112th Congress, 2d Session – – – – – – – – – – – – House Document 112–154

BROWARD COUNTY WATER PRESERVE AREAS PROJECT, COMPREHENSIVE EVERGLADES RESTORATION PLAN, CENTRAL AND SOUTHERN FLORIDA PROJECT, BROWARD AND MIAMI-DADE COUNTIES

COMMUNICATION

FROM

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

TRANSMITTING

A COMPREHENSIVE RESTORATION PLAN

PART 2 OF 3

DECEMBER 27, 2012.—Referred to the Committee on Transportation and Infrastructure and ordered to be printed

U.S. GOVERNMENT PRINTING OFFICE

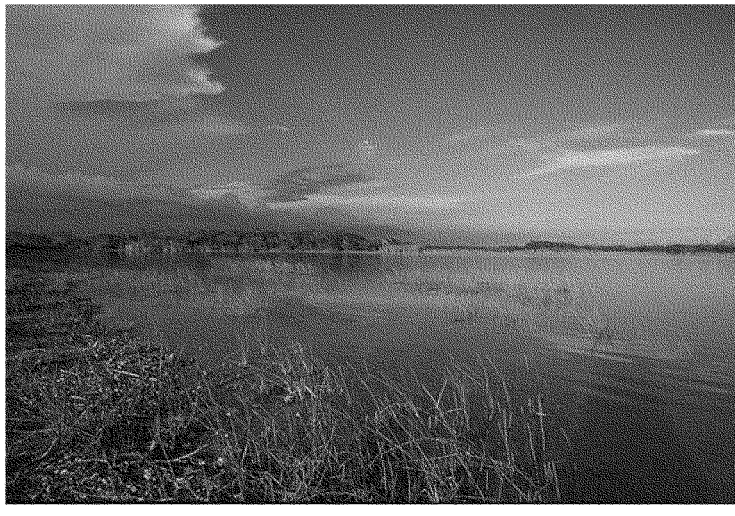
82–341 WASHINGTON : 2013

AUTHENTICATED
U.S. GOVERNMENT
INFORMATION
GPO

CENTRAL AND SOUTHERN FLORIDA PROJECT
BROWARD COUNTY WATER PRESERVE AREAS

REVISED FINAL
INTEGRATED PROJECT IMPLEMENTATION REPORT AND ENVIRONMENTAL IMPACT STATEMENT

Engineering – Appendix A



U.S. ARMY CORPS OF ENGINEERS
JACKSONVILLE DISTRICT

SOUTH FLORIDA WATER
MANAGEMENT DISTRICT

APRIL 2007 (REVISED MAY 2012)

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A.0 ENGINEERING

A.1 ENGINEERING DESIGN

A.1.1 Broward County Water Preserve Areas Project

The Water Preserve Areas (WPA) concept is an integral part of the Comprehensive Everglades Restoration Plan (CERP). Ecological restoration of the Everglades will require a significant increase in the quantity of water made available or retained for the natural system. One main tenet behind the WPA concept is the capture and storage of excess water that is currently lost to tide (the ocean) with ability to make releases later to meet agricultural and municipal demands for water supply with the objective of reducing the use of natural system water from the Water Conservation Areas (WCAs). WPA deliveries are also used to maintain the freshwater interface in protection of the surficial water table from saltwater intrusion. Another main tenet of the WPA concept is to control or reduce seepage from the WCAs while maintaining surficial aquifer flow through groundwater recharge with the stored water. Both tenets provide management of excess water and promote retention of water within the natural system for everglades restoration. Another tenet of the WPA concept is to provide a buffer area between urban and natural areas (WCAs). This is the reason WPA projects range all along the East Coast Protection Levees.

The Broward County WPA (BCWPA) Project differs from the other WPA projects because stormwater from the Western C-11 Basin is currently pumped to WCA 3 and not to tide. This project is planned and designed primarily to perform two functions: 1) capture and store excess surface water runoff from the Western C-11 Basin that is currently discharged untreated into the WCA 3, thus reducing nutrient loading to the natural system, and 2) reduce seepage loss from WCA 3. The C-11 and C-9 Impoundment components aid the WCA 3A and WCA 3B Seepage Management Area (3A SMA and 3B SMA) project component in reducing seepage from WCA 3A and WCA 3B by raised water levels that provide an opposing gradient to the seepage that currently flows toward the drained areas immediately to the east. Thus, BCWPA Project will immediately and independently "save" or increase water made available or for the restoration of the Everglades.

The BCWPA Selected Plan features two impoundments with a maximum normal pool storage depth of 4.3 feet: 1) C-11 Impoundment at 1,068 acres of aboveground surface area storage and 2) C-9 Impoundment at 1,641 acres of aboveground surface area storage (see ***Plate G-01***). Both impoundments include individual inflow pump stations, discharge structures, emergency overflow

spillways, and seepage control canals with associated structures. The impoundments may provide opportunities to increase flood damage reduction abilities through operational changes to the C&SF Project and local drainage systems. However, these opportunities are considered incidental and are not claimed benefits. Additionally, the impoundments may provide limited water quality improvements in the C-11 and C-9 canals.

The BCWPA Selected Plan also features approximately 4,353-acre plus wetland areas, 3A SMA and 3B SMA, which provide the ability to manage seepage from WCA 3A and WCA 3B and function as a natural habitat buffer between the larger WCA and urban development to the east (see ***Plate G-01***). Seasonal control of water levels in both SMAs also enhances hydroperiods, thus improving the habitat environment for native flora and fauna. The 3A SMA and 3B SMA include a full-length protective levee that functions to separate wetland or natural areas and developed areas to the east. The 3B SMA component also includes an improved conveyance canal that diverts excess water from the Western C-11 Basin by transference to the C-9 Impoundment, and in the future to North Lake Storage Area (NLBSA).

It should be noted that the use of the terms "dam, impoundment, and reservoir" are deemed here as interchangeable, dependent of course on the context in usage. For example, both CERP components C-11 Impoundment and C-9 Impoundment impound stormwater runoff in a deeper pool with a wide range of fluctuating water levels and in separate shallow wetland areas. Yet the wetlands are in no way thought to be reservoirs, much less dams, in how they were designed or to be operated. In this Engineering Appendix, the use of the term "reservoir" is exclusive to the 4.3-foot deep design pools. However, at times the term "impoundment" is used for the same areas, as well as the project itself with the "impoundment" in the name. The wetland areas are referred to by the same (i.e. wetlands) or as mitigation areas as their reason for being originates from a reconfiguration of Section 404 mitigation areas currently located within each component footprint.

A.1.2 Summary of Primary Operations

A.1.2.1 Water Conservation Area 3A/3B Seepage Management Area

The 3A SMA and the 3B SMA are primarily operated for the purpose of reducing seepage loss from WCA 3A and WCA 3B, respectively. Seepage from WCA 3 is reduced by managing a water level "step down" buffer strip (i.e. SMAs) between the water level in WCA 3 (to the west) and the controlled water table in areas to the east. This is accomplished by constructing a levee to prevent rainfall and pooled seepage from being drained by artificially established patterns and by controlling the wetland water levels seasonally with water control structures operated to enhance habitat. The 3A SMA will have a control water level of

+7.50 ft-NGVD during the wet season and +6.50 ft-NGVD during the dry season. The 3B SMA with a lower average ground elevation will have a control water level (again, surface and water table) of +6.50 ft-NGVD during the wet season and +5.50 ft-NGVD during the dry season. The term "control" is used here to mean "target" as all project modeling performed demonstrated that stages will fluctuate in similar manner as today's without project condition, but control will provide the wetlands with the ability to sustain their environmental value.

The C&SF L-37 Borrow (3A SMA) and L-33 Borrow (3B SMA) canals will also be managed with their respective area water levels. However, the C-502A Borrow and C-502B Conveyance and Borrow canals having a levee for separation from the wetland will have similar water levels, but may differ dependent on adjacent conditions required by existing US Highway 27 (US27) and lands to the east. The C-502B Canal may also exhibit higher stages when deliveries from the C-11 Impoundment to the C-9 Impoundment are being made. These higher stages may require frequency and duration control to avoid an adverse impact on the US 27 road base through saturation by soil capillary action within the road sub-base layer.

Excess rain and seepage water collected in 3A SMA (levels are above desirable hydropattern targets) are managed with outlet structures S-9XN (L-37 Borrow) and G-86N (C-502A Borrow) stoplog riser structures. These control structures discharge into the C-11 Canal where the excess water can be either pumped into WCA 3A through the S-9A Pump Station or released east into the Western C-11 Basin through the S-381 structure. Excess rain and seepage water collected in 3B SMA are directed to the C-11 Canal in a similar manner as 3A SMA with S-9XS (L-33 Borrow) stoplog riser and S-502B (C-502B Canal) Gated Culverts. If downstream conditions are advantageous and the C-9 Canal is within normal control stages, excess water may be released into the C-9 Canal with S-30 Gated Culverts from the C-502B Canal and S-511 Gated Culverts controlling the flow eastward. Under similar downstream constraints, discharge into the C-6 Canal is controlled with S-32 (L-33 Borrow, also connected to the C-9 Canal within 3B SMA) Gated Culverts. Gated culverts S-515 will control excess water flow down the C-6 Canal.

A.1.2.2 Diversion of Western C-11 Basin Runoff

The S-9 Pumping Station has the function of providing flood damage reduction for the Western C-11 Basin. The C-11 and C-9 Impoundments and C-502B (diversion) canal operate primarily for the purpose of reducing Western C-11 Basin's untreated stormwater runoff from being pumped into WCA 3A by the S-9 Pump Station. Thus, the project achieves its objectives by diverting stormwater runoff from WCA 3A to the C-11 Impoundment and the C-9 Impoundment (via the C-502B Canal). The initial diversion target for Western C-11 Basin runoff is

the C-11 Impoundment. As the impoundment nears capacity and if C-9 Impoundment has storage available, then diversion deliveries to the C-9 Impoundment are made. Deliveries from the C-11 Impoundment to the C-9 Impoundment are made through the S-504 Gated Spillway into the C-11 Canal, conveyed west under US 27 to the headwater of S-502B Gated Culverts. The S-502B structure is opened to allow conveyance of diverted water to the headwater of S-30 Gated Culverts on the C-9 Canal. The S-30 structure is opened to allow conveyance east under US 27 to the C-9 Impoundment inflow pump station S-509. The C-9 Canal gated culverts C-511 may or may not be closed dependent on if excess runoff in the C-9 Canal is desired to be pumped into the C-9 Impoundment as well. In the CERP 2050 recommended plan stormwater diverted from Western C-11 Basin and stormwater from C-9 Basin are routed to the North Lake Belt Storage Area (NLBSA).

A.1.2.3 Operation for Flood Damage Reduction

The BCWPA Project does not have as a purpose nor claim to improve flood damage reduction benefits for the residing basins. However, placement of water impounding features closer to the source of the stormwater should incidentally provide improved flood damage reduction abilities within the basins. The existing flood damage reduction systems (i.e. C&SF S-9 Pump Station for Western C-11 Basin and C&SF S-29 Gated Spillway for C-9 Basin) still retain their full capacity in reducing flood damages for the individual basins. Implementation of the BCWPA Project does not require, nor does it recommend removal of these flood damage reduction systems, but the systems are to remain and be maintained at current capacities and standards. The project still has as a constraint to not negatively impact existing level of flood protection as is discussed in ***Section A.2.3***. For instance, the service overflow spillways for the C-11 and C-9 Impoundments are sized to not exceed the basins' permitted discharge rate for the 25-year design storm extended to the 100-year project design storm event. If opportunities arise where operations can be made to improve flood damage reduction for the basins and still accomplish the claimed benefits of the project, then those operations will be considered with approved modification of the Operation Manual(s). Flexibility in the operational range of the S-9A pump station will mitigate any adverse impacts of seepage from the C-11 Impoundment south of the C-11 Canal. If the inter-basin transfer of water from C-11 to C-9 Impoundment raises canal levels west of S-381 and South of the C-11 Canal in C-502B then seepage control trenches and/or barriers will be implemented in lands owned by SFWMD that will be included in the project as necessary.

One location in the Seepage Management Area requires flood mitigation effort. The project will most likely impact the existing level of flood protection at Holly Lakes Mobile Home Park without a mitigating flood damage reduction system.

The system of levee, drainage/seepage canal with pumps to be implemented with BCWPA is to mitigate for project impacts only and not to substantially improve their individual systems.

A.1.2.4 Operation for Water Supply

During dry periods, maintenance of C-11, C-9, C-6 canal stages for prevention of saltwater intrusion into the surficial aquifer may be required. If water is available in the C-11 or C-9 Impoundments then that water may be released to meet those demands. Water available is defined as that water pooled 0.50-foot above the average existing grade within the impoundments. It should be noted that deliveries to meet coastal water demands rarely occur due to the existing seepage pattern of west to east.

Normal release operations for the C-11 Impoundment are made with the S-503A Gated Culvert structure if the S-9A pump station is operating to return seepage (which means the S-381 gate will be closed). If seepage return operations are not being performed, then releases can be made through the S-504 Gated Spillway. The S-13AW Gated Culverts are opened if transferring water from Western C-11 Basin into Eastern C-11 If there are coastal water demands and the C-11 Impoundment does not have water available, the S-381 Gate may be opened to allow the seepage collected in the C-11 Canal west of S-381 to be delivered eastward to meet demands as provided for under current operations.

Release operations for the C-9 Impoundment are made with the S-510 Gated Culvert structure and the S-511 Gated Culvert canal divide structure for conveyance eastward to maintain the water level at the S-29 Gates. If there are coastal water demands and the C-9 Impoundment does not have water available, the S-30 Gate may be opened to allow for seepage to be conveyed to the east to meet demands as provided for under current operations.

Release operations for 3A SMA and 3B SMA are made with the same structures used to manage excess rainfall and seepage. Excess water discharged into the C-11 Canal is returned to WCA 3A through pumping at the S-9A pump station.

A.1.2.4.1 Drawdown Operation

Engineering Regulations (ER 1110-2-50, 1975) require a minimum low-level discharge ability to reduce the pool within a period of 4 months to, for CERP type impoundments (i.e. no upstream watershed with gravity inflow), *"a pool level which will result in an amount of storage in the reservoir that is 10% of that at the beginning pool level."* The reason for this requirement is to provide flexibility in future project operation for unanticipated needs such as major repair of the structure, environmental controls or changes in reservoir regulations. The impoundments' outlet structures, as designed, meet this

requirement easily as design functions require a larger discharge ability than this minimal requirement.

Other than low-level discharge ability requirements, to attain project benefits the impoundment(s) must be drawn down to gain storage, thus divert runoff from being pumped into WCA 3 with succeeding storm events after the impoundment fills initially. During the wet season whenever the impoundments have a pool depth of a foot or more above average existing grade and conditions within the basin allow, i.e. canals are at or below control stages, water may be released to regain storage availability for the next storm event as long as such releases do not negatively impact existing levels of flood protection.

Bleed down operations (i.e. lowering the pool in a less controlled operation) are only to be performed when the pool is above normal maximum pool level, and this is to preserve the integrity of the embankment should an extreme event occur. Bleed down operations are performed with the overflow spillway(s) and may be augmented with control through discharge gated structure(s). Bleed down operations are expected on rare occurrences and may or may not occur with a significant volume of water being discharged. Significant is defined here as a volume of water larger than the design 100-year return frequency storm event.

A.1.2.5 C-9 Impoundment Flexibility

In the CERP recommended plan, the C-9 Impoundment functions as a stormwater settlement basin for releases from the North Lake Belt Storage Area (NLBSA). The NLBSA is scheduled to be implemented in 2036. During this interim time before NLBSA comes online, the C-9 Impoundment will function as a stormwater storage facility. Thus, the C-9 Impoundment will receive runoff either by way of that diverted from the C-11 Impoundment or directly from the C-9 Canal Basin. Should the NLBSA not be implemented under the CERP Plan, then C-9 may remain as an impoundment/reservoir feature.

A.1.2.6 C-11 and C-9 Impoundments Reconfigured Mitigation Area(s)

Both components, C-11 and C-9 Impoundments, have within their respective footprints current Department of the Army 404 Permit Mitigation Area(s) that are proposed to be reconfigured to achieve project goals. The mitigation areas will have a maximum "active" storage of one-foot depth measured above the average existing grade for the specific berm-enclosed area. The term "active" is used to differentiate the difference between project controlled inflow for additional diversion/storage through structure releases and that which may be considered as rainfall and seepage, or "passive" storage. It is proposed to acquire mitigation bank credits to replace the loss of DA 404 mitigation areas in the C-9 Impoundment. The mitigation areas will have inflow structures that control the

release of impoundment water from the associated impoundment when water is available. The mitigation areas will also have outflow structures that provide wetlands area stage control and a means to drain to near dry, if necessary, for maintenance operations. The storage of water in the mitigation areas is considered beneficial to original purposes in that currently those areas are relatively drier than ideal and the additional water will enhance their hydroperiods and provide environmental "lift." The USFWS has expressd concerns about selenium residues and potential effects on trust species with the proposed hydration of the FDOT optional mitigation area of the C-9 Impoundment. The PDT has determined a mitigation bank payment to cover the required FCUs is the best option with least risk and costs after coordination with HQ-USACE and SAD-USACE.

A.2 STATUS OF ENGINEERING ACTIVITIES

A.2.1 Level of Design Efforts

The level of effort performed for this PIR Selected Plan design is equivalent to a feasibility study design plan with additional analyses to support some of the more costly features, e.g. embankment design. Also, additional analyses (Savings Clause, etc.) were performed to meet WRDA 2000 requirements for all projects that fall under the CERP restoration program. However, additional effort notwithstanding, the level of effort presented in the PIR is appropriate to demonstrate a feasible and constructible design within an acceptable level of confidence in cost that would result in expected benefits.

The Non-Federal partner (SFWMD) produced a Basis of Design Report (BODR). SFWMD's Consultants also contributed additional field data and modeling analyses, as well as shared perspective on approach to design and costs of the to be cost-shared features. Though both agencies overall project cost estimates at this level of design are similar, minor differences in design and costing methodology associated with it are acknowledged. The more detailed design and analyses to be performed in the sequential design phases will further refine the design and cost estimate. There will continue to be close coordination during the Preconstruction, Engineering and Design (PED) phase by the Corps and SFWMD through reviews, comments, responses, and discussion of significant issues as they are identified. Therefore, known differences in costs of common features are not considered significant at this time. The cost estimate for the project as a whole ensures that the project, if authorized for construction, may be implemented based on the MCACES cost estimate included in this PIR.

A.2.2 Optimization and Cost Effective Analyses

Several cost effective analyses were performed in the optimization of the Selected Plan design. In some cases, the non-use of a cost effective solution was based on lack of data/information available in ensuring feasibility or due to environmental considerations. These include, but are not limited to, the following: (1) removal of steps and riprap from consideration for embankment revetments due to the environmental adverse impact on small critters, e.g. turtles and migratory bird chicks; (2) oversized seepage canals in the dimension of depth for seepage control; (3) seepage control structures, including pump capacities; and (4) material handling and processing. Additionally, in some cases, the non-use of a cost effective solution was based on the District's acceptance of a request from the SFWMD, to move the project forward on issues that require additional discussions in order to maintain the project schedule. These include, but are not limited to, the following: (1) use of an alternative wind-wave analysis than that documented in DCM-2; (2) not allowing operation of gates between storms when performing the hydrologic three-cycle storm PMF, though operation thereof are approved and included in the DCM-2 document; and (3) use of 14-foot wide embankment crest width versus narrower 12-foot width agreed to in the Draft WPA Feasibility Report (2001). It is expected that during detail design efforts, these non-use features will be revisited with final decision based on a more thorough investigation and cost effective analyses.

Currently, there is an important optimization and cost effective analysis being performed in consideration of environmental impacts cause by the use of steps and riprap for embankment revetments, and that primarily pertains to the embankment design for the C-9 Impoundment. Currently the embankment height for the C-9 Impoundment is the same as with the steps based on an overwash anylysis. The C-11 Impoundment having a Low Hazard Potential Classification does not require a higher embankment with step removal as the design events specified in DCM-2 do not impact the minimum freeboard required by Federal Regulations for earthen embankments with a low hazard rating (ER 1110-8-2(FR), 1991). However, discussions with the Non-Federal sponsor may lead to minor embankment modifications that meet both agencies definitive requirements, which at the same time maintain a cost effective design.

A.2.3 Level of Service Flood Protection

An impact to flood protection analysis performed under contract by the Non-Federal partner, SFWMD, has been completed with the final report, Flood Protection Analysis for Broward County Water Preserve Areas C-11 and C-9 Impoundments (Feb 2006), included in the Addendum of this Appendix. The analysis was performed to meet WRDA 2000 Savings Clause requirements to demonstrate that implementation of the project shall not significantly impact existing level of service flood protection. Available regional and sub-regional model results combined with supplemental calculations were put through

rigorous analyses to determine flood protection impacts that the project through implementation may create and evaluate effects of mitigating features and or operations. These analyses indicated that the Draft WPA Feasibility Study design created minor impacts for the Western C-11 Basin. Additional modeling was completed with the model report, Broward County C-11 Impoundment Level of Service Flood Protection Modeling Analysis (MSR 337) (May 2010), included in the Addendum of this Appendix. The modeling results suggest that short-term events could be managed by field operational strategy that would include the use of the S-9 pump station. This additional modeling indicated that the project could be designed and implemented in compliance with WRDA 2000 Savings Clause. Any additional analysis required – at least one more model simulation has been identified – shall be performed during detail design efforts to ensure that implementation of the project will not significantly impact the existing level of service flood protection.

A.2.4 Impoundment (Reservoir) Design

The two reservoirs included in the C-11 Impoundment and C-9 Impoundment project components were designed during the WPA Feasibility Study (Draft WPAFS, 2001) with engineering policies and regulations known at that time as interpreted by the Jacksonville District. Thus, reservoir(s) designs reported in the Draft PIR were based on these former understandings. Since then, discussions were held between multiple agencies that led to a series of documents known as the Design Criteria Memorandums (DCMs). The DCMs were a successful attempt to bridge USACE and State of Florida Regulations and Policies, and provide real targets required for design from what can be generally perceived as engineering guidance and suggested methodologies. The DCMs include selected design parameters, design alternatives and direction on required procedural analyses that may or may not be unique to the south Florida region for the design of impoundments, reservoirs and dams. However, the uses of the DCMs have their own interpretations and in general it can be stated they create additional opportunities for refinement as experimental and field data is retrieved and experience is gained. Therefore, the Selected Plan design included in this Final PIR is a sound and well-founded design that is acceptable to the Non-Federal partner and other agencies with a perspective on ensuring public safety and cost-effectiveness. Normal post-PIR design and additional cost-effective analyses to be performed during detail design efforts may lead to minor physical modifications of the design presented here. However, the MCACES cost provided is expected to capture any increase of cost changes resulting from those efforts with appropriate contingencies assigned based on risk and uncertainties, or a significant cost savings may be realized dependent on final results from the additional cost effectiveness analysis.

A.2.5 Florida Department of Transportation

As the selected Plan moves forward into detail design, additional coordination will be required between the Florida Department of Transportation (FDOT) and USACE. Issue of most concern and still unresolved is US 27 and Krome Avenue road base and sub-base elevations and how they correlate to design water levels in the 3A and 3B SMA. Based on US 27 crown elevations found on FDOT drawings and USGS Quad maps, extrapolations for road base elevations appear to indicate that design water levels in the Plan should be within range of acceptability. However, this relatively old data requires confirmation with new survey data or found in as-built drawings before the project can be constructed and operated fully as proposed here. The verification of acceptable water levels also influences the Draft PIR proposed highway swale system that has been deleted from this Final PIR based on lack of data and verification of acceptance. Additional issues requiring coordination are the further exchange of information regarding US 27 right-of-way limits (coordinates) and future highway plans regarding widening and other improvements. Also, points of ingress/egress to new levees, road shoulder slopes, clear zones and guardrail requirements for canal placement as designed all require further coordination efforts with FDOT.

A.2.6 Florida Power and Light

As the Selected Plan progresses forward into detail design, additional coordination will be required between the Florida Power and Light (FPL) and USACE. The issue of most concern is how the design water levels in the 3A and 3B SMA components may affect the high power transmission line poles (COR-TEN steel) concrete pads / galvanized connections. Survey data collected by the NFS indicates that approximately 94% of the pads are elevated high enough to be free from potential impact with proposed operations of 3A/3B SMA water levels, as modeled. The costs to raise 10% of the transmission poles with low pad elevations were added to 2007 MCACES cost estimate without final coordination with FPL. To reduce risk even further up to 30% of the SMA 3B poles were estimated to be raised as relocation costs for the 2011 Final PIR.

Another matter to be finalized is a 200-acre parcel(s) owned by FPL that is not currently used and remains in an undeveloped state (primarily as wetlands). Early coordination with FPL under the Draft WPA FS efforts resulted in a non-binding understanding that this parcel would be allowed by FPL to be used as part of 3B SMA for seepage management and hydroperiod enhancement (restoration), either through flowage easement or land donation/swap. However, in the most recent discussions between FPL and the Non-Federal sponsor, FPL indicated that they would prefer that the 200-acre parcel remain separated from the 3B SMA project at this time for planning purposes. However, FPL has not eliminated the possibility of further discussions in the future regarding shared use of those portions of the FPL parcel outside the footprint of any future FPL project on the property at the time detailed design of the project commences. In

recognition of FPL property rights, a three-foot berm is proposed to isolate the parcel(s) from the remaining 3B SMA. Flood damage reduction is not being considered at this time for the reasons listed here: (1) Should operation of the 3B SMA project impact the FPL property, then the project operations would have to be modified to mitigate for those impacts, either through modification of the Operational Manual or through structural feature(s), e.g. pump station; (2) Model results between the with project condition and without project (existing) condition demonstrate limited impact with unknown degree of significance. The reason for questionable significance is because duration of higher project produced water levels (significantly less than a foot in most cases) may be evident, but higher storm induced levels during flood events are not with the understanding of proposed operations and response of the system to be expected; (3) Pumping the area to maintain a lower water level for mitigation will cause adverse impact of abutting "to be restored" wetlands and will impact the existing wetlands within the parcel(s) irresponsibly; and (4) Should FPL choose to develop their parcel(s), the FEMA Base Flood elevation of the area is significantly above that that the project impacts with controlled water level operations and should not be further impacted.

An additional issue requiring further coordination is the functional maintenance of the existing FPL access road which passes through the western portion of 3A and 3B SMAs and the placement of ungated culverts under it to allow free flow east and west through wetlands.

A.2.7 Aquifer Storage and Recovery for C-9 Impoundment

The C-9 Impoundment is also recommended for a future Aquifer Storage and Recovery (ASR) pilot project/study in this Final PIR. Without ASR, the reservoir will operate with a maximum normal pool depth of 4.3 feet; however, because of the potential for a high seepage loss rate, the 4.3-foot depth may not be able to be maintained for extended periods of time. During the Draft PIR phase, based on initial geotechnical analyses with limited data collection, seepage losses were expected to be too high for cost effective control under most conditions, especially during the wet season when the focus is on not significantly impacting existing levels of service for flood protection. However, reports on analyses performed under the State Expedited Project/Initiatives (formerly known as Acceler8) with newly collected field data are indicating a better than expected seepage loss rate from the impounded water, i.e. less seepage. Therefore, the project delivery team is now recommending the allowance of storage to 4.3-foot depth for unlimited time unless monitoring demonstrates a need to limit normal pools for either duration or on seasonal basis. The project delivery team retains its recommendation for an ASR pilot project/study with this Final PIR.

A.3 DESIGN DATA

A.3.1 Survey, Imagery and Map Data

A.3.1.1 Light Imaging Detection and Ranging Survey Data

Light Imaging Detection and Ranging (LIDAR) technology was used to generate survey data for design work. Elevation units reported are in feet (accuracy to tenths) and are referenced to North Geodetic Vertical Datum (NGVD) 1929. Plan coordinates are referenced to Florida State Plane East Zone coordinate system in feet (NAD83). LIDAR data has a stated accuracy of ±0.5 feet.

The approximate conversion from NGVD29 to NAVD88 in the project area is negative (-) 1.54 feet. Per ER 1110-2-8160, all future PED phases for this project will utilize the reference datum NAVD88.

LIDAR data was used for site development and structural design. However, LIDAR data is not sufficiently accurate for final design. Conventional land based surveys (Plans and Specifications level) will be conducted for levee, embankment, and canal alignments, as well as for structure locations during the detailed design phase.

A.3.1.2 Digital Ortho Quarter Quad Imagery

Digital Ortho Quarter Quad imagery (DOQQ) with 2-meter pixel resolution was used as an aid for designing project features. The DOQQ photographic imagery was acquired in 1993 and 1994 and may not accurately depict current land use in plan view background imagery.

A.3.1.3 SPOT

SPOT imagery with 10-meter pixel resolution is used for presentation purposes of large land areas. The SPOT imagery used in this report was acquired in 1999.

A.3.1.4 Aerial and Map Atlases

Aerial and Map Atlases for Broward and Miami-Dade Counties were purchased from First American Real Estate Solutions. The aerial photography was scaled at 1-inch equals 300 feet or 1-inch equals 600 feet. The resolution and detail from the imagery was used for verifying land use changes compared to other imagery used in the design process. Other uses of the imagery included determining vegetation and infrastructure extent for clearing, locating and planning site access and boundaries, and locating major utilities like FPL aerial transmission lines. The photographic imagery in the atlases was acquired in late 1999 and early 2000.

A.3.2 Hydraulic Data

Hydraulic data is provided in this appendix first as general design data, i.e. description of feature and structure types incorporated in the design (see ***Section A.4***). Second level, more detail is provided on features and structures regarding operations and purpose in the associated project component sections (i.e. 3A/3B SMA, C-11 Impoundment, and C-9 Impoundment sections). Third and last level, specific analyses and/or detail reports providing greater detail into the design and parameters used to determine thereof in the latter sections of the specific components are supplied.

A.4 HYDRAULIC DESIGN

A.4.1 Design Criteria and Parameters

This section includes criteria and parameters that were used in the hydraulic design of the BCWPA Project as a component of CERP.

TABLE A-1: QUICK STRUCTURE FACT SHEET

Structure Number	Structure Type	Design (cfs)	Location	Tech Specs & Notes
3A and 3B Seepage Management Area				
S-502B	Gated Culverts	1,000	S of C-11 Canal, at Griffin Road	7-96" pipe or box gated culvert/bridge. Allows diversion south to C-9 Imp
S-514A	Flood Pump Station	60	Holly Lakes Trailer on C-502B Canal	Small pump station, includes 2(E)-30 cfs pumps.
S-515	Gated Culverts	600	Near junction of C-6 with US27, on C-6	2-96" pipe or box gated culverts. Separates water sources (C-6 Canal)
S-516A	Triangular -Prof Weir	7.5	Confluence of C-502B and L-33 canals	20-foot weir – triangular weir with upstream/downstream slope of 1 on 1.
S-516B	Triangular -Prof Weir	7.5	Confluence of C-502C and C-6 canals	20-foot weir – triangular weir with upstream/downstream slope of 1 on 1.
B-500	Bridge	1	FPL Sub-station	Spans across C-502B.
B-501	Bridge	1	Holly Lakes	Spans across C-502B U-Channel
FPL 1-4, FPL 7-19	Non-gated Culverts	< 1	Along FPL access Road within area	Single pipe 48" barrels
FPL 5 FPL 6	Non-gated Culverts	< 1	Along FPL access Road, in 3ASMA	Triple pipe 48" barrels
C-11 Impoundment				
S-503	Inflow Pump Bank	1,050	SE corner off C-11 Canal	Large pump station, includes 3(D)-350 cfs pumps
	Seepage Pump Bank	450	Share same bldg	Medium pump station, includes 3(E)-150 cfs pumps.
S-503A	Gated Culvert	200	SE corner on C-11 Canal, abut S-503	1-5'x6' gated box culvert, drawdown when S-381 in seep backpump ops.
S-504	Gated Culvert	1,000	On C-11 Canal, just east of SW corner	2-8'x8' gated box culvert, main discharge structure.
S-504B	Overflow Spillway	322	On the C-11 Canal east of S-504	8' service + 150' auxiliary spillway, discharges into C-11 Canal
S-505A	Weir and Sluice Gate	220 470	SE corner, N of C-11 Canal in C-511	130-foot weir. Sluice gate is 8'x8'. Emergency overflow of seepage canal

Structure Number	Structure Type	Design (cfs)	Location	Tech Specs & Notes
S-505B	Broad Crested Weir	250	SE-NE C-511 divide structure	150-foot weir. Controls stage between SE and NE C-511 reaches
S-505C	Broad Crested Weir	750	SW, just N of truck stop in C-511 canal	154-foot weir. Controls C-511 western reach stage.
S-505D	Bridge	750	SW corner in C-511 Seepage canal	1-10'x10' box culvert
S-505E	Bridge	non-rated	mid-north C-511 Seepage canal	6-12'x12' box culvert
O&M Access	Bridge	H-25	SE corner over C-511 Canal	14' wide bridge
S-506A	Gated Culvert	55	On C-511 in north, NW corner	1-48" pipe gated "sag" culvert. Delivers water to Mitigation area.
S-506B	Weir-gate Culvert	75	On C-511 in north, near cell tower	2-60" pipe culvert. Controls stage in Mitigation area
S-507A-F	Non-gated Culvert	minimum	SW 26th St	6-48" pipe , hydraulically connect mitigation areas on either side of street
S-508A	Non-gated Culvert	minimum	Confluence of C-512 and C-513 Canals	1-48" pipe culvert. SW26th St. Bridge, conveys flow into C-512.
S-508B	Non-gated Culvert	358	Confluence of C-512 and C-511 Canals	3-72" pipe culvert. Conveys flow from C-512 and C-513 into C-511.
S-508C	Non-gated Culvert	minimum	Between finger lakes in Mit area	1-48" pipe culvert. Provides drainage for western lake into eastern lake.
S-508D	Non-gated Culvert	minimum	Mid C-511 just south of eastern finger lake	1-48" pipe culvert. Provides drainage for eastern lake into C-511.
C-9 Impoundment				
S-509	Inflow Pump Station	1,075	S, middle on C-9 Canal	Large pump station, includes 4(D)-250 cfs, 1(E)-75 cfs pumps.
S-510	Gated Culverts	500	S, W of S-509 on C-9 Canal	2-96" pipe or box gated culverts, control rsvr discharge.
S-510A	Overflow Spillway	2,000	S mid-embankment	13' service + 150' auxiliary spillway, discharges into C-9 Canal.

Structure Number	Structure Type	Design (cfs)	Location	Tech Specs & Notes
S-511	Gated Culverts	500	SE corner in C-9 Canal	2-96" pipe or box gated culverts, reverse flow for runoff capture.
S-512A	Seepage Pump Station	225	E, middle on C-509 Seepage canal	Small pump station, includes 3(E)-75 cfs pumps.
S-512B	CIT Broad Crested Weir	150	SW corner in C-509 Seepage canal	90-foot weir – corrugated weir, single labyrinth design
(same site w/S-512B)	Gated Culverts	150	SW corner in C-509 Seepage canal	3-72" pipe flap-gate culverts/bridge, prevents backflow from C-9 Canal.
S-512C	CIT Broad Crested Weir	150	SE corner in C-509 Seepage canal	90-foot weir – corrugated weir, single labyrinth design
(same site w/S-512C)	Gated Culverts	150	SE corner in C-509 Seepage canal	3-72" pipe flap-gate culverts/bridge, prevents backflow from C-9 Canal.

Notes:

1. For pump stations, D=Diesel engine driven, E=Electric motor driven
2. Large pump station indicates capacity > 1000 cfs
3. Small pump station indicates capacity < 250 cfs
4. For gravity structures, "design capacities" do not imply maximum capacity
5. CIT=California Institute of Technology developed weir formula for weir with stilling basin commonly used

TABLE A-2: QUICK EMBANKMENT FACT SHEET

Embankment and Levee	Length feet	Side Slope 1V on ?H	Top Width feet	Average Ground ft-NGVD	Top of Levee ft-NGVD	Levee Height feet
3A and 3B Seepage Management Area						
L-502A – I-75 to STA82+00	8,200	3.0	12.0	7.50	8.50	1.0
L-502A – STA82+00 to STA172+00	9,000	3.0	12.0	6.00	8.50	2.5
L-502A – STA172+00 to C-11	11,500	3.0	12.0	6.00	8.50	2.5
L-502B north – C-11 to Holly Lakes	17,000	3.0	12.0	4.50	7.50	3.0
Holly Lakes – Constricted Reach						
L-502B south – Holly Lakes to C-9	19,100	3.0	12.0	4.50	6.50	2.0
L-502B south – C-9 to FL997	3,450	3.0	12.0	4.00	6.50	2.5
FL997 (Krome Avenue)						
L-502C – Holly Lakes Trailer Park	5,000	3.0	12.0	4.50	8.50	4.0
L-502E – Bishop-Nixon Berm	3,500	4.0	10.0	4.50	8.00	3.5
L-502F – FPL Separation	9,800	4.0	10.0	4.50	8.00	3.5
L-503 – C-6 to FL997 south of C-6	7,000	3.0	12.00	2.00	5.25	3.25
C-11 Impoundment						
D-511	32,245	3.0	14.0	6.00	14.50	8.5
L-511	22,400	3.0	12.0	6.00	11.00	5.0
L-512	7,550	4.0	12.0	6.50	9.50	3.0
L-513	1,470	4.0	12.0	6.00	8.00	2.0
L-514	8,650	4.0 (in) 6.0(out)	12.0	6.50	9.50	3.0
L-515	7,460	4.0	12.0	6.00	9.00	3.0
C-9 Impoundment						
D-509	35,030	3.0	14.0	4.50	19.50	15.0

TABLE A-3: QUICK CANAL FACT SHEET

Canal and Reach	Length	Bank Side Slope	Bottom Width	Average Ground	Canal Invert
	feet	1V on ?H	feet	ft-NGVD	ft-NGVD
3A and 3B Seepage Management Area					
C-502B from S-30 to Holly Lakes	18,830	1.0	50.0	4.5	-12.0
C-502B adjacent to Holly Lakes	2,220	0.8	25.0	4.5	-12.0
C-502B from Holly Lakes to S-502B	1,695	0.8	25.0	4.5	-12.0
US 27 West Existing Borrow Canal from C-11 Canal to C-9 Canal	38,500	1.0	40.0	±4.50	±(-0.50)
C-502C - Holly Lakes	5,000	2.0	5.0	6.1	0.0
C-503 – C-6 to FL997 south of C-6	7,000	1.0	15.0	2.0	-7.5
C-11 Impoundment					
C-511					
Eastern	14,070	2.5	10.0	6.0	-21.5
Northern	7,910	2.5	70.0	6.0	-1.5
Western	7,500	2.5	10.0	6.0	-20.0
C-512					
Eastern	5,280	2.5	10.0	6.0	-1.0
Western	2,640	2.5	10.0	6.0	0.0
C-513	1,460	3.0	10.0	6.0	-1.0
C-9 Impoundment					
C-509E	14,550	3.0	20.0	4.5	-8.0
C-509W	10,255	3.0	20.0	5.5	-8.0

A.4.1.1 Reservoirs

Included in this section are general assumptions, guidance parameters and primary references used in the design of the reservoir components of the project. More detailed information pertaining to the actual design of the reservoirs is found in the individual C-11 and C-9 Impoundment(s) sections.

A.4.1.1.1 Design Criteria Memorandums

USACE Engineering Regulations typically provide rules and policies that engineers must follow to correlate their design parameters and decisions for approval. USACE Engineering Manuals typically provide general guidance in formulations and procedures that can be followed to complete design efforts for typical projects. Therefore, these general based publications allow unique project factors to be considered to optimize designs on a case-by-case basis. The design of impoundments and reservoirs in south Florida is thought to be unique in that these features are not classic cross-stream dams, but include 360° perimeter embankments where each foot of increase in embankment height adds significantly to the cost of the project, especially as normal pool depths for these features are relatively shallow (for BCWPA, <4.5 feet). Another unique factor for south Florida reservoirs is the high design wind speed that is considered "reasonable" to be applied on the Probable Maximum Flood surcharged pool for High Hazard Potential Classification reservoirs. These factors led to a series of discussions between the Jacksonville District and the SFWMD that resulted in the Design Criteria Memorandums (DCM) that provide selected and USACE approved design formulations and procedures for reservoirs in south Florida that adhere to USACE and State of Florida engineering regulations. The following Final DCMs were utilized in the design of the C-11 and C-9 Impoundments:

- DCM-1, Hazard Potential Classification
- DCM-2, Wind and Precipitation Design Criteria for Freeboard
- DCM-3, Spillway Capacity and Reservoir Drawdown Criteria
- DCM-4, Minimum Dimensions of Dams and Embankments

Other draft DCMs were used in the design of other features of the project, some associated with the reservoirs, others not. Each DCM lists USACE, State of Florida, or literature references for all supporting data, procedures, and guidance that were used to complete the documentation(s).

DCM-2 produced as a non-binding guidance agreement for the project team's design use, four cases for completing a sensitivity analysis in selection of the embankment design. For most reservoirs with a High Hazard Potential Classification (HPC), Case 1 (scenario that includes the Probable Maximum Flood resulting from routing the Inflow Design Flood using the Probable Maximum Precipitation event in combination with the 100-year return frequency wind speed) is the selected condition for design as it claims the more conservative design. The conservative approach for this planning level of design is thought to be appropriate to capture costs prior to collecting additional field data and performing detail analyses, and in recognition of the importance of ensuring the public's safety. However, as with C-11 Impoundment's reservoir feature, a dam break analysis can be performed in demonstration of a

significantly low HPC that allows a different set of design parameters. For the C-11 Impoundment, preliminary dam break analyses were completed to demonstrate a Low HPC with design parameters that include the routing of the Inflow Design Flood with the 100-year 72-hour precipitation event and a minimum Category 1 Hurricane wind speed converted to a one-hour average. Further analysis of the dam breach and potential downstream impacts will be reviewed as outlined in DCM-1 during the Intermediate Design phase to verify the classification of the C-11 Impoundment as a low hazard potential facility.

Through dam break analyses it has been demonstrated that the C-9 Impoundment is to be designed in accordance with a High HPC due to, the risk to human life should a breach occur. Therefore, the methodology used for the design of the C-9 Impoundment follows DCM-2, Case 1. A cost effective alternative approach to be reviewed during detail design efforts utilizes a time lag between the pool attainment of the peak maximum surcharge stage and application of the 100-year design wind speed. The reasoning behind this alternative methodology (modified Case 1 in DCM-2) is based on the observed and well noted phenomena that very high wind speeds are rarely accompanied with heavy rainfall as inferred in USACE ER 110-8-2(FR) (1991).

A.4.1.1.2 USACE Inflow Design Floods For Dams and Reservoirs ER 1110-8-2(FR)

USACE Regulations ER 1110-8-2(FR) provides guidance in selecting the required minimum embankment height for a reservoir (or dam) based on following areas of discussion:

1. Standard 1 (equivalent to a High Hazard Potential Classification under FEMA guidelines) applies to the design of dams able of placing human life at risk or causing catastrophe, should they fail. Dam height with appropriate freeboard, spillways, regulating outlets, and structural designs will be such that the dam will safely pass an IDF (Inflow Design Flood) computed from probable maximum precipitation (PMP) occurring over the watershed above the dam. Standard 3 (equivalent to a Significant or Low Hazard Potential Classification under FEMA) applies to dams where an analysis clearly demonstrates that failure could be tolerated at some flood magnitude. The occurrence of overtopping floods must be relatively infrequent to make standard 3 acceptable. One-half of the PMF is the minimum acceptable IDF for standard 3 dams.

   Initially in the Draft WPA FS and the Draft PIR, both the C-11 and C-9 Impoundments were assumed as Standard 1 based on initial dam break analyses demonstrating that a structure failure could pose a risk to human life should the unlikely event occur. However, a reexamination of the C-11 Impoundment with a containment levee parallel with the

embankment with a follow up dam break analysis demonstrated that the C-11 Impoundment can now be classified as a Standard 3 (Low Hazard Potential Classification, FEMA). The C-9 Impoundment retains the Standard 1 classification.

A PMP with 55.7 inches depth of precipitation was used in the design of the impoundments. For CERP impoundments, all inflow occurs as either direct rainfall within perimeter embankments or as controlled inflow by pumping operations. Therefore, no gravity flows through a watershed basin need to be examined to complete this study requirement.

2. Foreknowledge of rainfall will not be assumed.

   Although today's technological tools (e.g. satellites and faster processing computers) provide for improved meteorological forecasting, as well as long term predictions, reservoir operations do not and will not include pre-storm drawdown operations. Often, the Non Federal partner operator of the C&SF Project system, exercises pre-storm drawdown operations for the areal primary and secondary canals to provide advantageous tailwater conditions for flood damage reduction in anticipation of rainfall events. Additional discharge from the reservoirs may curtail this benefit derived from currently performed pre-storm operations. The decrease in benefit is a perceived result of local canals having limited conveyance ability due to the flat topographic relief of the region and limited structure capacities along the coast.

3. Reservoir regulating outlets should not be assumed operable during the occurrence of an IDF, unless specifically designed for such purpose.

   For routing the PMF for the C-9 Impoundment reservoir, a 3-storm cycle was used in which no gated structures were assumed operable during the 72-hour single storm events, nor through the "dry" periods in between the individual events. The 3-storm cycle represents an antecedent condition setting storm, the design storm, and a subsequent following storm. The service and auxiliary (emergency) overflow spillways remained operational as they are completely passive structures requiring no mechanical action or operator intervention. In design of the overflow spillways and containment of a reservoir's breach (C-11 only), diesel engine pumps located onsite and at the S-9 Pump Station with emergency generators for control electronics were figured into the probability of limited control in extreme conditions.

   A cost effective analysis was performed that allowed for the operation of C-9 Impoundment gates during the "dry" period between the design storm

events. The analysis was performed in accordance with DCM-2 guidance for storms greater than the 100-year event. However, without definitive demonstration that the use of gates would not create additional impact to the flooded basin (C-9 Canal known to be out-of-bank for smaller floods), it became a District policy decision to not utilize this possible cost savings' approach for the project (through reduction of required embankment height).

4. An antecedent flood will be assumed to occur prior to the IDF and will be developed using sound engineering principles.

   Thirty and forty percent PMP storms were routed as part of the 3-storm cycle IDF as reference in the National Weather Service's HMR-56 and CERP DCM-2. These percent PMP storms provided the antecedent conditions prior to the middle 100 percent PMP event.

5. The objective in selection of design freeboard is to assure that failure of the dam will not result from wind setup, wave action, uncertainties in analytical procedures, and uncertainties in project function in combination with the most critical pool elevation.

   A complete wind setup, wind-wave generation, and wave run up with resulting wave overtopping (as overwash) analyses were performed to address this point of discussion.

6. Zero overwash is not always required under infrequent high pool conditions, but it is required that overwash will not be of such a magnitude and duration as to threaten the safety of the dam.

   Material type will consist primarily of processed (crushed) limestone found onsite(s) mixed with sands, similar to the Everglades Agricultural Area (EAA) reservoirs. Both projects make use of zoned embankments with an outer rock fill surface. This is mentioned in that the EAA has completed a field test cell experiment that demonstrated significant resistance to overtopping rates in excess of 0.23cfs/lf of embankment. This is very important since prior to the test, acceptable over-wash rates were constrained to two approaches due to limited available data/information: (1) USACE (2005) reference for non-cohesive soils was between 0.001cfs/lf to 0.01cfs/lf of over-wash and (2) risk and probability analysis that demonstrated that an over-wash rate of 0.1cfs/lf under Case 1 conditions had nearly the same probability of occurrence as other structure failure causes (in relative terms) and was acceptable based on that risk. With EAA test results in hand and stating that an over-wash rate of no more than 0.1cfs/lf would be acceptable under the design

conditions used for determination of embankment height, it turned out that the minimum freeboard requirements were the dominating factor for the C-11 Impoundment (3 feet for Low HPC earthen embankments). Additional analyses was completed for the C-9 Impoundment where the over-wash rate determined the embankment height. However, it should be stated that if approach 1 above (USACE, 2005) was used for final determination, the embankment heights would be higher than that presented in this PIR for design. The EAA test *Overwash Final Summary Report* (2006) is included in the back of the Hydraulic Appendix as an Addendum for reference.

7. Reservoirs with surcharge pool elevations within 3 feet of the maximum pool level for a substantial period of time, 36 hours or longer, have increased probability that high wind speeds in the critical fetch may coincide with this level. Therefore when the IDF pool hydrograph is within 3 feet of the maximum pool for 36 hours or longer . . . the minimum freeboard will be 5 feet for embankment dams . . . or greater as determined by consideration in (item 5 above).

   The minimum freeboard for C-11 Impoundment's reservoir as a Low HPC remained at 3 feet above the maximum surcharged pool as the pool did not recede 36 inches within the 36-hour allotted. The minimum freeboard for C-9 Impoundment's reservoir as a High HPC remained at 5 feet above the maximum surcharged pool as the pool did not recede 36 inches within the 36-hour allotted.

A cost effectiveness analysis was performed using this regulation bullet as a probability/risk inference that may allow for an alternative design procedure that maintains a safe structure. Though it was a District policy decision to not move forward with this possible cost savings' approach, it may still be reviewed during detail design efforts. The assumptions used for the analysis are noted here in the following. It is a commonly held observance that heavy rainfall total amounts are rarely accompanied by high wind speeds and if so, for short insignificant durations (relativity pertaining to reservoir scenarios, not residential and other structured buildings). Studies performed by the SFWMD under the State Expedited Project/Initiatives bore this out in analysis of hurricanes and rainfall recordings for each occurrence. SFWMD interpretation of this particular paragraph allows for the inference that within 36 hours of maximum surcharge pool, the probability is increased where high wind speeds will be considered. Since wind speeds are not defined in Engineering Regulations or Manuals, a 2-wind speed methodology is proposed and is utilized in this Final PIR for C-9 embankment height design. That is, a "reasonable" mid-range Category 1 hurricane wind speed of 1-hour duration will be applied to the reservoir at maximum surcharge (peak stage) and a 100-year return

frequency wind speed of 1-hour duration will be applied to the greater stage of 36-hours "prior to," or "after", the peak stage. For the reservoir, the 36-hours "prior to" the peak was approximately 0.2 feet greater than the "after;" therefore, the "prior to" case was used.

A.4.1.1.3 Embankment Crest Widths

Operation and maintenance, as well as constructability are all considerations that must be included in determining the crest width of an embankment. DCM-4 (2005) provides minimum dimensions for dams and embankments, including a minimum crest width of 12 feet. In *Design of Small Dams* (DOI-BR, 1977), a minimum crest width of 12 feet is recommended for all embankments. USDA (SCS, 1985) suggests a minimum crest width of 8 feet for dams 14 feet high or less. All references provide equations that show that minimum recommendations are applicable for the height of embankments (<14 feet) designed for this project.

The USACE typically design embankments with a crest width of 10 feet if stability calculations do not demonstrate a need for a wider crest. The SFWMD Operations personnel recommend crest widths of 14 feet for maintenance activities. Early during the draft WPA FS efforts (2001), a crest width of 12 feet was used as a compromise of width requirements based on drivability for operations maintenance working needs. Since then, however, DCM-4 was revised (2008) to specify a minimum crest width of 14 feet (12 foot wide driving surface with 1 foot shoulders on each side) based on safety concerns for the operations and maintenance personnel. It should be noted that USACE past experiences indicate that crest widths normally widen as a result of maintenance activities rather than narrow due to slow deterioration over the life of the project.

The "14-foot plus" crest width is expected to meet all safety in-the-field requirements for operation maintenance personnel and the safe transport of equipment required for maintenance activities. Also, maintenance activities for the embankment crest, e.g. grading, is expected to maintain the established width that is reduced through normal wear and tear impacts, such as rainfall (erosion) and driving on and off the crest onto the slopes (rounding).

A.4.1.2 Water Control Structures

A.4.1.2.1 Pump Stations

The BCWPA Selected Plan proposes to construct four pump stations. Two large-size pump stations were incorporated into the project; one of which provides both reservoir inflow and reservoir seepage management. All large-size pump stations include diesel engine driven pumps. Two small-size pump stations were also incorporated; one for maintaining existing levels of flood damage reduction abilities (project mitigation for possible flood impacts) and one for reservoir seepage management. All small-size pumps include in part electric pump motors.

It is important to note here that the reservoir inflow and seepage pump stations are not considered "flood control" pump stations. Their operational objective is to capture excess water in associated canals when reservoir storage is available. The seepage pump stations are to return pump intercepted seepage to prevent significant impact to the water table outside of the project area (thus, maintaining the existing level of service flood protection). However, should an extended power outage occur and the electric pumps are inoperable, excess seepage may temporarily be conveyed to the primary canals for return pump by the reservoir inflow pumps. Pump station control units will have power back-up generator units to enable remote operational control during power outages. The project does not replace the flood damage reduction abilities of the basin impacted by project implementation.

For the flood mitigation pump stations, design includes either a diesel generator for back-up power for the electric pumps or a secondary diesel engine driven pump as the back-up plant. Pump station control units will have power back-up generator units to enable remote operational control during power outages.
Pump station design was based on the following criteria.

A.4.1.2.1.1 Pump Rates

A.4.1.2.1.1.1 Inflow Pump Stations

Reservoir design inflow rates were generally identified in the CERP. Sub-regional modeling with the SFWMM model providing routing and boundary conditions verified pump rate requirements under the 2050 Plan that assumes North Lake Belt Storage Area (NLBSA) is operationally online. However, the BCWPA is projected to be constructed and operational by the year 2021 with NLBA scheduled near 2025. With a twelve year gap in operational commitments, further analyses were performed under the State Expedited Project/Initiatives to limit risks from over-construction by investigating lower pump inflow requirements. Resulting water budget models demonstrated

project effectiveness in the interim time period with a reduced inflow pump capacity of approximately half of that identified in the CERP (2050). Therefore, the inflow pump stations were resized from that identified by CERP for the interim period before NLBSA comes operationally online.

A.4.1.2.1.1.2 Seepage Pump Stations

The pump rate for maintenance of an optimum water surface elevation in the C-11 Impoundment and C-9 Impoundment seepage canals were determined and based on SEEP2D seepage analyses performed by the Geotechnical Branch (coordinated with the State Expedited Project/Initiatives). However, recent modeling using SFWMD's LECsR model (primarily founded on the GMS modeling platform with modifications) has identified new required pump capacities and seepage canal control stages.

A.4.1.2.1.1.3 Flood Damage Reduction (Mitigation) Pumps

Pump rates for maintenance of flood damage reduction abilities for Holly Lakes Mobile Home Park were determined and based on hydrologic analyses and hydraulic design.

A.4.1.2.1.1.4 Pump Mix

Pump mixes for the reservoirs were based on using a three to five bay pump station for the large pump stations. Pump mixes for maintenance of flood damage reduction ability and seepage management operations (small pump stations) were based on a minimum of two bay pump stations to minimize risk of impact to private lands should a single pump fail during critical times. All small flood control pump stations are equipped with electrical pumps that have diesel generators for an alternative power source in cases of power outages, or include a matching diesel powered pump of equal capacity. One criterion for all pump mixes was to utilize duplicate pump sizes as much as possible to reduce operation and maintenance costs. This is accounted for through a reduction in different spare parts required and focusing of mechanical expertise. Another criterion was to provide a pump mix that allows a smooth pump rate change interval from start-up to full capacity. All pump mixes were preliminary assessed and approved by SFWMD and USACE.

A.4.1.2.1.1.5 Pump Stages

The following pump station design and operation parameters were determined through analysis of Federal Emergency Management Agency (FEMA) Flood Maps, C&SF General Design Memorandums (GDM) and Water Control Plans, and investigation of local operations of current water conveyance and flood damage reduction systems. These parameters are defined here as follows:

A.4.1.2.1.1.6 Intake Water Surface Elevations

- *Maximum Non-Pumping*: Highest canal or pool stage that can be expected to occur, typically the Probable Maximum Flood stage if known.
- *Maximum Pumping*: Maximum canal or pool stage that can be pumped with any increase in stage requiring the pump to be turned off. In most cases, Maximum Non-Pumping and Maximum Pumping stages are identical.
- *Start Pumping*: Canal or pool stage when pump may be turned on as defined by system conditions, typically on the increasing limb.
- *Normal Drawdown*: Expected local drawdown at the pump station intake.
- *Minimum Drawdown*: Lowest local drawdown stage before pump is required to be turned off.
- *Minimum Non-Pumping*: Lowest canal or pool stage that can be expected to occur.

A.4.1.2.1.1.7 Discharge Water Surface Elevations

- *Maximum Non-Pumping*: Highest canal or pool stage that can be expected to occur, typically the Probable Maximum Flood stage if known.
- *Maximum Pumping*: Maximum canal or pool stage that can be pumped to, pump is subsequently turned off until stage decreases.
- *Normal Pumping*: Expected normal pool elevations for impoundments and design tailwater stages for conveyance canal pump stations (flood damage reduction drainage discharge).
- *Minimum Pumping*: Lowest canal or pool stage expected when pump may be turned on.
- *Minimum Non-Pumping*: Lowest canal or pool stage that can be expected to occur. In most cases, Minimum Pumping and Minimum Non-Pumping elevations are identical.

A.4.1.2.2 Spillways

The BCWPA Selected Plan includes an overflow non-gated spillway that discharges directly into the C-11 Canal from the C-11 Impoundment. The final design of this structure may be standardized for the C-9 Impoundment overflow spillway to simplify design, construction, and future operations and maintenance.

The spillway consists of auxiliary and service spillways that enter a channel to be discharged into the adjacent canals.

A.4.1.2.3 Gated Culverts

The BCWPA Selected Plan includes numerous gated culverts. Construction material for all culverts is to be round pipe and cast-in-place for gated boxes with water tight joints. For through-embankment culvert structures construction material will be round concrete pipe and cast in place concrete boxes with water tight joints. Other gated culvert material will be determined during detail design based on function and cost effectiveness, including life cycle costs.

All major conveyance culverts were designed to remain submerged year round to reduce aquatic growth within, thereby maintaining design surface roughness assumptions. With the exception of S-503A and S-506A gated culverts in the C-11 Impoundment, all gated culvert sites were designed with a minimum of two culverts to allow maintenance activities during operations if required.

Flow rate calculations and head losses were determined using Bernoulli's Energy equation with a predetermined entrance and loss coefficient for gated and non-gated culvert structures. An entrance and exit loss coefficient of 0.90 and 1.00 was used, respectively, for all gated culvert structures.

A.4.1.2.4 Weirs

A.4.1.2.4.1 Weir Structures

A.4.1.2.4.1.1 CIT Weir Structures

The BCWPA Selected Plan includes the design of California Institute of Technology (CIT)-type drop (weir) structures for the C-9 Impoundment (S-512B and S-512C). The CIT weir structure was designed using HDC 623 design charts and plates. However, the weir coefficient, CW, used for broad crested weirs was calculated using FDOT and USFHA Report No.0510610 and 0510552, "Performance and Design Standards for Control Weirs, An Investigation of Discharge Through Slotted Weirs," S.C. Kranc, Ph.D., PE, Melvin W. Anderson, Ph.D., PE, and Kevin C. McCarty, March 1993, University of South Florida. Other than the S-512B weir, weir structures are typical straight-line broad crested shapes with a single weir crest elevation

The S-512B and S-512C weir structures are non-gated broad crested weir structures with a single labyrinth design. The labyrinth design allows the fitting of a longer weir crest into a narrower channel where space or location is constrained due to cost effectiveness and function. The 'corrugation' also requires less upstream and downstream structure apron lengths saving costs in apron concrete.

A.4.1.2.4.1.2 Sheet-pile Weir Structures

The BCWPA Selected Plan includes the design of sheet-pile driven weirs with 2-foot in breadth concrete caps for the C-11 Impoundment (S-505A, S-505B and S-505C). The weir coefficient, C_W, was calculated using FDOT and USFHA Report No.0510610 and 0510552, "Performance and Design Standards for Control Weirs, An Investigation of Discharge Through Slotted Weirs," S.C. Kranc, Ph.D., PE, Melvin W. Anderson, Ph.D., PE, and Kevin C. McCarty, March 1993, University of South Florida.

One or more contain combination notched weirs for maximum control of the C-511 Seepage canal. The lower crested notch weir provides small overflow capacity (trickle) during off peak times, but provides a larger overall capacity when the impoundments are full correlating with highest rate of seepage expected.

A.4.1.2.4.1.3 Triangular-Profile Weir Structures

The BCWPA Selected Plan includes the design of triangular-profile weirs for two weir sites for 3B SMA (S-516A and S-516B). The triangular-profile--aka triangular cross-section--weir structures were designed using "Handbook of Hydraulics," E.F. Brater, Ph.D. and H.W. King, Ph.D., 7th Edition, 1996, McGraw-Hill. The weir coefficient was determined with use of Table 5.4 and interpolation for the design hydraulic head. It is noted that this edition of Handbook of Hydraulics uses the metric system and care must be used in translating the weir coefficient as it is unit dependent, though unit-less itself. This weir type was decided as most cost-effective because of simplicity, expected rock foundation and no requirement for dewatering during construction.

The S-516A and S-516B Weir structures have a triangular cross-section and provide stage control of the lower C-502B and C-503 Borrow Canals.

A.4.1.2.4.2 Overflow Spillways

Overflow spillways are non-gated for uncontrolled discharge operations. The BCWPA Selected Plan includes two overflow spillways: C-11 Impoundment S-504B spillway and C-9 Impoundment S-510A. Each spillway design consists of a service spillway that meets the basin's permitted discharge rate for the 25-year 72-hour storm event extended to the 100-year storm; and an emergency overflow spillway (also known as an auxiliary spillway) that is designed to protect the integrity of the reservoir without significantly impacting the public for the extreme storm event greater than the 100-year return storm. The C-9 Impoundment classic overflow spillway was designed to be in conformity of recommendations stated for baffled chute spillways in Bureau of Reclamation's Design of Small Dams, Chapter 9. This included the five major components of

design of an emergency overflow spillway: approach apron, baffle blocks, chute, training wall, and riprap. The C-11 Impoundment overflow spillway system consists of a driveable auxiliary spillway and a service spillway. S-504B is located on the southern side of the C-11 Impoundment and discharges into the C-11 Canal.

A.4.1.2.4.3 Service Spillways

The service spillway crest elevations were set at the reservoir's normal pool stage, i.e. inflow pump cutoff stage under normal operations. The crest lengths were set to not exceed the rate referenced in SFWMD's "Basis of Review for Environmental Resource Application with SFWMD, Feb. 2006" for up to the 100-year storm event, regardless of the actual event specified within the reference. The design intent was to ensure that the project would not violate the permitted discharge rate under variable meteorological conditions; thereby, preventing impact to the existing level of service flood protection. Refer to the project component sections for individual analysis.

A.4.1.2.4.4 Auxiliary Overflow Spillways (Emergency)

The emergency overflow spillway crest elevations were set at the surcharge stage resulting from routing the 100-year 72-hour storm with the service spillway alone (gates assumed inoperative). The crest lengths of the spillways were determined through routing of the Inflow Design Flood (IDF) using the Probable Maximum Precipitation event (PMP) and examining possible consequences of the discharge flow rate into the C&SF Canals adjacent to the impoundments. Factors included in the design allowable discharge included: inflow diesel pump sizes (not dependent on external power generating source and possible operation of return pumping), size of adjacent conveyance canal, site of nearest discharge point from the basin, and relative size of the basin containing the impoundment (judgment of impact when all else has been exposed to similar rainfall event at same time). Refer to the project component sections for individual analysis.

A.4.1.3 Other Non-Control Structures

A.4.1.3.1 Ungated Culverts

The BCWPA Selected Plan includes numerous ungated culverts. Construction material for all culverts is to be round pipe with water tight joints. Ungated culvert material will be determined during detail design based on function and cost effectiveness, including life cycle costs.

The ungated FPL series culverts located in the SMA serve the purpose of allowing equalization of surface water between the wetlands on the west side of

the FPL maintenance access road and the east side; thus, encouraging sheetflow through the area with its mild slope downward from north to south.

Flow rate calculations and head losses were determined using Bernoulli's Energy equation with a predetermined entrance and loss coefficient for gated and non-gated culvert structures. An entrance and exist loss coefficient of 0.90 (slide gate) and 1.00 was used, respectively, for all gated culvert structures.

A.4.1.3.2 Bridges

The BCWPA Selected Plan includes two replacement bridges – impacted by C-502B Canal required geometry – to provide access to properties not acquired for project purpose and three bridges to provide access to the impoundment area over the C-511 Canal. Therefore, five bridges are required to provide access over the C-502B Conveyance canal: (1) B-500 FPL Sub-station and (2) B-501 Holly Lakes Mobile Home Park and the C-511 Canal: (3) S-505D, (4) O&M maintenance bridge, and (5) S-505E. The O&M maintenance bridge, located east of the inflow pump station will allow O&M personnel to access the eastern bank of the seepage canal, C-511, in the southwest corner of the project without having to travel 6 miles. The actual final bridge design will be determined during the detailed design phase of the project.

A.4.1.4 Canals

The canals proposed in the BCWPA design are integrated with the existing Central and Southern Florida Project (C&SF) and future Comprehensive Environmental Restoration Plan (CERP) components. The following discussion is a discussion regarding canal hydraulic design parameters with theoretical function and development processes as used.

A.4.1.4.1 Manning's Roughness Coefficient

A Manning's roughness coefficient or n value of 0.035 was used for canal design in conveyance of design flows. The Broward and Miami-Dade County regions where the BCWPA components and canals will be constructed has ground features characteristically described as limestone covered with a relatively thin layer of overburden (peat, marl, muck). The canals will most likely be constructed by ripping, blasting or dragline operations to remove rock to required depths. These types of excavation methods leave a relatively coarse bottom and bank with sharp edged rocks and rubble. With canal age or maturation, some of these irregularities may become less defined resulting in a smoother perimeter with lower roughness values; although, vegetation may take root on sides providing a higher overall roughness value to conveyances. Aquatic growth is expected along the upper banks where the overburden lies, but the design depths should be relatively free of plant roots extending from bottom to

surface obstructing flow. The Manning's n value used was obtained from investigating various sources and noting them as follows:

In C&SF Project General Studies and Reports, Part VI, Section 5, as noted by the Soil Conservation Service, a value of at least 0.035 should be used where channels are constructed primarily in Miami Oolite. This value is for channels with no appreciable erosion and with rapid-growth vegetation along the upper banks because of the organic soil overburden. In the same General Studies and Reports issue, USGS recommended a Manning's n value between 0.030 and 0.035 to be used for designing large canals in the Everglades region. Other sources provide Manning's n values within the same ranges as SCS and USGS for similar type canals. Brater and King's Handbook of Hydraulics, 7th ed., provides an n value of 0.035 for canals with rough stony beds and weeds on earth banks in fair condition. From the preceding investigations, a Manning's n value of 0.035 appears to be appropriately applied to the design.

A.4.1.4.2 Dissolved Oxygen

One parameter of concern for canal depths is the creation of an anoxic zone with respect to very low dissolved oxygen (DO) concentrations.

With exception to conveyance operations, the canals will receive most of their water via seepage from the nearby conservation areas and the impoundments. Seepage water is naturally low in DO and with little expected "turnover" within the canal; the canal water is expected to have an existing low DO content as well. Indigenous fish survive in most low DO zones within a water column because of mobility and adaptability. However, when most fishes experience a quick change of their oxygenated environment with gate openings for deliveries, the very low DO concentration at the bottom will circulate downstream throughout the water column resulting in high fish kills. This condition is compounded if settled organic material is also stirred up creating an induced biological oxygen demand (BOD) in the low DO environment. Thus, the C-502B Conveyance canal has a relatively shallow design with a corresponding increase in cross-section area than maximum efficiency would require (minimal cross-section area). Canal depth for the majority of the reach ranges from 16 to 17 feet. The most efficient design would create canal depths ranging from about 29 to 33 feet. This design does increase the required volume to be excavated and associated costs, but it assists in achieving the objectives of ecosystem restoration brought by CERP. In detail design phase, the canal parameters may be modified slightly for optimal benefit cost ratio.

A.4.1.4.3 Seepage Interception Canals

Seepage interception canals include those surrounding the impoundments and the mitigating flood protection systems for the Holly Lakes Mobile Home Park.

The reservoir seepage canals (primarily C-511 and C-509) are designed to be deep to intercept seepage that may create impact to the ground storage of adjacent private lands, i.e. impacting the level of service flood protection. Additional modeling during the design phase will be required on the western boundaries to optimize the depth for the seepage canals located there to ensure that ponding will not occur between increase of water levels within the 3A and 3B SMA; and the storage pools within the reservoirs. It is also not desired to reduce sub-surface resistance to seepage from the WCA by allowing too much interception that creates a "popping up" of increased seepage, thus draining WCA 3. If this would occur, this would create the need for additional return pumping into WCA.

The mitigation flood protection systems' seepage canal (C-502C) is designed with a depth to minimize emergent vegetation growth (>5 feet). This design provides more than required capacity to mitigate for the possible flood impacts as demonstrated in the hydrologic analyses found in the 3A and 3B SMA section of this appendix.

A.4.1.4.4 Borrow Canals

Borrow canals (primarily C-502A, southern portion of C-502B--C-9 to C-6 Canal—and C-503), were not designed for conveyance and are only borrow sites to construct the L-502A Levee, L-502B Levee, and L-503 Levee. Water in borrow canals is not expected to become stagnant as seepage will provide a baseflow water supply with discharge outlets provided as either existing, or within Selected Plan as new construction features.

Additional minor borrow canals are designed to construct the small levee/berms around isolated marsh wetland areas (Mitigation Areas A and B) and other areas of concern requiring isolation and/or protection.

A.4.1.5 Levees

The BCWPA includes four levees: L-502A Levee, L-502B Levee, L-503 Levee and L-511 Levee (Containment). These levees are true levees and should not be confused with embankments that are designed for the reservoirs. The L-502 and L-503 levees do not hold impounded water as storage nor permanent pools, but have behind them wetland marsh areas with fluctuating water levels dependent on rainfall and collected seepage. The purposes of the two levees are twofold: (1) contain the rainfall and seepage driven system within the SMA and (2) prevent existing surface water within the SMA from mixing with agricultural and urban runoff being conveyed. The other levee, L-511 Levee, is designed as a containment levee to provide temporary control of a dam-break flow from the reservoir in case of an embankment failure (not expected to occur). The purpose of the levee is to prevent a dam-break from putting life at risk by a secondary

structure that also allows the reservoir to carry a Low Hazard Potential Classification. The levees will be over-built to allow for settling to design grade.

In addition to the above levees, several levee/berms are designed to function as protective wetland marsh berms within the C-11 Impoundment and 3A and 3B SMA project footprints. These levees are kept low (3 feet or less) to prevent a hazard-creating-wall should a breach occur as the design storage behind them is 1-foot plus that contributed by rainfall. Water storage is a misnomer in that water provided by project's operation is for hydration and enhancement of existing hydroperiods, and not retention for future needs.

A.5 C-11 IMPOUNDMENT

The C-11 Impoundment component features a 1,068-acre 4.3-foot deep, aboveground impoundment feature (also defined as a reservoir). The impoundment is expected to carry a Low Hazard Potential Classification following additional dam breach analysis during the design process. Other design elements include a combined inflow/seepage pump station, assorted gated and non-gated structures, several fixed weirs, one adjustable weir, an emergency overflow spillway, and perimeter embankments and seepage control canals. The design also includes two wetland marsh areas that when combined with the C-9 Impoundment and WCA 3A/3B SMA mitigation offset project impacts to existing, DA 404 permitted mitigation areas. The existing C&SF flood damage reduction system will remain operational to manage major storm events that produce more volume of water than project storage availability.

The primary purpose of the C-11 Impoundment is to reduce the pumping of untreated agricultural and urban runoff into WCA 3A. Project modeling demonstrated that the combined operation of the C-11 Impoundment and C-9 Impoundment will significantly reduce pumping of runoff into WCA 3A. The project with other elements included in the Broward County WPA project allow operational flexibility to transfer water to the C-9 Impoundment if storage is available enable the return of seepage and rainwater collected in the 3A and 3B SMAs to WCA 3A, and/or use the current option to send water eastward to tide through the C-11 and C-9 Canals if conveyance will not negatively impact existing levels of service flood protection. If all of these alternatives have been exhausted, then the existing S-9 pump station will be used to back pump excess flows into WCA 3A and maintain existing levels of flood protection. The storage pool in the C-11 Impoundment will also assist in reducing seepage from adjacent natural areas in the 3A and 3B SMAs, provide groundwater recharge, assist in meeting the agricultural, urban water supply demands and saltwater intrusion. The Impoundment may provide opportunities to further reduce the extent of damages from flooding through operational changes to the C&SF Project and local drainage systems and provide incidental water quality improvement.

The C-11 Impoundment is located in western Broward County, adjacent to and east of US 27 on the north bank of the C-11 Canal. The northern boundary of the project is approximately 3.5 miles south of the I-75/US 27 Interchange. The C-11 Canal is located 2.3 miles further south and makes up the southern boundary. The impoundment is approximately 1.5 miles in width from east to west for the northern half, and 1.0 mile in width for the southern half.

Southern and western access to the impoundment is made from US 27 along the C-11 Canal right-of-way/road, crossing over the S-505D bridge. Northern and eastern access may be made through the City of Weston on SW 26th Street and over the bridge structure (S-505E) spanning the C-511 Seepage canal. These access points are linked via the top/toe of the D-511 embankment which is drivable with a crest width of 12 feet plus two feet of shoulder.

A.5.1 Seepage Control

Seepage control for the C-11 Impoundment is accomplished through a system of structures, seepage canals, and a conveyance canal. Seepage was quantified using models that use flow net-type methodology in the calculation of seepage flow rates through various geologic layers. The software program, SEEP2D, with the GMS interface was employed for the purposes of this exercise. A safety factor of 1.5 was applied to determine pumping and structure size requirements. Structure data determined was also placed in the sub-regional MODFLOW model that was used to identify the Selected Plan through the alternative formulation phase during the WPA FS.

The southern seepage path is controlled with interception by the C-11 conveyance canal that may be managed in two ways: (1) seepage is return pumped into the impoundment with S-503 Pump Station or (2) pumped into WCA-3 by S-9A Pump Station as collected "ground" water. The S-503 Pump Station has 3-350 cfs diesel engines for inflow pump operations and seepage return if needed and 3-150 cfs electric pumps seepage return pumps. The S-9A Pump Station has 2-175 cfs diesel pumps and 2-75 cfs electric pumps. The C-11 Canal will be controlled at the existing authorized stage of 3.5 ft-NGVD or lower.

The Impoundment employs three seepage canals: C-511 that forms the main perimeter seepage canal adjacent to the embankment structure; C-512 that forms the majority of the northern Mitigation A seepage canal, and C-513 that forms the northeastern Mitigation B seepage canal. Stages are managed primarily by the S-503 seepage Pump Station and secondarily by S-505A weir structure overflow. Seepage collected in the C-511 Seepage Canal's eastern reach may be managed in two ways: (1) return pumped into the impoundment with the S-503 seepage Pump Station or (2) used to meet Western C-11 Basin

water supply demands via S-505A weir overflow. Since this portion of the seepage canal reach may experience backflow from untreated C-11 Canal water, it is not considered desirable to route the excess seepage to WCA-3 in same manner as seepage collected in the C-11 Canal west of the S-381 Divide Structure or the western C-511 Seepage Canal reach.

The C-511 Seepage Canal includes two stage divide weirs—one located in the eastern reach and one located in the western reach north of the truck stop. The maintenance of separate seepage control stages limits impacts, either through seepage outflows or over drainage of adjacent wetlands, from the project on lands outside of project area. A control of 6.0-6.5 ft NGVD is intended to enhance the existing mitigation wetland areas found to the north of the impoundment and prevent over drainage. This elevation will also promote wetland vegetation growth in the proposed wetland mitigation areas to be located in the project area located north of SW 26th Street. .A limit to higher stages is required to prevent negative impacts to the adjacent US 27 road base. These control stages will be extensively monitored and assessed to maintain no adverse impacts to US 27 or the mitigation areas and the project's Operating Manual modified as necessary. A second stage divide weir located in the southwestern corner of the Impoundment north of the truck stop controls the C-511 Canal adjacent to the truck stop at the same stage as the C-11 Canal west of S-381 (3.0-4.0 Ft, NGVD).

A.5.2 General Design and Operations

A.5.2.1 Features

The C-11 Impoundment has the following design features:

Structures

- S-503 Pump Station (inflow and seepage plants)
- S-503A Gated Culvert
- S-504 Gated Culvert
- S-504B Service & Auxiliary Spillway
- S-505A Weir and Sluice Gate
- S-505B Broad Crested Weir
- S-505C Broad Crested Weir
- S-505D Bridge (Open Box Culvert)
- S-506A Gated Culvert (sag)
- S-506B Weir-Gate Culvert
- S-507A through F Non-gated Culverts
- S-508A Non-gated Culvert
- S-508B Non-gated Culvert
- S-508C Non-gated Culvert
- S-508D Non-gated Culvert

Canals
- C-511 Seepage Canal
- C-512 Seepage Canal
- C-513 Seepage Canal

Levees
- D-511 Embankment
- L-511 Levee (Secondary Containment)
- L-512 Levee/Berm
- L-513 Levee/Berm

The D-511 Embankment is the perimeter embankment for the 4.3-foot storage pool reservoir. The L-511 Levee is the perimeter containment levee--parallel to D-511 Embankment except where US 27 performs the containment function--with the sole purpose of containing a impoundment breach in the very unlikely event it should occur. The containment levee together with the close proximity of the S-9 Pump Station allows the C-11 Impoundment reservoir to carry a Low Hazard Potential Classification.

A.5.2.2 Operation of Interior Wetland Marsh (Mitigation) Areas

Two wetland marsh mitigation areas are proposed to be created and maintained to provide mitigation credit to offset project impacts to existing permitted mitigation areas located within the C-11 and C-9 Impoundments. When both the C-11 and C-9 Impoundments are full and storage is available within the 475-acre "Mitigation A" (Mit. A) wetland area, water may be released into the wetland from the C-11 Impoundment (via the S-506A Gated Culvert). Releases from the Mit. A wetland area will be controlled by the S-506B Gated Culvert. The 13-acre "Mitigation B" (Mit. B) wetland area will receive direct rainfall and indirect seepage inflows from the reservoir. Mit. B excess water will be removed via overflow of the low L-513 Levee/berm into the C-513 Seepage Canal. Rainfall will contribute as well to their hydroperiods.

The water levels in the mitigation areas will be assessed and adaptively managed after construction to optimize project purposes, including wetland restoration. An optimum seasonal stage up to one-foot depth will be managed for the mutual benefit of establishing wetland habitat with associated hydroperiods and project storage ability. Greater depths due to rainfall on top of one foot of storage depth will be limited to short time duration and frequency to minimize adverse impacts. Water will not be released into the Mit. A wetland area if water levels are at or above the one foot target depth (no ability to make releases into Mit. B) as a result of direct rainfall.

A.5.2.3 Operations for Water Quality Benefits

The C-11 Impoundment is not expected to provide major water quality benefits for recipients of impoundment releases. However, stored water to be released cannot have a greater concentration of pollutants then the original contributing source. Releases from the impoundment will be monitored and assessed under normal operations to ensure meeting of this water quality assurance.

To maximize water quality benefits within the objectives of the project, water may be drawn down operationally to a half-foot depth (6.5 ft-NGVD) over interior average grade (6.0 ft-NGVD). This reduces the frequency of dry-outs that may allow mobilization of previously captured runoff constituent pollutants. Also, the longer periods of soil saturation increases microbial mass survival and viability to breakdown captured pollutants on next storm event.

A.5.2.4 Operations for Water Supply

Currently, under normal conditions, the C-11 Basin (Eastern and Western) has no need for water supply releases from the Conservation Areas as seepage from the WCA is of sufficient quantity to meet most demands with relatively few cutbacks. Monitoring will show if the recent construction of the S-381 Obermeyer gated structure in C-11 Canal results in need for water supply deliveries being required for agricultural, coastal and urban usage demands. If the C-11 Impoundment contains stored water greater than half-foot depth (6.5 ft-NGVD) above average grade, then water demands will be met with releases from the reservoir for the Western and Eastern C-11 Basins. Releases may be made through either of two gated structures, S-503A Gated Culvert or S-504 Gated Culvert. If the S-381 Obermeyer Gate is engaged (closed) due to S-9A Pump Station seepage return operations, then releases of up to 250 cfs may be made with the S-503A Gated Culvert. Otherwise, if S-381 is disengaged (open), releases through the S-13AW Gated Culverts, capacity (500 cfs), may be made with the S-504 Gated Culverts. If no stored water is available within the reservoir (stage at or below 6.5 ft-NGVD), then S-381 may be opened to provide the Western and Eastern C-11 Basins with water supply in identical manner as pre-project operations, i.e. seepage from natural system.

A.5.2.5 General Information

The C-11 Impoundment carries a Low Hazard Potential Classification (FEMA Guidelines) based on the preliminary dam-break analyses. This corresponds to the USACE Standard 3 condition as defined in USACE Inflow Design Floods for Dams and Reservoirs (ER 1110-8-2(FR), March 1991). The Impoundment consists primarily of a 1,068-acre 4.3-foot deep, aboveground reservoir that provides 4,592 acre-feet of storage. The project area also includes a 475-acre, 1-foot deep wetland marsh area (Mit. A) that provides 475 acre-feet of storage and

a 13-acre wetlands marsh area (Mit. B) that has no provision for storage. Embankment heights are 8.5 feet above average interior grade. A system of seepage canals and associated structures is included along the western, northern, and eastern boundaries.

TABLE A-4: C-11 IMPOUNDMENT DESIGN ELEVATIONS

	(ft-NGVD)
Top Of Levee	14.50
Maximum Surcharge Pool – PMF (not required for a Low HPC)	14.40
Maximum Surcharge Pool – Standard 3 ($^1/_2$PMF)	12.30
Maximum Design Surcharge Pool – DCM 2 (100-yr storm event	11.60
Normal Maximum Pool	10.30
Service Spillway Crest Elevation	10.30
Auxiliary Overflow Spillway Crest Elevation	11.60
Average Impoundment Ground Elevation (grade)	6.00

Average ground elevation based on LIDAR data

TABLE A-5: C-11 IMPOUNDMENT STORAGE CALCULATIONS

Storage Surface Area	1,068 acres
Normal Maximum Pool Depth	4.3 feet
Design Storage Volume	4,592 acre-feet
Fill Rate at 1,050 cfs (S-503)	1.95 feet/day or 0.08 feet/hour
Time to Fill 4.3 feet at 1,050 cfs	2.2 days
Drawdown Rate at 250 cfs (S-503A)	0.46 feet/day or 0.02 feet/hour
Time to Drawdown 4.3 feet at 250 cfs	9.3 days
Drawdown Rate at 1,000 cfs (S-504)	1.86 feet/day or 0.08 feet/hour
Time to Drawdown 4.3 feet at 1,000 cfs	2.3 days

A.5.2.6 Embankment Design

A.5.2.6.1 General Information

Project design parameters for impoundments, reservoirs and other water impounding structures in south Florida are provided in the joint USACE and SFWMD approved Design Criteria Memorandums (DCM) developed and

published between the two agencies. That pertaining specifically to determining the reservoirs embankment height is found in DCM-2, *Wind and Precipitation Design Criteria for Freeboard* (2006). The DCMs provide collectively Federal and State of Florida requirements in reservoir design dependent on the Hazard Potential Classification (HPC). Additionally, the DCMs provide recommended methodologies in use of design parameters and offer accepted avenues for the optimization of reservoir designs. Therefore, C-11 Impoundment embankment heights were designed using DCM-2 as the primary reference for all parameters and methodologies. Similar to USACE ER 1110-8-2(FR) minimum standards for earthen embankment freeboard requirements, the selected design height must be the greater between the minimum standard and that that assures failure will not occur from possible combination of design events resulting from surcharged stages with high winds, uncertainties in analytical procedures, and project operations in combination with critical design pool elevations. The minimum Federal standard freeboard on a reservoir with a Low HPC is 3 feet above the surcharge pool determined by routing the 100-year 72-hour event in accordance with DCM-2.

In addition to the DCM-2 design event (100-year 72-hour storm), the 50% PMP was routed to ensure safe passing of the minimum Standard 3 IDF in accordance with ER 1110-8-2(FR).

The two most important design parameters in the design of embankment heights (excluding minimum freeboard requirements) are the selection of the Inflow Design Flood (IDF) and the design wind speed. From these two parameters, all other parameters are derived either directly or indirectly, e.g. surcharge pools, spillway overflow, wind setup (or wind tide), wind-wave height, wave run-up, and wave over-wash (or overtopping). Dependent on Hazard Potential Classification (HPC), DCM-2 provides these two important design parameters. Since C-11 Impoundment reservoir is expected to carry a Low HPC, the design IDF for the reservoir is the 100-year 72-hour storm event and the "reasonable" wind speed is 60mph (minimum Category 1 Hurricane one-hour average wind). Therefore, the design embankment height for C-11 Impoundment is the greater between a minimum freeboard of 3 feet and that that assures failure will not occur as a result from wind setup, wave action, and uncertainties in analytical procedures and project function in combination with the application of a 60mph wind speed over the 100-year 72-hour surcharge pool.

A.5.2.7 Embankment Height Analysis

A.5.2.7.1 Hydrology (IDF)

Note: The data provided in this section were calculated on preliminary results of the reconfigured impoundment project (since the draft PIR). The results are considered applicable and appropriate given the closeness of the final configured

design to the preliminary estimates as provided in this final PIR. Some numbers relating to direct design have been arithmetically upgraded to account for the slightly deeper design of the normal pool, i.e. from 4-foot depth to 4.3-foot.

The 100 year frequency, 72-hour duration storm was used per DCM-2 for the C-11 Impoundment design due to its expected Low Hazard Potential Classification (HPC). Although the C-11 Impoundment carries a Low HPC, the Probable Maximum Precipitation (PMP) and the 50% PMP were also routed to compare the resulting maximum pool elevation against the design pool surcharge caused by the design 100-year frequency storm.

The PMP was developed according to guidelines from the Hydrometeorological Report (HMR) No. 51 (Probable Maximum Precipitation Estimates, Eastern U.S.) and HMR No. 52 (Probable Maximum Storm Computation). A value of 55.7 inches was selected from the all season 72 hr, 10 mi^2 PMP chart.

A synthetic 72-hour PMP rainfall event was developed according to HMR-52 to contain discrete PMP storm durations from 6 to 72 hours (*Table A-6*). The peak hour rainfall rate was calculated and smoothing was applied to yield the 1-hour distribution of the probable maximum storm (*Figure A-1*).

TABLE A-6: PROBABLE MAXIMUM PRECIPITATION FOR STORM DURATIONS 6 TO 72 HOURS

Storm Duration (hr)	6	12	24	48	72
PMP (in)	32.0	38.7	47.1	51.8	55.7

TABLE A-7: PRECIPITATION FOR EACH 6-HOUR INCREMENT OF THE 72 HR PMP

6-Hour Increment	1	2	3	4	5	6	7	8	9	10	11	12
Precipitation (in)	1.0	1.0	1.0	1.0	1.0	1.2	1.8	5.4	32.	6.7	3.0	0.7

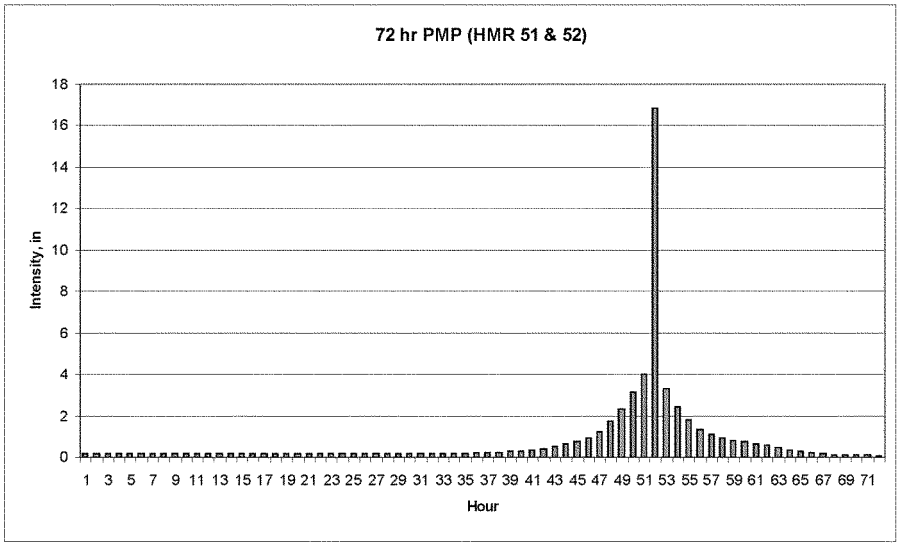

FIGURE A-1: HOURLY DISTRIBUTION OF THE SYNTHETIC 72 HR PROBABLE MAXIMUM PRECIPITATION

The Corps' HEC-RAS (River Analysis System) model was employed to determine the maximum pool (or surcharge pool) elevation and peak discharge. The model configuration consisted of a storage area equal to 1.63 square miles with a weir outlet. Since the impoundment itself is the tributary basin and its surface is considered impermeable when full, all storm precipitation was readily available for routing without any loss. The initial pool stage used in the routing model of C-11 Impoundment was the maximum normal pool stage of 10.3 feet NGVD.

The spillway crest elevation for the C-11 Impoundment was determined in accordance with these procedures. The 24-hour, 25-year return period rainfall is recommended in the SFWMD Technical Publication 81-3 May, 1981 Frequency Analysis of Rainfall Maximums for Central and South Florida for basin hydrologic modeling purposes. However, the 72-hour, 100-year return period rainfall was used to ensure that no impacts were made to existing levels of service flood protection. The 24-hour, 100-year rainfall amount for the C-11 basin was determined to be 12 inches. The ratio of 24-hour, 100-year rainfall to 72-hour, 100-year rainfall is 1.359. Thus the 72-hour, 100-year rainfall for the C-11 impoundment is 16.3 inches. The document "Basis of Review for Environmental Resource Applications within the SFWMD, February 12 2006" sets the allowable discharge for the C-11 Canal as 20 cfs per square mile; this rate translates to 33 cfs for the 1.63 square miles of impoundment. The length of the service spillway, 8 ft, was designed to limit the impoundment outflow to 32

cfs during the 72-hour, 100-year storm. The resulting peak stage of 11.6 ft-NGVD was used to define the crest elevation of the auxiliary overflow spillway.

The PMP analysis should consider an antecedent-setting event to address concerns over the sequencing of rainfall storms as described in the DCM-2 (HMR 56). Two routings must be performed to determine governing circumstances:

a)

1. From normal pool, route a **30**%PMF-72hr storm
   - Spillway on, but gates are inoperable
2. Provide for a **3-day** dry spell
   - Spillway on, gates are operable
3. Route a 100%PMF-72hr storm
   - Spillway on, gates are inoperable
4. Provide for a 10-day dry spell
   - Spillway on, gates are operable
5. Route a **30**%PMF-72hr storm
   - Spillway on, gates are inoperable

b)

1. From normal pool, route a **40**%PMF-72hr storm
   - Spillway on, but gates are inoperable
2. Provide for a **5-day** dry spell
   - Spillway on, gates are operable
3. Route a 100%PMF-72hr storm
   - Spillway on, gates are **in**operable
4. Provide for a 10-day dry spell
   - Spillway on, gates are operable
5. Route a **40**%PMF-72hr storm
   - Spillway on, gates are **in**operable

However, it was determined from the beginning that the proposed gated structure had the capacity (1,000 cfs) to drawdown the impoundment stage to normal pool elevation between storms. Therefore, the single PMP storm was used for this analysis.

TABLE A-8: INFLOW DESIGN FLOOD ANALYSIS

Probable Maximum Precipitation (PMP), 72-hour Rainfall	55.7	inches
SFWMD 100-year, 24-hour Rainfall	12.0	inches
SFWMD 100-year, 72-hour Rainfall	16.3	inches
4.3-foot deep Basin Area	1041	acres
Basin Area	1.63	sq miles
Normal Pool Elevation (Service Spillway Crest Elevation)	10.3	ft-NGVD
Service Spillway Length	8.0	ft
Auxiliary Overflow Spillway Crest Elevation (100yr, 72hr storm)	11.6	ft-NGVD
Peak IDF Instantaneous Inflow (100-year, 72-hour)	4,834	cfs
Probable Maximum Precipitation (PMP), 72-hour Rainfall	55.7	inches

Average ground elevation based on LIDAR data.

The 50% and 100% PMP storms were routed through the impoundment using 5 crest lengths: 50, 100, 150, 200, and 250 ft *Table A-9* and *Table A-10*). The 150 foot long crest was chosen as the most appropriate design with a peak pool elevation of 12.30 ft-NGVD, 0.70 feet above the spillway crest, a peak spillway discharge of 300 cfs and a recession time of 40 hours to reach 0.25 feet above the spillway crest.

Although the C-11 Impoundment is being designed for the 100-year frequency, 72-hour duration storm, the pool surcharge caused by the PMP remains contained within the proposed embankment height of 8.5 feet (14.50 ft-NGVD).

Note to remember in comparing the other IDFs performed for the C-11 Impoundment, the 100-year surcharge stage is 11.60ft-NGVD (auxiliary spillway crest elevation).

TABLE A-9: C-11 IMPOUNDMENT EMERGENCY OVERFLOW SPILLWAY – 50% PMP ROUTING

Crest Length (ft)	Peak Height Above Spillway Crest (feet)	Peak IDF Pool Elevation (ft-NGVD)	Peak IDF Spillway Discharge (cfs)
50	0.81	12.41	166
100	0.75	12.35	240
150	0.70	12.30	300
200	0.67	12.27	353
250	0.64	12.24	400

TABLE A-10: C-11 IMPOUNDMENT EMERGENCY OVERFLOW SPILLWAY – 100% PMP ROUTING

Crest Length (ft)	Peak Height Above Spillway Crest (feet)	Peak IDF Pool Elevation (ft-NGVD)	Peak IDF Spillway Discharge (cfs)
50	2.57	14.17	720
100	2.34	13.94	1,119
150	2.21	13.81	1,468
200	2.10	13.70	1,781
250	2.02	13.62	2,067

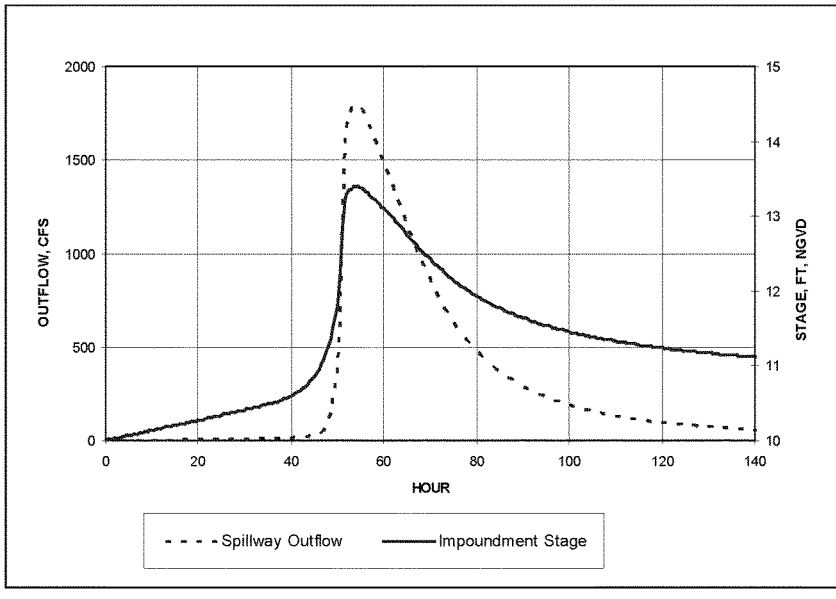

FIGURE A-2: ROUTING OF THE 72 HR PMP FOR THE C-11 IMPOUNDMENT WITH SERVICE SPILLWAY (8 FEET LONG) AND EMERGENCY SPILLWAY (150 FEET LONG)

A.5.2.7.2 Fetch Length

A fetch length of 1.835 miles (9,690 feet) was used in calculating wind setup for the C-11 Impoundment.

Wind fetch is the distance or reach that wind travels uninterrupted over a body of water in a general direction. Fetches fall into two categories, open-water fetches where wave growth is limited only by the incident meteorological conditions, and restricted fetches where wave growth is limited by a confined

geometry such as that of a lake, river, bay, or impoundment. The C-11 Impoundment is subject to a restricted fetch. The restricted fetch methodology applies the concept of wave development in off-wind directions and considers the shape of the basin. For this study, the wind direction is taken to be the direction corresponding to the maximum fetch distance. The fetch is defined as the radial average distance over an arc of 24 degrees centered on the wind direction. Measuring the longest reach and averaging that distance with multiple directional rays within 12 degrees on either side of the reach is one method of calculating the wind fetch. The total 24-degree field allows for small inconsistency in wind direction and influence by partial wind/wave blockage from obstructions bordering the longest reach length. EM 1110-2-1414 provides an illustrated procedure of the method. The fetch length determined by this method was used only for wind setup calculations as the wind-wave numerical model accounts for fetch implicitly.

A.5.2.7.3 Design Wind Speed

For reservoirs carrying a Low HPC, DCM-2 provides a "reasonable" wind speed of 60 mph.

The 60 mph wind is equivalent to a minimum Category 1 Hurricane sustained wind speed of 75 mph (one-minute average) converted to a one-hour average wind speed. USACE General Design Memorandum (Part I, Basic Report) states that south Florida levees should be constructed to withstand hurricane related wave impacts for duration of three to four hours. Employing the use of a design one-hour average wind speed is considered a conservative conversion for this reason. Also, more intense hurricanes typically travel with a higher "over land" speed producing higher wind speeds, but likely shorter durations.

A.5.2.7.4 Wind Setup

The wind setup for a Category 1 Hurricane wind speed of 60.3mph, applied over a water depth of 6.23 feet (100-year surcharge stage of +12.23 ft-NGVD), is calculated to be 0.67 feet in accordance with DCM-2. The wind setup for a Category 1 Hurricane wind speed of 60.3mph, applied over a water depth of 6.89 feet (50% PMP surcharge stage of +12.89ft-NGVD), is calculated to be 0.59 feet in accordance to ER 1110-8-2(FR), although the design wind speed is not defined in the ER.

Air movement across the water leads to the development of shear stresses between the air and water interface, also referred to as an inducement of drag. The result of drag causes water to "pile up" against the shore or dam, creating the vertical uplift effect known as "wind setup". A corresponding decrease in water level will occur along the opposite shore; not as an equal offset, but as a convex curved surface where conservation of mass is preserved. The amount of

wind set up is balanced between the opposing forces of wind generated drag and gravity induced return flow along the bottom boundary. This interaction creates a counter-intuitive effect whereby shallower bodies of water exhibit a higher degree of wind setup, i.e. shallower water "feels" more resistance to return flow than deeper water for identical contact area and roughness characteristic. For wind setup models, the most sensitive parameter is wind speed--typically a squared term representing energy input into the system. Fetch has a mostly linear function and as is evident upon investigating setup equations. Stillwater depth differs in function between the models used in the analysis; however, it always appears in the denominator illustrating its inverse proportionality.

Three wind setup models were investigated for applicability to the reservoir, the Zieder Zee formula (USACE, 1990), the Sibul equation (Brater et al., 1996), and the Bretschneider numerical method (Ippen, 1966). The Zieder Zee formula is an empirical equation that was derived and based on deep long and narrow water bodies (fjords). The formula does not account for conservation of mass and therefore tends to over predict setup when applied to shallower water bodies, i.e. does not allow for an exposed bottom. Zeider Zee is considered a conservative alternative and is often used for this reason, as well for its simplistic and familiar (though inconsistent) units-type formulation. The Sibul equation, developed through laboratory experiments and tested with field data, has shown good correlation with data collected for large bodies of water such as Lake Okeechobee and the Baltic Sea. However, the Sibul equation appears to under predict wind setup in shallow water cases when compared with other generally accepted models. Trend curves produced by graphing wind setup results over a range of depths illustrate that the Bretschneider method approaches a mean value between Zeider Zee and Sibul's methods. Although Bretschneider's model does not a have a numerical solution for all conditions (using numerical solution table found in reference), the solution curve appears stable enough for extrapolation with confidence. These reasons as discussed are why DCM-2 recommends the use of the Breschneider model for wind setup calculations for shallow reservoirs.

A.5.2.7.4.1 Bretschneider's Model

The Bretschneider numerical method allows for exposed bottom and was derived for rectangular water body shape with constant depth and under steady-state conditions. Several researchers independently developed the differential form of the model that is based on surface and bottom shear stresses and conservation of mass. Saville verified its usage with data collected in studies by USACE on Lake Okeechobee in Florida. For the Lake, it was determined that wind shear stress per unit weight of water was proportional to the wind kinematic energy ($\tau_S/\rho g = 3.0\text{x}10^{-6}U^2/g$) and ratio of bed shear stress to wind shear stress was approximately an order of magnitude ($\tau_B/\tau_S \cong 0.1$). Combining these two stress

factors qualitatively provides what is called the wind drag coefficient (κ). There is some ambiguity in assigning a value for the wind drag coefficient as it is not a true constant, especially under influence of winds speeds in excess of 90 mph where upon the stress appears to be reduced minimizing wind setup expectations. Since the design wind speed is 60 mph, this is trivial for C-11 Impoundment design condition.

Note, for an enclosed lake of regular shape (round versus rectangular with minor depth variations), the model takes on an integrated form with the unit-consistent "stress parameter" correlated with incremental section reach lengths. Recent work by Consultants under USACE contract have redone wind setup calculations for Lake Okeechobee using Bretschneider equations in their integrated form over incremental section reach lengths. Results showed minimal difference between wind setup values and when viewed from the scale of Lake Okeechobee to C-11 Impoundment, difference would be negligible and inconsequential.

A.5.2.7.4.2 Bottom Stress

Bottom shear stress acts as an opposing force that sustains potential energy gained by "piling" on the front slope of an embankment or dam. Therefore, bottom vegetation may play a significant role in determining wind setup as a contributor to bottom shear stress and is related to the depth parameter (Brater et al, 1996). Discussions with several biologists led to a consensual conclusion that reservoirs that fluctuate between dry conditions and normal pools on an annual basis, there will be little, if any, expected significant plots of permanent vegetation found within the reservoir. Since models show that C-11 Impoundment does dry out virtually every year for extended periods of time during the dry-season, the bottom was assumed smooth for all wind-wave analyses.

A.5.2.7.4.3 Wind-Wave Generation

As wind starts to blow over still water, developing wind stress at the air-sea boundary leads to the formation of small perturbations in the water surface. When the perturbations become large enough to affect the pattern of air flow a transfer of momentum and energy between the air layer and the water surface occurs, rapidly increasing wave heights. Wave heights build rapidly over a relatively short distance, increasing at a rate that varies dependent upon wind speed. Waves develop more quickly and with greater uniformity as wind speed increases. Wind waves, also known as oscillatory waves, are determined by five dominant factors: wind velocity or speed, distance over which the wind blows (fetch), duration of wind, decay distance the wave travels after leaving the generating area (not relevant to this study), and the water depth.

Wind driven waves are a highly complex mix of crests and troughs on the water surface, consisting of irregularly sized wave heights and moving in variable directions. Wave direction can be easily defined as an average of the directions of individual waves, but not so for wave heights. It has been found that the frequency of occurrence of waves above any given height can be closely approximated using the cumulative form of the Rayleigh distribution (USACES, 1984). This fact and resulting theoretical wave height distribution curves make it possible to determine average wave heights for a given percentage of waves based on a single significant wave height, Hs, defined as the average height of the one-third highest waves. The numerical model STWAVE provides wave heights in the form of significant wave heights.

A.5.2.7.4.4 STWAVE

The STWAVE numerical model developed by ERDC is considered to be the state-of-the-art wind-wave model for application to shallow reservoirs. There are other wind-wave models available e.g. SWAN; however, results generally are similar when compared. STWAVE is continually being updated as a favored platform by ERDC with additional abilities. For these reasons and those to be discussed following are why DCM-2 requires the use of the STWAVE model for final wind-wave calculations.

The STWAVE model is a two-dimensional spectral wave transformation model for the simulation of wave transformation over complex bathymetry. STWAVE accepts arbitrary directional wave spectra specified at an offshore boundary and propagates the spectral energy in the onshore direction. It is a finite-difference model, which calculates wave spectra on a Cartesian grid using a backward ray-tracing scheme (Smith et al., 1999). Model results, including spectral output, significant wave height, mean wave period, and wave direction, are obtained by numerically solving the steady-state spectral energy balance equation. The equation represents wave propagation (with refraction and shoaling) as being equivalent to that of source terms represented by distribution and dissipation of energy based on linear theory. Despite quantifying these source terms on an individual basis, they are solved via conservation of momentum flux to the forward and rear face of the spectrum where the energy is redistributed. However, the wave breaking source term dissipates energy based on water depth and wave steepness.

STWAVE has several inherent limitations. For the best application of the model to wave transformation problems, the following assumptions must be made: (1) mild bottom slopes, (2) negligible wave reflection, (3) spatially homogeneous offshore waves, (4) steady state waves, winds, and currents, (5) linear refraction and shoaling with negligible bottom friction effects, and (6) linear wave-current

interaction. Due to the nature of the solution scheme, spectral energy is limited to propagation in a half-plane directed toward shore. All energy propagated offshore is neglected.

A.5.2.7.4.5 Wave Run-up

Wave run-up can be described as the resulting forward translation of water mass that is converted from wave energy as waves encounter a sloped surface. Water rushes up the slope resulting in the vertical rise above the still water line known as run-up. Run-up depends primarily on incident wave steepness, slope of the surface on which it is incident, and characteristics of the surface, including surface roughness and porosity. For a given fixed slope, run-up will increase with decreasing wave steepness. For a given incident wave height and period, run-up will increase with increasing slope steepness.

