | ND | | 0.18 | 5.0 |
| Bromomethane | ND | | 0.80 | 10 |
| Carbon tetrachloride | ND | | 0.56 | 5.0 |
| Chlorobenzene | ND | | 0.17 | 5.0 |
| Chlorodibromomethane | ND | | 0.50 | 5.0 |
| Chloroethane | ND | | 0.84 | 10 |
| Chloroform | ND | | 0.18 | 5.0 |
| Chloromethane | ND | | 0.15 | 10 |
| Dichlorobromomethane | ND | | 0.50 | 5.0 |
| Ethylbenzene | ND | | 0.56 | 5.0 |
| Methylene Chloride | ND | | 0.45 | 5.0 |
| Tetrachloroethene | ND | | 0.20 | 5.0 |
| Toluene | ND | | 0.19 | 5.0 |
| trans-1,2-Dichloroethene | ND | | 0.24 | 5.0 |
| Trichloroethene | ND | | 0.29 | 5.0 |
| Vinyl chloride | ND | | 0.22 | 10 |
| 1,3-Dichloropropane | ND | | 0.50 | 5.0 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| Toluene-d8 | 111 | 77 - 116 |
| Dibromofluoromethane | 115 | 66 - 125 |
| 4-Bromofluorobenzene | 108 | 70 - 118 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9790-1

**Client Sample ID: CH01A**

Lab Sample ID: 700-9790-15 Date Sampled: 02/13/2006 0945
Client Matrix: Water Date Received: 02/15/2006 0903

**624 Purgeable Organic Compounds by GC/MS**

Method: 624 Analysis Batch: 700-17450 Instrument ID: VMG5973
Preparation: N/A Lab File ID: G021622.D
Dilution: 1.0 Initial Weight/Volume: 5 mL
Date Analyzed: 02/17/2006 0945 Final Weight/Volume: 5 mL
Date Prepared: N/A

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| 1,1,1-Trichloroethane | ND | | 0.19 | 5.0 |
| 1,1,2,2-Tetrachloroethane | ND | | 0.25 | 5.0 |
| 1,1,2-Trichloroethane | ND | | 0.31 | 5.0 |
| 1,1-Dichloroethane | ND | | 0.14 | 5.0 |
| 1,1-Dichloroethene | ND | | 0.38 | 5.0 |
| 1,2-Dichloroethane | ND | | 0.15 | 5.0 |
| 1,2-Dichloropropane | ND | | 0.15 | 5.0 |
| 2-Chloroethyl vinyl ether | ND | | 0.50 | 50 |
| Acrolein | ND | | 9.6 | 100 |
| Acrylonitrile | ND | | 0.67 | 100 |
| Benzene | ND | | 0.12 | 5.0 |
| Bromoform | ND | | 0.18 | 5.0 |
| Bromomethane | ND | | 0.80 | 10 |
| Carbon tetrachloride | ND | | 0.56 | 5.0 |
| Chlorobenzene | ND | | 0.17 | 5.0 |
| Chlorodibromomethane | ND | | 0.50 | 5.0 |
| Chloroethane | ND | | 0.84 | 10 |
| Chloroform | ND | | 0.18 | 5.0 |
| Chloromethane | ND | | 0.15 | 10 |
| Dichlorobromomethane | ND | | 0.50 | 5.0 |
| Ethylbenzene | ND | | 0.56 | 5.0 |
| Methylene Chloride | ND | | 0.45 | 5.0 |
| Tetrachloroethene | ND | | 0.20 | 5.0 |
| Toluene | ND | | 0.19 | 5.0 |
| trans-1,2-Dichloroethene | ND | | 0.24 | 5.0 |
| Trichloroethene | ND | | 0.29 | 5.0 |
| Vinyl chloride | ND | | 0.22 | 10 |
| 1,3-Dichloropropane | ND | | 0.50 | 5.0 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| Toluene-d8 | 107 | 77 - 116 |
| Dibromofluoromethane | 114 | 66 - 125 |
| 4-Bromofluorobenzene | 109 | 70 - 118 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9790-1

**Client Sample ID: CH01B**

Lab Sample ID: 700-9790-16 Date Sampled: 02/13/2006 0950
Client Matrix: Water Date Received: 02/15/2006 0903

**624 Purgeable Organic Compounds by GC/MS**

Method: 624 Analysis Batch: 700-17632 Instrument ID: VMG5973
Preparation: N/A Lab File ID: G022123.D
Dilution: 1.0 Initial Weight/Volume: 5 mL
Date Analyzed: 02/21/2006 1940 Final Weight/Volume: 5 mL
Date Prepared: N/A

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| 1,1,1-Trichloroethane | ND | | 0.19 | 5.0 |
| 1,1,2,2-Tetrachloroethane | ND | | 0.25 | 5.0 |
| 1,1,2-Trichloroethane | ND | | 0.31 | 5.0 |
| 1,1-Dichloroethane | ND | | 0.14 | 5.0 |
| 1,1-Dichloroethene | ND | | 0.38 | 5.0 |
| 1,2-Dichloroethane | ND | | 0.15 | 5.0 |
| 1,2-Dichloropropane | ND | | 0.15 | 5.0 |
| 2-Chloroethyl vinyl ether | ND | | 0.50 | 50 |
| Acrolein | ND | * | 9.6 | 100 |
| Acrylonitrile | ND | | 0.67 | 100 |
| Benzene | ND | | 0.12 | 5.0 |
| Bromoform | ND | | 0.18 | 5.0 |
| Bromomethane | ND | | 0.80 | 10 |
| Carbon tetrachloride | ND | | 0.56 | 5.0 |
| Chlorobenzene | ND | | 0.17 | 5.0 |
| Chlorodibromomethane | ND | | 0.50 | 5.0 |
| Chloroethane | ND | | 0.84 | 10 |
| Chloroform | ND | | 0.18 | 5.0 |
| Chloromethane | ND | | 0.15 | 10 |
| Dichlorobromomethane | ND | | 0.50 | 5.0 |
| Ethylbenzene | ND | | 0.56 | 5.0 |
| Methylene Chloride | ND | | 0.45 | 5.0 |
| Tetrachloroethene | ND | | 0.20 | 5.0 |
| Toluene | ND | | 0.19 | 5.0 |
| trans-1,2-Dichloroethene | ND | | 0.24 | 5.0 |
| Trichloroethene | ND | | 0.29 | 5.0 |
| Vinyl chloride | ND | | 0.22 | 10 |
| 1,3-Dichloropropane | ND | | 0.50 | 5.0 |

| Surrogate | %Rec | | Acceptance Limits |
|---|---|---|---|
| Toluene-d8 | 110 | | 77 - 116 |
| Dibromofluoromethane | 126 | * | 66 - 125 |
| 4-Bromofluorobenzene | 108 | | 70 - 118 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9790-1

**Client Sample ID:** **CH01C**

Lab Sample ID: 700-9790-17 Date Sampled: 02/13/2006 0955
Client Matrix: Water Date Received: 02/15/2006 0903

**624 Purgeable Organic Compounds by GC/MS**

Method: 624 Analysis Batch: 700-17632 Instrument ID: VMG5973
Preparation: N/A Lab File ID: G022124.D
Dilution: 1.0 Initial Weight/Volume: 5 mL
Date Analyzed: 02/21/2006 2011 Final Weight/Volume: 5 mL
Date Prepared: N/A

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| 1,1,1-Trichloroethane | ND | | 0.19 | 5.0 |
| 1,1,2,2-Tetrachloroethane | ND | | 0.25 | 5.0 |
| 1,1,2-Trichloroethane | ND | | 0.31 | 5.0 |
| 1,1-Dichloroethane | ND | | 0.14 | 5.0 |
| 1,1-Dichloroethene | ND | | 0.38 | 5.0 |
| 1,2-Dichloroethane | ND | | 0.15 | 5.0 |
| 1,2-Dichloropropane | ND | | 0.15 | 5.0 |
| 2-Chloroethyl vinyl ether | ND | | 0.50 | 50 |
| Acrolein | ND | * | 9.6 | 100 |
| Acrylonitrile | ND | | 0.67 | 100 |
| Benzene | ND | | 0.12 | 5.0 |
| Bromoform | ND | | 0.18 | 5.0 |
| Bromomethane | ND | | 0.80 | 10 |
| Carbon tetrachloride | ND | | 0.56 | 5.0 |
| Chlorobenzene | ND | | 0.17 | 5.0 |
| Chlorodibromomethane | ND | | 0.50 | 5.0 |
| Chloroethane | ND | | 0.84 | 10 |
| Chloroform | ND | | 0.18 | 5.0 |
| Chloromethane | ND | | 0.15 | 10 |
| Dichlorobromomethane | ND | | 0.50 | 5.0 |
| Ethylbenzene | ND | | 0.56 | 5.0 |
| Methylene Chloride | ND | | 0.45 | 5.0 |
| Tetrachloroethene | ND | | 0.20 | 5.0 |
| Toluene | ND | | 0.19 | 5.0 |
| trans-1,2-Dichloroethene | ND | | 0.24 | 5.0 |
| Trichloroethene | ND | | 0.29 | 5.0 |
| Vinyl chloride | ND | | 0.22 | 10 |
| 1,3-Dichloropropane | ND | | 0.50 | 5.0 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| Toluene-d8 | 109 | 77 - 116 |
| Dibromofluoromethane | 118 | 66 - 125 |
| 4-Bromofluorobenzene | 105 | 70 - 118 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9790-1

**Client Sample ID:** **SPELTO 01A**

Lab Sample ID: 700-9790-18 | Date Sampled: 02/13/2006 1415
Client Matrix: Water | Date Received: 02/15/2006 0903

**624 Purgeable Organic Compounds by GC/MS**

Method: 624 | Analysis Batch: 700-17632 | Instrument ID: VMG5973
Preparation: N/A | Lab File ID: G022125.D
Dilution: 1.0 | Initial Weight/Volume: 5 mL
Date Analyzed: 02/21/2006 2041 | Final Weight/Volume: 5 mL
Date Prepared: N/A

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| 1,1,1-Trichloroethane | ND | | 0.19 | 5.0 |
| 1,1,2,2-Tetrachloroethane | ND | | 0.25 | 5.0 |
| 1,1,2-Trichloroethane | ND | | 0.31 | 5.0 |
| 1,1-Dichloroethane | ND | | 0.14 | 5.0 |
| 1,1-Dichloroethene | ND | | 0.38 | 5.0 |
| 1,2-Dichloroethane | ND | | 0.15 | 5.0 |
| 1,2-Dichloropropane | ND | | 0.15 | 5.0 |
| 2-Chloroethyl vinyl ether | ND | | 0.50 | 50 |
| Acrolein | ND | * | 9.6 | 100 |
| Acrylonitrile | ND | | 0.67 | 100 |
| Benzene | ND | | 0.12 | 5.0 |
| Bromoform | ND | | 0.18 | 5.0 |
| Bromomethane | ND | | 0.80 | 10 |
| Carbon tetrachloride | ND | | 0.56 | 5.0 |
| Chlorobenzene | ND | | 0.17 | 5.0 |
| Chlorodibromomethane | ND | | 0.50 | 5.0 |
| Chloroethane | ND | | 0.84 | 10 |
| Chloroform | ND | | 0.18 | 5.0 |
| Chloromethane | ND | | 0.15 | 10 |
| Dichlorobromomethane | ND | | 0.50 | 5.0 |
| Ethylbenzene | ND | | 0.56 | 5.0 |
| Methylene Chloride | ND | | 0.45 | 5.0 |
| Tetrachloroethene | ND | | 0.20 | 5.0 |
| Toluene | ND | | 0.19 | 5.0 |
| trans-1,2-Dichloroethene | ND | | 0.24 | 5.0 |
| Trichloroethene | ND | | 0.29 | 5.0 |
| Vinyl chloride | ND | | 0.22 | 10 |
| 1,3-Dichloropropane | ND | | 0.50 | 5.0 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| Toluene-d8 | 108 | 77 - 116 |
| Dibromofluoromethane | 117 | 66 - 125 |
| 4-Bromofluorobenzene | 107 | 70 - 118 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9790-1

**Client Sample ID:** **SPELTO 01B**

Lab Sample ID: 700-9790-19 Date Sampled: 02/13/2006 1420
Client Matrix: Water Date Received: 02/15/2006 0903

**624 Purgeable Organic Compounds by GC/MS**

Method: 624 Analysis Batch: 700-17632 Instrument ID: VMG5973
Preparation: N/A Lab File ID: G022126.D
Dilution: 1.0 Initial Weight/Volume: 5 mL
Date Analyzed: 02/21/2006 2112 Final Weight/Volume: 5 mL
Date Prepared: N/A

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| 1,1,1-Trichloroethane | ND | | 0.19 | 5.0 |
| 1,1,2,2-Tetrachloroethane | ND | | 0.25 | 5.0 |
| 1,1,2-Trichloroethane | ND | | 0.31 | 5.0 |
| 1,1-Dichloroethane | ND | | 0.14 | 5.0 |
| 1,1-Dichloroethene | ND | | 0.38 | 5.0 |
| 1,2-Dichloroethane | ND | | 0.15 | 5.0 |
| 1,2-Dichloropropane | ND | | 0.15 | 5.0 |
| 2-Chloroethyl vinyl ether | ND | | 0.50 | 50 |
| Acrolein | ND | * | 9.6 | 100 |
| Acrylonitrile | ND | | 0.67 | 100 |
| Benzene | ND | | 0.12 | 5.0 |
| Bromoform | ND | | 0.18 | 5.0 |
| Bromomethane | ND | | 0.80 | 10 |
| Carbon tetrachloride | ND | | 0.56 | 5.0 |
| Chlorobenzene | ND | | 0.17 | 5.0 |
| Chlorodibromomethane | ND | | 0.50 | 5.0 |
| Chloroethane | ND | | 0.84 | 10 |
| Chloroform | ND | | 0.18 | 5.0 |
| Chloromethane | ND | | 0.15 | 10 |
| Dichlorobromomethane | ND | | 0.50 | 5.0 |
| Ethylbenzene | ND | | 0.56 | 5.0 |
| Methylene Chloride | ND | | 0.45 | 5.0 |
| Tetrachloroethene | ND | | 0.20 | 5.0 |
| Toluene | ND | | 0.19 | 5.0 |
| trans-1,2-Dichloroethene | ND | | 0.24 | 5.0 |
| Trichloroethene | ND | | 0.29 | 5.0 |
| Vinyl chloride | ND | | 0.22 | 10 |
| 1,3-Dichloropropane | ND | | 0.50 | 5.0 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| Toluene-d8 | 109 | 77 - 116 |
| Dibromofluoromethane | 122 | 66 - 125 |
| 4-Bromofluorobenzene | 109 | 70 - 118 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9790-1

**Client Sample ID: SPELTO 01C**

Lab Sample ID: 700-9790-20 Date Sampled: 02/13/2006 1425
Client Matrix: Water Date Received: 02/15/2006 0903

**624 Purgeable Organic Compounds by GC/MS**

Method: 624 Analysis Batch: 700-17632 Instrument ID: VMG5973
Preparation: N/A Lab File ID: G022127.D
Dilution: 1.0 Initial Weight/Volume: 5 mL
Date Analyzed: 02/21/2006 2142 Final Weight/Volume: 5 mL
Date Prepared: N/A

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| 1,1,1-Trichloroethane | ND | | 0.19 | 5.0 |
| 1,1,2,2-Tetrachloroethane | ND | | 0.25 | 5.0 |
| 1,1,2-Trichloroethane | ND | | 0.31 | 5.0 |
| 1,1-Dichloroethane | ND | | 0.14 | 5.0 |
| 1,1-Dichloroethene | ND | | 0.38 | 5.0 |
| 1,2-Dichloroethane | ND | | 0.15 | 5.0 |
| 1,2-Dichloropropane | ND | | 0.15 | 5.0 |
| 2-Chloroethyl vinyl ether | ND | | 0.50 | 50 |
| Acrolein | ND | * | 9.6 | 100 |
| Acrylonitrile | ND | | 0.67 | 100 |
| Benzene | ND | | 0.12 | 5.0 |
| Bromoform | ND | | 0.18 | 5.0 |
| Bromomethane | ND | | 0.80 | 10 |
| Carbon tetrachloride | ND | | 0.56 | 5.0 |
| Chlorobenzene | ND | | 0.17 | 5.0 |
| Chlorodibromomethane | ND | | 0.50 | 5.0 |
| Chloroethane | ND | | 0.84 | 10 |
| Chloroform | ND | | 0.18 | 5.0 |
| Chloromethane | ND | | 0.15 | 10 |
| Dichlorobromomethane | ND | | 0.50 | 5.0 |
| Ethylbenzene | ND | | 0.56 | 5.0 |
| Methylene Chloride | ND | | 0.45 | 5.0 |
| Tetrachloroethene | ND | | 0.20 | 5.0 |
| Toluene | ND | | 0.19 | 5.0 |
| trans-1,2-Dichloroethene | ND | | 0.24 | 5.0 |
| Trichloroethene | ND | | 0.29 | 5.0 |
| Vinyl chloride | ND | | 0.22 | 10 |
| 1,3-Dichloropropane | ND | | 0.50 | 5.0 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| Toluene-d8 | 106 | 77 - 116 |
| Dibromofluoromethane | 115 | 66 - 125 |
| 4-Bromofluorobenzene | 107 | 70 - 118 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9790-1

**Client Sample ID:** **CH01 Sediment**

Lab Sample ID: 700-9790-3 | Date Sampled: 02/13/2006 0920
Client Matrix: Solid | Date Received: 02/15/2006 0903

**8260B Volatile Organic Compounds by GC/MS**

Method: 8260B | Analysis Batch: 700-17535 | Instrument ID: VMG5973
Preparation: 5030B | Lab File ID: G022018.D
Dilution: 1.0 | Initial Weight/Volume: 5.27 g
Date Analyzed: 02/20/2006 1726 | Final Weight/Volume: 5 mL
Date Prepared: 02/20/2006 1726

| Analyte | DryWt Corrected: N | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| 1,1,1-Trichloroethane | | ND | | 1.4 | 4.7 |
| 1,1,2,2-Tetrachloroethane | | ND | | 1.6 | 4.7 |
| 1,1,2-Trichloroethane | | ND | | 1.1 | 4.7 |
| 1,1-Dichloroethane | | ND | | 0.95 | 4.7 |
| 1,1-Dichloroethene | | ND | | 1.2 | 4.7 |
| 1,2-Dichloroethane | | ND | | 1.9 | 4.7 |
| 1,2-Dichloropropane | | ND | | 1.1 | 4.7 |
| 1,3-Dichloropropene, Total | | ND | | 1.4 | 9.5 |
| 2-Chloroethyl vinyl ether | | ND | | 16 | 47 |
| Acrolein | | ND | | 27 | 95 |
| Acrylonitrile | | ND | | 59 | 95 |
| Benzene | | ND | | 1.0 | 4.7 |
| Bromoform | | ND | | 1.0 | 4.7 |
| Bromomethane | | ND | | 3.4 | 9.5 |
| Carbon tetrachloride | | ND | | 1.3 | 4.7 |
| Chlorobenzene | | ND | | 1.0 | 4.7 |
| Chlorodibromomethane | | ND | | 1.1 | 4.7 |
| Chloroethane | | ND | | 1.4 | 9.5 |
| Chloroform | | ND | | 0.78 | 4.7 |
| Chloromethane | | ND | | 2.2 | 9.5 |
| Dichlorobromomethane | | ND | | 1.1 | 4.7 |
| Ethylbenzene | | ND | | 1.7 | 4.7 |
| Methylene Chloride | | ND | | 1.5 | 4.7 |
| Tetrachloroethene | | ND | | 0.85 | 4.7 |
| Toluene | | ND | | 0.95 | 4.7 |
| trans-1,2-Dichloroethene | | ND | | 0.94 | 4.7 |
| Trichloroethene | | ND | | 0.85 | 4.7 |
| Vinyl chloride | | ND | | 1.5 | 9.5 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| Dibromofluoromethane | 124 | 59 - 132 |
| Toluene-d8 | 111 | 61 - 131 |
| 4-Bromofluorobenzene | 88 | 55 - 131 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9790-1

**Client Sample ID:** **CH02 Sediment**

Lab Sample ID: 700-9790-7 | Date Sampled: 02/13/2006 1200
Client Matrix: Solid | Date Received: 02/15/2006 0903

**8260B Volatile Organic Compounds by GC/MS**

Method: 8260B | Analysis Batch: 700-17535 | Instrument ID: VMG5973
Preparation: 5030B | Lab File ID: G022019.D
Dilution: 1.0 | Initial Weight/Volume: 5.22 g
Date Analyzed: 02/20/2006 1757 | Final Weight/Volume: 5 mL
Date Prepared: 02/20/2006 1757

| Analyte | DryWt Corrected: N | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| 1,1,1-Trichloroethane | | ND | | 1.4 | 4.8 |
| 1,1,2,2-Tetrachloroethane | | ND | | 1.6 | 4.8 |
| 1,1,2-Trichloroethane | | ND | | 1.1 | 4.8 |
| 1,1-Dichloroethane | | ND | | 0.96 | 4.8 |
| 1,1-Dichloroethene | | ND | | 1.2 | 4.8 |
| 1,2-Dichloroethane | | ND | | 1.9 | 4.8 |
| 1,2-Dichloropropane | | ND | | 1.1 | 4.8 |
| 1,3-Dichloropropene, Total | | ND | | 1.4 | 9.6 |
| 2-Chloroethyl vinyl ether | | ND | | 16 | 48 |
| Acrolein | | ND | | 27 | 96 |
| Acrylonitrile | | ND | | 59 | 96 |
| Benzene | | ND | | 1.1 | 4.8 |
| Bromoform | | ND | | 1.1 | 4.8 |
| Bromomethane | | ND | | 3.4 | 9.6 |
| Carbon tetrachloride | | ND | | 1.3 | 4.8 |
| Chlorobenzene | | ND | | 1.1 | 4.8 |
| Chlorodibromomethane | | ND | | 1.1 | 4.8 |
| Chloroethane | | ND | | 1.4 | 9.6 |
| Chloroform | | ND | | 0.79 | 4.8 |
| Chloromethane | | ND | | 2.2 | 9.6 |
| Dichlorobromomethane | | ND | | 1.1 | 4.8 |
| Ethylbenzene | | ND | | 1.7 | 4.8 |
| Methylene Chloride | | ND | | 1.5 | 4.8 |
| Tetrachloroethene | | ND | | 0.86 | 4.8 |
| Toluene | | ND | | 0.96 | 4.8 |
| trans-1,2-Dichloroethene | | ND | | 0.95 | 4.8 |
| Trichloroethene | | ND | | 0.86 | 4.8 |
| Vinyl chloride | | ND | | 1.5 | 9.6 |

| Surrogate | %Rec | | Acceptance Limits |
|---|---|---|---|
| Dibromofluoromethane | 133 | * | 59 - 132 |
| Toluene-d8 | 117 | | 61 - 131 |
| 4-Bromofluorobenzene | 100 | | 55 - 131 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9790-1

**Client Sample ID:** **SPELTO 01 Sediment**

Lab Sample ID: 700-9790-11 | Date Sampled: 02/13/2006 1420
Client Matrix: Solid | Date Received: 02/15/2006 0903

**8260B Volatile Organic Compounds by GC/MS**

Method: 8260B | Analysis Batch: 700-17535 | Instrument ID: VMG5973
Preparation: 5030B | Lab File ID: G022020.D
Dilution: 1.0 | Initial Weight/Volume: 5.09 g
Date Analyzed: 02/20/2006 1828 | Final Weight/Volume: 5 mL
Date Prepared: 02/20/2006 1828

| Analyte | DryWt Corrected: N | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| 1,1,1-Trichloroethane | | ND | | 1.5 | 4.9 |
| 1,1,2,2-Tetrachloroethane | | ND | | 1.7 | 4.9 |
| 1,1,2-Trichloroethane | | ND | | 1.2 | 4.9 |
| 1,1-Dichloroethane | | ND | | 0.98 | 4.9 |
| 1,1-Dichloroethene | | ND | | 1.3 | 4.9 |
| 1,2-Dichloroethane | | ND | | 2.0 | 4.9 |
| 1,2-Dichloropropane | | ND | | 1.2 | 4.9 |
| 1,3-Dichloropropene, Total | | ND | | 1.5 | 9.8 |
| 2-Chloroethyl vinyl ether | | ND | | 17 | 49 |
| Acrolein | | ND | | 28 | 98 |
| Acrylonitrile | | ND | | 61 | 98 |
| Benzene | | ND | | 1.1 | 4.9 |
| Bromoform | | ND | | 1.1 | 4.9 |
| Bromomethane | | ND | | 3.5 | 9.8 |
| Carbon tetrachloride | | ND | | 1.4 | 4.9 |
| Chlorobenzene | | ND | | 1.1 | 4.9 |
| Chlorodibromomethane | | ND | | 1.2 | 4.9 |
| Chloroethane | | ND | | 1.5 | 9.8 |
| Chloroform | | ND | | 0.81 | 4.9 |
| Chloromethane | | ND | | 2.3 | 9.8 |
| Dichlorobromomethane | | ND | | 1.2 | 4.9 |
| Ethylbenzene | | ND | | 1.8 | 4.9 |
| Methylene Chloride | | ND | | 1.6 | 4.9 |
| Tetrachloroethene | | ND | | 0.88 | 4.9 |
| Toluene | | ND | | 0.98 | 4.9 |
| trans-1,2-Dichloroethene | | ND | | 0.97 | 4.9 |
| Trichloroethene | | ND | | 0.88 | 4.9 |
| Vinyl chloride | | ND | | 1.6 | 9.8 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| Dibromofluoromethane | 125 | 59 - 132 |
| Toluene-d8 | 112 | 61 - 131 |
| 4-Bromofluorobenzene | 99 | 55 - 131 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9790-1

**Client Sample ID: SPELTO 02 Sediment**

Lab Sample ID: 700-9790-14 Date Sampled: 02/13/2006 1540
Client Matrix: Solid Date Received: 02/15/2006 0903

**8260B Volatile Organic Compounds by GC/MS**

Method: 8260B Analysis Batch: 700-17535 Instrument ID: VMG5973
Preparation: 5030B Lab File ID: G022021.D
Dilution: 1.0 Initial Weight/Volume: 5.15 g
Date Analyzed: 02/20/2006 1900 Final Weight/Volume: 5 mL
Date Prepared: 02/20/2006 1900

| Analyte | DryWt Corrected: N | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| 1,1,1-Trichloroethane | | ND | | 1.5 | 4.9 |
| 1,1,2,2-Tetrachloroethane | | ND | | 1.7 | 4.9 |
| 1,1,2-Trichloroethane | | ND | | 1.2 | 4.9 |
| 1,1-Dichloroethane | | ND | | 0.97 | 4.9 |
| 1,1-Dichloroethene | | ND | | 1.3 | 4.9 |
| 1,2-Dichloroethane | | ND | | 1.9 | 4.9 |
| 1,2-Dichloropropane | | ND | | 1.2 | 4.9 |
| 1,3-Dichloropropene, Total | | ND | | 1.5 | 9.7 |
| 2-Chloroethyl vinyl ether | | ND | | 17 | 49 |
| Acrolein | | ND | | 27 | 97 |
| Acrylonitrile | | ND | | 60 | 97 |
| Benzene | | ND | | 1.1 | 4.9 |
| Bromoform | | ND | | 1.1 | 4.9 |
| Bromomethane | | ND | | 3.5 | 9.7 |
| Carbon tetrachloride | | ND | | 1.4 | 4.9 |
| Chlorobenzene | | ND | | 1.1 | 4.9 |
| Chlorodibromomethane | | ND | | 1.2 | 4.9 |
| Chloroethane | | ND | | 1.5 | 9.7 |
| Chloroform | | ND | | 0.80 | 4.9 |
| Chloromethane | | ND | | 2.2 | 9.7 |
| Dichlorobromomethane | | ND | | 1.2 | 4.9 |
| Ethylbenzene | | ND | | 1.7 | 4.9 |
| Methylene Chloride | | ND | | 1.6 | 4.9 |
| Tetrachloroethene | | ND | | 0.87 | 4.9 |
| Toluene | | ND | | 0.97 | 4.9 |
| trans-1,2-Dichloroethene | | ND | | 0.96 | 4.9 |
| Trichloroethene | | ND | | 0.87 | 4.9 |
| Vinyl chloride | | ND | | 1.6 | 9.7 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| Dibromofluoromethane | 124 | 59 - 132 |
| Toluene-d8 | 109 | 61 - 131 |
| 4-Bromofluorobenzene | 101 | 55 - 131 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9790-1

**Client Sample ID:** **CH01 Water**

Lab Sample ID: 700-9790-1 | Date Sampled: 02/13/2006 0935
Client Matrix: Water | Date Received: 02/15/2006 0903

**625 Base/Neutral and Acid Organics in Wastewater**

Method: 625 | Analysis Batch: 700-17670 | Instrument ID: SMB5973
Preparation: 3520C | Prep Batch: 700-17550 | Lab File ID: B022229.D
Dilution: 5.0 | Initial Weight/Volume: 1000 mL
Date Analyzed: 02/23/2006 0340 | Final Weight/Volume: 1.0 mL
Date Prepared: 02/21/2006 0648 | Injection Volume:

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| 1,2,4-Trichlorobenzene | ND | | 1.2 | 10 |
| 1,2-Dichlorobenzene | ND | | 1.1 | 10 |
| 1,2-Diphenylhydrazine | ND | | 4.0 | 10 |
| 1,3-Dichlorobenzene | ND | | 1.1 | 10 |
| 1,4-Dichlorobenzene | ND | | 1.1 | 10 |
| 2,2'-oxybis(2-chloropropane) | ND | | 1.3 | 10 |
| 2,4,6-Trichlorophenol | ND | | 2.4 | 10 |
| 2,4-Dichlorophenol | ND | | 1.2 | 10 |
| 2,4-Dimethylphenol | ND | | 1.1 | 10 |
| 2,4-Dinitrophenol | ND | | 2.3 | 50 |
| 2,4-Dinitrotoluene | ND | | 2.2 | 10 |
| 2,6-Dinitrotoluene | ND | | 2.4 | 10 |
| 2-Chloronaphthalene | ND | | 1.7 | 10 |
| 2-Chlorophenol | ND | | 1.0 | 10 |
| 2-Nitrophenol | ND | * | 1.3 | 10 |
| 3,3'-Dichlorobenzidine | ND | | 7.1 | 20 |
| 4,6-Dinitro-2-methylphenol | ND | | 2.1 | 50 |
| 4-Bromophenyl phenyl ether | ND | | 1.7 | 10 |
| 4-Chloro-3-methylphenol | ND | | 1.0 | 10 |
| 4-Chlorophenyl phenyl ether | ND | | 1.5 | 10 |
| 4-Nitrophenol | ND | | 3.6 | 50 |
| Acenaphthene | ND | | 1.3 | 10 |
| Acenaphthylene | ND | | 2.4 | 10 |
| Anthracene | ND | | 1.0 | 10 |
| Benzidine | ND | | 8.4 | 80 |
| Benzo[a]anthracene | ND | | 1.0 | 10 |
| Benzo[a]pyrene | ND | | 5.6 | 10 |
| Benzo[b]fluoranthene | ND | | 9.5 | 10 |
| Benzo[g,h,i]perylene | ND | | 5.4 | 10 |
| Benzo[k]fluoranthene | ND | | 9.0 | 10 |
| Bis(2-chloroethoxy)methane | ND | | 5.4 | 10 |
| Bis(2-chloroethyl)ether | ND | | 3.0 | 10 |
| Bis(2-ethylhexyl) phthalate | ND | | 3.3 | 10 |
| Butyl benzyl phthalate | ND | | 2.8 | 10 |
| Chrysene | ND | | 2.3 | 10 |
| Dibenz(a,h)anthracene | ND | | 9.5 | 10 |
| Diethyl phthalate | ND | | 1.7 | 10 |
| Dimethyl phthalate | ND | | 1.2 | 10 |
| Di-n-butyl phthalate | ND | | 1.2 | 10 |
| Di-n-octyl phthalate | ND | | 1.8 | 10 |
| Fluoranthene | ND | | 1.0 | 10 |
| Fluorene | ND | | 1.5 | 10 |
| Hexachlorobenzene | ND | | 1.7 | 10 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9790-1

**Client Sample ID:** **CH01 Water**

Lab Sample ID: 700-9790-1 | Date Sampled: 02/13/2006 0935
Client Matrix: Water | Date Received: 02/15/2006 0903

**625 Base/Neutral and Acid Organics in Wastewater**

Method: 625 | Analysis Batch: 700-17670 | Instrument ID: SMB5973
Preparation: 3520C | Prep Batch: 700-17550 | Lab File ID: B022229.D
Dilution: 5.0 | Initial Weight/Volume: 1000 mL
Date Analyzed: 02/23/2006 0340 | Final Weight/Volume: 1.0 mL
Date Prepared: 02/21/2006 0648 | Injection Volume:

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Hexachlorobutadiene | ND | | 1.4 | 10 |
| Hexachlorocyclopentadiene | ND | | 1.8 | 10 |
| Hexachloroethane | ND | | 1.3 | 10 |
| Indeno[1,2,3-cd]pyrene | ND | | 2.9 | 10 |
| Isophorone | ND | | 1.1 | 10 |
| Naphthalene | ND | | 1.2 | 10 |
| Nitrobenzene | ND | | 1.4 | 10 |
| N-Nitrosodimethylamine | ND | | 2.2 | 10 |
| N-Nitrosodi-n-propylamine | ND | | 1.0 | 10 |
| N-Nitrosodiphenylamine | ND | | 10 | 10 |
| Pentachlorophenol | ND | | 2.1 | 50 |
| Phenanthrene | ND | | 1.2 | 10 |
| Phenol | ND | | 1.1 | 10 |
| Pyrene | ND | | 2.2 | 10 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| 2,4,6-Tribromophenol | 62 | 14 - 93 |
| 2-Fluorobiphenyl | 76 | 34 - 118 |
| 2-Fluorophenol | 35 | 25 - 102 |
| Nitrobenzene-d5 | 92 | 39 - 133 |
| Phenol-d5 | 47 | 21 - 95 |
| Terphenyl-d14 | 29 | 16 - 158 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9790-1

**Client Sample ID:** **CH01 Elutriate**

Lab Sample ID: 700-9790-2 | Date Sampled: 02/13/2006 0920
Client Matrix: Water | Date Received: 02/15/2006 0903

**625 Base/Neutral and Acid Organics in Wastewater**

Method: 625 | Analysis Batch: 700-17670 | Instrument ID: SMB5973
Preparation: 3520C | Prep Batch: 700-17550 | Lab File ID: B022228.D
Dilution: 5.0 | Initial Weight/Volume: 1000 mL
Date Analyzed: 02/23/2006 0306 | Final Weight/Volume: 1.0 mL
Date Prepared: 02/21/2006 0648 | Injection Volume:

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| 1,2,4-Trichlorobenzene | ND | | 1.2 | 10 |
| 1,2-Dichlorobenzene | ND | | 1.1 | 10 |
| 1,2-Diphenylhydrazine | ND | | 4.0 | 10 |
| 1,3-Dichlorobenzene | ND | | 1.1 | 10 |
| 1,4-Dichlorobenzene | ND | | 1.1 | 10 |
| 2,2'-oxybis(2-chloropropane) | ND | | 1.3 | 10 |
| 2,4,6-Trichlorophenol | ND | | 2.4 | 10 |
| 2,4-Dichlorophenol | ND | | 1.2 | 10 |
| 2,4-Dimethylphenol | ND | | 1.1 | 10 |
| 2,4-Dinitrophenol | ND | | 2.3 | 50 |
| 2,4-Dinitrotoluene | ND | | 2.2 | 10 |
| 2,6-Dinitrotoluene | ND | | 2.4 | 10 |
| 2-Chloronaphthalene | ND | | 1.7 | 10 |
| 2-Chlorophenol | ND | | 1.0 | 10 |
| 2-Nitrophenol | ND | * | 1.3 | 10 |
| 3,3'-Dichlorobenzidine | ND | | 7.1 | 20 |
| 4,6-Dinitro-2-methylphenol | ND | | 2.1 | 50 |
| 4-Bromophenyl phenyl ether | ND | | 1.7 | 10 |
| 4-Chloro-3-methylphenol | ND | | 1.0 | 10 |
| 4-Chlorophenyl phenyl ether | ND | | 1.5 | 10 |
| 4-Nitrophenol | ND | | 3.6 | 50 |
| Acenaphthene | ND | | 1.3 | 10 |
| Acenaphthylene | ND | | 2.4 | 10 |
| Anthracene | ND | | 1.0 | 10 |
| Benzidine | ND | | 8.4 | 80 |
| Benzo[a]anthracene | ND | | 1.0 | 10 |
| Benzo[a]pyrene | ND | | 5.6 | 10 |
| Benzo[b]fluoranthene | ND | | 9.5 | 10 |
| Benzo[g,h,i]perylene | ND | | 5.4 | 10 |
| Benzo[k]fluoranthene | ND | | 9.0 | 10 |
| Bis(2-chloroethoxy)methane | ND | | 5.4 | 10 |
| Bis(2-chloroethyl)ether | ND | | 3.0 | 10 |
| Bis(2-ethylhexyl) phthalate | 4.7 | J | 3.3 | 10 |
| Butyl benzyl phthalate | ND | | 2.8 | 10 |
| Chrysene | ND | | 2.3 | 10 |
| Dibenz(a,h)anthracene | ND | | 9.5 | 10 |
| Diethyl phthalate | ND | | 1.7 | 10 |
| Dimethyl phthalate | ND | | 1.2 | 10 |
| Di-n-butyl phthalate | ND | | 1.2 | 10 |
| Di-n-octyl phthalate | ND | | 1.8 | 10 |
| Fluoranthene | ND | | 1.0 | 10 |
| Fluorene | ND | | 1.5 | 10 |
| Hexachlorobenzene | ND | | 1.7 | 10 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9790-1

**Client Sample ID: CH01 Elutriate**

Lab Sample ID: 700-9790-2 Date Sampled: 02/13/2006 0920
Client Matrix: Water Date Received: 02/15/2006 0903

**625 Base/Neutral and Acid Organics in Wastewater**

Method: 625 Analysis Batch: 700-17670 Instrument ID: SMB5973
Preparation: 3520C Prep Batch: 700-17550 Lab File ID: B022228.D
Dilution: 5.0 Initial Weight/Volume: 1000 mL
Date Analyzed: 02/23/2006 0306 Final Weight/Volume: 1.0 mL
Date Prepared: 02/21/2006 0648 Injection Volume:

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Hexachlorobutadiene | ND | | 1.4 | 10 |
| Hexachlorocyclopentadiene | ND | | 1.8 | 10 |
| Hexachloroethane | ND | | 1.3 | 10 |
| Indeno[1,2,3-cd]pyrene | ND | | 2.9 | 10 |
| Isophorone | ND | | 1.1 | 10 |
| Naphthalene | ND | | 1.2 | 10 |
| Nitrobenzene | ND | | 1.4 | 10 |
| N-Nitrosodimethylamine | ND | | 2.2 | 10 |
| N-Nitrosodi-n-propylamine | ND | | 1.0 | 10 |
| N-Nitrosodiphenylamine | ND | | 10 | 10 |
| Pentachlorophenol | ND | | 2.1 | 50 |
| Phenanthrene | ND | | 1.2 | 10 |
| Phenol | ND | | 1.1 | 10 |
| Pyrene | ND | | 2.2 | 10 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| 2,4,6-Tribromophenol | 83 | 14 - 93 |
| 2-Fluorobiphenyl | 81 | 34 - 118 |
| 2-Fluorophenol | 45 | 25 - 102 |
| Nitrobenzene-d5 | 99 | 39 - 133 |
| Phenol-d5 | 61 | 21 - 95 |
| Terphenyl-d14 | 38 | 16 - 158 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9790-1

**Client Sample ID:** **CH02 Elutriate**

Lab Sample ID: 700-9790-6 Date Sampled: 02/13/2006 1200
Client Matrix: Water Date Received: 02/15/2006 0903

**625 Base/Neutral and Acid Organics in Wastewater**

Method: 625 Analysis Batch: 700-17670 Instrument ID: SMB5973
Preparation: 3520C Prep Batch: 700-17550 Lab File ID: B022230.D
Dilution: 5.0 Initial Weight/Volume: 1000 mL
Date Analyzed: 02/23/2006 0414 Final Weight/Volume: 1.0 mL
Date Prepared: 02/21/2006 0648 Injection Volume:

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| 1,2,4-Trichlorobenzene | ND | | 1.2 | 10 |
| 1,2-Dichlorobenzene | ND | | 1.1 | 10 |
| 1,2-Diphenylhydrazine | ND | | 4.0 | 10 |
| 1,3-Dichlorobenzene | ND | | 1.1 | 10 |
| 1,4-Dichlorobenzene | ND | | 1.1 | 10 |
| 2,2'-oxybis(2-chloropropane) | ND | | 1.3 | 10 |
| 2,4,6-Trichlorophenol | ND | | 2.4 | 10 |
| 2,4-Dichlorophenol | ND | | 1.2 | 10 |
| 2,4-Dimethylphenol | ND | | 1.1 | 10 |
| 2,4-Dinitrophenol | ND | | 2.3 | 50 |
| 2,4-Dinitrotoluene | ND | | 2.2 | 10 |
| 2,6-Dinitrotoluene | ND | | 2.4 | 10 |
| 2-Chloronaphthalene | ND | | 1.7 | 10 |
| 2-Chlorophenol | ND | | 1.0 | 10 |
| 2-Nitrophenol | ND | * | 1.3 | 10 |
| 3,3'-Dichlorobenzidine | ND | | 7.1 | 20 |
| 4,6-Dinitro-2-methylphenol | ND | | 2.1 | 50 |
| 4-Bromophenyl phenyl ether | ND | | 1.7 | 10 |
| 4-Chloro-3-methylphenol | ND | | 1.0 | 10 |
| 4-Chlorophenyl phenyl ether | ND | | 1.5 | 10 |
| 4-Nitrophenol | ND | | 3.6 | 50 |
| Acenaphthene | ND | | 1.3 | 10 |
| Acenaphthylene | ND | | 2.4 | 10 |
| Anthracene | ND | | 1.0 | 10 |
| Benzidine | ND | | 8.4 | 80 |
| Benzo[a]anthracene | ND | | 1.0 | 10 |
| Benzo[a]pyrene | ND | | 5.6 | 10 |
| Benzo[b]fluoranthene | ND | | 9.5 | 10 |
| Benzo[g,h,i]perylene | ND | | 5.4 | 10 |
| Benzo[k]fluoranthene | ND | | 9.0 | 10 |
| Bis(2-chloroethoxy)methane | ND | | 5.4 | 10 |
| Bis(2-chloroethyl)ether | ND | | 3.0 | 10 |
| Bis(2-ethylhexyl) phthalate | ND | | 3.3 | 10 |
| Butyl benzyl phthalate | ND | | 2.8 | 10 |
| Chrysene | ND | | 2.3 | 10 |
| Dibenz(a,h)anthracene | ND | | 9.5 | 10 |
| Diethyl phthalate | ND | | 1.7 | 10 |
| Dimethyl phthalate | ND | | 1.2 | 10 |
| Di-n-butyl phthalate | ND | | 1.2 | 10 |
| Di-n-octyl phthalate | ND | | 1.8 | 10 |
| Fluoranthene | ND | | 1.0 | 10 |
| Fluorene | ND | | 1.5 | 10 |
| Hexachlorobenzene | ND | | 1.7 | 10 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9790-1

**Client Sample ID:** **CH02 Elutriate**

Lab Sample ID: 700-9790-6 | Date Sampled: 02/13/2006 1200
Client Matrix: Water | Date Received: 02/15/2006 0903

**625 Base/Neutral and Acid Organics in Wastewater**

Method: 625 | Analysis Batch: 700-17670 | Instrument ID: SMB5973
Preparation: 3520C | Prep Batch: 700-17550 | Lab File ID: B022230.D
Dilution: 5.0 | Initial Weight/Volume: 1000 mL
Date Analyzed: 02/23/2006 0414 | Final Weight/Volume: 1.0 mL
Date Prepared: 02/21/2006 0648 | Injection Volume:

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Hexachlorobutadiene | ND | | 1.4 | 10 |
| Hexachlorocyclopentadiene | ND | | 1.8 | 10 |
| Hexachloroethane | ND | | 1.3 | 10 |
| Indeno[1,2,3-cd]pyrene | ND | | 2.9 | 10 |
| Isophorone | ND | | 1.1 | 10 |
| Naphthalene | ND | | 1.2 | 10 |
| Nitrobenzene | ND | | 1.4 | 10 |
| N-Nitrosodimethylamine | ND | | 2.2 | 10 |
| N-Nitrosodi-n-propylamine | ND | | 1.0 | 10 |
| N-Nitrosodiphenylamine | ND | | 10 | 10 |
| Pentachlorophenol | ND | | 2.1 | 50 |
| Phenanthrene | ND | | 1.2 | 10 |
| Phenol | ND | | 1.1 | 10 |
| Pyrene | ND | | 2.2 | 10 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| 2,4,6-Tribromophenol | 85 | 14 - 93 |
| 2-Fluorobiphenyl | 78 | 34 - 118 |
| 2-Fluorophenol | 48 | 25 - 102 |
| Nitrobenzene-d5 | 95 | 39 - 133 |
| Phenol-d5 | 65 | 21 - 95 |
| Terphenyl-d14 | 39 | 16 - 158 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9790-1

**Client Sample ID:** **SPELTO 01 Water**

Lab Sample ID: 700-9790-8 Date Sampled: 02/13/2006 1415
Client Matrix: Water Date Received: 02/15/2006 0903

**625 Base/Neutral and Acid Organics in Wastewater**

Method: 625 Analysis Batch: 700-17670 Instrument ID: SMB5973
Preparation: 3520C Prep Batch: 700-17550 Lab File ID: B022232.D
Dilution: 5.0 Initial Weight/Volume: 1000 mL
Date Analyzed: 02/23/2006 0522 Final Weight/Volume: 1.0 mL
Date Prepared: 02/21/2006 0648 Injection Volume:

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| 1,2,4-Trichlorobenzene | ND | | 1.2 | 10 |
| 1,2-Dichlorobenzene | ND | | 1.1 | 10 |
| 1,2-Diphenylhydrazine | ND | | 4.0 | 10 |
| 1,3-Dichlorobenzene | ND | | 1.1 | 10 |
| 1,4-Dichlorobenzene | ND | | 1.1 | 10 |
| 2,2'-oxybis(2-chloropropane) | ND | | 1.3 | 10 |
| 2,4,6-Trichlorophenol | ND | | 2.4 | 10 |
| 2,4-Dichlorophenol | ND | | 1.2 | 10 |
| 2,4-Dimethylphenol | ND | | 1.1 | 10 |
| 2,4-Dinitrophenol | ND | | 2.3 | 50 |
| 2,4-Dinitrotoluene | ND | | 2.2 | 10 |
| 2,6-Dinitrotoluene | ND | | 2.4 | 10 |
| 2-Chloronaphthalene | ND | | 1.7 | 10 |
| 2-Chlorophenol | ND | | 1.0 | 10 |
| 2-Nitrophenol | ND | * | 1.3 | 10 |
| 3,3'-Dichlorobenzidine | ND | | 7.1 | 20 |
| 4,6-Dinitro-2-methylphenol | ND | | 2.1 | 50 |
| 4-Bromophenyl phenyl ether | ND | | 1.7 | 10 |
| 4-Chloro-3-methylphenol | ND | | 1.0 | 10 |
| 4-Chlorophenyl phenyl ether | ND | | 1.5 | 10 |
| 4-Nitrophenol | ND | | 3.6 | 50 |
| Acenaphthene | ND | | 1.3 | 10 |
| Acenaphthylene | ND | | 2.4 | 10 |
| Anthracene | ND | | 1.0 | 10 |
| Benzidine | ND | | 8.4 | 80 |
| Benzo[a]anthracene | ND | | 1.0 | 10 |
| Benzo[a]pyrene | ND | | 5.6 | 10 |
| Benzo[b]fluoranthene | ND | | 9.5 | 10 |
| Benzo[g,h,i]perylene | ND | | 5.4 | 10 |
| Benzo[k]fluoranthene | ND | | 9.0 | 10 |
| Bis(2-chloroethoxy)methane | ND | | 5.4 | 10 |
| Bis(2-chloroethyl)ether | ND | | 3.0 | 10 |
| Bis(2-ethylhexyl) phthalate | ND | | 3.3 | 10 |
| Butyl benzyl phthalate | ND | | 2.8 | 10 |
| Chrysene | ND | | 2.3 | 10 |
| Dibenz(a,h)anthracene | ND | | 9.5 | 10 |
| Diethyl phthalate | ND | | 1.7 | 10 |
| Dimethyl phthalate | ND | | 1.2 | 10 |
| Di-n-butyl phthalate | ND | | 1.2 | 10 |
| Di-n-octyl phthalate | ND | | 1.8 | 10 |
| Fluoranthene | ND | | 1.0 | 10 |
| Fluorene | ND | | 1.5 | 10 |
| Hexachlorobenzene | ND | | 1.7 | 10 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9790-1

**Client Sample ID: SPELTO 01 Water**

Lab Sample ID: 700-9790-8 Date Sampled: 02/13/2006 1415
Client Matrix: Water Date Received: 02/15/2006 0903

**625 Base/Neutral and Acid Organics in Wastewater**

Method: 625 Analysis Batch: 700-17670 Instrument ID: SMB5973
Preparation: 3520C Prep Batch: 700-17550 Lab File ID: B022232.D
Dilution: 5.0 Initial Weight/Volume: 1000 mL
Date Analyzed: 02/23/2006 0522 Final Weight/Volume: 1.0 mL
Date Prepared: 02/21/2006 0648 Injection Volume:

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Hexachlorobutadiene | ND | | 1.4 | 10 |
| Hexachlorocyclopentadiene | ND | | 1.8 | 10 |
| Hexachloroethane | ND | | 1.3 | 10 |
| Indeno[1,2,3-cd]pyrene | ND | | 2.9 | 10 |
| Isophorone | ND | | 1.1 | 10 |
| Naphthalene | ND | | 1.2 | 10 |
| Nitrobenzene | ND | | 1.4 | 10 |
| N-Nitrosodimethylamine | ND | | 2.2 | 10 |
| N-Nitrosodi-n-propylamine | ND | | 1.0 | 10 |
| N-Nitrosodiphenylamine | ND | | 10 | 10 |
| Pentachlorophenol | ND | | 2.1 | 50 |
| Phenanthrene | ND | | 1.2 | 10 |
| Phenol | ND | | 1.1 | 10 |
| Pyrene | ND | | 2.2 | 10 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| 2,4,6-Tribromophenol | 69 | 14 - 93 |
| 2-Fluorobiphenyl | 68 | 34 - 118 |
| 2-Fluorophenol | 40 | 25 - 102 |
| Nitrobenzene-d5 | 84 | 39 - 133 |
| Phenol-d5 | 47 | 21 - 95 |
| Terphenyl-d14 | 57 | 16 - 158 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9790-1

**Client Sample ID:** **SPELTO 01 Elutriate**

Lab Sample ID: 700-9790-9 | Date Sampled: 02/13/2006 1420
Client Matrix: Water | Date Received: 02/15/2006 0903

**625 Base/Neutral and Acid Organics in Wastewater**

Method: 625 | Analysis Batch: 700-17670 | Instrument ID: SMB5973
Preparation: 3520C | Prep Batch: 700-17550 | Lab File ID: B022231.D
Dilution: 5.0 | Initial Weight/Volume: 1000 mL
Date Analyzed: 02/23/2006 0448 | Final Weight/Volume: 1.0 mL
Date Prepared: 02/21/2006 0648 | Injection Volume:

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| 1,2,4-Trichlorobenzene | ND | | 1.2 | 10 |
| 1,2-Dichlorobenzene | ND | | 1.1 | 10 |
| 1,2-Diphenylhydrazine | ND | | 4.0 | 10 |
| 1,3-Dichlorobenzene | ND | | 1.1 | 10 |
| 1,4-Dichlorobenzene | ND | | 1.1 | 10 |
| 2,2'-oxybis(2-chloropropane) | ND | | 1.3 | 10 |
| 2,4,6-Trichlorophenol | ND | | 2.4 | 10 |
| 2,4-Dichlorophenol | ND | | 1.2 | 10 |
| 2,4-Dimethylphenol | ND | | 1.1 | 10 |
| 2,4-Dinitrophenol | ND | | 2.3 | 50 |
| 2,4-Dinitrotoluene | ND | | 2.2 | 10 |
| 2,6-Dinitrotoluene | ND | | 2.4 | 10 |
| 2-Chloronaphthalene | ND | | 1.7 | 10 |
| 2-Chlorophenol | ND | | 1.0 | 10 |
| 2-Nitrophenol | ND | * | 1.3 | 10 |
| 3,3'-Dichlorobenzidine | ND | | 7.1 | 20 |
| 4,6-Dinitro-2-methylphenol | ND | | 2.1 | 50 |
| 4-Bromophenyl phenyl ether | ND | | 1.7 | 10 |
| 4-Chloro-3-methylphenol | ND | | 1.0 | 10 |
| 4-Chlorophenyl phenyl ether | ND | | 1.5 | 10 |
| 4-Nitrophenol | ND | | 3.6 | 50 |
| Acenaphthene | ND | | 1.3 | 10 |
| Acenaphthylene | ND | | 2.4 | 10 |
| Anthracene | ND | | 1.0 | 10 |
| Benzidine | ND | | 8.4 | 80 |
| Benzo[a]anthracene | ND | | 1.0 | 10 |
| Benzo[a]pyrene | ND | | 5.6 | 10 |
| Benzo[b]fluoranthene | ND | | 9.5 | 10 |
| Benzo[g,h,i]perylene | ND | | 5.4 | 10 |
| Benzo[k]fluoranthene | ND | | 9.0 | 10 |
| Bis(2-chloroethoxy)methane | ND | | 5.4 | 10 |
| Bis(2-chloroethyl)ether | ND | | 3.0 | 10 |
| Bis(2-ethylhexyl) phthalate | ND | | 3.3 | 10 |
| Butyl benzyl phthalate | ND | | 2.8 | 10 |
| Chrysene | ND | | 2.3 | 10 |
| Dibenz(a,h)anthracene | ND | | 9.5 | 10 |
| Diethyl phthalate | ND | | 1.7 | 10 |
| Dimethyl phthalate | ND | | 1.2 | 10 |
| Di-n-butyl phthalate | ND | | 1.2 | 10 |
| Di-n-octyl phthalate | ND | | 1.8 | 10 |
| Fluoranthene | ND | | 1.0 | 10 |
| Fluorene | ND | | 1.5 | 10 |
| Hexachlorobenzene | ND | | 1.7 | 10 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9790-1

**Client Sample ID:** **SPELTO 01 Elutriate**

Lab Sample ID: 700-9790-9 | Date Sampled: 02/13/2006 1420
Client Matrix: Water | Date Received: 02/15/2006 0903

**625 Base/Neutral and Acid Organics in Wastewater**

| | | | |
|---|---|---|---|
| Method: | 625 | Analysis Batch: 700-17670 | Instrument ID: SMB5973 |
| Preparation: | 3520C | Prep Batch: 700-17550 | Lab File ID: B022231.D |
| Dilution: | 5.0 | | Initial Weight/Volume: 1000 mL |
| Date Analyzed: | 02/23/2006 0448 | | Final Weight/Volume: 1.0 mL |
| Date Prepared: | 02/21/2006 0648 | | Injection Volume: |

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Hexachlorobutadiene | ND | | 1.4 | 10 |
| Hexachlorocyclopentadiene | ND | | 1.8 | 10 |
| Hexachloroethane | ND | | 1.3 | 10 |
| Indeno[1,2,3-cd]pyrene | ND | | 2.9 | 10 |
| Isophorone | ND | | 1.1 | 10 |
| Naphthalene | ND | | 1.2 | 10 |
| Nitrobenzene | ND | | 1.4 | 10 |
| N-Nitrosodimethylamine | ND | | 2.2 | 10 |
| N-Nitrosodi-n-propylamine | ND | | 1.0 | 10 |
| N-Nitrosodiphenylamine | ND | | 10 | 10 |
| Pentachlorophenol | ND | | 2.1 | 50 |
| Phenanthrene | ND | | 1.2 | 10 |
| Phenol | ND | | 1.1 | 10 |
| Pyrene | ND | | 2.2 | 10 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| 2,4,6-Tribromophenol | 87 | 14 - 93 |
| 2-Fluorobiphenyl | 85 | 34 - 118 |
| 2-Fluorophenol | 45 | 25 - 102 |
| Nitrobenzene-d5 | 104 | 39 - 133 |
| Phenol-d5 | 62 | 21 - 95 |
| Terphenyl-d14 | 61 | 16 - 158 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9790-1

**Client Sample ID:** **SPELTO 02 Elutriate**

Lab Sample ID: 700-9790-13 | Date Sampled: 02/13/2006 1540
Client Matrix: Water | Date Received: 02/15/2006 0903

**625 Base/Neutral and Acid Organics in Wastewater**

Method: 625 | Analysis Batch: 700-17670 | Instrument ID: SMB5973
Preparation: 3520C | Prep Batch: 700-17550 | Lab File ID: B022233.D
Dilution: 5.0 | Initial Weight/Volume: 1000 mL
Date Analyzed: 02/23/2006 0556 | Final Weight/Volume: 1.0 mL
Date Prepared: 02/21/2006 0648 | Injection Volume:

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| 1,2,4-Trichlorobenzene | ND | | 1.2 | 10 |
| 1,2-Dichlorobenzene | ND | | 1.1 | 10 |
| 1,2-Diphenylhydrazine | ND | | 4.0 | 10 |
| 1,3-Dichlorobenzene | ND | | 1.1 | 10 |
| 1,4-Dichlorobenzene | ND | | 1.1 | 10 |
| 2,2'-oxybis(2-chloropropane) | ND | | 1.3 | 10 |
| 2,4,6-Trichlorophenol | ND | | 2.4 | 10 |
| 2,4-Dichlorophenol | ND | | 1.2 | 10 |
| 2,4-Dimethylphenol | ND | | 1.1 | 10 |
| 2,4-Dinitrophenol | ND | | 2.3 | 50 |
| 2,4-Dinitrotoluene | ND | | 2.2 | 10 |
| 2,6-Dinitrotoluene | ND | | 2.4 | 10 |
| 2-Chloronaphthalene | ND | | 1.7 | 10 |
| 2-Chlorophenol | ND | | 1.0 | 10 |
| 2-Nitrophenol | ND | * | 1.3 | 10 |
| 3,3'-Dichlorobenzidine | ND | | 7.1 | 20 |
| 4,6-Dinitro-2-methylphenol | ND | | 2.1 | 50 |
| 4-Bromophenyl phenyl ether | ND | | 1.7 | 10 |
| 4-Chloro-3-methylphenol | ND | | 1.0 | 10 |
| 4-Chlorophenyl phenyl ether | ND | | 1.5 | 10 |
| 4-Nitrophenol | ND | | 3.6 | 50 |
| Acenaphthene | ND | | 1.3 | 10 |
| Acenaphthylene | ND | | 2.4 | 10 |
| Anthracene | ND | | 1.0 | 10 |
| Benzidine | ND | | 8.4 | 80 |
| Benzo[a]anthracene | ND | | 1.0 | 10 |
| Benzo[a]pyrene | ND | | 5.6 | 10 |
| Benzo[b]fluoranthene | ND | | 9.5 | 10 |
| Benzo[g,h,i]perylene | ND | | 5.4 | 10 |
| Benzo[k]fluoranthene | ND | | 9.0 | 10 |
| Bis(2-chloroethoxy)methane | ND | | 5.4 | 10 |
| Bis(2-chloroethyl)ether | ND | | 3.0 | 10 |
| Bis(2-ethylhexyl) phthalate | ND | | 3.3 | 10 |
| Butyl benzyl phthalate | ND | | 2.8 | 10 |
| Chrysene | ND | | 2.3 | 10 |
| Dibenz(a,h)anthracene | ND | | 9.5 | 10 |
| Diethyl phthalate | ND | | 1.7 | 10 |
| Dimethyl phthalate | ND | | 1.2 | 10 |
| Di-n-butyl phthalate | ND | | 1.2 | 10 |
| Di-n-octyl phthalate | ND | | 1.8 | 10 |
| Fluoranthene | ND | | 1.0 | 10 |
| Fluorene | ND | | 1.5 | 10 |
| Hexachlorobenzene | ND | | 1.7 | 10 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9790-1

**Client Sample ID:** **SPELTO 02 Elutriate**

Lab Sample ID: 700-9790-13 | Date Sampled: 02/13/2006 1540
Client Matrix: Water | Date Received: 02/15/2006 0903

**625 Base/Neutral and Acid Organics in Wastewater**

Method: 625 | Analysis Batch: 700-17670 | Instrument ID: SMB5973
Preparation: 3520C | Prep Batch: 700-17550 | Lab File ID: B022233.D
Dilution: 5.0 | Initial Weight/Volume: 1000 mL
Date Analyzed: 02/23/2006 0556 | Final Weight/Volume: 1.0 mL
Date Prepared: 02/21/2006 0648 | Injection Volume:

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Hexachlorobutadiene | ND | | 1.4 | 10 |
| Hexachlorocyclopentadiene | ND | | 1.8 | 10 |
| Hexachloroethane | ND | | 1.3 | 10 |
| Indeno[1,2,3-cd]pyrene | ND | | 2.9 | 10 |
| Isophorone | ND | | 1.1 | 10 |
| Naphthalene | ND | | 1.2 | 10 |
| Nitrobenzene | ND | | 1.4 | 10 |
| N-Nitrosodimethylamine | ND | | 2.2 | 10 |
| N-Nitrosodi-n-propylamine | ND | | 1.0 | 10 |
| N-Nitrosodiphenylamine | ND | | 10 | 10 |
| Pentachlorophenol | ND | | 2.1 | 50 |
| Phenanthrene | ND | | 1.2 | 10 |
| Phenol | ND | | 1.1 | 10 |
| Pyrene | ND | | 2.2 | 10 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| 2,4,6-Tribromophenol | 87 | 14 - 93 |
| 2-Fluorobiphenyl | 83 | 34 - 118 |
| 2-Fluorophenol | 46 | 25 - 102 |
| Nitrobenzene-d5 | 103 | 39 - 133 |
| Phenol-d5 | 56 | 21 - 95 |
| Terphenyl-d14 | 60 | 16 - 158 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9790-1

**Client Sample ID:** **CH01 Sediment**

Lab Sample ID: 700-9790-3 Date Sampled: 02/13/2006 0920
Client Matrix: Solid Date Received: 02/15/2006 0903

**8270C Semivolatile Organic Compounds by GCMS - Low Levels**

Method: 8270C Analysis Batch: 700-17635 Instrument ID: Agilent GC/MS 5973
Preparation: 3550B Prep Batch: 700-17433 Lab File ID: D022014.D
Dilution: 1.0 Initial Weight/Volume: 50.0 g
Date Analyzed: 02/20/2006 2013 Final Weight/Volume: 1.0 mL
Date Prepared: 02/17/2006 0900 Injection Volume:

| Analyte | DryWt Corrected: N | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| Acenaphthene | | ND | | 2.1 | 4.0 |
| Pyrene | | 2.7 | J | 1.0 | 4.0 |
| Acenaphthylene | | ND | | 1.2 | 4.0 |
| Anthracene | | ND | | 2.6 | 4.0 |
| Benzo[a]pyrene | | ND | | 1.2 | 4.0 |
| Benzo[b]fluoranthene | | ND | | 3.7 | 4.0 |
| Benzo[a]anthracene | | ND | | 1.3 | 4.0 |
| Benzo[g,h,i]perylene | | ND | | 1.8 | 4.0 |
| Benzo[k]fluoranthene | | ND | | 2.6 | 4.0 |
| Fluoranthene | | ND | | 2.1 | 4.0 |
| Fluorene | | ND | | 1.7 | 4.0 |
| Indeno[1,2,3-cd]pyrene | | ND | | 1.1 | 4.0 |
| Naphthalene | | ND | | 2.0 | 4.0 |
| Phenanthrene | | ND | | 2.3 | 4.0 |
| Chrysene | | ND | | 1.4 | 4.0 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| 2,4,6-Tribromophenol | 68 | 5.0 - 106 |
| 2-Fluorobiphenyl | 57 | 31 - 118 |
| 2-Fluorophenol | 56 | 10 - 128 |
| Nitrobenzene-d5 | 52 | 35 - 122 |
| Phenol-d5 | 48 | 29 - 113 |
| Terphenyl-d14 | 75 | 37 - 149 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9790-1

**Client Sample ID:** **CH01 Sediment**

Lab Sample ID: 700-9790-3 | Date Sampled: 02/13/2006 0920
Client Matrix: Solid | Date Received: 02/15/2006 0903

**8270C Semivolatile Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)**

Method: 8270C | Analysis Batch: 700-17742 | Instrument ID: SMC5973
Preparation: 3550B | Prep Batch: 700-17431 | Lab File ID: C022014.D
Dilution: 1.0 | Initial Weight/Volume: 50.0 g
Date Analyzed: 02/20/2006 2008 | Final Weight/Volume: 1.0 mL
Date Prepared: 02/17/2006 0900 | Injection Volume:

| Analyte | DryWt Corrected: N | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| 1,2,4-Trichlorobenzene | | ND | | 5.0 | 40 |
| 1,2-Dichlorobenzene | | ND | | 5.4 | 40 |
| 1,2-Diphenylhydrazine | | ND | | 4.2 | 40 |
| 1,3-Dichlorobenzene | | ND | | 6.2 | 40 |
| 1,4-Dichlorobenzene | | ND | | 4.2 | 40 |
| 2,4,6-Trichlorophenol | | ND | | 4.7 | 40 |
| 2,4-Dichlorophenol | | ND | | 4.3 | 40 |
| 2,4-Dimethylphenol | | ND | | 4.6 | 40 |
| 2,4-Dinitrophenol | | ND | | 5.2 | 200 |
| 2,4-Dinitrotoluene | | ND | | 4.3 | 40 |
| 2,6-Dinitrotoluene | | ND | | 5.3 | 40 |
| 2-Chloronaphthalene | | ND | | 5.0 | 40 |
| 2-Chlorophenol | | ND | | 5.0 | 40 |
| 2-Nitrophenol | | ND | | 4.3 | 40 |
| 3,3'-Dichlorobenzidine | | ND | | 8.4 | 79 |
| 4,6-Dinitro-2-methylphenol | | ND | | 9.4 | 200 |
| 4-Bromophenyl phenyl ether | | ND | | 5.0 | 40 |
| 4-Chloro-3-methylphenol | | ND | | 4.9 | 40 |
| 4-Chlorophenyl phenyl ether | | ND | | 4.6 | 40 |
| 4-Nitrophenol | | ND | | 9.2 | 200 |
| Benzidine | | ND | | 26 | 320 |
| Bis(2-chloroethyl)ether | | ND | | 5.0 | 40 |
| Bis(2-ethylhexyl) phthalate | | ND | | 4.4 | 40 |
| 2,2'-oxybis(2-chloropropane) | | ND | | 7.2 | 40 |
| Butyl benzyl phthalate | | ND | | 5.9 | 40 |
| Di-n-butyl phthalate | | ND | | 5.0 | 40 |
| Di-n-octyl phthalate | | ND | | 4.1 | 40 |
| Dibenz(a,h)anthracene | | ND | | 4.2 | 40 |
| Diethyl phthalate | | ND | | 4.7 | 40 |
| Dimethyl phthalate | | ND | | 4.9 | 40 |
| Hexachlorobenzene | | ND | | 5.4 | 40 |
| Hexachlorobutadiene | | ND | | 4.1 | 40 |
| Hexachlorocyclopentadiene | | ND | | 3.6 | 40 |
| Hexachloroethane | | ND | | 4.6 | 40 |
| Isophorone | | ND | | 5.4 | 40 |
| N-Nitrosodi-n-propylamine | | ND | | 4.7 | 40 |
| N-Nitrosodimethylamine | | ND | | 20 | 40 |
| N-Nitrosodiphenylamine | | ND | | 5.4 | 40 |
| Nitrobenzene | | ND | | 4.3 | 40 |
| Pentachlorophenol | | ND | | 4.3 | 200 |
| Phenol | | ND | | 4.3 | 40 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| 2,4,6-Tribromophenol | 89 | 5.0 - 106 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9790-1

**Client Sample ID:** **CH01 Sediment**

Lab Sample ID: 700-9790-3 | Date Sampled: 02/13/2006 0920
Client Matrix: Solid | Date Received: 02/15/2006 0903

**8270C Semivolatile Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)**

| | | | | | |
|---|---|---|---|---|---|
| Method: | 8270C | Analysis Batch: 700-17742 | Instrument ID: | SMC5973 | |
| Preparation: | 3550B | Prep Batch: 700-17431 | Lab File ID: | C022014.D | |
| Dilution: | 1.0 | | Initial Weight/Volume: | 50.0 | g |
| Date Analyzed: | 02/20/2006 2008 | | Final Weight/Volume: | 1.0 | mL |
| Date Prepared: | 02/17/2006 0900 | | Injection Volume: | | |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| 2-Fluorobiphenyl | 66 | 31 - 118 |
| 2-Fluorophenol | 55 | 10 - 128 |
| Nitrobenzene-d5 | 65 | 35 - 122 |
| Phenol-d5 | 59 | 29 - 113 |
| Terphenyl-d14 | 75 | 37 - 149 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9790-1

**Client Sample ID:** **CH02 Sediment**

Lab Sample ID: 700-9790-7 Date Sampled: 02/13/2006 1200
Client Matrix: Solid Date Received: 02/15/2006 0903

**8270C Semivolatile Organic Compounds by GCMS - Low Levels**

Method: 8270C Analysis Batch: 700-17635 Instrument ID: Agilent GC/MS 5973
Preparation: 3550B Prep Batch: 700-17433 Lab File ID: D022015.D
Dilution: 1.0 Initial Weight/Volume: 50.0 g
Date Analyzed: 02/20/2006 2047 Final Weight/Volume: 1.0 mL
Date Prepared: 02/17/2006 0900 Injection Volume:

| Analyte | DryWt Corrected: N | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| Acenaphthene | | ND | | 2.1 | 4.0 |
| Pyrene | | ND | | 1.0 | 4.0 |
| Acenaphthylene | | ND | | 1.2 | 4.0 |
| Anthracene | | ND | | 2.6 | 4.0 |
| Benzo[a]pyrene | | ND | | 1.2 | 4.0 |
| Benzo[b]fluoranthene | | ND | | 3.7 | 4.0 |
| Benzo[a]anthracene | | ND | | 1.3 | 4.0 |
| Benzo[g,h,i]perylene | | ND | | 1.8 | 4.0 |
| Benzo[k]fluoranthene | | ND | | 2.6 | 4.0 |
| Fluoranthene | | ND | | 2.1 | 4.0 |
| Fluorene | | ND | | 1.7 | 4.0 |
| Indeno[1,2,3-cd]pyrene | | ND | | 1.1 | 4.0 |
| Naphthalene | | ND | | 2.0 | 4.0 |
| Phenanthrene | | ND | | 2.3 | 4.0 |
| Chrysene | | ND | | 1.4 | 4.0 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| 2,4,6-Tribromophenol | 66 | 5.0 - 106 |
| 2-Fluorobiphenyl | 55 | 31 - 118 |
| 2-Fluorophenol | 47 | 10 - 128 |
| Nitrobenzene-d5 | 50 | 35 - 122 |
| Phenol-d5 | 46 | 29 - 113 |
| Terphenyl-d14 | 80 | 37 - 149 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9790-1