A.5.2.7.4.6 ACES

The ACES model was used to model wave run-up for the reservoirs and is recommended by DCM-2.

The ACES software package contains an application that provides for the estimation of wave run-up on rough and smooth impermeable surfaces. Five optional slope configurations were evaluated for this study: (1) a smooth (earthen, RCC, or soil cement) slope of 1V:3H, (2) a rough (riprap covered) slope of 1V:3H, (3) a rough (riprap covered) slope of 1V:2H, (4) a stepped (RCC) slope of 1V:3H, and (5) a smooth (RCC or soil cement) vertical wall.

Originally, two options based on preliminary cost-effectiveness, riprap 1V:3H and stepped RCC 1V:3H were selected for further cost evaluations. However, because of wave action, it was determined that native rock (i.e. limestone, portion having weathered characteristics) would be lacking in duration, thus requiring imported stone from out-of-state and increasing costs significantly. However, as a policy decision, both riprap and RCC steps (any vertical displacement greater than a few inches) are currently being removed from all embankment designs because of the adverse impact, environmentally, on native fauna, especially for turtles and migratory bird chicks. Stones and steps trap small animals that seek dry or higher ground, new territories, or other water bodies when draw-downs occur.

A.5.2.7.4.7 Effective Depth

Although the generation of wind waves (and therefore wave run-up and over-wash) is influenced by the presence of wind setup, the relationship is highly complex and is not presently included in the STWAVE model. Therefore, in order to include the total water level increase due to wind conditions at the

down-fetch face of the levee, wind setup is generally accounted for by adding the wind setup to the design water depth at the toe of the structure. The resulting "effective depth" then becomes the water depth used during calculation of wave run-up and subsequent over-wash.

A.5.2.7.5 Wave Over-Wash

Over-wash occurs when wave run-up reaches the crest of the embankment producing a dynamic water level greater than the crest. Over-wash may occur as spray and wave surge, including combination thereof. Over-wash is an important design element both in terms of predicting backside flooding and safeguarding structural integrity of the levee. Several methods exist for predicting the over-wash flow rate in a given situation. The ACES software package contains two methods, one for monochromatic wave over-wash as developed by Weggel (1976), the other for irregular wave over-wash developed by Ahrens (1977). Due to the irregular nature of the developed wave fields, Ahrens method was selected for this analysis.

Ahrens over-wash method was developed with the following assumptions: (1) run-up values created by an irregular wave field will follow a Rayleigh probability distribution, (2) significant deepwater wave height, Hs, causes significant run-up Rs, and (3) α, Q*o, and Ho in Weggel's over-wash equation remain constant for all members of the distribution. Ahrens estimates the over-wash rate by summing the over-wash contributions from each individual member of the run-up distribution over 199 elements. Ahren's equations modify Weggel's monochromatic expressions to account for the effect of irregular waves when freeboard, F, is less than the run-up of the significant wave, Rs. When the freeboard is greater than the run-up, Weggel's equation yields no over-wash while larger run-ups in the distribution may still overtop the structure. For these relatively high freeboards, the run-up distribution is broken into 999 elements, instead of 199, to better account for the effect of the higher run-ups. The over-wash equation for this larger distribution becomes:

$$Q = \frac{1}{999}\sum_{i=1}^{999} Q_i$$

where

Q = volume rate of over-wash caused by irregular waves ($ft^3/s - ft$)
Q_i = volume rate of over-wash caused by one run-up on the run-up distribution.

A.5.2.7.6 Acceptable Wave Over-Wash Rate

Firm guidance for an acceptable over-wash rate is, as pertaining to C-11 Impoundment project conditions (and CERP in general), not available. The

DCM-2 does not provide this design parameter as it is the designer's choice to make as they are the one to weigh all options and alternatives and finally make a sound engineering judgment based on all literature research, information received, data calculations, analyses results, observed field data, and risk assessments.

A.5.2.7.7 Literature Research and Information Received

USACE ER 1110-8-2(FR) states that "Zero over-wash is not always required under infrequent high pool conditions." Noting that C-11 Impoundment does not have a gravity fed watershed upstream of the reservoir as the impoundment is entirely aboveground and all inflow is pumped; only rainfall contributes to the high pool conditions. Therefore, high pools in themselves are directly related "in part" by infrequent design storm events, the 100-year return frequency event for C-11 Impoundment. The other directly related "part" is the design wind speed of 60 mph assumed over a one-hour average wind speed. Typically, hurricanes drop less than the 100-year rain event; however, some do. It is important at this time to remind the reader that C-11 Impoundment does carry a Low HPC with inclusion of the secondary containment levee feature.

USACE Coastal Engineering Manual provides guidance in over-wash rates based on Netherlands research (Technical, TACFD). This guidance provides an acceptable over-wash rate of 0.001 cfs/lf of levee for non-cohesive soils. However, wind duration producing the over-wash is unknown; also unknown are any other factors that may have a bearing on such recommendation. For example, with zoned embankment dams, the outer rock-fill consisting of gravel size material may self-armor during over-wash events. South Florida sands may contain a significant amount of limestone grains that possess cementitious characteristics (i.e. binding comparable to a non-cohesive likeness).

Research performed by USDA Agricultural Research Service is almost exclusively steady-state flow experiments on embankments, or hydraulic overtopping. Although this type of overtopping flow is not expected to occur with any CERP reservoir, use of steady flow research to account for the "mean" value of over-wash was suggested. However, regarding soil erosion, it is well known that strongly dynamic surge (unsteady) flows cause a higher rate of soil material entrainment than steady flows. For this reason, it was USACE decision that the dynamics of wave over-wash in how surges rush over the downslope may be misleading and should not be used to prevent confusion.

A.5.2.7.8 Data Calculations and Analyses Results

Expressed in the preceding note 3 is the dynamic characteristic of wave over-wash. Means to calculate soil erosion under this condition could not be performed for a couple of reasons. First reason is the lack of consistency of the

material that led to inability to describe it thoroughly enough to apply known fundamental sediment transport equations. The predominant limestone material can be sandy, rocky, hard, weathered with an unknown "mechanical" reaction to water flow when wet (referring to application of known equations). Another reason is that available unsteady flow models investigated do not have time steps small enough to capture wave dynamics at a scale of a hydraulically rough downslope and very shallow supercritical flow.

A.5.2.7.9 Risk Assessment

It has been noted that C-11 Impoundment reservoir carries a Low HPC. What this means is that should a breach in the embankment occur, no risk to life would be expected and property damage outside of the reservoir would be minimal. These expectations are the result of the project design including a secondary containment levee and the allowance for diesel pump stations, S-9 and S-503, to be able to pump and primarily control the outflow to limit damages.

A.5.2.7.10 Observed Field Data

The need to justify a wave over-wash rate is common to all CERP reservoirs. Another project, the Everglades Agricultural Area Reservoir (EAA) is a much larger project where one-foot of embankment conceptually costs $30,000,000. This cost figure led to many discussions over acceptable over-wash rates as cost-effectiveness became a prime concern to both agencies. To better understand wave over-wash rates and their impact on embankments backs slope, Consultants for SFWMD performed a field test utilizing a test cell embankment to represent true scale data and results. The embankment had a zoned limestone rock-fill exterior slope that would encounter the first of over-wash erosive impacts (bare surface, no vegetation). Flow over the embankment was originally to be steady-state; however, irregularities in the field provided a truer test that would enable assessment of extreme conditions that real wave over-wash may be seen.

The test covered 4 rates of flow: 0.001 cfs/lf, 0.01 cfs/lf, 0.1 cfs/lf, and lastly 0.23 cfs/lf (maximum the equipment set up could force) and lasted 8 hours at each rate. The manifold-pipe had 2 rows of adjustable nozzles that were trained downward onto a metal pan to direct flow down the slope. However, pan irregularities (equipment or placement thereof in relation to nozzles) actually created a forced spray from 1 set of nozzles down the top half of the slope, essentially simulating spray from an over-wash event. For other set of nozzles, irregularities caused more concentrated flows than the uniform across flow that was originally intended. Between the forced spray over the top half of the slope and the non-uniform concentrated flow leaving the apparatus; it was deemed a successful experiment in that it executed the test runs better than expected.

Results from the test demonstrated that the "mechanical" characteristics of the material allowed self-armoring to occur during exposure to the erosive flows. After 8-hours of the 0.1 cfs/lf (note that flows were concentrated, so actual rate was higher), the deepest encroachment into the embankment was less than a foot with a running length of about 6 feet tapering more shallow at the lower end. Little head-cutting at the toe (change of slopes) was observed, maximum was estimated to be about a foot and half drop with majority of the toe unscathed.

A.5.2.7.11 Established Acceptable Over-Wash Rate

Based mostly on observed field data from the EAA test cell, a project that contains the similar construction material for embankments that C-11 Impoundment has, same cross-section geometry, and the same zone embankment concept, the acceptable over-wash rate is 0.10 cfs/lf of embankment.

A.5.2.7.12 Results of Wind-Wave Analyses

The results of the wind-wave analyses can be seen in *Table A-9* with embankment armoring and embankment slope alternatives investigated.

A.5.2.7.13 Selected Embankment Height and Final Design

The design embankment height for C-11 Impoundment is the greater between a minimum freeboard of 3 feet and that that ensures failure will not occur as a result from wind setup, wave action, and uncertainties in analytical procedures and project function in combination with the application of a 60mph wind speed over the 100-year 72-hour surcharge pool.

The minimum embankment height that under design conditions creates an equal to or lower wave over-wash rate than 0.10 cfs/lf is 8.5 feet. The surcharge pool plus 3 feet of minimum freeboard being the comparison alternative is 8.5 feet. Therefore, the design embankment height for C-11 Impoundment is 8.5 feet with a crest elevation of 14.50 ft-NGVD assuming average interior ground elevation is 6.00 ft-NGVD.

Under alternative design conditions with an IDF using the 50% PMP, the embankment height of 8.5 feet still satisfies the embankment hydrologic Federal requirement of being able to safely pass the storm event without operable gates (assumed inoperable). Under design wind conditions and without gate use, the over-wash rate of 0.30 cfs/lf exceeds the allowable 0.10 cfs/lf; however, this is not a requirement per DCM-2. With the near proximity of the S-9 Pump Station with a 2,880 cfs capacity and "minimum" use of gates (2 separate gate structures with emergency backup power), the impoundment system would easily meet the

allowable over-wash rate with the combination 50%PMP and design wind event without significant impact to the basin. The impact analysis is qualitative and logic based, founded on the fact that much of the C-11 Western Basin has a long lag time because of the inefficient secondary drainage system. Also, the embankment height of 8.5 feet is capable of containing the IDF using the 100% PMP as a single event, though with no wind applied to the surcharge pool.

The embankment crest has a design width of 14 feet. The exterior of the perimeter embankment will be grassed and maintained for erosion protection. The design of the D-511 embankment for the C-11 Impoundment will be optimized under detailed design. Under detailed design, an analysis of a proposed vegetated wave bench will be considered. The vegetated wave bench proposed to reduce wave action on the levee and address the potential elimination armoring on the interior or waterside of the embankment. The proposal is a 50 – 100 ft bench with Bulrush and Cattail planted on the bench.

TABLE A-11: C-11 WIND-WAVE ANALYSIS

C-11 - Wave Runup and Overtopping - No Gates															
	Still Water	Wind	Wind	Effective	Signif	Slope	Runup	Overtopping for Levee Height (ft^3/s-ft)							
Case	Depth	Speed	Setup	Depth	Wave Ht	Type									
	(ft)	(mph)	(ft)	(ft)	(ft)		(ft)	6ft	6.5ft	7ft	7.5ft	8ft	8.5ft	9ft	9.5ft
4.3ft															
Normal	5.56	60	0.67	6.23	1.71	Smooth 1:3	3.42	99.000	1.531	0.803	0.421	0.214	0.104	0.047	0.020
Pool						Rough 1:3	1.85	99.000	1.133	0.342	0.091	0.020	0.000		
100yr						Rough 1:2	2.28	99.000	1.309	0.490	0.173	0.054	0.015	0.000	
Storm						Stepped 1:3	2.15	99.000	1.076	0.388	0.130	0.038	0.010	0.000	
						Step 1:1.5	3.22	99.000	1.356	0.673	0.330	0.155	0.069	0.028	0.012
						Vertical Wall	2.07	99.000	0.818	0.262	0.076	0.019	0.000		
4.3ft															
Normal	6.3	60	0.59	6.89	1.84	Smooth 1:3	3.49	99.000	99.000	2.049	1.071	0.571	0.298	0.149	0.071
Pool						Rough 1:3	1.90	99.000	99.000	1.806	0.564	0.165	0.041	0.009	0.000
50%						Rough 1:2	2.34	99.000	99.000	1.951	0.747	0.280	0.095	0.029	0.008
PMP						Stepped 1:3	2.21	99.000	99.000	1.626	0.598	0.214	0.069	0.019	0.005
						Step 1:1.5	3.32	99.000	99.000	1.845	0.925	0.468	0.229	0.107	0.047
						Vertical Wall	2.14	99.000	99.000	1.262	0.425	0.133	0.037	0.009	0.000

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A.5.2.8 Internal Spoil Mounds

In the Draft PIR as a High HPC, internal spoil mounds were designed to reduce fetch lengths that add to wind setup and wind-wave growth, when combined adding to required embankment heights. However, detail wind-wave analyses demonstrated that they were only slightly effective for this purpose and not cost-effective for project inclusion. Under the new HPC of Low, the internal spoil mounds are not effective at all as design storm conditions do not lead to a higher required embankment height than the required 3 feet of freeboard on the surcharge pool. Therefore, this feature has been deleted from the design altogether. Also, it has come to USACE awareness the impact that nesting migratory birds may have that can interfere with operations intended and needed to realize claimed project benefits. Because of this awareness, internal spoil mounds are undesired as they would pose as an attractant for migratory bird nesting. Therefore, these mounds are now removed from any further consideration, as well as incorporating a grading plan that can be executed cost effectively to remove high points as much as possible to do so.

A.5.2.9 Revetment

The interior or waterside slope of the perimeter D-509 Embankment will be armored with a 24" thick CSA Plate. The crest will be armored with a 12" thick CSA Plate. The exterior or landside of the perimeter embankment will be grassed and maintained for rainfall runoff erosion protection.

A.5.3 Mitigation Wetland Marsh Areas

The C-11 Impoundment footprint includes two existing separated mitigation areas that required the project team to maintain, relocate, or offset with additional mitigation credits within the project design, or in combination with the other project components under Broward County WPA. The project as designed limits adverse impacts to the two existing mitigation areas while providing a water supply to sustain their viability and a protective perimeter levee/berm. The project design also adds wetland marsh acreage for mitigation credits to offset the impacts caused by project implementation at other sites within BCWPA. Two mitigation wetland areas within C-11 Impoundment, Mitigation Area A and Mitigation Area B, are created by the existing and newly converted wetlands when combined.

A.5.3.1 Mitigation Area A

The main wetland marsh area within C-11 Impoundment is Mitigation Area A (Mit A) that includes a total of 475 acres of existing and newly converted to wetlands. The depth of water in the mitigation area will be dependent on

direct rainfall, seepage from the reservoir, releases from the reservoir through S-506A Gated Culvert structure--rated design capacity of 55 cfs, or the setting of the gate in the discharge S-506B Culvert into the C-511 Seepage Canal. The design allotment for project storage is 1-foot of water that provides water for the wetland hydroperiod while still assisting with one of the main project purpose of diverting runoff from S-9 Pump Station pumping into WCA to elsewhere with multi-purpose usage. Within Mit A some upland areas created by other historic land uses (i.e. dirt roads, structures, etc.) will be scraped down to average existing grade and other areas will be cleared.

The perimeter levee around Mit A includes the L-511 Levee and the L-512 and L-514 Levee/Berms.

A.5.3.2 Mitigation Area B

The other smaller wetland marsh area is Mitigation Area B (Mit B) that includes a total of 13 acres of newly converted wetlands. The depth of water in the mitigation area will be dependent on direct rainfall and seepage from the reservoir. That is, there is no direct water supply feature for this area. Excess water with heavy precipitation events may and is permitted to overflow L-513 Levee/Berm or SW 26th St. into adjacent and parallel C-513 and C-512 Seepage Canals, respectively. Within Mit Area B the upland areas created by other historic land uses (i.e. dirt roads, structures, etc.) will be scraped down to water table to establish/reestablish the new wetlands marsh area.

The perimeter levee around Mit Area B includes the L-511 Levee and the L-512 and L-513 Levee/Berms.

TABLE A-12: C-11 WETLAND MITIGATION AREA DESIGN

	Mitigation A	Mitigation B
Storage Area	475 acres	13 acres
Normal Maximum Pool Depth	1 foot	no project inflow
Storage	500 ac-ft	0 ac-ft
Maximum Normal Pool Depth	1 foot	surface
Fill Rate at 50 cfs	0.88 ft/day	1.02 ft/day
Average Marsh Ground Elevation (existing grade)	6.50 ft-NGVD	6.00 ft-NGVD
Maximum Mitigation Pool	9.50 ft-NGVD	8.00 ft-NGVD
Top Of Levee	9.50 ft-NGVD	8.00 ft-NGVD

Assumed average ground elevation based on LIDAR data

A.5.4 Water Control Structures

A.5.4.1 Pump Stations

A.5.4.1.1 S-503 Inflow Pump Station

S-503 Pump Station has a total design pumping capacity of 1,500 cfs—1,050cfs for inflow pumping and 450 cfs for seepage return pumping. The inflow pumping capacity was selected based on water budget modeling by SFWMD's Consultant for the interim period before North Lake Belt Storage Area comes online in approximately 25 years. The inflow bank has three bays that include three 350 cfs diesel engine driven pumps (see *Plate S-2*). The seepage return pumping capacity includes a safety design factor added to the recent 3-D groundwater LECsR modeling effort. The seepage bank also has three bays that include three 150 cfs electric motor driven pumps.

The pump station is located at the southeastern corner of the reservoir off the C-11 Canal, just east of the newly constructed S-381 Gated Obermeyer structure (see *Plate S-1*). The pump station is designed to capture available stormwater runoff in the Western C-11 basin between S-381 and S-13AW (inflow bank) and to return pump seepage intercepted by perimeter control C-511, C-512, and C-513 Seepage canals (seepage return bank).

All diesel pumps located in the inflow bank may be used simultaneously for maximum runoff capture or diversion operations. A 350 cfs pump can also be used to return pump seepage, thereby maintaining the C-11 Canal control stage during non-runoff events. For operational flexibility any combination of pumps can be used to maintain optimum canal levels.

A.5.4.2 Gated Culverts

S-503A Gated Culvert is a single barreled, gated box structure. The design flow is 200 cfs per with a 5.20-foot hydraulic head differential, although ultimate capacity is much higher than that used for design. The structure is located abutting S-503 Pump Station western side and discharges into the C-11 Canal just east of the S-381 Obermeyer Gate. The structure will allow discharges and releases from the impoundment to drawdown the storage pool to regain storage availability, meet water demands, and/or maintain optimum canal levels. The structure allows operational flexibility in that it provides this ability while S-381 and S-9A Pump Station are seepage return pump operations.

The culvert barrel is a 5 foot x 6 foot box culvert (cast-in-place) is 100 feet in length. The barrel invert on the downstream end is set at elevation -4.00 ft-NGVD. The gate is typical slide type. (see *Plate S-3*).

A.5.4.2.1 S-504 Gated Culverts

The S-504 Gated Culvert is a double-barrel, gated box structure. The design flow capacity is 1,000 cfs with a headwater and tailwater of 10.3 and 3.50 ft-NGVD, respectively. The design discharge is based on matching the C-11 and C-9 (S-509) Impoundments' inflow pump stations capacities. Until NLBSA comes online, the maximum diversion/transfer flow rate to the C-9 Impoundment will be 1,000 cfs. The culvert structure is located just east of thesouthwestern corner of the impoundment on the C-11 Canal. The structure will allow discharges and releases from the impoundment to drawdown the storage pool to regain storage availability, transfer water to the C-9 Impoundment or the NLBSA, meet water demands, and/or maintain optimum canal levels.

The culvert barrels consist of two 8 foot x 8 foot box culverts (cast-in-place) 180 feet in length. Barrel inverts are -8.00 ft-NGVD. The gates are typical slide type. (see *Plate S-5*).

A.5.4.2.2 S-506A Gated Culvert

The S-506A Gated Culvert is a single barrel, gated "sag" culvert structure. The design flow capacity is 55 cfs with a 3.25-foot hydraulic head differential. The structure is located in the northwestern corner of the impoundment. It conveys flow from the reservoir under C-511 and SW 26th St—hence the "sag" element—into Mitigation Area A, in order to manage the wetland hydroperiod or make use of the area for extended reservoir storage up to one-foot of depth.

The culvert barrel is a 48 inch diameter round culvert 340 feet in length. The barrel invert is set at elevation -0.5 ft-NGVD at the inlet/outlet and -6.0 ft-NGVD in the sag segment. The gate is typical slide (see *Plate S-10*).

A.5.4.2.3 S-506B Gated Culvert

The S-506B Gated Culvert is a double-barrel, gated round culvert structure. The design flow capacity is 75 cfs with a 3.0-foot hydraulic head differential. The structure is located in the northeastern corner of the impoundment and conveys flow from Mitigation Area A under L-511 (SW 26th St) into the C-511 seepage canal, to manage the wetland hydroperiod by ensuring depth durations are not prolonged to a point of causing significant adverse impact.

The two culvert barrels are 5-feet in diameter round and are 60 feet in length. Barrel inverts are set at elevation -2.5 ft-NGVD. The gates are adjustable weir type (see *Plate S-11*).

A.5.4.3 Weirs and other Spillover Water Control Structures

A.5.4.3.1 S-504B Service and Auxiliary Overflow Spillway

The S-504B spillway is a drive over spillway with a service and an auxiliary spillway. The spillway's purpose is to protect embankment integrity should a storm event occur with a less frequent return period than the design storm or succeeding multiple storm events occur that could place the reservoir's embankments at risk of breaching. The design service spillway crest length was selected to meet the permitted discharge rate set by basin location in accordance with SFWMD's "Basis of Review for Environmental Resource Application with SFWMD, Feb. 2006." See the hydrologic routing under the embankment height design section for more information pertaining to routing and design discharges.

S-504B consists of an overflow spillway structure. It contains the service spillway with 31 cfs capacity and an auxiliary spillway with 322 cfs capacity and is located on the southern embankment and discharges into the C-11 Canal. The spillway design is a combined broad-crested weir with a California Institute of Technology (CIT) type of discharge, i.e. vertical drop with endsill.

The service spillway has a crest elevation at 10.3 ft-NGVD or at the normal full pool elevation. It is 8 feet in length (see *Plate S-05* and *S-06*). The auxiliary spillway has a crest elevation of 11.6 ft-NGVD and is 150 feet in length.

A.5.4.3.2 S-505A Weir

The S-505A Weir is a non-gated broad crested weir structure. The design flow capacity is 220 cfs with a hydraulic head of 0.75 feet. The design flow capacity is that which enables "maximum" seepage to be controlled with minimal area impacts should a 150 cfs pump in the S-503 seepage be off-line. The weir is also associated with a sluice gate with a design flow capacity of an additional 470 cfs that is comparable in conveyance capacity with the S-503 seepage pump station of 450 cfs.

The structure is located at the southeastern boundary of the impoundment in the C-511 perimeter seepage canal. The structure will allow excess seepage that is discharged into the C-11 Canal to be return pumped into the reservoir

with the S-503 Pump Station inflow pump station. The structure limits C-11 Canal backflow upstream of the weir into C-511 Seepage canal during times of excess C-11 Canal stages.

The crest elevation is set at 5.0 ft-NGVD and is 130 feet in length. The sluice gate is 8 feet x 8 feet with an invert of -6.5 ft-NGVD (see *Plate S-04*).

A.5.4.3.3 S-505B Weir

The S-505B Weir is a non-gated broad crested weir structure with a 10-foot notch. The design flow capacity is 250 cfs with a hydraulic head of 0.80 feet. The weir is able to accommodate a higher flow capacity if seepage should prove to be at a higher rate than expected, i.e. the seepage management system would still retain acceptable capacity. The structure is located mid-reach of the eastern C-511 perimeter seepage canal, separating the southeastern and northeastern quadrants. The structure will allow excess staged water collected north of the structure (controlled at 6.0-6.5 ft-NGVD) to discharge south of the structure that is controlled at 3.5 ft-NGVD to prevent impact to flood damage reduction abilities for nearby private lands. The canal's northern reach higher control stage prevents over drainage of adjacent wetlands and reduces the seepage rate out of the reservoir.

The weir crest elevation is set at 6.00 ft-NGVD with a notch crest elevation at 5.30ft-NGVD and has an overall length of 150 feet (see *Plate S-07*).

A.5.4.3.4 S-505C Weir

The S-505C Weir is a non-gated broad crested weir structure with a 10-foot notch. The design flow capacity is 750 cfs with a hydraulic head of 1.25 feet. The weir is able to accommodate a higher flow capacity if seepage should prove to be at a higher rate than expected, i.e. the seepage management system would still retain acceptable capacity. The structure is located near the southwestern corner of the impoundment in the C-511 Seepage canal, just north of the adjacent Seminole Truck Stop. The structure will allow excess seepage that is discharged into the C-11 Canal to be pumped into the WCA-3A via the S-9A Pump Station. The seepage canal's control stage benefits seepage reduction from the WCA 3A, 3A SMA, Mitigation Area A and the impoundment.

The weir crest elevation is set at 6.00 ft-NGVD with a notch crest elevation at 5.30 ft-NGVD and has an overall length of 154 feet (see *Plate S-08*).

A.5.4.4 Non Water Control Structures

A.5.4.4.1 S-505D Non-Gated Culvert

The S-505D Non-gated Culvert is a single-barrel, box culvert structure. The culvert has a rated design flow capacity of 750 cfs. The structure is located near the southwestern corner of the impoundment and provides conveyance of seepage collected and spilled over the S-505C weir structure. The box structure also functions as a maintenance bridge to the reservoir from US-27 along the C-11 Canal.

The culvert barrel is a 10 foot x 10 foot box culvert and is 65 feet in length. The barrel invert is set at elevation -6.5 ft-NGVD.

A.5.4.4.2 S-507(A-F) Non-Gated Culverts

The S-507(A-F) Non-gated Culverts consist of six individual round culverts. The culverts have minimum flow requirements as their function is to maintain equal stages in the mitigation areas separated by SW 26th Street near the northwestern corner of the reservoir.

The culvert barrels are 48 inch diameter round culverts and are 72 feet in length. The barrel inverts are set at +0.5 ft-NGVD (see *Plate S-12*).

A.5.4.4.3 S-508A Gated Culvert

The S-508A Gated Culvert is a single-barrel, culvert structure. The culvert has a minimum flow capacity with minimal hydraulic head differential. The structure provides conveyance for seepage collected from the C-513 Canal to C-512 Canal under SW 26th St.

The culvert barrel is a 48 inch diameter round, 225 feet in length. The barrel invert is set at elevation – 1.0 ft-NGVD (see *Plate S-13*).

A.5.4.4.4 S-508B Gated Culvert

The S-508B Gated Culvert is a triple-barrel, culvert structure. The culvert has a 358 cfs design flow capacity with minimal hydraulic head differential. The structure provides conveyance of seepage collected from the C-512 Canal to C-511 Canal under L-511.

The culvert barrels are 72 inch diameter round culverts and are 272 feet in length. The barrel inverts are set at elevation –3.0 ft-NGVD (see *Plate S-14*).

A.5.4.4.5 S-508C Non-Gated Culvert

The S-508C Non-gated Culvert is a single-barrel, culvert structure. The culvert has a minimum design flow capacity with minimal hydraulic head differential. The structure is located between the finger lakes in Mitigation Area A and serves to equalize the western and the eastern finger lakes within Mitigation Area A.

The culvert barrel is a 48 inch diameter round culvert 225 feet in length. The barrel invert is set at elevation –3.0 ft-NGVD (see *Plate S-15*).

A.5.4.4.6 S-508D Non-Gated Culvert

The S-508D Non-gated Culvert is a single-barrel, culvert structure. The culvert has a minimum design flow capacity with minimal hydraulic head differential. The structure is located in Mitigation Area A between the eastern finger lake and the mid-reach of the C-511 seepage canal and provides conveyance of seepage collected from the Finger Lakes within Mitigation Area A to C-511 Seepage canal.

The culvert barrel is a 48-inch diameter round culvert 136 feet in length. The barrel invert is set at elevation –1.0 ft-NGVD (see *Plate S-16*).

A.5.5 Existing Features

A.5.5.1 S-13AW Gated Culvert

The structure is located in the C-11 Canal at the intersection of Griffin Road and 100th Avenue, approximately 8.6 miles east of S-381. The S-13AW gated culvert is a gated four barrel culvert structure. The culvert barrels are 6-foot diameter round CMP and are 200 feet in length. The barrel inverts are set at elevation –1.10 ft-NGVD. The design flow capacity is 500 cfs with a 0.50 hydraulic head differential. S-13AW is the basin divide structure between the western and eastern C-11 basins. The structure currently operates during dry conditions to maintain an optimum canal elevation to the east of 2.2 ft-NGVD at S-13 Pump Station. The S-13 is located approximately 4.5 miles east of S-13AW. The S-13AW structure is also opened to move water to C-11 East and then to tide through S-13E during runoff events in order to reduce pumping at the S-9 Pump Station under favorable tide and eastern C-11 basin conditions.

A.5.5.2 S-13 Flood Pump Station

The S-13 flood pump station is located in the C-11 Canal, approximately 300 feet west of US Highway-441. S-13 Pump Station has a total pumping capacity of 540 cfs. The pump station is designed to remove excess stormwater in the eastern C-11 basin and maintain an optimum upstream

water surface elevation of 2.2 ft-NGVD for the C-11 Canal. The structure is also equipped with a 16-foot wide by 11-foot high vertical lift gate that operates to maintain the optimum water surface elevation when conditions are favorable for gravity discharge to tide.

A.5.5.3 S-381 Gated Spillway

The S-381 gated spillway is located in the C-11 Canal near the southeastern corner of the impoundment, just west of the proposed S-503 Pump Station. The S-381 gated spillway is a three-bay Obermeyer (proprietary) gated structure that is engaged with a submerged bladder. The spillway design flow capacity is 2,880 cfs with a minimal (less than 1/10 foot) head differential. The design is based on matching S-9 Pump Station capacity with no negative impact to existing levels flood protection for the Western C-11 Basin. The S-381 gated spillway is normally closed for the backpumping of WCA 3 seepage collected in the C-11 Canal by the S-9A Pump Station. The S-381 gated spillway is opened only during S-9 Pump Station operations for flood damage reduction in the Western C-11 Basin or for releasing flows to the basin to meet water supply demands (including prevention of saltwater intrusion). The Obermeyer gate is designed so that in the unlikely event of failure it is in the open position. This allows water to be pumped through the S-9 Pump Station maintaining flood protection for the basin should the structure fail.

A.5.6 Embankments, Levee, and Levee/Berms

The C-11 Impoundment includes: (1) earthen embankment D-511 Embankment, (2) containment levee L-511 Levee, and (3) four levee/berms L-512, L-513, L-514, and L-515 Levee/Berms (low height and limited impounding abilities). Refer to *Table A-11* for their earthen constructed geometries and design parameters.

A.5.6.1 Embankments

A.5.6.1.1 D-511 Embankment

The D-511 Embankment is the impoundment embankment structure that allows the normal maximum storage of water up to 4.3 feet deep with a design crest elevation of 14.5 ft-NGVD or 8.5 feet above assumed average existing grade of 6.0 ft-NGVD. The embankment design meets the reservoir's Low HPC requirement with an associated L-511 Levee that enables the total impoundment design to contain and convey a possible breach flow to the C-11 Canal should D-511 fail unexpectedly. The embankment height was designed in accordance to DCM-2 and meets USACE Engineering Regulations. Refer to the *Embankment Height Analysis Section* for specifics in how the height

was determined for design. The embankment is constructed of homogeneous material and armored with soil cement (plate and steeped) revetment on the interior (lake side) to protect structure integrity from wave impacts during high wind events. The embankment is grassed on the exterior (land side) for prevention of typical rainfall runoff and occasional wave over-wash erosive-type forces. Earthen slopes are typical 1 on 3 or 3H:1V slopes. The embankment crest is 14 feet wide.

A.5.6.2 Levees

A.5.6.2.1 L-511 Levee

The L-511 Levee is the reservoir's secondary containment levee that enables the containment and conveyance of a possible breach flow to the C-11 Canal should D-511 fail unexpectedly. For this purpose, the levee has a design crest elevation of 11.0 ft-NGVD or 5.0 feet above assumed existing natural grade of 6.0 ft-NGVD. The levee is designed to withstand temporary high stages and is, therefore, not armored for wave impacts (no revetment). The levee is grassed on both slopes for prevention of typical rainfall runoff erosive-type forces. Earthen slopes are typical 1 on 3 or 3H:1V slopes.

Special note: During the Intermediate Design effort that may result in changes to the footprint and conveyance cross-section area of the C-511 seepage canal, a final dam breach simulation will be made to verify the adequateness (i.e. required height to prevent overtopping) of the L-511 crest elevation. An insignificant modification of final design crest elevation—relative to cost and overall project design effectiveness--may be required.

A.5.6.3 Levee/Berms

The levee/berms are low levees no more than 3 feet above an enclosed interior average existing grade to prevent the impoundment of water deep enough to pose a hazard under any meteorological event. That is, the limited storage depth on the interior will not be that that may create flooding nor a dangerous kinematic wave should a breach occur. Large precipitation events will cause ponding on both sides of the levee/berms limiting pressures on the structures, thereby virtually eliminating the possibility of a full breach. The levee/berms are able of extending storage availability (volume) for the C-11 Impoundment by providing one-foot of storage within Mitigation Area A wetlands enclosed by said structures. The levee/berms may provide additional ecosystem enhancement for the wetland areas which they

surround by allowing rainwater to be captured and detained, improving hydroperiods of these existing areas. Material for construction of these low earthen structures is expected to be a mix of degraded limestone, sands with some peat or muck.

A.5.6.3.1 L-512 Levee/Berm

The L-512 Levee/Berm is Mitigation Area A's mostly northern and eastern levee that allows the normal storage of water up to 1-foot deep with a design crest elevation of 9.5 ft-NGVD or 3-feet above the assumed average grade of 6.5 ft-NGVD. The levee is designed for low stages in an emergent vegetative environment that will not experience waves of any practical force. The levee is grassed on both slopes for prevention of typical rainfall runoff erosive-type forces. Earthen slopes are 1 on 4 or 4H:1V slopes due to expected mix of soils for construction of the low structures.

A.5.6.3.2 L-513 Levee/Berm

The L-513 Levee/Berm is Mitigation Area B's mostly eastern levee. Mitigation Area A has no inflow other than direct rainfall and seepage. The levee was designed with a crest elevation of 8.0 ft-NGVD or 2-feet above assumed average grade of 6.0 ft-NGVD. The levee is designed for low stages in an emergent vegetation environment that will not experience waves of any practical force. The levee is grassed on both slopes for prevention of typical rainfall runoff erosive-type forces. Earthen slopes are 1 on 4 or 4H:1V slopes due to expected mix of soils for construction of the low structures.

A.5.6.3.3 L-514 Levee/Berm

The L-514 Levee/Berm is Mitigation Area A's mostly western and northern levee that allows the normal storage of water up to 1-foot deep with a design crest elevation of 9.5 ft-NGVD and a maximum of 3-feet above assumed average grade of 6.5 ft-NGVD. The levee is designed for low stages in an emergent vegetative environment that will not experience waves of any practical force. The levee is grassed on both slopes for prevention of typical rainfall runoff erosive-type forces. Earthen slopes are 1 on 4 or 4H:1V slopes on the interior side and 1 on 6 or 6H:1V on the exterior side due to expected mix of soils for construction of the low structures. The exterior's 1 on 6 slope also provides a drivable slope for maintenance purposes.

A.5.6.3.4 L-515 Levee/Berm

The L-515 Levee/Berm is a levee/berm on the interior of Mitigation Area A surrounding the two finger-lakes. The levee/berm isolates the mitigation area pool from the lakes and does not allow the transfer of water.

Groundwater modeling has demonstrated that the deep abandoned quarries penetrate a highly conductive ground layer. This penetration coupled with potential increased hydraulic pressure (if the lakes were connected to the wetlands) could promote deep seepage popping up in adjacent lands. The levee berm has a design crest elevation of 9.0 ft-NGVD or 3-feet above assumed average existing grade of 6.0 ft-NGVD (or scraped to). The levee is designed for low stages in an emergent vegetation environment that will not experience waves of any practical force. The levee is grassed on both slopes for prevention of typical rainfall runoff erosive-type forces. Earthen slopes are 1 on 4 or 4H:1V slopes.

TABLE A-13: C-11 EMBANKMENT AND LEVEE DESIGN PARAMETERS

Embankment and Levee	Length	Side Slope	Top Width	Average Ground	Top of Levee	Levee Height
	feet	1V on ?H	feet	ft-NGVD	ft-NGVD	feet
D-511	32,245	3.0	14	6.00	14.50	8.5
L-511	22,400	3.0	12	6.00	11.00	5.0
L-512	7,550	4.0	12	6.50	9.50	3.0
L-513	1,470	4.0	12	6.00	8.00	2.0
L-514	8,650	4(in) 6(out)	12	6.50	9.50	3.0
L-515	7,460	4.0	12	6.00	9.00	3.0
All Earthen Totals	79,775					

A.5.7 Canals

The C-11 Impoundment includes only seepage canals for non-structural conveyance features. Refer to *Table A-14* for canal geometry and design parameters.

A.5.7.1 Seepage Canals

The Impoundment will include three seepage canals: (1) C-511 around the eastern, northern, and western perimeter of the reservoir, (2) C-512 around the mostly eastern and northern perimeter of Mitigation Area A, and (3) C-513 around the mostly eastern and perimeter of Mitigation Area B.

A.5.7.1.1 C-511 Seepage Canal

The C-511 Seepage canal has two purposes: (1) primary purpose is to intercept seepage from the reservoir to minimize impacts to nearby private

lands' existing levels of service of flood protection and (2) secondary purpose is to convey under emergency conditions breach flow to the C-11 Canal in the unlikely event that a breach should occur. The canal has two stage divide weir structures S-505B and S-505C for control. The canal receives excess seepage collected by the C-512 and C-513 Seepage canals and the Finger Lakes located in Mitigation Area A via the non-gated culvert S-508D under the L-511 Levee.

The southeastern reach of the seepage canal—south of S-505B--is maintained at the control stage of 3.5 ft-NGVD by the S-503 Pump Station (seepage bank). Should the pump station experience failure, the S-505A Weir structure combined with a sluice gate for control, provides gravity discharge into the C-11 Canal to prevent seepage canal impacts. Discharge into the C-11 Canal is managed by return pumping into the reservoir with the S-503 Pump Station (inflow) or by the S-9 or S-9A Pump Stations which function to provide primary and seepage control for the Western C-11 Basin. The control stage north of S-505B at a stage of 6.0-6.5 ft-NGVD is identified to prevent impact to the level of service of flood protection in areas to the east and over drainage of their design water table for wetlands and lakes.

The western reaches of the seepage canal—north of S-505C—is maintained at the control stage of 6.0-6.5 ft-NGVD by S-505C Weir control structure which prevents over-drainage of abutting wetlands and reduces the seepage rate out of the reservoir. The downstream weir structure prevents impacts to the existing Seminole Truck Stop and prevents backflow from elevated C-11 Canal stages during diversion operations of transferring water from the C-11 to the C-9 Impoundment. Excess seepage passively discharged through S-505C structures can either be pumped into WCA 3 by the S-9A Pump Station (seepage) or be return-pumped by the S-503 Pump Station (inflow) with disengagement of the S-381 Obermeyer Gate. Excess seepage may also be discharged passively by the S-505B Weir control structure into the C-511 eastern reach and managed in the same manner as described in the preceding eastern reach paragraph.

A.5.7.1.2 C-512 Seepage Canal

The C-512 Seepage canal intercepts seepage from Mitigation Area A eliminating or reducing negative impacts to nearby private lands' existing levels of service flood protection. The canal also receives excess seepage collected by the C-513 Seepage canals and discharges into the eastern reach of the C-511 Seepage canal.

The seepage canal is maintained at the control stage of 6.0 ft-NGVD and by discharge into the C-511 Seepage canal via the non-gated culvert S-508B

under the L-511 Levee. Excess collected seepage is managed in same manner as the C-511 Seepage canal's eastern reach.

A.5.7.1.3 C-513 Seepage Canal

The C-512 Seepage Canal intercepts seepage from Mitigation Area B eliminating or reducing negative impacts to nearby private lands' existing levels of service flood protection. The seepage canal is maintained at the control stage of 6.0 ft-NGVD and by discharges into the C-512 Seepage Canal via the non-gated culvert S-508A under SW 26th St. Excess collected seepage is managed in same manner as the C-511 Seepage Canal's eastern reach.

TABLE A-14: C-11 SEEPAGE CANAL DESIGN PARAMETERS

Canal and Reach	Length	Bank Side Slope	Bottom Width	Average Ground	Canal Invert
	feet	1V on ?H	feet	ft-NGVD	ft-NGVD
C-511					
Eastern	14,070	2.5	10	6.0	-21.50
Northern	7,910	2.5	70	6.0	-1.50
Western	7,500	2.5	10	6.0	-20.00
Sub-total	29,480				
C-512		2.5		6.0	
Eastern	5,280	2.5	10	6.0	-1.00
Western	2,640	2.5	10	6.0	0.00
Sub-total	7,920				
C-513	1,460	3.0	10	6.00	-1.00
All Canal Totals	38,860				

Assumed Average ground elevations based on LIDAR data

A.5.8 Instrumentation

All controllable structures are equipped for remote operation. Operational SCADA equipment, five groundwater monitoring sites, water quality monitoring sites and geotechnical instrumentation to monitor the operational safety of project features at the impoundment and wetland buffer marsh area have been identified. Associated instrumentation costs have been included in the cost estimate.

TABLE A-15: C-11 OPERATION INSTRUMENTATION

Number	Structure	Capacity (cfs)	Type	Pump Mix or Number of Gates	Water Surface, Gate & Precip Parameters	MOSCAD Type (light, regular)
S-503	Pump Station (inflow bank)	1,050	NC	3x350D,	T,P, (S381H)	R
	(seepage bank)	450	SC	2x220D, 1x100E	H, (S503T)	
S-503A	Gated Culvert	200	WS	1	(S381H, S503T) Gx1	L
S-504	Gated Spillway	1,000	NC	2	(S503T,S9H), Gx2	R
S-504B	Overflow Spillway	2,000	FC	0	0	
S-505A	Weir/Sluice comb	690	SC/FC	0	0	
S-505B	Weir	250	SC	0	0	
S-505C	Weir	750	SC/MA	3	0	
S-506A	Gated Culvert	55	NC/WS	1	T, (S503T), Gx1	L
S-506B	Gated Culvert	75	FC/WS	2, Boards	manual	

Type Legend:
FC = Flood Control
NC = Normal Control
SC = Seepage/Stage Control
WS = Water Supply
MA = Maintain Access

Water Surface Parameters:
H = headwater
T = tailwater
P = Precip
Position Sensors
G = Gate

TABLE A-16: C-11 WATER QUALITY INSTRUMENTATION

Number	Structure	Capacity (cfs)	Type	Pump Size Category	Water Quality Sampling Equipment
S-503	Pump Station-(inflow)	1,050	NC	medium	AS, GB
	(seepage)	450	SC	medium	
S-503A	Gated Culvert	200	WS		
S-504	Gated Spillway	1,000	NC		AS, GB
S-504B	Overflow Spillway	2,000	FC		GE
S-505A	Weir/Sluice comb	250	SC/FC		
S-505B	Weir	250	SC		
S-505C	Weir	750	SC/MA		GB
S-506A	Gated Culverts	55	NC/WS		
S-506B	Culvert	75	FC/WS		

Water Quality Parameters:
AS = Auto-Sampler
GB = Grab, nutrients--bi weekly
GF = Grab, nutrients--normal ops flow
GE = Grab, nutrients--emergency flow

A.5.9 Project Management

A.5.9.1 Project Access

The main access to the C-11 Impoundment is from the southwestern boundary off US 27 just south of the Seminole truck stop located at the intersection of US 27 and the C-11 Canal. Access to project site is gained by driving along the C-11 levee bank road and crossing over the C-511 Seepage Canal via the non-gated S-505D box culvert structure and onward to a fork in the road. At this point, one can continue to the top of the embankment or continue along the levee bank road. Access to the project site can also be gained by driving along SW 45th Street and crossing over the O&M Bridge located near the S-503 Pump Station in the southeastern corner of the Impoundment. Also, personnel will be able to reach the pump station from Griffin Road south of C-11 Canal, by passing over the S-381 structure service bridge.

Public access is made via US27 to SW 26th Street where a public parking area will be constructed near the western finger lake. Access to the embankment will be made via the S-505E Bridge.

A.5.9.2 Clearing and Grubbing

The C-11 Impoundment will require clearing and grubbing of embankment, levee and canal alignments. The reservoir interior will also be cleared of trees and woody vegetation that have the potential to die due to being submerged due to fluctuating water levels. The dead trees and vegetation would then present a safety issue if not removed and left to float. It could also accumulate, and/or become lodged in a control structure, thereby making it inoperable or inefficient. Biodegradable materials can be chipped and spread or stacked and burned. The clearing requirement for the reservoir encompasses about 30% to 50% of the impoundment. Possible reductions to the clearing requirements will be investigated during the design phase. Grubbing will only be performed along the embankment and seepage canal alignments. The cost estimate for clearing was based on using mechanical cutting/bulldozing with burn method

A limited number of infrastructures are located within the reservoir. These structures will require demolition, removal and disposal. Aboveground utilities will be abandoned and removed. Within the reservoir, SW 26th Street may be degraded upon completion or during construction, or may be gapped to allow flow through the levee-like raised roadway.

A.5.9.3 Construction Order

No specific construction order is apparent at this time. It is anticipated that the impoundment features could be constructed concurrently.

A.5.9.4 Disposal

The feasibility level design phase has demonstrated that a material balance can be achieved on-site and that off-site disposal sites are not needed. Excess disposal can be used for partial backfilling of on-site borrow pits to create viable fish refuge habitat.

A.5.9.5 Relocations

A buried fiber optics utility corridor exists on the west side of U.S. 27 along the western edge of the U.S. 27 right-of-way within the 70' project setback from US 27. Care in construction will need to be taken so as not to impact these facilities.

A.5.9.6 Surveying Requirements

A survey scope of work was developed for the C-11 Impoundment design region. Associated surveying costs have been included in the cost estimate.

A.5.9.7 Special Studies

A finer resolution 3-D groundwater and surface water routing model to study operations of the system and confirm groundwater levels has been performed. Preliminary results show that the project configuration as described here in the PIR is effective in preventing significant and adverse impacts on surrounding areas. The report is still being reviewed and may be made available as a supplement in the near future.

The mitigation wetlands, located north and outside of the project area, remain a point of indetermination regarding what is the legal requirement regarding the provision of drainage of excess water. Permits infer the drainage is to the east, remaining outside of the project area. Permits will be reviewed during Intermediate Design.

A.5.10 Hydraulic Data and Supporting Analyses

The C-11 Impoundment project has included a lot of additional design work since the original Final PIR. One major effort completed is the finer resolution 3-D groundwater and surface routing model work. This report is still being reviewed. Because the model simulations will have an impact on final hydraulic data which affects design headwaters and tailwaters, the typical Hydraulic Data Design Sheets for water control structures that were

included in the original Final PIR have been deleted from this section so as not to misrepresent final design stages until the model report has been properly reviewed and accepted. However, the pump station sheets have been edited with best available information and are included in *Section A.5.11* below.

A.5.10.1 Structure Hydraulic Data Sheets

A.5.10.1.1 S-503 Pump Station

Revisions:
19 May 2006 – Resized pump station for interim period without NLBSA
Added seepage pump station as a separate unit, located in same building.
20 May 2005 – Redesign pump mix.
21 July 2000 – Added pump station capacity criteria.
17 July 2000 – Original submission. Received SFWMD pump mix concurrence.

XY Coordinate[1] – 846990 628750

Location: SE corner of C-11 Impoundment, on C-11 Canal and C-511 Seepage Canal.

Purpose/Operational Intent: Inflow Pump Plant with combined Seepage Pump Station

This C-11 Impoundment feature will divert stormwater runoff originating from the Western C-11 Basin away from the S-9 Pump Station when storage availability exists in the C-11 or the C-9 impoundments.

Either of the diesel 350 cfs pumps may be used in maintaining the C-11 Canal reach between S-381 and S-13AW at 4.0 ft-NGVD or below as measured at S-13AW—headwater (stage control).

Seepage Pump Plant includes 3 identical 150 cfs electric pumps which provide continual control of the seepage canal in most cost–effective manner.

Design Condition:

Inflow capacity	1,050 cfs
Seepage Control	450 cfs

Pump Station Capacity Criteria:

The 1,050-cfs pump capacity provided by S-503 was identified by modeling to be appropriate during the interim period until North Lake Belt Storage Area comes online (≈25 years). S-503 at that time may be

redesigned and constructed for full S-9 Pump Station diversion with a capacity of 2,500 cfs.

Seepage pumps for the inflow plant are not included as the Western C-11 Critical Project provides a pump station S-9A for seepage collected in the reach of the C-11 Canal between S-9 and critical project gated spillway S-381 located just west of S-503.

The 3-150 electric seepage pumps together are equal to or greater than the actual calculated seepage rate in case of power outage conditions.

Number of Pumps	6 Pumps
Pump Mix Type and Size	
Inflow Pump Plant	
Diesel Engines	3 @ 350 cfs
Seepage Pump Plant	
Electric Motors	3 @ 150 cfs

Mix Criteria:

- The pump mix was designed to provide medium pump sizes that use typical suction bell intakes versus large pumps with Formed Suction Intakes (FSI).
- The pump station will have six bays; three identical 350 cfs diesel pumps and three identical 150 cfs electric pumps.
- The pump mix allows for intermediate flow values while having duplicate pumps at the station for essential operation and maintenance considerations.

Control	Manned & Remote by SCADA
Design Operating Heads (ft.)	
Normal (2.00 HW to 11.00 TW)	9.00 feet
Maximum (0.00 HW to 11.00 TW)	11.00 feet
Intake Water Surface Elevations	
Maximum Non-Pumping	6.50 ft-NGVD
Maximum Pumping	6.50 ft-NGVD
Start Pumping	3.20 ft-NGVD
Normal Drawdown	2.00 ft-NGVD
Minimum Drawdown	0.00 ft-NGVD
Minimum Non-Pumping	0.00 ft-NGVD
Channel Invert	-15.0 ft-NGVD

Discharge Water Surface Elevations

Maximum Non-Pumping	14.50 ft-NGVD
Maximum Pumping	11.00 ft-NGVD (see note)
Normal Pumping	11.00 ft-NGVD (see note)
Minimum Pumping	3.00 ft-NGVD
Minimum Non-Pumping	3.00 ft-NGVD
Channel Invert	-1.00 ft-NGVD

Notes:
[1] XY coordinates system used is NAD 83, Florida east, state plane
All elevations are in feet, NGVD (National Geodetic Vertical Datum of 1929)
Diesel generator is required for control station operations in cases of power outage.

The design normal and maximum discharge elevations are higher than the current maximum normal pool by 0.70 feet to allow greater storage should impoundment demonstrate less seepage loss than expected with construction and real-time operational monitoring.

Data Compiled from:
S-9 headwater elevation records from 1957 to present day
Selected Plan features

A.5.10.1.2 S-503A Gated Culvert (15AUG11)

S-503A
Gated Box Culverts

Revisions August 2011 - Revision

XY Coord
Location Western side of the S-503 Pump Station discharging into the C-11 Canal just east of the S-381 Obermeyer Gate
Purpose Impoundment's discharge structure east of S-381.

Notes 1. Riprap requirements have not been verified with Geotech.

Design Conditions		
Discharge (CFS)	200	cfs
Design Head	5.2	feet
Headwater Elevation	10.3	ft,NGVD
Tailwater Elevation	3.5	ft,NGVD
Maximum Expected Stages		
Headwater Elevation	14.5	ft,NGVD (out of bank)
Tailwater Elevation	6.5	ft,NGVD
Maximum Simultaneous Head Difference		
Maximum Headwater Elevation	11.6	ft,NGVD
Minimum Tailwater Elevation	1.5	ft,NGVD
Max Head Discharge Condition	10.1	feet
Culvert Data		
Number of Barrels	1	
Barrel Type	Concrete	
Single Culvert Barrel Width	60	inches
Single Culvert Barrel Height	72	inches
Barrel Length	100	feet
Barrel Invert Elevation	-4	ft, NGVD
Type of Control	Slide gate	
Canal Section		
Impoundment		
Side Slopes (Vert. on Hor.) 1 on	3	
Upstream Bottom Width	Pool	
Upstream Bottom Elevation	6	ft,NGVD
Pump Station Approach Channel		
Side Slopes (Vert. on Hor.) 1 on	Vertical	
Downstream Bottom Width	Lateral	
Downstream Bottom Elevation	-10.5	ft,NGVD
Riprap Requirements		
Design Flow Velocity	6.67	fps
Design Riprap Velocity	6.67	fps
Downstream Length	48	feet
Downstream Armored Area	2500	ft^2
Downstream Armored Area (Import Rock)	2500	ft^2
Downstream Armored Area (Local Rock)	0	ft^2
Protection Elevation	14.5	ft,NGVD

A.5.10.1.3
A.5.10.1.4 S-504 Gated Culverts (15AUG11)

S-504
Gated Box Culverts

Revisions August 2011 - Revision

XY Coord
Location C-11 Canal north bank just east of the southwest corner.
Purpose Impoundment's main discharge structure.

Notes 1. Riprap requirements have not been verified with Geotech.

Design Conditions		
Discharge (CFS)	1000	cfs
Headwater Elevation	10.3	ft,NGVD
Tailwater Elevation	3.5	ft,NGVD
Maximum Expected Stages		
Headwater Elevation	14.5	ft,NGVD (out of bank)
Tailwater Elevation	6.5	ft,NGVD
Maximum Simultaneous Head Difference		
Maximum Headwater Elevation	11.6	ft,NGVD
Minimum Tailwater Elevation	2.0	ft,NGVD
Max Head Discharge Condition	9.6	feet
Culvert Data		
Number of Barrels	2	
Barrel Type	Concrete	
Single Culvert Barrel Width	96	inches
Single Culvert Barrel Height	96	inches
Barrel Length	180	feet
Barrel Invert Elevation	-8.00	ft, NGVD
Type of Control	Slide gate	
Canal Section		
Impoundment		
Side Slopes (Vert. on Hor.) 1 on	3	
Bottom Width	Pool	
Bottom Elevation	6	ft,NGVD
C-11 Canal		
Side Slopes (Vert. on Hor.) 1 on	3	
Bottom Width	Lateral	
Bottom Elevation	-8.8	ft,NGVD
Riprap Requirements		
Design Flow Velocity	7.81	fps
Design Riprap Velocity	7.81	fps
Downstream Length	64	feet
Downstream Armored Area	2500	ft^2
Downstream Armored Area (Import Rock)	2500	ft^2
Downstream Armored Area (Local Rock)	0	ft^2
Protection Elevation	14.5	ft,NGVD

A.5.10.1.5 S-504B Service and Auxiliary Overflow Spillway (15AUG11)

S-504B
Broad Crested Weir

Revisions August 2011 - Revision

XY Coord
Location Southern embankment of the Impoundment discharging into the C-11 Canal.
Purpose Emergency overflow into the C-11 Canal.

Notes 1. Riprap requirements have not been verified with Geotech.

Design Conditions

Service Spillway		
Discharge (CFS)	31	cfs
Headwater Elevation	11.60	ft,NGVD
Tailwater Elevation	4.00	ft,NGVD
Auxiliary Spillway		
Discharge (CFS)	322	cfs
Headwater Elevation	12.30	ft,NGVD
Tailwater Elevation	4.00	ft,NGVD

Maximum Expected Stages

Headwater Elevation	14.50	ft,NGVD
Tailwater Elevation	6.50	ft,NGVD

Maximum Simultaneous Head Difference

Maximum Headwater Elevation	11.60	ft,NGVD
Minimum Tailwater Elevation	2.00	ft,NGVD
Max Head Discharge Condition	9.60	feet

Weir Design Data

Service Weir		
Weir Type	Broad Crested	
Crest Elevation	10.3	ft,NGVD
Weir Breadth	20.00	feet
Crest Length	8.00	feet
Weir Control	No Control	
Auxiliary Weir		
Weir Type	Broad Crested	
Crest Elevation	11.6	ft,NGVD
Weir Breadth	1.00	feet
Crest Length	150.00	feet
Weir Control	No Control	

Canal Section

Impoundment		
Side Slopes (Vert. on Hor.) 1 on	3	
Bottom Width	Pool	
Bottom Elevation	6.00	ft,NGVD
C-11 Canal		
Side Slopes (Vert. on Hor.) 1 on	3	
Bottom Width	Lateral	
Bottom Elevation	-15.00	ft,NGVD

Riprap Requirements

Design Flow Velocity	3.00	fps
Design Riprap Velocity	3.00	fps
Downstream Length	45.00	feet
Downstream Armored Area	4750.00	ft^2
Downstream Armored Area (Imported Rock)	1250.00	ft^2
Downstream Armored Area (Local Rock)	3500.00	ft^2

A.5.10.1.6 S-505A Fixed Weir and Gated Culvert (15AUG11)

S-505A
Weir with Gated Box Culverts

Revisions August 2011 - Revision

XY Coord
Location At the confluence of the C-511 and C-11 Canlas southest of the Impoundment.
Purpose Maintain optimal seepage canal stage and discharge excess seepage into C-11 in the event power failure at the seepage pump bank.

Notes 1. Riprap requirements have not been verified with Geotech.

Design Conditions	
Gated Box Culverts	
Discharge (CFS)	470.00 cfs
Design Head	0.75 feet
Headwater Elevation	6.50 ft,NGVD
Tailwater Elevation	3.50 ft,NGVD
Weir	
Discharge (CFS)	220.00 cfs
Design Head	0.75 feet
Headwater Elevation	6.50 ft,NGVD
Tailwater Elevation	3.50 ft,NGVD
Maximum Expected Stages	
Headwater Elevation	7.00 ft,NGVD
Tailwater Elevation	6.50 ft,NGVD
Maximum Simultaneous Head Difference	
Maximum Headwater Elevation	7.00 ft,NGVD
Minimum Tailwater Elevation	1.50 ft,NGVD
Max Head Discharge Condition	5.50 feet
Culvert Data	
Number of Barrels	1
Barrel Type	Concrete
Single Culvert Barrel Width	96.00 inches
Single Culvert Barrel Height	96.00 inches
Barrel Length	6.67 feet
Barrel Invert Elevation	-6.50 ft, NGVD
Type of Control	Sluice Gate
Weir Design Data	
Weir Type	Broad Crested
Crest Elevation	5.00 ft,NGVD
Weir Breadth	2.00 feet
Crest Length	130.00 feet
Weir Control	None
Canal Section	
C-511 Canal	
Side Slopes (Vert. on Hor.) 1 on	3
Bottom Width	Lateral
Bottom Elevation	-20.00 ft,NGVD
C-11 Canal	
Side Slopes (Vert. on Hor.) 1 on	3
Bottom Width	Lateral
Bottom Elevation	-15.00 ft,NGVD
Riprap Requirements	
Design Flow Velocity	7.34 fps
Design Riprap Velocity	7.34 fps
Downstream Length	64.00 feet
Downstream Armored Area	2000.00 ft^2
Downstream Armored Area (Imported Rock)	2000.00 ft^2
Downstream Armored Area (Local Rock)	0.00 ft^2
Protection Elevation	14.50 ft,NGVD

A.5.10.1.7 S-505B Fixed Weir (15AUG11)

S-505B
Non-Gated Broad Crested Weir

Revisions August 2011 - Revision

XY Coord

Location In the eastern reach of C-511, just east of Weston's Winmill Lakes Mitigation Area, and just norht of the Buddhist Retreat.

Purpose Maintain upstream canal stage of 6.0-6.5 NGVD in the northern and western C-511 reaches.

Notes 1. Riprap requirements have not been verified with Geotech.

Design Conditions

Weir	
Notch Discharge	< 25 cfs (normal conditions)
Discharge	250.00 cfs (> 50% PMP)
Design Head	0.80 feet
Headwater Elevation	6.50 ft,NGVD
Tailwater Elevation	3.50 ft,NGVD
Maximum Expected Stages	
Headwater Elevation	7.00 ft,NGVD
Tailwater Elevation	6.50 ft,NGVD
Maximum Simultaneous Head Difference	
Maximum Headwater Elevation	7.00 ft,NGVD
Minimum Tailwater Elevation	1.50 ft,NGVD
Max Head Discharge Condition	5.50 feet
Weir Design Data	
Weir Type	Broad Crested
Crest Elevation	6.00 ft,NGVD
Weir Breadth	2.00 feet
Crest Length	150.00 feet
Notch Crest Elevation	5.30 ft, NGVD
Notch Crest Length	10.00 feet
Minimum Tieback Elevation	6.50 ft, NGVD
Weir Control	None
Canal Section	
C-511 Canal	
Side Slopes (Vert. on Hor.) 1 on	3
Bottom Width	Lateral
Bottom Elevation	-20.00 ft,NGVD
C-511 Canal	
Side Slopes (Vert. on Hor.) 1 on	3
Bottom Width	Lateral
Bottom Elevation	-20.00 ft,NGVD
Riprap Requirements	
Design Flow Velocity	2.18 fps
Design Riprap Velocity	2.18 fps
Downstream Length	22.00 feet
Downstream Armored Area	1000.00 ft^2
Downstream Armored Area (Imported Rock)	250.00 ft^2

A.5.10.1.8 S-505C Fixed Weir (15AUG11)

S-505C
Non-Gated Broad Crested Weir

Revisions August 2011 - Revision

XY Coord

Location In the southwest corner of the Impoundment in the C-511 Canal, just north of the adjacent Seminole Truckstop.

Purpose Maintain upstream canal stage of 6.0-6.5 NGVD in the northern and western C-511 reaches.

Notes 1. Riprap requirements have not been verified with Geotech.

Design Conditions

Weir	
Notch Discharge	74.00 cfs (normal conditions)
Discharge	750.00 cfs (> 50% PMP)
Design Head	1.25 feet
Headwater Elevation	6.50 ft,NGVD
Tailwater Elevation	3.50 ft,NGVD
Maximum Expected Stages	
Headwater Elevation	7.00 ft,NGVD
Tailwater Elevation	6.50 ft,NGVD
Maximum Simultaneous Head Difference	
Maximum Headwater Elevation	7.00 ft,NGVD
Minimum Tailwater Elevation	1.50 ft,NGVD
Max Head Discharge Condition	5.50 feet
Weir Design Data	
Weir Type	Broad Crested
Crest Elevation	6.00 ft,NGVD
Weir Breadth	2.00 feet
Crest Length	154.00 feet
Notch Crest Elevation	5.30 ft, NGVD
Notch Crest Length	10.00 feet
Minimum Tieback Elevation	6.00 ft, NGVD
Weir Control	None
Canal Section	
C-511 Canal	
Side Slopes (Vert. on Hor.) 1 on	3
Bottom Width	Lateral
Bottom Elevation	-1.00 ft,NGVD
C-511 Canal	
Side Slopes (Vert. on Hor.) 1 on	3
Bottom Width	Lateral
Bottom Elevation	-15.00 ft,NGVD
Riprap Requirements	
Design Flow Velocity	4.09 fps
Design Riprap Velocity	4.09 fps
Downstream Length	38.00 feet
Downstream Armored Area	2000.00 ft^2
Downstream Armored Area (Imported Rock)	400.00 ft^2
Downstream Armored Area (Local Rock)	1600.00 ft^2

A.5.10.1.9 S-505D Gated Culverts (15AUG11)

S-505D
Gated Box Culverts

Revisions 1 August 2011 - Revision

XY Coord
Location Near the southwestern corner of the Impoundment
Purpose Provides conveyance of seepage collected and spilled over the S-505C weir.

Notes 1. Riprap requirements have not been verified with Geotech.

Design Conditions		
Discharge (CFS)	750	cfs
Headwater Elevation	3.5	ft,NGVD
Tailwater Elevation	3.5	ft,NGVD
Maximum Expected Stages		
Headwater Elevation	6.5	ft,NGVD
Tailwater Elevation	6.5	ft,NGVD
Maximum Simultaneous Head Difference		
Maximum Headwater Elevation	6.5	ft,NGVD
Minimum Tailwater Elevation	2.0	ft,NGVD
Max Head Discharge Condition	4.5	feet
Culvert Data		
Number of Barrels	1	
Barrel Type	Concrete	
Single Culvert Barrel Width	120	inches
Single Culvert Barrel Height	120	inches
Barrel Length	65	feet
Barrel Invert Elevation	-6.5	ft, NGVD
Type of Control	None	
Canal Section		
C-511 Canal		
Side Slopes (Vert. on Hor.) 1 on	3	
Bottom Width	Lateral	
Bottom Elevation	6	ft,NGVD
C-11 Canal		
Side Slopes (Vert. on Hor.) 1 on	3	
Bottom Width	Lateral	
Bottom Elevation	-8.8	ft,NGVD
Riprap Requirements		
Design Flow Velocity	7.5	fps
Design Riprap Velocity	7.5	fps
Downstream Length	50	feet
Downstream Armored Area	2500	ft^2
Downstream Armored Area (Imported Rock)	2500	ft^2
Downstream Armored Area (Local Rock)	0	ft^2
Protection Elevation	14.5	ft,NGVD

A.5.10.1.10 S-506A Gated Culverts (15AUG11)

S-506A
Gated Round Culverts

Revisions August 2011 - Revision

XY Coord
Location On the northern reach of the D-511 embankment, west of the Finger Lakes
Purpose To pass water from the impoundment to northwestern Mitigation Area A

Notes
1. This is a "sag" culvert, which travels below C-511.
2. Riprap requirements have not been verified with Geotech.

Design Conditions	
Discharge (CFS)	55 cfs
Design Head	3.25 feet
Headwater Elevation	10.30 ft,NGVD
Tailwater Elevation	7.50 ft,NGVD
Maximum Expected Stages	
Headwater Elevation	14.50 ft,NGVD
Tailwater Elevation	8.00 ft,NGVD
Maximum Simultaneous Head Difference	
Maximum Headwater Elevation	11.60 ft,NGVD
Minimum Tailwater Elevation	6.50 ft,NGVD
Culvert Data	
Number of Barrels	1
Barrel Type	Concrete
Barrel Diameter	4.0 feet
Barrel Length	340.0 feet
Barrel Invert (Inlet, Outlet, Sag)	
Inlet and Outlet	-0.50 ft, NGVD
Sag	-6.00 ft, NGVD
Miter Cut	4 @ 45 deg
Type of Control	Slide Gate
Canal Section	
Impoundment	
Side Slopes (Vert. on Hor.) 1 on	3
Upstream Bottom Width	Pool
Upstream Bottom Elevation	6.00 ft,NGVD
Mitigation Area A	
Side Slopes (Vert. on Hor.) 1 on	3
Downstream Bottom Width	Pool
Downstream Bottom Elevation	7.00 ft,NGVD
Riprap Requirements	
Design Flow Velocity	4.38 fps
Design Riprap Velocity	4.38 fps
Downstream Length	32.00 feet
Downstream Armored Area	1300.00 ft^2
Downstream Armored Area (Imported Rock)	200.00 ft^2
Downstream Armored Area (Local Rock)	1100.00 ft^2

A.5.10.1.11 S-506B Flap-Gated Culverts (15AUG11)

S-506B
Gated Round Culverts

Revisions August 2011 - Revision

XY Coord
Location On the bank of the C-511 Canal, east of the Finger Lakes
Purpose To pass water from Mitigation A to C-511

Notes 1. Riprap requirements have not been verified with Geotech.

Design Conditions

Discharge (CFS)	75 cfs
Design Head	3.00 feet
Headwater Elevation	10.30 ft,NGVD
Tailwater Elevation	7.50 ft,NGVD

Maximum Expected Stages

Headwater Elevation	14.50 ft,NGVD
Tailwater Elevation	9.50 ft,NGVD

Maximum Simultaneous Head Difference

Maximum Headwater Elevation	11.60 ft,NGVD
Minimum Tailwater Elevation	6.50 ft,NGVD

Culvert Data

Number of Barrels	2
Barrel Type	Concrete
Barrel Diameter	5.0 feet
Barrel Length	60.0 feet
Barrel Invert Elevation	-2.50 ft,NGVD
Type of Control	Slide Gate

Canal Section

Impoundment	
Side Slopes (Vert. on Hor.) 1 on	3
Upstream Bottom Width	Pool
Upstream Bottom Elevation	6.00 ft,NGVD
Mitigation Area A	
Side Slopes (Vert. on Hor.) 1 on	3
Downstream Bottom Width	Pool
Downstream Bottom Elevation	6.50 ft,NGVD

Riprap Requirements

Design Flow Velocity	1.91 fps
Design Riprap Velocity	1.91 fps
Downstream Length	30.00 feet
Downstream Armored Area	750.00 ft^2
Downstream Armored Area (Imported Rock)	250.00 ft^2
Downstream Armored Area (Local Rock)	500.00 ft^2

A.5.10.1.12 S-507A-F Non-Gated Culverts (15AUG11)

S-507A-F
Gated Round Culverts

Revisions August 2011 - Revision

XY Coord
Location Under SW 26th Street in Mitigation A
Purpose To hydraulically connect Mitigation Area A on either side of SW 26th Street

Notes 1. Riprap requirements have not been verified with Geotech.

Design Conditions

Discharge (CFS)	Min cfs
Headwater Elevation	7.50 ft,NGVD
Tailwater Elevation	7.50 ft,NGVD

Maximum Expected Stages

Headwater Elevation	9.50 ft,NGVD
Tailwater Elevation	9.50 ft,NGVD

Maximum Simultaneous Head Difference < 0.25 feet

Culvert Data

Number of Barrels	6
Barrel Type	Concrete
Barrel Diameter	4.0 feet
Barrel Length	72.0 feet
Barrel Invert Elevation	0.50 ft,NGVD
Type of Control	None

Canal Section

Mitigation Area A

Side Slopes (Vert. on Hor.) 1 on	3
Downstream Bottom Width	Pool
Downstream Bottom Elevation	6.50 ft,NGVD

Riprap Requirements

Design Flow Velocity	0.08 fps
Design Riprap Velocity	0.08 fps
Downstream Length	0.00 feet
Downstream Armored Area	0.00 ft^2
Downstream Armored Area (Local Rock)	0.00 ft^2

A.5.10.1.13 S-508A Non-Gated Culverts (15AUG11)

S-508A
Gated Round Culverts

Revisions August 2011 - Revision

XY Coord
Location Confluence of C-512 and C513
Purpose Conveys seepage from C-513 to C-512 under SW 26th Street

Notes 1. Riprap requirements have not been verified with Geotech.

Design Conditions

Discharge (CFS)	Min cfs
Headwater Elevation	6.00 ft,NGVD
Tailwater Elevation	6.00 ft,NGVD

Maximum Expected Stages

Headwater Elevation	7.00 ft,NGVD
Tailwater Elevation	7.00 ft,NGVD

Maximum Simultaneous Head Difference

Maximum Headwater Elevation	7.00 ft,NGVD
Minimum Tailwater Elevation	3.50 ft,NGVD

Culvert Data

Number of Barrels	1
Barrel Type	Concrete
Barrel Diameter	4.0 feet
Barrel Length	225.0 feet
Barrel Invert Elevation	-1.00 ft,NGVD
Type of Control	None

Canal Section

C-513	
Side Slopes (Vert. on Hor.) 1 on	2.5
Upstream Bottom Width	10.00 ft,NGVD
Upstream Bottom Elevation	-1.00 ft,NGVD
C-512	
Side Slopes (Vert. on Hor.) 1 on	2.5
Downstream Bottom Width	10.00 ft,NGVD
Downstream Bottom Elevation	0.00 ft,NGVD

Riprap Requirements

Design Flow Velocity	0.51 fps
Design Riprap Velocity	0.51 fps
Downstream Length	28.00 feet
Downstream Armored Area	150.00 ft^2
Downstream Armored Area (Imported Rock)	0.00 ft^2
Downstream Armored Area (Local Rock)	150.00 ft^2

A.5.10.1.14 S-508B Non-Gated Culverts (15AUG11)

S-508B
Gated Round Culverts

Revisions August 2011 - Revision

XY Coord
Location Between the C-512 and C-511 Canal.
Purpose To convey seepage collected in the C-512 Canal to the C-511 Canal.

Notes 1. Riprap requirements have not been verified with Geotech.

Design Conditions

Discharge (CFS)	358 cfs
Headwater Elevation	6.00 ft,NGVD
Tailwater Elevation	6.00 ft,NGVD

Maximum Expected Stages

Headwater Elevation	7.00 ft,NGVD
Tailwater Elevation	7.00 ft,NGVD

Maximum Simultaneous Head Difference

Maximum Headwater Elevation	7.00 ft,NGVD
Minimum Tailwater Elevation	3.50 ft,NGVD

Culvert Data

Number of Barrels	3
Barrel Type	Concrete
Barrel Diameter	6.0 feet
Barrel Length	272.0 feet
Barrel Invert Elevation	-3.00 ft,NGVD
Type of Control	None

Canal Section

C-512	
Side Slopes (Vert. on Hor.) 1 on	2.5
Upstream Bottom Width	10.00 ft,NGVD
Upstream Bottom Elevation	0.00 ft,NGVD
C-511	
Side Slopes (Vert. on Hor.) 1 on	2.5
Downstream Bottom Width	Lateral
Downstream Bottom Elevation	-1.50 ft,NGVD

Riprap Requirements

Design Flow Velocity	6.08 fps
Design Riprap Velocity	6.08 fps
Downstream Length	48.00 feet
Downstream Armored Area	2500.00 ft^2
Downstream Armored Area (Local Rock)	2500.00 ft^2
Downstream Armored Area (Local Rock)	0.00 ft^2

A.5.10.1.15 S-508C Non-Gated Culverts (15AUG11)

S-508C
Non-Gated Round Culverts

Revisions August 2011 - Revision

XY Coord
Location Between the Finger Lakes in Mitigation Area A
Purpose To convey seepage collected in the western Finger Lake to the eastern Finger Lake.

Notes 1. Riprap requirements have not been verified with Geotech.

Design Conditions

Discharge (CFS)	Min cfs
Headwater Elevation	6.00 ft,NGVD
Tailwater Elevation	6.00 ft,NGVD

Maximum Expected Stages

Headwater Elevation	8.50 ft,NGVD
Tailwater Elevation	8.50 ft,NGVD

Maximum Simultaneous Head Difference < 0.25 feet

Culvert Data

Number of Barrels	1
Barrel Type	Concrete
Barrel Diameter	4.0 feet
Barrel Length	225.0 feet
Barrel Invert Elevation	-3.00 ft,NGVD
Type of Control	None

Canal Section

Western Finger Lake	
Side Slopes (Vert. on Hor.) 1 on	Vertical
Upstream Bottom Width	Pool
Upstream Bottom Elevation	Pool
Eastern Finger Lake	
Side Slopes (Vert. on Hor.) 1 on	Vertical
Downstream Bottom Width	Pool
Downstream Bottom Elevation	Pool

Riprap Requirements

Design Flow Velocity	0.51 fps
Design Riprap Velocity	0.51 fps
Armored Area	150.00 ft^2
Downstream Armored Area (Imported Rock)	0.00 ft^2
Downstream Armored Area (Local Rock)	150.00 ft^2

A.5.10.1.16 S-508D Non-Gated Culverts (15AUG11)

S-508D
Non-Gated Round Culverts

Revisions August 2011 - Revision

XY Coord
Location Connects the eastern Finger Lake to C-511 Canal.
Purpose To convey seepage collected in the Finger Lakes to C-511 Canal.

Notes 1. Riprap requirements have not been verified with Geotech.

Design Conditions	
Discharge (CFS)	Min cfs
Headwater Elevation	6.00 ft,NGVD
Tailwater Elevation	6.00 ft,NGVD
Maximum Expected Stages	
Headwater Elevation	8.50 ft,NGVD
Tailwater Elevation	7.00 ft,NGVD
Maximum Simultaneous Head Difference	< 0.25 feet
Culvert Data	
Number of Barrels	1
Barrel Type	Concrete
Barrel Diameter	4.0 feet
Barrel Length	136.0 feet
Barrel Invert Elevation	-1.00 ft,NGVD
Type of Control	None
Canal Section	
Eastern Finger Lake	
Side Slopes (Vert. on Hor.) 1 on	Vertical
Upstream Bottom Width	Pool
Upstream Bottom Elevation	Pool
C-511	
Side Slopes (Vert. on Hor.) 1 on	2.5
Downstream Bottom Width	Lateral
Downstream Bottom Elevation	-1.50 ft,NGVD
Riprap Requirements	
Design Flow Velocity	0.51 fps
Design Riprap Velocity	0.51 fps
Downstream Length	28.00 feet
Downstream Armored Area	300.00 ft^2
Downstream Armored Area (Imported Rock)	0.00 ft^2
Downstream Armored Area (Local Rock)	300.00 ft^2

A.5.10.2 Canal Hydraulic Data Sheets

C-511(N-W)
Max Capacity = 509cfs

HW Station =	6209	feet
TW Station =	0	feet
Length =	6209	feet
Average Nat Grd =	6	ft, NGVD
Headwater El=	5.5	ft, NGVD
Tailwater El=	5.25	ft, NGVD
Average WSEl =	5.375	ft, NGVD
Delta H =	0.25	feet
E.G. Slope =	0	
Slope =	0.000040	
Slope ^0.5 =	0.0063454	
Left Side Slope 1 on =	2.5	
Right Side Slope 1 on =	2.5	
Trial Depth =	6.875	ft
Trial Bottom Width	70	

Water Depth	Conveyence for Manning's n n = 0.03	n = 0.035	n = 0.04	Bottom Elev ft,NGVD	Ground Topwidth feet	WS Topwidth feet	Area Sq ft	Wp feet	R	AR^2/3
6.13	485	416	364	-0.75	103.8	100.6	522.5	103.0	5.07	1542.9
6.38	520	446	390	-1.00	105.0	101.9	547.9	104.3	5.25	1655.1
6.63	557	477	417	-1.25	106.3	103.1	573.5	105.7	5.43	1771.0
6.88	594	509	446	-1.50	107.5	104.4	599.4	107.0	5.60	1890.4
7.13	633	542	475	-1.75	108.8	105.6	625.7	108.4	5.77	2013.6
7.38	673	577	505	-2.00	110.0	106.9	652.2	109.7	5.94	2140.4
8.38	844	723	633	-3.00	115.0	111.9	761.6	115.1	6.62	2684.3

FIGURE A-3: C-511 - REACH 5-6-7

C-511(W)
Max Capacity = 2,426cfs

HW Station =	7507	feet
TW Station =	0	feet
Length =	7507	feet
Average Nat Grd =	6	ft, NGVD
Headwater El=	5.25	ft, NGVD
Tailwater El=	5	ft, NGVD
Average WSEl =	5.125	ft, NGVD
Delta H =	0.25	feet
E.G. Slope =	0	
Slope =	0.000033	
Slope ^0.5 =	0.00577081	
Left Side Slope 1 on =	2.5	
Right Side Slope 1 on =	2.5	
Trial Depth =	25.125	ft
Trial Bottom Width	10	

Water Depth	Conveyence for Manning's n n = 0.03	n = 0.035	n = 0.04	Bottom Elev ft,NGVD	Ground Topwidth feet	WS Topwidth feet	Area Sq ft	Wp feet	R	AR^2/3
24.38	2,625	2,250	1,969	-19.25	196.3	131.9	1,729.1	141.3	12.24	9183.6
24.63	2,692	2,308	2,019	-19.50	197.5	133.1	1,762.2	142.6	12.36	9419.0
24.88	2,761	2,366	2,071	-19.75	198.8	134.4	1,795.7	144.0	12.47	9658.0
25.13	2,830	2,426	2,123	-20.00	200.0	135.6	1,829.4	145.3	12.59	9900.8
25.38	2,901	2,486	2,175	-20.25	201.3	136.9	1,863.5	146.6	12.71	10147.4
25.63	2,972	2,548	2,229	-20.50	202.5	138.1	1,897.9	148.0	12.82	10397.7
26.63	3,269	2,802	2,452	-21.50	207.5	143.1	2,038.5	153.4	13.29	11437.5

FIGURE A-4: C-511 - REACH 7-8

C-511(N-E)
Max Capacity = 347cfs

HW Station =	1634	feet
TW Station =	0	feet
Length =	1634	feet
Average Nat Grd =	6	ft, NGVD
Headwater El=	4.5	ft, NGVD
Tailwater El=	4.45	ft, NGVD
Average WSEl =	4.475	ft, NGVD
Delta H =	0.05	feet
E.G. Slope =	0	
Slope =	0.000031	
Slope ^0.5 =	0.005532	
Left Side Slope 1 on =	2.5	
Right Side Slope 1 on =	2.5	
Trial Depth =	5.975	ft
Trial Bottom Width	70	

Water Depth	Conveyence for Manning's n n = 0.03	n = 0.035	n = 0.04	Bottom Elev ft,NGVD	Ground Topwidth feet	WS Topwidth feet	Area Sq ft	Wp feet	R	AR^2/3
5.23	320	275	240	-0.75	103.8	96.1	434.0	98.1	4.42	1169.3
5.48	348	298	261	-1.00	105.0	97.4	458.2	99.5	4.61	1268.4
5.73	376	322	282	-1.25	106.3	98.6	482.7	100.8	4.79	1371.0
5.98	405	347	304	-1.50	107.5	99.9	507.5	102.2	4.97	1477.4
6.23	435	373	326	-1.75	108.8	101.1	532.6	103.5	5.15	1587.4
6.48	466	400	350	-2.00	110.0	102.4	558.1	104.9	5.32	1701.0
7.48	601	515	450	-3.00	115.0	107.4	662.9	110.3	6.01	2192.1

FIGURE A-5: C-511 - REACH 6-5

C-511(E)
Max Capacity = 2,521cfs

HW Station =	14069	feet
TW Station =	0	feet
Length =	14069	feet
Average Nat Grd =	6	ft, NGVD
Headwater El=	4.45	ft, NGVD
Tailwater El=	4	ft, NGVD
Average WSEl =	4.225	ft, NGVD
Delta H =	0.45	feet
E.G. Slope =	0	
Slope =	0.000032	
Slope ^0.5 =	0.005656	
Left Side Slope 1 on =	2.5	
Right Side Slope 1 on =	2.5	
Trial Depth =	25.725	ft
Trial Bottom Width	10	

Water Depth	Conveyence for Manning's n n = 0.03	n = 0.035	n = 0.04	Bottom Elev ft,NGVD	Ground Topwidth feet	WS Topwidth feet	Area Sq ft	Wp feet	R	AR^2/3
24.98	2,733	2,342	2,049	-20.75	203.8	134.9	1,809.1	144.5	12.52	9754.7
25.23	2,801	2,401	2,101	-21.00	205.0	136.1	1,843.0	145.8	12.64	9999.0
25.48	2,871	2,461	2,153	-21.25	206.3	137.4	1,877.2	147.2	12.75	10247.1
25.73	2,941	2,521	2,206	-21.50	207.5	138.6	1,911.7	148.5	12.87	10499.0
25.98	3,013	2,582	2,260	-21.75	208.8	139.9	1,946.5	149.9	12.99	10754.6
26.23	3,085	2,645	2,314	-22.00	210.0	141.1	1,981.6	151.2	13.10	11014.2
27.23	3,387	2,903	2,540	-23.00	215.0	146.1	2,125.3	156.6	13.57	12091.2

FIGURE A-6: C-511: 5-4-3-2-1

C-512(W)
Max Capacity = 136cfs

HW Station =	2639 feet
TW Station =	0 feet
Length =	2639 feet
Average Nat Grd =	6 ft, NGVD
Headwater El=	5 ft, NGVD
Tailwater El=	4.5 ft, NGVD
Average WSEl =	4.75 ft, NGVD
Delta H =	0.5 feet
E.G. Slope =	0
Slope =	0.000189
Slope ^0.5 =	0.013765
Left Side Slope 1 on =	3
Right Side Slope 1 on =	3
Trial Depth =	4.75 ft
Trial Bottom Width	10

Water Depth	Conveyence for Manning's n n = 0.03	n = 0.035	n = 0.04	Bottom Elev ft,NGVD	Ground Topwidth feet	WS Topwidth feet	Area Sq ft	Wp feet	R	AR^2/3
4.00	110	95	83	0.75	41.5	34.0	88.0	35.3	2.49	161.8
4.25	125	107	94	0.50	43.0	35.5	96.7	36.9	2.62	183.8
4.50	142	121	106	0.25	44.5	37.0	105.8	38.5	2.75	207.6
4.75	159	136	119	0.00	46.0	38.5	115.2	40.0	2.88	233.0
5.00	177	152	133	-0.25	47.5	40.0	125.0	41.6	3.00	260.2
5.25	197	169	148	-0.50	49.0	41.5	135.2	43.2	3.13	289.2
6.25	289	248	217	-1.50	55.0	47.5	179.7	49.5	3.63	424.3

FIGURE A-7: C-511 - REACH B-C

C-512(E)
Max Capacity = 131cfs

HW Station =	5279 feet
TW Station =	0 feet
Length =	5279 feet
Average Nat Grd =	6 ft, NGVD
Headwater El=	5 ft, NGVD
Tailwater El=	4.5 ft, NGVD
Average WSEl =	4.75 ft, NGVD
Delta H =	0.5 feet
E.G. Slope =	0
Slope =	0.000095
Slope ^0.5 =	0.009732
Left Side Slope 1 on =	2.5
Right Side Slope 1 on =	2.5
Trial Depth =	5.75 ft
Trial Bottom Width	10

Water Depth	Conveyence for Manning's n n = 0.03	n = 0.035	n = 0.04	Bottom Elev ft,NGVD	Ground Topwidth feet	WS Topwidth feet	Area Sq ft	Wp feet	R	AR^2/3
5.00	114	98	85	-0.25	47.5	35.0	112.5	36.9	3.05	236.4
5.25	126	108	95	-0.50	49.0	36.3	121.4	38.3	3.17	262.1
5.50	139	120	105	-0.75	50.5	37.5	130.6	39.6	3.30	289.4
5.75	153	131	115	-1.00	52.0	38.8	140.2	41.0	3.42	318.2
6.00	168	144	126	-1.25	53.5	40.0	150.0	42.3	3.55	348.8
6.25	184	157	138	-1.50	55.0	41.3	160.2	43.7	3.67	381.0
7.25	254	218	191	-2.50	61.0	46.3	203.9	49.0	4.16	527.2

FIGURE A-8: C-511 - REACH B-A

C-513
Max Capacity = 100cfs

HW Station =	1462 feet
TW Station =	0 feet
Length =	1462 feet
Average Nat Grd =	6 ft, NGVD
Headwater El=	4.5 ft, NGVD
Tailwater El=	4.4 ft, NGVD
Average WSEl =	4.45 ft, NGVD
Delta H =	0.1 feet
E.G. Slope =	0
Slope =	0.000068
Slope ^0.5 =	0.00827
Left Side Slope 1 on =	2.5
Right Side Slope 1 on =	2.5
Trial Depth =	5.45 ft
Trial Bottom Width	10

Water Depth	Conveyence for Manning's n n = 0.03	n = 0.035	n = 0.04	Bottom Elev ft,NGVD	Ground Topwidth feet	WS Topwidth feet	Area Sq ft	Wp feet	R	AR^2/3
4.70	85	73	64	-0.25	41.3	33.5	102.2	35.3	2.90	207.6
4.95	95	81	71	-0.50	42.5	34.8	110.8	36.7	3.02	231.5
5.20	105	90	79	-0.75	43.8	36.0	119.6	38.0	3.15	256.8
5.45	116	100	87	-1.00	45.0	37.3	128.8	39.3	3.27	283.8
5.70	128	110	96	-1.25	46.3	38.5	138.2	40.7	3.40	312.3
5.95	140	120	105	-1.50	47.5	39.8	148.0	42.0	3.52	342.5
6.95	197	169	148	-2.50	52.5	44.8	190.3	47.4	4.01	480.3

FIGURE A-9: C-511 - REACH A-B

A.5.10.3 Dam Break Analysis

HEC RAS Version 3.1.3 was used to perform the dam break analysis to determine the Hazard Potential Classification of the impoundment. HEC RAS, developed by the U.S. Army Corps of Engineers Hydrologic Engineering Center, is approved by FEMA. Note that the dam break analysis performed for this PIR is a preliminary one. Additional dam break analyses will be performed in accordance with DCM-1 and included at the intermediate plans and specifications phase to verify design hazard classifications. Once a more detailed dam break analysis is performed, flood inundation mapping will be completed to be in accordance with current MMC standards.

A.5.10.3.1 Dam Break Modeling

There are two types of modeled dam-breaks, overtopping and piping. A levee design feature for the C-11 Impoundment is the ability to contain regulatory storm events. Additionally, the impoundments will have an emergency spillway for conditions that are able of passing the Probable Maximum Precipitation (PMP) storm event without damage to embankment integrity. Because of these design features, an overtopping dam break in comparison to

a dam break by piping is considered to be an extremely remote possibility. Therefore, only piping dam breaks were modeled.

Earthen dams do not tend to fail completely, nor do they fail instantaneously. Additionally, the time of failure is usually much longer for piping than overtopping because the upstream embankment face is slowly eroded in the very early phase of the piping. As the erosion proceeds, an increasingly larger opening is formed; this is eventually hastened by caving–in of the top portion of the dam. However, because of risk and uncertainties with any dam break analysis, a conservative assumption that the final breached width and time for breach formation modeled would resemble an overtopped dam with total collapse, was used with this analysis.

A.5.10.3.2 Canals

HEC RAS requires a channel with momentum or mass flow for convergence as part of the numerical solution requirement. From the modeler perspective, an existing or proposed channel typically provides a definitive downstream boundary condition for convergence that is required to solve the implicit finite-difference solution of the Saint-Vanant equations.

A.5.10.3.3 Existing Canals

The C-11 Canal is located to the south of the impoundment. The simulations included an approximate 11 mile reach of the C-11 Canal between the S-9 and S-13 pump stations.

A.5.10.3.4 Impoundment Seepage Canal

C-11 Impoundment design will include a seepage canal that is adjacent to the west, north and east of the impoundment embankment. The west seepage canal is shallow (elevation -1 ft NGVD) with a wide bottom width (112 ft). The east seepage canal is deeper (elevation -21.5 ft NGVD) with a narrow bottom width (10 ft).

A.5.10.3.5 Control Structures Included in Simulations

A.5.10.3.5.1.1 Weirs

There are three fixed crest weirs located along the impoundment seepage canal. The S-505A structure, located at the southwest corner of the impoundment, is an overflow structure from the west seepage canal into the C-11 Canal. The S-505B, located north of the impoundment, is a stage control structure that separates the west and east seepage canals. The S-

505C structure, located at the southeastern corner of the impoundment, is an overflow structure from the east seepage canal into the C-11 Canal.

A.5.10.3.5.1.2 Pump Stations

Existing pump stations, S-9 and S-13, were included in the simulations. The S-9 pumps C-11 canal flows into Water Conservation Area (WCA) 3. S-13 pumps C-11 east basin flows to a tidal section of the North New River against high tides when the gate discharge at S-13 won't allow flow to tide through gravity.

A.5.10.3.5.1.3 Dam Breach Parameters

Breach time of total failure and final breach width are two factors that dominate depth and time of flood inundation calculations. Parameters used to develop model are discussed in the following sections.

A.5.10.3.5.1.4 Breach Width

FLDWAV documentation provided two equations to assist in predicting the final breached width of a levee. One equation is the following:

$$b = 9.5k_0(V_r h_d)^{0.25}$$

where,
b = average breach width (ft)
k_o = 0.7 piping and 1.0 overtopping
V_r = reservoir volume (ac-ft)
h_d = height of water over breach bottom (ft)

This equation gives a standard error estimate of ±94 ft, which represents an average error of ±54% of the $\bar{b}$ data collected by NWS. The second equation is shown as follows:

$0.5hd << \bar{b} << 8hd$ where b = average breach width (ft)
hd = height of water over breach bottom (ft)

The Washington Department of Ecology has the following criteria for calculating breach parameters:

$$W_b = \frac{27V_m - H^2(CZ_b + HZ_b Z_3/3)}{H(C + H Z_3/2)}$$

where,
W_b = Width of breach (ft) at base elevation of breach
C = Crest width of dam (ft)
$V_m = 3.75(V_w H)^{0.77}$
V_m = Volume of material in breach (cubic yards) that is eroded
V_w = Volume of water stored in the reservoir (ac-ft) at the water surface elevation

H = Height of water (ft) over the base elevation of breach

$Z_3 = Z_1 + Z_2$,

Z_1 = Slope (Z_1:1) of interior face and Z_2 = Slope (Z_2:1) of exterior slope
The U.S. Army Corps of Engineers (COE), the Federal Energy Regulatory Commission (FERC), and the National Weather Service (NWS) also have criteria for estimating breach widths (b). These criteria are summarized below:

COE	$b = 1/2$ to $3*h_d$
FERC	$b = h_d \leq b \leq 5*h_d$
NWS	$b = 2*h_d \leq b \leq 5*h_d$

The FLDWAV and WSDE equations yielded the largest breach width values. Estimated breach widths are summarized in the following table.

TABLE A-17: SUMMARY OF BREACH WIDTH CALCULATIONS

Calculated Breach Width (ft)	Criteria
75	FLWAV (piping)
108	FLDWAV (overtopping)
1,860	WSDE
12	COE
20	FERC
20	NWS

The simulations were performed using breach width of 136 ft which represents 25% increase over the estimated value using the FLDWAV equations.

A.5.10.3.5.1.5 Time of Formation

FLDWAV documentation provided one equation to assist in predicting the full breach time of formation. This equation is shown as follows:

$$\tau = 0.59 V_r^{0.47} / h_d^{0.9}$$

where,

τ = time to complete failure (hr)
V_r = reservoir volume (ac-ft)
h_d = height of water over breach bottom

This equation gives a standard error estimate of ±0.9 hrs that represents an average error of ±70% of the τ data collected by NWS.

The WSDE has the following criteria for predicting time for breach development:

$t = 0.028 V_m^{0.36}$
V_m = Volume of material in breach (cubic yards) that is eroded

Estimated times for breach developments are summarized in the following table:

TABLE A-18: TIME FOR BREACH DEVELOPMENT

Time for Breach Development (hrs)	Criteria
8.5	FLWAV
0.9	WSDE
0.5 to 4	COE
0.1 to 1	FERC
0.1 to 0.5	NWS
1.5	Jacksonville District Design

The simulations were performed using a time for breach development of 1.5 hour.

A.5.10.3.5.1.6 Equilibrium with Peak Flow

FLDWAV documentation does provide a means to check the reasonableness of the breach parameters $\bar{b}$ and τ. Calculating the expected peak discharge

(cfs) through the breach using the two equations shown as follows performs this check:

$$Q_p^* = 370(V_r h_d)^{0.5}$$

where,

Q_p^* = peak discharge (cfs)
V_r = reservoir volume (ac-ft)
h_d = height of water over breach bottom

$$Q_p = 3.1\bar{b}\left[C/(\tau + C/\sqrt{h_d})\right]^3$$

where,

Q_p = peak discharge (cfs)
$C = 23.4As/\bar{b}$
As = surface area (acres)
τ = time of failure (hr)
h_d = height of water over breach bottom

The first equation is calculated with impoundment design features. If Qp* >> Qp, then either $\bar{b}$ is too small and/or τ is too large. It is worth noting that for the larger reservoirs, Qp is quite sensitive to $\bar{b}$ and rather insensitive to τ, while for the smaller reservoirs Qp is fairly sensitive to τ and somewhat insensitive to $\bar{b}$. The equation for Q_p* over estimates the peak discharge by an average of 130 percent.

The following table summarizes estimated peak discharges using the equations shown above.

TABLE A-19: ESTIMATED PEAK DISCHARGES

Breach Condition	Q_p* (cfs)	Q_p (cfs)
Sunny Day	47,550 (20,670*)	3,930
Wet Day	110,555 (48,070*)	13,560

* Percent error subtracted from direct calculations.

A.5.10.3.5.1.7 Roughness Coefficient

HEC RAS uses Manning's n for a roughness coefficient to represent energy losses for wave front propagation. Manning's n values range from 0.02 to 0.05 for cultivated areas (Chows Open Channel Hydraulics). Manning's n values range from 0.25 to 0.040 for excavated (rock cut) channels (Chow Open

Channel Hydraulics). For the simulations a Manning's n values of 0.05 and 0.03 were used for the impoundment and canals, respectively.

A.5.10.3.6 Model Results

A.5.10.3.6.1 Impoundment Breach Simulations

Simulations were performed for breaches to the east, north, west and south of the C-11 Impoundment. For the sunny day breach the stage in the impoundment was set at 11.7 ft NGVD. For the PMP breach the stage in the impoundment was set at 15.2 ft NGVD. Additional simulations will be performed and included at the intermediate plans and specifications phase to verify hazard classifications in accordance with DCM-1.

For the east, north, west breaches, estimated flows from the breaches were routed first through the east/west seepage canals and then through the C-11. For the south breach, estimated flows were routed into the C-11 Canal west of the S-381 Structure and then into the east/west seepage canals. The C-11 and east/west seepage canals were hydraulically connected via overflow structures S-505A and S-505B.

A portion of C-11 flows were diverted to WCA 3, the C-11 west and east basins. WCA 3, C-11 west and east basins were modeled as storage areas. WCA 3 and the C-11 east basin were hydraulically connected to the C-11 canal via pump stations S-9 and S-13, respectively. A lateral weir structure was used to hydraulically connect the C-11 Canal to the C-11 west basin.

A.5.10.3.6.2 Impoundment East Breach Simulations

The results of the dam break simulations for the east break are summarized in *Table A-20* and *Table A-21*. *Figure A-10* and *Figure A-11* show maximum water surface profiles for the seepage canal (east and west) and C-11 Canal.

TABLE A-20: EAST BREACH RESULTS – PEAK DISCHARGES FOR SUNNY DAY AND PMP

Breach Condition	Peak Discharge at Breach(cfs)	Peak Discharge into C-11 SE of Impoundment(cfs)	Peak Discharge into C-11 SW of Impoundment(cfs)
Sunny Day	4,898	3,028	1,070
PMP	11,030	6,776	3,230

TABLE A-21: EAST SUNNY DAY BREACH RESULTS – PEAK WATER STAGES AND VELOCITY

Breach Condition	Peak Stage East Seepage Canal (ft NGVD)	Peak Velocity (fps)	Peak Stage West Seepage Canal (ft NGVD)	Peak Velocity (fps)	Peak Stage C-11 Canal (ft NGVD)	Peak Velocity (fps)
Sunny Day	8.4	1.4	8.4	1.4	6.2	3.4
PMP	11.2	2.5	11.2	1.7	12.8	3.7

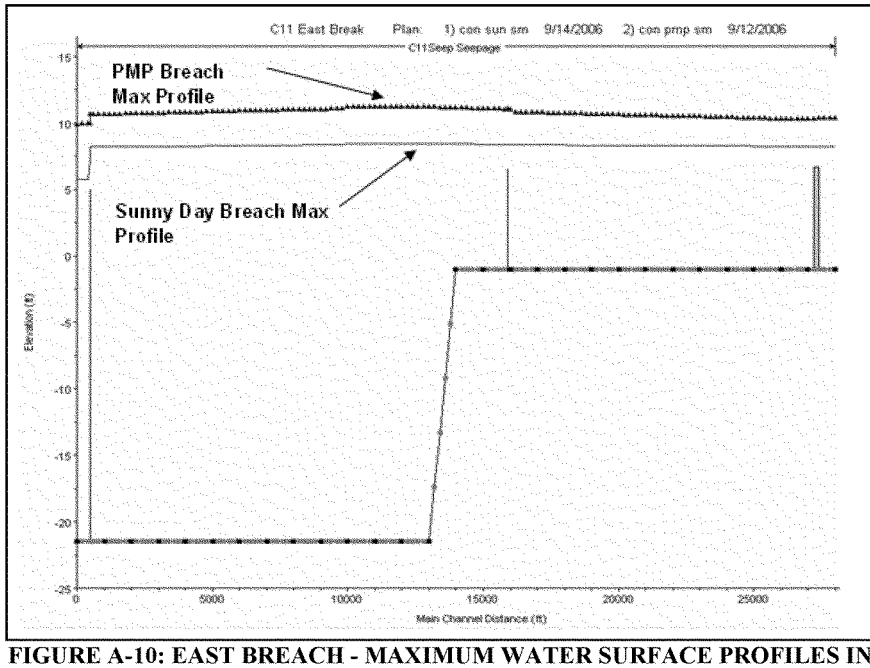

FIGURE A-10: EAST BREACH - MAXIMUM WATER SURFACE PROFILES IN SEEPAGE CANAL FOR SUNNY DAY AND PMP

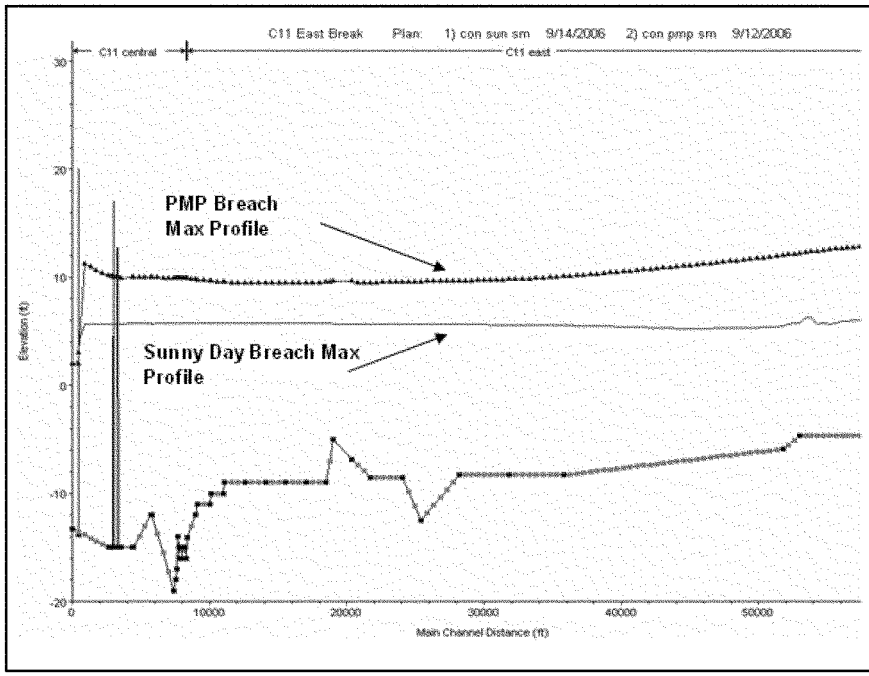

FIGURE A-11: EAST BREACH - MAXIMUM WATER SURFACE PROFILES IN C-11 CANAL FOR SUNNY DAY AND PMP

A.5.10.3.6.3 Impoundment North Breach Simulations

The results of the dam break simulations for the north break are summarized in *Table A-22* and *Table A-23*. *Figure A-12* and *Figure A-13* show maximum water surface profiles for the seepage canal (east and west) and C-11 Canal.

TABLE A-22: NORTH BREACH RESULTS – PEAK DISCHARGES FOR SUNNY DAY AND PMP

Breach Condition	Peak Discharge at Breach (cfs)	Peak Discharge into C-11 SE of Impoundment (cfs)	Peak Discharge into C-11 SW of Impoundment (cfs)
Sunny Day	4,800	2,295	1,905
PMP	10,990	5,620	4,400

TABLE A-23: NORTH BREACH RESULTS – PEAK WATER STAGES, TIME TO MAXIMUM STAGE AND VELOCITY

Breach Condition	Peak Stage East Seepage Canal (ft NGVD)	Peak Velocity (fps)	Peak Stage West Seepage Canal (ft NGVD)	Peak Velocity (fps)	Peak Stage C-11 Canal (ft NGVD)	Peak Velocity (fps)
Sunny Day	7.9	1.1	9.2	1.7	5.9	3.3
PMP	10.8	2.0	11.6	2.7	12.8	3.7

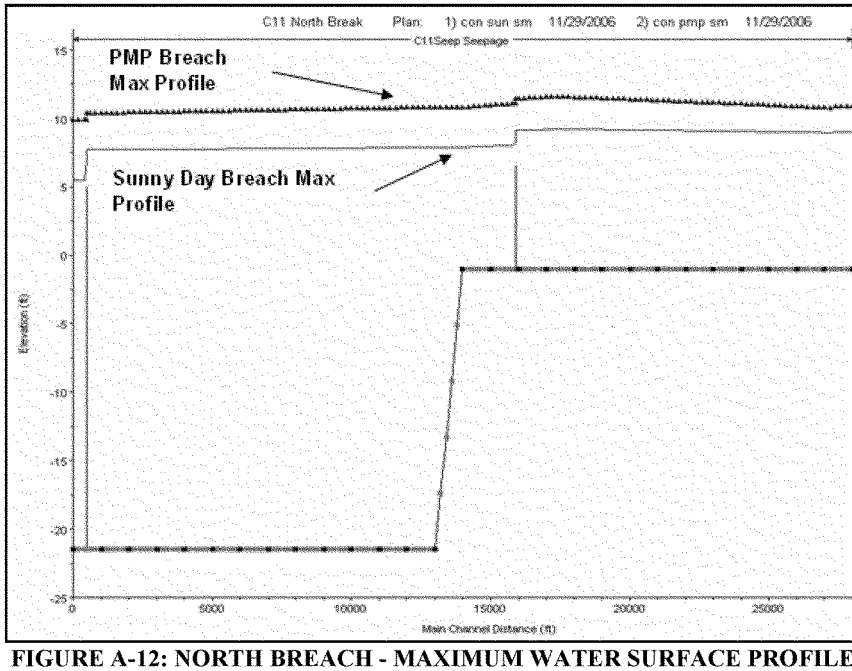

FIGURE A-12: NORTH BREACH - MAXIMUM WATER SURFACE PROFILES IN SEEPAGE CANAL FOR SUNNY DAY AND PMP

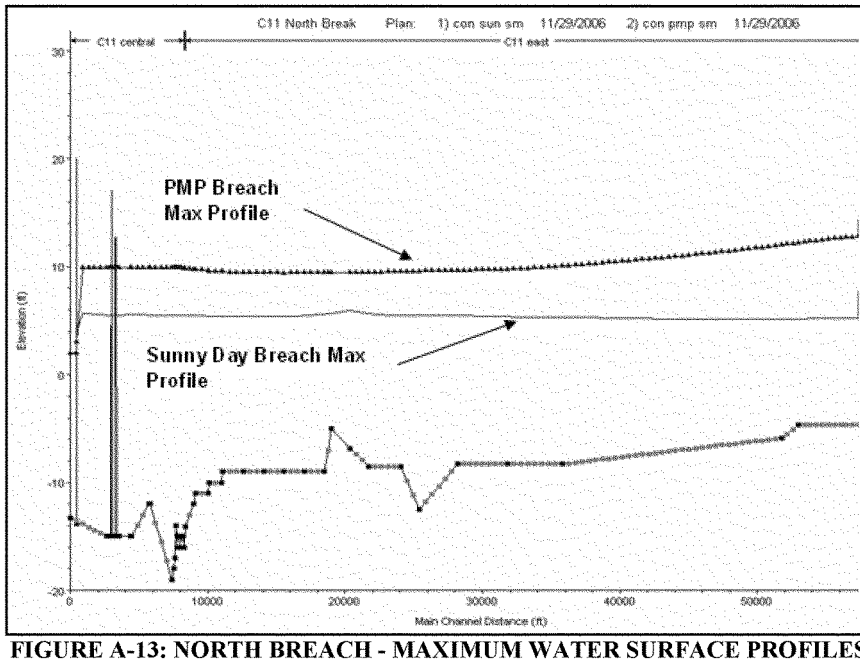

FIGURE A-13: NORTH BREACH - MAXIMUM WATER SURFACE PROFILES IN C-11 CANAL FOR SUNNY DAY AND PMP

A.5.10.3.6.4 Impoundment West Breach Simulations

The results of the dam break simulations for the west break are summarized in *Table A-24* and *Table A-25*. *Figure A-14* and *Figure A-15* show maximum water surface profiles for the seepage canal (east and west) and C-11 Canal.

TABLE A-24: WEST BREACH RESULTS – PEAK DISCHARGES FOR SUNNY DAY AND PMP

Breach Condition	Peak Discharge at Breach (cfs)	Peak Discharge into C-11 SE of Impoundment (cfs)	Peak Discharge into C-11 SW of Impoundment (cfs)
Sunny Day	4,800	2,090	2,045
PMP	10,965	5,012	5,084

TABLE A-25: WEST BREACH RESULTS – PEAK WATER STAGE AND VELOCITY

Breach Condition	Peak Stage East Seepage Canal (ft NGVD)	Peak Velocity (fps)	Peak Stage West Seepage Canal (ft NGVD)	Peak Velocity (fps)	Peak Stage C-11 Canal (ft NGVD)	Peak Velocity (fps)
Sunny Day	7.7	1.1	9.3	1.6	5.6	3.1
PMP	10.6	1.8	11.6	2.5	12.8	3.9

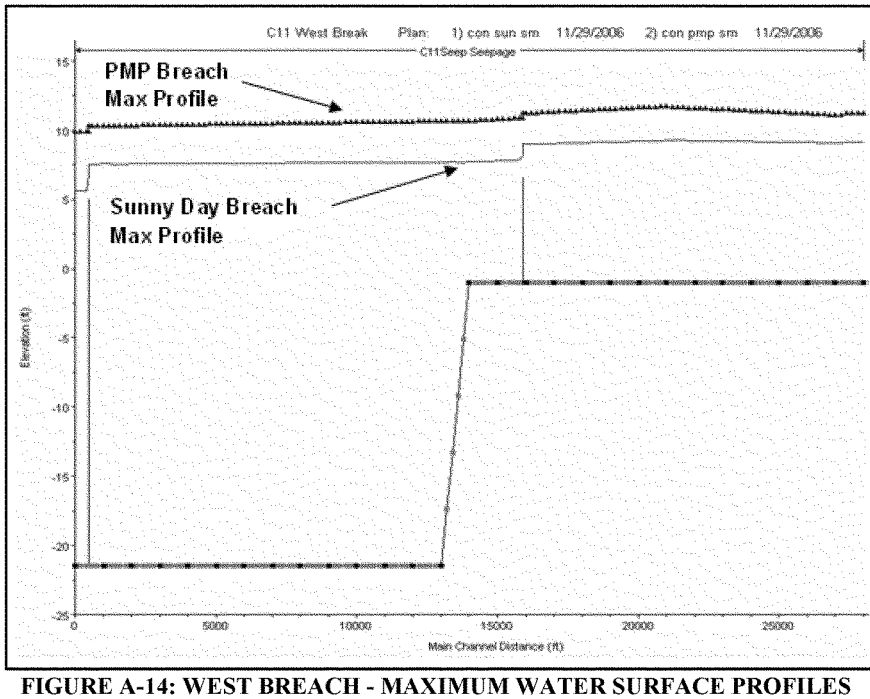

FIGURE A-14: WEST BREACH - MAXIMUM WATER SURFACE PROFILES IN SEEPAGE CANAL FOR SUNNY DAY AND PMP

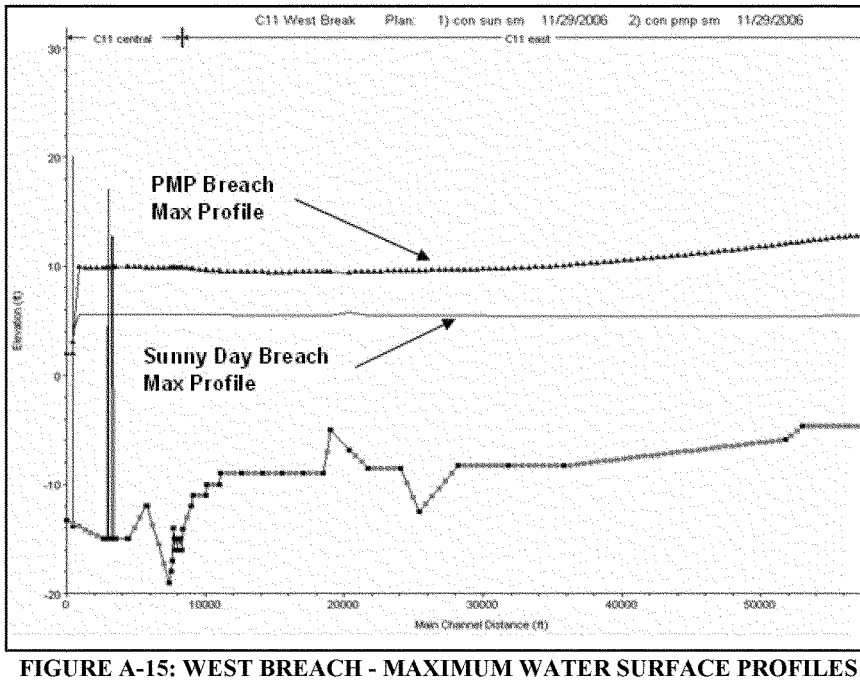

FIGURE A-15: WEST BREACH - MAXIMUM WATER SURFACE PROFILES IN C-11 CANAL FOR SUNNY DAY AND PMP

A.5.10.3.6.5 Impoundment South Breach Simulations

The results of the dam break simulations for the south break are summarized in ***Table A-26*** and ***Table A-27***. ***Figure A-16*** and ***Figure A-17*** show maximum water surface profiles for the seepage canal (east and west) and C-11 canal.

TABLE A-26: SOUTH BREACH RESULTS – PEAK DISCHARGES FOR SUNNY DAY AND PMP

Breach Condition	Peak Discharge at Breach (cfs)	Peak Discharge into East Seepage Canal from C-11 Canal (cfs)	Peak Discharge into West Seepage Canal from C-11 Canal (cfs)
Sunny Day	4,800	238	0
PMP	10,966	460	1,130

TABLE A-27: SOUTH BREACH RESULTS – PEAK WATER STAGE AND VELOCITY

Breach Condition	Peak Stage East Seepage Canal (ft NGVD)	Peak Velocity (fps)	Peak Stage West Seepage Canal (ft NGVD)	Peak Velocity (fps)	Peak Stage C-11 Canal (ft NGVD)	Peak Velocity (fps)
Sunny Day	4.2	0.2	6.8	0.1	5.8	3.3
PMP	10.0	0.3	10.1	0.5	12.8	3.8

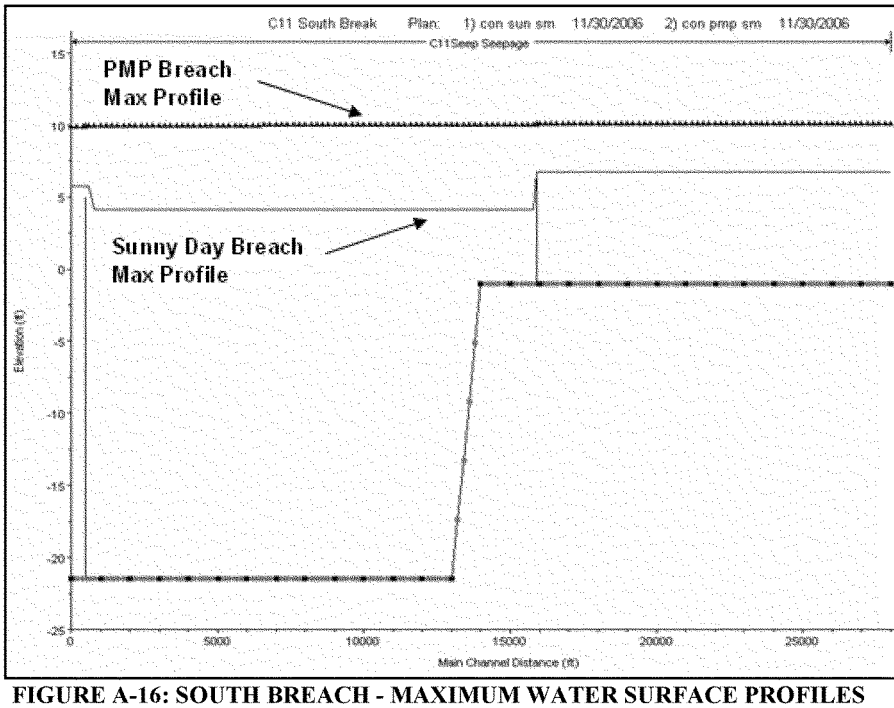

FIGURE A-16: SOUTH BREACH - MAXIMUM WATER SURFACE PROFILES IN SEEPAGE CANAL FOR SUNNY DAY AND PMP

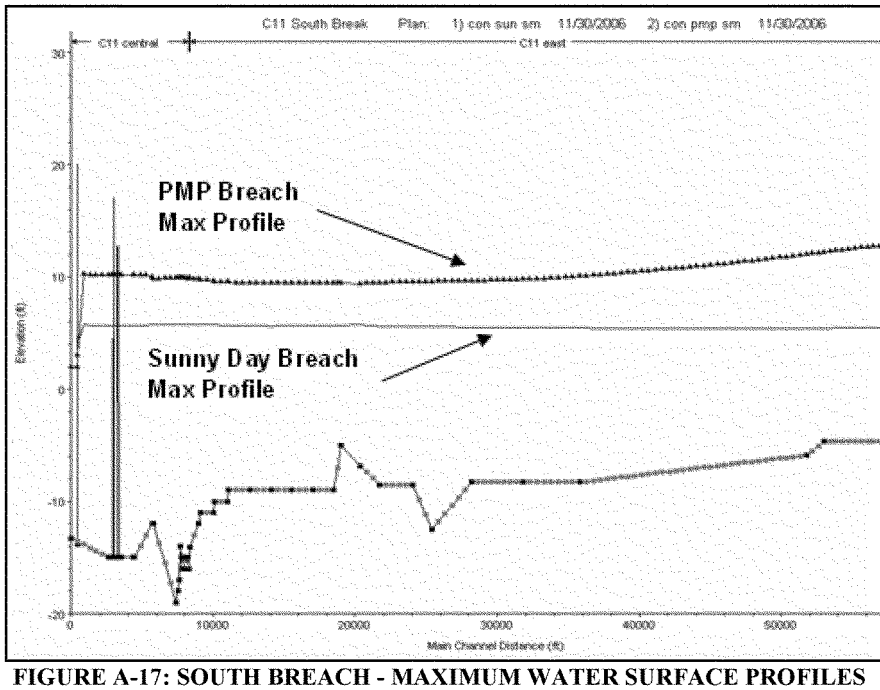

FIGURE A-17: SOUTH BREACH - MAXIMUM WATER SURFACE PROFILES IN C-11 CANAL FOR SUNNY DAY AND PMP

A.5.10.4 Wind and Wave Analysis

A.5.10.4.1 Introduction

The purpose of this study is to provide estimates for wave run-up and embankment over-wash flow rates for selected water depths and embankment heights at the C-11 Impoundment. The C-11 Impoundment is a project component of the larger Western C-11 Basin. Western C-11 Basin is located adjacent to the eastern boundary of Water Conservation Area 3 (WCA 3) and south of I-75/I-595 in Broward County, Florida (***Figure A-18***). The Western C-11 Basin is an integral part of the Central and Southern Florida flood project and, along with the C-11 Canal, provides a primary flood control pumping outlet to WCA 3. The purpose of the C-11 Impoundment is to reduce pumping of untreated water into WCA 3, reduce seepage from WCA 3, and provide water supply when demands exist. The C-11 Impoundment covers approximately 1,831 acres of the C-11 Basin. The C-11 Impoundment has two attached, but separated, wetland mitigation areas to the north.

For study purposes, the C-11 Impoundment was modeled for two design conditions, a 100 year storm event combined with a 60mph wind and a storm event approximating a one-half PMP event, also with a 60mph wind. For each design case, a full 180 degree array of incident wind directions was evaluated.

Wave heights due to wind-growth within the reservoir were estimated for each design case using the numerical wave transformation model STWAVE (Steady-state spectral WAVE). Based on model results, wave run-up on exterior levees was then calculated using the US Army Corps of Engineers' (USACE) Automated Coastal Engineering System (ACES). Over-wash rates for a range of embankment heights were then determined.

A.5.10.4.2 Design Wind Condition

The design wind condition is a key parameter in the determination of levee superiority. The design wind condition consists of three elements, the wind speed, wind direction, and wind duration. All three elements directly contribute to both the growth and magnitude of wind-waves within the reservoir as well as the amount of wind setup that the reservoir will experience.

As part of the greater Comprehensive Everglades Restoration Plan (CERP), a reservoir may be defined by one of three Hazard Potential Classifications (HPC), High, Significant, or Low. Classification is determined by the level of risk associated with a potential embankment failure. Based on classification guidelines, C-11 Impoundment carries a Low HPC. As such, freeboard requirements are to be determined based upon a precipitation event in combination with a 60mph, 1-hour wind speed (SFWMD and ACOE, 2006). This wind speed is considered to be an over water wind speed.

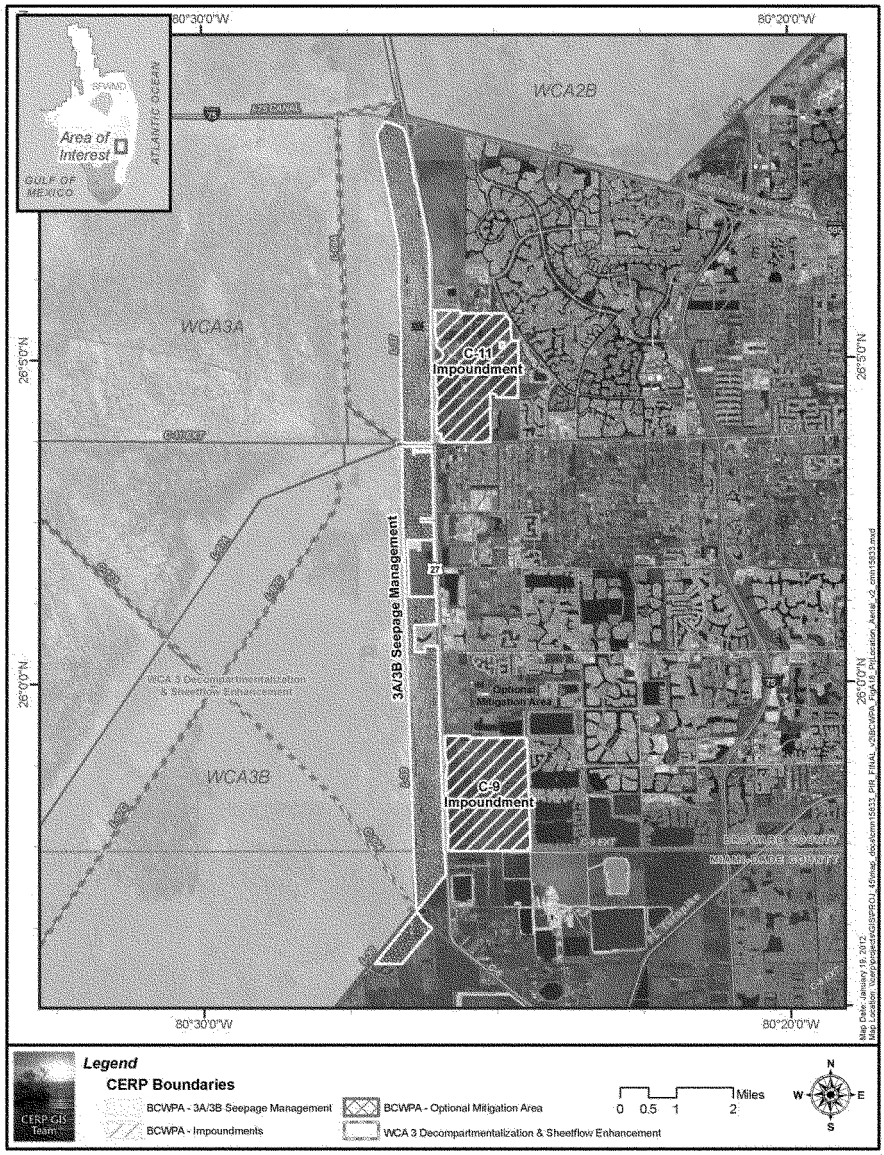

FIGURE A-18: LOCATION OF RESERVOIR (IMPOUNDMENT)

A.5.10.4.3 Adjustment of over-water wind speed to fetch-limited wind speed

In calculating the design wind speed an adjustment is needed in the event that the duration required to achieve a fully developed wind speed exceeds the 1-hour duration of the 100 year wind speed. If the duration exceeds the 1-hour wind duration, the wind speed must be adjusted for the longer duration.

The wind duration (in seconds) required to produce a fetch-limited wave field for a given fetch and wind speed can be expressed as follows (USACE, 2005):

$$t_{x,u} = 77.75 \frac{F^{0.67}}{u^{0.34} g^{0.33}}$$

where

t = wind duration (seconds)
F = straight line fetch distance over which the wind blows (meters)
u = wind velocity (meters/second)
g = acceleration due to gravity (meters/second^2)

Converting to English units provides the following:

$$t_{x,u} = 112 \frac{F^{0.67}}{u^{0.34}}$$

where t is duration in minutes, F is the fetch distance in miles, and u is the wind speed in miles per hour.

A.5.10.4.4 Determination of Fetch

Fetch is defined as a distance over which the wind speed and direction are reasonably constant. Fetches fall into two categories, open-water fetches, where wave growth is limited only by the incident meteorological conditions, and restricted fetches, where wave growth is limited by a confined geometry such as that of a lake, river, bay, or reservoir. The C-11 Impoundment is subject to a restricted fetch. The restricted fetch methodology applies the concept of wave development in off-wind directions and considers the shape of the basin. The fetch is defined as the radial average over an arc of 24 degrees centered on the wind direction. For this study, the wind direction (for determination of the fetch-limited wind speed) is taken to be the direction corresponding to the maximum fetch distance. This will provide the maximum design fetch for determining the maximum possible duration. ***Figure A-19*** indicates the 24-degree arc for each cell, divided into 3-degree

intervals. Averaging the radial lengths over each arc gives average fetch length of 1.84mi for C-11.

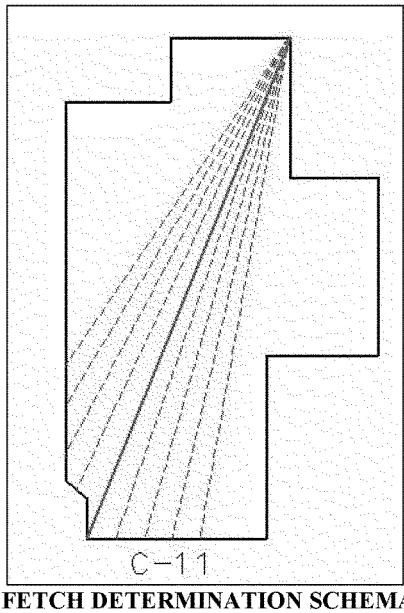

FIGURE A-19: FETCH DETERMINATION SCHEMATIC FOR C-11

Applying the average fetch for each cell to the above duration equation yields a duration, $t_{u,x}$, for the growth of a fully developed wave field, of 42 minutes in C-11. This duration does not exceed the 1-hour design wind duration and, therefore, the design wind speed for the C-11 Impoundment remains 60mph.

A.5.10.4.5 Wind Setup Analysis

Wind set up occurs when wind blows in a fairly constant direction over a body of water. Wind blowing across the water causes the surface layer to move in the direction of the wind due to shear stress development between the air and water. This causes water to "pile up" against the shore, creating the effect known as "wind setup". A corresponding drop in water level will occur along the upwind shore.

Three wind setup models were investigated for applicability to the C-11 Impoundment, the Zieder Zee formula (USACE, 1990), the Brater and King method (Brater et al., 1996), and the Bretschneider method (Ippen, 1966). Although the Zeider Zee formula is generally recommended in USACE

Engineering Manuals, it is empirically derived based on deepwater fjords and produces unrealistically high setup values for shallower waters. The Sibul method (Brater et al., 1996), developed through laboratory experiments and tested with field data, has shown good correlation with data gathered for large bodies of water such as Lake Okeechobee and the Baltic Sea. However, the Sibul model appears to under predict wind set up in shallow water cases when compared with other generally accepted models. Bretschneider's model is a physics based model allowing for the different shear forces developed by the wind on water surface and by return flow on bottom bed. This model was solved numerically using Lake Okeechobee data and appears well founded on water bodies similar to CERP reservoirs. Bretschneider's model was therefore selected as the model to calculate wind setup for the C-11 Impoundment.

A.5.10.4.6 Bretschneider

The numerical model presented by Bretschneider was derived under steady-state wind conditions, i.e. constant speed and direction along a channel axis. The differential form of the model, based on surface and bottom shear stresses as well as conservation of mass, determines wind setup as a function of the effective stress. The effective non-dimensional stress parameter employed in this method can be expressed as:

$$\frac{\kappa U^2 F}{g d^2}$$

where,

- κ = wind drag coefficient
- U = wind speed
- F = fetch length
- g = acceleration due to gravity
- d = water depth

Based on the calculated value of this stress parameter, wind setup can be determined from tabulated data presented in Ippen (1966).

It should be noted that the wind drag coefficient κ, is not a constant. Its value can be influenced by such factors as wind speed, wave steepness (eddy correlation), and salinity. For this study, a wind drag coefficient value of 3.3×10^{-6} was assigned. This value is based upon studies of Lake Okeechobee (Ippen, 1966) and is considered to be representative of conditions at C-11 as well.

A.5.10.4.7 Wind Setup Results

Wind setup values, corresponding to maximum surcharge pool depths, are provided in ***Table A-28.***

TABLE A-28: WIND SETUP

C-11 Case	Maximum Normal Pool Depth (feet)	Maximum Surcharge Pool Depth (feet)	**Stillwater Depth (feet)**	**Design Wind Speed *Adjusted* (mph)**	**Fetch Length (miles)**	**Wind Setup (feet)**
100yr, 60mph	**4.3**	**1.26**	**5.56**	**60**	**1.84**	**0.67**
½ PMP, 60mph	**4.3**	**2.00**	**6.30**	**60**	**1.84**	**0.59**

A.5.10.4.8 Wave Height Analysis

A.5.10.4.8.1 Model

The STWAVE model is a two-dimensional spectral wave transformation model for the simulation of wave transformation over complex bathymetry. STWAVE accepts arbitrary directional wave spectra specified at an offshore boundary and propagates the spectral energy in the onshore direction. It is a finite-difference model, which calculates wave spectra on a Cartesian grid using a backward ray-tracing scheme (Smith et al., 1999). Model results, including spectral output, significant wave height, mean wave period, and wave direction, are obtained by numerically solving the steady-state spectral energy balance equation. This equation is given as:

$$\frac{\partial c c_g E(f,\theta)}{\partial x} + \frac{\partial c c_g E(f,\theta)}{\partial y} = S_{at} + S_{nl} + S_{ds} + S_{br}$$

The left-hand side of the equation represents wave propagation (refraction and shoaling) where:

E = spectral energy density
f = frequency of spectral component
θ = propagation direction of spectral component
c = phase speed of spectral component
c_g = group velocity of spectral component
x,y = plan-view spatial coordinates

Source terms, making up the right-hand side of the equation, represent distribution and dissipation of energy based on principals of linear theory. These terms are defined as:

S_{at} = wind input
S_{nl} = nonlinear wave-wave interactions
S_{ds} = dissipation within the wave field
S_{br} = depth-induced wave breaking.

Despite quantifying these source terms on an individual basis, S_{at}, S_{nl}, and S_{ds} are solved via conservation of momentum flux to the forward and rear face of the spectrum where the energy is redistributed. S_{br} dissipates energy based on water depth and wave steepness.

STWAVE has several inherent limitations. For the best application of the model to wave transformation problems, the following assumptions must be made:

a. Negligible wave reflection (mild bottom slopes)
b. Spatially homogeneous offshore waves
c. Steady state waves, winds, and currents
d. Linear refraction and shoaling with negligible bottom friction effects
e. Linear wave-current interaction.

Due to the nature of the solution scheme, spectral energy is limited to propagation in a half-plane directed toward shore. All energy propagated offshore is neglected.

A.5.10.4.8.2 Wave Model Inputs

A.5.10.4.8.2.1 Bathymetry

Topographic data for the C-11 Impoundment project area was obtained from the Water Preserve Area (WPA) LIDAR survey (NAD 83\NGVD 29). Survey data indicates that elevations within the project area vary significantly. In addition to moderate changes in grade, a series of furrows, channels, and spoil mounds create a complex bottom topography in the reservoir (***Figure A-20***). Two design depths were considered for this evaluation, a depth of 5.56ft (corresponding to a 100 yr storm event) and a depth of 6.16ft (corresponding to a ½ PMP event). Design depths represent the average depth over the entire reservoir basin.

A.5.10.4.8.2.2 STWAVE Grids

In order to analyze wind-wave generation within the reservoir compartment an STWAVE computational grid was generated using the SMS (Surface-water Modeling System) software package developed by Brigham Young University (Brigham Young, 1997). The C-11 Impoundment is irregular in shape with a computation grid consisting of 584 land and water cells in the east to west direction and 944 land and water cells in the north to south direction. The Grid cell resolution was 12.5 feet, producing a grid coverage of approximately 1.4 miles by 2.2 miles for the C-11 Impoundment. A single base input grid was generated for with water levels adjusted accordingly prior to each model run.

In order to evaluate wind-wave heights at each levee of concern (i.e. along all exterior reservoir boundaries), it was necessary to specify four separate forcing boundaries (boundaries along which input conditions are introduced) for each grid. This was accomplished by reorienting the computational grid, by rotating in 90 degree increments, from its original orientation such that each levee became the primary focal point of the growing wave fields. The four orientations are referred to as Orientation A (original orientation – central wind from the west), Orientation B (central wind from the south), Orientation C (central wind from the east), and Orientation D (central wind from the north). ***Figure A-21*** illustrates the four forcing boundaries and levees of interest.

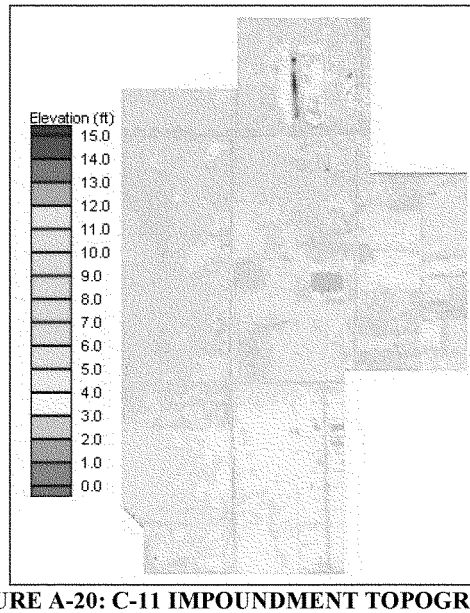

FIGURE A-20: C-11 IMPOUNDMENT TOPOGRAPHY

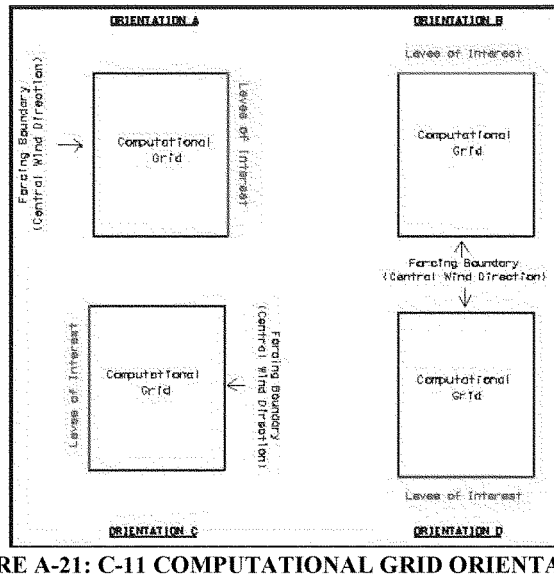

FIGURE A-21: C-11 COMPUTATIONAL GRID ORIENTATIONS

A.5.10.4.8.2.3 Wind and Current Input

It is assumed that each wind-wave growth case begins with a still water surface. This eliminates the need for a measured or simulated spectral wave field to be applied at the forcing boundary of the model domain. Therefore, the only energy input conditions required are wind conditions consisting of a wind speed and wind direction. A single wind speed of 60mph was the design wind condition for both project cases. This wind speed was applied to an array of 13 incident wind directions, covering a levee directed half-plane for each grid orientation. Incident wind directions ranged from –90 degree to +90 degree (relative to a transect perpendicular to the levee of interest) in 15 degree increments. ***Table A-29*** summarizes the STWAVE incident wind directions along with their corresponding "true" directions (measured clockwise from 0 degrees due North) for each grid orientation. All wind speed and wind direction combinations were run with each orientation of the computational grid.

Currents were not included in this study.

TABLE A-29: INCIDENT WIND DIRECTIONS

STWAVE Model Direction (deg)	"True" Direction (winds from) (deg)			
	Orientation A	Orientation B	Orientation C	Orientation D
+90	180	90	0	270
+75	195	105	15	285
+60	210	120	30	300
+45	225	135	45	315
+30	240	150	60	330
+15	255	165	75	345
0	270	180	90	0
-15	285	195	105	15
-30	300	210	120	30
-45	315	225	135	45
-60	330	240	150	60
-75	345	255	165	75
-90	0	270	180	90

A.5.10.4.8.2.4 STWAVE Model Output

A.5.10.4.8.2.4.1 General

Wind waves, also known as oscillatory waves, are most commonly defined by their height, length, and period. These characteristics, as measured at a

given location, are determined by five dominant factors: the velocity of the wind (wind speed), the distance over which the wind blows (fetch), the duration over which the wind blows, the decay distance the wave travels after leaving the generating area (not relevant to this study), and the water depth.

The process of wind wave growth (assuming initial still water) begins with the motion of the air above the water disturbing the surface of the water. As wind begins to blow over the water, wind stress at the air-sea boundary leads to the formation of small perturbations in the water surface. When the perturbations become large enough to affect the pattern of air flow a transfer of momentum and energy between the air layer and the water surface occurs, rapidly increasing wave heights. Wave heights build rapidly over a relatively short distance, increasing at a rate that varies dependent upon wind speed. Waves develop more quickly and with greater uniformity as wind speed increases.

Wind driven waves are a highly complex mix of crests and troughs on the water surface, consisting of irregularly sized wave heights and moving in variable directions. This is particularly true while the waves remain under the influence of the wind. For design purposes, it is often necessary to describe a full wave field with a single representative wave height and direction. Wave direction can be easily defined as an average of the directions of individual waves. Wave height can also be represented as an average value. However, these averages are typically described in terms of the average height of a given percentage of the highest waves in the field. It has been found that the frequency of occurrence of waves above any given height can be closely approximated using the cumulative form of the Rayleigh distribution (USACE, 1984). This fact and resulting theoretical wave height distribution curves make it possible to determine average wave heights for a given percentage of waves based on a single significant wave height, Hs, defined as the average height of the one-third highest waves. The numerical model STWAVE provides wave heights that are in the form of significant wave heights.

Using the STWAVE model, wave heights over the computational domain were recorded for all wind speed, wind direction, and water depth combination as well as wave heights along the exterior reservoir boundaries.

A.5.10.4.8.2.5 Results

Maximum significant wave heights at the down-fetch levee face and corresponding peak wave periods for both design cases are provided in ***Table A-30***. Maximum wave conditions were determined from complete

results for each orientation of each alternative design grid for the C-11 project sites.

TABLE A-30: SIGNIFICANT WAVE HEIGHTS AND PEAK PERIODS - C-11 IMPOUNDMENT

Case	Wind Speed (mph)	Significant Wave Height (ft)	Peak Period (sec)
1 100yr, 60mph wind	60	1.77	3.4
2 ½ PMP, 60mph wind	60	1.84	3.4

A.5.10.4.8.3 Wave Run-up and Over-wash Analysis

A.5.10.4.8.3.1 Wave Run-up

Wave run-up can be described as the resulting forward translation of water mass that is converted from wave energy as waves encounter a sloped surface. Water rushes up the slope resulting in the vertical rise above the still water line known as run-up (***Figure A-22***). Run-up depends primarily on incident wave steepness, slope of the surface on which it is incident, and characteristics of the surface, including surface roughness and porosity. For a given fixed slope, run-up will increase with decreasing wave steepness. For a given incident wave height and period, run-up will increase with increasing slope steepness.

A.5.10.4.8.3.2 Effective Depth

Although the generation of wind waves (and therefore wave run-up and over-wash) is influenced by the presence of wind setup, the relationship is highly complex and is not presently included in the STWAVE model. Therefore, in order to predict the total water level increase due to wind conditions at the down-fetch face of the levee, wind setup must be accounted for with a computation exterior to the model. To account for the wind set-up, the water level change due to wind setup was added directly to the project water depth (still water depth + precipitation). The resulting "effective depth" was then entered as the water depth when determining the freeboard, *F*, in the computation of the over-wash flow rates.

A.5.10.4.8.3.3 ACES

The ACES software package contains an application that provides for the estimation of wave run-up on rough and smooth impermeable surfaces. Six slope configurations were evaluated for this study, a smooth (earthen, RCC, or soil cement) slope (1V:3H), a rough (riprap covered) slope (1V:3H), a rough (riprap covered) slope (1V:2H), a stepped (RCC) slope (1V:3H), a stepped (RCC) slope (1:1.5), and a smooth (RCC or soil cement) vertical wall.

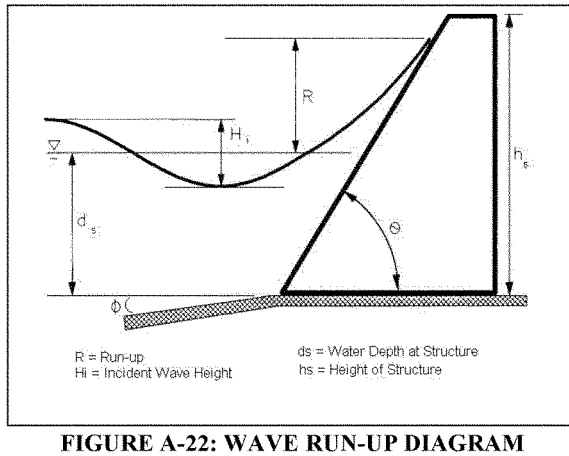

FIGURE A-22: WAVE RUN-UP DIAGRAM

A.5.10.4.8.3.4 Smooth Slope Wave Run-up

Smooth slope run-up, as presented by Ahrens and Titus (1985), recommends the following general equation:

$$R = CH_i$$

where

R = run-up,
H_i = incident wave height,
C = coefficient characterized by the surf parameter ξ, defined as:

$$= \frac{\tan\theta}{\sqrt{\frac{H_i}{L_o}}}$$

θ = angle between structure face and horizontal (18.435° = 1V:3H slope)
L_o = deepwater wavelength

according to the following three specific wave-structure scenarios:

f. $\xi \leq 2$ - waves plunging directly on the run-up slope.
g. $\xi \geq 3.5$ – wave conditions that are nonbreaking and are regarded as standing or surging waves.
h. $2 < \xi < 3.5$ – transition conditions where breaking characteristics are difficult to define.

Corresponding expressions for coefficient C are then:

i. Plunging wave conditions ($\xi \leq 2$)

$$C_p = 1.002\xi$$

j. Nonbreaking wave conditions ($\xi \geq 3.5$)

$$C_{nb} = 1.181\left(\frac{\pi}{2\theta}\right)^{0.375} \exp\left[3.187\left(\frac{\eta_c}{H_i} - 0.5\right)^2\right]$$

where

η_c = crest height of the wave above the still-water level calculated using the Stream Function Wave Theory (Dean, 1974)

k. Transitional wave conditions ($2 < \xi < 3.5$)

$$C_t = \left(\frac{3.5-\xi}{1.5}\right)C_p + \left(\frac{\xi-2}{1.5}\right)C_{nb}$$

The ACES application uses a more convenient but less accurate expression for the coefficient under nonbreaking conditions derived by Ahrens and Burke (unpublished report):

$$C_{nb} = 1.087\sqrt{\frac{\pi}{2\theta}} + 0.775\Pi$$

where

Π = Goda's (1983) nonlinearity parameter

$$= \frac{\frac{H_i}{L}}{\tanh^3\left(\frac{2\pi d_s}{L}\right)}$$

L = incident wave length
d_s = water depth at the toe of the structure.

A.5.10.4.8.3.5 Rough Slope Wave Run-up

The rough slope wave run-up formulation, as presented by Ahrens and McCartney (1975), was empirically derived from physical model studies conducted for specific structures and wave climates. According to this method, run-up is predicted as a nonlinear function of the surf parameter, ξ, and is defined as follows:

$$R = Hi\frac{a\xi}{1+b\xi}$$

where,

R = run-up,
H_i = incident wave height,
a,b = empirical coefficients associated with slope roughness, (0.956 and 0.398, respectively)
ξ = $\frac{\tan\theta}{\sqrt{\frac{H_i}{L_o}}}$
= angle between structure water face and horizontal, (18.435° - equivalent to a 1V:3H slope)
L_o = deepwater wavelength.

The empirical coefficients a and b were determined from data compiled for run-up experiments on riprap slopes.

A.5.10.4.8.3.6 Stepped Slope Wave Run-up

Although the ACES software package does not allow for the analysis of wave run-up on stepped slopes, run-up estimates may still be obtained by employing rough slope correction factors (Table 2-2 in EM 1110-2-1614). The estimated run-up is obtained by multiplying the rough slope wave run-up (as presented previously) by the correction factor for a stepped surface of given

slope divided by the correction factor for quarrystone. For a stepped surface of slope 1:3, the correction factor is 0.70. For a stepped surface of slope 1:1.5 the correction factor is 0.75. Combined with a quarrystone correction factor of 0.60, the stepped slope wave run-up equations are as follows:

For a 1:3 stepped slope:

$$R_{1/3} = (1.17)R_{rough}$$

For a 1:1.5 stepped slope:

$$R_{1/1.5} = (1.25)R_{rough}$$

The above equations are applicable when $1 \leq H_o'/K_r$, where H_o' is the unrefracted deepwater wave height and Kr is the riser height.

A.5.10.4.8.3.7 Vertical Wall Wave Run-up

The ACES software package allows for the evaluation of run-up on vertical walls using the smooth wave run-up formulation detailed previously.

A.5.10.4.8.3.8 Wave Run-up Results

Table A-31 provides wave run-up values for both design cases. For each case, run-up was determined for six slope types: (1) 1V:3H smooth (earthen, RCC, or soil cement) slopes, (2) 1V:3H rough (riprap) slopes, (3) 1V:2H rough (riprap) slopes, (4) 1V:3H RCC or soil cement steps, (5) 1V:1.5H RCC or soil cement steps, and (6) RCC or soil cement vertical wall. Due to maintenance concerns, no slopes steeper than 1V:3H were considered for smooth levees.

TABLE A-31: WAVE RUN-UP FOR C-11 ALTERNATIVES

Alternative	Slope Type	Wave Run-up (ft)
1 100yr, 60mph	Smooth (1V:3H) Rough (1V:3H) Rough (1V:2H) Stepped (1V:3H) Stepped (1V:1.5H) Vertical	3.42 1.85 2.28 2.15 3.22 2.07
2 ½ PMP, 60mph	Smooth (1V:3H) Rough (1V:3H) Rough (1V:2H) Stepped (1V:3H) Stepped (1V:1.5H) Vertical	3.49 1.90 2.34 2.21 3.32 2.14

A.5.10.4.8.3.9 Over-wash

Over-wash occurs when wave run-up and wind setup levels combine to produce a water level greater than the height of the levee. Over-wash is an important design element both in terms of predicting backside flooding and safeguarding structural integrity of the levee. Several methods exist for predicting the over-wash flow rate in a given situation. The ACES software package contains two methods, one for monochromatic wave over-wash as developed by Weggel (1976), the other for irregular wave over-wash developed by Ahrens (1977). Due to the irregular nature of the developed wave fields, Ahrens method was selected for this analysis.

Ahrens over-wash method was developed with the following assumptions:

Run-up values caused by an irregular wave field will follow a Rayleigh probability distribution.
Significant deepwater wave height, H_s, causes significant run-up R_s
α, Q^*_o, and H_o in Weggel's over-wash equation remain constant for all members of the distribution.

Ahrens estimates the over-wash rate by summing the over-wash contributions from each individual member of the run-up distribution:

$$Q = \frac{1}{199}\sum_{i=1}^{199} Q_i$$

where

Q = volume rate of over-wash caused by irregular waves ($ft^3/s - ft$)

Q_i = volume rate of over-wash caused by one run-up on the run-up distribution

$$= C_w\sqrt{gQ_o^*(H_{so})^3}\left(\frac{R_i + F}{R_i - F}\right)^{\frac{-0.1085}{\alpha}}$$

where

C_w = wind correction factor

g = gravitational acceleration

Q^*_o, α = empirical coefficients (see USACE (1984))

H_{so} = deepwater significant wave height

F = Freeboard (levee height – water depth)

R_i = run-up value having exceedance probability $p = \sqrt{\frac{\ln\frac{1}{p}}{2}}R_s$

p = 0.005*i, i = 1,2,3,...,199

R_s = run-up with a given deepwater significant wave height and period

Ahren's equations modify Weggel's monochromatic expressions to account for the effect of irregular waves when freeboard, F, is less than the run-up of the significant wave, R_s. When the freeboard is greater than the run-up, Weggel's equation yields no over-wash while larger run-ups in the distribution may still overtop the structure. For these relatively high freeboards, the run-up distribution is broken into 999 elements, instead of 199, to better account for the effect of the higher run-ups. The over-wash equation for this larger distribution becomes:

$$Q = \frac{1}{999}\sum_{i=1}^{999} Q_i$$

where

p = 0.001*i, i = 1,2,3,...,999.

A.5.10.4.8.4 Wave Run-up and Over-wash Flow Rate Results

Table A-32 provides wave run-up values and corresponding rates of over-wash computed for the two C-11 design cases. The table contains information for both wind speed and water depth combinations for the maximum

significant wave incident to the levee face. Included are the six slope configurations. Over-wash rates are provided in half-foot increments for levee heights beginning at 6 feet.

A.5.10.4.8.5 Summary

The purpose of this analysis is to provide wave run-up and over-wash rates for an array of levee heights for the C-11 Impoundment. These wave run-up and over-wash rates must be combined with site specific geotechnical information, structural design investigations, and economic evaluation to provide an optimum levee height for the given project location. Results from this analysis are presented as part of the larger C-11 investigation and do not constitute, in and of themselves, a recommendation for a final levee height design.

TABLE A-32: C-11 WAVE RUN-UP AND OVER-WASH RATES

C-11 - Wave Run-up and Overtopping																			
	Still Water	Wind	Wind	Effective	Significant	Wave	Slope	Run-up	Overtopping according to Levee Height (ft^3/s-ft)										
Case	Depth	Speed	Set up	Depth	Wave Height	Period	Type												
	(ft)	(mph)	(ft)	(ft)	(ft)	(sec)		(ft)	6ft	6.5ft	7ft	7.5ft	8ft	8.5ft	9ft	9.5ft	10ft	10.5ft	11ft
4.3ft																			
100yr/	5.56	60	0.67	6.23	1.77	3.4	Smooth 1:3	3.42	submerged	1.531	0.803	0.421	0.214	0.104	0.047	0.020	0.009	0.000	
60mph							Rough 1:3	1.85	submerged	1.133	0.342	0.091	0.020	0.000					
							Rough 1:2	2.28	submerged	1.309	0.490	0.173	0.054	0.015	0.000				
							Stepped 1:3	2.15	submerged	1.076	0.388	0.130	0.038	0.010	0.000				
							Stepped 1:1.5	3.22	submerged	1.356	0.673	0.330	0.155	0.069	0.028	0.012	0.000		
							Vertical Wall	2.07	submerged	0.818	0.262	0.076	0.019	0.000					
4.3ft																			
½ PMP,	6.16	60	0.59	6.89	1.84	3.4	Smooth 1:3	3.49	submerged	submerged	2.049	1.071	0.571	0.298	0.149	0.071	0.032	0.014	0.006
60mph							Rough 1:3	1.90	submerged	submerged	1.806	0.564	0.165	0.041	0.009	0.000			
							Rough 1:2	2.34	submerged	submerged	1.951	0.747	0.280	0.095	0.029	0.008	0.000		
							Stepped 1:3	2.21	submerged	submerged	1.626	0.598	0.214	0.069	0.019	0.005	0.000		
							Stepped 1:1.5	3.32	submerged	submerged	1.845	0.925	0.468	0.229	0.107	0.047	0.019	0.008	0.000
							Vertical Wall	2.14	submerged	submerged	1.262	0.425	0.133	0.037	0.009	0.000			

A.5.10.4.8.6 References

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A.6 C-9 IMPOUNDMENT

A.6.1 General Information

The C-9 Impoundment project component features a 1,641 acre 4.3-foot deep, aboveground impoundment feature (also defined as a reservoir) as the main element of design that carries a High Hazard Potential Classification. Other design features include two pump stations (inflow and seepage), assorted gated and non-gated structures, several fixed weirs, an emergency overflow spillway, and perimeter levees and seepage control canals. The design also includes the purchase of mitigation credits to offset project impacts to existing permitted mitigation areas. The existing C&SF flood damage reduction system will remain operational to manage storm events. Incidental flood protection benefits may be realized by implementing the project.

The primary purpose of the C-9 Impoundment features is to supplement C-11 Impoundment storage to reduce the pumping of untreated agricultural and urban runoff from the C-11 western basin into WCA 3A through the S-9A pump station. Project modeling demonstrated that the combined operation of the C-9 Impoundment and C-11 Impoundment will significantly reduce pumping of runoff into WCA 3A. Another purpose of the C-9 Impoundment is to pump and store excess stormwater runoff from the C-9 Basin when storage volume is not needed for the western C-11 basin. This allows the capture of runoff which would be lost runoff to tide. The storage pool will assist in reducing seepage losses from adjacent natural areas WCA 3B and 3B SMA, provide groundwater recharge, and provide benefits in meeting the urban, and saltwater intrusion prevention water supply demands. The impoundment may additionally provide opportunities to further reduce the extent of damages from flooding through operational changes to the C&SF Project and local drainage systems and provide limited water quality improvements.

The project design requires use of the conveyance canals C-502B Canal and the S-502B Gated Culvert structure to transfer water from the C-11 Impoundment to the C-9 Impoundment.

The C-9 Impoundment is located in southwestern Broward County, adjacent to and east of US 27 on the north bank of the C-9 Canal. The northern boundary of the project is approximately 10.7 miles south of the I-75/US-27 Interchange. The

C-9 Canal, 1.9 miles further south makes up the southern boundary of the Impoundment. The C-9 Canal is also approximately 0.4 miles north of the intersection of Krome Avenue and US 27. The Impoundment is approximately 1.4 miles in width from east to west.

Access to the impoundment is made from US 27 along the C-9 Canal levee/bank/road, crossing over the S-512B Flap-gated Culvert structure.

An alternate access to the Impoundment, top of embankment, and major structural features is from the northern boundary where the S-512A seepage pump station is located. This location can be reached from SW 196th Avenue off Pines Boulevard.

A.6.2 Seepage Control

Seepage control for the C-9 Impoundment is accomplished through a system of structures, seepage canals, and a conveyance canal. Seepage was quantified using the SEEP2D model that uses a flow net-type methodology in the calculation of seepage flow rates through various geologic layers. A safety factor of 1.5 was applied to determine pumping and structure size requirements. Structure data was also placed in the sub-regional MODFLOW model that was used to identify the Selected Plan through the alternative formulation phase during the WPA FS.

Seepage south of the impoundment is intercepted by the C-9 Canal with return pumping into the reservoir by the S-509 Pump Station. The Pump Station has 4-250 cfs diesel pumps for inflow pump operations and a 1-75 cfs electric pump primarily for seepage pump operations. When deliveries from C-11 Basin are not being made, the S-511 structure will be closed and the C-9 Canal will be controlled at the existing authorized stage measured at the coastal structure S-29 Gated Spillway. This stage varies depending on the elevations of the tide.

The Impoundment employs two seepage canals: C-509E that forms the eastern perimeter seepage canal adjacent to the D-509 Embankment and C-509W that forms the western perimeter seepage canal adjacent to same embankment structure. The C-509E Seepage canal stages require control to prevent impact to flood protection of adjacent private lands. The impoundment's eastern half seepage is controlled at a stage of 3.0 ft-NGVD with interception by C-509A Seepage canal with stage exceedance managed primarily by the S-512A Pump Station and secondarily by S-512C Weir structure. Seepage collected may be managed in either of two ways: (1) return pumping into the reservoir with the S-512A Pump Station or (2) discharge to the C-9 Canal to meet water supply demands through the S-512C Weir. The S-512A Pump Station serves as a seepage pump plant and contains 3-75 cfs electric motor pumps for this purpose.

Should the pump station malfunction or experience a power outage, the combined S-512C Weir and associated Flap-gated Culvert structure provides relief of excess stages temporarily when the seepage canal stage increases to 4.05 ft-NGVD. The S-512C Flap-gated Culvert structure also prevents the backflow up the C-509 Canal with increase stages of C-9 Canal during flood events.

The C-509W Seepage canal stages require control to prevent impact to US 27 road base that runs along and parallel to the seepage canal. The impoundment's western half seepage is controlled at a stage of 4.0 ft-NGVD with stage exceedance managed by the combined overflow and conveyance into C-9 Canal via S-512B Weir and associated Flap-gated Culvert structure. Seepage conveyed into C-9 Canal may be managed in either of three ways: (1) return pumped into the impoundment with the S-509 Pump Station, (2) used to meet C-9 Basin water supply demands, or (3) conveyed to tide via the coastal S-29 Gated Spillway. The S-509 Pump Station serves primarily as an inflow pump station with 4-250 cfs diesel engine pumps for this purpose. However, the pump station also includes a 1-75cfs electric motor pump to handle intercepted seepage as a secondary function. The S-512B Flap-gated Culvert structure prevents backflow up the C-509 Canal with stage increases in C-9 Canal during flood events or C-11 to C-9 diversion operations.

A.6.3 General Design and Operations

A.6.3.1 Features

The C-9 Impoundment has the following design features:

Structures
- S-509 Pump Station
- S-510 Gated Culverts
- S-510A Service & Auxiliary Spillway
- S-511 Gated Culverts
- S-512A Seepage Pump Station
- S-512B CIT Weir & Flap-gated Culverts
- S-512C CIT Weir & Flap-gated Culverts

Canals
- C-509E Seepage Canal
- C-509W Seepage Canal

Levees
- D-509 Embankment

The D-509 Embankment is the perimeter embankment for the 4.3-foot storage pool.

A.6.3.2 Operations for Water Quality Benefits

The C-9 Impoundment is not expected to provide major water quality benefits for recipients of reservoir releases. However, stored water released from the reservoir cannot have a greater concentration of pollutants then the original contributing source. Releases from the reservoir will be monitored and assessed under normal operations to ensure water quality standards are met.

To maximize water quality benefits within the objectives of the project, water may be drawn down operationally to a half-foot depth (5.0 ft-NGVD) over interior average grade (4.5 ft-NGVD). This reduces the frequency of dry-outs that may allow mobilization of previously captured runoff constituent pollutants. Also, the longer periods of soil saturation increases microbial mass survival and viability to breakdown captured pollutants on next storm event.

A.6.3.2.1 Water Supply

Currently, under normal conditions, there are relatively few water releases from WCA 3 to the C-9 Basin due to the configuration of the C&SF Flood Control Project. Operation of the proposed C-9 Impoundment may result in the ability to make limited deliveries to the basin to meet coastal and urban water supply demand.

If the C-9 Impoundment contains a stored water depth greater than one half-foot above average grade (5.0 ft-NGVD), then water supply demands will be met with releases from the reservoir. If the reservoir is at or below this minimal depth then S-511 may be opened to provide the basin with water supply in an identical manner as pre-project operations, i.e. through S-30 Gated culvert structure. Project implementation also improves groundwater levels and surface flows to the Snake Creek estuary salinity.

A.6.4 Reservoir

A.6.4.1 General Information

The C-9 Impoundment carries a High Hazard Potential Classification (FEMA Guidelines) justified through dam-break analyses. This corresponds to the USACE Standard 1 condition as defined in USACE Inflow Design Floods for Dams and Reservoirs (ER 1110-8-2(FR), March 1991). The impoundment consists of a 1,641-acre 4.3-foot deep, above ground reservoir that provides 7,056 acre-feet of storage. Embankment heights are 15.0 feet above average interior grade. A system of seepage canals and associated structures is included along the western, northern, and eastern project boundaries.

TABLE A-33: C-9 IMPOUNDMENT DESIGN ELEVATIONS

	(ft-NGVD)
Top of Levee	19.50
Maximum Surcharge Pool -- PMF	13.15
Normal Maximum Pool	8.80
Service Spillway Crest Elevation	8.80
Auxiliary Overflow Spillway Crest Elevation	10.10
Average Impoundment Ground Elevation (grade)	4.50

Average ground elevation based on LIDAR data

TABLE A-34: C-9 IMPOUNDMENT STORAGE CALCULATIONS

Storage Surface Area	1,641 acres
Normal Maximum Pool Depth	4.3 feet
Design Storage Volume	7,056 acre-feet
Fill Rate at 1,000 cfs	1.21 feet/day or 0.05 feet/hour
Time to Fill 4.3 feet at 1,000 cfs	3.6 days
Drawdown Rate at 500 cfs	0.60 feet/day or 0.03 feet/hour
Time to Drawdown 4.3 feet at 500 cfs	7.1 days

A.6.4.2 Embankment Design

A.6.4.2.1 General Information

Project design parameters for reservoirs and other water impounding structures in south Florida are provided in the DCMs developed and published jointly between the USACE and SFWMD and the Florida Department of Environmental Protection. The documents pertaining specifically to determining the reservoirs embankment height is DCM-2, *Wind and Precipitation Design Criteria for Freeboard* (2006). The DCMs provide Hazard Potential Classification (HPC) requirements recommended methodologies in use of design parameters and offer accepted avenues for the optimization of reservoir designs. The C-9 Impoundment embankment heights were designed using DCM-2 as the primary reference for all parameters and methodologies. The USACE ER 1110-8-2(FR) require minimum standards for earthen embankment freeboard to include the selected design height (which must be the greater

between the 1) minimum standard and that 2) height which assures failure) will not occur from a possible combination of events resulting from surcharged stages with high winds, uncertainties in analytical procedures, and project operations in combination with critical design pool elevations. The minimum Federal standard freeboard on a reservoir with a High HPC is 5 feet above the maximum surcharge pool as determined by routing the 72-hour PMP event in accordance with DCM-2

The two most important design parameters in the design of embankment heights (excluding minimum freeboard requirements) are the selection of the Inflow Design Flood (IDF) and the design wind speed. From these two parameters, all other parameters are derived either directly or indirectly, e.g. surcharge pools, spillway overflow, wind setup (or wind tide), wind-wave height, wave run-up, and wave over-wash (or overtopping). Dependent on Hazard Potential Classification (HPC), DCM-2 provides these two important design parameters. Since C-9 Impoundment carries a High HPC, the design IDF for the reservoir is the 72-hour PMP storm event and the "reasonable" wind speed is the 100-year return frequency event. Therefore, the design embankment height for C-9 Impoundment is the greater between a minimum freeboard of 5 feet and that which assures failure will not occur as a result from wind setup, wave action, and uncertainties in analytical procedures and project function in combination with the application of a "reasonable" wind speed over the surcharge pool.

A cost effective analysis was performed to identify other possible design approaches resulting with one alternative approach seemingly to have merit for future investigations. With the C-9 Impoundment, the low normal pool depth creates an opportunity that deeper reservoirs are unable to utilize as an alternative design approach. The design approach uses the time-interval relationship between the reservoir reaching its peak maximum surcharge pool and the application of the design wind speed as is inferred in ER 1110-8-2(FR) and EM 1110-2-1460. The reason that deeper reservoirs are at a disadvantage is the complex and non-linear relationship between water depth, wind speed and wind-wave growth. If this design approach was used for the design of the embankment, the embankment height requirement would be reduced by approximately 1.0 foot. Ultimately, this approach was not used in design of the embankment; however, the approach is believed to have merit and may still be considered during the detail design effort. The alternative design approach is presented in ***Section A.6.12.4*** of this Appendix.

A.6.4.3 Embankment Height Analysis

A.6.4.3.1 DCM-2 Case Studies

The DCM-2 provides four cases (or conditions) for High HPC reservoirs that are storm rainfall-wind speed differentiated that are to be considered in determining embankment height and design. They are capsulated in *Table A-33*:

TABLE A-35: DCM-2: 4 CASES FOR DAM/IMPOUNDMENT ANALYSES

		Precipitation or Reservoir Level		
		Normal Full Storage	100-Year Storm	PMP
Wind Condition	100-Year Wind			3
	156 mph Category 5		3	
	200 mph (PMW)	3		
	Hurricane Easy (1950)	Storm Specific Wind and Precipitation		

Case 1 combines the 100-year wind with the pool(s) established with routing the Probable Maximum Precipitation (PMP) event. This is based primarily on ER 1110-8-2(FR) requirement for a Standard 1 reservoir ability of safely passing the IDF computed from the PMP occurring over the watershed above the site (for CERP reservoirs, the watershed is direct rainfall within the perimeter of the embankment since inflows from outside the reservoir are controlled with pumping operations).

Case 2 combines the Category 5 Hurricane wind speed with the pool(s) established with routing the 100-year return interval precipitation event and is based on an acceptable alternative and for sensitivity analysis. South Florida large storms are almost exclusively cyclonic in nature that move through the region with a groundspeed that typically precludes heavy rainfall. Hurricanes do stall at times; however, major hurricanes of Category 4 or 5 usually require ideal conditions for continual strength and that means maintaining movement over warm waters. When a hurricane becomes stationary or moves very slowly, surface water that is greatly disturbed turns over water from cooler depths (upwelling) that tend to reduce or sap hurricane strength until movement is regained over warmer waters. Thus, it is unlikely a small reservoir located off the coast will be exposed to a Category 5 Hurricane wind speed for a duration

that may risk the integrity of its embankments. However, since Case 2 is considered to have acceptance as a real possibility, it has been added to the analyses for comparison to Case 1 results and is presented in the individual reservoir sections.

Case 3 combines the Probable Maximum Wind (PMW) with the normal pool (inflow pump off water level) and is based primarily on USACE Hydrologic Engineering Requirements for Reservoirs (EM 1110-2-1420, Oct 1997) guidance. In DCM-2, the PMW was identified with maximum winds recorded during the greatest hurricanes with a result assumed to be equivalent to a 200mph one-minute average wind speed. The major problem with using such wind speeds (after conversion to a 1-hour average) is the assumption that models used for wind-wave generation are applicable. This is further complicated in that it has been noted that sea surfaces present a slicker surface (less surface stress) with high wind speeds (probably through wave blow-out and foam creation—white-out conditions). It is not known if this is also applies to freshwater pools. Therefore, in DCM-2, it was agreed that Case 3 would not provide the embankment height parameter, but would help form the sensitivity analysis.

Case 4 presents the conditions experienced with major Hurricane Easy which contained wind speeds of 125mph (3-second gust recorded before anemometer broke) and a rainfall depth of 3.77 feet (45.2") over 72-hours. This case presents another alternative for input to a sensitivity analysis, but has for all reservoir cases presented the lowest embankment height requirement because of the wind speed conversion to the 1-hour average and lesser rainfall than determined PMP events. For High HPC dam/reservoir (Standard 1), ER 1110-2-1420 states that the dam/reservoir must be able of safely passing the IDF computed with the PMP event.

All High HPC CERP reservoir s analyzed up to this point have shown that Case 1 dominates as the most critical design methodology (highest embankment requirement). This also supports the requirement that these reservoirs must be able to safely pass the IDF computed with the PMP event. Therefore, Case 1 was set as the design methodology for the C-9 Impoundment.

A.6.4.3.2 Hydrology (IDF)

Note: The data provided in this section were calculated on preliminary results of the reconfigured impoundment project (since the draft PIR). The results are considered applicable and appropriate given the closeness of the final configured design to the preliminary estimates as provided in this final PIR. Some numbers relating to direct design have been arithmetically upgraded to account for the slightly deeper design of the normal pool, i.e. from 4-foot depth to 4.3-foot.

The Probable Maximum Precipitation (PMP), 72-hour duration storm was used to design the C-9 Impoundment due to its High Hazard Potential Classification (HPC) per DCM-2. The PMP was developed according to guidelines from the Hydrometeorological Report (HMR) No. 51 (Probable Maximum Precipitation Estimates, Eastern U.S.) and HMR No. 52 (Probable Maximum Storm Computation). A value of 55.7 inches was selected from the all season 72 hr, 10 mi^2 PMP chart.

A synthetic 72-hour PMP rainfall event was developed according to HMR-52 to contain discrete PMP storm durations from 6 to 72 hours (*Table A-36*). The peak hour rainfall rate was calculated and smoothing was applied to yield the 1-hour distribution of the probable maximum storm (*Table A-37*).

TABLE A-36: PROBABLE MAXIMUM PRECIPITATION FOR STORM DURATIONS 6 TO 72 HOURS

Storm Duration (hr)	6	12	24	48	72
PMP (in)	32.0	38.7	47.1	51.8	55.7

TABLE A-37: PRECIPITATION FOR EACH 6-HOUR INCREMENT OF THE 72 HR PMP

6-Hour Increment	1	2	3	4	5	6	7	8	9	10	11	12
Precipitation (in)	1.0	1.0	1.0	1.0	1.0	1.2	1.8	5.4	32.	6.7	3.0	0.7

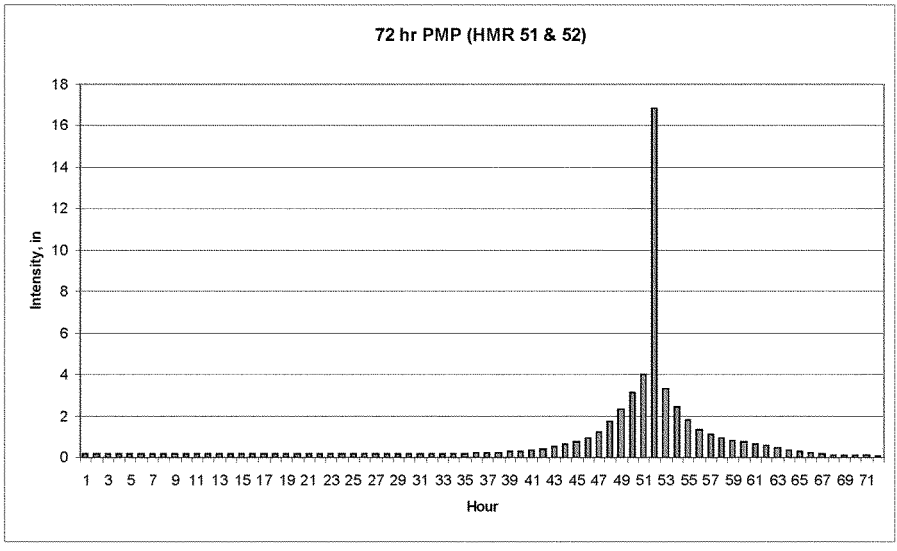


FIGURE A-23: HOURLY DISTRIBUTION OF THE SYNTHETIC 72 HR PROBABLE MAXIMUM PRECIPITATION

The Corps' HEC-RAS (River Analysis System) model was employed to determine the maximum pool (or surcharge pool) elevation and peak discharge. The model configuration consisted of a storage area equal to 2.58 square miles with a weir outlet. Since the impoundment itself is the tributary basin and its surface is considered impermeable when full, all storm precipitation was readily available for routing without any loss. The initial pool stage used in the routing model of C-9 Impoundment was the maximum normal pool stage of 8.80 feet NGVD.

The spillway crest elevation for the C-9 Impoundment was determined in accordance with the following procedures. The 24-hour, 25-year return period rainfall is recommended in the SFWMD Technical Publication 81-3 May, 1981 Frequency Analysis of Rainfall Maximums for Central and South Florida for basin hydrologic modeling purposes. However, the 72-hour, 100-year return period rainfall was used to ensure that no impacts were made to existing levels of service flood protection. The 24-hour, 100-year rainfall amount for the C-9 basin was determined to be 12 inches. The ratio of 24-hour, 100-year rainfall to 72-hour, 100-year rainfall is 1.359. Thus the 72-hour, 100-year rainfall for the C-9 Impoundment is 16.3 inches. The document "Basis of Review for Environmental Resource Applications within the SFWMD, February 12 2006" sets the allowable discharge for the C-9 Canal Basin as 20 cfs per square mile; this rate translates to 52 cfs for the 2.58 square miles of impoundment. The length of the service spillway, 13 ft, was designed to limit the impoundment

outflow to 52 cfs during the 72-hour, 100-year storm. The resulting peak stage, 10.1 ft, NGVD, was used to define the crest elevation of the auxiliary overflow spillway.

TABLE A-38: C-9 IMPOUNDMENT INFLOW DESIGN FLOOD ANALYSIS

Probable Maximum Precipitation (PMP) 72-Hour Rainfall	55.7	inches
SFWMD 100-year, 24-hour Rainfall	12	inches
SFWMD 100-year, 72-hour Rainfall	16.3	inches
4.3-foot deep Basin Area	1641	acres
Basin Area	2.58	sq miles
Normal Pool Elevation (Service Spillway Crest Elevation)	8.8	ft-NGVD
Service Spillway Length	13.0	ft
Auxiliary Overflow Spillway Crest Elevation (100yr, 72hr storm)	10.1	ft-NGVD
Peak IDF Instantaneous Inflow	27,978	cfs

Average ground elevation based on LIDAR data.

The PMP analysis should consider an antecedent-setting event to address concerns over the sequencing of rainfall storms as described in the Design Criteria Memorandum (DCM-2, Acceler8 Ref# P 599). Two routings must be performed to determine governing circumstances:

a) Three-Cycle 160% PMF Routing
From normal pool, route a 30% PMF-72hr storm
- Spillway on, gates are inoperable

Provide for a 3-day dry spell
- Spillway on, gates are operable

Route a 100%PMF-72hr storm
- Spillway on, gates are inoperable

Provide for a 10-day dry spell
- Spillway on, gates are operable

Route a 30%PMF-72hr storm
- Spillway on, gates are inoperable

b)
1. From normal pool, route a 40%PMF-72hr storm
   - Spillway on, but gates are inoperable
2. Provide for a 5-day dry spell
   - Spillway on, gates are operable
3. Route a 100%PMF-72hr storm
   - Spillway on, gates are inoperable

4. Provide for a 10-day dry spell
   - Spillway on, gates are operable
5. Route a 40%PMF-72hr storm
   - Spillway on, gates are inoperable

All simulations were done with gates inoperable for the entire simulation period. This decision was made to alleviate the need for operations personnel to decide, based on meteorological forecasting and downstream conditions, whether to operate or not to operate the gates between storm events as allowed ensuring the integrity of the structure. Stages resulting from performing the PMF with gate operations are provided in ***Table A-41*** of this section.

The 160% and 180% PMF Routings were performed using 5 crest lengths: 50, 100, 150, 200, and 250 feet (***Table A-39*** and ***Table A-40***). The 150 foot long crest was chosen as the most appropriate design with a peak pool elevation of 13.15 feet, 3.05 feet above the spillway crest, a peak spillway discharge of 2,478 cfs and a recession time of 99 hours to reach 0.25 feet above the spillway crest.

TABLE A-39: C-9 IMPOUNDMENT EMERGENCY OVERFLOW SPILLWAY – 160% PMF ROUTING

Crest Length (ft)	Peak Height Above Spillway Crest (feet)	Peak IDF Pool Elevation (ft-NGVD)	Peak IDF Spillway Discharge (cfs)
50	3.48	13.58	1,243
100	3.21	13.31	1,892
150	3.03	13.13	2,478
200	2.89	12.99	2,959
250	2.78	12.88	3,411

TABLE A-40: C-9 IMPOUNDMENT EMERGENCY OVERFLOW SPILLWAY – 180% PMF ROUTING

Crest Length (ft)	Peak Height Above Spillway Crest (feet)	Peak IDF Pool Elevation (ft-NGVD)	Peak IDF Spillway Discharge (cfs)
50	3.55	13.65	1,277
100	3.25	13.35	1,922
150	3.05	13.15	2,478
200	2.90	13.00	2,973
250	2.78	12.88	3,419

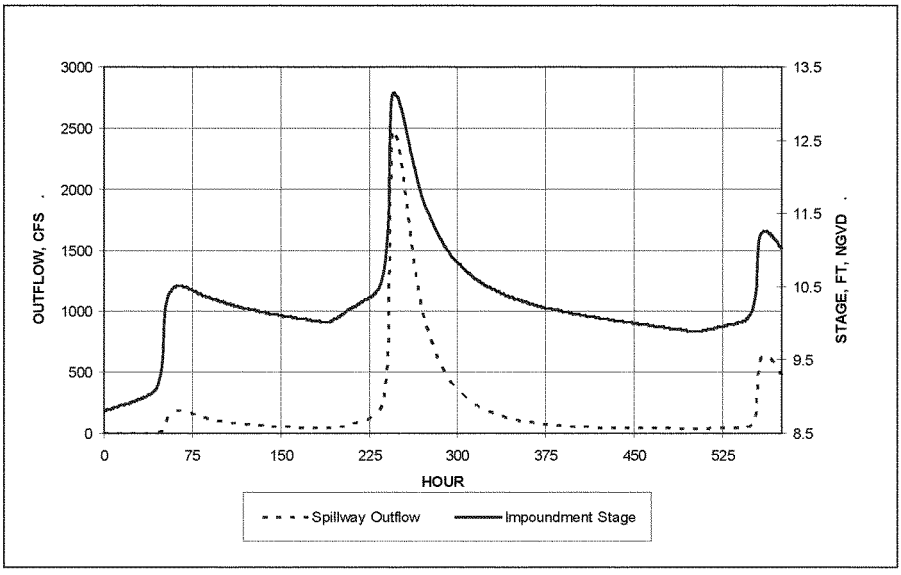


FIGURE A-24: 180% 72 HR PMF ROUTING FOR THE C-9 IMPOUNDMENT WITH SERVICE SPILLWAY (13 FT LONG) AND AUXILIARY SPILLWAY (150 FT LONG)

Another cost-effective alternative in performing the PMP analysis exactly as described in the DCM-2, which involved simulating gates as operable during dry periods in the Three Cycle Storms, was investigated. It was determined that the proposed gated structure, with a design capacity of 500 cfs, had a drawdown rate of 0.6 ft/day, which was sufficient to bring the impoundment stage back to normal pool elevation between storms. Therefore, the single PMP storm was performed using 5 crest lengths: 50, 100, 150, 200 and 250 feet (***Table A-41***).

TABLE A-41: C-9 IMPOUNDMENT EMERGENCY OVERFLOW SPILLWAY – SINGLE PMF ROUTING

Crest Length (ft)	Peak Height Above Spillway Crest (feet)	Peak IDF Pool Elevation (ft-NGVD)	Peak IDF Spillway Discharge (cfs)
50	2.70	12.80	878
100	2.49	12.59	1,321
150	2.36	12.46	1,714
200	2.26	12.36	2,075
250	2.18	12.28	2,404

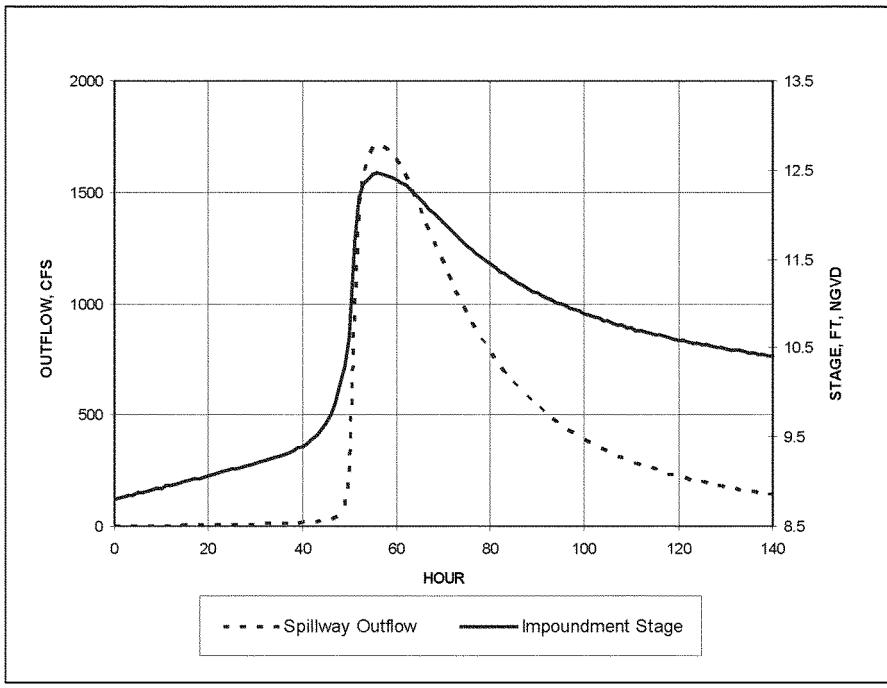


FIGURE A-25: SINGLE 72 HR PMF ROUTING FOR THE C-9 IMPOUNDMENT WITH SERVICE SPILLWAY (13 FT LONG) AND EMERGENCY SPILLWAY (150 FT LONG)

A.6.4.3.3 Fetch Length

A fetch length of 2.11 miles (11,150 feet) was used in calculating wind setup for the C-9 Impoundment.

Wind fetch is the distance or reach that wind travels uninterrupted over a body of water in a general direction. Fetches fall into two categories, open-water fetches where wave growth is limited only by the incident meteorological conditions, and restricted fetches where wave growth is limited by a confined geometry such as that of a lake, river, bay, or reservoir. The C-9 Impoundment is subject to a restricted fetch. The restricted fetch methodology applies the concept of wave development in off-wind directions and considers the shape of the basin. For this study, the wind direction is taken to be the direction corresponding to the maximum fetch distance. The fetch is defined as the radial average distance over an arc of 24 degrees centered on the wind direction. Measuring the longest reach and averaging that distance with multiple

directional rays within 12 degrees on either side of the reach is one method of calculating the wind fetch. The total 24-degree field allows for small inconsistency in wind direction and influence by partial wind/wave blockage from obstructions bordering the longest reach length. EM 1110-2-1414 provides an illustrated procedure of the method. The fetch length determined by this method was used only for wind setup calculations as the wind-wave numerical model accounts for fetch implicitly.

A.6.4.3.4 Design Wind Speed

For reservoirs carrying a High HPC, DCM-2 provides a "reasonable" wind speed equivalent to the 100-year wind speed for the location of the reservoir.

The wind speed applied over the reservoir's surcharged pool is that converted to a one-hour average speed for effective duration in the building of waves and design probable impact, with respect to wave impingement, on embankments. The one-hour average is considered conservative as durations of 3 to 4 hours are typically assumed for time of impact that embankments/levees are designed to withstand without loss of integrity (Partial Definite Project Report, Central and Southern Florida Project, Part I, Coastal Areas South of St. Lucie Canal). Shorter time averaged wind speeds were not considered for various reasons, among them is the "blowing the s off" phenomenon (sometimes related to "white-out" conditions), time for wave growth to reflect shorter bursts, and the empirical knowledge that indicates a lowering of the wind/water interface drag coefficient for wind speeds exceeding 90mph.

A.6.4.3.4.1 100-Year Return Interval Wind Speed

Determination of the 100-year wind speed at a site using the Florida Building Code (www.sbcci.org/floridacodes.htm, Section 1606 Wind Loads) begins with Figure 1606, which is reproduced herein as *Figure A-26*. The wind speeds on the figure are 3-second gusts in miles per hour that would be expected to occur at the standard reference height of 33 feet (10 meters) above the ground surface. The wind speeds are further identified as representing 50-year to 100- year peak gusts. The conservative assumption is to assume that the wind speeds on the figure represent 50-year wind speeds and convert the values to 100-year wind speeds, as shown in *Table A-42*. The equivalent 100-year wind speeds listed in the table use a factor of 1.07 to convert hurricane wind speeds from a 50-year to a 100-year return (American Society of Civil Engineers (ASCE) Table C 6-3, ASCE 2003). After conversion to a one-hour average, the design wind speed to be applied to the surcharge pool pre/post 36 hours from the peak was determined to be 113mph.

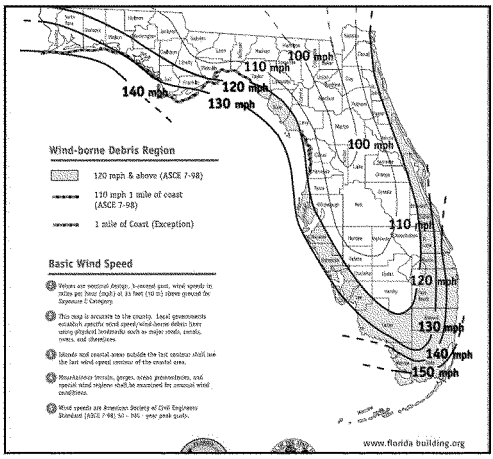


FIGURE A-26: FLORIDA 50-YEAR TO 100-YEAR GUST WIND SPEEDS (MPH)

TABLE A-42: WIND SPEED CONVERSION FACTORS BY RETURN PERIOD

RETURN PERIOD IN YEARS	CONVERSION FACTOR
500	1.23
200	1.14
100	1.07
50	1.00
25	0.88

A.6.4.3.5 Wind Setup

The wind setup for the 100-year wind speed of 113 mph, applied over the peak maximum surcharge pool depth of 8.65 feet (maximum surcharge stage of +13.15 ft-NGVD), is calculated to be 1.65 feet in accordance with DCM-2.

Air movement across the water leads to the development of shear stresses between the air and water interface, also referred to as an inducement of drag. The result of drag causes water to "pile up" against the shore or dam, creating the vertical uplift effect known as "wind setup". A corresponding decrease in water level will occur along the opposite shore; not as an equal offset, but as a convex curved surface where conservation of mass is preserved. The amount of wind set up is balanced between the opposing forces of wind generated drag and gravity induced return flow along the bottom boundary. This interaction creates a counter-intuitive effect whereby shallower bodies of water exhibit a higher degree of wind setup, i.e. shallower water "feels" more resistance to return flow than deeper water for identical contact area and roughness characteristic. For

wind setup models, the most sensitive parameter is wind speed--typically a squared term representing energy input into the system. Fetch has a mostly linear function and as is evident upon investigating setup equations. Stillwater depth differs in function between the models used in the analysis; however, it always appears in the denominator illustrating its inverse proportionality.

Three wind setup models were investigated for applicability to the reservoir, the Zieder Zee formula (USACE, 1990), the Sibul equation (Brater et al., 1996), and the Bretschneider numerical method (Ippen, 1966). The Zieder Zee formula is an empirical equation that was derived and based on deep long and narrow water bodies (fjords). The formula does not account for conservation of mass and therefore tends to over predict setup when applied to shallower water bodies, i.e. does not allow for an exposed bottom. Zeider Zee is considered a conservative alternative and is often used for this reason, as well for its simplistic and familiar (though inconsistent) units-type formulation. The Sibul equation, developed through laboratory experiments and tested with field data, has shown good correlation with data collected for large bodies of water such as Lake Okeechobee and the Baltic Sea. However, the Sibul equation appears to under predict wind setup in shallow water cases when compared with other generally accepted models. Trend curves produced by graphing wind setup results over a range of depths illustrate that the Bretschneider method approaches a mean value between Zeider Zee and Sibul's methods. Although Bretschneider's model does not a have a numerical solution for all conditions (using numerical solution table found in reference), the solution curve appears stable enough for extrapolation with confidence. These reasons as discussed are why DCM-2 recommends the use of the Breschneider model for wind setup calculations for shallow reservoirs.

A.6.4.3.5.1 Bretschneider's Model

The Bretschneider numerical method allows for exposed bottom and was derived for rectangular water body shape with constant depth and under steady-state conditions. Several researchers independently developed the differential form of the model that is based on surface and bottom shear stresses and conservation of mass. Saville verified its usage with data collected in studies by USACE on Lake Okeechobee in Florida. For the Lake, it was determined that wind shear stress per unit weight of water was proportional to the wind kinematic energy ($\tau_S/\rho g = 3.0\text{x}10^{-6}U^2/g$) and ratio of bed shear stress to wind shear stress was approximately an order of magnitude ($\tau_B/\tau_S \cong 0.1$). Combining these two stress factors qualitatively provides what is called the wind drag coefficient (κ). There is some ambiguity in assigning a value for the wind drag coefficient as it is not a true constant, especially under influence of winds speeds in excess of 90 mph where upon the stress appears to be reduced minimizing wind setup expectations. For the on-peak maximum surcharge pool this maybe trivial since

the design wind speed is 68 mph. However, for the surcharge pool 36 hours pre/post from the peak, this phenomenon may be significant since the design wind speed is higher at 113mph. Therefore, it is expected that the wind setup calculated under this pool state and wind speed is conservative, but unquantifiable as such.

Note, for an enclosed lake of regular shape (round versus rectangular with minor depth variations), the model takes on an integrated form with the unit-consistent "stress parameter" correlated with incremental section reach lengths. Recent work by Consultants under USACE contract have redone wind setup calculations for Lake Okeechobee using Bretschneider equations in their integrated form over incremental section reach lengths. Results showed minimal difference between wind setup values and when viewed from the scale of Lake Okeechobee to C-9 Impoundment, difference would be negligible and inconsequential.

A.6.4.3.5.2 Bottom Stress

Bottom shear stress acts as an opposing force that sustains potential energy gained by "piling" on the front slope of an embankment or dam. Therefore, bottom vegetation may play a significant role in determining wind setup as a contributor to bottom shear stress and is related to the depth parameter (Brater et al, 1996). Discussions with several biologists led to a consensual conclusion that reservoirs that fluctuate between dry conditions and normal pools on an annual basis, there will be little, if any, expected significant plots of permanent vegetation found within the reservoir. Since models show that C-9 Impoundment does dry out virtually every year for extended periods of time during the dry-season, the bottom was assumed smooth for all wind-wave analyses.

A.6.4.3.5.3 Wind-Wave Generation

As wind starts to blow over still water, developing wind stress at the air-sea boundary leads to the formation of small perturbations in the water surface. When the perturbations become large enough to affect the pattern of air flow a transfer of momentum and energy between the air layer and the water surface occurs, rapidly increasing wave heights. Wave heights build rapidly over a relatively short distance, increasing at a rate that varies dependent upon wind speed. Waves develop more quickly and with greater uniformity as wind speed increases. Wind waves, also known as oscillatory waves, are determined by five dominant factors: wind velocity or speed, distance over which the wind blows (fetch), duration of wind, decay distance the wave travels after leaving the generating area (not relevant to this study), and the water depth.

Wind driven waves are a highly complex mix of crests and troughs on the water surface, consisting of irregularly sized wave heights and moving in variable directions. Wave direction can be easily defined as an average of the directions of individual waves, but not so for wave heights. It has been found that the frequency of occurrence of waves above any given height can be closely approximated using the cumulative form of the Rayleigh distribution (USACES, 1984). This fact and resulting theoretical wave height distribution curves make it possible to determine average wave heights for a given percentage of waves based on a single significant wave height, H_s, defined as the average height of the one-third highest waves. The numerical model STWAVE provides wave heights in the form of significant wave heights.

A.6.4.3.5.4 STWAVE

The STWAVE numerical model developed by ERDC is considered to be the state-of-the-art wind-wave model for application to shallow reservoirs. There are other wind-wave models available e.g. SWAN; however, results generally are similar when compared. STWAVE is continually being updated as a favored platform by ERDC with additional abilities. For these reasons and those to be discussed following are why DCM-2 requires the use of the STWAVE model for final wind-wave calculations.

The STWAVE model is a two-dimensional spectral wave transformation model for the simulation of wave transformation over complex bathymetry. STWAVE accepts arbitrary directional wave spectra specified at an offshore boundary and propagates the spectral energy in the onshore direction. It is a finite-difference model, which calculates wave spectra on a Cartesian grid using a backward ray-tracing scheme (Smith et al., 1999). Model results, including spectral output, significant wave height, mean wave period, and wave direction, are obtained by numerically solving the steady-state spectral energy balance equation. The equation represents wave propagation (with refraction and shoaling) as being equivalent to that of source terms represented by distribution and dissipation of energy based on linear theory. Despite quantifying these source terms on an individual basis, they are solved via conservation of momentum flux to the forward and rear face of the spectrum where the energy is redistributed. However, the wave breaking source term dissipates energy based on water depth and wave steepness.

STWAVE has several inherent limitations. For the best application of the model to wave transformation problems, the following assumptions must be made: (1) mild bottom slopes, (2) negligible wave reflection, (3) spatially homogeneous offshore waves, (4) steady state waves, winds, and currents, (5) linear refraction and shoaling with negligible bottom friction effects, and (6) linear wave-current interaction. Due to the nature of the solution scheme, spectral energy is limited to propagation in a half-plane directed toward shore. All energy propagated offshore is neglected.

A.6.4.3.5.5 Wave Run-up

Wave run-up can be described as the resulting forward translation of water mass that is converted from wave energy as waves encounter a sloped surface. Water rushes up the slope resulting in the vertical rise above the still water line known as run-up. Run-up depends primarily on incident wave steepness, slope of the surface on which it is incident, and characteristics of the surface, including surface roughness and porosity. For a given fixed slope, run-up will increase with decreasing wave steepness. For a given incident wave height and period, run-up will increase with increasing slope steepness.

A.6.4.3.5.6 ACES

The ACES model was used to model wave run-up for the reservoirs and is recommended by DCM-2.

The ACES software package contains an application that provides for the estimation of wave run-up on rough and smooth impermeable surfaces. Five optional slope configurations were evaluated for this study: (1) a smooth (earthen, RCC, or soil cement) slope of 1V:3H, (2) a rough (riprap covered) slope of 1V:3H, (3) a rough (riprap covered) slope of 1V:2H, (4) a stepped (RCC) slope of 1V:3H, and (5) a smooth (RCC or soil cement) vertical wall.

A.6.4.3.5.7 ACES and COASTAL ENGINEERING MANUAL

Originally, two options based on preliminary cost-effectiveness, riprap 1V:3H and stepped RCC 1V:3H were selected for further cost evaluations. However, because of wave action, it was determined that native rock (i.e. limestone, portion having weathered characteristics) would be lacking in duration, thus requiring imported stone from out-of-state and increasing costs significantly. However, as a policy decision, both riprap and RCC steps (any vertical displacement greater than a few inches) are currently being removed from all embankment designs because of the adverse impact, environmentally, on native fauna, especially for turtles and migratory bird chicks. Stones and steps trap small animals that seek dry or higher ground, new territories, or other water bodies when draw-downs.

To optimize the embankments without the use of riprap or steps, the team looked at the alternative of constructing a wave break bench/berm on the waterside as an option. The wave break bench functions by causing the design wave to break and dissipate most of its energy prior to striking the higher slope of the embankment, thus reducing wave run up and consequential wave over-wash.

The ACES model was still used to determine wave run up and over-wash. The Coastal Engineering Manual (USACE, 2005) provides a means of optimizing the dimensions of embankments with wave bench features. Using this methodology, a range of wave bench dimensions was evaluated. *Table A-43A* provides the bench dimensions and minimum embankment crest elevations required to meet the 0.10 cfs/lf criterion. Embankment elevations were rounded to the nearest 0.5 feet for constructability.

A.6.4.3.5.8 Effective Depth

Although the generation of wind waves (and therefore wave run-up and over-wash) is influenced by the presence of wind setup, the relationship is highly complex and is not presently included in the STWAVE model. Therefore, in order to include the total water level increase due to wind conditions at the down-fetch face of the levee, wind setup is generally accounted for by adding the wind setup to the design water depth at the toe of the structure. The resulting "effective depth" then becomes the water depth used during calculation of wave run-up and subsequent over-wash.

A.6.4.3.6 Wave Over-wash

Over-wash occurs when wave run-up reaches the crest of the embankment producing a dynamic water level greater than the crest. Over-wash may occur as spray and wave surge, including combination thereof. Over-wash is an important design element both in terms of predicting backside flooding and safeguarding structural integrity of the levee. Several methods exist for predicting the over-wash flow rate in a given situation. The ACES software package contains two methods, one for monochromatic wave over-wash as developed by Weggel (1976), the other for irregular wave over-wash developed by Ahrens (1977). Due to the irregular nature of the developed wave fields, Ahrens method was selected for this analysis.

Ahrens over-wash method was developed with the following assumptions: (1) run-up values created by an irregular wave field will follow a Rayleigh probability distribution, (2) significant deepwater wave height, H_s, causes significant run-up R_s, and (3) α, Q^*_o, and H_o in Weggel's over-wash equation remain constant for all members of the distribution. Ahrens estimates the over-wash rate by summing the over-wash contributions from each individual member of the run-up distribution over 199 elements. Ahren's equations modify Weggel's monochromatic expressions to account for the effect of irregular waves when freeboard, F, is less than the run-up of the significant wave, R_s. When the freeboard is greater than the run-up, Weggel's equation yields no over-wash while larger run-ups in the distribution may still overtop the structure. For these relatively high freeboards, the run-up distribution is broken into 999

elements, instead of 199, to better account for the effect of the higher run-ups. The over-wash equation for this larger distribution becomes:

$$Q = \frac{1}{999}\sum_{i=1}^{999} Q_i$$

where

Q = volume rate of over-wash caused by irregular waves ($ft^3/s - ft$)
Q_i = volume rate of over-wash caused by one run-up on the run-up distribution.

A.6.4.3.6.1 Acceptable Wave Over-wash Rate

Firm guidance for an acceptable over-wash rate is, as pertaining to C-9 Impoundment project conditions (and CERP in general), not available. The DCM-2 does not provide this design parameter as it is the designer's choice to make as they are the one to weigh all options and alternatives and finally make a sound engineering judgment based on all literature research, information received, data calculations, analyses results, observed field data, and risk assessments.

A.6.4.3.6.2 Literature Research and Information Received

USACE ER 1110-8-2(FR) states that "Zero over-wash is not always required under infrequent high pool conditions." Noting that C-9 Impoundment does not have a gravity fed watershed upstream of the reservoir as the impoundment is entirely aboveground and all inflow is pumped; only rainfall contributes to the high pool conditions. Therefore, high pools in themselves are directly related "in part" by infrequent design storm events, the 10,000-year return frequency PMP event for C-9 Impoundment. The other directly related "part" is the design wind speed of 68mph (on-peak max surcharge pool) and 113mph (36 hours pre/post peak surcharge pool) assumed over a one-hour average wind speed. Typically, hurricanes drop less than the 100-year rain event; however, some do.

USACE Coastal Engineering Manual provides guidance in over-wash rates based on Netherlands research (Technical, TACFD). This guidance provides as an acceptable over-wash rate of 0.001 cfs/lf of levee for non-cohesive soils. However, wind duration producing the over-wash is unknown; also unknown are any other factors that may have a bearing on such recommendation. For example, with zoned-embankment dams, the outer rock-fill consisting of gravel size material may self-armor during over-wash events. South Florida sands may contain a significant amount of limestone grains that possess cementitious characteristics (i.e. binding comparable to a non-cohesive likeness).

Research performed by USDA Agricultural Research Service is almost exclusively steady-state flow experiments on embankments, or hydraulic

overtopping. Although this type of overtopping flow is not expected to occur with any CERP reservoir, use of steady flow research to account for the "mean" value of over-wash was suggested. However, regarding soil erosion, it is well known that strongly dynamic surge (unsteady) flows cause a higher rate of soil material entrainment than steady flows. For this reason, it was USACE decision that the dynamics of wave over-wash in how surges rush over the downslope may be misleading and should not be used to prevent confusion.

A.6.4.3.6.3 Data Calculations and Analyses Results

Expressed in the preceding note 3 is the dynamic characteristic of wave over-wash. Means to calculate soil erosion under this condition could not be performed for a couple of reasons. First reason is the lack of consistency of the material that led to inability to describe it thoroughly enough to apply known fundamental sediment transport equations. The predominant limestone material can be sandy, rocky, hard, weathered with an unknown "mechanical" reaction to water flow when wet (referring to application of known equations). Another reason is that available unsteady flow models investigated do not have time steps small enough to capture wave dynamics at a scale of a hydraulically rough downslope and very shallow supercritical flow.

A.6.4.3.6.4 Observed Field Data

The need to justify a wave over-wash rate is common to all CERP reservoirs. Another project, the Everglades Agricultural Area Reservoir (EAA) is a much larger project where one-foot of embankment conceptually costs $25,000,000 (the report from this field demonstration can be found in the Supporting Documentation Section). This cost figure led to many discussions over acceptable over-wash rates as cost-effectiveness became a prime concern to both agencies. To better understand wave over-wash rates and their impact on embankments backs slope, Consultants for SFWMD performed a field test utilizing a test cell embankment to represent true scale data and results. The embankment had a zoned limestone rock-fill exterior slope that would encounter the first of over-wash erosive impacts (bare surface, no vegetation). Flow over the embankment was originally to be steady-state; however, irregularities in the field provided a truer test that would enable assessment of extreme conditions that real wave over-wash may be seen.

The test covered 4 rates of flow: 0.001 cfs/lf, 0.01 cfs/lf, 0.1 cfs/lf, and lastly 0.23 cfs/lf (maximum the equipment set up could force) and lasted 8 hours at each rate. The manifold-pipe had 2 rows of adjustable nozzles that were trained downward onto a metal pan to direct flow down the slope. However, pan irregularities (equipment or placement thereof in relation to nozzles) actually created a forced spray from 1 set of nozzles down the top half of the slope, essentially simulating spray from an over-wash event. For other set of nozzles,

irregularities caused more concentrated flows than the uniform across flow that was originally intended. Between the forced spray over the top half of the slope and the non-uniform concentrated flow leaving the apparatus; it was deemed a successful experiment in that it executed the test runs better than expected.

Results from the test demonstrated that the "mechanical" characteristics of the material allowed self-armoring to occur during exposure to the erosive flows. After 8-hours of the 0.1 cfs/lf (note that flows were concentrated, so actual rate was higher), the deepest encroachment into the embankment was less than a foot with a running length of about 6 feet tapering more shallow at the lower end. Little head-cutting at the toe (change of slopes) was observed, maximum was estimated to be about a foot and half drop with majority of the toe unscathed.

A.6.4.3.6.5 Established Acceptable Over-wash Rate

Based mostly on observed field data from the EAA test cell, a project that contains the same construction material for embankments that C-9 Impoundment has, same cross-section geometry, and the same zone embankment concept, the acceptable over-wash rate is 0.10 cfs/lf of embankment.

A.6.4.3.6.6 Results of Wind-Wave Analyses

The results of the wind-wave analyses can be seen in *Table A-43* with embankment armoring and embankment slope alternatives investigated.

A.6.4.3.6.7 Selected Embankment Height and Final Design

The design embankment height for C-9 Impoundment is the greater between a minimum freeboard of 5 feet (High HPC) and that that assures failure will not occur as a result from wind setup, wave action, and uncertainties in analytical procedures and project function in combination with the application of a 100-year wind speed over the PMF maximum peak surcharged pool.

The selection of an embankment height that ensures structure integrity under design conditions is dependent on three variables that have a significant impact on wave run up and consequential wave over-wash: (1) waterside slope of the embankment, (2) configuration if other than a simple straight smooth slope (in this case a wave break bench), and (3) type of armor to be placed to protect the embankment from impinging waves. Therefore, the process of selecting the most cost effective design is an iterative exercise between the three. At time of writing, two alternatives for the embankment exist both requiring detailed cost

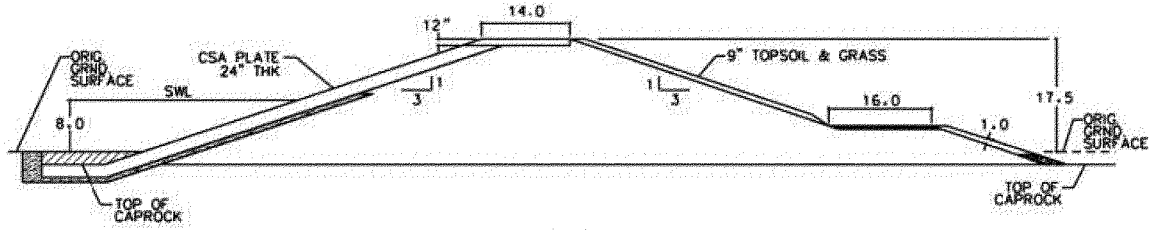
estimates for final selection, Alt-HI (higher smooth slope embankment) and Alt-WB (lower slope embankment that includes a wave break bench in its configuration.

The design embankment is a simple straight smooth 1-on-3 slope that is 15.0 feet high above the calculated average existing grade of the project area. The waterside slope is armored with a 24" thick CSA Plate from toe to crest. The crest is armored with a 12" thick CSA Plate, 14.0 feet wide. This embankment design limits the over-wash rate to 0.677 cfs/lf (based on a distributed wave analysis, NOT an average rate of overwash as is commonly used to denote relative resistance capability) under DCM-2 defined design storm events. The minimum Federal standard freeboard for this reservoir is 5 feet above the maximum surcharge pool, or 4.3 normal full pool + 4.35 foot surcharge pool + 5.0 foot freeboard equals an embankment height of 13.65 feet. Therefore, the design that meets project requirements is the 15.0 feet high embankment with a crest elevation of 19.5 ft-NGVD (average existing grade is 4.50 ft-NGVD). The landside of the perimeter embankment will be grassed and maintained for rainfall runoff erosion protection. See *Table A-43* for final analysis results. See ____ on the overwash analysis for the C-9 Impoudment embankment.

The design of the D-509 embankment for the C-9 Impoundment will be optimized under detailed design. Under detailed design, an analysis of a proposed vegetated wave bench will be considered. The vegetated wave bench proposed to reduce wave action on the levee and address the potential elimination armoring on the interior or waterside of the embankment. The proposal is a 50 – 100 ft bench with Bulrush and Cattail planted on the bench.

TABLE A-43: WIND-WAVE ANALYSIS

Case	Still Water Depth (ft)	Wind Speed (mph)	Wind Setup (ft)	Effect. Depth (ft)	Signif. Wave Ht (ft)	Wave Per (sec)	Slope Type	Runup (ft)	Overtopping according to Levee Height (ft^3/s-ft) ; Natural Grade = 4.50 ft NGVD										
									13ft	13.5ft	14ft	14.5ft	15ft	15.5ft	16ft	16.5ft	17ft	17.5ft	18ft
4.3ft Normal Pool	8.65	113.1	1.56	10.21	4.56	4.3	Smooth 1:3	6.94	2.537	1.865	1.351	0.964	0.677	0.468	0.318	0.211	0.138	0.094	0.060
							Rough 1:3	4.13	0.726	0.388	0.197	0.101	0.047	0.021	0.008	0.000			
							Rough 1:2	5.21	1.547	0.977	0.599	0.357	0.205	0.121	0.066	0.035	0.018	0.009	0.000
							Stepped 1:3	4.82	1.002	0.607	0.355	0.200	0.108	0.060	0.031	0.015	0.007	0.000	
							Stepped 1:1.5	7.49	2.957	2.213	1.635	1.192	0.858	0.609	0.425	0.293	0.198	0.132	0.092
							Vertical Wall	5.56	1.352	0.859	0.533	0.322	0.189	0.107	0.064	0.035	0.019	0.009	0.005



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A.6.4.4 Internal Spoil Mounds

In the Draft PIR as a High HPC, internal spoil mounds were designed to reduce fetch lengths that add to wind setup and wind-wave growth, when combined adding to required embankment heights. However, detail wind-wave analyses demonstrated that they were only slightly effective for this purpose and not cost-effective for project inclusion. Therefore, this feature has been deleted from the design altogether. Also, it has come to USACE awareness the impact that nesting migratory birds may have that can interfere with operations intended and needed to realize claimed project benefits. Because of this awareness, internal spoil mounds are undesired as they would pose as an attractant for migratory bird nesting. Therefore, these mounds are now removed from any further consideration, as well as incorporating a grading plan that can be executed cost effectively to remove high points as much as possible to do so.

A.6.4.5 Revetment

The interior or waterside slope of the perimeter D-509 Embankment will be armored with a 24" thick CSA Plate. The crest will be armored with a 12" thick CSA Plate. The exterior or landside of the perimeter embankment will be grassed and maintained for rainfall runoff erosion protection.

A.6.5 Water Control Structures

A.6.5.1 Pump Stations

A.6.5.1.1 S-509 Inflow Pump Station

S-509 Pump Station has a total design pumping capacity of 1,075cfs—1,000cfs for inflow pumping and 75cfs for seepage return pumping. The pump station is located on the southern boundary of the reservoir on the C-9 Canal (see ***Plate S-17***). The pump station is designed to capture available stormwater runoff in the C-9 Basin and diverted water from the C-11 Impoundment (Western C-11 Basin), and to return pump seepage intercepted by the C-9 Canal and C-509 perimeter seepage canal conveyed to the C-9 Canal.

S-509 Pump Station has five bays that include four 250cfs diesel engine driven pumps and one 75cfs electric motor driven pump. All diesel pumps may be used simultaneously for maximum runoff capture or receiving diverted water from C-11 Impoundment. The 75cfs and one 250cfs pumps can be used to return pump seepage and maintain C-9 Canal level during non-runoff event times. For operational flexibility any combination of pumps can be used to maintain optimum canal levels (see ***Plate S-18***).

A.6.5.1.2 S-512A Seepage Pump Station

S-512A Pump Station has a design pumping capacity of 225cfs. The pumping capacity was based on SEEP2D modeling results with a safety factor of 1.5 applied. The pump station is located on the eastern boundary of the reservoir, midway between the northern and southern boundaries. The pump station is designed to return pump seepage intercepted by the C-509 Seepage canal eastern reach to maintain an optimal stage of 3.00 ft-NGVD (see *Plate S-22*).

S-512A Pump Station has three bays that include three identical 75-cfs electric motor driven pumps.

A.6.5.2 Gated Culverts and Spillways

A.6.5.2.1 S-510 Gated Culverts

S-510 Gated Culverts is a double-barreled, gated culvert structure. The design flow is 500 cfs with a 0.93-foot hydraulic head differential. The structure is located on the southern boundary of the reservoir in near vicinity of the S-509 Pump Station and discharges into the C-9 Canal. The structure controls releases from the reservoir to drawdown the storage pool, to meet water demands and/or maintain optimal canal stages.

Culvert barrels are 8-foot diameter (or equivalent box culverts) and are 75 feet in length. Barrel inverts are set at elevation –6.00 ft-NGVD (see ***Plate S-19***).

A.6.5.2.2 S-511 Gated Culverts

S-511 Gated Culverts is a double-barreled, gated culvert structure. The design flow capacity is 500cfs with a 0.90-foot hydraulic head differential. The structure is located in the C-9 Canal just east of the southeastern corner of the reservoir. The structure functions as a canal divide. The gate position is dependent on the feature operational mode. Scenarios given include the following: (1) when water is released from Impoundment into the C-9 Canal, the gate may be opened fully or partially to move water to the east if desired, but would be closed if water was to move south by way of C-502B Canal west of US 27 through the existing S-30 Gated Culverts structure, (2) during storm runoff events, the gate may be opened fully or partially that would benefit pumping of the C-9 Basin with or without simultaneous diversion operations from the C-11 Impoundment. Additionally, the structure will include a manatee barrier to prevent manatees from migrating further west up the C-9 Canal.