**Client Sample ID:** **CH02 Sediment**

Lab Sample ID: 700-9790-7 | Date Sampled: 02/13/2006 1200
Client Matrix: Solid | Date Received: 02/15/2006 0903

**8270C Semivolatile Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)**

| | | | | | |
|---|---|---|---|---|---|
| Method: | 8270C | Analysis Batch: 700-17742 | Instrument ID: | SMC5973 | |
| Preparation: | 3550B | Prep Batch: 700-17431 | Lab File ID: | C022015.D | |
| Dilution: | 1.0 | | Initial Weight/Volume: | 50.0 | g |
| Date Analyzed: | 02/20/2006 2043 | | Final Weight/Volume: | 1.0 | mL |
| Date Prepared: | 02/17/2006 0900 | | Injection Volume: | | |

| Analyte | DryWt Corrected: N | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| 1,2,4-Trichlorobenzene | | ND | | 5.0 | 40 |
| 1,2-Dichlorobenzene | | ND | | 5.4 | 40 |
| 1,2-Diphenylhydrazine | | ND | | 4.2 | 40 |
| 1,3-Dichlorobenzene | | ND | | 6.2 | 40 |
| 1,4-Dichlorobenzene | | ND | | 4.2 | 40 |
| 2,4,6-Trichlorophenol | | ND | | 4.7 | 40 |
| 2,4-Dichlorophenol | | ND | | 4.3 | 40 |
| 2,4-Dimethylphenol | | ND | | 4.6 | 40 |
| 2,4-Dinitrophenol | | ND | | 5.2 | 200 |
| 2,4-Dinitrotoluene | | ND | | 4.3 | 40 |
| 2,6-Dinitrotoluene | | ND | | 5.3 | 40 |
| 2-Chloronaphthalene | | ND | | 5.0 | 40 |
| 2-Chlorophenol | | ND | | 5.0 | 40 |
| 2-Nitrophenol | | ND | | 4.3 | 40 |
| 3,3'-Dichlorobenzidine | | ND | | 8.4 | 79 |
| 4,6-Dinitro-2-methylphenol | | ND | | 9.4 | 200 |
| 4-Bromophenyl phenyl ether | | ND | | 5.0 | 40 |
| 4-Chloro-3-methylphenol | | ND | | 4.9 | 40 |
| 4-Chlorophenyl phenyl ether | | ND | | 4.6 | 40 |
| 4-Nitrophenol | | ND | | 9.2 | 200 |
| Benzidine | | ND | | 26 | 320 |
| Bis(2-chloroethyl)ether | | ND | | 5.0 | 40 |
| Bis(2-ethylhexyl) phthalate | | ND | | 4.4 | 40 |
| 2,2'-oxybis(2-chloropropane) | | ND | | 7.2 | 40 |
| Butyl benzyl phthalate | | ND | | 5.9 | 40 |
| Di-n-butyl phthalate | | ND | | 5.0 | 40 |
| Di-n-octyl phthalate | | ND | | 4.1 | 40 |
| Dibenz(a,h)anthracene | | ND | | 4.2 | 40 |
| Diethyl phthalate | | ND | | 4.7 | 40 |
| Dimethyl phthalate | | ND | | 4.9 | 40 |
| Hexachlorobenzene | | ND | | 5.4 | 40 |
| Hexachlorobutadiene | | ND | | 4.1 | 40 |
| Hexachlorocyclopentadiene | | ND | | 3.6 | 40 |
| Hexachloroethane | | ND | | 4.6 | 40 |
| Isophorone | | ND | | 5.4 | 40 |
| N-Nitrosodi-n-propylamine | | ND | | 4.7 | 40 |
| N-Nitrosodimethylamine | | ND | | 20 | 40 |
| N-Nitrosodiphenylamine | | ND | | 5.4 | 40 |
| Nitrobenzene | | ND | | 4.3 | 40 |
| Pentachlorophenol | | ND | | 4.3 | 200 |
| Phenol | | ND | | 4.3 | 40 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| 2,4,6-Tribromophenol | 90 | 5.0 - 106 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9790-1

**Client Sample ID:** **CH02 Sediment**

Lab Sample ID: 700-9790-7 | Date Sampled: 02/13/2006 1200
Client Matrix: Solid | Date Received: 02/15/2006 0903

**8270C Semivolatile Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)**

| | | | |
|---|---|---|---|
| Method: | 8270C | Analysis Batch: 700-17742 | Instrument ID: SMC5973 |
| Preparation: | 3550B | Prep Batch: 700-17431 | Lab File ID: C022015.D |
| Dilution: | 1.0 | | Initial Weight/Volume: 50.0 g |
| Date Analyzed: | 02/20/2006 2043 | | Final Weight/Volume: 1.0 mL |
| Date Prepared: | 02/17/2006 0900 | | Injection Volume: |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| 2-Fluorobiphenyl | 64 | 31 - 118 |
| 2-Fluorophenol | 51 | 10 - 128 |
| Nitrobenzene-d5 | 62 | 35 - 122 |
| Phenol-d5 | 54 | 29 - 113 |
| Terphenyl-d14 | 74 | 37 - 149 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9790-1

**Client Sample ID:** **SPELTO 01 Sediment**

Lab Sample ID: 700-9790-11 Date Sampled: 02/13/2006 1420
Client Matrix: Solid Date Received: 02/15/2006 0903

**8270C Semivolatile Organic Compounds by GCMS - Low Levels**

Method: 8270C Analysis Batch: 700-17635 Instrument ID: Agilent GC/MS 5973
Preparation: 3550B Prep Batch: 700-17433 Lab File ID: D022016.D
Dilution: 1.0 Initial Weight/Volume: 50.0 g
Date Analyzed: 02/20/2006 2121 Final Weight/Volume: 1.0 mL
Date Prepared: 02/17/2006 0900 Injection Volume:

| Analyte | DryWt Corrected: N | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| Acenaphthene | | ND | | 2.1 | 4.0 |
| Pyrene | | ND | | 1.0 | 4.0 |
| Acenaphthylene | | ND | | 1.2 | 4.0 |
| Anthracene | | ND | | 2.6 | 4.0 |
| Benzo[a]pyrene | | ND | | 1.2 | 4.0 |
| Benzo[b]fluoranthene | | ND | | 3.7 | 4.0 |
| Benzo[a]anthracene | | ND | | 1.3 | 4.0 |
| Benzo[g,h,i]perylene | | ND | | 1.8 | 4.0 |
| Benzo[k]fluoranthene | | ND | | 2.6 | 4.0 |
| Fluoranthene | | ND | | 2.1 | 4.0 |
| Fluorene | | ND | | 1.7 | 4.0 |
| Indeno[1,2,3-cd]pyrene | | ND | | 1.1 | 4.0 |
| Naphthalene | | ND | | 2.0 | 4.0 |
| Phenanthrene | | ND | | 2.3 | 4.0 |
| Chrysene | | ND | | 1.4 | 4.0 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| 2,4,6-Tribromophenol | 62 | 5.0 - 106 |
| 2-Fluorobiphenyl | 54 | 31 - 118 |
| 2-Fluorophenol | 48 | 10 - 128 |
| Nitrobenzene-d5 | 51 | 35 - 122 |
| Phenol-d5 | 46 | 29 - 113 |
| Terphenyl-d14 | 77 | 37 - 149 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9790-1

**Client Sample ID:** **SPELTO 01 Sediment**

Lab Sample ID: 700-9790-11 | Date Sampled: 02/13/2006 1420
Client Matrix: Solid | Date Received: 02/15/2006 0903

**8270C Semivolatile Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)**

Method: 8270C | Analysis Batch: 700-17742 | Instrument ID: SMC5973
Preparation: 3550B | Prep Batch: 700-17431 | Lab File ID: C022016.D
Dilution: 1.0 | Initial Weight/Volume: 50.0 g
Date Analyzed: 02/20/2006 2118 | Final Weight/Volume: 1.0 mL
Date Prepared: 02/17/2006 0900 | Injection Volume:

| Analyte | DryWt Corrected: N | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| 1,2,4-Trichlorobenzene | | ND | | 5.0 | 40 |
| 1,2-Dichlorobenzene | | ND | | 5.4 | 40 |
| 1,2-Diphenylhydrazine | | ND | | 4.2 | 40 |
| 1,3-Dichlorobenzene | | ND | | 6.2 | 40 |
| 1,4-Dichlorobenzene | | ND | | 4.2 | 40 |
| 2,4,6-Trichlorophenol | | ND | | 4.7 | 40 |
| 2,4-Dichlorophenol | | ND | | 4.3 | 40 |
| 2,4-Dimethylphenol | | ND | | 4.6 | 40 |
| 2,4-Dinitrophenol | | ND | | 5.2 | 200 |
| 2,4-Dinitrotoluene | | ND | | 4.3 | 40 |
| 2,6-Dinitrotoluene | | ND | | 5.3 | 40 |
| 2-Chloronaphthalene | | ND | | 5.0 | 40 |
| 2-Chlorophenol | | ND | | 5.0 | 40 |
| 2-Nitrophenol | | ND | | 4.3 | 40 |
| 3,3'-Dichlorobenzidine | | ND | | 8.4 | 79 |
| 4,6-Dinitro-2-methylphenol | | ND | | 9.4 | 200 |
| 4-Bromophenyl phenyl ether | | ND | | 5.0 | 40 |
| 4-Chloro-3-methylphenol | | ND | | 4.9 | 40 |
| 4-Chlorophenyl phenyl ether | | ND | | 4.6 | 40 |
| 4-Nitrophenol | | ND | | 9.2 | 200 |
| Benzidine | | ND | | 26 | 320 |
| Bis(2-chloroethyl)ether | | ND | | 5.0 | 40 |
| Bis(2-ethylhexyl) phthalate | | ND | | 4.4 | 40 |
| 2,2'-oxybis(2-chloropropane) | | ND | | 7.2 | 40 |
| Butyl benzyl phthalate | | ND | | 5.9 | 40 |
| Di-n-butyl phthalate | | ND | | 5.0 | 40 |
| Di-n-octyl phthalate | | ND | | 4.1 | 40 |
| Dibenz(a,h)anthracene | | ND | | 4.2 | 40 |
| Diethyl phthalate | | ND | | 4.7 | 40 |
| Dimethyl phthalate | | ND | | 4.9 | 40 |
| Hexachlorobenzene | | ND | | 5.4 | 40 |
| Hexachlorobutadiene | | ND | | 4.1 | 40 |
| Hexachlorocyclopentadiene | | ND | | 3.6 | 40 |
| Hexachloroethane | | ND | | 4.6 | 40 |
| Isophorone | | ND | | 5.4 | 40 |
| N-Nitrosodi-n-propylamine | | ND | | 4.7 | 40 |
| N-Nitrosodimethylamine | | ND | | 20 | 40 |
| N-Nitrosodiphenylamine | | ND | | 5.4 | 40 |
| Nitrobenzene | | ND | | 4.3 | 40 |
| Pentachlorophenol | | ND | | 4.3 | 200 |
| Phenol | | ND | | 4.3 | 40 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| 2,4,6-Tribromophenol | 81 | 5.0 - 106 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9790-1

**Client Sample ID:** **SPELTO 01 Sediment**

Lab Sample ID: 700-9790-11 | Date Sampled: 02/13/2006 1420
Client Matrix: Solid | Date Received: 02/15/2006 0903

**8270C Semivolatile Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)**

| | | | | | |
|---|---|---|---|---|---|
| Method: | 8270C | Analysis Batch: 700-17742 | Instrument ID: | SMC5973 | |
| Preparation: | 3550B | Prep Batch: 700-17431 | Lab File ID: | C022016.D | |
| Dilution: | 1.0 | | Initial Weight/Volume: | 50.0 | g |
| Date Analyzed: | 02/20/2006 2118 | | Final Weight/Volume: | 1.0 | mL |
| Date Prepared: | 02/17/2006 0900 | | Injection Volume: | | |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| 2-Fluorobiphenyl | 62 | 31 - 118 |
| 2-Fluorophenol | 53 | 10 - 128 |
| Nitrobenzene-d5 | 64 | 35 - 122 |
| Phenol-d5 | 54 | 29 - 113 |
| Terphenyl-d14 | 68 | 37 - 149 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9790-1

**Client Sample ID:** **SPELTO 02 Sediment**

Lab Sample ID: 700-9790-14 | Date Sampled: 02/13/2006 1540
Client Matrix: Solid | Date Received: 02/15/2006 0903

**8270C Semivolatile Organic Compounds by GCMS - Low Levels**

| | | | | | |
|---|---|---|---|---|---|
| Method: | 8270C | Analysis Batch: 700-17635 | Instrument ID: | Agilent GC/MS 5973 | |
| Preparation: | 3550B | Prep Batch: 700-17433 | Lab File ID: | D022017.D | |
| Dilution: | 1.0 | | Initial Weight/Volume: | 50.0 | g |
| Date Analyzed: | 02/20/2006 2155 | | Final Weight/Volume: | 1.0 | mL |
| Date Prepared: | 02/17/2006 0900 | | Injection Volume: | | |

| Analyte | DryWt Corrected: N | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| Acenaphthene | | ND | | 2.1 | 4.0 |
| Pyrene | | ND | | 1.0 | 4.0 |
| Acenaphthylene | | ND | | 1.2 | 4.0 |
| Anthracene | | ND | | 2.6 | 4.0 |
| Benzo[a]pyrene | | ND | | 1.2 | 4.0 |
| Benzo[b]fluoranthene | | ND | | 3.7 | 4.0 |
| Benzo[a]anthracene | | ND | | 1.3 | 4.0 |
| Benzo[g,h,i]perylene | | ND | | 1.8 | 4.0 |
| Benzo[k]fluoranthene | | ND | | 2.6 | 4.0 |
| Fluoranthene | | ND | | 2.1 | 4.0 |
| Fluorene | | ND | | 1.7 | 4.0 |
| Indeno[1,2,3-cd]pyrene | | ND | | 1.1 | 4.0 |
| Naphthalene | | ND | | 2.0 | 4.0 |
| Phenanthrene | | ND | | 2.3 | 4.0 |
| Chrysene | | ND | | 1.4 | 4.0 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| 2,4,6-Tribromophenol | 68 | 5.0 - 106 |
| 2-Fluorobiphenyl | 59 | 31 - 118 |
| 2-Fluorophenol | 53 | 10 - 128 |
| Nitrobenzene-d5 | 57 | 35 - 122 |
| Phenol-d5 | 49 | 29 - 113 |
| Terphenyl-d14 | 80 | 37 - 149 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9790-1

**Client Sample ID:** **SPELTO 02 Sediment**

Lab Sample ID: 700-9790-14 Date Sampled: 02/13/2006 1540
Client Matrix: Solid Date Received: 02/15/2006 0903

**8270C Semivolatile Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)**

Method: 8270C Analysis Batch: 700-17742 Instrument ID: SMC5973
Preparation: 3550B Prep Batch: 700-17431 Lab File ID: C022017.D
Dilution: 1.0 Initial Weight/Volume: 50.0 g
Date Analyzed: 02/20/2006 2153 Final Weight/Volume: 1.0 mL
Date Prepared: 02/17/2006 0900 Injection Volume:

| Analyte | DryWt Corrected: N | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| 1,2,4-Trichlorobenzene | | ND | | 5.0 | 40 |
| 1,2-Dichlorobenzene | | ND | | 5.4 | 40 |
| 1,2-Diphenylhydrazine | | ND | | 4.2 | 40 |
| 1,3-Dichlorobenzene | | ND | | 6.2 | 40 |
| 1,4-Dichlorobenzene | | ND | | 4.2 | 40 |
| 2,4,6-Trichlorophenol | | ND | | 4.7 | 40 |
| 2,4-Dichlorophenol | | ND | | 4.3 | 40 |
| 2,4-Dimethylphenol | | ND | | 4.6 | 40 |
| 2,4-Dinitrophenol | | ND | | 5.2 | 200 |
| 2,4-Dinitrotoluene | | ND | | 4.3 | 40 |
| 2,6-Dinitrotoluene | | ND | | 5.3 | 40 |
| 2-Chloronaphthalene | | ND | | 5.0 | 40 |
| 2-Chlorophenol | | ND | | 5.0 | 40 |
| 2-Nitrophenol | | ND | | 4.3 | 40 |
| 3,3'-Dichlorobenzidine | | ND | | 8.4 | 79 |
| 4,6-Dinitro-2-methylphenol | | ND | | 9.4 | 200 |
| 4-Bromophenyl phenyl ether | | ND | | 5.0 | 40 |
| 4-Chloro-3-methylphenol | | ND | | 4.9 | 40 |
| 4-Chlorophenyl phenyl ether | | ND | | 4.6 | 40 |
| 4-Nitrophenol | | ND | | 9.2 | 200 |
| Benzidine | | ND | | 26 | 320 |
| Bis(2-chloroethyl)ether | | ND | | 5.0 | 40 |
| Bis(2-ethylhexyl) phthalate | | ND | | 4.4 | 40 |
| 2,2'-oxybis(2-chloropropane) | | ND | | 7.2 | 40 |
| Butyl benzyl phthalate | | ND | | 5.9 | 40 |
| Di-n-butyl phthalate | | ND | | 5.0 | 40 |
| Di-n-octyl phthalate | | ND | | 4.1 | 40 |
| Dibenz(a,h)anthracene | | ND | | 4.2 | 40 |
| Diethyl phthalate | | ND | | 4.7 | 40 |
| Dimethyl phthalate | | ND | | 4.9 | 40 |
| Hexachlorobenzene | | ND | | 5.4 | 40 |
| Hexachlorobutadiene | | ND | | 4.1 | 40 |
| Hexachlorocyclopentadiene | | ND | | 3.6 | 40 |
| Hexachloroethane | | ND | | 4.6 | 40 |
| Isophorone | | ND | | 5.4 | 40 |
| N-Nitrosodi-n-propylamine | | ND | | 4.7 | 40 |
| N-Nitrosodimethylamine | | ND | | 20 | 40 |
| N-Nitrosodiphenylamine | | ND | | 5.4 | 40 |
| Nitrobenzene | | ND | | 4.3 | 40 |
| Pentachlorophenol | | ND | | 4.3 | 200 |
| Phenol | | ND | | 4.3 | 40 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| 2,4,6-Tribromophenol | 91 | 5.0 - 106 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9790-1

**Client Sample ID:** **SPELTO 02 Sediment**

Lab Sample ID: 700-9790-14 | Date Sampled: 02/13/2006 1540
Client Matrix: Solid | Date Received: 02/15/2006 0903

**8270C Semivolatile Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)**

| | | | |
|---|---|---|---|
| Method: | 8270C | Analysis Batch: 700-17742 | Instrument ID: SMC5973 |
| Preparation: | 3550B | Prep Batch: 700-17431 | Lab File ID: C022017.D |
| Dilution: | 1.0 | | Initial Weight/Volume: 50.0 g |
| Date Analyzed: | 02/20/2006 2153 | | Final Weight/Volume: 1.0 mL |
| Date Prepared: | 02/17/2006 0900 | | Injection Volume: |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| 2-Fluorobiphenyl | 75 | 31 - 118 |
| 2-Fluorophenol | 61 | 10 - 128 |
| Nitrobenzene-d5 | 72 | 35 - 122 |
| Phenol-d5 | 63 | 29 - 113 |
| Terphenyl-d14 | 80 | 37 - 149 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9790-1

**Client Sample ID:** **CH01 Water**

Lab Sample ID: 700-9790-1 | Date Sampled: 02/13/2006 0935
Client Matrix: Water | Date Received: 02/15/2006 0903

**608 Organochlorine Pesticides/PCBs in Water**

Method: 608 | Analysis Batch: 700-17877 | Instrument ID: MSGY
Preparation: CWA_Prep_CLLE | Prep Batch: 700-17552 | Lab File ID: Y022333.D
Dilution: 1.0 | Initial Weight/Volume: 1000 mL
Date Analyzed: 02/24/2006 0229 | Final Weight/Volume: 5.0 mL
Date Prepared: 02/21/2006 0654 | Injection Volume:
Column ID: PRIMARY

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Aldrin | ND | | 0.0045 | 0.050 |
| alpha-BHC | ND | * | 0.0056 | 0.050 |
| beta-BHC | ND | * | 0.0036 | 0.050 |
| Chlordane (technical) | ND | | 0.032 | 0.50 |
| 4,4'-DDD | ND | | 0.0076 | 0.10 |
| 4,4'-DDE | ND | | 0.0064 | 0.10 |
| 4,4'-DDT | ND | | 0.0084 | 0.10 |
| delta-BHC | ND | * | 0.010 | 0.050 |
| Dieldrin | ND | | 0.0074 | 0.10 |
| Endosulfan I | ND | | 0.0044 | 0.050 |
| Endosulfan II | ND | | 0.0047 | 0.10 |
| Endosulfan sulfate | ND | | 0.0090 | 0.10 |
| Endrin | ND | | 0.0067 | 0.10 |
| Endrin aldehyde | ND | | 0.0069 | 0.10 |
| gamma-BHC (Lindane) | ND | * | 0.0049 | 0.050 |
| Heptachlor | ND | | 0.0037 | 0.050 |
| Heptachlor epoxide | ND | | 0.0039 | 0.050 |
| PCB-1221 | ND | | 0.17 | 2.0 |
| PCB-1248 | ND | | 0.14 | 1.0 |
| PCB-1232 | ND | | 0.13 | 1.0 |
| PCB-1254 | ND | | 0.12 | 1.0 |
| PCB-1242 | ND | | 0.18 | 1.0 |
| PCB-1260 | ND | | 0.12 | 1.0 |
| PCB-1016 | ND | | 0.11 | 1.0 |
| Toxaphene | ND | | 0.31 | 5.0 |

| Surrogate | %Rec | | Acceptance Limits |
|---|---|---|---|
| DCB Decachlorobiphenyl | 20 | * | 30 - 150 |
| Tetrachloro-m-xylene | 63 | | 30 - 150 |

**Analytical Data**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Client Sample ID:** **CH01 Elutriate**

Lab Sample ID: 700-9790-2
Client Matrix: Water

Date Sampled: 02/13/2006 0920
Date Received: 02/15/2006 0903

**608 Organochlorine Pesticides/PCBs in Water**

Method: 608
Preparation: CWA_Prep_CLLE
Dilution: 1.0
Date Analyzed: 02/24/2006 0026
Date Prepared: 02/21/2006 0654

Analysis Batch: 700-17877
Prep Batch: 700-17552

Instrument ID: MSGY
Lab File ID: Y022329.D
Initial Weight/Volume: 1000 mL
Final Weight/Volume: 5.0 mL
Injection Volume:
Column ID: PRIMARY

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Aldrin | ND | | 0.0045 | 0.050 |
| alpha-BHC | ND | * | 0.0056 | 0.050 |
| beta-BHC | ND | * | 0.0036 | 0.050 |
| Chlordane (technical) | ND | | 0.032 | 0.50 |
| 4,4'-DDD | ND | | 0.0076 | 0.10 |
| 4,4'-DDE | ND | | 0.0064 | 0.10 |
| 4,4'-DDT | ND | | 0.0084 | 0.10 |
| delta-BHC | ND | * | 0.010 | 0.050 |
| Dieldrin | ND | | 0.0074 | 0.10 |
| Endosulfan I | ND | | 0.0044 | 0.050 |
| Endosulfan II | ND | | 0.0047 | 0.10 |
| Endosulfan sulfate | ND | | 0.0090 | 0.10 |
| Endrin | ND | | 0.0067 | 0.10 |
| Endrin aldehyde | ND | | 0.0069 | 0.10 |
| gamma-BHC (Lindane) | ND | * | 0.0049 | 0.050 |
| Heptachlor | ND | | 0.0037 | 0.050 |
| Heptachlor epoxide | ND | | 0.0039 | 0.050 |
| PCB-1016 | ND | | 0.11 | 1.0 |
| PCB-1221 | ND | | 0.17 | 2.0 |
| PCB-1248 | ND | | 0.14 | 1.0 |
| PCB-1232 | ND | | 0.13 | 1.0 |
| PCB-1254 | ND | | 0.12 | 1.0 |
| PCB-1242 | ND | | 0.18 | 1.0 |
| PCB-1260 | ND | | 0.12 | 1.0 |
| Toxaphene | ND | | 0.31 | 5.0 |

| Surrogate | %Rec | | Acceptance Limits |
|---|---|---|---|
| DCB Decachlorobiphenyl | 22 | * | 30 - 150 |
| Tetrachloro-m-xylene | 60 | | 30 - 150 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9790-1

**Client Sample ID:** **CH02 Elutriate**

Lab Sample ID: 700-9790-6 Date Sampled: 02/13/2006 1200
Client Matrix: Water Date Received: 02/15/2006 0903

**608 Organochlorine Pesticides/PCBs in Water**

Method: 608 Analysis Batch: 700-17877 Instrument ID: MSGY
Preparation: CWA_Prep_CLLE Prep Batch: 700-17552 Lab File ID: Y022336.D
Dilution: 1.0 Initial Weight/Volume: 1000 mL
Date Analyzed: 02/24/2006 0401 Final Weight/Volume: 5.0 mL
Date Prepared: 02/21/2006 0654 Injection Volume:
Column ID: PRIMARY

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Aldrin | ND | | 0.0045 | 0.050 |
| alpha-BHC | ND | * | 0.0056 | 0.050 |
| beta-BHC | ND | * | 0.0036 | 0.050 |
| Chlordane (technical) | ND | | 0.032 | 0.50 |
| 4,4'-DDD | ND | | 0.0076 | 0.10 |
| 4,4'-DDE | ND | | 0.0064 | 0.10 |
| 4,4'-DDT | ND | | 0.0084 | 0.10 |
| delta-BHC | ND | * | 0.010 | 0.050 |
| Dieldrin | ND | | 0.0074 | 0.10 |
| Endosulfan I | ND | | 0.0044 | 0.050 |
| Endosulfan II | ND | | 0.0047 | 0.10 |
| Endosulfan sulfate | ND | | 0.0090 | 0.10 |
| Endrin | ND | | 0.0067 | 0.10 |
| Endrin aldehyde | ND | | 0.0069 | 0.10 |
| gamma-BHC (Lindane) | ND | * | 0.0049 | 0.050 |
| Heptachlor | ND | | 0.0037 | 0.050 |
| Heptachlor epoxide | ND | | 0.0039 | 0.050 |
| PCB-1016 | ND | | 0.11 | 1.0 |
| PCB-1221 | ND | | 0.17 | 2.0 |
| PCB-1248 | ND | | 0.14 | 1.0 |
| PCB-1232 | ND | | 0.13 | 1.0 |
| PCB-1254 | ND | | 0.12 | 1.0 |
| PCB-1242 | ND | | 0.18 | 1.0 |
| PCB-1260 | ND | | 0.12 | 1.0 |
| Toxaphene | ND | | 0.31 | 5.0 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| DCB Decachlorobiphenyl | 30 | 30 - 150 |
| Tetrachloro-m-xylene | 78 | 30 - 150 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9790-1

**Client Sample ID:** **SPELTO 01 Water**

Lab Sample ID: 700-9790-8 Date Sampled: 02/13/2006 1415
Client Matrix: Water Date Received: 02/15/2006 0903

**608 Organochlorine Pesticides/PCBs in Water**

Method: 608 Analysis Batch: 700-17877 Instrument ID: MSGY
Preparation: CWA_Prep_CLLE Prep Batch: 700-17552 Lab File ID: Y022338.D
Dilution: 1.0 Initial Weight/Volume: 1000 mL
Date Analyzed: 02/24/2006 0502 Final Weight/Volume: 5.0 mL
Date Prepared: 02/21/2006 0654 Injection Volume:
Column ID: PRIMARY

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Aldrin | ND | | 0.0045 | 0.050 |
| alpha-BHC | ND | * | 0.0056 | 0.050 |
| beta-BHC | ND | * | 0.0036 | 0.050 |
| Chlordane (technical) | ND | | 0.032 | 0.50 |
| 4,4'-DDD | ND | | 0.0076 | 0.10 |
| 4,4'-DDE | ND | | 0.0064 | 0.10 |
| 4,4'-DDT | ND | | 0.0084 | 0.10 |
| delta-BHC | ND | * | 0.010 | 0.050 |
| Dieldrin | ND | | 0.0074 | 0.10 |
| Endosulfan I | ND | | 0.0044 | 0.050 |
| Endosulfan II | ND | | 0.0047 | 0.10 |
| Endosulfan sulfate | ND | | 0.0090 | 0.10 |
| Endrin | ND | | 0.0067 | 0.10 |
| Endrin aldehyde | ND | | 0.0069 | 0.10 |
| gamma-BHC (Lindane) | ND | * | 0.0049 | 0.050 |
| Heptachlor | ND | | 0.0037 | 0.050 |
| Heptachlor epoxide | ND | | 0.0039 | 0.050 |
| PCB-1016 | ND | | 0.11 | 1.0 |
| PCB-1221 | ND | | 0.17 | 2.0 |
| PCB-1248 | ND | | 0.14 | 1.0 |
| PCB-1232 | ND | | 0.13 | 1.0 |
| PCB-1254 | ND | | 0.12 | 1.0 |
| PCB-1242 | ND | | 0.18 | 1.0 |
| PCB-1260 | ND | | 0.12 | 1.0 |
| Toxaphene | ND | | 0.31 | 5.0 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| DCB Decachlorobiphenyl | 52 | 30 - 150 |
| Tetrachloro-m-xylene | 77 | 30 - 150 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9790-1

**Client Sample ID:** **SPELTO 01 Elutriate**

Lab Sample ID: 700-9790-9 | Date Sampled: 02/13/2006 1420
Client Matrix: Water | Date Received: 02/15/2006 0903

**608 Organochlorine Pesticides/PCBs in Water**

Method: 608 | Analysis Batch: 700-17877 | Instrument ID: MSGY
Preparation: CWA_Prep_CLLE | Prep Batch: 700-17552 | Lab File ID: Y022337.D
Dilution: 1.0 | Initial Weight/Volume: 1000 mL
Date Analyzed: 02/24/2006 0431 | Final Weight/Volume: 5.0 mL
Date Prepared: 02/21/2006 0654 | Injection Volume:
Column ID: PRIMARY

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Aldrin | ND | | 0.0045 | 0.050 |
| alpha-BHC | ND | * | 0.0056 | 0.050 |
| beta-BHC | ND | * | 0.0036 | 0.050 |
| Chlordane (technical) | ND | | 0.032 | 0.50 |
| 4,4'-DDD | ND | | 0.0076 | 0.10 |
| 4,4'-DDE | ND | | 0.0064 | 0.10 |
| 4,4'-DDT | ND | | 0.0084 | 0.10 |
| delta-BHC | ND | * | 0.010 | 0.050 |
| Dieldrin | ND | | 0.0074 | 0.10 |
| Endosulfan I | ND | | 0.0044 | 0.050 |
| Endosulfan II | ND | | 0.0047 | 0.10 |
| Endosulfan sulfate | ND | | 0.0090 | 0.10 |
| Endrin | ND | | 0.0067 | 0.10 |
| Endrin aldehyde | ND | | 0.0069 | 0.10 |
| gamma-BHC (Lindane) | ND | * | 0.0049 | 0.050 |
| Heptachlor | ND | | 0.0037 | 0.050 |
| Heptachlor epoxide | ND | | 0.0039 | 0.050 |
| PCB-1221 | ND | | 0.17 | 2.0 |
| PCB-1248 | ND | | 0.14 | 1.0 |
| PCB-1232 | ND | | 0.13 | 1.0 |
| PCB-1254 | ND | | 0.12 | 1.0 |
| PCB-1242 | ND | | 0.18 | 1.0 |
| PCB-1260 | ND | | 0.12 | 1.0 |
| PCB-1016 | ND | | 0.11 | 1.0 |
| Toxaphene | ND | | 0.31 | 5.0 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| DCB Decachlorobiphenyl | 49 | 30 - 150 |
| Tetrachloro-m-xylene | 80 | 30 - 150 |

**Analytical Data**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Client Sample ID:** **SPELTO 02 Elutriate**

Lab Sample ID: 700-9790-13
Client Matrix: Water

Date Sampled: 02/13/2006 1540
Date Received: 02/15/2006 0903

**608 Organochlorine Pesticides/PCBs in Water**

Method: 608
Preparation: CWA_Prep_CLLE
Dilution: 1.0
Date Analyzed: 02/24/2006 0533
Date Prepared: 02/21/2006 0654

Analysis Batch: 700-17877
Prep Batch: 700-17552

Instrument ID: MSGY
Lab File ID: Y022339.D
Initial Weight/Volume: 1000 mL
Final Weight/Volume: 5.0 mL
Injection Volume:
Column ID: PRIMARY

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Aldrin | ND | | 0.0045 | 0.050 |
| alpha-BHC | ND | * | 0.0056 | 0.050 |
| beta-BHC | ND | * | 0.0036 | 0.050 |
| Chlordane (technical) | ND | | 0.032 | 0.50 |
| 4,4'-DDD | ND | | 0.0076 | 0.10 |
| 4,4'-DDE | ND | | 0.0064 | 0.10 |
| 4,4'-DDT | ND | | 0.0084 | 0.10 |
| delta-BHC | ND | * | 0.010 | 0.050 |
| Dieldrin | ND | | 0.0074 | 0.10 |
| Endosulfan I | ND | | 0.0044 | 0.050 |
| Endosulfan II | ND | | 0.0047 | 0.10 |
| Endosulfan sulfate | ND | | 0.0090 | 0.10 |
| Endrin | ND | | 0.0067 | 0.10 |
| Endrin aldehyde | ND | | 0.0069 | 0.10 |
| gamma-BHC (Lindane) | ND | * | 0.0049 | 0.050 |
| Heptachlor | ND | | 0.0037 | 0.050 |
| Heptachlor epoxide | ND | | 0.0039 | 0.050 |
| PCB-1221 | ND | | 0.17 | 2.0 |
| PCB-1248 | ND | | 0.14 | 1.0 |
| PCB-1232 | ND | | 0.13 | 1.0 |
| PCB-1254 | ND | | 0.12 | 1.0 |
| PCB-1242 | ND | | 0.18 | 1.0 |
| PCB-1260 | ND | | 0.12 | 1.0 |
| PCB-1016 | ND | | 0.11 | 1.0 |
| Toxaphene | ND | | 0.31 | 5.0 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| DCB Decachlorobiphenyl | 46 | 30 - 150 |
| Tetrachloro-m-xylene | 69 | 30 - 150 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9790-1

**Client Sample ID:** **CH01 Sediment**

Lab Sample ID: 700-9790-3 Date Sampled: 02/13/2006 0920
Client Matrix: Solid Date Received: 02/15/2006 0903

**8081A Organochlorine Pesticides by Gas Chromatography**

Method: 8081A Analysis Batch: 700-17870 Instrument ID: MSGY
Preparation: 3550B Prep Batch: 700-17522 Lab File ID: Y022516.D
Dilution: 1.0 Initial Weight/Volume: 50.0 g
Date Analyzed: 02/25/2006 1653 Final Weight/Volume: 5.0 mL
Date Prepared: 02/20/2006 0900 Injection Volume:
Column ID: PRIMARY

| Analyte | DryWt Corrected: N | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| Aldrin | | ND | | 0.17 | 1.0 |
| alpha-BHC | | ND | | 0.072 | 1.0 |
| beta-BHC | | ND | | 0.072 | 1.0 |
| Chlordane (technical) | | ND | | 0.90 | 10 |
| 4,4'-DDD | | ND | | 0.20 | 2.0 |
| 4,4'-DDE | | ND | | 0.18 | 2.0 |
| 4,4'-DDT | | ND | | 0.32 | 2.0 |
| delta-BHC | | ND | | 0.15 | 1.0 |
| Dieldrin | | ND | | 0.16 | 2.0 |
| Endosulfan I | | ND | | 0.072 | 1.0 |
| Endosulfan II | | ND | | 0.23 | 2.0 |
| Endosulfan sulfate | | ND | | 0.20 | 2.0 |
| Endrin | | ND | | 0.23 | 2.0 |
| Endrin aldehyde | | ND | * | 0.23 | 2.0 |
| gamma-BHC (Lindane) | | ND | | 0.066 | 1.0 |
| Heptachlor | | ND | | 0.11 | 1.0 |
| Heptachlor epoxide | | ND | | 0.078 | 1.0 |
| Toxaphene | | ND | | 6.6 | 100 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| DCB Decachlorobiphenyl | 71 | 30 - 150 |
| Tetrachloro-m-xylene | 55 | 30 - 150 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9790-1

**Client Sample ID:** **CH02 Sediment**

Lab Sample ID: 700-9790-7 | Date Sampled: 02/13/2006 1200
Client Matrix: Solid | Date Received: 02/15/2006 0903

**8081A Organochlorine Pesticides by Gas Chromatography**

Method: 8081A | Analysis Batch: 700-17870 | Instrument ID: MSGY
Preparation: 3550B | Prep Batch: 700-17522 | Lab File ID: Y022515.D
Dilution: 1.0 | Initial Weight/Volume: 50.0 g
Date Analyzed: 02/25/2006 1622 | Final Weight/Volume: 5.0 mL
Date Prepared: 02/20/2006 0900 | Injection Volume:
Column ID: PRIMARY

| Analyte | DryWt Corrected: N | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| Aldrin | | ND | | 0.17 | 1.0 |
| alpha-BHC | | ND | | 0.072 | 1.0 |
| beta-BHC | | ND | | 0.072 | 1.0 |
| Chlordane (technical) | | ND | | 0.90 | 10 |
| 4,4'-DDD | | ND | | 0.20 | 2.0 |
| 4,4'-DDE | | ND | | 0.18 | 2.0 |
| 4,4'-DDT | | ND | | 0.32 | 2.0 |
| delta-BHC | | ND | | 0.15 | 1.0 |
| Dieldrin | | ND | | 0.16 | 2.0 |
| Endosulfan I | | ND | | 0.072 | 1.0 |
| Endosulfan II | | ND | | 0.23 | 2.0 |
| Endosulfan sulfate | | ND | | 0.20 | 2.0 |
| Endrin | | ND | | 0.23 | 2.0 |
| Endrin aldehyde | | ND | * | 0.23 | 2.0 |
| gamma-BHC (Lindane) | | ND | | 0.066 | 1.0 |
| Heptachlor | | ND | | 0.11 | 1.0 |
| Heptachlor epoxide | | ND | | 0.078 | 1.0 |
| Toxaphene | | ND | | 6.6 | 100 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| DCB Decachlorobiphenyl | 74 | 30 - 150 |
| Tetrachloro-m-xylene | 45 | 30 - 150 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9790-1

**Client Sample ID:** **SPELTO 01 Sediment**

Lab Sample ID: 700-9790-11 Date Sampled: 02/13/2006 1420
Client Matrix: Solid Date Received: 02/15/2006 0903

**8081A Organochlorine Pesticides by Gas Chromatography**

Method: 8081A Analysis Batch: 700-17870 Instrument ID: MSGY
Preparation: 3550B Prep Batch: 700-17522 Lab File ID: Y022517.D
Dilution: 1.0 Initial Weight/Volume: 50.0 g
Date Analyzed: 02/25/2006 1723 Final Weight/Volume: 5.0 mL
Date Prepared: 02/20/2006 0900 Injection Volume:
Column ID: PRIMARY

| Analyte | DryWt Corrected: N | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| Aldrin | | ND | | 0.17 | 1.0 |
| alpha-BHC | | ND | | 0.072 | 1.0 |
| beta-BHC | | ND | | 0.072 | 1.0 |
| Chlordane (technical) | | ND | | 0.90 | 10 |
| 4,4'-DDD | | ND | | 0.20 | 2.0 |
| 4,4'-DDE | | ND | | 0.18 | 2.0 |
| 4,4'-DDT | | ND | | 0.32 | 2.0 |
| delta-BHC | | ND | | 0.15 | 1.0 |
| Dieldrin | | ND | | 0.16 | 2.0 |
| Endosulfan I | | ND | | 0.072 | 1.0 |
| Endosulfan II | | ND | | 0.23 | 2.0 |
| Endosulfan sulfate | | ND | | 0.20 | 2.0 |
| Endrin | | ND | | 0.23 | 2.0 |
| Endrin aldehyde | | ND | * | 0.23 | 2.0 |
| gamma-BHC (Lindane) | | ND | | 0.066 | 1.0 |
| Heptachlor | | ND | | 0.11 | 1.0 |
| Heptachlor epoxide | | ND | | 0.078 | 1.0 |
| Toxaphene | | ND | | 6.6 | 100 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| DCB Decachlorobiphenyl | 77 | 30 - 150 |
| Tetrachloro-m-xylene | 51 | 30 - 150 |

**Analytical Data**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Client Sample ID:** **SPELTO 02 Sediment**

Lab Sample ID: 700-9790-14
Client Matrix: Solid

Date Sampled: 02/13/2006 1540
Date Received: 02/15/2006 0903

**8081A Organochlorine Pesticides by Gas Chromatography**

Method: 8081A
Preparation: 3550B
Dilution: 1.0
Date Analyzed: 02/25/2006 1754
Date Prepared: 02/20/2006 0900

Analysis Batch: 700-17870
Prep Batch: 700-17522

Instrument ID: MSGY
Lab File ID: Y022518.D
Initial Weight/Volume: 50.0 g
Final Weight/Volume: 5.0 mL
Injection Volume:
Column ID: PRIMARY

| Analyte | DryWt Corrected: N | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| Aldrin | | ND | | 0.17 | 1.0 |
| alpha-BHC | | ND | | 0.072 | 1.0 |
| beta-BHC | | ND | | 0.072 | 1.0 |
| Chlordane (technical) | | ND | | 0.90 | 10 |
| 4,4'-DDD | | ND | | 0.20 | 2.0 |
| 4,4'-DDE | | ND | | 0.18 | 2.0 |
| 4,4'-DDT | | ND | | 0.32 | 2.0 |
| delta-BHC | | ND | | 0.15 | 1.0 |
| Dieldrin | | ND | | 0.16 | 2.0 |
| Endosulfan I | | ND | | 0.072 | 1.0 |
| Endosulfan II | | ND | | 0.23 | 2.0 |
| Endosulfan sulfate | | ND | | 0.20 | 2.0 |
| Endrin | | ND | | 0.23 | 2.0 |
| Endrin aldehyde | | ND | | 0.23 | 2.0 |
| gamma-BHC (Lindane) | | ND | | 0.066 | 1.0 |
| Heptachlor | | ND | | 0.11 | 1.0 |
| Heptachlor epoxide | | ND | | 0.078 | 1.0 |
| Toxaphene | | ND | | 6.6 | 100 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| DCB Decachlorobiphenyl | 71 | 30 - 150 |
| Tetrachloro-m-xylene | 50 | 30 - 150 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9790-1

**Client Sample ID:** **CH01 Sediment**

Lab Sample ID: 700-9790-3 | Date Sampled: 02/13/2006 0920
Client Matrix: Solid | Date Received: 02/15/2006 0903

**8082 Polychlorinated Biphenyls (PCBs) by Gas Chromatography**

Method: 8082 | Analysis Batch: 700-17870 | Instrument ID: MSGY
Preparation: 3550B | Prep Batch: 700-17524 | Lab File ID: Y022516pcb.D
Dilution: 1.0 | Initial Weight/Volume: 50.0 g
Date Analyzed: 02/25/2006 1653 | Final Weight/Volume: 5.0 mL
Date Prepared: 02/20/2006 0900 | Injection Volume:
Column ID: PRIMARY

| Analyte | DryWt Corrected: N | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| PCB-1016 | | ND | | 1.8 | 20 |
| PCB-1221 | | ND | | 1.1 | 40 |
| PCB-1232 | | ND | | 2.2 | 20 |
| PCB-1242 | | ND | | 1.7 | 20 |
| PCB-1248 | | ND | | 2.6 | 20 |
| PCB-1254 | | ND | | 1.9 | 20 |
| PCB-1260 | | ND | * | 1.6 | 20 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| DCB Decachlorobiphenyl | 71 | 30 - 150 |
| Tetrachloro-m-xylene | 47 | 30 - 150 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9790-1

**Client Sample ID:** **CH02 Sediment**

Lab Sample ID: 700-9790-7 | Date Sampled: 02/13/2006 1200
Client Matrix: Solid | Date Received: 02/15/2006 0903

**8082 Polychlorinated Biphenyls (PCBs) by Gas Chromatography**

Method: 8082 | Analysis Batch: 700-17870 | Instrument ID: MSGY
Preparation: 3550B | Prep Batch: 700-17524 | Lab File ID: Y022515pcb.D
Dilution: 1.0 | Initial Weight/Volume: 50.0 g
Date Analyzed: 02/25/2006 1622 | Final Weight/Volume: 5.0 mL
Date Prepared: 02/20/2006 0900 | Injection Volume:
Column ID: PRIMARY

| Analyte | DryWt Corrected: N | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| PCB-1016 | | ND | | 1.8 | 20 |
| PCB-1221 | | ND | | 1.1 | 40 |
| PCB-1232 | | ND | | 2.2 | 20 |
| PCB-1242 | | ND | | 1.7 | 20 |
| PCB-1248 | | ND | | 2.6 | 20 |
| PCB-1254 | | 150 | | 1.9 | 20 |
| PCB-1260 | | ND | * | 1.6 | 20 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| DCB Decachlorobiphenyl | 73 | 30 - 150 |
| Tetrachloro-m-xylene | 38 | 30 - 150 |

**Analytical Data**

Client: Providence Engineering & Environmental  Job Number: 700-9790-1

**Client Sample ID:** **SPELTO 01 Sediment**

Lab Sample ID: 700-9790-11  Date Sampled: 02/13/2006 1420
Client Matrix: Solid  Date Received: 02/15/2006 0903

**8082 Polychlorinated Biphenyls (PCBs) by Gas Chromatography**

Method: 8082  Analysis Batch: 700-17870  Instrument ID: MSGY
Preparation: 3550B  Prep Batch: 700-17524  Lab File ID: Y022517pcb.D
Dilution: 1.0  Initial Weight/Volume: 50.0 g
Date Analyzed: 02/25/2006 1723  Final Weight/Volume: 5.0 mL
Date Prepared: 02/20/2006 0900  Injection Volume:
Column ID: PRIMARY

| Analyte | DryWt Corrected: N | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| PCB-1016 | | ND | | 1.8 | 20 |
| PCB-1221 | | ND | | 1.1 | 40 |
| PCB-1232 | | ND | | 2.2 | 20 |
| PCB-1242 | | ND | | 1.7 | 20 |
| PCB-1248 | | ND | | 2.6 | 20 |
| PCB-1254 | | ND | | 1.9 | 20 |
| PCB-1260 | | ND | * | 1.6 | 20 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| DCB Decachlorobiphenyl | 78 | 30 - 150 |
| Tetrachloro-m-xylene | 44 | 30 - 150 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9790-1

**Client Sample ID:** **SPELTO 02 Sediment**

Lab Sample ID: 700-9790-14 | Date Sampled: 02/13/2006 1540
Client Matrix: Solid | Date Received: 02/15/2006 0903

**8082 Polychlorinated Biphenyls (PCBs) by Gas Chromatography**

Method: 8082 | Analysis Batch: 700-17870 | Instrument ID: MSGY
Preparation: 3550B | Prep Batch: 700-17524 | Lab File ID: Y022518pcb.D
Dilution: 1.0 | Initial Weight/Volume: 50.0 g
Date Analyzed: 02/25/2006 1754 | Final Weight/Volume: 5.0 mL
Date Prepared: 02/20/2006 0900 | Injection Volume:
Column ID: PRIMARY

| Analyte | DryWt Corrected: N | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| PCB-1016 | | ND | | 1.8 | 20 |
| PCB-1221 | | ND | | 1.1 | 40 |
| PCB-1232 | | ND | | 2.2 | 20 |
| PCB-1242 | | ND | | 1.7 | 20 |
| PCB-1248 | | ND | | 2.6 | 20 |
| PCB-1254 | | ND | | 1.9 | 20 |
| PCB-1260 | | ND | * | 1.6 | 20 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| DCB Decachlorobiphenyl | 71 | 30 - 150 |
| Tetrachloro-m-xylene | 43 | 30 - 150 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9790-1

**Client Sample ID: CH01 Water**

Lab Sample ID: 700-9790-1 | Date Sampled: 02/13/2006 0935
Client Matrix: Water | Date Received: 02/15/2006 0903

**200.8 ICPMS Metals by 200.8 CWA-Dissolved**

Method: 200.8 | Analysis Batch: 680-37853 | Instrument ID: ICP MS
Preparation: 4.1.4 | Prep Batch: 680-37202 | Lab File ID: N/A
Dilution: 1.0 | Initial Weight/Volume: 50 mL
Date Analyzed: 02/25/2006 0717 | Final Weight/Volume: 250 mL
Date Prepared: 02/23/2006 1624

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Antimony | ND | | 1.0 | 2.5 |
| Arsenic | 1.4 | J | 0.60 | 2.5 |
| Beryllium | ND | | 0.15 | 0.50 |
| Cadmium | ND | | 0.10 | 0.50 |
| Chromium | ND | | 1.5 | 5.0 |
| Copper | 0.69 | J | 0.39 | 2.5 |
| Lead | ND | | 0.50 | 1.5 |
| Nickel | 1.3 | | 0.15 | 1.0 |
| Silver | ND | | 0.25 | 1.0 |
| Thallium | ND | | 0.25 | 1.0 |
| Zinc | 13 | J | 3.5 | 20 |

Method: 200.8 | Analysis Batch: 680-37853 | Instrument ID: ICP MS
Preparation: 4.1.4 | Prep Batch: 680-37202 | Lab File ID: N/A
Dilution: 4.0 | Initial Weight/Volume: 50 mL
Date Analyzed: 03/01/2006 1947 | Final Weight/Volume: 250 mL
Date Prepared: 02/23/2006 1624

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Selenium | ND | | 2.0 | 10 |

**245.1 Mercury in Water by CVAA**

Method: 245.1 | Analysis Batch: 700-17468 | Instrument ID: LEEMAN PS200
Preparation: 245.1 | Prep Batch: 700-17459 | Lab File ID: N/A
Dilution: 1.0 | Initial Weight/Volume: 40.0 mL
Date Analyzed: 02/17/2006 1625 | Final Weight/Volume: 40.0 mL
Date Prepared: 02/17/2006 1015

| Analyte | Result (mg/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Mercury | ND | | 0.000078 | 0.00020 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9790-1

**Client Sample ID: CH01 Elutriate**

Lab Sample ID: 700-9790-2 Date Sampled: 02/13/2006 0920
Client Matrix: Water Date Received: 02/15/2006 0903

**200.8 ICPMS Metals by 200.8 CWA-Total Recoverable**

Method: 200.8 Analysis Batch: 680-37851 Instrument ID: ICP MS
Preparation: 4.1.4 Prep Batch: 680-37205 Lab File ID: N/A
Dilution: 1.0 Initial Weight/Volume: 50 mL
Date Analyzed: 02/25/2006 0458 Final Weight/Volume: 250 mL
Date Prepared: 02/23/2006 1637

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Antimony | ND | | 1.0 | 2.5 |
| Arsenic | 5.6 | | 0.60 | 2.5 |
| Cadmium | ND | | 0.10 | 0.50 |
| Chromium | ND | | 1.5 | 5.0 |
| Copper | 0.99 | J | 0.39 | 2.5 |
| Lead | 0.72 | J | 0.50 | 1.5 |
| Nickel | 1.6 | | 0.15 | 1.0 |
| Silver | ND | | 0.25 | 1.0 |
| Thallium | ND | | 0.25 | 1.0 |
| Zinc | 15 | J B | 3.5 | 20 |

Method: 200.8 Analysis Batch: 680-37851 Instrument ID: ICP MS
Preparation: 4.1.4 Prep Batch: 680-37205 Lab File ID: N/A
Dilution: 4.0 Initial Weight/Volume: 50 mL
Date Analyzed: 03/01/2006 2204 Final Weight/Volume: 250 mL
Date Prepared: 02/23/2006 1637

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Selenium | ND | | 2.0 | 10 |

Method: 200.8 Analysis Batch: 680-37851 Instrument ID: ICP MS
Preparation: 4.1.4 Prep Batch: 680-37205 Lab File ID: N/A
Dilution: 4.0 Initial Weight/Volume: 50 mL
Date Analyzed: 03/03/2006 1210 Final Weight/Volume: 250 mL
Date Prepared: 02/23/2006 1637

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Beryllium | ND | | 0.60 | 2.0 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9790-1

**Client Sample ID: CH01 Elutriate**

| | | | |
|---|---|---|---|
| Lab Sample ID: | 700-9790-2 | Date Sampled: | 02/13/2006 0920 |
| Client Matrix: | Water | Date Received: | 02/15/2006 0903 |

**245.1 Mercury in Water by CVAA**

| | | | | | |
|---|---|---|---|---|---|
| Method: | 245.1 | Analysis Batch: 700-17622 | Instrument ID: | LEEMAN PS200 | |
| Preparation: | 245.1 | Prep Batch: 700-17565 | Lab File ID: | N/A | |
| Dilution: | 1.0 | | Initial Weight/Volume: | 40.0 | mL |
| Date Analyzed: | 02/22/2006 1107 | | Final Weight/Volume: | 40.0 | mL |
| Date Prepared: | 02/21/2006 1015 | | | | |

| Analyte | Result (mg/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Mercury | 0.00019 | J | 0.000078 | 0.00020 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9790-1

**Client Sample ID: CH01 Sediment**

Lab Sample ID: 700-9790-3 Date Sampled: 02/13/2006 0920
Client Matrix: Solid Date Received: 02/15/2006 0903

**6020 Inductively Coupled Plasma - Mass Spectrometry**

Method: 6020 Analysis Batch: 680-37413 Instrument ID: ICP MS
Preparation: 3050B Prep Batch: 680-37134 Lab File ID: N/A
Dilution: 1.0 Initial Weight/Volume: 1.08 g
Date Analyzed: 02/24/2006 2300 Final Weight/Volume: 1000 mL
Date Prepared: 02/23/2006 1049

| Analyte | DryWt Corrected: N | Result (mg/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| Antimony | | ND | | 0.19 | 0.46 |
| Arsenic | | 3.6 | | 0.11 | 0.46 |
| Beryllium | | 0.30 | | 0.028 | 0.093 |
| Cadmium | | 0.11 | | 0.019 | 0.093 |
| Chromium | | 7.8 | | 0.28 | 0.93 |
| Copper | | 6.8 | B | 0.035 | 0.46 |
| Lead | | 5.7 | | 0.093 | 0.28 |
| Selenium | | 0.21 | J | 0.093 | 0.46 |
| Silver | | ND | | 0.046 | 0.19 |
| Thallium | | 0.082 | J | 0.046 | 0.19 |
| Zinc | | 29 | B | 0.25 | 3.7 |

Method: 6020 Analysis Batch: 680-37413 Instrument ID: ICP MS
Preparation: 3050B Prep Batch: 680-37134 Lab File ID: N/A
Dilution: 1.0 Initial Weight/Volume: 1.08 g
Date Analyzed: 02/25/2006 2210 Final Weight/Volume: 1000 mL
Date Prepared: 02/23/2006 1049

| Analyte | DryWt Corrected: N | Result (mg/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| Nickel | | 7.8 | B | 0.028 | 0.19 |

**7471A Mercury in Solid or Semisolid Waste (Manual Cold Vapor Technique)**

Method: 7471A Analysis Batch: 700-17545 Instrument ID: LEEMAN PS200
Preparation: 7471A Prep Batch: 700-17497 Lab File ID: N/A
Dilution: 1.0 Initial Weight/Volume: 0.74 g
Date Analyzed: 02/20/2006 1524 Final Weight/Volume: 40.0 mL
Date Prepared: 02/20/2006 0920

| Analyte | DryWt Corrected: N | Result (mg/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| Mercury | | 0.013 | | 0.0054 | 0.011 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9790-1

**Client Sample ID: CH02 Elutriate**

Lab Sample ID: 700-9790-6 | Date Sampled: 02/13/2006 1200
Client Matrix: Water | Date Received: 02/15/2006 0903

**200.8 ICPMS Metals by 200.8 CWA-Total Recoverable**

Method: 200.8 | Analysis Batch: 680-37851 | Instrument ID: ICP MS
Preparation: 4.1.4 | Prep Batch: 680-37205 | Lab File ID: N/A
Dilution: 1.0 | Initial Weight/Volume: 50 mL
Date Analyzed: 02/25/2006 0505 | Final Weight/Volume: 250 mL
Date Prepared: 02/23/2006 1637

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Antimony | ND | | 1.0 | 2.5 |
| Arsenic | 3.6 | | 0.60 | 2.5 |
| Cadmium | ND | | 0.10 | 0.50 |
| Chromium | ND | | 1.5 | 5.0 |
| Copper | 1.5 | J | 0.39 | 2.5 |
| Lead | 0.85 | J | 0.50 | 1.5 |
| Nickel | 2.4 | | 0.15 | 1.0 |
| Silver | ND | | 0.25 | 1.0 |
| Thallium | ND | | 0.25 | 1.0 |
| Zinc | 17 | J B | 3.5 | 20 |

Method: 200.8 | Analysis Batch: 680-37851 | Instrument ID: ICP MS
Preparation: 4.1.4 | Prep Batch: 680-37205 | Lab File ID: N/A
Dilution: 4.0 | Initial Weight/Volume: 50 mL
Date Analyzed: 03/01/2006 2212 | Final Weight/Volume: 250 mL
Date Prepared: 02/23/2006 1637

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Selenium | ND | | 2.0 | 10 |

Method: 200.8 | Analysis Batch: 680-37851 | Instrument ID: ICP MS
Preparation: 4.1.4 | Prep Batch: 680-37205 | Lab File ID: N/A
Dilution: 4.0 | Initial Weight/Volume: 50 mL
Date Analyzed: 03/03/2006 1217 | Final Weight/Volume: 250 mL
Date Prepared: 02/23/2006 1637

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Beryllium | ND | | 0.60 | 2.0 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9790-1

**Client Sample ID: CH02 Elutriate**

| | | | |
|---|---|---|---|
| Lab Sample ID: | 700-9790-6 | Date Sampled: | 02/13/2006 1200 |
| Client Matrix: | Water | Date Received: | 02/15/2006 0903 |

**245.1 Mercury in Water by CVAA**

| | | | | | |
|---|---|---|---|---|---|
| Method: | 245.1 | Analysis Batch: 700-17622 | | Instrument ID: | LEEMAN PS200 |
| Preparation: | 245.1 | Prep Batch: 700-17565 | | Lab File ID: | N/A |
| Dilution: | 1.0 | | | Initial Weight/Volume: | 40.0 mL |
| Date Analyzed: | 02/22/2006 1108 | | | Final Weight/Volume: | 40.0 mL |
| Date Prepared: | 02/21/2006 1015 | | | | |

| Analyte | Result (mg/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Mercury | 0.00018 | J | 0.000078 | 0.00020 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9790-1

**Client Sample ID: CH02 Sediment**

Lab Sample ID: 700-9790-7 | Date Sampled: 02/13/2006 1200
Client Matrix: Solid | Date Received: 02/15/2006 0903

**6020 Inductively Coupled Plasma - Mass Spectrometry**

Method: 6020 | Analysis Batch: 680-37413 | Instrument ID: ICP MS
Preparation: 3050B | Prep Batch: 680-37134 | Lab File ID: N/A
Dilution: 1.0 | Initial Weight/Volume: 1.11 g
Date Analyzed: 02/24/2006 2307 | Final Weight/Volume: 1000 mL
Date Prepared: 02/23/2006 1049

| Analyte | DryWt Corrected: N | Result (mg/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| Antimony | | ND | | 0.18 | 0.45 |
| Arsenic | | 2.1 | | 0.11 | 0.45 |
| Beryllium | | 0.14 | | 0.027 | 0.090 |
| Cadmium | | 0.037 | J | 0.018 | 0.090 |
| Chromium | | 4.0 | | 0.27 | 0.90 |
| Copper | | 2.1 | B | 0.034 | 0.45 |
| Lead | | 2.9 | | 0.090 | 0.27 |
| Selenium | | ND | | 0.090 | 0.45 |
| Silver | | ND | | 0.045 | 0.18 |
| Thallium | | ND | | 0.045 | 0.18 |
| Zinc | | 15 | B | 0.24 | 3.6 |

Method: 6020 | Analysis Batch: 680-37413 | Instrument ID: ICP MS
Preparation: 3050B | Prep Batch: 680-37134 | Lab File ID: N/A
Dilution: 1.0 | Initial Weight/Volume: 1.11 g
Date Analyzed: 02/25/2006 2217 | Final Weight/Volume: 1000 mL
Date Prepared: 02/23/2006 1049

| Analyte | DryWt Corrected: N | Result (mg/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| Nickel | | 5.6 | B | 0.027 | 0.18 |

**7471A Mercury in Solid or Semisolid Waste (Manual Cold Vapor Technique)**

Method: 7471A | Analysis Batch: 700-17545 | Instrument ID: LEEMAN PS200
Preparation: 7471A | Prep Batch: 700-17497 | Lab File ID: N/A
Dilution: 1.0 | Initial Weight/Volume: 0.58 g
Date Analyzed: 02/20/2006 1529 | Final Weight/Volume: 40.0 mL
Date Prepared: 02/20/2006 0920

| Analyte | DryWt Corrected: N | Result (mg/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| Mercury | | 0.017 | | 0.0069 | 0.014 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9790-1

**Client Sample ID: SPELTO 01 Water**

Lab Sample ID: 700-9790-8 Date Sampled: 02/13/2006 1415
Client Matrix: Water Date Received: 02/15/2006 0903

**200.8 ICPMS Metals by 200.8 CWA-Dissolved**

Method: 200.8 Analysis Batch: 680-37853 Instrument ID: ICP MS
Preparation: 4.1.4 Prep Batch: 680-37202 Lab File ID: N/A
Dilution: 1.0 Initial Weight/Volume: 50 mL
Date Analyzed: 02/25/2006 0724 Final Weight/Volume: 250 mL
Date Prepared: 02/23/2006 1624

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Antimony | ND | | 1.0 | 2.5 |
| Arsenic | 1.7 | J | 0.60 | 2.5 |
| Beryllium | ND | | 0.15 | 0.50 |
| Cadmium | 0.11 | J | 0.10 | 0.50 |
| Chromium | ND | | 1.5 | 5.0 |
| Copper | 0.90 | J | 0.39 | 2.5 |
| Lead | ND | | 0.50 | 1.5 |
| Nickel | 0.94 | J | 0.15 | 1.0 |
| Silver | ND | | 0.25 | 1.0 |
| Thallium | ND | | 0.25 | 1.0 |
| Zinc | 15 | J | 3.5 | 20 |

Method: 200.8 Analysis Batch: 680-37853 Instrument ID: ICP MS
Preparation: 4.1.4 Prep Batch: 680-37202 Lab File ID: N/A
Dilution: 4.0 Initial Weight/Volume: 50 mL
Date Analyzed: 03/01/2006 1954 Final Weight/Volume: 250 mL
Date Prepared: 02/23/2006 1624

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Selenium | ND | | 2.0 | 10 |

**245.1 Mercury in Water by CVAA**

Method: 245.1 Analysis Batch: 700-17468 Instrument ID: LEEMAN PS200
Preparation: 245.1 Prep Batch: 700-17459 Lab File ID: N/A
Dilution: 1.0 Initial Weight/Volume: 40.0 mL
Date Analyzed: 02/17/2006 1627 Final Weight/Volume: 40.0 mL
Date Prepared: 02/17/2006 1015

| Analyte | Result (mg/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Mercury | ND | | 0.000078 | 0.00020 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9790-1

**Client Sample ID: SPELTO 01 Elutriate**

Lab Sample ID: 700-9790-9 | Date Sampled: 02/13/2006 1420
Client Matrix: Water | Date Received: 02/15/2006 0903

**200.8 ICPMS Metals by 200.8 CWA-Total Recoverable**

Method: 200.8 | Analysis Batch: 680-37851 | Instrument ID: ICP MS
Preparation: 4.1.4 | Prep Batch: 680-37205 | Lab File ID: N/A
Dilution: 1.0 | Initial Weight/Volume: 50 mL
Date Analyzed: 02/25/2006 0513 | Final Weight/Volume: 250 mL
Date Prepared: 02/23/2006 1637

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Antimony | ND | | 1.0 | 2.5 |
| Arsenic | 1.5 | J | 0.60 | 2.5 |
| Cadmium | ND | | 0.10 | 0.50 |
| Chromium | ND | | 1.5 | 5.0 |
| Copper | 1.0 | J | 0.39 | 2.5 |
| Lead | ND | | 0.50 | 1.5 |
| Nickel | 1.1 | | 0.15 | 1.0 |
| Silver | ND | | 0.25 | 1.0 |
| Thallium | ND | | 0.25 | 1.0 |
| Zinc | 39 | B | 3.5 | 20 |

Method: 200.8 | Analysis Batch: 680-37851 | Instrument ID: ICP MS
Preparation: 4.1.4 | Prep Batch: 680-37205 | Lab File ID: N/A
Dilution: 4.0 | Initial Weight/Volume: 50 mL
Date Analyzed: 03/01/2006 2219 | Final Weight/Volume: 250 mL
Date Prepared: 02/23/2006 1637

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Selenium | ND | | 2.0 | 10 |

Method: 200.8 | Analysis Batch: 680-37851 | Instrument ID: ICP MS
Preparation: 4.1.4 | Prep Batch: 680-37205 | Lab File ID: N/A
Dilution: 4.0 | Initial Weight/Volume: 50 mL
Date Analyzed: 03/03/2006 1224 | Final Weight/Volume: 250 mL
Date Prepared: 02/23/2006 1637

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Beryllium | ND | | 0.60 | 2.0 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9790-1

**Client Sample ID: SPELTO 01 Elutriate**

| | | | |
|---|---|---|---|
| Lab Sample ID: | 700-9790-9 | Date Sampled: | 02/13/2006 1420 |
| Client Matrix: | Water | Date Received: | 02/15/2006 0903 |

**245.1 Mercury in Water by CVAA**

| | | | | | |
|---|---|---|---|---|---|
| Method: | 245.1 | Analysis Batch: 700-17622 | | Instrument ID: | LEEMAN PS200 |
| Preparation: | 245.1 | Prep Batch: 700-17565 | | Lab File ID: | N/A |
| Dilution: | 1.0 | | | Initial Weight/Volume: | 40.0 mL |
| Date Analyzed: | 02/22/2006 1110 | | | Final Weight/Volume: | 40.0 mL |
| Date Prepared: | 02/21/2006 1015 | | | | |

| Analyte | Result (mg/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Mercury | 0.00024 | | 0.000078 | 0.00020 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9790-1

**Client Sample ID: SPELTO 01 Sediment**

Lab Sample ID: 700-9790-11 | Date Sampled: 02/13/2006 1420
Client Matrix: Solid | Date Received: 02/15/2006 0903

**6020 Inductively Coupled Plasma - Mass Spectrometry**

Method: 6020 | Analysis Batch: 680-37413 | Instrument ID: ICP MS
Preparation: 3050B | Prep Batch: 680-37134 | Lab File ID: N/A
Dilution: 1.0 | Initial Weight/Volume: 1.10 g
Date Analyzed: 02/24/2006 2314 | Final Weight/Volume: 1000 mL
Date Prepared: 02/23/2006 1049

| Analyte | DryWt Corrected: N | Result (mg/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| Antimony | | ND | | 0.18 | 0.45 |
| Arsenic | | 1.9 | | 0.11 | 0.45 |
| Beryllium | | 0.083 | J | 0.027 | 0.091 |
| Cadmium | | ND | | 0.018 | 0.091 |
| Chromium | | 3.2 | | 0.27 | 0.91 |
| Copper | | 0.72 | B | 0.035 | 0.45 |
| Lead | | 1.8 | | 0.091 | 0.27 |
| Selenium | | ND | | 0.091 | 0.45 |
| Silver | | ND | | 0.045 | 0.18 |
| Thallium | | ND | | 0.045 | 0.18 |
| Zinc | | 12 | B | 0.25 | 3.6 |

Method: 6020 | Analysis Batch: 680-37413 | Instrument ID: ICP MS
Preparation: 3050B | Prep Batch: 680-37134 | Lab File ID: N/A
Dilution: 1.0 | Initial Weight/Volume: 1.10 g
Date Analyzed: 02/25/2006 2225 | Final Weight/Volume: 1000 mL
Date Prepared: 02/23/2006 1049

| Analyte | DryWt Corrected: N | Result (mg/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| Nickel | | 4.2 | B | 0.027 | 0.18 |

**7471A Mercury in Solid or Semisolid Waste (Manual Cold Vapor Technique)**

Method: 7471A | Analysis Batch: 700-17545 | Instrument ID: LEEMAN PS200
Preparation: 7471A | Prep Batch: 700-17497 | Lab File ID: N/A
Dilution: 1.0 | Initial Weight/Volume: 0.68 g
Date Analyzed: 02/20/2006 1530 | Final Weight/Volume: 40.0 mL
Date Prepared: 02/20/2006 0920

| Analyte | DryWt Corrected: N | Result (mg/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| Mercury | | ND | | 0.0059 | 0.012 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9790-1

**Client Sample ID: SPELTO 02 Elutriate**

Lab Sample ID: 700-9790-13 Date Sampled: 02/13/2006 1540
Client Matrix: Water Date Received: 02/15/2006 0903

**200.8 ICPMS Metals by 200.8 CWA-Total Recoverable**

Method: 200.8 Analysis Batch: 680-37851 Instrument ID: ICP MS
Preparation: 4.1.4 Prep Batch: 680-37205 Lab File ID: N/A
Dilution: 1.0 Initial Weight/Volume: 50 mL
Date Analyzed: 02/25/2006 0520 Final Weight/Volume: 250 mL
Date Prepared: 02/23/2006 1637

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Antimony | ND | | 1.0 | 2.5 |
| Arsenic | 2.1 | J | 0.60 | 2.5 |
| Cadmium | ND | | 0.10 | 0.50 |
| Chromium | ND | | 1.5 | 5.0 |
| Copper | 0.94 | J | 0.39 | 2.5 |
| Lead | ND | | 0.50 | 1.5 |
| Nickel | 1.0 | | 0.15 | 1.0 |
| Silver | ND | | 0.25 | 1.0 |
| Thallium | ND | | 0.25 | 1.0 |
| Zinc | 15 | J B | 3.5 | 20 |