Culvert barrels are 8-foot diameter (or equivalent box culverts) and are 60 feet in length. Barrel inverts are set at elevation –5.50 ft-NGVD (see ***Plate S-21***).

A.6.5.2.3 S-512B and S-512C Flap-Gated Culverts

S-512B and S-512C Flap-Gated Culverts are triple barreled, gated culvert structures. The design flow capacity is 150cfs with a 0.25-foot hydraulic head differential. The structures are co-located with the S-512B and S-512C Weirs, respectively, at the southwestern and southeastern corner boundaries of the reservoir in the C-509W and C-509E Seepage canals, respectively. The structures have two functions: (1) prevent backflow up the C-509 Seepage Canals when C-11 Impoundment diversion operations are being performed and (2) provide access across the C-509 Seepage Canal to the Impoundment and C-9 levee bank road.

Culvert barrels are 6-foot diameter (or equivalent box culverts) and are 40 feet in length. Barrel inverts are set at elevation –3.00 ft-NGVD (see ***Plate S-23***).

A.6.5.3 Weirs and other Water Control Structures

A.6.5.3.1 S-510A Emergency Overflow Spillway

The S-510A reservoir service and auxiliary overflow spillway is a non-gated spillway located near the southwestern boundary and will discharge into the C-9 Canal (see ***Plate S-20***). The spillway's purpose for a High HPC reservoir is to protect embankment integrity by prevention of hydraulic or excessive wave overtopping in case of an incalculable event, succeeding extreme storm events, or mis-operation of the pump station that could place the reservoir's embankments at risk of failure. The design service spillway crest length was calculated to meet--without exceeding--the basin permitted discharge rate for the 25-yr 3-day design event in accordance with SFWMD's "Basis of Review for Environmental Resource Application with SFWMD, Feb. 2006." The maximum spillway discharge that occurred by routing the Probable Maximum Precipitation (PMP) event was approximately 425 cfs.

The service spillway crest is set at 8.80 ft-NGVD or at the normal maximum full pool level and is 13 feet in length. The auxiliary spillway crest is set at 10.10 ft-NGVDand is 50 feet in length.

A.6.5.3.2 S-512B and S-512C CIT Weirs

S-512B and S-512C Weirs are non-gated broad crested weir structures based on California Institute of Technology (CIT) design parameters. The design flow capacity is 150cfs with a hydraulic head of 0.70 feet. The structures are co-located with the S-512B and S-512C Flap-gated Culvert structures, respectively, at the southwestern and southeastern corner boundaries of the reservoir in the C-509E and C-509W Seepage Canals, respectively.

The S-512B structure will allow excess seepage that is discharged into the C-9 Canal to be return pumped into the reservoir with the S-509 Pump Station. The structure limits drawdown effects upstream of the weir with a control stage between 4.40 ft-NGVD and 5.10 ft-NGVD during S-509 pumping operations. The seepage canal's control stage benefits seepage reduction from the WCA-3B, 3B SMA, northern boundary mitigation area and the reservoir.

The S-512C structure will provide emergency relief of excess stages in the eastern C-509 Canal reach should the S-512A Pump Station experience a power outage temporarily. Separation between normal operations of the C-9 Canal and the C-509E Seepage Canal is desired to maintain the C-509E Seepage Canal at optimal stage for seepage control of the reservoir.

The weir crest elevations are set at 4.05 ft-NGVD and are 90 feet in width. The weirs are corrugated in shape with 10-foot sides (see ***Plate S-23***).

A.6.6 Existing Structures

A.6.6.1 S-30 Gated Culverts

S-30 Gated Culvert structure is a triple-barreled structure. The structure is located on C-9 Canal and serves as a bridge for US 27. The structure is used to release excess water from the Everglades Buffer Strip (3B SMA) and on rare occasions allow excess C-9 Basin water to route as reverse flow through to C-6 Canal for flood control (via L-33 Borrow to S-32 Gated Culvert). Under the Selected Plan, the structure will provide control for maintaining seasonal water levels in 3B SMA and water diverted from Western C-11 Basin to the C-9 Impoundment. The barrels are culverts with 7-foot diameters (288 feet in length).

A.6.6.2 S-29A Gated Spillway

S-29 Gated Spillway is a four-bay spillway with a design flow of 4,780 cfs. The structure is located in the City of North Miami Beach near the mouth of the C-9 Canal and about 500 feet from the shore of Lake Maule. The structure maintains optimum water control stages upstream in C-9 Canal and is able to pass the Standard Project Flood (SPF). The optimum control stage as measured at S-29 is 2.00 ft-NGVD for normal operations to prevent coastal saltwater intrusion. The structure weir crest elevation is set at –11.00 ft-NGVD with gate dimensions of 15.0 feet high by 22.8 feet wide.

A.6.7 Embankments

A.6.7.1 D-509 Embankment

The D-509 Embankment is the reservoir's embankment structure that allows the normal maximum storage of water up to 4.3 feet deep safely under all design conditions as prescribed in DCM-2.

The embankment is a simple straight smooth 1-on-3 slope that is 15 feet high above the calculated average existing grade of the project area. The waterside slope is armored with a 24" thick CSA Plate from toe to crest. The crest is armored with a 12" thick CSA Plate, 14.0 feet wide. This embankment design limits the over-wash rate to 0.677 (based on a distributed wave analysis, NOT an average rate of overwash as is commonly used to denote relative resistance capability) under DCM-2 defined design storm events. The minimum Federal standard freeboard for this reservoir is 5 feet above the maximum surcharge pool, or 4.3 normal full pool + 4.35 surcharge pool + 5.0 feet freeboard equals an embankment height of 13.65 feet. Therefore, the design that meets project requirements is the 15 feet high embankment with a crest elevation of 19.5 ft-NGVD (average existing grade is 4.50 ft-NGVD). The landside of the perimeter embankment will be grassed and maintained for rainfall runoff erosion protection.

The embankment height was designed in accordance to DCM-2 and meets USACE Engineering Regulations. Refer to the Embankment Height Analysis Section for specifics in how the height was determined for design.

TABLE A-44: C-9 EMBANKMENT AND LEVEE DESIGN PARAMETERS

Embankment and Levee	Length	Side Slope	Top Width	Average Ground	Top of Levee	Levee Height
	feet	1V on ?H	feet	ft-NGVD	ft-NGVD	feet
D-509	35,030	3.0	14	4.50	19.5	15.0

A.6.8 Canals

The C-9 Impoundment project includes seepage canals that also provide borrow for embankment construction fill requirements. Therefore, generally speaking, the canals are over designed for seepage conveyance requirements.

A.6.8.1 Seepage Canals

The Impoundment will include two seepage canals, one aligned along the eastern boundary, C-509E and one aligned along the western boundary, C-509W.

A.6.8.1.1 C-509E Seepage Canal

The C-509E Seepage Canal is the reservoir's eastern perimeter seepage interception canal and is located along and parallel to the northern and eastern D-509 Embankment. The S-512A Pump Station located on C-509E return pumps excess collected seepage from this canal when canal stages are higher than 3.0 ft-NGVD. The S-512C Weir and Culvert structure located on C-509E at the confluence with the C-9 Canal provides secondary control should the S-512A Pump Station fail. Should loss of power or other mechanical failure occur, excess seepage will begin to overflow the S-512C Weir at stage 4.05ft-NGVD. This will prevent impacts to developed areas located to the east of the impoundment. Backflow up the seepage canals from high stages expected with floods collected in the C-9 Canal is prevented with the S-512C Flap-gated Culvert.

A.6.8.1.2 C-509W Seepage Canal

The C-509W Seepage Canal is the reservoir's western perimeter seepage interception canal located along and parallel to the western D-509 Embankment. This seepage canal is controlled at an elevation of 4.05 ft-NGVD by the S-512B Weir and Flap-gated Culvert located on C-509W at the confluence with the C-9 Canal. Backflow up the seepage canals from high stages in the C-9 Canal expected with diversion of C-11 Basin water operations is prevented with the S-512B Flap-gated Culvert.

TABLE A-45: C-509W SEEPAGE CANAL DESIGN PARAMETERS

Canal and Reach	Length	Bank Side Slope	Bottom Width	Average Ground	Canal Invert
	feet	1V on ?H	feet	ft-NGVD	ft-NGVD
Eastern					
C-509E	14,550	3.0	20.0	4.5	-8.00
Western					
C-509W	10,255	3.0	20.0	5.5	-8.00
All Canal Totals	24,805				

Average ground elevations based on LIDAR data

A.6.9 Instrumentation

All controllable structures are equipped for remote operation. Operational SCADA equipment, five groundwater monitoring sites, water quality monitoring sites and geotechnical instrumentation to monitor the operational safety of project features at the reservoir and wetland mitigation area have been identified. Associated instrumentation costs have been included in the cost estimate.

TABLE A-46: C-9 IMPOUNDMENT OPERATION INSTRUMENTATION

Number	Structure	capacity (cfs)	Type	Pump Mix or Number of Gates	Water Surface, Gate & Precip Parameters	MOSCAD Type (light, regular)
S-509	Pump Station	1,000	NC	4x250D,75E	H,T,P	R
S-510	Gated Culverts	500	NC	2	2xG	(S-509)
S-510A	Non-gated Spillway	450	FC			
S-511	Gated Culverts	500	FC	2	H,G (S-509H)	L
S-512A	Pump Station	225	SC	3x75E	H (S509T)	R
S-512B	Weir, Flapgated Clv	150	SC	3	0	
S-512C	Weir, Flapgated Clv	150	SC	3	0	

Type Legend:
WS = Water Supply
NC = Normal Control
FC = Flood Control
SC = Seepage Control
WSC = Water Surface Elevation Control
MA = Maintain Access

Water Surface Parameters:

H = headwater
T = tailwater
P = Precip
Position Sensors
G = Gate

TABLE A-47: C-9 IMPOUNDMENT WATER QUALITY INSTRUMENTATION

Number	Structure	capacity (cfs)	Type	Pump Size Category	Water Quality Sampling Equipment
S-509	Pump Station	1,000	NC	medium	AS, GB
S-510	Gated Culverts	500	NC		AS, GB
S-510A	Non-gated Spillway	450	FC		GE
S-511	Gated Culverts	500	FC		
S-512A	Pump Station	225	SC	small	
S-512B	Weir Flapgated Culvert	150	SC		
S-512C	Weir Flapgated Culvert	150	SC		

Water Quality Parameters:
AS = Auto-Sampler
GB = Grab, nutrients--bi weekly
GF = Grab, nutrients--normal ops flow
GE = Grab, nutrients--emergency flow

A.6.10 Project Management

A.6.10.1 Project Access

The main access to the C-9 Impoundment, top of embankment, and major structural features (i.e. S-509 inflow pump station and S-510 discharge spillway) is from the southwestern corner off of US 27 over the S-512B culvert structure, just north of the C-9 Canal along the canal's levee bank road.

An alternate access to the Impoundment, top of embankment, and major structural features is from the northern boundary where the S-512A seepage pump station is located. This location can be reached from SW 196th Avenue off Pines Boulevard.

A.6.10.2 Clearing and Grubbing

The C-9 Impoundment will require clearing and grubbing of embankment, levee and canal alignments. The reservoir interior will also be cleared of trees and woody vegetation that have the potential to die due to root submergence and fluctuating water levels. Dead trees and vegetation may present a safety issue if not removed and left to float, accumulate, and/or jam control structures, making gates inoperable or ineffective. Biodegradable materials can be chipped and spread or stacked and burned. Clearing limits of the reservoir shall be the full project footprint. Possible reductions to the clearing requirements will be investigated during the design phase. Grubbing will only be performed along the embankment and seepage canal alignments. The cost estimate for clearing was based on using mechanical cutting/bulldozing with burn method.

There are two to three sited infrastructures located within the impoundment boundaries. These structures will require demolition, removal and disposal. Aboveground utilities will be disconnected, removed and disposed of accordingly.

A.6.10.3 Construction Order

No specific construction order is apparent at this time. It is anticipated that C-9 Impoundment features could be constructed concurrently.

A.6.10.4 Disposal

The feasibility level design phase has demonstrated that a material balance can be achieved on-site and that off-site disposal sites may not be required. There are no known on-site borrow pits that can be partially backfilled with excess material to create viable fish refuge habitat, but there are two sites just to the north of the reservoir. Off-site disposal areas may need to be utilized if other features within the BCWPA project cannot use the excess material.

A.6.10.5 Relocations

A utility corridor exists on the west side of US 27 along the western edge of the US 27 Right-Of-Way and is expected to be within the 70' setback from US 27. Electrical and telephone utilities inside the impoundment will be abandoned and removed.

A.6.10.6 Surveying Requirements

A survey scope of work was developed for the C-9 Impoundment design region. Associated surveying costs have been included in the cost estimate.

A.6.10.7 Special Studies

A.6.10.7.1 S-509 Inflow Pump Station Location

The Comprehensive Review Study operational plans for the C-9 Impoundment (known in the Restudy as the C-9 Impoundment) and North Lake Belt Storage Area (NLBSA) are systematic and described as follows. Urban runoff would first be conveyed to the NLBSA for storage (2,500 cfs), and then later pumped from the NLBSA into the C-9 Impoundment (1,000 cfs) for settlement. After settlement, the water would then be distributed to assist in meeting water supply demands. However, there is an interim period between C-9 Impoundment and NLBSA construction. The C-9 Impoundment and NLBSA scheduled completion years according to the Master Implementation Sequencing Plan 1.0 (MISP 1.0) are 2010 and Band 5 (2025-2030), respectively. This 20-year span dictates that the C-9 Impoundment functions as a reservoir prior to the construction of NLBSA. The current project design incorporates the S-509 Pump Station (1,000 cfs) at the C-9 Impoundment to pump diverted runoff from the C-11 Basin and urban runoff from the C-9 Basin into the C-9 Impoundment directly without use of the NLBSA.

Several factors were considered in locating the S-509 Pump Station at the C-9 Impoundment site instead of a NLBSA site and they are described as follows:

The primary reason is the inconsistency of using a pump designed for a total hydraulic lift of 10.5 feet (without NLBSA) and one with approximately 25 feet (with NLBSA). There is a mechanical horsepower difference that may require the use of different motors for the pumps.

There is a structural difference of 10 feet for planned intake depth requirements.

Locating the pump station for the NLBSA site may be inconsistent with the final design which depends on the rock mining schedule and other unforeseen difficulties in the 17-year interim time span.

Life cycles for pumps are similar to the 17-year difference in construction schedules. A more economical and efficient pump station at the C-9 Impoundment site may over the project life span be a better investment for this feature.

The concerns with constructing the pump station at a NLBSA site when it is contingent on an unauthorized project to be constructed 20 years later are many. Therefore, the recommended design sites the pump station at the C-9 Impoundment.

A.6.10.7.2 C-9 Canal Improvement

The embankments for the reservoir will need construction material that may be acquired from the adjacent C-9 Canal versus the interior of the project footprint. The C-9 Canal may be improved from the current capacity of 600 cfs as rated by S-30 Gated Culvert structure to accommodate the larger required capacity of 2,500 cfs necessary when NLBSA comes on-line under the 2050 With Project plan. Although the current reservoir design requires 1,000 cfs maximum conveyance to accommodate the inflows from the S-509 Pump Station and S-510 Gated Spillway the S-30 structure and C-9 Canal are able of conveying that flow requirement under greater hydraulic head without risk to existing feature failure.

TABLE A-48: C-9 CANAL IMPROVEMENT

	Length	Inside Slope	Outside Slope	Bottom Width	Average Ground	Canal Invert	Canal Cut Depth
	feet	1V on ?H	1V on ?H	feet	ft-NGVD	ft-NGVD	feet
C-9 Improvement	5,065	1.0	1.0	50.0	5.0	-16.5	21.5
Existing C-9 Canal	5,065	1.0	1.0	20.0	5.0	-11.0	16

Average ground elevations based on LIDAR data

A.6.10.7.3 Additional information included in Draft PIR

The Comprehensive Review Study proposed gravity flow up to 2500 cfs as part of the C-11 western basin diversion of stormwater runoff to the North Lake Belt Storage Area (NLBSA). Currently, however, the C-9 Canal capacity from US 27

downstream is approximately 560 cfs as measured at the C&SF S-30 structure. The relatively large increase in required capacity necessitated an enlargement of C-9 Canal from US-27 to the projected location of the NLBSA inflow spillway, approximately a mile. In the interim period between the construction of the C-9 Impoundment and the NLBSA, a limited flow capacity of 1000 cfs will be utilized for direct pumping into the C-9 Impoundment from the C-9 Canal.

The C-9 Canal improvement is constrained by a north bank slightly above the existing grade of 4.5 ft-NGVD and by a non-paved rock quarry access road on the south bank. The access road will be relocated between 40 and 60 feet farther south to allow space for canal enlargement. The canal bottom elevation will require deepening from approximately –11.0 to –16.5 ft-NGVD. The operating canal stage will be controlled at a higher elevation of 4.00 ft-NGVD (versus existing 3.0 ft-NGVD) without downstream impacts with construction of the proposed gated divide structure S-511. The canal bottom width will be increased from approximately 20 feet to 50 feet. The canal stages derived from backwater calculations during maximum flow are given as follows: 4.00 ft-NGVD at S-30 and 3.7 ft-NGVD at the project location of the NLBSA inflow spillway. With the preceding modifications, maximum flow capacity to the NLBSA inflow spillway creates a canal flow velocity not exceeding 2 fps.

In the interim period between the construction of the C-9 Impoundment and the NLBSA, the C-9 Canal control stage may be modified dependent on operating conditions and set guidelines. This flexibility is afforded by the construction of the gated divide structure S-511 in the C-9 Canal. When C-11 diversion flows are being delivered to the C-9 Impoundment, S-511 may be closed if flow rates are creating excessive stages in the C-9 Canal. If diversion flows are not being made or are not triggering closure of S-511, then S-511 may remain and allow the pumping of the western C-9 Basin runoff into the C-9 Impoundment until the NLBSA is constructed and on-line. Upon construction of the NLBSA, western C-9 Basin runoff will be pumped directly into the NLBSA.

A.6.10.7.4 C-9 Conveyance Canal

TABLE A-49: C-9 IMPOUNDMENT – C-9 CONVEYANCE CANAL IMPROVEMENTS

C-9 Impoundment - WPA Feasibility Study
C-9 Canal Conveyance Improvement

Discharge Q =	2500	cfs
HW Station =	5100	feet
TW Station =	0	feet
Length =	5065	feet
Average Nat Grd =	4.50	ft, NGVD
Headwater El=	4.00	ft, NGVD
Tailwater El=	3.70	ft, NGVD
Average WSEl =	3.85	ft, NGVD
Delta H =	0.3	feet
E.G. Slope =	0	
Slope =	0.000059	
Slope ^0.5 =	0.00766965	
Conveyance Req'd =	325,960	Target Conveyance
Left Side Slope 1 on =	1	
Right Side Slope 1 on =	1	
Trial Depth =	20.35	ft
Trial Bottom Width	50	

Water Depth	Conveyence for Manning's n n = 0.03	n = 0.035	n = 0.04	Vel fps	Bottom Elev ft,NGVD	Ground Topwidth feet	WS Topwidth feet
19.60	372,401	319,201	279,301	1.83	-15.75	90.5	89.2
19.85	380,930	326,511	285,697	1.80	-16.00	91.0	89.7
20.10	389,554	333,903	292,165	1.77	-16.25	91.5	90.2
20.35	398,274	341,378	298,705	1.75	-16.50	92.0	90.7
20.60	407,090	348,934	305,318	1.72	-16.75	92.5	91.2
20.85	416,002	356,573	312,002	1.69	-17.00	93.0	91.7
21.85	452,617	387,957	339,462	1.59	-18.00	95.0	93.7

Extension Length =	5065	feet
Average Ground Elevation =	4.50	ft-NGVD
Bottom of Canal =	-16.50	ft-NGVD
Depth of Cut =	21.00	feet
Canal Bottom Width =	50.00	feet
Left Side Slope 1 on =	1	
Right Side Slope 1 on =	1	
Ground Topwidth =	92.0	feet
Volume of Cut =	279,701	cubic yards

A.6.10.7.5 Required Studies

The next phase of detail design will include a finer resolution groundwater and surface water routing model to study operations of the system and confirm groundwater level results during this study.

A.6.11 Hydraulic Data and Supporting Analyses

A.6.11.1 Structure Hydraulic Data Sheets

A.6.11.1.1 S-509 Pump Station

S-509 Pump Station				
Revisions				
	25 January 2001 – Altered Pump stage data to meet area design			
	21 July 2000 – Original submission, received SFWMD pump mix concurrence			
	20 May 2005 – Redesign pump mix			
XY Coordinate1	847910 590520			
Location:	Southern boundary of C-9 Impoundment, east of US 27I			
Purpose/Operational Intent				
	Inflow Pump Plant			
	Pump Station is interim until NLBSA comes on-line. Pump Station may then be reconfigured and engineered for operation as inflow into C-9 Impoundment.			
	Pumps C-11 diversion flow conveyed to the C-9 Canal via S-30 operation			
	Pumps western C-9 Basin runoff via S-511 operation			
Design Condition				
	Inflow capacity 1,000 cfs			
	Seepage Control 75 cfs			
Pump Station capacity Criteria:				
	1,000 cfs pump rate identified with D-13R. Also allows capture of C-9 Basin if capacity exists and storage of C-11 Basin diversion flows is not necessary			
Number of Pumps				
	5 Pumps			
Pump Mix Type and Size				
	Diesel Engines	4 @ 250 cfs		
	Electric Motors	1 @ 75 cfs		
Mix Criteria:				
	The pump mix was redesigned to provide medium pump sizes that use typical suction bell intakes versus large pumps with Formed Suction Intakes (FSI)			
	The pump mix allows for intermediate flow values while having duplicate pumps at the station for essential operation and maintenance considerations			
	A 250 cfs pump can be used to assist in seepage control			
Control				
	Local & Remote by SCADA			
Design Heads2				
	Normal (1.5 HW to 10.5 TW) 9.00 feet			

S-509 Pump Station	
	Maximum (0.0 HW to 10.5 TW) 10.50 feet
Intake Water Surface Elevations	
	Maximum Non-Pumping 7.00 ft-NGVD
	Maximum Pumping 7.00 ft-NGVD
	Start Pumping 3.50 ft-NGVD
	Normal Drawdown 2.00 ft-NGVD
	Minimum Drawdown Pumping 0.00 ft-NGVD
	Minimum Non-Pumping 0.00 ft-NGVD
	Channel Invert -16.00 ft-NGVD
Discharge Water Surface Elevations	
	Maximum Non-Pumping 13.50 ft-NGVD
	Maximum Pumping 10.50 ft-NGVD (see note)
	Normal Pumping 10.50 ft-NGVD (see note)
	Minimum Pumping 2.00 ft-NGVD
	Minimum Non-Pumping 2.00 ft-NGVD
	Channel Invert -2.00 ft-NGVD

Notes:
[1] XY coordinates system used is NAD 83, Florida east, state plane.
[2] Interim data is used for status of pump station before construction of the NLBSA. Interim data is also used for the permanent case where the NLBSA is **not** constructed.
All elevations are in feet, NGVD (National Geodetic Vertical Datum of 1929)
Diesel generator is required for control station operations in case of power outage.
The design normal and maximum discharge elevations are higher than the current maximum normal pool by two feet to allow greater storage should impoundment demonstrate less seepage loss than expected with construction and real-time operational monitoring.

A.6.11.1.2 S-512A Pump Station

S-512A Pump Station		
Revisions:	12 December 2000 – Original submission	
	3 August 2005 – Reduced pump capacity from 225cfs to 150cfs with remaining 75cfs managed via gravity flow through S-512B structure. Location changed from northern to eastern boundary	
XY Coordinate1	845250 600920	
Location	Midway between northern and southern boundaries along the eastern boundary	
Purpose/Operational Intent	Flood Control Control WSE in eastern C-509E seepage collection canal at approximately 3.0 ft-NGVD	
Design Condition	Seepage Control 225 cfs	
Pump Station capacity Criteria	The design pump rate was determined by seepage rate analysis and incorporating a safety factor of 1.5.	
Number of Pumps	3 Pumps	
Pump Mix Type and Size Electric	3 @ 75 cfs	
Mix Criteria:		
	S-512A will have three 75 cfs pumps that are identical to the one at S-509 Pump Station.	
	Pumps are utilized for stage control in C-509E and C-509A Seepage canals	
Control	Remote by SCADA or Local	
Design Heads		
	Normal (2.5 HW to 10.5 TW)	8.00 feet
	Maximum (2.0 HW to 10.5 TW)	8.50 feet
Intake Water Surface Elevations	Maximum Non-Pumping	7.00 ft-NGVD
	Maximum Pumping	7.00 ft-NGVD
	Start Pumping	3.10 ft-NGVD
	Normal Pumping	2.50 ft-NGVD
	Minimum Drawdown Pumping	2.00 ft-NGVD
	Minimum Non-Pumping	2.00 ft-NGVD
	Channel Invert	-4.50 ft-NGVD
Discharge Water Surface Elevations		
	Maximum Non-Pumping	13.50 ft-NGVD
	Maximum Pumping	10.50 ft-NGVD (see note)
	Normal Pumping	10.50 ft-NGVD (see note)
	Minimum Pumping	3.00 ft-NGVD
	Minimum Non-Pumping	3.00 ft-NGVD
	Channel Invert	-2.00 ft-NGVD

Notes:

[1] XY coordinates system used is NAD 83, Florida east, state plane.

All elevations are in feet, NGVD (National Geodetic Vertical Datum of 1929)
The design normal and maximum discharge elevations are higher than the current maximum normal pool by two feet to allow greater storage should impoundment demonstrate less seepage loss than expected with construction and real-time operational monitoring.

Data Compiled from:
Selected Plan parameters.

A.6.11.1.3 S-510 Gated Culverts

S-510
Gated Round Culverts

Revisions 12 October 2000 - Original Submission
30 June 2005 - Mod spillway 1000cfs to gated 500 cfs
6 July 2010 - Equivalent concrete structure
August 2011 - Revision

XY Coord
Location On C-9 Canal near S-509 Inflow Pump Station
Purpose Impoundment Discharge Structure

Notes 1. Riprap requirements have not been verified with Geotech.

Design Conditions	
Discharge (CFS)	500 cfs
Design Head	0.93 feet
Headwater Elevation	8.80 ft,NGVD
Tailwater Elevation	4.00 ft,NGVD
Maximum Expected Stages	
Headwater Elevation	12.50 ft,NGVD
Tailwater Elevation	6.50 ft,NGVD
Maximum Simultaneous Head Difference	
Maximum Headwater Elevation	11.50 ft,NGVD
Minimum Tailwater Elevation	4.00 ft,NGVD
Culvert Data	
Number of Barrels	2
Barrel Type	Concrete
Barrel Diameter	8.0 feet
Barrel Length	60.0 feet
Barrel Invert Elevation	-6.00 ft,NGVD
Type of Control	Slide Gate
Canal Section	
Impoundment	
Side Slopes (Vert. on Hor.) 1 on	3
Upstream Bottom Width	Pool
Upstream Bottom Elevation	6.00 ft,NGVD
C-9 Canal	
Side Slopes (Vert. on Hor.) 1 on	3
Downstream Bottom Width	50.00
Downstream Bottom Elevation	-16.00 ft,NGVD
Riprap Requirements	
Design Flow Velocity	4.97 fps
Design Riprap Velocity	4.97 fps
Downstream Length	50.00 feet
Downstream Armored Area	2000.00 ft^2
Downstream Armored Area (Imported Rock)	750.00 ft^2
Downstream Armored Area (Local Rock)	1250.00 ft^2

A.6.11.1.4 S-511 Gated Culverts

S-511
Gated Round Culverts

Revisions 5 December 2000 - Original Submission
13 December 2001 - Redesign, material Box to
6 July 2010 - Equivalent concrete structure
August 2011 - Revision

XY Coord 851307 590420
Location On C-9 Canal, near SE corner of Impoundment.
Purpose Controls dry season deliveries to C-9 runoff. Reverse flow allows capture of excess C-9 runoff.

Notes 1. Riprap requirements have not been verified with Geotech.

Design Conditions	
Discharge (CFS)	500 cfs
Design Head	0.90 feet
Headwater Elevation	8.80 ft,NGVD
Tailwater Elevation	4.00 ft,NGVD
Maximum Expected Stages	
Headwater Elevation	12.50 ft,NGVD
Tailwater Elevation	6.50 ft,NGVD
Maximum Simultaneous Head Difference	
Maximum Headwater Elevation	11.50 ft,NGVD
Minimum Tailwater Elevation	4.00 ft,NGVD
Culvert Data	
Number of Barrels	2
Barrel Type	Concrete
Barrel Diameter	8.0 feet
Barrel Length	60.0 feet
Barrel Invert Elevation	-5.50 ft,NGVD
Type of Control	Slide Gate
Canal Section	
Impoundment	
Side Slopes (Vert. on Hor.) 1 on	3
Upstream Bottom Width	Pool
Upstream Bottom Elevation	6.00 ft,NGVD
C-9 Canal	
Side Slopes (Vert. on Hor.) 1 on	3
Downstream Bottom Width	50.00
Downstream Bottom Elevation	-16.00 ft,NGVD
Riprap Requirements	
Design Flow Velocity	4.97 fps
Design Riprap Velocity	4.97 fps
Downstream Length	50.00 feet
Downstream Armored Area	2000.00 ft^2
Downstream Armored Area (Imported Rock)	750.00 ft^2
Downstream Armored Area (Local Rock)	1250.00 ft^2

A.6.11.1.5 S-512B and S-512C CIT Weirs

S-512B and S-512C
CIT Weir Structure

Revisions 5 September 2005 - Original Submission
20 May 2005 - Redesign, corrugated, matches S-505C
August 2011 - Revision

XY Coord 847200 628910
Location SW and SE corners of C-9 Impoundment on C-509.
Purpose Controls stage in C-509 Seepage Canal.

Notes 1. Riprap requirements have not been verified with Geotech.

Design Conditions	
Discharge (CFS)	150 cfs
Design Head	0.70 feet
Headwater Elevation	4.75 ft,NGVD
Tailwater Elevation	3.50 ft,NGVD
Maximum Expected Stages	
Headwater Elevation	7.00 ft,NGVD
Tailwater Elevation	7.00 ft,NGVD
Maximum Simultaneous Head Difference	
Maximum Headwater Elevation	5.50 ft,NGVD
Minimum Tailwater Elevation	1.00 ft,NGVD
	4.5
Weir Data	
Weir Type	Broad Crested
Weir Breadth	0.67 feet
Crest Length – Corrugated with 10-ft sides (x9)	90 feet
Crest Elevation	4.05 ft, NGVD
Maximum Head on Crest	2.95 feet
Upstream Weir Height, P	9.05 feet
Minimum Tieback Wall Elevation	7 ft, NGVD
Weir Control	Not Gated
Downstream Stilling Basin	
Apron Width	50 feet
Apron Length	-0.7 ft, NGVD
Length (feet)	10 feet
Minimum Sidewall Elevation	7 ft, NGVD
End Sill Elevation	-0.55 ft, NGVD
Canal Section	
C-509W and C-509E	
Side Slopes (Vert. on Hor.) 1 on	3
Upstream Bottom Width	50.00 feet
Upstream Bottom Elevation	-5.00 ft,NGVD
C-9 Canal	
Side Slopes (Vert. on Hor.) 1 on	3
Downstream Bottom Width	pool
Downstream Bottom Elevation	-10.00 ft,NGVD
Riprap Requirements	
Design Flow Velocity	3.43 fps
Design Riprap Velocity	4.30 fps
Downstream Length	36.00 feet
Downstream Armored Area	1000.00 ft^2
Downstream Armored Area (Imported Rock)	250.00 ft^2
Downstream Armored Area (Local Rock)	750.00 ft^2
Control Protection Elevation	7.50 ft,NGVD

A.6.11.1.6 S-512B and S-512C Flap Gated Culverts

S-512B and S-512C
Flap Gated Culverts

Revisions 5 September 2000 - Original Submission
20 May 2005 - Redesign, flap gate, matches S-505C
6 July 2010 - Equivalent concrete structure
August 2011 - Revision

XY Coord 894020 733125
Location Bridge for C-9 Canal's south bank on western and eastern sides of impoundment.
Purpose Provide crossover of C-509 Seepage Canal with flap gates to prevent backflow.

Notes 1. Riprap requirements have not been verified with Geotech.

Design Conditions	
Discharge (CFS)	150 cfs
Design Head	0.25 feet
Headwater Elevation	5.00 ft,NGVD
Tailwater Elevation	4.75 ft,NGVD
Maximum Expected Stages	
Headwater Elevation	8.00 ft,NGVD
Tailwater Elevation	7.00 ft,NGVD
Maximum Simultaneous Head Difference	
Maximum Headwater Elevation	7.00 ft,NGVD
Minimum Tailwater Elevation	6.00 ft,NGVD
	1
Culvert Data	
Number of Barrels	3
Barrel Type	Concrete
Barrel Diameter	6 feet
Barrel Length	40 feet
Barrel Invert Elevation	-3 ft, NGVD
Type of Control	Flap Gate
Canal Section	
C-509W and C-509E	
Side Slopes (Vert. on Hor.) 1 on	3
Upstream Bottom Width	15.00 feet
Upstream Bottom Elevation	-1.00 ft,NGVD
C-9 Canal	
Side Slopes (Vert. on Hor.) 1 on	3
Downstream Bottom Width	75.00
Downstream Bottom Elevation	-5.00 ft,NGVD
Riprap Requirements	
Design Flow Velocity	2.55 fps
Design Riprap Velocity	3.82 fps
Downstream Length	40.00 feet
Downstream Armored Area	2000.00 ft^2
Downstream Armored Area (Imported Rock)	700.00 ft^2
Downstream Armored Area (Local Rock)	1300.00 ft^2

TABLE A-50: C-9 IMPOUNDMENT – NORTH/EAST WETLAND BOUNDARY SEEPAGE CANAL C-509M

C-9 Impoundment - WPA Feasibility Study
North/East Mitigation Seepage Canal - C-509M

Discharge Q =	75	cfs
HW Station =	9940	feet
TW Station =	0	feet
Length =	9940	feet
Average Nat Grd =	5.25	ft, NGVD
Headwater El=	3.30	ft, NGVD
Tailwater El=	2.9	ft, NGVD
Average WSEI =	3.1	ft, NGVD
Delta H =	0.4	feet
E.G. Slope =	0	
Slope =	0.000040	
Slope ^0.5 =	0.00634361	
Conveyance Req'd =	11,823	Target Conveyance
Left Side Slope 1 on =	3	
Right Side Slope 1 on =	3	
Trial Depth =	5.1	ft
Trial Bottom Width	10	

Water Depth	Conveyence for Manning's n n = 0.03	n = 0.035	n = 0.04	Vel fps	Bottom Elev ft,NGVD	Ground Topwidth feet	WS Topwidth feet
4.35	9,566	8,199	7,174	0.75	-1.25	49.0	36.1
4.60	10,774	9,235	8,081	0.69	-1.50	50.5	37.6
4.85	12,069	10,345	9,052	0.63	-1.75	52.0	39.1
5.10	13,452	11,531	10,089	0.58	-2.00	53.5	40.6
5.35	14,926	12,794	11,195	0.54	-2.25	55.0	42.1
5.60	16,493	14,136	12,369	0.50	-2.50	56.5	43.6
6.60	23,728	20,339	17,796	0.38	-3.50	62.5	49.6

Extension Length =	9940	feet
Average Ground Elevation =	5.25	ft-NGVD
Bottom of Canal =	-2.00	ft-NGVD
Depth of Cut =	7.25	feet
Canal Bottom Width =	10.00	feet
Left Side Slope 1 on =	3	
Right Side Slope 1 on =	3	
Ground Topwidth =	53.5	feet
Volume of Cut =	84,763	cubic yards

TABLE A-51: C-9 IMPOUNDMENT – NORTHERN AND EASTERN BOUNDARY SEEPAGE CANAL C-509

C-9 Impoundment - WPA Feasibility Study
North/East Impoundment Seepage Canal - C-509

Discharge Q =	150	cfs
HW Station =	15380	feet
TW Station =	0	feet
Length =	15380	feet
Average Nat Grd =	4.24	ft, NGVD
Headwater El=	3.10	ft, NGVD
Tailwater El=	2.85	ft, NGVD
Average WSEl =	2.98	ft, NGVD
Delta H =	0.25	feet
E.G. Slope =	0.00	
Slope =	0.000016	
Slope ^0.5 =	0.00403	
Conveyance Req'd =	37,205	Target Conveyance
Left Side Slope 1 on =	3	
Right Side Slope 1 on =	3	
Trial Depth =	7.47	ft
Trial Bottom Width	20	

F&W Littoral Zone Cut

Littoral Zone Length	15380	feet
Littoral Zone Bottom	2.00	ft, NGVD
Littoral Zone Width	30.00	feet
Depth of Cut	2.24	feet
Volume of Cut	38230	cubic yards

Water Depth	Conveyence for Manning's n n = 0.03	n = 0.035	n = 0.04	Vel fps	Bottom Elev ft,NGVD	Ground Topwidth feet	WS Topwidth feet
6.72	35,447	30,383	26,585	0.56	-3.75	67.9	60.3
6.97	38,210	32,751	28,657	0.53	-4.00	69.4	61.8
7.22	41,094	35,223	30,820	0.50	-4.25	70.9	63.3
7.47	44,100	37,800	33,075	0.47	-4.50	72.4	64.8
7.72	47,231	40,484	35,423	0.45	-4.75	73.9	66.3
7.97	50,488	43,276	37,866	0.43	-5.00	75.4	67.8
8.97	64,816	55,556	48,612	0.36	-6.00	81.4	73.8

Extension Length =	15380	feet
Average Ground Elevation =	4.24	ft-NGVD
Bottom of Canal =	-4.50	ft-NGVD
Depth of Cut =	8.73	feet
Canal Bottom Width =	20.00	feet
Left Side Slope 1 on =	3	
Right Side Slope 1 on =	3	
Ground Topwidth =	72.4	feet
Volume of Cut =	229,783	cubic yards

TABLE A-52: C-9 IMPOUNDMENT – WESTERN WETLAND BOUNDARY SEEPAGE CANAL C-509 (NORTHERN)

C-9 Impoundment - WPA Feasibility Study
West Mitigate/Impound Seepage Canal - C-509

Discharge Q =	40	cfs
HW Station =	5025	feet
TW Station =	0	feet
Length =	5025	feet
Average Nat Grd =	5.93	ft, NGVD
Headwater El=	5.90	ft, NGVD
Tailwater El=	5.85	ft, NGVD
Average WSEI =	5.88	ft, NGVD
Delta H =	0.05	feet
E.G. Slope =	0.00	
Slope =	0.000010	
Slope ^0.5 =	0.00315	
Conveyance Req'd =	12,681	Target Conveyance
Left Side Slope 1 on =	3	
Right Side Slope 1 on =	3	
Trial Depth =	6.87	ft
Trial Bottom Width	10	

F&W Littoral Zone Cut

Littoral Zone Length	5025	feet
Littoral Zone Bottom	3.00	ft, NGVD
Littoral Zone Width	30.00	feet
Depth of Cut	2.93	feet
Volume of Cut	16331	cubic yards

Water Depth	Conveyence for Manning's n n = 0.03	n = 0.035	n = 0.04	Vel fps	Bottom Elev ft,NGVD	Ground Topwidth feet	WS Topwidth feet
6.12	20,057	17,192	15,043	0.23	-0.25	47.0	46.7
6.37	21,923	18,791	16,442	0.22	-0.50	48.5	48.2
6.62	23,890	20,477	17,917	0.20	-0.75	50.0	49.7
6.87	25,960	22,251	19,470	0.19	-1.00	51.5	51.2
7.12	28,135	24,116	21,102	0.18	-1.25	53.0	52.7
7.37	30,419	26,073	22,814	0.17	-1.50	54.5	54.2
8.37	40,665	34,856	30,499	0.14	-2.50	60.5	60.2

Extension Length =	5025	feet
Average Ground Elevation =	5.93	ft-NGVD
Bottom of Canal =	-1.00	ft-NGVD
Depth of Cut =	6.92	feet
Canal Bottom Width =	10.00	feet
Left Side Slope 1 on =	3	
Right Side Slope 1 on =	3	
Ground Topwidth =	51.5	feet
Volume of Cut =	39,615	cubic yards

TABLE A-53: C-9 IMPOUNDMENT – WESTERN BOUNDARY SEEPAGE CANAL C-509 (MIDDLE)

C-9 Impoundment - WPA Feasibility Study
West Mitigate/Impound Seepage Canal - C-509

Discharge Q =	95	cfs
HW Station =	6515	feet
TW Station =	0	feet
Length =	6515	feet
Average Nat Grd =	5.00	ft, NGVD
Headwater El=	5.85	ft, NGVD
Tailwater El=	5.65	ft, NGVD
Average WSEl =	5.75	ft, NGVD
Delta H =	0.20	feet
E.G. Slope =	0.00	
Slope =	0.000031	
Slope ^0.5 =	0.00554	
Conveyance Req'd =	17,146	Target Conveyance
Left Side Slope 1 on =	3	
Right Side Slope 1 on =	3	
Trial Depth =	6.75	ft
Trial Bottom Width	10	

Water Depth	Conveyence for Manning's n n = 0.03	n = 0.035	n = 0.04	Vel fps	Bottom Elev ft,NGVD	Ground Topwidth feet	WS Topwidth feet
6.00	19,197	16,455	14,398	0.57	-0.25	41.5	46.0
6.25	21,015	18,013	15,761	0.53	-0.50	43.0	47.5
6.50	22,933	19,657	17,200	0.50	-0.75	44.5	49.0
6.75	24,953	21,388	18,715	0.47	-1.00	46.0	50.5
7.00	27,078	23,210	20,308	0.44	-1.25	47.5	52.0
7.25	29,309	25,122	21,982	0.41	-1.50	49.0	53.5
8.25	39,339	33,719	29,504	0.33	-2.50	55.0	59.5

Extension Length =	6515	feet
Average Ground Elevation =	5.00	ft-NGVD
Bottom of Canal =	-1.00	ft-NGVD
Depth of Cut =	6.00	feet
Canal Bottom Width =	10.00	feet
Left Side Slope 1 on =	3	
Right Side Slope 1 on =	3	
Ground Topwidth =	46.0	feet
Volume of Cut =	40,538	cubic yards

TABLE A-54: C-9 IMPOUNDMENT – NORTHERN BOUNDARY SEEPAGE CANAL C-509 (SOUTHERN)

C-9 Impoundment - WPA Feasibility Study
West Mitigate/Impound Seepage Canal - C-509

Discharge Q =	150 cfs
HW Station =	6515 feet
TW Station =	0 feet
Length =	6515 feet
Average Nat Grd =	5.01 ft, NGVD
Headwater El=	5.65 ft, NGVD
Tailwater El=	5.00 ft, NGVD
Average WSEI =	5.33 ft, NGVD
Delta H =	0.65 feet
E.G. Slope =	0.00
Slope =	0.000100
Slope ^0.5 =	0.00999
Conveyance Req'd =	15,017 Target Conveyance
Left Side Slope 1 on =	3
Right Side Slope 1 on =	3
Trial Depth =	6.32 ft
Trial Bottom Width	10

Water Depth	Conveyence for Manning's n n = 0.03	n = 0.035	n = 0.04	Vel fps	Bottom Elev ft,NGVD	Ground Topwidth feet	WS Topwidth feet
5.57	16,300	13,971	12,225	1.01	-0.25	41.5	43.4
5.82	17,949	15,385	13,462	0.94	-0.50	43.0	44.9
6.07	19,696	16,882	14,772	0.88	-0.75	44.5	46.4
6.32	21,542	18,464	16,156	0.82	-1.00	46.0	47.9
6.57	23,488	20,133	17,616	0.77	-1.25	47.5	49.4
6.82	25,537	21,889	19,153	0.72	-1.50	49.0	50.9
7.82	34,805	29,833	26,104	0.57	-2.50	55.0	56.9

Extension Length =	6515	feet
Average Ground Elevation =	5.01	ft-NGVD
Bottom of Canal =	-1.00	ft-NGVD
Depth of Cut =	6.00	feet
Canal Bottom Width =	10.00	feet
Left Side Slope 1 on =	3	
Right Side Slope 1 on =	3	
Ground Topwidth =	46.0	feet
Volume of Cut =	40,538	cubic yards

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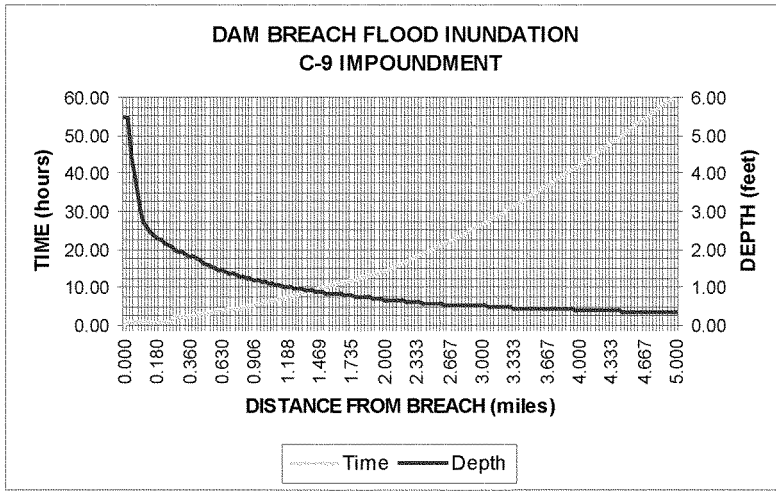
A.6.11.2 Dam Break Analysis

A.6.11.2.1 Summary Discussion

The levee breach final width modeled was set at 1,250 feet. This breach width represents four times the theoretical breach width with theoretical width including the addition of two times the equation standard deviation. The time modeled for full breach to occur was set at 0.50 hours. This time for full breach represents approximately one fourteenth of the theoretical time with theoretical time including the subtraction of two times the equation standard deviation.

A.6.11.2.1.1 Dam Breach Parameters and Graph Results



Impoundment and Breach Parameters:

$b \Rightarrow$ Full breach bottom width,	to be determined, feet
$b_s \Rightarrow$ Standard error for FLDWAV b,	94, feet
$t \Rightarrow$ Time for full breach to occur,	to be determined, hours
$t_s \Rightarrow$ Standard error for FLDWAV t,	0.9, hours
$Q \Rightarrow$ Calculated peak flow,	to be determined, cfs
$Q_p \Rightarrow$ Independent expected peak flow,	$370\ (V_r\ h_d)^{0.5}$, cfs
$h_d \Rightarrow$ Water surface height above bottom of breach,	5.2, feet
$k_o \Rightarrow$ Coefficient of breach type,	0.7
$V_r \Rightarrow$ Impoundment volume,	8060, acft
$A_s \Rightarrow$ Surface area of impounded water,	1550, acre
$C \Rightarrow$ Calculation intermediate variable,	$23.4\ A_s / b$

Breach Width, b:

1.	$b = 0.5\ h_d < b < 8.0\ h_d$	42 feet
2.	$b = 9.5\ k_o\ (V_r\ h_d)^{0.25}$	95 feet
3.	$b = 2\ b_s + 9.5\ k_o\ (V_r\ h_d)^{0.25}$	283 feet

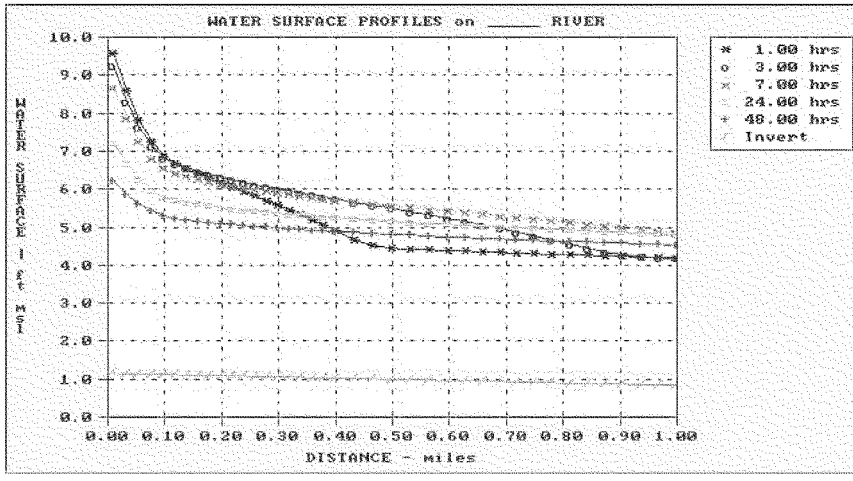
Breach Time, t:

1.	$t = 0.59\ V_r^{0.47} / h_d^{0.9}$	9.17 hours
2.	$t = 2\ t_s - 0.59\ V_r^{0.47} / h_d^{0.9}$	7.37 hours

Designed Breach b and t:

1.	$Q_p = 370\ (V_r\ h_d)^{0.5}$	75,748 cfs
2.	$Q = 3.1\ b_{(3.)}\ [C / (t_{(2.)} + C / h_d^{0.5})]^3$	7,190 cfs
	Breach b and t adjustment:	
3.	$Q = 3.1\ b_{(4.)}\ [C / (t_{(3.)} + C / h_d^{0.5})]^3$	40,932 cfs
	where $b_{(4.)}$	1250 feet
	$t_{(3.)}$	0.50 hours

Design b = 1250 feet
Design t = 0.50 hours



A.6.11.3 Dam Break Analysis

A.6.11.3.1 Introduction

FLDWAV is a flood routing model developed by the National Weather Service (NWS) for real-time flood forecasting of dam-break floods and natural floods; dam-breach flood analysis for levee sunny-day piping or overtopping associated with the PMF flood; floodplain inundation mapping for contingency dam-break flood planning; and design of waterway improvements. FLDWAV replaces the older NWS DAMBRK and DWOPER/NETWORK models by incorporating their combined abilities, as well as providing new hydraulic simulation features. The model executes by solving the complete Saint-Venant equations for one-dimensional unsteady flow using a four-point implicit finite-difference numerical solution. Full documentation of the model may be located at http://hsp.nws.noaa.gov/oh/hrl/rvrmech/rvrmain.htm or by mail:

- Hydrologic Research Laboratory
- Office of Hydrology
- National Weather Service (NWS), NOAA
- Silver Spring, Maryland 20910

A.6.11.4 Modeled Dam Break

There are two types of modeled dam-breaks, overtopping and piping. A levee design feature for the WPA impoundments is the ability to contain regulatory storm events. Additionally, the impoundments will have an emergency spillway for conditions that are able of passing the Probable Maximum Precipitation storm event without damage to levee integrity. Because of these design features, an overtopping dam break in comparison to a dam break by piping is considered to be an extremely remote possibility. Therefore, only piping dam breaks were modeled.

Earthen dams do not tend to fail completely, nor do they fail instantaneously. Additionally, the time of failure is usually much longer for piping than overtopping because the upstream levee face is slowly eroded in the very early phase of the piping. As the erosion proceeds, an increasingly larger opening is formed; this is eventually hastened by caving–in of the top portion of the dam. However, for conservative reasons the final breached width and time for breach formation modeled resembled an overtopped dam with total collapse.

FLDWAV has the ability to model controlled dam discharges via gates and spillways during a breach event. This allows a damping effect to the flood wave originating from the breach. Once again for conservative reasons, this option was not utilized so as to simulate the worst-case scenario.

A.6.11.5 Dam Break Wave Channel Design

FLDWAV was developed for many potential unsteady flow or flood routing locales, but best suited for classical type dams. Classic dams are generally located within watersheds with natural river channels/gorges or floodplains that act as outlets or floodways with a known or unknown stage versus discharge profile. Outlet channels and floodways are beneficial for an analysis because they provide true channel parameters in the downstream direction. Also, historic data may be available allowing for calibration of the channel parametric coefficients (e.g. Manning's n, contraction/expansion, etc.) corresponding to stages with known flow rates. From the FLDWAV modeler perspective, an existing channel provides a downstream boundary condition for convergence that is required to employ the Newton-Raphson scheme of solving the implicit finite-difference solution of the Saint-Vanant equations. However, for the WPA impoundments, there are no natural channels or floodways that meet this purpose. Therefore, it was necessary to create a synthetic channel that meets FLDWAV model requirements.

A.6.11.6 Existing Canals

Canals are a common physical feature of South Florida's infrastructure for flood protection and water supply. However, canals in proximity of the WPA impoundments will not have sufficient capacity to route a dynamic wave with a dam breach magnitude effectively to a less impacted area. The WPA impoundments will have peripheral seepage canals running parallel to the levees. However, the water mass momentum during a breach event will be perpendicular to the seepage canal. This placement allows for eroded levee soil material to settle out of the critical wave path. Adding to the levee soil material is the material displaced by the typical scour hole that occurs immediately downstream of the breached levee. Therefore, the breached levee would fill or plug the getaway path that a seepage canal may provide. An aerial photo of the FPL cooling water reservoir break taken October 31, 1979 (FPL Dike Failure and its Impact on Project Facilities, Martin and Okeechobee Counties, October 30 – November 6, 1979, prepared by SFWMD) illustrates this occurrence.

A.6.11.6.1 Convergence Channel

FLDWAV requires a channel with steady or unsteady flow for convergence as part of the downstream boundary condition. A uniform 3 foot × 3 foot channel was therefore modeled with a steady state flow of 50 cfs. The flow rate was determined by increasing the flow until a visually smooth convergence appeared in the generated output graphs. The rate of 50 cfs is considered negligible in comparison to the flow rate of a breached impoundment.

A.6.11.6.2 Primary Channel

A 150-foot wide channel was modeled for conveyance of the first flood impingement. Residential development exists or may exist adjacent to all of the WPA impoundments. Recognizing that a major thoroughfare may be in close proximity of an impoundment, this channel was designed to reflect a lower roughness value of finite cross-section area. Pavement, center-divide, and front lawns or buffer lands was included in the roughness coefficient used. In a real event where an expected main thoroughfare does not exist, the flood impact will be over-predicted giving a conservative value for emergency planning purposes.

A.6.11.6.3 Floodway Channel

In a Newtonian classical sense, floodwater will travel from a breached levee downstream in a path of least resistance (typically represented as one-dimensional flow). However, in flat terrain floodwater will also seek a steady equilibrium state where it travels partially in all directions simultaneously

(two and three-dimensional flow). Notwithstanding, there will exist a preferred or primary direction that will contain the majority of the mass flow. The determination of the primary direction is important because the model solutions for FLDWAV are for the one-dimensional unsteady flow Saint Venant equations. On a flat surface the primary direction is taken as the one stemming from the forward momentum that results in a somewhat elliptical pattern. This geometric pattern was estimated and analyzed by sensitivity analysis for appropriateness.

A.6.11.6.4 Floodway Projection

Three channels with projected angles of 60°, 90° and 120° were simulated with flow loss factors of 60%, 33% and 15%, respectively. The flow loss factors represent the flow that is lost outside of the primary flow direction. The flow loss factors were calculated based on geometric analysis of the flow pattern expected from a dam breaching into a flat floodplain without an existing effective floodway. Based on the three simulations, the 60° projection was found to have the median value. See ***Table A-55***. Therefore, a 60°-projected channel was used for the dam-break analyses. Each cross section width was calculated with an additional 150 feet to account for the 150-foot primary channel.

TABLE A-55: MODELED RESULTS OF PROJECTED CHANNEL ANGLES

Cross-Section (mi)	Depth Inundated (ft)			Time to Peak (hrs)		
	60°	90°	120°	60°	90°	120°
0.2	2.46	2.51	2.27	4.36	4.43	4.50
0.5	1.73	1.82	1.55	5.01	5.15	5.29
1.0	1.15	1.21	1.02	7.36	7.29	7.94
1.5	0.84	0.88	0.73	10.87	10.65	11.94

Note: The values shown represent the base values used in the model before other analyses were placed into use; therefore, they are not indicative of the final result.

A.6.11.6.5 Floodway Slope

The topographic relief surrounding the WPA impoundments is essentially flat terrain, though there is a small degree of slope characteristic of the historic Everglades sheet-flow path. However, the location of the WPA impoundments on the Everglades eastern edge actually places them downhill, in some aspects, from the coastal ridge where the majority of the existing development lays. Additionally, in some cases industry and development have altered the terrain near the WPA impoundments. These alterations include rock quarrying, stormwater retention lake systems, and

wetland mitigation areas. Because of the difficulty in determining an actual slope in many instances, it was determined to model a slope that represents the prevailing downhill slope in the region and provides results that are compatible with emergency planning purposes. The prevailing slope for the region was determined to be approximately 3 feet vertical on 10 miles horizontal or 0.000057, more or less. After the 5-mile cross-section, a falling slope of 1-foot per 2 miles was used for model stability (loop rating curve).

Floodway side slopes varied with cross-section width. Since the terrain has already been discussed as being flat, the side slopes were also modeled relatively flat. A 0.05-foot rise from the convergence channel was used, and a 0.05-foot rise from the primary channel was also used. This created essentially a flat floodplain. A vertical non-overtopped bank was modeled on the floodway boundary as flow losses were calculated by a model variable assigned for that purpose (QLOS).

A.6.11.6.6 Roughness Coefficient

FLDWAV uses Manning's η for a roughness coefficient to represent energy losses for wave front propagation. This is a difficult feature to quantify in the WPA scenario since an impoundment breach may occur in a developed subdivision where no true physical measurement of roughness is possible. This difficulty is complicated by two facts; (1) Manning's formula is not actually valid for floodplain flows of this nature and (2) no calibration is available for this type of breach setting. Therefore, a response (flood inundation) versus Manning's η was calculated and is shown in ***Table A-56***. The Manning's η in the analysis ranged from 0.10 to 0.40 (model displays discontinuity when Manning's $\eta \geq 0.50$).

TABLE A-56: ROUGHNESS COEFFICIENT SENSITIVITY ON DEPTH

Cross-Section (mi)	MANNING'S η-VALUES (Flood Inundation, ft)[1]					
	.05/.10	.05/.20	.10/10	.15/.20	.15/.30	.15/.40
0.2	2.30	2.73	2.30	2.73	2.91	3.01
0.5	1.66	1.92	1.66	1.92	2.02	2.07
1.0	1.12	1.26	1.12	1.26	1.32	1.35
1.5	0.82	0.91	0.82	0.91	0.95	0.98

[1] The first value is the η assigned for the 150-foot primary channel, the second value is the η assigned for the floodway.
Note: The values shown represent the base values used in the model before other analyses were placed into use; therefore, they are not indicative of the final result.

Three noteworthy conclusions are illustrated as follows:

1. Depth of inundation increases with higher Manning's η values.
2. The 150-foot primary channel is insensitive to the assigned η-value.
3. There is a more significant change in depth of inundation proportionately for equal changes in the lower η-values.

What is not illustrated in ***Table A-56*** is the difference in the flood wave propagation time as it travels away from the breached levee. The travel time changes with different η-values. This is illustrated in ***Table A-57*** (units are hours). The times reported are for maximum Water Surface Elevation (WSE) occurrence at the cross-section.

TABLE A-57: ROUGHNESS COEFFICIENT SENSITIVITY ON PEAK TIME

Cross-Section (mi)	MANNING'S η-VALUES (Time, hrs)			
	0.10	0.20	0.30	0.40
0.2	0.214	0.500	0.786	1.144
0.5	0.786	1.573	2.502	3.504
1.0	2.860	5.210	7.722	10.15
1.5	6.078	10.78	15.59	20.16

Note: The values shown represent the base values used in the model before other analyses were placed into use; therefore, they are not indicative of the final result.

Analysis of ***Table A-56*** and ***Table A-57*** illustrate that the selection of a Manning's η cannot be done arbitrary or without regard to real expectations with reference to depths and time of floodwater inundation.

The Manning's η value used to calculate depth of flood inundation was set as the following noting that FLDWAV linearly interpolates between set values: (1) convergence channels set at 0.02, lower and upper, (2) primary channel set at 0.02 and 0.15, respectively, (3) floodway channel set at 0.15 and 0.20, respectively, and (4) side bank set at 0.01 to represent fluid-to-fluid interface. The η-value used to calculate time of flood inundation was changed for the primary and floodway channels as noted in the following: (1) primary channel set at 0.02 lower and 0.10 upper, and (2) floodway channel set at 0.10, lower and upper. The selection of 0.15 and 0.20 for η-values in determining the depth of floodwater inundation was made based on three sources of research, described in the following:

1. Revised Corps guidelines provide an equation to estimate Manning's η using the ratio of total width of a cross-section (W) to total width of streets and right-of-ways (ΣWs) located within the cross-section (U.S. Army Corps of Engineers Memorandum, 18 May 1981, Subject:

Interim Guidelines for Estimating "n" values of Flood Plains, Paragraph 4.a. revised 15 May 1982).

$= \eta_S(W/\Sigma Ws)$ where η_S is typically valued at 0.03.

Example provided gave W = 1500 feet and ΣWs = 240 feet. The resulting Manning's η was calculated to be 0.19. A cross-section located near the Acme B Impoundment had the following values identified: W = 1340 feet, ΣWs = 180 feet, resulting Manning's η was calculated to be 0.22. This section is presently sparsely populated with unpaved roads, but in the future it is thought that further development will most likely develop with the same infrastructure footprint as aerials show.

2. University of Florida research and abstract by B.A. Christensen, PhD states that for heavily vegetated or urbanized areas, calibrations of numerical models often show η-values in excess of 0.20 (Replacing Manning's Formula by the Darcy-Weisbach Formula in Analysis of Vegetated Floodplains, International Conference on Advances in Ground-water Hydrology, 16 November 1997, co-authored S.R. Davie, M.E.). Therefore, it is estimated that a wave front through this area may have a conservative η-value between 0.15 and 0.20 overall. This is in recognition of the low number of trees and large yards typical of the developments bordering now on the Everglades.
3. SFWMD draft "ENR Flow Test for Determination of Friction Factors (Manning's n) for the Everglades Protection Project's Stormwater Treatment Areas, December 1994. The draft states that a Manning's η of 0.84 was calibrated for peak stage and flow conditions through a heavily vegetated area. This area additionally contained remnants of agricultural barriers. The draft also stated that this η-value was believed to be very conservative. Therefore, it is thought that a wave front through open spaces having wetlands and other brush indigenous to the area may have a conservative η-value between 0.15 and 0.20 (opposite in consideration for flow desired for stormwater settlement). This is in recognition of bending sawgrasses with higher depths of flow that effectively lowers the characteristic η-value.

   The use of the lower η-value of 0.10 for time of flood inundation was estimated based on FLDWAV results and real expectations. The decrease in time is conservative and is a better choice for emergency planning purposes.

A.6.11.7 Levee Breach Parameters

Breach time of total failure and final breach width are two factors that dominate depth and time of flood inundation calculations. ***Table A-58*** provides a summary of results for the impoundments modeled. Parameters used to develop model are discussed in the following sections.

TABLE A-58: DAM BREAK SUMMARIES

Parameter	Hillsboro Impoundment	C-11 Impoundment	C-9 Impoundment
Surface Area (acres)	1680	1500	1550
Crest Elev (ft-NGVD)	19.40	11.20	9.70
Bottom Elev (ft-NGVD)	10.00	6.00	4.50
Calculated $\bar{b}$ (ft)	130	94	95
Modeled $\bar{b}$ (ft)	1250	1250	1250
Calculated τ (hr)	7.40	9.03	9.17
Modeled τ (hr)	1.00	1.00	1.00
Depth @ 0.1 Mile	4.65	3.05	2.75
Depth @ 0.2 Mile	3.69	2.47	2.24
Depth @ 0.3 Mile	3.12	2.17	1.96
Depth @ 0.5 Mile	2.39	1.77	1.60
Depth @ 0.75 Mile	1.97	1.46	1.32
Depth @ 1.0 Mile	1.68	1.25	1.13
Depth @ 1.5 Mile	1.29	0.97	0.87
Depth @ 2.0 Mile	1.01	0.76	0.68
Time @ 0.1 Mile	0.80	1.00	1.00
Time @ 0.2 Mile	0.90	1.10	1.00
Time @ 0.3 Mile	0.95	1.80	2.15
Time @ 0.5 Mile	1.45	2.50	3.30
Time @ 0.75 Mile	2.35	3.80	4.40
Time @ 1.0 Mile	3.50	5.35	6.10
Time @ 1.5 Mile	6.60	9.10	9.90
Time @ 2.0 Mile	10.9	13.20	14.25

A.6.11.7.1 Breach Final Width

FLDWAV documentation provided two equations to assist in predicting the final breached width of a levee. One equation is the following:

$\bar{b}$ = 9.5ko(Vr hd)0.25 where b = average breach width(ft)
ko = 0.7 piping 1.0 overtopping)
Vr = reservoir volume (ac-ft)
hd = height of water over breach bottom (ft)

This equation gives a standard error estimate of ±94 ft, which represents an average error of ±54% of the $\bar{b}$ data collected by NWS. The second equation is shown as follows:

$0.5hd << \bar{b} << 8hd$ where b = average breach width(ft)
hd =height of water over breach bottom (ft)

Actual breach width modeled relied on a conservative approach utilizing equations shown in *Equilibrium with Peak Flow* Section.

A.6.11.7.2 Time of Formation

FLDWAV documentation provided one equation to assist in predicting the full breach time of formation. This equation is shown as follows:

$\tau = 0.59\ Vr0.47/\ hd0.9$ where τ = time of failure (hr)
Vr =reservoir volume (ac-ft)
hd =height of water over breach bottom

This equation gives a standard error estimate of ±0.9 hrs that represents an average error of ±70% of the τ data collected by NWS. Actual breach time of formation modeled relied on a conservative approach utilizing equations shown in ***Equilibrium with Peak Flow*** Section.

A.6.11.7.3 Equilibrium with Peak Flow

FLDWAV documentation does provide a means to check the reasonableness of the breach parameters $\bar{b}$ and τ. Calculating the expected peak discharge (cfs) through the breach using the two equations shown as follows performs this check:

$Qp^* = 370\ (Vr\ hd)0.5$ where Qp^* = peak discharge (cfs)
Vr = reservoir volume (ac-ft)
hd = height of water over breach bottom

$Qp = 3.1\ \bar{b}\ [C/(\tau + C/\sqrt{hd})]3$ where Qp = peak discharge (cfs)
$C = 23.4As/\ \bar{b}$
As = surface area (acres)
τ = time of failure (hr)
hd = height of water over breach bottom

The first equation is calculated with impoundment design features. The second equation is calculated with values obtained by solving the equations found in ***Breach Final Width*** and ***Time of Formation*** Sections. If $Qp^* >> Qp$, then either $\bar{b}$ is too small and/or τ is too large. All modeled breach widths were increased to the values shown in ***Table A-58***. Also, all time of

formations were decreased to the values shown in ***Table A-58***. In general, Qp was recalculated with modified $\bar{b}$ and τ values until it was approximately 66 percent of Qp* for conservative reasons. It is worth noting that for the larger reservoirs, Qp is quite sensitive to $\bar{b}$ and rather insensitive to τ, while for the smaller reservoirs Qp is fairly sensitive to τ and somewhat insensitive to $\bar{b}$.

A.6.11.7.4 Other Parameters

Input variables for the FLDWAV program are placed in Data Groups. Variables with their corresponding values in brackets [ ] are described here in the group order they appear in the data input file.

Data Group 1	
EPSY	Depth tolerance in Newton-Raphson Iteration scheme. Values range between 0.001 and 1.0 feet. [0.01].
THETA	Acceleration factor in solving tributary junction problem. Values range between 0.5 and 1.0. No tributaries were modeled; therefore, value of unity was used. [1].
F1	θ weighting factor in finite difference technique. Values range between 0.5 and 1.0. The lower range minimizes the loss of accuracy associated with greater values when using the fully implicit or backward difference scheme. [0.6, recommended by NWS].
XFACT	Factor to convert units describing location of computation points along the routing reach from miles to feet. See METRIC. [5280].
DTHYD	Time interval of all input hydrographs. If time interval is not constant, value of 0 is used. [0].
DTOUT	Time interval of all output hydrographs. If models are run in stand-alone mode and not part of the National Weather Service interface NWSRFS, then a value of 0 is used. [0].
METRIC	Parameter indicating if input/output is in the English system or the Metric system. Regardless of choice, all computations within FLDWAV are performed in English units. [0] METRIC=0, English system METRIC=1, Metric system English system was preferred for ease of analysis with one system of units.

Data Group 2	
JN	Total number of rivers in the system being routed simultaneously. One channel was modeled. [1].
NU	Number of values associated with observed hydrographs. Model would not run with a value less than 2; therefore, [2].
ITMAX	Maximum number of iterations allowed in the Newton-Raphson Iteration scheme for solving the system of nonlinear equations. [10. recommended by NWS].
KWARM	Number of time steps used for warm-up procedure. If KWARM is greater than 0, the model assumes steady-state initial conditions and will solve the routing equation KWARM times without incrementing the time. [2, recommended by NWS].
KFLP	Parameter indicating the use of the floodplain option for conveyance. [0] KFLP=0, no floodplain (composite channel used). KFLP=1, floodplain used with conveyance K. KFLP>2, Floodplain used and KFLP is the number of points in the conveyance table A composite channel was used because of the lack of an existing channel for model convergence to occur. It was assumed that existing canals or channels at each impoundment were either non-existent, negligible impact because of small capacity, or flowed perpendicular to dam break with debris blockage effecting impact.
NET	Future parameter not available. [0]. ICOND Parameter indicating the type of initial conditions. If running in stand-alone mode and not a part of NWSRFS, 0 is used. [0].
FUTURE DATA – [all 0's].	
Data Group 3	
NYQD	Number of sets in stage-discharge values in empirical rating curve at downstream boundary. No empirical data is available or applicable. [0].
KCG	Utilized for gates or spillways functions. [0].
NCG	See KCG. [0].
KPRES	Parameter indicating method of computing hydraulic radius, R. [1]. KPRES=0, R=A/B where A is cross-sectional area and B is channel top width. KPRES=1, R=A/P where P is wetted perimeter.

Data Group 4	
NCS	Indicates number of values in table of top width (BS) vs. elevation (HS). This value applies to all cross sections in the river system. [5].
KPL	Parameter indicating what information will be plotted. This parameter has no effect on FLDGRF utility. [3]. KPL=0, nothing is plotted. KPL=1, stage hydrographs are plotted. KPL=2, discharge hydrographs are plotted. KPL=3, both are plotted.
JNK	Parameter indicating if hydraulic information will be printed. Values range from 0 for no printout to 9 (10 for dynamic routing information for each iteration). [9].
KRE VRS	Parameter indicating use of the low flow filter. [0]. KREVRS=0, low flow filter is activated disallowing water surface elevations (WSEs) and discharges to go below the initial condition. KREVRS=1, low flow filter is off and reverse flow is allowed. NFGRF Parameter indicating if FLDGRF data will be generated. NFGRF=0, data is generated. NFGRF=1, data is not generated.
IOB S	Parameter indicating if observed data are available at gauging stations. [0]. IOBS=0, no data is available. IOBS=1, a mathematical function is used to describe the inflow hydrograph.
KTE RM	Parameter indicating if the terms in the equation of motion will be printed as special information. [0, recommended by NWS]. KTERM=0, will not printed. KTERM=1, will be printed.
NP	Parameter indicating if Automatic Calibration option is used to determine Manning's n value. No stage vs. discharge data is available. [0]. NP=0, calibration not used. NP=1, calibration is performed. NP=4, calibration using average cross-sections is performed.
NPS T	Parameter used with NP. If NP=0, then [0].
NPE ND	Parameter used with NP. If NP=0, then [0].

Data Group 7	
TH E	Time in hours whereby routing computations will terminate. [120].
DT HII	Initial computation time step in hours.
	DTHII=0, variable time step is used based on inflow hydrographs and dam failure times. DTHII>0, constant time step is used. DTHII<0, an array of time steps will be read where NDT=|DTHII|.
	Since no hydrographs or dam failure times data is available, value of greater than 0 was used. Value used was based on minimal value achieving a satisfactory graphic output without unexplainable distortion. [0.0715].
DT HP LT	Time step at whereby computed/observed hydrograph data are stored for plotting. Value set at DTHPLT=DTHII. [0.0715].
FR DF R	Window for critical Froude no. in mixed-flow algorithm. Default value is 0.5. [0].
DT EX P	Computational time step in hours for explicit routing. Initial computation time step in hours. Explicit routing was not used. [0]. DTEXP=0, explicit routing not used. DTEXP>0, constant time step is used. DTEXP<0, variable time step is used based on the Courant number. MDT Divisor for determining the time step. If DTHII≠0, then [0].
Data Group 10	
NLEV	Total number of cross-section reaches in the system that has levees. The composite channel modeled does not allow levee overtopping; therefore, [0].
DHLV	The difference between the maximum and the minimum levee crest elevations along the reach. If NLEV=0, then [0].
DTHLV	Computational time step to be used during levee overtopping/failure. If NLEV=0, then [0].
Data Group 12	
NBT	Total number of actual cross-sections on channel. [15].
NPT1	First cross-section number after interpolation for which debug information will be printed. [1].
NPT2	Final cross-section number after interpolation for which debug information will be printed. [15].
EPQJ	Discharge tolerance in Newton-Raphson Iteration scheme in channel. [100].
COFW	Coefficient of wind stress on channel. The floodplain was modeled as a composite channel running through developed lands. Therefore, wind stress is expected to have minimal effect when compared to open land inundated with floodwaters. [0].
VWIND	Wind velocity expected over channel. See COFW. [0].
WINAGL	Acute angle that wind makes with the channel axis. See COFW. [0].

Data Group 13	
KU	Parameter indicating the type of upstream boundary condition being specified for the channel. KU=1, stage hydrograph is the upstream boundary condition. KU=2, discharge hydrograph is the upstream boundary condition. Because of the layout and operations of individual impoundments, no stage or discharge hydrographs are available. However, a synthetic channel was required for model convergence. Therefore, a synthetic discharge hydrograph was created to meet model requirements. [2].
KD	Parameter indicating the type of downstream boundary condition being specified for the channel. KD=1, stage hydrograph is the downstream boundary condition. KD=2, discharge hydrograph is the downstream boundary condition. KD=3, single-valued rating curve of discharge as a function of stage is the boundary condition. KD=4, looped rating curve is generated based on Manning's equation where the friction slope is computed based on the momentum equation. KD=5, normal flow computed from Manning's equation is the downstream boundary condition. KD=7, looped rating curve is generated where the friction slope is computed based on conveyance Because of the layout and operations of individual impoundments, no stage or discharge hydrographs are available. Since the dam break analyses produces a kinematic wave (unsteady flow), the momentum equation was made. [4].
NQL	Total number of lateral flows. See KFLP. [0].
NGAGE	Denotes number of stations that computed values will be plotted. Also, may indicate number of observed hydrographs that will be compared to computed hydrographs. The former case is used in the analyses. [6].
NRCM1	Total number of Manning n reaches for channel. [8].
NQCM	Total number of values in the Manning n table. Also, denotes whether Manning n is a function of WSE or Discharge. [0]. NQCM=0, Manning n is a function of WSE and the number of table values is equal to NCS. NQCM>0, Manning n is a function of WSE. NQCM<0, Manning n is a function of discharge.
NSTR	Future model parameter. [0].

Data Group 14	
MIXF	Parameter indicating flow regime in the channel. MIXF=0, subcritical flow MIXF=1, supercritical flow MIXF=2, mix flow, with moving hydraulic jump. MIXF=3, hydraulic jump moves only with Froude>2. MIXF=4, hydraulic jump is stationary. MIXF=5, modified implicit techniques is used to solve mixed flows. The surrounding area, hence the modeled channel slope is essentially flat with little or no slope. A hydraulic jump is expected to occur immediately adjacent to the dam breach, but no further reoccurrence is expected downstream since no further energy will be applied in the form of gravitational force. Subcritical flow is expected throughout. [0].
MUD	Parameter indicating the use of the mud/debris flow option in the channel. MUD=0, dynamic routing of non-mudflow (water) will be done. MUD=1, dynamic routing of mudflow will be done. Mud is not expected to be a heavy impact on the flow. Area is flat whereby heavy muds should settle quickly. Also, area is expected to be developed and lands with assorted tropical vegetation and grasses. [0].
KFTR	Parameter indicating the use of Kalman Filter option on channel. The Kalman Filter can be turned on to update the forecast if the channel has stage observations for more than 2 gauging stations. KFTR=0, switch is off. KFTR=1, switch is on No gauging stations; therefore, [0].
KLOS	Parameter indicating the computation of volume losses in the channel. KLOS=0, losses are not computed. KLOS=1, Losses will be computed. The modeling scheme employed in the analyses requires losses to be computed. [1].
FUTURE TA [0].	
Data Group 17	
XLOS1	First location of the reach where flow loss will occur. [0.01].
XLOS2	Last location of the reach where flow loss will occur. [0.10].
QLOS	Percentage of the loss in terms of total active flow amount. See *0*. [-60].
ALOS	Loss distribution coefficient. For linear loss, [1].
Data Group 18	
XT	Location of stations or cross-sections where computations are made. Index goes from 1 to NBT.

Data Group 19	
DXM	Minimum computational distance step between cross sections. If DXM is less than the distance between two adjacent cross-sections read in, then intermediate cross-sections are created within the program via a linear interpolation procedure. Index goes from 1 to NBT-1.
Data Group 20	
KRCH	Parameter indicating routing method or internal boundary condition in each reach. KRCH=0, implicit dynamic routing. KRCH=1, implicit diffusion routing. KRCH=4, level pool routing. KRCH=5, explicit dynamic routing (upwind). KRCH=6, implicit (local partial inertial) routing. KRCH=10-28, dam and variations of the dam. KRCH=35, bridge. Value of [10] was selected for the first boundary since the impoundments are essentially dams. Because of the model requirements and number of assumed parameters, implicit routing was selected as the best fundamental approach between reaches. Value of [0] was used for these requirements. Index goes from 1 to NRCH.
Data Group 26	
SAR	Surface area in acres of impoundment storage at elevation HSAR. Index goes from 1 to 8. If less than 8 values are needed for description, set remaining values to 0. Impoundments are regular shaped; therefore, only two values were used to describe the storage vs. surface area parameter.
HSAR	Elevation that the impoundment surface area SAR is defined. Values are read starting at the top of the impoundment going to the bottom. Index goes from 1 to 8. Set unused values to 0.

Data Group 28	
LAD	Reach number corresponding to location of dam (levee). The impoundment is the origin of the model channel floodway; therefore, [1}.
HDD	Elevation set for top of levee. For piping though, the WSE at start of breach is applicable.
CLL	Length of levee crest that breach occurs. This is for an uncontrolled emergency spillway that is not applicable since overtopping was not modeled. Arbitrary number assigned.
CDOD	Discharge coefficient for uncontrolled weir flow over the top of the levee. See CLL. However, values permitted ranged from 2.6 to 3.1. [3]
QTD	Discharge through turbines. No turbines. [0].
ICHAN	Parameter indicating if channel conditions at impoundment will switch from manual control to channel control (e.g. lock and dam control). ICHAN=0, no channel control. ICHAN=1, channel switch is allowed. No control structures modeled. [0].
Data Group 29	
ICG	Parameter indicating type of moveable gate structure. No control structures modeled. [0].
HSPD	Elevation of uncontrolled spillway crest. See CLL. [0].
SPL	Crest length of uncontrolled spillway. See CLL. [0].
CSD	Discharge coefficient of uncontrolled spillway. See ICG. [0].
HGTD	Average elevation of center of gate opening for moveable gates. See ICG. [0].
CGD	Discharge coefficient for gate flow times the area of the gates. See ICG. [0].
Data Group 47	
TFH	Time (hours) from beginning of breach formation until final breach width.
DTHDB	Computational time step (hours) to be used after failure of levee. [0]. DTHDB=0, time step will computed as TFH/MDT. DTHDB≠0, time step will be the smallest of the two options.
HFDD	Elevation of water when failure of levee commences.
BBD	Final breach bottom width.
ZBCH	Side slope of breach in terms of 1 on horizontal. Sensitive to soil angle of friction. [1.5].
YBMIN	Lowest elevation that bottom breach reaches.
BREXP	Exponent used in development of the breach. Ranges from 1 to 4 (higher number reflects slower failure time). Value of ≥ 2 is recommended for piping; however, 1 is more conservative. [1].
CPIP	Centerline elevation of piping breach. Used an elevation one-foot above the breach bottom. See YBMIN
Data Group 50	
NGS	Sequence number of each observed/plotting station on channel. Index goes from 1 to NGAGE.
Data Group 56	
ST1	Observed stages (ft) or discharges (cfs) at upstream boundary of channel. Model convergence requires a channel for stability. A channel was modeled for this requirement with a steady flow of 50 cfs. The flow rate was

	determined through trial and error resulting in the minimal flow required that meets model requirements. [50].
Data Group 57	
T1	Time array associated with upstream hydrograph ST1. Index goes from 1 to NU.
Data Group 70 (for cross-sections NCS=I)	
FLST	Elevation that flooding commences. See KFLP. Value of 0 recommended if no flooding. [0].
YDI	Initial WSE (ft-msl) at cross-section I. If steady state conditions exist, the YDI value at the downstream location of the channel and pool levels behind the levee must be read in and the model will do backwater computations. All other values are set to 0. Otherwise, all values are read in. The former case applies; however, the model does not show a particular sensitivity to either process. This is probably because of the loop-rating curve for the downstream boundary condition that works well. [0].
QDI	Initial discharges (cfs) at cross-section I. If steady state conditions exist, all QDI values are read in as zero and the QDI values are generated by summation of flows from upstream to downstream. If unsteady state condition exists, all QDI values are read in. The former case applies. [0].
ASI	Active cross-sectional area (sq ft) below the lowest HS elevation at cross-section I. [0].
Data Group 71 (for cross-section NCS=I)	
HS	Elevation corresponding to each top width BS. Elevations are measured from the bottom of the cross-section upward. Varies with impoundment.
Data Group 72 (for cross-section NCS=I)	
BS	Top width (ft) of active flow portion of channel cross-section corresponding to each elevation HS.
Data Group 77 (for cross-section NCS=I)	
BSS	Top width (ft) of dead storage (inactive) portion of channel cross-section corresponding to each elevation HS.

Data Group 79	
FKEC	Expansion or contraction coefficient. Expansion coefficients vary from –0.05 to –0.75 and contraction coefficients vary from +0.10 to +0.40. Larger values are associated with very abrupt changes in the cross-section along the channel. If expansion/contraction is negligible, then FKEC is set to 0. An expansion coefficient was used for the first 0.30 mile of the modeled channel. The coefficient decreased with distance from the levee breach until the value of 0 was used passed the 0.30-mile marker. This was done conservatively to represent some effect as the expansion took place in proportion to the width of the channel at a particular point. Farther downstream of the breach, the expansion angle is the same, but the width is much greater, minimizing any real effect of the expansion process.
Data Group 80	
NCM	Station number of upstream-most station in subreach that has same Manning n. Index goes from 1 to NRCM.

A.6.11.8 Wind and Wave Analysis

A.6.11.8.1 Introduction

The purpose of this study is to provide estimates for wave run-up and embankment over-wash flow rates for selected water depths and embankment heights at the C-9 Impoundment. The C-9 Impoundment is a project component of the larger C-9 Basin. C-9 Basin is located adjacent to the eastern boundary of Water Conservation Area 3 (WCA 3) and south of I-75/I-595 in Broward County, Florida (***Figure A-27***). The C-9 Basin is an integral part of the Central and Southern Florida flood project and, along with the C-9 Canal, provides a primary flood control outlet to Biscayne Bay (tide). The purpose of the C-9 Impoundment is to reduce seepage from WCA 3, provide additional storage to C-11 Impoundment for diversion of water from S-9 Pump Station. The C-9 Impoundment covers approximately 1,807 acres of the C-9 Basin.

For study purposes, the C-9 Impoundment was modeled for each of the four design cases outlined in DCM-2 as well as two additional design conditions, a 36-hour pre- and post-peak Probable Maximum Precipitation (PMP) storm event combined with a 100-year wind, and a peak PMP storm event combined with a 100-year wind during which all gated culverts are inoperable. For each design case, a full 180 degree array of incident wind directions was evaluated.

Wave heights due to wind-growth within the reservoir were estimated for each design case using the numerical wave transformation model STWAVE (Steady-state spectral WAVE). Based on model results, wave run-up on exterior levees was then calculated using the US Army Corps of Engineers' (USACE) Automated Coastal Engineering System (ACES). Over-wash rates for a range of embankment heights were then determined.

A.6.11.8.2 Design Wind Condition

The design wind condition is a key parameter in the determination of levee superiority. The design wind condition consists of three elements, the wind speed, wind direction, and wind duration. All three elements directly contribute to both the growth and magnitude of wind-waves within the reservoir as well as the amount of wind setup that the reservoir will experience.

As part of the greater Comprehensive Everglades Restoration Plan (CERP), a reservoir may be defined by one of three Hazard Potential Classifications (HPC), High, Significant, or Low. Classification is determined by the level of risk associated with a potential embankment failure. Based on classification

guidelines, C-9 Impoundment carries a High HPC with the inflow design flood (IDF) defined as the flood resulting from the PMP event. As such, freeboard requirements are to be determined based upon combinations of reservoir level, precipitation, and wind conditions that are reasonably expected to occur simultaneously, or within 36 hours of the maximum surcharge level. The following four design cases, as outlined in DCM-2, were evaluated for the C-9 Impoundment study (SFWMD and ACOE, 2006):

Case 1 PMP storm event with 100-year wind condition
Case 2 100-year precipitation event with a Category 5 hurricane wind condition
Case 3 Normal full storage pool level with a Probably Maximum Wind (PMW) condition.
Case 4 Conditions reflective of the historical storm, Hurricane Easy

For the C-9 Impoundment study two additional cases were evaluated, a 36-hour pre- and post-peak Probable Maximum Precipitation (PMP) storm event combined with a 100-year wind, and a peak PMP storm event combined with a 100-year wind during which all gated culverts are inoperable.

A.6.11.8.2.1 100 year wind speed (Case 1)

The first step in determining the 100 year wind speed for a given location is to obtain reliable wind data for the area of interest. While wind velocity data may exist in the form of local anemometer readings, this type of data is considered to be unreliable for high velocity wind measurements due to the physical limitations of these instruments. The American Society of Civil Engineers (ASCE), however, has compiled a record of reliable high velocity wind data based on extensive meteorological measurements and hurricane frequency analyses that cover the Atlantic and Gulf Coasts (ASCE, 2003). Wind information from this source, specifically for the state of Florida, can also be found in the Florida Building Code (Section 1606 Wind Loads). The Florida Building Code provides this data in a graphical format, depicting isovels of 50 year return period, maximum 3-second average wind speeds (gusts) (***Figure A-28***). These wind speeds are assumed to be measured at an elevation of 33 ft and may be determined through linear interpolation of the isovels as necessary.

The 3-second gusts provided by the Florida Building Code are used primarily in the evaluation of the structural stability of buildings and are not directly applicable to earthen embankments or wind-wave analyses. However, these conditions can be adjusted to wind speeds that are appropriate for such investigations. Three steps are required to convert a 3-second gust wind speed to an appropriate 100 year design wind speed: (1) conversion of the 50

year, 3-second gust to a 100 year, 1-hour average wind speed (2) adjustment from an over-land wind speed to an over-water wind speed, and (3) adjustment of over-water wind speed to fetch-limited wind speed.

A.6.11.8.2.2 Conversion of 50 Year, 3-second Gust to 100 Year, 1-hour Average Wind Speed

Conversion of the 50 year, 3 second gust wind speed takes place in two stages. The first stage is to convert the gust wind speed from a 50 year to a 100 year return period. This is done using conversion factors located in ***Table A-60*** (ASCE, 2003).

From ***Figure A-28***, the 50 year, 3-second gust corresponding to the C-9 Impoundment location is 133mph. Using ***Table A-59***, a conversion factor of 1.07 is applied to this wind speed, resulting in a 100 year, 3-second gust wind speed of 142.3mph.

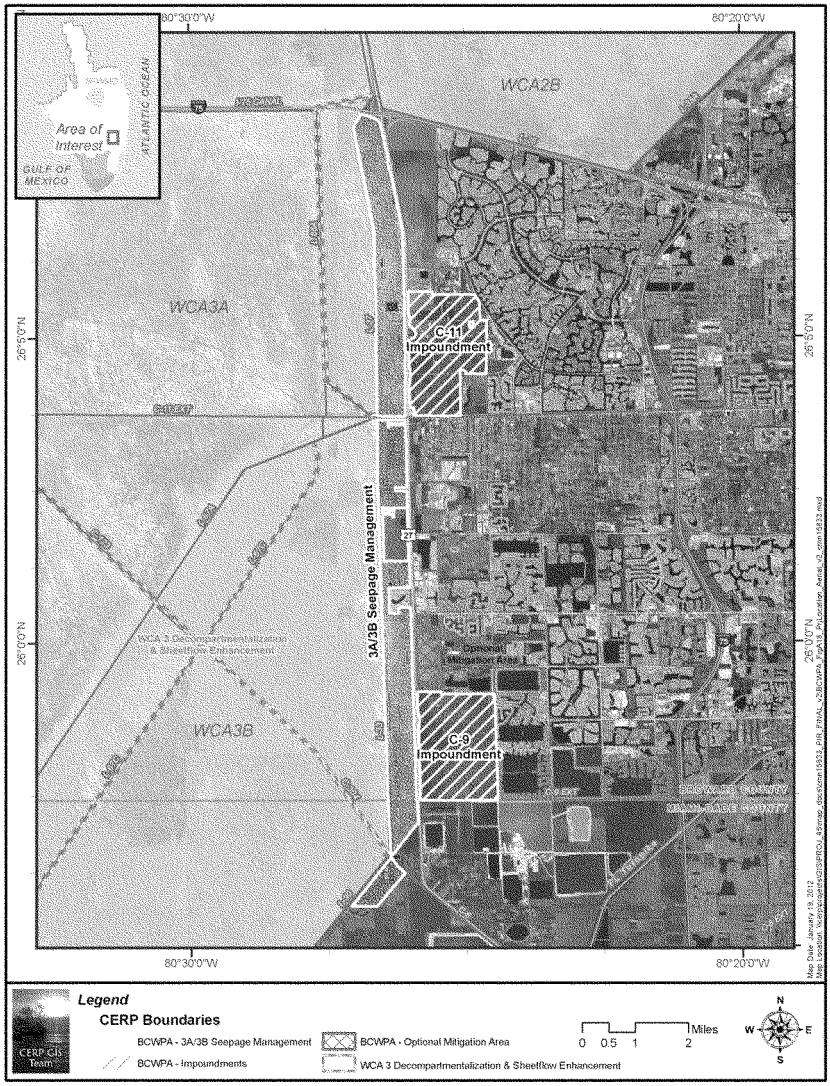


FIGURE A-27: LOCATION OF RESERVOIR (IMPOUNDMENT)

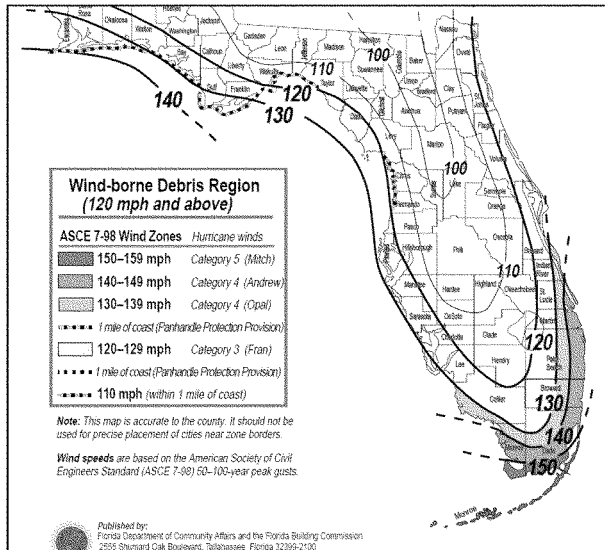


FIGURE A-28: 50 YEAR, 3-SECOND GUST WIND SPEED ISOVELS

The second stage is to convert the 3-second gust wind speed to a 1-hour average wind speed. ***Figure A-29*** provides a means of converting wind speed estimates from one averaging interval to another, using ratios of winds of various durations to 1-hour average wind speeds.

TABLE A-59: RETURN PERIOD CONVERSION FACTORS

Return Period (years)	Conversion Factor
500	**1.23**
200	**1.14**
100	**1.07**
50	**1.00**
25	**0.88**

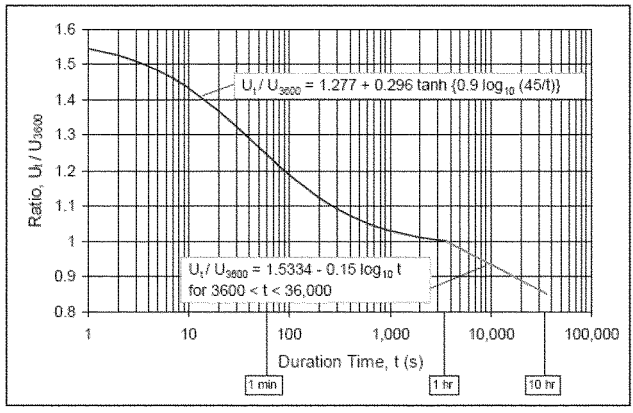


FIGURE A-29: RATIO OF WIND SPEED OF AND DURATION TO 1-HOUR WIND SPEED

Figure A-29 from the "Shore Protection Manual" includes defining equations for wind durations of less than or equal to 1 hour (U_t < 3,600 seconds) and durations between 1 and 10 hours (3,600 < Ut <36,000 seconds). In this particular case, the duration (3 seconds) is less than 1 hour, resulting in the application of the following equation:

$$\frac{U_t}{U_{3600}} = 1.277 + 0.296 \tanh\left\{0.9 \log_{10}\left(\frac{45}{t}\right)\right\}$$

where,

U_t = wind speed of duration less than 1 hour (130.45mph)
U_{3600} = 1 hour wind speed
t = duration less than 1 hour (3 sec)

Solving the above equations for U_{3600}, results in a 100 year, 1 hour wind speed of 94.3mph.

A.6.11.8.2.3 Adjustment from Over-Land Wind Speed to Over-Water Wind Speed

The next adjustment required to reach an appropriate design wind speed, is to account for land effects in the measured data. Wind observations over water are typically the best choice for wave prediction. When wind speed data comes from predominantly land based sources (i.e. airports and other urban sources), the effects of local frictional characteristics and topography

must be accounted for. Otherwise, wave growth will occur in a transitional boundary layer, which does not suitably represent actual over-water conditions. In cases where the fetch (horizontal distance over which winds generate waves) is less than 16 km (~10 miles) and wind speeds are relatively high, it is recommended that wind speeds resulting from land based measurements be increased to by a factor of 1.2 to better represent over-water conditions (USACE, 2005). Applying this factor to the 100 year, 1-hour wind speed of 94.3mph gives an adjusted over-water wind speed of 113.1mph.

A.6.11.8.2.4 Adjustment of Over-Water Wind Speed to Fetch-Limited Wind Speed

The final adjustment to be made in calculating the design wind speed is applicable only to reservoirs of relatively long fetch length over which a fully developed wind field will develop within the duration of the design wind condition. If the duration required to achieve a fully developed wind speed exceeds the 1-hour duration of the 100 year design wind speed, the wind speed must be adjusted for the longer duration.

The wind duration (in seconds) required to produce a fetch-limited wave field for a given fetch and wind speed can be expressed as follows (USACE, 2005):

$$t_{x,u} = 77.75 \frac{F^{0.67}}{u^{0.34} g^{0.33}}$$

where

t = wind duration (seconds)
F = straight line fetch distance over which the wind blows (meters)
u = wind velocity (meters/second)
g = acceleration due to gravity (meters/second2)

Converting to English units provides the following:

$$t_{x,u} = 112 \frac{F^{0.67}}{u^{0.34}}$$

where t is duration in minutes, F is the fetch distance in miles, and u is the wind speed in miles per hour.

A.6.11.8.2.5 Determination of Fetch

Fetch is defined as a distance over which the wind speed and direction are reasonably constant. Fetches fall into two categories, open-water fetches,

where wave growth is limited only by the incident meteorological conditions, and restricted fetches, where wave growth is limited by a confined geometry such as that of a lake, river, bay, or reservoir. The C-9 Impoundment is subject to a restricted fetch. The restricted fetch methodology applies the concept of wave development in off-wind directions and considers the shape of the basin. The fetch is defined as the radial average over an arc of 24 degrees centered on the wind direction. For this study, the wind direction (for determination of the fetch-limited wind speed) is taken to be the direction corresponding to the maximum fetch distance. This will provide the maximum design fetch for determining the maximum possible duration. ***Figure A-30*** indicates the 24-degree arc for each cell, divided into 3-degree intervals. Averaging the radial lengths over each arc gives average fetch length of 2.13 miles for C-9 Impoundment.

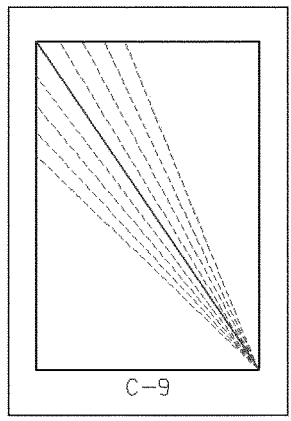


FIGURE A-30: FETCH DETERMINATION SCHEMATIC FOR C-9

Applying the average fetch for each cell to the above duration equation yields a duration, $t_{u,x}$, for the growth of a fully developed wave field of 37 minutes in C-9 Impoundment. This duration does not exceed the 1-hour design wind duration and, therefore, the 100-year design wind speed for the C-9 Impoundment remains 113.1mph.

A.6.11.8.2.5.1 Category 5 wind speed (Case 2)

In accordance with DCM-2, the wind speed for Case 2 is the minimum wind speed in the Category 5 hurricane classification. Based on the Saffir-Simpson Hurricane scale, the design wind speed is 156mph (1-minute

average). Converted to a 1-hour average wind speed, the design wind speed becomes 125mph.

A.6.11.8.2.5.2 Probable Maximum Wind Speed (Case 3)

In accordance with DCM-2, the PMW is designated a velocity of 200mph (1-minute, over water average). Converted to a 1-hour average wind speed, the PMW design wind speed becomes 161mph.

A.6.11.8.2.5.3 Hurricane Easy (Case 4)

In accordance with DCM-2, Hurricane Easy is represented by a maximum 3-second wind gust of 125mph. Converted to a 1-hour average wind speed, the design wind speed for Case 4 becomes 99.3mph. DCM-2 states that a minimum of 100mph is required for all design wind speed cases. Therefore, the design wind speed for Case 4 becomes 100mph.

A.6.11.8.3 Wind Setup Analysis

Wind set up occurs when wind blows in a fairly constant direction over a body of water. Wind blowing across the water causes the surface layer to move in the direction of the wind due to shear stress development between the air and water. This causes water to "pile up" against the shore, creating the effect known as "wind setup". A corresponding drop in water level will occur along the upwind shore.

Three wind setup models were investigated for applicability to the C-9 Impoundment, the Zieder Zee formula (USACE, 1990), the Brater and King method (Brater et al., 1996), and the Bretschneider method (Ippen, 1966). Although the Zeider Zee formula is generally recommended in USACE Engineering Manuals, it is empirically derived based on deepwater fjords and produces unrealistically high setup values for shallower waters. The Sibul method (Brater et al., 1996), developed through laboratory experiments and tested with field data, has shown good correlation with data gathered for large bodies of water such as Lake Okeechobee and the Baltic Sea. However, the Sibul model appears to under predict wind set up in shallow water cases when compared with other generally accepted models. Bretschneider's model is a physics based model allowing for the different shear forces developed by the wind on water surface and by return flow on bottom bed. This model was solved numerically using Lake Okeechobee data and appears well founded on water bodies similar to CERP reservoirs. Bretschneider's model was therefore selected as the model to calculate wind setup for the C-9 Impoundment.

A.6.11.8.4 Bretschneider

The numerical model presented by Bretschneider was derived under steady-state wind conditions, i.e. constant speed and direction along a channel axis. The differential form of the model, based on surface and bottom shear stresses as well as conservation of mass, determines wind setup as a function of the effective stress. The effective non-dimensional stress parameter employed in this method can be expressed as:

$$\frac{\kappa U^2 F}{g d^2}$$

where,

κ = wind drag coefficient
U = wind speed
F = fetch length
g = acceleration due to gravity
d = water depth

Based on the calculated value of this stress parameter, wind setup can be determined from tabulated data presented in Ippen (1966).
It should be noted that the wind drag coefficient κ, is not a constant. Its value can be influenced by such factors as wind speed, wave steepness (eddy correlation), and salinity. For this study, a wind drag coefficient value of 3.3x10-6 was assigned. This value is based upon studies of Lake Okeechobee (Ippen, 1966) and is considered to be representative of conditions at C-9 as well.

A.6.11.8.5 Wind Setup Results

Wind setup values, corresponding to maximum surcharge pool depths, are provided in ***Table A-60***.

TABLE A-60: WIND SETUP

C-9 Case	Maximum Normal Pool Depth (feet)	Maximum Surcharge Pool Depth (feet)	Stillwater Depth (feet)	Design Wind Speed Adjusted (mph)	Fetch Length (miles)	Wind Setup (feet)
Case 1: PMP, 100yr wind	4.3	3.53	7.83	113.1	2.13	1.88
Case 2: 100yr precip., Cat5 wind	4.3	1.26	5.56	125.0	2.13	3.08
Case 3: Normal pool, PMW	4.3	0.00	4.30	161.0	2.13	5.09
Case 4: Hurricane Easy	4.3	2.98	7.28	100.0	2.13	1.59
36hr PMP 100yr wind	4.3	2.07	6.37	113.1	2.13	2.25
Peak PMP, 100yr wind, No Gate Op	4.3	4.35	8.65	113.1	2.13	1.56

A.6.11.8.6 Wave Height Analysis

A.6.11.8.6.1 Model

The STWAVE model is a two-dimensional spectral wave transformation model for the simulation of wave transformation over complex bathymetry. STWAVE accepts arbitrary directional wave spectra specified at an offshore boundary and propagates the spectral energy in the onshore direction. It is a finite-difference model, which calculates wave spectra on a Cartesian grid using a backward ray-tracing scheme (Smith et al., 1999). Model results, including spectral output, significant wave height, mean wave period, and

wave direction, are obtained by numerically solving the steady-state spectral energy balance equation. This equation is given as:

$$\frac{\partial c c_g E(f,\theta)}{\partial x} + \frac{\partial c c_g E(f,\theta)}{\partial y} = S_{at} + S_{nl} + S_{ds} + S_{br}$$

The left-hand side of the equation represents wave propagation (refraction and shoaling) where:

E = spectral energy density
f = frequency of spectral component
θ = propagation direction of spectral component
c = phase speed of spectral component
c_g = group velocity of spectral component
x,y = plan-view spatial coordinates

Source terms, making up the right-hand side of the equation, represent distribution and dissipation of energy based on principals of linear theory. These terms are defined as:

S_{at} = wind input
S_{nl} = nonlinear wave-wave interactions
S_{ds} = dissipation within the wave field
S_{br} = depth-induced wave breaking.

Despite quantifying these source terms on an individual basis, S_{at}, S_{nl}, and S_{ds} are solved via conservation of momentum flux to the forward and rear face of the spectrum where the energy is redistributed. S_{br} dissipates energy based on water depth and wave steepness.

STWAVE has several inherent limitations. For the best application of the model to wave transformation problems, the following assumptions must be made:

Negligible wave reflection (mild bottom slopes)
Spatially homogeneous offshore waves
Steady state waves, winds, and currents
Linear refraction and shoaling with negligible bottom friction effects
Linear wave-current interaction

Due to the nature of the solution scheme, spectral energy is limited to propagation in a half-plane directed toward shore. All energy propagated offshore is neglected.

A.6.11.8.7 Wave Model Inputs

A.6.11.8.7.1 Bathymetry

Topographic data for the C-9 Impoundment project area was obtained from the Water Preserve Area (WPA) LIDAR survey (NAD 83\NGVD 29). Survey data indicates that elevations within the project area vary significantly. In addition to moderate changes in grade, a series of furrows, channels, and spoil mounds create a complex bottom topography in reservoir (***Figure A-31***). Two design depths were considered for this evaluation, a depth of 6.37 foot (corresponding to a 36 hour pre/post peak PMP storm event) and a depth of 7.83 foot (corresponding to a peak PMP event). Design depths represent the average depth over the entire reservoir basin.

A.6.11.8.7.2 STWAVE Grids

In order to analyze wind-wave generation within the reservoir compartment an STWAVE computational grid was generated using the SMS (Surface-water Modeling System) software package developed by Brigham Young University (Brigham Young, 1997). The C-9 Impoundment is irregular in shape with a computation grid consisting of 560 land and water cells in the east to west direction and 824 land and water cells in the north to south direction. Grid cell resolution was 12.5 feet, producing a grid coverage of approximately 1.3 miles by 2.0 miles for the C-9 Impoundment. A single base input grid was generated for with water levels adjusted accordingly prior to each model run.

In order to evaluate wind-wave heights at each levee of concern (i.e. along all exterior reservoir boundaries), it was necessary to specify four separate forcing boundaries (boundaries along which input conditions are introduced) for each grid. This was accomplished by reorienting the computational grid, by rotating in 90 degree increments, from its original orientation such that each levee became the primary focal point of the growing wave fields. The four orientations are referred to as Orientation A (original orientation – central wind from the west), Orientation B (central wind from the south), Orientation C (central wind from the east), and Orientation D (central wind from the north). ***Figure A-32*** illustrates the four forcing boundaries and levees of interest.

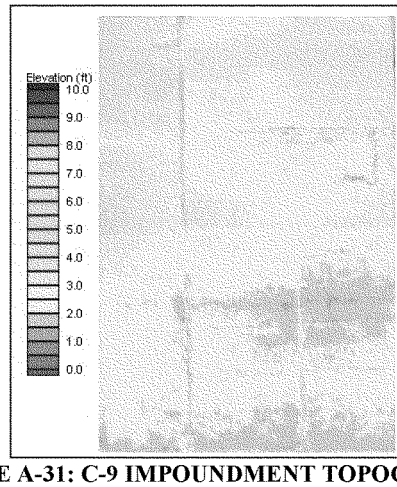


FIGURE A-31: C-9 IMPOUNDMENT TOPOGRAPHY

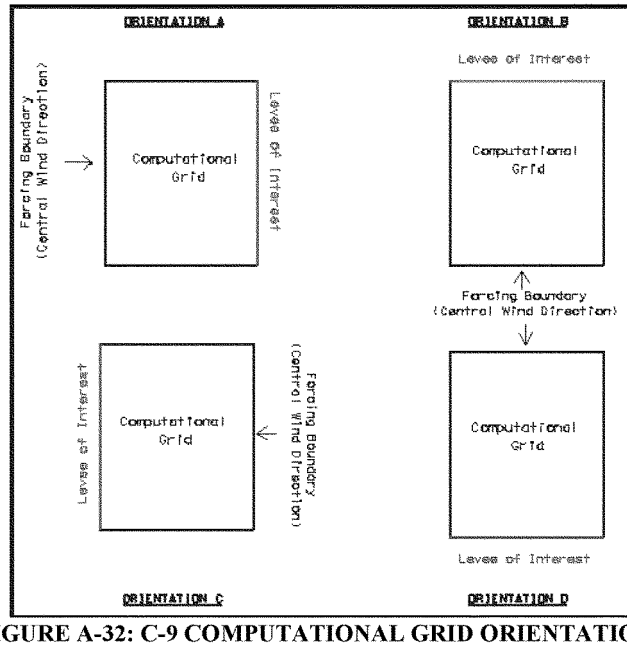


FIGURE A-32: C-9 COMPUTATIONAL GRID ORIENTATIONS

A.6.11.8.7.3 Wind and Current Input

It is assumed that each wind-wave growth case begins with a still water surface. This eliminates the need for a measured or simulated spectral wave field to be applied at the forcing boundary of the model domain. Therefore, the only energy input conditions required are wind conditions consisting of a wind speed and wind direction. Two wind speeds, 113.1 mph and 68.3 mph were the design wind conditions. This wind speed was applied to an array of 13 incident wind directions, covering a levee directed half-plane for each grid orientation. Incident wind directions ranged from –90° to +90° (relative to a transect perpendicular to the levee of interest) in 15° increments. ***Table A-61*** summarizes the STWAVE incident wind directions along with their corresponding "true" directions (measured clockwise from 0° due North) for each grid orientation. All wind speed and wind direction combinations were run with each orientation of the computational grid. Currents were not included in this study.

TABLE A-61: INCIDENT WIND DIRECTIONS

STWAVE Model Direction (deg)	"True" Direction (winds from) (deg)			
	Orientation A	Orientation B	Orientation C	Orientation D
+90	180	90	0	270
+75	195	105	15	285
+60	210	120	30	300
+45	225	135	45	315
+30	240	150	60	330
+15	255	165	75	345
0	270	180	90	0
-15	285	195	105	15
-30	300	210	120	30
-45	315	225	135	45
-60	330	240	150	60
-75	345	255	165	75
-90	0	270	180	90

A.6.11.8.8 STWAVE Model Output

A.6.11.8.8.1 General

Wind waves, also known as oscillatory waves, are most commonly defined by their height, length, and period. These characteristics, as measured at a given location, are determined by five dominant factors: the velocity of the wind (wind speed), the distance over which the wind blows (fetch), the duration over which the wind blows, the decay distance the wave travels

after leaving the generating area (not relevant to this study), and the water depth.

The process of wind wave growth (assuming initial still water) begins with the motion of the air above the water disturbing the surface of the water. As wind begins to blow over the water, wind stress at the air-sea boundary leads to the formation of small perturbations in the water surface. When the perturbations become large enough to affect the pattern of air flow a transfer of momentum and energy between the air layer and the water surface occurs, rapidly increasing wave heights. Wave heights build rapidly over a relatively short distance, increasing at a rate that varies dependent upon wind speed. Waves develop more quickly and with greater uniformity as wind speed increases.

Wind driven waves are a highly complex mix of crests and troughs on the water surface, consisting of irregularly sized wave heights and moving in variable directions. This is particularly true while the waves remain under the influence of the wind. For design purposes, it is often necessary to describe a full wave field with a single representative wave height and direction. Wave direction can be easily defined as an average of the directions of individual waves. Wave height can also be represented as an average value. However, these averages are typically described in terms of the average height of a given percentage of the highest waves in the field. It has been found that the frequency of occurrence of waves above any given height can be closely approximated using the cumulative form of the Rayleigh distribution (USACE, 1984). This fact and resulting theoretical wave height distribution curves make it possible to determine average wave heights for a given percentage of waves based on a single significant wave height, Hs, defined as the average height of the one-third highest waves. The numerical model STWAVE provides wave heights that are in the form of significant wave heights.

Using the STWAVE model, wave heights over the computational domain were recorded for all wind speed, wind direction, and water depth combination as well as wave heights along the exterior reservoir boundaries.

A.6.11.8.9 Results

Maximum significant wave heights at the down-fetch levee face and corresponding peak wave periods for both design cases are provided in ***Table A-62***. Maximum wave conditions were determined from complete results for each orientation of each alternative design grid for the C-9 Impoundment project sites.

TABLE A-62: SIGNIFICANT WAVE HEIGHTS AND PEAK PERIODS - C-9 IMPOUNDMENT

Case	Wind Speed (mph)	Significant Wave Height (ft)	Peak Period (sec)
Case 1: PMP, 100yr wind	113.1	3.94	4.3
Case 2: 100yr precip., Cat5 wind	125.0	3.41	4.5
Case 3: Normal pool, PMW	161.0	2.85	4.2
Case 4: Hurricane Easy	100.0	3.74	4.0
36hr PMP 100yr wind	113.1	3.67	4.3
Peak PMP, 100yr wind, No Gate Op	113.1	4.56	4.3

A.6.11.8.10 Wave Run-up and Over-wash Analysis

A.6.11.8.10.1 Wave Run-up

Wave run-up can be described as the resulting forward translation of water mass that is converted from wave energy as waves encounter a sloped surface. Water rushes up the slope resulting in the vertical rise above the still water line known as run-up (***Figure A-33***). Run-up depends primarily on incident wave steepness, slope of the surface on which it is incident, and characteristics of the surface, including surface roughness and porosity. For a given fixed slope, run-up will increase with decreasing wave steepness. For a given incident wave height and period, run-up will increase with increasing slope steepness.

A.6.11.8.10.2 Effective Depth

Although the generation of wind waves (and therefore wave run-up and over-wash) is influenced by the presence of wind setup, the relationship is highly complex and is not presently included in the STWAVE model. Therefore, in order to predict the total water level increase due to wind conditions at the down-fetch face of the levee, wind setup must be accounted for with a computation exterior to the model. To account for the wind set-up, the water

level change due to wind setup was added directly to the project water depth (still water depth + precipitation). The resulting "effective depth" was then entered as the water depth when determining the freeboard, F, in the computation of the over-wash flow rates.

A.6.11.8.10.3 ACES

The ACES software package contains an application that provides for the estimation of wave run-up on rough and smooth impermeable surfaces. Six slope configurations were evaluated for this study, a smooth (earthen, RCC, or soil cement) slope (1V:3H), a rough (riprap covered) slope (1V:3H), a rough (riprap covered) slope (1V:2H), a stepped (RCC) slope (1V:3H), a stepped (RCC) slope (1:1.5), and a smooth (RCC or soil cement) vertical wall.

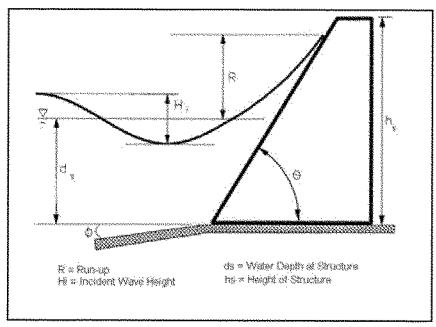


FIGURE A-33: WAVE RUN-UP DIAGRAM

A.6.11.8.10.4 Smooth Slope Wave Run-up

Smooth slope run-up, as presented by Ahrens and Titus (1985), recommends the following general equation:

$$R = CH_i$$

where

R = run-up,

H_i = incident wave height,

C = coefficient characterized by the surf parameter ξ, defined as:

$$= \frac{\tan\theta}{\sqrt{\frac{H_i}{L_o}}}$$

θ = angle between structure face and horizontal (18.435° = 1V:3H slope)
L_o = deepwater wavelength

according to the following three specific wave-structure scenarios:
$\xi \leq 2$ - waves plunging directly on the run-up slope.
$\xi \geq 3.5$ – wave conditions that are nonbreaking and are regarded as standing or surging waves.
$2 < \xi < 3.5$ – transition conditions where breaking characteristics are difficult to define.

Corresponding expressions for coefficient C are then:

Plunging wave conditions ($\xi \leq 2$)

$$C_p = 1.002\xi$$

Nonbreaking wave conditions ($\xi \geq 3.5$)

$$C_{nb} = 1.181\left(\frac{\pi}{2\theta}\right)^{0.375} \exp\left[3.187\left(\frac{\eta_c}{H_i} - 0.5\right)^2\right]$$

where

η_c = crest height of the wave above the still-water level calculated using the Stream Function Wave Theory (Dean, 1974)

Transitional wave conditions ($2 < \xi < 3.5$)

$$C_t = \left(\frac{3.5-\xi}{1.5}\right)C_p + \left(\frac{\xi-2}{1.5}\right)C_{nb}$$

The ACES application uses a more convenient but less accurate expression for the coefficient under nonbreaking conditions derived by Ahrens and Burke (unpublished report):

$$C_{nb} = 1.087\sqrt{\frac{\pi}{2\theta}} + 0.775\Pi$$

where

Π = Goda's (1983) nonlinearity parameter

$$= \frac{\frac{H_i}{L}}{\tanh^3\left(\frac{2\pi d_s}{L}\right)}$$

L = incident wave length
d_s = water depth at the toe of the structure.

A.6.11.8.10.5 Rough Slope Wave Run-up

The rough slope wave run-up formulation, as presented by Ahrens and McCartney (1975), was empirically derived from physical model studies conducted for specific structures and wave climates. According to this method, run-up is predicted as a nonlinear function of the surf parameter, ξ, and is defined as follows:

$$R = Hi\frac{a\xi}{1+b\xi}$$

where,

R = run-up,
Hi = incident wave height,
a,b = empirical coefficients associated with slope roughness, (0.956 and 0.398, respectively)

$$\xi = \frac{\tan\theta}{\sqrt{\frac{Hi}{L_o}}}$$

= angle between structure water face and horizontal, (18.435° - equivalent to a 1V:3H slope)
L_o = deepwater wavelength.

The empirical coefficients a and b were determined from data compiled for run-up experiments on riprap slopes.

A.6.11.8.10.6 Stepped Slope Wave Run-up

Although the ACES software package does not allow for the analysis of wave run-up on stepped slopes, run-up estimates may still be obtained by employing rough slope correction factors (Table 2-2 in EM 1110-2-1614). The estimated run-up is obtained by multiplying the rough slope wave run-up (as presented previously) by the correction factor for a stepped surface of given slope divided by the correction factor for quarrystone. For a stepped surface

of slope 1:3, the correction factor is 0.70. For a stepped surface of slope 1:1.5 the correction factor is 0.75. Combined with a quarrystone correction factor of 0.60, the stepped slope wave run-up equations are as follows:

For a 1:3 stepped slope:

$$R_{1/3} = (1.17)R_{rough}$$

For a 1:1.5 stepped slope:

$$R_{1/1.5} = (1.25)R_{rough}$$

The above equations are applicable when $1 \leq Ho'/Kr$, where Ho' is the unrefracted deepwater wave height and Kr is the riser height.

A.6.11.8.10.7 Vertical Wall Wave Run-up

The ACES software package allows for the evaluation of run-up on vertical walls using the smooth wave run-up formulation detailed previously.

A.6.11.8.10.8 Wave Run-up Results

Table A-63 provides wave run-up values for both design cases. For each case, run-up was determined for six slope types: (1) 1V:3H smooth (earthen, RCC, or soil cement) slopes, (2) 1V:3H rough (riprap) slopes, (3) 1V:2H rough (riprap) slopes, (4) 1V:3H RCC or soil cement steps, (5) 1V:1.5H RCC or soil cement steps, and (6) RCC or soil cement vertical wall. Due to maintenance concerns, no slopes steeper than 1V:3H were considered for smooth levees.

A.6.11.8.10.9 Over-Wash

Over-wash occurs when wave run-up and wind setup levels combine to produce a water level greater than the height of the levee. Over-wash is an important design element both in terms of predicting backside flooding and safeguarding structural integrity of the levee. Several methods exist for predicting the over-wash flow rate in a given situation. The ACES software package contains two methods, one for monochromatic wave over-wash as developed by Weggel (1976), the other for irregular wave over-wash developed by Ahrens (1977). Due to the irregular nature of the developed wave fields, Ahrens method was selected for this analysis.

TABLE A-63: WAVE RUN-UP FOR C-9 ALTERNATIVES

Alternative	Wave Run-up (ft), by Slope Type					
	Smooth (1V:3H)	Rough (1V:3H)	Rough (1V:2H)	Stepped (1V:3H)	Stepped (1V:1.5H)	Vertical
Case 1: PMP, 100yr wind	6.45	3.73	4.67	4.35	6.69	4.77
Case2: 100yr precip., Cat5 wind	6.28	3.46	4.29	4.04	6.08	4.16
Case 3: Normal pool, PMW	5.36	2.93	3.62	3.42	5.13	3.34
Case 4: Hurricane Easy	5.85	3.44	4.33	4.02	6.22	4.53
36hr PMP 100yr wind	6.23	3.55	4.43	4.14	6.33	4.49
Peak PMP, 100yr wind, No Gate Op	6.94	4.13	5.21	4.82	7.49	5.56

Ahrens over-wash method was developed with the following assumptions:

Run-up values caused by an irregular wave field will follow a Rayleigh probability distribution.
Significant deepwater wave height, H_s, causes significant run-up R_s
α, Q^*_o, and H_o in Weggel's over-wash equation remain constant for all members of the distribution.

Ahrens estimates the over-wash rate by summing the over-wash contributions from each individual member of the run-up distribution:

$$Q = \frac{1}{199}\sum_{i=1}^{199} Q_i$$

where

Q = volume rate of over-wash caused by irregular waves ($ft^3/s - ft$)
Q_i = volume rate of over-wash caused by one run-up on the run-up distribution

$$= C_w \sqrt{g Q_o^* (H_{so})^3} \left(\frac{R_i + F}{R_i - F} \right)^{\frac{-0.1085}{\alpha}}$$

where

C_w = wind correction factor
g = gravitational acceleration
Q^*_o, α = empirical coefficients (see USACE (1984))
H_{so} = deepwater significant wave height
F = Freeboard (levee height – water depth)
R_i = run-up value having exceedance probability $p = \sqrt{\frac{\ln \frac{1}{p}}{2}} R_s$

p = 0.005*i, i = 1,2,3,...,199
R_s = run-up with a given deepwater significant wave height and period

Ahren's equations modify Weggel's monochromatic expressions to account for the effect of irregular waves when freeboard, F, is less than the run-up of the significant wave, Rs. When the freeboard is greater than the run-up, Weggel's equation yields no over-wash while larger run-ups in the distribution may still overtop the structure. For these relatively high freeboards, the run-up distribution is broken into 999 elements, instead of 199, to better account for the effect of the higher run-ups. The over-wash equation for this larger distribution becomes:

$$Q = \frac{1}{999} \sum_{i=1}^{999} Q_i$$

where

p = 0.001*i, i = 1,2,3,...,999.

A.6.11.8.10.10 Wave Run-up and Over-wash Flow Rate Results

Table A-65 through ***Table A-70*** provide wave run-up values and corresponding rates of over-wash computed for each of the C-9 design cases. Each table contains information for both wind speed and water depth combinations for the maximum significant wave incident to the levee face. Included are the six slope configurations. Over-wash rates are provided in half-foot increments.

A.6.11.8.10.11 Summary

The purpose of this analysis is to provide wave run-up and over-wash rates for an array of levee heights for the C-9 Impoundment. These wave run-up and over-wash rates must be combined with site specific geotechnical information, structural design investigations, and economic evaluation to provide an optimum levee height for the given project location. Results from this analysis are presented as part of the larger C-9 investigation and do not constitute, in and of themselves, a recommendation for a final levee height design.

TABLE A-64: C-9 WAVE RUN-UP AND OVER-WASH RATES, CASE 1

Case	Still Water Depth (ft)	Wind Speed (mph)	Wind Setup (ft)	Effect. Depth (ft)	Signif. Wave Ht (ft)	Wave Per (sec)	Slope Type	Runup (ft)	Overtopping according to Levee Height (ft³/s-ft) 13ft	13.5ft	14ft	14.5ft	15ft	15.5ft	16ft	16.5ft	17ft	17.5ft	18ft	18.5ft	19ft	19.5ft	20ft
4.3ft Normal Pool	7.83	113.1	1.88	9.71	3.94	4.3	Smooth 1:3	6.45	1.270	0.890	0.613	0.414	0.274	0.178	0.112	0.074	0.046	0.027	0.016	0.009	0.005	0.000	
							Rough 1:3	3.73	0.194	0.093	0.040	0.016	0.006	0.000									
							Rough 1:2	4.67	0.541	0.305	0.165	0.091	0.046	0.023	0.010	0.000							
							Stepped 1:3	4.35	0.334	0.179	0.091	0.048	0.022	0.010	0.000								
							Stepped 1:1.5	6.69	1.392	0.979	0.677	0.460	0.307	0.201	0.128	0.086	0.054	0.033	0.020	0.011	0.006	0.000	
							Vertical Wall	4.77	0.407	0.225	0.119	0.065	0.033	0.016	0.007	0.000							

TABLE A-65: C-9 WAVE RUN-UP AND OVER-WASH RATES, CASE 2

Case	Still Water Depth (ft)	Wind Speed (mph)	Wind Setup (ft)	Effect. Depth (ft)	Signif. Wave Ht (ft)	Wave Per (sec)	Slope Type	Runup (ft)	Overtopping according to Levee Height (ft³/s-ft) 12ft	12.5ft	13ft	13.5ft	14ft	14.5ft	15ft	15.5ft	16ft	16.5ft	17ft	17.5ft	18ft	18.5ft	19ft
4.3ft Normal Pool	5.56	113.1	3.08	8.64	3.41	4.5	Smooth 1:3	6.28	1.002	0.693	0.470	0.313	0.203	0.129	0.085	0.052	0.031	0.018	0.010	0.006	0.003	0.001	0.001
							Rough 1:3	3.46	0.103	0.045	0.017	0.006	0.002										
							Rough 1:2	4.29	0.320	0.166	0.087	0.042	0.019	0.008	0.003	0.001							
							Stepped 1:3	4.04	0.198	0.097	0.049	0.022	0.009	0.004	0.001								
							Stepped 1:1.5	6.08	0.948	0.635	0.417	0.267	0.167	0.102	0.065	0.038	0.022	0.012	0.007	0.003	0.002	0.001	
							Vertical Wall	4.16	0.194	0.093	0.046	0.020	0.009	0.003	0.001								

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TABLE A-66: C-9 WAVE RUN-UP AND OVER-WASH RATES, CASE 3

Case	Still Water Depth (ft)	Wind Speed (mph)	Wind Setup (ft)	Effect. Depth (ft)	Signif. Wave Ht (ft)	Wave Per (sec)	Slope Type	Runup (ft)	Overtopping according to Levee Height (ft^3/s-ft) 12ft	12.5ft	13ft	13.5ft	14ft	14.5ft	15ft	15.5ft	16ft	16.5ft	17ft	17.5ft	18ft	18.5ft	19ft
4.3ft Normal Pool	4.3	113.1	5.09	9.39	2.85	4.2	Smooth 1:3	5.36	1.781	1.202	0.789	0.503	0.311	0.187	0.108	0.065	0.036	0.019	0.010	0.005	0.002	0.001	
							Rough 1:3	2.93	0.342	0.132	0.049	0.016	0.004	0.001									
							Rough 1:2	3.62	0.817	0.405	0.187	0.086	0.035	0.013	0.004	0.001							
							Stepped 1:3	3.42	0.521	0.247	0.108	0.047	0.018	0.006	0.002								
							Stepped 1:1.5	5.13	1.812	1.170	0.732	0.444	0.260	0.147	0.086	0.046	0.024	0.012	0.005	0.002	0.001		
							Vertical Wall	3.34	0.481	0.206	0.081	0.032	0.011	0.003	0.001								

TABLE A-67: C-9 WAVE RUN-UP AND OVER-WASH RATES, CASE 4

Case	Still Water Depth (ft)	Wind Speed (mph)	Wind Setup (ft)	Effect. Depth (ft)	Signif. Wave Ht (ft)	Wave Per (sec)	Slope Type	Runup (ft)	Overtopping according to Levee Height (ft^3/s-ft) 12ft	12.5ft	13ft	13.5ft	14ft	14.5ft	15ft	15.5ft	16ft	16.5ft	17ft	17.5ft	18ft	18.5ft	19ft
4.3ft Normal Pool	7.28	100.0	1.59	8.87	3.74	4.0	Smooth 1:3	5.85	0.918	0.613	0.401	0.256	0.159	0.096	0.061	0.036	0.020	0.011	0.006	0.000			
							Rough 1:3	3.44	0.132	0.058	0.023	0.008	0.000										
							Rough 1:2	4.33	0.388	0.206	0.105	0.054	0.026	0.011	0.005	0.000							
							Stepped 1:3	4.02	0.237	0.118	0.059	0.027	0.012	0.005	0.000								
							Stepped 1:1.5	6.22	1.039	0.707	0.472	0.309	0.198	0.124	0.075	0.048	0.029	0.017	0.009	0.005	0.000		
							Vertical Wall	4.53	0.308	0.164	0.084	0.044	0.021	0.010	0.000								

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TABLE A-68: C-9 WAVE RUN-UP AND OVER-WASH RATES, 36-HOUR PRE/POST PEAK PMP WITH 100-YR WIND

Case	Still Water Depth (ft)	Wind Speed (mph)	Wind Setup (ft)	Effect. Depth (ft)	Signif. Wave Ht (ft)	Wave Per (sec)	Slope Type	Runup (ft)	Overtopping according to Levee Height (ft^3/s-ft)													
									13ft	13.5ft	14ft	14.5ft	15ft	15.5ft	16ft	16.5ft	17ft	17.5ft	18ft	18.5ft	19ft	19.5ft	20ft
4.3ft Normal Pool	7.83	113.1	1.88	9.71	3.94	4.3	Smooth 1:3	6.45	1.270	0.890	0.613	0.414	0.274	0.178	0.112	0.074	0.046	0.027	0.016	0.009	0.005	0.000	
							Rough 1:3	3.73	0.194	0.093	0.040	0.016	0.006	0.000									
							Rough 1:2	4.67	0.541	0.305	0.165	0.091	0.046	0.023	0.010	0.000							
							Stepped 1:3	4.35	0.334	0.179	0.091	0.048	0.022	0.010	0.000								
							Stepped 1:1.5	6.69	1.392	0.979	0.677	0.460	0.307	0.201	0.128	0.086	0.054	0.033	0.020	0.011	0.006	0.000	
							Vertical Wall	4.77	0.407	0.225	0.119	0.065	0.033	0.016	0.007	0.000							

TABLE A-69: C-9 WAVE RUN-UP AND OVER-WASH RATES, PEAK PMP WITH CATEGORY I HURRICANE WIND

Case	Still Water Depth (ft)	Wind Speed (mph)	Wind Setup (ft)	Effect. Depth (ft)	Signif. Wave Ht (ft)	Wave Per (sec)	Slope Type	Runup (ft)	Overtopping according to Levee Height (ft^3/s-ft)													
									12ft	12.5ft	13ft	13.5ft	14ft	14.5ft	15ft	15.5ft	16ft	16.5ft	17ft	17.5ft	18ft	18.5ft	19ft
4.3ft Normal Pool	5.56	113.1	3.08	8.64	3.41	4.5	Smooth 1:3	6.28	1.002	0.693	0.470	0.313	0.203	0.129	0.085	0.052	0.031	0.018	0.010	0.006	0.003	0.001	0.001
							Rough 1:3	3.46	0.103	0.045	0.017	0.006	0.002										
							Rough 1:2	4.29	0.320	0.166	0.087	0.042	0.019	0.008	0.003	0.001							
							Stepped 1:3	4.04	0.198	0.097	0.049	0.022	0.009	0.004	0.001								
							Stepped 1:1.5	6.08	0.948	0.635	0.417	0.267	0.167	0.102	0.065	0.038	0.022	0.012	0.007	0.003	0.002	0.001	
							Vertical Wall	4.16	0.194	0.093	0.046	0.020	0.009	0.003	0.001								

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A.6.11.10 Alternative Design Approach for D-509 Embankment

It is broadly accepted that maximum winds do not occur simultaneously with maximum rainfall. This is inferred in USACE Inflow Design Floods for Dams and Reservoirs (ER 1110-8-2(FR), Mar 1991) Paragraph 9.c. as presented here:

"Reservoirs with surcharge pool elevations within three feet of the maximum pool level for a substantial period of time, 36 hours or longer, have increased probability that high winds in the critical fetch may coincide with this level. Therefore, when the IDF pool hydrograph is within three feet of the maximum pool for 36 hours or longer or where the project has been designed with little surcharge for the maximum pool above the full pool elevation, the minimum freeboard will be five feet for embankment dams."

This is also supported in USACE Hydrologic Engineering Requirements for Reservoirs (EM 1110-2-1420, Oct 1997) Paragraph 15-1.b. as presented here:

"Freeboard is generally based on maximum probable wind conditions when the reference elevation is the normal operating pool. When estimating the freeboard to be used with the probable maximum reservoir level, a lesser wind condition is used because it is improbable that maximum wind conditions will occur simultaneously with the maximum flood level."

Additional "draft" analyses completed by the Non-Federal Sponsor conducted as part of the State Expedited Project/Initiatives supports USACE documentation even further as shown in the following figure:

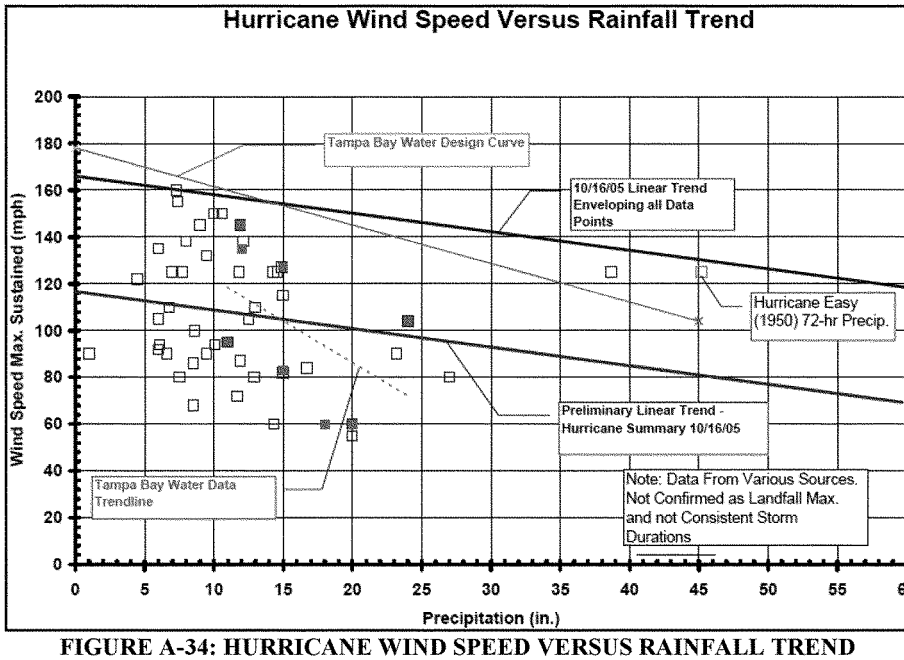

FIGURE A-34: HURRICANE WIND SPEED VERSUS RAINFALL TREND

Should be noted in the preceding figure is that all Category 4 and 5 Hurricanes had total precipitation depths less than 15 inches. Hurricane Easy (barometric recorded pressure 28.30in Hg) and the marked storm near were both Category 3 Hurricanes. Their appearance does not deflect the assumption of low probability as is evident in their outlier position on the chart.

Taking the preceding information into account, taking uncertainties with vegetative growth (assuming conservatively "none"), taking into consideration that a sunny day break would probably not pose a High HPC (Significant or Low HPC more probable, though conservatively assuming High HPC), a dual design wind speed comparison is recommended that follows ER 1110-8-2(FR) in that a High HPC reservoir must be able to safely pass the IDF computed with the PMP event. The reservoir embankment height was designed with the greater requirement between a Category 1 Hurricane wind speed on the maximum surcharge stage and a 100-year wind speed on the surcharge stage corresponding to a 36-hour after maximum (or peak) surcharge. As an additional conservative margin of safety the actual stage used was 36-hours before peak as it provided the higher stage between the two 36-hours from peak stage by approximately 0.2 feet.

This modified form of Case 1 through optimization appears in ***Table A-70*** below to illustrate relative risk and probability of case conditions to each other as design parameters:

TABLE A-70: FOUR PLUS CASES FOR ANALYSIS AND DESIGN

		Impoundment Routed Surcharge Pool				
Reasonable Wind Speed	Wind Speed (sustained)	Lower Pool Hurricane-Season	Normal Maximum	100-yr Storm Routed	Other Routed Storm	PMF
	PMW (200mph)		Case 2			
	Category 5 (156mph)			Case 3		
	100-year (150mph)				36-hr Off Peak PMP	Case 1
	Category 3 (125mph)				Case 4 (80%PMP)	
	Category 1 (85mph)					36-hr On Peak PMP

Applying simple probability calculations for events occurring as shown in the following table provides another perspective on risk associated with the 36-hour inference when applied as a trend line illustrating similar risks.

TABLE A-71: FOUR ALTS PROBABILITY OF EVENTS

Case	3-day Event	Probability	Max Wind Speed	Probability	Joint Probability
1	PMP	1 in 42,000	100-year	1 in 100	1 in 4,200,000
2	100-year	1 in 100	Category 5	1 in 490	1 in 49,000
3	Normal Pool	≈1 in 1	PMW	1 in 42,000	1 in 42,000
4	Easy-80% PMP	1 in 3,100	Easy Cat3	1 in 100	1 in 310,000

Visual inspection of ***Figure A-35*** definitely shows a trend of probability of event (thus risk) progressing from top to bottom and slightly across. It is not intended in this discussion to provide a reason or justification for acceptable risk, but to bring forth equivalent risks that are considered acceptable as established by the joint agencies design document DCM-2, and USACE Regulations and Policies.

DCM-2 Four Alternatives (plus)

High HPC		Reservoir Routed Surcharge Pool				
Reasonable Wind Speed	Wind Speed (sustain'd)	Lower Pool Hur-Season	Normal Maximum	100-yr Storm Routed	Other Routed Storm	PMF
	PMW (200 mph)		Case 2 (2x10^-5)			
	Category 5 (156 mph)			Case 3 (2x10^-5)		
	100-year (150 mph)				36-hr Off Peak PMP	Case 1 (2x10^-7)
	Category 3 (125 mph)				Case 4 (3x10^-6)	
	Category 1 (85 mph)					36-On Peak/ Off-Season

FIGURE A-35: ILLUSTRATION OF TREND IN ALTERNATIVES

A.6.11.10.1 Category 1 Hurricane Wind Speed

In reference to the Saffir-Simpson Hurricane Wind Scale the wind speed of a Category 1 Hurricane falls between 74mph and 95mph. A mid-range wind speed of 85mph was selected for use in the analysis. After conversion to a one-hour average, the design wind speed to be applied to the peak maximum surcharge pool was determined to be 68mph.

TABLE A-72: WIND-WAVE ANALYSIS

C-9 - Wave Run-up and Overtopping – With Spillway																
Case	Still Water Depth (ft)	Wind Speed (mph)	Wind Setup (ft)	Effect Depth (ft)	Signif Wave Height (ft)	Slope Type	Run-up (ft)	Overtopping according to Levee Height (ft^3/s-ft)								
								11.5ft	12ft	12.5ft	13ft	13.5ft	14ft	14.5ft	15ft	15.5ft
4.3ft Normal Pool	6.37	113.1	2.25	8.62	3.67	Smooth 1:3	6.23	1.384	0.968	0.664	0.447	0.295	0.190	0.119	0.078	0.047
						Rough 1:3	3.55	0.254	0.114	0.051	0.020	0.007	0.000			
						Rough 1:2	4.43	0.630	0.351	0.187	0.095	0.050	0.024	0.011	0.000	
						Stepped 1:3	4.14	0.403	0.214	0.108	0.055	0.026	0.011	0.000		
						Stepped 1:1.5	6.33	1.453	1.010	0.689	0.461	0.302	0.194	0.121	0.079	0.048
						Vertical Wall	4.49	0.469	0.254	0.132	0.065	0.034	0.016	0.007	0.000	
4.3ft Normal Pool	7.83	68.34 (85mph -1min ave)	0.71	8.54	2.89	Smooth 1:3	4.76	0.295	0.172	0.097	0.053	0.029	0.015	0.007	0.000	
						Rough 1:3	2.74	0.023	0.007	0.000						
						Rough 1:2	3.44	0.080	0.035	0.014	0.005	0.000				
						Stepped 1:3	3.20	0.049	0.020	0.007	0.000					
						Stepped 1:1.5	4.92	0.284	0.166	0.095	0.052	0.029	0.015	0.008	0.000	
						Vertical Wall	3.41	0.043	0.018	0.007	0.000					

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A.6.12 C-9 Impoundment Mitigation Areas Option

A.6.12.1 General Information

As previously discussed, the C-9 Impoundment project component has existing DA 404 mitigation areas. If mitigation bank credits cannot be acquired then an option would be to construct two wetland marsh areas that when combined with C-11 Impoundment and WCA 3A/3B SMA mitigation credits offset project impacts to the existing DA 404 permitted mitigation areas. The C-9 Impoundment footprint includes three existing separated mitigation areas that required the project team to maintain, relocate, or offset with additional mitigation credits within the project design, or in combination with the other project components under Broward County WPA. The project as designed limits adverse impacts to one of the existing mitigation areas while providing a water supply to sustain its viability and a protective perimeter levee/berm. Two mitigation wetland areas within C-9 Impoundment, Mitigation Area C and Mitigation Area D, are re-created by the use of the protective levee/berm L-509A and L-509B.The C-9 Impoundment could benefit the two northern wetland marsh areas by providing the areas with a water source that can be used to improve their wetland hydroperiods. The wetland areas would also be used for storage of up to two feet depth in the southern area and up to one-foot depth in the northern area during wet periods, when water is available in the C-9 Impoundment and the northern wetlands will not be adversely impacted by delivery. Maximum storage depths (storage plus rainfall) will only be allowed for a short duration of time to not adversely impact the wetland marsh habitat.

In addition to the above levees, several levee/berms are designed to function as protective wetland marsh berms within the C-9 Impoundment project footprint. These levees are kept low (3 feet or less) to prevent a hazard-creating-wall should a breach occur as the design storage behind them is 1-foot plus that contributed by rainfall. Water storage is a misnomer in that water provided by project's operation is for hydration and enhancement of existing hydroperiods, and not retention for future needs.

A.6.12.2 Seepage Control

Seepage control for the Mitigation Areas is accomplished through a system of structures, seepage canals, and a conveyance canal.

The Mitigation Areas employs two seepage canals: C-509A that forms the eastern perimeter seepage canal adjacent to the L-509A Levee/Berm and C-509B that forms the western perimeter seepage canal adjacent to the L-509B Levee/Berm. The eastern C-509A Seepage canal stages require control to prevent impact to flood protection of adjacent private lands. The impoundment's eastern half seepage is controlled at a stage of 3.0 ft-NGVD with interception by

C-509A Seepage canal with stage exceedance managed primarily by the S-512A Pump Station and secondarily by S-512C Weir structure. Seepage collected may be managed in either of two ways: (1) return pumping into the reservoir with the S-512A Pump Station or (2) discharge to the C-9 Canal to meet water supply demands through the S-512C Weir. The S-512A Pump Station serves as a seepage pump plant and contains 3-75 cfs electric motor pumps for this purpose. Should the pump station malfunction or experience a power outage, the combined S-512C Weir and associated Flap-gated Culvert structure provides relief of excess stages temporarily when the seepage canal stage increases to 4.05 ft-NGVD. The S-512C Flap-gated Culvert structure also prevents the backflow up the C-509 Canal with increase stages of C-9 Canal during flood events.

The C-509W Seepage Canal stages require control to prevent impact to US 27 road base that runs along and parallel to the seepage canal. The impoundment's western half seepage is controlled at a stage of 4.0 ft-NGVD with interception by the C-509B Seepage Canal with stage exceedance managed by the combined overflow and conveyance into C-9 Canal via S-512B Weir and associated Flap-gated Culvert structure. Seepage conveyed into C-9 Canal may be managed in either of three ways: (1) return pumped into the impoundment with the S-509 Pump Station, (2) used to meet C-9 Basin water supply demands, or (3) conveyed to tide via the coastal S-29 Gated Spillway. The S-509 Pump Station serves primarily as an inflow pump station with 4-250 cfs diesel engine pumps for this purpose. However, the pump station also includes a 1-75cfs electric motor pump to handle intercepted seepage as a secondary function. The S-512B Flap-gated Culvert structure prevents backflow up the C-509 Canal with stage increases in C-9 Canal during flood events or C-11 to C-9 diversion operations.

A.6.12.3 General Design and Operation

A.6.12.3.1 Features

The C-9 Impoundment Mitigation Areas C and D has the following design features:

Structures
- S-513A Gated Culverts
- S-513B Box Weir & Culvert

Canals
- C-509A Seepage Canal
- C-509B Seepage Canal

Levees
- L-509A Levee
- L-509B Levee/Berm

A.6.12.3.2 Operation of Interior Wetland March (Mitigation) Areas

There are two wetland areas to be maintained for mitigation credit to offset impacts to existing permitted mitigation areas as a result of project implementation. The 105-acre "Mitigation Area C" (Mit. C) Wetlands will have a direct water source from the reservoir via the S-513A Gated Culvert. Excess water stages will be controlled by a notched hardened-earth spillway in the L-509A Levee. The 234-acre "Mitigation Area D" (Mit. D) Wetlands will receive water through the S-513B Box Weir Culvert structure after the Mit C wetland area is filled. Excess water stages are controlled through reverse flow through the S-513B structure and indirectly by the same notched spillway as Mit. C.

The wetland mitigation areas will be managed to provide wetland restoration and additional temporary storage for the impoundment but will be assessed and adaptively managed and optimized after construction. An optimum seasonal stage up to two-foot depth is proposed for (Mit. C wetland area) and one-foot depth for the Mit. D wetland area. Depths will be managed to account for rainfall in addition to diversion storage. Diversion storage will be limited to short durations of time and frequency to minimize negative impact to these existing and to-be-restored natural areas. Water will not be released into either wetland area if water levels are at or above target depths. Note, direct rainfall in and seepage out will provide similar fluctuating hydroperiods that are observed in natural settings; however, it must be recognized that limiting extreme stages, both high and low, is advantageous to the ecosystem's flora and fauna.

A.6.12.3.3 Operations for Water Quality Benefits

Mitigation Areas C and D will not have any specific operations for water quality benefits.

A.6.12.4 Reservoir

A.6.12.4.1 General Information

The impoundment consists of a 1,641-acre 4.3-foot deep, above ground reservoir that provides 7,056 acre-feet of storage. The project area could also include a 234-acre 1-foot deep wetland mitigation area (Mit. D) that provides 234 acre-feet of storage and a 105-acre 2-foot deep wetlands mitigation area (Mit. C) that provides 210 acre-feet of storage. A system of seepage canals and associated structures is included along the western, northern, and eastern project boundaries.

A.6.12.4.2 Optional Mitigation Area C, Southern Compartment

The design of the C-9 Impoundment also includes consideration of providing water for a 125 acre optional mitigation area (Mit. C) located north of the impoundment. The maximum normal pool for Mit. C is 2 feet deep and the outflow spillway and impoundment levee/berm is designed to safely pass the 100-year frequency, 72-hour duration storm.

The Corps' HEC-RAS (River Analysis System) model was employed to determine the maximum pool (or surcharge pool) elevation and peak discharge. The model configuration consisted of a storage area equal to 125 acres with a weir outlet. Since the impoundment itself is the tributary basin and its surface is considered impermeable when full, all storm precipitation was readily available for routing without any loss. The initial pool stage used in the routing model of C-9 Impoundment was the maximum normal pool stage of 7.0 ft NGVD

The 100 year frequency, 72-hour duration storm was used to design the mitigation impoundment due to its low hazard classification. The 24-hour, 100-year return period rainfall was picked from SFWMD Technical Publication 81-3 May, 1981 Frequency Analysis of Rainfall Maximums for Central and South Florida. The 24-hour, 100-year rainfall amount for the C-9 basin was determined to be 12.2 inches. The ratio of 24-hour, 100-year rainfall to 72-hour, 100-year rainfall is 1.359. Thus the 72-hour, 100-year rainfall for the C-9 Impoundment is 16.3 inches.

The overflow spillway does not meet the criteria for maximum allowable discharge (20 cfs per square mile during the 25-year frequency, 72-hour duration storm for the C-9 Basin). The discharge will be controlled downstream in the seepage canal before reaching the C-9 Canal Basin.

Table A-73: Mitigation Area C, Inflow Design Flood Analysis

SFWMD 100-year, 24-hour Rainfall	12.2	inches
SFWMD 100-year, 72-hour Rainfall	16.3	inches
2-foot deep Basin Area	125	acres
Basin Area	0.20	sq miles
Impoundment Ground Elevation	5.0	ft-NGVD
Normal Pool Elevation (Spillway Crest Elevation)	7.0	ft-NGVD
Spillway Length	160.0	ft
Peak IDF Instantaneous Inflow	580	cfs

Table A-74: Mitigation Area C, Overflow Spillway

Storm Event Frequency	Peak Outflow Rate (cfs)	Peak Water Surface Elevation (ft, NGVD)
25-year, 72-hour	114	7.40
100-year, 72-hour	163	7.50

A.6.12.4.3 Mitigation Area C

The southern FDOT optional mitigation wetland marsh area within C-9 Impoundment is Mitigation Area C (Mit C) that includes a total of 105 acres of existing and newly protected wetlands. The depth of water in the mitigation area will be dependent on direct rainfall, seepage from the reservoir, or releases from the reservoir through S-513A Gated Culvert structure--rated design capacity of 50 cfs. The design allotment for project storage is 2 feet of depth that provides water for the wetland hydroperiod while still assisting with one of the main project purpose of diverting runoff from S-9 Pump Station pumping into WCA to elsewhere with multi-purpose usage. Excess water within Mit. C is allowed to overflow the lower western levee/berm into C-509A Seepage Canal where the levee is hardened for this purpose.

The perimeter levee around Mit C includes the L-509A Levee/Berm.

A.6.12.4.4 Mitigation Area D

The other larger wetland marsh area (northern FDOT optional mitigation area) is Mitigation Area D (Mit D) that includes a total of 234 acres of newly protected wetlands. The depth of water in the mitigation area will be dependent on direct rainfall and excess water in Mit. C that overflows the S-513B Box Weir (and Culvert). The design allotment for project storage is 1-foot of depth that provides water for the wetland hydroperiod while still assisting with one of the main project purpose of diverting runoff from S-9 Pump Station pumping into WCA to elsewhere with multi-purpose usage. Excess water above 2 feet in Mit. D may backflow through S-513B into Mit. C where excess water is allowed to overflow the lower western levee/berm into C-509A Seepage Canal where the levee is hardened for this purpose.

The perimeter levee around Mit B includes the L-509B Levee/Berm.

TABLE A-75: C-9 WETLAND MITIGATION AREA DESIGN

	Mitigation C	Mitigation D
Storage Area	105 acres	234 acres
Normal Maximum Pool Depth	2 feet	1 foot
Storage	210 ac-ft	234 ac-ft
Maximum Normal Pool Depth	3.0 feet	3.0 feet
Fill Rate at 50 cfs	0.94 ft/day	0.42 ft/day
Average Marsh Ground Elevation (existing grade)	4.50 ft-NGVD	4.50 ft-NGVD
Maximum Mitigation Pool	7.50 ft-NGVD	7.50 ft-NGVD
Top Of Levee	10.00 ft-NGVD	7.50 ft-NGVD

Assumed average ground elevation based on LIDAR data

A.6.12.5 Water Control Structures

A.6.12.5.1 Gated Culverts and Spillways

A.6.12.5.1.1 S-513A Gated Culvert

S-513A Gated Culvert is a double-barreled, gated culvert structure. The design flow capacity is 50cfs with a 0.50-foot hydraulic head differential. The structure is located at the northern boundary in the embankment that separates the reservoir from the wetland mitigation area, Mit. C, discharging into the wetland. The structure will operate to release water into the mitigation area to manage the Mit. C and Mit. D (via S-513B Box Weir Culvert) wetland hydroperiods.

Culvert barrels are 4-foot diameter (or equivalent box culverts) and are 125 feet in length. Barrel inverts are set at elevation –1.00 ft-NGVD (see ***Plate S-24***).

A.6.12.5.2 Weirs and other Water Control Structures

A.6.12.5.2.1 S-513B Box Weir and Culvert

The S-513B Box Weir and Culvert structure is a non-gated weir with a single-barrel culvert outlet. The design flow capacity is 15cfs with a hydraulic head of 0.35 feet. The structure is located midpoint of the northern Mit. C boundary at the northern terminal end of the C-509A and C-509B Seepage Canals. The Box Weir overflow conveys Mit. C water to Mit. D when Mit. C nears the design 2-foot stage, or above. The design discharge of 15cfs provides the ability of filling 1-foot of water into Mit. D in 7.5 days. The capacity of 15cfs is more than enough to account for daily evapotranspiration losses (approx. 3cfs) and seepage losses (approx 0.3cfs) to maintain the vitality of the wetland marsh area. The passive structure also allows excess water in Mit. D (stage exceeding 2 feet in

depth) to backflow into Mit. C, where a hardened lower-notch in the L-509A levee allows excess water to be controlled with overflow into the C-509B Seepage Canal. The Box Weir includes a 6-foot × 6-foot box culvert on edge with an upper edge (weir crest) set at 6.40ft-NGVD. The Culvert includes a 4-foot diameter and is 180 feet in length. Barrel invert is set at 0.00ft-NGVD (see ***Plate S-25***).

A.6.12.6 Levees and Levee/Berms

A.6.12.6.1 Levees

Levees are structures that are not expected to have permanent pools on either side and do not pose a hazard to life, nor significant property loss should a breach occur. Because of the existing scraped conditions of the mitigation area (Mit. C) enclosed by the L-509A Levee, a permanent pool is not expected on the interior side the majority of the time when a fluctuating water surface exists in the wetland as a result of hydroperiod enhancement.

A.6.12.6.1.1 L-509A Levee

The L-509A Levee is Mitigation Area C's wetland marsh area levee that enables the existing wetland design to carry a Low HPC with a 2-foot depth of water storage. Mit. C is an existing scraped mitigation wetland. The water to be added to it is expected to provide hydration and enhance its hydroperiod. This grade/stage relationship will be further investigated with additional survey information to be obtained during detail design. To ensure costs are captured, a 5.5-foot high levee is designed providing a 3-foot freeboard on the surcharged pool with an IDF using the 100-year precipitation event as referenced in DCM-2 for a Low HPC impoundment. For this purpose, the levee has a design crest elevation of 10.0 ft-NGVD or 5.5 feet above assumed average existing grade of 4.5 ft-NGVD. The levee is designed for the temporary storage of approximately 2 foot high stages and is therefore not armored for wave impacts (no revetment). The dense emergent vegetation found onsite that may prevent significant wave growth. The levee is grassed on both slopes for prevention of typical rainfall runoff erosive-type forces. Earthen slopes are 1 on 3 or 3H:1V slopes.

A.6.12.6.2 Levee/Berms

The levee/berms are low levees no more than 3 feet above an enclosed interior average existing grade to prevent the impoundment of water deep enough to pose a hazard under any meteorological event. That is, the limited storage depth on the interior will not be that that may create flooding nor a dangerous kinematic wave should a breach occur. Large precipitation events will cause ponding on both sides of the levee/berms limiting pressures on the structures, thereby virtually eliminating the possibility of a full breach. The levee/berms are able of providing additional storage volume for the C-9 Impoundment by the

allowance of utilizing one-foot of storage within the mitigation wetlands (Mit. D) enclosed by said structures. The levee/berms also provide an ecosystem protective berm function allowing the capture of and drainage prevention of rain water assisting existing hydroperiods of the natural areas. Material for construction of these low earthen structures is expected to be a mix of degraded limestone, sands with some peat or muck.

A.6.12.6.2.1 L-509B Levee/Berm

The L-509B Levee/Berm is Mitigation Area D's perimeter levee. It allows the normal storage of water up to 1-foot deep with a design crest elevation of 7.5ft-NGVD and a maximum of 3.0 feet above assumed average existing grade of 4.5 ft-NGVD. The levee is designed for low stages in an emergent vegetative environment that will not experience waves of any practical force. The levee is grassed on both slopes for prevention of typical rainfall runoff erosive-type forces. Earthen slopes are 1 on 4 or 4H:1V slopes due to expected mix of soils for construction of the low structures.

Table A-76: C-9 Embankment and Levee Design Parameters

Embankment and Levee	Length	Side Slope	Top Width	Average Ground	Top of Levee	Levee Height
	feet	1V on ?H	feet	ft-NGVD	ft-NGVD	feet
L-509A	6,750	3.0	12	4.50	10.00	5.5
L-509B	14,475	4.0	12	4.50	7.50	3.0
Totals	21,225					

A.6.12.7 Canals

A.6.12.7.1 Seepage Canals

The Impoundment will include four seepage canals, two that are aligned along the eastern boundary and two aligned along the western boundary: (1) eastern boundary includes the C-509E and C-509A Seepage Canals and (2) western boundary includes C-509W and C-509B Seepage Canals.

The Borrow for construction of the L-509B Levee/Berm for Mit. D wetland area comes from an internal "scraped" shallow canal that is connected to the outlet of the S-513B Box Weir and Culvert structure. The shallow canal has no other functions than for borrow to construct the Levee/Berm and to spread flow received from Mit. C to all perimeter points within Mit. D.

A.6.12.7.1.1 C-509E and C-509A Seepage Canal

The C-509E Seepage Canal is the reservoir's eastern perimeter seepage interception canal and is located along and parallel to the northern and eastern D-509 Embankment. The C-509A Seepage Canal is Mit. C eastern perimeter seepage interception canal located along and parallel to the eastern L-509A Levee. The S-512A Pump Station located on C-509E return pumps excess collected seepage from these two canals when canal stages are higher than 3.0 ft-NGVD. The S-512C Weir and Culvert structure located on C-509E at the confluence with the C-9 Canal provides secondary control should the S-512A Pump Station fail. Should loss of power or other mechanical failure occur, excess seepage will begin to overflow the S-512C Weir at stage 4.05ft-NGVD. This will prevent impacts to developed areas located to the east of the impoundment. Backflow up the seepage canals from high stages expected with floods collected in the C-9 Canal is prevented with the S-512C Flap-gated Culvert.

A.6.12.7.1.2 C-509W and C-509B Seepage Canal

The C-509W Seepage Canal is the reservoir's western perimeter seepage interception canal located along and parallel to the western D-509 Embankment. The C-509B Seepage Canal is the Mit. C western perimeter seepage interception canal located along and parallel to the western L-509A Levee. These two seepage canals are controlled at an elevation of 4.05 ft-NGVD by the S-512B Weir and Flap-gated Culvert located on C-509W at the confluence with the C-9 Canal. Backflow up the seepage canals from high stages in the C-9 Canal expected with diversion of C-11 Basin water operations is prevented with the S-512B Flap-gated Culvert.

TABLE A-77: C-509W SEEPAGE CANAL DESIGN PARAMETERS

Canal and Reach	Length	Bank Side Slope	Bottom Width	Average Ground	Canal Invert
	feet	1V on ?H	feet	ft-NGVD	ft-NGVD
Eastern					
C-509A	3,600	3.0	10.0	4.5	-5.50
Western					
C-509B	3,630	3.0	10.0	4.5	-5.50
All Canal Totals	4,230				

Average ground elevations based on LIDAR data

A.6.12.8 Instrumentation

All controllable structures are equipped for remote operation. Operational SCADA equipment, five groundwater monitoring sites, water quality monitoring sites and geotechnical instrumentation to monitor the operational safety of project features at the reservoir and wetland mitigation area have been identified. Associated instrumentation costs have been included in the cost estimate.

Table A-78: C-9 Impoundment Operation Instrumentation

Number	Structure	capacity (cfs)	Type	Pump Mix or Number of Gates	Water Surface, Gate & Precip Parameters	MOSCAD Type (light, regular)
S-513A	Gated Culvert	50	WS	2	T,P,G (S509T)	L
S-513B	Box Weir, Culvert	15	WS	1	H,T	L

Type Legend:
WS = Water Supply
NC = Normal Control
FC = Flood Control
SC = Seepage Control
WSC = Water Surface Elevation Control
MA = Maintain Access

Water Surface Parameters:
H = headwater
T = tailwater
P = Precip
Position Sensors
G = Gate

Table A-79: C-9 Impoundment Water Quality Instrumentation

Number	Structure	capacity (cfs)	Type	Pump Size Category	Water Quality Sampling Equipment
S-513A	Gated Culvert	50	WS		
S-513B	Box Weir, Culvert	15	WS		

Water Quality Parameters:
AS = Auto-Sampler
GB = Grab, nutrients--bi weekly
GF = Grab, nutrients--normal ops flow
GE = Grab, nutrients--emergency flow

A.6.12.9 Project Management

A.6.12.9.1 Project Access

An alternate access to the Impoundment, top of embankment, and major structural features is from the northern boundary where the S-512A seepage pump station is located. This location can be reached from SW 196th Avenue off Pines Boulevard.

A.6.12.9.2 Clearing

No clearing will be performed for the existing mitigation areas located in the FDOT optional mitigation area other than that required along the levee and canal alignment.

A.6.12.9.3 Construction Order

No specific construction order is apparent at this time. It is anticipated that C-9 Impoundment features could be constructed concurrently.

A.6.12.9.4 Disposal

The feasibility level design phase has demonstrated that a material balance can be achieved on-site and that off-site disposal sites may not be required. There are no known on-site borrow pits that can be partially backfilled with excess material to create viable fish refuge habitat, but there are two sites just to the north of the reservoir. Off-site disposal areas may need to be utilized if other features within the BCWPA project cannot use the excess material.

A.6.12.9.5 Relocations

A utility corridor exists on the west side of US 27 along the western edge of the US 27 Right-Of-Way and is expected to be within the 70' setback from US 27. Electrical and telephone utilities inside the impoundment will be abandoned and removed.

A.6.12.9.6 Surveying Requirements

A survey scope of work was developed for the C-9 Impoundment design region. Associated surveying costs have been included in the cost estimate.

A.6.12.10 Hydraulic Data and Supporting Analyses

A.6.12.10.1 Structure Hydraulic Data Sheets

A.6.12.10.1.1 S-513A Gated Culverts

S-513A
Gated Round Culverts

Revisions 8 December 2000 - Original Submission
18 May 2005 - Redesign, slide gate
6 July 2010 - Equivalent concrete structure
August 2011 - Revision

XY Coord 844230 601000
Location Borders C-9 Impoundment and C-9 Mitigation area
Purpose Controls discharge from impoundment to mitigation area to gain extra storage. Assist hydroperiod management in mitigation area.

Notes 1. Riprap requirements have not been verified with Geotech.

Design Conditions	
Discharge (CFS)	50 cfs
Design Head	0.50 feet
Headwater Elevation	6.00 ft,NGVD
Tailwater Elevation	5.50 ft,NGVD
Maximum Expected Stages	
Headwater Elevation	13.50 ft,NGVD
Tailwater Elevation	11.50 ft,NGVD
Maximum Simultaneous Head Difference	
Maximum Headwater Elevation	12.50 ft,NGVD
Minimum Tailwater Elevation	6.00 ft,NGVD
Culvert Data	
Number of Barrels	2
Barrel Type	Concrete
Barrel Diameter	4.0 feet
Barrel Length	125.0 feet
Barrel Invert Elevation	-1.00 ft,NGVD
Type of Control	Slide Gate
Canal Section	
Impoundment	
Side Slopes (Vert. on Hor.) 1 on	1
Upstream Bottom Width	Pool
Upstream Bottom Elevation	-2.00 ft,NGVD
Mitigation Area C	
Side Slopes (Vert. on Hor.) 1 on	1
Downstream Bottom Width	Pool
Downstream Bottom Elevation	-2.00 ft,NGVD
Riprap Requirements	
Design Flow Velocity	1.99 fps
Design Riprap Velocity	1.99 fps
Downstream Length	20.00 feet
Downstream Armored Area	300.00 ft^2
Downstream Armored Area (Imported Rock)	150.00 ft^2
Downstream Armored Area (Local Rock)	150.00 ft^2

A.6.12.10.1.2 S-513B Box Weir Culvert

S-513B
Gated Round Culverts

Revisions 8 December 2000 - Original Submission
18 May 2005 - Redesign, slide gate
6 July 2010 - Equivalent concrete structure
August 2011 - Revision

XY Coord 844230 601000
Location Borders C-9 Impoundment and C-9 Mitigation area
Purpose Controls discharge from impoundment to mitigation area to gain extra storage. Assist hydroperiod management in mitigation area.

Notes 1. Riprap requirements have not been verified with Geotech.

Design Conditions	
Discharge (CFS)	15 cfs
Design Head	0.35 feet
Headwater Elevation	6.75 ft,NGVD
Tailwater Elevation	5.25 ft,NGVD
Maximum Expected Stages	
Headwater Elevation	10.00 ft,NGVD
Tailwater Elevation	7.50 ft,NGVD
Maximum Simultaneous Head Difference	
Maximum Headwater Elevation	10.00 ft,NGVD
Minimum Tailwater Elevation	5.25 ft,NGVD
Box Weir Data	
Weir Type	Broad Crested
Weir Breadth	1 feet
Crest Length (6' x 6' Box rim)	24 feet
Crest Elevation	6.4 ft, NGVD
Box Invert (vertical on edge)	-0.5 ft, NGVD
Top Hinged Lid with Bars	
Skimmer Plate to Prevent Floating Debris Entry	
Culvert Data	
Number of Barrels	1
Barrel Type	Concrete
Barrel Diameter	4.0 feet
Barrel Length	180.0 feet
Barrel Invert Elevation	0.00 ft,NGVD
Type of Control	None
Canal Section	
Mitigation Area C	
Side Slopes (Vert. on Hor.) 1 on	1
Upstream Bottom Width	Pool
Upstream Bottom Elevation	-2.00 ft,NGVD
Mitigation Area D	
Side Slopes (Vert. on Hor.) 1 on	1
Downstream Bottom Width	Pool
Downstream Bottom Elevation	-2.00 ft,NGVD
Downstream Stilling Basin	
Apron Width (earthen)	6 feet
Apron Elevation	-1.5 ft, NGVD
Length (feet)	30 feet
Riprap Requirements	
Design Flow Velocity	3.36 fps
Design Riprap Velocity	3.36 fps
Downstream Length	15.00 feet
Downstream Armored Area	200.00 ft^2
Downstream Armored Area (Imported Rock)	150.00 ft^2
Downstream Armored Area (Local Rock)	50.00 ft^2

A.7 WCA 3A AND WCA 3B SEEPAGE MANAGEMENT AREA

A.7.1 General Information

The WCA 3A and WCA 3B Seepage Management Areas (3A and 3B SMAs) are wetland marsh areas also known as the WCA 3A and WCA 3B Everglades Buffer Strip. The design for those areas includes a new conveyance canal with associated levees, borrow canals, and water control structures. The design also includes considerations for mitigating flood impacts for the following existing facilities: a mobile home park and the FPL transmission power lines and associated access road.

The purpose of the Seepage Management Area features is to provide a system to reduce seepage losses from WCA 3 and to establish a habitat buffer between the WCA natural area and urban development occurring to the east. Seepage reduction for WCA 3 helps retain water in the natural system. The WCA 3 has been impacted by drawdowns to meet agricultural and urban water supply demands, and prevention of saltwater intrusion into the surficial aquifer. Project modeling demonstrated that controlling higher water levels/stages seasonally in the study area and associated canals reduced seepage losses significantly. Also, controlling water levels seasonally recreate or enhance hydroperiods within the wetland area that are beneficial to improving native flora and fauna.

The C-502B Conveyance Canal, the expanded US 27 west borrow canal, within the 3B SMA has the purpose of conveying excess runoff from the Western C-11 Basin that is diverted away from the S-9 and S-9A pump stations south to the C-9 Impoundment (and future CERP component, North Lake Belt Storage Area (NLBSA). The canal will also serve (after additional capacity improvements) another future CERP component, North New River Improvements, as a portion of a conveyance system that provides an alternate water supply delivery route from Lake Okeechobee (LOK) to Miami-Dade County and the South Dade Conveyance System (SDCS).

The WCA 3A SMA is located in Broward County and is bounded by the I-75/US-27 interchange (north), US 27 (east), C-11 Canal (south), and Everglades Protection Levee C&SF L-37 (west). The area is approximately 6.3 miles in length from north to south and 0.6 miles in width from east to west.

The WCA 3B SMA is located in Broward and Miami-Dade Counties and is bounded by the C-11 Canal (north), US 27 (east), former Boy Scout Camp (south), and Everglades Protection Levees C&SF L-30 and L-33 (west). The area is approximately 8.6 miles in length from north to south and 0.6 miles in width from east to west.

A.7.2 Seepage Control

Other than the purpose of seepage management for WCA 3, the 3A SMA and the 3B SMA provide seepage control to prevent negative impacts to existing areas within and outside the project area part of the WRDA 2000 Savings Clause requirements. These areas include the US 27, Holly Lakes Mobile Home Park, FPL Sub-station, South Broward Drainage District residents, and other residents who live in or near the project area.

The proposed parallel canal system that includes C-502A and C-502B will function as seepage interception canals that will collect seepage from WCA 3, 3A and 3B SMAs. If canal stages rise above levels expected to cause negative impacts, stages may be reduced or "controlled" by discharging into the existing C&SF system in the following manner:

The C-502A Borrow Canal stage is controlled by the existing G-86N structure which discharges into the C-11 Canal. Initial control stages set are at 7.5 ft-NGVD during the wet-season and 6.5 ft-NGVD during the dry season.

The C-502B Canal stage north of Krome Ave is dual controlled by new S-502B Gated Culverts which discharges into the C-11 Canal and the existing S-30 structure which discharges into the C-9 Canal. These reaches may also be alternately controlled with the existing S-32 structure with discharge ability into the C-6 Canal. Initial stages are set at 6.5 ft-NGVD during the wet-season, 5.5 ft-NGVD during the dry season.

The C-502B Borrow Canal stage north of Krome Avenue is controlled by the new S-516A Weir which discharges into the L-33 Canal. Initial stages are set at 5.0 ft-NGVD during the wet season and 4.8 ft-NGVD during the dry season.

C-502B Borrow Canal stage south of Krome Ave is controlled by the new S-516A Weir which discharges into the L-33 Canal. Initial stages are set at 5.0 ft-NGVD during the wet-season, 4.8 ft-NGVD during the dry season.

C-503 Borrow Canal stage is controlled by the new S-516B Weir which discharges into the C-6 Canal. Initial stages are set at 5.0 ft-NGVD during the wet-season, 4.8 ft-NGVD during the dry season.

The control stage for the canals will initially be set to mirror that of the adjacent marsh wetlands. These stages will be monitored and may be adjusted through the adaptive management proves to avoid impacts in and outside the project area. Resulting refinements will be updated in the Project Operation Manual.

A.7.3 General Design and Operations

A.7.3.1 Features

The WCA 3A and WCA 3B Seepage Management Area have the following design features:

Structures:

S-502B Gated Culverts (replacement for G-86S)

S-515 Gated Culverts
S-516A Triangular-Profile Weir
S-516B Triangular-Profile Weir
FPL Non-gated Culverts 1-19

Bridges

B-500 FPL Sub-station
B-501 Holly Lakes Mobile Home Park

Canals

C-502B Canal (conveyance)
C-502A Borrow Canal
C-502B Borrow Canal
C-503 Borrow Canal

Levees

L-502A Levee
L-502B Levee
L-502B Levee (side cast)
L-502E Levee/Berm
L-503 Levee

Flood Damage Reduction Systems

Holly Lakes Mobile Home Park

S-514A Pump Station
L-502C Levee
C-502C Seepage Canal

The L-502A and L-502B Levees provide the ability to control stages within the 3A and 3B SMAs, as well as maintain the separation of wetland/natural area water from diverted urban runoff water and WCA 3 seepage (i.e. protective berm). The L-503 Levee provides the same ability as L-502A and L-502B to control stages within the southern tip of WCA 3B SMA south of the C-6 Canal (Miami Canal). The L-502E Levee/Berm is a low-level protective berm separating the project area from FPL lands.

The C-502B Conveyance Canal conveys up to 1,000 cfs of runoff diverted from the Western C-11 Basin to the C-9 Impoundment and in the future to SDCS and NLBSA.

A.7.3.2 Operations for Interior Wetland Marsh Areas

Water levels in the wetland marsh areas are not directly controlled. No project facilities direct inflow or removal of water is. Instead, water levels are controlled indirectly through seepage--to and from—the surrounding new and existing borrow and conveyance canals. The only water the SMAs receive is through rainfall and groundwater seepage. Operation of the canals will provide wetland enhancement benefits but also has to take into consideration the prevention of adverse impacts to private lands as required by WRDA 2000.

The lack of direct control of the wetland marsh areas' water levels provides for a more natural hydroperiod that fluctuates with natural wet and dry times, mimicking a natural ecosystem strongly tied to sub-regional hydrology.

The wetland area water levels will be assessed and adaptively managed after construction for optimizing project purposes. The water levels will be managed in the following manner: (1) 3A SMA will initially be controlled at +7.50 ft-NGVD during the wet season and +6.5 ft-NGVD during the dry season, (2) northern 3B SMA—north of Krome Ave.--will be controlled at +6.5 ft-NGVD during the wet season and +5.5 ft-NGVD during the dry season, (3) mid-3B SMA—south of Krome Ave. and north of C-6 Canal—will be controlled at approximately +5.0 ft-NGVD, and (4) southern 3B SMA—south of C-6 Canal—will be controlled at approximately +5.0 ft-NGVD.

Water levels in the 3A SMA are maintained with existing stoplog structures S-9XN (L-37 Borrow) and G-86N (C-502A Borrow) both discharging into the C-11 Canal where the stage is maintained by the existing pump stations S-9 and S-9A.

Water levels in the northern 3B SMA are maintained with existing stoplog structures S-9XS (L-33 Borrow), G-86S (C-502B Conveyance), and the new S-502B Gated Culverts (may supplement or replace G-86S). All structures discharge to the north into the C-11 Canal where stage is maintained by the existing pump stations S-9 and S-9A. Gated culverts S-30 (C-502B Conveyance) discharges south into the C-9 Canal where excess water may be used to meet urban or environmental water supply demands or routed to tide when tailwater conditions allow. If tailwater conditions in the C-9 Canal do not allow eastern flow, excess water may be pumped into the C-9 Impoundment for later release to meet urban or environmental water supply needs or discharge to tide. Structure S-32 (L-33 Borrow Canal) discharges south into the C-6 Canal where excess water may be used to meet water supply demands or routed to tide when tailwater conditions allow.

Discharge water into the C-6 Canal may be temporary held back upstream by the S-515 Gated Culverts structure if downstream conditions are not favorable

for further discharge downstream without impact to existing levels of flood protection.

Water levels in the northern 3B SMA are maintained by the new S-516A Weir structure in the C-502B Borrow Canal.), that discharges into the L-33 Canal and then into the C-6 Canal. Discharge water into the C-6 Canal may be temporary held back upstream by the S-515 Gated Culverts structure if downstream conditions are not favorable for discharge downstream without impact to existing levels of flood protection.

Water levels in southern 3B SMA are maintained by the new S-516B Weir structure (C-503 Borrow) that discharges into the C-6 Canal. Discharge water into the C-6 Canal may be temporary held back upstream by the S-515 Gated Culverts structure if downstream conditions are not favorable for discharge downstream without impact to existing levels of service flood protection.

A.7.3.3 Operations for Water Supply

Excess water (rainfall and seepage from WCA 3A) collected in the 3A and 3B SMAs and directed into the C-11 Canal is returned to the WCA through the S-9A Seepage Pump Station. In the future, with the implementation of additional CERP components, excess water in the SMAs may be directed south for environmental deliveries to Everglades National Park via the L-30 Canal. Operations for interior wetland marsh areas are as described in the preceding section.

A.7.3.4 Operations for Holly Lakes Mobile Home Park

A "ring" flood damage reduction system is included in the project for the Holly Lakes Mobile Home Park to mitigate for possible impact to their existing surface water management system due to an increase in water level control in northern 3B SMA. The system includes a levee (L-502C), borrow canal (C-502C) and electric motor pump station with power backup generator set (S-514A). The stage in the perimeter canal will be controlled by seepage interception within the borrow canal and pumped into the C-502B Conveyance Canal.

A.7.4 Water Control Structures

A.7.4.1 Pump Stations

A.7.4.1.1 S-514A Pump Station (formerly S-507A)

The S-514A is a flood protection pump station for Holly Lakes Mobile Home Park which offsets possible reduction of effectiveness of the existing surface

water management system. Loss of effectiveness may occur due to reduced ground storage resulting from the increased control elevation of the lands surrounding the park. The pump station provides a total pumping capacity of 60 cfs. It is located on the north side of the park and pumps from the C-502C Canal and discharges into the C-502B Conveyance canal.

S-514A is a 2-bay pump station with two 30 cfs electric motor driven pumps. Both pumps combined provide more flood protection than required for a 100-year 24-hour storm event. For operational flexibility, one pump or both can be used for optimum canal levels.

A.7.4.2 Gated Spillways and Culverts

A.7.4.2.1 S-502B Gated Culvert Structure

The S-502B Gated Culverts is a seven barreled, gated culvert structure. The design flow capacity is 1,000 cfs with a 0.29-foot hydraulic head differential. The structure is located south of the C-11 Canal in alignment with Griffin Road to the west of US 27. The structure will operate when diversion operations from C-11 Basin to C-9 Impoundment occur. The structure will also function as the replaced G-86S stoplog riser in maintaining C-502B Conveyance Canal stages, but at new project stages between +6.5 ft-NGVD (wet season) and +5.50 ft-NGVD (dry season).

Culvert barrels are 8-foot diameter round and are 60 feet in length. Barrel inverts are set at elevation –6.0 ft-NGVD (see ***Plate S-26***).

A.7.4.2.2 S-515 Gated Culverts

The S-515 Gated Culverts is a double-barreled, gated culvert structure. The design flow is 600 cfs with a design head of 1.3 feet. The structure is located on C-6 Canal near the junction of C-6 Canal with US 27. The structure has the project purpose of allowing higher stages to be held within the C-6 Canal between it and the S-31 Gated Culverts at L-30/L-33 Levee terminus meeting. The higher stage will provide additional seepage management part of the objective of the 3B SMA. The structure will also operate the same as the S-31 structure by controlling dry-season water supply deliveries for the C-6/C-7 Canal basins. Additionally, the structure will include a manatee barrier to prevent manatees from migrating further west up the C-6 Canal.

Culvert barrels are 8-foot diameter round and are 60 feet in length. Barrel inverts are set at elevation –5.5 ft-NGVD (see ***Plate S-27***).

A.7.4.3 Weirs and other Water Control Structures

A.7.4.3.1 S-516A Triangular-Profile Weir

The S-516A Weir is an ungated triangular-profile (aka triangular cross-section) weir structure with a weir coefficient determined from the "Handbook of Hydraulics" by Brater and King, 7th edition (1996). The design flow is 7.5 cfs with a hydraulic head of 0.20 feet. The structure is located at the confluence of the C-502B Borrow Canal with the C-6 Canal. The structure will allow excess water collected in the C-502B Borrow Canal to discharge into the L-33 Canal north of C-6 Canal to prevent impact to flood damage reduction abilities for nearby privately-owned properties. The borrow canal's control stage benefits seepage reduction for WCA-3B and the 3B SMA.

The weir crest elevation is set at 4.80 ft-NGVD and is 20 feet in width. The weir has a triangular cross-section with 1-on-1 upstream and downstream slopes (see ***Plate S-28***). The weir is a "driveable" weir to allow access to the northern 3B SMA.

A.7.4.3.2 S-516B Triangular-Profile Weir

The S-516B Weir is identical to that of the S-516A Weir structure (see S-516A Weir preceding this paragraph). The structure is located at the confluence of the C-503 Borrow Canal with the C-6 Canal. The structure will allow excess water collected in the C-503 Borrow Canal to discharge into the C-6 Canal to prevent impact to flood damage reduction abilities for nearby privately owned properties. Controlling the borrow canal's stage benefits seepage reduction for the WCA 3B and 3B SMA, and enhances the enclosed wetlands' hydroperiod.

The weir crest elevation is set at 4.8 ft-NGVD and is 20 feet in width. The weir has a triangular cross-section with 1-on-1 (H:V)upstream and downstream slopes (see ***Plate S-28***).

A.7.4.4 Non-Control Structures

A.7.4.4.1 Ungated Culverts

A.7.4.4.1.1 FPL Non-gated Culverts 1 through 19

FPL has an unpaved maintenance access road that runs north to south through the 3A and 3B SMA. Nineteen ungated culverts will be placed along the length of the access road to promote east-west flows under the road in the wetland area. All culverts will have inlet and outlet pools with a minimum surface area of 900 square feet (30'x30') and 6-foot minimum depth. In the 3A SMA the culverts are numbered FPL 1 through 9. In the 3B SMA the culverts are to be numbered

FPL 10 through 19. Additional culverts may be required in the next design phase if shown to be necessary.

FPL culverts 1 through 4 and 7 through 19 are single barreled, ungated culvert structures (see ***Plate S-29***). The flow rate will be variable dependent on water table elevations and wetland inundation at the time. Relatively slow flow rates on the order of less than 1 fps are desirable. Culvert barrels are round 4-foot diameter culverts and are 30 feet in length. The barrel inverts are set at elevation 0.0 ft-NGVD for complete submergence to reduce interior vegetation growth.

FPL culverts 4, 5 and 6 are triple barreled, ungated culvert structures (see ***Plate S-29***). The flow rate will be variable dependent on water table elevations and wetland inundation at the time. Culvert barrels are round 4-foot diameter culverts and are 30 feet in length. The barrel inverts are set at elevation 0.0 ft-NGVD for complete submergence to reduce interior vegetation growth.

A.7.4.4.2 Bridges

Bridges are used for canal crossings where water control structures are not required. Because the C-502B Canal is gravity flow over a relatively long distance that has insignificant relief, head losses are critical to the performance of the canal. Well-designed bridge structures will provide conveyance with small head loss in comparison to typical head losses associated with culvert structures. Therefore, bridges are used throughout the project design.

A.7.4.4.2.1 B-500 Bridge

B-500 is a bridge structure used for FPL access to the FPL power substation spanning across C-502B. The bridge is located about 7.5 miles south of the I-75/US-27 Interchange on US 27.

A.7.4.4.2.2 B-501 Bridge

B-501 is a bridge structure used for access to the Holly Lakes Mobile Home Park spanning across C-502B where the channel has been modified to a concrete U-channel. The bridge is located about 9.0 miles south of the I-75/US-27 Interchange on US-27.

A.7.4.4.3 Existing Structures

A.7.4.4.3.1 S-9 Flood Pump Station

The S-9 Pump Station is a flood control pump station for the Western C-11 Basin. The pump station is located at the western end of the C-11 Canal

between the L-37 and L-33 Levees. The pump station provides a total pumping capacity of 2,880 cfs. The pump station discharges the urban runoff collected in the western C-11 Canal Basin directly into WCA 3A.

A.7.4.4.3.2 S-9A Seepage Pump Station

The S-9A Pump Station is a seepage control pump station that replaced the S-9 Pump Station role of backpumping seepage losses from WCA 3. The pump station is located on the L-37 Levee just north of the S-9 Pump Station. The pump station provides a total pumping capacity of 500 cfs for seepage collected in the C-11 Canal between the pump station and the S-381 Obermeyer Gate. Riser -control structures S-9XN, S-9XS, G-86N, and G-86S all control water levels within the Everglades Buffer Strip (3A and 3B SMAs) and discharges excess water into the C-11 Canal. The pump station discharges into WCA 3A. S-9A is a 4-bay pump station with two. 175 cfs diesel engine driven pumps, and two 75 cfs electric motor driven pumps. For operational flexibility any combination of pumps can be used to maintain optimum canal levels.

A.7.4.4.3.3 S-9XN and S-9XS Culverts with Risers

S-9XN and S-9XS Stoplog Riser structures are double-barreled stoplog riser structures. S-9XN is located on the L-37 Borrow Canal at the confluence with the C-11 Canal. S-9XS is located on the L-33 Borrow Canal at the confluence with the C-11 Canal. The structures are used to control WCA seepage by controlling stages in the borrow canals. Excess seepage water is discharged into the C-11 Canal where it is available for backpumping into WCA 3A. The barrels are CMP culverts with 6-foot diameters.

A.7.4.4.3.4 G-86N and G-86S Culverts with Risers

The G-86S Stoplog Riser structure is to be replaced with the S-502B Gated Culvert structure. The G-86N Stoplog Riser structure will remain in operation. Both structures are single-barreled stoplog riser structures. G-86N is located on the US 27 Borrow Canal at the confluence with C-11 Canal on the north side. G-86S is located on the US 27 Borrow Canal at the confluence with C-11 Canal on the south side. The structures are used to control WCA seepage by controlling stages in the US 27 borrow canal. Excess seepage water is discharged into the C-11 Canal where it is available for backpumping into WCA 3A. The barrels are CMP culverts with 5-foot diameters.

A.7.4.4.3.5 S-30 Gated Culverts

The S-30 Gated Culvert structure is a triple-barreled structure. S-30 is located on the C-9 Canal and serves as a bridge for US 27. The structure is used to release excess water from the Everglades Buffer Strip (3B SMA) and on rare

occasions allow excess C-9 Basin water to route as reverse flow through to the C-6 Canal for flood control (via L-33 Borrow to S-32 Gated Culvert). Under the Selected Plan, the structure will provide control for maintaining seasonal water levels in 3B SMA and water diverted from the Western C-11 Basin to the C-9 Impoundment. The barrels are culverts with 7-foot diameters, each 288 feet in length.

A.7.4.4.3.6 S-32 Gated Culverts

The S-32 Gated Culvert structure is a double-barreled structure. S-32 is located on the L-33 Borrow Canal and discharges into the C-6 Canal. The structure is used to release excess water from the Everglades Buffer Strip (3B SMA) for seepage management purposes and on rare occasions allow excess C-9 Basin water to route through to the C-6 Canal for flood control. Under the Selected Plan, the structure will provide control for maintaining seasonal water levels in the WCA 3B SMA. The barrels are CMP culverts with 6-foot diameters.

A.7.4.4.3.7 S-32A Gated Culvert

The S-32A Gated Culvert structure is a single-barreled structure. S-32A is located on the L-30 Borrow Canal at the confluence with the C-6 Canal. The structure is used to release excess water from the L-30 Borrow Canal for seepage management purposes. Under the Selected Plan, the structure may allow excess water from the 3B SMA to be routed into the L-30 Borrow Canal for conveyance south should a demand exist and conditions are favorable for operations. The barrel is a CMP culvert with a 4.5-foot diameter.

A.7.4.5 Embankments, Levees, and Levee/Berms

The 3A and 3B SMAs project component has four levees to contain canal conveyances and excess stages within the 3A and 3B SMAs: L-502A Levee, L-502B Levee (north), L-502B Levee (south, 2 levees separated by Krome Avenue), and L-503 Levee; and one flood damage reduction levee the L-506C Levee. In addition to the 3B SMA levees, the project includes 2 levee/berms the L-502E Levee/Berm and L-502F Levee Berm.

A.7.4.5.1 Levees

Levees are structures that are not expected to have permanent pools on either side and do not pose a hazard to life, nor significant property loss should a breach occur. Because of the fluctuating hydroperiods within the Seepage Management Areas and indirect control of water levels, permanent pools are not expected on the interior side the majority of the time. All levees will have a top width of 12 feet and grassed side slopes with a 1 on 3 (V:H) slope.

A.7.4.5.1.1 L-502A Levee

The L-502A Levee provides retention of excess stages of the 3A SMA wetland area and functions as a barrier to waters of different water quality, wetland versus stormwater runoff from US 27 (treated in a dry retention treatment swale system). The levee extends north from the C-11 Canal to I-75 and is located on the west side of the C-502A Borrow Canal with a 15-foot setback from the canal top-of-bank. The levee design crest elevation of 8.5 ft-NGVD is below that of US 27 road grade (between ±12.0 ft-NGVD and ±13.0 ft-NGVD) over the greater part of the reach. However, the levee will be overbuilt to an elevation of 9.5 ft-NGVD to allow for settling. Therefore, the public may enjoy the recreational-type scenery of the wetlands as they drive along the divided highway. Should the borrow canal stages rise extraordinarily high (FEMA 100-year base flood is 9.0 ft-NGVD), overflow would be into the SMA versus the highway that also serves as a hurricane evacuation route. Levee overtopping will not present a hazard potential as no private property or dwellings exist reside in the 3A SMA. The levee has a crest width of 10 feet with side slopes of 1V:3H.

The L-502A levee will contain reinforced overflow sections. These reinforced overflow sections will be approximately 50 feet in length and be reinforced with TRM or other geotechnical product to provide overflow protection for the levee. Soil hardening is another alternative. The overflow section will be approximately every 1/2 mile. The L-502A levee will contain six overflow sections.

A.7.4.5.1.2 L-502B Levee (North)

The L-502B Levee (north)provides retention of excess stages of the 3B SMA and functions as a barrier to waters of different water quality, wetland versus stormwater runoff from US 27. The Levee is to be constructed with borrow from excavation of the C-502B Conveyance Canal. The levee extends northward from the C-9 Canal to the S-502B Gated Culvert 500 feet south of C-11 Canal and is located west of C-502B Canal with a 40-foot setback from canal top-of-bank. The setback dimension is designed to allow canal enlargement that is identified with the North New River Improvement project if deemed necessary in the future. The levee design crest elevation is approximately 6.5 to 7.5 ft, NGVD, which is 2.0 – 3.0 feet above existing grade with a width varying less than 10 feet. Some borrow material will still be hauled to designated disposal areas for temporary use or for permanent (design) disposal. Levee side slopes are 1V:3H.

The L-502B Levee (north) will contain reinforced overflow sections. These reinforced overflow sections will be approximately 50 feet in length and be reinforced with TRM or other geotechnical product to provide overflow protection

for the levee. Soil hardening is another alternative. The overflow section will be approximately every ½ mile. The L-502B Levee (north) will contain seven overflow sections.

A.7.4.5.1.3 L-502B Levee (South)

The L-502B Levee (south) provides retention of excess stages of the 3B SMA and functions as a barrier to waters of different water quality, wetland versus stormwater runoff from US 27. The levee extends from the C-9 Canal south along US 27 and Krome Avenue to the L-33 Canal The levee is located west of the C-502B Conveyance Canal with a 15-foot setback from canal top-of-bank.

The levee design crest elevation of 6.5 ft-NGVD is below that of US 27 road grade (between ±11.0 ft-NGVD and ±12.0 ft-NGVD) over the greater part of the reach. The levee will be overbuilt to an elevation of 7.5 ft-NGVD to allow for settling. The public may enjoy the recreational-type scenery of the wetlands as they drive along the divided highway. Should the borrow canal stages rise extraordinarily high (FEMA 100-year base flood is 8.0 ft-NGVD), overflow would be into the SMA versus the highway that also serves as a hurricane evacuation route. Levee overtopping will not present a hazard potential as no private property or dwellings exist in the 3B SMA other than sites that are provided with flood damage reduction mitigating systems. The levee has a crest width of 12 feet with side slopes of 1V:3H.

The levee height as design is not expected to be overtopped as it is approximately 0.25 feet higher than the boundary bank/levee for the C-6 Canal. Should the area experience a high volume precipitation event, overflow will occur over the bank/levee with discharge into the C-6 Canal. The C-6 provides overflow relief of the 3B SMA to tide if necessary through project and C&SF system structures. The levee has a crest width of 12 feet with side slopes of 1V:3H.

The L-502B Levee (south) levee will contain reinforced overflow sections. These reinforced overflow sections will be approximately 50 feet in length and be reinforced with TRM or other geotechnical product to provide overflow protection for the levee. Soil hardening is another alternative. The overflow section will be approximately every ½ mile. The L-502B Levee (south) will contain two overflow sections.

A.7.4.5.1.4 L-502C Levee

The L-502C Levee is the levee forming the Holly Lakes Mobile Home Park perimeter flood damage reduction system and functions to protect the Park from elevated water levels within 3B SMA. Seepage under and through the levee is

collected in the C-502C Seepage Canal and pumped into C-502B Conveyance Canal for flood protection. The levee design crest elevation is 8.50 ft-NGVD, which provides 2.0 feet of levee superiority when 3B SMA is at design wet season control stage of 6.50 ft-NGVD. The design levee height is thought adequate as the FEMA 100-year flood is 8.00 ft-NGVD and C-502B provides overflow relief for the 3B SMA discharging to tide if necessary through project and C&SF system structures.

A.7.4.5.1.5 L-503 Levee

The L-503 Levee provides retention of excess stages of the 3B SMA wetland area and functions as a boundary barrier to separate project wetlands from land outside of the project such as areas approved for mining. The levee has two continuous directional reaches: (1) slants southwesterly from C-6 Canal (Miami Canal) along the proposed alignment for future NNR Deliveries and (2) east-west reach along northern boundary of the former Boy Scout camp. Both reaches are located east and south of the C-503 Borrow Canal with a 15-foot setback from canal top-of-bank. The levee design crest elevation of 7.25 ft-NGVD and is above that of C-6 Canal bank/levee. The levee will be overbuilt to an elevation of 8.25 ft-NGVD to allow for settling. Levee overtopping is not expected since the design levee height is above that of C-6 Canal bank/levee, but in the event overtopping occurs, no impacts are expected as no private property or dwellings exist in the area. The levee has a crest width of 12 feet with side slopes of 1V:3H.

A.7.4.5.2 Levee/Berms

The levee/berms are low levees no more than 3 feet above the enclosed average existing grade to prevent the impoundment of water deep enough to pose a hazard under any meteorological event. That is, the limited storage depth on the interior will not be that that may create flooding nor a dangerous kinematic wave should a breach occur. Large precipitation events will cause ponding on both sides of the levee/berms limiting pressures on the structures, thereby virtually eliminating the possibility of a full breach. The levee/berms may also provide an ecosystem protective berm function by the capture of and detention of rainwater that is expected to enhance hydroperiods of the existing natural areas. Material for construction of these low earthen structures is expected to be a mix of degraded limestone and sands with some peat or muck. All levee/berms have a top width of 10 feet and grassed side slopes with a 1 on 4 slope (or 4H:1V).

A.7.4.5.2.1 L-502E Levee/Berm

The L-502E Levee/Berm is a scrape formed berm surrounding the Bishop-Nixon properties/tracts. The tracts contain HTRW issues and it was decided by the Non-Federal sponsor, SFWMD, to omit these tracts from the project at this time.

The berm will function by isolating runoff from the site until such water is proved to have no impact to the surrounding wetlands. For this reason, the berm is to be constructed with surrounding material knowing that the berm will degrade with time. The HTRW is not considered high risk, which allows this assumption to be valid and considered sound design. The berm design crest elevation is 8.0 ft-NGVD, which provides 1.5 feet of levee superiority when 3B SMA is at the wet season control stage of 6.5 ft-NGVD. The design height is also thought adequate, as the FEMA 100-year flood is approximately 8.0 ft-NGVD.

A.7.4.5.2.2 L-502F Levee/Berm

The L-502F Levee/Berm is a natural area protective levee/berm with a design crest elevation of 8.0 ft-NGVD or 3.0 feet above an assumed average existing grade of 5.0 ft-NGVD. The levee/berm separates project lands from FPL lands, though FPL those lands remain as yet undeveloped and contain existing wetland marsh areas. The levee is designed for low stages in an emergent vegetation environment that will not experience waves of any practical force.

TABLE A-80: SMA LEVEE DESIGN PARAMETERS

Levee and Side Cast Levee Reach	Length	Top of Levee	Average Ground	Levee Height	Top Width	Side Slope
	feet	ft-NGVD	ft-NGVD	feet	feet	1V on ?H
L-502A – I-75 to STA82+00	8,200	8.5	7.50	1.0	12.0	3.0
L-502A – STA82+00 to STA172+00	9,000	8.5	6.00	2.5	12.0	3.0
L-502A – STA172+00 to C-11	11,500	8.5	6.00	2.5	12.0	3.0
L-502B north – C-11 to Holly Lakes	17,000	7.5	4.50	3.0	12.0	3.0
Holly Lakes – Constricted Reach						
L-502B south – Holly Lakes to C-9	19,100	6.5	4.50	2.0	12.0	3.0
L-502B south – C-9 to FL997	3,450	6.5	4.00	2.5	12.0	3.0
FL997 (Krome Avenue)						
L-502C – Holly Lakes Trailer Park	5,000	8.50	4.50	4	12.0	3.0
L-502E – Bishop-Nixon Berm	3,500	8.00	4.50	3.5	10.0	4.0
L-502F – FPL Separation	9,800	8.00	4.50	3.5	10.0	4.0
L-503 – C-6 to FL997 south of C-6	7,000	7.25	2.00	5.25	12.0	3.0
Totals (minus flood levees)	72,720 feet					

Note:
1. Levees will be overbuilt by one-foot to allow for settling.
2. Spoil Mound Levee will not be overbuilt as it is spoil material that will remain higher than required levee height to function as a 3B SMA Levee.
3. Average ground elevation based on LIDAR data

A.7.4.5.3 Canals

A.7.4.5.3.1 Conveyance Canal

A.7.4.5.3.1.1 C-502B Conveyance Canal

The only main conveyance canal for this project component is the C-502B Conveyance Canal. Construction of the C-502B Canal will primarily consist of enlargement of the existing US 27 west borrow canal. The canal design conveyance capacity is 1,000 cfs and includes the reach from the C-11 Canal to C-9 Canal. The C-502B Canal control stages will be managed to prevent excess seepage loss from WCA 3B and to prevent excess seepage from flowing out of 3B SMA to the east toward South Broward Drainage District residents. Another factor in stage control for long durations is to maintain the highest stage possible that does not impact the road base of the parallel US 27. These control stages will be determined by analysis of monitoring results with implementation of project features. However, they are expected to reflect the seasonally controlled water levels in the 3B SMA between 5.5 and 6.5 ft-NGVD when deliveries are not being made. Backwater calculations for deliveries showed canal stages ranging from 3.94 ft-NGVD at the tailwater of S-502B gated culvert structure (upstream) to 3.00 ft-NGVD at the headwater of S-30 gated culvert structure (downstream). Refer to ***TABLE A-81***.

The C-502B Conveyance Canal has one unique feature with a 2,385-foot constricted reach that abuts the Holly Lakes Mobile Home Park and the US 27 right-of-way. The constricted canal reach was designed to reduce impact to the Trailer Park through acquisition of land while still providing low head loss conveyance in the constrained channel width with US 27 on the eastern bank. The canal flow transitions into the constricted area with ±45 lf transitional reach where the depth increases by one-foot and the bank side slope increases in steepness from 1-on-1 to 1-on-3/4 (V:H). The discharge side is geometrically identical to the entrance with exception that the canal depth remains one-foot lower than the inflow side. Several model runs were performed and minimal head losses are expected through the constricted reach, even if the flow rate increases by 500 cfs. Refer to data section for analysis procedures and results.

With future CERP Projects coming online, the C-502B may be enlarged further as part of North New River Deliveries (part of WCA 3 Decompartmentalization) that will allow water supply deliveries to be conveyed from Lake Okeechobee to SDCS at a conceptual design capacity of 1,500 cfs through this project area. The enlargement of C-502B may also be required for deliveries to the NLBSA at a conceptual design capacity of 2,500 cfs.

The existing US 27 West Borrow Canal was assumed to have the following dimensions as shown in ***TABLE A-82*** for volume calculations:

TABLE A-81: CANAL C-502B - SUMMARY OF HYDRAULIC DESIGN DATA

Station	Water Surface Elevation	Mean Channel Velocity	Bottom Elevation	Bottom Width	Side Slope	Average Natural Grade
	ft NGVD	fps	ft NGVD	feet	1V on ?H	ft NGVD
0+00 (C-9 Canal, HW of S-30)	3.00	1.03	-12.0	50.0	1.0	4.50
188+30 (south xsection)	3.45	0.99	-12.0	25.0	0.75	4.50
194+32 (middle Holly Lakes)	3.45	1.77	-12.0	25.0	0.75	4.50
210+50 (north xsection)	3.47	1.77	-12.0	25.0	0.75	4.50
380+00 (TW of S-502B)	3.94	1.03	-12.0	50.0	1.0	4.50

Notes:
Design Volume Rate of Flow is 1,000 cfs
Stationing corresponds to backwater HEC-RAS model.
Average ground elevation based on LIDAR data

TABLE A-82: US 27 WEST EXISTING BORROW CANAL

Station	Water Surface Elevation	Mean Channel Velocity	Bottom Elevation	Bottom Width	Side Slope	Average Natural Grade
	ft NGVD	fps	ft NGVD	feet	1V on ?H	ft NGVD
~ 38,500 feet (C-11 Canal to C-9 Canal)	±5.00	N/A	±(-0.50)	40.0	1.0	±4.50

A.7.4.6 Flood Damage Reduction Canal

A.7.4.6.1 C-502C Flood Damage Reduction Canal

The C-502C Canal consists of a "ring" seepage canal used to provide flood damage reduction for the Holly Lakes Mobile Home Park. The canal design conveyance capacity is greater than 60 cfs the design pump station capacity of S-514A. Parameters for canal design included a control depth greater than 5 feet for reducing some types of vegetation growth. The canal reach starts in the southeast corner of the Park, runs west, north, and then east around the Park's perimeter to pump station S-514A located in the northeast corner. S-514A discharges excess water into the C-502B Canal. The C-502C Canal control stage will be maintained at 5.5 ft-NGVD with the pump station. Refer to ***Table A-83***.

TABLE A-83: CANAL C-502C

	Length	Side Slope	Bottom Width	Average Ground	Bottom Elev	Depth of Cut
	feet	1V on ?H	feet	ft-NGVD	ft-NGVD	feet
C-502C - Holly Lakes	5,000	2.0	5.0	6.1	0.0	6.1

Average ground elevation based on LIDAR data

A.7.4.7 Borrow Canals

A.7.4.7.1 C-502A Borrow Canal

The C-502A Borrow Canal consists of a new canal created by the excavation of material for L-502A Levee, the main purpose of the feature reach. The borrow canal is located north of the C-11 Canal; south of I-75; abutting the southbound right-of-way of US 27, and is east of the L-502A Levee with a 15-foot setback from levee toe. The canal will primarily intercept seepage from WCA in the 3A and 3A SMA. Excess water accumulated in the borrow canal will be controlled by G-86N Stoplog structure that discharges into the C-11 Canal. The canal control stage may vary initially with project implementation dependent on groundwater monitoring results over the area. However the initial setting of canal control stage will be seasonal with a stage of 7.0 ft-NGVD during the wet season and 6.50 ft-NGVD during the dry season. The canal will also receive stormwater runoff from US 27 via parallel dry retention swale treatment system. As a borrow canal, the bottom elevation will vary with quantity of material required to construct the L-502A to a design height of 8.5 ft-NGVD as natural grade varies from ±8.0 ft-NGVD near I-75 to ±6.0 ft-NGVD near the C-11 Canal. The canal bottom width will be a minimum of 5 feet. Side slopes are assumed to be 1V:1H at this time (see ***Plates G-02, G-03*** and ***G-08***).

A.7.4.7.2 C-502B Borrow Canal

The C-502B Borrow Canal consists of a new canal created by the excavation of material for the L-502B Levee, the main purpose of the feature reach. The borrow canal is located north of FL 997 (Krome Ave.), south of the C-9 Canal, abutting the southbound ROW of US 27 till curving southwestward to terminate at a designated point on Krome Ave., and east of the L-502B Levee with a 15-foot setback from levee toe. The canal will primarily intercept seepage from WCA 3. Excess water accumulated in the borrow canal will be controlled by new S-502B Gated Culverts in the far north (north terminal end of C-502B Conveyance Canal) and the existing S-30 structure in the north, that discharges into the C-11 and C-9 Canals, respectively. As a borrow canal, the bottom elevation will vary with the quantity of material required to construct the L-502B to a design height of 6.5 – 7.0 ft-NGVD as existing grade varies between ±3.0 and ±5.0 ft-NGVD. The canal bottom width will be a minimum of 5 feet. Side slopes are assumed to be 1V:1H at this time (see ***Plates G-04*** through ***G-06, Plate G-09***, and ***Plate G-10***).

A.7.4.7.3 C-503 Borrow Canal

The C-503 Borrow Canal consists of a new canal created by the excavation of material for L-503 Levee construction, the main purpose of the feature reach. The borrow canal is located south of C-6 Canal running ±0.35 mile from and

parallel to Krome Ave. to north boundary of the former Boy Scout camp, then west to Krome Ave., staying east and north of the L-503 Levee with a 15-foot setback from the levee toe. The canal will primarily intercept seepage from WCA 3. Excess water accumulated in the borrow canal above stage of 4.8 ft-NGVD will be controlled by the S-516B Weir structure that discharges into the C-6 Canal. A stage of 5.0 ft-NGVD is maintained during non-precipitation events providing a trickle flow between 5.0 and 7.50 cfs. During storm events, the weir is designed with a ability of passing over 25 cfs with a canal stage of 5.5 ft-NGVD. As a borrow canal, the bottom elevation will vary with quantity of material required to construct L-502B to a design height of 7.25 ft-NGVD as existing grade varies between ±2.0 and ±5.0 ft-NGVD. The canal bottom width will be a minimum of 5 feet. Side slopes are assumed to be 1V:1H at this time (see ***Plates G-04*** through ***G-06*** and ***Plate G-08***).

A.7.5 Other Features

A.7.5.1 Fish and Wildlife Design Features

The 3A and 3B SMAs will function as a natural buffer area preventing urban development encroachment from the east. Located adjacent to WCA 3A and WCA 3B, the area increases spatial extent for the historic everglades ecosystem. In addition to spatial extent the project provides the following benefits as well: (1) excavation for the canals will provide fish habitat and (2) enhancement of hydroperiods within the 3A and 3B SMAs should provide better quality habitat for native flora and fauna and promote their population expansion.

A.7.5.2 Mitigation Wetland Credits

Implementation of the BCWPA Project will impact several existing mitigation wetland areas that require relocation offset (provide ecological lift within the project), or purchased of credits from a mitigation bank. The 3A and 3B SMAs also contain areas that are classified as uplands. These areas (identified in the main report) are to be scraped to average existing grade and are expected to transition into wetlands. As these areas are relatively small and surrounded by high quality wetland marsh, natural seeding is expected to provide planting that would normally be required to attain this permitting requirement.

A.7.6 Instrumentation

All controllable structures are equipped for remote operation. Operational SCADA equipment, nine groundwater monitoring sites, and water quality monitoring sites have been identified. No geotechnical instrumentation was identified as being required. Associated instrumentation costs have been included in the cost estimate.

TABLE A-84: SMA OPERATION INSTRUMENTATION

Number	Structure	capacity (cfs)	Type	Pump Mix or Number of Gates	Water Surface, Gate & Precip Parameters	MOSCAD Type (light, regular)
S-502B	Gated Culverts	1,000	WS/MA	7	T,7xG (S504AT)	L
S-514A	Pump Station	60	FC	2x30E	H,T,P	R
S-30	Ex Gated Clv	1,000	WS	2	H,3xG (S509H)	R
S-515	Gated Culverts	600	WS	2	H,T,2xG	L
S-516A	Weir	25	WS	0	0	
S-516B	Weir	25	WS	0	0	
B-500	Bridge		MA	0	0	
B-501	Bridge		MA	0	0	

Type Legend:
WS = Water Supply
FC = Flood Control
SC = Seepage Control
WSC = Water Surface Elevation Control
MA = Maintain Access

Water Surface Parameters:
H = Headwater
T = Tailwater
P = Precipitation
Position Sensors
G = Gate

TABLE A-85: SMA WATER QUALITY INSTRUMENTATION

Number	Structure	capacity (cfs)	Type	Pump Size Category	Water Quality Sampling Equipment
S-502B	Gated Culverts	1,000	WS/FC		AS
S-514A	Pump Station	60	FC	small	GF
S-515	Gated Culverts	600	WS		
S-516A	Weir	25	WS		GE
S-516B	Weir	25	WS		GE
B-501	Bridge		MA		
B-502	Bridge		MA		

Water Quality Parameters:
AS = Auto-Sampler
GB = Grab, nutrients--bi weekly
GF = Grab, nutrients--normal ops flow
GE = Grab, nutrients--emergency flow

A.7.7 Project Management

A.7.7.1 Access to Project Features

Access to the structures around 3B Seepage Management Area is available from the I-75/I-595/US 27 interchange.

Access to the S-502B Gated Culvert structure can be achieved by driving south on US 27 about 5.9 miles from the interchange area and turning right (west) onto Griffin Road and continuing to structure.

The B-500 bridge (FPL substation) is accessed from US 27 and is located about 7.5 miles south of the interchange area. The B-501 bridge (Holly Lakes Trailer Park) is accessed from US 27 and is located about 9.0 miles south of the interchange area.

Access to the S-514A Pump Station (Holly Lakes Trailer Park) can be achieved by driving south on US 27 about 9.0 miles from the interchange area.

Access to the S-515 Gated Culvert on the C-6 Canal can be achieved by driving south on US 27 about 14.6 miles from the interchange area.

Access to the S-516A Weir structure at the confluence of C-502B Borrow with C-6 Canal can be achieved by driving south on US 27 about 13.4 miles from the interchange area to Krome Ave., turn right (west) and travel about 0.9 miles to to the west bank of the L-33 Canal.

Access to the S-516B Weir structure at the confluence of C-503 Borrow with C-6 Canal can be achieved by driving south on US 27 about 13.4 miles from the interchange area to Krome Ave., turn right (west) and travel about 0.9 miles to the south west bank of the C-6 Canal. Get on and travel down (southeast) along the C-6 Canal levee/bank to weir.

A.7.7.2 Construction Order

It is anticipated that before water levels within the 3B SMA are allowed to be increased, mitigation flood damage reduction systems for Holly Lakes Mobile Home Park isrequired to be constructed and operational. Also, final mitigation requirements for the FPL transmission power line poles should be in place. The temporary water level increases may not adversely impact the FPL transmission power line poles. Other than these construction features, no specific construction order is apparent at this time.

A.7.7.3 Clearing Requirements

Clearing and grubbing limits include levee and canal alignments. Biodegradable materials can be chipped and spread or stacked and burned.

Most of the Melaleuca growth proposed for eradication in the 3A and 3B SMAs identified in the Draft WPAFS has already been accomplished with other funds. Therefore, with the exception to areas to be cleared or scraped for mitigation offsetting credit, no other Melaleuca removal is expected—with exception to levee and canal alignments proposed for clear and grubbing operations.

There are only 2 or 3 infrastructures located within the design area. These structures will require demolition, removal and disposal. Aboveground utilities will be disconnected and removed.

A.7.7.4 Disposal Area Requirements

Calculations show that approximately 5.3 million cubic yards of usable excavation material will be generated from constructing the C-502B Conveyance canal. The C-11 and C-9 Impoundment sites may be used as off-site disposal sites where the excess material may be used for construction of perimeter embankments, internal levees, mitigation area levees or used to backfill abandoned quarry pits found onsite.

A.7.7.5 Utility and Other Relocations

A fiber optics utility corridor exists along the eastern boundary of the 3A and 3B SMAs within the western edge of the FDOT ROW for US 27. The fiber optic cables are installed below ground and within the 70-foot project setback from US 27. Location of exact alignment will be required before construction may proceed.

A FPL flowage easement is being considered inside the 3A and 3B SMAs that would include improvements to raise portions of the existing FPL maintenance access road, where needed, and the installation of culverts, where needed, to maintain existing access routes to the transmission lines and 24-hour, 7-days a week servicing ability.

A.7.7.6 Surveying Requirements

A survey scope of work was developed for the 3A SMA and 3B SMA project area. Associated surveying costs have been included in the cost estimate.

A.7.7.7 Special Studies

A.7.7.7.1 North New River Improvement

The Comprehensive Everglades Restoration Plan proposes releases up to 1,500 cfs from Lake Okeechobee for dry season deliveries to meet water supply demands for the South Dade Conveyance System (SDCS). The releases or deliveries would be made through the modified C&SF Spillway S-351 into the North New River Canal. The deliveries were to be routed south through the modified C&SF gated structure S-150 into an enlarged C&SF L-38W Borrow Canal. The deliveries were then are routed further south along the WCA 3A L-38W Borrow Canal through a new gated structure under I-75 into the C-502A Canal.

The C-502A Canal reach lies entirely within the 3A SMA project area. The C-502A Canal is bounded to the west by Levee L-502A (crest elev. 8.5 ft-NGVD) and to the east by Highway US 27 (crest elev. 12.0 ft-NGVD). The canal under normal conditions will not be allowed to overflow its banks and only in extreme cases overflow only into the seepage management area. The existing grade for the C-502A reach is approximately 8.5 ft-NGVD in the north (I-75) and falls to approximately 5.5 ft-NGVD in the south (C-11 Canal). When deliveries are not being made, the stages within the C-502A are expected to mirror that maintained in the WCA 3A with a control elevation stage of 7.50 ft-NGVD during the wet season and 6.5 ft-NGVD during the dry season. The canal stages during deliveries are designed to be close to these controlled stages.