Method: 200.8 Analysis Batch: 680-37851 Instrument ID: ICP MS
Preparation: 4.1.4 Prep Batch: 680-37205 Lab File ID: N/A
Dilution: 4.0 Initial Weight/Volume: 50 mL
Date Analyzed: 03/01/2006 2226 Final Weight/Volume: 250 mL
Date Prepared: 02/23/2006 1637

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Selenium | ND | | 2.0 | 10 |

Method: 200.8 Analysis Batch: 680-37851 Instrument ID: ICP MS
Preparation: 4.1.4 Prep Batch: 680-37205 Lab File ID: N/A
Dilution: 4.0 Initial Weight/Volume: 50 mL
Date Analyzed: 03/03/2006 1232 Final Weight/Volume: 250 mL
Date Prepared: 02/23/2006 1637

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Beryllium | ND | | 0.60 | 2.0 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9790-1

**Client Sample ID: SPELTO 02 Elutriate**

| | | | |
|---|---|---|---|
| Lab Sample ID: | 700-9790-13 | Date Sampled: | 02/13/2006 1540 |
| Client Matrix: | Water | Date Received: | 02/15/2006 0903 |

**245.1 Mercury in Water by CVAA**

| | | | | | |
|---|---|---|---|---|---|
| Method: | 245.1 | Analysis Batch: 700-17622 | Instrument ID: | LEEMAN PS200 | |
| Preparation: | 245.1 | Prep Batch: 700-17565 | Lab File ID: | N/A | |
| Dilution: | 1.0 | | Initial Weight/Volume: | 40.0 | mL |
| Date Analyzed: | 02/22/2006 1111 | | Final Weight/Volume: | 40.0 | mL |
| Date Prepared: | 02/21/2006 1015 | | | | |

| Analyte | Result (mg/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Mercury | ND | | 0.000078 | 0.00020 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9790-1

**Client Sample ID: SPELTO 02 Sediment**

Lab Sample ID: 700-9790-14 Date Sampled: 02/13/2006 1540
Client Matrix: Solid Date Received: 02/15/2006 0903

**6020 Inductively Coupled Plasma - Mass Spectrometry**

Method: 6020 Analysis Batch: 680-37413 Instrument ID: ICP MS
Preparation: 3050B Prep Batch: 680-37134 Lab File ID: N/A
Dilution: 1.0 Initial Weight/Volume: 1.05 g
Date Analyzed: 02/24/2006 2321 Final Weight/Volume: 1000 mL
Date Prepared: 02/23/2006 1049

| Analyte | DryWt Corrected: N | Result (mg/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| Antimony | | ND | | 0.19 | 0.48 |
| Arsenic | | 2.3 | | 0.11 | 0.48 |
| Beryllium | | 0.098 | | 0.029 | 0.095 |
| Cadmium | | ND | | 0.019 | 0.095 |
| Chromium | | 3.4 | | 0.29 | 0.95 |
| Copper | | 0.98 | B | 0.036 | 0.48 |
| Lead | | 1.9 | | 0.095 | 0.29 |
| Selenium | | ND | | 0.095 | 0.48 |
| Silver | | ND | | 0.048 | 0.19 |
| Thallium | | ND | | 0.048 | 0.19 |
| Zinc | | 13 | B | 0.26 | 3.8 |

Method: 6020 Analysis Batch: 680-37413 Instrument ID: ICP MS
Preparation: 3050B Prep Batch: 680-37134 Lab File ID: N/A
Dilution: 1.0 Initial Weight/Volume: 1.05 g
Date Analyzed: 02/25/2006 2232 Final Weight/Volume: 1000 mL
Date Prepared: 02/23/2006 1049

| Analyte | DryWt Corrected: N | Result (mg/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| Nickel | | 5.3 | B | 0.029 | 0.19 |

**7471A Mercury in Solid or Semisolid Waste (Manual Cold Vapor Technique)**

Method: 7471A Analysis Batch: 700-17545 Instrument ID: LEEMAN PS200
Preparation: 7471A Prep Batch: 700-17497 Lab File ID: N/A
Dilution: 1.0 Initial Weight/Volume: 0.78 g
Date Analyzed: 02/20/2006 1532 Final Weight/Volume: 40.0 mL
Date Prepared: 02/20/2006 0920

| Analyte | DryWt Corrected: N | Result (mg/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| Mercury | | 0.0089 | J | 0.0051 | 0.010 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9790-1

**General Chemistry**

**Client Sample ID:** **CH01 Water**

Lab Sample ID: 700-9790-1 | Date Sampled: 02/13/2006 0935
Client Matrix: Water | Date Received: 02/15/2006 0903

| Analyte | Result | Qual | Units | MDL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Ammonia | ND | | mg/L | 0.0070 | 0.030 | 1.0 | 350.1 |
| | Anly Batch: 700-17775 | Date Analyzed | 02/24/2006 1655 | | | | |
| Nitrogen, Kjeldahl | ND | | mg/L | 0.15 | 0.20 | 1.0 | 351.2 |
| | Anly Batch: 700-17598 | Date Analyzed | 02/21/2006 1719 | | | | |
| | Prep Batch: 700-17595 | Date Prepared: | 02/20/2006 2206 | | | | |
| Nitrogen, Nitrate Nitrite | 48 | | mg/L | 12 | 25 | 500 | 353.2 |
| | Anly Batch: 700-17716 | Date Analyzed | 02/23/2006 1649 | | | | |
| Phosphorus, Total | 0.27 | | mg/L | 0.000030 | 0.10 | 1.0 | 365.4 |
| | Anly Batch: 700-17597 | Date Analyzed | 02/21/2006 1719 | | | | |
| | Prep Batch: 700-17596 | Date Prepared: | 02/20/2006 2206 | | | | |

| Analyte | Result | Qual | Units | RL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Nitrogen, Organic | 1.2 | | mg/L | 0.030 | 0.030 | 1.0 | Nitrogen,Org |
| | Anly Batch: 700-17860 | Date Analyzed | 02/24/2006 1655 | | | | |

**Analytical Data**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**General Chemistry**

**Client Sample ID:** **CH01 Elutriate**

Lab Sample ID: 700-9790-2
Client Matrix: Water

Date Sampled: 02/13/2006 0920
Date Received: 02/15/2006 0903

| Analyte | Result | Qual | Units | MDL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Ammonia | 0.18 | B | mg/L | 0.0070 | 0.030 | 1.0 | 350.1 |
| Anly Batch: 700-17775 | Date Analyzed | | 02/24/2006 1655 | | | | |
| Nitrogen, Kjeldahl | 0.97 | | mg/L | 0.15 | 0.20 | 1.0 | 351.2 |
| Anly Batch: 700-17598 | Date Analyzed | | 02/21/2006 1714 | | | | |
| Prep Batch: 700-17595 | Date Prepared: | | 02/20/2006 2206 | | | | |
| Nitrogen, Nitrate Nitrite | 0.45 | | mg/L | 0.024 | 0.050 | 1.0 | 353.2 |
| Anly Batch: 700-17716 | Date Analyzed | | 02/23/2006 1648 | | | | |
| Phosphorus, Total | 0.20 | | mg/L | 0.000030 | 0.10 | 1.0 | 365.4 |
| Anly Batch: 700-17597 | Date Analyzed | | 02/21/2006 1714 | | | | |
| Prep Batch: 700-17596 | Date Prepared: | | 02/20/2006 2206 | | | | |

| Analyte | Result | Qual | Units | RL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Nitrogen, Organic | 0.79 | | mg/L | 0.030 | 0.030 | 1.0 | Nitrogen,Org |
| Anly Batch: 700-17860 | Date Analyzed | | 02/24/2006 1655 | | | | |

**Analytical Data**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**General Chemistry**

**Client Sample ID:** **CH01 Sediment**

Lab Sample ID: 700-9790-3
Client Matrix: Solid

Date Sampled: 02/13/2006 0920
Date Received: 02/15/2006 0903

| Analyte | Result | Qual | Units | MDL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Ammonia-Soluble | 0.18 | J B | mg/Kg | 0.14 | 0.49 | 1.0 | 350.1 |
| Anly Batch: 700-17780 | Date Analyzed | | 02/24/2006 1655 | | | DryWt Corrected: N | |
| TKN | 1000 | B | mg/Kg | 2.4 | 40 | 1.0 | 351.2 |
| Anly Batch: 700-17598 | Date Analyzed | | 02/21/2006 1715 | | | DryWt Corrected: N | |
| Prep Batch: 700-17595 | Date Prepared: | | 02/20/2006 2206 | | | | |
| Nitrogen, Nitrate Nitrite-Soluble | 3.3 | * B | mg/Kg | 0.47 | 0.98 | 1.0 | 353.2 |
| Anly Batch: 700-17783 | Date Analyzed | | 02/24/2006 1819 | | | DryWt Corrected: N | |
| Phosphorus, Total | 460 | | mg/Kg | 0.48 | 20 | 1.0 | 365.4 |
| Anly Batch: 700-17597 | Date Analyzed | | 02/21/2006 1715 | | | DryWt Corrected: N | |
| Prep Batch: 700-17596 | Date Prepared: | | 02/20/2006 2206 | | | | |

| Analyte | Result | Qual | Units | RL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Percent Moisture | 58 | | % | 0.10 | 0.10 | 1.0 | 160.3 |
| Anly Batch: 700-17490 | Date Analyzed | | 02/17/2006 1600 | | | | |
| Percent Solids | 42 | | % | 0.10 | 0.10 | 1.0 | 160.3 |
| Anly Batch: 700-17490 | Date Analyzed | | 02/17/2006 1600 | | | | |
| Nitrogen, Total | 1000 | | mg/Kg | 50 | 50 | 1.0 | Total Nitrogen |
| Anly Batch: 700-17812 | Date Analyzed | | 02/21/2006 1657 | | | DryWt Corrected: N | |

**Analytical Data**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**General Chemistry**

**Client Sample ID:** **CH02 Elutriate**

Lab Sample ID: 700-9790-6
Client Matrix: Water

Date Sampled: 02/13/2006 1200
Date Received: 02/15/2006 0903

| Analyte | Result | Qual | Units | MDL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Ammonia | 0.33 | B | mg/L | 0.0070 | 0.030 | 1.0 | 350.1 |
| | Anly Batch: 700-17775 | Date Analyzed | 02/24/2006 1701 | | | | |
| Nitrogen, Kjeldahl | 1.8 | | mg/L | 0.15 | 0.20 | 1.0 | 351.2 |
| | Anly Batch: 700-17598 | Date Analyzed | 02/21/2006 1720 | | | | |
| | Prep Batch: 700-17595 | Date Prepared: | 02/20/2006 2206 | | | | |
| Nitrogen, Nitrate Nitrite | 0.52 | | mg/L | 0.024 | 0.050 | 1.0 | 353.2 |
| | Anly Batch: 700-17716 | Date Analyzed | 02/23/2006 1650 | | | | |
| Phosphorus, Total | 0.32 | | mg/L | 0.000030 | 0.10 | 1.0 | 365.4 |
| | Anly Batch: 700-17597 | Date Analyzed | 02/21/2006 1720 | | | | |
| | Prep Batch: 700-17596 | Date Prepared: | 02/20/2006 2206 | | | | |

| Analyte | Result | Qual | Units | RL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Nitrogen, Organic | 1.5 | | mg/L | 0.030 | 0.030 | 1.0 | Nitrogen,Org |
| | Anly Batch: 700-17860 | Date Analyzed | 02/24/2006 1655 | | | | |

**Analytical Data**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**General Chemistry**

**Client Sample ID:** **CH02 Sediment**

Lab Sample ID: 700-9790-7
Client Matrix: Solid

Date Sampled: 02/13/2006 1200
Date Received: 02/15/2006 0903

| Analyte | Result | Qual | Units | MDL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Ammonia-Soluble | 0.25 | J B | mg/Kg | 0.095 | 0.34 | 1.0 | 350.1 |
| Anly Batch: 700-17780 | Date Analyzed | | 02/24/2006 1655 | | | DryWt Corrected: N | |
| TKN | 130 | B | mg/Kg | 1.6 | 26 | 1.0 | 351.2 |
| Anly Batch: 700-17598 | Date Analyzed | | 02/21/2006 1721 | | | DryWt Corrected: N | |
| Prep Batch: 700-17595 | Date Prepared: | | 02/20/2006 2206 | | | | |
| Nitrogen, Nitrate Nitrite-Soluble | 1.0 | * B | mg/Kg | 0.33 | 0.68 | 1.0 | 353.2 |
| Anly Batch: 700-17783 | Date Analyzed | | 02/24/2006 1819 | | | DryWt Corrected: N | |
| Phosphorus, Total | 390 | | mg/Kg | 0.31 | 13 | 1.0 | 365.4 |
| Anly Batch: 700-17597 | Date Analyzed | | 02/21/2006 1721 | | | DryWt Corrected: N | |
| Prep Batch: 700-17596 | Date Prepared: | | 02/20/2006 2206 | | | | |

| Analyte | Result | Qual | Units | RL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Percent Moisture | 31 | | % | 0.10 | 0.10 | 1.0 | 160.3 |
| Anly Batch: 700-17490 | Date Analyzed | | 02/17/2006 1600 | | | | |
| Percent Solids | 69 | | % | 0.10 | 0.10 | 1.0 | 160.3 |
| Anly Batch: 700-17490 | Date Analyzed | | 02/17/2006 1600 | | | | |
| Nitrogen, Total | 130 | | mg/Kg | 50 | 50 | 1.0 | Total Nitrogen |
| Anly Batch: 700-17812 | Date Analyzed | | 02/21/2006 1657 | | | DryWt Corrected: N | |

**Analytical Data**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**General Chemistry**

**Client Sample ID:** **SPELTO 01 Water**

Lab Sample ID: 700-9790-8
Client Matrix: Water

Date Sampled: 02/13/2006 1415
Date Received: 02/15/2006 0903

| Analyte | Result | Qual | Units | MDL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Ammonia | 0.014 | J B | mg/L | 0.0070 | 0.030 | 1.0 | 350.1 |
| Anly Batch: 700-17775 | Date Analyzed | | 02/24/2006 1749 | | | | |
| Nitrogen, Kjeldahl | ND | | mg/L | 0.15 | 0.20 | 1.0 | 351.2 |
| Anly Batch: 700-17598 | Date Analyzed | | 02/21/2006 1722 | | | | |
| Prep Batch: 700-17595 | Date Prepared: | | 02/20/2006 2206 | | | | |
| Nitrogen, Nitrate Nitrite | 83 | | mg/L | 12 | 25 | 500 | 353.2 |
| Anly Batch: 700-17716 | Date Analyzed | | 02/23/2006 1656 | | | | |
| Phosphorus, Total | 0.25 | | mg/L | 0.000030 | 0.10 | 1.0 | 365.4 |
| Anly Batch: 700-17597 | Date Analyzed | | 02/21/2006 1722 | | | | |
| Prep Batch: 700-17596 | Date Prepared: | | 02/20/2006 2206 | | | | |

| Analyte | Result | Qual | Units | RL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Nitrogen, Organic | 0.14 | | mg/L | 0.030 | 0.030 | 1.0 | Nitrogen,Org |
| Anly Batch: 700-17860 | Date Analyzed | | 02/24/2006 1655 | | | | |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9790-1

**General Chemistry**

**Client Sample ID:** **SPELTO 01 Elutriate**

Lab Sample ID: 700-9790-9 | Date Sampled: 02/13/2006 1420
Client Matrix: Water | Date Received: 02/15/2006 0903

| Analyte | Result | Qual | Units | MDL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Ammonia | 0.019 | J B | mg/L | 0.0070 | 0.030 | 1.0 | 350.1 |
| Anly Batch: 700-17775 | Date Analyzed | | 02/24/2006 1847 | | | | |
| Nitrogen, Kjeldahl | 0.20 | | mg/L | 0.15 | 0.20 | 1.0 | 351.2 |
| Anly Batch: 700-17598 | Date Analyzed | | 02/21/2006 1721 | | | | |
| Prep Batch: 700-17595 | Date Prepared: | | 02/20/2006 2206 | | | | |
| Nitrogen, Nitrate Nitrite | 0.49 | | mg/L | 0.024 | 0.050 | 1.0 | 353.2 |
| Anly Batch: 700-17716 | Date Analyzed | | 02/23/2006 1655 | | | | |
| Phosphorus, Total | 0.19 | | mg/L | 0.000030 | 0.10 | 1.0 | 365.4 |
| Anly Batch: 700-17597 | Date Analyzed | | 02/21/2006 1721 | | | | |
| Prep Batch: 700-17596 | Date Prepared: | | 02/20/2006 2206 | | | | |

| Analyte | Result | Qual | Units | RL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Nitrogen, Organic | 0.18 | | mg/L | 0.030 | 0.030 | 1.0 | Nitrogen,Org |
| Anly Batch: 700-17860 | Date Analyzed | | 02/24/2006 1655 | | | | |

**Analytical Data**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**General Chemistry**

**Client Sample ID:** **SPELTO 01 Sediment**

Lab Sample ID: 700-9790-11
Client Matrix: Solid

Date Sampled: 02/13/2006 1420
Date Received: 02/15/2006 0903

| Analyte | Result | Qual | Units | MDL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Ammonia-Soluble | ND | | mg/Kg | 0.14 | 0.49 | 1.0 | 350.1 |
| Anly Batch: 700-17780 | Date Analyzed | | 02/24/2006 1655 | | | DryWt Corrected: N | |
| TKN | 130 | B | mg/Kg | 1.8 | 29 | 1.0 | 351.2 |
| Anly Batch: 700-17598 | Date Analyzed | | 02/21/2006 1723 | | | DryWt Corrected: N | |
| Prep Batch: 700-17595 | Date Prepared: | | 02/20/2006 2206 | | | | |
| Nitrogen, Nitrate Nitrite-Soluble | 2.0 | * B | mg/Kg | 0.47 | 0.98 | 1.0 | 353.2 |
| Anly Batch: 700-17783 | Date Analyzed | | 02/24/2006 1819 | | | DryWt Corrected: N | |
| Phosphorus, Total | 290 | | mg/Kg | 0.35 | 15 | 1.0 | 365.4 |
| Anly Batch: 700-17597 | Date Analyzed | | 02/21/2006 1723 | | | DryWt Corrected: N | |
| Prep Batch: 700-17596 | Date Prepared: | | 02/20/2006 2206 | | | | |

| Analyte | Result | Qual | Units | RL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Percent Moisture | 16 | | % | 0.10 | 0.10 | 1.0 | 160.3 |
| Anly Batch: 700-17490 | Date Analyzed | | 02/17/2006 1600 | | | | |
| Percent Solids | 84 | | % | 0.10 | 0.10 | 1.0 | 160.3 |
| Anly Batch: 700-17490 | Date Analyzed | | 02/17/2006 1600 | | | | |
| Nitrogen, Total | 130 | | mg/Kg | 50 | 50 | 1.0 | Total Nitrogen |
| Anly Batch: 700-17812 | Date Analyzed | | 02/21/2006 1657 | | | DryWt Corrected: N | |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9790-1

**General Chemistry**

**Client Sample ID:** **SPELTO 02 Elutriate**

Lab Sample ID: 700-9790-13 Date Sampled: 02/13/2006 1540
Client Matrix: Water Date Received: 02/15/2006 0903

| Analyte | Result | Qual | Units | MDL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Ammonia | 0.027 | J B | mg/L | 0.0070 | 0.030 | 1.0 | 350.1 |
| Anly Batch: 700-17775 | Date Analyzed | | 02/24/2006 1837 | | | | |
| Nitrogen, Kjeldahl | 0.30 | | mg/L | 0.15 | 0.20 | 1.0 | 351.2 |
| Anly Batch: 700-17598 | Date Analyzed | | 02/21/2006 1724 | | | | |
| Prep Batch: 700-17595 | Date Prepared: | | 02/20/2006 2206 | | | | |
| Nitrogen, Nitrate Nitrite | 0.61 | | mg/L | 0.024 | 0.050 | 1.0 | 353.2 |
| Anly Batch: 700-17716 | Date Analyzed | | 02/23/2006 1657 | | | | |
| Phosphorus, Total | 0.13 | | mg/L | 0.000030 | 0.10 | 1.0 | 365.4 |
| Anly Batch: 700-17597 | Date Analyzed | | 02/21/2006 1724 | | | | |
| Prep Batch: 700-17596 | Date Prepared: | | 02/20/2006 2206 | | | | |

| Analyte | Result | Qual | Units | RL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Nitrogen, Organic | 0.28 | | mg/L | 0.030 | 0.030 | 1.0 | Nitrogen,Org |
| Anly Batch: 700-17860 | Date Analyzed | | 02/24/2006 1655 | | | | |

**Analytical Data**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**General Chemistry**

**Client Sample ID:** **SPELTO 02 Sediment**

Lab Sample ID: 700-9790-14
Client Matrix: Solid

Date Sampled: 02/13/2006 1540
Date Received: 02/15/2006 0903

| Analyte | Result | Qual | Units | MDL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Ammonia-Soluble | 0.25 | J B | mg/Kg | 0.12 | 0.43 | 1.0 | 350.1 |
| Anly Batch: 700-17780 | Date Analyzed | | 02/24/2006 1655 | | | DryWt Corrected: N | |
| TKN | 80 | B | mg/Kg | 2.2 | 36 | 1.0 | 351.2 |
| Anly Batch: 700-17598 | Date Analyzed | | 02/21/2006 1725 | | | DryWt Corrected: N | |
| Prep Batch: 700-17595 | Date Prepared: | | 02/20/2006 2206 | | | | |
| Nitrogen, Nitrate Nitrite-Soluble | 1.3 | * B | mg/Kg | 0.41 | 0.86 | 1.0 | 353.2 |
| Anly Batch: 700-17783 | Date Analyzed | | 02/24/2006 1819 | | | DryWt Corrected: N | |
| Phosphorus, Total | 250 | | mg/Kg | 0.43 | 18 | 1.0 | 365.4 |
| Anly Batch: 700-17597 | Date Analyzed | | 02/21/2006 1725 | | | DryWt Corrected: N | |
| Prep Batch: 700-17596 | Date Prepared: | | 02/20/2006 2206 | | | | |

| Analyte | Result | Qual | Units | RL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Percent Moisture | 19 | | % | 0.10 | 0.10 | 1.0 | 160.3 |
| Anly Batch: 700-17490 | Date Analyzed | | 02/17/2006 1600 | | | | |
| Percent Solids | 81 | | % | 0.10 | 0.10 | 1.0 | 160.3 |
| Anly Batch: 700-17490 | Date Analyzed | | 02/17/2006 1600 | | | | |
| Nitrogen, Total | 81 | | mg/Kg | 50 | 50 | 1.0 | Total Nitrogen |
| Anly Batch: 700-17812 | Date Analyzed | | 02/21/2006 1657 | | | DryWt Corrected: N | |

# QUALITY CONTROL RESULTS

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Method Blank - Batch: 700-17450**

**Method: 624**
**Preparation: N/A**

Lab Sample ID: MB 700-17450/3
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/16/2006 1200
Date Prepared: N/A

Analysis Batch: 700-17450
Prep Batch: N/A
Units: ug/L

Instrument ID: VMG5973
Lab File ID: G021605.D
Initial Weight/Volume: 5 mL
Final Weight/Volume: 5 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| 1,1,1-Trichloroethane | ND | | 0.19 | 5.0 |
| 1,1,2,2-Tetrachloroethane | ND | | 0.25 | 5.0 |
| 1,1,2-Trichloroethane | ND | | 0.31 | 5.0 |
| 1,1-Dichloroethane | ND | | 0.14 | 5.0 |
| 1,1-Dichloroethene | ND | | 0.38 | 5.0 |
| 1,2-Dichloroethane | ND | | 0.15 | 5.0 |
| 1,2-Dichloropropane | ND | | 0.15 | 5.0 |
| 2-Chloroethyl vinyl ether | ND | | 0.50 | 50 |
| Acrolein | ND | | 9.6 | 100 |
| Acrylonitrile | ND | | 0.67 | 100 |
| Benzene | ND | | 0.12 | 5.0 |
| Bromoform | ND | | 0.18 | 5.0 |
| Bromomethane | ND | | 0.80 | 10 |
| Carbon tetrachloride | ND | | 0.56 | 5.0 |
| Chlorobenzene | ND | | 0.17 | 5.0 |
| Chlorodibromomethane | ND | | 0.50 | 5.0 |
| Chloroethane | ND | | 0.84 | 10 |
| Chloroform | ND | | 0.18 | 5.0 |
| Chloromethane | ND | | 0.15 | 10 |
| Dichlorobromomethane | ND | | 0.50 | 5.0 |
| Ethylbenzene | ND | | 0.56 | 5.0 |
| Methylene Chloride | ND | | 0.45 | 5.0 |
| Tetrachloroethene | ND | | 0.20 | 5.0 |
| Toluene | ND | | 0.19 | 5.0 |
| trans-1,2-Dichloroethene | ND | | 0.24 | 5.0 |
| Trichloroethene | ND | | 0.29 | 5.0 |
| Vinyl chloride | ND | | 0.22 | 10 |
| 1,3-Dichloropropane | ND | | 0.50 | 5.0 |

| Surrogate | % Rec | Acceptance Limits |
|---|---|---|
| Toluene-d8 | 111 | 77 - 116 |
| Dibromofluoromethane | 118 | 66 - 125 |
| 4-Bromofluorobenzene | 107 | 70 - 118 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17450**

**Method: 624**
**Preparation: N/A**

LCS Lab Sample ID: LCS 700-17450/1
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/16/2006 1028
Date Prepared: N/A

Analysis Batch: 700-17450
Prep Batch: N/A
Units: ug/L

Instrument ID: VMG5973
Lab File ID: G021602.D
Initial Weight/Volume: 5 mL
Final Weight/Volume: 5 mL

LCSD Lab Sample ID: LCSD 700-17450/2
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/16/2006 1059
Date Prepared: N/A

Analysis Batch: 700-17450
Prep Batch: N/A
Units: ug/L

Instrument ID: VMG5973
Lab File ID: G021603.D
Initial Weight/Volume: 5 mL
Final Weight/Volume: 5 mL

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| 1,1,1-Trichloroethane | 96 | 91 | 52 - 162 | 5 | 25 | | |
| 1,1,2,2-Tetrachloroethane | 95 | 104 | 46 - 157 | 9 | 25 | | |
| 1,1,2-Trichloroethane | 113 | 113 | 52 - 150 | 0 | 25 | | |
| 1,1-Dichloroethane | 102 | 99 | 59 - 155 | 3 | 40 | | |
| 1,1-Dichloroethene | 106 | 103 | 1 - 234 | 2 | 25 | | |
| 1,2-Dichloroethane | 92 | 91 | 49 - 155 | 1 | 26 | | |
| 1,2-Dichloropropane | 109 | 108 | 1 - 210 | 1 | 25 | | |
| 2-Chloroethyl vinyl ether | 123 | 126 | 1 - 305 | 3 | 40 | | |
| Acrolein | 123 | 136 | 54 - 145 | 10 | 74 | | |
| Acrylonitrile | 114 | 117 | 10 - 183 | 3 | 41 | | |
| Benzene | 99 | 97 | 37 - 151 | 2 | 31 | | |
| Bromoform | 105 | 109 | 45 - 169 | 3 | 30 | | |
| Bromomethane | 117 | 123 | 1 - 242 | 5 | 32 | | |
| Carbon tetrachloride | 96 | 89 | 50 - 150 | 8 | 25 | | |
| Chlorobenzene | 101 | 103 | 37 - 160 | 1 | 25 | | |
| Chlorodibromomethane | 101 | 101 | 37 - 151 | 0 | 40 | | |
| Chloroethane | 116 | 122 | 14 - 230 | 5 | 36 | | |
| Chloroform | 99 | 99 | 51 - 138 | 1 | 25 | | |
| Chloromethane | 89 | 94 | 1 - 273 | 5 | 40 | | |
| Dichlorobromomethane | 94 | 93 | 53 - 149 | 1 | 25 | | |
| Ethylbenzene | 103 | 100 | 37 - 162 | 3 | 25 | | |
| Methylene Chloride | 106 | 105 | 1 - 221 | 1 | 37 | | |
| Tetrachloroethene | 111 | 105 | 64 - 148 | 6 | 40 | | |
| Toluene | 122 | 116 | 47 - 150 | 5 | 25 | | |
| trans-1,2-Dichloroethene | 102 | 99 | 54 - 156 | 3 | 40 | | |
| Trichloroethene | 110 | 104 | 71 - 157 | 6 | 25 | | |
| Vinyl chloride | 103 | 109 | 1 - 251 | 6 | 40 | | |
| 1,3-Dichloropropane | 98 | 99 | 50 - 150 | 1 | 40 | | |

| Surrogate | LCS % Rec | LCSD % Rec | Acceptance Limits |
|---|---|---|---|
| Toluene-d8 | 111 | 108 | 77 - 116 |
| Dibromofluoromethane | 111 | 113 | 66 - 125 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17450**

**Method: 624**
**Preparation: N/A**

| | | | | | |
|---|---|---|---|---|---|
| LCS Lab Sample ID: | LCS 700-17450/1 | Analysis Batch: | 700-17450 | Instrument ID: | VMG5973 |
| Client Matrix: | Water | Prep Batch: | N/A | Lab File ID: | G021602.D |
| Dilution: | 1.0 | Units: | ug/L | Initial Weight/Volume: | 5 mL |
| Date Analyzed: | 02/16/2006 1028 | | | Final Weight/Volume: | 5 mL |
| Date Prepared: | N/A | | | | |

| | | | | | |
|---|---|---|---|---|---|
| LCSD Lab Sample ID: | LCSD 700-17450/2 | Analysis Batch: | 700-17450 | Instrument ID: | VMG5973 |
| Client Matrix: | Water | Prep Batch: | N/A | Lab File ID: | G021603.D |
| Dilution: | 1.0 | Units: | ug/L | Initial Weight/Volume: | 5 mL |
| Date Analyzed: | 02/16/2006 1059 | | | Final Weight/Volume: | 5 mL |
| Date Prepared: | N/A | | | | |

| Surrogate | LCS % Rec | LCSD % Rec | Acceptance Limits |
|---|---|---|---|
| 4-Bromofluorobenzene | 112 | 111 | 70 - 118 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Method Blank - Batch: 700-17632**

**Method: 624**
**Preparation: N/A**

Lab Sample ID: MB 700-17632/3
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/21/2006 1808
Date Prepared: N/A

Analysis Batch: 700-17632
Prep Batch: N/A
Units: ug/L

Instrument ID: VMG5973
Lab File ID: G022120.D
Initial Weight/Volume: 5 mL
Final Weight/Volume: 5 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| 1,1,1-Trichloroethane | ND | | 0.19 | 5.0 |
| 1,1,2,2-Tetrachloroethane | ND | | 0.25 | 5.0 |
| 1,1,2-Trichloroethane | ND | | 0.31 | 5.0 |
| 1,1-Dichloroethane | ND | | 0.14 | 5.0 |
| 1,1-Dichloroethene | ND | | 0.38 | 5.0 |
| 1,2-Dichloroethane | ND | | 0.15 | 5.0 |
| 1,2-Dichloropropane | ND | | 0.15 | 5.0 |
| 2-Chloroethyl vinyl ether | ND | | 0.50 | 50 |
| Acrolein | ND | | 9.6 | 100 |
| Acrylonitrile | ND | | 0.67 | 100 |
| Benzene | ND | | 0.12 | 5.0 |
| Bromoform | ND | | 0.18 | 5.0 |
| Bromomethane | ND | | 0.80 | 10 |
| Carbon tetrachloride | ND | | 0.56 | 5.0 |
| Chlorobenzene | ND | | 0.17 | 5.0 |
| Chlorodibromomethane | ND | | 0.50 | 5.0 |
| Chloroethane | ND | | 0.84 | 10 |
| Chloroform | ND | | 0.18 | 5.0 |
| Chloromethane | ND | | 0.15 | 10 |
| Dichlorobromomethane | ND | | 0.50 | 5.0 |
| Ethylbenzene | ND | | 0.56 | 5.0 |
| Methylene Chloride | ND | | 0.45 | 5.0 |
| Tetrachloroethene | ND | | 0.20 | 5.0 |
| Toluene | ND | | 0.19 | 5.0 |
| trans-1,2-Dichloroethene | ND | | 0.24 | 5.0 |
| Trichloroethene | ND | | 0.29 | 5.0 |
| Vinyl chloride | ND | | 0.22 | 10 |
| 1,3-Dichloropropane | ND | | 0.50 | 5.0 |

| Surrogate | % Rec | Acceptance Limits |
|---|---|---|
| Toluene-d8 | 108 | 77 - 116 |
| Dibromofluoromethane | 118 | 66 - 125 |
| 4-Bromofluorobenzene | 112 | 70 - 118 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17632**

**Method: 624**
**Preparation: N/A**

LCS Lab Sample ID: LCS 700-17632/2
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/21/2006 1707
Date Prepared: N/A

Analysis Batch: 700-17632
Prep Batch: N/A
Units: ug/L

Instrument ID: VMG5973
Lab File ID: G022118.D
Initial Weight/Volume: 5 mL
Final Weight/Volume: 5 mL

LCSD Lab Sample ID: LCSD 700-17632/1
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/21/2006 1636
Date Prepared: N/A

Analysis Batch: 700-17632
Prep Batch: N/A
Units: ug/L

Instrument ID: VMG5973
Lab File ID: G022117.D
Initial Weight/Volume: 5 mL
Final Weight/Volume: 5 mL

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| 1,1,1-Trichloroethane | 91 | 95 | 52 - 162 | 4 | 25 | | |
| 1,1,2,2-Tetrachloroethane | 103 | 102 | 46 - 157 | 1 | 25 | | |
| 1,1,2-Trichloroethane | 122 | 120 | 52 - 150 | 1 | 25 | | |
| 1,1-Dichloroethane | 102 | 106 | 59 - 155 | 4 | 40 | | |
| 1,1-Dichloroethene | 102 | 111 | 1 - 234 | 9 | 25 | | |
| 1,2-Dichloroethane | 94 | 90 | 49 - 155 | 4 | 26 | | |
| 1,2-Dichloropropane | 109 | 109 | 1 - 210 | 1 | 25 | | |
| 2-Chloroethyl vinyl ether | 134 | 136 | 1 - 305 | 2 | 40 | | |
| Acrolein | 155 | 149 | 54 - 145 | 4 | 74 | * | * |
| Acrylonitrile | 128 | 127 | 10 - 183 | 1 | 41 | | |
| Benzene | 98 | 100 | 37 - 151 | 3 | 31 | | |
| Bromoform | 97 | 98 | 45 - 169 | 1 | 30 | | |
| Bromomethane | 127 | 127 | 1 - 242 | 0 | 32 | | |
| Carbon tetrachloride | 92 | 98 | 50 - 150 | 7 | 25 | | |
| Chlorobenzene | 99 | 102 | 37 - 160 | 3 | 25 | | |
| Chlorodibromomethane | 97 | 95 | 37 - 151 | 1 | 40 | | |
| Chloroethane | 135 | 137 | 14 - 230 | 1 | 36 | | |
| Chloroform | 100 | 100 | 51 - 138 | 0 | 25 | | |
| Chloromethane | 117 | 120 | 1 - 273 | 3 | 40 | | |
| Dichlorobromomethane | 92 | 94 | 53 - 149 | 2 | 25 | | |
| Ethylbenzene | 95 | 102 | 37 - 162 | 7 | 25 | | |
| Methylene Chloride | 110 | 113 | 1 - 221 | 2 | 37 | | |
| Tetrachloroethene | 103 | 111 | 64 - 148 | 7 | 40 | | |
| Toluene | 120 | 125 | 47 - 150 | 4 | 25 | | |
| trans-1,2-Dichloroethene | 99 | 107 | 54 - 156 | 8 | 40 | | |
| Trichloroethene | 108 | 111 | 71 - 157 | 3 | 25 | | |
| Vinyl chloride | 123 | 140 | 1 - 251 | 13 | 40 | | |
| 1,3-Dichloropropane | 101 | 102 | 50 - 150 | 0 | 40 | | |

| Surrogate | LCS % Rec | LCSD % Rec | Acceptance Limits |
|---|---|---|---|
| Toluene-d8 | 113 | 114 | 77 - 116 |
| Dibromofluoromethane | 112 | 111 | 66 - 125 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17632**

**Method: 624**
**Preparation: N/A**

| | | | | | |
|---|---|---|---|---|---|
| LCS Lab Sample ID: | LCS 700-17632/2 | Analysis Batch: | 700-17632 | Instrument ID: | VMG5973 |
| Client Matrix: | Water | Prep Batch: | N/A | Lab File ID: | G022118.D |
| Dilution: | 1.0 | Units: | ug/L | Initial Weight/Volume: | 5 mL |
| Date Analyzed: | 02/21/2006 1707 | | | Final Weight/Volume: | 5 mL |
| Date Prepared: | N/A | | | | |

| | | | | | |
|---|---|---|---|---|---|
| LCSD Lab Sample ID: | LCSD 700-17632/1 | Analysis Batch: | 700-17632 | Instrument ID: | VMG5973 |
| Client Matrix: | Water | Prep Batch: | N/A | Lab File ID: | G022117.D |
| Dilution: | 1.0 | Units: | ug/L | Initial Weight/Volume: | 5 mL |
| Date Analyzed: | 02/21/2006 1636 | | | Final Weight/Volume: | 5 mL |
| Date Prepared: | N/A | | | | |

| Surrogate | LCS % Rec | LCSD % Rec | Acceptance Limits |
|---|---|---|---|
| 4-Bromofluorobenzene | 113 | 112 | 70 - 118 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Method Blank - Batch: 700-17535**

**Method: 8260B**
**Preparation: 5030B**

Lab Sample ID: MB 700-17535/3
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/20/2006 1043
Date Prepared: 02/20/2006 1043

Analysis Batch: 700-17535
Prep Batch: N/A
Units: ug/Kg

Instrument ID: VMG5973
Lab File ID: G022005.D
Initial Weight/Volume: 5 mL
Final Weight/Volume: 5 g

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| 1,1,1-Trichloroethane | ND | | 1.5 | 5.0 |
| 1,1,2,2-Tetrachloroethane | ND | | 1.7 | 5.0 |
| 1,1,2-Trichloroethane | ND | | 1.2 | 5.0 |
| 1,1-Dichloroethane | ND | | 1.0 | 5.0 |
| 1,1-Dichloroethene | ND | | 1.3 | 5.0 |
| 1,2-Dichloroethane | ND | | 2.0 | 5.0 |
| 1,2-Dichloropropane | ND | | 1.2 | 5.0 |
| 1,3-Dichloropropene, Total | ND | | 1.5 | 10 |
| 2-Chloroethyl vinyl ether | ND | | 17 | 50 |
| Acrolein | ND | | 28 | 100 |
| Acrylonitrile | ND | | 62 | 100 |
| Benzene | ND | | 1.1 | 5.0 |
| Bromoform | ND | | 1.1 | 5.0 |
| Bromomethane | ND | | 3.6 | 10 |
| Carbon tetrachloride | ND | | 1.4 | 5.0 |
| Chlorobenzene | ND | | 1.1 | 5.0 |
| Chlorodibromomethane | ND | | 1.2 | 5.0 |
| Chloroethane | ND | | 1.5 | 10 |
| Chloroform | ND | | 0.82 | 5.0 |
| Chloromethane | ND | | 2.3 | 10 |
| Dichlorobromomethane | ND | | 1.2 | 5.0 |
| Ethylbenzene | ND | | 1.8 | 5.0 |
| Methylene Chloride | ND | | 1.6 | 5.0 |
| Tetrachloroethene | ND | | 0.90 | 5.0 |
| Toluene | ND | | 1.0 | 5.0 |
| trans-1,2-Dichloroethene | ND | | 0.99 | 5.0 |
| Trichloroethene | ND | | 0.90 | 5.0 |
| Vinyl chloride | ND | | 1.6 | 10 |

| Surrogate | % Rec | Acceptance Limits |
|---|---|---|
| Dibromofluoromethane | 130 | 59 - 132 |
| Toluene-d8 | 111 | 61 - 131 |
| 4-Bromofluorobenzene | 104 | 55 - 131 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17535**

**Method: 8260B**
**Preparation: 5030B**

LCS Lab Sample ID: LCS 700-17535/1
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/20/2006 0941
Date Prepared: 02/20/2006 0941

Analysis Batch: 700-17535
Prep Batch: N/A
Units: ug/Kg

Instrument ID: VMG5973
Lab File ID: G022003.D
Initial Weight/Volume: 5 mL
Final Weight/Volume: 5 g

LCSD Lab Sample ID: LCSD 700-17535/2
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/20/2006 1012
Date Prepared: 02/20/2006 1012

Analysis Batch: 700-17535
Prep Batch: N/A
Units: ug/Kg

Instrument ID: VMG5973
Lab File ID: G022004.D
Initial Weight/Volume: 5 mL
Final Weight/Volume: 5 g

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| 1,1-Dichloroethene | 125 | 123 | 48 - 154 | 1 | 46 | | |
| Benzene | 113 | 113 | 69 - 137 | 0 | 42 | | |
| Chlorobenzene | 110 | 107 | 70 - 138 | 3 | 34 | | |
| Toluene | 117 | 112 | 66 - 141 | 5 | 32 | | |
| Trichloroethene | 125 | 121 | 68 - 138 | 4 | 34 | | |

| Surrogate | LCS % Rec | LCSD % Rec | Acceptance Limits |
|---|---|---|---|
| Dibromofluoromethane | 128 | 127 | 59 - 132 |
| Toluene-d8 | 114 | 110 | 61 - 131 |
| 4-Bromofluorobenzene | 112 | 106 | 55 - 131 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Method Blank - Batch: 700-17550**

**Method: 625**
**Preparation: 3520C**

Lab Sample ID: MB 700-17550/1-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/22/2006 2200
Date Prepared: 02/21/2006 0648

Analysis Batch: 700-17670
Prep Batch: 700-17550
Units: ug/L

Instrument ID: SMB5973
Lab File ID: B022219.D
Initial Weight/Volume: 1000 mL
Final Weight/Volume: 1.0 mL
Injection Volume:

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| 1,2,4-Trichlorobenzene | ND | | 0.24 | 2.0 |
| 1,2-Dichlorobenzene | ND | | 0.22 | 2.0 |
| 1,2-Diphenylhydrazine | ND | | 0.80 | 2.0 |
| 1,3-Dichlorobenzene | ND | | 0.22 | 2.0 |
| 1,4-Dichlorobenzene | ND | | 0.22 | 2.0 |
| 2,2'-oxybis(2-chloropropane) | ND | | 0.26 | 2.0 |
| 2,4,6-Trichlorophenol | ND | | 0.48 | 2.0 |
| 2,4-Dichlorophenol | ND | | 0.24 | 2.0 |
| 2,4-Dimethylphenol | ND | | 0.22 | 2.0 |
| 2,4-Dinitrophenol | ND | | 0.46 | 10 |
| 2,4-Dinitrotoluene | ND | | 0.44 | 2.0 |
| 2,6-Dinitrotoluene | ND | | 0.48 | 2.0 |
| 2-Chloronaphthalene | ND | | 0.34 | 2.0 |
| 2-Chlorophenol | ND | | 0.20 | 2.0 |
| 2-Nitrophenol | ND | | 0.26 | 2.0 |
| 3,3'-Dichlorobenzidine | ND | | 1.4 | 4.0 |
| 4,6-Dinitro-2-methylphenol | ND | | 0.42 | 10 |
| 4-Bromophenyl phenyl ether | ND | | 0.34 | 2.0 |
| 4-Chloro-3-methylphenol | ND | | 0.20 | 2.0 |
| 4-Chlorophenyl phenyl ether | ND | | 0.30 | 2.0 |
| 4-Nitrophenol | ND | | 0.72 | 10 |
| Acenaphthene | ND | | 0.26 | 2.0 |
| Acenaphthylene | ND | | 0.48 | 2.0 |
| Anthracene | ND | | 0.20 | 2.0 |
| Benzidine | ND | | 1.7 | 16 |
| Benzo[a]anthracene | ND | | 0.20 | 2.0 |
| Benzo[a]pyrene | ND | | 1.1 | 2.0 |
| Benzo[b]fluoranthene | ND | | 1.9 | 2.0 |
| Benzo[g,h,i]perylene | ND | | 1.1 | 2.0 |
| Benzo[k]fluoranthene | ND | | 1.8 | 2.0 |
| Bis(2-chloroethoxy)methane | ND | | 1.1 | 2.0 |
| Bis(2-chloroethyl)ether | ND | | 0.60 | 2.0 |
| Bis(2-ethylhexyl) phthalate | ND | | 0.66 | 2.0 |
| Butyl benzyl phthalate | ND | | 0.56 | 2.0 |
| Chrysene | ND | | 0.46 | 2.0 |
| Dibenz(a,h)anthracene | ND | | 1.9 | 2.0 |
| Diethyl phthalate | ND | | 0.34 | 2.0 |
| Dimethyl phthalate | ND | | 0.24 | 2.0 |
| Di-n-butyl phthalate | ND | | 0.24 | 2.0 |
| Di-n-octyl phthalate | ND | | 0.36 | 2.0 |
| Fluoranthene | ND | | 0.20 | 2.0 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Method Blank - Batch: 700-17550**

**Method: 625**
**Preparation: 3520C**

Lab Sample ID: MB 700-17550/1-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/22/2006 2200
Date Prepared: 02/21/2006 0648

Analysis Batch: 700-17670
Prep Batch: 700-17550
Units: ug/L

Instrument ID: SMB5973
Lab File ID: B022219.D
Initial Weight/Volume: 1000 mL
Final Weight/Volume: 1.0 mL
Injection Volume:

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Fluorene | ND | | 0.30 | 2.0 |
| Hexachlorobenzene | ND | | 0.34 | 2.0 |
| Hexachlorobutadiene | ND | | 0.28 | 2.0 |
| Hexachlorocyclopentadiene | ND | | 0.36 | 2.0 |
| Hexachloroethane | ND | | 0.26 | 2.0 |
| Indeno[1,2,3-cd]pyrene | ND | | 0.58 | 2.0 |
| Isophorone | ND | | 0.22 | 2.0 |
| Naphthalene | ND | | 0.24 | 2.0 |
| Nitrobenzene | ND | | 0.28 | 2.0 |
| N-Nitrosodimethylamine | ND | | 0.44 | 2.0 |
| N-Nitrosodi-n-propylamine | ND | | 0.20 | 2.0 |
| N-Nitrosodiphenylamine | ND | | 2.0 | 2.0 |
| Pentachlorophenol | ND | | 0.42 | 10 |
| Phenanthrene | ND | | 0.24 | 2.0 |
| Phenol | ND | | 0.22 | 2.0 |
| Pyrene | ND | | 0.44 | 2.0 |

| Surrogate | % Rec | Acceptance Limits |
|---|---|---|
| 2,4,6-Tribromophenol | 90 | 14 - 93 |
| 2-Fluorobiphenyl | 78 | 34 - 118 |
| 2-Fluorophenol | 49 | 25 - 102 |
| Nitrobenzene-d5 | 86 | 39 - 133 |
| Phenol-d5 | 60 | 21 - 95 |
| Terphenyl-d14 | 86 | 16 - 158 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17550**

**Method: 625**
**Preparation: 3520C**

LCS Lab Sample ID: LCS 700-17550/2-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/22/2006 2234
Date Prepared: 02/21/2006 0648

Analysis Batch: 700-17670
Prep Batch: 700-17550
Units: ug/L

Instrument ID: SMB5973
Lab File ID: B022220.D
Initial Weight/Volume: 1000 mL
Final Weight/Volume: 1.0 mL
Injection Volume:

LCSD Lab Sample ID: LCSD 700-17550/3-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/22/2006 2308
Date Prepared: 02/21/2006 0648

Analysis Batch: 700-17670
Prep Batch: 700-17550
Units: ug/L

Instrument ID: SMB5973
Lab File ID: B022221.D
Initial Weight/Volume: 1000 mL
Final Weight/Volume: 1.0 mL
Injection Volume:

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| 1,2,4-Trichlorobenzene | 68 | 78 | 34 - 103 | 14 | 28 | | |
| 1,2-Dichlorobenzene | 57 | 68 | 23 - 104 | 16 | 30 | | |
| 1,3-Dichlorobenzene | 51 | 60 | 19 - 101 | 16 | 31 | | |
| 1,4-Dichlorobenzene | 63 | 73 | 30 - 95 | 15 | 31 | | |
| 2,2'-oxybis(2-chloropropane) | 72 | 81 | 12 - 129 | 12 | 23 | | |
| 2,4,6-Trichlorophenol | 76 | 88 | 47 - 124 | 15 | 22 | | |
| 2,4-Dichlorophenol | 66 | 80 | 42 - 121 | 20 | 30 | | |
| 2,4-Dimethylphenol | 56 | 65 | 27 - 126 | 14 | 43 | | |
| 2,4-Dinitrophenol | 50 | 61 | 17 - 147 | 19 | 63 | | |
| 2,4-Dinitrotoluene | 98 | 103 | 36 - 129 | 4 | 32 | | |
| 2,6-Dinitrotoluene | 93 | 97 | 46 - 128 | 4 | 24 | | |
| 2-Chloronaphthalene | 80 | 85 | 43 - 115 | 7 | 22 | | |
| 2-Chlorophenol | 53 | 70 | 45 - 116 | 27 | 34 | | |
| 2-Nitrophenol | 63 | 81 | 38 - 121 | 26 | 24 | | * |
| 3,3'-Dichlorobenzidine | 86 | 88 | 1.0 - 119 | 2 | 72 | | |
| 4,6-Dinitro-2-methylphenol | 58 | 70 | 42 - 135 | 18 | 33 | | |
| 4-Bromophenyl phenyl ether | 94 | 100 | 39 - 109 | 6 | 26 | | |
| 4-Chloro-3-methylphenol | 75 | 84 | 48 - 128 | 12 | 31 | | |
| 4-Chlorophenyl phenyl ether | 87 | 91 | 40 - 121 | 4 | 26 | | |
| 4-Nitrophenol | 79 | 84 | 20 - 144 | 6 | 44 | | |
| Acenaphthene | 82 | 86 | 34 - 134 | 5 | 35 | | |
| Acenaphthylene | 79 | 83 | 44 - 129 | 4 | 28 | | |
| Anthracene | 87 | 87 | 44 - 126 | 0 | 21 | | |
| Benzo[a]anthracene | 89 | 93 | 39 - 134 | 4 | 34 | | |
| Benzo[a]pyrene | 86 | 87 | 30 - 132 | 2 | 24 | | |
| Benzo[b]fluoranthene | 86 | 87 | 34 - 138 | 1 | 32 | | |
| Benzo[g,h,i]perylene | 90 | 92 | 32 - 133 | 3 | 39 | | |
| Benzo[k]fluoranthene | 88 | 84 | 30 - 147 | 4 | 34 | | |
| Bis(2-chloroethoxy)methane | 86 | 95 | 36 - 125 | 10 | 20 | | |
| Bis(2-chloroethyl)ether | 67 | 75 | 22 - 132 | 11 | 58 | | |
| Bis(2-ethylhexyl) phthalate | 101 | 104 | 43 - 130 | 3 | 26 | | |
| Butyl benzyl phthalate | 94 | 99 | 43 - 136 | 5 | 41 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17550**

**Method: 625**
**Preparation: 3520C**

LCS Lab Sample ID: LCS 700-17550/2-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/22/2006 2234
Date Prepared: 02/21/2006 0648

Analysis Batch: 700-17670
Prep Batch: 700-17550
Units: ug/L

Instrument ID: SMB5973
Lab File ID: B022220.D
Initial Weight/Volume: 1000 mL
Final Weight/Volume: 1.0 mL
Injection Volume:

LCSD Lab Sample ID: LCSD 700-17550/3-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/22/2006 2308
Date Prepared: 02/21/2006 0648

Analysis Batch: 700-17670
Prep Batch: 700-17550
Units: ug/L

Instrument ID: SMB5973
Lab File ID: B022221.D
Initial Weight/Volume: 1000 mL
Final Weight/Volume: 1.0 mL
Injection Volume:

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| Chrysene | 86 | 92 | 39 - 138 | 7 | 31 | | |
| Dibenz(a,h)anthracene | 98 | 102 | 32 - 134 | 3 | 35 | | |
| Diethyl phthalate | 90 | 91 | 48 - 128 | 1 | 49 | | |
| Dimethyl phthalate | 85 | 89 | 47 - 122 | 5 | 31 | | |
| Di-n-butyl phthalate | 81 | 86 | 43 - 133 | 6 | 29 | | |
| Di-n-octyl phthalate | 93 | 101 | 41 - 129 | 8 | 33 | | |
| Fluoranthene | 75 | 77 | 39 - 139 | 2 | 24 | | |
| Fluorene | 83 | 86 | 41 - 130 | 3 | 23 | | |
| Hexachlorobenzene | 93 | 98 | 33 - 124 | 5 | 31 | | |
| Hexachlorobutadiene | 60 | 71 | 26 - 104 | 17 | 30 | | |
| Hexachlorocyclopentadiene | 8 | 9 | 1.0 - 87 | 11 | 67 | | |
| Hexachloroethane | 48 | 59 | 21 - 94 | 20 | 35 | | |
| Indeno[1,2,3-cd]pyrene | 96 | 102 | 26 - 140 | 6 | 38 | | |
| Isophorone | 72 | 78 | 34 - 140 | 8 | 33 | | |
| Naphthalene | 69 | 76 | 26 - 121 | 10 | 33 | | |
| Nitrobenzene | 78 | 87 | 34 - 124 | 10 | 40 | | |
| N-Nitrosodiphenylamine | 120 | 127 | 30 - 130 | 6 | 50 | | |
| Pentachlorophenol | 87 | 92 | 34 - 133 | 6 | 33 | | |
| Phenanthrene | 90 | 93 | 45 - 129 | 3 | 20 | | |
| Phenol | 50 | 64 | 29 - 122 | 25 | 36 | | |
| Pyrene | 84 | 86 | 32 - 122 | 2 | 42 | | |

| Surrogate | LCS % Rec | | LCSD % Rec | | Acceptance Limits |
|---|---|---|---|---|---|
| 2,4,6-Tribromophenol | 101 | * | 107 | * | 14 - 93 |
| 2-Fluorobiphenyl | 82 | | 88 | | 34 - 118 |
| 2-Fluorophenol | 36 | | 51 | | 25 - 102 |
| Nitrobenzene-d5 | 82 | | 90 | | 39 - 133 |
| Phenol-d5 | 52 | | 65 | | 21 - 95 |
| Terphenyl-d14 | 86 | | 90 | | 16 - 158 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Matrix Spike/**
**Matrix Spike Duplicate Recovery Report - Batch: 700-17550**

**Method: 625**
**Preparation: 3520C**

| | | | | | |
|---|---|---|---|---|---|
| MS Lab Sample ID: | 700-9790-9 | Analysis Batch: | 700-17670 | Instrument ID: | SMB5973 |
| Client Matrix: | Water | Prep Batch: | 700-17550 | Lab File ID: | B022234.D |
| Dilution: | 2.0 | | | Initial Weight/Volume: | 500 mL |
| Date Analyzed: | 02/23/2006 0630 | | | Final Weight/Volume: | 1.0 mL |
| Date Prepared: | 02/21/2006 0648 | | | Injection Volume: | |

| | | | | | |
|---|---|---|---|---|---|
| MSD Lab Sample ID: | 700-9790-9 | Analysis Batch: | 700-17670 | Instrument ID: | SMB5973 |
| Client Matrix: | Water | Prep Batch: | 700-17550 | Lab File ID: | B022235.D |
| Dilution: | 2.0 | | | Initial Weight/Volume: | 500 mL |
| Date Analyzed: | 02/23/2006 0703 | | | Final Weight/Volume: | 1.0 mL |
| Date Prepared: | 02/21/2006 0648 | | | Injection Volume: | |

| | % Rec. | | | | | |
|---|---|---|---|---|---|---|
| Analyte | MS | MSD | Limit | RPD | RPD Limit | MS Qual MSD Qual |
| 1,2,4-Trichlorobenzene | 81 | 81 | 34 - 103 | 0 | 28 | |
| 1,4-Dichlorobenzene | 70 | 71 | 30 - 95 | 2 | 31 | |
| 2,4-Dinitrotoluene | 98 | 99 | 36 - 129 | 1 | 32 | |
| 2-Chlorophenol | 73 | 75 | 45 - 116 | 4 | 34 | |
| 2-Nitrophenol | 78 | 81 | 38 - 121 | 3 | 24 | |
| 4-Chloro-3-methylphenol | 85 | 88 | 48 - 128 | 4 | 31 | |
| 4-Nitrophenol | 58 | 65 | 20 - 144 | 11 | 44 | |
| Acenaphthene | 89 | 88 | 34 - 134 | 2 | 35 | |
| Acenaphthylene | 60 | 59 | 44 - 129 | 1 | 28 | |
| Anthracene | 59 | 60 | 44 - 126 | 1 | 21 | |
| Benzo[a]anthracene | 76 | 78 | 39 - 134 | 2 | 34 | |
| Benzo[a]pyrene | 77 | 77 | 30 - 132 | 0 | 24 | |
| Benzo[b]fluoranthene | 83 | 78 | 34 - 138 | 7 | 32 | |
| Benzo[g,h,i]perylene | 75 | 81 | 32 - 133 | 8 | 39 | |
| Benzo[k]fluoranthene | 73 | 77 | 30 - 147 | 5 | 34 | |
| Bis(2-chloroethoxy)methane | 107 | 106 | 36 - 125 | 1 | 20 | |
| Bis(2-chloroethyl)ether | 82 | 81 | 22 - 132 | 2 | 58 | |
| Dibenz(a,h)anthracene | 83 | 88 | 32 - 134 | 7 | 35 | |
| Fluoranthene | 53 | 53 | 39 - 139 | 0 | 24 | |
| Fluorene | 76 | 77 | 41 - 130 | 1 | 23 | |
| Indeno[1,2,3-cd]pyrene | 93 | 102 | 26 - 140 | 9 | 38 | |
| Naphthalene | 71 | 70 | 26 - 121 | 2 | 33 | |
| N-Nitrosodi-n-propylamine | 74 | 75 | 30 - 130 | 1 | 30 | |
| Pentachlorophenol | 45 | 55 | 34 - 133 | 20 | 33 | |
| Phenanthrene | 63 | 63 | 45 - 129 | 0 | 20 | |
| Phenol | 56 | 61 | 29 - 122 | 8 | 36 | |
| Pyrene | 91 | 88 | 32 - 122 | 3 | 42 | |

| Surrogate | MS % Rec | MSD % Rec | Acceptance Limits |
|---|---|---|---|

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Matrix Spike/**
**Matrix Spike Duplicate Recovery Report - Batch: 700-17550**

**Method: 625**
**Preparation: 3520C**

| | | | | | |
|---|---|---|---|---|---|
| MS Lab Sample ID: | 700-9790-9 | Analysis Batch: | 700-17670 | Instrument ID: | SMB5973 |
| Client Matrix: | Water | Prep Batch: | 700-17550 | Lab File ID: | B022234.D |
| Dilution: | 2.0 | | | Initial Weight/Volume: | 500 mL |
| Date Analyzed: | 02/23/2006 0630 | | | Final Weight/Volume: | 1.0 mL |
| Date Prepared: | 02/21/2006 0648 | | | Injection Volume: | |

| | | | | | |
|---|---|---|---|---|---|
| MSD Lab Sample ID: | 700-9790-9 | Analysis Batch: | 700-17670 | Instrument ID: | SMB5973 |
| Client Matrix: | Water | Prep Batch: | 700-17550 | Lab File ID: | B022235.D |
| Dilution: | 2.0 | | | Initial Weight/Volume: | 500 mL |
| Date Analyzed: | 02/23/2006 0703 | | | Final Weight/Volume: | 1.0 mL |
| Date Prepared: | 02/21/2006 0648 | | | Injection Volume: | |

| Surrogate | MS % Rec | | MSD % Rec | | Acceptance Limits |
|---|---|---|---|---|---|
| 2,4,6-Tribromophenol | 105 | * | 105 | * | 14 - 93 |
| 2-Fluorobiphenyl | 87 | | 85 | | 34 - 118 |
| 2-Fluorophenol | 54 | | 57 | | 25 - 102 |
| Nitrobenzene-d5 | 99 | | 98 | | 39 - 133 |
| Phenol-d5 | 60 | | 64 | | 21 - 95 |
| Terphenyl-d14 | 82 | | 80 | | 16 - 158 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Method Blank - Batch: 700-17431**

**Method: 8270C**
**Preparation: 3550B**

Lab Sample ID: MB 700-17431/1-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/20/2006 1342
Date Prepared: 02/17/2006 0900

Analysis Batch: 700-17742
Prep Batch: 700-17431
Units: ug/Kg

Instrument ID: SMC5973
Lab File ID: C022003.D
Initial Weight/Volume: 30.0 g
Final Weight/Volume: 1.0 mL
Injection Volume:

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| 1,2,4-Trichlorobenzene | ND | | 8.4 | 66 |
| 1,2-Dichlorobenzene | ND | | 9.0 | 66 |
| 1,2-Diphenylhydrazine | ND | | 7.0 | 66 |
| 1,3-Dichlorobenzene | ND | | 10 | 66 |
| 1,4-Dichlorobenzene | ND | | 7.0 | 66 |
| 2,4,6-Trichlorophenol | ND | | 7.8 | 66 |
| 2,4-Dichlorophenol | ND | | 7.2 | 66 |
| 2,4-Dimethylphenol | ND | | 7.6 | 66 |
| 2,4-Dinitrophenol | ND | | 8.6 | 340 |
| 2,4-Dinitrotoluene | ND | | 7.2 | 66 |
| 2,6-Dinitrotoluene | ND | | 8.8 | 66 |
| 2-Chloronaphthalene | ND | | 8.4 | 66 |
| 2-Chlorophenol | ND | | 8.4 | 66 |
| 2-Nitrophenol | ND | | 7.2 | 66 |
| 3,3'-Dichlorobenzidine | ND | | 14 | 130 |
| 4,6-Dinitro-2-methylphenol | ND | | 16 | 340 |
| 4-Bromophenyl phenyl ether | ND | | 8.4 | 66 |
| 4-Chloro-3-methylphenol | ND | | 8.2 | 66 |
| 4-Chlorophenyl phenyl ether | ND | | 7.6 | 66 |
| 4-Nitrophenol | ND | | 15 | 340 |
| Benzidine | ND | | 44 | 540 |
| Bis(2-chloroethyl)ether | ND | | 8.4 | 66 |
| Bis(2-ethylhexyl) phthalate | ND | | 7.4 | 66 |
| 2,2'-oxybis(2-chloropropane) | ND | | 12 | 66 |
| Butyl benzyl phthalate | ND | | 9.8 | 66 |
| Di-n-butyl phthalate | ND | | 8.4 | 66 |
| Di-n-octyl phthalate | ND | | 6.8 | 66 |
| Dibenz(a,h)anthracene | ND | | 7.0 | 66 |
| Diethyl phthalate | ND | | 7.8 | 66 |
| Dimethyl phthalate | ND | | 8.2 | 66 |
| Hexachlorobenzene | ND | | 9.0 | 66 |
| Hexachlorobutadiene | ND | | 6.8 | 66 |
| Hexachlorocyclopentadiene | ND | | 6.0 | 66 |
| Hexachloroethane | ND | | 7.6 | 66 |
| Isophorone | ND | | 9.0 | 66 |
| N-Nitrosodi-n-propylamine | ND | | 7.8 | 66 |
| N-Nitrosodimethylamine | ND | | 33 | 66 |
| N-Nitrosodiphenylamine | ND | | 9.0 | 66 |
| Nitrobenzene | ND | | 7.2 | 66 |
| Pentachlorophenol | ND | | 7.2 | 340 |
| Phenol | ND | | 7.2 | 66 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Method Blank - Batch: 700-17431**

**Method: 8270C**
**Preparation: 3550B**

Lab Sample ID: MB 700-17431/1-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/20/2006 1342
Date Prepared: 02/17/2006 0900

Analysis Batch: 700-17742
Prep Batch: 700-17431
Units: ug/Kg

Instrument ID: SMC5973
Lab File ID: C022003.D
Initial Weight/Volume: 30.0 g
Final Weight/Volume: 1.0 mL
Injection Volume:

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|

| Surrogate | % Rec | Acceptance Limits |
|---|---|---|
| 2,4,6-Tribromophenol | 65 | 5.0 - 106 |
| 2-Fluorobiphenyl | 61 | 31 - 118 |
| 2-Fluorophenol | 51 | 10 - 128 |
| Nitrobenzene-d5 | 61 | 35 - 122 |
| Phenol-d5 | 52 | 29 - 113 |
| Terphenyl-d14 | 69 | 37 - 149 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17431**

**Method: 8270C**
**Preparation: 3550B**

LCS Lab Sample ID: LCS 700-17431/2-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/20/2006 1417
Date Prepared: 02/17/2006 0900

Analysis Batch: 700-17742
Prep Batch: 700-17431
Units: ug/Kg

Instrument ID: SMC5973
Lab File ID: C022004.D
Initial Weight/Volume: 30.0 g
Final Weight/Volume: 1.0 mL
Injection Volume:

LCSD Lab Sample ID: LCSD 700-17431/3-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/20/2006 1452
Date Prepared: 02/17/2006 0900

Analysis Batch: 700-17742
Prep Batch: 700-17431
Units: ug/Kg

Instrument ID: SMC5973
Lab File ID: C022005.D
Initial Weight/Volume: 30.0 g
Final Weight/Volume: 1.0 mL
Injection Volume:

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| 1,2,4-Trichlorobenzene | 68 | 71 | 34 - 103 | 4 | 22 | | |
| 1,4-Dichlorobenzene | 59 | 62 | 30 - 95 | 5 | 31 | | |
| 2-Chlorophenol | 64 | 69 | 36 - 106 | 7 | 38 | | |
| 4-Chloro-3-methylphenol | 72 | 76 | 48 - 128 | 6 | 32 | | |
| 4-Nitrophenol | 76 | 80 | 20 - 144 | 5 | 57 | | |
| N-Nitrosodi-n-propylamine | 58 | 62 | 28 - 111 | 7 | 37 | | |
| Pentachlorophenol | 84 | 91 | 34 - 133 | 8 | 55 | | |
| Phenol | 62 | 67 | 32 - 107 | 7 | 39 | | |

| Surrogate | LCS % Rec | LCSD % Rec | Acceptance Limits |
|---|---|---|---|
| 2,4,6-Tribromophenol | 92 | 93 | 5.0 - 106 |
| 2-Fluorobiphenyl | 71 | 72 | 31 - 118 |
| 2-Fluorophenol | 58 | 60 | 10 - 128 |
| Nitrobenzene-d5 | 72 | 73 | 35 - 122 |
| Phenol-d5 | 60 | 62 | 29 - 113 |
| Terphenyl-d14 | 75 | 77 | 37 - 149 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Method Blank - Batch: 700-17433**

**Method: 8270C**
**Preparation: 3550B**

Lab Sample ID: MB 700-17433/1-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/20/2006 1428
Date Prepared: 02/17/2006 0900

Analysis Batch: 700-17635
Prep Batch: 700-17433
Units: ug/Kg

Instrument ID: Agilent GC/MS 5973
Lab File ID: D022004.D
Initial Weight/Volume: 30.0 g
Final Weight/Volume: 1.0 mL
Injection Volume:

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Acenaphthene | ND | | 3.5 | 6.7 |
| Pyrene | ND | | 1.7 | 6.7 |
| Acenaphthylene | ND | | 2.0 | 6.7 |
| Anthracene | ND | | 4.4 | 6.7 |
| Benzo[a]pyrene | ND | | 2.0 | 6.7 |
| Benzo[b]fluoranthene | ND | | 6.2 | 6.7 |
| Benzo[a]anthracene | ND | | 2.1 | 6.7 |
| Benzo[g,h,i]perylene | ND | | 3.0 | 6.7 |
| Benzo[k]fluoranthene | ND | | 4.3 | 6.7 |
| Fluoranthene | ND | | 3.5 | 6.7 |
| Fluorene | ND | | 2.9 | 6.7 |
| Indeno[1,2,3-cd]pyrene | ND | | 1.9 | 6.7 |
| Naphthalene | ND | | 3.4 | 6.7 |
| Phenanthrene | ND | | 3.8 | 6.7 |
| Chrysene | ND | | 2.3 | 6.7 |

| Surrogate | % Rec | Acceptance Limits |
|---|---|---|
| 2,4,6-Tribromophenol | 58 | 5.0 - 106 |
| 2-Fluorobiphenyl | 58 | 31 - 118 |
| 2-Fluorophenol | 48 | 10 - 128 |
| Nitrobenzene-d5 | 55 | 35 - 122 |
| Phenol-d5 | 47 | 29 - 113 |
| Terphenyl-d14 | 68 | 37 - 149 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17433**

**Method: 8270C**
**Preparation: 3550B**

LCS Lab Sample ID: LCS 700-17433/2-A
Client Matrix: Solid
Dilution: 2.0
Date Analyzed: 02/20/2006 1502
Date Prepared: 02/17/2006 0900

Analysis Batch: 700-17635
Prep Batch: 700-17433
Units: ug/Kg

Instrument ID: Agilent GC/MS 5973
Lab File ID: D022005.D
Initial Weight/Volume: 30.0 g
Final Weight/Volume: 1.0 mL
Injection Volume:

LCSD Lab Sample ID: LCSD 700-17433/3-A
Client Matrix: Solid
Dilution: 2.0
Date Analyzed: 02/20/2006 1536
Date Prepared: 02/17/2006 0900

Analysis Batch: 700-17635
Prep Batch: 700-17433
Units: ug/Kg

Instrument ID: Agilent GC/MS 5973
Lab File ID: D022006.D
Initial Weight/Volume: 30.0 g
Final Weight/Volume: 1.0 mL
Injection Volume:

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| 1,2,4-Trichlorobenzene | 60 | 61 | 34 - 103 | 2 | 22 | | |
| 1,4-Dichlorobenzene | 52 | 53 | 30 - 95 | 2 | 31 | | |
| 2,4-Dinitrotoluene | 80 | 83 | 36 - 129 | 4 | 37 | | |
| 2-Chlorophenol | 60 | 61 | 45 - 116 | 2 | 38 | | |
| 4-Chloro-3-methylphenol | 71 | 74 | 48 - 128 | 5 | 32 | | |
| 4-Nitrophenol | 72 | 64 | 20 - 144 | 11 | 57 | | |
| Acenaphthene | 64 | 65 | 34 - 134 | 2 | 49 | | |
| N-Nitrosodi-n-propylamine | 69 | 71 | 30 - 130 | 4 | 37 | | |
| Pentachlorophenol | 71 | 73 | 34 - 133 | 3 | 55 | | |
| Phenol | 59 | 61 | 29 - 122 | 3 | 39 | | |
| Pyrene | 80 | 82 | 32 - 122 | 3 | 42 | | |

| Surrogate | LCS % Rec | LCSD % Rec | Acceptance Limits |
|---|---|---|---|
| 2,4,6-Tribromophenol | 77 | 76 | 5.0 - 106 |
| 2-Fluorobiphenyl | 67 | 66 | 31 - 118 |
| 2-Fluorophenol | 67 | 65 | 10 - 128 |
| Nitrobenzene-d5 | 61 | 60 | 35 - 122 |
| Phenol-d5 | 60 | 59 | 29 - 113 |
| Terphenyl-d14 | 86 | 85 | 37 - 149 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Method Blank - Batch: 700-17552**