The C-502A Canal also receives Western C-11 Basin diverted water up to 1,000 cfs in the interim period between the construction of the C-9 Impoundment and the future North Lake Belt Storage Area (NLBSA). At the completeion of the NLBSA, the C-502B Canal will receive 2,500 cfs for delivery south to the C-9 Canal for distribution to either the C-9 Impoundment or the NLBSA. The C-502 A and C-502B Canals will be designed for the 1,500 cfs Lake Okeechobee deliveries to the SDCS in order to be able to convey the 2,500 cfs diverted C-11 western basin flows.

The C-502B Canal reach lies entirely within the 3B SMA project area. The C-502B Conveyance canal has the capacity to pass up to 1,000 cfs to the C-9 Canal and the capacity to pass up to 560 cfs south from the C-9 Canal to the C-6 Canal. At the completion of the NLBSA, the C-502B Conveyance Canal will have the capacity to pass up to 2,500 cfs to the C-9 Canal and the capacity to pass up to 2,000 cfs south from the C-9 Canal to the C-6 Canal. The 2,000 cfs delivery consists of 1,500 cfs originating from Lake Okeechobee releases plus an additional 500 cfs supplemented by releases from the C-9 Impoundment through spillway S-30. Canal C-502B is bounded to the west by Levee L-502B (crest elev. 6.5-7.0 ft-NGVD north and 5.0-6.5 ft-NGVD south of C-9 Canal) and is bounded to the east by Highway US 27 (crest elev. 11.0 ft-NGVD). The canal under normal conditions will not be allowed to overflow its banks and only in extreme cases overflow only into the seepage management area. The existing grade for the C-502B reach is approximately 5.5 ft-NGVD in the north (C-11 Canal) and falls to approximately 4.5 ft-NGVD in the south (C-6 Canal). Total design conveyance of the C-502B flowing south to C-6 through spillway S-508 is 2,000 cfs. For SDCS deliveries, 1,400 cfs will be conveyed south of the C-6 Canal into a south reaching canal running parallel to L-30 Borrow Canal. The remaining 600 cfs is designated for deliveries down the C-6/C-7 Canals to meet water supply demands. When deliveries are not being made, the stages within C-502B are expected to mirror that in the WCA 3B Seepage Management Area maintaining a controlled stage of 6.5 ft-NGVD during the wet season and 5.5 ft-NGVD during

the dry season. The canal stages during deliveries are designed to be close to these controlled stages.

A.7.7.8 Required Studies

The next phase of design should include a finer resolution groundwater and surface water routing model using Plan & Specification level Geotechnical core boring data to study operations of the system and confirm groundwater level results of these initial studies.

A.7.8 Hydraulic Data and Supporting Analyses

A.7.8.1 Structure Hydraulic Sheets

A.7.8.1.1 S-502B Gated Culvert

Gated Round Culverts			
Revision	12 October 2000 - Original Submission		
	27 April 2005 - Redesign		
XY Coord	894020 733125		
Location	HW of C-502B Canal near C-11 Canal, Service bridge for Griffin Road		
Purpose	Divert flow from C-11 Basin to C-9 Impoundment (future NLBSA)		
Notes	1. Riprap requirements have not been verified with Geotech.		
Design Conditions			
	Discharge (CFS)	1,000 cfs	
	Headwater Elevation	7.25 ft, NGVD	
	Tailwater Elevation	6.95 ft, NGVD	
Maximum Expected Stages			
	Headwater Elevation	8.00 ft, NGVD	
	Tailwater Elevation	8.00 ft, NGVD	
Maximum Head Difference			
	Maximum Headwater Elevation	2.00 ft, NGVD	
	Minimum Tailwater Elevation	8.00 ft, NGVD	
Culvert Data			
	Number of Barrels	7	
	Barrel Type		
	Barrel Diameter	8.0 feet	
	Barrel Length	60.0 feet	
	Barrel Invert Elevation	-6.00 ft, NGVD	
	Type of Control	Slide Gate	
Canal Data			
	Side Slopes Cotangent	1	
	Upstream Bottom Width	65.00 feet	
	Upstream Bottom Elevation	-10.00 ft, NGVD	
	Downstream Bottom Width	45.00 feet	
	Downstream Bottom Elevation	-10.00 ft, NGVD	
Riprap Requirements			
	Design Barrel Velocity	2.84 fps	
	Design Riprap Velocity	4.00 feet	
	Riprap Protected Area	3,000 sq feet	
	Riprap Thickness	2.5 feet	
	Riprap Bedding Thickness	1.0 ft, NGVD	
Control Protection Elevation (match Griffin Road)		9.00 ft, NGVD	

A.7.8.1.2 S-514A Pump Station

S-514A Pump Station	
Revisions	24 January 2001 – Removed Mix Criteria comment associated with providing a duplicate pump.
	30 November 2000 – Finalized prior to SFWMD concurrence
	31 October 2000 – Original submission.
XY Coordinate[1]	842140 611720
Location	Broward County, Holly Lakes Mobile Home Park off of US 27, western side
Purpose/Operational Intent	
	Flood Control, Seepage Control
	Offset potential flooding and seepage problems that may occur because of the holding of higher water table elevations within the WCA 3B Seepage Management Area
Design Condition	
	Flood Control 60 cfs
	Seepage Control Required
Pump Station capacity Criteria	
	Pump station capacity provides the ability to remove approximately 12" of basin runoff within the Park's protection levee within a 24-hour period
Number of Pumps	
	2 Pumps
Pump Mix Type and Size	
	Electric 2 @ 30 cfs
Mix Criteria	Two pumps allow for an intermediate pumping rate and in the event of a single pump failure 50% of total pumping capacity remains
Control	Local & Remote by SCADA
Design Heads	
	Normal (6.00 HW to 6.50 TW) 1.00 feet
	Maximum (6.00 HW to 8.50 TW) 2.50 feet
Intake Water Surface Elevations	
	Maximum Non-Pumping 8.50 ft-NGVD
	Maximum Pumping 8.50 ft-NGVD
	Start Pumping 5.70 ft-NGVD
	Normal Drawdown 5.0 to 5.5 ft-NGVD
	Minimum Drawdown Pumping 4.50 ft-NGVD
	Minimum Non-Pumping 4.00 ft-NGVD
	Channel Invert 1.00 ft-NGVD
Discharge Water Surface Elevations	
	Maximum Non-Pumping 8.50 ft-NGVD
	Maximum Pumping 8.50 ft-NGVD
	Normal Pumping 6.50 ft-NGVD
	Minimum Pumping 5.00 ft-NGVD
	Minimum Non-Pumping 4.00 ft-NGVD
	Channel Invert -10.00 ft-NGVD

Notes:
[1] XY coordinates system used is NAD 83, Florida east, state plane.
All elevations are in feet, NGVD (National Geodetic Vertical Datum of 1929)
Diesel generator is required for control station and electric pumps in cases of power outage.

Data Compiled from: EN-HI modeling and EN-HH design.

A.7.8.1.3 S-515 Gated Culvert

S-515 Gated Culvert		
Revision	19 September 2000 - Original Submission	
	18 May 2005 - Redesign	
XY Coord	843510 581850	
Location	On C-6 Canal, near junction with US 27.	
Purpose	Divide structure between normal NESRS, CLBSA, SDCS, and C-6 deliveries.	
Notes	1. Riprap requirements have not been verified with Geotech.	
Design Conditions		
	Discharge (CFS)	600 cfs
	Headwater Elevation	4.80 ft, NGVD
	Tailwater Elevation	3.50 ft, NGVD
Maximum Expected Stages		
	Headwater Elevation	8.00 ft, NGVD
	Tailwater Elevation	6.00 ft, NGVD
Maximum Head Difference		
	Maximum Headwater Elevation	8.00 ft, NGVD
	Minimum Tailwater Elevation	3.00 ft, NGVD
Culvert Data		
	Number of Barrels	2
	Barrel Type	
	Barrel Diameter	8.0 feet
	Barrel Length	60.0 feet
	Barrel Invert Elevation	-5.50ft, NGVD
	Type of Control	Slide Gate
Canal Data		
	Side Slopes Cotangent	3
	Upstream/Downstream Bottom Width	20.00 feet
	Upstream/Downstream Bottom Elevation	-6.00 ft, NGVD
Riprap Requirements		
	Design Barrel Velocity	5.97 fps
	Design Riprap Velocity	6.90 fps
	Riprap Protected Area	2,500 sq-ft
	Riprap Thickness	2.00 feet
	Riprap Bedding Thickness	1.00 feet
Control Protection Elevation		8.50 ft, NGVD

A.7.8.1.4 S-516A Triangular-Profile Weir

S-516A Triangular Profile Weir			
Revision	14 May 2005 - Original Submission		
	6 July 2005 - Redesign from CIT to triangular profile		
XY Coord	N/A		
Location	Confluence of C-502B with C-6 Canal		
Purpose	Controls stage in C-502B Borrow canal		
Design Conditions			
	Discharge, Q	7.50 cfs	
	Headwater Elevation	5.00 ft, NGVD	
	Tailwater Elevation	2.00 ft, NGVD	
Maximum Expected Stages			
	Headwater Elevation	7.50 ft, NGVD	
	Tailwater Elevation	7.50 ft, NGVD	
Maximum Concurrent Head Difference			
	Maximum Headwater Elevation	5.50 ft, NGVD	
	Minimum Tailwater Elevation	2.00 ft, NGVD	
Weir Data			
	Weir Type	Triangular-Profile	
	Crest Length, L	20.0 feet	
	Crest Elevation	4.80 ft, NGVD	
	Maximum Head on Crest	1.00 feet	
	Upstream Weir Slope	1 on 1	
	Downstream Weir Slope	1 on 1	
	Minimum Tieback (Levee) Elevation	7.50 ft, NGVD	
Downstream Stilling Basin			
	Apron (Earthen) Width	15.0 feet	
	Apron Elevation	-5.00 ft, NGVD	
	Length (measured from base to canal)	10.00 feet	
	Minimum Sidewall (Levee) Elevation	7.50 ft, NGVD	
Canal Data			
	Side Slopes Cotangent	1	
	Upstream Bottom Width	15.00 feet	
	Upstream Bottom Elevation	-5.00 ft, NGVD	
	Downstream Bottom Width	Pool feet	
	Downstream Bottom Elevation	-10.00 ft, NGVD	
Riprap Requirements			
	Upstream Velocity at crest	25.40 fps	
	Downstream Velocity Over Apron (Earthen)	4.50 fps	
	Design Riprap Velocity	15.00 fps	
	Riprap Protected Area	1,000 sq-ft	
	Riprap Thickness	2.5 feet	
	Riprap Bedding Thickness	1.0 feet	

A.7.8.1.5 S-516B Triangular-Profile Weir

S-516B Triangular Profile Weir			
Revision	14 May 2005 - Original Submission		
	6 July 2005 - Redesign from CIT to triangular profile		
XY Coord	N/A		
Location	Confluence of C-503 with C-6 Canal		
Purpose	Controls stage in C-503 Borrow Canal		
Design Conditions			
	Discharge, Q	7.50 cfs	
	Headwater Elevation	5.00 ft, NGVD	
	Tailwater Elevation	2.00 ft, NGVD	
Maximum Expected Stages			
	Headwater Elevation	7.50 ft, NGVD	
	Tailwater Elevation	7.50 ft, NGVD	
Maximum Concurrent Head Difference			
	Maximum Headwater Elevation	5.50 ft, NGVD	
	Minimum Tailwater Elevation	2.00 ft, NGVD	
Weir Data			
	Weir Type	Triangular-Profile	
	Crest Length, L	20.0 feet	
	Crest Elevation	4.80 ft, NGVD	
	Maximum Head on Crest	1.00 feet	
	Upstream Weir Slope	1 on 1	
	Downstream Weir Slope	1 on 1	
	Minimum Tieback (Levee) Elevation	7.50 ft, NGVD	
Downstream Stilling Basin			
	Apron (Earthen) Width	15.0 feet	
	Apron Elevation	-5.00 ft, NGVD	
	Length (measured from base to canal)	10.00 feet	
	Minimum Sidewall (Levee) Elevation	7.50 ft, NGVD	
Canal Data			
	Side Slopes Cotangent	1	
	Upstream Bottom Width	15.00 feet	
	Upstream Bottom Elevation	-5.00 ft, NGVD	
	Downstream Bottom Width	Pool feet	
	Downstream Bottom Elevation	-10.00 ft, NGVD	
Riprap Requirements			
	Upstream Velocity at crest	25.40 fps	
	Downstream Velocity Over Apron (Earthen)	4.50 fps	
	Design Riprap Velocity	15.00 fps	
	Riprap Protected Area	1,000 sq-ft	
	Riprap Thickness	2.5 feet	
	Riprap Bedding Thickness	1.0 feet	

A.7.8.1.6 FPL 1-4 and 7-9 Maintenance Road Culverts

Ungated Culverts			
Revision	21 December 2000 - Original Submission		
	20 May 2005 - Reduced size 72" to 48"; material to		
XY Coord	Varies along access road		
Location	Within northern Everglades Buffer Strip		
Purpose	Provides surface water conveyance east of the FPL road from C-500A.		
Notes	1. Riprap requirements have not been verified with Geotech.		
Design Conditions			
	Discharge (CFS)	Not Determined	
	Headwater Elevation	7.50 ft, NGVD	
	Tailwater Elevation	7.45 ft, NGVD	
Maximum Expected Stages			
	Headwater Elevation	9.00 ft, NGVD	
	Tailwater Elevation	9.00 ft, NGVD	
Maximum Head Difference			
	Maximum Headwater Elevation	7.50 ft, NGVD	
	Minimum Tailwater Elevation	7.45 ft, NGVD	
Culvert Data			
	Number of Barrels	1	
	Barrel Type		
	Barrel Diameter	4.0 feet	
	Barrel Length	30.0 feet	
	Barrel Invert Elevation	0.00 ft, NGVD	
	Type of Control	None	
Canal Data			
	Side Slopes Cotangent	1	
	Upstream Bottom Width	30' X 30' Pool	
	Upstream Bottom Elevation	-2.00 ft, NGVD	
	Downstream Bottom Width	30' X 30' Pool	
	Downstream Bottom Elevation	-2.00 ft, NGVD	
Riprap Requirements			
	Design Barrel Velocity	n/a fps	
	Design Riprap Velocity	n/a fps	
	Riprap Protected Area	200 sq-ft	
	Riprap Thickness	1.0 feet	
	Riprap Bedding Thickness	1.0 feet	
Control Protection Elevation		n/a	ft, NGVD

A.7.8.1.7 FPL 5 and 6 Maintenance Road Culverts

Ungated Culverts			
Revision	21 December 2000 - Original Submission		
	20 May 2005 - Reduced size 72" to 48"; material to		
XY Coord	Varies along access road		
Location	Within northern Everglades Buffer Strip		
Purpose	Provides surface water conveyance east of the FPL road from C-500A.		
Notes	1. Riprap requirements have not been verified with Geotech.		
Design Conditions			
	Discharge (CFS)	Not Determined	
	Headwater Elevation	7.50 ft, NGVD	
	Tailwater Elevation	7.45 ft, NGVD	
Maximum Expected Stages			
	Headwater Elevation	9.00 ft, NGVD	
	Tailwater Elevation	9.00 ft, NGVD	
Maximum Head Difference			
	Maximum Headwater Elevation	7.50 ft, NGVD	
	Minimum Tailwater Elevation	7.45 ft, NGVD	
Culvert Data			
	Number of Barrels	3	
	Barrel Type		
	Barrel Diameter	4.0 feet	
	Barrel Length	30.0 feet	
	Barrel Invert Elevation	0.00 ft, NGVD	
	Type of Control	None	
Canal Data			
	Side Slopes Cotangent	1	
	Upstream Bottom Width	30' X 30' Pool	
	Upstream Bottom Elevation	-2.00 ft, NGVD	
	Downstream Bottom Width	30' X 30' Pool	
	Downstream Bottom Elevation	-2.00 ft, NGVD	
Riprap Requirements			
	Design Barrel Velocity	n/a fps	
	Design Riprap Velocity	n/a fps	
	Riprap Protected Area	200 sq-ft	
	Riprap Thickness	1.0 feet	
	Riprap Bedding Thickness	1.0 feet	
Control Protection Elevation		n/a ft, NGVD	

A.7.8.1.8 FPL 10-19 Maintenance Road Culverts

Ungated Culverts				
Revision	21 December 2000 - Original Submission			
	20 May 2005 - Reduced 72" to 48"; material to			
XY Coord	Varies along access road			
Location	Within southern Everglades Buffer Strip			
Purpose	Provides surface water conveyance east of the FPL road from C-500B.			
Notes	1. Riprap requirements have not been verified with Geotech.			
Design Conditions				
	Discharge (CFS)	Not Determined		
	Headwater Elevation	6.50 ft, NGVD		
	Tailwater Elevation	6.45 ft, NGVD		
Maximum Expected Stages				
	Headwater Elevation	8.00 ft, NGVD		
	Tailwater Elevation	8.00 ft, NGVD		
Maximum Head Difference				
	Maximum Headwater Elevation	6.50 ft, NGVD		
	Minimum Tailwater Elevation	6.45 ft, NGVD		
Culvert Data				
	Number of Barrels	1		
	Barrel Type			
	Barrel Diameter	4.0 feet		
	Barrel Length	30.0 feet		
	Barrel Invert Elevation	0.00 ft, NGVD		
	Type of Control	None		
Canal Data				
	Side Slopes Cotangent	1		
	Upstream Bottom Width	30' X 30' Pool		
	Upstream Bottom Elevation	-2.00 ft, NGVD		
	Downstream Bottom Width	30' X 30' Pool		
	Downstream Bottom Elevation	-2.00 ft, NGVD		
Riprap Requirements				
	Design Barrel Velocity	n/a fps		
	Design Riprap Velocity	n/a fps		
	Riprap Protected Area	200 sq-ft		
	Riprap Thickness	1.0 feet		
	Riprap Bedding Thickness	1.0 feet		
Control Protection Elevation		n/a ft, NGVD		

A.7.8.2 Canal Model Results

A.7.8.2.1 C-502B Conveyance Canal

TABLE A-86: C-502B HEC-RAS RESULTS(UPDATED 13 JUL11)

Profile Output Table - Standard Table 1

File Options Std. Tables Locations Help

HEC-RAS Plan: BWB0 River: C502B Reach: C502B Profile: Q = 1000 CFS

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
C502B	37340	Q = 1000 CFS	1000.00	-12.50	2.44	S-402B Tailwater	2.46	0.000026	1.03	970.28	79.88	0.05
C502B	37036	Q = 1000 CFS	1000.00	-12.50	2.43		2.45	0.000026	1.03	969.65	79.87	0.05
C502B	36031	Q = 1000 CFS	1000.00	-12.50	2.41		2.42	0.000026	1.03	967.59	79.81	0.05
C502B	35030	Q = 1000 CFS	1000.00	-12.50	2.38		2.40	0.000026	1.04	965.51	79.76	0.05
C502B	34028	Q = 1000 CFS	1000.00	-12.50	2.36		2.37	0.000026	1.04	963.43	79.71	0.05
C502B	33028	Q = 1000 CFS	1000.00	-12.50	2.33		2.35	0.000026	1.04	961.34	79.66	0.05
C502B	32028	Q = 1000 CFS	1000.00	-12.50	2.30		2.32	0.000026	1.04	959.23	79.60	0.05
C502B	31028	Q = 1000 CFS	1000.00	-12.50	2.28		2.29	0.000027	1.04	957.12	79.55	0.05
C502B	30029	Q = 1000 CFS	1000.00	-12.50	2.25		2.27	0.000027	1.05	954.99	79.50	0.05
C502B	28026	Q = 1000 CFS	1000.00	-12.50	2.20		2.21	0.000027	1.05	950.70	79.39	0.05
C502B	27024	Q = 1000 CFS	1000.00	-12.50	2.17		2.18	0.000027	1.05	948.53	79.34	0.05
C502B	26025	Q = 1000 CFS	1000.00	-12.50	2.14		2.16	0.000027	1.06	946.35	79.28	0.05
C502B	25025	Q = 1000 CFS	1000.00	-12.50	2.11		2.13	0.000028	1.06	944.16	79.23	0.05
C502B	24025	Q = 1000 CFS	1000.00	-12.50	2.08		2.10	0.000028	1.06	941.96	79.17	0.05
C502B	23025	Q = 1000 CFS	1000.00	-12.50	2.06		2.07	0.000028	1.06	939.74	79.11	0.05
C502B	22025	Q = 1000 CFS	1000.00	-12.50	2.03		2.05	0.000028	1.07	937.51	79.06	0.05
C502B	21370	Q = 1000 CFS	1000.00	-12.50	2.01		2.03	0.000028	1.07	936.04	79.02	0.05
C502B	21320	Q = 1000 CFS	1000.00	-12.50	2.01		2.03	0.000028	1.07	935.93	79.02	0.05
C502B	21310.*	Q = 1000 CFS	1000.00	-12.75	2.00		2.03	0.000042	1.26	793.38	67.57	0.06
C502B	21300.*	Q = 1000 CFS	1000.00	-13.00	1.99		2.02	0.000052	1.39	720.62	61.12	0.07
C502B	21290.*	Q = 1000 CFS	1000.00	-13.25	1.99		2.02	0.000068	1.55	644.99	54.67	0.08
C502B	21280	Q = 1000 CFS	1000.00	-13.50	1.97		2.02	0.000017	1.77	566.39	48.21	0.09
C502B	21091	Q = 1000 CFS	1000.00	-13.50	1.97	Holly Lakes	2.02	0.000017	1.77	566.25	48.21	0.09
C502B	21020	Q = 1000 CFS	1000.00	-13.50	1.97	Trailer Park	2.02	0.000017	1.77	566.17	48.20	0.09
C502B	20020	Q = 1000 CFS	1000.00	-13.50	1.95		2.00	0.000017	1.77	565.33	48.18	0.09
C502B	19107	Q = 1000 CFS	1000.00	-13.50	1.94		1.98	0.000017	1.77	564.59	48.16	0.09
C502B	19097.*	Q = 1000 CFS	1000.00	-13.50	1.94		1.98	0.000064	1.51	661.44	55.66	0.08
C502B	19087.*	Q = 1000 CFS	1000.00	-13.50	1.95		1.98	0.000046	1.32	758.21	63.15	0.07
C502B	19077.*	Q = 1000 CFS	1000.00	-13.50	1.95		1.97	0.000034	1.17	855.05	70.66	0.06
C502B	19067	Q = 1000 CFS	1000.00	-13.50	1.96		1.97	0.000023	0.99	1011.78	80.91	0.05
C502B	18911	Q = 1000 CFS	1000.00	-13.50	1.95		1.97	0.000023	0.99	1011.49	80.91	0.05
C502B	18002	Q = 1000 CFS	1000.00	-13.50	1.93		1.95	0.000023	0.99	1009.81	80.87	0.05
C502B	17019	Q = 1000 CFS	1000.00	-13.50	1.91		1.93	0.000023	0.99	1007.99	80.82	0.05
C502B	16017	Q = 1000 CFS	1000.00	-13.50	1.89		1.90	0.000023	0.99	1006.12	80.77	0.05
C502B	15017	Q = 1000 CFS	1000.00	-13.50	1.86		1.88	0.000023	1.00	1004.25	80.73	0.05
C502B	14017	Q = 1000 CFS	1000.00	-13.50	1.84		1.86	0.000023	1.00	1002.36	80.68	0.05
C502B	12016	Q = 1000 CFS	1000.00	-13.50	1.79		1.81	0.000024	1.00	998.57	80.59	0.05
C502B	10016	Q = 1000 CFS	1000.00	-13.50	1.75		1.76	0.000024	1.01	994.74	80.49	0.05
C502B	9014	Q = 1000 CFS	1000.00	-13.50	1.72		1.74	0.000024	1.01	992.81	80.44	0.05
C502B	8014	Q = 1000 CFS	1000.00	-13.50	1.70		1.71	0.000024	1.01	990.87	80.40	0.05
C502B	7014	Q = 1000 CFS	1000.00	-13.50	1.67		1.69	0.000024	1.01	988.92	80.35	0.05
C502B	5013	Q = 1000 CFS	1000.00	-13.50	1.62		1.64	0.000025	1.02	985.00	80.25	0.05
C502B	4013	Q = 1000 CFS	1000.00	-13.50	1.60		1.62	0.000025	1.02	983.02	80.20	0.05
C502B	3012	Q = 1000 CFS	1000.00	-13.50	1.58		1.59	0.000025	1.02	981.03	80.15	0.05
C502B	2011	Q = 1000 CFS	1000.00	-13.50	1.55		1.57	0.000025	1.02	979.03	80.10	0.05
C502B	1011	Q = 1000 CFS	1000.00	-13.50	1.53		1.54	0.000025	1.02	977.02	80.05	0.05
C502B	10	Q = 1000 CFS	1000.00	-13.50	1.50	-11.23 C-9	1.52	0.000025	1.03	975.00	80.00	0.05

Note: Stationing was performed independent from CAD site layout, but difference is insignificant and results are considered reliable.
* denotes internal HEC-RAS model interpolated station.

A.7.8.3 Canal Reach Alternative Analysis

A.7.8.3.1 Updated Canal Reach Alternative Analysis

The concrete lined channel along the Holly Lakes Mobile Home Park remained unchanged from what was documented. A 25-foot bottom width channel with a -12.0 ft- NGVD invert and 1-verticle on 0.75-horizontal side slope was modeled using a Manning's n coefficient of 0.015. A Manning n coefficient of 0.035 was used for the remaining canal reaches.

The Broward WPA Microstation base map design file was used for the canal centerline alignment in ArcMap. HEC-GeoRAS was used to cut cross sections approximately every 1000 feet along the canal reach. An old LIDAR digital elevation model with 10-foot grid cells was provided. The accuracy of the LIDAR is stated as ±1.0 feet. The canal alignment and river stationing is based on the Broward WPA Microstation base map. The procedure followed to create the HEC-RAS geometry file derived slightly different river stationing than what is documented. Once the geometry was exported from HEC-GeoRAS, the data was imported into HEC-RAS where the canal cross section profile template was cut along the canal centerline.

The HEC-RAS model was used to establish the 1-foot head loss water surface profile from S-502B tailwater to the C-9 canal with the smallest canal cross section possible. It was determined that a bottom width of 50-feet to the north and south of the Holly Lakes Trailer Park will achieve the design objectives.

Based on the digital elevation model data used, the design flow rate of 1000 cfs is achieved at a water surface profile that is below natural ground level. As a result, the levee/berm height to the west of the C-502B canal can be two feet or lower above natural ground level or 2.5-3.0 feet above the design water surface profile.

A.7.8.3.2 Original Canal Reach Alternative Analysis

This analysis outlines the method used to model canal C-502B from C-11 Canal (TW of S502B) to C-9 Canal (HW of S-30). This section of C-502B has an overall length of ±38,000 ft. with a constriction near the middle of the reach at the Holly Lakes Trailer Park. The canal was modeled with a flow rate of 1,000 cfs and a downstream water surface elevation (WSE) boundary condition of + 6.2 ft-NGVD. The objective of this effort was to optimize canal geometry and costs with an upstream WSE target of +6.9 ft-NGVD or less.

The original trapezoidal channel for which all alternatives were compared to is best divided into three types of sections: two—upstream and downstream--long reaches, two short transitional reaches, and a constricted reach. The original

geometry for the upstream and downstream sections included a bottom width of 45 ft., 1V: 1H side slopes, and a Manning's n of 0.035 for the entire wetted perimeter cross-section. The constricted reach of the canal was modeled as a concrete lined U-channel with a bottom width of 50 ft. and a Manning's n of 0.015 for the entire wetted perimeter cross-section. The transition section was generated using the HEC-RAS cross section interpolation function and the Manning's n was set to 0.024 for the banks (sheet pile) and 0.035 for the channel bottom. The length of the transition was defined by a 15-degree angle between the top of the upstream cross section and the top of the constricted reach. This distance was rounded up to a more practical value of 60 ft., station to station. The depth was set to -10.00 ft-NGVD for the upstream channel and to -11.00 ft-NGVD from the constricted reach through the downstream end. After running the model with these constraints, the upstream WSE was computed to be + 6.91 ft-NGVD.

For the second alternative, the original geometry was preserved, but the value of Manning's n was changed in the U-channel to 0.035 for the bed and 0.024 on the banks to model sheet pile walls with earthen bottom. This alternative produced an increase in the upstream WSE of about 0.05 ft. (+6.96 ft-NGVD).

The next alternative explored included widening the U-channel by five feet. This geometry was modeled using both a concrete U-channel and a U-channel comprised of sheet pile. This alternative produced nearly no change in upstream WSEs from the original geometry.

Another alternative reviewed involved increasing the depth of the entire canal by one foot (-11.00 ft-NGVD upstream and -12.00 ft-NGVD from constriction point to either terminal end of the canal). This change was applied to each of the previous alternatives. The result had the best outcome from the U-channel designs: an upstream WSE of + 6.79 ft-NGVD. This design; however, is not as cost-effective as a completely earthen canal would be (including constriction reach).

Therefore, the next alternative modeled was a complete earthen trapezoidal channel with a 1V: $^1/_2$H side slope in place of the U-channel. With this geometry, the model was set up with a station-to-station transition reach of 30 ft. This model used a bottom width value of 45 ft. for the upstream and downstream sections and 50 ft. for the constricted reach. In addition, a Manning's n value of 0.035 was set for the entirety of the canal. When this alternative was modified by reducing the channel elevation by one foot, the resulting upstream WSE was found to be + 6.81 ft-NGVD. After consulting with geotechnical engineers; however, this alternative was disregarded due to soil-slope constraints.

The next alternative explored was changing the side slope at the constriction to a tentative acceptable 1V: $^3/_4$H. The constricted reach was constrained to a design top width less than 55 ft. to avoid acquisition of additional Right-of-Way from Holly Lakes private owners. This resulted in a practical bottom width of 25 ft. for the constricted reach. The Manning's n value for this alternative was 0.035 throughout. The original upstream depth of -10.0 ft-NGVD produced an increase in upstream WSE of 0.12 ft. (+ 7.02 ft-NGVD). Therefore, the channel elevations were reduced by one foot, resulting in an upstream WSE of + 6.88 ft-NGVD (about 0.03 ft. below the original design depth of + 6.91 ft-NGVD). This alternative was selected as the current design to be used.

The following table outlines the various alternatives modeled and the corresponding results.

TABLE A-87: SUMMARY OF HYDRAULIC INVESTIGATIONS: C-502B (HOLLY LAKES)

Alt	Constrct Slope	Constrct b (ft)	Up/Dnstr b (ft)	Bottom Elev. (ft-NGVD)	Mann's n	Top Width T (ft)	Transition Length (ft)	WSE (ft-NGVD)
				Upstrm	Cnstrct'n	Main(av)		
				Dnstrm	Trans.	Cnstrct'n		
1 (FS)	Vertical w/ conc. bed	50	45	-10.00	0.015	79.11	60	6.91
				-11.00	0.024	50		
2	Vertical w/ conc. bed	50	45	-11.00	0.015	80.99	60	6.79
				-12.00	0.024	50		
3	Vertical w/ sht pile	50	45	-10.00	0.024	79.17	60	6.96
				-11.00	0.024	50		
4	Vertical w/ sht pile	50	45	-11.00	0.024	81.04	60	6.84
				-12.00	0.024	50		
5	Vertical w/ conc. bed	55	45	-10.00	0.015	79.11	60	6.91
				-11.00	0.024	55		
6	Vertical w/ conc. bed	55	45	-11.00	0.015	80.99	60	6.79
				-12.00	0.024	55		
7	Vertical w/ sht pile	55	45	-10.00	0.024	79.15	60	6.95
				-11.00	0.024	55		
8	Vertical w/ sht pile	55	45	-11.00	0.024	81.02	60	6.82
				-12.00	0.024	55		
9	1 : 1/2	50	45	-10.00	0.024	79.14	30	6.94
				-11.00	0.024	67.56		
10	1 : 1/2	50	45	-11.00	0.024	81.01	30	6.81
				-12.00	0.024	68.5		
11	1 : 3/4	25	45	-10.00	0.035	79.23	60	7.02
				-11.00	0.035	51.39		
12 (SP)	1 : 3/4	25	45	-11.00	0.035	81.08	30	6.88
				-12.00	0.035	52.78		

Notes:

1. Downstream boundary condition WSE was set to +6.20 ft-NGVD for all alternatives.
2. Constriction bottom Manning's n for concrete U-channel was assigned 0.015, all other alternatives used earthen bottom Manning's n of 0.035.

TABLE A-88 L-502A/B LEVEES AND C-502A/B CANALS DATA WITH IMPACTS

Levee / Canal	From STA	To STA	Avg Nat Grade	Top El / Invert	Crest W / Bottom W	Base W / Top W	Setback	Side Slope	Clear & Grub	Peat / Rock
	ft	ft	ft-NGVD	ft-NGVD	ft	ft	ft	1V:?H	ac	cy
I-75	0+00	82+00	7.50	11.00	12.0	41.0	15.0	3.0	16.9	73,041
				-4.50	10.0	34.0		1.0		46,983
L-502A C-502A	82+00	172+00	6.00	11.00	12.0	50.0	15.0	3.0	21.9	99,233
				-7.00	15.0	41.0		1.0		79,733
	172+00	287+00	6.00	11.00	12.0	50.0	15.0	3.0	25.6	52,463
C-11Canal				-5.00	10.0	32.0		1.0		102,574
C-11 Canal	0+00	170+00	4.50	14.00	12.0	77.0	40.0	3.0	74.5	179,869
L-502B C-502B				-10.00	45.0	74.0		1.0		403,939
	193+32	384+32	4.50	14.40	12.0	79.4	40.0	3.0	84.8	204,598
C-9 Canal				-10.50	45.0	75.0		1.0		484,166
C-9 Canal	0+00	34+50	4.00	10.50	12.0	59.0	15.0	3.0	8.6	9,634
L-502B C-502B				-8.00	10.0	34.0		1.0		43,853
	39+30	84+00	2.00	10.50	12.0	71.0	15.0	3.0	13.2	15,066
C-6 Canal				-11.65	15.0	42.3		1.0		84,167

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TABLE A-89: HOLLY LAKES SEEPAGE AND CONVEYANCE CANAL C-502C

WCA 3B Seepage Management - WPA Feasibility Study
Holly Lakes C-502C Seepage Canal

Discharge Q =	60	cfs
HW Station =	7090	feet
TW Station =	0	feet
Length =	7090	feet
Average Nat Grd =	6.10	ft, NGVD
Headwater El=	6.30	ft, NGVD
Tailwater El=	6.00	ft, NGVD
Average WSEl =	6.15	ft, NGVD
Delta H =	0.30	feet
E.G. Slope =	0.00	
Slope =	0.000042	
Slope ^0.5 =	0.00650	
Conveyance Req'd =	9,224	Target Conveyance
Left Side Slope 1 on =	2	
Right Side Slope 1 on =	2	
Trial Depth =	6.15	ft
Trial Bottom Width	5	

Water Depth	Conveyence for Manning's n n = 0.03	n = 0.035	n = 0.04	Vel fps	Bottom Elev ft,NGVD	Ground Topwidth feet	WS Topwidth feet
5.40	8,648	7,412	6,486	0.70	0.75	26.4	26.6
5.65	9,579	8,210	7,184	0.65	0.50	27.4	27.6
5.90	10,568	9,059	7,926	0.61	0.25	28.4	28.6
6.15	11,618	9,959	8,714	0.56	0.00	29.4	29.6
6.40	12,730	10,911	9,547	0.53	-0.25	30.4	30.6
6.65	13,904	11,918	10,428	0.49	-0.50	31.4	31.6
7.65	19,255	16,504	14,441	0.39	-1.50	35.4	35.6

Extension Length =	7090	feet
Average Ground Elevation =	6.10	ft-NGVD
Bottom of Canal =	0.00	ft-NGVD
Depth of Cut =	6.10	feet
Canal Bottom Width =	5.00	feet
Left Side Slope 1 on =	2	
Right Side Slope 1 on =	2	
Ground Topwidth =	29.4	feet
Volume of Cut =	27,551	cubic yards

A.7.8.4 Flood Analysis

A.7.8.4.1 Changes to Existing Flood Protection System

When the subregional modeling identified areas where increased flood protection was necessary, site-specific design changes were made to ensure existing levels of flood protection was maintained. To assist in this design process site specific modeling was used. The only area where this occurred was the Holly Lakes Mobile Home Park. Further description of this effort is provided below. Design features included to address changes to flood protection include S-514A pump station, C-502C seepage collection canal, and L-502C perimeter levee for Holly Lakes Mobile Home.

A.7.8.4.2 Site-Specific Flood Protection Modeling at Holly Lakes Mobile Home Park

This section of the Appendix describes the site-specific modeling performed to address expected changes to the groundwater elevation, and thus the level of flood protection, at the Holly Lakes Mobile Home Park located within the 3A and 3B Levee Seepage Management design region. The components will raise water levels within this area to reduce seepage losses from WCA-3B. A perimeter levee, seepage collection canal, and pump station are proposed for flood protection at this location. Structure S-514A will provide seepage management and flood control through an appropriate pump mix. The Corps' Hydrologic Modeling System (HMS) was used to develop a model to help determine the appropriate flood control pump size. The pump must be able to maintain the existing level of flood protection for a 24-hour rainfall event with a 100-year return period (0.01 exceedence probability).

A.7.8.4.3 Existing Conditions

The Holly Lakes Mobile Home Park was developed with landfill that was most likely excavated from a centrally located borrow area herein referred to as Holly Lakes. Ground elevations in the filled area range from approximately 8.0 to 11.0 feet NGVD. Elevations of unfilled adjacent wetland areas range from approximately 5.5 feet to 7.0 feet. Currently, Holly Lakes has an uncontrolled connection to the US 27 west borrow canal through a culvert estimated to be 60 inches in diameter. The water surface elevation in the US 27 canal is controlled by structure G-86S located approximately 3 miles to the north. Structure G-86S is a single-barrel 60-inch diameter corrugated metal pipe (CMP) discharging through the southern bank of the C-11 Canal. There is no design discharge for this structure. Stoplogs in a CMP riser pipe effect control. Stoplogs are normally set with a crest elevation of 5.5 feet. The drainage divide between the C-9 and C-11 basins is located near the West Hollywood Lakes development. During periods of heavy

rainfall when the stage in the US 27 Canal at West Hollywood Lakes rises above 5.5 feet, stoplogs are removed, and are replaced when the stage at West Hollywood Lakes drops below 5.5 feet. The S-9 pump station discharging to WCA-3A controls water levels in the Western C-11 Canal. The Holly Lakes Mobile Home Park is located in the C-11 Basin just north of the drainage divide and runoff has been observed flowing north at the point where the Holly Lake culvert enters the US 27 Canal. There are numerous culvert road crossings between the Mobile Home Park and G-86S. These culverts, many of which appear to be undersized, when combined with debris and vegetation in the US 27 Canal, reduce the canal's capacity to convey runoff to the C-11 Canal.

A.7.8.4.4 Existing Flood Protection

The Holly Lakes Mobile Home Park is located in an area with FEMA Flood Zone designation AH, which corresponds to a base flood elevation of 8.0 ft-NGVD for a 100-year event. Runoff from impervious surfaces in the Mobile Home Park drains outward to the adjacent wetlands or inward to Holly Lake and/or its connector ditch to the US 27 west borrow canal. Limited stage data (***Table A-84***) provided by the South Broward Drainage District (SBDD) indicates the stage of Holly Lakes is relatively constant between 4.7 and 5.7 ft-NGVD which corresponds with the operation of G-86S. The SBDD data shows a peak stage of approximately 7.0 ft-NGVD occurring on October 18 and 22, 1999. This stage is associated with the recession of floodwaters from Hurricane Irene, which represented one of largest rainfall events on record for South Florida. The hurricane made landfall on October 15, 1999, and SBDD personnel estimate high water at the Mobile Home Park reached approximately 9.0 ft-NGVD, although this high stage was not recorded. Most of the structures are estimated to have first floor elevations of approximately 11.0 ft-NGVD.

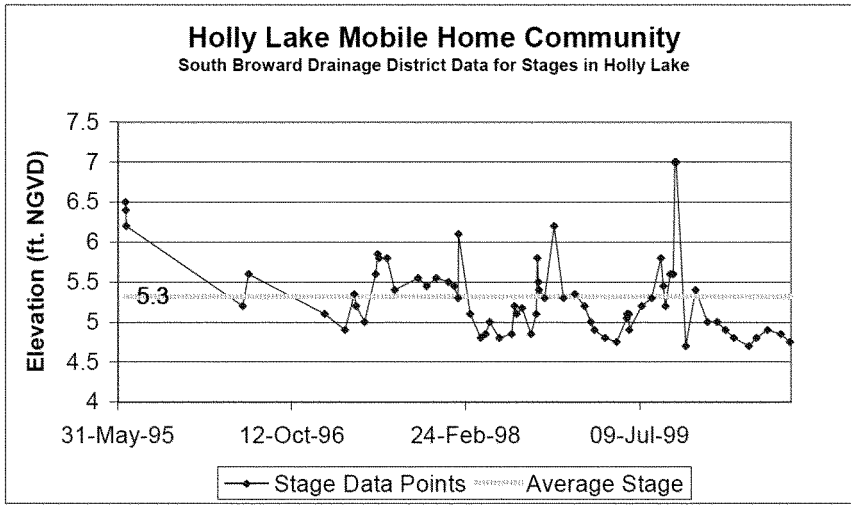

FIGURE A-36: HOLLY LAKE STAGE DATA

A.7.8.4.5 With-Project Conditions

Several WPA project components will affect the Holly Lakes Mobile Home Park. In the wet season, the WCA 3A and 3B Levee Seepage Management components are designed to hold the water level at 6.5 ft-NGVD in the wetland areas between L-33 and the proposed L-502B levees. The US 27 west borrow canal will be replaced by Canal C-502B from the C-11 Canal to the north continuing southward along US 27 to the C-6 Canal to the south. The C-502B design capacity is 1,000 cfs. This will increase to 2,500 cfs when the NLBSA is completed. The C-11 and C-9 Impoundments and the North Lake Belt Storage Area (NLBSA) will be linked via the C-502B Canal. The primary purpose of these storage areas is to divert urban runoff from the western C-11 basin previously pumped into WCA 3A via S-9 pump station, reduce losses to tide by storing the runoff from these basins and releasing water back to the basins when needed, reducing urban demands on the natural system. In the dry season, C-11 and C-9 Impoundment discharges or Lake Okeechobee deliveries will be made down C-502B Canal to the South Dade Conveyance System. In the wet season, C-502B Canal will allow stormwater from the western C-11 basin to be diverted away from S-9 pump station to the C-9 Impoundment, NLBSA or to tide via C-9 and/or C-6. When the C-11 and C-9 Impoundments or NLBSA are full, and C-6 and C-9 Canals are at discharge capacity, the S-9 pump station will maintain the existing level of flood protection in the Western C-11 Basin.

A.7.8.4.6 Maintaining Flood Protection at Holly Lakes Mobile Home Park

By design, there will be an increase of approximately 1 foot in groundwater stage in this area due to the increased water levels called for in the WCA 3A and 3B Levee Seepage Management components. This changes the antecedent conditions by reducing the amount of rainfall that can be absorbed before runoff is generated. This change to the existing level of flood protection will be mitigated by the L-502C levee and associated C-502C seepage collection canal and the S-514A seepage and flood control pump station. A total pump capacity of 60 cfs is needed to remove approximately 12-inches of rainfall within the perimeter levee, plus seepage inflow, and preventing the peak stage from rising above 8.0 ft-NGVD. Two 30-cfs electric pumps are proposed with backup diesel power generation. One of the pumps will maintain the seepage canal and Holly Lakes Mobile Home Park at approximately 5.5 ft-NGVD (seepage pump on at 5.7 ft-NGVD and off at 5.3 ft-NGVD). When the stage in the seepage canal and Holly Lake continues to rise and reaches 6.0 ft-NGVD, the second pump will come on until the stage falls to 5.0 ft-NGVD. HMS modeling of the design storm under these operational parameters shows that 60-cfs total pump capacity will result in a peak stage of approximately 7.3 ft-NGVD within the perimeter levee L-502C. This will be adequate to maintain the existing level of flood protection.

HMS was used to predict the peak stage that would be expected within the proposed perimeter levee resulting from design storm precipitation plus estimated levee seepage inflow.

TABLE A-90: S-514A PUMP SIZE DATA

Pump Size (cfs)	Rainfall Event	Peak Storage (ac-ft)	Peak Elevation (ft)
0	10yr	97.48	7.72
40	10yr	54.99	6.77
50	10yr	49.97	6.61
60	10yr	45.59	6.47
70	10yr	41.78	6.35
80	10yr	38.49	6.25
90	10yr	35.65	6.16
100	10yr	33.22	6.09
120	10yr	29.62	5.99
150	10yr	25.92	5.92
200	10yr	21.48	5.85
0	100yr	136.88	8.26
40	100yr	89.17	7.55
50	100yr	82.42	7.41
60	100yr	76.43	7.29
70	100yr	70.06	7.18
80	100yr	66.21	7.08
90	100yr	61.80	6.98
100	100yr	57.79	6.85
120	100yr	50.79	6.63
150	100yr	42.28	6.37
200	100yr	32.32	6.06

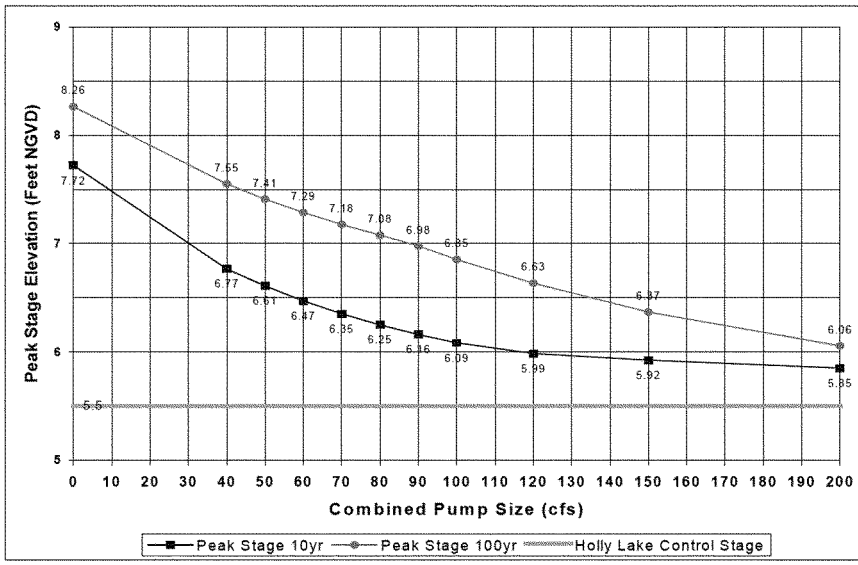

FIGURE A-37: S-514A PUMP SIZE DATA

Figure A-38 shows the HMS model layout of the Holly Lakes Mobile Home Park. Predicted runoff was developed using the SCS method and the parameters used are shown in ***Table A-91.*** The site was divided into three runoff-generating areas according to land use. A constant inflow source was also added to account for perimeter levee seepage. Accordingly, the Levee Seepage element represents 3.0 cfs of total levee seepage into the site. This seepage estimate is based on the seepage analysis done for the nearby C-9 Impoundment. For the On-site Storage element, a relationship of storage vs. elevation was developed to represent the Holly Lakes Mobile Home Park encircled by the L-502C levee.

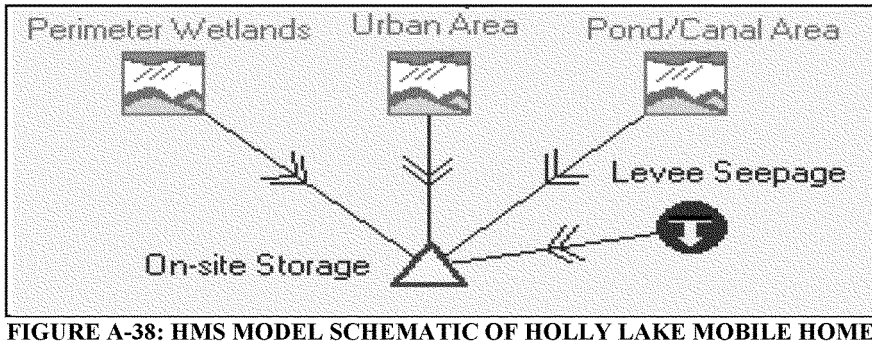

FIGURE A-38: HMS MODEL SCHEMATIC OF HOLLY LAKE MOBILE HOME PARK

TABLE A-91: ELEMENTS GENERATING RUNOFF USING SCS METHOD FOR HOLLY LAKE

	Perimeter Wetlands	Urban Area	Lake/Canal Area
Area (acres/sq-mi)	7/0.011	90/0.14	21/0.033
SCS Curve No	91	94	100
%Impervious	0	65	100
Lag (minutes)	34	106	7.5
Initial Loss (inches)	0	0	0
Baseflow (cfs)	0.0	0.0	0.0

Modeling Assumptions and Miscellaneous Data:

The model simulation period was 48 hours at 1-minute time-steps. Perimeter seepage Canal C-502C will connect to Holly Lakes Mobile Home Park via the existing ditch. S-514A pumps will discharge from the seepage canal to C-502B Conveyance canal (the improved US 27 west borrow canal).

The seepage inflow rate was estimated assuming a 1-foot head difference along the perimeter levee. In the C-9 Impoundment seepage analysis, a head difference of 2 feet produces a seepage rate of 0.0008 cfs per foot of levee. As the head difference increases, the relationship appears to be linear so extrapolating backwards for the assumed head difference of 1 foot gives a seepage rate of 0.0004 cfs/ft. The perimeter levee is approximately 8000 feet long. Therefore, a constant flow rate of 3.0 cfs was applied to On-site Storage element in all cases.

A seepage pump will be in the mix and it will maintain Holly Lakes Mobile Home Park and the seepage canal at approximately 5.5 ft-NGVD (seepage

pump on at 5.7 ft-NGVD and off at 5.3 ft-NGVD). Therefore, the beginning stage of the On-site Storage element is 5.5 feet.

The S-514A flood control pump will come on when the Lake/Canal stage is at 5.7 ft-NGVD and go off between 5.0 and 5.5 ft-NGVD.

On-site Storage versus elevation assumptions are based on the topographic contours generated from recent survey data.

The S-514A pump station was simulated by adding a constant outflow to the on-site Storage element for elevations 6.0 and greater. This simulates the pump coming on when the stage in Holly Lake and the seepage collection Canal C-502C reaches the trigger elevation of 6.0 ft-NGVD. The outflow rates varied to match the pump sizes used in the various runs to generate the data in ***Table A-85*** and ***Figure A-37***.

FIGURE A-39: S-514B PUMP SIZE DATA

A.8 SUPPORTING DOCUMENTATION

A.8.1 Everglades Agricultural Area (EAA) Overwash Field Test Results

A.8.1.1 EAA Overwash Test Summary

A.8.1.1.1 Introduction

In order to evaluate the potential impacts of waves overtopping the EAA Reservoir embankments and the resultant erosion on the downstream slope, an embankment Overwash Test program was designed and implemented by the State of Florida's Expedited Projects/Initiatives (District). The Barnard-Parsons Joint Venture, contracted as the Construction Manager @ Risk (CMR) for the EAA Reservoir A-1 construction project, was selected to fabricate, assemble, operate and dismantle the Overwash Testing apparatus.

A.8.1.1.2 Objectives

The objective of the work was to build and operate a system to simulate an overwash scenario of approximately 0.001 cfs/l-ft, 0.01 cfs/l-ft and 0.1 cfs/l-ft of embankment. Tests were conducted for each discharge scenario over an approximate 8 hour period. An accurate flow measuring system was implemented to track both the instantaneous flow rate and total accumulative flow over the test durations. The overwash slopes were surveyed before and after the tests were conducted. Measurements were

taken to determine the volume of eroded material accumulated in catch basins constructed at the toe of the slopes.

A.8.1.1.3 Testing

The Overwash Test apparatus was fabricated by Godwin Pumps in their New Jersey facility. The test apparatus, shown in Figures 1 and 2, consisted of a 30 foot long, 10" dia. header pipe with twenty ¾", eight ½", and four ¼" evenly spaced nozzles. Each nozzle was equipped with a ball valve which allowed for quick changes to the flow regimes and maintenance (cleaning of partially clogged nozzles) during testing. The equipment was delivered and assembled at the EAA test cell project site on October 7, 2006. The overwash tests were run on the downstream slope of EAA Test Cell #2, which had been constructed in early 2005 for hydraulic testing purposes. Four "test strips" were constructed on the 3:1 slope, each approximately fifty feet wide, with a separate catch basin excavated at the toe of each strip. Total height of the test embankment was approximately 17 feet.

The test apparatus was checked out functionally and the actual overwash flow rate tests began on Monday October 9, 2006 with the initial flow rate of 0.001 cfs per l-ft on Test Strip A. Testing was completed on October 13, 2006.

FIGURE A-40: OVERWASH TEST APPARATUS

A.8.1.1.4 Overwash Rate of 0.001 CFS per Linear Foot (Test No. 1)

For the low flow test of 0.001 cfs per lf, which corresponds to 13.4 gpm for the 30 foot wide section, a one-inch line and flow meter were used to supply the test head manifold. Only the ¼-inch nozzles (four in total) were required to attain the desired flow rate control. ***Figure A-41*** demonstrates the test head manifold during testing. ***Figure A-42*** and ***Figure A-43*** display the pre and post conditions from the 8 hour test which was conducted on Monday October 9, 2006. Mr. Bruce Phillips witnessed and documented the test which started at 8:30 am and concluded at 4:30 pm (8 hr duration).

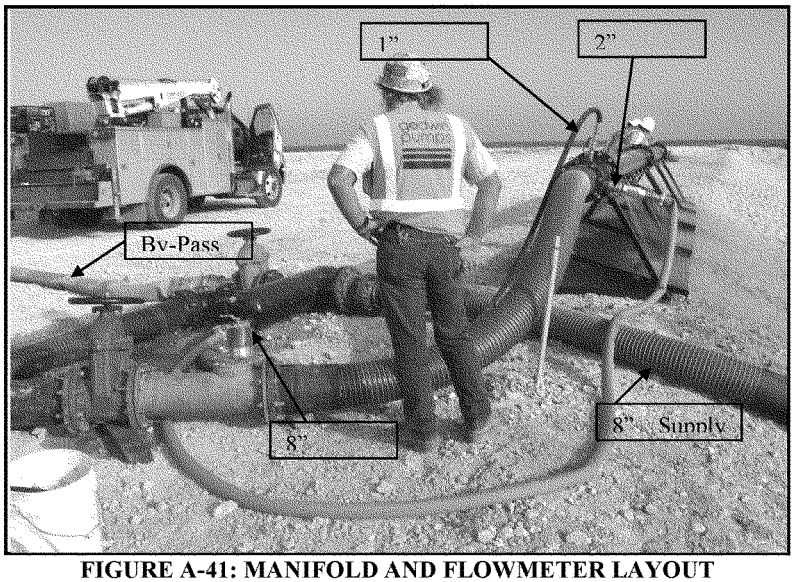

FIGURE A-41: MANIFOLD AND FLOWMETER LAYOUT

FIGURE A-42: TEST NO. 1 EMBANKMENT PRE-CONDITION (0.001 CFS/L-FT)

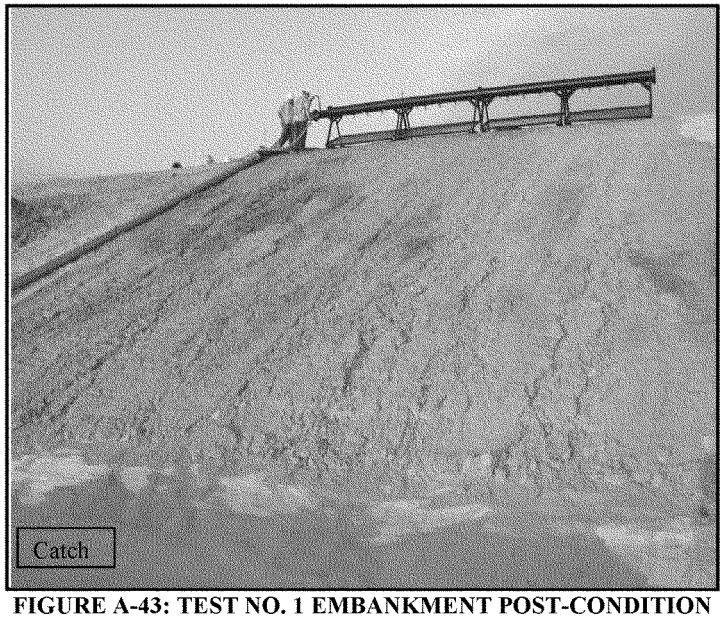

FIGURE A-43: TEST NO. 1 EMBANKMENT POST-CONDITION (8 HRS @ 0.001 CFS/L-FT)

As evidenced in ***Figure A-43*** and ***Figure A-44***, very little erosion occurred at the 13.4 gpm flow rate during the 8 hour test duration. It is important to note that this test, and all subsequent program tests for EAA, were conducted on the exposed surface of the embankment and conservatively portrays the actual erosive resistance of the "as-built" condition of the impoundment embankment at the lower flow rates, which is designed to be a grass slope underlain by a nine inch layer of topsoil (muck). Also, the eroded material originated from the first two to three inches of loose surficial material caused by the machine work required to trim the embankment to a 3:1 slope.

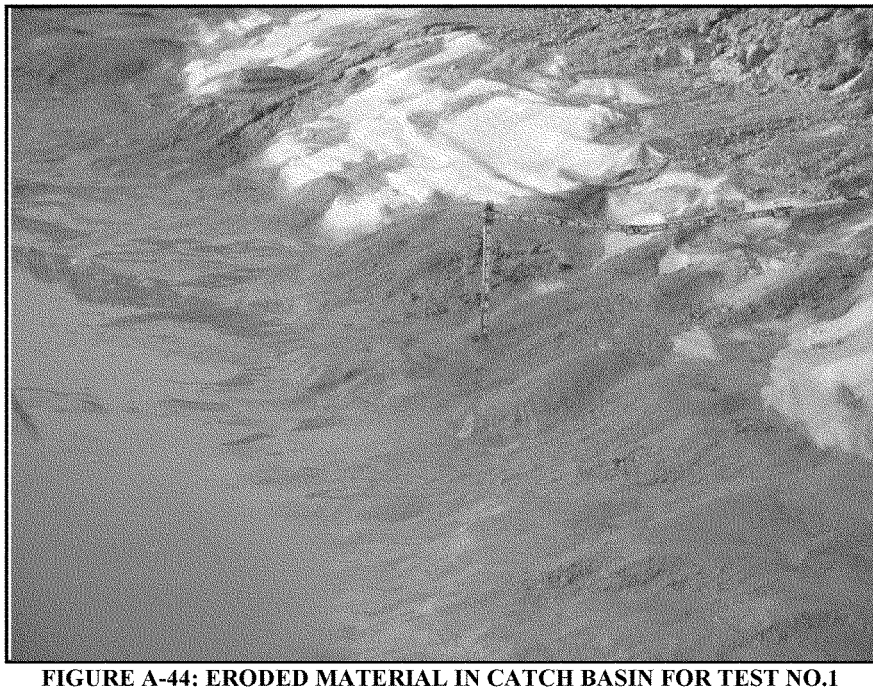

FIGURE A-44: ERODED MATERIAL IN CATCH BASIN FOR TEST NO.1 (0.001 CFS/L-FT)

A.8.1.1.5 Overwash Rate of 0.01 CFS Per Linear Foot with Pre-Soak (Test No. 2)

Due to the fact that very little material was removed from the slope in the 0.001 cfs/l-ft test, the medium overwash test rate of 0.01 cfs/l-ft was also run on the same test section (Test Strip A). The lower rate was also considered as

a pre-soak condition. The amount of erosion resulting from the 0.001 cfs/lf test (refer to ***Figure A-44***) was not surveyed before the higher 0.01 cfs/lf test flow rate, as it was not deemed to be significant and was alternatively included with the amount measured at the conclusion of the 0.01 cfs/l-ft test.

Testing began at approximately 8:00 am on October 10, 2006 and was witnessed by Mr. Bruce Phillips and Mr. Kevin Clark. The two-inch line and flow meter were used to supply flow to the Manifold Test Head. Both the ¼-inch and ½-inch nozzles were used to attain the desired flow rate of 0.01 cfs/l-ft (134 gpm for the 30 ft wide test section). ***Figure A-43*** demonstrates the pre-0.01 cfs/l-ft test condition and ***Figure A-45*** and ***Figure A-46*** portray the condition during and at the end of the 8 hour test respectively.

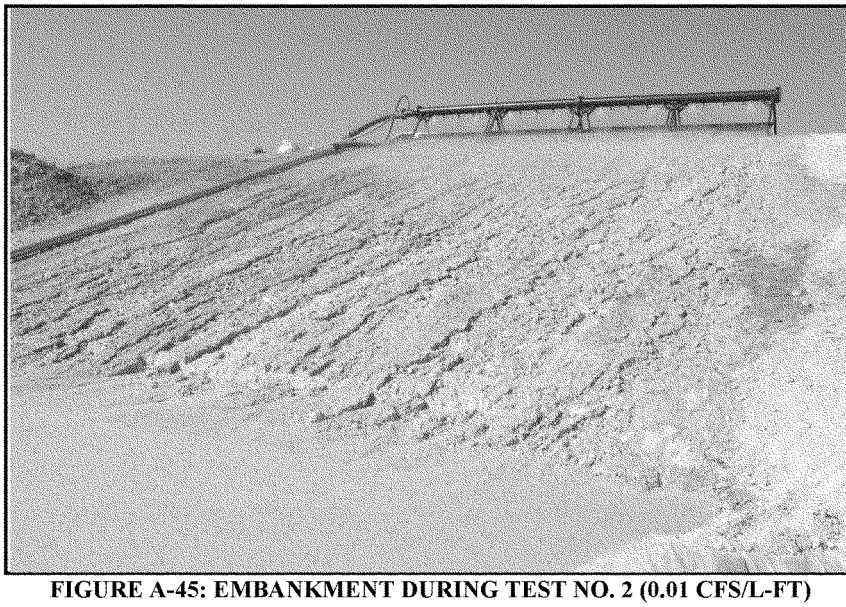

FIGURE A-45: EMBANKMENT DURING TEST NO. 2 (0.01 CFS/L-FT)

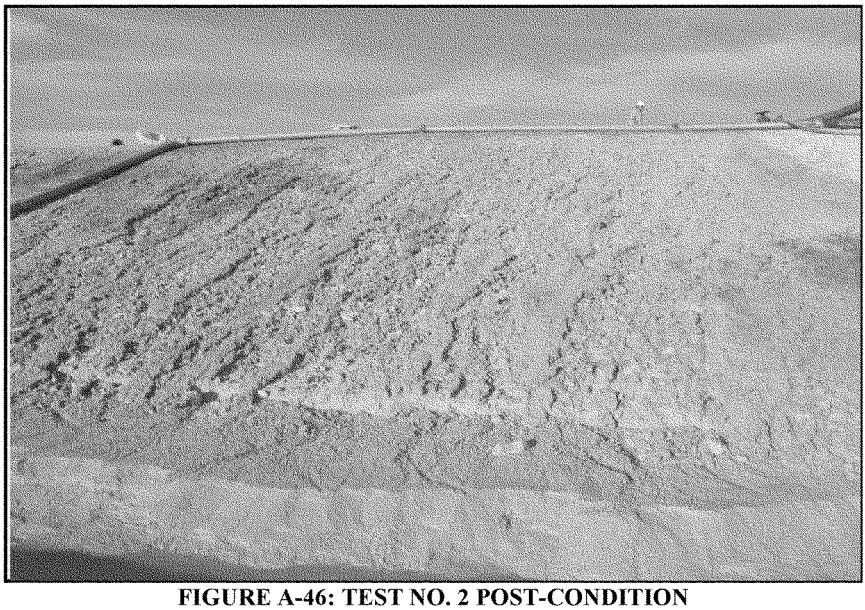

FIGURE A-46: TEST NO. 2 POST-CONDITION (8 HRS @ 0.01 CFS/L-FT WITH PRE-SOAK)

A.8.1.1.6 Overwash Rate of 0.01 CFS per Linear Foot with No Pre-Soak (Test No. 3)

The testing system was relocated to Test Strip B at the conclusion of Test No. 2 between 5:00 and 6:00 pm October 10, 2006. The testing began at approximately 8:00 am on October 11, 2006 on the dry embankment slope. Mr. Bruce Phillips and Mr. Kevin Clark observed the testing throughout the day and flow was stopped at 4:00 pm at the conclusion of the 8 hour test (Test No. 3). ***Figure A-47*** and ***Figure A-49*** show the pre- and post- test conditions. ***Figure A-48*** demonstrates the typical flow conditions during the test.

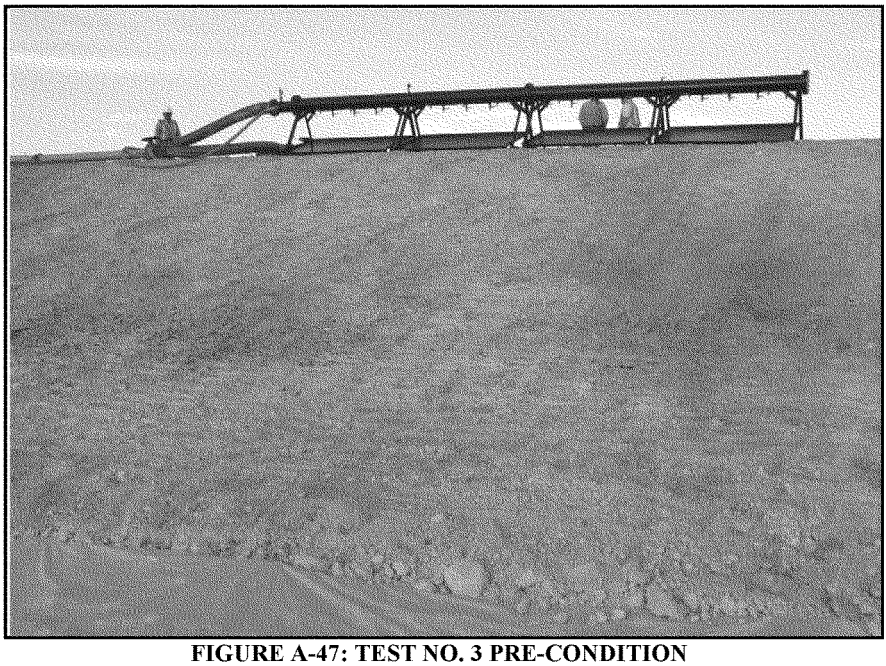

FIGURE A-47: TEST NO. 3 PRE-CONDITION (0.01 CFS/L-FT ON DRY EMBANKMENT)

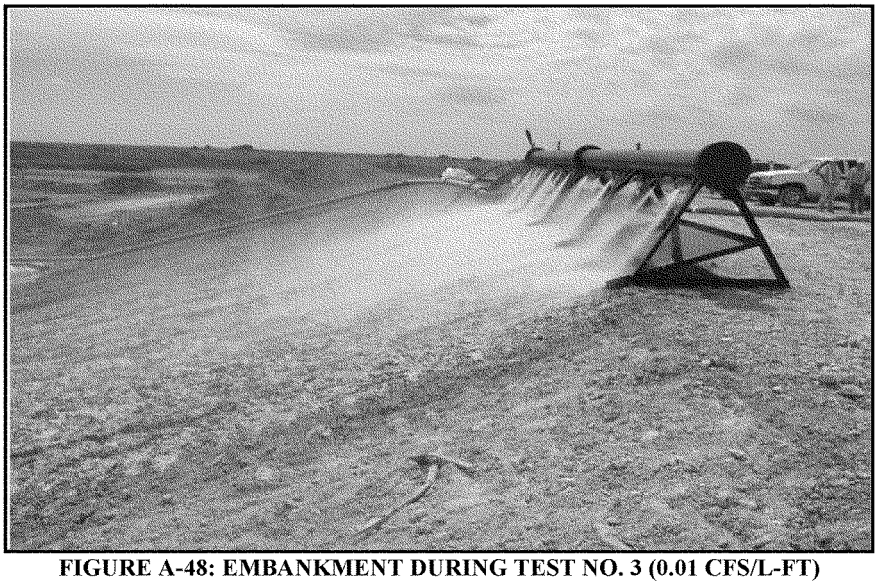

FIGURE A-48: EMBANKMENT DURING TEST NO. 3 (0.01 CFS/L-FT)

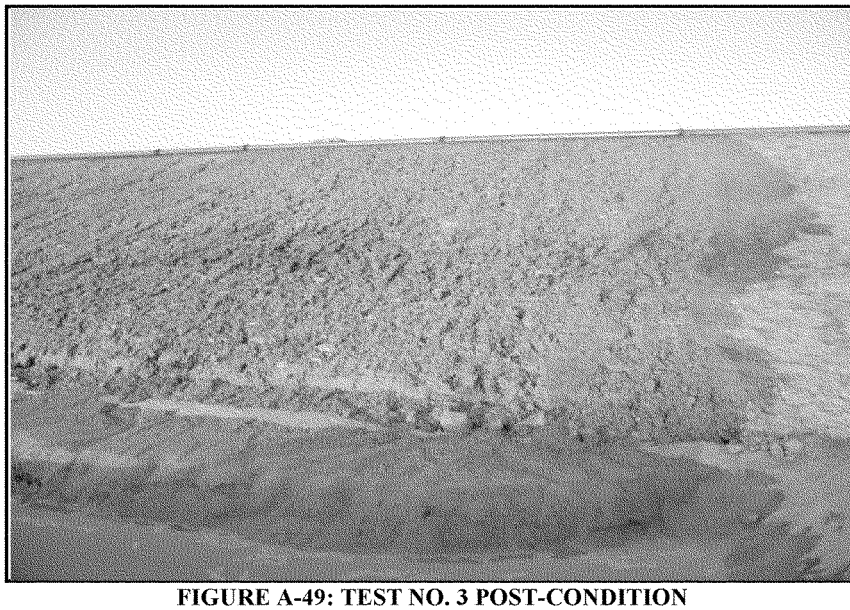

FIGURE A-49: TEST NO. 3 POST-CONDITION (8 HRS @0.01 CFS/L-FT ON DRY EMBANKMENT)

As with the 0.01 cfs/l-ft test on the pre-soaked embankment, the overall erosion volume at the end of the "dry embankment" test appeared similar (refer to ***Figure A-50***). However, it was noticed that the initial rate of erosion appeared quicker in the dry embankment test (Test No. 3) perhaps due to the fact that the pre-soaking of Test No. 2 had occurred over 8 hours (i.e. Test No. 1) and had slowly removed a portion of the finer material from the localized erosion channels that were formed. At the conclusion of the test, the depths of the scoured channels were measured. Channels with up to 4" of erosion were noted (reference ***Figure A-51***).

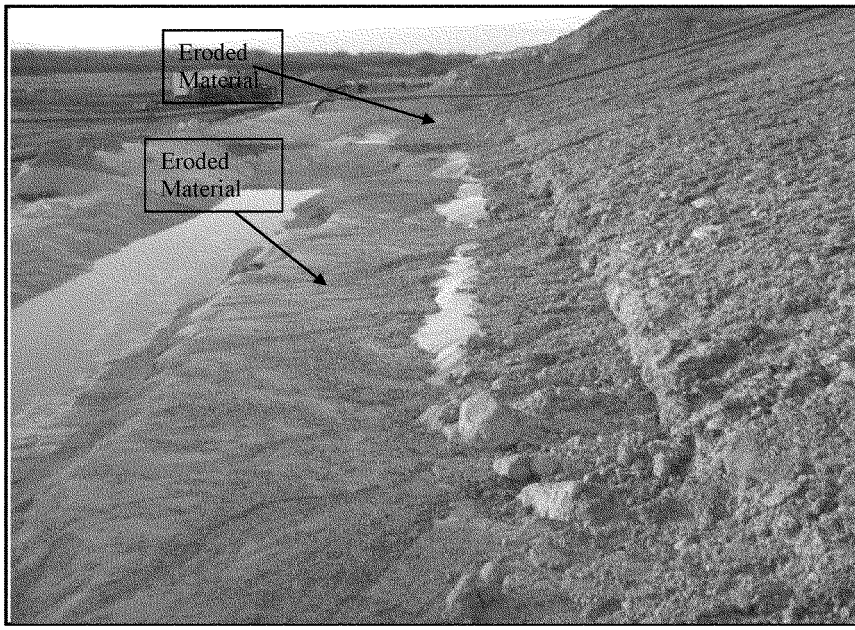

FIGURE A-50: TEST NOS. 2 & 3 CATCH BASINS POST CONDITION (8 HRS @ 0.01 CFS/L-FT ON BOTH WET AND DRY EMBANKMENT SLOPES)

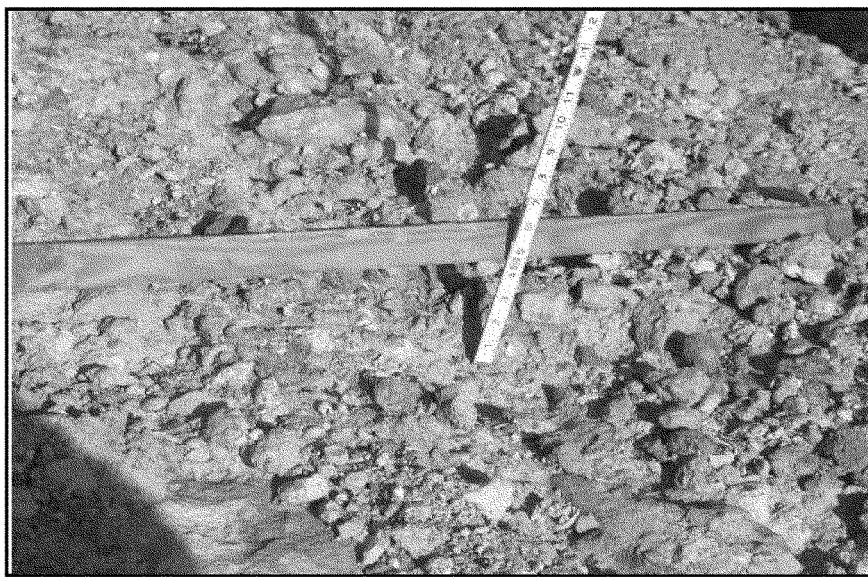

FIGURE A-51: EROSION AFTER 8 HRS @ 0.01 CFS/L-FT (4" MAX. SCOUR)

A.8.1.1.7 Overwash Rate of 0.10 CFS Per Linear Foot with No Pre-Soak (Test No.4)

The testing system was relocated to Test Strip C at the conclusion of Test No. 3 between 5:00 and 6:00 pm October 11, 2006. The testing began at approximately 8:00 am on October 12, 2006 on the dry embankment. All of the 32 nozzles were opened to attain the desired flow rate of 0.1 cfs/l-ft of embankment (1340 gpm for the 30' wide test section). Mr. Bruce Phillips and Mr. Kevin Clark observed the testing throughout the day and flow was stopped at 4:00 pm at the conclusion of the approximate 8 hour test (Test No. 4). Representatives from the A8 Program, USACE, Black and Veatch, FDEP, and others were at the project site and observed the testing for a portion of the day (refer to Attachment A).

FIGURE A-52: TEST NO.4 PRE-CONDITION (TEST STRIP C - 0.10 CFS/L-FT)

It appeared that most of the erosion occurred within the first 2 hours of testing with only small additional surface and down cutting occurring after this point. The embankment slope appeared to be somewhat self-armoring with the larger rock settling into the areas where the fine material had been

removed. Also, due to the nature of the rock fill (i.e. limestone), the compacted matrix material seemed to have a cementitious quality which resisted further erosion. At the conclusion of the test, the depths of the flow channels were measured with the maximum found to be approximately 12-inches deep (see ***Figure A-55***).

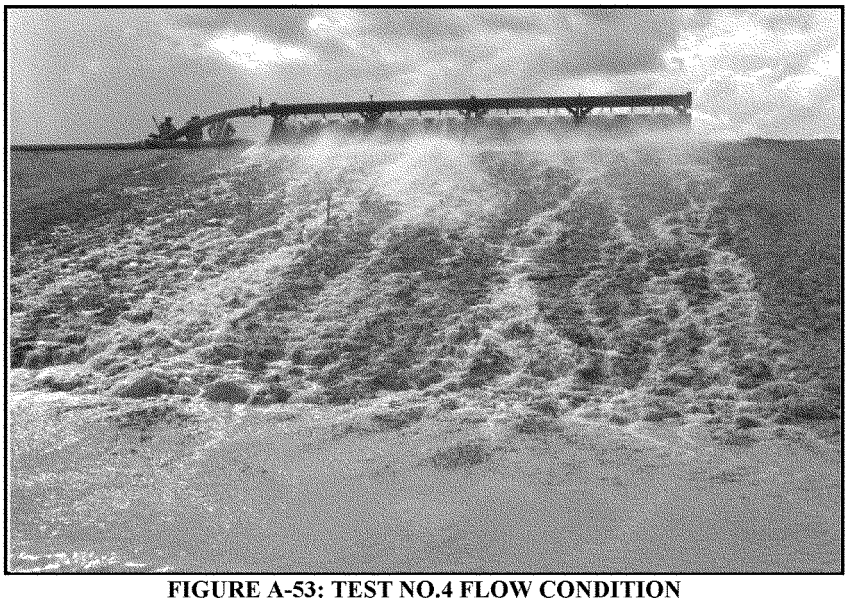

FIGURE A-53: TEST NO.4 FLOW CONDITION (TEST STRIP C - 0.10 CFS/L-FT)

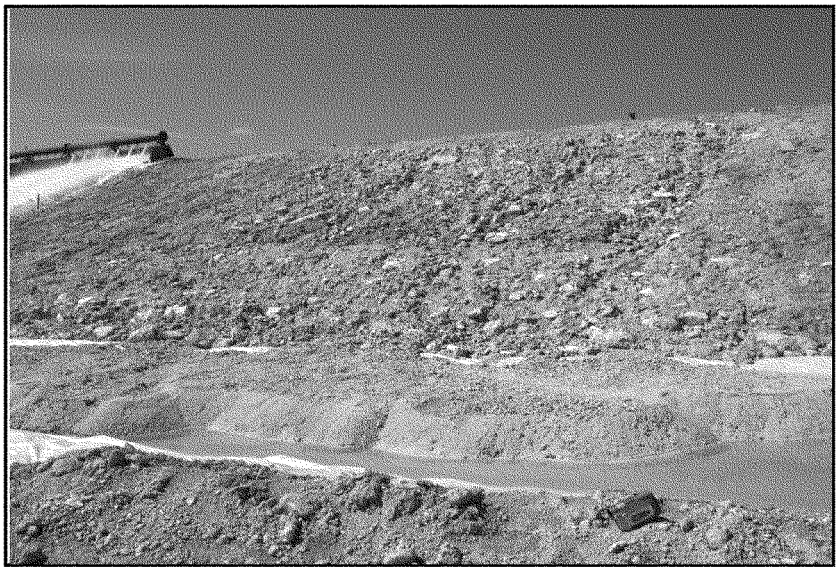

FIGURE A-54: TEST NO. 4 POST-CONDITION (8 HRS @ 0.10 CFS/L-FT)

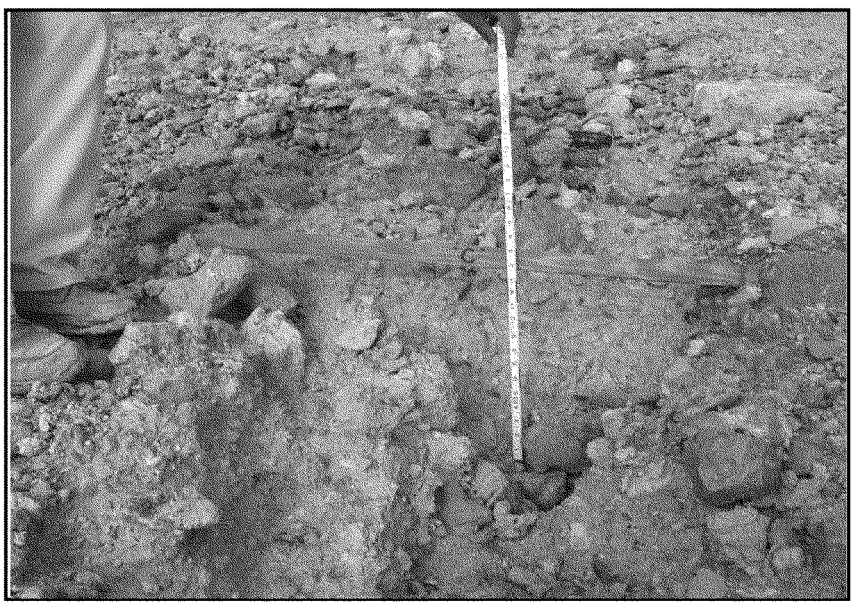

FIGURE A-55: EROSION AFTER 8 HRS @ 0.1 CFS/L-FT (12" MAX. SCOUR)

A.8.1.1.8 Overwash Rate of 0.23 CFS Per Linear Foot (Test No. 5)

The test system was relocated to Test Strip B in order to take advantage of the "pre-soak" conditions approximated from the previous 0.01 cfs/l-ft test and accompanying erosion that approximates an antecedent rainfall event. The test was started at 7:45 Am and concluded at approximately 4:00 PM. Mr. Bruce Phillips and Mr. Kevin Clark witnessed the test and made observations. The system was maximized at the 1550 gpm rate and therefore only one-half of the test apparatus (with 16 nozzles removed – valves fully open) was used to double the effective flow per unit width. The 1550 gpm average flow rate over the 15 ft width (right side of Test Strip B, or "B1") translates into approximately 0.23 cfs/l-ft. ***Figure A-56*** and ***Figure A-57*** demonstrate the pre- and post- test conditions and ***Figure A-58*** displays the flow conditions during the test.

FIGURE A-56: TEST NO. 5 PRE-CONDITION (0.23 CFS/L-FT)

FIGURE A-57: TEST NO.5 POST-CONDITION (8 HRS @ 0.23 CFS/L-FT)

As with the previous tests, most of the erosion occurred in the first few hours of the test but some increased localized scour was also noted in the impact zone approximately one-third to one-half the way down the slope. This zone is apparent in the survey data provided in Attachment 2 (reference "Test B1", Cross Sections 2 and 3). At the conclusion of the test, the depths in the flow channels were measured with the maximum found to be approximately 18-inches deep (see ***Figure A-59***). More significant erosion occurred when compared to the 0.1 cfs/l-ft test but this flow did not ultimately affect the integrity of the embankment material over the 8 hour test duration.

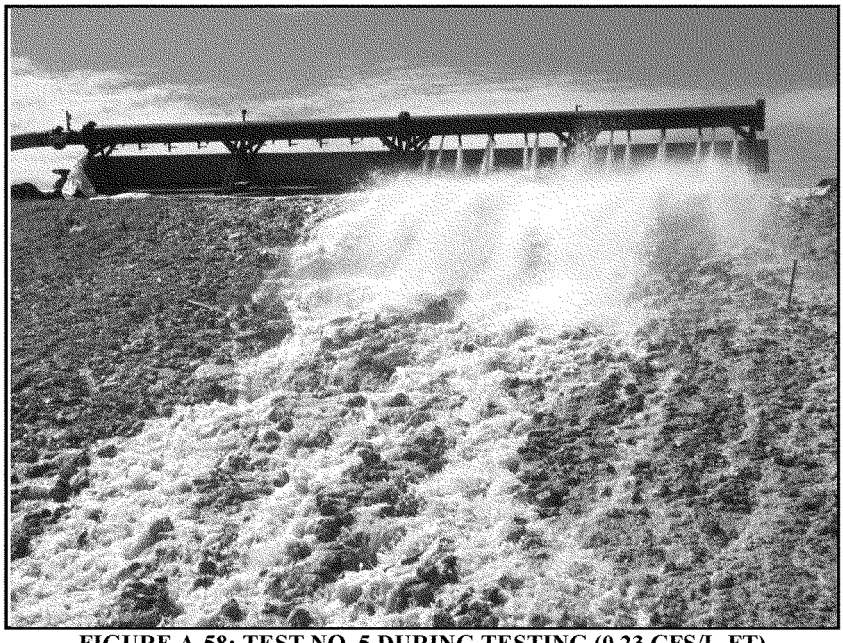

FIGURE A-58: TEST NO. 5 DURING TESTING (0.23 CFS/L-FT)

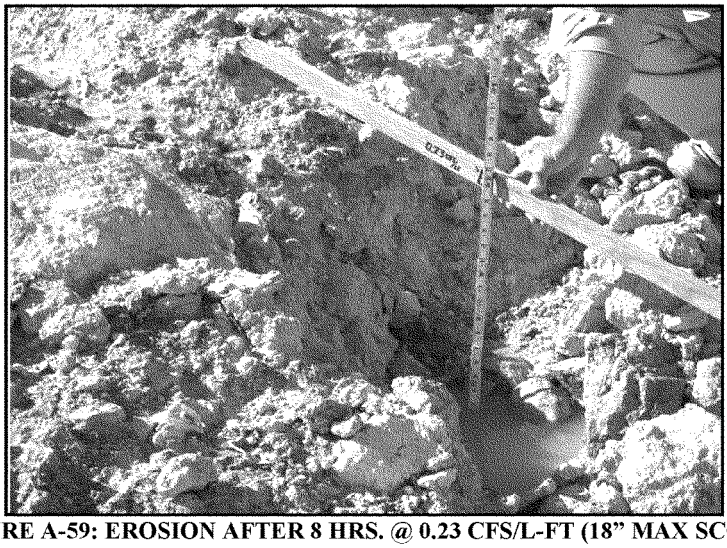

FIGURE A-59: EROSION AFTER 8 HRS. @ 0.23 CFS/L-FT (18" MAX SCOUR)

A.8.1.2 Conclusions

The surface of the test embankment sections was resurveyed on October 16th & 17th, 2006 after all overwash testing was completed. Both conventional GPS (pre test surface conditions) and laser survey techniques (post test surface conditions) were used. Results from these surveys are shown in Attachment B. Estimates of the volume of eroded material from the applicable individual tests are given in ***Table A-92***. Samples of the eroded material were collected for classification.

TABLE A-92: EROSION SUMMARY

Test No.	Test Location	Flow Rate	Test Date	Volume of Eroded Material
1	Test Strip A (30 ft wide)	0.001 cfs/l-ft (13.4 gpm over 30 ft)	09-OCT-06	Less than 25 cubic feet
2	Test Strip A (30 ft wide)	0.01 cfs/l-ft (134 gpm over 30 ft)	10-OCT-06	125 cubic feet
3	Test Strip B (30 ft wide)	0.01 cfs/l-ft (134 gpm over 30 ft)	11-OCT-06	Observed as similar to Test 2 but separate measurement performed
4	Test Strip C (30 ft wide)	0.10 cfs/l-ft (1340 gpm over 30 ft)	12-OCT-06	325 cubic feet
5	Test Strip B1 (15 ft wide)	0.23 cfs/l-ft (1550 gpm over 15 ft)	13-OCT-06	Exceeded catch basin capacity

In summary, the amount of erosion incurred during each of the 8-hour test durations did not affect the ultimate integrity of the test cell embankment, even at the maximum 0.23 cfs/l-ft flow rate that was tested (i.e. system/pump capacity). Without further studies to specifically determine the overwash rate that would remove a sufficient amount of material to the extent that the integrity of the embankment was jeopardized, it is felt that the 0.1 to 0.2 cfs/l-ft of embankment overwash rate could be set as a conservative maximum for design of the EAA A-1 embankment. This conclusion presumes that the downstream shell of the EAA A-1 Impoundment will be constructed in a similar manner and with material (random rockfill) consistent with that used in the construction of the downstream shell of Test Cell #2.

A.8.2 Future Testing/Recommendations

Large scale rockfill gradation testing of the downstream embankment material in Test Cell #2 is planned to be conducted in the near future. Samples of eroded material were collected from each of the individual catch

basins for further classification. Results from both of these testing efforts will be included later as an attachment to this report.

Additional overwash testing programs are currently being planned for the C-43 and C-44 Test Cell embankments in order to evaluate the performance of embankments constructed of clean to silty sands with hydro-seeded and sodded downstream slopes.

A.8.2.1 EAA Overwash Test Survey Results

A.8.3 C-9 and C-11 Impoundments Embankment Evaluation and Optimization Analysis

A.8.3.1 Introduction

Due to wildlife entrapment concerns, stepped embankments are no longer considered to be a viable option for CERP impoundments. Both the C-9 and C-11 Impoundments were originally designed to have stepped embankments. The purpose of this analysis is to evaluate three flat-plate (smooth) slope embankment alternatives for both C-9 and C-11 Impoundments using design water stage and wind speeds developed during the stepped embankment analysis. This updated evaluation includes the following tasks:

Embankment Alternative 1: Computation of the average over-wash rate for each design water depth and wind speed condition, applying the existing C-9 and C-11 design embankment crests.

Embankment Alternative 2: Determination of minimum C-9 and C-11 embankment crest elevations required to limit the average rate of over-wash to 0.10cfs/lf.

Embankment Alternative 3: Evaluation and optimization of an internal wave breaking berm, where applicable.

A.8.3.2 Project Site

The C-9 and C-11 Impoundments are project components of the larger C-9 Basin and Western C-11 Basin, respectively. Both basins are located adjacent to the eastern boundary of Water Conservation Area 3 (WCA 3) and south of I-75/I-595 in Broward County, Florida (***Figure A-60***). The C-9 Basin is an integral part of the Central and Southern Florida flood project and, along with the C-9 Canal, provides a primary flood control outlet to Biscayne Bay (tide). The purpose of the C-9 Impoundment is to provide storage for diverted western C-11 Basin runoff, reduce seepage from WCA 3, provide an additional water source and meet water supply. The C-9 Impoundment

covers approximately 1,807 acres of the C-9 Basin. The Western C-11 Basin is an integral part of the Central and Southern Florida flood project and, along with the C-11 Canal, provides a primary flood control pumping outlet to WCA 3. The purpose of the C-11 Impoundment is to reduce pumping of untreated water into WCA 3, reduce seepage from WCA 3, and provide water supply when demands exist. The C-11 Impoundment covers approximately 1,831 acres of the C-11 Basin. The C-11 Impoundment has two attached, but separated, wetland mitigation areas to the north.

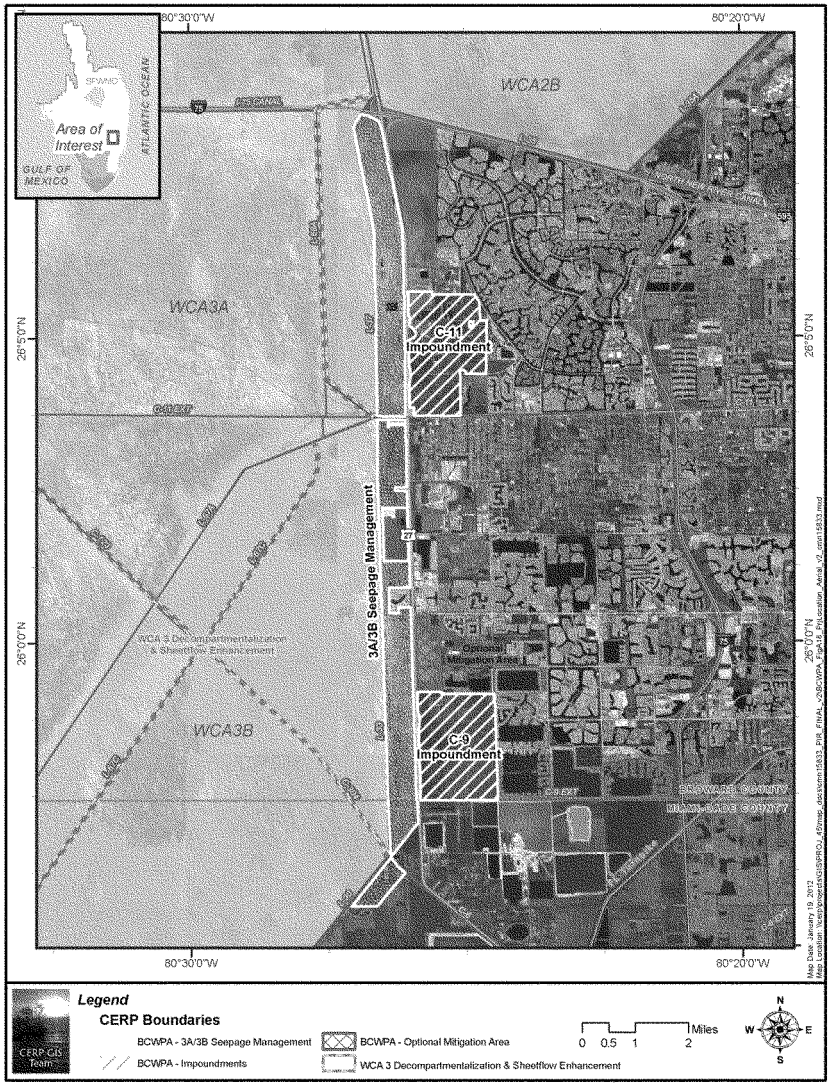

FIGURE A-60: C-9 AND C-11 PROJECT SITE LOCATIONS

A.8.3.3 Study Overview

In order to evaluate the flat-plate slope design, the wave climate within the C-9 and C-11 Impoundments was first estimated using the numerical wave transformation model STWAVE (Steady-state spectral WAVE) and a 100-year design wind. STWAVE wave results combined with wind setup were then used to calculate wave run-up and corresponding over-wash rates for the existing design crest elevation (embankment alternative 1). This was done using methodologies from the US Army Corps of Engineer's (USACE) Automated Coastal Engineering System (ACES). To provide additional information for this embankment alternative, a probabilistic breakdown of over-wash rates for the design wave climate for each water depth case was also completed. Optimization of embankment crest elevations for each embankment (embankment alternative 2) was then completed based on the allowable over-wash rate of 0.10cfs/lf. Lastly, STWAVE wave results were combined with wind setup and used to determine wave breaking berm dimensions that would reduce over-wash to the allowable rate of 0.10cfs/lf (embankment alternative 3).

A.8.3.4 Design Water Levels

Both the C-9 and C-11 Impoundments have a normal pool depth of 4.3ft. The C-9 Impoundment has been classified as a high hazard potential reservoir (HHP) and is subject to evaluation using the four design cases outlined in Design Criteria Memorandum No. 2 (DCM-2) (SFWMD, 2006). The governing design case was found to be "Case 1", the PMP design stage combined with a 100-yr wind speed. The change in water level due to the PMP is expected to be 4.35ft, resulting in a design still water pool elevation of 13.15ft-NGVD (4.3ft normal pool + 4.35ft PMP + 4.5ft-NGVD natural grade).

The C-11 Impoundment has been classified as a low hazard potential reservoir (LHP). A LHP reservoir is not subject to the DCM-2 design cases as a HHP reservoir. Instead, two alternative design cases were investigated, (1) a 100-yr storm water level with a 60mph wind speed and (2) a 50% PMP water level with a 60mph wind speed. The resulting design still water levels for the 100-yr storm and 50% PMP were 11.56ft-NGVD (4.3ft normal pool + 1.26ft 100-yr storm + 6.0ft-NGVD natural grade) and 12.16ft-NGVD (4.3ft normal pool + 1.86ft 50% PMP + 6.0ft-NGVD natural grade), respectively.

A.8.3.5 Design Wind Conditions

The design wind condition is a key parameter in the determination of embankment superiority. The design wind condition consists of three elements, including wind speed, wind direction, and wind duration. Because C-9 has been classified a HHP reservoir, the design wind is the 100-year wind

speed. This wind speed was determined, using the wind conversion procedures outlined in DCM-2, to be 113.1mph. C-11, classified a LHP reservoir, is subject to a required design wind speed was determined to be 60mph (SFWMD, 2006)

A.8.3.6 Wind Setup Analysis

Wind set up occurs when wind blows in a fairly constant direction over a body of water. Wind blowing across the water causes the surface layer to move in the direction of the wind due to shear stress development between the air and water. This causes water to "pile up" against the shore, creating the effect known as "wind setup". A corresponding drop in water level will occur along the upwind shore.

Three wind setup models were investigated for applicability to the C-9 and C-11 Impoundments, the Zieder Zee formula (USACE, 1990), the Brater and King method (Brater et al., 1996), and the Bretschneider method (Ippen, 1966). Of the three, Bretschneider's model was determined to be the most applicable to shallow water reservoirs.

A.8.3.6.1 Bretschneider

The numerical model presented by Bretschneider was derived under steady-state wind conditions, i.e. constant speed and direction along a channel axis. The differential form of the model, based on surface and bottom shear stresses as well as conservation of mass, determines wind setup as a function of the effective stress. The effective stress parameter is expressed as:

$$\frac{\kappa U^2 F}{g d^2}$$

where, κ is the wind drag coefficient (3.3x10-6 based on Ippen, 1966), U is the wind speed, F is the fetch length, g is acceleration due to gravity, and d is water depth. Based on the calculated value of this stress parameter, wind setup can be determined from tabulated data presented in Ippen (1966).

A.8.3.6.1.1 Determination of Fetch

Fetch is defined as a distance over which the wind speed and direction are reasonably constant. Fetches fall into two categories, open-water fetches, where wave growth is limited only by the incident meteorological conditions, and restricted fetches, where wave growth is limited by a confined geometry such as that of a lake, river, bay, or reservoir. Both C-9 and C-11 Impoundments are subject to a restricted fetch. The restricted fetch

methodology applies the concept of wave development in off-wind directions and considers the shape of the basin. The fetch is defined as the radial average over an arc of 24 degrees centered on the wind direction. For this study, the wind direction (for determination of the fetch-limited wind speed) is taken to be the direction corresponding to the maximum fetch distance. This will provide the maximum design fetch for determining the maximum possible set-up. ***Figure A-61*** shows an example of a 24-degree arc, divided into 3-degree intervals used for determining the fetch at C-9 and C-11. Averaging the radial lengths over each arc gives an average fetch of 2.13 miles for C-9 and 1.84 miles for C-11.

A.8.3.6.2 Wind Setup Results

Based on design water levels and wind speeds, wind setup for C-9 was found to be 1.56ft. Wind setup values for C-11 were found to be 0.67ft for the 100-yr storm pool and 0.59ft for the 50% PMP pool.

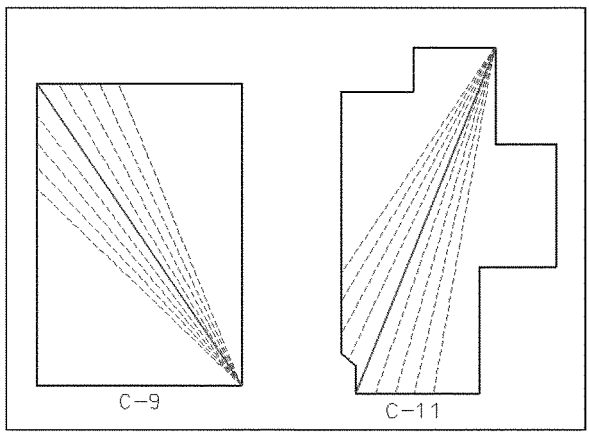

FIGURE A-61: C-9 AND C-11 IMPOUNDMENT FETCH EXAMPLES

A.8.3.7 Wave Height Analysis

A.8.3.7.1 Model

The STWAVE model is a two-dimensional spectral wave transformation model for the simulation of wave transformation over complex bathymetry. STWAVE accepts arbitrary directional wave spectra specified at an offshore boundary and propagates the spectral energy in the onshore direction. It is a finite-difference model, which calculates wave spectra on a Cartesian grid

using a backward ray-tracing scheme (Smith et al., 1999). Model results, including spectral output, significant wave height, mean wave period, and wave direction, are obtained by numerically solving the steady-state spectral energy balance equation. This equation is given as:

$$\frac{\partial c c_g E(f,\theta)}{\partial x} + \frac{\partial c c_g E(f,\theta)}{\partial y} = S_{at} + S_{nl} + S_{ds} + S_{br}$$

The left-hand side of the equation represents wave propagation (refraction and shoaling) where E is spectral energy density, f is frequency of the spectral component, θ is the propagation direction of spectral component, c is the phase speed of spectral component, c_g is the group velocity of spectral component, and x,y are the plan-view spatial coordinates.

Source terms, making up the right-hand side of the equation, represent distribution and dissipation of energy based on principals of linear theory. These terms are defined as the wind input (S_{at}), nonlinear wave-wave interactions (S_{nl}), dissipation within the wave field (S_{ds}), and depth induced wave breaking (S_{br}).

The assumptions made in STWAVE are as follows: mild bottom slope and negligible wave reflection; steady waves, currents, and winds; linear refraction and shoaling; and depth uniform current. Due to the nature of the solution scheme for the STWAVE version employed, spectral energy is limited to propagation in a half-plane directed toward shore. All energy propagated offshore is neglected.

A.8.3.7.2 Wave Model Inputs

A.8.3.7.2.1 Bathymetry

Topographic data for the C-9 and C-11 Impoundment project was obtained from the Water Preserve Area (WPA) LIDAR survey (NAD 83\NGVD 29). Survey data indicates that elevations within the project area vary significantly. In addition to moderate changes in grade, a series of furrows, channels, and spoil mounds create a complex bottom topography in each of the reservoirs.

A.8.3.7.2.2 STWAVE Grids

The STWAVE input grids for C-9 and C-11 Impoundments were generated using the SMS (Surface-water Modeling System) software package developed by Brigham Young University (Brigham Young, 1997). The resulting C-9 Impoundment computation grid consisted of 560 cells by 824 cells with a

resolution of 12.5ft. The C-11 grid consisted of 584 cells by 944 cells with a resolution of 12.5ft.

A.8.3.7.2.3 Wind and Current Input

It is assumed that each wind-wave growth case begins with a still water surface. This eliminates the need for a measured or simulated spectral wave field to be applied at the forcing boundary of the model domain. Therefore, the only energy input conditions required are wind conditions consisting of a wind speed and wind direction. The design wind speed was applied to an array of 72 incident wind directions covering a full range of possible directions. Incident wind directions ranged from 0° to +355° in 5° increments.

Currents were not included in this study.

A.8.3.7.3 STWAVE Wave Height Results

Wind driven waves are a highly complex mix of crests and troughs on the water surface, consisting of multidirectional, irregular waves. This is particularly true while the waves remain under the influence of the wind. For design purposes, it is often necessary to describe a full wave field with a single representative wave height and direction. Wave direction can be easily defined as an average of the individual wave directions. Wave height can also be represented as an average value. However, these averages are typically described in terms of the average height of a given percentage of the highest waves in the field. It has been found that the frequency of occurrence of waves above any given height can be closely approximated using the cumulative form of the Rayleigh distribution (USACES, 1984). This fact and resulting theoretical wave height distribution curves make it possible to determine average wave heights for a given percentage of waves based on a single significant wave height, H_s, which is defined as the average height of the one-third highest waves. The numerical model STWAVE outputs wave heights in the form of significant wave heights.

Maximum significant wave heights at the down-fetch exterior (perimeter) with corresponding peak wave periods, for each reservoir and design pool depth are provided in ***Table A-93***.

TABLE A-93: MAXIMUM SIGNIFICANT WAVE HEIGHTS AND WAVE PERIODS

Reservoir	Design Condition	Significant Wave Height (ft)	Peak Wave Period (sec)
C-9	PMP	4.56	4.3
C-11	100-yr Storm	1.77	3.4
	50% PMP	1.84	3.4

A.8.3.8 Wave Run-up and Over-wash Rates

A.8.3.8.1 Wave Run-up

Wave run-up can be described as the resulting forward translation of water mass that is converted from wave energy as waves encounter a sloped surface. The water rushes up the slope, resulting in the vertical rise above the still water line, is known as run-up (***Figure A-62***). Run-up depends primarily on incident wave steepness, slope of the surface on which it is incident, and characteristics of the surface, including surface roughness and porosity. For this analysis only a single 1V:3H smooth impermeable concrete slope was considered.

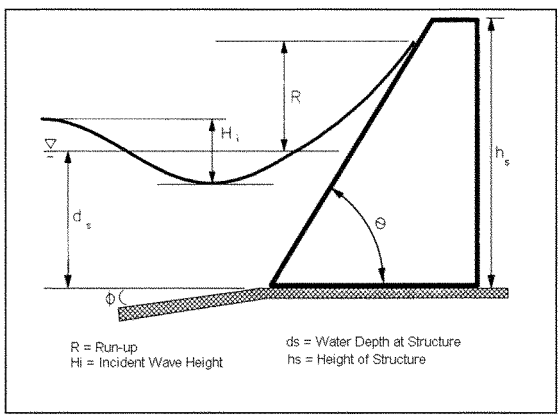

FIGURE A-62: WAVE RUN-UP DIAGRAM

A.8.3.8.1.1 Effective Depth

Although the generation of wind waves (and therefore wave run-up and over-wash) is influenced by the presence of wind setup, the relationship is highly complex and is not presently included in the STWAVE model. Therefore, in order to predict the total water level increase due to wind conditions at the down-fetch face of the embankment, wind setup must be accounted for with a computation exterior to the model. To account for the wind set-up, the water level change due to wind setup was added directly to the maximum surcharge depth (i.e. normal pool depth + precipitation + wind setup). The resulting "effective depth" is then used in the determination of the freeboard, *F*, and the computation of the over-wash flow rates. The effective depth for C-9 Impoundment was found to be 10.21ft. The effective depths for C-11 Impoundment were found to be 6.23ft for the 100-yr storm case and 6.89ft for the 50% PMP case.

A.8.3.8.1.2 Smooth Slope Wave Run-up

Smooth slope run-up, as presented by Ahrens and Titus (1985), recommends the following general equation:

$$R = CH_i$$

where R is wave run-up, H_i is the incident wave height, and C is a coefficient characterized by the surf similarity parameter ξ.

A.8.3.8.2 Over-wash

Over-wash occurs when wave run-up and wind setup levels combine to produce a water level greater than the height of the levee. Over-wash is an important design element both in terms of predicting backside flooding and safeguarding structural integrity of the levee. Several methods exist for predicting the over-wash flow rate in a given situation. This analysis employs an irregular wave over-wash method developed by Ahrens (1977). This method uses the following assumptions: run-up values caused by an irregular wave field will follow a Rayleigh probability distribution; significant deepwater wave height, H_s, causes significant run-up R_s; and parameters α, Q^*_o, and H_o remain constant for all members of the distribution.

Ahrens estimates the over-wash rate by summing the over-wash contributions from each individual member of the run-up distribution:

$$Q = \frac{1}{199}\sum_{i=1}^{199} Q_i$$

Where Q is the volume rate of over-wash caused by irregular waves ($ft^3/s - ft$) and Q_i is the volume rate of over-wash caused by one run-up on the run-up distribution.

Ahrens accounts for the effect of irregular waves when the freeboard is less than the run-up of the significant wave, R_s. When the freeboard is greater than the significant wave run-up, R_s, larger run-ups in the distribution may still overtop the structure. For these relatively high freeboards, the run-up distribution is broken into 999 elements, instead of 199, to better resolve the effect of the higher run-ups. The over-wash equation for this larger distribution becomes:

$$Q = \frac{1}{999}\sum_{i=1}^{999} Q_i$$

A.8.3.9 Embankment Alternative 1: Existing Crest Elevation

Table A-94 provides average rates of over-wash computed for the maximum significant wave conditions for each reservoir and design case using the existing design crest for each embankment. This alternative allows the embankment crest to remain at the design elevation. However, over-wash rates exceeding the allowable over-wash rate of 0.10cfs/lf would require armoring of the backside slope of the embankment for two of the three cases. The average over-wash rate of 0.104cfs/lf of the C-11 Impoundment, 100yr storm case falls within tolerance of the allowable over-wash and, therefore, no backside armor would be required.

TABLE A-94: OVER-WASH RATES FOR C-9 AND C-11 EXISTING EMBANKMENT ELEVATIONS

Impoundment	Design Condition	Existing Embankment Height (ft)	Existing Embankment Elevation (ft-NGVD)	Average Over-wash Rate (cfs/lf)
C-9	PMP	15.0	19.5	0.677
C-11	100-yr Storm	8.5	14.5	0.104
	50% PMP	8.5	14.5	0.298

A.8.3.9.1 Over-Wash Probability Evaluation

Traditionally, over-wash rates for an embankment are given in terms of an average rate for the entire wave field (based on a Rayleigh distribution of the component waves). However, in order to refine embankment designs for the C-9 and C-11 Impoundments, including armor on the exterior slope, a more detailed over-wash analysis was completed. The result is a breakdown of the number of waves (per hour) expected to result in a given range of over-wash rates. These over-wash rates can be translated into flow velocities. Such velocities are key in determining (and refining) the level of backside armor protection required should the existing crest elevation be maintained for the design.

The range of expected wave heights in each given wave field (represented by the maximum significant wave height results from STWAVE), was determined by first assuming that wave heights in the wave field are represented by a Rayleigh distribution (Longuet-Higgins, 1952). Wave heights exceeded by specified percentages (0.1% (H_{max}), 1%, 2%, 5%, 10%, 13.5% (H_s),20%, 30%, 40%, 50%, 60%, 70%, 80%, and 90%) of waves (in the wave field) can then be determined for each reservoir based on the cumulative probability distribution P(H) (i.e., the percentage of waves having a height equal to or less than H), defined as:

$$P(H) = 1 - e^{-\left(\frac{H}{H_{rms}}\right)^2}$$

where

H_{rms} = Root mean square wave height

Over-wash rates for each of the exceeded wave heights were then calculated for the existing embankment height of each reservoir, using a monochromatic variation of the previously discussed over-wash formulation (Weggel, 1976). The number of waves falling into each range of over-wash for the exceeded wave heights was computed from the peak wave period for each design case, determined from the STWAVE runs (3600sec/Tp). The number of waves per hour for C-9 Impoundment is estimated to be 837. The number of waves per hour for C-11 Impoundment, for both design storm conditions, is expected to be 1059.

Based on the total number of waves, the previously specified percentages of exceedence (0.1% , 1%, 2%, 5%, 10%, 13.5%,20%, 30%, 40%, 50%, 60%, 70%, 80%, and 90%), the corresponding wave heights, and resulting over-wash rates, the number of waves along the segment of embankment (per hour) falling between a given range of over-wash rates were computed. ***Table A-95***

provides the number of waves falling within a specified range of wave heights (based on percent exceedence) along with the corresponding range of over-wash rates for each of the three design conditions. For example the maximum significant wave height for C-9 Impoundment is 4.56ft (***Table A-93***). From ***Table A-95***, it can be seen that the significant wave height falls within the range of wave heights exceeded by 13.5% of all waves in the wave field and will have an over-wash rate between 2.191 and 2.702 cfs/lf. Note that the over-wash rates provided in ***Table A-95*** are based on individual, isolated wave heights from the wave field (monochromatic waves) and should not be confused with the average over-wash rates traditionally used to describe the impact of a wave field (***Table A-94*** for example).

A.8.3.10 Embankment Alternative 2: Optimization of Embankment Heights

As ***Table A-94*** indicates, applying the existing crest elevation produces over-wash rates greater than the present allowable average over-wash rate of 0.10cfs/lf for two of the three design cases, resulting in external embankments that are lower than required. Using the same over-wash formulations, embankments for both reservoirs were optimized by determining the crest elevation requirements based on the target average over-wash rate of 0.10cfs/lf. For this alternative, additional height results in the need for additional fill material, but the need for backside slope armor is eliminated. ***Table A-96*** provides the minimum allowable crest elevations for each embankment segment based on the 0.10cfs/lf over-wash criteria. Note that there is no raised crest elevation for the C-11 Impoundment 100-year storm case because the existing crest elevation is sufficient to limit over-wash to the allowable level.

TABLE A-95: OVER-WASH PROBABILITY ANALYSIS RESULTS

% of Waves Exceeding	C-9 (PMP)				C-11 (100yr Storm)				C-11 (50% PMP)			
	Wave Height Range (ft)	Number Of Waves (per hour)	Over-wash Range		Wave Height Range (ft)	Number Of Waves (per hour)	Over-wash Range		Wave Height Range (ft)	Number Of Waves (per hour)	Over-wash Range	
			Min (cfs/lf)	Max (cfs/lf)			Min (cfs/lf)	Max (cfs/lf)			Min (cfs/lf)	Max (cfs/lf)
0.1	8.5	1	10.728	10.728	3.3	1	1.621	1.621	3.4	1	2.692	2.692
1	6.9 - 8.5	8	6.721	10.728	2.7 - 3.3	10	0.997	1.621	2.8 - 3.4	10	1.794	2.692
2	6.4 - 6.9	8	5.506	6.721	2.5 - 2.7	11	0.813	0.997	2.6 - 2.8	11	1.517	1.794
5	5.6 - 6.4	25	3.891	5.506	2.2 - 2.5	32	0.572	0.813	2.2 - 2.6	32	1.149	1.517
10	4.9 - 5.6	42	2.702	3.891	1.9 - 2.2	53	0.400	0.572	2.0 - 2.2	53	0.863	1.149

13.5	4.6 - 4.9	29	2.191	2.702	1.8 - 1.9	37	0.324	0.400	1.8 - 2.0	37	0.743	0.863
20	4.1 - 4.6	54	1.539	2.191	1. 6 - 1.8	69	0.235	0.324	1.6 - 1.8	69	0.581	0.743
30	3.5 - 4.1	84	0.889	1.539	1.4 - 1.6	106	0.146	0.235	1.4 - 1.6	106	0.425	0.581
40	3.1 - 3.5	84	0.475	0.889	1.2 - 1.4	106	0.083	0.146	1.2 - 1.4	106	0.299	0.425
50	2.7 - 3.1	84	0.196	0.475	1.0 - 1.2	106	0.033	0.083	1.1 - 1.2	106	0.201	0.299
60	2.3 - 2.7	84	0.045	0.196	0.9 - 1.0	106	0.001	0.033	0.9 - 1.1	106	0.118	0.201
70	1.9 - 2.3	84	0.000	0.045	0.7 - 0.9	106	0.000	0.001	0.8 - 0.9	106	0.048	0.118
80	1.5 - 1.9	84	0.000	0.000	0.6 - 0.7	106	0.000	0.000	0.6 - 0.8	106	0.000	0.048
90	1.0 - 1.5	84	0.000	0.000	0.4 - 0.6	106	0.000	0.000	0.4 - 0.6	106	0.000	0.000
100	0.0 - 1.0	84	0.000	0.000	0.0 - 0.4	106	0.000	0.000	0.0 - 0.4	106	0.000	0.000
Total		837				1059				1059		

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TABLE A-96: MINIMUM CREST ELEVATION FOR 0.10CFS/LF OVER-WASH

Impoundment	Design Condition	Design Embankment Height (ft)	Design Embankment Elevation (ft-NGVD)	Average Over-wash Rate (cfs/lf)
C-9	PMP	17.5	19.5	0.100
C-11	100-yr Storm	----	----	----
	50% PMP	9.5	15.5	0.071

A.8.3.11 Embankment Alternative 3: Wave Breaking Berm Optimization

In order to further optimize the smooth slope embankment, the addition of a wave breaking berm along the internal toe of the embankment was investigated. Preliminary fill volume computations indicated that the wave berm option for C-11 Impoundment would be not be practical and, therefore, this alternative is presented only for the C-9 Impoundment. The focus was entirely on meeting the single over-wash criteria of 0.10cfs/lf. Wave berm and embankment dimensions, configured for the allowable average over-wash rate, resulted in an embankment cross-section that does not require backside slope armoring.

The Coastal Engineering Manual (USACE, 2005) provides a means of optimizing the dimensions of embankments with wave berm features. Using this methodology, a range of wave berm dimensions was evaluated. ***Table A-97*** provides the berm dimensions and minimum embankment crest elevations required to meet the 0.10cfs/lf criterion. Embankment elevations were rounded to the nearest 0.5ft for constructability. Each configuration detailed in ***Table A-97*** meets the allowable over-wash criteria. A complete design and cost analysis is required to determine the most optimum wave berm configuration.

A.8.3.12 Summary

In the course of this analysis three general alternative flat-plate slope configurations were evaluated for two Impoundments (C-9 and C-11). The first embankment alternative consisted of maintaining each reservoir embankment crest at the existing design elevation. Over-wash results indicated that, while this would allow other reservoir features to remain unchanged, it would require the addition of backside slope armor to protect against increased over-wash in two of the three design cases (C-9 Impoundment PMP and C-11 Impoundment 50% PMP). Replacement of the steps with flat plate armor in C-11 Impoundment for the 100yr storm design case raised the average over-wash rate, however, it remained within tolerance of the allowable average over-wash

rate of 0.10cfs/lf. A probability based breakdown of over-wash rates was provided to assist in determining backside armor requirements.

The second embankment alternative consisted of raising embankment crests to an elevation that restricts over-wash to an average rate of 0.10cfs/lf. This analysis applied only to the C-9 Impoundment PMP and C-11 Impoundment 50% PMP design cases as the C-11 Impoundment 100 yr storm case meets allowable over-wash criteria at the existing design crest elevation. Over-wash results indicated that this alternative requires additional fill material, but eliminates the need for backside slope armoring.

TABLE A-97: WAVE BREAK BERM AND EMBANKMENT DIMENSIONS REQUIRED FOR 0.10CFS/LF OVER-WASH

Still Water Depth over the Berm (ft)	Wave Berm Width (ft)	Wave Berm Elevation (ft-NAVD)	Crest Elevation With Berm (ft-NAVD)	Over-wash Rate (cfs/lf)
4	35	9.15	20.0	0.10
	30	9.15	20.0	0.10
	25	9.15	20.0	0.10
	20	9.15	20.0	0.10
	15	9.15	20.5	0.10
	10	9.15	20.5	0.10
3	35	10.15	19.0	0.10
	30	10.15	19.0	0.10
	25	10.15	19.5	0.10
	20	10.15	19.5	0.10
	15	10.15	20.0	0.10
	10	10.15	20.0	0.10
2	35	11.15	18.5	0.10
	30	11.15	18.5	0.10
	25	11.15	19.0	0.10
	20	11.15	19.0	0.10
	15	11.15	19.5	0.10
	10	11.15	20.0	0.10

The third embankment alternative introduced an internal wave breaking berm. Analysis of this alternative resulted in a range of wave berm and embankment dimensions that, combined, would result in an average over-wash rate no greater than 0.10cfs/lf. As with raising the embankment, this alternative may require additional fill, but would eliminate the need for backside slope armoring.

A.8.3.13 References

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A.8.4 DCM-1 Final

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Design Criteria Memorandum: DCM-1 Revision 00.0

Effective Date: September 12, 2005 **Acceler8 Ref. #: P 599**

Subject: Hazard Potential Classification

1. Introduction

This memorandum provides guidance regarding hazard potential classification of impoundments to be designed and constructed for the CERP projects. Hazard potential classification is a system that categorizes dams according to the degree of potential adverse incremental consequences of a failure or mis-operation of a dam (FEMA 333). The hazard potential classification is not an indication of the current condition of the dam or the expected condition of a dam that is being designed, the structural integrity or the spillway capacity. The hazard potential classification results in the selection of the appropriate inflow design flood (IDF) and freeboard requirements, and is used to determine other design criteria for the dam and appurtenant facilities. A formal hazard potential classification report shall be prepared for all CERP impoundments, using the outline presented in this DCM, and submitted for approval prior to completion of the Basis of Design Report.

This memorandum provides a guideline for the hazard potential classification of impoundments that store water for CERP projects, primarily with references to existing Federal guidelines. Select key elements of hazard potential classification are summarized herein; however this document is not intended to be a repetition of the Federal dam safety guidelines. Specific issues that affect the hazard classification of CERP dams are addressed in the following sections. This memorandum presents the joint criteria and recommendations developed by the South Florida Water Management District (SFWMD), Florida Department of Environmental Protection (FDEP) and the U.S. Army Corps of Engineers (USACE) for hazard potential classification of CERP impoundments.

2. Structure Definition

Earthfill embankments are generally defined based on the function of the structure, with the two primary classifications of: 1) embankment dam, or 2) levee. The functions associated with these two classifications are:

1. A dam is "an artificial barrier that has the ability to impound water … for the purpose of storage or control of water." (FEMA 148).

2. A levee is defined as an embankment whose primary purpose is to furnish flood protection from seasonal high water and which is therefore subject to water loading for periods of only a few days or weeks a year. (USACE, 2000).

The key difference between a dam and a levee is that a dam contains water for prolonged periods, longer than normal flood protection requirements, or permanently. Based on Florida Statutes, a dam is

This document provides working level guidance to assist project teams in the implementation of projects and project features under the Comprehensive Everglades Restoration Plan (CERP) implemented by the South Florida Water Management District, the Florida Department of Environmental Protection, and the U.S. Army Corps of Engineers. This guidance does not supersede existing or future federal or state regulations, does not constitute policy for any of these agencies, and does not create authority beyond that granted to any agency member carrying out their duties.

defined as "Any artificial or natural barrier, with appurtenant works, raised to obstruct or impound, or which does obstruct or impound any of the surface waters of the state" (FS 373). A definition of a dam is also included in Public Law 104-303, Section 215, National Dam Safety Program Act and subsequent implementation documents including the National Inventory of Dams (NID) Methodology State and Federal Agency Manual. The following definition will apply to CERP impoundments:

> **Dam:** Any artificial barrier, including appurtenant works, which impounds or diverts water, and which (1) is twenty-five feet or more in height from the natural bed of the stream or watercourse measured at the downstream toe of the barrier or from the lowest elevation of the outside limit of the barrier if it is not across a stream channel or watercourse, to the maximum water storage elevation or (2) has an impounding capacity at maximum water storage elevation of fifty acre-feet or more. The criteria do not apply to any such barrier which is not in excess of six feet in height regardless of storage capacity, or which has a storage capacity at maximum water storage elevation not in excess of fifteen acre-feet regardless of height. This lower size limitation is to be waived if there is a potentially significant downstream hazard. The definition is shown graphically on **Figure DCM 1-1**.

The design criteria apply whether the dam has a permanent reservoir or temporary storage. The impounding capacity at maximum water storage elevation includes storage of floodwaters above normal full storage elevation (FEMA 93, April 2004).

CERP impoundments defined as a dam will be designed in accordance with dam design criteria. Levee design criteria will only be applicable to impoundments that are not defined as a dam and "... an embankment whose primary purpose is to furnish flood protection from seasonal high water and which is therefore subject to water loading for periods of only a few days or weeks a year." (USACE, EM 1110-2-1913).

3. Hazard Potential Classification Categories

Hazard potential classification of CERP impoundments will be developed following FEMA guidelines, supplemented by U.S. Army Corps of Engineers (USACE) and U.S. Bureau of Reclamation (USBR) criteria as clarified below. The classification of dams based on the hazard potential has been presented in various forms in a number of Federal and State documents, including the following:

- *Federal Guidelines for Dam Safety: Hazard Potential Classification Systems for Dams*, FEMA 333, April 2004.
- *Federal Guidelines for Dam Safety: Selecting and Accommodating Inflow Design Floods for Dams*, FEMA 94, April 2004.
- *Safety of Dams – Policy and Procedures*, U.S. Army Corps of Engineers (USACE), Engineering Circular EC 1110-2-6061, April 30, 2004.

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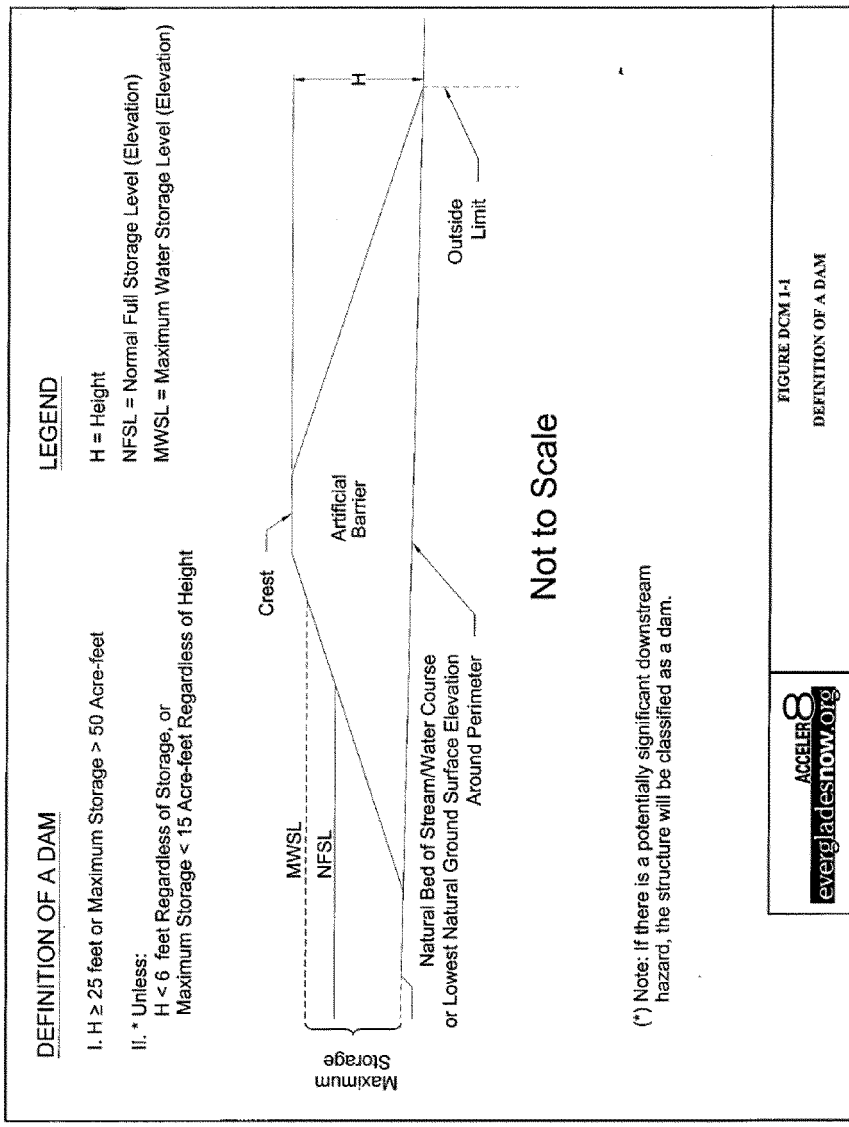

FIGURE DCM 1-1
DEFINITION OF A DAM

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- *Safety of Dams – Policy and Procedures*, ER 1110-2-1156 (Draft), U.S. Army Corps of Engineers (USACE), April 30, 2004, attachment to Engineering Circular EC 1110-2-6061.
- *Downstream Hazard Classification Guidelines*, ACER Technical Memorandum No. 11, U.S. Bureau of Reclamation. 1988.
- *Engineering Guidelines*, Chapter II, Selecting and Accommodating Inflow Design Floods for Dams, Federal Energy Regulatory Commission, October 1993.
- *Basis of Review for Environmental Resource Permit Applications*, Appendix 6 - Above Ground Impoundments, South Florida Water Management District, April 6, 2003.
- *Class of Dams, National Engineering Manual, 210-V, Part 520, Soil & Water Resource Development, Subpart C, Dams, Natural Resource Conservation Service(NRCS), Oct. 1990*

Although the documents listed above have mostly similar hazard potential classifications, some differences exist (in particular in terminology used). The Federal Emergency Management Agency (FEMA), under the Department of Homeland Security, Chairs the National Dam Safety Review Board and Interagency Committee on Dam Safety (ICODS). The Dam Safety Review Board and ICODS guide the direction of the National Dam Safety Program. The guidelines developed by FEMA (listed below under References) provide the consensus of coordination of dam safety methods and terminology among the various federal, state and private sectors.

The primary references that were considered for the hazard potential classification for CERP projects were the USACE, USBR (ACER TM No. 11), and FEMA 333. Hazard Potential Classification categories by the USACE, are presented in Appendix G, Table G-1 of ER 1110-2-1156 (Draft), *Safety of Dams – Policy and Procedures*, (USACE, 2004). The draft Engineer Regulation (ER) is currently an attachment to Engineer Circular EC 1110-2-6061. The USACE definitions differ from the FEMA definitions in one particular key point as described below.

The three hazard potential classifications defined by the USACE (2004) are: 1) high hazard, 2) significant hazard, and 3) low hazard and are presented in Table 1, below.

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Table 1: Hazard Potential Classification

CATEGORY[1]	LOW	SIGNIFICANT	HIGH
Direct Loss of Life[2]	None expected (due to rural location with no permanent structures for human habitation)	Uncertain (rural location with few residences and only transient or industrial development)	Certain (one or more extensive residential, commercial or industrial development)
Lifeline Losses[3]	No disruption of services - repairs are cosmetic or rapidly repairable damage	Disruption of essential facilities and access	Disruption of critical facilities and access
Property Losses[4]	Private agricultural lands, equipment and isolated buildings	Major public and private facilities	Extensive public and private facilities
Environmental Losses[5]	Minimal incremental damage	Major mitigation required	Extensive mitigation cost or impossible to mitigate

Notes:

1. Categories are based upon project performance and do not apply to individual structures within a project.
2. Loss of life potential based upon inundation mapping of area downstream of the project. Analyses of loss of life potential shall take into account the extent of development and associated population risk, time of flood wave travel and warning time.
3. Indirect threats to life caused by the interruption of lifeline services due to project failure, or operation, i.e., direct loss of (or access to) critical medical facilities or loss of water or power supply, communications, power supply, etc.
4. Direct economic impact of value of property damages to project facilities and downstream property and indirect economic impact due to loss of project services, i.e., impact on navigation industry of the loss of a dam and navigation pool, or impact upon a community of the loss of water or power supply.
5. Environmental impact downstream caused by the incremental flood wave produced by the project failure, beyond which would normally be expected for the magnitude flood event under a without project conditions.

FEMA definitions for hazard potential classification categories follow:

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- Low Hazard Potential – Dams assigned a low hazard potential classification are those where failure or mis-operation results in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the owner's property.
- Significant Hazard Potential – Dams assigned the significant hazard potential classification are those dams where failure or mis-operation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.
- High Hazard Potential – Dams assigned the high hazard potential classification are those where failure or mis-operation will probably cause loss of human life.

Hazard Potential Classification	Loss of Human Life	Economic, Environmental, Lifeline Losses
Low	None Expected	Low and generally limited to Owner
Significant	None Expected	Yes
High	Probable. One or more expected	Yes (but not necessary for this classification)

The conflict between the two sources occurs in the definition of loss of life. Specifically, the USACE definition uses "certain" loss of human life versus the FEMA definition of "probable" loss of human life. Quantifying human responses to a dam failure and determining at risk population in some of the remote locations with absolute certainty is difficult. For CERP projects, the high hazard potential classification will be defined as "one in which a dam failure would probably cause loss of human life."

4. Structure Classification

The Hazard Potential Classification (HPC) shall be determined for each CERP impoundment that stores water and shall be used for determination of the inflow design flood, freeboard and other standard design applications. The HPC of the entire structure shall be based on the most severe consequences from a breach location around the perimeter of the structure and shall consider both normal full storage (NFSL) and maximum water storage (MWSL) conditions (including storage of flood waters).

Dams for CERP projects will in most cases be several miles in length, and a wide variation in conditions downstream of different segments of a dam will likely occur. As described in FEMA 333 and Table G-1 (USACE, 2004), HPC is based on project performance and does not apply to individual

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structures within a project: ***each structure will have a single hazard potential classification that will be applied to the entire structure*** (FEMA 333). The principle of a single hazard classification for an entire structure gives consideration, in part, to the fact that conditions downstream from a dam may change substantially over time. Following construction of dams, the areas adjacent to reservoirs have historically become attractive for residential and commercial development. The U.S. Bureau of Reclamation (USBR) has developed detailed guidelines presented in ACER TM No. 11 for use in the evaluation of the danger to people, residences, and vehicles in inundation areas (USBR, 1988). The figures relate velocity and depth in the inundation areas to high danger, judgement, and low danger zones.

5. Dam-Break Studies

A HPC study is based on field investigations and a review of available data, including topographic maps and land use information. In many cases the HPC is not apparent from a field reconnaissance (e.g. the presence of commercial or residential property nearby or the surrounding area consists entirely of agricultural land), and detailed studies including dam-break analyses of various flood flow conditions are required to evaluate the incremental effects of dam failure as compared with flow conditions without a dam failure. The dam-break analysis is used to assess the economic damage and loss of life potential based on dam-break model results and on inundation mapping of the area downstream of a project under various flow conditions.

A dam-break study is performed to assess the consequences due to a theoretical failure under normal (full reservoir with normal streamflow conditions prevailing) and flood-flow conditions. Dam-break studies include water surface elevations, flood wave travel times, rates of water rise at critical structures, velocity of flow, duration of inundation, and flood inundation maps related to a theoretical breach of the dam. As described in Section 4, above, each structure will have a single HPC and the HPC will be used to determine the appropriate IDF for each impoundment.

A dam-break study should include analysis of incremental flood-flows to determine the condition where a dam failure would no longer significantly increase the threat to life or property. A dam-break study of incremental flood flow conditions, typically referred to as an Incremental Damage Assessment (IDA) study, should be considered in determining the design flood conditions for impoundments that are classified as High or Significant Hazard Potential where it appears that the increase to the threat to life or property could occur at levels lower than the PMF. A flood less than the PMF may be adopted as the IDF in those situations where the consequences of dam failure at flood flows larger than the selected IDF are acceptable. Generally, acceptable consequences exist when evaluation of the area affected indicates that there would be no significant incremental increase in the hazard to life or property resulting from the occurrence of a failure during floods larger than the proposed IDF. An IDA analysis for each flood condition will include, water surface elevations, with and without dam failure, flood wave travel times, rates of rise in water surface elevation at critical structures and flood inundation maps. USBR ACER TM No. 11 information should be used in an evaluation of the potential hazard to property and people.

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Based on the unique conditions of CERP impoundments that can cover large surface areas with very long perimeter embankment lengths, implementation of an IDA study may show that a dam break on a remotely located section of embankment may not increase the threat to loss of life or property for the closest critical structures. Consequently, analysis of the IDA along segments of a reservoir could lead to the potential to decrease the design flood (hence the embankment height) of segments of the dam. Parametric analysis of design storms and freeboard at several CERP impoundments show that the primary factor in freeboard determination is related to wind induced setup and wave run-up. CERP impoundments consist of fully enclosed basins, and freeboard from the design flood is a result of direct precipitation with negligible run-off contribution. Contribution of runoff from a drainage basin to an increased flood storage level is inconsequential. Consequently, a reduction in the design flood storage level from an IDA conducted by segments could have only limited cost reduction benefit (i.e. benefits only from direct precipitation and not basin run-off contributions). Since dam-break analyses and flood routing studies do not provide precise results, evaluation of the consequences of failure should be conservative. Therefore, the determination of ***one*** HPC for the entire structure based on an IDA study shall only be considered. In other words, an IDA study for determination of the design flood shall only be based on the incremental consequences at the most critical feature based on theoretical failure at any location along the embankment and differing dam-break flood levels for individual segments of the embankment shall not be used.

Acceptable computer models for performing dam-break studies include NWS DAMBRK, BOSS DAMBRK, FLDWAV, MIKE 11 and HEC-RAS v.3.1 or later. Breach dimensions and time of formation are to be determined using the most appropriate parameters based on FERC Engineering Guidelines for Suggested Breach Parameters, BREACH (Fread 1988, revised 1991), references to Froelich in the manual for FLDWAV (Froelich 1987 and 1995), or the Washington Department of Ecology guidelines for cohesion-less embankments. Two-dimensional unsteady flow models may also be used if they are applicable to dam-break situations.

Suggested dam-break parameters have been defined by the Federal Energy Regulatory Commission (FERC, 1998, Table 1, Chapter II, Selecting and Accommodating Inflow Design Floods for Dams), in the documentation for FLDWAV (Fread, 1998), and the State of Washington Department of Ecology (1992) has further evaluated dam-breach conditions for cohesion-less soil embankments. Because of the large volume of the CERP reservoirs in relation to the dam height and the relatively unique nature of dams in the flat topography of Florida, some assumptions that are typically used in dam-break analysis do not have the historical precedence of wide use in dam-break modeling. Some of the unique factors and recommended considerations in the dam-break studies for CERP projects are described in **Attachment DCM 1A**. A useful check of breach parameters can be performed using equations 6.12 and 6.13 of the FLDWAV documentation (Fread and Lewis, 1998).

Designers are encouraged to submit preliminary results and dam-break parameters to the SFWMD, USACE and FDEP during the analysis stage and to obtain concurrence on the results before completing preliminary design.

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6. Documenting Project Hazard Potential Classification

The HPC shall be determined and documented in a report for each Project. The HPC report shall be prepared in the following format (based on draft Jacksonville District (2004) recommendations):

a. **Project Description.** Describe all of the pertinent project features, size and location and the purpose of the report documenting the hazard potential classification for the named project.

b. **Hazard Potential Classification.** State the classification made as a result of the study. If the proposed dam is classified as high or significant hazard based on obvious hazards in the floodplain or low hazard classification based on an obvious lack of downstream hazards, state that no formal hazard potential classification study is required. If the observed hazards indicate that the dam lies in a judgment zone between significant and low hazard, a conservative preliminary classification of significant should be assigned to the impoundment with a recommendation to perform a formal hazard classification for the dam. A formal classification generally includes more precise information related to depths and velocities from dam breach flows, and may require surveying the downstream floodplain at selected locations to obtain accurate cross-section data.

c. **Discussion.**

1) Description of Proposed Dam and Floodplain Area(s). Provide a brief description of the proposed dam and embankment and general characteristics of the downstream floodplain including a map (USGS or more current area specific map showing the site and relationship to population centers and critical structures, location of the nearest residences, identification of Hurricane Evacuation Routes, etc.).

2) Status of Inundation Map. State whether inundation maps exist or if plans are underway to prepare them.

3) Method. State what sources of information and what analyses were used in determining the hazard potential classification. Inundation maps are to show maximum stage, maximum velocity and time of flood wave arrival from start of the breach.

4) Analysis and Field Observations. Give detailed results of hydraulic studies and field observations. Along with numerical data, describe issues where the engineer's professional judgment was required, and the factors involved in making various decisions.

5) Summary and Conclusions. Restate the downstream hazard potential classification and summarize data used and assumptions made in determining the classification.

6) Enclosures. Enclose photographs with captions and any other pertinent data, such as topographic maps showing floodplain area(s) or other graphical data.

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18. Washington State Department of Ecology, July 1992. *Dam Break Inundation Analysis and Downstream Hazard Classification*, Technical Note No. 1, Dam Safety Guidelines. U.S. Bureau of Reclamation (USBR), 2004. *Comparison Between the Methods used in MIKE 11 2003, FLDWAV 1.0, and HEC-RAS 3.1.1 to Compute Flows Through a Dam Breach*, U.S. Department of Interior, Bureau of Reclamation, Technical Service Center.

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Attachment DCM 1A

Dam-Breach Parameter Considerations

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ATTACHMENT DCM 1A

Dam-Breach Parameter Considerations

An encircling, earth-fill embankment will generally form the new CERP impoundments. Therefore, a potential embankment breach could theoretically occur in any direction. Natural ground surrounding the reservoir is relatively flat and there is not one, specific defined stream/river channel that would define the travel of a dam-break flood. A defined stream/river channel typically defines the location of the dam and would contain a flood wave and outflows from a dam break; thereby defining flow direction and a flood plain. Based on the site conditions and uncertainties associated with parameter selection, the first phase of a dam breach study should include a sensitivity analyses based on various parameters such as time for breach development, final breach size, ground slope, and lateral expansion of dam break floods. Parametric analysis should be used to estimate the flooding in the areas surrounding the reservoir; supplemented by specific modeling in the direction of population at risk and critical structures. Recommendations for use in development of dam-break analysis for CERP impoundments are described below.

Breach Parameters.

The state-of the-practice in dam-break analysis has been developed based on empirical analysis of historical breaches of existing dams. Embankment construction material for CERP impoundments will predominantly consist of cohesionless soil for the interior and exterior shells of the embankment, with differing methods to provide an impervious water retaining "core" at each project. Standards for dam-break parameters have been developed by several authors/agencies (e.g. Fread 1988, Federal Energy Regulatory Commission (FERC 2003), State of Washington, Department of Ecology and others).

Selection of dam breach parameters is based on the type and internal configuration of the dam. For CERP impoundments, the dam structures will consist of earth -fill, or earth-rock fill embankment dams. Embankment types will be zoned structures with the zones varying between projects depending on the borrow material available at each site, and foundation conditions. Cohesion-less material is widely available at most CERP dam sites, and at several sites consists of clean to slightly silty sand (SP, SP-SM, SM) that would be very erodible under dam-break conditions, but ranges to gravel and rockfill at some sites. The water retaining "impervious core" of the embankments will vary by project, ranging from clay/sandy clay soil, to a slurry wall barrier, or a synthetic geomembrane. Slope protection will likely consist of soil-cement, but could be constructed using rip rap or engineered erosion protection products. Modeling of breach parameters (breach dimensions and breach formulation) will be developed using standards for dam-break studies, and based on the embankment construction material and geometry. The following sources should be used for developing dam breach parameters:

- General Dam Breach Modeling. Federal Energy Regulatory Commission, Chapter II, 1998.
- For embankments constructed predominantly of cohesion-less soil, it is likely that a dam-break would result in a wider breach than indicated by the FERC dam-break

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parameters, which suggest a maximum dam breach width that is five times the height of the dam. An evaluation of a number of historical dam failures, including embankments constructed of cohesionless soil, has resulted in the capability to relate the dam breach size to the volume and height of water in a reservoir (MacDonald and Langridge-Monopolis, 1984). The Washington Department of Ecology (1992) has summarized the breach size relationship for cohesionless embankment materials as follows:

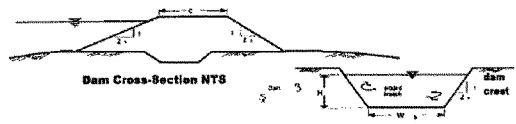
$$V_m = 3.75 * (V_w * H)^{0.77}$$

where:

V_m = Volume of material in breach (cubic yards) that is eroded

V_w = Volume of water stored in the reservoir (acre-feet) at the water surface elevation under consideration

H = Height of water (feet) over the base elevation of the breach



Breach Cross-Section NTS

The above relationship estimates the breach volume which can be related through the cross sectional area of the embankment to the breach width. For a trapezoidal breach with side-slopes of (Z_b:1):

$$W_b = \frac{27V_m - H^2(CZ_b + HZ_bZ_3/3)}{H(C + HZ_3/2)}$$

where:

W_b = Width of breach (ft) at base elevation of breach

C = Crest width of dam (ft)

$Z_3 = Z_1 + Z_2$ and

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Z_1 = Slope (Z_1:1) of interior face of dam

Z_2 = Slope (Z_2:1) of exterior slope of dam

Sensitivity analysis should be performed for each of the suggested breach parameters used in the dam-break analysis for determining the potential flood inundation impacts.

Lateral Spread of Breach.

The area surrounding CERP reservoirs is generally quite flat for long distances, which can make it difficult to determine an inundation area(s). Dam-break modeling involves the use of 1-D models (1-D model does not predict the lateral flow expansion). Due to the relative flat ground surface and lack of a confined channel boundary along the perimeter of the embankment, a dam break flood wave would expand laterally as the flood travels downstream (similar to the expansion of jet discharge). Lateral expansion of the dam break floods will need to be used to simulate the flood plain geometry.

The USACE Hydrologic Engineering Center (2002) has concluded that in most cases, an expansion ratio of between 1:1 and 2:1 (longitudinal:lateral) is appropriate for routing flow through bridge openings in the HEC-RAS model. However, the hydro-dynamics of flow from a dam breach would be significantly different than the flow through a bridge opening. Flow from a dam breach would be expected to be a high force, jet-type discharge when breach back-cutting intersects the reservoir pool, which would then decrease as the flow expands laterally in flat terrain. The initial surge could occur as a much narrower jet, resulting in greater flow depths and shorter travel times near the embankment than modeling at a 1:1 or 2:1 expansion ratio. A submerged jet, which is normally modeled at a 4 longitudinal to 1 lateral expansion ratio, would provide another index value for modeling of breach flow on flat terrain. Modeling of breach flow downstream of a dam-break should include a sensitivity analysis for breach flow expansion ratio's ranging from 2:1 to 4:1 (longitudinal:lateral), and engineering judgment used for determining inundation limits and travel times for the flood mapping. Alternatively, a 2-dimensional mathematical hydraulic model study of breach flow in flat terrain would need to be performed to define predicted lateral spread of breach flow.

Another method of evaluating flood-wave development and travel times due to a dam-break in flat terrain could be utilization of numerical models such as FLDWAV. FLDWAV involves an array of parameter including the parameter QLOSS. The parameter QLOSS provides a value that could be used to model lateral expansion of a dam-break flood wave by assuming different loss values along the path being analyzed. As noted above for modeling of expansion ratios, parametric and sensitivity analysis will be required to assess conditions for analysis of potential downstream hazards. And to establish the reasonableness of the QLOSS values used.

Location of Breach.

Since an encircling earth fill embankment will form the new reservoirs, a potential breach could theoretically occur in any direction. Modeling will need to include the potential for a breach to occur at locations around the perimeter of the embankment. A "Dam Break methodology" that considers a

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"general" dam breach occurring around the perimeter, in combination with "specific dam break locations", such as towards nearby highways and residences, should be used. One method of modeling a "general dam-break" should include an approach to represent the routing of a dam-break flood around the entire perimeter. An example is shown on **Figure DCM 1A-1**. The general dam-break modeling approach should include modeling of the perimeter ground slope, and developing contours for flood inundation depth, velocity, travel times and rate of rise at key distances from the exterior embankment toe. Inundation mapping should include analysis of specific dam break locations for key structures that have been identified as potentially affected by a dam-break flood (see example shown on **Figure DCM 1A-2**), including the effects of obstructions such as canals and roads.

Designers are encouraged to submit preliminary results and dam-break parameters to the SFWMD, USACE and FDEP during the analysis stage, and to obtain concurrence on the results before completing preliminary design.

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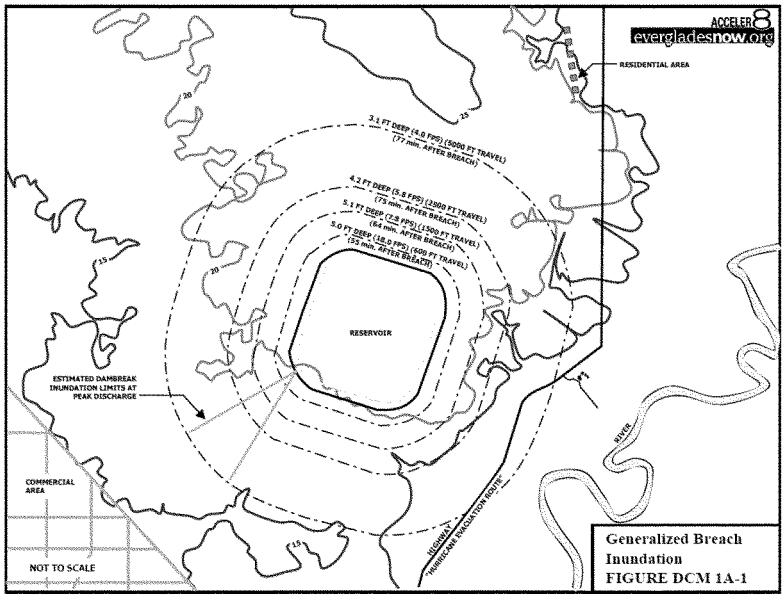
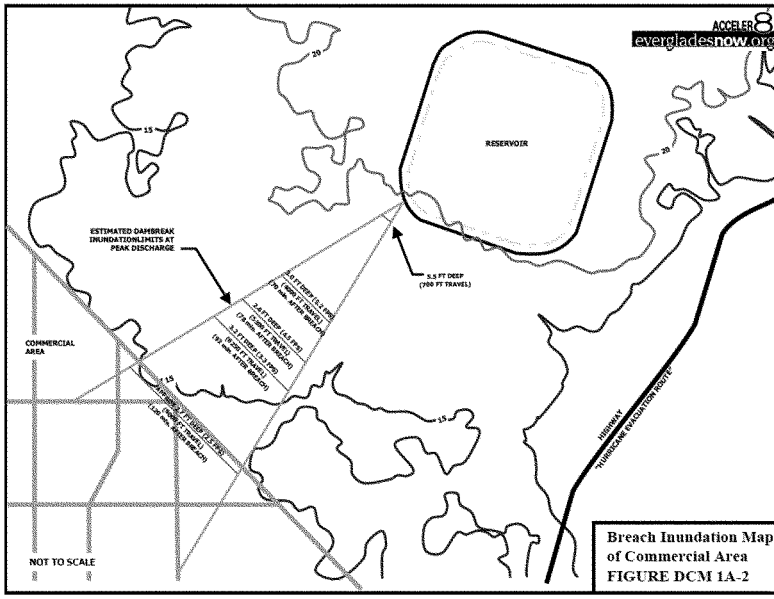


Generalized Breach Inundation
FIGURE DCM 1A-1


ACCELER8
everglADESnow.org
RESERVOIR
ESTIMATED DAMBREAK INUNDATION LIMITS AT PEAK DISCHARGE
5.5 FT DEEP (700 FT TRAVEL)
COMMERCIAL AREA
NOT TO SCALE
HIGHWAY "HURRICANE EVACUATION ROUTE"
Breach Inundation Map of Commercial Area
FIGURE DCM 1A-2

A.8.5 DCM-2 Final

Design Criteria Memorandum: DCM-2

Effective Date: February 6, 2006 **Acceler8 Ref #: P 599**

Subject: Wind and Precipitation Design Criteria for Freeboard

1. Introduction

DCM – 2 presents the SFWMD design criteria for the determination of the wind speed coincident with precipitation and/or normal full storage level. Determination of the controlling conditions for establishing freeboard on storage impoundments will be defined and detailed. This memorandum is an overview and is not intended to be a comprehensive presentation of hydrologic design criteria.

Freeboard allowance is determined from wave characteristics, wind setup and wave run-up, as well as a several other factors. This memorandum addresses the combined wind and precipitation design criteria for freeboard determination of high, significant and low hazard dams. Dams assigned the high hazard potential classification are those where failure or mis-operation will probably cause loss of human life (FEMA 333). Significant hazard dams will have similar freeboard design criteria because of potential for high economic losses or loss of highly valued environmental ecosystems. Low hazard dams may have different freeboard design criteria based on socio-economic analysis performed on a case-by-case scenario. Hazard potential classification is covered in **DCM – 1**.

This memorandum presents the joint criteria and recommendations developed by the South Florida Water Management District (SFWMD), the U.S. Army Corps of Engineer's (USACE) and the Florida Department of Environmental Protection (FDEP) for developing wind speed and precipitation events for freeboard determination of CERP impoundments.

2. Freeboard Determination

Freeboard is defined as the vertical distance between the crest of a dam and some specified pool level, usually the normal full storage level or the maximum flood level (USACE, 1997). Freeboard and flood control storage are required to provide the capacity to store and/or route the design storm through the reservoir considering inflows, precipitation on the reservoir basin and wind generated waves without overtopping of the embankment. The objective in selection of design freeboard is to assure that failure of the dam will not result from wind setup, wave action, uncertainties in analytical procedures, and uncertainties in project function in combination with the most critical pool elevation (USACE, 1991). Freeboard determination should be based on site-specific conditions that can be reasonably expected to occur simultaneously. Settlement, waves induced by potential landslides, or malfunction of the spillway and/or outlet works are also important considerations for freeboard determination. This memorandum identifies and develops design criteria for logical combinations of reservoir levels/precipitation, and wind conditions for freeboard determination. Freeboard is shown graphically on **Figure DCM 2-1**. The reference elevation for freeboard determination will be the "normal full storage level" (NFSL) elevation which is defined as the maximum elevation of storage at an un-gated, uncontrolled level where outflow would begin with continued storage. For a reservoir with outflow

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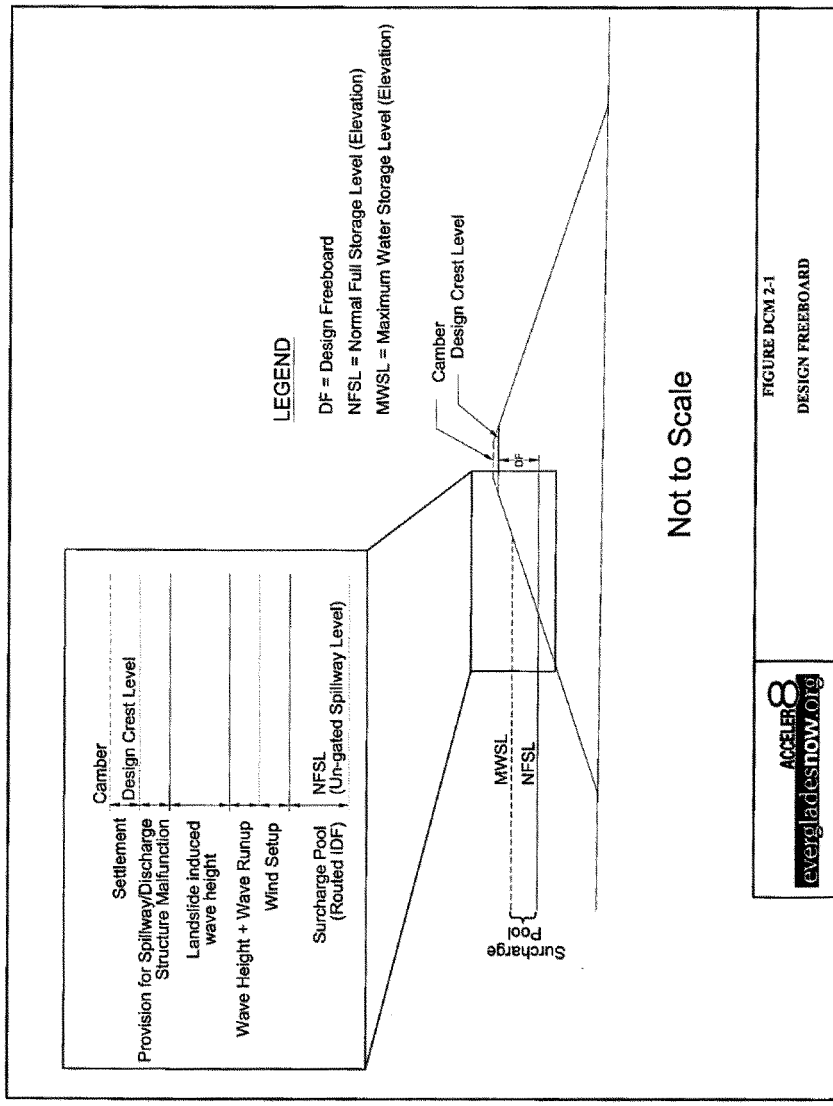

FIGURE DCM 2-1
DESIGN FREEBOARD

controlled in part by moveable gates or other means, the NFSL is the maximum level to which water may rise under normal operating conditions, exclusive of any provision for flood surcharge. The maximum water storage level (MWSL) is defined as the maximum (still-water) level resulting from routing of the inflow design flood (IDF). Surcharge pool is defined as the storage between the normal full storage elevation and the maximum water storage level. Spillway design and routing of the IDF is an integral part of freeboard determination and is to be included in design of the impoundments. The IDF, wind and wave design requirements for CERP impoundments are included in **DCM-2**. Spillway requirements for CERP impoundments are included in **DCM-3**.

Embankment freeboard will be determined as the minimum required embankment height above the reference pool level (normal full storage level) to prevent overtopping from the defined condition. As defined by the USACE (1997):

> *Freeboard is generally based on probable maximum wind conditions when the reference elevation is the normal operating level. When estimating the reservoir level to be used with the probable maximum reservoir level, a lesser wind condition is used because it is improbable that maximum wind conditions will occur simultaneously with the maximum flood level.*

Neither the probable maximum wind (PMW) condition nor the lesser wind condition associated with the maximum flood level is numerically defined in any standard reference document. In addition, the duration of the flood level near the maximum pool level needs to be included in the freeboard determination. As described in ER 1110-2-8 (FR) paragraph 9c., *"when the IDF pool hydrograph is within three feet of the maximum pool for 36 hours or longer or where the project has been designed with little surcharge for the maximum pool above full pool elevation, the minimum freeboard will be five feet for embankment dams and three feet for concrete dams or greater ...."*

Therefore, design criteria to be used for high and significant hazard water storage impoundments and dams for the CERP program were developed as detailed herein. Design criteria for impoundments classified as low hazard potential are also included.

2.1 High and Significant Hazard Potential

Several impoundments to be constructed for CERP will be high or significant hazard structures with the IDF defined as the flood resulting from the Probable Maximum Precipitation (PMP) event. Determination of design criteria will include combinations of reservoir level, precipitation and wind conditions that are reasonably expected to occur simultaneously or within 36 hours of the maximum surcharge pool level. A list of four combinations of precipitation and wind conditions that could be reasonably expected to occur are presented in **Table DCM 2-1.** Each combination of precipitation and wind will be hereafter referred to as **Case** x. These four cases are also described in the following paragraphs.

- **Case 1** consists of a 100-year wind combined with the PMP.
- **Case 2** consists of a 100-year precipitation event combined with a Category 5 hurricane, wind condition.

- **Case 3** consists of a PMW combined with the normal full storage level, and
- **Case 4** consists of a storm specific (historical) event.

Case 1 (the 100-year wind combined with the PMP) and **Case 3** (a PMW assumed to be 200 mph wind combined with the normal full storage level) are consistent with the USACE criteria (USACE, 1997). The remaining two cases (**Case 2** and **Case 4**) were developed to address specific combinations of wind and precipitation that have occurred or could reasonably be expected to occur in southern Florida.

Table DCM 2-1: Reservoir Level/Precipitation and Wind Conditions Reasonably Expected to Occur Simultaneously for Freeboard Determination

		Precipitation or Reservoir Level		
		Normal Full Storage	100-Year Storm	PMP
Wind Condition	100-Year Wind			■
	156 mph Category 5		■	
	200 mph (PMW)	■		
	Hurricane Easy (1950)	Storm Specific Wind and Precipitation		

The values of wind speed and definition of the type of wind (gust, one-minute, fastest-mile) required further analysis to identify the method to be used in analyzing conditions for freeboard determination. In particular, since there is no consensus definition of a "lesser wind condition." Comparison of various wind speeds that could be used for design criteria were evaluated for each of the reservoir level/precipitation events described in **Table DCM 2-1**, and each case is presented below.

2.1.1 Case 1: PMP Combined with 100-Year Wind

The Probable Maximum Flood (PMF) results from routing the Probable Maximum Precipitation (PMP) event. The PMP is determined using the National Oceanic and Atmospheric Administration (NOAA) published data in Hydrometeorological Report (HMR) Numbers 51, 52, and 53. As shown in HMR 51, the PMP depth for southern Florida ranges from about 32 to 60 inches for 6 hour and 72 hour storm duration's, respectively. For CERP reservoirs, inflow is derived from a combination of pumping into the impoundment and direct rainfall rather than gravity inflow from a contributory drainage area. Therefore, the PMF will primarily result from the PMP falling directly on the reservoir surface, plus an insignificant contribution of runoff from the surrounding perimeter crest road and interior slope. The PMF for design will depend on the PMF hydrograph (duration) that produces the critical condition

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within the impoundment and at the dam. The critical condition could result from the inflow rate, timing or total volume of storm event, dependent on the spillway design and reservoir storage available at the beginning of the storm event. The PMF hydrograph for design could result from a high-intensity local storm or a general storm with a long duration. Therefore, the PMP event that develops the most critical condition, determined from the various storms identified in HMR 51, will be the design PMF for the impoundment and associated structures.

Identification of an appropriate design wind to be used in conjunction with the unlikely PMF does not have a documented standard practice or requirement in Florida. Therefore, different sources of wind conditions that are typically used in facility design were evaluated. Sources included:

- USACE regulations,
- US Bureau of Reclamation Design Guidelines for Dams,
- Federal Energy Regulatory Commission,
- Florida Building Code,
- The American Society of Civil Engineer's Manual on Wind Load Conditions ASCE 07-02 (ASCE, 2003), and
- Comparable projects.

The basic wind speeds for building design presented by the ASCE for hurricane prone areas and in the Florida Building Code are based on 3-second gusts for 50-year to 100-year return periods (ASCE, 2003, Fig. 6-1b and Table C 6-3). ASCE Figure 6-1b (ASCE, 2003) corresponds to Figure 1606 in the Florida Building Code.

Various wind conditions were considered in developing combinations of precipitation/reservoir level and wind events that could reasonably be expected to occur simultaneously. Since there is little documentation in this area, other areas of standard practice that could be used as a potential guideline were reviewed. One analogous condition that is used in standard practice is the method for determining the PMF based freeboard for impoundments in the northern States. The PMF for cool season months in the northern States is determined as the PMP in combination with snowmelt from the 100-year snow-pack (FERC, 2001, pg. 66). In many places in northern States, particularly in mountainous areas, the contribution of snowmelt of the 100-year snow-pack with the PMF runoff is very significant. This can be summarized as using an extreme precipitation event, in combination with a "lesser" snowmelt condition. In identifying a combination of events for freeboard determination, a level of risk or probability of occurrence similar to the PMP plus 100-year snow-melt would be an analogous selection. While a PMF in Florida obviously would not have a snowmelt contribution, a similar critical condition (i.e. level of risk or probability of occurrence) that is characteristic of Florida would be the combination of the PMP with an extreme wind speed of some lesser condition. An example of a lesser wind condition would be a 100-year recurrence interval wind speed.

The 100-year wind condition (has a 1 in 100 probability of occurrence each year) represents a severe criterion when placed in combination with the PMP event. The 100-year wind speed was identified as a "lesser wind condition" that could be reasonably expected to occur simultaneously with a PMP event, and will be used for defining **Case 1** in the freeboard determination. In addition, a recurrence interval of 100 years will be used for the frequency of occurrence for the analysis since this will allow the magnitude to vary with the site location in Florida, such as distance inland. Wind speeds for any given

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frequency are logically greater near the coast than they would be near the center of Florida as hurricanes generally decrease in strength/intensity once the eye of the hurricane makes land fall. Faster moving hurricanes tend to only weaken slightly as they move across the peninsula of Florida, but generally have less rainfall due to this fast progression. Significant surcharge pool levels may not result from an individual storm. However, sequential precipitation events frequently occur with storms that provide extreme precipitation events. Therefore, a minimum design wind speed will be used for all of the impoundments. Slower moving hurricanes generally have greater rainfall but diminish more in strength as they move across the peninsula of Florida.

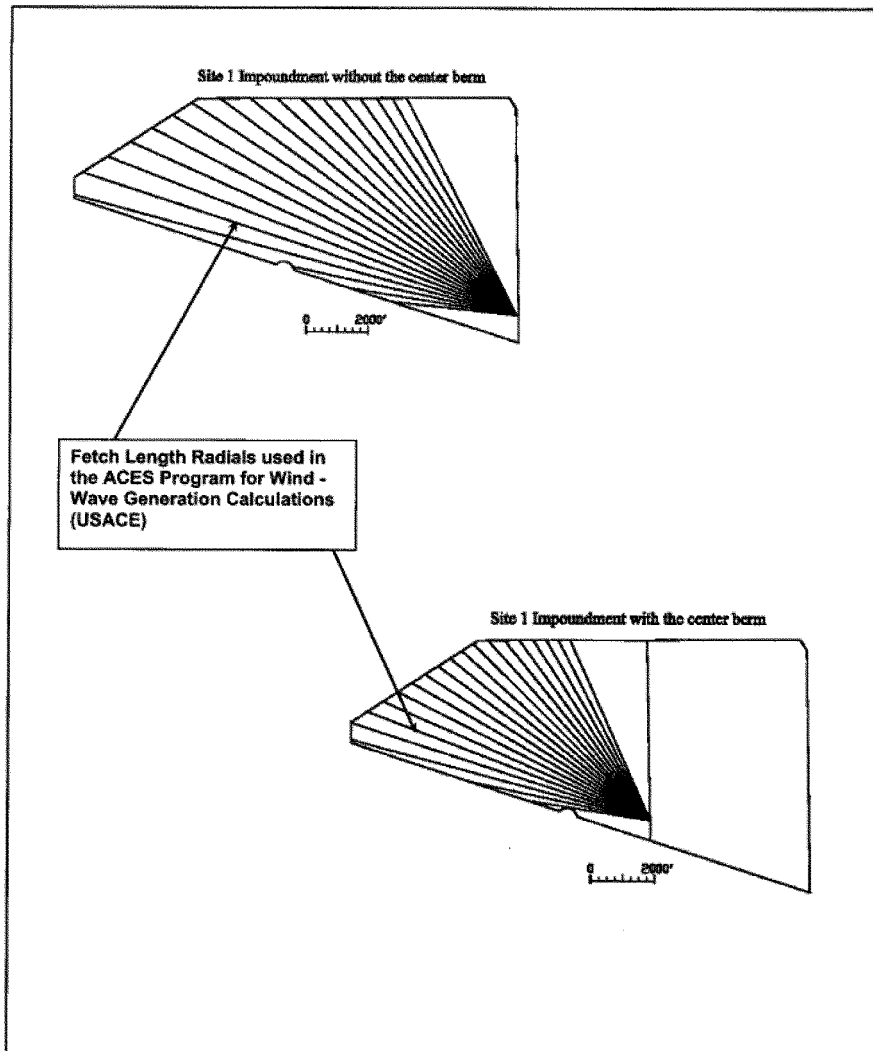
An alternative wind speed for freeboard determination has been considered in a working draft document by the USACE (Jacksonville District, 2004). The USACE selected a 125 mph wind speed as the value to be used in combination with the PMP. The 125 mph wind speed would be applied to all reservoirs to be designed in the CERP study area. Based on our understanding, the 125 mph wind speed represents a wind at the reference level of 33 feet above ground surface, and is interpreted to represent a wind of sufficient magnitude and duration to develop significant reservoir waves. In summary, the December 2004 Working Draft by the USACE (Jacksonville District) states that the maximum design wind speed recommended for CERP impoundments is 125 mph based on the following:

1. Acknowledging South Florida's Building Code requirement for 120 mph.
2. The theorized maximum sustained wind velocities of 130 mph for Water Conservation Area (WCA) 1 and 2 which is further referenced to C&SF GDM summarized data as *"It is estimated that the maximum sustained velocity on Lake Okeechobee would be about 115 mph, with a lake wide average of 85 mph. WCA-1 and -2 maximum sustained velocity would be 130 mph (area average of 100 mph) with WCA-3 having a 120 mph (area average of 85 mph)."*
3. GDM specifies for provision of protection against wave action for 3 or 4 hours in the case of a stagnated hurricane.
4. Category 3 Hurricane on Saffir-Simpson Scale.

The basis for selecting the 100-year wind speed from the Florida Building Code and ASCE (2003) for CERP projects, and the method to be used to calculate wind speeds for design for **Case 1** are described in the following section.

2.1.1.1 100 - Year Wind Speed.

Determination of the 100-year wind speed at a site using the Florida Building Code (www.sbcci.org/floridacodes.htm, Section 1606 Wind Loads) begins with Figure 1606, which is reproduced herein as **Figure DCM 2-2**. The wind speeds on **Figure DCM 2-2** are 3-second gusts in miles per hour that would be expected to occur 33 feet (10 meters) above the ground surface. The 33-ft height for wind speeds is a standard reference height. The wind speeds are further identified as representing ***50-year to 100- year*** peak gusts.



ACCELER8 everglADESnow.org

FIGURE DCM 2-2

EXAMPLE ACES Fetch Length Radials (Site 1)

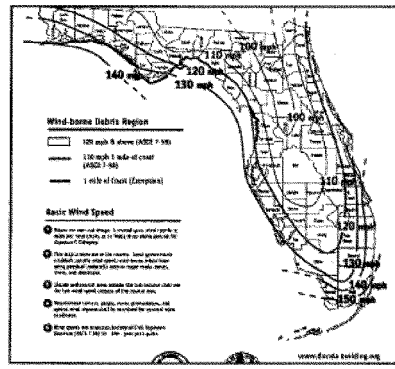


Figure DCM 2-2: Florida 50-Year to 100-Year Gust Wind Speeds (mph) (ref. ASCE 7-02, Figure 6-1b; Florida Building Code, Figure 1606)

The conservative assumption is to assume that the wind speeds on **Figure DCM 2-2** represent 50-year wind speeds and convert the values to 100-year wind speeds, as shown below. The equivalent 100-year wind speeds listed in **Table DCM 2-2**, use a factor of 1.07 to convert hurricane wind speeds from a 50-year to a 100-year return (from the standard structural design reference of the American Society of Civil Engineers (ASCE) Table C 6-3, ASCE 2003). For example, if an area with a 125-mph wind speed is selected from **Figure DCM 2-2**, the corresponding 3-second gust 100-year wind speed would be 134 mph.

Table DCM 2-2: Wind Speed Conversion Factors by Return Period

Return Period (years)	Conversion Factor
500	1.23
200	1.14
100	1.07
50	1.00
25	0.88

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The 3-second gust wind speeds shown on **Figure DCM 2-2** are of an insufficient duration to fully develop significant waves. Specifically, the wind speed duration of 3 seconds is insufficient to develop the wave height, which would occur due to the traction of a constant wind at this speed and propagate the wave across the reservoir. Therefore, wind speed adjustments appropriate for developing significant reservoir waves are to be developed as shown below.

ASCE Figure 6-1b (ASCE, 2003) shows the same wind speeds as Figure 1606 in the Florida Building Code. Figures 6-1a, 6-1b, and 6-1c (ASCE, 2003) cover the Gulf and Atlantic coasts from southern Texas to Florida to North Carolina and to Maine. The figures provide "smoothed" contours of wind speed and are based on a substantial amount of data and analysis. It would be impractical for CERP dam design consultants to duplicate the scope of data analysis used in developing the ASCE figures and is generally not necessary. Use of these figures provides reliable and consistent data from location to location. The analysis of local wind speed gage data, even from first-order stations, would provide unreliable and inconsistent results from location to location because of routine gage malfunctions at extreme wind speeds and the "hit and miss" nature of hurricanes relative to data recording stations. Freeboard criteria for CERP reservoirs, therefore, will be based on Figure 1606 of the Florida Building Code for wind speed data, rather than developing wind speeds based on local gage data, with the appropriate adjustments described below. Figure 1606, which is identified as being based on 50-year to 100-year wind speeds, will be conservatively interpreted as representing 50-year wind speeds for application to freeboard determination.

2.1.1.2 Duration Adjustment of Wind Speeds

When evaluating wave generation in water bodies of different sizes, different wind speed averaging intervals are appropriate. The current Coastal Engineering Manual notes that if extreme wind speeds are being considered, wind speed should be adjusted from the averaging time of the observation (3-second on **Figure DCM 2-2**) to an averaging time appropriate for wave prediction (USACE, 2003, pg. II-2-34). To adjust the wind speeds for duration, the Coastal Engineering Manual references a figure on page II-2-4, which also includes the defining equations? The following equations (USACE, 2003, pg. II-2-4) show the calculation adjustments for the ratio of wind speeds by various durations, to 1-hour average wind speeds.

For $t \leq 3{,}600$: $$\frac{U_t}{U_{3,600}} = 1.277 + 0.296 \tanh\left(0.9 \log_{10}\left(\frac{45}{t}\right)\right) \quad \text{Eqn. 1}$$

For $3{,}600 < t < 36{,}000$: $$\frac{U_t}{U_{3,600}} = -0.15 \log_{10} t + 1.5334 \quad \text{Eqn. 2}$$

where:

t = time (seconds)

U_t = wind speed (mph) at time t (seconds)

$U_{3,600}$ = 1-hour average wind speed (mph)

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For a given wind speed and fetch, there is an associated wind duration that, if exceeded, cannot increase the wave size because of the limiting effects of the fetch and depth. The following equation (USACE, 2003, Eqn. II-2-35) can be used to determine whether or not waves in a particular situation can be categorized as fetch limited.

$$t_{x,u} = 77.23\frac{X^{0.67}}{u^{0.34}g^{0.33}} \qquad \text{Eqn. 3}$$

where:

t = wind duration time (seconds)

X = fetch length (meters)

u = wind velocity (meters/sec)

g = gravitational constant (meters/sec^2)

In English units, the above equation would be:

$$t = 112\frac{X^{0.67}}{u^{0.34}} \qquad \text{Eqn. 4}$$

where:

t = wind duration time (minutes)

X = fetch length (miles)

u = wind velocity (mph)

The above Eqn. 4 is also presented in a current publication on freeboard analysis (Holler, 2004). An example can clarify the procedure for determining the 100-year wind speed that would be coincident with the PMP.

2.1.1.3 Example Wind Speed Adjustments

The following wind speed determination generally follows the example procedure for estimating winds for wave prediction provided in the Coastal Engineering Manual beginning on page II-2-34 (USACE, 2003).

1. Assume the reservoir is in an area where the gust-wind is 125 mph based on the Florida Building Code **(Figure DCM 2-2)**.

2. Adjust the 50-year, 3-second wind speed to an equivalent 100-year wind speed:

   (125 mph) * 1.07 = 134 mph

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3. Adjust the134 mph, 3-second wind speed to a 1-hour wind speed duration with Eqn. 1

$$\frac{U_3}{U_{3,600}} = 1.51$$

The resulting 1-hour average wind speed would be 89 mph (134 mph/1.51).

4. Adjust the over land wind speed to an over water wind speed (USACE, 2003, pg. II-2-36). Considering that various sources provide some conflicting information regarding overland versus over water wind speed adjustments, the conservative approach has been taken that adjusts over land wind speeds to an over water wind speed using a factor of 1.2. The resulting over water wind speed is (89 mph)*1.2 = 107 mph.

5. Assume the reservoir fetch is 5 miles. For this 107 mph wind speed, the minimum duration from Eqn. 4 is 67 minutes (4,020 seconds). Eqn. 4 is used to determine whether or not waves in a particular situation should be categorized as fetch limited.

6. Adjust the 1-hour 107 mph wind speed to 67 minutes duration using Eqn. 2.

$$\frac{U_{4,020}}{U_{3,600}} = 0.993$$

The resulting 67-minute average wind speed to be used for the freeboard determination would be 106 mph. Note, that if the fetch distance was longer, the adjusted wind speed could be less than 100 mph. The minimum wind speed for impoundment design will be a 100 mph over-water, one hour wind speed.

In summary, the application of a 100-year frequency wind speed with the PMF is judged to be of a similar level of risk or probability for freeboard determination, as applied in engineering practice elsewhere for reservoir design. Based on reviews and discussions it was agreed that the 100-year wind speed will be used to represent an extreme, but reasonably possible wind speed in combination with the PMF, for **Case 1** as described above. The 100-year wind speed will be determined from the Florida Building Code or ASCE 07-02 map (and assuming the values have a recurrence interval of 50 years) for the specific project site, and adjusted to the 100-year recurrence interval at the applicable over water wind height, and duration required for wave setup and wind run-up analysis.

2.1.2 Case 2: 100-Year Precipitation Combined with Category 5 Hurricane Winds

Case 2 was identified as one combination of precipitation and wind conditions that could be reasonably expected to occur simultaneously. Freeboard **Case 2** defined in **Table DCM 2-1** includes a Category 5 wind speed as defined by the Saffir-Simpson Hurricane Scale with a 100-year precipitation event. The Saffir-Simpson Hurricane Scale classifies hurricanes based on intensity and damage potential using five categories from 1 through 5, with 5 being the most intense. The Saffir-Simpson Hurricane Scale categorizes hurricanes based on 1-minute sustained wind speeds (ASCE, 2004, pg. 116). The Saffir-

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Simpson hurricane wind speeds are presented in **Table DCM 2-3**, including adjustments to comparable gust (3-second) and 1-hour average wind speeds based on Eqn. 1.

Table DCM 2-3: Saffir-Simpson Hurricane Categories with Duration Adjusted Winds

Hurricane Category	Reference Wind Speed (1-min. avg.)	Duration Adjusted Wind Speed (3-sec. Gust)	Duration Adjusted Wind Speed (1-hour avg.)
1	74 - 95 mph	90 - 115 mph	59 - 76 mph
2	96 - 110 mph	116 - 133 mph	77 - 88 mph
3	111 - 130 mph	134 - 158 mph	89 - 104 mph
4	131 - 155 mph	159 - 188 mph	105 - 124 mph
5	> 155 mph	> 188 mph	> 124 mph

From **Table DCM 2-3**, it is evident that the 3-second gust wind speeds for southern Florida shown in the Florida Building Code (see **Figure DCM 2-2)** mostly fall into the Category 2 equivalent wind speed classification when compared to the duration adjusted values. **Case 2** consists of a reference design wind speed selected for combination with the 100-year precipitation event. The wind speed for **Case 2**, the minimum wind speed that would classify a hurricane as Category 5 will be used, and interpreted as an over water wind speed (i.e. the factor to convert an over land wind speed to an over water wind speed is not applied). The Category 5, 156 mph wind speed for a 1-minute average converts to 125 mph for a 1-hour average wind speed that would have a sufficient duration to generate significant winds on the water surface.

The 100-year precipitation depths coincident with the Category 5 wind speeds can be determined from Technical Publication EMA # 390 - *Frequency Analysis of Daily Rainfall Maxima for Central and Southern Florida* (Pathak 2001). In the freeboard determination, the 3-day 100-year precipitation, as shown on **Figure DCM 2-3**, will be combined with the Category 5 wind speeds for **Case 2**.

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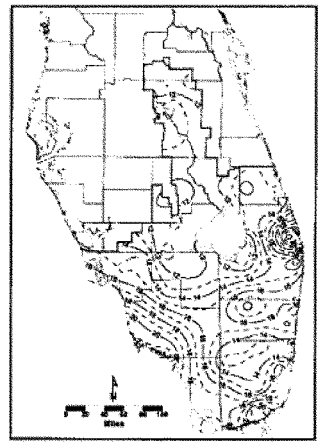

Figure DCM 2-3: 100-Year, 3-Day Precipitation (inches) (ref. Pathak, 2001)

2.1.3 Case 3: Probable Maximum Wind Speed

A third combination of precipitation and wind conditions that could be reasonably expected to occur simultaneously would include a PMW. It is reasonable to assume that a PMW could occur, and reasonable combinations of extreme precipitation events and extreme (but lesser than maximum) wind conditions are considered in **Case 1** and **Case 2**. Therefore, another logical occurrence of events to be considered would be a PMW combined with the reservoir level at the normal full storage level, which is typically considered as the uncontrolled spillway level. There are no known standard references that define the PMW, applicable to southern Florida. Identifying a PMW in a hurricane area poses substantial difficulty, ranging from recorded readings limited by the maximum speed capability of the instrument or damage from flying debris, to fixed point land based instrument locations that most likely have not experienced/recorded the maximum wind conditions (which vary substantially in various sectors of a cyclonic event) generated by the storm. Therefore, selection and application of a PMW for freeboard determination will be used for evaluation of the sensitivity of an extreme wind speed in combination with a normal full storage level. Two hundred miles per hour was initially selected at the workshop as the preliminary wind speed for **Case 3**. A review of historic hurricane wind speeds was performed to evaluate wind speed records and develop an appropriate value to represent a PMW.

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NOAA has listed the highest recorded wind speeds on its Atlantic Oceanographic and Meteorological Laboratory (AORL) Internet site (http://www.aoml.noaa.gov/hrd/tcfaq/E1.html). For the Atlantic region, Hurricane Camille (1969) and Hurricane Allen (1980) are listed as having maximum winds estimated at 190 mph. The AORL Internet site (http://www.aoml.noaa.gov/hrd/tcfaq/D4.html) also notes that the National Hurricane Center uses the 1-minute averaging time as standard for reporting sustained winds. Although the exact measurement location for these winds was not specified, they were assumed to be over water winds on the Saffir-Simpson Hurricane Scale (1-minute avg. duration). Hurricane Camille is listed as an example of a Category 5 hurricane.

The Coastal Engineering Manual notes that the central pressure of Hurricane Camille as it moved onshore at a speed of about 6 m/sec in 1969 was about 912 mb, which corresponds to a 1-minute wind speed of approximately 150 mph (USACE, 1993, pg. II-2-31). Hurricane Gilbert (1988) is listed on the AORL Internet site as having the lowest recorded sea level pressure of 888 mb, which corresponds to roughly a 170 mph 1-minute wind speed. A new low for a recorded sea level pressure for an Atlantic storm was apparently set by Hurricane Wilma in 2005, at 882 mb, with a corresponding 1-minute wind speed of approximately 181 mph.

An overview of reports on historical storms (between 1900 and 1995) with sustained wind speeds of at least 125 mph shows a significant number of recorded and estimated wind events greater than 175 mph (Hurricane Camille) for sustained winds (1 minute or longer in duration sustained wind) potentially up to 250 mph for a peak wind gust (1935). Wind readings reported include measured and estimated (including engineering and scientific estimates based on analysis of damage and/or barometric pressure gradients). More than 25 events of sustained winds greater than 125 mph have been reported (Barnes 1998). Some of the more significant events include:

a. September 1935 Labor Day Hurricane: An estimated sustained wind speed of 200 mph was developed based on damage and the estimate was supported by a scientific analysis of barometric pressure gradients recorded during the hurricane.

b. August 1969 Hurricane Camille: An estimated sustained wind of >175 mph,

c. September 1928 Lake Okeechobee Hurricane: Recorded and estimated sustained wind of >150 mph,

d. September 1926 Miami Hurricane: Recorded and estimated sustained wind >150 mph; sustained wind of 128 mph for 5 consecutive minutes; sustained wind of 138 mph for 2 minutes; and 42 minutes of sustained winds >120 mph,

e. September 1945 at Carysfort Reef Lighthouse: a 2 minute maximum recorded average wind speed of 170 mph,

f. September 1947 at Hillsboro Lighthouse: a sustained wind of 155 mph was recorded,

g. September 1949 Delray Beach: a 1 minute maximum wind speed of 153 mph and a 5 minute maximum wind speed of 132 mph were measured.

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h. September 1960 Hurricane Donna: sustained wind speed of 140 to 150 mph were reported over a wide geographic area ranging from Fort Myers on the west coast to Ft. Meade in Polk County in Central Florida.

In review of historical data, design of facilities must consider that maximum sustained winds speeds (interpreted as 1 minute duration, minimum) would certainly exceed more than 150 mph (essentially a Category 5 hurricane) and would be expected to be in excess of 175 mph. A PMW does not have an established definition. However, in the context of determining criteria for reservoir design and freeboard determination, a correlation with the definition of a PMP would be appropriate. As such, the PMW would be defined as theoretically the highest wind speed for a given duration (1 minute sustained wind) that is physically possible from a cyclonic storm over land and at the reference elevation (33 feet, 10 meter). Additional considerations in determining a PMW would include the limited database of measurement of cyclonic winds based on fixed, land-based weather stations, equipment limitations, damage to instruments from debris, and the probability that extreme hurricane winds that vary around the hurricane vortex are not fully measured in any storm event.

At the December 2004 Design Criteria Workshop, a 200 mph value was identified as an appropriate value for the PMW considering the difficulty of measuring accurate hurricane wind speed, and the high incidence of failure of anemometers in high winds. The data presented in the previous paragraphs indicate the 200 mph wind speed represents a reasonable but conservative upper value for the PMW, if used in combination with a highly probable reservoir level. Therefore a 200 mph wind speed, which is well above the Category 5 minimum wind speed of 156 mph, will be considered the PMW for design of impoundments on CERP projects with a high or significant hazard potential classification (in accordance with **DCM-1**), in combination with the reservoir level at the normal full storage level (i.e. uncontrolled spillway crest level). The 200 mph assumed PMW will be interpreted as corresponding to an over-water, 1-minute average wind (i.e. the factor to convert an over-land wind speed to an over-water wind speed is not applied). Using a procedure similar to that provided for the 100-year wind speed, an example PMW wind speed for reservoir freeboard determination is shown as follows:

1. Adjust the 200 mph, 60-second wind speed to a 1-hour wind speed duration with Eqn. 1

   $$\frac{U_{60}}{U_{3,600}} = 1.24$$

   The resulting 1-hour average wind speed is 161 mph.

2. Assume the reservoir fetch is 5 miles. For this 161 mph wind speed, the minimum duration from Eqn. 4 is 59 minutes. Therefore, the 161-mph 1-hour wind speed would be the applicable wind coincident with the normal full storage level.

It was also considered that the PMW could vary by location in a manner similar to the 100-year wind speed. However, considering the lack of any data records or standard references providing a basis for variation of PMW conditions with location, the 200 mph, 1-minute over-water PMW was identified as the wind speed for **Case 3**. Due to uncertainties inherent in determining extreme winds and the application to wave generation (e.g. it has been reported that waves break up or "blow apart" under high wind conditions), the **Case 3** freeboard determination will be calculated based on the wave height with

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a 2 percent frequency, for manual computations using the SPM/CEM. **Case 3** is to be used only for "sensitivity identification" and not as a selected design condition. Wave models are unlikely capable of yielding results within a degree of confidence for design for these extreme wind speeds, especially over relatively shallow water bodies. Even for 125-mph wind, model capabilities are most likely being "stretched" for project conditions.

2.1.4 Case 4: Storm Specific Wind and Precipitation

In addition to precipitation and wind conditions based on frequency analysis of the region, severe hurricane events have occurred in the State of Florida historically. Combinations of extreme precipitation and wind (Storm Specific) were also evaluated. A storm specific case of precipitation and wind conditions could be reasonably expected to occur and is included as **Case 4**. Storm records show that a 24-hour rainfall record occurred from Hurricane Easy in 1950. Hurricane Easy occurred in the upper Florida west coast over a three-day period, about 90 miles north of Tampa, Florida. Yankeetown was part of the area where the circling hurricane hit twice and a peak 24-hour rainfall of 38.7 inches was recorded, with a 72-hour rainfall depth of 45.2 inches. The precipitation depths from Hurricane Easy at Yankeetown, FL should be routed with the water surface elevation starting at the normal full storage level along with the assumed wind speed for the **Case 4** condition.

A maximum 3-second gust wind speed of 125 mph was recorded during Hurricane Easy, before the anemometer was knocked down by a falling tree (Barnes, 1998). It is unknown whether 125 mph is representative of the maximum wind speed generated by the storm specific hurricane event, or what wind condition occurred in the latter portion of the storm. However, this represents the best available information for use in analysis of wind and precipitation from a recorded storm event that has occurred simultaneously, and is too be used as the assumed wind speed.

A wind speed of 125 mph (3-second wind gust) is similar to the 100-year wind, location specific wind speed determined in the Example comparison, earlier. **Case 4** analysis will consist of the precipitation depths from Hurricane Easy at Yankeetown, FL (both the 24-hour and 72 hour rainfall durations) in combination with a 125 mph (3-second gust) wind speed. Appropriate adjustments to meet the required over-water conditions, wind duration for wave development, etc. are to be applied to the 125-mph, 3-second wind gust. Similarly, storm specific conditions from historical events near the site should also be considered.

2.2 Minimum Freeboard

Combined wind and precipitation design criteria for freeboard determination at high and significant hazard potential impoundments are described in the previous section. Minimum freeboard as described in this section, applies to high, significant and low hazard potential impoundments. The minimum will be the greater of the freeboard determined from the combined wind and precipitation criteria, or the minimum defined in this section.

CERP impoundments will generally be constructed with sandy soil as embankment material. At some sites rockfill or roller-compacted concrete may also be viable alternatives for dam construction. Slope protection consisting of rock riprap, soil-cement or other erosion-resistant layer will be provided on the reservoir (interior) side of the dam to provide wave protection. The exterior slope of the embankment

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will typically consist of sandy soil with vegetative cover. "Hardening" of the downstream slope to allow for over-topping is not planned.

Freeboard is an integral part of all dams. The objective in selection of the design freeboard is to assure that failure of the dam will not result from wind setup, wave action, uncertainties in analytical procedures, and uncertainties in project function in combination with the most critical pool elevation (USACE, ER 1110-8-2 (FR)). Because the impoundments will generally be constructed with highly erodible embankment shell material, freeboard design criteria of zero over-wash resulting from wind setup and wave action is desireable. Zero over-wash is not always required under infrequent high pool conditions. However, it is required that the over-wash not be of such magnitude and duration as to threaten the safety of the dam (USACE, ER 1110-8-2 (FR)).

Under some circumstances, freeboard may not be the same along the entire embankment length. Based on the geometry of many of the CERP impoundments, the fetch length and bathymetry of the storage area could vary significantly for different segments of the embankment. Where impoundments have significant embankment lengths, the risk conditions could vary significantly along the perimeter. Consequently, calculation of freeboard heights could consider the different wind setup/wave heights that could occur and the risk condition associated with embankment segments, in establishing the minimum crest height for a given precipitation and wind combination along various embankment segments.

In addition, a risk based assessment for final determination of the IDF, spillway sizing and freeboard height is required for all hazard classifications. Guidelines for risk based assessment have been prepared by various Federal agencies. The recommended guideline for Incremental Damage Assessment (IDA) for CERP impoundments is *Chapter 2, Selecting and Accommodating Inflow Design Floods for Dams*, Federal Energy Regulatory Commission, Engineering Guidelines for the Evaluation of Hydropower Projects (October 1993). Alternatively, other established methods of conducting and IDA would also be considered.

2.2.1 High and Significant Hazard Potential

High and significant hazard potential reservoirs/impoundments with surcharge pool elevations within three feet of the maximum surcharge pool level (maximum water storage level-MWSL) for a period of 36 hours or longer, have increased probability that high winds in the critical fetch may coincide with this level. Therefore, when the inflow design flood hydrograph is within three feet of the maximum surcharge pool for 36 hours or longer or where the project has been designed with little surcharge for the maximum pool above the normal full storage elevation (NFSL), the minimum freeboard will be five feet (USACE, 1991) for embankment dams (i.e. five feet above maximum water storage level (MWSL)).

Freeboard height, over-wash rate, magnitude and duration are to be evaluated to determine the required freeboard height to safely pass the design event(s). Supporting data for freeboard determination is to include:

1. Freeboard height versus over-wash rate,

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2. Maximum stage versus frequency of exceedance,

3. Narrative description of basis for selection of the freeboard height,

4. Include an analysis of each **Case** described in **DCM – 2**, as well as any other conditions as determined by the designer.

An example of the freeboard height versus over-wash rate and maximum reservoir stage versus frequency of exceedance are shown in **Attachment A**. The supporting data is to be provided for each cell or segment of the impoundment if different freeboard heights are recommended.

2.2.2 Low Hazard Potential

Low hazard potential (HPC) impoundments are facilities that are operated for storage (including **some** Stormwater Treatment Area's – STAs) that do not pose a significant risk, therefore less stringent criteria will be satisfactory. Low hazard potential impoundments are to be determined in accordance with the procedures described in **DCM –1**. The IDF produced MWSL will be determined by routing the 100-year, 24-hour recurrence interval precipitation event (versus the PMP that is required for impoundments with High and Significant HPC). The minimum freeboard for design of Low HPC impoundments is 3 feet on top of the MWSL (unless 36-hour exemption allowed under ER 1111-8-2(FR) is applicable). However, the design freeboard must take the following functional and operational conditions into consideration.

Freeboard requirements for low HPC storage impoundments will be the greater between the described minimum 3 feet or the combination impact of wind setup plus wave runup due to a 60 mph 1-hour wind condition with the MWSL. Low HPC storage impoundments are those impoundments that will most likely not sustain emergent vegetation that dampen waves significantly, due to dry season and operational "dry-outs."

Low HPC storage impoundments with shallow water depths and sustained emergent vegetation (sufficiently developed to impede the build up of significant wave trains), will have the minimum described 3 feet of freeboard. Impoundments meeting this requirement are expected to primarily be low HPC STAs that will be operated as flow through impoundments for the treatment of water to an improved water quality (i.e. treatment process attained in shallow - less than 4 feet of water depth - with sustained vegetation and dryout is not expected except under extreme drought conditions), for the express purpose of water treatment.

2.3 Wind Direction

The height of the wave run-up on a slope depends in part on the incident wind direction and the prevailing wind direction. The prevailing wind direction is not readily identifiable in the Florida peninsula due to the variety of directions by which a hurricane can travel, in addition to the varying wind directions within the hurricane storm itself. Therefore, an assessment of probability of wind by sectors was evaluated from several weather stations.

As described in the Conceptual High Levee Optimization Report (JM/JV dated May 21, 2004), the wind directions were grouped into 16 sectors, 22.5° for each sector. For example, the North (N) sector

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is 11.25° from each side of the true north, East (E) sector is 11.25° from each side of east direction, South (S) sector is 11.25° from each side of south direction, and West (W) sector is 11.25° from each side of west direction. **Figure DCM 2-4** shows the percentages of wind occurrences in 16 sectors at the West Palm Beach International Airport.

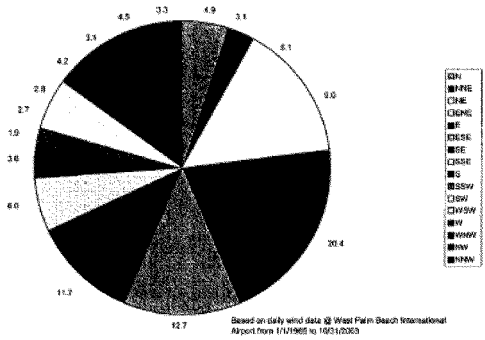

Figure DCM 2-4. Wind Speed Probability by Sector (22.5° interval)

Based on the probability of wind direction by sector at the Palm Beach International weather station, which yielded similar results to other weather stations evaluated in southern Florida, a prevailing wind direction will not be assumed. Winds occurring from any direction are to be considered in analyzing maximum fetch distances, wind setup and wave height plus runup. Analysis of local wind records should be considered in selecting spillway locations.

2.4 Wave Height and Runup

Analysis of conditions to develop freeboard is a complex process. Freeboard height calculations can be performed using spreadsheet and hand calculations using the procedures outlined in the Shore Protection Manual (USACE 1984) and other guidance documents. In recent years computer programs (numerical models) have been developed that allow for faster computations. Numerical models are required by the USACE for the **selected design alternative**. The computer program Steady-State Spectral Wave Model (STWAVE), which can be used for the development of wind-generated wave fields, and the computer program Automated Coastal Engineering System (ACES) which contains models for the computation of wave run-up and overtopping are the recommended numerical models. ACES (WES, 1992) was developed by the Waterways Experiment Station (WES) of the USACE. STWAVE (CHL, 2001) was developed by the Coastal and Hydraulics Laboratory (CHL) of the U.S.

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Army Engineer Research and Development Center. An example of the fetch length radials used for wind-wave generation calculations in the ACES program is shown on **Figure DCM 2-2**.

Wave fields include monochromatic (regular) waves and irregular waves. The irregular waves are to be used to evaluate wave fields to determine wave height for freeboard determination. Thorough understanding of the freeboard design process and the basis of the various factors to be applied is critical to effective use of these computer programs. Adequate training and access to technical support is recommended. The programs should not be used for specific project circumstances that are beyond the limitations of the programs.

The traditional spreadsheet/hand calculations using primarily the Coastal Engineering Manual – CEM (USACE, 2003) and the Shore Protection Manual - SPM (USACE, 1984) can be used for analysis of various alternatives. Although the Coastal Engineering Manual is the most current document, the Shore Protection Manual is referenced for wave runup calculations since that portion of the Coastal Engineering Manual is in Draft form at this time. Wave heights from the CEM/SPM utilize Rayleigh Distribution to evaluate wave fields for structures (e.g. significant wave, 2 percent frequency wave, 5 percent frequency wave etc.). Irregular waves in STWAVE and ACES are similarly used to evaluate wave fields for structures.

The results of final computer-generated parameters are also to be compared with the traditional hand calculation methods for the final selected configuration. A direct one-to-one comparison may not result in an exact match. However, order of magnitude agreement should result. An example of the hand calculation method for developing wind speed, wave height and runup for freeboard determination is presented in **Attachment A**. The example computation is presented for **Case 1** condition, and would be repeated in a similar manner for **Cases 2, 3 and 4** in the determination of the controlling freeboard condition and the required dam crest level.

2.5 Wind Setup

Wind setup is one of the required components in the determination of freeboard. On the shallowest CERP impoundments, wind setup is a particularly important component of freeboard, and may even exceed the wave runup component in magnitude. Three methods are available for determining wind setup. The most widely used wind setup equation as applied to reservoirs is probably the Zeider Zee equation, which normally results in the highest wind setup determination of the three methods. The Zeider Zee equation (USACE, 1997, pg. 15-3) is expressed as:

$$S = \frac{U^2 F}{1400d} \qquad \text{Eqn. 5}$$

Where:

S = wind setup (feet) above the stillwater level

U = average wind velocity (miles per hour) over the fetch

F = fetch length (miles)

d = average depth (feet) of water generally along the fetch line

Although the Zeider Zee equation is commonly suggested for determining wind setup in reservoirs, typical reservoirs in the U.S. are substantially deeper than the typical CERP impoundments. Because the Zeider Zee equation may yield results that excessively over-estimate wind setup at average reservoir water depths that are more typical of CERP impoundments, guidance is provided in this section to recommended alternative wind setup methods.

The recommended alternative to the Zeider Zee equation at lower impoundment depths (average stillwater depth less than 16 feet including surcharge depth), is the Bretschneider method (Bretschneider, 1966). The Bretschneider method normally results in wind setup heights that approach the mean value of results for the Zeider Zee and Sibul equations. For an enclosed reservoir of regular or somewhat irregular shape, an effective stress parameter in the Bretschneider method is presented in an integrated form as follows:

$$\frac{\kappa U^2 F}{g d^2} = \sum_{i=1}^{i=M} \left(\frac{\kappa U^2 \Delta x}{g (d_i)^2} \right) \qquad \text{Eqn. 6}$$

where:

κ = a constant equal to 3.3 x 10^{-6} (dimensionless)

U = average wind velocity (feet per second) over the fetch

F = fetch length (feet)

g = the gravitational constant (32.17 ft/sec^2)

d = average depth (feet) of water generally along the fetch line

i = section number

x = horizontal distance (feet)

The effective stress parameter is used for determining the wind setup (S in feet) as a function of S/d with Tables 5.2 and 5.3 as provided by Bretschneider (1966). The method accounts for wind conditions that may create a partially exposed reservoir bottom along the fetch line.

The Sibul equation (Brater and King, 1976) generally yields the lowest wind setup values of the three wind setup equations. The Sibul equation is expressed as:

$$\frac{S}{d} = 2.44 \times 10^{-5} \left(\frac{F}{d} \right)^{1.66} \left(\frac{U^2}{Fg} \right)^{2.02 \left(\frac{F}{d} \right)^{-0.0768}} \qquad \text{Eqn. 7}$$

where:

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S = wind setup (feet) above the stillwater level

d = average depth (feet) of water generally along the fetch line

F = fetch length (feet)

U = average wind velocity (feet per second) over the fetch

g = the gravitational constant (32.17 ft/sec^2)

The Bretschneider method is recommended for shallow impoundments with average depths less than 16 feet. Under conditions where the Bretschneider method does not have a numerical solution, the wind setup for the more shallow reservoirs can be computed as the average of the wind setup results for the Zeider Zee and the Sibul equations. For the deeper impoundments, with average depths greater or equal to 16 feet, the Zeider Zee equation is recommended because the equation provides a continuous solution without excessive over-estimation of wind setup.

3. Summary

The state-of-the-practice for freeboard determination includes consideration of combinations of reservoir level/precipitation and wind conditions that are reasonably expected to occur simultaneously. Additional considerations include: settlement, waves induced by landslides or malfunction of the spillway and/or outlet works. At a minimum, freeboard determination for design of high and significant hazard potential impoundments will include the precipitation and wind combinations for **Cases 1** through **4** described in this memorandum, as well as settlement, and malfunction of the spillway and/or outlet works for freeboard determination. Freeboard determination will be based on zero over-wash or over-wash that is not of such magnitude and duration as to threaten the safety of the dam. The Rayleigh Distribution (irregular wave field) will be used for the wave analysis. The recommended method for assessing the over-wash potential is an evaluation of the over-wash rate versus embankment height, in conjunction with an analysis of the probability of exceedance of the precipitation plus wind condition (residual risk based on hydrologic conditions) versus a selected embankment height. A methodology for analysis of mixed populations (e.g. precipitation and wind conditions) is included in USACE EM 1110-2-1415.

Considering information in standard references for freeboard and discussions at the Acceler8 Design Criteria Workshop (Dec. 2004), it is most appropriate to determine freeboard for each impoundment for the four cases of combined precipitation and wind events, at a minimum. The most likely controlling case for freeboard would be for a reservoir level resulting from the PMP for the critical condition, combined with a 100-year wind speed – **Case 1**. The 100-year wind speed will be developed for the specific site location using the Florida Building Code and **Table DCM 2-2** (ASCE, 2003), and with the fetch length of the reservoir. The figures, which are identified as being based on 50-year to 100-year wind speeds, will be conservatively interpreted as representing 50-year wind speeds. Calculation of wind set-up and wave run-up will be in accordance with the applicable portions of the USACE Coastal Engineering Manual, with the adjustments shown above. Bretschneider's and Zeider-Zee equations will be used for wind setup analysis. **Cases 2, 3** and **4** will also be evaluated for each impoundment

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facility, to consider the different sizes, configurations, orientations and types of impoundments, to determine what conditions will be the controlling factor.

The minimum freeboard will be determined based on **Cases 1, 2** and **4**. It is recognized that development of a PMW is difficult considering the available information. In addition, knowledge of wind and wave conditions on water surfaces at extreme velocities, such as 200 mph 60-second (or 161 mph 1-hour duration) wind speed for **Case 3**, are not well understood. Some reports note that waves may break up or "blow apart" at high wind conditions. Equations and models for determining wind-wave generation and wind setup therefore may be extremely conservative. Setup reduction has been observed over salt water only, and has been interpreted to be a result of the thick layer of foam developed due to salinity. Consequently, **Case 3** is to be evaluated and used as part of a sensitivity/parametric analysis of setup and wave height analysis, but will not be required as the final basis for determining the minimum freeboard height. Wave generation for **Case 3** will be based on the wave height with a 2 percent frequency. Wave models are unlikely capable of yielding results within a degree of confidence for design for these extreme wind speeds, especially over relatively shallow water bodies. Engineering judgment is to be used in interpreting and applying the results of the **Case 3** analysis. **Case 3** is to be used only for "sensitivity identification" and not as a selected design condition.

Routing of the precipitation event and spillway design will also affect the freeboard determination. For high and significant hazard structures, the design storm is the PMP event unless an IDA demonstrates that a flood less than the PMF results in consequences of dam failure at PMF flood flows that are acceptable. Development and routing of the probable maximum flood (PMF) is to include antecedent storm conditions and un-gated and gated spillway/outlet releases. Spillway design guidelines are covered in Design Criteria Memorandum **DCM-3**. However, antecedent storm conditions for flood routing of the 72-hour PMP will be as follows:

Flood routing for **Case 1** (100 year wind event in combination with the 72-hour PMP) to determine the governing conditions will include the following two scenarios:

1. Routing starts at normal full storage level (uncontrolled spillway crest level),

    a. Route 30 percent of the 72-hour PMF (Time scale 0-hr to 72-hr): un-gated spillway flows, gated structures are in-operable.

    b. A 3-day dry interval with un-gated spillway flow, gated structures are operable (Time scale 72-hr to 144-hr).

    c. Route 100 percent of the 72-hour PMF (Time scale 144-hr to 216-hr): un-gated spillway flows, gated structures are in-operable.

    d. A 10-day dry interval with un-gated spillway flow, gated structures are operable (Time scale 216-hr to 456-hr).

    e. Route 30 percent of the 72-hour PMF (Time scale 456-hr to 528-hr): un-gated spillway flows, gated structures are in-operable.

2. Routing starts at normal full storage level (uncontrolled spillway crest level),

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a. Route 40 percent of the 72-hour PMF (Time scale 0-hr to 72-hr): un-gated spillway flows, gated structures are in-operable.

b. A 5-day dry interval with un-gated spillway flow, gated structures are operable (Time scale 72-hr to 192-hr).

c. Route 100 percent of the 72-hour PMF (Time scale 192-hr to 264-hr): un-gated spillway flows, gated structures are in-operable.

d. A 10-day dry interval with un-gated spillway flow, gated structures are operable (Time scale 264-hr to 504-hr).

e. Route 40 percent of the 72-hour PMF (Time scale 504-hr to 576-hr): un-gated spillway flows, gated structures are in-operable.

Design of impoundments is a complex process of evaluation of the inflow design flood based on the HPC, spillway, outlet structure sizing and operation, and the potential consequences in the unlikely event of dam failure. A risk based assessment for final determination of the IDF, spillway sizing and freeboard height is required for all hazard classifications. Guidelines for risk based assessment have been prepared by various Federal agencies. The recommended guideline for IDA for CERP impoundments is *Chapter 2, Selecting and Accommodating Inflow Design Floods for Dams*, Federal Energy Regulatory Commission, Engineering Guidelines for the Evaluation of Hydropower Projects (October 1993).

This memorandum provides an overall assessment of referenced regulations/engineering manuals for CERP projects and engineering practice, and the interpretation of reasonable combinations of events that are to be evaluated in the design of water storage impoundments (as defined by the National Dam Safety Act) as a minimum. The project designer will have the most complete and thorough understanding of all of the conditions of the facility being designed, and therefore will be the most knowledgeable of conditions that could reasonable be expected to occur. Therefore, the designer for each facility is responsible for determining if other reasonable combinations of events are likely to occur that could be a controlling factor for the determination of freeboard. The designer is to perform further analysis of other reasonable combinations, if deemed necessary, for determination of the final freeboard height to be used for design.

4. References

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7. Federal Emergency Management Agency, October 1998 (reprinted 2004). *Federal Guidelines for Dam Safety: Hazard Potential Classification Systems for Dams*, FEMA 333.

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10. Jacksonville District, Corps of Engineers, December 4, 2004. *Analysis and Hydraulic Design of Embankment Heights for Aboveground Impoundments and Reservoirs for Projects of the Comprehensive Everglades Restoration Plan*, Working Draft.

11. National Weather Service Hydrometeorlogical Report HMR 51, "Probable Maximum Precipitation Estimates, United States East of the 105th Meridian", NOAA, August 1980.

12. National Weather Service Hydrometeorlogical Report HMR 52, "Application of Probable Maximum Precipitation Estimates, United States East of the 105th Meridian", NOAA, August 1982.

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16. U.S. Army Corps of Engineers (USACE), June 30, 1995, Design *of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614.

17. U.S. Army Corps of Engineers (USACE), March 1, 1991. *Inflow Design Floods for Dams and Reservoirs*, ER 1110-8-2(FR).

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18. U.S. Army Corps of Engineers (USACE), March 5, 1993. *Hydrologic Frequency Analysis*, EM 1110-2-1415.

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5. Attachments

Attachment DCM 2A Example Wind Speed and Wave Heights Calculation for Freeboard Determination

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DCM 2 Attachment A

Example of Determining Wind Speed and Wave Height for Freeboard Requirement Based on DCM-2, Case 1

Introduction

An example calculation of wind speed, wind setup and wave runup for freeboard determination was prepared using Reservoir A-1, located about 17 miles south of Lake Okeechobee. In general the reservoir will be trapezoidal in shape, with a surface area of about 17,000 acres and a perimeter embankment length of about 120,000 lineal feet. Interior dikes are planned to reduce the maximum over-water fetch distance that would generate waves. Two spillways were assumed for Reservoir A-1, each with a capacity of 3,000 cfs. Each spillway consisted of an uncontrolled spillway overflow section and a gated spillway section. The uncontrolled spillway section consisted of a 100-foot long, concrete ogee crest with a capacity of approximately 3,000 cfs at 4 feet of head. The inflow design flood (IDF) of 51.9 inches (4.3 ft) was assumed for this analysis. The IDF was routed for the antecedent flood conditions shown in Section 3 (**DCM –2**) and the resulting routed flood peak surcharge depth was 4.5 ft. The gated section of the spillway was designed for additional discharge capacity and was sized for emergency evacuation of the reservoir in accordance with USACE ER 1110-2-50, and the gated section was assumed to be closed/inoperative for purposes of routing the IDF. The preliminary embankment layout and spillway locations are shown on **Figure DCM 2A-1**.

Reservoir freeboard related to wind conditions has traditionally been calculated following procedures in the Shore Protection Manual (SPM) and the Coastal Engineering Manual (CEM). In recent years, computer based numerical codes have been developed (e.g. STWAVE and ACES). The manual/spreadsheet approach based on the SPM/CEM (see discussion in Section 2.4, **DCM – 2**) is satisfactory for analysis of alternatives. However, the numerical programs STWAVE and ACES (or equivalent) are required by the USACE for the final selected alternative for CERP impoundments. In addition, the residual risk associated with over-wash rates versus freeboard height and the freeboard height versus frequency of exceedance are required for analysis and selection of the design freeboard.

The following example includes: 1) manual/spreadsheet following the procedures in the SPM/CEM, 2) computer programs STWAVE and ACES results, and 3) residual risk assessment. A comparison of the results by the manual/spreadsheet and computer program is also provided for information.

1. Manual/Spreadsheet (SPM/CEM Procedure)

Calculation of wind and wave related freeboard requirements involve numerous data sources and technical references, in addition to project specific conditions and engineering judgment. The steps below provide an example of the process of "weaving" through the various references required for freeboard determination. The example demonstrates determination of the required freeboard at

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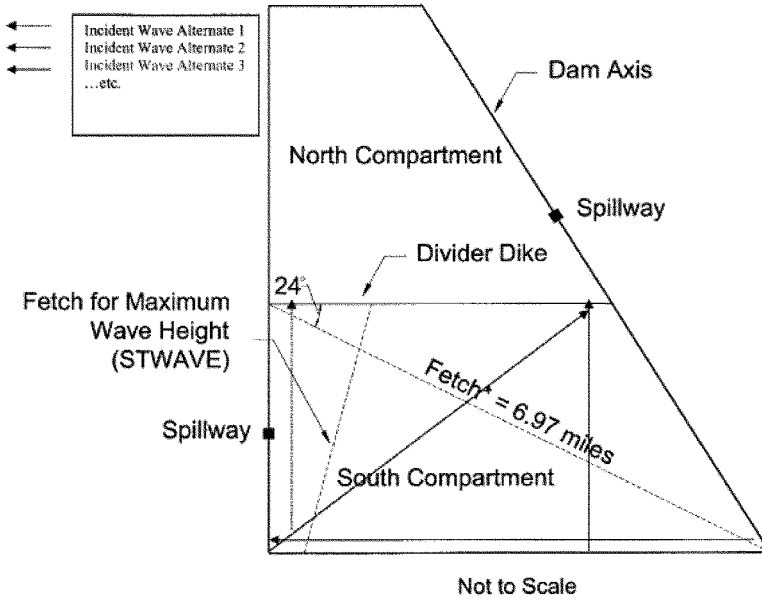

(*) Note: The procedure for estimating the fetch length is to construct nine radials from the point of interest at 3 degree intervals. The average length of radials is used to represent the fetch length at the point of interest. In order to simplify the computations, only the length of the central radial is used for the computations of wind set-up and wave run-up in this example. Since the length of the central radial is the longest among nine radials, this approach is slightly conservative. The procedure of constructing nine radials to compute the representative fetch length should be followed for design phase.
When estimating fetch length, some of the directions along the central radials are not normal to the axis of the embankment. Corrections for central radials not normal to the axis of embankments should be made following the method described in Bureau of Reclamation's report "ACER Technical Memorandum No. 2, Freeboard Criteria and Guideline for computing Freeboard Allowances for Storage Dams, Revised 1992".