**Method: 608**
**Preparation: CWA_Prep_CLLE**

Lab Sample ID: MB 700-17552/1-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/24/2006 0735
Date Prepared: 02/21/2006 0654

Analysis Batch: 700-17877
Prep Batch: 700-17552
Units: ug/L

Instrument ID: MSGY
Lab File ID: Y022343.D
Initial Weight/Volume: 1000 mL
Final Weight/Volume: 5.0 mL
Injection Volume:
Column ID: PRIMARY

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Aldrin | ND | | 0.0045 | 0.050 |
| alpha-BHC | ND | | 0.0056 | 0.050 |
| beta-BHC | ND | | 0.0036 | 0.050 |
| Chlordane (technical) | ND | | 0.032 | 0.50 |
| 4,4'-DDD | ND | | 0.0076 | 0.10 |
| 4,4'-DDE | ND | | 0.0064 | 0.10 |
| 4,4'-DDT | ND | | 0.0084 | 0.10 |
| delta-BHC | ND | | 0.010 | 0.050 |
| Dieldrin | ND | | 0.0074 | 0.10 |
| Endosulfan I | ND | | 0.0044 | 0.050 |
| Endosulfan II | ND | | 0.0047 | 0.10 |
| Endosulfan sulfate | ND | | 0.0090 | 0.10 |
| Endrin | ND | | 0.0067 | 0.10 |
| Endrin aldehyde | ND | | 0.0069 | 0.10 |
| gamma-BHC (Lindane) | ND | | 0.0049 | 0.050 |
| Heptachlor | ND | | 0.0037 | 0.050 |
| Heptachlor epoxide | ND | | 0.0039 | 0.050 |
| PCB-1016 | ND | | 0.11 | 1.0 |
| PCB-1221 | ND | | 0.17 | 2.0 |
| PCB-1248 | ND | | 0.14 | 1.0 |
| PCB-1232 | ND | | 0.13 | 1.0 |
| PCB-1254 | ND | | 0.12 | 1.0 |
| PCB-1242 | ND | | 0.18 | 1.0 |
| PCB-1260 | ND | | 0.12 | 1.0 |
| Toxaphene | ND | | 0.31 | 5.0 |

| Surrogate | % Rec | Acceptance Limits |
|---|---|---|
| DCB Decachlorobiphenyl | 60 | 30 - 150 |
| Tetrachloro-m-xylene | 76 | 30 - 150 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17552**

**Method: 608**
**Preparation: CWA_Prep_CLLE**

LCS Lab Sample ID: LCS 700-17552/2-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/24/2006 0603
Date Prepared: 02/21/2006 0654

Analysis Batch: 700-17877
Prep Batch: 700-17552
Units: ug/L

Instrument ID: MSGY
Lab File ID: Y022340.D
Initial Weight/Volume: 1000 mL
Final Weight/Volume: 5.0 mL
Injection Volume:
Column ID: PRIMARY

LCSD Lab Sample ID: LCSD 700-17552/3-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/24/2006 0806
Date Prepared: 02/21/2006 0654

Analysis Batch: 700-17877
Prep Batch: 700-17552
Units: ug/L

Instrument ID: MSGY
Lab File ID: Y022344.D
Initial Weight/Volume: 1000 mL
Final Weight/Volume: 5.0 mL
Injection Volume:
Column ID: PRIMARY

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| Aldrin | 104 | 103 | 32 - 120 | 0 | 25 | | |
| alpha-BHC | 133 | 123 | 17 - 106 | 8 | 30 | * | * |
| beta-BHC | 140 | 130 | 34 - 136 | 8 | 35 | * | |
| 4,4'-DDD | 116 | 118 | 49 - 140 | 2 | 39 | | |
| 4,4'-DDE | 102 | 103 | 44 - 115 | 1 | 18 | | |
| 4,4'-DDT | 106 | 117 | 37 - 150 | 10 | 27 | | |
| delta-BHC | 156 | 133 | 17 - 123 | 16 | 41 | * | * |
| Dieldrin | 101 | 98 | 40 - 142 | 3 | 42 | | |
| Endosulfan I | 81 | 78 | 24 - 147 | 3 | 24 | | |
| Endosulfan II | 86 | 84 | 45 - 145 | 2 | 22 | | |
| Endosulfan sulfate | 100 | 103 | 40 - 141 | 3 | 28 | | |
| Endrin | 97 | 94 | 36 - 137 | 3 | 25 | | |
| Endrin aldehyde | 92 | 100 | 52 - 148 | 8 | 34 | | |
| gamma-BHC (Lindane) | 123 | 112 | 24 - 118 | 9 | 26 | * | |
| Heptachlor | 78 | 77 | 34 - 114 | 1 | 26 | | |
| Heptachlor epoxide | 104 | 102 | 37 - 130 | 2 | 31 | | |

| Surrogate | LCS % Rec | LCSD % Rec | Acceptance Limits |
|---|---|---|---|
| DCB Decachlorobiphenyl | 51 | 58 | 30 - 150 |
| Tetrachloro-m-xylene | 76 | 78 | 30 - 150 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Method Blank - Batch: 700-17522**

**Method: 8081A**
**Preparation: 3550B**

Lab Sample ID: MB 700-17522/1-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/26/2006 0235
Date Prepared: 02/20/2006 0900

Analysis Batch: 700-17870
Prep Batch: 700-17522
Units: ug/Kg

Instrument ID: MSGY
Lab File ID: Y022535.D
Initial Weight/Volume: 30.0 g
Final Weight/Volume: 5.0 mL
Injection Volume:
Column ID: PRIMARY

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Aldrin | ND | | 0.29 | 1.7 |
| alpha-BHC | ND | | 0.12 | 1.7 |
| beta-BHC | ND | | 0.12 | 1.7 |
| Chlordane (technical) | ND | | 1.5 | 17 |
| 4,4'-DDD | ND | | 0.34 | 3.3 |
| 4,4'-DDE | ND | | 0.30 | 3.3 |
| 4,4'-DDT | ND | | 0.54 | 3.3 |
| delta-BHC | ND | | 0.25 | 1.7 |
| Dieldrin | ND | | 0.26 | 3.3 |
| Endosulfan I | ND | | 0.12 | 1.7 |
| Endosulfan II | ND | | 0.39 | 3.3 |
| Endosulfan sulfate | ND | | 0.34 | 3.3 |
| Endrin | ND | | 0.38 | 3.3 |
| Endrin aldehyde | ND | | 0.38 | 3.3 |
| gamma-BHC (Lindane) | ND | | 0.11 | 1.7 |
| Heptachlor | ND | | 0.19 | 1.7 |
| Heptachlor epoxide | ND | | 0.13 | 1.7 |
| Toxaphene | ND | | 11 | 170 |

| Surrogate | % Rec | Acceptance Limits |
|---|---|---|
| DCB Decachlorobiphenyl | 76 | 30 - 150 |
| Tetrachloro-m-xylene | 48 | 30 - 150 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17522**

**Method: 8081A**
**Preparation: 3550B**

LCS Lab Sample ID: LCS 700-17522/2-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/26/2006 0033
Date Prepared: 02/20/2006 0900

Analysis Batch: 700-17870
Prep Batch: 700-17522
Units: ug/Kg

Instrument ID: MSGY
Lab File ID: Y022531.D
Initial Weight/Volume: 30.0 g
Final Weight/Volume: 5.0 mL
Injection Volume:
Column ID: PRIMARY

LCSD Lab Sample ID: LCSD 700-17522/3-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/26/2006 0103
Date Prepared: 02/20/2006 0900

Analysis Batch: 700-17870
Prep Batch: 700-17522
Units: ug/Kg

Instrument ID: MSGY
Lab File ID: Y022532.D
Initial Weight/Volume: 30.0 g
Final Weight/Volume: 5.0 mL
Injection Volume:
Column ID: PRIMARY

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| Aldrin | 65 | 73 | 25 - 128 | 11 | 38 | | |
| 4,4'-DDT | 60 | 56 | 24 - 148 | 7 | 26 | | |
| Dieldrin | 71 | 73 | 22 - 145 | 3 | 30 | | |
| Endrin | 97 | 103 | 26 - 140 | 7 | 32 | | |
| gamma-BHC (Lindane) | 65 | 71 | 20 - 128 | 9 | 37 | | |
| Heptachlor | 46 | 48 | 19 - 139 | 3 | 38 | | |

| Surrogate | LCS % Rec | LCSD % Rec | Acceptance Limits |
|---|---|---|---|
| DCB Decachlorobiphenyl | 76 | 79 | 30 - 150 |
| Tetrachloro-m-xylene | 48 | 54 | 30 - 150 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Method Blank - Batch: 700-17524**

**Method: 8082**
**Preparation: 3550B**

Lab Sample ID: MB 700-17524/1-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/26/2006 0235
Date Prepared: 02/20/2006 0900

Analysis Batch: 700-17870
Prep Batch: 700-17524
Units: ug/Kg

Instrument ID: MSGY
Lab File ID: Y022535pcb.D
Initial Weight/Volume: 30.0 g
Final Weight/Volume: 5.0 mL
Injection Volume:
Column ID: PRIMARY

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| PCB-1016 | ND | | 3.0 | 33 |
| PCB-1260 | ND | | 2.6 | 33 |

| Surrogate | % Rec | Acceptance Limits |
|---|---|---|
| DCB Decachlorobiphenyl | 76 | 30 - 150 |
| Tetrachloro-m-xylene | 41 | 30 - 150 |

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17524**

**Method: 8082**
**Preparation: 3550B**

LCS Lab Sample ID: LCS 700-17524/6-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/26/2006 0134
Date Prepared: 02/20/2006 0900

Analysis Batch: 700-17870
Prep Batch: 700-17524
Units: ug/Kg

Instrument ID: MSGY
Lab File ID: Y022533.D
Initial Weight/Volume: 30.0 g
Final Weight/Volume: 5.0 mL
Injection Volume:
Column ID: PRIMARY

LCSD Lab Sample ID: LCSD 700-17524/7-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/26/2006 0205
Date Prepared: 02/20/2006 0900

Analysis Batch: 700-17870
Prep Batch: 700-17524
Units: ug/Kg

Instrument ID: MSGY
Lab File ID: Y022534.D
Initial Weight/Volume: 30.0 g
Final Weight/Volume: 5.0 mL
Injection Volume:
Column ID: PRIMARY

| Surrogate | LCS % Rec | LCSD % Rec | Acceptance Limits |
|---|---|---|---|
| DCB Decachlorobiphenyl | 75 | 70 | 30 - 150 |
| Tetrachloro-m-xylene | 36 | 38 | 30 - 150 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Method Blank - Batch: 680-37202**

**Method: 200.8**
**Preparation: 4.1.4**
**Dissolved**

Lab Sample ID: MB 680-37202/7-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/25/2006 0542
Date Prepared: 02/23/2006 1624

Analysis Batch: 680-37853
Prep Batch: 680-37202
Units: ug/L

Instrument ID: ICP MS
Lab File ID: N/A
Initial Weight/Volume: 50 mL
Final Weight/Volume: 250 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Antimony | ND | | 1.0 | 2.5 |
| Arsenic | ND | | 0.60 | 2.5 |
| Beryllium | ND | | 0.15 | 0.50 |
| Cadmium | ND | | 0.10 | 0.50 |
| Chromium | ND | | 1.5 | 5.0 |
| Copper | ND | | 0.39 | 2.5 |
| Lead | ND | | 0.50 | 1.5 |
| Nickel | ND | | 0.15 | 1.0 |
| Silver | ND | | 0.25 | 1.0 |
| Thallium | ND | | 0.25 | 1.0 |
| Zinc | ND | | 3.5 | 20 |

**Method Blank - Batch: 680-37202**

**Method: 200.8**
**Preparation: 4.1.4**
**Dissolved**

Lab Sample ID: MB 680-37202/7-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 03/01/2006 1812
Date Prepared: 02/23/2006 1624

Analysis Batch: 680-37853
Prep Batch: 680-37202
Units: ug/L

Instrument ID: ICP MS
Lab File ID: N/A
Initial Weight/Volume: 50 mL
Final Weight/Volume: 250 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Selenium | ND | | 0.50 | 2.5 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 680-37202**

**Method: 200.8**
**Preparation: 4.1.4**
**Dissolved**

LCS Lab Sample ID: LCS 680-37202/8-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/25/2006 0549
Date Prepared: 02/23/2006 1624

Analysis Batch: 680-37853
Prep Batch: 680-37202
Units: ug/L

Instrument ID: ICP MS
Lab File ID: N/A
Initial Weight/Volume: 50 mL
Final Weight/Volume: 250 mL

LCSD Lab Sample ID: LCSD 680-37202/9-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/25/2006 0557
Date Prepared: 02/23/2006 1624

Analysis Batch: 680-37853
Prep Batch: 680-37202
Units: ug/L

Instrument ID: ICP MS
Lab File ID: N/A
Initial Weight/Volume: 50 mL
Final Weight/Volume: 250 mL

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| Chromium | 95 | 96 | 85 - 115 | 1 | 20 | | |
| Copper | 98 | 99 | 85 - 115 | 1 | 20 | | |
| Lead | 104 | 106 | 85 - 115 | 2 | 20 | | |
| Nickel | 97 | 98 | 85 - 115 | 1 | 20 | | |
| Silver | 98 | 99 | 85 - 115 | 1 | 20 | | |
| Thallium | 99 | 102 | 85 - 115 | 3 | 20 | | |
| Zinc | 97 | 97 | 85 - 115 | 0 | 20 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 680-37202**

**Method: 200.8**
**Preparation: 4.1.4**
**Dissolved**

| | | | |
|---|---|---|---|
| LCS Lab Sample ID: | LCS 680-37202/8-A | Analysis Batch: 680-37853 | Instrument ID: ICP MS |
| Client Matrix: | Water | Prep Batch: 680-37202 | Lab File ID: N/A |
| Dilution: | 1.0 | Units: ug/L | Initial Weight/Volume: 50 mL |
| Date Analyzed: | 03/01/2006 1819 | | Final Weight/Volume: 250 mL |
| Date Prepared: | 02/23/2006 1624 | | |

| | | | |
|---|---|---|---|
| LCSD Lab Sample ID: | LCSD 680-37202/9-A | Analysis Batch: 680-37853 | Instrument ID: ICP MS |
| Client Matrix: | Water | Prep Batch: 680-37202 | Lab File ID: N/A |
| Dilution: | 1.0 | Units: ug/L | Initial Weight/Volume: 50 mL |
| Date Analyzed: | 03/01/2006 1826 | | Final Weight/Volume: 250 mL |
| Date Prepared: | 02/23/2006 1624 | | |

| | % Rec. | | | | | | |
|---|---|---|---|---|---|---|---|
| Analyte | LCS | LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
| Selenium | 103 | 105 | 85 - 115 | 2 | 20 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Matrix Spike/**
**Matrix Spike Duplicate Recovery Report - Batch: 680-37202**

**Method: 200.8**
**Preparation: 4.1.4**
**Dissolved**

| | | | |
|---|---|---|---|
| MS Lab Sample ID: | 700-9680-J-1-B MS^D | Analysis Batch: 680-37853 | Instrument ID: ICP MS |
| Client Matrix: | Water | Prep Batch: 680-37202 | Lab File ID: N/A |
| Dilution: | 1.0 | | Initial Weight/Volume: 50 mL |
| Date Analyzed: | 02/25/2006 0626 | | Final Weight/Volume: 250 mL |
| Date Prepared: | 02/23/2006 1624 | | |

| | | | |
|---|---|---|---|
| MSD Lab Sample ID: | 700-9680-J-1-C MSD^D | Analysis Batch: 680-37853 | Instrument ID: ICP MS |
| Client Matrix: | Water | Prep Batch: 680-37202 | Lab File ID: N/A |
| Dilution: | 1.0 | | Initial Weight/Volume: 50 mL |
| Date Analyzed: | 02/25/2006 0633 | | Final Weight/Volume: 250 mL |
| Date Prepared: | 02/23/2006 1624 | | |

| | % Rec. | | | | | |
|---|---|---|---|---|---|---|
| Analyte | MS | MSD | Limit | RPD | RPD Limit | MS Qual MSD Qual |
| Chromium | 113 | 106 | 75 - 125 | 6 | 20 | |
| Copper | 98 | 93 | 75 - 125 | 5 | 20 | |
| Lead | 93 | 86 | 75 - 125 | 8 | 20 | |
| Nickel | 100 | 95 | 75 - 125 | 5 | 20 | |
| Silver | 93 | 90 | 75 - 125 | 4 | 20 | |
| Thallium | 80 | 75 | 75 - 125 | 6 | 20 | |
| Zinc | 92 | 85 | 75 - 125 | 8 | 20 | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Matrix Spike/**
**Matrix Spike Duplicate Recovery Report - Batch: 680-37202**

**Method: 200.8**
**Preparation: 4.1.4**
**Dissolved**

| | | | |
|---|---|---|---|
| MS Lab Sample ID: | 700-9680-J-1-B MS^D | Analysis Batch: 680-37853 | Instrument ID: ICP MS |
| Client Matrix: | Water | Prep Batch: 680-37202 | Lab File ID: N/A |
| Dilution: | 4.0 | | Initial Weight/Volume: 50 mL |
| Date Analyzed: | 03/01/2006 1856 | | Final Weight/Volume: 250 mL |
| Date Prepared: | 02/23/2006 1624 | | |

| | | | |
|---|---|---|---|
| MSD Lab Sample ID: | 700-9680-J-1-C MSD^D | Analysis Batch: 680-37853 | Instrument ID: ICP MS |
| Client Matrix: | Water | Prep Batch: 680-37202 | Lab File ID: N/A |
| Dilution: | 4.0 | | Initial Weight/Volume: 50 mL |
| Date Analyzed: | 03/01/2006 1903 | | Final Weight/Volume: 250 mL |
| Date Prepared: | 02/23/2006 1624 | | |

| | % Rec. | | | | | | |
|---|---|---|---|---|---|---|---|
| Analyte | MS | MSD | Limit | RPD | RPD Limit | MS Qual | MSD Qual |
| Selenium | 103 | 101 | 75 - 125 | 2 | 20 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Method Blank - Batch: 680-37205**

**Method: 200.8**
**Preparation: 4.1.4**
**Total Recoverable**

Lab Sample ID: MB 680-37205/7-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/25/2006 0309
Date Prepared: 02/23/2006 1637

Analysis Batch: 680-37851
Prep Batch: 680-37205
Units: ug/L

Instrument ID: ICP MS
Lab File ID: N/A
Initial Weight/Volume: 50 mL
Final Weight/Volume: 250 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Antimony | ND | | 1.0 | 2.5 |
| Arsenic | ND | | 0.60 | 2.5 |
| Cadmium | ND | | 0.10 | 0.50 |
| Chromium | ND | | 1.5 | 5.0 |
| Copper | ND | | 0.39 | 2.5 |
| Lead | ND | | 0.50 | 1.5 |
| Nickel | ND | | 0.15 | 1.0 |
| Silver | ND | | 0.25 | 1.0 |
| Thallium | ND | | 0.25 | 1.0 |
| Zinc | 4.3 | J | 3.5 | 20 |

**Method Blank - Batch: 680-37205**

**Method: 200.8**
**Preparation: 4.1.4**
**Total Recoverable**

Lab Sample ID: MB 680-37205/7-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 03/01/2006 2016
Date Prepared: 02/23/2006 1637

Analysis Batch: 680-37851
Prep Batch: 680-37205
Units: ug/L

Instrument ID: ICP MS
Lab File ID: N/A
Initial Weight/Volume: 50 mL
Final Weight/Volume: 250 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Selenium | ND | | 0.50 | 2.5 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Method Blank - Batch: 680-37205**

**Method: 200.8**
**Preparation: 4.1.4**
**Total Recoverable**

Lab Sample ID: MB 680-37205/7-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 03/03/2006 0632
Date Prepared: 02/23/2006 1637

Analysis Batch: 680-37851
Prep Batch: 680-37205
Units: ug/L

Instrument ID: ICP MS
Lab File ID: N/A
Initial Weight/Volume: 50 mL
Final Weight/Volume: 250 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Beryllium | ND | | 0.15 | 0.50 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 680-37205**

**Method: 200.8**
**Preparation: 4.1.4**
**Total Recoverable**

LCS Lab Sample ID: LCS 680-37205/8-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/25/2006 0316
Date Prepared: 02/23/2006 1637

Analysis Batch: 680-37851
Prep Batch: 680-37205
Units: ug/L

Instrument ID: ICP MS
Lab File ID: N/A
Initial Weight/Volume: 50 mL
Final Weight/Volume: 250 mL

LCSD Lab Sample ID: LCSD 680-37205/9-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/25/2006 0323
Date Prepared: 02/23/2006 1637

Analysis Batch: 680-37851
Prep Batch: 680-37205
Units: ug/L

Instrument ID: ICP MS
Lab File ID: N/A
Initial Weight/Volume: 50 mL
Final Weight/Volume: 250 mL

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| Antimony | 100 | 94 | 85 - 115 | 6 | 20 | | |
| Arsenic | 109 | 97 | 85 - 115 | 12 | 20 | | |
| Cadmium | 101 | 93 | 85 - 115 | 8 | 20 | | |
| Chromium | 109 | 94 | 85 - 115 | 14 | 20 | | |
| Copper | 113 | 98 | 85 - 115 | 14 | 20 | | |
| Lead | 106 | 101 | 85 - 115 | 5 | 20 | | |
| Nickel | 111 | 97 | 85 - 115 | 13 | 20 | | |
| Silver | 103 | 99 | 85 - 115 | 4 | 20 | | |
| Thallium | 103 | 98 | 85 - 115 | 5 | 20 | | |
| Zinc | 103 | 97 | 85 - 115 | 6 | 20 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 680-37205**

**Method: 200.8**
**Preparation: 4.1.4**
**Total Recoverable**

| | | | |
|---|---|---|---|
| LCS Lab Sample ID: | LCS 680-37205/8-A | Analysis Batch: 680-37851 | Instrument ID: ICP MS |
| Client Matrix: | Water | Prep Batch: 680-37205 | Lab File ID: N/A |
| Dilution: | 1.0 | Units: ug/L | Initial Weight/Volume: 50 mL |
| Date Analyzed: | 03/01/2006 2023 | | Final Weight/Volume: 250 mL |
| Date Prepared: | 02/23/2006 1637 | | |

| | | | |
|---|---|---|---|
| LCSD Lab Sample ID: | LCSD 680-37205/9-A | Analysis Batch: 680-37851 | Instrument ID: ICP MS |
| Client Matrix: | Water | Prep Batch: 680-37205 | Lab File ID: N/A |
| Dilution: | 1.0 | Units: ug/L | Initial Weight/Volume: 50 mL |
| Date Analyzed: | 03/01/2006 2030 | | Final Weight/Volume: 250 mL |
| Date Prepared: | 02/23/2006 1637 | | |

| | % Rec. | | | | | | |
|---|---|---|---|---|---|---|---|
| Analyte | LCS | LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
| Selenium | 99 | 97 | 85 - 115 | 2 | 20 | | |

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 680-37205**

**Method: 200.8**
**Preparation: 4.1.4**
**Total Recoverable**

| | | | |
|---|---|---|---|
| LCS Lab Sample ID: | LCS 680-37205/8-A | Analysis Batch: 680-37851 | Instrument ID: ICP MS |
| Client Matrix: | Water | Prep Batch: 680-37205 | Lab File ID: N/A |
| Dilution: | 1.0 | Units: ug/L | Initial Weight/Volume: 50 mL |
| Date Analyzed: | 03/03/2006 0639 | | Final Weight/Volume: 250 mL |
| Date Prepared: | 02/23/2006 1637 | | |

| | | | |
|---|---|---|---|
| LCSD Lab Sample ID: | LCSD 680-37205/9-A | Analysis Batch: 680-37851 | Instrument ID: ICP MS |
| Client Matrix: | Water | Prep Batch: 680-37205 | Lab File ID: N/A |
| Dilution: | 1.0 | Units: ug/L | Initial Weight/Volume: 50 mL |
| Date Analyzed: | 03/03/2006 0646 | | Final Weight/Volume: 250 mL |
| Date Prepared: | 02/23/2006 1637 | | |

| | % Rec. | | | | | | |
|---|---|---|---|---|---|---|---|
| Analyte | LCS | LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
| Beryllium | 98 | 98 | 85 - 115 | 0 | 20 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Matrix Spike/**
**Matrix Spike Duplicate Recovery Report - Batch: 680-37205**

**Method: 200.8**
**Preparation: 4.1.4**
**Total Recoverable**

MS Lab Sample ID: 700-9680-D-3-B MS^R
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/25/2006 0352
Date Prepared: 02/23/2006 1637

Analysis Batch: 680-37851
Prep Batch: 680-37205

Instrument ID: ICP MS
Lab File ID: N/A
Initial Weight/Volume: 50 mL
Final Weight/Volume: 250 mL

MSD Lab Sample ID: 700-9680-D-3-C MSD^R
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/25/2006 0400
Date Prepared: 02/23/2006 1637

Analysis Batch: 680-37851
Prep Batch: 680-37205

Instrument ID: ICP MS
Lab File ID: N/A
Initial Weight/Volume: 50 mL
Final Weight/Volume: 250 mL

| Analyte | % Rec. MS | % Rec. MSD | Limit | RPD | RPD Limit | MS Qual | MSD Qual |
|---|---|---|---|---|---|---|---|
| Antimony | 99 | 100 | 75 - 125 | 1 | 20 | | |
| Arsenic | 97 | 98 | 75 - 125 | 2 | 20 | | |
| Cadmium | 91 | 92 | 75 - 125 | 1 | 20 | | |
| Chromium | 98 | 105 | 75 - 125 | 7 | 20 | | |
| Copper | 92 | 98 | 75 - 125 | 6 | 20 | | |
| Lead | 91 | 91 | 75 - 125 | 0 | 20 | | |
| Nickel | 92 | 98 | 75 - 125 | 5 | 20 | | |
| Silver | 84 | 93 | 75 - 125 | 10 | 20 | | |
| Thallium | 89 | 90 | 75 - 125 | 1 | 20 | | |
| Zinc | 92 | 92 | 75 - 125 | 0 | 20 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Matrix Spike/**
**Matrix Spike Duplicate Recovery Report - Batch: 680-37205**

**Method: 200.8**
**Preparation: 4.1.4**
**Total Recoverable**

| | | | |
|---|---|---|---|
| MS Lab Sample ID: | 700-9680-D-3-B MS^R | Analysis Batch: 680-37851 | Instrument ID: ICP MS |
| Client Matrix: | Water | Prep Batch: 680-37205 | Lab File ID: N/A |
| Dilution: | 4.0 | | Initial Weight/Volume: 50 mL |
| Date Analyzed: | 03/01/2006 2059 | | Final Weight/Volume: 250 mL |
| Date Prepared: | 02/23/2006 1637 | | |

| | | | |
|---|---|---|---|
| MSD Lab Sample ID: | 700-9680-D-3-C MSD^R | Analysis Batch: 680-37851 | Instrument ID: ICP MS |
| Client Matrix: | Water | Prep Batch: 680-37205 | Lab File ID: N/A |
| Dilution: | 4.0 | | Initial Weight/Volume: 50 mL |
| Date Analyzed: | 03/01/2006 2106 | | Final Weight/Volume: 250 mL |
| Date Prepared: | 02/23/2006 1637 | | |

| | % Rec. | | | | | | |
|---|---|---|---|---|---|---|---|
| Analyte | MS | MSD | Limit | RPD | RPD Limit | MS Qual | MSD Qual |
| Selenium | 96 | 97 | 75 - 125 | 0 | 20 | | |

**Matrix Spike/**
**Matrix Spike Duplicate Recovery Report - Batch: 680-37205**

**Method: 200.8**
**Preparation: 4.1.4**
**Total Recoverable**

| | | | |
|---|---|---|---|
| MS Lab Sample ID: | 700-9680-D-3-B MS^R | Analysis Batch: 680-37851 | Instrument ID: ICP MS |
| Client Matrix: | Water | Prep Batch: 680-37205 | Lab File ID: N/A |
| Dilution: | 4.0 | | Initial Weight/Volume: 50 mL |
| Date Analyzed: | 03/03/2006 0716 | | Final Weight/Volume: 250 mL |
| Date Prepared: | 02/23/2006 1637 | | |

| | | | |
|---|---|---|---|
| MSD Lab Sample ID: | 700-9680-D-3-C MSD^R | Analysis Batch: 680-37851 | Instrument ID: ICP MS |
| Client Matrix: | Water | Prep Batch: 680-37205 | Lab File ID: N/A |
| Dilution: | 4.0 | | Initial Weight/Volume: 50 mL |
| Date Analyzed: | 03/03/2006 0723 | | Final Weight/Volume: 250 mL |
| Date Prepared: | 02/23/2006 1637 | | |

| | % Rec. | | | | | | |
|---|---|---|---|---|---|---|---|
| Analyte | MS | MSD | Limit | RPD | RPD Limit | MS Qual | MSD Qual |
| Beryllium | 100 | 98 | 75 - 125 | 3 | 20 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Method Blank - Batch: 700-17459**

**Method: 245.1**
**Preparation: 245.1**

Lab Sample ID: MB 700-17459/1-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/17/2006 1559
Date Prepared: 02/17/2006 1015

Analysis Batch: 700-17468
Prep Batch: 700-17459
Units: mg/L

Instrument ID: LEEMAN PS200
Lab File ID: N/A
Initial Weight/Volume: 40.0 mL
Final Weight/Volume: 40.0 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Mercury | ND | | 0.000078 | 0.00020 |

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17459**

**Method: 245.1**
**Preparation: 245.1**

LCS Lab Sample ID: LCS 700-17459/2-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/17/2006 1601
Date Prepared: 02/17/2006 1015

Analysis Batch: 700-17468
Prep Batch: 700-17459
Units: mg/L

Instrument ID: LEEMAN PS200
Lab File ID: N/A
Initial Weight/Volume: 40.0 mL
Final Weight/Volume: 40.0 mL

LCSD Lab Sample ID: LCSD 700-17459/3-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/17/2006 1602
Date Prepared: 02/17/2006 1015

Analysis Batch: 700-17468
Prep Batch: 700-17459
Units: mg/L

Instrument ID: LEEMAN PS200
Lab File ID: N/A
Initial Weight/Volume: 40.0 mL
Final Weight/Volume: 40.0 mL

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| Mercury | | | | | | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Method Blank - Batch: 700-17565**

**Method: 245.1**
**Preparation: 245.1**

Lab Sample ID: MB 700-17565/1-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/22/2006 1043
Date Prepared: 02/21/2006 1015

Analysis Batch: 700-17622
Prep Batch: 700-17565
Units: mg/L

Instrument ID: LEEMAN PS200
Lab File ID: N/A
Initial Weight/Volume: 40.0 mL
Final Weight/Volume: 40.0 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Mercury | ND | | 0.000078 | 0.00020 |

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17565**

**Method: 245.1**
**Preparation: 245.1**

LCS Lab Sample ID: LCS 700-17565/2-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/22/2006 1045
Date Prepared: 02/21/2006 1015

Analysis Batch: 700-17622
Prep Batch: 700-17565
Units: mg/L

Instrument ID: LEEMAN PS200
Lab File ID: N/A
Initial Weight/Volume: 40.0 mL
Final Weight/Volume: 40.0 mL

LCSD Lab Sample ID: LCSD 700-17565/3-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/22/2006 1046
Date Prepared: 02/21/2006 1015

Analysis Batch: 700-17622
Prep Batch: 700-17565
Units: mg/L

Instrument ID: LEEMAN PS200
Lab File ID: N/A
Initial Weight/Volume: 40.0 mL
Final Weight/Volume: 40.0 mL

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| Mercury | 114 | 113 | 80 - 120 | 2 | 20 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Method Blank - Batch: 680-37134**

**Method: 6020**
**Preparation: 3050B**

Lab Sample ID: MB 680-37134/11-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/24/2006 2117
Date Prepared: 02/23/2006 1049

Analysis Batch: 680-37413
Prep Batch: 680-37134
Units: mg/Kg

Instrument ID: ICP MS
Lab File ID: N/A
Initial Weight/Volume: 1.00 g
Final Weight/Volume: 1000 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Antimony | ND | | 0.20 | 0.50 |
| Arsenic | ND | | 0.12 | 0.50 |
| Beryllium | ND | | 0.030 | 0.10 |
| Cadmium | ND | | 0.020 | 0.10 |
| Chromium | ND | | 0.30 | 1.0 |
| Copper | 0.085 | J | 0.038 | 0.50 |
| Lead | ND | | 0.10 | 0.30 |
| Selenium | ND | | 0.10 | 0.50 |
| Silver | ND | | 0.050 | 0.20 |
| Thallium | ND | | 0.050 | 0.20 |
| Zinc | 0.31 | J | 0.27 | 4.0 |

**Method Blank - Batch: 680-37134**

**Method: 6020**
**Preparation: 3050B**

Lab Sample ID: MB 680-37134/11-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/25/2006 2028
Date Prepared: 02/23/2006 1049

Analysis Batch: 680-37413
Prep Batch: 680-37134
Units: mg/Kg

Instrument ID: ICP MS
Lab File ID: N/A
Initial Weight/Volume: 1.00 g
Final Weight/Volume: 1000 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Nickel | 0.051 | J | 0.030 | 0.20 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 680-37134**

**Method: 6020**
**Preparation: 3050B**

| | | | | | |
|---|---|---|---|---|---|
| LCS Lab Sample ID: | LCS 680-37134/12-A | Analysis Batch: | 680-37413 | Instrument ID: | ICP MS |
| Client Matrix: | Solid | Prep Batch: | 680-37134 | Lab File ID: | N/A |
| Dilution: | 1.0 | Units: | mg/Kg | Initial Weight/Volume: | 1.00 g |
| Date Analyzed: | 02/24/2006 2125 | | | Final Weight/Volume: | 1000 mL |
| Date Prepared: | 02/23/2006 1049 | | | | |

| | | | | | |
|---|---|---|---|---|---|
| LCSD Lab Sample ID: | LCSD 680-37134/13-A | Analysis Batch: | 680-37413 | Instrument ID: | ICP MS |
| Client Matrix: | Solid | Prep Batch: | 680-37134 | Lab File ID: | N/A |
| Dilution: | 1.0 | Units: | mg/Kg | Initial Weight/Volume: | 1.00 g |
| Date Analyzed: | 02/24/2006 2132 | | | Final Weight/Volume: | 1000 mL |
| Date Prepared: | 02/23/2006 1049 | | | | |

| | % Rec. | | | | | | |
|---|---|---|---|---|---|---|---|
| Analyte | LCS | LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
| Antimony | 95 | 93 | 75 - 125 | 2 | 20 | | |
| Arsenic | 97 | 95 | 75 - 125 | 1 | 20 | | |
| Beryllium | 94 | 91 | 75 - 125 | 3 | 20 | | |
| Cadmium | 94 | 91 | 75 - 125 | 3 | 20 | | |
| Chromium | 95 | 96 | 75 - 125 | 2 | 20 | | |
| Copper | 107 | 99 | 75 - 125 | 8 | 20 | | |
| Lead | 100 | 100 | 75 - 125 | 0 | 20 | | |
| Selenium | 93 | 93 | 75 - 125 | 0 | 20 | | |
| Silver | 102 | 99 | 75 - 125 | 3 | 20 | | |
| Thallium | 95 | 97 | 75 - 125 | 2 | 20 | | |
| Zinc | 97 | 95 | 75 - 125 | 3 | 20 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 680-37134**

**Method: 6020**
**Preparation: 3050B**

LCS Lab Sample ID: LCS 680-37134/12-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/25/2006 2035
Date Prepared: 02/23/2006 1049

Analysis Batch: 680-37413
Prep Batch: 680-37134
Units: mg/Kg

Instrument ID: ICP MS
Lab File ID: N/A
Initial Weight/Volume: 1.00 g
Final Weight/Volume: 1000 mL

LCSD Lab Sample ID: LCSD 680-37134/13-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/25/2006 2043
Date Prepared: 02/23/2006 1049

Analysis Batch: 680-37413
Prep Batch: 680-37134
Units: mg/Kg

Instrument ID: ICP MS
Lab File ID: N/A
Initial Weight/Volume: 1.00 g
Final Weight/Volume: 1000 mL

| | % Rec. | | | | | | |
|---|---|---|---|---|---|---|---|
| Analyte | LCS | LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
| Nickel | 101 | 99 | 75 - 125 | 3 | 20 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Matrix Spike/**
**Matrix Spike Duplicate Recovery Report - Batch: 680-37134**

**Method: 6020**
**Preparation: 3050B**

| | | | |
|---|---|---|---|
| MS Lab Sample ID: | 700-9680-D-2-B MS | Analysis Batch: 680-37413 | Instrument ID: ICP MS |
| Client Matrix: | Solid | Prep Batch: 680-37134 | Lab File ID: N/A |
| Dilution: | 1.0 | | Initial Weight/Volume: 1.10 g |
| Date Analyzed: | 02/24/2006 2201 | | Final Weight/Volume: 1000 mL |
| Date Prepared: | 02/23/2006 1049 | | |

| | | | |
|---|---|---|---|
| MSD Lab Sample ID: | 700-9680-D-2-C MSD | Analysis Batch: 680-37413 | Instrument ID: ICP MS |
| Client Matrix: | Solid | Prep Batch: 680-37134 | Lab File ID: N/A |
| Dilution: | 1.0 | | Initial Weight/Volume: 1.10 g |
| Date Analyzed: | 02/24/2006 2208 | | Final Weight/Volume: 1000 mL |
| Date Prepared: | 02/23/2006 1049 | | |

| Analyte | % Rec. MS | % Rec. MSD | Limit | RPD | RPD Limit | MS Qual | MSD Qual |
|---|---|---|---|---|---|---|---|
| Antimony | 93 | 93 | 75 - 125 | 0 | 20 | | |
| Arsenic | 97 | 103 | 75 - 125 | 3 | 20 | | |
| Beryllium | 106 | 102 | 75 - 125 | 3 | 20 | | |
| Cadmium | 101 | 100 | 75 - 125 | 1 | 20 | | |
| Chromium | 104 | 105 | 75 - 125 | 0 | 20 | | |
| Copper | 106 | 106 | 75 - 125 | 0 | 20 | B | B |
| Lead | 93 | 97 | 75 - 125 | 2 | 20 | | |
| Selenium | 102 | 101 | 75 - 125 | 1 | 20 | | |
| Silver | 108 | 106 | 75 - 125 | 2 | 20 | | |
| Thallium | 103 | 103 | 75 - 125 | 0 | 20 | | |
| Zinc | 91 | 94 | 75 - 125 | 1 | 20 | B | B |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Matrix Spike/**
**Matrix Spike Duplicate Recovery Report - Batch: 680-37134**

**Method: 6020**
**Preparation: 3050B**

| | | | |
|---|---|---|---|
| MS Lab Sample ID: | 700-9680-D-2-B MS | Analysis Batch: 680-37413 | Instrument ID: ICP MS |
| Client Matrix: | Solid | Prep Batch: 680-37134 | Lab File ID: N/A |
| Dilution: | 1.0 | | Initial Weight/Volume: 1.10 g |
| Date Analyzed: | 02/25/2006 2112 | | Final Weight/Volume: 1000 mL |
| Date Prepared: | 02/23/2006 1049 | | |

| | | | |
|---|---|---|---|
| MSD Lab Sample ID: | 700-9680-D-2-C MSD | Analysis Batch: 680-37413 | Instrument ID: ICP MS |
| Client Matrix: | Solid | Prep Batch: 680-37134 | Lab File ID: N/A |
| Dilution: | 1.0 | | Initial Weight/Volume: 1.10 g |
| Date Analyzed: | 02/25/2006 2119 | | Final Weight/Volume: 1000 mL |
| Date Prepared: | 02/23/2006 1049 | | |

| | % Rec. | | | | | | |
|---|---|---|---|---|---|---|---|
| Analyte | MS | MSD | Limit | RPD | RPD Limit | MS Qual | MSD Qual |
| Nickel | 85 | 85 | 75 - 125 | 0 | 20 | B | B |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Method Blank - Batch: 700-17497**

**Method: 7471A**
**Preparation: 7471A**

Lab Sample ID: MB 700-17497/1-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/20/2006 1520
Date Prepared: 02/20/2006 0920

Analysis Batch: 700-17545
Prep Batch: 700-17497
Units: mg/Kg

Instrument ID: LEEMAN PS200
Lab File ID: N/A
Initial Weight/Volume: 0.40 g
Final Weight/Volume: 40.0 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Mercury | ND | | 0.010 | 0.020 |

**Laboratory Control Sample - Batch: 700-17497**

**Method: 7471A**
**Preparation: 7471A**

Lab Sample ID: LCS 700-17497/2-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/20/2006 1728
Date Prepared: 02/20/2006 0920

Analysis Batch: 700-17548
Prep Batch: 700-17497
Units: mg/Kg

Instrument ID: LEEMAN PS200
Lab File ID: N/A
Initial Weight/Volume: 0.40 g
Final Weight/Volume: 40.0 mL

| Analyte | Spike Amount | Result | % Rec. | Limit | Qual |
|---|---|---|---|---|---|
| Mercury | 0.204 | 0.18 | 89 | 80 - 120 | |

**Matrix Spike/**
**Matrix Spike Duplicate Recovery Report - Batch: 700-17497**

**Method: 7471A**
**Preparation: 7471A**

MS Lab Sample ID: 700-9790-3
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/20/2006 1526
Date Prepared: 02/20/2006 0920

Analysis Batch: 700-17545
Prep Batch: 700-17497

Instrument ID: LEEMAN PS200
Lab File ID: N/A
Initial Weight/Volume: 0.78 g
Final Weight/Volume: 40.0 mL

MSD Lab Sample ID: 700-9790-3
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/20/2006 1528
Date Prepared: 02/20/2006 0920

Analysis Batch: 700-17545
Prep Batch: 700-17497

Instrument ID: LEEMAN PS200
Lab File ID: N/A
Initial Weight/Volume: 0.59 g
Final Weight/Volume: 40.0 mL

| Analyte | % Rec. MS | % Rec. MSD | Limit | RPD | RPD Limit | MS Qual | MSD Qual |
|---|---|---|---|---|---|---|---|
| Mercury | 104 | 100 | 80 - 120 | 21 | 20 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Method Blank - Batch: 700-17775**

**Method: 350.1**
**Preparation: N/A**

Lab Sample ID: MB 700-17775/1
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/24/2006 1655
Date Prepared: N/A

Analysis Batch: 700-17775
Prep Batch: N/A
Units: mg/L

Instrument ID: KONELAB AUTOANALYZE
Lab File ID: N/A
Initial Weight/Volume: 10 mL
Final Weight/Volume: 10 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Ammonia | 0.012 | J | 0.0070 | 0.030 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17775**

**Method: 350.1**
**Preparation: N/A**

LCS Lab Sample ID: LCS 700-17775/41
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/24/2006 1837
Date Prepared: N/A

Analysis Batch: 700-17775
Prep Batch: N/A
Units: mg/L

Instrument ID: KONELAB AUTOANALYZE
Lab File ID: N/A
Initial Weight/Volume: 10 mL
Final Weight/Volume: 10 mL

LCSD Lab Sample ID: LCSD 700-17775/42
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/24/2006 1837
Date Prepared: N/A

Analysis Batch: 700-17775
Prep Batch: N/A
Units: mg/L

Instrument ID: KONELAB AUTOANALYZ
Lab File ID: N/A
Initial Weight/Volume: 10 mL
Final Weight/Volume: 10 mL

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| Ammonia | 90 | 91 | 85 - 115 | 1.6 | 30.0 | | |

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17775**

**Method: 350.1**
**Preparation: N/A**

LCS Lab Sample ID: LCS 700-17775/49
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/24/2006 1847
Date Prepared: N/A

Analysis Batch: 700-17775
Prep Batch: N/A
Units: mg/L

Instrument ID: KONELAB AUTOANALYZE
Lab File ID: N/A
Initial Weight/Volume: 10 mL
Final Weight/Volume: 10 mL

LCSD Lab Sample ID: LCSD 700-17775/50
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/24/2006 1847
Date Prepared: N/A

Analysis Batch: 700-17775
Prep Batch: N/A
Units: mg/L

Instrument ID: KONELAB AUTOANALYZ
Lab File ID: N/A
Initial Weight/Volume: 10 mL
Final Weight/Volume: 10 mL

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| Ammonia | 91 | 92 | 85 - 115 | 0.8 | 30.0 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Method Blank - Batch: 700-17780**

**Method: 350.1**
**Preparation: N/A**

Lab Sample ID: MB 700-17780/1
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/24/2006 1655
Date Prepared: N/A

Analysis Batch: 700-17780
Prep Batch: N/A
Units: mg/Kg

Instrument ID: No Equipment Assigned
Lab File ID: N/A
Initial Weight/Volume: 10 mL
Final Weight/Volume: 10 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Ammonia-Soluble | 0.012 | J | 0.0070 | 0.025 |

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17780**

**Method: 350.1**
**Preparation: N/A**

LCS Lab Sample ID: LCS 700-17780/2
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/24/2006 1655
Date Prepared: N/A

Analysis Batch: 700-17780
Prep Batch: N/A
Units: mg/Kg

Instrument ID: No Equipment Assigned
Lab File ID: N/A
Initial Weight/Volume: 10 mL
Final Weight/Volume: 10 mL

LCSD Lab Sample ID: LCSD 700-17780/3
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/24/2006 1655
Date Prepared: N/A

Analysis Batch: 700-17780
Prep Batch: N/A
Units: mg/Kg

Instrument ID: No Equipment Assigned
Lab File ID: N/A
Initial Weight/Volume: 10 mL
Final Weight/Volume: 10 mL

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| Ammonia-Soluble | 91 | 92 | 75 - 125 | 1 | 30 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Method Blank - Batch: 700-17595**

**Method: 351.2**
**Preparation: 351.2**

Lab Sample ID: MB 700-17595/1-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/21/2006 1703
Date Prepared: 02/20/2006 2206

Analysis Batch: 700-17598
Prep Batch: 700-17595
Units: mg/Kg

Instrument ID: QUICKCHEM 8000
Lab File ID: TPTK0221.FDT
Initial Weight/Volume: 20 mL
Final Weight/Volume: 20 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| TKN | 0.12 | J | 0.0075 | 0.13 |

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17595**

**Method: 351.2**
**Preparation: 351.2**

LCS Lab Sample ID: LCS 700-17595/2-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/21/2006 1704
Date Prepared: 02/20/2006 2206

Analysis Batch: 700-17598
Prep Batch: 700-17595
Units: mg/Kg

Instrument ID: QUICKCHEM 8000
Lab File ID: TPTK0221.FDT
Initial Weight/Volume: 20 mL
Final Weight/Volume: 20 mL

LCSD Lab Sample ID: LCSD 700-17595/3-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/21/2006 1705
Date Prepared: 02/20/2006 2206

Analysis Batch: 700-17598
Prep Batch: 700-17595
Units: mg/Kg

Instrument ID: QUICKCHEM 8000
Lab File ID: TPTK0221.FDT
Initial Weight/Volume: 20 mL
Final Weight/Volume: 20 mL

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| TKN | 94 | 82 | 65 - 135 | 14 | 50 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Method Blank - Batch: 700-17716**

**Method: 353.2**
**Preparation: N/A**

Lab Sample ID: MB 700-17716/2
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/23/2006 1632
Date Prepared: N/A

Analysis Batch: 700-17716
Prep Batch: N/A
Units: mg/L

Instrument ID: QUICKCHEM 8000
Lab File ID: NO30223.FDT
Initial Weight/Volume: 10 mL
Final Weight/Volume: 10 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Nitrogen, Nitrate Nitrite | ND | | 0.024 | 0.050 |

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17716**

**Method: 353.2**
**Preparation: N/A**

LCS Lab Sample ID: LCS 700-17716/4
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/23/2006 1635
Date Prepared: N/A

Analysis Batch: 700-17716
Prep Batch: N/A
Units: mg/L

Instrument ID: QUICKCHEM 8000
Lab File ID: NO30223.FDT
Initial Weight/Volume: 10 mL
Final Weight/Volume: 10 mL

LCSD Lab Sample ID: LCSD 700-17716/5
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/23/2006 1636
Date Prepared: N/A

Analysis Batch: 700-17716
Prep Batch: N/A
Units: mg/L

Instrument ID: QUICKCHEM 8000
Lab File ID: NO30223.FDT
Initial Weight/Volume: 10 mL
Final Weight/Volume: 10 mL

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| Nitrogen, Nitrate Nitrite | 89 | 90 | 80 - 120 | 1.2 | 30.0 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Method Blank - Batch: 700-17783**

**Method: 353.2**
**Preparation: N/A**

Lab Sample ID: MB 700-17783/1
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/24/2006 1819
Date Prepared: N/A

Analysis Batch: 700-17783
Prep Batch: N/A
Units: mg/Kg

Instrument ID: QUICKCHEM 8000
Lab File ID: N/A
Initial Weight/Volume: 10 mL
Final Weight/Volume: 10 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Nitrogen, Nitrate Nitrite-Soluble | 0.030 | J | 0.024 | 0.050 |

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17783**

**Method: 353.2**
**Preparation: N/A**

LCS Lab Sample ID: LCS 700-17783/2
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/24/2006 1819
Date Prepared: N/A

Analysis Batch: 700-17783
Prep Batch: N/A
Units: mg/Kg

Instrument ID: QUICKCHEM 8000
Lab File ID: N/A
Initial Weight/Volume: 10 mL
Final Weight/Volume: 10 mL

LCSD Lab Sample ID: LCSD 700-17783/3
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/24/2006 1819
Date Prepared: N/A

Analysis Batch: 700-17783
Prep Batch: N/A
Units: mg/Kg

Instrument ID: QUICKCHEM 8000
Lab File ID: N/A
Initial Weight/Volume: 10 mL
Final Weight/Volume: 10 mL

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| Nitrogen, Nitrate Nitrite-Soluble | 89 | 113 | 90 - 110 | 23.4 | 10.0 | * | * |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9790-1

**Method Blank - Batch: 700-17596**

**Method: 365.4**
**Preparation: 365.2/365.3**

Lab Sample ID: MB 700-17596/1-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/21/2006 1703
Date Prepared: 02/20/2006 2206

Analysis Batch: 700-17597
Prep Batch: 700-17596
Units: mg/Kg

Instrument ID: QUICKCHEM 8000
Lab File ID: TPTK0221.FDT
Initial Weight/Volume: 20 mL
Final Weight/Volume: 20 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Phosphorus, Total | ND | | 0.0015 | 0.063 |

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17596**

**Method: 365.4**
**Preparation: 365.2/365.3**

LCS Lab Sample ID: LCS 700-17596/2-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/21/2006 1704
Date Prepared: 02/20/2006 2206

Analysis Batch: 700-17597
Prep Batch: 700-17596
Units: mg/Kg

Instrument ID: QUICKCHEM 8000
Lab File ID: TPTK0221.FDT
Initial Weight/Volume: 20 mL
Final Weight/Volume: 20 mL

LCSD Lab Sample ID: LCSD 700-17596/3-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/21/2006 1705
Date Prepared: 02/20/2006 2206

Analysis Batch: 700-17597
Prep Batch: 700-17596
Units: mg/Kg

Instrument ID: QUICKCHEM 8000
Lab File ID: TPTK0221.FDT
Initial Weight/Volume: 20 mL
Final Weight/Volume: 20 mL

| | % Rec. | | | | | | |
|---|---|---|---|---|---|---|---|
| Analyte | LCS | LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
| Phosphorus, Total | 91 | 81 | 60 - 140 | 12.6 | 40.0 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

# APPENDIX D

# SEVERN TRENT LABORATORIES, INC. ANALYTICAL REPORT (FEBRUARY 16, 2006 SAMPLES)

# ANALYTICAL REPORT

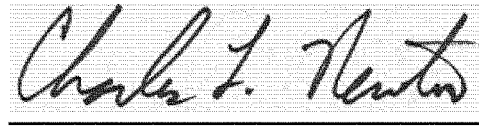
Job Number: 700-9901-1

Job Description: Providence Engineering & Envvironmental

For:

Providence Engineering & Environmental
6160 Perkins Road
Suite 100
Baton Rouge, LA 70808

Attention: Mr. Phillip Parker



Charles Newton
Project Manager I
cnewton@stl-inc.com
03/14/2006

## METHOD SUMMARY

Client: Providence Engineering & Environmental Job Number: 700-9901-1

| Description | Lab Location | Method | Preparation Method |
|---|---|---|---|
| **Matrix: Solid** | | | |
| Volatile Organic Compounds by GC/MS | STL-MOB | SW846 8260B | |
| Purge-and-Trap Low Level | STL-MOB | | SW846 5030B |
| Semivolatile Compounds by Gas Chromatography/Mass Spectrometry (GC/MS) | STL-MOB | SW846 8270C | |
| Ultrasonic Extraction | STL-MOB | | SW846 3550B |
| Semivolatile Organic Compounds by GCMS - Low Levels | STL-MOB | SW846 8270C | |
| Ultrasonic Extraction | STL-MOB | | SW846 3550B |
| Organochlorine Pesticides by Gas Chromatography | STL-MOB | SW846 8081A | |
| Ultrasonic Extraction | STL-MOB | | SW846 3550B |
| Polychlorinated Biphenyls (PCBs) by Gas Chromatography | STL-MOB | SW846 8082 | |
| Ultrasonic Extraction | STL-MOB | | SW846 3550B |
| Inductively Coupled Plasma - Mass Spectrometry | STL-SAV | SW846 6020 | |
| Acid Digestion of Sediments, Sludges, and Soils | STL-SAV | | SW846 3050B |
| Mercury in Solid or Semisolid Waste (Manual Cold Vapor Technique) | STL-MOB | SW846 7471A | |
| Mercury in Solid or Semi-Solid Waste (Manual | STL-MOB | | SW846 7471A |
| Nitrogen (Ammonia, Colorimetric, Automated Phenate) | STL-MOB | MCAWW 350.1 | |
| Deionized Water Leaching Procedure (Routine) | STL-MOB | | ASTM NONE |
| Nitrogen, Total Kjeldahl (Colorimetric, Semi-Automated Block Digester, AAII) | STL-MOB | MCAWW 351.2 | |
| Nitrogen, Total Kjeldahl (Colorimetric, | STL-MOB | | MCAWW 351.2 |
| Nitrogen, Nitrate-Nitrite (Colorimetric, Automated, Cadmium Reduction) | STL-SAV | MCAWW 353.2 | |
| Procedure for Sediment Samples, Nitrate + Nitrite | STL-SAV | | EPA/COE 183 |
| Total Phosphorus | STL-MOB | EPA 365.4 | |
| Sample Digestion for Total Phosphorous | STL-MOB | | MCAWW 365.2/365.3 |
| Percent Moisture | STL-MOB | EPA 160.3 | |
| **Matrix: Water** | | | |
| Purgeable Organic Compounds by GC/MS | STL-MOB | 40CFR136A 624 | |
| Base/Neutral and Acid Organics in Wastewater | STL-MOB | 40CFR136A 625 | |
| Continuous Liquid-Liquid Extraction | STL-MOB | | SW846 3520C |
| Organochlorine Pesticides/PCBs in Water | STL-MOB | 40CFR136A 608 | |
| Continuous LiqLiq Extractions for Clean Water Act | STL-MOB | | 40CFR136A |
| ICPMS Metals by 200.8 CWA | STL-SAV | EPA 200.8 | |
| Total Recoverable Metals for 200.8 | STL-SAV | | MCAWW 4.1.4 |
| Sample Filtration performed in the Field | STL-SAV | | FIELD_FLTRD |

**STL Mobile**

## METHOD SUMMARY

Client: Providence Engineering & Environmental Job Number: 700-9901-1

**Matrix: Water**

| | | | |
|---|---|---|---|
| Mercury in Water by CVAA | STL-MOB | EPA 245.1 | |
| Digestion for CVAA Mercury in Waters | STL-MOB | | EPA 245.1 |
| Nitrogen (Ammonia, Colorimetric, Automated Phenate) | STL-MOB | MCAWW 350.1 | |
| Nitrogen, Total Kjeldahl (Colorimetric, Semi-Automated Block Digester, AAII) | STL-MOB | MCAWW 351.2 | |
| Nitrogen, Total Kjeldahl (Colorimetric, | STL-MOB | | MCAWW 351.2 |
| Nitrogen, Nitrate-Nitrite (Colorimetric, Automated, Cadmium Reduction) | STL-SAV | MCAWW 353.2 | |
| Total Phosphorus | STL-MOB | EPA 365.4 | |
| Sample Digestion for Total Phosphorous | STL-MOB | | MCAWW 365.2/365.3 |
| Organic Nitrogen | STL-MOB | EPA Nitrogen,Org | |

### LAB REFERENCES:

STL-SAV = STL-Savannah
STL-MOB = STL-Mobile

### METHOD REFERENCES:

40CFR136A - "Methods for Organic Chemical Analysis of Municipal Industrial Wastewater", 40CFR, Part 136, Appendix A, October 26, 1984 and subsequent revisions.

EPA - US Environmental Protection Agency

MCAWW - "Methods For Chemical Analysis Of Water And Wastes", EPA-600/4-79-020, March 1983 And Subsequent Revisions.

SW846 - "Test Methods For Evaluating Solid Waste, Physical/Chemical Methods", Third Edition, November 1986 And Its Updates.

## METHOD / ANALYST SUMMARY

Client: Providence Engineering & Environmental Job Number: 700-9901-1

| Method | Analyst | Analyst ID |
|---|---|---|
| 40CFR136A 624 | Var, Kerry | KBV |
| SW846 8260B | Var, Kerry | KBV |
| 40CFR136A 625 | Pham, Van T | VTP |
| SW846 8270C | Huynh, HoangNam | HH |
| SW846 8270C | Nguyen, LanHuong | LN |
| 40CFR136A 608 | Nguyen, Khanh | KN |
| SW846 8081A | Nguyen, Khanh | KN |
| SW846 8082 | Nguyen, Khanh | KN |
| EPA 200.8 | Boyuk, Brian | BB |
| EPA 200.8 | Eaton, Cliff | CE |
| EPA 245.1 | Bruce, Timothy R | TRB |
| SW846 6020 | Eaton, Cliff | CE |
| SW846 7471A | Bruce, Timothy R | TRB |
| EPA 160.3 | Giang, My | MG |
| MCAWW 350.1 | Bradley, Katie | KB |
| MCAWW 351.2 | Flanagan, Mike | MF |
| MCAWW 353.2 | Howard, Juantrell | JH |
| EPA 365.4 | Flanagan, Mike | MF |
| EPA Nitrogen,Org | Bradley, Katie | KB |

## SAMPLE SUMMARY

Client: Providence Engineering & Environmental Job Number: 700-9901-1

| Lab Sample ID | Client Sample ID | Client Matrix | Date/Time Sampled | Date/Time Received |
|---|---|---|---|---|
| 700-9901-5 | MSRiv01-Sediment | Solid | 02/16/2006 1610 | 02/17/2006 1557 |
| 700-9901-6 | MSRiv01-Water | Water | 02/16/2006 1530 | 02/17/2006 1557 |
| 700-9901-7 | MSRiv01A | Water | 02/16/2006 1330 | 02/17/2006 1557 |
| 700-9901-8 | MSRiv01B | Water | 02/16/2006 1430 | 02/17/2006 1557 |
| 700-9901-9 | MSRiv01C | Water | 02/16/2006 1530 | 02/17/2006 1557 |
| 700-9901-10 | MSRiv01-Elutriate | Water | 02/16/2006 0000 | 02/17/2006 1557 |

# SAMPLE RESULTS

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9901-1

**Client Sample ID:** **MSRiv01A**

Lab Sample ID: 700-9901-7 Date Sampled: 02/16/2006 1330
Client Matrix: Water Date Received: 02/17/2006 1557

**624 Purgeable Organic Compounds by GC/MS**

Method: 624 Analysis Batch: 700-17901 Instrument ID: VMG5973
Preparation: N/A Lab File ID: G022737.D
Dilution: 1.0 Initial Weight/Volume: 5 mL
Date Analyzed: 02/28/2006 0426 Final Weight/Volume: 5 mL
Date Prepared: N/A

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| 1,1,1-Trichloroethane | ND | | 0.19 | 5.0 |
| 1,1,2,2-Tetrachloroethane | ND | | 0.25 | 5.0 |
| 1,1,2-Trichloroethane | ND | | 0.31 | 5.0 |
| 1,1-Dichloroethane | ND | | 0.14 | 5.0 |
| 1,1-Dichloroethene | ND | | 0.38 | 5.0 |
| 1,2-Dichloroethane | ND | | 0.15 | 5.0 |
| 1,2-Dichloropropane | ND | | 0.15 | 5.0 |
| 2-Chloroethyl vinyl ether | ND | | 0.50 | 50 |
| Acrolein | ND | * | 9.6 | 100 |
| Acrylonitrile | ND | | 0.67 | 100 |
| Benzene | ND | | 0.12 | 5.0 |
| Bromoform | ND | | 0.18 | 5.0 |
| Bromomethane | ND | | 0.80 | 10 |
| Carbon tetrachloride | ND | | 0.56 | 5.0 |
| Chlorobenzene | ND | | 0.17 | 5.0 |
| Chlorodibromomethane | ND | | 0.50 | 5.0 |
| Chloroethane | ND | | 0.84 | 10 |
| Chloroform | ND | | 0.18 | 5.0 |
| Chloromethane | ND | | 0.15 | 10 |
| Dichlorobromomethane | ND | | 0.50 | 5.0 |
| Ethylbenzene | ND | | 0.56 | 5.0 |
| Methylene Chloride | ND | | 0.45 | 5.0 |
| Tetrachloroethene | ND | | 0.20 | 5.0 |
| Toluene | ND | | 0.19 | 5.0 |
| trans-1,2-Dichloroethene | ND | | 0.24 | 5.0 |
| Trichloroethene | ND | | 0.29 | 5.0 |
| Vinyl chloride | ND | | 0.22 | 10 |
| 1,3-Dichloropropane | ND | | 0.50 | 5.0 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| Toluene-d8 | 104 | 77 - 116 |
| Dibromofluoromethane | 120 | 66 - 125 |
| 4-Bromofluorobenzene | 98 | 70 - 118 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9901-1

**Client Sample ID:** **MSRiv01B**

Lab Sample ID: 700-9901-8 Date Sampled: 02/16/2006 1430
Client Matrix: Water Date Received: 02/17/2006 1557

**624 Purgeable Organic Compounds by GC/MS**

Method: 624 Analysis Batch: 700-17901 Instrument ID: VMG5973
Preparation: N/A Lab File ID: G022738.D
Dilution: 1.0 Initial Weight/Volume: 5 mL
Date Analyzed: 02/28/2006 0456 Final Weight/Volume: 5 mL
Date Prepared: N/A

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| 1,1,1-Trichloroethane | ND | | 0.19 | 5.0 |
| 1,1,2,2-Tetrachloroethane | ND | | 0.25 | 5.0 |
| 1,1,2-Trichloroethane | ND | | 0.31 | 5.0 |
| 1,1-Dichloroethane | ND | | 0.14 | 5.0 |
| 1,1-Dichloroethene | ND | | 0.38 | 5.0 |
| 1,2-Dichloroethane | ND | | 0.15 | 5.0 |
| 1,2-Dichloropropane | ND | | 0.15 | 5.0 |
| 2-Chloroethyl vinyl ether | ND | | 0.50 | 50 |
| Acrolein | ND | * | 9.6 | 100 |
| Acrylonitrile | ND | | 0.67 | 100 |
| Benzene | ND | | 0.12 | 5.0 |
| Bromoform | ND | | 0.18 | 5.0 |
| Bromomethane | ND | | 0.80 | 10 |
| Carbon tetrachloride | ND | | 0.56 | 5.0 |
| Chlorobenzene | ND | | 0.17 | 5.0 |
| Chlorodibromomethane | ND | | 0.50 | 5.0 |
| Chloroethane | ND | | 0.84 | 10 |
| Chloroform | ND | | 0.18 | 5.0 |
| Chloromethane | ND | | 0.15 | 10 |
| Dichlorobromomethane | ND | | 0.50 | 5.0 |
| Ethylbenzene | ND | | 0.56 | 5.0 |
| Methylene Chloride | ND | | 0.45 | 5.0 |
| Tetrachloroethene | ND | | 0.20 | 5.0 |
| Toluene | ND | | 0.19 | 5.0 |
| trans-1,2-Dichloroethene | ND | | 0.24 | 5.0 |
| Trichloroethene | ND | | 0.29 | 5.0 |
| Vinyl chloride | ND | | 0.22 | 10 |
| 1,3-Dichloropropane | ND | | 0.50 | 5.0 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| Toluene-d8 | 110 | 77 - 116 |
| Dibromofluoromethane | 116 | 66 - 125 |
| 4-Bromofluorobenzene | 98 | 70 - 118 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9901-1

**Client Sample ID:** **MSRiv01C**

Lab Sample ID: 700-9901-9 Date Sampled: 02/16/2006 1530
Client Matrix: Water Date Received: 02/17/2006 1557

**624 Purgeable Organic Compounds by GC/MS**

Method: 624 Analysis Batch: 700-17901 Instrument ID: VMG5973
Preparation: N/A Lab File ID: G022739.D
Dilution: 1.0 Initial Weight/Volume: 5 mL
Date Analyzed: 02/28/2006 0527 Final Weight/Volume: 5 mL
Date Prepared: N/A

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| 1,1,1-Trichloroethane | ND | | 0.19 | 5.0 |
| 1,1,2,2-Tetrachloroethane | ND | | 0.25 | 5.0 |
| 1,1,2-Trichloroethane | ND | | 0.31 | 5.0 |
| 1,1-Dichloroethane | ND | | 0.14 | 5.0 |
| 1,1-Dichloroethene | ND | | 0.38 | 5.0 |
| 1,2-Dichloroethane | ND | | 0.15 | 5.0 |
| 1,2-Dichloropropane | ND | | 0.15 | 5.0 |
| 2-Chloroethyl vinyl ether | ND | | 0.50 | 50 |
| Acrolein | ND | * | 9.6 | 100 |
| Acrylonitrile | ND | | 0.67 | 100 |
| Benzene | ND | | 0.12 | 5.0 |
| Bromoform | ND | | 0.18 | 5.0 |
| Bromomethane | ND | | 0.80 | 10 |
| Carbon tetrachloride | ND | | 0.56 | 5.0 |
| Chlorobenzene | ND | | 0.17 | 5.0 |
| Chlorodibromomethane | ND | | 0.50 | 5.0 |
| Chloroethane | ND | | 0.84 | 10 |
| Chloroform | ND | | 0.18 | 5.0 |
| Chloromethane | ND | | 0.15 | 10 |
| Dichlorobromomethane | ND | | 0.50 | 5.0 |
| Ethylbenzene | ND | | 0.56 | 5.0 |
| Methylene Chloride | ND | | 0.45 | 5.0 |
| Tetrachloroethene | ND | | 0.20 | 5.0 |
| Toluene | ND | | 0.19 | 5.0 |
| trans-1,2-Dichloroethene | ND | | 0.24 | 5.0 |
| Trichloroethene | ND | | 0.29 | 5.0 |
| Vinyl chloride | ND | | 0.22 | 10 |
| 1,3-Dichloropropane | ND | | 0.50 | 5.0 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| Toluene-d8 | 105 | 77 - 116 |
| Dibromofluoromethane | 113 | 66 - 125 |
| 4-Bromofluorobenzene | 103 | 70 - 118 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9901-1

**Client Sample ID:** **MSRiv01-Elutriate**

Lab Sample ID: 700-9901-10 Date Sampled: 02/16/2006 0000
Client Matrix: Water Date Received: 02/17/2006 1557

**624 Purgeable Organic Compounds by GC/MS**

Method: 624 Analysis Batch: 700-17901 Instrument ID: VMG5973
Preparation: N/A Lab File ID: G022740.D
Dilution: 1.0 Initial Weight/Volume: 5 mL
Date Analyzed: 02/28/2006 0558 Final Weight/Volume: 5 mL
Date Prepared: N/A

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| 1,1,1-Trichloroethane | ND | | 0.19 | 5.0 |
| 1,1,2,2-Tetrachloroethane | ND | | 0.25 | 5.0 |
| 1,1,2-Trichloroethane | ND | | 0.31 | 5.0 |
| 1,1-Dichloroethane | ND | | 0.14 | 5.0 |
| 1,1-Dichloroethene | ND | | 0.38 | 5.0 |
| 1,2-Dichloroethane | ND | | 0.15 | 5.0 |
| 1,2-Dichloropropane | ND | | 0.15 | 5.0 |
| 2-Chloroethyl vinyl ether | ND | | 0.50 | 50 |
| Acrolein | ND | * | 9.6 | 100 |
| Acrylonitrile | ND | | 0.67 | 100 |
| Benzene | ND | | 0.12 | 5.0 |
| Bromoform | ND | | 0.18 | 5.0 |
| Bromomethane | ND | | 0.80 | 10 |
| Carbon tetrachloride | ND | | 0.56 | 5.0 |
| Chlorobenzene | ND | | 0.17 | 5.0 |
| Chlorodibromomethane | ND | | 0.50 | 5.0 |
| Chloroethane | ND | | 0.84 | 10 |
| Chloroform | ND | | 0.18 | 5.0 |
| Chloromethane | ND | | 0.15 | 10 |
| Dichlorobromomethane | ND | | 0.50 | 5.0 |
| Ethylbenzene | ND | | 0.56 | 5.0 |
| Methylene Chloride | ND | | 0.45 | 5.0 |
| Tetrachloroethene | ND | | 0.20 | 5.0 |
| Toluene | ND | | 0.19 | 5.0 |
| trans-1,2-Dichloroethene | ND | | 0.24 | 5.0 |
| Trichloroethene | ND | | 0.29 | 5.0 |
| Vinyl chloride | ND | | 0.22 | 10 |
| 1,3-Dichloropropane | ND | | 0.50 | 5.0 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| Toluene-d8 | 108 | 77 - 116 |
| Dibromofluoromethane | 112 | 66 - 125 |
| 4-Bromofluorobenzene | 102 | 70 - 118 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9901-1

**Client Sample ID:** **MSRiv01-Sediment**

Lab Sample ID: 700-9901-5 Date Sampled: 02/16/2006 1610
Client Matrix: Solid % Moisture: 41.8 Date Received: 02/17/2006 1557

**8260B Volatile Organic Compounds by GC/MS**

Method: 8260B Analysis Batch: 700-17753 Instrument ID: VMG5973
Preparation: 5030B Lab File ID: G022409.D
Dilution: 1.0 Initial Weight/Volume: 5.21 g
Date Analyzed: 02/24/2006 1320 Final Weight/Volume: 5 mL
Date Prepared: 02/24/2006 1320

| Analyte | DryWt Corrected: Y | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| 1,1,2,2-Tetrachloroethane | | ND | | 2.8 | 8.2 |
| 1,1,1-Trichloroethane | | ND | | 2.5 | 8.2 |
| 1,1,2-Trichloroethane | | ND | | 2.0 | 8.2 |
| Toluene | | ND | | 1.6 | 8.2 |
| 1,1-Dichloroethane | | ND | | 1.6 | 8.2 |
| 1,1-Dichloroethene | | ND | | 2.1 | 8.2 |
| 1,2-Dichloroethane | | ND | | 3.3 | 8.2 |
| 1,2-Dichloropropane | | ND | | 2.0 | 8.2 |
| Benzene | | ND | | 1.8 | 8.2 |
| Bromoform | | ND | | 1.8 | 8.2 |
| Bromomethane | | ND | | 5.9 | 16 |
| Carbon tetrachloride | | ND | | 2.3 | 8.2 |
| Chlorobenzene | | ND | | 1.8 | 8.2 |
| Chlorodibromomethane | | ND | | 2.0 | 8.2 |
| Chloroethane | | ND | | 2.5 | 16 |
| Chloromethane | | ND | | 3.8 | 16 |
| Chloroform | | ND | | 1.4 | 8.2 |
| Dichlorobromomethane | | ND | | 2.0 | 8.2 |
| 1,3-Dichloropropene, Total | | ND | | 2.5 | 16 |
| Ethylbenzene | | ND | | 3.0 | 8.2 |
| Methylene Chloride | | ND | | 2.6 | 8.2 |
| 2-Chloroethyl vinyl ether | | ND | | 28 | 82 |
| Acrolein | | ND | | 46 | 160 |
| Acrylonitrile | | ND | | 100 | 160 |
| Trichloroethene | | ND | | 1.5 | 8.2 |
| Vinyl chloride | | ND | | 2.6 | 16 |
| trans-1,2-Dichloroethene | | ND | | 1.6 | 8.2 |
| Tetrachloroethene | | ND | | 1.5 | 8.2 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| Dibromofluoromethane | 102 | 59 - 132 |
| Toluene-d8 | 88 | 61 - 131 |
| 4-Bromofluorobenzene | 93 | 55 - 131 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9901-1

**Client Sample ID: MSRiv01-Water**

Lab Sample ID: 700-9901-6 Date Sampled: 02/16/2006 1530
Client Matrix: Water Date Received: 02/17/2006 1557

**625 Base/Neutral and Acid Organics in Wastewater**

Method: 625 Analysis Batch: 700-17908 Instrument ID: SMB5973
Preparation: 3520C Prep Batch: 700-17663 Lab File ID: B022423.D
Dilution: 5.0 Initial Weight/Volume: 1000 mL
Date Analyzed: 02/25/2006 0054 Final Weight/Volume: 1.0 mL
Date Prepared: 02/22/2006 0738 Injection Volume:

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| 1,2,4-Trichlorobenzene | ND | | 1.2 | 10 |
| 1,2-Dichlorobenzene | ND | | 1.1 | 10 |
| 1,2-Diphenylhydrazine | ND | | 4.0 | 10 |
| 1,3-Dichlorobenzene | ND | | 1.1 | 10 |
| 1,4-Dichlorobenzene | ND | | 1.1 | 10 |
| 2,2'-oxybis(2-chloropropane) | ND | | 1.3 | 10 |
| 2,4,6-Trichlorophenol | ND | | 2.4 | 10 |
| 2,4-Dichlorophenol | ND | | 1.2 | 10 |
| 2,4-Dimethylphenol | ND | | 1.1 | 10 |
| 2,4-Dinitrophenol | ND | | 2.3 | 50 |
| 2,4-Dinitrotoluene | ND | | 2.2 | 10 |
| 2,6-Dinitrotoluene | ND | | 2.4 | 10 |
| 2-Chloronaphthalene | ND | | 1.7 | 10 |
| 2-Chlorophenol | ND | | 1.0 | 10 |
| 2-Nitrophenol | ND | | 1.3 | 10 |
| 3,3'-Dichlorobenzidine | ND | | 7.1 | 20 |
| 4,6-Dinitro-2-methylphenol | ND | | 2.1 | 50 |
| 4-Bromophenyl phenyl ether | ND | | 1.7 | 10 |
| 4-Chloro-3-methylphenol | ND | | 1.0 | 10 |
| 4-Chlorophenyl phenyl ether | ND | | 1.5 | 10 |
| 4-Nitrophenol | ND | | 3.6 | 50 |
| Acenaphthene | ND | | 1.3 | 10 |
| Acenaphthylene | ND | | 2.4 | 10 |
| Anthracene | ND | | 1.0 | 10 |
| Benzidine | ND | | 8.4 | 80 |
| Benzo[a]anthracene | ND | | 1.0 | 10 |
| Benzo[a]pyrene | ND | | 5.6 | 10 |
| Benzo[b]fluoranthene | ND | | 9.5 | 10 |
| Benzo[g,h,i]perylene | ND | | 5.4 | 10 |
| Benzo[k]fluoranthene | ND | | 9.0 | 10 |
| Bis(2-chloroethoxy)methane | ND | | 5.4 | 10 |
| Bis(2-chloroethyl)ether | ND | | 3.0 | 10 |
| Bis(2-ethylhexyl) phthalate | ND | | 3.3 | 10 |
| Butyl benzyl phthalate | ND | | 2.8 | 10 |
| Chrysene | ND | | 2.3 | 10 |
| Dibenz(a,h)anthracene | ND | | 9.5 | 10 |
| Diethyl phthalate | ND | | 1.7 | 10 |
| Dimethyl phthalate | ND | | 1.2 | 10 |
| Di-n-butyl phthalate | ND | | 1.2 | 10 |
| Di-n-octyl phthalate | ND | | 1.8 | 10 |
| Fluoranthene | ND | | 1.0 | 10 |
| Fluorene | ND | | 1.5 | 10 |
| Hexachlorobenzene | ND | | 1.7 | 10 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9901-1

**Client Sample ID:** **MSRiv01-Water**

Lab Sample ID: 700-9901-6 Date Sampled: 02/16/2006 1530
Client Matrix: Water Date Received: 02/17/2006 1557

**625 Base/Neutral and Acid Organics in Wastewater**

Method: 625 Analysis Batch: 700-17908 Instrument ID: SMB5973
Preparation: 3520C Prep Batch: 700-17663 Lab File ID: B022423.D
Dilution: 5.0 Initial Weight/Volume: 1000 mL
Date Analyzed: 02/25/2006 0054 Final Weight/Volume: 1.0 mL
Date Prepared: 02/22/2006 0738 Injection Volume:

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Hexachlorobutadiene | ND | | 1.4 | 10 |
| Hexachlorocyclopentadiene | ND | | 1.8 | 10 |
| Hexachloroethane | ND | | 1.3 | 10 |
| Indeno[1,2,3-cd]pyrene | ND | | 2.9 | 10 |
| Isophorone | ND | | 1.1 | 10 |
| Naphthalene | ND | | 1.2 | 10 |
| Nitrobenzene | ND | | 1.4 | 10 |
| N-Nitrosodimethylamine | ND | | 2.2 | 10 |
| N-Nitrosodi-n-propylamine | ND | | 1.0 | 10 |
| N-Nitrosodiphenylamine | ND | * | 10 | 10 |
| Pentachlorophenol | ND | | 2.1 | 50 |
| Phenanthrene | ND | | 1.2 | 10 |
| Phenol | ND | | 1.1 | 10 |
| Pyrene | ND | | 2.2 | 10 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| 2,4,6-Tribromophenol | 49 | 14 - 93 |
| 2-Fluorobiphenyl | 74 | 34 - 118 |
| 2-Fluorophenol | 41 | 25 - 102 |
| Nitrobenzene-d5 | 96 | 39 - 133 |
| Phenol-d5 | 46 | 21 - 95 |
| Terphenyl-d14 | 35 | 16 - 158 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9901-1

**Client Sample ID: MSRiv01-Elutriate**

Lab Sample ID: 700-9901-10 Date Sampled: 02/16/2006 0000
Client Matrix: Water Date Received: 02/17/2006 1557

**625 Base/Neutral and Acid Organics in Wastewater**

Method: 625 Analysis Batch: 700-17908 Instrument ID: SMB5973
Preparation: 3520C Prep Batch: 700-17663 Lab File ID: B022424.D
Dilution: 5.0 Initial Weight/Volume: 1000 mL
Date Analyzed: 02/25/2006 0128 Final Weight/Volume: 1.0 mL
Date Prepared: 02/22/2006 0738 Injection Volume:

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| 1,2,4-Trichlorobenzene | ND | | 1.2 | 10 |
| 1,2-Dichlorobenzene | ND | | 1.1 | 10 |
| 1,2-Diphenylhydrazine | ND | | 4.0 | 10 |
| 1,3-Dichlorobenzene | ND | | 1.1 | 10 |
| 1,4-Dichlorobenzene | ND | | 1.1 | 10 |
| 2,2'-oxybis(2-chloropropane) | ND | | 1.3 | 10 |
| 2,4,6-Trichlorophenol | ND | | 2.4 | 10 |
| 2,4-Dichlorophenol | ND | | 1.2 | 10 |
| 2,4-Dimethylphenol | ND | | 1.1 | 10 |
| 2,4-Dinitrophenol | ND | | 2.3 | 50 |
| 2,4-Dinitrotoluene | ND | | 2.2 | 10 |
| 2,6-Dinitrotoluene | ND | | 2.4 | 10 |
| 2-Chloronaphthalene | ND | | 1.7 | 10 |
| 2-Chlorophenol | ND | | 1.0 | 10 |
| 2-Nitrophenol | ND | | 1.3 | 10 |
| 3,3'-Dichlorobenzidine | ND | | 7.1 | 20 |
| 4,6-Dinitro-2-methylphenol | ND | | 2.1 | 50 |
| 4-Bromophenyl phenyl ether | ND | | 1.7 | 10 |
| 4-Chloro-3-methylphenol | ND | | 1.0 | 10 |
| 4-Chlorophenyl phenyl ether | ND | | 1.5 | 10 |
| 4-Nitrophenol | ND | | 3.6 | 50 |
| Acenaphthene | ND | | 1.3 | 10 |
| Acenaphthylene | ND | | 2.4 | 10 |
| Anthracene | ND | | 1.0 | 10 |
| Benzidine | ND | | 8.4 | 80 |
| Benzo[a]anthracene | ND | | 1.0 | 10 |
| Benzo[a]pyrene | ND | | 5.6 | 10 |
| Benzo[b]fluoranthene | ND | | 9.5 | 10 |
| Benzo[g,h,i]perylene | ND | | 5.4 | 10 |
| Benzo[k]fluoranthene | ND | | 9.0 | 10 |
| Bis(2-chloroethoxy)methane | ND | | 5.4 | 10 |
| Bis(2-chloroethyl)ether | ND | | 3.0 | 10 |
| Bis(2-ethylhexyl) phthalate | ND | | 3.3 | 10 |
| Butyl benzyl phthalate | ND | | 2.8 | 10 |
| Chrysene | ND | | 2.3 | 10 |
| Dibenz(a,h)anthracene | ND | | 9.5 | 10 |
| Diethyl phthalate | ND | | 1.7 | 10 |
| Dimethyl phthalate | ND | | 1.2 | 10 |
| Di-n-butyl phthalate | ND | | 1.2 | 10 |
| Di-n-octyl phthalate | ND | | 1.8 | 10 |
| Fluoranthene | ND | | 1.0 | 10 |
| Fluorene | ND | | 1.5 | 10 |
| Hexachlorobenzene | ND | | 1.7 | 10 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9901-1

**Client Sample ID:** **MSRiv01-Elutriate**

Lab Sample ID: 700-9901-10 | Date Sampled: 02/16/2006 0000
Client Matrix: Water | Date Received: 02/17/2006 1557

**625 Base/Neutral and Acid Organics in Wastewater**

| | | | | | |
|---|---|---|---|---|---|
| Method: | 625 | Analysis Batch: 700-17908 | Instrument ID: | SMB5973 | |
| Preparation: | 3520C | Prep Batch: 700-17663 | Lab File ID: | B022424.D | |
| Dilution: | 5.0 | | Initial Weight/Volume: | 1000 | mL |
| Date Analyzed: | 02/25/2006 0128 | | Final Weight/Volume: | 1.0 | mL |
| Date Prepared: | 02/22/2006 0738 | | Injection Volume: | | |

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Hexachlorobutadiene | ND | | 1.4 | 10 |
| Hexachlorocyclopentadiene | ND | | 1.8 | 10 |
| Hexachloroethane | ND | | 1.3 | 10 |
| Indeno[1,2,3-cd]pyrene | ND | | 2.9 | 10 |
| Isophorone | ND | | 1.1 | 10 |
| Naphthalene | ND | | 1.2 | 10 |
| Nitrobenzene | ND | | 1.4 | 10 |
| N-Nitrosodimethylamine | ND | | 2.2 | 10 |
| N-Nitrosodi-n-propylamine | ND | | 1.0 | 10 |
| N-Nitrosodiphenylamine | ND | * | 10 | 10 |
| Pentachlorophenol | ND | | 2.1 | 50 |
| Phenanthrene | ND | | 1.2 | 10 |
| Phenol | ND | | 1.1 | 10 |
| Pyrene | ND | | 2.2 | 10 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| 2,4,6-Tribromophenol | 50 | 14 - 93 |
| 2-Fluorobiphenyl | 72 | 34 - 118 |
| 2-Fluorophenol | 42 | 25 - 102 |
| Nitrobenzene-d5 | 95 | 39 - 133 |
| Phenol-d5 | 45 | 21 - 95 |
| Terphenyl-d14 | 21 | 16 - 158 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9901-1

**Client Sample ID:** **MSRiv01-Sediment**

Lab Sample ID: 700-9901-5 Date Sampled: 02/16/2006 1610
Client Matrix: Solid % Moisture: 41.8 Date Received: 02/17/2006 1557

**8270C Semivolatile Organic Compounds by GCMS - Low Levels**

Method: 8270C Analysis Batch: 700-17696 Instrument ID: Agilent GC/MS 5973
Preparation: 3550B Prep Batch: 700-17636 Lab File ID: D022218.D
Dilution: 1.0 Initial Weight/Volume: 30.0 g
Date Analyzed: 02/22/2006 1630 Final Weight/Volume: 1.0 mL
Date Prepared: 02/22/2006 0900 Injection Volume:

| Analyte | DryWt Corrected: Y | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| 1-Methylnaphthalene | | 8.6 | J | 7.4 | 12 |
| 2-Methylnaphthalene | | 13 | | 6.5 | 12 |
| Acenaphthene | | ND | | 6.0 | 12 |
| Acenaphthylene | | 5.1 | J | 3.4 | 12 |
| Anthracene | | 21 | | 7.6 | 12 |
| Benzo[a]anthracene | | 45 | | 3.6 | 12 |
| Benzo[a]pyrene | | 43 | | 3.4 | 12 |
| Benzo[b]fluoranthene | | 66 | | 11 | 12 |
| Benzo[g,h,i]perylene | | 34 | | 5.2 | 12 |
| Benzo[k]fluoranthene | | 19 | | 7.4 | 12 |
| Chrysene | | 80 | | 3.9 | 12 |
| Fluoranthene | | 83 | | 6.0 | 12 |
| Fluorene | | 6.4 | J | 5.0 | 12 |
| Indeno[1,2,3-cd]pyrene | | 26 | | 3.3 | 12 |
| Naphthalene | | 8.8 | J | 5.8 | 12 |
| Phenanthrene | | 47 | | 6.5 | 12 |
| Pyrene | | 94 | | 2.9 | 12 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| 2,4,6-Tribromophenol | 68 | 5.0 - 106 |
| 2-Fluorobiphenyl | 61 | 31 - 118 |
| 2-Fluorophenol | 50 | 10 - 128 |
| Nitrobenzene-d5 | 53 | 35 - 122 |
| Phenol-d5 | 49 | 29 - 113 |
| Terphenyl-d14 | 74 | 37 - 149 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9901-1

**Client Sample ID:** **MSRiv01-Sediment**

Lab Sample ID: 700-9901-5 Date Sampled: 02/16/2006 1610
Client Matrix: Solid % Moisture: 41.8 Date Received: 02/17/2006 1557

**8270C Semivolatile Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)**

Method: 8270C Analysis Batch: 700-17714 Instrument ID: SMA5972
Preparation: 3550B Prep Batch: 700-17631 Lab File ID: A022220.D
Dilution: 1.0 Initial Weight/Volume: 30.0 g
Date Analyzed: 02/22/2006 2225 Final Weight/Volume: 1.0 mL
Date Prepared: 02/22/2006 0900 Injection Volume:

| Analyte | DryWt Corrected: Y | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| 1,2,4-Trichlorobenzene | | ND | | 14 | 110 |
| 1,2-Dichlorobenzene | | ND | | 15 | 110 |
| 1,2-Diphenylhydrazine | | ND | | 12 | 110 |
| 1,3-Dichlorobenzene | | ND | | 18 | 110 |
| 1,4-Dichlorobenzene | | ND | | 12 | 110 |
| 2,2'-oxybis(2-chloropropane) | | ND | | 21 | 110 |
| 2,4,6-Trichlorophenol | | ND | | 13 | 110 |
| 2,4-Dichlorophenol | | ND | | 12 | 110 |
| 2,4-Dimethylphenol | | ND | | 13 | 110 |
| 2,4-Dinitrophenol | | ND | | 15 | 580 |
| 2,4-Dinitrotoluene | | ND | | 12 | 110 |
| 2,6-Dinitrotoluene | | ND | | 15 | 110 |
| 2-Chloronaphthalene | | ND | | 14 | 110 |
| 2-Chlorophenol | | ND | | 14 | 110 |
| 2-Nitrophenol | | ND | * | 12 | 110 |
| 3,3'-Dichlorobenzidine | | ND | | 24 | 230 |
| 4,6-Dinitro-2-methylphenol | | ND | | 27 | 580 |
| 4-Bromophenyl phenyl ether | | ND | | 14 | 110 |
| 4-Chloro-3-methylphenol | | ND | * | 14 | 110 |
| 4-Chlorophenyl phenyl ether | | ND | | 13 | 110 |
| 4-Nitrophenol | | ND | | 26 | 580 |
| Benzidine | | ND | | 76 | 930 |
| Bis(2-chloroethoxy)methane | | ND | * | 13 | 110 |
| Bis(2-chloroethyl)ether | | ND | | 14 | 110 |
| Bis(2-ethylhexyl) phthalate | | ND | | 13 | 110 |
| Butyl benzyl phthalate | | ND | | 17 | 110 |
| Dibenz(a,h)anthracene | | ND | | 12 | 110 |
| Diethyl phthalate | | ND | | 13 | 110 |
| Dimethyl phthalate | | ND | | 14 | 110 |
| Di-n-butyl phthalate | | ND | | 14 | 110 |
| Di-n-octyl phthalate | | ND | | 12 | 110 |
| Hexachlorobenzene | | ND | | 15 | 110 |
| Hexachlorobutadiene | | ND | | 12 | 110 |
| Hexachlorocyclopentadiene | | ND | | 10 | 110 |
| Hexachloroethane | | ND | | 13 | 110 |
| Isophorone | | ND | | 15 | 110 |
| Nitrobenzene | | ND | | 12 | 110 |
| N-Nitrosodimethylamine | | ND | | 57 | 110 |
| N-Nitrosodi-n-propylamine | | ND | | 13 | 110 |
| N-Nitrosodiphenylamine | | ND | | 15 | 110 |
| Pentachlorophenol | | ND | * | 12 | 580 |
| Phenol | | ND | | 12 | 110 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9901-1

**Client Sample ID:** **MSRiv01-Sediment**

| | | | | | |
|---|---|---|---|---|---|
| Lab Sample ID: | 700-9901-5 | | | Date Sampled: | 02/16/2006 1610 |
| Client Matrix: | Solid | % Moisture: | 41.8 | Date Received: | 02/17/2006 1557 |

**8270C Semivolatile Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)**

| | | | | | |
|---|---|---|---|---|---|
| Method: | 8270C | Analysis Batch: 700-17714 | | Instrument ID: | SMA5972 |
| Preparation: | 3550B | Prep Batch: 700-17631 | | Lab File ID: | A022220.D |
| Dilution: | 1.0 | | | Initial Weight/Volume: | 30.0 g |
| Date Analyzed: | 02/22/2006 2225 | | | Final Weight/Volume: | 1.0 mL |
| Date Prepared: | 02/22/2006 0900 | | | Injection Volume: | |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| 2,4,6-Tribromophenol | 33 | 5.0 - 106 |
| 2-Fluorobiphenyl | 48 | 31 - 118 |
| 2-Fluorophenol | 72 | 10 - 128 |
| Nitrobenzene-d5 | 36 | 35 - 122 |
| Phenol-d5 | 73 | 29 - 113 |
| Terphenyl-d14 | 78 | 37 - 149 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9901-1

**Client Sample ID:** **MSRiv01-Water**

Lab Sample ID: 700-9901-6 Date Sampled: 02/16/2006 1530
Client Matrix: Water Date Received: 02/17/2006 1557

**608 Organochlorine Pesticides/PCBs in Water**

Method: 608 Analysis Batch: 700-17817 Instrument ID: MSGY
Preparation: CWA_Prep_CLLE Prep Batch: 700-17661 Lab File ID: Y022418.D
Dilution: 1.0 Initial Weight/Volume: 1000 mL
Date Analyzed: 02/24/2006 2202 Final Weight/Volume: 5.0 mL
Date Prepared: 02/22/2006 0733 Injection Volume:
Column ID: PRIMARY

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Aldrin | ND | | 0.0045 | 0.050 |
| alpha-BHC | ND | | 0.0056 | 0.050 |
| beta-BHC | ND | | 0.0036 | 0.050 |
| Chlordane (technical) | ND | | 0.032 | 0.50 |
| 4,4'-DDD | ND | | 0.0076 | 0.10 |
| 4,4'-DDE | ND | | 0.0064 | 0.10 |
| 4,4'-DDT | ND | | 0.0084 | 0.10 |
| delta-BHC | ND | | 0.010 | 0.050 |
| Dieldrin | ND | | 0.0074 | 0.10 |
| Endosulfan I | ND | | 0.0044 | 0.050 |
| Endosulfan II | ND | | 0.0047 | 0.10 |
| Endosulfan sulfate | ND | | 0.0090 | 0.10 |
| Endrin | ND | | 0.0067 | 0.10 |
| Endrin aldehyde | ND | | 0.0069 | 0.10 |
| gamma-BHC (Lindane) | ND | | 0.0049 | 0.050 |
| Heptachlor | ND | | 0.0037 | 0.050 |
| Heptachlor epoxide | ND | | 0.0039 | 0.050 |
| PCB-1016 | ND | | 0.11 | 1.0 |
| PCB-1221 | ND | | 0.17 | 2.0 |
| PCB-1248 | ND | | 0.14 | 1.0 |
| PCB-1232 | ND | | 0.13 | 1.0 |
| PCB-1254 | ND | | 0.12 | 1.0 |
| PCB-1242 | ND | | 0.18 | 1.0 |
| PCB-1260 | ND | | 0.12 | 1.0 |
| Toxaphene | ND | | 0.31 | 5.0 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| DCB Decachlorobiphenyl | 15 * | 30 - 150 |
| Tetrachloro-m-xylene | 47 | 30 - 150 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9901-1

**Client Sample ID:** **MSRiv01-Elutriate**

Lab Sample ID: 700-9901-10 Date Sampled: 02/16/2006 0000
Client Matrix: Water Date Received: 02/17/2006 1557

**608 Organochlorine Pesticides/PCBs in Water**

Method: 608 Analysis Batch: 700-17817 Instrument ID: MSGY
Preparation: CWA_Prep_CLLE Prep Batch: 700-17661 Lab File ID: Y022419.D
Dilution: 1.0 Initial Weight/Volume: 1000 mL
Date Analyzed: 02/24/2006 2232 Final Weight/Volume: 5.0 mL
Date Prepared: 02/22/2006 0733 Injection Volume:
Column ID: PRIMARY

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Aldrin | ND | | 0.0045 | 0.050 |
| alpha-BHC | ND | | 0.0056 | 0.050 |
| beta-BHC | ND | | 0.0036 | 0.050 |
| Chlordane (technical) | ND | | 0.032 | 0.50 |
| 4,4'-DDD | ND | | 0.0076 | 0.10 |
| 4,4'-DDE | ND | | 0.0064 | 0.10 |
| 4,4'-DDT | ND | | 0.0084 | 0.10 |
| delta-BHC | ND | | 0.010 | 0.050 |
| Dieldrin | ND | | 0.0074 | 0.10 |
| Endosulfan I | ND | | 0.0044 | 0.050 |
| Endosulfan II | ND | | 0.0047 | 0.10 |
| Endosulfan sulfate | ND | | 0.0090 | 0.10 |
| Endrin | ND | | 0.0067 | 0.10 |
| Endrin aldehyde | ND | | 0.0069 | 0.10 |
| gamma-BHC (Lindane) | ND | | 0.0049 | 0.050 |
| Heptachlor | ND | | 0.0037 | 0.050 |
| Heptachlor epoxide | ND | | 0.0039 | 0.050 |
| PCB-1016 | ND | | 0.11 | 1.0 |
| PCB-1221 | ND | | 0.17 | 2.0 |
| PCB-1248 | ND | | 0.14 | 1.0 |
| PCB-1232 | ND | | 0.13 | 1.0 |
| PCB-1254 | ND | | 0.12 | 1.0 |
| PCB-1242 | ND | | 0.18 | 1.0 |
| PCB-1260 | ND | | 0.12 | 1.0 |
| Toxaphene | ND | | 0.31 | 5.0 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| DCB Decachlorobiphenyl | 10 * | 30 - 150 |
| Tetrachloro-m-xylene | 45 | 30 - 150 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9901-1

**Client Sample ID:** **MSRiv01-Sediment**

Lab Sample ID: 700-9901-5 Date Sampled: 02/16/2006 1610
Client Matrix: Solid % Moisture: 41.8 Date Received: 02/17/2006 1557

**8081A Organochlorine Pesticides by Gas Chromatography**

Method: 8081A Analysis Batch: 700-17870 Instrument ID: MSGY
Preparation: 3550B Prep Batch: 700-17522 Lab File ID: Y022509.D
Dilution: 1.0 Initial Weight/Volume: 50.0 g
Date Analyzed: 02/25/2006 1318 Final Weight/Volume: 5.0 mL
Date Prepared: 02/20/2006 0900 Injection Volume:
Column ID: PRIMARY

| Analyte | DryWt Corrected: Y | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| Aldrin | | ND | | 0.30 | 1.8 |
| alpha-BHC | | ND | | 0.12 | 1.8 |
| beta-BHC | | ND | | 0.12 | 1.8 |
| Chlordane (technical) | | ND | | 1.5 | 18 |
| 4,4'-DDD | | ND | | 0.35 | 3.4 |
| 4,4'-DDE | | ND | | 0.31 | 3.4 |
| 4,4'-DDT | | ND | | 0.56 | 3.4 |
| delta-BHC | | ND | | 0.26 | 1.8 |
| Dieldrin | | ND | | 0.27 | 3.4 |
| Endosulfan I | | ND | | 0.12 | 1.8 |
| Endosulfan II | | ND | | 0.40 | 3.4 |
| Endosulfan sulfate | | ND | | 0.35 | 3.4 |
| Endrin | | ND | | 0.39 | 3.4 |
| Endrin aldehyde | | ND | * | 0.39 | 3.4 |
| gamma-BHC (Lindane) | | ND | | 0.11 | 1.8 |
| Heptachlor | | ND | | 0.20 | 1.8 |
| Heptachlor epoxide | | ND | | 0.13 | 1.8 |
| Toxaphene | | ND | | 11 | 180 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| DCB Decachlorobiphenyl | 85 | 30 - 150 |
| Tetrachloro-m-xylene | 76 | 30 - 150 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9901-1

**Client Sample ID:** **MSRiv01-Sediment**

Lab Sample ID: 700-9901-5 Date Sampled: 02/16/2006 1610
Client Matrix: Solid % Moisture: 41.8 Date Received: 02/17/2006 1557

**8082 Polychlorinated Biphenyls (PCBs) by Gas Chromatography**

Method: 8082 Analysis Batch: 700-17870 Instrument ID: MSGY
Preparation: 3550B Prep Batch: 700-17524 Lab File ID: Y022509pcb.D
Dilution: 1.0 Initial Weight/Volume: 50.0 g
Date Analyzed: 02/25/2006 1318 Final Weight/Volume: 5.0 mL
Date Prepared: 02/20/2006 0900 Injection Volume:
Column ID: PRIMARY

| Analyte | DryWt Corrected: Y | Result (ug/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| PCB-1016 | | ND | | 3.1 | 34 |
| PCB-1221 | | ND | | 1.9 | 69 |
| PCB-1232 | | ND | | 3.8 | 34 |
| PCB-1242 | | ND | | 2.9 | 34 |
| PCB-1248 | | ND | | 4.4 | 34 |
| PCB-1254 | | ND | | 3.2 | 34 |
| PCB-1260 | | ND | * | 2.7 | 34 |

| Surrogate | %Rec | Acceptance Limits |
|---|---|---|
| DCB Decachlorobiphenyl | 85 | 30 - 150 |
| Tetrachloro-m-xylene | 67 | 30 - 150 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9901-1

**Client Sample ID: MSRiv01-Sediment**

| | | | |
|---|---|---|---|
| Lab Sample ID: | 700-9901-5 | Date Sampled: | 02/16/2006 1610 |
| Client Matrix: | Solid % Moisture: 41.8 | Date Received: | 02/17/2006 1557 |

**6020 Inductively Coupled Plasma - Mass Spectrometry**

| | | | |
|---|---|---|---|
| Method: | 6020 | Analysis Batch: 680-37413 | Instrument ID: ICP MS |
| Preparation: | 3050B | Prep Batch: 680-37134 | Lab File ID: N/A |
| Dilution: | 1.0 | | Initial Weight/Volume: 1.06 g |
| Date Analyzed: | 02/24/2006 2329 | | Final Weight/Volume: 1000 mL |
| Date Prepared: | 02/23/2006 1049 | | |

| Analyte | DryWt Corrected: Y | Result (mg/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| Antimony | | ND | | 0.32 | 0.81 |
| Arsenic | | 5.5 | | 0.19 | 0.81 |
| Beryllium | | 0.56 | | 0.049 | 0.16 |
| Cadmium | | 0.39 | | 0.032 | 0.16 |
| Chromium | | 15 | | 0.49 | 1.6 |
| Copper | | 12 | B | 0.062 | 0.81 |
| Lead | | 15 | | 0.16 | 0.49 |
| Selenium | | 0.32 | J | 0.16 | 0.81 |
| Silver | | ND | | 0.081 | 0.32 |
| Thallium | | 0.14 | J | 0.081 | 0.32 |
| Zinc | | 58 | B | 0.44 | 6.5 |

| | | | |
|---|---|---|---|
| Method: | 6020 | Analysis Batch: 680-37413 | Instrument ID: ICP MS |
| Preparation: | 3050B | Prep Batch: 680-37134 | Lab File ID: N/A |
| Dilution: | 1.0 | | Initial Weight/Volume: 1.06 g |
| Date Analyzed: | 02/25/2006 2239 | | Final Weight/Volume: 1000 mL |
| Date Prepared: | 02/23/2006 1049 | | |

| Analyte | DryWt Corrected: Y | Result (mg/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| Nickel | | 16 | B | 0.049 | 0.32 |

**7471A Mercury in Solid or Semisolid Waste (Manual Cold Vapor Technique)**

| | | | |
|---|---|---|---|
| Method: | 7471A | Analysis Batch: 700-17846 | Instrument ID: LEEMAN PS200 |
| Preparation: | 7471A | Prep Batch: 700-17806 | Lab File ID: N/A |
| Dilution: | 1.0 | | Initial Weight/Volume: 1.15 g |
| Date Analyzed: | 02/27/2006 1531 | | Final Weight/Volume: 40.0 mL |
| Date Prepared: | 02/27/2006 0948 | | |

| Analyte | DryWt Corrected: Y | Result (mg/Kg) | Qualifier | MDL | RL |
|---|---|---|---|---|---|
| Mercury | | 0.041 | | 0.0060 | 0.012 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9901-1

**Client Sample ID: MSRiv01-Water**

Lab Sample ID: 700-9901-6 Date Sampled: 02/16/2006 1530
Client Matrix: Water Date Received: 02/17/2006 1557

**200.8 ICPMS Metals by 200.8 CWA-Dissolved**

Method: 200.8 Analysis Batch: 680-37853 Instrument ID: ICP MS
Preparation: 4.1.4 Prep Batch: 680-37202 Lab File ID: N/A
Dilution: 1.0 Initial Weight/Volume: 50 mL
Date Analyzed: 02/25/2006 0710 Final Weight/Volume: 250 mL
Date Prepared: 02/23/2006 1624

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Antimony | ND | | 1.0 | 2.5 |
| Arsenic | 1.1 | J | 0.60 | 2.5 |
| Beryllium | ND | | 0.15 | 0.50 |
| Cadmium | ND | | 0.10 | 0.50 |
| Chromium | ND | | 1.5 | 5.0 |
| Copper | 2.2 | J | 0.39 | 2.5 |
| Lead | ND | | 0.50 | 1.5 |
| Nickel | 1.6 | | 0.15 | 1.0 |
| Silver | ND | | 0.25 | 1.0 |
| Thallium | ND | | 0.25 | 1.0 |
| Zinc | 4.7 | J | 3.5 | 20 |

Method: 200.8 Analysis Batch: 680-37853 Instrument ID: ICP MS
Preparation: 4.1.4 Prep Batch: 680-37202 Lab File ID: N/A
Dilution: 4.0 Initial Weight/Volume: 50 mL
Date Analyzed: 03/01/2006 1939 Final Weight/Volume: 250 mL
Date Prepared: 02/23/2006 1624

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Selenium | ND | | 2.0 | 10 |

**245.1 Mercury in Water by CVAA**

Method: 245.1 Analysis Batch: 700-17622 Instrument ID: LEEMAN PS200
Preparation: 245.1 Prep Batch: 700-17565 Lab File ID: N/A
Dilution: 1.0 Initial Weight/Volume: 40.0 mL
Date Analyzed: 02/22/2006 1121 Final Weight/Volume: 40.0 mL
Date Prepared: 02/21/2006 1015

| Analyte | Result (mg/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Mercury | 0.000093 | J | 0.000078 | 0.00020 |

**Analytical Data**

Client: Providence Engineering & Environmental | Job Number: 700-9901-1

**Client Sample ID: MSRiv01-Elutriate**

Lab Sample ID: 700-9901-10 | Date Sampled: 02/16/2006 0000
Client Matrix: Water | Date Received: 02/17/2006 1557

**200.8 ICPMS Metals by 200.8 CWA-Total Recoverable**

Method: 200.8 | Analysis Batch: 680-37851 | Instrument ID: ICP MS
Preparation: 4.1.4 | Prep Batch: 680-37205 | Lab File ID: N/A
Dilution: 1.0 | Initial Weight/Volume: 50 mL
Date Analyzed: 02/25/2006 0451 | Final Weight/Volume: 250 mL
Date Prepared: 02/23/2006 1637

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Antimony | ND | | 1.0 | 2.5 |
| Arsenic | 7.8 | | 0.60 | 2.5 |
| Copper | 19 | | 0.39 | 2.5 |
| Cadmium | 0.43 | J | 0.10 | 0.50 |
| Silver | ND | | 0.25 | 1.0 |
| Chromium | 23 | | 1.5 | 5.0 |
| Nickel | 22 | | 0.15 | 1.0 |
| Lead | 19 | | 0.50 | 1.5 |
| Thallium | ND | | 0.25 | 1.0 |
| Zinc | 72 | B | 3.5 | 20 |

Method: 200.8 | Analysis Batch: 680-37851 | Instrument ID: ICP MS
Preparation: 4.1.4 | Prep Batch: 680-37205 | Lab File ID: N/A
Dilution: 4.0 | Initial Weight/Volume: 50 mL
Date Analyzed: 03/01/2006 2157 | Final Weight/Volume: 250 mL
Date Prepared: 02/23/2006 1637

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Selenium | ND | | 2.0 | 10 |

Method: 200.8 | Analysis Batch: 680-37851 | Instrument ID: ICP MS
Preparation: 4.1.4 | Prep Batch: 680-37205 | Lab File ID: N/A
Dilution: 4.0 | Initial Weight/Volume: 50 mL
Date Analyzed: 03/03/2006 1202 | Final Weight/Volume: 250 mL
Date Prepared: 02/23/2006 1637

| Analyte | Result (ug/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Beryllium | 1.0 | J | 0.60 | 2.0 |

**Analytical Data**

Client: Providence Engineering & Environmental Job Number: 700-9901-1

**Client Sample ID: MSRiv01-Elutriate**

| | | | |
|---|---|---|---|
| Lab Sample ID: | 700-9901-10 | Date Sampled: | 02/16/2006 0000 |
| Client Matrix: | Water | Date Received: | 02/17/2006 1557 |

**245.1 Mercury in Water by CVAA**

| | | | | | |
|---|---|---|---|---|---|
| Method: | 245.1 | Analysis Batch: 700-17622 | | Instrument ID: | LEEMAN PS200 |
| Preparation: | 245.1 | Prep Batch: 700-17565 | | Lab File ID: | N/A |
| Dilution: | 1.0 | | | Initial Weight/Volume: | 40.0 mL |
| Date Analyzed: | 02/22/2006 1123 | | | Final Weight/Volume: | 40.0 mL |
| Date Prepared: | 02/21/2006 1015 | | | | |

| Analyte | Result (mg/L) | Qualifier | MDL | RL |
|---|---|---|---|---|
| Mercury | ND | | 0.000078 | 0.00020 |

**Analytical Data**

Client: Providence Engineering & Environmental

Job Number: 700-9901-1

**General Chemistry**

**Client Sample ID:** **MSRiv01-Sediment**

Lab Sample ID: 700-9901-5
Client Matrix: Solid

Date Sampled: 02/16/2006 1610
Date Received: 02/17/2006 1557

| Analyte | Result | Qual | Units | MDL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Ammonia-Soluble | 31 | B | mg/Kg | 0.13 | 0.47 | 1.0 | 350.1 |
| | Anly Batch: 700-17780 | Date Analyzed | 02/24/2006 1655 | | | DryWt Corrected: N | |
| TKN | 260 | | mg/Kg | 3.7 | 62 | 1.0 | 351.2 |
| | Anly Batch: 700-17939 | Date Analyzed | 03/01/2006 1239 | | | DryWt Corrected: Y | |
| | Prep Batch: 700-17803 | Date Prepared: | 02/24/2006 1656 | | | | |
| Nitrogen, Nitrate Nitrite | ND | | mg/Kg | 4.3 | 8.6 | 1.0 | 353.2 |
| | Anly Batch: 680-38782 | Date Analyzed | 03/13/2006 1113 | | | DryWt Corrected: Y | |
| | Prep Batch: 680-38781 | Date Prepared: | 03/10/2006 1400 | | | | |
| Phosphorus, Total | 230 | B | mg/Kg | 0.75 | 31 | 1.0 | 365.4 |
| | Anly Batch: 700-17938 | Date Analyzed | 03/01/2006 1239 | | | DryWt Corrected: Y | |
| | Prep Batch: 700-17804 | Date Prepared: | 02/24/2006 1656 | | | | |

| Analyte | Result | Qual | Units | RL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Percent Moisture | 42 | | % | 0.10 | 0.10 | 1.0 | 160.3 |
| | Anly Batch: 700-17624 | Date Analyzed | 02/21/2006 1430 | | | | |
| Percent Solids | 58 | | % | 0.10 | 0.10 | 1.0 | 160.3 |
| | Anly Batch: 700-17624 | Date Analyzed | 02/21/2006 1430 | | | | |

**Analytical Data**

Client: Providence Engineering & Environmental

Job Number: 700-9901-1

**General Chemistry**

**Client Sample ID:** **MSRiv01-Water**

Lab Sample ID: 700-9901-6
Client Matrix: Water

Date Sampled: 02/16/2006 1530
Date Received: 02/17/2006 1557

| Analyte | Result | Qual | Units | MDL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Ammonia | 0.035 | B | mg/L | 0.0070 | 0.030 | 1.0 | 350.1 |
| Anly Batch: 700-17683 | Date Analyzed | | 02/22/2006 2004 | | | | |
| Nitrogen, Kjeldahl | ND | | mg/L | 0.15 | 0.20 | 1.0 | 351.2 |
| Anly Batch: 700-17939 | Date Analyzed | | 03/01/2006 1231 | | | | |
| Prep Batch: 700-17803 | Date Prepared: | | 02/24/2006 1656 | | | | |
| Nitrogen, Nitrate Nitrite | 370 | | mg/L | 13 | 25 | 500 | 353.2 |
| Anly Batch: 680-38778 | Date Analyzed | | 03/13/2006 1423 | | | | |
| Phosphorus, Total | 0.22 | B | mg/L | 0.000030 | 0.10 | 1.0 | 365.4 |
| Anly Batch: 700-17938 | Date Analyzed | | 03/01/2006 1231 | | | | |
| Prep Batch: 700-17804 | Date Prepared: | | 02/24/2006 1656 | | | | |

| Analyte | Result | Qual | Units | RL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Nitrogen, Organic | ND | | mg/L | 0.030 | 0.030 | 1.0 | Nitrogen,Org |
| Anly Batch: 700-18447 | Date Analyzed | | 03/01/2006 1223 | | | | |

**Analytical Data**

Client: Providence Engineering & Environmental

Job Number: 700-9901-1

**General Chemistry**

**Client Sample ID:** **MSRiv01-Elutriate**

Lab Sample ID: 700-9901-10
Client Matrix: Water

Date Sampled: 02/16/2006 0000
Date Received: 02/17/2006 1557

| Analyte | Result | Qual | Units | MDL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Ammonia | 0.47 | B | mg/L | 0.0070 | 0.030 | 1.0 | 350.1 |
| Anly Batch: 700-17683 | Date Analyzed | | 02/22/2006 2004 | | | | |
| Nitrogen, Kjeldahl | 1.9 | | mg/L | 0.15 | 0.20 | 1.0 | 351.2 |
| Anly Batch: 700-17939 | Date Analyzed | | 03/01/2006 1234 | | | | |
| Prep Batch: 700-17803 | Date Prepared: | | 02/24/2006 1656 | | | | |
| Nitrogen, Nitrate Nitrite | 2.0 | | mg/L | 0.050 | 0.10 | 2.0 | 353.2 |
| Anly Batch: 680-38778 | Date Analyzed | | 03/13/2006 1545 | | | | |
| Phosphorus, Total | 0.82 | B | mg/L | 0.000030 | 0.10 | 1.0 | 365.4 |
| Anly Batch: 700-17938 | Date Analyzed | | 03/01/2006 1234 | | | | |
| Prep Batch: 700-17804 | Date Prepared: | | 02/24/2006 1656 | | | | |

| Analyte | Result | Qual | Units | RL | RL | Dil | Method |
|---|---|---|---|---|---|---|---|
| Nitrogen, Organic | 1.4 | | mg/L | 0.030 | 0.030 | 1.0 | Nitrogen,Org |
| Anly Batch: 700-18447 | Date Analyzed | | 03/01/2006 1223 | | | | |

# QUALITY CONTROL RESULTS

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9901-1

**Method Blank - Batch: 700-17901**

**Method: 624**
**Preparation: N/A**

Lab Sample ID: MB 700-17901/3
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/27/2006 1612
Date Prepared: N/A

Analysis Batch: 700-17901
Prep Batch: N/A
Units: ug/L

Instrument ID: VMG5973
Lab File ID: G022713.D
Initial Weight/Volume: 5 mL
Final Weight/Volume: 5 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| 1,1,1-Trichloroethane | ND | | 0.19 | 5.0 |
| 1,1,2,2-Tetrachloroethane | ND | | 0.25 | 5.0 |
| 1,1,2-Trichloroethane | ND | | 0.31 | 5.0 |
| 1,1-Dichloroethane | ND | | 0.14 | 5.0 |
| 1,1-Dichloroethene | ND | | 0.38 | 5.0 |
| 1,2-Dichloroethane | ND | | 0.15 | 5.0 |
| 1,2-Dichloropropane | ND | | 0.15 | 5.0 |
| 2-Chloroethyl vinyl ether | ND | | 0.50 | 50 |
| Acrolein | ND | | 9.6 | 100 |
| Acrylonitrile | ND | | 0.67 | 100 |
| Benzene | ND | | 0.12 | 5.0 |
| Bromoform | ND | | 0.18 | 5.0 |
| Bromomethane | ND | | 0.80 | 10 |
| Carbon tetrachloride | ND | | 0.56 | 5.0 |
| Chlorobenzene | ND | | 0.17 | 5.0 |
| Chlorodibromomethane | ND | | 0.50 | 5.0 |
| Chloroethane | ND | | 0.84 | 10 |
| Chloroform | ND | | 0.18 | 5.0 |
| Chloromethane | ND | | 0.15 | 10 |
| Dichlorobromomethane | ND | | 0.50 | 5.0 |
| Ethylbenzene | ND | | 0.56 | 5.0 |
| Methylene Chloride | ND | | 0.45 | 5.0 |
| Tetrachloroethene | ND | | 0.20 | 5.0 |
| Toluene | ND | | 0.19 | 5.0 |
| trans-1,2-Dichloroethene | ND | | 0.24 | 5.0 |
| Trichloroethene | ND | | 0.29 | 5.0 |
| Vinyl chloride | ND | | 0.22 | 10 |
| 1,3-Dichloropropane | ND | | 0.50 | 5.0 |

| Surrogate | % Rec | Acceptance Limits |
|---|---|---|
| Toluene-d8 | 105 | 77 - 116 |
| Dibromofluoromethane | 107 | 66 - 125 |
| 4-Bromofluorobenzene | 105 | 70 - 118 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9901-1

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17901**

**Method: 624**
**Preparation: N/A**

LCS Lab Sample ID: LCS 700-17901/2
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/27/2006 1511
Date Prepared: N/A

Analysis Batch: 700-17901
Prep Batch: N/A
Units: ug/L

Instrument ID: VMG5973
Lab File ID: G022711.D
Initial Weight/Volume: 5 mL
Final Weight/Volume: 5 mL

LCSD Lab Sample ID: LCSD 700-17901/1
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/27/2006 1441
Date Prepared: N/A

Analysis Batch: 700-17901
Prep Batch: N/A
Units: ug/L

Instrument ID: VMG5973
Lab File ID: G022710.D
Initial Weight/Volume: 5 mL
Final Weight/Volume: 5 mL

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| 1,1,1-Trichloroethane | 81 | 82 | 52 - 162 | 1 | 25 | | |
| 1,1,2,2-Tetrachloroethane | 94 | 93 | 46 - 157 | 0 | 25 | | |
| 1,1,2-Trichloroethane | 103 | 103 | 52 - 150 | 0 | 25 | | |
| 1,1-Dichloroethane | 95 | 98 | 59 - 155 | 3 | 40 | | |
| 1,1-Dichloroethene | 100 | 104 | 1 - 234 | 4 | 25 | | |
| 1,2-Dichloroethane | 77 | 75 | 49 - 155 | 3 | 26 | | |
| 1,2-Dichloropropane | 94 | 98 | 1 - 210 | 4 | 25 | | |
| 2-Chloroethyl vinyl ether | 106 | 103 | 1 - 305 | 3 | 40 | | |
| Acrolein | 157 | 146 | 54 - 145 | 7 | 74 | * | * |
| Acrylonitrile | 117 | 112 | 10 - 183 | 5 | 41 | | |
| Benzene | 84 | 86 | 37 - 151 | 2 | 31 | | |
| Bromoform | 92 | 95 | 45 - 169 | 3 | 30 | | |
| Bromomethane | 102 | 107 | 1 - 242 | 5 | 32 | | |
| Carbon tetrachloride | 78 | 84 | 50 - 150 | 8 | 25 | | |
| Chlorobenzene | 91 | 95 | 37 - 160 | 4 | 25 | | |
| Chlorodibromomethane | 89 | 92 | 37 - 151 | 3 | 40 | | |
| Chloroethane | 124 | 128 | 14 - 230 | 3 | 36 | | |
| Chloroform | 92 | 92 | 51 - 138 | 0 | 25 | | |
| Chloromethane | 101 | 108 | 1 - 273 | 7 | 40 | | |
| Dichlorobromomethane | 80 | 82 | 53 - 149 | 2 | 25 | | |
| Ethylbenzene | 88 | 93 | 37 - 162 | 5 | 25 | | |
| Methylene Chloride | 104 | 107 | 1 - 221 | 3 | 37 | | |
| Tetrachloroethene | 97 | 104 | 64 - 148 | 7 | 40 | | |
| Toluene | 103 | 107 | 47 - 150 | 3 | 25 | | |
| trans-1,2-Dichloroethene | 95 | 100 | 54 - 156 | 5 | 40 | | |
| Trichloroethene | 92 | 99 | 71 - 157 | 7 | 25 | | |
| Vinyl chloride | 111 | 122 | 1 - 251 | 10 | 40 | | |
| 1,3-Dichloropropane | 89 | 87 | 50 - 150 | 2 | 40 | | |

| Surrogate | LCS % Rec | LCSD % Rec | Acceptance Limits |
|---|---|---|---|
| Toluene-d8 | 107 | 103 | 77 - 116 |
| Dibromofluoromethane | 115 | 108 | 66 - 125 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9901-1

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17901**

**Method: 624**
**Preparation: N/A**

| | | | | | |
|---|---|---|---|---|---|
| LCS Lab Sample ID: | LCS 700-17901/2 | Analysis Batch: | 700-17901 | Instrument ID: | VMG5973 |
| Client Matrix: | Water | Prep Batch: | N/A | Lab File ID: | G022711.D |
| Dilution: | 1.0 | Units: | ug/L | Initial Weight/Volume: | 5 mL |
| Date Analyzed: | 02/27/2006 1511 | | | Final Weight/Volume: | 5 mL |
| Date Prepared: | N/A | | | | |

| | | | | | |
|---|---|---|---|---|---|
| LCSD Lab Sample ID: | LCSD 700-17901/1 | Analysis Batch: | 700-17901 | Instrument ID: | VMG5973 |
| Client Matrix: | Water | Prep Batch: | N/A | Lab File ID: | G022710.D |
| Dilution: | 1.0 | Units: | ug/L | Initial Weight/Volume: | 5 mL |
| Date Analyzed: | 02/27/2006 1441 | | | Final Weight/Volume: | 5 mL |
| Date Prepared: | N/A | | | | |

| Surrogate | LCS % Rec | LCSD % Rec | Acceptance Limits |
|---|---|---|---|
| 4-Bromofluorobenzene | 109 | 110 | 70 - 118 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9901-1

**Method Blank - Batch: 700-17753**

**Method: 8260B**
**Preparation: 5030B**

Lab Sample ID: MB 700-17753/3
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/24/2006 1117
Date Prepared: 02/24/2006 1117

Analysis Batch: 700-17753
Prep Batch: N/A
Units: ug/Kg

Instrument ID: VMG5973
Lab File ID: G022405.D
Initial Weight/Volume: 5 mL
Final Weight/Volume: 5 g

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| 1,1,2,2-Tetrachloroethane | ND | | 1.7 | 5.0 |
| 1,1,1-Trichloroethane | ND | | 1.5 | 5.0 |
| 1,1,2-Trichloroethane | ND | | 1.2 | 5.0 |
| Toluene | ND | | 1.0 | 5.0 |
| 1,1-Dichloroethane | ND | | 1.0 | 5.0 |
| 1,1-Dichloroethene | ND | | 1.3 | 5.0 |
| 1,2-Dichloroethane | ND | | 2.0 | 5.0 |
| 1,2-Dichloropropane | ND | | 1.2 | 5.0 |
| Benzene | ND | | 1.1 | 5.0 |
| Bromoform | ND | | 1.1 | 5.0 |
| Bromomethane | ND | | 3.6 | 10 |
| Carbon tetrachloride | ND | | 1.4 | 5.0 |
| Chlorobenzene | ND | | 1.1 | 5.0 |
| Chlorodibromomethane | ND | | 1.2 | 5.0 |
| Chloroethane | ND | | 1.5 | 10 |
| Chloromethane | ND | | 2.3 | 10 |
| Chloroform | ND | | 0.82 | 5.0 |
| Dichlorobromomethane | ND | | 1.2 | 5.0 |
| 1,3-Dichloropropene, Total | ND | | 1.5 | 10 |
| Ethylbenzene | ND | | 1.8 | 5.0 |
| Methylene Chloride | ND | | 1.6 | 5.0 |
| 2-Chloroethyl vinyl ether | ND | | 17 | 50 |
| Acrolein | ND | | 28 | 100 |
| Acrylonitrile | ND | | 62 | 100 |
| Trichloroethene | ND | | 0.90 | 5.0 |
| Vinyl chloride | ND | | 1.6 | 10 |
| trans-1,2-Dichloroethene | ND | | 0.99 | 5.0 |
| Tetrachloroethene | ND | | 0.90 | 5.0 |

| Surrogate | % Rec | Acceptance Limits |
|---|---|---|
| Dibromofluoromethane | 94 | 59 - 132 |
| Toluene-d8 | 93 | 61 - 131 |
| 4-Bromofluorobenzene | 94 | 55 - 131 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9901-1

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17753**

**Method: 8260B**
**Preparation: 5030B**

LCS Lab Sample ID: LCS 700-17753/1
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/24/2006 1015
Date Prepared: 02/24/2006 1015

Analysis Batch: 700-17753
Prep Batch: N/A
Units: ug/Kg

Instrument ID: VMG5973
Lab File ID: G022403.D
Initial Weight/Volume: 5 mL
Final Weight/Volume: 5 g

LCSD Lab Sample ID: LCSD 700-17753/2
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/24/2006 1046
Date Prepared: 02/24/2006 1046

Analysis Batch: 700-17753
Prep Batch: N/A
Units: ug/Kg

Instrument ID: VMG5973
Lab File ID: G022404.D
Initial Weight/Volume: 5 mL
Final Weight/Volume: 5 g

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| Toluene | 101 | 97 | 66 - 141 | 4 | 32 | | |
| 1,1-Dichloroethene | 112 | 102 | 48 - 154 | 9 | 46 | | |
| Benzene | 95 | 90 | 69 - 137 | 5 | 42 | | |
| Chlorobenzene | 109 | 104 | 70 - 138 | 5 | 34 | | |
| Trichloroethene | 107 | 98 | 68 - 138 | 9 | 34 | | |

| Surrogate | LCS % Rec | LCSD % Rec | Acceptance Limits |
|---|---|---|---|
| Dibromofluoromethane | 96 | 99 | 59 - 132 |
| Toluene-d8 | 90 | 94 | 61 - 131 |
| 4-Bromofluorobenzene | 96 | 100 | 55 - 131 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9901-1

**Method Blank - Batch: 700-17663**

**Method: 625**
**Preparation: 3520C**

Lab Sample ID: MB 700-17663/1-A
Client Matrix: Water
Dilution: 5.0
Date Analyzed: 02/24/2006 2204
Date Prepared: 02/22/2006 0738

Analysis Batch: 700-17908
Prep Batch: 700-17663
Units: ug/L

Instrument ID: SMB5973
Lab File ID: B022418.D
Initial Weight/Volume: 1000 mL
Final Weight/Volume: 1.0 mL
Injection Volume:

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| 1,2,4-Trichlorobenzene | ND | | 1.2 | 10 |
| 1,2-Dichlorobenzene | ND | | 1.1 | 10 |
| 1,2-Diphenylhydrazine | ND | | 4.0 | 10 |
| 1,3-Dichlorobenzene | ND | | 1.1 | 10 |
| 1,4-Dichlorobenzene | ND | | 1.1 | 10 |
| 2,2'-oxybis(2-chloropropane) | ND | | 1.3 | 10 |
| 2,4,6-Trichlorophenol | ND | | 2.4 | 10 |
| 2,4-Dichlorophenol | ND | | 1.2 | 10 |
| 2,4-Dimethylphenol | ND | | 1.1 | 10 |
| 2,4-Dinitrophenol | ND | | 2.3 | 50 |
| 2,4-Dinitrotoluene | ND | | 2.2 | 10 |
| 2,6-Dinitrotoluene | ND | | 2.4 | 10 |
| 2-Chloronaphthalene | ND | | 1.7 | 10 |
| 2-Chlorophenol | ND | | 1.0 | 10 |
| 2-Nitrophenol | ND | | 1.3 | 10 |
| 3,3'-Dichlorobenzidine | ND | | 7.1 | 20 |
| 4,6-Dinitro-2-methylphenol | ND | | 2.1 | 50 |
| 4-Bromophenyl phenyl ether | ND | | 1.7 | 10 |
| 4-Chloro-3-methylphenol | ND | | 1.0 | 10 |
| 4-Chlorophenyl phenyl ether | ND | | 1.5 | 10 |
| 4-Nitrophenol | ND | | 3.6 | 50 |
| Acenaphthene | ND | | 1.3 | 10 |
| Acenaphthylene | ND | | 2.4 | 10 |
| Anthracene | ND | | 1.0 | 10 |
| Benzidine | ND | | 8.4 | 80 |
| Benzo[a]anthracene | ND | | 1.0 | 10 |
| Benzo[a]pyrene | ND | | 5.6 | 10 |
| Benzo[b]fluoranthene | ND | | 9.5 | 10 |
| Benzo[g,h,i]perylene | ND | | 5.4 | 10 |
| Benzo[k]fluoranthene | ND | | 9.0 | 10 |
| Bis(2-chloroethoxy)methane | ND | | 5.4 | 10 |
| Bis(2-chloroethyl)ether | ND | | 3.0 | 10 |
| Bis(2-ethylhexyl) phthalate | ND | | 3.3 | 10 |
| Butyl benzyl phthalate | ND | | 2.8 | 10 |
| Chrysene | ND | | 2.3 | 10 |
| Dibenz(a,h)anthracene | ND | | 9.5 | 10 |
| Diethyl phthalate | ND | | 1.7 | 10 |
| Dimethyl phthalate | ND | | 1.2 | 10 |
| Di-n-butyl phthalate | ND | | 1.2 | 10 |
| Di-n-octyl phthalate | ND | | 1.8 | 10 |
| Fluoranthene | ND | | 1.0 | 10 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9901-1

**Method Blank - Batch: 700-17663**

**Method: 625**
**Preparation: 3520C**

Lab Sample ID: MB 700-17663/1-A
Client Matrix: Water
Dilution: 5.0
Date Analyzed: 02/24/2006 2204
Date Prepared: 02/22/2006 0738

Analysis Batch: 700-17908
Prep Batch: 700-17663
Units: ug/L

Instrument ID: SMB5973
Lab File ID: B022418.D
Initial Weight/Volume: 1000 mL
Final Weight/Volume: 1.0 mL
Injection Volume:

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Fluorene | ND | | 1.5 | 10 |
| Hexachlorobenzene | ND | | 1.7 | 10 |
| Hexachlorobutadiene | ND | | 1.4 | 10 |
| Hexachlorocyclopentadiene | ND | | 1.8 | 10 |
| Hexachloroethane | ND | | 1.3 | 10 |
| Indeno[1,2,3-cd]pyrene | ND | | 2.9 | 10 |
| Isophorone | ND | | 1.1 | 10 |
| Naphthalene | ND | | 1.2 | 10 |
| Nitrobenzene | ND | | 1.4 | 10 |
| N-Nitrosodimethylamine | ND | | 2.2 | 10 |
| N-Nitrosodi-n-propylamine | ND | | 1.0 | 10 |
| N-Nitrosodiphenylamine | ND | | 10 | 10 |
| Pentachlorophenol | ND | | 2.1 | 50 |
| Phenanthrene | ND | | 1.2 | 10 |
| Phenol | ND | | 1.1 | 10 |
| Pyrene | ND | | 2.2 | 10 |

| Surrogate | % Rec | Acceptance Limits |
|---|---|---|
| 2,4,6-Tribromophenol | 92 | 14 - 93 |
| 2-Fluorobiphenyl | 83 | 34 - 118 |
| 2-Fluorophenol | 60 | 25 - 102 |
| Nitrobenzene-d5 | 108 | 39 - 133 |
| Phenol-d5 | 71 | 21 - 95 |
| Terphenyl-d14 | 73 | 16 - 158 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9901-1

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17663**

**Method: 625**
**Preparation: 3520C**

LCS Lab Sample ID: LCS 700-17663/2-A
Client Matrix: Water
Dilution: 2.0
Date Analyzed: 02/24/2006 2238
Date Prepared: 02/22/2006 0738

Analysis Batch: 700-17908
Prep Batch: 700-17663
Units: ug/L

Instrument ID: SMB5973
Lab File ID: B022419.D
Initial Weight/Volume: 1000 mL
Final Weight/Volume: 1.0 mL
Injection Volume:

LCSD Lab Sample ID: LCSD 700-17663/3-A
Client Matrix: Water
Dilution: 2.0
Date Analyzed: 02/24/2006 2312
Date Prepared: 02/22/2006 0738

Analysis Batch: 700-17908
Prep Batch: 700-17663
Units: ug/L

Instrument ID: SMB5973
Lab File ID: B022420.D
Initial Weight/Volume: 1000 mL
Final Weight/Volume: 1.0 mL
Injection Volume:

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| 1,2,4-Trichlorobenzene | 76 | 80 | 34 - 103 | 4 | 28 | | |
| 1,2-Dichlorobenzene | 64 | 67 | 23 - 104 | 4 | 30 | | |
| 1,3-Dichlorobenzene | 66 | 68 | 19 - 101 | 4 | 31 | | |
| 1,4-Dichlorobenzene | 65 | 69 | 30 - 95 | 6 | 31 | | |
| 2,4,6-Trichlorophenol | 92 | 99 | 47 - 124 | 8 | 22 | | |
| 2,4-Dichlorophenol | 85 | 91 | 42 - 121 | 6 | 30 | | |
| 2,4-Dimethylphenol | 72 | 78 | 27 - 126 | 8 | 43 | | |
| 2,4-Dinitrophenol | 67 | 79 | 17 - 147 | 16 | 63 | | |
| 2,4-Dinitrotoluene | 111 | 115 | 36 - 129 | 4 | 32 | | |
| 2,6-Dinitrotoluene | 102 | 106 | 46 - 128 | 4 | 24 | | |
| 2-Chloronaphthalene | 89 | 93 | 43 - 115 | 4 | 22 | | |
| 2-Chlorophenol | 72 | 75 | 45 - 116 | 5 | 34 | | |
| 2-Nitrophenol | 92 | 98 | 38 - 121 | 7 | 24 | | |
| 3,3'-Dichlorobenzidine | 70 | 70 | 1.0 - 119 | 0 | 72 | | |
| 4,6-Dinitro-2-methylphenol | 95 | 102 | 42 - 135 | 8 | 33 | | |
| 4-Bromophenyl phenyl ether | 99 | 104 | 39 - 109 | 5 | 26 | | |
| 4-Chloro-3-methylphenol | 88 | 92 | 48 - 128 | 4 | 31 | | |
| 4-Chlorophenyl phenyl ether | 93 | 97 | 40 - 121 | 4 | 26 | | |
| 4-Nitrophenol | 72 | 73 | 20 - 144 | 1 | 44 | | |
| Acenaphthene | 86 | 90 | 34 - 134 | 5 | 35 | | |
| Acenaphthylene | 76 | 80 | 44 - 129 | 5 | 28 | | |
| Anthracene | 82 | 85 | 44 - 126 | 4 | 21 | | |
| Benzo[a]anthracene | 90 | 91 | 39 - 134 | 2 | 34 | | |
| Benzo[a]pyrene | 87 | 89 | 30 - 132 | 2 | 24 | | |
| Benzo[b]fluoranthene | 98 | 92 | 34 - 138 | 6 | 32 | | |
| Benzo[g,h,i]perylene | 89 | 94 | 32 - 133 | 6 | 39 | | |
| Benzo[k]fluoranthene | 88 | 95 | 30 - 147 | 8 | 34 | | |
| Bis(2-chloroethoxy)methane | 103 | 106 | 36 - 125 | 3 | 20 | | |
| Bis(2-chloroethyl)ether | 89 | 90 | 22 - 132 | 1 | 58 | | |
| Bis(2-ethylhexyl) phthalate | 75 | 70 | 43 - 130 | 7 | 26 | | |
| Butyl benzyl phthalate | 74 | 73 | 43 - 136 | 1 | 41 | | |
| Chrysene | 86 | 87 | 39 - 138 | 2 | 31 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9901-1

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17663**

**Method: 625**
**Preparation: 3520C**

LCS Lab Sample ID: LCS 700-17663/2-A
Client Matrix: Water
Dilution: 2.0
Date Analyzed: 02/24/2006 2238
Date Prepared: 02/22/2006 0738

Analysis Batch: 700-17908
Prep Batch: 700-17663
Units: ug/L

Instrument ID: SMB5973
Lab File ID: B022419.D
Initial Weight/Volume: 1000 mL
Final Weight/Volume: 1.0 mL
Injection Volume:

LCSD Lab Sample ID: LCSD 700-17663/3-A
Client Matrix: Water
Dilution: 2.0
Date Analyzed: 02/24/2006 2312
Date Prepared: 02/22/2006 0738

Analysis Batch: 700-17908
Prep Batch: 700-17663
Units: ug/L

Instrument ID: SMB5973
Lab File ID: B022420.D
Initial Weight/Volume: 1000 mL
Final Weight/Volume: 1.0 mL
Injection Volume:

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| Dibenz(a,h)anthracene | 93 | 99 | 32 - 134 | 7 | 35 | | |
| Diethyl phthalate | 87 | 89 | 48 - 128 | 2 | 49 | | |
| Dimethyl phthalate | 94 | 97 | 47 - 122 | 3 | 31 | | |
| Di-n-butyl phthalate | 71 | 74 | 43 - 133 | 5 | 29 | | |
| Di-n-octyl phthalate | 85 | 88 | 41 - 129 | 4 | 33 | | |
| Fluoranthene | 73 | 75 | 39 - 139 | 3 | 24 | | |
| Fluorene | 87 | 91 | 41 - 130 | 4 | 23 | | |
| Hexachlorobenzene | 95 | 100 | 33 - 124 | 6 | 31 | | |
| Hexachlorobutadiene | 67 | 71 | 26 - 104 | 6 | 30 | | |
| Hexachlorocyclopentadiene | 27 | 28 | 1.0 - 87 | 0 | 67 | | |
| Hexachloroethane | 63 | 67 | 21 - 94 | 7 | 35 | | |
| Indeno[1,2,3-cd]pyrene | 103 | 110 | 26 - 140 | 7 | 38 | | |
| Isophorone | 87 | 90 | 34 - 140 | 3 | 33 | | |
| Naphthalene | 73 | 76 | 26 - 121 | 4 | 33 | | |
| Nitrobenzene | 97 | 100 | 34 - 124 | 4 | 40 | | |
| N-Nitrosodiphenylamine | 132 | 137 | 30 - 130 | 4 | 50 | * | * |
| Pentachlorophenol | 59 | 67 | 34 - 133 | 12 | 33 | | |
| Phenanthrene | 85 | 90 | 45 - 129 | 6 | 20 | | |
| Phenol | 63 | 63 | 29 - 122 | 0 | 36 | | |
| Pyrene | 79 | 80 | 32 - 122 | 1 | 42 | | |

| Surrogate | LCS % Rec | | LCSD % Rec | | Acceptance Limits |
|---|---|---|---|---|---|
| 2,4,6-Tribromophenol | 109 | * | 108 | * | 14 - 93 |
| 2-Fluorobiphenyl | 87 | | 85 | | 34 - 118 |
| 2-Fluorophenol | 56 | | 57 | | 25 - 102 |
| Nitrobenzene-d5 | 102 | | 101 | | 39 - 133 |
| Phenol-d5 | 64 | | 62 | | 21 - 95 |
| Terphenyl-d14 | 79 | | 77 | | 16 - 158 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9901-1

**Method Blank - Batch: 700-17631**

**Method: 8270C**
**Preparation: 3550B**

Lab Sample ID: MB 700-17631/1-A
Client Matrix: Solid
Dilution: 5.0
Date Analyzed: 02/22/2006 1751
Date Prepared: 02/22/2006 0900

Analysis Batch: 700-17714
Prep Batch: 700-17631
Units: ug/Kg

Instrument ID: SMA5972
Lab File ID: A022212.D
Initial Weight/Volume: 30.0 g
Final Weight/Volume: 1.0 mL
Injection Volume:

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| 1,2,4-Trichlorobenzene | ND | | 42 | 330 |
| 1,2-Dichlorobenzene | ND | | 45 | 330 |
| 1,2-Diphenylhydrazine | ND | | 35 | 330 |
| 1,3-Dichlorobenzene | ND | | 52 | 330 |
| 1,4-Dichlorobenzene | ND | | 35 | 330 |
| 2,2'-oxybis(2-chloropropane) | ND | | 60 | 330 |
| 2,4,6-Trichlorophenol | ND | | 39 | 330 |
| 2,4-Dichlorophenol | ND | | 36 | 330 |
| 2,4-Dimethylphenol | ND | | 38 | 330 |
| 2,4-Dinitrophenol | ND | | 43 | 1700 |
| 2,4-Dinitrotoluene | ND | | 36 | 330 |
| 2,6-Dinitrotoluene | ND | | 44 | 330 |
| 2-Chloronaphthalene | ND | | 42 | 330 |
| 2-Chlorophenol | ND | | 42 | 330 |
| 2-Nitrophenol | ND | | 36 | 330 |
| 3,3'-Dichlorobenzidine | ND | | 70 | 660 |
| 4,6-Dinitro-2-methylphenol | ND | | 78 | 1700 |
| 4-Bromophenyl phenyl ether | ND | | 42 | 330 |
| 4-Chloro-3-methylphenol | ND | | 41 | 330 |
| 4-Chlorophenyl phenyl ether | ND | | 38 | 330 |
| 4-Nitrophenol | ND | | 77 | 1700 |
| Benzidine | ND | | 220 | 2700 |
| Bis(2-chloroethoxy)methane | ND | | 39 | 330 |
| Bis(2-chloroethyl)ether | ND | | 42 | 330 |
| Bis(2-ethylhexyl) phthalate | ND | | 37 | 330 |
| Butyl benzyl phthalate | ND | | 49 | 330 |
| Dibenz(a,h)anthracene | ND | | 35 | 330 |
| Diethyl phthalate | ND | | 39 | 330 |
| Dimethyl phthalate | ND | | 41 | 330 |
| Di-n-butyl phthalate | ND | | 42 | 330 |
| Di-n-octyl phthalate | ND | | 34 | 330 |
| Hexachlorobenzene | ND | | 45 | 330 |
| Hexachlorobutadiene | ND | | 34 | 330 |
| Hexachlorocyclopentadiene | ND | | 30 | 330 |
| Hexachloroethane | ND | | 38 | 330 |
| Isophorone | ND | | 45 | 330 |
| Nitrobenzene | ND | | 36 | 330 |
| N-Nitrosodimethylamine | ND | | 170 | 330 |
| N-Nitrosodi-n-propylamine | ND | | 39 | 330 |
| N-Nitrosodiphenylamine | ND | | 45 | 330 |
| Pentachlorophenol | ND | | 36 | 1700 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9901-1

**Method Blank - Batch: 700-17631**

**Method: 8270C**
**Preparation: 3550B**

Lab Sample ID: MB 700-17631/1-A
Client Matrix: Solid
Dilution: 5.0
Date Analyzed: 02/22/2006 1751
Date Prepared: 02/22/2006 0900

Analysis Batch: 700-17714
Prep Batch: 700-17631
Units: ug/Kg

Instrument ID: SMA5972
Lab File ID: A022212.D
Initial Weight/Volume: 30.0 g
Final Weight/Volume: 1.0 mL
Injection Volume:

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Phenol | ND | | 36 | 330 |

| Surrogate | % Rec | Acceptance Limits |
|---|---|---|
| 2,4,6-Tribromophenol | 21 | 5.0 - 106 |
| 2-Fluorobiphenyl | 61 | 31 - 118 |
| 2-Fluorophenol | 72 | 10 - 128 |
| Nitrobenzene-d5 | 57 | 35 - 122 |
| Phenol-d5 | 74 | 29 - 113 |
| Terphenyl-d14 | 77 | 37 - 149 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9901-1

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17631**

**Method: 8270C**
**Preparation: 3550B**

LCS Lab Sample ID: LCS 700-17631/2-A
Client Matrix: Solid
Dilution: 5.0
Date Analyzed: 02/22/2006 1825
Date Prepared: 02/22/2006 0900

Analysis Batch: 700-17714
Prep Batch: 700-17631
Units: ug/Kg

Instrument ID: SMA5972
Lab File ID: A022213.D
Initial Weight/Volume: 30.0 g
Final Weight/Volume: 1.0 mL
Injection Volume:

LCSD Lab Sample ID: LCSD 700-17631/3-A
Client Matrix: Solid
Dilution: 5.0
Date Analyzed: 02/22/2006 1859
Date Prepared: 02/22/2006 0900

Analysis Batch: 700-17714
Prep Batch: 700-17631
Units: ug/Kg

Instrument ID: SMA5972
Lab File ID: A022214.D
Initial Weight/Volume: 30.0 g
Final Weight/Volume: 1.0 mL
Injection Volume:

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| 1,2,4-Trichlorobenzene | 65 | 63 | 34 - 103 | 3 | 22 | | |
| 1,4-Dichlorobenzene | 79 | 66 | 30 - 95 | 18 | 31 | | |
| 2,4-Dinitrotoluene | 38 | 33 | 26 - 115 | 12 | 37 | | |
| 2-Chlorophenol | 60 | 50 | 36 - 106 | 17 | 38 | | |
| 4-Chloro-3-methylphenol | 39 | 37 | 48 - 128 | 5 | 32 | * | * |
| 4-Nitrophenol | 22 | 26 | 20 - 144 | 16 | 57 | J | J |
| Pentachlorophenol | 22 | 24 | 34 - 133 | 12 | 55 | J * | J * |
| Phenol | 51 | 49 | 32 - 107 | 3 | 39 | | |

| Surrogate | LCS % Rec | LCSD % Rec | Acceptance Limits |
|---|---|---|---|
| 2,4,6-Tribromophenol | 49 | 31 | 5.0 - 106 |
| 2-Fluorobiphenyl | 72 | 66 | 31 - 118 |
| 2-Fluorophenol | 73 | 68 | 10 - 128 |
| Nitrobenzene-d5 | 54 | 52 | 35 - 122 |
| Phenol-d5 | 69 | 77 | 29 - 113 |
| Terphenyl-d14 | 76 | 74 | 37 - 149 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9901-1

**Method Blank - Batch: 700-17636**

**Method: 8270C**
**Preparation: 3550B**

Lab Sample ID: MB 700-17636/1-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/22/2006 1448
Date Prepared: 02/22/2006 0900

Analysis Batch: 700-17696
Prep Batch: 700-17636
Units: ug/Kg

Instrument ID: Agilent GC/MS 5973
Lab File ID: D022215.D
Initial Weight/Volume: 30.0 g
Final Weight/Volume: 1.0 mL
Injection Volume:

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| 1-Methylnaphthalene | ND | | 4.3 | 6.7 |
| 2-Methylnaphthalene | ND | | 3.8 | 6.7 |
| Acenaphthene | ND | | 3.5 | 6.7 |
| Acenaphthylene | ND | | 2.0 | 6.7 |
| Anthracene | ND | | 4.4 | 6.7 |
| Benzo[a]anthracene | ND | | 2.1 | 6.7 |
| Benzo[a]pyrene | ND | | 2.0 | 6.7 |
| Benzo[b]fluoranthene | ND | | 6.2 | 6.7 |
| Benzo[g,h,i]perylene | ND | | 3.0 | 6.7 |
| Benzo[k]fluoranthene | ND | | 4.3 | 6.7 |
| Chrysene | ND | | 2.3 | 6.7 |
| Fluoranthene | ND | | 3.5 | 6.7 |
| Fluorene | ND | | 2.9 | 6.7 |
| Indeno[1,2,3-cd]pyrene | ND | | 1.9 | 6.7 |
| Naphthalene | ND | | 3.4 | 6.7 |
| Phenanthrene | ND | | 3.8 | 6.7 |
| Pyrene | ND | | 1.7 | 6.7 |

| Surrogate | % Rec | Acceptance Limits |
|---|---|---|
| 2,4,6-Tribromophenol | 66 | 5.0 - 106 |
| 2-Fluorobiphenyl | 72 | 31 - 118 |
| 2-Fluorophenol | 53 | 10 - 128 |
| Nitrobenzene-d5 | 61 | 35 - 122 |
| Phenol-d5 | 51 | 29 - 113 |
| Terphenyl-d14 | 94 | 37 - 149 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9901-1

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17636**

**Method: 8270C**
**Preparation: 3550B**

LCS Lab Sample ID: LCS 700-17636/2-A
Client Matrix: Solid
Dilution: 2.0
Date Analyzed: 02/22/2006 1522
Date Prepared: 02/22/2006 0900

Analysis Batch: 700-17696
Prep Batch: 700-17636
Units: ug/Kg

Instrument ID: Agilent GC/MS 5973
Lab File ID: D022216.D
Initial Weight/Volume: 30.0 g
Final Weight/Volume: 1.0 mL
Injection Volume:

LCSD Lab Sample ID: LCSD 700-17636/3-A
Client Matrix: Solid
Dilution: 2.0
Date Analyzed: 02/22/2006 1556
Date Prepared: 02/22/2006 0900

Analysis Batch: 700-17696
Prep Batch: 700-17636
Units: ug/Kg

Instrument ID: Agilent GC/MS 5973
Lab File ID: D022217.D
Initial Weight/Volume: 30.0 g
Final Weight/Volume: 1.0 mL
Injection Volume:

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| 1,4-Dichlorobenzene | 51 | 49 | 30 - 95 | 3 | 31 | | |
| 2,4-Dinitrotoluene | 74 | 72 | 36 - 129 | 3 | 37 | | |
| 4-Chloro-3-methylphenol | 74 | 71 | 48 - 128 | 4 | 32 | | |
| Acenaphthene | 61 | 60 | 34 - 134 | 3 | 49 | | |
| Pyrene | 91 | 87 | 32 - 122 | 4 | 42 | | |

| Surrogate | LCS % Rec | LCSD % Rec | Acceptance Limits |
|---|---|---|---|
| 2,4,6-Tribromophenol | 71 | 69 | 5.0 - 106 |
| 2-Fluorobiphenyl | 63 | 61 | 31 - 118 |
| 2-Fluorophenol | 61 | 59 | 10 - 128 |
| Nitrobenzene-d5 | 58 | 55 | 35 - 122 |
| Phenol-d5 | 55 | 55 | 29 - 113 |
| Terphenyl-d14 | 94 | 89 | 37 - 149 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9901-1

**Method Blank - Batch: 700-17661**

**Method: 608**
**Preparation: CWA_Prep_CLLE**

Lab Sample ID: MB 700-17661/1-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/24/2006 2029
Date Prepared: 02/22/2006 0733

Analysis Batch: 700-17817
Prep Batch: 700-17661
Units: ug/L

Instrument ID: MSGY
Lab File ID: Y022415608.D
Initial Weight/Volume: 1000 mL
Final Weight/Volume: 5.0 mL
Injection Volume:
Column ID: PRIMARY

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Aldrin | ND | | 0.0045 | 0.050 |
| alpha-BHC | ND | | 0.0056 | 0.050 |
| beta-BHC | ND | | 0.0036 | 0.050 |
| Chlordane (technical) | ND | | 0.032 | 0.50 |
| 4,4'-DDD | ND | | 0.0076 | 0.10 |
| 4,4'-DDE | ND | | 0.0064 | 0.10 |
| 4,4'-DDT | ND | | 0.0084 | 0.10 |
| delta-BHC | ND | | 0.010 | 0.050 |
| Dieldrin | ND | | 0.0074 | 0.10 |
| Endosulfan I | ND | | 0.0044 | 0.050 |
| Endosulfan II | ND | | 0.0047 | 0.10 |
| Endosulfan sulfate | ND | | 0.0090 | 0.10 |
| Endrin | ND | | 0.0067 | 0.10 |
| Endrin aldehyde | ND | | 0.0069 | 0.10 |
| gamma-BHC (Lindane) | ND | | 0.0049 | 0.050 |
| Heptachlor | ND | | 0.0037 | 0.050 |
| Heptachlor epoxide | ND | | 0.0039 | 0.050 |
| PCB-1016 | ND | | 0.11 | 1.0 |
| PCB-1221 | ND | | 0.17 | 2.0 |
| PCB-1248 | ND | | 0.14 | 1.0 |
| PCB-1232 | ND | | 0.13 | 1.0 |
| PCB-1254 | ND | | 0.12 | 1.0 |
| PCB-1242 | ND | | 0.18 | 1.0 |
| PCB-1260 | ND | | 0.12 | 1.0 |
| Toxaphene | ND | | 0.31 | 5.0 |

| Surrogate | % Rec | Acceptance Limits |
|---|---|---|
| DCB Decachlorobiphenyl | 40 | 30 - 150 |
| Tetrachloro-m-xylene | 69 | 30 - 150 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9901-1

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17661**

**Method: 608**
**Preparation: CWA_Prep_CLLE**

LCS Lab Sample ID: LCS 700-17661/2-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/24/2006 1928
Date Prepared: 02/22/2006 0733

Analysis Batch: 700-17817
Prep Batch: 700-17661
Units: ug/L

Instrument ID: MSGY
Lab File ID: Y022413608.D
Initial Weight/Volume: 1000 mL
Final Weight/Volume: 5.0 mL
Injection Volume:
Column ID: PRIMARY

LCSD Lab Sample ID: LCSD 700-17661/3-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/24/2006 1959
Date Prepared: 02/22/2006 0733

Analysis Batch: 700-17817
Prep Batch: 700-17661
Units: ug/L

Instrument ID: MSGY
Lab File ID: Y022414608.D
Initial Weight/Volume: 1000 mL
Final Weight/Volume: 5.0 mL
Injection Volume:
Column ID: PRIMARY

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| Aldrin | 87 | 69 | 32 - 120 | 23 | 25 | | |
| alpha-BHC | 92 | 70 | 17 - 106 | 27 | 30 | | |
| beta-BHC | 97 | 78 | 34 - 136 | 23 | 35 | | |
| 4,4'-DDD | 94 | 99 | 49 - 140 | 5 | 39 | | |
| 4,4'-DDE | 90 | 88 | 44 - 115 | 3 | 18 | | |
| 4,4'-DDT | 86 | 94 | 37 - 150 | 9 | 27 | | |
| delta-BHC | 101 | 81 | 17 - 123 | 22 | 41 | | |
| Dieldrin | 85 | 73 | 40 - 142 | 16 | 42 | | |
| Endosulfan I | 95 | 81 | 24 - 147 | 15 | 24 | | |
| Endosulfan II | 88 | 79 | 45 - 145 | 11 | 22 | | |
| Endosulfan sulfate | 92 | 92 | 40 - 141 | 0 | 28 | | |
| Endrin | 82 | 81 | 36 - 137 | 1 | 25 | | |
| Endrin aldehyde | 89 | 87 | 52 - 148 | 3 | 34 | | |
| gamma-BHC (Lindane) | 95 | 74 | 24 - 118 | 24 | 26 | | |
| Heptachlor | 72 | 76 | 34 - 114 | 5 | 26 | | |
| Heptachlor epoxide | 89 | 74 | 37 - 130 | 18 | 31 | | |

| Surrogate | LCS % Rec | LCSD % Rec | Acceptance Limits |
|---|---|---|---|
| DCB Decachlorobiphenyl | 41 | 58 | 30 - 150 |
| Tetrachloro-m-xylene | 80 | 60 | 30 - 150 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9901-1

**Method Blank - Batch: 700-17522**

**Method: 8081A**
**Preparation: 3550B**

Lab Sample ID: MB 700-17522/1-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/26/2006 0235
Date Prepared: 02/20/2006 0900

Analysis Batch: 700-17870
Prep Batch: 700-17522
Units: ug/Kg

Instrument ID: MSGY
Lab File ID: Y022535.D
Initial Weight/Volume: 30.0 g
Final Weight/Volume: 5.0 mL
Injection Volume:
Column ID: PRIMARY

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Aldrin | ND | | 0.29 | 1.7 |
| alpha-BHC | ND | | 0.12 | 1.7 |
| beta-BHC | ND | | 0.12 | 1.7 |
| Chlordane (technical) | ND | | 1.5 | 17 |
| 4,4'-DDD | ND | | 0.34 | 3.3 |
| 4,4'-DDE | ND | | 0.30 | 3.3 |
| 4,4'-DDT | ND | | 0.54 | 3.3 |
| delta-BHC | ND | | 0.25 | 1.7 |
| Dieldrin | ND | | 0.26 | 3.3 |
| Endosulfan I | ND | | 0.12 | 1.7 |
| Endosulfan II | ND | | 0.39 | 3.3 |
| Endosulfan sulfate | ND | | 0.34 | 3.3 |
| Endrin | ND | | 0.38 | 3.3 |
| Endrin aldehyde | ND | | 0.38 | 3.3 |
| gamma-BHC (Lindane) | ND | | 0.11 | 1.7 |
| Heptachlor | ND | | 0.19 | 1.7 |
| Heptachlor epoxide | ND | | 0.13 | 1.7 |
| Toxaphene | ND | | 11 | 170 |

| Surrogate | % Rec | Acceptance Limits |
|---|---|---|
| DCB Decachlorobiphenyl | 76 | 30 - 150 |
| Tetrachloro-m-xylene | 48 | 30 - 150 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9901-1

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17522**

**Method: 8081A**
**Preparation: 3550B**

LCS Lab Sample ID: LCS 700-17522/2-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/26/2006 0033
Date Prepared: 02/20/2006 0900

Analysis Batch: 700-17870
Prep Batch: 700-17522
Units: ug/Kg

Instrument ID: MSGY
Lab File ID: Y022531.D
Initial Weight/Volume: 30.0 g
Final Weight/Volume: 5.0 mL
Injection Volume:
Column ID: PRIMARY

LCSD Lab Sample ID: LCSD 700-17522/3-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/26/2006 0103
Date Prepared: 02/20/2006 0900

Analysis Batch: 700-17870
Prep Batch: 700-17522
Units: ug/Kg

Instrument ID: MSGY
Lab File ID: Y022532.D
Initial Weight/Volume: 30.0 g
Final Weight/Volume: 5.0 mL
Injection Volume:
Column ID: PRIMARY

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| Aldrin | 65 | 73 | 25 - 128 | 11 | 38 | | |
| 4,4'-DDT | 60 | 56 | 24 - 148 | 7 | 26 | | |
| Dieldrin | 71 | 73 | 22 - 145 | 3 | 30 | | |
| Endrin | 97 | 103 | 26 - 140 | 7 | 32 | | |
| gamma-BHC (Lindane) | 65 | 71 | 20 - 128 | 9 | 37 | | |
| Heptachlor | 46 | 48 | 19 - 139 | 3 | 38 | | |

| Surrogate | LCS % Rec | LCSD % Rec | Acceptance Limits |
|---|---|---|---|
| DCB Decachlorobiphenyl | 76 | 79 | 30 - 150 |
| Tetrachloro-m-xylene | 48 | 54 | 30 - 150 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

## Quality Control Results

Client: Providence Engineering & Environmental

Job Number: 700-9901-1

**Method Blank - Batch: 700-17524**

**Method: 8082**
**Preparation: 3550B**

Lab Sample ID: MB 700-17524/1-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/26/2006 0235
Date Prepared: 02/20/2006 0900

Analysis Batch: 700-17870
Prep Batch: 700-17524
Units: ug/Kg

Instrument ID: MSGY
Lab File ID: Y022535pcb.D
Initial Weight/Volume: 30.0 g
Final Weight/Volume: 5.0 mL
Injection Volume:
Column ID: PRIMARY

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| PCB-1016 | ND | | 3.0 | 33 |
| PCB-1260 | ND | | 2.6 | 33 |

| Surrogate | % Rec | Acceptance Limits |
|---|---|---|
| DCB Decachlorobiphenyl | 76 | 30 - 150 |
| Tetrachloro-m-xylene | 41 | 30 - 150 |

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17524**

**Method: 8082**
**Preparation: 3550B**

LCS Lab Sample ID: LCS 700-17524/6-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/26/2006 0134
Date Prepared: 02/20/2006 0900

Analysis Batch: 700-17870
Prep Batch: 700-17524
Units: ug/Kg

Instrument ID: MSGY
Lab File ID: Y022533.D
Initial Weight/Volume: 30.0 g
Final Weight/Volume: 5.0 mL
Injection Volume:
Column ID: PRIMARY

LCSD Lab Sample ID: LCSD 700-17524/7-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/26/2006 0205
Date Prepared: 02/20/2006 0900

Analysis Batch: 700-17870
Prep Batch: 700-17524
Units: ug/Kg

Instrument ID: MSGY
Lab File ID: Y022534.D
Initial Weight/Volume: 30.0 g
Final Weight/Volume: 5.0 mL
Injection Volume:
Column ID: PRIMARY

| Surrogate | LCS % Rec | LCSD % Rec | Acceptance Limits |
|---|---|---|---|
| DCB Decachlorobiphenyl | 75 | 70 | 30 - 150 |
| Tetrachloro-m-xylene | 36 | 38 | 30 - 150 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9901-1

**Method Blank - Batch: 680-37202**

**Method: 200.8**
**Preparation: 4.1.4**
**Dissolved**

Lab Sample ID: MB 680-37202/7-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/25/2006 0542
Date Prepared: 02/23/2006 1624

Analysis Batch: 680-37853
Prep Batch: 680-37202
Units: ug/L

Instrument ID: ICP MS
Lab File ID: N/A
Initial Weight/Volume: 50 mL
Final Weight/Volume: 250 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Antimony | ND | | 1.0 | 2.5 |
| Arsenic | ND | | 0.60 | 2.5 |
| Beryllium | ND | | 0.15 | 0.50 |
| Cadmium | ND | | 0.10 | 0.50 |
| Chromium | ND | | 1.5 | 5.0 |
| Copper | ND | | 0.39 | 2.5 |
| Lead | ND | | 0.50 | 1.5 |
| Nickel | ND | | 0.15 | 1.0 |
| Silver | ND | | 0.25 | 1.0 |
| Thallium | ND | | 0.25 | 1.0 |
| Zinc | ND | | 3.5 | 20 |

**Method Blank - Batch: 680-37202**

**Method: 200.8**
**Preparation: 4.1.4**
**Dissolved**

Lab Sample ID: MB 680-37202/7-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 03/01/2006 1812
Date Prepared: 02/23/2006 1624

Analysis Batch: 680-37853
Prep Batch: 680-37202
Units: ug/L

Instrument ID: ICP MS
Lab File ID: N/A
Initial Weight/Volume: 50 mL
Final Weight/Volume: 250 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Selenium | ND | | 0.50 | 2.5 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9901-1

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 680-37202**

**Method: 200.8**
**Preparation: 4.1.4**
**Dissolved**

LCS Lab Sample ID: LCS 680-37202/8-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/25/2006 0549
Date Prepared: 02/23/2006 1624

Analysis Batch: 680-37853
Prep Batch: 680-37202
Units: ug/L

Instrument ID: ICP MS
Lab File ID: N/A
Initial Weight/Volume: 50 mL
Final Weight/Volume: 250 mL

LCSD Lab Sample ID: LCSD 680-37202/9-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/25/2006 0557
Date Prepared: 02/23/2006 1624

Analysis Batch: 680-37853
Prep Batch: 680-37202
Units: ug/L

Instrument ID: ICP MS
Lab File ID: N/A
Initial Weight/Volume: 50 mL
Final Weight/Volume: 250 mL

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| Antimony | 94 | 96 | 85 - 115 | 1 | 20 | | |
| Arsenic | 98 | 93 | 85 - 115 | 5 | 20 | | |
| Beryllium | 93 | 96 | 85 - 115 | 2 | 20 | | |
| Cadmium | 93 | 95 | 85 - 115 | 2 | 20 | | |
| Chromium | 95 | 96 | 85 - 115 | 1 | 20 | | |
| Copper | 98 | 99 | 85 - 115 | 1 | 20 | | |
| Lead | 104 | 106 | 85 - 115 | 2 | 20 | | |
| Nickel | 97 | 98 | 85 - 115 | 1 | 20 | | |
| Silver | 98 | 99 | 85 - 115 | 1 | 20 | | |
| Thallium | 99 | 102 | 85 - 115 | 3 | 20 | | |
| Zinc | 97 | 97 | 85 - 115 | 0 | 20 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9901-1

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 680-37202**

**Method: 200.8**
**Preparation: 4.1.4**
**Dissolved**

| | | | | | |
|---|---|---|---|---|---|
| LCS Lab Sample ID: | LCS 680-37202/8-A | Analysis Batch: | 680-37853 | Instrument ID: | ICP MS |
| Client Matrix: | Water | Prep Batch: | 680-37202 | Lab File ID: | N/A |
| Dilution: | 1.0 | Units: | ug/L | Initial Weight/Volume: | 50 mL |
| Date Analyzed: | 03/01/2006 1819 | | | Final Weight/Volume: | 250 mL |
| Date Prepared: | 02/23/2006 1624 | | | | |

| | | | | | |
|---|---|---|---|---|---|
| LCSD Lab Sample ID: | LCSD 680-37202/9-A | Analysis Batch: | 680-37853 | Instrument ID: | ICP MS |
| Client Matrix: | Water | Prep Batch: | 680-37202 | Lab File ID: | N/A |
| Dilution: | 1.0 | Units: | ug/L | Initial Weight/Volume: | 50 mL |
| Date Analyzed: | 03/01/2006 1826 | | | Final Weight/Volume: | 250 mL |
| Date Prepared: | 02/23/2006 1624 | | | | |

| | % Rec. | | | | | | |
|---|---|---|---|---|---|---|---|
| Analyte | LCS | LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
| Selenium | 103 | 105 | 85 - 115 | 2 | 20 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9901-1

**Method Blank - Batch: 680-37205**

**Method: 200.8**
**Preparation: 4.1.4**
**Total Recoverable**

Lab Sample ID: MB 680-37205/7-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/25/2006 0309
Date Prepared: 02/23/2006 1637

Analysis Batch: 680-37851
Prep Batch: 680-37205
Units: ug/L

Instrument ID: ICP MS
Lab File ID: N/A
Initial Weight/Volume: 50 mL
Final Weight/Volume: 250 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Antimony | ND | | 1.0 | 2.5 |
| Arsenic | ND | | 0.60 | 2.5 |
| Copper | ND | | 0.39 | 2.5 |
| Cadmium | ND | | 0.10 | 0.50 |
| Silver | ND | | 0.25 | 1.0 |
| Chromium | ND | | 1.5 | 5.0 |
| Nickel | ND | | 0.15 | 1.0 |
| Lead | ND | | 0.50 | 1.5 |
| Thallium | ND | | 0.25 | 1.0 |
| Zinc | 4.3 | J | 3.5 | 20 |

**Method Blank - Batch: 680-37205**

**Method: 200.8**
**Preparation: 4.1.4**
**Total Recoverable**

Lab Sample ID: MB 680-37205/7-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 03/01/2006 2016
Date Prepared: 02/23/2006 1637

Analysis Batch: 680-37851
Prep Batch: 680-37205
Units: ug/L

Instrument ID: ICP MS
Lab File ID: N/A
Initial Weight/Volume: 50 mL
Final Weight/Volume: 250 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Selenium | ND | | 0.50 | 2.5 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9901-1

**Method Blank - Batch: 680-37205**

**Method: 200.8**
**Preparation: 4.1.4**
**Total Recoverable**

Lab Sample ID: MB 680-37205/7-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 03/03/2006 0632
Date Prepared: 02/23/2006 1637

Analysis Batch: 680-37851
Prep Batch: 680-37205
Units: ug/L

Instrument ID: ICP MS
Lab File ID: N/A
Initial Weight/Volume: 50 mL
Final Weight/Volume: 250 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Beryllium | ND | | 0.15 | 0.50 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9901-1

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 680-37205**

**Method: 200.8**
**Preparation: 4.1.4**
**Total Recoverable**

LCS Lab Sample ID: LCS 680-37205/8-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/25/2006 0316
Date Prepared: 02/23/2006 1637

Analysis Batch: 680-37851
Prep Batch: 680-37205
Units: ug/L

Instrument ID: ICP MS
Lab File ID: N/A
Initial Weight/Volume: 50 mL
Final Weight/Volume: 250 mL

LCSD Lab Sample ID: LCSD 680-37205/9-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/25/2006 0323
Date Prepared: 02/23/2006 1637

Analysis Batch: 680-37851
Prep Batch: 680-37205
Units: ug/L

Instrument ID: ICP MS
Lab File ID: N/A
Initial Weight/Volume: 50 mL
Final Weight/Volume: 250 mL

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| Antimony | 100 | 94 | 85 - 115 | 6 | 20 | | |
| Arsenic | 109 | 97 | 85 - 115 | 12 | 20 | | |
| Copper | 113 | 98 | 85 - 115 | 14 | 20 | | |
| Cadmium | 101 | 93 | 85 - 115 | 8 | 20 | | |
| Silver | 103 | 99 | 85 - 115 | 4 | 20 | | |
| Chromium | 109 | 94 | 85 - 115 | 14 | 20 | | |
| Nickel | 111 | 97 | 85 - 115 | 13 | 20 | | |
| Lead | 106 | 101 | 85 - 115 | 5 | 20 | | |
| Thallium | 103 | 98 | 85 - 115 | 5 | 20 | | |
| Zinc | 103 | 97 | 85 - 115 | 6 | 20 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental Job Number: 700-9901-1

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 680-37205**

**Method: 200.8**
**Preparation: 4.1.4**
**Total Recoverable**

| | | | |
|---|---|---|---|
| LCS Lab Sample ID: | LCS 680-37205/8-A | Analysis Batch: 680-37851 | Instrument ID: ICP MS |
| Client Matrix: | Water | Prep Batch: 680-37205 | Lab File ID: N/A |
| Dilution: | 1.0 | Units: ug/L | Initial Weight/Volume: 50 mL |
| Date Analyzed: | 03/01/2006 2023 | | Final Weight/Volume: 250 mL |
| Date Prepared: | 02/23/2006 1637 | | |

| | | | |
|---|---|---|---|
| LCSD Lab Sample ID: | LCSD 680-37205/9-A | Analysis Batch: 680-37851 | Instrument ID: ICP MS |
| Client Matrix: | Water | Prep Batch: 680-37205 | Lab File ID: N/A |
| Dilution: | 1.0 | Units: ug/L | Initial Weight/Volume: 50 mL |
| Date Analyzed: | 03/01/2006 2030 | | Final Weight/Volume: 250 mL |
| Date Prepared: | 02/23/2006 1637 | | |

| | % Rec. | | | | | | |
|---|---|---|---|---|---|---|---|
| Analyte | LCS | LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
| Selenium | 99 | 97 | 85 - 115 | 2 | 20 | | |

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 680-37205**

**Method: 200.8**
**Preparation: 4.1.4**
**Total Recoverable**

| | | | |
|---|---|---|---|
| LCS Lab Sample ID: | LCS 680-37205/8-A | Analysis Batch: 680-37851 | Instrument ID: ICP MS |
| Client Matrix: | Water | Prep Batch: 680-37205 | Lab File ID: N/A |
| Dilution: | 1.0 | Units: ug/L | Initial Weight/Volume: 50 mL |
| Date Analyzed: | 03/03/2006 0639 | | Final Weight/Volume: 250 mL |
| Date Prepared: | 02/23/2006 1637 | | |

| | | | |
|---|---|---|---|
| LCSD Lab Sample ID: | LCSD 680-37205/9-A | Analysis Batch: 680-37851 | Instrument ID: ICP MS |
| Client Matrix: | Water | Prep Batch: 680-37205 | Lab File ID: N/A |
| Dilution: | 1.0 | Units: ug/L | Initial Weight/Volume: 50 mL |
| Date Analyzed: | 03/03/2006 0646 | | Final Weight/Volume: 250 mL |
| Date Prepared: | 02/23/2006 1637 | | |

| | % Rec. | | | | | | |
|---|---|---|---|---|---|---|---|
| Analyte | LCS | LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
| Beryllium | 98 | 98 | 85 - 115 | 0 | 20 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9901-1

**Method Blank - Batch: 700-17565**

**Method: 245.1**
**Preparation: 245.1**

Lab Sample ID: MB 700-17565/1-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/22/2006 1043
Date Prepared: 02/21/2006 1015

Analysis Batch: 700-17622
Prep Batch: 700-17565
Units: mg/L

Instrument ID: LEEMAN PS200
Lab File ID: N/A
Initial Weight/Volume: 40.0 mL
Final Weight/Volume: 40.0 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Mercury | ND | | 0.000078 | 0.00020 |

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17565**

**Method: 245.1**
**Preparation: 245.1**

LCS Lab Sample ID: LCS 700-17565/2-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/22/2006 1045
Date Prepared: 02/21/2006 1015

Analysis Batch: 700-17622
Prep Batch: 700-17565
Units: mg/L

Instrument ID: LEEMAN PS200
Lab File ID: N/A
Initial Weight/Volume: 40.0 mL
Final Weight/Volume: 40.0 mL

LCSD Lab Sample ID: LCSD 700-17565/3-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/22/2006 1046
Date Prepared: 02/21/2006 1015

Analysis Batch: 700-17622
Prep Batch: 700-17565
Units: mg/L

Instrument ID: LEEMAN PS200
Lab File ID: N/A
Initial Weight/Volume: 40.0 mL
Final Weight/Volume: 40.0 mL

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| Mercury | 114 | 113 | 80 - 120 | 2 | 20 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9901-1

**Method Blank - Batch: 680-37134**

**Method: 6020**
**Preparation: 3050B**

Lab Sample ID: MB 680-37134/11-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/24/2006 2117
Date Prepared: 02/23/2006 1049

Analysis Batch: 680-37413
Prep Batch: 680-37134
Units: mg/Kg

Instrument ID: ICP MS
Lab File ID: N/A
Initial Weight/Volume: 1.00 g
Final Weight/Volume: 1000 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Antimony | ND | | 0.20 | 0.50 |
| Arsenic | ND | | 0.12 | 0.50 |
| Beryllium | ND | | 0.030 | 0.10 |
| Cadmium | ND | | 0.020 | 0.10 |
| Chromium | ND | | 0.30 | 1.0 |
| Copper | 0.085 | J | 0.038 | 0.50 |
| Lead | ND | | 0.10 | 0.30 |
| Selenium | ND | | 0.10 | 0.50 |
| Silver | ND | | 0.050 | 0.20 |
| Thallium | ND | | 0.050 | 0.20 |
| Zinc | 0.31 | J | 0.27 | 4.0 |

**Method Blank - Batch: 680-37134**

**Method: 6020**
**Preparation: 3050B**

Lab Sample ID: MB 680-37134/11-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/25/2006 2028
Date Prepared: 02/23/2006 1049

Analysis Batch: 680-37413
Prep Batch: 680-37134
Units: mg/Kg

Instrument ID: ICP MS
Lab File ID: N/A
Initial Weight/Volume: 1.00 g
Final Weight/Volume: 1000 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Nickel | 0.051 | J | 0.030 | 0.20 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9901-1

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 680-37134**

**Method: 6020**
**Preparation: 3050B**

LCS Lab Sample ID: LCS 680-37134/12-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/24/2006 2125
Date Prepared: 02/23/2006 1049

Analysis Batch: 680-37413
Prep Batch: 680-37134
Units: mg/Kg

Instrument ID: ICP MS
Lab File ID: N/A
Initial Weight/Volume: 1.00 g
Final Weight/Volume: 1000 mL

LCSD Lab Sample ID: LCSD 680-37134/13-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/24/2006 2132
Date Prepared: 02/23/2006 1049

Analysis Batch: 680-37413
Prep Batch: 680-37134
Units: mg/Kg

Instrument ID: ICP MS
Lab File ID: N/A
Initial Weight/Volume: 1.00 g
Final Weight/Volume: 1000 mL

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| Antimony | 95 | 93 | 75 - 125 | 2 | 20 | | |
| Arsenic | 97 | 95 | 75 - 125 | 1 | 20 | | |
| Beryllium | 94 | 91 | 75 - 125 | 3 | 20 | | |
| Cadmium | 94 | 91 | 75 - 125 | 3 | 20 | | |
| Chromium | 95 | 96 | 75 - 125 | 2 | 20 | | |
| Copper | 107 | 99 | 75 - 125 | 8 | 20 | | |
| Lead | 100 | 100 | 75 - 125 | 0 | 20 | | |
| Selenium | 93 | 93 | 75 - 125 | 0 | 20 | | |
| Silver | 102 | 99 | 75 - 125 | 3 | 20 | | |
| Thallium | 95 | 97 | 75 - 125 | 2 | 20 | | |
| Zinc | 97 | 95 | 75 - 125 | 3 | 20 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9901-1

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 680-37134**

**Method: 6020**
**Preparation: 3050B**

| | | | |
|---|---|---|---|
| LCS Lab Sample ID: | LCS 680-37134/12-A | Analysis Batch: 680-37413 | Instrument ID: ICP MS |
| Client Matrix: | Solid | Prep Batch: 680-37134 | Lab File ID: N/A |
| Dilution: | 1.0 | Units: mg/Kg | Initial Weight/Volume: 1.00 g |
| Date Analyzed: | 02/25/2006 2035 | | Final Weight/Volume: 1000 mL |
| Date Prepared: | 02/23/2006 1049 | | |

| | | | |
|---|---|---|---|
| LCSD Lab Sample ID: | LCSD 680-37134/13-A | Analysis Batch: 680-37413 | Instrument ID: ICP MS |
| Client Matrix: | Solid | Prep Batch: 680-37134 | Lab File ID: N/A |
| Dilution: | 1.0 | Units: mg/Kg | Initial Weight/Volume: 1.00 g |
| Date Analyzed: | 02/25/2006 2043 | | Final Weight/Volume: 1000 mL |
| Date Prepared: | 02/23/2006 1049 | | |

| | % Rec. | | | | | | |
|---|---|---|---|---|---|---|---|
| Analyte | LCS | LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
| Nickel | 101 | 99 | 75 - 125 | 3 | 20 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

## Quality Control Results

Client: Providence Engineering & Environmental

Job Number: 700-9901-1

**Method Blank - Batch: 700-17806**

**Method: 7471A**
**Preparation: 7471A**

Lab Sample ID: MB 700-17806/1-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/27/2006 1512
Date Prepared: 02/27/2006 0948

Analysis Batch: 700-17846
Prep Batch: 700-17806
Units: mg/Kg

Instrument ID: LEEMAN PS200
Lab File ID: N/A
Initial Weight/Volume: 0.40 g
Final Weight/Volume: 40.0 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Mercury | ND | | 0.010 | 0.020 |

**Laboratory Control Sample - Batch: 700-17806**

**Method: 7471A**
**Preparation: 7471A**

Lab Sample ID: LCS 700-17806/2-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/27/2006 1619
Date Prepared: 02/27/2006 0948

Analysis Batch: 700-17849
Prep Batch: 700-17806
Units: mg/Kg

Instrument ID: LEEMAN PS200
Lab File ID: N/A
Initial Weight/Volume: 0.40 g
Final Weight/Volume: 40.0 mL

| Analyte | Spike Amount | Result | % Rec. | Limit | Qual |
|---|---|---|---|---|---|
| Mercury | 0.295 | 0.31 | 104 | 80 - 120 | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9901-1

**Method Blank - Batch: 700-17683**

**Method: 350.1**
**Preparation: N/A**

Lab Sample ID: MB 700-17683/1
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/22/2006 1855
Date Prepared: N/A

Analysis Batch: 700-17683
Prep Batch: N/A
Units: mg/L

Instrument ID: KONELAB AUTOANALYZE
Lab File ID: N/A
Initial Weight/Volume: 10 mL
Final Weight/Volume: 10 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Ammonia | 0.026 | J | 0.0070 | 0.030 |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental Job Number: 700-9901-1

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17683**

**Method: 350.1**
**Preparation: N/A**

LCS Lab Sample ID: LCS 700-17683/32
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/22/2006 1913
Date Prepared: N/A

Analysis Batch: 700-17683
Prep Batch: N/A
Units: mg/L

Instrument ID: KONELAB AUTOANALYZE
Lab File ID: N/A
Initial Weight/Volume: 10 mL
Final Weight/Volume: 10 mL

LCSD Lab Sample ID: LCSD 700-17683/37
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/22/2006 1944
Date Prepared: N/A

Analysis Batch: 700-17683
Prep Batch: N/A
Units: mg/L

Instrument ID: KONELAB AUTOANALYZ
Lab File ID: N/A
Initial Weight/Volume: 10 mL
Final Weight/Volume: 10 mL

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| Ammonia | 94 | 92 | 85 - 115 | 2.8 | 30.0 | | |

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17683**

**Method: 350.1**
**Preparation: N/A**

LCS Lab Sample ID: LCS 700-17683/4
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/22/2006 1855
Date Prepared: N/A

Analysis Batch: 700-17683
Prep Batch: N/A
Units: mg/L

Instrument ID: KONELAB AUTOANALYZE
Lab File ID: N/A
Initial Weight/Volume: 10 mL
Final Weight/Volume: 10 mL

LCSD Lab Sample ID: LCSD 700-17683/5
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 02/22/2006 1855
Date Prepared: N/A

Analysis Batch: 700-17683
Prep Batch: N/A
Units: mg/L

Instrument ID: KONELAB AUTOANALYZ
Lab File ID: N/A
Initial Weight/Volume: 10 mL
Final Weight/Volume: 10 mL

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| Ammonia | 90 | 90 | 85 - 115 | 0.1 | 30.0 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9901-1

**Method Blank - Batch: 700-17780**

**Method: 350.1**
**Preparation: N/A**

Lab Sample ID: MB 700-17780/1
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/24/2006 1655
Date Prepared: N/A

Analysis Batch: 700-17780
Prep Batch: N/A
Units: mg/Kg

Instrument ID: No Equipment Assigned
Lab File ID: N/A
Initial Weight/Volume: 10 mL
Final Weight/Volume: 10 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Ammonia-Soluble | 0.012 | J | 0.0070 | 0.025 |

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17780**

**Method: 350.1**
**Preparation: N/A**

LCS Lab Sample ID: LCS 700-17780/2
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/24/2006 1655
Date Prepared: N/A

Analysis Batch: 700-17780
Prep Batch: N/A
Units: mg/Kg

Instrument ID: No Equipment Assigned
Lab File ID: N/A
Initial Weight/Volume: 10 mL
Final Weight/Volume: 10 mL

LCSD Lab Sample ID: LCSD 700-17780/3
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 02/24/2006 1655
Date Prepared: N/A

Analysis Batch: 700-17780
Prep Batch: N/A
Units: mg/Kg

Instrument ID: No Equipment Assigned
Lab File ID: N/A
Initial Weight/Volume: 10 mL
Final Weight/Volume: 10 mL

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| Ammonia-Soluble | 91 | 92 | 75 - 125 | 1 | 30 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9901-1

**Method Blank - Batch: 700-17803**

**Method: 351.2**
**Preparation: 351.2**

Lab Sample ID: MB 700-17803/1-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 03/01/2006 1229
Date Prepared: 02/24/2006 1656

Analysis Batch: 700-17939
Prep Batch: 700-17803
Units: mg/L

Instrument ID: QUICKCHEM 8000
Lab File ID: TKN0301.FDT
Initial Weight/Volume: 20 mL
Final Weight/Volume: 20 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Nitrogen, Kjeldahl | ND | | 0.15 | 0.20 |

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17803**

**Method: 351.2**
**Preparation: 351.2**

LCS Lab Sample ID: LCS 700-17803/2-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 03/01/2006 1229
Date Prepared: 02/24/2006 1656

Analysis Batch: 700-17939
Prep Batch: 700-17803
Units: mg/L

Instrument ID: QUICKCHEM 8000
Lab File ID: TKN0301.FDT
Initial Weight/Volume: 20 mL
Final Weight/Volume: 20 mL

LCSD Lab Sample ID: LCSD 700-17803/3-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 03/01/2006 1230
Date Prepared: 02/24/2006 1656

Analysis Batch: 700-17939
Prep Batch: 700-17803
Units: mg/L

Instrument ID: QUICKCHEM 8000
Lab File ID: TKN0301.FDT
Initial Weight/Volume: 20 mL
Final Weight/Volume: 20 mL

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| Nitrogen, Kjeldahl | 90 | 81 | 75 - 125 | 10 | 40 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9901-1

**Method Blank - Batch: 680-38778**

**Method: 353.2**
**Preparation: N/A**

Lab Sample ID: MB 680-38778/1
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 03/13/2006 1158
Date Prepared: N/A

Analysis Batch: 680-38778
Prep Batch: N/A
Units: mg/L

Instrument ID: KoneLab2
Lab File ID: N/A
Initial Weight/Volume: 10 mL
Final Weight/Volume: 10 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Nitrogen, Nitrate Nitrite | ND | | 0.025 | 0.050 |

**Laboratory Control Sample - Batch: 680-38778**

**Method: 353.2**
**Preparation: N/A**

Lab Sample ID: LCS 680-38778/2
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 03/13/2006 1158
Date Prepared: N/A

Analysis Batch: 680-38778
Prep Batch: N/A
Units: mg/L

Instrument ID: KoneLab2
Lab File ID: N/A
Initial Weight/Volume: 10 mL
Final Weight/Volume: 10 mL

| Analyte | Spike Amount | Result | % Rec. | Limit | Qual |
|---|---|---|---|---|---|
| Nitrogen, Nitrate | 1.00 | 1.0 | 104 | 80 - 120 | |
| Nitrogen, Nitrate Nitrite | 1.00 | 1.0 | 104 | 80 - 120 | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

## Quality Control Results

Client: Providence Engineering & Environmental

Job Number: 700-9901-1

**Method Blank - Batch: 680-38781**

**Method: 353.2**
**Preparation: 183**

Lab Sample ID: MB 680-38781/1-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 03/13/2006 1113
Date Prepared: 03/10/2006 1400

Analysis Batch: 680-38782
Prep Batch: 680-38781
Units: mg/Kg

Instrument ID: KoneLab2
Lab File ID: N/A
Initial Weight/Volume: 1.00 g
Final Weight/Volume: 100 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Nitrogen, Nitrate Nitrite | ND | | 2.5 | 5.0 |

**Laboratory Control Sample - Batch: 680-38781**

**Method: 353.2**
**Preparation: 183**

Lab Sample ID: LCS 680-38781/2-A
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 03/13/2006 1113
Date Prepared: 03/10/2006 1400

Analysis Batch: 680-38782
Prep Batch: 680-38781
Units: mg/Kg

Instrument ID: KoneLab2
Lab File ID: N/A
Initial Weight/Volume: 1.00 g
Final Weight/Volume: 100 mL

| Analyte | Spike Amount | Result | % Rec. | Limit | Qual |
|---|---|---|---|---|---|
| Nitrogen, Nitrate Nitrite | 100 | 110 | 107 | 75 - 125 | |

**Matrix Spike/**
**Matrix Spike Duplicate Recovery Report - Batch: 680-38781**

**Method: 353.2**
**Preparation: 183**

MS Lab Sample ID: 700-9901-5
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 03/13/2006 1113
Date Prepared: 03/10/2006 1400

Analysis Batch: 680-38782
Prep Batch: 680-38781

Instrument ID: KoneLab2
Lab File ID: N/A
Initial Weight/Volume: 1.08 g
Final Weight/Volume: 100 mL

MSD Lab Sample ID: 700-9901-5
Client Matrix: Solid
Dilution: 1.0
Date Analyzed: 03/13/2006 1113
Date Prepared: 03/10/2006 1400

Analysis Batch: 680-38782
Prep Batch: 680-38781

Instrument ID: KoneLab2
Lab File ID: N/A
Initial Weight/Volume: 1.01 g
Final Weight/Volume: 100 mL

| Analyte | % Rec. MS | % Rec. MSD | Limit | RPD | RPD Limit | MS Qual | MSD Qual |
|---|---|---|---|---|---|---|---|
| Nitrogen, Nitrate Nitrite | 108 | 108 | 75 - 125 | 7 | 30 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

**Quality Control Results**

Client: Providence Engineering & Environmental

Job Number: 700-9901-1

**Method Blank - Batch: 700-17804**

**Method: 365.4**
**Preparation: 365.2/365.3**

Lab Sample ID: MB 700-17804/1-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 03/01/2006 1229
Date Prepared: 02/24/2006 1656

Analysis Batch: 700-17938
Prep Batch: 700-17804
Units: mg/L

Instrument ID: QUICKCHEM 8000
Lab File ID: TKN0301.FDT
Initial Weight/Volume: 20 mL
Final Weight/Volume: 20 mL

| Analyte | Result | Qual | MDL | RL |
|---|---|---|---|---|
| Phosphorus, Total | 0.054 | J | 0.000030 | 0.10 |

**Laboratory Control/**
**Laboratory Control Duplicate Recovery Report - Batch: 700-17804**

**Method: 365.4**
**Preparation: 365.2/365.3**

LCS Lab Sample ID: LCS 700-17804/2-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 03/01/2006 1229
Date Prepared: 02/24/2006 1656

Analysis Batch: 700-17938
Prep Batch: 700-17804
Units: mg/L

Instrument ID: QUICKCHEM 8000
Lab File ID: TKN0301.FDT
Initial Weight/Volume: 20 mL
Final Weight/Volume: 20 mL

LCSD Lab Sample ID: LCSD 700-17804/3-A
Client Matrix: Water
Dilution: 1.0
Date Analyzed: 03/01/2006 1230
Date Prepared: 02/24/2006 1656

Analysis Batch: 700-17938
Prep Batch: 700-17804
Units: mg/L

Instrument ID: QUICKCHEM 8000
Lab File ID: TKN0301.FDT
Initial Weight/Volume: 20 mL
Final Weight/Volume: 20 mL

| Analyte | % Rec. LCS | % Rec. LCSD | Limit | RPD | RPD Limit | LCS Qual | LCSD Qual |
|---|---|---|---|---|---|---|---|
| Phosphorus, Total | 106 | 98 | 60 - 140 | 7 | 40 | | |

Calculations are performed before rounding to avoid round-off errors in calculated results.

# APPENDIX E

# USACE 404(b)(1) GUIDELINES EVALUATION EXAMPLE

## Section 404(b)(1) Guidelines Evaluation Example

This appendix presents a Section 404(b)(1) Guideline Evaluation Example for the implementation of the Caminada Headlands and Shell Island Restoration projects. This evaluation is based on the regulations found in the Code of Federal Regulations (CFR) at 40 CFR 230, Section 404(b)(1): Guidelines for Specification of Disposal Sites for Dredged or Fill Material. The regulations implement Sections 404(b) and 501(a) of the Clean Water Act, which govern the disposal of dredged and fill material inside the territorial sea baseline [§230.2(b)].

### 404 (b)(1) Evaluation

The following Section 404(b)(1) evaluation example is presented in a format that addresses all required elements of the evaluation.

### *Project Description*

a. Location: All restoration projects proposed for restoration exist in the Gulf of Mexico near the mouth of the Mississippi River. The project area (see **Figure 1**) consists of four potential borrow sources and two restoration sites (Caminada Headlands and Shell Island). The three potential borrow sources for Shell Island restoration are the Empire Borrow Source, the Sandy Point Borrow Source, and the Mississippi River at Nairn Borrow Source. The one potential borrow source for Caminada Headlands restoration is the South Pelto Borrow Source which is part of Ship Shoal.

b. General Description: This project addresses the restoration of the Caminada Headland and Shell Island barrier island shoreline reaches of the Barataria Basin. These landforms are in dire need of restoration due to a combination of natural and anthropogenic forces. Sediment loss can be attributed to natural cycles, dredging activities, and the channelization and levee system of the lower Mississippi River, which discharges the vast majority of its sediment off the continental shelf into deep water.

   Restoration of these landforms will help protect and restore unique habitats that are crucial to the viability of migratory birds, commercial and recreational fisheries, and a great variety of terrestrial and aquatic species. These landforms also contribute to maintenance of water quality in the region by reducing suspended sediment and nutrient loading in the aquatic environment. In addition, they reduce the impacts of flooding and storm surges on infrastructures in the coastal region, including highways, oil and gas production facilities, pipelines, and navigation features, such as ports and channels.

c. Authority and Purpose: Authority to implement the evaluation of Water Quality Impacts on the various dredge and restoration project areas is granted by the Louisiana Department of Natural Resources.

d. General Description of Dredged Material: Approximately 10.5 million cubic yards of dredged material would be removed from the four potential borrow sources and deposited in the two identified restoration areas. The dredge material from the potential borrow sites is generally a sandy/silty material. Geotechnical testing of the dredge material was performed as part of the Feasibility Study.

e. Proposed Dredged Material Placement Sites: The three potential borrow sources for Shell Island restoration are the Empire Borrow Source, the Sandy Point Borrow Source, and the Mississippi River at Nairn Borrow Source. The one potential borrow source for Caminada Headlands restoration is the South Pelto Borrow Source which is part of Ship Shoal.

f. Disposal Method: Dredged material placement/disposal will use the same methods described in the Feasibility Study.

***Factual Determinations***

a. Physical Substrate Determinations

(1) Substrate Elevation and Slope: There will be no changes to substrate elevation and side slopes due to consolidated implementation because the ultimate configuration is the same.

(2) Sediment Type: There will be no changes to sediment type due to consolidated implementation because the ultimate configuration and sediment type is the same.

(3) Dredged Material Movement: A dredging method has not been determined at this time. Conventional and hydraulic dredging are being evaluated as part of the Feasibility Study. Dredged material movement would be by barge/transport vessel or pipeline with maximized capacity (*i.e.* minor short-term movement), to reduce the frequency of events (*e.g.*, number of dredging episodes) and the frequency of dredged material movement.

(4) Physical Effects on Benthos: The physical effects on benthos would be as described in the Section 3.3 of the *Water Quality Assessment Report* (*i.e.* minor short-term disruption and no long-term impact).

(5) Other Effects: None identified

(6) Action to Minimize Impacts: Not applicable

b. Water Circulation, Fluctuations, and Salinity Determinations

(1) Water

(a) Salinity: Because dredging and placement does not govern the overall water mass movements (tidal flow and river discharge) that control salinity, predicted changes in salinity for consolidated implementation are minimal and less than or equal to the magnitude of change described in the *Water Quality Assessment Report*.

(b) Water Chemistry: The small, localized effects on water chemistry during consolidated dredging and placement operations would be similar to those described in the *Water Quality Assessment Report*, but would reduce the frequency of events (*i.e.* number of dredging episodes) and the frequency of effects. The effects are associated with sediment resuspension from dredging activities and barge overflow from dredged material suitable for remediation. The localized effects will be limited to the period of time that the dredging activities take place which would be of less overall duration than unconsolidated implementation.

(c) Clarity: The temporary and localized increase in turbidity described in the *Water Quality Assessment Report* associated with sediment resuspension during dredging and placement activities and barge overflow would occur during consolidated implementation, but the frequency of events (*i.e.* number of dredging episodes) and the frequency of effects would be reduced.

(d) Color: Minor temporary changes possible

(e) Odor: Odors typical of dredging operations will be created in the project area during dredging and placement operations under consolidated implementation. Because the site is remote from residential areas, potential odors will have minimal to no impact, and be no different from unconsolidated implementation.

(f) Taste: Not applicable

(g) Dissolved Gas Levels: Turbulence created by barge overflow may cause temporary, primarily surface variations in dissolved gas levels, but no difference from unconsolidated implementation.

(h) Nutrients: Temporary and localized nutrient increases may occur due to sediment resuspension during dredging and placement activities and barge overflow. No long-term increase in nutrients and eutrophication will result attributable to consolidated implementation.

(i) Eutrophication: A short-term, localized increase in nutrients could contribute to an increase in algal growth. However, the limited quantity of disturbed sediments will result in minimal short-term nutrient releases

which will not result in project area eutrophication nor differ from short term impacts without consolidation.

(j) Other: None identified

(2) Current Patterns and Circulation: No impacts identified

(3) Normal Water Level Fluctuations: No impacts identified

(4) Salinity Gradients: No impacts expected

(5) Actions to Minimize Impacts: Not applicable

c. Suspended Particulate/Turbidity Determination

(1) Change at Placement Site: As with the unconsolidated actions, short-term, localized increases in suspended particulates/turbidity are expected as a result of barge overflow and placement of material at ocean remediation/artificial reef sites, but these will be no different than from unconsolidated implementation, and no long-term changes are expected.

(2) Effects on Chemical and Physical Properties of the Water Column: Impacts should be short-term and localized as a result of dredging and placement activities, but these will be no different than from unconsolidated impacts, and no long-term changes are expected.

(3) Effects on Biota: Short-term exposure due to localized sediment resuspension during dredging activities and barge overflow are expected, but this will be no different than from unconsolidated implementation and no long-term effects are projected.

(4) Action to Minimize Impacts: Where appropriate, dredging activities will adhere to mechanical dredging limitations (*e.g.*, slow hoist-rates) and no barge overflow as proscribed by state water quality certifications and dredging permits.

d. Contaminant Determination: As noted in 40 CFR §227.13 (b), dredged material which meets the criteria set forth in the following paragraphs (b)(1), (2), or (3) of 40 CFR §227.13is environmentally acceptable for ocean dumping without further testing under this section *(if)*:

(1) Dredged material is composed predominantly of sand, gravel, rock, or any other naturally occurring bottom material with particle sizes larger than silt, and the material is found in areas of high current or wave energy such as streams with large bed loads or coastal areas with shifting bars and channels; or

(2) Dredged material is for beach nourishment or restoration and is composed predominantly of sand, gravel or shell with particle sizes compatible with material on the receiving beaches; or

(3) *When* (ii) The site from which the material proposed for disposal is far removed from known existing and historical sources of pollution so as to provide reasonable assurance that such material has not been contaminated by such pollution. Surface samples were collected and analyzed as part of the *Water Quality Assessment*. There is no evidence of soils contamination above the Louisiana Department of Environmental Quality's (LDEQ's) Risk Evaluation/Correction Action Program (RECAP) screening standards.

The volume and type of material to be removed will be the same under either unconsolidated or consolidated implementation. Since the dredge area sediments in the project areas are predominantly undisturbed, and a large percentage of the clean material consists of rock and clay, the majority of the dredged material to be removed below the existing authorized channel depth meets the criteria listed above under (b) (1) and (b) (3) (ii) for ocean disposal without testing. Barge overflow related to sediments from the channel area should not contain any contaminants and therefore will have no adverse environmental impacts. In addition, rock material removed from the project area could be used in the construction of artificial reefs.

e. Aquatic Ecosystems and Organisms Determination: No impact

f. Proposed Disposal Site Determination: Appropriate disposal sites as identified in the *Water Quality Assessment Report* or identified following release of the report will be used.

g. Determination of Cumulative Effects on the Aquatic Ecosystem: None identified

h. Determination of Secondary Effects on the Aquatic Ecosystem: None identified

***Findings of Compliance or Noncompliance***

a. There are no practicable alternatives for the proposed action under the jurisdiction of Section 404(b)(1) Guidelines.

b. The proposed action does not appear to violate applicable state water quality standards or effluent standards.

c. The proposed action will not result in significant adverse impacts on human health or welfare, including municipal and private water supplies, recreational and commercial fishing, plankton, fish, shellfish, wildlife and special aquatic sites.

d. All appropriate steps to minimize adverse environmental impacts will be taken.

e. No significant adaptations of the guidelines were made relative to this evaluation.

***Conclusions***

Based on all of the above, the proposed action is determined to be in compliance with the Section 404(b)(1) Guidelines, subject to appropriate and reasonable conditions, to be determined on a case-by-case basis, to protect the public interest, assuming appropriate mitigation measures are implemented during construction.

# APPENDIX F

# USACE 404(b)(1) SHORT FORM

`The following short form 404(b)(1) evaluation follows the format designed by the Office of the Chief of Engineers, (OCE). As a measure to avoid unnecessary paperwork and to streamline regulation procedures while fulfilling the spirit and intent of environmental statutes, New Orleans District is using this format for all proposed project elements requiring 404 evaluation, but involving no adverse significant impacts.

**PROJECT DESCRIPTION.**

This project addresses the restoration of the Caminada Headland and Shell Island barrier island shoreline reaches of the Barataria Basin. These landforms are in dire need of restoration due to a combination of natural and anthropogenic forces. Sediment loss can be attributed to natural cycles, dredging activities, and the channelization and levee system of the lower Mississippi River, which discharges the vast majority of its sediment off the continental shelf into deep water.

Restoration of these landforms will help protect and restore unique habitats that are crucial to the viability of migratory birds, commercial and recreational fisheries, and a great variety of terrestrial and aquatic species. These landforms also contribute to maintenance of water quality in the region by reducing suspended sediment and nutrient loading in the aquatic environment. In addition, they reduce the impacts of flooding and storm surges on infrastructures in the coastal region, including highways, oil and gas production facilities, pipelines, and navigation features, such as ports and channels.

| 1. Review of Compliance (§230.10 (a)-(d)). | Preliminary[1] | | Final[2] | |
|---|---|---|---|---|
| A review of this project indicates that: | | | | |
| a. The discharge represents the least environ-mentally damaging practicable alternative and if in a special aquatic site, the activity associated with the discharge must have direct access or proximity to, or be located in the aquatic ecosystem to fulfill its basic purpose (if no, see section 2 and information gathered for environmental assessment alternative); | YES | NO* | YES | NO |
| b. The activity does not appear to: (1) violate applicable state water quality standards or effluent standards prohibited under Section 307 of the Clean Water Act; (2) jeopardize the existence of Federally listed endangered or threatened species or their habitat; and (3) violate requirements of any Federally designated marine sanctuary (if no, see section 2b and check responses from resource and water quality certifying agencies); | FOR (1) ONLY<br>YES | <u>NO</u>* | YES | NO |
| c. The activity will not cause or contribute to significant degradation of waters of the United States including adverse effects on human health, life stages of organisms dependent on the aquatic ecosystem, ecosystem diversity, productivity and stability, and recreational, esthetic, and economic values (if no, see section 2); | YES | NO* | YES | NO |
| d. Appropriate and practicable steps have been taken to minimize potential adverse impacts of the discharge on the aquatic ecosystem (if no, see section 5). | YES | NO* | YES | NO |

| 2. Technical Evaluation Factors (Subparts C-F). | N/A | Not Significant | Significant* |
|---|---|---|---|
| a. Physical and Chemical Characteristics of the Aquatic Ecosystem (Subpart C). | | | |
| (1) Substrate impacts. | | X | |
| (2) Suspended particulates/turbidity impacts. | | X | |
| (3) Water column impacts. | | X | |
| (4) Alteration of current patterns and water circulation. | | X | |
| (5) Alteration of normal water fluctuations/ hydroperiod. | | X | |
| (6) Alteration of salinity gradients. | | X | |
| b. Biological Characteristics of the Aquatic Ecosystem (Subpart D). | | | |
| (1) Effect on threatened/endangered species and their habitat. | | | |
| (2) Effect on the aquatic food web. | | | |
| (3) Effect on other wildlife (mammals, birds, reptiles, and amphibians). | | | |
| c. Special Aquatic Sites (Subpart E). | | | |
| (1) Sanctuaries and refuges. | | | |
| (2) Wetlands. | | | |
| (3) Mud flats. | | | |
| (4) Vegetated shallows. | | | |
| (5) Coral reefs. | | | |
| (6) Riffle and pool complexes. | | | |
| d. Human Use Characteristics (Subpart F). | | | |
| (1) Effects on municipal and private water supplies. | X | | |
| (2) Recreational and commercial fisheries impacts. | | | |
| (3) Effects on water-related recreation. | | | |
| (4) Esthetic impacts. | | | |
| (5) Effects on parks, national and historical monuments, national seashores, wilderness areas, research sites, and similar preserves. | | | |

Remarks. Where a check is placed under the significant category, the preparer has attached explanation.

3. Evaluation of Dredged or Fill Material (Subpart G).[3]

a. The following information has been considered in evaluating the biological availability of possible contaminants in dredged or fill material.

| | |
|---|---|
| (1) Physical characteristics | X |
| (2) Hydrography in relation to known or anticipated sources of contaminants | X |
| (3) Results from previous testing of the material or similar material in the vicinity of the project . | X |
| (4) Known, significant sources of persistent pesticides from land runoff or percolation | X |
| (5) Spill records for petroleum products or designated (Section 311 of CWA) hazardous substances | X |
| (6) Other public records of significant introduction of contaminants from industries, municipalities, or other sources | X |
| (7) Known existence of substantial material deposits of substances which could be released in harmful quantities to the aquatic environment by man-induced discharge activities | X |
| (8) Other sources (specify) | |

Appropriate references: Sediment and water quality samples were collected from the two proposed restoration project areas and four potential borrow source areas. Sediment, water, and elutriate samples were analyzed for known or anticipated contaminants (including pesticides). A full disucsion on the testing and results cau be found in the water quality assessment report

b. Au evaluation of the appropriate informatiou in 3a above indicates that there is reason to believe the proposed dredge or fill material is not a carrier of contaminauts, or the material meets the testing exclusion criteria.

YES NO*

4. Disposal Site Delineation (§230.11(f)).

a. The following factors, as appropriate, have been considered in evaluating the disposal site.

| | |
|---|---|
| (1) Depth of water at disposal site | X |
| (2) Current velocity, direction, and variability at disposal site | X |
| (3) Degree of turbulence | X |
| (4) Water column stratification | X |
| (5) Discharge vessel speed and direction | |
| (6) Rate of discharge | |
| (7) Dredged material characteristics (constituents, amount, and type of material, settling velocities) | X |
| (8) Number of discharges per unit of time | |
| (9) Other factors affecting rates and patterns of mixing (specify) | |

Appropriate references:

Same as 3(a)

b. An evaluation of the appropriate factors in 4a above indicates that the disposal site and/or size of mixing zone are acceptable.

YES NO*

NE – Not evaluated

5. Actions to Minimize Adverse Effects (Subpart H).

All appropriate and practicable steps have been taken, through application of the recommendations of §230.70-230.77 to ensure minimal adverse effects of the proposed discharge.

YES NO*

Actions taken: At this time no specific construction techniques have been identified, specific mitigation methods should be evaluated during the final design stage to reduce the potential construction impacts. The mitigation methods should be based upon planned construction methods and locations.

6. Factual Determination (§230.11).

A review of appropriate information as identified in items 2-5 above indicates that there is minimal potential for short- or long-term environmental effects of the proposed discharge as related to:

| | | | |
|---|---|---|---|
| a. | Physical substrate at the disposal site (review sections 2a, 3, 4, and 5 above). | YES | NO* |
| b. | Water circulation, fluctuation and salinity (review sections 2a, 3, 4, and 5). | YES | NO* |
| c. | Suspended particulates/turbidity (review sections 2a, 3, 4, and 5) | YES | NO* |
| d. | Contaminant availability (review sections 2a, 3, and 4). | YES | NO* |
| e. | Aquatic ecosystem structure and function (review sections 2b and c, 3, and 5). | YES | NO* |
| f. | Disposal site (review sections 2, 4, and 5). | YES | NO* |
| g. | Cumulative impact on the aquatic ecosystem. | YES | NO* |
| h. | Secondary impacts on the aquatic ecosystem. | YES | NO* |

*A negative, significant, or unknown response indicates that the project may not be in compliance with the Section 404(b)(1) Guidelines.

[1]Negative responses to three or more of the compliance criteria at this stage indicates that the proposed projects may not be evaluated using this "short form procedure". Care should be used in assessing pertinent portions of the technical information of items 2a-d, before completing the final review of compliance.
[2]Negative responses to one of the compliance criteria at this stage indicates that the proposed project does not comply with the guidelines. If the economics of navigation and anchorage of Section 404(b)(2) are to be evaluated in the decision-making process, the "short form" evaluation process is inappropriate.
[3]If the dredged or fill material cannot be excluded from individual testing, the "short form" evaluation process is inappropriate.

7. Evaluation Responsibility.

   a. Water Quality input provided by: Phillip L. Parker, P.E.

      Position: Project Manager, Providence Engineering and Environmental Group LLC

      Date:

   b. This evaluation was reviewed by: _____

      Position:

      Date:

8. Findings.

   a. The proposed disposal site for discharge of dredged or fill material complies with the Section 404(b)(1) guidelines .....

   b. The proposed disposal site for discharge of dredged or fill material complies with the Section 404(b)(1) guidelines with the inclusion of the following conditions .....

   c. The proposed disposal site for discharge of dredged or fill material does not comply with the Section 404(b)(1) guidelines for the following reason(s):

      (1) There is a less damaging practicable alternative .....
      (2) The proposed discharge will result in significant degradation of the aquatic ecosystem
      (3) The proposed discharge does not include all practicable and appropriate measures to minimize potential harm to the aquatic ecosystem .....

Date: _____

_____
Richard P. Wagenaar
Colonel, EN
Commanding

**Annex 5: Letters of No Objection from Facility Owners**

Harold C. Harper, Jr.
Land Representative

Chevron U.S.A. Inc.
935 Gravier Street
New Orleans, Louisiana 70112-1625
Tel 504 592 6718
Fax 504 592 6060
hharper@chevron.com

Chevron

July 25, 2006

Department of the Army
New Orleans District Corps of Engineers
P.O. Box 60267
New Orleans, LA 70160-0267
Attn: Mr. Greg DeBose

Re: LCA Barrier Island Feasibility Study
Headland and Shell Island Reaches
Lafourche and Plaquemine Parishes, Louisiana

Dear Mr. DeBose,

I am the Landman for Chevron responsible for the Bay Marchand Field. I have been forwarded a copy of your e-mail dated June 20, 2006 addressed to our Operations Supervisor, Mr. Tab Guidry regarding a proposal by the Department of the Army, New Orleans District Corps of Engineers (Corps) to place dredged material along 13 miles of coastline including the Port Fourchon/Bay Marchand coastline. The Corps requested that Chevron complete the questionnaires attached to that e-mail, and we have attached the completed questionnaires herewith.

Your e-mail has also requested our consent to the proposed project. While we have no objections to this proposal, Chevron is not the sole rights holder to the property in question and there are several items that would need to be addressed before Chevron could consent or provide a letter of no objection to this project. Primarily, Chevron would look to the Corps for an indemnity and letter agreement to provide that the Corps:

1. obtain all other necessary permits, consents and permissions;
2. perform the work at its sole risk and cost without interference to Chevron operations;
3. grant Chevron U.S.A. Inc. (CVX) and Chevron Pipe Line (CPL) observation and stop work authority rights, should CVX or CPL facilities be exposed to threat;
4. provide indemnification, hold harmless and defense for CVX/CPL and our lessor, Edward Wisner Donation against any losses or claims of any nature arising from the work or project;
5. provide indemnification, hold harmless and defense for CVX/CPL for any claims asserted by our lessor, Edward Wisner Donation
6. provide for and obtain approval of such indemnity agreement by our lessor, Edward Wisner Donation

**The information attached and furnished by Chevron is believed to be accurate, but Chevron makes no representations or warranties, express, implied, statutory or otherwise, either as to the accuracy of, or completeness of, or in any way with respect to such information or any condition or aspect thereof. Any decision or action taken by the Corps with respect to the information or its use shall be at the sole cost, risk and expense of the Corps and based solely on its independent judgment and knowledge.**

Please call me at (504) 592-6718 if you should have any questions.

Yours truly,

Harold C. Harper, Jr.
Land Representative, Bay Marchand Asset Team

Gordon R. Cain
Land Manager

Chevron U.S.A. Inc.
935 Gravier Street
New Orleans, Louisiana 70112-1625
Tel 504 592 6718
Fax 504 592 6356
GordonCain@chevron.com

May 7, 2007

Department of the Army
New Orleans District
Corps of Engineers
P.O. Box 60267
New Orleans, Louisiana 70160-0267
Attention: Mr. Gregory DeBose

**Letter of No Objection**
**Proposed Shoreline Restoration Project**
**Caminada HeadlandArea**
**Lafourche and Jefferson Parishes, Louisiana**

Ladies and Gentlemen:

By letter with attached exhibits dated April 2, 2007, the Corps of Engineers, New Orleans District (Corps) requested that Chevron U.S.A. Inc. (Chevron) provide a letter of no objection to the further study of the proposed Shoreline Restoration Project for selected areas of Caminada Headland Area in an effort to evaluate the effects of restoration of that shoreline.

The Corps intends to further study up to ten (10) alternatives in the effort to evaluate the effects of restoration of that shoreline but has not yet determined which alternative will be presented for congressional approval and therefore has not yet prepared the specification or developed a construction practice for the proposed Shoreline Restoration Project.

Chevron conducts oil and gas drilling, producing and hydrocarbon gathering, via pipelines, operations on mineral leasehold interest located in the Bay Marchand Field and conducts production handling operations in the Fourchon Terminal Area on land leased from the Edward Wisner Donation. Chevron, along with its affiliate, Chevron Pipe Line Company (CPL), operates numerous pipelines delivering oil and gas from Chevron near shore and offshore leases to facilities located at the Fourchon Terminal in the Caminada Headland Area.

Chevron has no objection to the further study of the proposed Shoreline Restoration Project in the Caminada Headland Area, subject to the following conditions:

1. This letter of no objection is limited to further study only and is accepted by the Corps under the condition and with the understanding that it is subject to the prior receipt and approval by Chevron of the Corps' detailed plans, specifications and construction

practices for the alternative recommended to Congress and chosen for implementation under the proposed Shoreline Restoration Project, when such is recommended to Congress or otherwise becomes available and that, if approved by Chevron, will be subject to additional provisions and conditions.

2. Prior to commencement to any work, the Corps shall secure all necessary permission from all landowners and other interest owners including Edward Wisner Donation and CPL for all activities related to the proposed shoreline restoration project.

3. Prior to commencement to any work, the Corps shall secure all necessary permits from all governmental agencies having jurisdiction thereof for all activities related to the proposed shoreline restoration project.

4. Any further operations, including on-site inspection and evaluation, conducted by the Corps shall be with prior notice to Chevron and at no cost or expense to Chevron and shall not interfere with Chevron's operations in the area.

If you should have any questions please call Mr. Harold Harper at (504) 592-6718.

Sincerely,

CHEVRON U.S.A. INC.

Gordon R. Cain

Gordon R. Cain
Assistant Secretary

cc: Edward Wisner Donation
1300 Perdido Street, Rm. 2W86
New Orleans, LA 70112
Attention: Ms. C. Cathy Norman

Chevron Pipe Line Company
4800 Fournace Place
Bellaire, Texas 77401-2324
Attention: Mr. Thomas August

EDWARD WISNER DONATION ADVISORY COMMITTEE

C. CATHY NORMAN
SECRETARY TREASURER
LAND MANAGER

ROOM 2W06, CITY HALL
1300 PERDIDO STREET
NEW ORLEANS, LA 70112
(504) 658-4960
FAX (504) 658-4965
WISNERDONATION@AOL.COM

MAILING ADDRESS
P. O. BOX 52284
NEW ORLEANS, LA 70152-2284

Wisner

REPRESENTING
CHARITY HOSPITAL / MEDICAL CENTER OF LOUISIANA
CITY OF NEW ORLEANS
THE SALVATION ARMY
TULANE UNIVERSITY
THE WISNER FAMILY

U. S. Army Corps of Engineers
P. O. Box 60267
New Orleans, La. 70160-0267
Attn: Mr. Gregory DeBose

April 30, 2007

Re: LCA – BBBS Briefing for Pipeline Stakeholders
Barataria Basin Barrier Shoreline Restoration Study
Caminada Headland & Shell Island

Dear Mr. DeBose:

Thank you for including me in the recent meeting for the pipeline stake holders in the Fourchon area. As you know the Edward Wisner Donation is the primary landowner for the entire area covered by the Caminada Headland project and desires to work closely with the Corps and DNR in furtherance of the construction of this very important project.

In 2005 Wisner formed an organization known as FRRI (Fourchon Region Restoration Initiative) to promote the restoration of the Fourchon area. This organization is comprised of several of the stakeholders in the area including the Greater Lafourche Port Commission, Shell, Chevron, LOOP, Wisner and several representatives from government and non profit organizations. The purpose of the group is to assist and facilitate the restoration of one of the most important headland areas in the Gulf of Mexico. This geographic area is largely at risk and home to not only extremely important fish, marsh and dune habitat, but also critically important oil and gas infrastructure that services the entire nation.

Wisner supports the idea of large restoration projects as recommended in the 1999 USACOE 905(b) reconnaissance report. This report advocated comprehensive systemic coastal restoration approaches to the Louisiana Coastal land loss crisis. As such, Wisner has some suggestions about the future of the Caminada/Shell Island Project.

In the expectation of limiting the risk of more damage to this area during this post storm recovery period, Wisner hopes that this project will move forward quickly and has pledged to make every effort to facilitate and assist towards that endeavor. Wisner has

not yet settled the land rights for this area with the State of Louisiana but will engage in this effort as soon as possible.

I was unsure from the letter that I received from the Corps of Engineers whether the request for a letter of no objection applied to Landowners or merely the Pipeline stakeholders that were addressed at the meeting. However, once the land rights issue is settled, Wisner will issue a formal letter of no objection for this project.

Because we are committed to the belief that the benefits from the Caminada Headland project far out weight the benefits of the Shell Island project, Wisner strongly encourages the separation of the two projects. The Caminada project involves beach nourishment and marsh creation verses the Shell Island Project which will rebuild almost an entire barrier island. Wisner feels that funding possibilities for the Caminada project might improve if the projects are separated by reducing the overall cost and relieving the Caminada project of its more ambitious and costly counterpart. Additionally, the Caminada headland project involves an extremely important working coast that cannot be ignored. The additional size and expense of joining the two projects poses possible delays and logistical problems, with separate and different contractors working and designing the two projects independently. Wisner hopes that this separation can occur after the draft feasibility report and DEIS is completed on the current project tentative schedule.

As to the alternatives for restoration, Wisner welcomes any large scale project with ongoing re nourishments to help move Louisiana forward from small scale projects such as CWPPRA to the larger projects needed to save our coast. Therefore Alternatives 7 through 10 are preferable for the Caminada Headland.

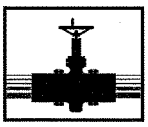
Please continue to keep Wisner informed as to the progress on this project. Please do not hesitate to contact me for information or assistance.

Sincerely,

C. Cathy Norman

C. Cathy Norman
Secretary Treasurer/Land Manager

Cc: Mr. Walter O. Baumy, USACOE
Secretary Scott Angelle, DNR
Mr. Ted Falgout, GLPC
Mr. Randy Hanchey, DNR
Mr. Andrew Beall, DNR
Mr. Kirk Rhinehardt, DNR
Ms. Helen Hoffpuir, DNR



PLAINS
PIPELINE, L.P.

July 7, 2009

Christopher Talbert
Relocations Section
Department of the Army
New Orleans District Corps of Engineers
P.O. Box 60267
New Orleans, Louisiana70160

Re: LCA Barataria Shoreline Restoration Feasibility Study
(Our File L7058)

Dear Mr. Talbert:

This letter is in response to your e-mail to our Dan Nerbonne on June 10, 2009 requesting our consent to place dredged material on our pipeline in connection with the referenced feasibility study.

Conceptually, subject to the following requirements, Plains Pipeline, L.P. ("Plains") as operator of the BOA Pipeline, has no objection to the Corps of Engineers placing the dredged material over our pipeline as long as the following requirements are strictly adhered to:

1. Plains Operations will be notified and invited to a pre-job and preplanning meetings to be sure that all agencies and contractors are aware of our requirements to protect the pipeline. You should coordinate all meetings and contact with Plains through the undersigned at the letterhead address or my designated engineer. My office phone no. is 601-271-8786, my cell phone number is 601-466-5455 and my facsimile number is 601-261-4140.
2. Plains will have the opportunity to review the scope of work for the areas around the pipeline and approve the work plan as it relates to structural and metallurgical integrity for our pipeline.
3. Plains Operations will be give a 30-day notice of mobilization prior to the start of the project.
4. Project Operations over or within 250 ft. of the pipeline will require advance written notice of at least 14 days.
5. Plains will determine the areas where the contract will be allowed to cross the pipeline with heavy equipment and will require adequate covering over the pipeline to protect pipeline damage.
6. In addition to the above requirements the Corps will require the Contractor to notify the Louisiana one call system prior to project start up and any excavation activities.

PLAINS
PIPELINE, L.P.

7. A Plains inspector will be on site during any work within 250 ft. of Plains' pipeline and work will not commence nor continue without inspector on site.

Subject to the Corps' agreement to adhere to the foregoing requirements, Plains has no objection to the Corps placing dredged material over our pipeline. If the foregoing requirements are satisfactory, please have an authorized officer execute in the space provided below and return a duplicate original of this letter to the attention of the writer.

Very truly yours,

PLAINS PIPELINE, L.P.
By Plains Marketing GP Inc.
Its General Partner

Richard B. McMichael
22 Milbranch Rd Suite 1000
Hattiesburg, Ms 39402
Ph. 601.271.8786
Email. rbmcmichael@paalp.com

cc: Phillip R. Smith
Dan Nerbonne
D. L. Rohrbacher

***ACCEPTED AND AGREED***:

DEPARTMENT OF THE ARMY
U.S. CORPS OF ENGINEERS

By: _____
Name: _____
Title: _____
Date: _____

**Talbert, Christopher J MVN**

**From:** Belisle, Thomas D (Tommy) [Tommy.Belisle@ElPaso.com]
**Sent:** Monday, June 22, 2009 3:50 PM
**To:** Talbert, Christopher J MVN
**Subject:** FW: LCA Barataria Shoreline Restoration

**Attachments:** Headland Reach.jpg; Shell Island Reach.jpg; TN Gas Pipeline.pdf

Headland Reach.jpg (3 MB)

Shell Island Reach.jpg (2 MB)

TN Gas Pipeline.pdf (46 KB)

Mr. Talbert,

Please be advised that insofar as Tennessee Gas Pipeline and Southern Natural Gas facilities are concerned we have no objection to your proposals as attached. If you require additional information or have any questions please contact me.

Tommy Belisle

Elpaso Pipeline Services

Gulf Coast Division

158 Regal Row

Houma, La. 70360

985-223-6412

---

From: Talbert, Christopher J MVN [mailto:Christopher.J.Talbert@usace.army.mil]
Sent: Wednesday, June 10, 2009 3:05 PM
To: Belisle, Thomas D (Tommy)
Subject: LCA Barataria Shoreline Restoration

<<Headland Reach.jpg>> <<Shell Island Reach.jpg>> <<TN Gas Pipeline.pdf>> Engineering Division Relocations Section

Tennessee Gas Pipeline Co./Southern Natural Gas Mr. Tommy Belisle Sugar Mill Point
158 Regal Row
Houma, LA 70360

Mr. Belisle:

Please reference your telephone conversation conducted on June 8, 2009 and a letter sent to you April 2, 2007, both regarding the LCA Barataria Shoreline Restoration Feasibility Study and more specifically the need of a letter of no objection to place dredged material over your pipeline.

During this discussion, I mentioned the study consists of placing dredged material in Caminada Headland and Shell Island Reaches, a 13 mile reach of shoreline from Bayou

Lafourche to the western edge of Caminada Pass and from Grand Bayou Pass to the Empire Canal at Shell Island Bay. Additionally, I mentioned we have not received, to date, the letter of no objection for placing this dredged material over your pipeline. Please note at this current time, the feasibility study remains in progress and placement of dredged material will not occur in the near future.

I have attached, per the letter mentioned above, the original letter, copies of drawings showing your pipeline in the Corps' project Right-of-Way (ROW) for your information.

If your letter is prepared and ready to send, please mail to:

Department of the Army

New Orleans District Corps of Engineers

P.O. Box 60267

New Orleans, LA 70160

Attn: Christopher Talbert, ED-S

or by email to christopher.talbert@usace.army.mil
<mailto:christopher.talbert@usace.army.mil> .

Please call if you have any questions or comments.

Sincerely,

Christopher Talbert
Civil Engineer, Relocations Section
Engineering Division
CEMVN-ED-S
Office: (504) 862-1407
Fax: (504) 862-1888

**********
This email and any files transmitted with it from the El Paso Corporation are confidential and intended solely for the use of the individual or entity to whom they are addressed. If you have received this email in error please notify the sender.
**********

137 Northpark Blvd. • Covington, LA 70433
TELEPHONE (985) 276-6100 • FAX (985) 276-6284

July 22, 2010

U.S. Army Corps of Engineers - New Orleans, District
ATTN: Christopher Talbert, Room 206
7400 Leake Ave.
New Orleans, LA 70118

**RE: REQUEST FOR LETTER OF NO OBJECTION FOR BARATARIA BARRIER SHORELINE PROJECT**

Dear Mr. Talbert:

I appreciate you contacting LOOP and providing information pertaining to the Barataria Barrier Shoreline Project. This project will help bolster and align well with our own coastal erosion efforts. While LOOP does not object to the overall concept of the plan, at this time, we are unable to provide a letter of no objection without more details relative to installation procedures. LOOP operates three pipelines in its right of way; a 48" crude oil line, a 30" brine line, and a 4" diesel line running from LOOP's Fourchon Booster Station to our Marine Terminal. We have three principal concerns pertaining to this project and our pipeline integrity: heavy equipment moving across our right of way both on the marine and beach locations, the procedures and impact of dredging lines crossing over our pipelines, and how the dredging process will work.

It is important for us to ensure that we are aware of any equipment passing over our pipelines and that action is taken to minimize any potential impact. To mitigate potential damage to our pipelines, procedures well need to be implemented that provide for mats to be placed across our right of way for equipment to utilize when crossing. This action should also be processed through Louisiana One-Call to ensure LOOP is made aware of when the work will take place.

The other areas of concern pertain to the procedures to be utilized when placing the dredged sand along the beach and right-of-way. A primary concern here is the crossing of our offshore right-of-way with the dredge pipeline as the cover is minimal in some areas. We want to ensure that if the lines pumping sand from offshore cross over our right-of-way that we are aware of the procedures to be used and the precautions to be taken to minimize any potential impacts to our pipelines.

LOOP would like to make you aware that there has been significant erosion of the beach in the area in and around our right of way. This erosion has resulted in rock jetties and pilings

just offshore of the beach along the right-of-way. Additionally, the drawings pertaining to this project do not appear to have the proper location of LOOP's pipeline. Attached is a map containing the exact locations of points along the right-of-way.

LOOP appreciates the research and work that the Corps of Engineers has put into combating erosion problems on Louisiana's coastline, and we fully support the concept of filling the beaches out. If this project takes place, we would like more information pertaining to the procedures used and precautions taken when crossing pipeline rights of way. We look forward to working with you to insure that there will be no impact on the integrity of our pipelines and toward the development of an acceptable letter of no objection.

If you have any questions or need any further information, feel free to call me at (985)276-6263.

Sincerely,

Drew Lohoff
Regulatory Representative

**Annex 6: Cost**

---

**Total Project Cost Summary**
**Mii Caminada Headland**
**Mii Shell Island**
**Barataria Basin Barrier Shoreline Restoration Project Cost and Schedule Risk Analysis Report**

****** TOTAL PROJECT COST SUMMARY ******

PROJECT: LCA, BBBS, Caminada Headland and Shell Island
LOCATION: Jefferson Parish, LA

DISTRICT: New Orleans
POC: CHIEF, COST ENGINEERING, Thomas D. Murphy

PREPARED: 12/8/2011

This Estimate reflects the scope and schedule in report; Barataria Barrier Shoreline Restoration Feasibility Study, LCA Study

| | | | | | | Program Year (Budget EC): 2012 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Effective Price Level Date: 1 OCT 11 | | | | FULLY FUNDED PROJECT ESTIMATE | | | | |
| | | | | | | | | | | Spent Thru: | | | | |
| WBS NUMBER | Civil Works Feature & Sub-Feature Description | COST ($K) | CNTG ($K) | CNTG (%) | TOTAL ($K) | ESC (%) | COST ($K) | CNTG ($K) | TOTAL ($K) | 1-Oct-10 ($K) | | COST ($K) | CNTG ($K) | FULL ($K) |
| A | B | C | D | E | F | G | H | I | J | K | L | M | N | O |
| **17** | BEACH REPLENISHMENT | $301,139 | $95,397 | 32% | $396,536 | 1.9% | $306,858 | $97,209 | $404,067 | | | $320,611 | $101,556 | $422,167 |
| | **CONSTRUCTION ESTIMATE TOTALS:** | $301,139 | $95,397 | | **$396,536** | 1.9% | $306,858 | $97,209 | $404,067 | | | $320,611 | $101,556 | $422,167 |
| 01 | LANDS AND DAMAGES | $2,929 | $732 | 25% | $3,661 | | $2,929 | $732 | $3,661 | | | $2,929 | $732 | $3,661 |
| 31 | ADAPTIVE MANAGEMENT/MONITORING | $975 | $310 | 32% | $1,285 | 1.1% | $986 | $313 | $1,299 | | | $1,282 | $407 | $1,690 |
| 30 | PLANNING, ENGINEERING & DESIGN | $5,440 | $1,360 | 25% | $6,800 | | $5,440 | $1,360 | $6,800 | | | $5,440 | $1,360 | $6,800 |
| 31 | CONSTRUCTION MANAGEMENT | $9,311 | $2,964 | 32% | $12,295 | 1.1% | $9,417 | $3,018 | $12,435 | | | $10,626 | $3,408 | $14,034 |
| | **PROJECT COST TOTALS:** | $319,794 | $100,783 | 32% | **$420,577** | 1.8% | $325,630 | $102,632 | $428,262 | | | $340,888 | $107,463 | $448,351 |

_____ CHIEF, COST ENGINEERING, Thomas D. Murphy

_____ PROJECT MANAGER, Bill Hicks

_____ CHIEF, REAL ESTATE, Linda Labure

_____ CHIEF, PLANNING

_____ CHIEF, ENGINEERING

_____ CHIEF, OPERATIONS

_____ CHIEF, CONSTRUCTION

_____ CHIEF, CONTRACTING

_____ CHIEF, PM-PB

_____ CHIEF, DPM

| | | |
|---|---|---|
| ESTIMATED FEDERAL COST: | 65% | **$291,428** |
| ESTIMATED NON-FEDERAL COST: | 35% | **$156,923** |
| **ESTIMATED TOTAL PROJECT COST:** | | **$448,351** |

**** CONTRACT COST SUMMARY ****

PROJECT: LCA, BBBS, Caminada Headland and Shell Island
LOCATION: Jefferson Parish, LA
This Estimate reflects the scope and schedule in report; Barataria Barrier Shoreline Restoration Feasibility Study, LCA Study

DISTRICT: New Orleans
POC: CHIEF, COST ENGINEERING, Thomas D. Murphy

PREPARED: 12/8/2011

Estimate Prepared: 1-Dec-10
Effective Price Level: 1 OCT 10

Program Year (Budget EC): 2012
Effective Price Level Date: 1 OCT 11

| WBS NUMBER | Civil Works Feature & Sub-Feature Description | COST ($K) | CNTG ($K) | CNTG (%) | TOTAL ($K) | ESC (%) | COST ($K) | CNTG ($K) | TOTAL ($K) | FULLY FUNDED PROJECT ESTIMATE Mid-Point Date | ESC (%) | COST ($K) | CNTG ($K) | FULL ($K) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | B | C | D | E | F | G | H | I | J | P | L | M | N | O |
| | PHASE 1 | | | | | | | | | | | | | |
| **17** | BEACH REPLENISHMENT<br>Caminada Headland Marsh and Beach Alt 5 | $153,420 | $45,596 | 29.7% | $199,016 | 1.9% | $156,334 | $46,462 | $202,796 | 2014Q4 | 4.6% | $163,486 | $48,588 | $212,074 |
| | **CONSTRUCTION ESTIMATE TOTALS:** | $153,420 | $45,596 | 30% | **$199,016** | | $156,334 | $46,462 | $202,796 | | | $163,486 | $48,588 | $212,074 |
| 01 | LANDS AND DAMAGES | $1,321 | $330 | 25% | $1,651 | | $1,321 | $330 | $1,651 | | | $1,321 | $330 | $1,651 |
| **31** | ADAPTIVE MANAGEMENT/MONITORING | $480 | $143 | 29.7% | $623 | 1.1% | $485 | $144 | $630 | 2019Q2 | 30.0% | $631 | $188 | $819 |
| **30** | PLANNING, ENGINEERING & DESIGN<br>Project Management<br>Planning & Environmental Compliance<br>Engineering & Design<br>Engineering Tech Review ITR & VE<br>Contracting & Reprographics<br>Engineering During Construction<br>Planning During Construction<br>Project Operations | $2,883 | $721 | 25% | $3,604 | | $2,883 | $721 | $3,604 | 2012Q4 | | $2,883 | $721 | $3,604 |
| **31** | CONSTRUCTION MANAGEMENT<br>Construction Management<br>Project Operation:<br>Project Management | $3,450 | $1,025 | 29.7% | $4,475 | 1.1% | $3,489 | $1,037 | $4,526 | 2014Q4 | 9.9% | $3,834 | $1,139 | $4,973 |
| | **CONTRACT COST TOTALS:** | $161,554 | $47,815 | | **$209,369** | | $164,512 | $48,695 | $213,207 | | | $172,155 | $50,966 | **$223,120** |

**** CONTRACT COST SUMMARY ****

PROJECT: LCA, BBBS, Caminada Headland and Shell Island
LOCATION: Jefferson Parish, LA
This Estimate reflects the scope and schedule in report; Barataria Barrier Shoreline Restoration Feasibility Study, LCA Study

DISTRICT: New Orleans PREPARED: 12/8/2011
POC: CHIEF, COST ENGINEERING, Thomas D. Murphy

Estimate Prepared: 1-Dec-10
Effective Price Level: 1 OCT 10

Program Year (Budget EC): 2012
Effective Price Level Date: 1 OCT 11

| WBS NUMBER | Civil Works Feature & Sub-Feature Description | COST ($K) | CNTG ($K) | CNTG (%) | TOTAL ($K) | ESC (%) | COST ($K) | CNTG ($K) | TOTAL ($K) | FULLY FUNDED PROJECT ESTIMATE Mid-Point Date | ESC (%) | COST ($K) | CNTG ($K) | FULL ($K) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | B | C | D | E | F | G | H | I | J | P | L | M | N | O |
| | PHASE 2 | | | | | | | | | | | | | |
| **17** | BEACH REPLENISHMENT<br>Shell Island Beach and Marsh Alt 5 | $139,065 | $46,948 | 33.8% | $186,013 | 1.9% | $141,706 | $47,840 | $189,546 | 2014Q3 | 4.1% | $147,563 | $49,817 | $197,381 |
| | **CONSTRUCTION ESTIMATE TOTALS:** | $139,065 | $46,948 | 34% | **$186,013** | | $141,706 | $47,840 | $189,546 | | | $147,563 | $49,817 | $197,381 |
| 01 | LANDS AND DAMAGES | $1,608 | $402 | 25% | $2,010 | | $1,608 | $402 | $2,010 | | | $1,608 | $402 | $2,010 |
| **31** | ADAPTIVE MANAGEMENT/MONITORING | $495 | $167 | 33.8% | $662 | 1.1% | $501 | $169 | $670 | 2019Q2 | 30.0% | $651 | $220 | $871 |
| **30** | PLANNING, ENGINEERING & DESIGN<br>Project Management<br>Planning & Environmental Compliance<br>Engineering & Design<br>Engineering Tech Review ITR & VE<br>Contracting & Reprographics<br>Engineering During Construction<br>Planning During Construction<br>Project Operations | $2,557 | $639 | 25% | $3,196 | | $2,557 | $639 | $3,196 | 2012Q4 | | $2,557 | $639 | $3,196 |
| **31** | CONSTRUCTION MANAGEMENT<br>Construction Management<br>Project Operation:<br>Project Management | $2,901 | $979 | 33.8% | $3,880 | 1.1% | $2,934 | $991 | $3,924 | 2014Q3 | 8.8% | $3,191 | $1,077 | $4,269 |
| | **CONTRACT COST TOTALS:** | $146,626 | $49,136 | | **$195,762** | | $149,306 | $50,040 | $199,346 | | | $155,571 | $52,156 | **$207,726** |

****** TOTAL PROJECT COST SUMMARY ******

PROJECT: LCA, BBBS, Caminada Headland and Shell Island
LOCATION: Jefferson Parish, LA
This Estimate reflects the scope and schedule in report; Barataria Barrier Shoreline Restoration Feasibility Study, LCA Study

DISTRICT: New Orleans PREPARED: 12/8/2011
POC: CHIEF, COST ENGINEERING, Thomas D. Murphy

| | | Estimate Prepared: 1-Dec-10<br>Effective Price Level: 1 OCT 10 | | | | Program Year (Budget EC): 2012<br>Effective Price Level Date: 1 OCT 11 | | | | FULLY FUNDED PROJECT ESTIMATE | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WBS NUMBER<br>*A* | Civil Works Feature & Sub-Feature Description<br>*B* | COST ($K)<br>*C* | CNTG ($K)<br>*D* | CNTG (%)<br>*E* | TOTAL ($K)<br>*F* | ESC (%)<br>*G* | COST ($K)<br>*H* | CNTG ($K)<br>*I* | TOTAL ($K)<br>*J* | Mid-Point Date<br>*P* | ESC (%)<br>*L* | COST ($K)<br>*M* | CNTG ($K)<br>*N* | FULL ($K)<br>*O* |
| | PHASE 3 | | | | | | | | | | | | | |
| **17** | BEACH REPLENISHMENT<br>Caminada Headland - Plantings TY1 | $2,703 | $868 | 32.1% | $3,571 | 1.9% | $2,754 | $885 | $3,639 | 2016Q2 | 7.2% | $2,954 | $949 | $3,903 |
| | **CONSTRUCTION ESTIMATE TOTALS:** | $2,703 | $868 | 32% | **$3,571** | | $2,754 | $885 | $3,639 | | | $2,954 | $949 | $3,903 |
| 01 | LANDS AND DAMAGES | | | | | | | | | | | | | |
| **30** | PLANNING, ENGINEERING & DESIGN<br>Project Management<br>Planning & Environmental Compliance<br>Engineering & Design<br>Engineering Tech Review ITR & VE<br>Contracting & Reprographics<br>Engineering During Construction<br>Planning During Construction<br>Project Operations | | | | | | | | | | | | | |
| **31** | CONSTRUCTION MANAGEMENT<br>Construction Management<br>Project Operation:<br>Project Management | $640 | $206 | 32.1% | $846 | 1.1% | $647 | $208 | $855 | 2016Q2 | 16.6% | $754 | $242 | $997 |
| | **CONTRACT COST TOTALS:** | $3,343 | $1,074 | | **$4,417** | | $3,402 | $1,093 | $4,495 | | | $3,708 | $1,192 | **$4,900** |

**** CONTRACT COST SUMMARY ****

PROJECT: LCA, BBBS, Caminada Headland and Shell Island
LOCATION: Jefferson Parish, LA
This Estimate reflects the scope and schedule in report; Barataria Barrier Shoreline Restoration Feasibility Study, LCA Study

DISTRICT: New Orleans PREPARED: 12/8/2011
POC: CHIEF, COST ENGINEERING, Thomas D. Murphy

| | | Estimate Prepared: 1-Dec-10<br>Effective Price Level: 1 OCT 10 | | | | Program Year (Budget EC): 2012<br>Effective Price Level Date: 1 OCT 11 | | | | FULLY FUNDED PROJECT ESTIMATE | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WBS NUMBER | Civil Works Feature & Sub-Feature Description | COST ($K) | CNTG ($K) | CNTG (%) | TOTAL ($K) | ESC (%) | COST ($K) | CNTG ($K) | TOTAL ($K) | Mid-Point Date | ESC (%) | COST ($K) | CNTG ($K) | FULL ($K) |
| A | B | C | D | E | F | G | H | I | J | P | L | M | N | O |
| | PHASE 4 | | | | | | | | | | | | | |
| **17** | BEACH REPLENISHMENT | $1,115 | $396 | 35.6% | $1,511 | 1.9% | $1,136 | $404 | $1,540 | 2015Q4 | 6.4% | $1,208 | $430 | $1,638 |
| | Shell Island - Plantings TY1 | | | | | | | | | | | | | |
| | **CONSTRUCTION ESTIMATE TOTALS:** | $1,115 | $396 | 36% | **$1,511** | | $1,136 | $404 | $1,540 | | | $1,208 | $430 | $1,638 |
| 01 | LANDS AND DAMAGES | | | | | | | | | | | | | |
| **30** | PLANNING, ENGINEERING & DESIGN | | | | | | | | | | | | | |
| | Project Management | | | | | | | | | | | | | |
| | Planning & Environmental Compliance | | | | | | | | | | | | | |
| | Engineering & Design | | | | | | | | | | | | | |
| | Engineering Tech Review ITR & VE | | | | | | | | | | | | | |
| | Contracting & Reprographics | | | | | | | | | | | | | |
| | Engineering During Construction | | | | | | | | | | | | | |
| | Planning During Construction | | | | | | | | | | | | | |
| | Project Operations | | | | | | | | | | | | | |
| **31** | CONSTRUCTION MANAGEMENT | | | | | | | | | | | | | |
| | Construction Management | $320 | $114 | 35.6% | $434 | 1.1% | $324 | $115 | $439 | 2015Q4 | 14.3% | $370 | $132 | $502 |
| | Project Operation: | | | | | | | | | | | | | |
| | Project Management | | | | | | | | | | | | | |
| | **CONTRACT COST TOTALS:** | $1,435 | $510 | | **$1,945** | | $1,460 | $519 | $1,979 | | | $1,578 | $561 | **$2,140** |

**** CONTRACT COST SUMMARY ****

PROJECT: LCA, BBBS, Caminada Headland and Shell Island
LOCATION: Jefferson Parish, LA
This Estimate reflects the scope and schedule in report: Barataria Barrier Shoreline Restoration Feasibility Study, LCA Study

DISTRICT: New Orleans PREPARED: 12/8/2011
POC: CHIEF, COST ENGINEERING, Thomas D. Murphy

| | | Estimate Prepared: 1-Dec-10<br>Effective Price Level: 1 OCT 10 | | | | Program Year (Budget EC): 2012<br>Effective Price Level Date: 1 OCT 11 | | | | FULLY FUNDED PROJECT ESTIMATE | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WBS NUMBER | Civil Works Feature & Sub-Feature Description | COST ($K) | CNTG ($K) | CNTG (%) | TOTAL ($K) | ESC (%) | COST ($K) | CNTG ($K) | TOTAL ($K) | Mid-Point Date | ESC (%) | COST ($K) | CNTG ($K) | FULL ($K) |
| A | B | C | D | E | F | G | H | I | J | P | L | M | N | O |
| | PHASE 5 | | | | | | | | | | | | | |
| **17** | BEACH REPLENISHMENT | $2,729 | $861 | 31.6% | $ 3,590 | 1.9% | $2,781 | $878 | $3,658 | 2017Q3 | 9.7% | $3,049 | $962 | **$4,012** |
| | Caminada Headland - Plantings TY2 | | | | $ - | | | | | | | | | |
| | | | | | $ - | | | | | | | | | |
| | | | | | $ - | | | | | | | | | |
| | | | | | $ - | | | | | | | | | |
| | **CONSTRUCTION ESTIMATE TOTALS:** | $2,729 | $861 | 32% | **3,590** | | $2,781 | $878 | $3,658 | | | $3,049 | $962 | $4,012 |
| 01 | LANDS AND DAMAGES | | | | $ - | | | | | | | | | |
| **30** | PLANNING, ENGINEERING & DESIGN | | | | | | | | | | | | | |
| | Project Management | | | | | | | | | | | | | |
| | Planning & Environmental Compliance | | | | | | | | | | | | | |
| | Engineering & Design | | | | | | | | | | | | | |
| | Engineering Tech Review ITR & VE | | | | | | | | | | | | | |
| | Contracting & Reprographics | | | | | | | | | | | | | |
| | Engineering During Construction | | | | | | | | | | | | | |
| | Planning During Construction | | | | | | | | | | | | | |
| | Project Operations | | | | | | | | | | | | | |
| **31** | CONSTRUCTION MANAGEMENT | | | | | | | | | | | | | |
| | Construction Management | $880 | $278 | 31.6% | 1,158 | 1.1% | $890 | $281 | $1,171 | 2017Q3 | 22.2% | $1,087 | $343 | $1,431 |
| | Project Operation: | | | | | | | | | | | | | |
| | Project Management | | | | | | | | | | | | | |
| | **CONTRACT COST TOTALS:** | $3,609 | $1,139 | | **4,748** | | $3,671 | $1,159 | $4,829 | | | $4,137 | **$1,306** | **$5,442** |



Filename: Caminada and Shell TPCS rev 120811 FINAL.xlsx
TPCS

****** TOTAL PROJECT COST SUMMARY ******

****** CONTRACT COST SUMMARY ******

PROJECT: LCA, BBBS, Caminada Headland and Shell Island
LOCATION: Jefferson Parish, LA
This Estimate reflects the scope and schedule in report; Barataria Barrier Shoreline Restoration Feasibility Study, LCA Study

DISTRICT: New Orleans PREPARED: 12/8/2011
POC: CHIEF, COST ENGINEERING, Thomas D. Murphy

Estimate Prepared: 1-Dec-10
Effective Price Level: 1 OCT 10

Program Year (Budget EC): 2012
Effective Price Level Date: 1 OCT 11

| WBS NUMBER | Civil Works Feature & Sub-Feature Description | COST ($K) | CNTG ($K) | CNTG (%) | TOTAL ($K) | ESC (%) | COST ($K) | CNTG ($K) | TOTAL ($K) | FULLY FUNDED PROJECT ESTIMATE Mid-Point Date | ESC (%) | COST ($K) | CNTG ($K) | FULL ($K) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | B | C | D | E | F | G | H | I | J | P | L | M | N | O |
| | PHASE 6 | | | | | | | | | | | | | |
| **17** | BEACH REPLENISHMENT | $1,089 | $389 | 35.7% | $ 1,478 | 1.9% | $1,110 | $396 | $1,506 | 2016Q4 | 8.2% | $1,200 | $428 | **$1,628** |
| | Shell Island - Plantings TY2 | | | | $ - | | | | | | | | | |
| | | | | | $ - | | | | | | | | | |
| | | | | | $ - | | | | | | | | | |
| | | | | | $ - | | | | | | | | | |
| | **CONSTRUCTION ESTIMATE TOTALS:** | $1,089 | $389 | 36% | **1,478** | | $1,110 | $396 | $1,506 | | | $1,200 | $428 | $1,628 |
| 01 | LANDS AND DAMAGES | | | | $ - | | | | | | | | | |
| **30** | PLANNING, ENGINEERING & DESIGN | | | | | | | | | | | | | |
| | Project Management | | | | | | | | | | | | | |
| | Planning & Environmental Compliance | | | | | | | | | | | | | |
| | Engineering & Design | | | | | | | | | | | | | |
| | Engineering Tech Review ITR & VE | | | | | | | | | | | | | |
| | Contracting & Reprographics | | | | | | | | | | | | | |
| | Engineering During Construction | | | | | | | | | | | | | |
| | Planning During Construction | | | | | | | | | | | | | |
| | Project Operations | | | | | | | | | | | | | |
| **31** | CONSTRUCTION MANAGEMENT | | | | | | | | | | | | | |
| | Construction Management | $400 | $143 | 35.7% | 543 | 1.1% | $405 | $144 | $549 | 2016Q4 | 18.8% | $481 | $171 | $652 |
| | Project Operation: | | | | | | | | | | | | | |
| | Project Management | | | | | | | | | | | | | |
| | **CONTRACT COST TOTALS:** | $1,489 | $531 | | **2,020** | | $1,514 | $540 | $2,055 | | | $1,681 | $600 | **$2,281** |

****** TOTAL PROJECT COST SUMMARY ******

****** CONTRACT COST SUMMARY ******

PROJECT: LCA, BBBS, Caminada Headland and Shell Island
LOCATION: Jefferson Parish, LA
This Estimate reflects the scope and schedule in report; Barataria Barrier Shoreline Restoration Feasibility Study, LCA Study

DISTRICT: New Orleans PREPARED: 12/8/2011
POC: CHIEF, COST ENGINEERING, Thomas D. Murphy

| | | Estimate Prepared: 1-Dec-10<br>Effective Price Level: 1 OCT 10 | | | | Program Year (Budget EC): 2012<br>Effective Price Level Date: 1 OCT 11 | | | | FULLY FUNDED PROJECT ESTIMATE | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WBS NUMBER | Civil Works Feature & Sub-Feature Description | COST ($K) | CNTG ($K) | CNTG (%) | TOTAL ($K) | ESC (%) | COST ($K) | CNTG ($K) | TOTAL ($K) | Mid-Point Date | ESC (%) | COST ($K) | CNTG ($K) | FULL ($K) |
| A | B | C | D | E | F | G | H | I | J | P | L | M | N | O |
| | PHASE 7 | | | | | | | | | | | | | |
| **17** | BEACH REPLENISHMENT | $730 | $235 | 32.2% | $ 965 | 1.9% | $744 | $239 | $983 | 2018Q2 | 11.1% | $827 | $266 | $1,093 |
| | Caminada Headland - Plantings TY3 | | | | $ - | | | | | | | | | |
| | | | | | $ - | | | | | | | | | |
| | | | | | $ - | | | | | | | | | |
| | | | | | $ - | | | | | | | | | |
| | **CONSTRUCTION ESTIMATE TOTALS:** | $730 | $235 | 32% | **965** | | $744 | $239 | $983 | | | $827 | $266 | $1,093 |
| 01 | LANDS AND DAMAGES | | | | $ - | | | | | | | | | |
| **30** | PLANNING, ENGINEERING & DESIGN | | | | | | | | | | | | | |
| | Project Management | | | | | | | | | | | | | |
| | Planning & Environmental Compliance | | | | | | | | | | | | | |
| | Engineering & Design | | | | | | | | | | | | | |
| | Engineering Tech Review ITR & VE | | | | | | | | | | | | | |
| | Contracting & Reprographics | | | | | | | | | | | | | |
| | Engineering During Construction | | | | | | | | | | | | | |
| | Planning During Construction | | | | | | | | | | | | | |
| | Project Operations | | | | | | | | | | | | | |
| **31** | CONSTRUCTION MANAGEMENT | | | | | | | | | | | | | |
| | Construction Management | $480 | $154 | 32.2% | 634 | 1.1% | $485 | $156 | $642 | 2018Q2 | 25.5% | $609 | $196 | $805 |
| | Project Operation: | | | | | | | | | | | | | |
| | Project Management | | | | | | | | | | | | | |
| | **CONTRACT COST TOTALS:** | $1,210 | $389 | | **1,599** | | $1,229 | $395 | $1,625 | | | $1,436 | $462 | **$1,898** |



Filename: Caminada and Shell TPCS rev 120811 FINAL.xlsx
TPCS

**** CONTRACT COST SUMMARY ****

PROJECT: LCA, BBBS, Caminada Headland and Shell Island
LOCATION: Jefferson Parish, LA
This Estimate reflects the scope and schedule in report; Barataria Barrier Shoreline Restoration Feasibility Study, LCA Study

DISTRICT: New Orleans PREPARED: 12/8/2011
POC: CHIEF, COST ENGINEERING, Thomas D. Murphy

| | | Estimate Prepared: 1-Dec-10<br>Effective Price Level: 1 OCT 10 | | | | Program Year (Budget EC): 2012<br>Effective Price Level Date: 1 OCT 11 | | | | FULLY FUNDED PROJECT ESTIMATE | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WBS NUMBER | Civil Works Feature & Sub-Feature Description | COST ($K) | CNTG ($K) | CNTG (%) | TOTAL ($K) | ESC (%) | COST ($K) | CNTG ($K) | TOTAL ($K) | Mid-Point Date | ESC (%) | COST ($K) | CNTG ($K) | FULL ($K) |
| A | B | C | D | E | F | G | H | I | J | P | L | M | N | O |
| | PHASE 8 | | | | | | | | | | | | | |
| **17** | BEACH REPLENISHMENT | $288 | $103 | 35.6% | $ 391 | 1.9% | $293 | $105 | $398 | 2017Q4 | 10.1% | $323.3 | $115.2 | $438.5 |
| | Shell Island - Plantings TY3 | | | | $ - | | | | | | | | | |
| | | | | | $ - | | | | | | | | | |
| | | | | | $ - | | | | | | | | | |
| | | | | | $ - | | | | | | | | | |
| | **CONSTRUCTION ESTIMATE TOTALS:** | $288 | $103 | 36% | **391** | | $293 | $105 | $398 | | | $323.3 | $115.2 | $438.5 |
| 01 | LANDS AND DAMAGES | | | | $ - | | | | | | | | | |
| **30** | PLANNING, ENGINEERING & DESIGN | | | | | | | | | | | | | |
| | Project Management | | | | | | | | | | | | | |
| | Planning & Environmental Compliance | | | | | | | | | | | | | |
| | Engineering & Design | | | | | | | | | | | | | |
| | Engineering Tech Review ITR & VE | | | | | | | | | | | | | |
| | Contracting & Reprographics | | | | | | | | | | | | | |
| | Engineering During Construction | | | | | | | | | | | | | |
| | Planning During Construction | | | | | | | | | | | | | |
| | Project Operations | | | | | | | | | | | | | |
| **31** | CONSTRUCTION MANAGEMENT | | | | | | | | | | | | | |
| | Construction Management | $240 | $86 | 35.6% | 326 | 1.1% | $243 | $87 | $329 | 2017Q4 | 23.3% | $299.3 | $106.7 | $406.0 |
| | Project Operation: | | | | | | | | | | | | | |
| | Project Management | | | | | | | | | | | | | |
| | **CONTRACT COST TOTALS:** | $528 | $188 | | **716** | | $536 | $191 | $727 | | | $622.5 | $221.9 | **$844.4** |



Filename: Caminada and Shell TPCS rev 120811 FINAL.xlsx
TPCS

LCA Barataria Basin Barrier Shoreline - Caminada Rev Oct 27, 2011



| | |
|---|---|
| Estimated by | Benjamin Salamone, John Petitbon |
| Designed by | LDNR by CEC Inc. / SJB |
| Prepared by | |
| Preparation Date | 12/1/2010 |
| Effective Date of Pricing | 12/1/2010 |
| Estimated Construction Time | Days |

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Designed by
LDNR by CEC Inc. / SJB
Estimated by
Benjamin Salamone, John Petitbon
Prepared by

**Direct Costs**
LaborCost
EQCost
MatlCost
SubBidCost
ShipCost

| Design Document | |
|---|---|
| Document Date | 10/27/2011 |
| District | New Orleans District |
| Contact | john petitbon |
| Budget Year | 2012 |
| UOM System | Original |

**Timeline/Currency**

| | |
|---|---|
| Preparation Date | 12/1/2010 |
| Escalation Date | 12/1/2010 |
| Eff. Pricing Date | 12/1/2010 |
| Estimated Duration | 0 Day(s) |
| Currency | US dollars |
| Exchange Rate | 1.000000 |

**Costbook CB06EB: MII English Cost Book 2006**

**Labor LB06NatFD: Labor National 2006**
**Note: http://www.wdol.gov/, Dec 2010 rates from local payroll data used**

**Labor Rates**
LaborCost1
LaborCost2
LaborCost3
LaborCost4

**Equipment EP07R03: MII Equipment Region 3 2007**
**Note: fuel and CMR updated Dec 2010**

**03 SOUTHEAST**

| | |
|---|---|
| Sales Tax | 8.75 |
| Working Hours per Year | 1,530 |
| Labor Adjustment Factor | 0.86 |
| Cost of Money | 3.13 |
| Cost of Money Discount | 25.00 |
| Tire Recap Cost Factor | 1.50 |
| Tire Recap Wear Factor | 1.80 |
| Tire Repair Factor | 0.15 |
| Equipment Cost Factor | 1.00 |
| Standby Depreciation Factor | 0.50 |

**Fuel**

| | |
|---|---|
| Electricity | 0.090 |
| Gas | 2.600 |
| Diesel Off-Road | 2.650 |
| Diesel On-Road | 3.100 |

**Shipping Rates**

| | |
|---|---|
| Over 0 CWT | 10.26 |
| Over 240 CWT | 9.59 |
| Over 300 CWT | 8.41 |
| Over 400 CWT | 7.64 |
| Over 500 CWT | 4.49 |
| Over 700 CWT | 4.36 |
| Over 800 CWT | 4.99 |

| Date | Author | Note |
|---|---|---|
| 10/1/2008 | JP | The Louisiana Coastal Area (LCA) Ecosystem Restoration Study has identified the Barataria Basin Shoreline Restoration (Caminada Headland and Shell Island) as a near term critical project. This shoreline is considered critical due to its greatly degraded state and its key role in protecting and preserving larger inland wetland areas and bays.<br><br>This estimate is for the Caminada Headland portion. The Caminada Headland project site is located in Lafourche and Jefferson Parishes and is approximately 13 - 14 miles long extending from Caminada Pass on the eastern end, separating the Headland from Grand Isle, to Belle Pass on the western end.<br><br>For Caminada Headland, Alternative 5 is the selected plan and consists of dune restoration and marsh creation along the Caminada Headland. The project provides for the restoration of the coastal barrier shoreline along the Headland and provide for marsh platform creation and restoration of hydrologic conditions, ecosystem processes and habitats for these coastal segments and nearby estuaries.<br><br>There are no mitigation costs as this is an environmental restoration project. There are no Relocation costs. Potential future lifts/O&M is the responsibility of the Local Sponsor and shown only for information purposes. There is no armoring.<br><br>The Barataria Barrier Shoreline Restoration Feasibility Study as described in the LCA Study is recommended for authorization based on resolutions adopted by the Committees on Public Works of the U.S. House of Representatives and Senate, dated October 19, 1967 and April 19, 1967 respectively. The LCA study was approved and signed by the Chief of Engineers, USACE on January 31, 2005 and the project has been recommended for specific Congressional authorization with implementation subject to approval by the Assistant Secretary of the Army for Civil Works.<br><br>Access: LA Hwy 1 and Hwy 3090 is the only land access onto the Caminada Headland. Access is also available from the Gulf of Mexico.<br><br>Escalation has been included to the anticipated midpoint of the construction features. Dune and marsh creation is to start approx April 2013 + 1/2 duration based on the schedule for the project. The planting will follow in the years after construction of the dune and marsh.<br><br>Estimate Philosophy: The estimate development used the standard approaches for a feasibility estimate structure regarding labor, equipment, materials, crews, unit prices, quotes, sub- and prime contractor markups. The estimate provides a "fair and reasonable" estimate that depicts the local market conditions.<br><br>Bid competition: It is assumed normal market conditions will apply with bidding competition.<br><br>Contract Acquisition Strategy: Unknown at this time, however it is assumed to be a large business because there are no small business/set aside contractors for large hydraulic dredging.<br><br>Labor: It is assumed that the labor market for this type work will not be an issue similar to the potential labor shortages in the building construction market in the area.<br><br>Overtime percentages are based on contractor data. Pipeline/cutterhead dredges have staggered pay weeks (Sun -> Sat) and crew weeks (Wed -> 2nd Tues) to reduce overtime costs. Pipeline dredge's resulting OT is 15.5%. However this workday/workhour/payday combination cannot be entered in MII so as close an approximation as possible has been entered. Hopper dredges only consider Sat and Sun as OT days at 1.5x<br><br>Labor Rates: Based upon local information, contractor payroll data from the New Orleans District, Gov't hopper dredge, and estimators with experiences this past year.<br><br>Materials: Cost quotes are used on major construction items.<br><br>Equipment: Rates used are based on prevailing industry rates and from the USACE EP-1110-1-8, Region III, 2007. Adjustments for fuel, filters, oil and grease (FOG) prices and facility capital cost of money (FCCM). Judicious use of owned verses rental rates was considered.<br><br>Fuel: Fuels (gasoline, on and off-road diesel) were based on local market. |

| Date | Author | Note |
|---|---|---|
| 10/1/2008 | JP | Crews: Major crew and productivity rates were developed by senior USACE estimators familiar with the type of work and based on historical data. |
| | | Field Office Overhead: The estimate allows a field office overhead rate of 5% based on historical data and applies to all bid items. |
| | | Home Office Overhead: The rates are based upon estimating and negotiating experience, and consultation with local construction representatives. |
| | | Taxes: Local taxes will be applied. |
| | | Bond: Bond is assumed 1% applied against the prime contractor, assuming large contracts. |
| | | E&D and S&A: USACE Costs to manage design (E&D) and construction (S&A) are based on data provided by NOD PPPMD and Construction Div. |
| | | Contingencies: Contingencies are based on a Cost Risk Analysis using Crystal Ball software. The base contingency was 28.1%. The contingency was then adjusted to account for the additional escalation due to the risk adjusted schedule - resulting in a contingency range of 29.72% to 32.16% depending on feature schedule. |
| | | Escalation: Escalation is based upon the US Army Corps of Engineers Engineering Manual (EM) 1110-2-1304 Civil Works Construction Cost Index System (CWCCIS) revised 30 Sept 2010. The additional escalation due to the Risk Adjusted project schedule was added to the base contingency resulting in an adjusted contingency. Real estate values are never escalated because real estate costs are not predictable into the future; it is very possible that values could decrease - Judi Gutierrez 092408. |
| 4/23/2009 | JBP | revised to exclude the parking lot, walkways, and associated real estate costs |
| 7/7/2009 | JBP | revised to use CEDEP dredge software and approximate remaining work in Mii since CEDEP does not adequately handle all aspects of dredge estimating. Other revisions from ATR comments. |
| 1/11/2011 | JBP | estimate revised to: |
| | | re-arrange bid items to accumulate costs for initial construction and TY plantings for easier transfer to TPCS |
| | | adjust Mob/Demob for non-operating, owned equipment to only use 8 hrs/day to meet 40 hr max standby. Assume mob/demob will occur during 2 different weekly periods so do not cap time at 40 hrs. |
| | | remove OT markup on Mob/Demob equipment |
| | | update fringe amount on labor to be 10% as originally stated. |
| 1/20/2011 | jbp | real estate costs revised |
| 5/15/2011 | jbp | revised O&M plan to 650,000 cy 6 times every 10 years. |

**Direct Cost Markups**
Productivity
Overtime

**Category**
Productivity
Overtime

**Method**
Productivity
Overtime

| | Days/Week | Hours/Shift | Shifts/Day | 1st Shift | 2nd Shift | 3rd Shift |
|---|---|---|---|---|---|---|
| *Standard* | *5.00* | *8.00* | *1.00* | *8.00* | *0.00* | *0.00* |
| *Actual* | *7.00* | *8.00* | *1.00* | *12.00* | *0.00* | *0.00* |

| *Day* | *OT Factor* | *Working* | *OT Percent* | *FCCM Percent* |
|---|---|---|---|---|
| *Monday* | *1.50* | *Yes* | *26.19* | *(52.38)* |
| *Tuesday* | *1.50* | *Yes* | | |
| *Wednesday* | *1.50* | *Yes* | | |
| *Thursday* | *1.50* | *Yes* | | |
| *Friday* | *1.50* | *Yes* | | |
| *Saturday* | *1.50* | *Yes* | | |
| *Sunday* | *1.50* | *Yes* | | |

Sales Tax — TaxAdj — Running % on Selected Costs
*MatlCost*

small tools — MiscDirect — Running % on Selected Costs
*LaborCost*

overtime 7/10

Overtime — Overtime

| | Days/Week | Hours/Shift | Shifts/Day | 1st Shift | 2nd Shift | 3rd Shift |
|---|---|---|---|---|---|---|
| *Standard* | *5.00* | *8.00* | *1.00* | *8.00* | *0.00* | *0.00* |
| *Actual* | *7.00* | *8.00* | *1.00* | *10.00* | *0.00* | *0.00* |

| *Day* | *OT Factor* | *Working* | *OT Percent* | *FCCM Percent* |
|---|---|---|---|---|
| *Monday* | *1.50* | *Yes* | *21.43* | *(42.86)* |
| *Tuesday* | *1.50* | *Yes* | | |
| *Wednesday* | *1.50* | *Yes* | | |
| *Thursday* | *1.50* | *Yes* | | |
| *Friday* | *1.50* | *Yes* | | |
| *Saturday* | *1.50* | *Yes* | | |
| *Sunday* | *1.50* | *Yes* | | |

overtime dredge marine 15.5

Overtime — Overtime

| | Days/Week | Hours/Shift | Shifts/Day | 1st Shift | 2nd Shift | 3rd Shift |
|---|---|---|---|---|---|---|
| *Standard* | *6.00* | *8.00* | *1.00* | *8.00* | *0.00* | *0.00* |
| *Actual* | *7.00* | *8.00* | *1.00* | *10.00* | *0.00* | *0.00* |

| *Day* | *OT Factor* | *Working* | *OT Percent* | *FCCM Percent* |
|---|---|---|---|---|
| *Monday* | *1.50* | *Yes* | *15.71* | *(42.86)* |
| *Tuesday* | *1.50* | *Yes* | | |
| *Wednesday* | *1.50* | *Yes* | | |
| *Thursday* | *1.50* | *Yes* | | |
| *Friday* | *1.50* | *Yes* | | |

| | | |
|---|---|---|
| *Saturday* | *1.50* | *Yes* |
| *Sunday* | *1.50* | *Yes* |

| **Contractor Markups** | **Category** | **Method** | |
|---|---|---|---|
| JOOH | JOOH | Running % | |
| HOOH | HOOH | Running % | |
| Profit | Profit | Profit Weighted Guidelines | |
| *Guideline* | *Value* | *Weight* | *Percentage* |
| *Risk* | *0.075* | *20* | *1.50* |
| *Difficulty* | *0.075* | *15* | *1.13* |
| *Size* | *0.030* | *15* | *0.45* |
| *Period* | *0.120* | *15* | *1.80* |
| *Invest (Contractor's)* | *0.070* | *5* | *0.35* |
| *Assist (Assistance by)* | *0.120* | *5* | *0.60* |
| *SubContracting* | *0.119* | *25* | *2.98* |
| *Total* | | *100* | *8.79* |

| | | |
|---|---|---|
| Bond | Bond | Running % |
| Excise Tax | Excise | Running % |
| Mobilization and Demobilization | MiscContract | Direct % |

| **Owner Markups** | **Category** | **Method** |
|---|---|---|
| Contingency | Contingency | Contract % |
| Escalation | Escalation | Running % |
| SIOH | SIOH | Running % |

| Description | Quantity | UOM | ContractCost | Contingency | Escalation | ProjectCost |
|---|---|---|---|---|---|---|
| **bid schedule summary** | | | **339,615,322.15** | **0.00** | **0.00** | **339,615,322.15** |
| **1 Caminada Headland Alt 5 - initial construction** | **1.0000** | **LS** | **169,712,687.65** | **0.00** | **0.00** | **169,712,687.65** |
| | | | *1,320,600.00* | | | *1,320,600.00* |
| **01 Lands and Damages** | **1.0000** | **EA** | **1,320,600.00** | **0.00** | **0.00** | **1,320,600.00** |
| **B Acquisitions** | **1.0000** | **LS** | **97,000.00** | **0.00** | **0.00** | **97,000.00** |
| **C Condemnations** | **1.0000** | **LS** | **55,000.00** | **0.00** | **0.00** | **55,000.00** |
| **E Appraisal** | **1.0000** | **LS** | **75,600.00** | **0.00** | **0.00** | **75,600.00** |
| | | | *1,093,000.00* | | | *1,093,000.00* |
| **R Real Estate Payments** | **1.0000** | **EA** | **1,093,000.00** | **0.00** | **0.00** | **1,093,000.00** |
| | | | *1,093,000.00* | | | *1,093,000.00* |
| **1 Land Payments** | **1.0000** | **EA** | **1,093,000.00** | **0.00** | **0.00** | **1,093,000.00** |
| **06 Adaptive Management / Monitoring** | **1.0000** | **LS** | **480,000.00** | **0.00** | **0.00** | **480,000.00** |
| | | | *480,000.00* | | | *480,000.00* |
| **1 Adaptive Management / Monitoring** | **1.0000** | **EA** | **480,000.00** | **0.00** | **0.00** | **480,000.00** |
| | | | *480,000.00* | | | *480,000.00* |
| **1 Adaptive Management / Monitoring** | **1.0000** | **EA** | **480,000.00** | **0.00** | **0.00** | **480,000.00** |
| | | | *159,579,287.65* | | | *159,579,287.65* |
| **17 Beach Replenishment** | **1.0000** | **EA** | **159,579,287.65** | **0.00** | **0.00** | **159,579,287.65** |
| | | | *159,579,287.65* | | | *159,579,287.65* |
| **00** | **1.0000** | **EA** | **159,579,287.65** | **0.00** | **0.00** | **159,579,287.65** |
| **02 Beach and Marsh construction** | **1.0000** | **LS** | **153,419,257.65** | **0.00** | **0.00** | **153,419,257.65** |
| | | | *5,350,274.55* | | | *5,350,274.55* |
| **01 Mob & Demob** | **1.0000** | **EA** | **5,350,274.55** | **0.00** | **0.00** | **5,350,274.55** |
| **01a Mob & Demob - Beach/Dune** | **1.0000** | **LS** | **2,564,379.73** | **0.00** | **0.00** | **2,564,379.73** |
| | | | *13,472.18* | | | *13,472.18* |
| **Mob/Demob monthly pipeline crew Mob/Demob monthly pipeline crew** | **7.8000** | **DAY** | **105,083.03** | **0.00** | **0.00** | **105,083.03** |
| | | | *54,251.93* | | | *54,251.93* |
| **prelay shore pipe** | **1.0000** | **EA** | **54,251.93** | **0.00** | **0.00** | **54,251.93** |
| | | | *51,524.61* | | | *51,524.61* |
| **prelay submerged pipe** | **1.0000** | **EA** | **51,524.61** | **0.00** | **0.00** | **51,524.61** |
| | | | *450,850.26* | | | *450,850.26* |
| **pickup shore pipe** | **1.0000** | **EA** | **450,850.26** | **0.00** | **0.00** | **450,850.26** |
| | | | *54,132.01* | | | *54,132.01* |
| **pickup submerged pipe** | **1.0000** | **EA** | **54,132.01** | **0.00** | **0.00** | **54,132.01** |

| Description | Quantity | UOM | ContractCost | Contingency | Escalation | ProjectCost |
|---|---|---|---|---|---|---|
| | | | *27,221.28* | | | *27,221.28* |
| **mob/demob pipeline Mob/Demob pipeline** | **13.6000** | **DAY** | **370,209.45** | **0.00** | **0.00** | **370,209.45** |
| **01b Mob & Demob - marsh** | **1.0000** | **LS** | **2,785,894.82** | **0.00** | **0.00** | **2,785,894.82** |
| | | | *9,878.46* | | | *9,878.46* |
| **Mob/Demob monthly pipeline crew Mob/Demob monthly pipeline crew** | **7.8000** | **DAY** | **77,051.99** | **0.00** | **0.00** | **77,051.99** |
| | | | *54,251.93* | | | *54,251.93* |
| **prelay shore pipe** | **1.0000** | **EA** | **54,251.93** | **0.00** | **0.00** | **54,251.93** |
| | | | *148,627.79* | | | *148,627.79* |
| **prelay submerged pipe** | **1.0000** | **EA** | **148,627.79** | **0.00** | **0.00** | **148,627.79** |
| | | | *348,352.41* | | | *348,352.41* |
| **pickup shore pipe** | **1.0000** | **EA** | **348,352.41** | **0.00** | **0.00** | **348,352.41** |
| | | | *338,974.01* | | | *338,974.01* |
| **pickup submerged pipe** | **1.0000** | **EA** | **338,974.01** | **0.00** | **0.00** | **338,974.01** |
| | | | *65,988.14* | | | *65,988.14* |
| **mob/demob pipeline Mob/Demob pipeline** | **13.6000** | **DAY** | **897,438.76** | **0.00** | **0.00** | **897,438.76** |
| | | | *5.89* | | | *5.89* |
| **02 marsh fill** | **5,360,000.0000** | **CY** | **31,588,079.65** | **0.00** | **0.00** | **31,588,079.65** |
| | | | *21.88* | | | *21.88* |
| **03 Beach and Dune Fill** | **5,100,000.0000** | **CY** | **111,593,376.70** | **0.00** | **0.00** | **111,593,376.70** |
| **04 Dike construction for Marsh Fill** | **1.0000** | **LS** | **1,282,226.22** | **0.00** | **0.00** | **1,282,226.22** |
| | | | *14.00* | | | *14.00* |
| **05 Sand Fencing** | **71,500.0000** | **LF** | **1,001,000.00** | **0.00** | **0.00** | **1,001,000.00** |
| | | | *2,364.95* | | | *2,364.95* |
| **12 Option Sea Turtle Trawling Mobilization** | **1.0000** | **EA** | **2,364.95** | **0.00** | **0.00** | **2,364.95** |
| | | | *4,279.50* | | | *4,279.50* |
| **13 Option Sea Turtle Trawling** | **608.0000** | **DAY** | **2,601,935.57** | **0.00** | **0.00** | **2,601,935.57** |
| | | | *2,702,160.00* | | | *2,702,160.00* |
| **Plantings/Vegetation TY1** | **1.0000** | **EA** | **2,702,160.00** | **0.00** | **0.00** | **2,702,160.00** |
| | | | *5.00* | | | *5.00* |
| **06 Dune Vegetation TY1** | **377,274.0000** | **EA** | **1,886,370.00** | **0.00** | **0.00** | **1,886,370.00** |
| | | | *100.00* | | | *100.00* |
| **11 Aerial Seeding TY1** | **771.0000** | **ACR** | **77,100.00** | **0.00** | **0.00** | **77,100.00** |
| | | | *5.00* | | | *5.00* |
| **07 Supratidal Vegetation TY1** | **147,738.0000** | **EA** | **738,690.00** | **0.00** | **0.00** | **738,690.00** |
| | | | *2,728,445.00* | | | *2,728,445.00* |
| **Plantings/Vegetation TY2** | **1.0000** | **EA** | **2,728,445.00** | **0.00** | **0.00** | **2,728,445.00** |

| Description | Quantity | UOM | ContractCost | Contingency | Escalation | ProjectCost |
|---|---|---|---|---|---|---|
| | | | *5.00* | | | *5.00* |
| 08 Marsh Vegetation TY2 | 145,885.0000 | EA | 729,425.00 | 0.00 | 0.00 | 729,425.00 |
| | | | *10.00* | | | *10.00* |
| 10 Woody Vegetation TY2 | 199,902.0000 | EA | 1,999,020.00 | 0.00 | 0.00 | 1,999,020.00 |
| | | | *729,425.00* | | | *729,425.00* |
| Plantings/Vegetation TY3 | 1.0000 | EA | 729,425.00 | 0.00 | 0.00 | 729,425.00 |
| | | | *5.00* | | | *5.00* |
| 09 Marsh Vegetation TY3 | 145,885.0000 | EA | 729,425.00 | 0.00 | 0.00 | 729,425.00 |
| 30 Planning, Engineering & Design | 1.0000 | LS | 2,883,200.00 | 0.00 | 0.00 | 2,883,200.00 |
| 31 S & A | 1.0000 | LS | 5,449,600.00 | 0.00 | 0.00 | 5,449,600.00 |
| 2 Caminada Headland - Renourishment O&M - Initial event | 1.0000 | LS | 5,663,421.15 | 0.00 | 0.00 | 5,663,421.15 |
| | | | *5,511,421.15* | | | *5,511,421.15* |
| 17 Beach Replenishment - incremental cost over Fed Std | 1.0000 | EA | 5,511,421.15 | 0.00 | 0.00 | 5,511,421.15 |
| | | | *5,511,421.15* | | | *5,511,421.15* |
| 00 | 1.0000 | EA | 5,511,421.15 | 0.00 | 0.00 | 5,511,421.15 |
| 01 Caminada Beach replenishment - beneficial use - initial time | 1.0000 | LS | 9,874,504.61 | 0.00 | 0.00 | 9,874,504.61 |
| | | | *2,776,974.57* | | | *2,776,974.57* |
| 01 Mob & Demob | 1.0000 | EA | 2,776,974.57 | 0.00 | 0.00 | 2,776,974.57 |
| 01b Mob & Demob - renourishment | 1.0000 | LS | 2,776,974.57 | 0.00 | 0.00 | 2,776,974.57 |
| | | | *11,198.05* | | | *11,198.05* |
| Mob/Demob monthly pipeline crew Mob/Demob monthly pipeline crew | 7.8000 | DAY | 87,344.80 | 0.00 | 0.00 | 87,344.80 |
| | | | *13,793.42* | | | *13,793.42* |
| prelay shore pipe | 1.0000 | EA | 13,793.42 | 0.00 | 0.00 | 13,793.42 |
| | | | *292,644.28* | | | *292,644.28* |
| prelay submerged pipe | 1.0000 | EA | 292,644.28 | 0.00 | 0.00 | 292,644.28 |
| | | | *27,649.42* | | | *27,649.42* |
| pickup shore pipe | 1.0000 | EA | 27,649.42 | 0.00 | 0.00 | 27,649.42 |
| | | | *402,246.44* | | | *402,246.44* |
| pickup submerged pipe | 1.0000 | EA | 402,246.44 | 0.00 | 0.00 | 402,246.44 |
| | | | *93,209.43* | | | *93,209.43* |
| mob/demob pipeline Mob/Demob pipeline | 13.6000 | DAY | 1,267,648.21 | 0.00 | 0.00 | 1,267,648.21 |
| | | | *10.92* | | | *10.92* |
| 02 renourishment fill | 650,000.0000 | CY | 7,097,530.04 | 0.00 | 0.00 | 7,097,530.04 |
| 02 Belle Pass / Port Fourchon - O&M Federal Standard (credit) | 1.0000 | LS | 4,363,083.46- | 0.00 | 0.00 | 4,363,083.46- |

| Description | Quantity | UOM | ContractCost | Contingency | Escalation | ProjectCost |
|---|---|---|---|---|---|---|
| | | | *931,083.46-* | | | *931,083.46-* |
| 01 Mob & Demob | 1.0000 | EA | 931,083.46- | 0.00 | 0.00 | 931,083.46- |
| 01b Mob & Demob - Fed Standard | 1.0000 | LS | 931,083.46- | 0.00 | 0.00 | 931,083.46- |
| | | | *5.28-* | | | *5.28-* |
| 02 maintenance dredging - Fed Standard | 650,000.0000 | CY | 3,432,000.00- | 0.00 | 0.00 | 3,432,000.00- |
| 30 Planning, Engineering & Design | 1.0000 | LS | 0.00 | 0.00 | 0.00 | 0.00 |
| 31 S & A (incremental over Fed std) | 1.0000 | LS | 152,000.00 | 0.00 | 0.00 | 152,000.00 |
| 3 Caminada Headland - Renourishment O&M - all over the initial time = 29 times | 29.0000 | LS | 164,239,213.35 | 0.00 | 0.00 | 164,239,213.35 |
| | | | *5,511,421.15* | | | *5,511,421.15* |
| 17 Beach Replenishment - incremental cost over Fed Std | 29.0000 | EA | 159,831,213.35 | 0.00 | 0.00 | 159,831,213.35 |
| | | | *159,831,213.35* | | | *159,831,213.35* |
| 00 | 1.0000 | EA | 159,831,213.35 | 0.00 | 0.00 | 159,831,213.35 |
| 01 Caminada Beach replenishment - beneficial use - all over initial | 29.0000 | LS | 286,360,633.69 | 0.00 | 0.00 | 286,360,633.69 |
| 02 Belle Pass / Port Fourchon - O&M Federal Standard (credit) | 29.0000 | LS | 126,529,420.34- | 0.00 | 0.00 | 126,529,420.34- |
| 30 Planning, Engineering & Design | 1.0000 | LS | 0.00 | 0.00 | 0.00 | 0.00 |
| 31 S & A (incremental over Fed std) | 29.0000 | LS | 4,408,000.00 | 0.00 | 0.00 | 4,408,000.00 |

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| Mob/Demob monthly pipeline crew Mob/Demob monthly pipeline crew | 1 |
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| pickup submerged pipe | 1 |
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| Mob/Demob monthly pipeline crew Mob/Demob monthly pipeline crew | 2 |
| prelay shore pipe | 2 |
| prelay submerged pipe | 2 |
| pickup shore pipe | 2 |
| pickup submerged pipe | 2 |
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LCA Barataria Basin Barrier Shoreline - Shell Rev Oct 27, 2011



| | |
|---|---|
| Estimated by | Benjamin Salamone, John Petitbon |
| Designed by | LDNR by Coastal Planning & Engineering Inc |
| Prepared by | |
| Preparation Date | 12/1/2010 |
| Effective Date of Pricing | 12/1/2010 |
| Estimated Construction Time | Days |

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| Date | Author | Note |
|---|---|---|
| 10/1/2008 | JP | The Louisiana Coastal Area (LCA) Ecosystem Restoration Study has identified the Barataria Basin Shoreline Restoration (Caminada Headland and Shell Island) as a near term critical project. This shoreline is considered critical due to its greatly degraded state and its key role in protecting and preserving larger inland wetland areas and bays.<br><br>This estimate is for the Shell Island portion. The Shell Island project site is located in Plaquemines Parish, immediately west of the Empire Jetties. The 1 island configuration is approx. 23,970 LF long.<br><br>For Shell Island, Alternative 5 is the selected plan and consists of dune restoration and marsh creation in a 1 island configuration. The project provides for the restoration of the coastal barrier shoreline and provides for marsh platform creation and restoration of hydrologic conditions, ecosystem processes and habitats for these coastal segments and nearby estuaries.<br><br>There are no mitigation costs as this is an environmental restoration project. There are no Relocation costs. There is potential O&M renourishment that is the responsibility of the Local Sponsor at years 20 and 40 and is shown only for information purposes.<br><br>The Barataria Barrier Shoreline Restoration Feasibility Study as described in the LCA Study is recommended for authorization based on resolutions adopted by the Committees on Public Works of the U.S. House of Representatives and Senate, dated October 19, 1967 and April 19, 1967 respectively. The LCA study was approved and signed by the Chief of Engineers, USACE on January 31, 2005 and the project has been recommended for specific Congressional authorization with implementation subject to approval by the Assistant Secretary of the Army for Civil Works.<br><br>Access: Access is available from the Gulf of Mexico and Empire Waterway.<br><br>Escalation will be included to the anticipated midpoint of the construction features. Dune and marsh creation is to start approx April 2013 + 1/2 duration based on the current schedule for the project. The planting will follow in the years after construction of the dune and marsh.<br><br>Estimate Philosophy: The estimate development used the standard approaches for a feasibility estimate structure regarding labor, equipment, materials, crews, unit prices, quotes, sub- and prime contractor markups. The estimate provides a "fair and reasonable" estimate that depicts the local market conditions.<br><br>Bid competition: It is assumed normal market conditions will apply with bidding competition.<br><br>Contract Acquisition Strategy: Unknown at this time, however it is assumed to be a large business because there are few if any small business/set aside contractors for large hydraulic dredging.<br><br>Labor: It is assumed that the labor market for this type work will not be an issue similar to the potential labor shortages in the building construction market in the area.<br><br>Overtime percentages are based on contractor data. Pipeline/cutterhead dredges have staggered pay weeks (Sun -> Sat) and crew weeks (Wed -> 2nd Tues) to reduce overtime costs. Pipeline dredge's resulting OT is 15.5%. However this workday/workhour/payday combination cannot be entered in Mii so as close an approximation as possible has been entered.<br><br>Labor Rates: Based upon local information and contractor payroll data from the New Orleans District and estimators with experiences this past year.<br><br>Materials: Cost quotes are used on major construction items.<br><br>Equipment: Rates used are based on prevailing industry rates and from the USACE EP-1110-1-8, Region III, 2007. Adjustments for fuel, filters, oil and grease (FOG) prices and facility capital cost of money (FCCM). Judicious use of owned verses rental rates was considered.<br><br>Fuel: Fuels (gasoline, on and off-road diesel) were based on local market.<br><br>Crews: Major crew and productivity rates were developed by senior USACE estimators familiar with the type of work and based on historical data. |

| Date | Author | Note |
|---|---|---|
| 10/1/2008 | JP | Field Office Overhead: The estimate allows a field office overhead rate of 5% based on historical data.<br><br>Home Office Overhead: The rates are based upon estimating and negotiating experience, and consultation with local construction representatives.<br><br>Taxes: Local taxes will be applied.<br><br>Bond: Bond is assumed 1% applied against the prime contractor, assuming large contracts.<br><br>E&D and S&A: USACE Costs to manage design (E&D) and construction (S&A) are based on data provided by NOD PPPMD and Construction Div.<br><br>Contingencies: Contingencies are based on a Cost Risk Analysis using Crystal Ball software. The base contingency result was 32.66%. The contingency was then adjusted to account for the additional escalation due to the risk adjusted schedule - resulting in a contingency range of 33.76% to 35.68%.<br><br>Escalation: Escalation is based upon the US Army Corps of Engineers Engineering Manual (EM) 1110-2-1304 Civil Works Construction Cost Index System (CWCCIS) revised 30 Sept 2010. The additional escalation due to the Risk Adjusted project schedule was added to the base contingency resulting in an adjusted contingency.<br><br>Real estate values are never escalated because real estate costs are not predictable into the future; it is very possible that values could decrease - Judi Gutierrez 092408. |
| 7/7/2009 | JP | Revised to use CEDEP dredge estimate program and approximate remaining work in Mii since CEDEP does not adequately handle all aspects of dredge estimating. Other revisions from ATR comments. |
| 11/19/2010 | JP | Estimate revised per HDQ direction to change from Shell Alternative 1 (2 island footprint) to Shell Alternative 5 (1 island footprint) with re-nourishment. |
| 1/11/2011 | JP | estimate revised to:<br><br>re-arrange bid items to accumulate costs for initial construction and TY plantings for easier transfer to TPCS<br><br>adjust Mob/Demob for non-operating, owned equipment to only use 8 hrs/day to meet 40 hr max standby. Assume mob/demob will occur during 2 different weekly periods so do not cap time at 40 hrs.<br><br>remove OT markup on Mob/Demob equipment<br><br>update fringe amount on labor to be 10% as originally stated.<br><br>removed contingency |
| 1/20/2011 | JP | real estate costs rev |

| Description | Quantity | UOM | ContractCost | Contingency | Escalation | ProjectCost |
|---|---|---|---|---|---|---|
| **bid schedule summary** | | | **242,923,220.71** | **0.00** | **0.00** | **242,923,220.71** |
| **1 Shell Island - Alt 5 - 1 Island - Initial Construction** | **1.0000** | **LS** | **150,075,465.82** | **0.00** | **0.00** | **150,075,465.82** |
| | | | *1,607,600.00* | | | *1,607,600.00* |
| **01 Lands and Damages** | **1.0000** | **EA** | **1,607,600.00** | **0.00** | **0.00** | **1,607,600.00** |
| **B Acquisitions** | **1.0000** | **LS** | **278,000.00** | **0.00** | **0.00** | **278,000.00** |
| **C Condemnations** | **1.0000** | **LS** | **154,000.00** | **0.00** | **0.00** | **154,000.00** |
| **E Appraisal** | **1.0000** | **LS** | **279,600.00** | **0.00** | **0.00** | **279,600.00** |
| | | | *896,000.00* | | | *896,000.00* |
| **R Real Estate Payments** | **1.0000** | **EA** | **896,000.00** | **0.00** | **0.00** | **896,000.00** |
| | | | *896,000.00* | | | *896,000.00* |
| **1 Land Payments** | **1.0000** | **EA** | **896,000.00** | **0.00** | **0.00** | **896,000.00** |
| **06 Adaptive Management / Monitoring** | **1.0000** | **LS** | **495,000.00** | **0.00** | **0.00** | **495,000.00** |
| | | | *495,000.00* | | | *495,000.00* |
| **1 Adaptive Management / Monitoring** | **1.0000** | **EA** | **495,000.00** | **0.00** | **0.00** | **495,000.00** |
| | | | *495,000.00* | | | *495,000.00* |
| **1 Adaptive Management / Monitoring** | **1.0000** | **EA** | **495,000.00** | **0.00** | **0.00** | **495,000.00** |
| | | | *141,555,265.82* | | | *141,555,265.82* |
| **17 Beach Replenishment** | **1.0000** | **EA** | **141,555,265.82** | **0.00** | **0.00** | **141,555,265.82** |
| | | | *141,555,265.82* | | | *141,555,265.82* |
| **00** | **1.0000** | **EA** | **141,555,265.82** | **0.00** | **0.00** | **141,555,265.82** |
| **02 Beach and Marsh construction** | **1.0000** | **LS** | **139,065,065.82** | **0.00** | **0.00** | **139,065,065.82** |
| | | | *9,512,646.22* | | | *9,512,646.22* |
| **01 Mob & Demob** | **1.0000** | **EA** | **9,512,646.22** | **0.00** | **0.00** | **9,512,646.22** |
| **01b Mob & Demob - marsh** | **1.0000** | **LS** | **1,263,504.70** | **0.00** | **0.00** | **1,263,504.70** |
| | | | *14,837.74* | | | *14,837.74* |
| **Mob/Demob monthly pipeline crew Mob/Demob monthly pipeline crew** | **3.0000** | **DAY** | **44,513.21** | **0.00** | **0.00** | **44,513.21** |
| | | | *40,804.01* | | | *40,804.01* |
| **prelay shore pipe** | **1.0000** | **EA** | **40,804.01** | **0.00** | **0.00** | **40,804.01** |
| | | | *131,869.76* | | | *131,869.76* |
| **prelay submerged pipe** | **1.0000** | **EA** | **131,869.76** | **0.00** | **0.00** | **131,869.76** |
| | | | *768,307.64* | | | *768,307.64* |
| **pickup shore pipe** | **1.0000** | **EA** | **768,307.64** | **0.00** | **0.00** | **768,307.64** |
| | | | *129,241.27* | | | *129,241.27* |
| **pickup submerged pipe** | **1.0000** | **EA** | **129,241.27** | **0.00** | **0.00** | **129,241.27** |
| **01a Mob & Demob - Beach/Dune** | **1.0000** | **LS** | **8,249,141.53** | **0.00** | **0.00** | **8,249,141.53** |

| Description | Quantity | UOM | ContractCost | Contingency | Escalation | ProjectCost |
|---|---|---|---|---|---|---|
| | | | *14,852.05* | | | *14,852.05* |
| **Mob/Demob monthly pipeline crew Mob/Dernob monthly pipeline crew** | **7.8000** | **DAY** | **115,845.97** | **0.00** | **0.00** | **115,845.97** |
| | | | *221,820.95* | | | *221,820.95* |
| **prelay shore pipe** | **1.0000** | **EA** | **221,820.95** | **0.00** | **0.00** | **221,820.95** |
| | | | *1,071,055.75* | | | *1,071,055.75* |
| **prelay submerged pipe** | **1.0000** | **EA** | **1,071,055.75** | **0.00** | **0.00** | **1,071,055.75** |
| | | | *137,374.15* | | | *137,374.15* |
| **pickup shore pipe** | **1.0000** | **EA** | **137,374.15** | **0.00** | **0.00** | **137,374.15** |
| | | | *1,057,913.28* | | | *1,057,913.28* |
| **pickup submerged pipe** | **1.0000** | **EA** | **1,057,913.28** | **0.00** | **0.00** | **1,057,913.28** |
| | | | *167,834.59* | | | *167,834.59* |
| **mob/dernob pipeline Mob/Dernob pipeline** | **13.6000** | **DAY** | **2,282,550.36** | **0.00** | **0.00** | **2,282,550.36** |
| | | | *19.90* | | | *19.90* |
| **02 Beach and Dune Fill - 1 Island - Alt 5** | **5,611,700.0000** | **CY** | **111,698,495.75** | **0.00** | **0.00** | **111,698,495.75** |
| | | | *14.00* | | | *14.00* |
| **03 Sand Fencing** | **23,800.0000** | **LF** | **333,200.00** | **0.00** | **0.00** | **333,200.00** |
| | | | *6.64* | | | *6.64* |
| **10 marsh fill** | **2,138,500.0000** | **CY** | **14,192,322.05** | **0.00** | **0.00** | **14,192,322.05** |
| **11 Dike construction for Marsh Fill** | **1.0000** | **LS** | **1,456,230.87** | **0.00** | **0.00** | **1,456,230.87** |
| **12 Breach Closure** | **1.0000** | **LS** | **471,399.84** | **0.00** | **0.00** | **471,399.84** |
| **13 Geotube Containment** | **1.0000** | **LS** | **1,400,771.09** | **0.00** | **0.00** | **1,400,771.09** |
| | | | *1,114,590.00* | | | *1,114,590.00* |
| **Plantings/Vegetation TY1** | **1.0000** | **EA** | **1,114,590.00** | **0.00** | **0.00** | **1,114,590.00** |
| | | | *5.00* | | | *5.00* |
| **04 Dune Vegetation TY1** | **104,193.0000** | **EA** | **520,965.00** | **0.00** | **0.00** | **520,965.00** |
| | | | *100.00* | | | *100.00* |
| **09 Aerial Seeding TY1** | **318.0000** | **ACR** | **31,800.00** | **0.00** | **0.00** | **31,800.00** |
| | | | *5.00* | | | *5.00* |
| **05 Supratidal Vegetation TY1** | **112,365.0000** | **EA** | **561,825.00** | **0.00** | **0.00** | **561,825.00** |
| | | | *1,088,235.00* | | | *1,088,235.00* |
| **Plantings/Vegetation TY2** | **1.0000** | **EA** | **1,088,235.00** | **0.00** | **0.00** | **1,088,235.00** |
| | | | *5.00* | | | *5.00* |
| **06 Marsh Vegetation TY2** | **57,475.0000** | **EA** | **287,375.00** | **0.00** | **0.00** | **287,375.00** |
| | | | *10.00* | | | *10.00* |
| **08 Woody Vegetation TY2** | **80,086.0000** | **EA** | **800,860.00** | **0.00** | **0.00** | **800,860.00** |

| Description | Quantity | UOM | ContractCost | Contingency | Escalation | ProjectCost |
|---|---|---|---|---|---|---|
| | | | *287,375.00* | | | *287,375.00* |
| **Plantings/Vegetation TY3** | **1.0000** | **EA** | **287,375.00** | **0.00** | **0.00** | **287,375.00** |
| | | | *5.00* | | | *5.00* |
| **07 Marsh Vegetation TY3** | **57,475.0000** | **EA** | **287,375.00** | **0.00** | **0.00** | **287,375.00** |
| **30 Planning, Engineering & Design** | **1.0000** | **LS** | **2,556,800.00** | **0.00** | **0.00** | **2,556,800.00** |
| **31 S & A** | **1.0000** | **LS** | **3,860,800.00** | **0.00** | **0.00** | **3,860,800.00** |
| **2 Shell Island - TY20 O&M Re-nourishment** | **1.0000** | **LS** | **47,338,314.88** | **0.00** | **0.00** | **47,338,314.88** |
| | | | *45,410,051.83* | | | *45,410,051.83* |
| **17 Beach / Marsh Renourishment** | **1.0000** | **EA** | **45,410,051.83** | **0.00** | **0.00** | **45,410,051.83** |
| | | | *45,410,051.83* | | | *45,410,051.83* |
| **00** | **1.0000** | **EA** | **45,410,051.83** | **0.00** | **0.00** | **45,410,051.83** |
| **02 Beach and Marsh construction** | **1.0000** | **LS** | **45,410,051.83** | **0.00** | **0.00** | **45,410,051.83** |
| | | | *8,394,151.37* | | | *8,394,151.37* |
| **01 Mob & Demob** | **1.0000** | **EA** | **8,394,151.37** | **0.00** | **0.00** | **8,394,151.37** |
| **01b Mob & Demob - marsh** | **1.0000** | **LS** | **1,280,401.93** | **0.00** | **0.00** | **1,280,401.93** |
| | | | *14,912.34* | | | *14,912.34* |
| **Mob/Demob monthly pipeline crew Mob/Demob monthly pipeline crew** | **3.0000** | **DAY** | **44,737.02** | **0.00** | **0.00** | **44,737.02** |
| | | | *41,784.80* | | | *41,784.80* |
| **prelay shore pipe** | **1.0000** | **EA** | **41,784.80** | **0.00** | **0.00** | **41,784.80** |
| | | | *131,869.76* | | | *131,869.76* |
| **prelay submerged pipe** | **1.0000** | **EA** | **131,869.76** | **0.00** | **0.00** | **131,869.76** |
| | | | *784,000.27* | | | *784,000.27* |
| **pickup shore pipe** | **1.0000** | **EA** | **784,000.27** | **0.00** | **0.00** | **784,000.27** |
| | | | *129,241.27* | | | *129,241.27* |
| **pickup submerged pipe** | **1.0000** | **EA** | **129,241.27** | **0.00** | **0.00** | **129,241.27** |
| **01a Mob & Demob - Beach/Dune** | **1.0000** | **LS** | **7,113,749.44** | **0.00** | **0.00** | **7,113,749.44** |
| | | | *15,001.26* | | | *15,001.26* |
| **Mob/Demob monthly pipeline crew Mob/Demob monthly pipeline crew** | **7.8000** | **DAY** | **117,009.81** | **0.00** | **0.00** | **117,009.81** |
| | | | *225,744.10* | | | *225,744.10* |
| **prelay shore pipe** | **1.0000** | **EA** | **225,744.10** | **0.00** | **0.00** | **225,744.10** |
| | | | *1,071,055.75* | | | *1,071,055.75* |
| **prelay submerged pipe** | **1.0000** | **EA** | **1,071,055.75** | **0.00** | **0.00** | **1,071,055.75** |
| | | | *139,335.73* | | | *139,335.73* |
| **pickup shore pipe** | **1.0000** | **EA** | **139,335.73** | **0.00** | **0.00** | **139,335.73** |

| Description | Quantity | UOM | ContractCost | Contingency | Escalation | ProjectCost |
|---|---|---|---|---|---|---|
| | | | *1,057,913.28* | | | *1,057,913.28* |
| **pickup submerged pipe** | **1.0000** | **EA** | **1,057,913.28** | **0.00** | **0.00** | **1,057,913.28** |
| | | | *167,834.59* | | | *167,834.59* |
| **mob/demob pipeline Mob/Demob pipeline** | **13.6000** | **DAY** | **2,282,550.36** | **0.00** | **0.00** | **2,282,550.36** |
| | | | *19.95* | | | *19.95* |
| **02 Beach and Dune Fill - 1 Island re-nourishment** | **1,512,000.0000** | **CY** | **30,165,102.22** | **0.00** | **0.00** | **30,165,102.22** |
| | | | *6.70* | | | *6.70* |
| **10 marsh fill** | **907,200.0000** | **CY** | **6,079,743.52** | **0.00** | **0.00** | **6,079,743.52** |
| **11 Dike construction for Marsh Fill** | **1.0000** | **LS** | **771,054.72** | **0.00** | **0.00** | **771,054.72** |
| **31 S & A** | **1.0000** | **LS** | **1,928,263.05** | **0.00** | **0.00** | **1,928,263.05** |
| **3 Shell Island - TY40 O&M Re-nourishment** | **1.0000** | **LS** | **45,509,440.01** | **0.00** | **0.00** | **45,509,440.01** |
| | | | *43,640,055.23* | | | *43,640,055.23* |
| **17 Beach Replenishment** | **1.0000** | **EA** | **43,640,055.23** | **0.00** | **0.00** | **43,640,055.23** |
| | | | *43,640,055.23* | | | *43,640,055.23* |
| **00** | **1.0000** | **EA** | **43,640,055.23** | **0.00** | **0.00** | **43,640,055.23** |
| **02 Beach and Marsh construction** | **1.0000** | **LS** | **43,640,055.23** | **0.00** | **0.00** | **43,640,055.23** |
| | | | *8,394,151.37* | | | *8,394,151.37* |
| **01 Mob & Demob** | **1.0000** | **EA** | **8,394,151.37** | **0.00** | **0.00** | **8,394,151.37** |
| **01b Mob & Demob - marsh** | **1.0000** | **LS** | **1,280,401.93** | **0.00** | **0.00** | **1,280,401.93** |
| | | | *14,912.34* | | | *14,912.34* |
| **Mob/Demob monthly pipeline crew Mob/Demob monthly pipeline crew** | **3.0000** | **DAY** | **44,737.02** | **0.00** | **0.00** | **44,737.02** |
| | | | *41,784.80* | | | *41,784.80* |
| **prelay shore pipe** | **1.0000** | **EA** | **41,784.80** | **0.00** | **0.00** | **41,784.80** |
| | | | *131,869.76* | | | *131,869.76* |
| **prelay submerged pipe** | **1.0000** | **EA** | **131,869.76** | **0.00** | **0.00** | **131,869.76** |
| | | | *784,000.27* | | | *784,000.27* |
| **pickup shore pipe** | **1.0000** | **EA** | **784,000.27** | **0.00** | **0.00** | **784,000.27** |
| | | | *129,241.27* | | | *129,241.27* |
| **pickup submerged pipe** | **1.0000** | **EA** | **129,241.27** | **0.00** | **0.00** | **129,241.27** |
| **01a Mob & Demob - Beach/Dune** | **1.0000** | **LS** | **7,113,749.44** | **0.00** | **0.00** | **7,113,749.44** |
| | | | *15,001.26* | | | *15,001.26* |
| **Mob/Demob monthly pipeline crew Mob/Demob monthly pipeline crew** | **7.8000** | **DAY** | **117,009.81** | **0.00** | **0.00** | **117,009.81** |
| | | | *225,744.10* | | | *225,744.10* |
| **prelay shore pipe** | **1.0000** | **EA** | **225,744.10** | **0.00** | **0.00** | **225,744.10** |

| Description | Quantity | UOM | ContractCost | Contingency | Escalation | ProjectCost |
|---|---|---|---|---|---|---|
| | | | *1,071,055.75* | | | *1,071,055.75* |
| **prelay submerged pipe** | **1.0000** | **EA** | **1,071,055.75** | **0.00** | **0.00** | **1,071,055.75** |
| | | | *139,335.73* | | | *139,335.73* |
| **pickup shore pipe** | **1.0000** | **EA** | **139,335.73** | **0.00** | **0.00** | **139,335.73** |
| | | | *1,057,913.28* | | | *1,057,913.28* |
| **pickup submerged pipe** | **1.0000** | **EA** | **1,057,913.28** | **0.00** | **0.00** | **1,057,913.28** |
| | | | *167,834.59* | | | *167,834.59* |
| **mob/demob pipeline Mob/Demob pipeline** | **13.6000** | **DAY** | **2,282,550.36** | **0.00** | **0.00** | **2,282,550.36** |
| | | | *19.95* | | | *19.95* |
| **02 Beach and Dune Fill - 1 Island re-nourishment** | **1,512,000.0000** | **CY** | **30,165,102.22** | **0.00** | **0.00** | **30,165,102.22** |
| | | | *6.70* | | | *6.70* |
| **10 marsh fill** | **643,600.0000** | **CY** | **4,309,746.92** | **0.00** | **0.00** | **4,309,746.92** |
| **11 Dike construction for Marsh Fill** | **1.0000** | **LS** | **771,054.72** | **0.00** | **0.00** | **771,054.72** |
| **31 S & A** | **1.0000** | **LS** | **1,869,384.78** | **0.00** | **0.00** | **1,869,384.78** |

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| Mob/Demob monthly pipeline crew Mob/Demob monthly pipeline crew | 1 |
| prelay shore pipe | 1 |
| prelay submerged pipe | 1 |
| pickup shore pipe | 1 |
| pickup submerged pipe | 1 |
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| prelay shore pipe | 2 |
| prelay submerged pipe | 2 |
| pickup shore pipe | 2 |
| pickup submerged pipe | 2 |
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| prelay shore pipe | 3 |
| prelay submerged pipe | 3 |
| pickup shore pipe | 3 |
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| Mob/Demob monthly pipeline crew Mob/Demob monthly pipeline crew | 4 |
| prelay shore pipe | 4 |
| prelay submerged pipe | 5 |
| pickup shore pipe | 5 |
| pickup submerged pipe | 5 |
| mob/demob pipeline Mob/Demob pipeline | 5 |
| 02 Beach and Dune Fill - 1 Island re-nourishment | 5 |
| 10 marsh fill | 5 |

| Description | Page |
|---|---|
| 11 Dike construction for Marsh Fill | 5 |
| 31 S & A | 5 |

US Army Corps
of Engineers®

# Barataria Basin Barrier Shoreline Restoration
# Project Cost and Schedule Risk Analysis Report

*Prepared for:*

U.S. Army Corps of Engineers,
New Orleans District

*Prepared by:*

U.S. Army Corps of Engineers
Cost Engineering Section, New Orleans District
New Orleans, LA

December 12, 2010

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## EXECUTIVE SUMMARY

This report presents a recommendation for the total project cost and schedule contingencies for the Louisiana Coastal Authority Barataria Basin Barrier Shoreline (BBBS) project near Grand Isle, Louisiana. In compliance with Engineer Regulation (ER) 1110-2-1302 CIVIL WORKS COST ENGINEERING, dated September 15, 2008, a formal risk analysis study was conducted for the development of contingency on the total project cost. The purpose of this risk analysis study was to establish project contingencies by identifying and measuring the cost and schedule impact of project uncertainties with respect to the estimated total project cost.

The most likely fully funded total project initial cost for the project is estimated to be approximately $345 Million. Based on the results of the analysis, the New Orleans District Cost Engineering Section recommends a contingency value of approximately $107 Million, or 31%, for a total project cost of $452 Million.

The following tables ES-1 and ES-2 portray both the baseline cost and fully funded cost, respectively, of the recommended alternatives based on the anticipated contracts. The costs are intended to address the congressional request of estimates to implement the project. The contingency is based on an 80% confidence level, as per accepted USACE Civil Works guidance.

## Table ES-1. Cost Summary – Baseline Project Cost

| BBBS Restoration Total Project Costs | | COST ($1,000) | CNTG ($1,000) | TOTAL ($1,000) |
|---|---|---|---|---|
| **01** | Lands and Damages | 4,359 | 1,089 | 5,448 |
| **17** | Beach Replenishment | 301,051 | 95,369 | 396,420 |
| **22** | Feasibility Studies | 1,465 | | 1,465 |
| **30** | Planning, Engineering, and Design | 5,440 | 1,360 | 6,800 |
| **31** | Construction Management | 9,311 | 2,984 | 12,295 |
| | **TOTAL PROJECT COSTS** | **321,626** | **100,803** | **422,429** |

Notes:

1) Costs include all contingencies, supported by a risk analysis

2) Costs exclude O&M and Life Cycle Cost estimates

3) Costs taken from TPCS

## Table ES-2. Cost Summary – Fully Funded Project Cost

| BBBS Restoration Total Project Costs | | COST ($1,000) | CNTG ($1,000) | TOTAL ($1,000) |
|---|---|---|---|---|
| **01** | Lands and Damages | 4,359 | 1,089 | 5,448 |
| **17** | Beach Replenishment | 319,508 | 101,207 | 420,715 |
| **22** | Feasibility Studies | 4,449 | | 4,449 |
| **30** | Planning, Engineering, and Design | 5,440 | 1,360 | 6,800 |
| **31** | Construction Management | 10,950 | 3,512 | 14,462 |
| | **TOTAL PROJECT COSTS** | **341,722** | **107,168** | **451,874** |

Notes:

1) Costs include all contingencies and escalation, supported by a risk analysis

2) Costs exclude O&M and Life Cycle Cost estimates

3) Costs taken from TPCS

## KEY FINDINGS/OBSERVATIONS/RECOMMENDATIONS

The key cost risk drivers identified through sensitivity analysis for the Caminada Headland portion of the project are Internal Risk I-2 (Beach and Dune Fill Issues) and External Risks E-2 (Fuel Prices), E-3 (Severe Weather/Downtime), and E-5 (Bidder's Risk in Volatile Market), which together contribute roughly 96% of the statistical cost variance.

The key schedule risk drivers identified through sensitivity analysis for the Caminada Headland portion of the project are Internal Risk I-2 (Beach and Dune Fill Issues) and External Risks E-1 (Sponsor's Ability to Fund its Share), E-3 (Severe Weather/Downtime) and E-7 (Turtle Trawling Issues), which together contribute 93% of the statistical cost variance.

The key cost risk drivers identified through sensitivity analysis for the Shell Island portion of the project are Internal Risk I-2 (Beach Fill Issues) and External Risks E-2 (Fuel Prices), E-3 (Severe Weather/Downtime), and E-5 (Bidder's Risk in Volatile Market) which together contribute nearly 95% of the statistical cost variance.

The key schedule risk drivers identified through sensitivity analysis for the Shell Island portion of the project are Internal Risk I-2 (Beach Fill Issues) and External Risks E-1 (Sponsor's Ability to Fund its Share) and E-3 (Severe Weather/Downtime), which together contribute nearly 92% of the statistical schedule variance.

Recommendations, as detailed within the main report, include the implementation of cost and schedule contingencies, further iterative study of risks throughout the project life-cycle, potential mitigation throughout the PED phase, and proactive monitoring and control of risk identified in this study.

## 1.0 PURPOSE

The purpose of this report is to present the results from the Cost and Schedule Risk Analysis (CSRA) for the Louisiana Coastal Authority (LCA) Barataria Basin Barrier Shoreline (BBBS) project. The results include the recommended contingencies to be added to the estimated base costs in order to be confident that the actual project execution will be within the resulting estimated budget value. Furthermore, the scope of the report includes the identification and communication of important steps, logic, key assumptions, limitations, and decisions to help ensure that risk analysis results can be appropriately interpreted. The results are intended to provide project leadership with contingency information for scheduling, budgeting, and project control purposes, as well as to provide tools to support decision making and risk management as the project progresses through planning and implementation.

## 2.0 PROJECT BACKGROUND

The Barataria Barrier Shoreline Restoration Feasibility Study, as described in the LCA Study, is recommended for authorization based on resolutions adopted by the Committees on Public Works of the U.S. House of Representatives and Senate, dated October 19, 1967 and April 19, 1967 respectively. The LCA study was approved and signed by the Chief of Engineers, USACE on January 31, 2005 and the project has been recommended for specific Congressional authorization with implementation subject to approval by the Assistant Secretary of the Army for Civil Works.

The construction of the LCA BBBS project is authorized by Title VII of WRDA 2007, PL 110-114, Section 7006(c)(1)(C). The Study area is comprised of two different project areas: Caminada Headland and Shell Island, which border the Gulf of Mexico to the north. The Caminada Headland portion of the project is on the southwest edge of Caminada Bay, near Port Fourchon, and extends northeast to Caminada Pass. The Shell Island project covers the southern border of Bastion Bay, east of Barataria Bay.

Both project areas have experienced extensive land loss and are in dire need of rehabilitation. The scope of the BBBS project includes reducing land loss and storm damage potential, increasing sediment input to supplement longshore sediment transport processes along the shoreline, and restoring shoreline, dune and marsh habitat for fish and wildlife species. Originally, 10 alternatives were evaluated for the Caminada Headland and 8 for Shell Island. 4 alternatives for each site were selected for the final study. After HDQ review, the final recommended plan was alternative 5 for Caminada Headland and alternative 5 for Shell Island. Those alternatives were what the cost estimate was based on, and thus what the risk analyses are based on as well. Both projects mainly consist of beach and marsh replenishment with dredged material, as well as plantings of vegetation in the following years.

Because there were two different, independent cost estimates developed for the project areas, two separate risk analyses were performed to capture the risks associated with each independently.

## 3.0 RISK ANALYSIS BACKGROUND

Risk analyses are required for any project whose cost exceeds $40 Million. In addition to broadly defined risk analysis standards and recommended practices, a risk analysis is to be performed to meet the requirements and recommendations of the following documents and sources:

- Cost and Schedule Risk Analysis Process guidance prepared by the USACE Cost Engineering Directory of Expertise for Civil Works (Cost Engineering Dx).
- Engineer Regulation (ER) 1110-2-1302 CIVIL WORKS COST ENGINEERING, dated September 15, 2008.
- Engineer Technical Letter (ETL) CONSTRUCTION COST ESTIMATING GUIDE FOR CIVIL WORKS, dated September 30, 2008.

The risk analysis process uses *Monte Carlo* techniques to determine probabilities and contingency. The *Monte Carlo* techniques are facilitated computationally by a commercially available risk analysis software package (Crystal Ball) that is an add-in to Microsoft Excel. The software determines contingency amounts based on specific 'confidence levels'. These confidence levels express the probability that the corresponding contingency amount will cover the cost of the project being studied.

In general, the amount of contingency included in project control plans depends on the project leadership's willingness to accept risk of project overruns. The less risk that project leadership is willing to accept, the more contingency that should be applied in the project control plans. This risk of overrun is expressed by Crystal Ball in a probabilistic context using confidence levels. The Cost Engineering Dx guidance for cost and schedule risk analysis focuses on risk and opportunity potential, all project features, internal and external risks to the project. The Cost Engineering Dx recommends budget presentation with a contingency value at the eighty-percent level of confidence (80%) for successful project execution within the established budget. This 80% confidence level is the standard normally provided to Congress by USACE and other Government agencies.

The intent of a risk analysis is to determine the probability of various cost outcomes and quantify the required contingency needed in the cost estimate to achieve any desired level of cost confidence. A similar process is also used to determine the probability of various project schedule duration impacts and then quantify the required schedule contingency (float) needed in the schedule to achieve any desired level of schedule confidence.

However, in this risk analysis, the contingencies for both Real Estate (RE) and Planning, Engineering and Design (PED) were predetermined. The RE contingency of 25% was provided by the MVN RE office. The PED cost and contingency of 25% was written into the LCA legislation. Therefore, this risk analysis mainly focused on the risks and opportunities associated with the construction features of the project.

## 4.0 METHODOLOGY / PROCESS

The general process of conducting a risk analysis began with identifying risk factors for the project. The risk identification process included the major PDT members knowledgeable with the potential impacts. The risks were then inserted in the respective project risk registers and quantified. The registers were then refined to only include 'high impact' risks. Once established a revised final risk register was created for each project. The final risk register serves as the risk models used within the Crystal Ball software. Once the software ran the simulations, the results were analyzed, resulting in refined study continuation for the final results. These primary steps of the risk analysis process, in functional terms, are described in the following subsections.

### 4.1 Identify Risk Factors

A single, formal PDT meeting was held at the New Orleans District office for the purposes of identifying and assessing risk factors for both Caminada Headland and Shell Island. The meeting, conducted November 6$^{th}$, 2008, was comprised of representatives from multiple project team disciplines and functions, including project management, cost engineering, design, environmental compliance, and real estate. The meeting focused primarily on risk factor identification using brainstorming techniques.

Additionally, conference calls and informal meetings were conducted throughout the risk analysis process as needed to further facilitate risk factor identification and assessment.

### 4.2 Populate Risk Register and Quantify Risk Factors

A risk register is a tool commonly used in project planning and risk analysis. The risk register reflects the results of risk factor identification and assessment, risk factor

quantification, and contingency analysis. The risks discussed in the meeting with the PDT were transferred into a risk register template in Microsoft Excel.

Similar to the identification and assessment process, risk factor quantification involved multiple project team disciplines and functions. However, the quantification process relied more extensively on collaboration between the cost engineers performing the risk analysis and the cost estimators of the original cost estimate, and less on the PDT members from other functions and disciplines. This process used an iterative approach to estimate the following elements of each risk factor:

- Maximum possible value for the risk factor
- Minimum possible value for the risk factor
- Most likely value (the original estimate value, if applicable)
- Nature of the probability density function used to approximate risk factor uncertainty
- Affected cost and/or schedule elements

The resulting product from the PDT discussions was captured within the original risk registers, as presented in Appendix A, for both cost and schedule risk concerns. Note, however, that the original risk registers differ from the final ones used to perform the risk analyses. This is due to the refining of risks from further study and market research after the initial registers were populated.

### 4.3 Refine Risk Register

During the initial 'brainstorming' session, a generic list of potential risks was used to identify risk factors for the project. As such, many of the risks on the initial risk register were phased out in this refining stage because they would not result in a large enough

monetary or schedule impact to the project, or they were too vague, in which case they were altered to focus on one single facet of the project.

### 4.4 Run Program and Analyze Contingencies

Once the risk registers were refined, the final quantitative impacts of risk factors served as the risk model and were analyzed using a combination of professional judgment, empirical data and analytical techniques. Risk factor impacts were quantified using probability distributions (density functions) because risk factors are entered into the Crystal Ball software in the form of probability density functions. Information was extracted from the cost estimates and placed into Microsoft Excel for cost risk analysis purposes. For the schedule risk analysis, the durations for each risk (if applicable) were placed into a similar Excel file. The software uses the most likely, low, and high values for various risks. The most likely value is usually the value used in the cost estimate. The low and high values, or best-case and worst-case values, are quantified based off a number of factors, including, but not limited to, the cost estimate. The software uses these values in conjunction with the associated probability distribution assigned to each risk to run its *Monte Carlo* simulations. Once the software has finished its simulation – in the cases of Caminada Headland and Shell Island, each simulation consisted of 10,000 trials - the total cost of the project with contingency is forecast for specific confidence levels. The resulting 80% confidence level contingency amount is the difference between the 80% cost forecast and the base cost estimate. For schedule contingency analysis, the contingency was calculated as the difference between the 80% level duration forecast and the base schedule duration, shown in months. These new durations suggested by the 80% confidence level were then incorporated into the escalation calculation, i.e., the final cost contingency is a combination of cost and schedule risks computed into dollars.

The forecasts for cost and/or schedule risk can then be analyzed to determine the recommended level of contingency for the project. As stated earlier, the contingencies suggested by the higher confidence levels will account for more risk in the project; conversely, the amounts suggested by the lower confidence levels could possible leave the project without sufficient funding if some events do not go as planned.

## 5.0 KEY ASSUMPTIONS

Key assumptions are those that are most likely to affect the determinations and/or estimates of risk presented in the risk analysis. The key assumptions are important to help ensure that project leadership and other decision makers understand the steps, logic, limitations, and decisions made in the risk analysis, as well as any resultant limitations on the use of outcomes and results. For this project, the assumptions include:

1. Level of Design: The cost comparisons and risk analyses performed and reflected within this report are based upon design scope and estimates that are considered to be well developed and designed.
2. Design Scope: The prescribed scope satisfies the requirements of this acquisition.
3. Operation and Maintenance: Operation and maintenance activities were not included in the cost estimate or schedules, because they will be the responsibility of the Local Sponsor if they are performed. Funding is not being requested.
4. Contract Acquisition Strategy: Consistent with cost estimate and schedule assumptions, it is assumed that the contract acquisition strategy is firm fixed price.
5. Confidence Levels: The Wall Walla Cost Engineering guidance generally focuses on the eighty-percent level of confidence (80%) for cost contingency calculation. For this risk analysis, the eighty-percent level of confidence (80%) was used. It should be noted that the use of 80% as a decision criteria is a moderately risk averse approach, generally resulting in higher cost contingencies. However, the 80% level of confidence also assumes a small degree of risk that the recommended contingencies may be inadequate to completely capture actual project costs.
6. Impacts Studied: Only the 'high' risk level factors were considered for the purposes of calculating cost contingency. Guidance from Walla Walla suggests that any risk that could potentially alter the cost by more than 1% should be studied. Thus, all of

the risks ultimately studied in both the Caminada Headland and Shell Island risk analyses meet that criteria. However, that doesn't necessarily mean that all of those risks should be classified as 'high impact' risks on the final model. The impacts of the risks in the final risk model are labeled according to their importance in final the model only. Within the model, any risk that impacts the project cost by 1% or less was classified as a 'low' impact risk, but still studied. 'Moderate' impact risks were classified as anything from 1.1% to 5.0%. Anything over 5% was classified as a 'high' impact risk. To illustrate why this labeling system was chosen over labeling all risks 'high' impact, assume a $100 Million project has two risks - Risk A, which can potentially cause a $20 Million swing (20%), and Risk B, which can cause a $3 Million swing (3%). Under the "study every risk over 1%" thinking, both would be classified as 'high' impact risks, since they both can cause a 1% change in the total project cost. However, it does not seem prudent to label both risks as being 'high' impact, since one can cause a $3 Million difference and the other a $20 Million difference. In both the Caminada Headland and Shell Island simulations, there are risks with all three impact levels displayed – low, moderate, and high.

## 6.0 RESULTS

The cost and schedule risk analysis results are provided in the following sections. In addition to contingency calculation results, sensitivity analyses are presented to provide decision makers with an understanding of variability and the key contributors to the cause of this variability.

### 6.1 Cost Risk Analysis Contingency Results

The construction cost contingencies calculated for the 80% confidence level and rounded to the nearest thousand are shown for Caminada Headland and Shell Island in Tables 1 and 2, respectively. The construction cost contingencies for the 50% and 100% confidence levels are also provided for illustrative purposes.

The final, ATR-approved Mii cost estimate produced by MVN Cost Engineering gave initial construction costs of roughly $160 Million for Caminada Headland and $142 Million for Shell Island. At the 80% confidence level, the base estimate construction cost contingency was quantified as approximately $45 Million for Caminada Headland, with a total construction cost of approx. $205 Million. For Shell Island, the contingency was approx. $46 Million for a total cost of approx. $188 Million.

**Table 1. Base Estimate Cost Contingency Summary – Caminada Headland**

| Risk Analysis Forecast | Crystal Ball Forecast Cost | Total Contingency[1] ($) | Total Contingency (%) |
|---|---|---|---|
| **50% Confidence Level** | | | |
| Total Project Cost | $184,948 | $25,421 | 15.9% |
| **80% Confidence Level** | | | |
| Total Project Cost | $204,323 | $44,796 | 28.1% |
| **100% Confidence Level** | | | |
| Total Project Cost | $262,053 | $102,526 | 64.3% |

Notes:

1) Includes cost contingency, but not schedule contingency impacts.

**Table 2. Base Estimate Cost Contingency Summary – Shell Island**

| Risk Analysis Forecast | Crystal Ball Forecast Cost | Total Contingency[1] ($) | Total Contingency (%) |
|---|---|---|---|
| **50% Confidence Level** | | | |
| Total Project Cost | $169,081 | $27,562 | 19.5% |
| **80% Confidence Level** | | | |
| Total Project Cost | $187,726 | $46,207 | 32.7% |
| **100% Confidence Level** | | | |
| Total Project Cost | $246,620 | $105,101 | 74.3% |

Notes:

1) Includes cost contingency, but not schedule contingency impacts.

### 6.2 Schedule Risk Analysis Contingency Results

The original durations from MVN Cost Engineering for Caminada Headland and Shell were 30.8 months and 25.9 months, respectively. At the 80% confidence level, the projected durations for the two jobs were 50.24 months for Caminada Headland – an increase of 63.1% - and 41.42 months for Shell – an increase of 59.9%. The schedule contingencies were calculated by applying the high level schedule risks identified in the risk register for each option to the durations of critical path and near critical path tasks. These durations suggested by the 80% confidence level were then incorporated into the escalation calculation, which was used to find the total contingency to be applied to the estimate.

**Table 3. Base Estimate Schedule Contingency Summary – Caminada Headland**

| Risk Analysis Forecast | Crystal Ball Forecast Schedule | Total Contingency[1] | Total Contingency (%) |
|---|---|---|---|
| **50% Confidence Level** | | | |
| Total Project Duration | 45.00 months | 14.20 months | 46.1% |
| **80% Confidence Level** | | | |
| Total Project Duration | 50.24 months | 19.44 months | 63.1% |
| **100% Confidence Level** | | | |
| Total Project Duration | 68.34 months | 37.54 months | 121.9% |

Notes:

1) Includes schedule contingency, but not cost contingency impacts.

**Table 4. Base Estimate Schedule Contingency Summary – Shell Island**

| Risk Analysis Forecast | Crystal Ball Forecast Schedule | Total Contingency[1] | Total Contingency (%) |
|---|---|---|---|
| **50% Confidence Level** | | | |
| Total Project Duration | 37.33 months | 11.43 months | 44.1% |
| **80% Confidence Level** | | | |
| Total Project Duration | 41.42 months | 15.52 months | 59.9% |
| **100% Confidence Level** | | | |
| Total Project Duration | 53.24 months | 27.34 months | 105.6% |

Notes:

1) Includes schedule contingency, but not cost contingency impacts.

**6.3 Sensitivity Analysis Results**

Sensitivity analysis ranks the relative impact of each risk/opportunity as a percentage of total cost uncertainty. The Crystal Ball software uses a statistical measure (contribution to variance) that approximates the impact of each risk/opportunity contributing to variability of cost outcomes during *Monte Carlo* simulation.

The risks/opportunities considered as key or primary cost drivers are ranked in order of importance in contribution to variance bar charts. Opportunities that have a potential to reduce project cost and are shown with a negative sign; risks are shown with a positive sign to reflect the potential to increase project cost. A longer bar in the sensitivity analysis chart represents a greater potential impact to total project cost.

Figures 1 and 2 present both the Shell and Caminada Headland sensitivity analyses for cost growth risk that includes the high level cost risks identified in the risk register. Likewise, Figures 3 and 4 present a sensitivity analysis for schedule growth risk that includes the high level schedule risks identified in the risk register.

The key cost risk drivers identified through sensitivity analysis for Caminada Headland are Internal Risk I-2 (Beach and Dune Fill Issues) and External Risks E-2 (Fuel Prices), E-3 (Severe Weather/Downtime), and E-5 (Bidder's Risk in Volatile Market), which together contribute roughly 96% of the statistical cost variance. The key cost risk drivers for Shell Island are Internal Risk I-2 (Beach Fill Issues) and External Risks E-2 (Fuel Prices), E-3 (Severe Weather/Downtime), and E-5 (Bidder's Risk in Volatile Market) which together contribute nearly 95% of the statistical cost variance.

The key schedule risk drivers identified through sensitivity analysis for Caminada Headland are Internal Risk I-2 (Beach and Dune Fill Issues) and External Risks E-1 (Sponsor's Ability to Fund its Share), E-3 (Severe Weather/Downtime) and E-7 (Turtle Trawling Issues), which together contribute 93% of the statistical cost variance. The key schedule risk drivers for Shell Island are Internal Risk I-2 (Beach Fill Issues) and External Risks E-1 (Sponsor's Ability to Fund its Share) and E-3 (Severe

weather/Downtime), which together contribute nearly 92% of the statistical schedule variance.

**Figure 1. Cost Sensitivity Analysis – Caminada Headland Island**

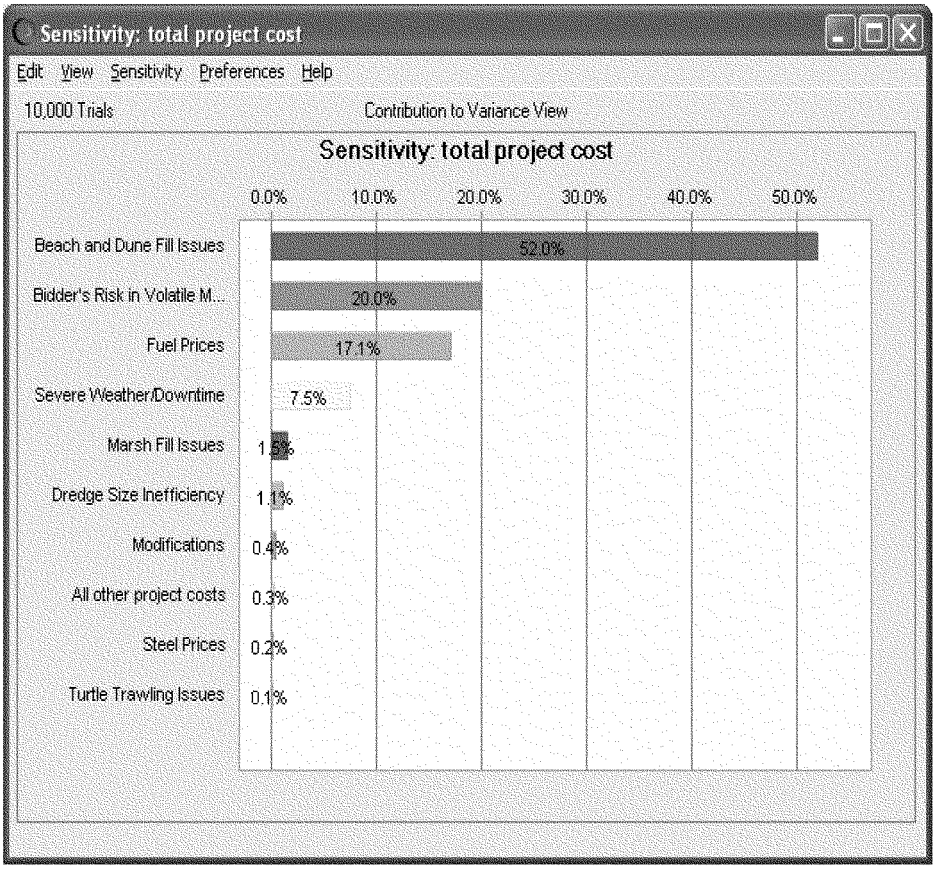


**Figure 2. Cost Sensitivity Analysis – Shell Island**

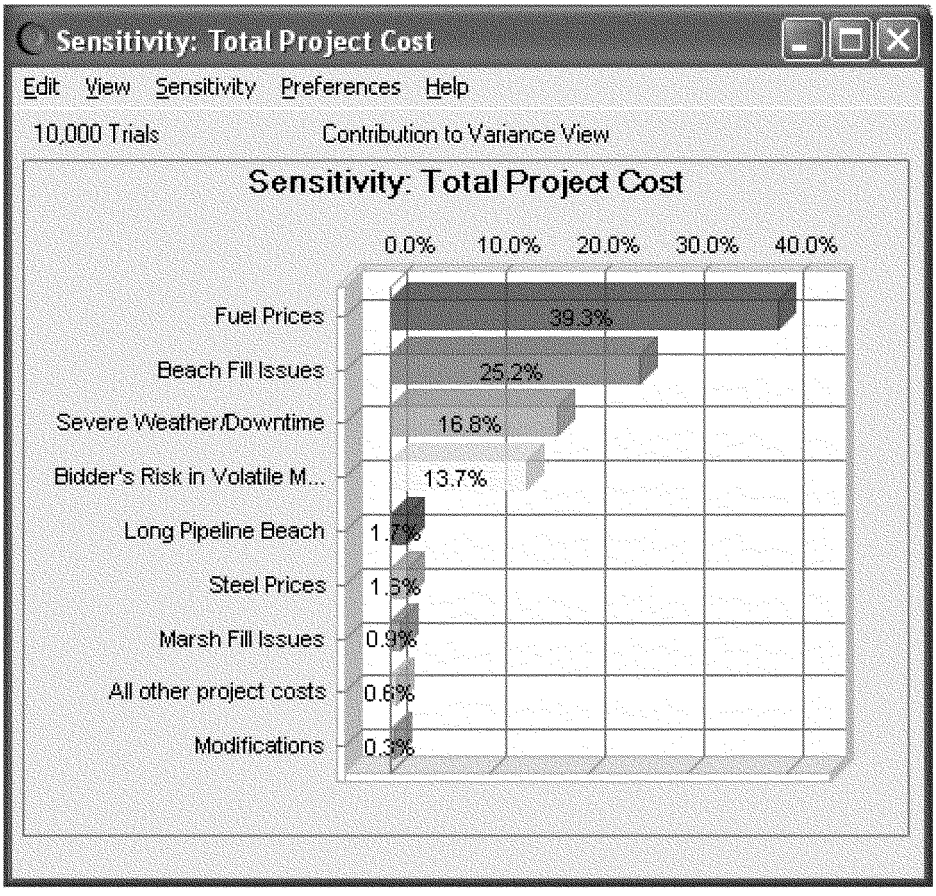


**Figure 3. Schedule Sensitivity Analysis – Caminada Headland Island**

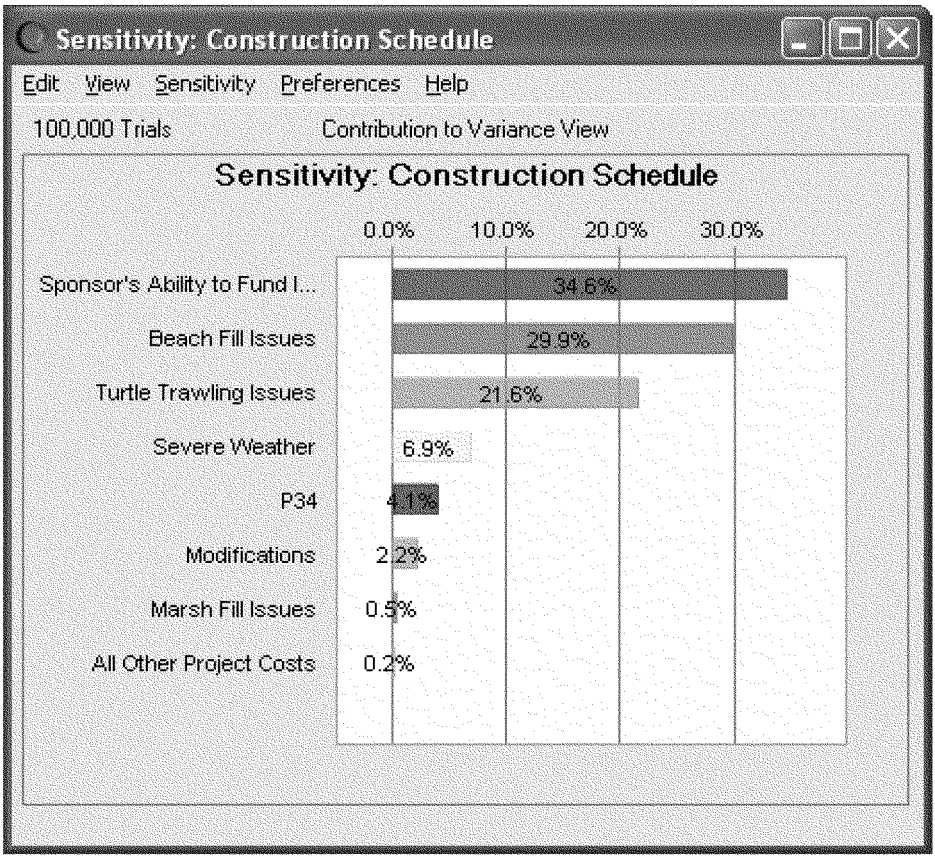
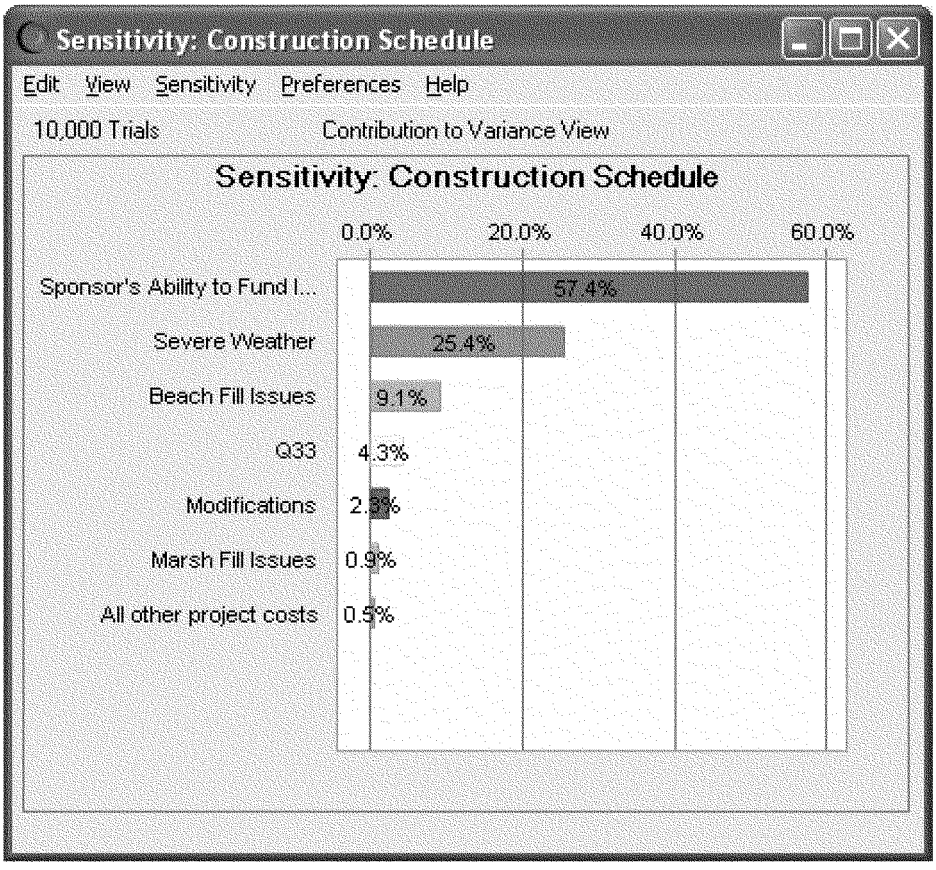


**Figure 4. Schedule Sensitivity Analysis – Shell Island**



## 7.0 MAJOR FINDINGS/OBSERVATIONS/RECOMMENDATIONS

This section provides a summary of significant risk analysis results that are identified in the preceding sections of the report. Risk analysis results are intended to provide project leadership with contingency information for scheduling, budgeting, and project control purposes, as well as to provide tools to support decision making and risk management as projects progress through planning and implementation. Because of the potential for use of risk analysis results for such diverse purposes, this section also reiterates and highlights important steps, logic, key assumptions, limitations, and decisions to help ensure that the risk analysis results are appropriately interpreted.

### 7.1 Major Findings/Observations

The total construction cost comparison summaries from Crystal Ball are provided in Tables 5 and 6. Additional major findings and observations of the risk analysis are listed below.

1. Base cost contingency recommended for Caminada Headland is roughly $45 Million, for a total cost of roughly $205 Million. For Shell Island, the base cost contingency recommended is roughly $46 Million, for a total cost of roughly $188 Million. These figures are based off the 80% confidence level values calculated by Crystal Ball.
2. Schedule duration contingency recommended for Caminada Headland is roughly 19 months, for a total duration of roughly 50 months. For Shell Island, the schedule duration contingency recommended is roughly 16 months, for a total of roughly 41 months. These figures are based off the 80% confidence level values calculated by Crystal Ball.
3. Operation and maintenance activities were not included in the cost estimate or schedules. Potential future O&M is the responsibility of the Local Sponsor and

funding is not being requested. Therefore, a full lifecycle risk analysis was not performed.

**Table 5. Baseline Construction Cost Comparison Summary – Caminada Headland**

| Confidence Level | Total Project Cost ($1,000) |
|---|---|
| 0% | $122,161,589 |
| 5% | $153,443,626 |
| 10% | $159,775,282 |
| 15% | $164,490,143 |
| 20% | $168,422,735 |
| 25% | $171,537,576 |
| 30% | $174,379,462 |
| 35% | $177,211,968 |
| 40% | $179,672,926 |
| 45% | $182,337,635 |
| 50% | $184,948,464 |
| 55% | $187,912,008 |
| 60% | $190,531,752 |
| 65% | $193,511,385 |
| 70% | $196,625,851 |
| 75% | $200,073,300 |
| 80% | $204,322,593 |
| 85% | $209,070,183 |
| 90% | $214,473,190 |
| 95% | $222,399,789 |
| 100% | $262,052,993 |

**Table 6. Baseline Construction Cost Comparison Summary – Shell Island**

| Confidence Level | Total Project Cost ($1,000) |
|---|---|
| 0% | $95,267,020 |
| 5% | $134,550,772 |
| 10% | $141,738,190 |
| 15% | $147,118,858 |
| 20% | $151,203,187 |
| 25% | $154,662,367 |
| 30% | $157,671,577 |
| 35% | $160,786,702 |
| 40% | $163,713,779 |
| 45% | $166,475,859 |
| 50% | $169,081,166 |
| 55% | $171,935,203 |
| 60% | $174,520,697 |
| 65% | $177,521,193 |
| 70% | $180,457,969 |
| 75% | $183,898,621 |
| 80% | $187,726,093 |
| 85% | $192,382,037 |
| 90% | $197,985,981 |
| 95% | $205,436,790 |
| 100% | $246,619,708 |

### 7.2 Recommendations

Risk Management is an all-encompassing, iterative, and life-cycle process of project management. The Project Management Institute's (PMI) *A Guide to the Project Management Body of Knowledge (PMBOK® Guide), 4th edition*, states that "project risk management includes the processes concerned with conducting risk management planning, identification, analysis, responses, and monitoring and control on a project." Risk identification and analysis are processes within the knowledge area of risk management. Its outputs pertinent to this effort include the risk register, risk quantification (risk analysis model), contingency report, and the sensitivity analysis.

The intended use of these outputs is implementation by the project leadership with respect to risk responses (such as mitigation) and risk monitoring and control. In short, the effectiveness of the project risk management effort requires that the proactive management of risks not conclude with the study completed in this report.

This section provides a list of recommendations for continued management of the risks identified and analyzed in this study. (Note: this list is not all-inclusive)

1. Timely Funding: With respect to receiving project funding (Sponsor's Ability to Fund Its Share, Risk E-1 on both projects) in a timely manner, proactive project and cost management are critical.
2. Schedule Quality: Due to the nature of the projects, the schedule quality was adequate enough to be studied as a risk. It is recommended that project leadership use the results of the schedule risk analysis in the development of a high-quality schedule, creating a risk based schedule.
3. Risk Management: The outputs created during the risk analysis effort are recommended to be used as tools in future risk management processes. The risk register should be updated at each major project milestone. The results of the sensitivity analysis may also be used for response planning strategy and development. These tools should be used in conjunction with regular risk review meetings. As an example, recommended uses of the risk register include:

- Documenting risk mitigation strategies being pursued in response to the identified risks and their assessment in terms of probability and impact.
- Providing project sponsors, stakeholders and leadership/management with a documented framework from which risk status can be reported in the context of project controls.
- Communicating risk management issues.
- Providing a mechanism for eliciting risk analysis feedback and project control input.
- Identifying risk transfer, elimination or mitigation actions required for implementation of risk management plans.

4. Risk Analysis Updates: Project leadership should review risk items identified in the original risk register and add others, as required, throughout the project life-cycle. Risks should be reviewed for status and reevaluation (using qualitative measure, at a minimum) and placed on risk management watch lists if any risk's likelihood or impact significantly increases. Project leadership should also be mindful of the potential for secondary (new risks created specifically by the response to an original risk) and residual risks (risks that remain and have unintended impact following response).

# APPENDIX A

DETAILED RISK REGISTERS

# Caminada Headland – Initial Risk Register

| Risk No. | Risk/Opportunity Event | Discussion and Concerns | Project Cost | | | | | Project Schedule | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Likelihood* | Impact* | Risk Level* | Percent Risk | Rough Order Impact ($) | Likelihood* | Impact* | Risk Level* | Rough Order Impact (mo) |
| **Internal Risks** (Internal Risk Items are those that are generated, caused, or controlled within the PDT's sphere of influence.) | | | | | | | | | | | |
| I-1 | Changes in Priority | Pulling funding for this project, would delay construction but would eventually be done, funding allocated | Unlikely | Marginal | Low | | | Unlikely | Critical | Moderate | |
| I-2 | Functional Resources Overloaded/Shift of Staff Priorities | Lack of internal human resources to execute project due to heavy workload, overloaded staff, and shifting priorities. Schedule not cost risk | Unlikely | Marginal | Low | | | Unlikely | Significant | Moderate | |
| I-3 | Accelerated Contract Schedule | Accelerated schedule, increasing costs in overtime, double shifts, but decreasing construction duration. | Very Unlikely | Marginal | Low | | | Very Unlikely | Marginal | Low | |
| I-4 | Dredge Acquisition | Dredge/Equipment availability according to market | Likely | Significant | High | -10% to 25% | | Likely | Significant | High | |
| I-5 | Quantity changes | Hurricanes have resulted in land losses. Quantities may have changed. | Likely | Significant | Moderate | | | Unlikely | Marginal | Low | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| I-6 | Estimating/Scheduling Errors | Chance for oversights, errors, etc., as the PED schedule, acquisition strategy, and scoping information are driving the estimate and schedule quality. | Unlikely | Marginal | Low | | | Unlikely | Marginal | Low | |
| I-7 | Borrow issues/availability | | Very unlikely | Significant | Low | | | Very unlikely | Significant | Low | |
| I-8 | Utility Relocations | Utility relocations plan is currently being defined -- not fully captured in estimate at this time. Unknown oil & gas pipelines more impact to schedule | unlikely | Marginal | Low | 1% | | Very unlikely | Significant | Low | |
| I-9 | Sea Turtles | Critical for hopper dredges, could mandate shutdown of job | Likely | Significant | High | 40-50% | | Likely | critical | High | |
| I-10 | Environmental Assessment/Potential Mitigation | Piping Plover habitat | Likely | marginal | moderate | | | likely | marginal | moderate | |
| I-11 | Geotechnical Issues | Testing complete | Very Unlikely | marginal | Low | | | Very Unlikely | marginal | Low | |
| I-12 | Confidence in Technical Assumptions | There is the possibility that assumptions were in error at the technical planning stages. | Very Unlikely | marignal | Low | | | Very Unlikely | marignal | Low | |
| I-13 | Historical Cost Growth in Modifications | Risk associated with cost and schedule growth due to modifications | Likely | Significant | High | | | Very Unlikely | marignal | Low | |

| **External Risks** (External Risk Items are those that are generated, caused, or controlled exclusively outside the PDT's sphere of influence.) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| E-1 | Cost of Fuel | $3.77/gal used to develop Cost estimate | likely | significant | High | 10% | | likely | negligble | Low | |
| E-2 | Sponsor's Ability to Fund Its Share | Sponsor to provide 25% cost share on project. Potential delays in providing the funds. Time not cost critical | likely | negligble | low | | | likely | significant | High | |
| E-3 | Severe Weather | Risks associated with a severe tropical storm, hurricane, or severe flooding event.2 hurricane seasons | likely | significant | High | 3-4% | | likely | significant | High | |



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# Caminada Headland – Final Risk Register - Model

| Risk No. | Risk Event | Issues | Likelihood | Impact | Cost Risk Level | Likelihood | Impact | Schedule Risk Level | Distribution |
|---|---|---|---|---|---|---|---|---|---|
| **Internal Risks** (Internal Risk Items are those that are generated, caused, or controlled within the PDT's sphere of influence.) | | | | | | | | | |
| I-1 | Marsh Fill Issues | Borrow to Fill Ratio, Dredge Production Rate | Unlikely | Significant | Moderate | Unlikely | Significant | Moderate | Triangular |
| I-2 | Beach and Dune Fill Issues | Borrow to Fill Ratio, Dredge Production Rate | Likely | Critical | High | Likely | Critical | High | Triangular |
| I-4 | All other project costs | Placeholder for costs not captured in summation of risks being studied | Likely | Negligible | Low | Likely | Negligible | Low | Triangular |
| **External Risks** (External Risk Items are those that are generated, caused, or controlled exclusively outside the PDT's sphere of influence.) | | | | | | | | | |
| E-1 | Sponsor's Ability to Fund Its Share | State of LA has been known to be late in appropriating funds | Likely | Marginal | Moderate | Likely | Significant | High | Uniform |
| E-2 | Fuel Prices | Fuel prices may fluctuate, changing the estimate cost | Likely | Significant | High | Likely | Negligible | Low | Triangular |
| E-3 | Severe Weather/Downtime | Severe weather may impact the project cost and/or schedule | Likely | Significant | High | Likely | Significant | High | Triangular |
| E-4 | Modifications | Modifications are likely, so costs have been added to account for these | Likely | Negligible | Low | Likely | Marginal | Moderate | Uniform |
| E-5 | Bidder's Risk in Volatile Market | Risk to Bidder(s) in a competitive or non-competitive market will impact their price | Likely | Significant | High | Likely | Negligible | Low | Uniform |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| E-6 | Steel Prices | Steel prices may fluctuate, changing the estimate cost | Likely | Moderate | High | Likely | Negligible | Low | Triangular |
| E-7 | Turtle Trawling Issues | Variance mainly to project schedule, overhead costs | Likely | marginal | Moderate | Likely | Critical | High | Triangular |
| E-8 | Dredge Size Inefficiency | A more economical/efficient/larger dredge may be available. | Likely | marginal | Moderate | Likely | marginal | Moderate | Triangular |



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# Shell Island – Initial Risk Register

| Risk No. | Risk/Opportunity Event | Discussion and Concerns | Project Cost | | | | Project Schedule | | | | Variance Distribution |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Likelihood * | Impact * | Risk Level* | Rough Order Impact ($) | Likelihood * | Impact * | Risk Level* | Rough Order Impact (mo) | |
| **Internal Risks** (Internal Risk Items are those that are generated, caused, or controlled within the PDT's sphere of influence.) | | | | | | | | | | | |
| I-1 | Pipeline from Borrow Area | Navigation Issues, new borrow permits from MMS, State of LA should take care of oyster plans | Likely | Significant | High | | Likely | Significant | High | | Triangular |
| I-2 | Changes in priority | Pulling funding for this project for other immediate needs. | Unlikely | Marginal | Low | | Unlikely | Significant | Moderate | | Uniform |
| I-3 | Confidence in Technical Assumptions | There is the possibility that assumptions were in error at the technical planning stages. | Very Unlikely | Negligible | Low | | Very Unlikely | Negligible | Low | | Triangular |
| I-4 | Dredge Acquisition | Dredges for the project may not be available at all times. | Unlikely | Critical | Moderate | | Unlikely | Critical | Moderate | | Triangular |
| I-5 | Environmental Assessment/Potential Mitigation | Local birds and turtles could pose some threat to cost/schedule. | Very Unlikely | Negligible | Low | | Very Unlikely | Marginal | Low | | Triangular |
| I-6 | Estimating/Scheduling Errors | Chance for oversights, errors, etc., as the PED schedule and scope of work are driving the estimate and schedule quality. | Unlikely | Marginal | Low | | Unlikely | Marginal | Low | | Uniform |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| I-7 | Functional Resources Overloaded/Shift of Staff Priorities | Lack of internal human resources to execute project due to heavy workload, overloaded staff, and shifting priorities. | Unlikely | Marginal | Low | | Unlikely | Significant | Moderate | | Triangular |
| I-8 | Geotechnical Issues | Currently conservatively designed. Conditions may be better than the current design. May represent some savings. | Unlikely | Marginal | Low | | Unlikely | Negligible | Low | | Triangular |
| I-9 | Inexperienced Staff Assigned | Inexperienced staff due to workload or turnover of experienced staff. | Very Likely | Marginal | Moderate | | Very Likely | Significant | High | | Triangular |
| I-10 | Quantity Changes | Quantities may have changed due to recent hurricanes. | Likely | Marginal | Moderate | | Likely | Marginal | Moderate | | Triangular |
| I-11 | Staff Turnover/Losing Staff at Critical Points | Potential to lose critical staff throughout life of project due to workload and attrition. | Very Unlikely | Significant | Low | | Very Unlikely | Marginal | Low | | Triangular |
| I-12 | Survey Information | Surveys may be irrelevant/incorrect. | Very Unlikely | Significant | Low | | Very Unlikely | Significant | Low | | Triangular |
| **External Risks** (External Risk Items are those that are generated, caused, or controlled exclusively outside the PDT's sphere of influence.) | | | | | | | | | | | |
| E-1 | Sponsor's Ability to Fund Its Share | Procuring funds from the State of LA has been known to take long periods of time in the past. | Likely | Negligible | Low | | Likely | Significant | High | | Uniform |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| E-2 | Oil/Gas Prices | Fluctuations in fuel costs could have a profound impact on the project cost. | Likely | Significant | High | | Likely | Negligible | Low | | Triangular |
| E-3 | Severe Weather | Risks associated with a severe tropical storm, hurricane, or severe flooding event. | Likely | Significant | High | | Likely | Significant | High | | Triangular |



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# Shell Island – Final Risk Register - Model

| Risk No. | Risk Event | Issues | Notes | Likelihood | Impact | Cost Risk Level | Likelihood | Impact | Schedule Risk Level | Distribution |
|---|---|---|---|---|---|---|---|---|---|---|
| **Internal Risks** (Internal Risk Items are those that are generated, caused, or controlled within the PDT's sphere of influence.) | | | | | | | | | | |
| I-1 | Marsh Fill Issues | Borrow to Fill Ratio, Quantity changes due to survey inaccuracies | Without borings for the borrow areas, an accurate borrow to fill ratio cannot be determined. Since Hurricane Gustav, there may have been some impacts to the site, possibly requiring additional material. | Unlikely | Significant | Moderate | Unlikely | Significant | Moderate | Triangular |
| I-2 | Beach Fill Issues | Borrow to Fill Ratio, Quantity changes due to survey inaccuracies | Without borings for the borrow areas, an accurate borrow to fill ratio cannot be determined. Since Hurricane Gustav, there may have been some impacts to the site, possibly requiring additional material. | Likely | Critical | High | Likely | Critical | High | Triangular |
| I-3 | All other project costs | Placeholder for costs not captured in summation of risks being studied | | Likely | Negligible | Low | Likely | Negligible | Low | Triangular |
| **External Risks** (External Risk Items are those that are generated, caused, or controlled exclusively outside the PDT's sphere of influence.) | | | | | | | | | | |
| E-1 | Sponsor's Ability to Fund Its Share | State of LA has been known to be late in appropriating funds | A delay in appropriating the funds for this project would delay the start of the project, and could possibly (though unlikely) result in there being no adequate | Likely | Negligible | Low | Likely | Significant | High | Uniform |



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| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | dredges available for the work. | | | | | | | |
| E-2 | Fuel Prices | Fuel prices may fluctuate, changing the estimate cost | | Likely | Significant | High | Likely | Negligible | Low | Triangular |
| E-3 | Severe Weather/Downtime | Severe weather may impact the project cost and schedule. | Severe weather will cause the Contractor to bid higher than normal because he will not be able to run his dredge as efficiently as in good weather. Storms will make him evacuate the area, cutting into his working time and increasing project length. Conversely, good weather will allow him to work very efficiently, possibly decreasing the contract cost and duration. It is probable, however, that he will build some delays into his estimate to account for time lost depending on the storm forecast for the Gulf of Mexico during the contract time. | Likely | Significant | High | Likely | Significant | High | Triangular |
| E-4 | Modifications | Modifications are likely, so costs have been added to account for these | Modifications are built into the project, since it is anticipated that some costs for mods will be required. | Likely | Negligible | Low | Likely | Marginal | Moderate | Uniform |
| E-5 | Bidder's Risk in Volatile Market | Risk to Bidder(s) in a competitive or non-competitive market will impact their price | In a competitive market, the bid prices will be lower. In a saturated market, the price | Likely | Significant | High | Likely | Negligible | Low | Uniform |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | will be higher because there will be fewer bidders interested in the project. | | | | | | | |
| E-6 | Steel Prices | Cost of steel has fluctuated wildly over the past year; similar flucuations could occur between now and project start date. | | Likely | Negligible | Low | Likely | Negligible | Low | Triangular |
| E-7 | Long Pipeline Beach | risk in productivity/efficiency with long pipeline and boosters and installation of long pipeline for the Beach work | concerns over productivity on long pipeline with numerous boosters and installation of long pipeline | Likely | Significant | High | Likely | Significant | High | Triangular |

FOR CONTINUATION OF HOUSE DOCUMENT 113-46

LOUISIANA COASTAL AREA, BARATARIA BASIN BARRIER SHORELINE RESTORATION PROJECT LaFOURCHE, JEFFERSON, AND PLAQUEMINES PARISHES, LOUISIANA FINAL REPORT

SEE PART 3