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FIGURE DCM 2A-1

EXAMPLE RESERVOIR A-1
EMBANKMENT PLAN

Reservoir A-1 South Compartment, for one alternative and one of the **Cases** described in **DCM – 2**. This example is based on **DCM-2, Case 1**, with an inflow design flood based on the PMP event and a 100-yr annual recurrence interval (ARI) wind speed. The example does not include internal dikes in the South Compartment. The fetch length is 6.97 miles and the angle between the central radial and the axis normal to the embankment is 24 degrees, as shown on **Figure DCM 2A-1**. The maximum water storage depth is 16.5 ft (normal full storage level of 12 ft plus routed peak surcharge depth of 4.5 ft) resulting from the design PMP (**Case 1** specified in **DCM-2**) antecedent storm sequence. A complete determination of freeboard would also include analysis of the other **Cases** described in **DCM-2**.

Six primary references are used in this example calculation, which are:

- U.S. Army Corps of Engineers (USACE), 1984. *Shore Protection Manual*, Coastal Engineering Research Center, Waterways Experiment Station, Second Printing. Referred to as SPM in this document
- U.S. Army Corps of Engineers (USACE), July 31, 2003. *Coastal Engineering Manual*, EM-1110-2-1100, Part II Coastal Hydrodynamics. Referred to as CEM in this document.
- U.S. Army Corps of Engineers (USACE), March 5, 1993. *Hydrologic Frequency Analysis*, EM-1110-2-1415.
- U.S. Army Corps of Engineers (USACE), October 31, 1997. *Hydrologic Engineering Requirements for Reservoirs*, EM-1110-2-1420.
- U.S. Army Corps of Engineers (USACE), March 1, 1991. *Inflow Design Floods for Dams and Reservoirs*, ER 1110-8-2 (FR).
- U.S. Bureau of Reclamation (USBR), 1988. *Downstream Hazard Classification Guidelines*, ACER Technical Memorandum No. 11, U.S. Department of the Interior.

In general, freeboard determination for wind and wave conditions consists of three areas. They are:

a. Determine Design Wind Condition,

b. Wind Setup, and

c. Wave Height and Wave Run-up.

Steps 1 through 33 summarize the methodology described in **DCM-2**, and the technical references used in the calculations. The calculation steps consist of:

- Determine the appropriate wind speed – Steps 1 through 8.

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- Determine the wind stress factor for use in equations that determine wave parameters – Steps 9 and 10.
- Determine deep-water wave parameters – Steps 11 through 13.
- Determine whether use of deep water or shallow-water wave parameters are indicated – Step 14.
- Because shallow water wave conditions were indicated in Step 14, determine shallow water wave parameters including the maximum wave height – Steps 15 through 17.
- Determine wind set-up and the resulting depth at the toe of the embankment – Steps 18 and 19.
- Determine whether depth limited wave breaking occurs – Step 20.
- Because runup curves are based on deep-water wave heights, determine an equivalent deep-water wave height for the shallow-water wave height – Steps 21 and 22.
- Determine runup parameters – Steps 23 through 27.
- Determine the smooth surface runup – Step 28.
- Correct runup for scale effects – Step 29.
- Reduce runup for dam surface roughness – Step 30.
- Adjust runup for fetch axis angle with dam – Steps 31 and 32.
- Determine IDF and wind related freeboard height for **Case 1** – Step 33.

A. Determine Design Wind Speed

The design wind speed is used to develop setup in the reservoir induced by wind acting on the surface of the reservoir, as well as wave height and run-up on the embankment slope. The wind speed used to calculate reservoir setup and wave height is defined as the maximum sustained over-water wind speed measured at height of 33 feet (10 meters). Wind speed records are typically reported as 3-second gusts or one-minute duration over land speeds measured at a height of 33 feet. The design wind speed in steps 1 through 10.

Step 1: Select 50-yr 3-sec gust wind speed
The wind speed map shown in ASCE 7-02 and the Florida Building Code (duplicated as **Figure DCM 2-2**) will be used to determine the site specific wind speed. The wind speed shown on the map is the 3-second, overland wind gust in miles per hour (mph), occurring 33 feet (10 meter) above the ground surface. The wind speed is interpreted as the 50-year annual recurrence interval (ARI). From **Figure DCM 2-2**, the 50-yr ARI, 3-sec gust wind speed at Reservoir A1 site would be 125 mph.

Step 2: Determine 100-yr ARI, 3-sec gust wind speed
Based on **Table DCM 2-2**, the wind speed conversion factor between 100-yr and 50-yr ARI wind speed is 1.07. Therefore, the 100-yr ARI, 3-sec gust wind speed would be 133.8 mph (125 mph in Step 1 multiply by 1.07).

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Step 3: Determine 100-yr 1-hr wind speed
The 3-sec gust wind speed is then converted to a 1-hr wind speed. The 1-hr wind speed approximates the appropriate wind duration for the fetch distance being analyzed. From Eqn. 1 **(DCM-2)**, the ratio between 3-sec gust wind speed and 1-hr wind speed is 1.51. Therefore, the 1-hr wind speed would be 88.6 mph (133.8 mph in Step 2 divided by 1.51).

Step 4: Determine 1-hr wind speed over water
The wind speed computed in Step 3 is an over-land wind speed and will be converted into wind speed over-water in order to compute the wave height. Figure II-2-20 of the CEM is used for conversion of over-land to over-water winds speeds with fetch lengths less than 10 miles. The ratio of over-water to over-land wind speed (Figure II-2-20) is 1.2. Therefore, the 100-yr ARI, 1-hr over-water wind speed would be 106.3 mph (88.6 mph in Step 3 multiplied by 1.2).

Step 5: Estimate fetch-limited duration
Based on the length of travel over-water (fetch), the wind speed used to compute the wave-length, period and height is based on the fetch length and the wind duration required to develop the full wave height (i.e. fetch-limited duration). From Eqn. 4 **(DCM-2)**, the fetch-limited duration for a fetch distance of 6.97 miles would be 84 minutes for the 106.3 mph wind speed calculated in Step 4.

Step 6: Estimate ratio between 84-minute wind speed and 1-hr wind speed
From Eqn. 2 **(DCM-2)**, the ratio between 84-minute wind speed and 1-hr wind speed would be 0.978.

Step 7: Determine 100-yr 84-minute wind speed
This step adjusts the 1-hr wind speed to an equivalent 84-minute wind speed. From Step 6, the conversion ratio is 0.978. Therefore, the fetch-limited wind speed would be 104 mph (106.3 mph in Step 4 multiplied by 0.978).

Step 8: Stability correction
For some conditions an adjustment for stability of the boundary layer may be needed due to air-sea temperature differences. The adjustment (using a correction factor, R_T) may be needed for fetches longer than 16 km (10 miles) as described in the CEM (pg. II-2-36). Since the fetch length of this example the fetch length is 6.97 miles, an adjustment due to air-sea temperature difference is not needed. The wind speed of 104 mph is the effective wind speed (U) defined in Eqn. 3-27 of the SPM.

Step 9: Compute wind stress factor
The wind stress factor (U_A) is defined in Eqn. 3-28b of SPM Vol. I. This correction is needed to reflect the surface roughness due to wave over the water surface. From Eqn. 3-28b, the wind stress factor (U_A) was calculated to be 180 mph.

Step 10: Change unit of U_A

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The wind speed computed in Step 9 is then converted to feet per second (ft/sec) to compute the shallow-water wave height and deep-water wave height. The wind stress factor (U_A) would be 264 ft/sec (180 mph in Step 9 multiplied by 1.467).

B. Wind Setup and Wave Properties

The design wind speed determined in A., above, is used to calculate wave properties for the reservoir. Wave development varies based on the geometry of the reservoir (depth of water, fetch length, etc.). The equations differ depending on whether deep-water, shallow water or transitional conditions occur. Steps 11 through 23 demonstrate wind setup calculations and development of wave properties for one condition.

Step 11: Compute deep-water significant wave height
Based on the fetch distance of 6.97 miles and a U_A of 264 ft/sec, the deep-water wave height is 14.25 ft. (Eqn. 3-33c of SPM Vol. I).

Step 12: Compute deep-water wave period
The deep-water wave period of 6.02 second, is calculated based on the fetch distance of 6.97 miles and U_A of 264 ft/sec (Eqn. 3-34c of the SPM).

Step 13: Compute deep-water wave length
The maximum wave height of 186 ft is then computed from Eqn. 2-8a (SPM Vol. I), using the deep-water wave period for the maximum wave height and the deep-water wave-length

Step 14: Compute relative depth
The relative depth is used to determine whether the computations of wave height and period should be based on the shallow-water equations or deep-water equations. The SPM (pg. 2-9) states that the shallow-water equations should be used to compute the wave period and height when the relative depth is less than 0.5. The relative depth (d/L_o) is the ratio between effective depth and deep-water wave-length. The calculated relative depth is 0.089 (Effective depth of 16.47 ft. divided by the deep-water wave-length (186 ft) in Step 13. Since the ratio is less than 0.5, transitional/shallow-water conditions are indicated.

Step 15: Compute shallow-water wave period
Based on the effective water depth of 16.47 ft, fetch distance of 6.97 miles and U_A of 264 ft/sec, the shallow-water wave period, computed from Eqn. 3-40 in the SPM, is 5.13 seconds.

Step 16: Compute shallow-water significant wave height
Based on the effective water depth of 16.47 ft, fetch distance of 6.97 miles and U_A of 264 ft/sec, the shallow-water wave height, computed from Eqn. 3-39 in the SPM, is 7.82 ft.

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Step 17: Compute shallow-water wave height for zero over-wash
The freeboard height that results in zero over-wash is the design criteria for high and significant hazard dams, for wave runup conditions and freeboard determination due to the erosive nature of embankment material (see **DCM-2**, Section 2 discussion). A wave height with a 2% frequency will be used to analyze a "low probability of over-wash" condition, to evaluate alternative embankment sections. In addition, the 2% frequency wave height will be used for a manual check of the STWAVE generated value.

The shallow-water wave height in Step 16 is the significant wave height. Using Equations 3-7 and 3-10 in the SPM, the 2% wave height ($H_{2\%}$) is calculated as 1.40 times the significant wave height. Therefore, the maximum wave height would be 10.95 ft (7.82 ft. in Step 16 multiplied by 1.40). Note: If deep-water wave length conditions are determined, Steps 15 through 17 would use deep water equations.

Step 18: Compute wind set-up
Based on the effective depth of 16.47 ft, fetch distance of 6.97 miles, and effective wind speed of 104 mph, the wind set-up is then computed using Eqn. 15-1 (USACE EM 1110-2-1420), as 3.31 ft. It should be noted that the effective wind speed (U) in Step 7 is used to compute the wind set-up not the wind stress factor (U_A) in Step 9 (Note, for average stillwater depth less than 16 feet, the Bretschneider method would be used. See Section 2.5, **DCM – 2**).

Step 19: Compute water depth at toe of the structure (dam)
The water depth at the toe of the structure (d_s) would be 19.78 ft, which is the sum of the effective depth of 16.47 ft plus wind set-up of 3.31 ft in Step 18.

Step 20: Check for depth limited wave breaking
Based on SPM Eqn. 2-91 and 3-50, the depth limited wave breaking height is 0.78 times depth. The depth limited wave height is 15.43 feet (0.78 multiplied by 19.78 ft from Step 19). Therefore, the maximum wave height of 10.95 feet from Step 17 is not limited by wave breaking.

Step 21: Estimate ratio between deep-water wave height and equivalent deep water wave height
Runup curves were developed in reference to equivalent deepwater wave heights. The relative depth calculated in Step 14 is less than 0.5. Therefore, an equivalent deep water wave height (H'_o) needs to be computed. The value of H/H'_o (shallow-water wave height / equivalent deep water wave height) is estimated based on the value of d/L_o (effective depth / deep water wave length). The relationship between d/L_o and H/H'_o is listed in Table C-1 of SPM Vol. II, Appendix C. Based on d/L_o of 0.089 in Step 14, the H/H'_o would be 0.9433.

Step 22: Compute equivalent deep-water wave height
The equivalent deep-wave wave height (H'_o) would be 11.61 ft (10.95 ft in Step 17 divided by 0.9433 in Step 18).

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Step 23: Compute ratio of d_s/H'_o
The ratio between the water depth at toe of dike and the equivalent deep-water wave height is then calculated. The ratio would be 1.70 (19.78 ft in Step 19 divided by 11.61 ft in Step 22).

C. Wave Runup

Wave runup is based on the wave height, slope and roughness of the runup surface, and the incident angle of the wind to the slope surface. Steps 24 through 32 demonstrate the calculation of wave runup for one condition.

Step 24: Compute ratio of $H'_o / (g * T_o^2)$
To determine the wave runup, calculate $H'_o / (g * T_o^2)$. H'_o is the equivalent deep-water wave height in Step 22 and T_o is the deep-water wave period in Step 12. The computed value of $H'_o / (g * T_o^2)$ would be 0.0100. This value is used to estimate the wave runup, R_u at the dam. Figures 7-8 through 7-12 in SPM Vol. II show the relationships between R/H'_o and slope of upstream face of the dam (reservoir side) for a series of d_s/H'_o values. These relationships are also expressed as a function of a series of $H'_o / (g * T_o^2)$ curves. Figure 7-10 in the SPM shows the relationship between R/H'_o and slope of upstream face of the dike for the value of d_s/H'_o at 0.8. Figure 7-11 in the SPM shows the relationship between R/H'_o and slope of upstream face of the dike for the value of d_s/H'_o at 2.0. Since the value of d_s/H'_o in Step 23 is 1.70, the value of R/H'_o needs to be interpolated between Figure 7-10 (d_s/H'_o at 0.8) and Figure 7-11 (d_s/H'_o at 2.0).

Step 25: Estimate R/H'_o for d_s/H'_o at 0.8
For slope of upstream face of dike at 3H to 1V, Curve 1 in the attached **Figure DCM 2-A2** was developed based on the values of R/H'_o and a series of $H'_o / (g * T_o^2)$ values for d_s/H'_o at 0.8. For value of $H'_o / (g * T_o^2)$ at 0.0100, the value of R/H'_o was estimated to be 1.20 from Curve 1 in **Figure DCM 2-A2**.

Step 26: Estimate R/H'_o for d_s/H'_o at 2.0
For slope of upstream face of dike at 3H to 1V, Curve 2 in the attached **Figure DCM 2-A2** was developed based on the values of R/H'_o and a series of $H'_o / (g * T_o^2)$ values for d_s/H'_o at 2.0. For value of $H'_o / (g * T_o^2)$ at 0.0132, the value of R/H'_o was estimated to be 1.25 from Curve 2 in **Figure DCM 2-A2**.

Step 27: Estimate R/H'_o for d_s/H'_o at 1.70
The value of R/H'_o was interpolated between Steps 24 and 25/26 for the value of d_s/H'_o at 1.70. The ratio of R/H'_o would be 1.24.

Step 28: Compute smooth surface wave runup
Wave runup for the design wind speed of 104 mph (from Step 8) and fetch length of 6.97 miles would be 14.40 ft (1.24 in Step 27 multiplied the equivalent deep-water wave height at 11.61 ft in Step 22).

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Step 29: Wave runup correction due to scale effects
Figures 7-8 through 7-12 of the SPM were developed based on small-scale laboratory tests. The wave runup values predicted by Figures 7-8 through 7-12 are expected to be smaller than the wave runup on prototype structure because of the inability to scale roughness effects in small-scale laboratory tests (reference SPM Vol. II). The wave runup values from Figure 7-8 through 7-12 are therefore adjusted for scale effects by using Figure 7-13 in the SPM. The correction factor would be 1.12 for slope of upstream face of dam at 3H to 1V. The corrected wave runup value of 16.13 ft is then calculated (14.40 ft in Step 28 multiplied by 1.12).

Step 30: Correction due to dam surface roughness
As described in the example description, the upstream slope is assumed to be constructed using random placed quarry stone. The surface roughness factor for random placed quarry stone is estimated to be 0.55, from Table 7-2 of the SPM. The corrected wave runup due to dam surface roughness would be 8.87 ft (16.13 ft in Step 29 in multiplied by 0.55).

Step 31: Correction factor due to fetch axis not normal to the dam axis
The wave runup computed in Step 28 is based on the assumption that the fetch axis is normal to the dam axis. If the fetch axis is not normal to the dam axis, the wave runup in Step 28 needs to be corrected. A correction curve for incident angles greater or less than 90 degrees has been developed by the U.S. Bureau of Reclamation (Figure 8 of ACER TM No. 2). The angle between the axis of fetch length at 6.97 miles and the embankment axis was calculated to be 24 degrees. From Figure 8 in ACER TM No. 2, the correction factor would be 0.957.

Step 32: Wave runup
The adjusted wave runup would be 8.5 feet (0.957 in Step 31 multiplied by 8.87 ft in Step 30).

D. Freeboard Calculation

The required design freeboard (minimum height above the normal full storage level to the dam crest) is calculated as the sum of:

Flood Surcharge (routed flood) depth
+ Wind Setup
+ Wave height + runup
+ Embankment settlement
+ Waves induced by potential landslides
+ Provision for malfunction of the spillway or discharge structure
= Minimum required design freeboard

Freeboard for this example is calculated in Step 33, below.

Step 33: Minimum required freeboard for **Case 1**

STWAVE: Hs = 7.28 ft => ACES => Height = 28 ft,
Freeboard (not incl. flood surcharge) = 11.53 ft
Manual Comp: Hs = 7.82 ft => ACES => Height = 28 ft,
Freeboard (not incl. flood surcharge) = 11.53 ft

SPM/CEM Significant Wave Height. One additional comparison calculation was also performed. The calculated wave height (Hs) for the longest fetch from the manual calculation was input to the ACES model and used to calculate the freeboard. The results are shown below.

Hs = 7.82 ft from Manual Comp. => Procedure => Height = 28.14 ft,
Freeboard (not incl. flood surcharge) = 11.67 ft

Note that based on the manual calculations in **Table DCM2-A1**, the comparable value of freeboard is 11.80 feet (3.31 ft in Step 18 plus 8.49 ft in Step 32). The comparable height value from the manual calculation would be 28.3 feet (12.0 ft normal full storage level, plus 4.5 ft routed surcharge depth, plus 3.3 ft wind setup, plus 8.5 ft wave runup).

From these results, it can be concluded that, for this particular case, the minimum freeboard determined using the hand computation method (with a wave height of 2 percent frequency using the Rayleigh Distribution) is in good agreement with the minimum freeboard determined using the combined STWAVE/ACES method (using wind conditions along the fetch axis) based on an overtopping rate of 0.1cfs/ft. Analysis for freeboard determination for design, must also include variable wind directions and the bathymetric conditions. As the incident wind direction changes, the wave heights at the down-wind embankment are affected not only by the fetch distance, but the water depth and geometry of the impoundment as well. The fact that the manual computation procedure does not necessarily calculate the maximum possible wave height at the embankment may be a concern. In order to analyze the maximum possible wave height at the embankment, extensive manual computations would be required. Numerical models capable of determining wave transformation over the entire impoundment allowing for variable wind directions and bathymetric conditions (such as STWAVE and ACES) provide an effective capability to analyze the conditions at the CERP impoundments.

Numerical modeling and manual computations can be used for determination of the wind-related portion of freeboard determination. The use of the numerical models requires significant setup and run-time, is not always possible or desire-able for the design of alternatives. Manual computations with sufficient analysis and sensitivity analysis related to wave transformation and bathymetric conditions would be suitable for analysis of alternative embankment sections, but can require extensive analysis of complex conditions. Numerical models are required by the USACE for the selected design alternative. It is also recommended that the results of final computer- generated parameters for the selected design alternative, be compared with the traditional hand calculation methods. A direct one-to-one comparison may not result in an exact match. However, order of magnitude agreement should result.

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Summary

The examples above provide an estimate of freeboard for only one of the Cases defined in **DCM-2**. In order to complete the determination of the design freeboard, analysis of **Cases 2, 3,** and **4** (described in **DCM-2 Section 3),** other combinations of conditions that could be likely to occur, and a more detailed analysis of the spillway capacity and routing of the IDF (as described in Section 3, **DCM-2** and **DCM-3, Spillway Capacity and Reservoir Drawdown Criteria),** is required. Alternative spillway configurations, such as a wider spillway (gated or un-gated) that would reduce the peak routed flood depth should be analyzed. In addition, alternatives to reduce the fetch length and/or wave height/runup should also be analyzed to reduce the wind-related portion of the freeboard height.

Due to the diverse nature of the data that is used, and the various reference documents containing all of the necessary data, it is important that designers fully understand and utilize the referenced documents and the background. The example "weave" through the referenced regulations/engineering manuals, and the **Case 1** condition is just one of the reasonable combinations of events described in **DCM-2** that is to be evaluated for the design of CERP impoundments classified as a dam. The project designer will have the most complete and thorough understanding of all of the conditions of the facility being designed, and therefore will be the most knowledgeable of conditions that could reasonable be expected to occur. Therefore, the designer for each facility is responsible for analyzing the four Cases presented in **DCM-2** and determining if other reasonable combinations of events are likely to occur. In addition, the designer must apply engineering judgement in analyzing the risk and acceptable over-wash rate that is selected for each embankment.

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The example is based on the calculations in the South Compartment without internal dikes. The fetch length (F) is 6.97 miles and the angle between the central radial and the axis normal to the embankment is 24 degrees. The effective (routing of the IDF and the antecedent flood sequence) reservoir water depth is 16.47 ft (d), which is based on reservoir bottom at El. 12.0 ft plus the routed peak surcharge depth of 4.47 feet during the PMP.

Table DCM 2-A1 – Example Computation and Numerical Model Results: Wind Setup – Wave Runup - Freeboard

Description		Manual Calculations			
Step	**Computed Item**	**Value**	**Equation**	**Reference**	**Remark**
A.	**Determine design Wind Speed**				
1	50-yr 3-sec wind	125 mph		Figure DCM 2-2	
2	100-yr 3-sec wind	133.8 mph	= 125 * 1.07	Table DCM 2-2	
3	100-yr 1-hr wind	88.6 mph	= 133.8 / 1.51	Eq. 1, DCM-2	wind speed over land
4	wind speed over water(1-hr)	106.3 mph	= 88.6 * 1.2	Fig II-2-20, CEM	
5	fetch-limited duration	84 min.		DCM-2, Eqn. 4	
6	ratio of wind speed (84 min) to wind speed (1-hr)	0.978		Eq. 2, DCM-2	
7	wind speed over water(84-min)	104 mph	= 106.3 * 0.978		
8	stability correction	none		pp. II-2-36, CEM	
9	wind stress factor, U_A	180 mph	Eq. 3-28b	pp. 3-30, SPM Vol. I	
10	wind stress factor, U_A	264 ft/sec	= 180 *1.467		change mph to ft/sec
B.	**Wind Setup and Wave Properties**				
11	deep water significant wave	14.25 ft	Eq. 3-33c	pp. 3-44, SPM Vol. I	

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Description		Manual Calculations			
Step	**Computed Item**	**Value**	**Equation**	**Reference**	**Remark**
	height				
12	deep water wave period, T_0	6.02 sec	Eq. 3-34c	pp. 3-44, SPM Vol. I	
13	deep water wave length, L_o	186 ft	Eq. 2-8a	pp. 2-9, SPM Vol. I	
14	relative depth, d/L_o	0.089	=16.47 / 186	pp2-9, SPM	
15	shallow-water wave period	5.13 sec	Eq. 3-40	pp. 3-55, SPM Vol. I	
16	shallow-water significant wave height	7.82 ft	Eq. 3-39	pp. 3-55, SPM Vol. I	
17	shallow water 2% wave	10.95 ft	=1.40 * 7.82	Eq. 3-7 and 3-10 of SPM Vol. I	
18	wind set-up	3.31 ft	Eqn 15-1	EM 1110-2-1420	
19	water depth at toe of dam, d_s	19.78 ft	= 3.31 + 16.47		
20	depth limited wave breaking	15.43 ft	0.78*19.78	Eqn. 2-91 and 3-50 of SPM	
21	H/H'_o	0.9433		Table C-1, SPM Vol. II Appendix C	based on d/L_o @ 0.089
22	H'_o, equivalent deep-water wave height	11.61 ft	= 10.95 / 0.9433		
23	d_s/H'_o	1.70	= 19.78 / 11.61		
C.	**Wave Height and Runup**				
24	$H'_o/(g * T_0^2)$	0.0100	= 11.61 / (32.17 * 6.02^2)	Fig. 7-8 through 7-12, SPM Vol. II	
25	R/H'_o for d_s/H'_o @ 0.8	1.20		Fig 7-10, pp. 7-21, SPM Vol. I & Fig A2	based on $H'_o/(g * T_0^2)$ @ 0.0100
26	R/H'_o for d_s/H'_o @ 2.0	1.25		Fig 7-11, pp. 7-22, SPM Vol. I & Fig A2	based on $H'_o/(g * T_0^2)$ @ 0.0100
27	R/H'_o for d_s/H'_o @ 1.70	1.24			interpolate R/H'_o between steps 25 & 26

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Description		Manual Calculations			
Step	**Computed Item**	**Value**	**Equation**	**Reference**	**Remark**
28	wave run-up, R	14.40 ft	= 1.24 * 11.61		
29	wave runup correction due to scale effects	16.13 ft	=1.12 * 14.40	Figure 7-13, SPM Vol. II	
30	wave runup corrected due to surface roughness	8.87 ft	= 16.13 * 0.55	Table 7-2, SPM Vol. II	Based on surface roughness factor of 0.55
31	correction factor due to angle	0.957		Figure 8	ACER TM No. 2
32	wave runup at embankment	8.5 ft	= 0.957 * 8.87		
D.	**Freeboard Calculation**				
33	Required Freeboard – **Case 1** (not including settlement, landslides induce waves or spillway/discharge structure malfunction)	~16.30 ft	= 4.5+3.31 + 8.5		wave runup + wind setup

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Table DCM 2-A2: Example Problem - Reservoir A-1 Southern Compartment

	Still Water Depth (NFSL)	Wind Speed	Wind Setup	Effective Depth	Significant Wave Height	Wave Period	Slope Type	Runup	Qo*	Overtopping (cfs/ft) by embankment height										
	(ft)	(mph)	(ft)	(ft)	(ft)	(sec)		(ft)		20ft	25ft	26ft	27ft	28ft	29ft	30ft	31ft	32ft	33ft	34ft
STWAVE Maximum	16.47	106.33	3.27	19.74	8.37	6.7	Rough 1V:3H	8.25	0.020	22.208	1.895	1.026	0.528	0.272	0.129	0.057	0.024	0.009	0.003	0.001
STWAVE Fetch Axis	16.47	106.33	3.27	19.74	7.28	5.6	Rough 1V:3H	6.71	0.020	19.021	0.790	0.342	0.147	0.055	0.019	0.005	0.001			
Manual Comp Fetch Axis	16.47	106.33	3.27	19.74	7.82	5.1	Rough 1V:3H	6.63	0.020	20.895	0.824	0.351	0.148	0.055	0.018	0.005	0.001			

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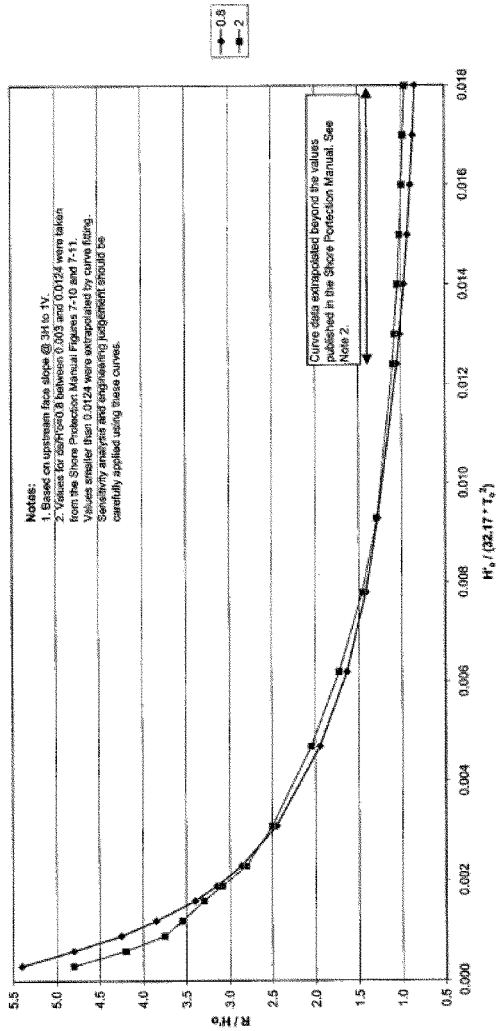
Figure DCM 2- A2
R / H^{1}_{o} vs $H^{1}_{o} / (g * T_{o}^{2})$

Notes:
1. Based on upstream face slope @ 3H to 1V.
2. Values for dsR'/H'o 0.8 between 0.003 and 0.0124 were taken from the Shore Protection Manual Figures 7-10 and 7-11. Values smaller than 0.0124 were extrapolated by curve fitting. Sensitivity analysis and engineering judgement should be carefully applied using these curves.



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A.8.6 DCM-3 Final

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Design Criteria Memorandum: DCM-3 **Revision 001.0**

Effective Date: February 3, 2006 **Acceler8 Ref. #: P599**

Subject: Spillway Capacity and Reservoir Drawdown Criteria

1. Introduction

This memorandum presents the SFWMD hydraulic design criteria for spillway and reservoir drawdown for CERP projects, with primary reference to established Federal guidelines.

The two primary reference documents that are to be used for spillway design criteria are:

Federal Emergency Management Agency October 1998 (Reprinted April 2004), *Federal Guidelines for Dam Safety: Selecting and Accommodating Inflow Design Floods for Dams*, FEMA 94.

Inflow Design Floods for Dams and Reservoirs, ER 1110-8-2(FR), U.S. Army Corps of Engineers (USACE), March 1, 1991.

A spillway is required for CERP high and significant hazard potential (determined in accordance with **DCM-1**) water storage impoundments to provide a means for safely passing flood flows, and to maintain storage levels at or below the maximum full storage (elevation) level (MFSL) to accommodate the inflow design flood (IDF). Spillway design will also be used in the determination of impoundment freeboard, as described in **DCM-2.** Design of a spillway should be considered for CERP low hazard classification water storage impoundments, but is not required. In addition, the SFWMD has requirements for maximum allowable discharge under normal conditions for new projects as detailed in the SFWMD *Basis of Review for Environmental Resources Permit Applications* (Appendixes 2 and 6).

Reservoir drawdown capability is also required for reservoir impoundments to accommodate operation and/or maintenance requirements, as well as the potential need for reservoir evacuation in the event of an emergency condition. The primary reference that is to be used for reservoir draw down is:

Low Level Discharge Facilities for Drawdown of Impoundments, ER 1110-2-50, U.S. Army Corps of Engineers (USACE), August 22, 1975.

Select key spillway and outlet design criteria are summarized herein. Specific issues that could also affect spillway design criteria of CERP dams that are not included in Federal guidelines are also addressed in the following sections. However, this document is not intended to be a comprehensive presentation of the referenced documents. This memorandum presents the joint criteria and recommendations developed by the SFWMD, the Florida Department of Environmental Protection (FDEP), and the U.S. Army Corps of Engineer's (USACE) for evaluating spillway and reservoir drawdown of CERP impoundments.

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2. Design Floods

Design flood conditions for the CERP impoundments will include an IDF based on the hazard classification of the impoundment and potential impacts due to flooding associated with the "Water Quantity Criteria" in the SFWMD *Basis of Review for Environmental Resource Applications* (December 2004, and future updates). The Federal Emergency Management Agency (FEMA) defines the IDF as *"The flood flow above which the incremental increase in water surface elevation downstream due to failure of a dam or other water retaining structure is no longer considered to present an unacceptable additional downstream threat"* (FEMA, 2004). The IDF for a dam is the flood hydrograph used for determining or evaluating the maximum height of a dam, freeboard, and flood storage requirements as well as for the design of appurtenant features (in particular sizing of the spillway and outlet works/discharge structure).

The adequacy of a spillway must be evaluated by considering the hazard potential that would result from failure of the project works during flood flows. If failure of the project works would present an unacceptable downstream threat, the project works must be designed to either withstand overtopping for the loading condition that would occur during a flood up to the probable maximum flood (PMF), or to the point where a failure would no longer cause an unacceptable additional downstream threat. The Hazard Potential Classification (HPC) for each CERP project in the Acceler8 program will be determined as specified in design criteria memorandum **DCM-1.** Based on the HPC, the IDF will be defined as the flood resulting from the probable maximum precipitation (PMP) event, or a lesser storm event. Unlike many reservoirs, all of the inflow to the CERP impoundments will occur by pumping and direct precipitation since there are no gravity (tributary) inflows to the impoundments which are formed by fully encircling embankments. The design will assume that the inflow pumps (but not necessarily seepage return pumps) will be shut down when the reservoir level reaches the normal full storage (elevation) level (NFSL).

The effects of changing the downstream flow regime can potentially change the risks to affected properties. The Water Quantity Criteria presented in Appendix 2 of SFWMD's *Basis of Review for Environmental Resource Applications* relates to these concerns. In addition, FEMA Flood Insurance Rate Maps (FIRM) define the 100-year flood plain for purposes of flood insurance. The Water Quantity Criteria and 100-year flood plain will need to be included in the analysis of spillway design.

3. Spillway Capacity

Spillway capacity should be determined as an economical combination of spillway capacity and surcharge storage. Surcharge storage is defined as the storage between the NFSL (still water) and the maximum water storage (still water flood level) level (MWSL). Determining the economical combination of surcharge storage/spillway capacity requires evaluation of the cost of increasing spillway capacity versus the cost of raising the embankment to provide the required freeboard (routed maximum flood level plus the height required for wind setup and wave run-up, as described in **DCM-2**). Reservoir flood routing is used to determine the temporal and water level variation of the hydrograph as the flood passes through the reservoir. Increasing the spillway capacity will reduce the necessary surcharge storage (determined by flood routing), thereby lowering the required height of the dam. Alternatives analysis should be performed to optimize spillway capacity to reduce the flood surcharge (in contrast to storing the entire IDF in the reservoir without flood routing). Key factors in routing of the IDF include: a) the initial reservoir level at the start of the design flood, b) ungated spillway capacity that operates regardless of outside (personnel or mechanical)

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action, c) gated spillway capacity that could be operated by outside action in a "dry spell" following a storm event or a defined sequence of storms that would comprise the IDF, and d) freeboard requirements for wind setup, wave height and wave run-up.

The initial reservoir level that is to be used for the flood routing for spillway design is the "normal full storage (elevation) level." The NFSL is defined as the maximum elevation of storage at an un-gated, uncontrolled level where outflow would begin with continued storage. For a reservoir whose outflow is controlled partly by moveable gates or other means, the NFSL elevation is the maximum level to which water may rise under normal operating conditions, exclusive of any provision for flood surcharge. Essentially the NFSL is the maximum reservoir level that the reservoir would return to following an inflow of water, without outside action. An uncontrolled (i.e. ungated) spillway crest would generally define the NFSL. Design of ungated spillway structures should also consider minimizing the potential for reservoir capacity loss due to wind setup in the reservoir. It should also be noted that the volume of the 25 year, 72 hour storm (as described in the *Basis of Review* document) does not have to be "reserved" below the NFSL (uncontrolled, service spillway crest), as the storm is encompassed within reservoir storage below the NFSL and routing of releases within the allowable discharge.

An uncontrolled crest spillway is the primary method typically used in the design of water storage impoundments for passing the IDF. Reservoirs in relatively flat terrain such as the Florida Everglades region do not have the advantage of high discharge rates that can occur in steeper terrain in mountainous areas (which provide the potential for high discharge capacities from the high hydrostatic head). Reservoir capacity in the Everglades area is primarily obtained by constructing a fully enclosed perimeter embankment with a large surface area. Spillway capacity at each CERP impoundment could be provided by a number of engineering options. The simplest spillway option would be the construction of a wide, uncontrolled (un-gated) weir. Spillway capacity has the benefit of an increase in discharge rate as an exponential function of the hydrostatic head above the spillway crest. The discharge over a spillway weir therefore increases exponentially with the increase in reservoir surcharge pool depth above the control level. The only methods to decrease the maximum flood level for flood routing are to: a) increase the spillway crest length, and/or b) include a gated structure with a lower crest level than the uncontrolled (ungated) spillway section that is operated by outside action.

A gated spillway alternative would be a structure that could be opened to provide reservoir drawdown following a flood event when external action (personnel or mechanical) could be reasonably expected. Gated spillways can also be used to provide reservoir drawdown if necessary during a dam safety emergency event. Gated spillways are often located adjacent to an ungated spillway to reduce the number of structures passing through the dam and to minimize structure cost when the outlet structures can be combined.

Releases during and following a storm event are to consist of a combination of uncontrolled spillway releases plus gated spillway and outlet discharge release capacity. However, when considering the hazard potential of a reservoir impoundment, conservative assumptions for the IDF and operation or in-operability assumptions for gated spillways and outlet releases must be made. Reservoir regulating outlets (gated spillway and discharge outlets) shall not be assumed to be operable during the occurrence of the IDF nor should it be assumed that regulating outlets or spillway gates would be attended during the IDF.

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Optimization of the impoundment design will include analysis of the uncontrolled spillway capacity, gated spillway and discharge outlet capacity, and embankment height, all determined by routing of the IDF storm. Storm events that could lead to flooding often occur as a series of major storms. The potential for a series of major floods should be considered in the spillway design. The spillway capacity should provide for the evacuation of sufficient surcharge storage to accommodate a major flood antecedent to the IDF. In view of the uncertainties involved in estimating reservoir levels that might reasonably be expected to exist at the beginning of the IDF, an antecedent storm condition will be included in the analysis of the IDF. For high hazard potential impoundments, the antecedent storm conditions defined in **DCM-2** will be used for spillway design. For CERP high and significant hazard impoundments, the "full flood control pool level" (shown in the *Basis of Review* document) will generally be the uncontrolled spillway crest level.

Another area of concern in spillway design is the potential impact from discharges on downstream areas. Allowable discharges have been developed for various basins in the SFWMD and are defined in Appendix 2 of the *Basis of Review for Environmental Resource Applications.*

Allowable discharge for storm events up to the 100-year event shall be based on the SFWMD *Basis of Review for Environmental Resource Applications* (December 2004, and the most current update at the time of design). To reduce the potential for impacts downstream from flood releases, the reservoir outflow resulting from events up to the 100-year event shall not exceed the Allowable Discharge, based on the formula applicable to the project basin; or increase the downstream inundation beyond the pre-design 100-year limits. This is defined as the Allowable Discharge. Meeting this criterion and safely passing the PMF may require additional spillway width with different crest elevations, notched spillways or a combination of both.

Spillway capacity required for meeting the Allowable Discharge will be designated the "Service Spillway Capacity" and the additional capacity required to safely pass the IDF will be designated "Auxiliary Spillway Capacity" or "Auxiliary Discharge Structure." The related structures required for the Allowable Discharge and IDF will also be referred to as Service Spillway and Auxiliary Spillway, respectively. The relationship of the spillway crest level(s), crest level and NFSL are shown of **Figure DCM 3-1**.

4. Spillway Location

The location and size of the spillways on the dam must consider the flood carrying capacity of the downstream flow conveyance system. Downstream flooding impacts from reservoir spillway discharges must be considered. For the larger reservoirs having miles of embankment length, reservoir outflow capacity using multiple spillways should be considered. The receiving canals/river channel capacity must be considered and if feasible, spillways should be co-located with larger receiving channels when siting of the spillway(s). In some cases, consideration should be given to increasing capacity of receiving channels in conjunction with construction of new spillways. The location of spillways should also include the need to have physical access (vehicular and personnel) to the spillway(s) during flooding conditions. A generalized layout of spillway locations is shown on **Figure DCM 3-2**.

Spillway design must consider that sustained winds could come from any direction. Sustained winds on long fetches can cause substantial wind setup during the IDF. If wind setup causes increased water levels on the windward side of the reservoir, it will also cause lower water levels on the leeward side. Reservoir

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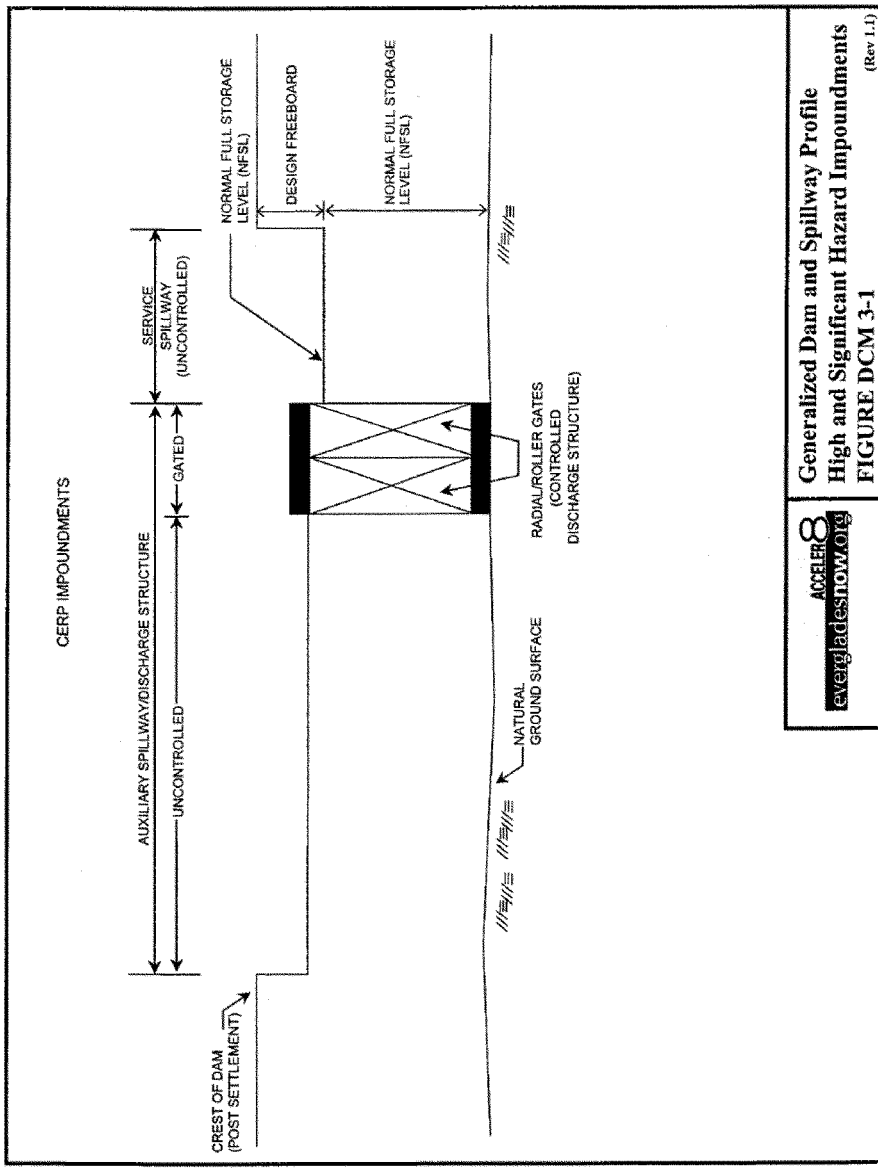
CERP IMPOUNDMENTS
AUXILIARY SPILLWAY/DISCHARGE STRUCTURE
UNCONTROLLED
GATED
SERVICE SPILLWAY (UNCONTROLLED)
CREST OF DAM (POST SETTLEMENT)
NORMAL FULL STORAGE LEVEL (NFSL)
DESIGN FREEBOARD
NORMAL FULL STORAGE LEVEL (NFSL)
RADIAL/ROLLER GATES (CONTROLLED DISCHARGE STRUCTURE)
NATURAL GROUND SURFACE
ACCELER8
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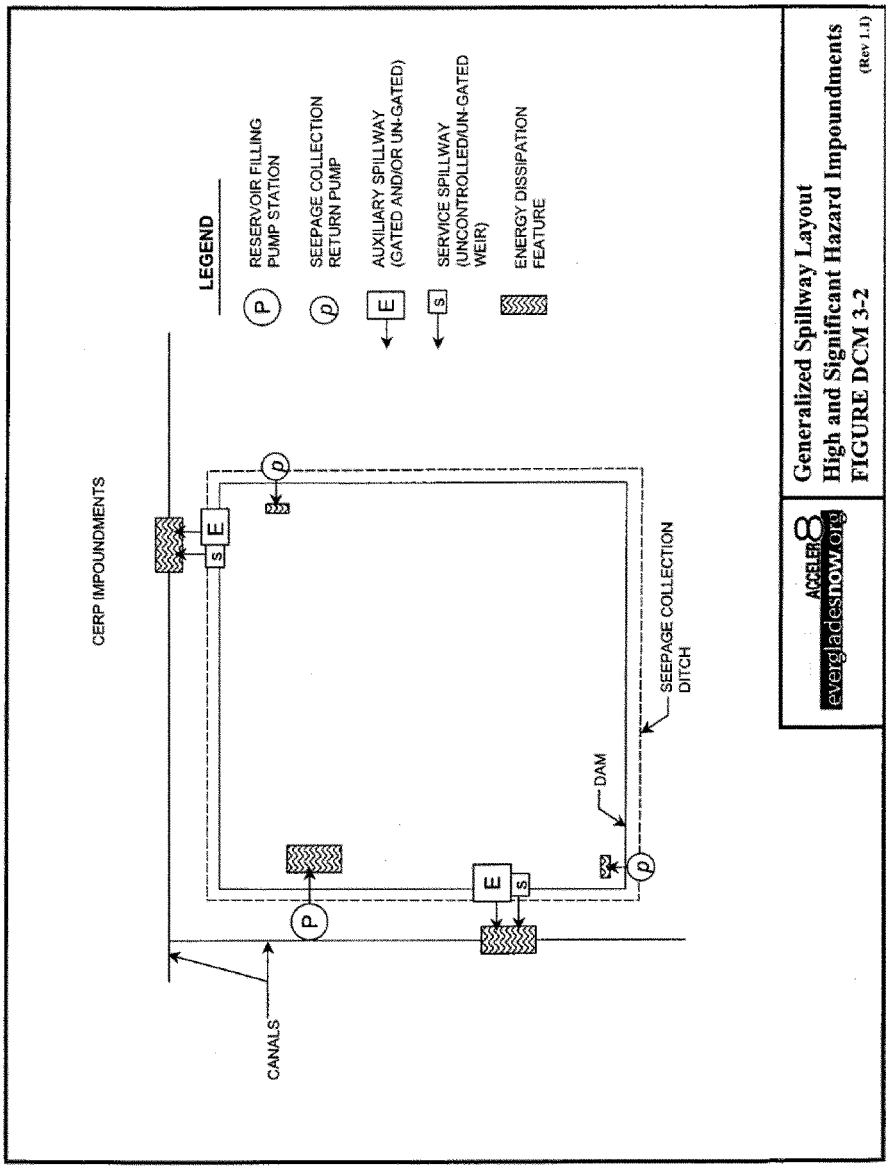
Generalized Dam and Spillway Profile
High and Significant Hazard Impoundments
FIGURE DCM 3-1
(Rev 1.1)


LEGEND
RESERVOIR FILLING PUMP STATION
SEEPAGE COLLECTION RETURN PUMP
AUXILIARY SPILLWAY (GATED AND/OR UN-GATED)
SERVICE SPILLWAY (UNCONTROLLED/UN-GATED WEIR)
ENERGY DISSIPATION FEATURE
CERP IMPOUNDMENTS
CANALS
DAM
SEEPAGE COLLECTION DITCH
P
p
E
S
ACCELERATE
evergladesnow.org
Generalized Spillway Layout
High and Significant Hazard Impoundments
FIGURE DCM 3-2
(Rev 1.1)

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routing of the IDF should consider the most critical effects of wind setup on water levels at the spillways. Wind setup requirements (as described in **DCM-2**) may require spillways at more than one location and/or opposite ends of the reservoir.

5. Reservoir Drawdown

Reservoir drawdown requirements will be based on USACE ER 1110-2-50, *Low Level Discharge Facilities for Drawdown of Impoundments*. At a minimum, low level discharge facilities will be sized to be capable of reducing the normal full storage to a pool level which will result in an amount of storage in the reservoir that is 10 percent of the NFSL, within a period of four months. The beginning pool level for drawdown will be the NFSL.

6. References

Federal Emergency Management Agency, October 1998 (Reprinted April 2004). *Federal Guidelines for Dam Safety: Selecting and Accommodating Inflow Design Floods for Dams*, FEMA 94.

U.S. Army Corps of Engineers (USACE), August 22, 1975. *Low Level Discharge Facilities for Drawdown of Impoundments*, ER 1110-2-50.

U.S. Army Corps of Engineers (USACE), March 1, 1991. *Inflow Design Floods for Dams and Reservoirs*, ER 1110-8-2(FR).

South Florida Water Management District (SFWMD), *Basis of Review for Environmental Resource Applications*, December 2004.

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This document provides working level guidance to assist in the implementation of projects and project features under the Comprehensive Everglades Restoration Plan implemented by South Florida Water Management District, the Florida Department of Environmental Protection and the U.S. Army Corp of Engineers. This guidance does not supersede existing or future federal or state regulations, does not constitute policy for any of these agencies, and does not create authority beyond that granted to any agency member carrying out their duties.

A.9 CIVIL DESIGN

A.9.1 Material Balance and Disposal

All required materials for the construction of the embankments and levees, with the exception of the granular chimney drain feature of the embankment and road surfacing material, will be obtained from the excavation and processing of the corresponding seepage or conveyance canals along each of the embankment or levee components of the project. The C-11 Impoundment embankment will be constructed with a homogenous fill material and chimney drain (non- calcareous gravel material with filter layer), see plate G-15A. The C-9 Impoundment embankment will be constructed with a suitable fill material, Core zone, and chimney drain (non- calcareous gravel with filter layer), see plate G15-B. The C-9 and C-11 Impoundment embankments will have erosion protection on the upstream face with plate Cement Stabilized Aggregate (CSA). If there is excess excavated material it will be deposited in the abandoned borrow pits within the impoundment and wetland mitigation areas. The old borrow pits within the mitigation areas are expected to be backfilled up to elevation 4.0 feet NGVD29, or approximately 2 feet below average existing ground elevation. The old borrow pit within the C-11 impoundment is expected to be backfilled up to elevation 1.0 feet NGVD29, or approximately 5 feet below existing ground elevation.

The following embankments will be constructed with suitable fill material. The core excavation material will be processed and graded to obtain a select gradation required for the all embankments: L-502A, L-512 (Northeast and East levees of Mitigation Area "A"), L-513 (North and East Levee of Mitigation Area "B"), L-514 (Northwest and West Levee of Mitigation Area "A"), L-502B (South of C-9 Canal), L-503, Holly Lakes Mobile Home Park Levee, and Bishop/Nixon Levee. The seepage control levees and canals, such as L-502A/C-502A, L502B/C-502B (South), and L-503/C-503, and the flood protection levees and canals, such as those for Holly Lakes Mobile Home Park, were designed to obtain a balanced quantity of required fill from the canals excavation along side. The excavation of the conveyance canal C-502B (North) is a source of loose excavated material since the spoil mounds along its side will be entirely built with excavated rock. It is expected that the excavation of this canal will provide over 200,000 cubic yards of suitable fill material that will be processed, screened, and graded for the purpose of constructing access ramps and roads.

The most fill demanding and material unbalanced features of the project are the construction of the C-11 and C-9 Impoundment embankments. The impoundments are also the areas where the excess excavated suitable fill will be disposed. Therefore, aggregate processing will take place within the

impoundments footprint. This will reduce the hauling distances for the processing and placing of most of the required embankment materials.

The only materials that will be required to be brought in from outside sources will be the non-calcareous gravel material, sand, and Cement Stabilized Aggregate (CSA) for upstream slope protection. The surface unsuitable material that will be scrapped or removed for either the excavation of canals or the construction of embankments will be disposed within the available disposal areas inside the project site. A small amount of excavated asphaltic concrete, generated during the degrading of two existing roads within the footprint of the C-11 Impoundment, will be required to be disposed off site for environmental considerations. There is the possibility that this material will be taken by asphalt processing plants as recycle asphalt which is used in new asphaltic concrete mixes.

The following tables detail the computation and balance of earthwork materials.

MATERIALS COMPUTATION AND BALANCE SHEET
8-Feb-07

LEVEE/CANAL SECTION	DISTANCE (FT) (A)	REQ. SUITABLE FILL (CY) (B)	EXCV. SUITABLE FILL (CY) (C = D + E)	BLASTED ROCK (CY) (D)	LOOSE FILL (CY) (E)	BALANCE (CY) (NEG = FILL REQ.) (F = C - B)	UNSUITABLE MTL. TO DISPOSE (CY) (G)
L-502A/C-502A							
REACH 1	8,200	46,884	46,983	39,466	7,517	99	73,041
REACH 2	9,000	79,733	79,733	59,003	20,731	0	99,233
REACH 3	11,500	101,881	102,574	53,986	48,588	692	52,463
		228,499	229,290	152,454	76,835	791	224,738
REQ. SELECT FILL =		66,265	EXCAV. LOOSE FILL AVAIL. =		76,835	BALANCE =	10,571
REQ. RANDOM FILL =		162,234	EXCAV. BLASTED ROCK AVAIL. =		152,454	BALANCE =	-9,780
C-11 EMBANKMENT	34,550	518,680	2,094,278	1,354,404	739,874	1,575,598	556,157
MITIGATION AREA "A"	2,554	16,671	36,284	23,584	12,699	19,612	26,638
MITIGATION AREA "B"	15,847	105,004	44,056	28,636	15,420	-60,948	106,023
		640,356	2,174,618	1,406,625	767,993	1,534,262	688,818
REQ. SELECT FILL =		128,135	EXCAV. LOOSE FILL AVAIL. =		767,993	BALANCE =	639,858
REQ. RANDOM FILL =		577,648	EXCAV. BLASTED ROCK AVAIL. =		1,406,625	BALANCE =	828,977
DRAIN SAND		84,330 CY	MATERIAL BROUGHT IN FROM OUTSIDE SOURCES.				
8" PERF. PVC		35,000 LF	GEOTEXTILE QUANTITES INCLUDED BELOW.				
10" PVC PIPE		1,050 LF					
GEOTEXTILE		205,489 SY	INCL. GEOTEXTILES FOR CSA, TOE PROT. & PVC PIPE.				
CSA PLATE		35,959 CY	VOLUME OF AGGREGATE REQ. INCL. IN RANDOM FILL ABOVE.				
CSA STEPS		38,390 CY	VOLUME OF AGGREGATE REQ. INCL. IN RANDOM FILL ABOVE.				
ROAD SURFACE		10,237 CY	MATERIAL BROUGHT IN FROM OUTSIDE SOURCES.				
TOPSOIL SURF		29,459 CY	THIS QTY. DEDUCTED FROM EXCESS FOR DISPOSAL.				
HYDROSEEDING		137,032 SY					
L-502B/C-502B							
REACH 4	3,450	43,646	43,853	43,853	0	208	9,634
REACH5	4,470	83,668	84,167	84,167	0	500	15,066
		127,313	128,021	128,021	0	707	24,700
REQ. SELECT FII =		42,013	EXCAV. LOOSE FILL AVAIL. =		0	BALANCE =	-42,013
REQ. RANDOM FILL =		85,300	EXCAV. BLASTED ROCK AVAIL. =		128,021	BALANCE =	42,721

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MATERIALS COMPUTATION AND BALANCE SHEET
8-Feb-07

LEVEE/CANAL SECTION	DISTANCE (FT) (A)	REQ. SUITABLE FILL (CY) (B)	EXCV. SUITABLE FILL (CY) (C = D + E)	BLASTED ROCK (CY) (D)	LOOSE FILL (CY) (E)	BALANCE (CY) (NEG = FILL REQ.) (F = C - B)	UNSUITABLE MTL. TO DISPOSE (CY) (G)
L-503/C-503							
REACH 1	7,000	75,852	78,445	54,912	23,534	2,593	16,113
	REQ. SELECT FII =	25,031	EXCAV. LOOSE FILL AVAIL. =		23,534	BALANCE =	-1,498
	REQ. RANDOM FILL =	50,821	EXCAV. BLASTED ROCK AVAIL. =		54,912	BALANCE =	4,091
JONES PARK	2,050	20,604	20,712	14,498	6,214	108	5,133
	REQ. SELECT FII =	6,799	EXCAV. LOOSE FILL AVAIL. =		6,214	BALANCE =	-586
	REQ. RANDOM FILL =	13,805	EXCAV. BLASTED ROCK AVAIL. =		14,498	BALANCE =	693
L-502B/C-502B							
REACH 1	17,000	395,556	462,872	324,011	138,862	67,317	156,353
REACH 2	2,332	0	39,993	27,995	11,998	39,993	7,250
REACH 3	19,100	475,000	585,024	409,517	175,507	110,024	179,392
		870,556	1,087,890	761,523	326,367	217,334	342,995
	REQ. SELECT FII =	0	EXCAV. LOOSE FILL AVAIL. =		326,367	BALANCE =	326,367
	REQ. RANDOM FILL =	870,556	EXCAV. BLASTED ROCK AVAIL. =		761,523	BALANCE =	-109,033
FP&L BERM	9,837	69,952	0	0	0	-69,952	45,250
	REQ. SELECT FII =	0	EXCAV. LOOSE FILL AVAIL. =		0	BALANCE =	0
	REQ. RANDOM FILL =	69,952	EXCAV. BLASTED ROCK AVAIL. =		0	BALANCE =	-69,952
HOLLEY LAKES	5,000	55,727	56,420	39,494	16,926	693	15,947
	REQ. SELECT FII =	18,947	EXCAV. LOOSE FILL AVAIL. =		16,926	BALANCE =	-2,021
	REQ. RANDOM FILL =	36,780	EXCAV. BLASTED ROCK AVAIL. =		39,494	BALANCE =	2,714
BISHOP/NIXON	3,500	12,734	13,181	9,226	3,954	446	9,533
	REQ. SELECT FII =	4,330	EXCAV. LOOSE FILL AVAIL. =		3,954	BALANCE =	-375
	REQ. RANDOM FILL =	8,405	EXCAV. BLASTED ROCK AVAIL. =		9,226	BALANCE =	822

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MATERIALS COMPUTATION AND BALANCE SHEET

8-Feb-07

LEVEE/CANAL SECTION	DISTANCE (FT) (A)	REQ. SUITABLE FILL (CY) (B)	EXCV. SUITABLE FILL (CY) (C = D + E)	BLASTED ROCK (CY) (D)	LOOSE FILL (CY) (E)	BALANCE (CY) (NEG = FILL REQ.) (F = C - B)	UNSUITABLE MTL. TO DISPOSE (CY) (G)
C-8 EMBANKMENT	34,840	1,387,354	1,050,911	735,638	315,273	-336,443	452,758
NORTH AREA	14,475	110,975	125,450	81,543	43,908	14,475	68,435
SOUTH AREA	8,673	99,740	94,870	61,665	33,204	-4,970	89,396
		1,598,068	1,271,231	878,845	392,385	-326,838	610,589

REQ. SELECT FILL =	349,988	EXCAV. LOOSE FILL AVAIL. =	392,385	BALANCE =	42,397
REQ. RANDOM FILL =	1,359,135	EXCAV. BLASTED ROCK AVAIL. =	878,845	BALANCE =	-480,290

DRAIN SAND	118,714 CY	MATERIAL BROUGHT IN FROM OUTSIDE SOURCES.
8" PERF. PVC	35,000 LF	GEOTEXTILE QUANTITES INCLUDED BELOW.
10" PVC PIPE	1,050 LF	
GEOTEXTILE	287,054 SY	INCL. GEOTEXTILES FOR CSA, TOE PROT. & PVC PIPE.
CSA PLATE	46,195 CY	VOLUME OF AGGREGATE REQ. INCL. IN RANDOM FILL ABOVE.
CSA STEPS	80,003 CY	VOLUME OF AGGREGATE REQ. INCL. IN RANDOM FILL ABOVE.
ROAD SURFACE	10,323 CY	MATERIAL BROUGHT IN FROM OUTSIDE SOURCES.
TOPSOIL SURF	53,336 CY	THIS QTY. DEDUCTED FROM EXCESS FOR DISPOSAL.
HYDROSEEDING	219,123 SY	

SUMMARY:

TOTAL REQ. SELECT FILL =	641,508	TOTAL EXCAVATED LOOSE FILL =	1,614,208
TOTAL REQ. RANDOM FILL =	3,234,635	TOTAL EXCAV. BLASTED ROCK =	3,445,599
	3,876,143		5,059,807

EXCESS SUITABLE MATERIAL TO BE DISPOSED IN QUARRY PITS = 1,183,664 CY

TOTAL EXCAVATED UNSUITABLE SOIL FOR DISPOSAL = 1,901,020 CY

ASPHALTIC CONCRETE TO BE DISPOSED OFF SITE = 6,933 CY

NOTE: 1. THE SURPLUS OF THE EXCAVATED SUITABLE MATERIALS 1,183,664 CY WILL BE DEPOSITED IN THE C-11 EXIST. BORROW PITS
2. THE SURPLUS EXCAVATED PEAT 1,901,020 CY WILL BE SCRAPPED-OFF AND MOVE ASIDE ON LOCATION.

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A.10 STRUCTURAL DESIGN

A.10.1 General

Numerous structural features are proposed for the Broward County Water Preserve Areas. These structures include pumping stations, gated and non-gated culverts, overflow spillways, bridges and weirs. Details of these project features are presented in the structural plates included in Appendix A.

A.10.2 Pumping Stations

There are five pump station structures proposed for the Broward County Water Preserve Areas. Typical plan views and details are presented in *Plates S-1, S-2, S-17, S-18* and *S-22*. Pumping station designs are based on comparisons to previous designs prepared by the Jacksonville District

The primary structural components of a pumping station are substructure, operating floor and superstructure. The substructure includes the sumps and water passages that conduct water to the pump intakes. The operating floor supports pumps, diesel engines, and generators. The superstructure is the building enclosure for equipment and personnel areas in the plant.

A.10.3 Overflow Spillways

There are five overflow spillway structures proposed for the Broward County Water Preserve Areas. As shown on *Plates S-6* and *S-20*, spillway components include a crest, wingwalls, approach slabs, and a baffled chute. The crest is 50' wide and is designed to allow access along the top of the levee. The crest and approach slabs are designed to support an HS-20 truck loading. Wingwalls are used to direct flow to the spillway chute.

A.10.4 Culverts

Numerous gated and non-gated culvert structures are proposed for the Broward County Water Preserve Areas. Both circular and box shaped structures will be utilized. Optimum material types for circular culverts shall be determined during detailed design. Box culverts will be constructed using cast-in-place reinforced concrete. Details of these culverts are shown in the structural plates. All slide gates will be stainless steel.

A.10.5 Weirs

There are two triangular profile weirs and five broad crested weirs proposed for the Broward County Water Preserve Areas. Details of the triangular profile

weirs are shown on *Plate S-28*. Details of the other weir structures are shown on *Plates S-4, S-7, S-8* and *S-23*.

A.10.6 Bridges

There are five bridges proposed for the Broward County Water Preserve Areas. Two are replacement bridges (B-500 and B-501). Three are new bridges (S-505D, S-505E, and the O&M maintenance bridge) and details are shown on ***Plate S-9***. Roadway bridge designs including maintenance of traffic will be consistent with current industry practices including requirements of the Florida Department Transportation (FDOT) and American Association of Highway Transportation Officials (AASHTO). Typical design load rating shall be HL-93.

A.10.7 References

Structural designs will be prepared in accordance with criteria presented in the following references:

- USACE EM 1110-2-2104 Strength Design for Reinforced Concrete Hydraulic Structures
- USACE EM 1110-2-3102 General Principles of Pumping Station Design and Layout
- USACE EM 1110-2-3104 Structural and Architectural Design of Pumping Stations
- USACE EM 1110-2-2701 Vertical Lift Gates
- USACE EM 1110-2-2100 Stability Analysis of Concrete Structures
- AISC Manual of Steel Construction,
- ACI Building Code Requirements for Structural Concrete
- PCI Design Handbook
- The Florida Building Code
- Florida Department of Transportation Roadway and Traffic Design Standards
- Florida Department of Transportation Standard Specifications for Road and Bridge Construction
- AASHTO Standard Specifications for Highway Bridges
- SFWMD Major Pump Station Engineering Guidelines

A.11 MECHANICAL AND ELECTRICAL DESIGN

A.11.1 Utility Relocation

A.11.1.1 General

Since the BCWPA Project is located in the largely undeveloped area along the western edge of urbanized Broward and Miami-Dade Counties, the need for

utility relocation has been minimized. Conflicts with existing or proposed utilities have been avoided by design modification whenever possible. The cases where utility relocation will be required include construction sites for structures and canals, as well as within areas developed for water storage. All known necessary utility relocations are listed, since accounting for the impact of any construction interference is an essential part of project planning.

A.11.1.2 Electrical Lines

As would be expected adjacent to a metropolitan area, both high voltage transmission and consumer delivery distribution electrical lines are either close to or cross the BCWPA.

In order to construct impoundments, all the residential and commercial properties contained within the area will be acquired, the associated structures demolished, and the electrical distribution lines relocated, abandoned or salvaged. The BCWPA components that will require electrical utility relocation due to land acquisition are the C-11 Impoundment, approximately 10.0 miles of line and the C-9 Impoundment, approximately 0.5 mile of line.
Aerial electrical distribution lines along the entrance of the Holly Lakes Mobile Home Park in the middle of Seepage Area WCA 3B will require relocation during canal construction.

In addition, potential project effects upon an FPL electrical transmission corridor located within 3A/3B SMAs are being evaluated. The issue centers on the effect occasionally raising the water level by zero to two feet will have on the transmission towers including the need to assure that the towers are not damaged by the project and that access for maintenance is maintained. Existing survey information and updated modeling, to be conducted during detailed design, will be used to identify the specific towers within the transmission line corridor and any portion of the access road that may be affected. Based on currently available information, it is estimated that up to 30% of the towers in 3B SMA may be affected by the project. Proposed solutions include elevating the access road and base areas, covering the tower bases with a protective coating, raising the towers in place, or moving the towers to new higher base pads adjacent to where they are now located. Once the potential impacts are identified during detailed design, the most cost effective plan for utility protection will be executed under separate agreements between FPL and the USACE as part of the project costs.

A.11.1.3 Communication Lines and Towers

Since the BellSouth/AT&T telephone lines are co-located with the FPL distribution power lines, relocation of telephone lines due to impoundment construction is approximately the same as described above for electrical lines.

The specific impacted telephone facilities will be determined during detailed design and measures to protect these facilities will be executed under separate agreements between AT&T and USACE with the cost borne by the project.

In addition to aerial lines, BellSouth/AT&T has approximately 8.0 miles of underground fiber optic lines and one remote terminal unit within the C-11 Impoundment. There is a second Bell South/AT&T remote terminal unit on the south side of S.W. 26th Street just west of the City of Weston Public Works Facility and east of the C-11 Impoundment that serves the SBA Tower Site. Since it is now located outside the perimeter levee for the impoundment, it can remain where it is. Current access to the site is available from the west via S.W. 26th Street. However, since the final design of the impoundment may eliminate this access route from the west, a permit condition was included in the Surface Water Management Permit issued to the City of Weston for their Public Works Facility requiring the City to provide an alternate access route through the Public Works Facility. If S.W. 26th Street or an equivalent access route is not included in the final design of the impoundment. BellSouth/AT&T has said that the fiber optic lines will need to be rerouted, since they are an important part of its communication network in the area.

There is a major fiber optics trunk route that runs alongside the west side of U.S. 27 within the FDOT ROW for U.S. 27. It includes Bell South/AT&T and Level 3 Communications (which acquired the four fiber optic companies previously located within this corridor over the last six years, including WilTel Communications, Epik Communications, Broadwing Communications and Northstar Communications. In the event fiber optic lines require relocation due to project canal or culvert construction, the preferred relocation procedure involves boring a route underneath and then splicing that line back into the system.

Prior to its acquisition by Level 3 Communications, and as a result of an agreement executed with the SFWMD on December 15, 2004, the WilTel Communications fiber optic line that extended east from U.S. 27 along SW 26th Street to its operational amplifier located on the east side of the C-11 Impoundment on the SBA Communication tower site and the amplifier facilities were relocated to a site in Pembroke Pines outside the C-11 and C-9 Impoundment project lands..

Two communication towers are located on property owned by the SBA Corporation on the south side of S.W. 26th Street and along the east side of the C-11 Impoundment, in the City of Weston. These communication towers are a 300-foot self-supported tower owned by the SBA Corporation and a 280-foot guy-wire tower owned by Crown Castle International.

Design alternatives for these communication tower sites that were investigated include: (a) leaving the facilities in place by adjusting the C-11 Impoundment boundary design while maintaining access from the east through the City of Weston Public Works Facility, as described above, if access from the west via S.W. 26th Street or an equivalent access road is not included in the final design for the impoundment and (b) relocating the facilities to adjacent sites within 1800 feet to the east. Relocation would require securing permits and zoning approval and a changeover plan to maintain continuous service. Keeping the facilities in place by design accommodation and raising access elevations, if needed, would be more compatible with the owners' needs and is the preferred design option.

A.11.1.4 Underground Utilities

A.11.1.4.1 Fiber Optic

An underground BellSouth fiber optic cable that serves the FPL Andytown Substation located within the WCA 3B Seepage Management Area will need to be relocated during construction. Entry to the substation requires construction of a maintenance bridge over canal C-502B. BellSouth suggested including a protective conduit for the fiber optic cable in the bridge design.

At the Johnson Street entrance to the Holly Lakes Mobile Home Park, near the middle of 3B Seepage Management Area, construction of a new maintenance bridge across canal C-502B will require the relocation of a BellSouth underground fiber optic line, which enters the subdivision there. AT&T cable television service enters the area at this entrance as well, suspended overhead from FPL poles, and will need to be protected or relocated along with the FPL electric lines. Aerial BellSouth telephone lines that enter at the south end of the Holly Lakes Mobile Home Park, on FPL utility poles, will also need to be relocated during canal construction.

A.11.1.4.2 Water

The City of Pembroke Pines has a 24-inch water main along the entrance road to the Holly Lakes Mobile Home Park, as well as a 12-inch water main near its south end, that will require relocation due to construction of canal C-502B. The 12-inch water line may be accommodated by a surface connection above the canal.

A.11.1.4.3 Sewer

The City of Pembroke Pines has two 10-inch wastewater pipes that enter the Holly Lakes Mobile Home Park from US 27 that will require relocation due to

construction of canal C-502B. These pipes are located parallel to the Johnson Street entrance, near the middle of Seepage Area WCA 3B.

A.11.2 Mechanical Design

A.11.2.1 Pump Station General Information and Size Criteria

The pumping stations of the BCWPA Project shall be broken into two categories: small-sized and large-sized. For this type of project, small-sized pumping stations have a total pumping capacity of less than 250 cubic feet per second (cfs); while large-sized pumping stations have a total pumping capacity greater than 1000 cfs.

The large-sized BCWPA pumping stations will use a simplified design and be configured with sets of relatively smaller sized pumps, the largest of which are 350 cfs. This design allows more flexible operation, with an increased number of steps designed to match available water supplies and seepage requirements. Such smaller sized pumps and less powerful pump drive engines would be available from more manufacturers, and offer the advantages of shorter lead times and more competitive pricing, and may eliminate or reduce the need for station auxiliaries, such as lubrication and centralized vacuum systems.

The pump stations shall be designed in accordance with Hydraulic Institute Standards, EM 1110-2-3102 (General Principles of Pumping Station Design and Layout), EM 1110-2-3105 (Mechanical and Electrical Design of Pumping Stations) and SFWMD's Major Pumping Station Engineering Guidelines (MPSEG), as applicable. The pumping stations will also follow the guidance of ETL 1110-2-313 (Hydraulic Design Guidance for Rectangular Sumps of Small Pumping Stations with Vertical Pumps and Ponded Approaches). The use of formed suction intakes and siphon discharges for the larger pumps shall be evaluated during detailed design for each pumping station, and shall be based upon the channel intake design, the required pumping heads, and life cycle cost analysis.

It is assumed that axial flow or mixed flow pumps will be used for all pumping stations. All of the pumps will be water-lubricated. Small-sized pumping stations will be designed with horizontal discharge vertical axial flow pumps. A horizontal discharge pipe located above the maximum water level offers backflow prevention and makes an air release or siphon breaker unnecessary. Large-sized pumping stations will be designed with vertical, axial flow or mixed flow pumps and use either a horizontal discharge or siphon type discharge. Pumping station criteria and information are located on *Table A-98*, BCWPA Pumping Station Information.

Needle beams, or stoplogs, will allow dewatering inspection and maintenance of individual intake sump bays at each pump station. Multiple needle beam sections will be stacked in intake bay wall slots across the flow path, and installed with a mobile crane. Installation access is provided through openings protected by grating or plates on the intake service bridge. Sufficient needle beams will be furnished at each pump station for dewatering one pump bay of each size. Needle beams will be constructed of a low maintenance material, such as aluminum, and will be stored at the station and provided with convenient access.

TABLE A-98: BCWPA PUMPING STATION INFORMATION

Project Design Region	Pump Station	Total Flow capacity (cfs)	No. Of Pumps	Pump Drive Type	Flow Rate (cfs)	Intake, Min. Draw-down Pumping Level (ft) NGVD	Dis-charge Max. Pumping Level (ft) NGVD	Total Head (ft)	Pump Dia-meter (in)	Drive Rating (hp)
3B SMA	S-514A	60	2	Electric	30	4.5	8.5	8.9	24	50
C-11	S-503	1500	3	Diesel	350	0.0	11.0	21.8	84	1240
			3	Electric	150	0.0	11.0	18.7	42	350
C-9	S-509	1075	4	Diesel	250	1.0	11.0	17.2	72	700
			1	Electric	75	1.0	12.25	16.0	36	200
	S-512A	225	3	Electric	75	2.0	12.25	15.5	36	200

A.11.2.2 Small-Sized Pumping Stations

Pumping stations that are categorized as small-sized pumping stations are listed below in *Table A-99.*

TABLE A-99: SMALL-SIZED PUMP STATIONS BY DESIGN REGION

Pump Station	Design Region
S-514A (Holly Lakes Mobile Home Park)	3B Seepage Management Area
S-512A	C-9 Impoundment

The small-sized pumping stations will each have two or three pumping systems. The pumps in each of the stations will be axial flow type vertical shaft pumps. Power to the pumps will be provided by direct-drive electric motors or diesel engines through right angle reduction gear drives. *Table A-98* lists the number

of pumps, the capacities of the pumps, the drives, etc., for each of the pumping stations in the BCWPA.

Pumping station S-512A will be a three-bay station. The other small pumping station will be a two-bay stations with smaller pumping systems. The pumps are expected to run at no less than 600 rpm with a minimum efficiency of 80% for the 75 cfs pumps, and 70% for the smaller pumps. The pump drives needed will range from 10 to 200 horsepower each.

Each of the small-sized pumping stations will include various support items including the following:

- Removable roof hatches to allow hoisting of pumping equipment for maintenance or repair
- Ventilation system to provide fresh air in the pump bays and generator area.
- Stilling wells containing float switches to be used for pump operations and water level monitoring.
- Trash rake/rack system will be an automatic, continuously rolling, flex rake and trash rack system such as that manufactured by Duperon.

Pumping station S-514A is being built to minimize damages to the development located adjacent to the WCA 3A Seepage Management Area, the Holly Lakes Mobile Home Park. This small pumping station will backpump seepage water collected in a canal. Because of the need to assure operation of this pumping station during a loss of commercial electricity, S-514A will also include:

Emergency generator to supply power to the electrical equipment at the station in the event of commercial power outage has been provided. This will include providing power for the lights, controls for the pumps, ventilation fans, trash rake, etc. Additionally, this will include providing emergency power for the electric pump motors. The generator may be located within the pumping station or in its own building equipped with electrical power, lighting and ventilation. If a separate building is provided, the building shall sit as close as practicable to the pumping station.

Diesel fuel system, including secondarily-contained aboveground fuel storage tanks, capable of holding enough fuel to operate the emergency generator continuously for 7 days. The Florida Administrative Code (FAC) shall be followed in designing the fuel system for the pumping station. The designer shall coordinate with local and state authorities to ensure that the various permits (air, fuel, etc.) are all adequately addressed.

Control systems for the motor/engine pump drives as described in the Electrical Design section below.

A.11.2.3 Large-Sized Pumping Stations

Pumping stations that are categorized as large-sized pumping stations are listed below in *Table A-100.*

TABLE A-100: LARGE-SIZED PUMP STATIONS BY DESIGN REGION

Pump Station	Design Region
S-503	C-11 Impoundment
S-509	C-9 Impoundment

A.11.2.4 Pumps: Pumping capacity, Pump Sizes, and General Information

The large-sized pumping stations will each have five or six pumping systems. The pumps in each of the stations will be axial flow or mixed flow vertical shaft pumps. Power to the pumps will be provided by either diesel engines through right angle reduction gear drives or by direct-drive electric motors. *Table A-98* lists the number of pumps, the capacities of the pumps, the drives, etc., for each of the pumping stations in the BCWPA.

The diesel engine driven pumps are expected to run at less than 400 rpm with a minimum design operating point efficiency of 80%. The diesel engine pump drives will range from 700 to 1240 horsepower each. Electric motor driven pumps should not operate at less than 600 rpm. The electric motor pump drives are expected to be 200 and 350 horsepower each.

Each of the large-sized pumping stations will include various support items including the following:

- Diesel fuel system, including secondarily-contained aboveground fuel storage tanks, capable of holding enough fuel to operate all engine driven pumps and the emergency generator continuously for 7 days. Day tanks shall be provided and sized to adequately supply the diesel engine pump drives and generator within the limitations of NFPA 37. The Florida Administrative Code (FAC) shall be followed in designing the fuel system for the pumping station.
- Overhead bridge-type electric crane/hoist capable of lifting and moving loads up to the heaviest loads in the pumping station. The crane/hoist will handle pumping station equipment such as the diesel engine pump drives, reduction gears, and the pumps during initial installation as well as for general service thereafter.

- Toilet facility with a water closet and a lavatory
- Kitchen-type sink
- Potable water system and a septic system for the plumbing fixtures
- Ventilation system to provide fresh air in the pump bays, generator area, and toilet room
- Air-conditioning system for the office
- Stilling wells containing float switches to be used for pump operations and water level monitoring.
- Trash rake/rack system to remove debris from pump intake water will be provided. The typical system shown on the plates is an automatic, continuously rolling, flex rake and trash rack system such as that manufactured by Duperon.
- Emergency generator to supply power to the electrical equipment at the stations in the event of commercial power outage. At both stations, this will include providing power for the lights, controls for the pumps, ventilation fans, trash rake, etc. The emergency generator will not be sized to handle the load for the electric motor driven pumps.
- Controls system for the engine/motor pump drives as described in the Electrical Design section below.

During the detailed design, the designer shall coordinate with local and state authorities to ensure that the various permits (air, fuel, etc.) are all adequately addressed.

A.11.2.4.1 Pump Intake and Discharge Design

The larger pumps for the large-sized pumping stations may be designed with Formed Suction Intakes (FSI) and may include siphon discharges. FSIs have been shown to be more efficient than typical suction bell intakes, but the design decision on whether to use them will be based on comparing potential efficiency savings with increased construction costs over the life of the project.

In order to reduce the engine size and horsepower (and fuel) required to overcome the head on the large pumps, siphoning discharge systems may be used. If used, priming would be accomplished by means of a station vacuum system; however, with the impeller submerged as shown and depending on the characteristics of the equipment offered, the pumping systems should be capable of being self-priming in an emergency. During self-priming, the engine pump drives may be subjected to momentary overload. Again, the design decision on whether to use siphon discharges for the larger pumps in the large-sized pumping stations will be based on comparing potential savings on the cost of the diesel engine pump drives and the lower fuel requirements with the increased construction costs over the life-cycle of the pumping station. Note that if the siphon discharge is used, each pump discharge tube will be provided with twin

vertical-lift type backflow gates with relief flaps located at the siphon terminus. The gates are needed to prevent the possibility of reverse siphoning and backflow due to incomplete breaking of the prime during pump shut-down. Each gate will be raised and lowered by a single screw-stem with a Limitorque-type electric motor operator controlled from within the station.

For discharge pipes that will be below high water levels, a second means of preventing backflow will also be incorporated. The discharge pipes will have their upper invert elevation (summit) above the high water level on the discharge side. The siphon would then self-break.

During design development the discharge arrangement will be selected based on a life cycle cost analysis of the operational and construction costs.

A.11.2.5 Gated Spillways

A.11.2.5.1 General

Gated spillways with a vertical lift type gate system, which lifts the gate straight up from above will be used on S-504 and S-510.

A.11.2.5.2 Vertical Lift Gate Operating Mechanism

Vertical lift gates open when lifted in the vertical direction by a motor and cable system. The operating mechanism for each gate will be of the electric motor/double stage reduction gear type with rotative limit switch to delimit the upper and lower position of the gate, cable slack limit switch and gate travel readout or gate position indicator system. The double stage reduction gear will be centered on the operating platform above each gate and will be of the double output shaft type. The gate lift system design will include the following features:

- All mechanical components will be installed on a common frame to facilitate the removal of the operating mechanism from the platform as a unit allowing minimum disturbance of alignments between components.
- The systems will be able of lifting the gate at a speed of six inches per minute ± 10 %.
- The electric motor and brake will be interlocked for a fail-safe operation.
- A removable wire rope link between the gate and each wire rope connection at the gate.

After opening the gate to the maximum allowed by the system, a set of dogging slings should support the gate at an intermediate open position. The operating platform will be designed in coordination with the structural engineer to support the weight of the gate, the operating mechanism and any thrust loads developed

by the system. The platform will be sized in order to allow adequate clearance between the operating mechanism and the fence.

A.11.2.6 Generator

Each gated spillway will have an emergency backup generator fueled with liquid petroleum gas (LPG), located in a control room. A generator is required because of the need to assure spillway operation during commercial power outages. An underground LPG tank with sufficient capacity to assure operation of the spillway for at least 7 days will be used.

A.11.2.7 Gated Culverts

A.11.2.7.1 General

The gated culverts will use a slide type gate mechanism, especially suitable to this project because of the relatively low head requirement and because constructed of aluminum. If increased water-tightness is desired, resilient rubber seals will be part of the design.

A.11.2.7.2 Operating Mechanism

The culvert gate will be a commercially available self-contained aluminum gate unit similar to those manufactured by Waterman Industries, Inc. and Hydro Gate Corporation. An electric operator will operate the rising stem of design suitable for attaching to a concrete bulkhead. The electric operator will include, but not be limited to, the motor, actuator unit gearing, limit switch gearing, position limit switches, torque switches, stem nut, declutch lever, high precision gate position potentiometer, and handwheel as a self-contained unit. The actuator will have sufficient capacity to raise or lower the gate at a speed of 6-inch/min against the operating heads. The handwheel will operate in the clockwise direction to close. External declutch lever will be pad locked in either the manual (handwheel) or motor mode.

A.11.3 Electrical Design

A.11.3.1 General

As a minimal each pump station electrical system shall consist of the following:

A.11.3.2 Power Service

Coordination with the local power company for the sources of power, new power line routings to the pump stations and culvert slide gates, and any associated costs for building the new power lines shall be conducted as warranted by the

design. Appropriate power, typically 480-volts for pumping stations and 208-volts for spillways/gated culverts, will be provided via a pad-mounted step-down transformer supplied by the utility company. The electrical service shall include power distribution panels, power for the equipment and auxiliary systems, equipment monitoring systems, communications systems and general facilities electrical, such as exterior and interior lighting, receptacles, grounding systems, and water level and other fluids monitoring systems. The electrical systems shall be protected from the elements. Transient Voltage Surge Suppression (TVSS) shall be provided at the service entrance.

A.11.3.3 Grounding

Pump station main grounding will include a grounding grid consisting of ground rods and #4/0 ground wire, which will be bonded to the embedded metallic masses, sheet pile, and structural steel. Frames or enclosures of electrical equipment will be bonded to the grounding system. Ground conductor will be bare, soft annealed copper cable and ground rods would be of copper clad type.

A.11.3.4 Lighting

High intensity discharge, industrial high bay luminaries will be used for the main pump station area with industrial fluorescent fixtures with electronic ballasts for office and general type areas. Exterior lighting for security purposes would be automatically controlled by photoelectric cells and contactors.

A.11.3.5 Lightning Protection

A roof mounted lightning protection system shall be installed. The system shall consist of interconnected air terminals with ground conductors to connect to the station-grounding grid. Conductors shall be stranded.

A.11.3.6 Backup Generators and Automatic Transfer Switches

Large-sized pumping stations may use up to two diesel engine-driven generator sets (genset) up to 500 kW each to provide backup power. Small-sized pumping stations will use one diesel engine-driven generator set up to 250 kW to provide backup power. These generators must provide sufficient power to operate the station at full capacity, including running all auxiliary equipment, continuously for as long as one week. Generators and automatic transfer switches shall be products from the same manufacturer.

A.11.3.7 Stilling Wells and Water Level Sensors

The latest South Florida Water Management District standards for stilling wells and water level sensors shall be used. The water level sensors are sole source

items. One water level sensor with readout shall provide continuous level. Two water level sensors shall provide normal cutoff and ultimate cutoff for the pump.

A.11.4 Large-Sized Pumping Stations

A.11.4.1 Service

A single line diagram for pumping station S-503 is shown on *Plate E-1.* The SCADA System Diagram is shown on *Plate E-2* and the engine control panel is shown on *Plate E-3.*

A single line diagram for pumping station S-509 is shown on *Plate E-4.* The SCADA System Diagram is shown on *Plate E-5* and the engine control panel is shown on *Plate E-6.*

A.11.4.2 Equipment and Surge Suppression

Switchgear rated for 480 volt, three phases with a main breaker will be connected to the incoming service and would feed engine control centers and station equipment. Each engine control center will house starters and controls for auxiliary equipment for respective engine unit. Main switchboard would also feed a small transformer to supply 120/208 volts for small loads. Surge suppression shall be provided for each electrical/electronic system within or outside the structure.

A.11.4.3 Controls and Monitoring

Each large-sized pumping station shall have a centralized monitoring and control room. The controls systems shall include manual, automatic and telemetry abilities for the pumps and auxiliary systems. Each diesel engine for pumps will have a separate motor control center to supply power and house controls for engine auxiliaries, such as jacket water pump, engine lube pump, fuel filter pump, etc. Diesel engines will also be equipped with a separate instrument panel and will house engine start/stop controls, pressure and temperature indicators to indicate engine performance. The engine start/stop controls shall operate locally at the engine, remotely from control room and telemetrically from the central control station.

A.11.4.4 Fire Detection and Alarm

The pump station shall be equipped with fire detection and alarm panel. An audible and visual alarm shall be activated at the station when a fire is detected. The alarm status shall be transmitted via the telemetry system to the central control station.

A.11.4.5 Intrusion Detection and Alarm

The pump station shall be equipped with intrusion detection and alarm system. An audible and visual alarm shall be activated at the station when an intrusion is detected. The alarm status shall be transmitted via the telemetry system to the central control station.

A.11.4.6 Closed Circuit Television (CCTV) System

The pump station shall be equipped with a closed circuit television system with pan-tilt-zoom cameras. The output from the system shall be viewable in the station control room and at the central control station.

A.11.5 Small-Sized Pumping Stations

A.11.5.1 Service

A single line diagram for pumping station S-512A is shown on *Plate E-7*. The SCADA System Diagram is shown on *Plate E-8*. The electric motor controls are shown on *Plate E-9*. Pumping station S-514A shall have single line diagram, SCADA System Diagram and motor controls similar to pumping station S-512A.

A.11.5.2 Equipment and Surge Suppression

A motor control center rated for 480 volt, three phases with a main breaker will be connected to the incoming service and would feed electric motors and station equipment. The MCC would also feed a small transformer to supply 120/208 volts for small loads. A diesel generator would provide backup power for the station. Surge suppression shall be provided for each electrical/electronic system within or outside the structure.

A.11.5.3 Controls and Monitoring

The controls systems shall include manual, automatic and telemetry abilities for the pumps and auxiliary systems. Electric motor driven pumps shall be controlled from the MCC. Diesel engines will be equipped with a separate instrument panel, which will house engine start/stop controls; pressure and temperature indicators to indicate engine performance. Equipment, water levels devices, fuels levels devices, bearing water flow, pump temperatures, and well head pressures shall be electrical monitored for safe operation or as required by equipment manufacturers. The engine start/stop controls shall operate locally at the engine, remotely from control room and from the central control station.

A.11.5.4 Fire Detection and Alarm

The pump station shall be equipped with fire detection and alarm panel. An audible and visual alarm shall be activated at the station when a fire is detected. The alarm status shall be transmitted via the telemetry system to the central control station.

A.11.5.5 Intrusion Detection and Alarm

The pump station shall be equipped with intrusion detection and alarm system. An audible and visual alarm shall be activated at the station when an intrusion is detected. The alarm status shall be transmitted via the telemetry system to the central control station.

A.11.5.6 Closed Circuit Television (CCTV) System

The pump station shall be equipped with a closed circuit television system with pan-tilt-zoom cameras. The output from the system shall be viewable in the station control room and at the central control station.

A.11.6 Gated Spillways

A single line diagram for vertical lift gate is shown on *Plate E-10* and control cabinets are shown on *Plate E-11.*

A.11.6.1 Power Service

A 120/240 volt single phase or 208Y/120 volt, three phase, electrical service shall be provided by the local utility company. A 120/240 volt single phase or 208Y/120 volt, three phase engine-generator units shall be provided to supply necessary electrical power for gate operations. Transient Voltage Surge Suppression (TVSS) shall be provided at the service entrance.

A.11.6.2 Grounding

Structure main grounding will include a grounding loop consisting of ground rods and ground wire, which will be bonded to the embedded metallic masses, sheet pile, and structural steel. Frames or enclosures of electrical equipment will be bonded to the grounding system. Ground conductor will be bare, soft annealed copper cable and ground rods would be of copper clad type.

A.11.6.3 Lighting

Industrial fluorescent fixtures with electronic ballasts will provide interior lighting. Photoelectric cells and contactors would automatically control exterior lighting for nighttime operations.

A.11.6.4 Backup Generators and Transfer Switches

Backup generators and automatic transfer switches shall be sized sufficiently to carry the load required. Generators and transfer switches shall be supplied by the same manufacturer. Each structure may use a diesel engine-driven generator sets (genset) up to 250 kW to provide backup power. The generators must provide sufficient power to operate the structure at full capacity, including running all auxiliary equipment, continuously for as long as one week.

A.11.6.5 Stilling Wells and Water Level Sensors

The latest South Florida Water Management District standards for stilling wells and water level sensors shall be used. The water level sensors are sole source items. One water level sensor with readout shall provide continuous level.

A.11.6.6 Power Distribution and Surge Suppression

A control center will be connected to the load side of the automatic transfer switch and will house a main breaker, combination starter for the gate motor, lighting panel, relay compartment, and a circuit for exterior lighting. Surge suppression shall be provided for each electrical/electronic system within or outside the structure.

A.11.6.7 Gate and Motor Controls

Duplicate open-close push button station in the control house and at the spillway structure would be provided for manual gate control. Necessary open, close, automatic control relays, and limit switches would be incorporated in the gate control circuit. A time delay relay will provide a 5-second energization delay to a dumping solenoid valve to permit unloaded start of the hydraulic power unit motor. Power and control circuits for water level recorders and gate position recorders will be provided.

A.11.6.8 Control and Monitoring

Each spillway shall have a control center that house a main breaker, combination starter for the gate motor, lighting panel, relay compartment, and a circuit for exterior lighting. Duplicate open-close push button station in the control house and at the spillway structure would be provided for manual gate

control. Necessary open, close, automatic control relays, and limit switches would be incorporated in the gate control circuit. A time delay relay will provide a 5-second delay to a dumping solenoid valve to permit unloaded start of the hydraulic power unit motor. Power and control circuits for water level recorders and gate position recorders will be provided. Main and auxiliary equipment, water levels devices, and wellhead pressures shall be electrical monitored for safe operation or as required by equipment manufacturers.

A.11.6.9 Gated Culverts

Gated culverts shall have an electrical service distribution system, SCADA system design, and gate controls similar to those shown for vertical lift gates.

A.11.7 Telemetry

A.11.7.1 General

The OS-SCADA system shall control main and auxiliary equipment, as well as monitor level sensing devices at each of the facility. The station equipment, controls, and sensing devices at the facility shall provide status and receive control signals from the OS-SCADA system. The remote automation components installed at the pump station and other structures are the remote terminal unit (RTU) shown on *Plate E-10* and communication channel to the SFWMD control center. The access for the RTU to the control center is via microwave gateway. The automation components of all pump stations and structures that will eventually be operated and maintained by South Florida Water Management District (SFWMD) must conform to SFWMD standards in order to (1) achieve cost efficiency in design, construction, operation and maintenance (2) meet safety, reliability, and performance requirements during routine and emergency operations. The automation components are broadly defined to include hardware, software, communications and user interface elements.

A.11.7.2 Site Requirements

Each site that requires remote automation shall be equipped with a RTU compatible with the existing SFWMD's Motorola MOSCAD system. RTU software shall be in accordance with the SFWMD standard load set.

A.11.7.3 Network Requirements

SFWMD is concerned about bandwidth and efforts have been taken to combine monitored of controlled parameters of structures that are within 500 feet of each other into a single MOSCAD location. The combining reduces the number of MOSCAD equipment that will be transmitting by the radio-based telemetry

system; and thereby reducing potential interference. Network requirements include the construction of a microwave antenna site with equipment shelter and 300-ft tower within SMA 3A/3B or other suitable location. Additional coordination during plans and specification shall finalize the network requirements.

A.11.7.4 Implementation and Construction

The construction plans will contain plans for the hardware components of the telemetry system. SFWMD is working on a basic interface program that would be load as the structures are completed. A software contractor would then be contracted to edit the basic program for the specific structure.

A.11.7.5 Operation and Maintenance

The operation and maintenance of the OS-SCADA network shall be performed by SFWMD. In conjunction with the current telemetry subcontractor, SFWMD is working toward a core program that would be loaded during installation of the OS-SCADA hardware components. This core program reduces the number of program hours needed to place each structure on the network. Similarity of the new components with the existing components will reduce both personnel training cost and parts inventory holding cost.

The current mixes of components function very well together with minimal interfacing concern. Duplication of the existing MOSCAD board/components would require some sole sourcing.

A.12 GEOTECHNICAL DESIGN

A.12.1 Project Description and Purpose

A.12.1.1 General Description and Background

The Broward County Water Preserve Area (BCWPA) Project Implementation Report (PIR) has been prepared to evaluate the design components associated with the project. The BCWPA features represent three components out of the larger Comprehensive Everglades Restoration Plan (CERP) that consists of approximately 60 different components. The purpose and function of each individual WPA is to capture storm water for longer-term storage. The stored water will be utilized for a variety of purposes including ecosystem restoration, domestic water supply, agricultural water supply, aquifer recharge, and prevention of salt-water intrusion. Currently, storm water is discharged south, east and west through a series of large conveyance canals. Frequently, these discharges can cause negative environmental impacts in the Everglades or Ocean estuaries. It is envisioned that all the WPAs will allow these discharges

to be minimized. In addition, the WPAs may provide water supply during times of drought or low water.

A Feasibility Study for the WPA was completed in 2000, evaluating nine different design regions, including those now incorporated as part of the BCWPA. Each design region is composed of different types of project features, some of which include embankments, canals, structures (pump stations, weirs, etc.), fish and wildlife enhancement features, and some recreational features like boat ramps. Each of the nine design regions was analyzed as one sub-system first, followed by an analysis of the WPA system as a whole. The BCWPA includes the following components: Seepage Management Area WCA 3A, Seepage Management Area WCA 3B, C-11 Impoundment and C-9 Impoundment.

For a general layout of the project site, please refer to *Plate G-1.*

A.12.1.1.1 Water Conservation Area 3A Seepage Management Area

The WCA 3A Design Region includes a wetland seepage management area, 3A SMA, and levees. The proposed wetland storage area is located adjacent to the northeast section of WCA 3B. The 3A SMA wetlands cover approximately 2,000 acres. The wetland area will manage water levels that will vary from the wet season to the dry season. The area may store up to one feet of excess storm water behind an earthen embankment approximately 2-3 feet high.

A.12.1.1.2 Water Conservation Area 3B Seepage Managemernt Area

The Seepage Management Design Region includes a wetland seepage management area, 3B SMA, conveyance canals, levees, structures, and some fish & wildlife enhancement features. The proposed wetland storage area is located adjacent to the northeast section of WCA 3B. The 3B SMA wetlands cover approximately 2,200 acres. The wetland area will manage water levels that will vary from the wet season to the dry season. The area may store up to two feet of excess storm water behind an earthen embankment approximately 2.5 to 3 feet high.

A.12.1.1.3 C-11 Impoundment

The C-11 Impoundment Design Region includes one impoundment, a wetland mitigation area, conveyance canals, seepage collection canals, embankments, structures (pump stations, weirs, etc.), and one recreational boat ramp. The proposed impoundment is located adjacent to the northeastern section of WCA 3B, east US 27 and north of the existing C-11 Canal. The C-11 Impoundment and mitigation areas will cover approximately 1,831 acres. The impoundment

will store up to four feet of excess storm water behind an earthen embankment approximately 8.5 feet high (see *Section A.5.2.6).*

A.12.1.1.4 C-9 Impoundment

Similarly to the C-11 Impoundment, the C-9 Impoundment Design Region includes one impoundment, improved conveyance canals, seepage collection canals, embankments, structures (pump stations, weirs, etc..), and some fish & wildlife enhancement features. The proposed impoundment is located adjacent to the northeastern section of Water Conservation Area 3B east of US 27 and north of the existing Miami Canal. The C-9 Impoundment and mitigation areas will cover approximately 1,807 acres. The impoundment will store up to four feet of excess storm water behind an earthen embankment approximately 15 feet high (see *Section A.6.4.3*).

A.12.2 Summary of Key Geotechnical Design Considerations

A.12.2.1 General Description and Background

Due to the numerous project features and various components, research on pertinent geotechnical issues was performed during the WPA Feasibility Study to determine relevant regulations and design criterion. An attempt was made to review and list all relevant Corps of Engineers Engineering Manuals (EMs) for the purpose of developing design guidelines for Dams, levees, structures, etc. The following sections discuss this effort and its application to the overall design effort. Should Corps design guidance be updated between the completion date of this report and the final design phase of the project, the updated guidance will be used.

A.12.2.1.1 Embankments

All evaluations presented in this Geotechnical appendix conform to the general requirements presented in EM-1110-2-2300, entitled "General Design and Construction Considerations for Earth and Rock-Fill Dams." Embankment levees are thoroughly discussed in EM-1110-2-1913, entitled "Design and Construction of Levees."

During the feasibility study, a document referred to as the "white paper" was prepared by the Jacksonville District's Engineering Division to determine the overall impact of any re-interpretation of CERP assumptions and as a result, it was established that all embankments built for water storage, whether permanent or short term, are to be classified as dams, with minor differences in design based on use. The C-11 Impoundment and C-9 Impoundment shall be classified, designed and constructed as dams. Seepage Management Area WCA 3A and Seepage Management Area WCA 3B shall also be classified as dams, but

their design will not be as rigorous due to their actual functionality as a flood protection levee. In general, these latter areas, as described above, will only impound a maximum of one (1) foot of water during uncommon rainfall events. In addition, these levees will be located distant from any urbanized areas that may be affected in case of levee failure.

For classification purposes, two main types of embankment dams were selected. The two main types of embankment dams are earth and rock-fill dams, depending on the material utilized for construction. Generally, it is more economical to construct the dam from onsite borrow materials. Therefore, the available borrow material may dictate the type of dam chosen. Onsite field inspections and site-specific subsurface investigations usually determine the type and quantity of onsite borrow material available.

Based upon preliminary subsurface investigations and a review of existing geotechnical data, it was determined that both types of embankment dams can be constructed. In general, the embankments will be constructed out of onsite processed materials. For the C-11 Impoundment, both unconsolidated (sands) and consolidated (limestone rock) materials will be used for the embankment fill. For the C-9 Impoundment, the embankment material will most likely consist of processed limestone rock. Additional subsurface investigations will be required at both impoundment locations for final design details.

Once the embankment type is selected, the designer must select an economical embankment section based upon site-specific topography, geology, hydrogeology, dam geometry, and overall project purpose. Multiple sections were considered during the Feasibility Study phase. Designs utilizing impervious cores require identification of appropriate onsite borrow sources. The presence of ultra pervious limestone bedrock in the dam foundation requires additional characterization of the hydrogeology and a thorough analysis of "underseepage" potential. At this time, a zoned exterior embankment is being considered for the C-9 impoundment, and a homogenous fill embankment for C-11 impoundment. Typically, a zoned embankment will include a central impervious core that is surrounded by more pervious "shells" that support the core. An internal drain may also be included with this type of embankment construction as a way of controlling any water that passes through the core. Besides seepage control, other engineering requirements for the dam embankments may include foundation treatment, slope protection, emergency spillways, dam freeboard, special construction methods, instrumentation, and in-depth subsurface exploration/testing. Some of these items are discussed in the following sections.

A.12.2.1.2 Foundation Treatment

In all cases, the foundation of the dam should be founded on competent soils or bedrock. Foundation treatment of dams is a requirement if questionable soils or

bedrock are present or uncovered during site-specific subsurface investigations. EM-1110-2-2300, Chapter 5 discusses required foundation preparation and treatment. Foundation preparation and treatment involves clearing and grubbing of stumps and large roots within the first three feet below ground surface followed by inspection of foundation material type. In some cases an inspection trench up to six feet deep may be excavated. Natural shallow deposits of soft organic sediments, peat, or fill deposits should be removed in a dam foundation. Once these objectionable soils are removed, the foundation will be backfilled with suitable soil or processed limestone, depending on the available material. Placement of embankment fill below the groundwater table, however, should not be permitted unless excavation dewatering takes place so that the fill may be placed in the dry and in compacted layers. This is highly recommended as placement of compacted limestone fill greatly reduces underseepage immediately underneath the dam. In addition, dam foundations should not contain voids, cavities or caverns that could be found in a limestone bedrock environment. Typically, any large voids or cavities that may be encountered will be filled with suitable soil or pumped full of high-slump concrete or grout. With respect to the possibility of sinkholes occurring within the project area, the Florida Geological Society reports the occurrence of sinkhole development in south Florida to not be that common. Nevertheless, the potential for this type of hazard will be examined further during the detailed design phase of the project.

Based upon the limited subsurface investigations available to date for this study, some foundation treatment is envisioned. This treatment is expected to consist of clearing and grubbing with the removal of unsuitable foundation soils. Limestone is predominant throughout the entire project site and is found, on average, within the upper five feet, in some cases, extending for more than 70 ft of depth. The subsurface investigations revealed the presence of peat and other organic sediments that will have to be removed prior to the construction of any dams. During SPT sampling, no voids or cavities were encountered or recorded, although the cores retrieved depicted highly weathered vuggy limestone, with the voids typically filled with sand. The presence of such dictates the permeability values used for this layer. Additional information on the subsurface investigations is available below.

A.12.2.1.3 Seepage Control with Embankments and Conveyance Canals

Seepage control of embankment through-seepage and underseepage is critical to maintaining a safe and stable dam. Seepage losses from conveyance canals may be beneficial as part of an environmental restoration project but they may also be detrimental in some cases. Therefore, the control of seepage is a prime consideration for the WPA design regions.

Seepage control within the embankments is necessary to eliminate excessive uplift pressures, downstream slope instability, piping of the embankment material and subsequent loss of the water resource. Seepage can occur directly through an embankment constructed with pervious material, due to piping, or under seepage that travels in one of the foundation layers beneath an embankment and surfaces at some point on the downstream side. Piping can occur either within the embankment or within the embankment's foundation soils. In all cases, pathways need to be monitored and controlled. With respect to the exterior embankments for the C-9 Impoundment, through-seepage will be controlled by the placement of a select material core and a granular chimney/blanket drain that will be piped to drain. The height of the core section was determined from the normal pool depth plus the design-storm surcharge depth plus 1 foot. For C-9 Impoundment exterior embankments, this height is 11 feet. For the C-11 Impoundment, through seepage will be controlled by the placement of a homogenous fill material and a granular chimney drain that will be piped to drain.

The materials used for embankment construction and the actual construction procedures have a significant effect on seepage through the embankment. However, the expected head differences between upstream and downstream stages and the duration of such stages should have minimal effects on the development of embankment piping if the proper fill material and construction procedures are followed. The use of compacted limestone fill as an embankment material is widely employed throughout Florida, whether for levees or roadway embankments. Field and laboratory tests have confirmed that hydraulic conductivity values from 10^{-3} to 10^{-4} cm/s are attainable when using at least 95% of the maximum dry density based on the Modified Proctor (ASTM D 1557) as the basis for field compaction requirements.

Seepage out of conveyance canals is also a consideration. Conveyance canals may carry water of varying quality, acting as a possible source of groundwater contamination. In general, the canal stage will determine if a particular reach is "losing" (net seepage loss) or "gaining" (net seepage gain). Measures to reduce seepage into or out of canals include reducing the head differential between the canal and surrounding natural groundwater level or the impoundment level, lining the canal to reduce bed permeability or altering the canal geometry. It is anticipated that seepage into or out of the conveyance canals will be through the surficial limestone media. Piping of such is not anticipated in the short term, but the possibility of the existence and expansion of solution cavities shall be considered and shall be studied during the detail design phase. Additional subsurface investigations are required to evaluate these issues in more detail.

Seepage beneath the embankments will be managed (in part) by the internal blanket drain and by the construction of exterior seepage collection canals.

These canals will be designed to capture most (if not all) of the water leaving the impoundments via under seepage.

A.12.2.1.4 Slope Protection

Slope protection of the embankment is critical to maintaining a safe and stable dam. Uncontrolled erosion from wave action or runoff, wind and other sources can lead to substantial problems and costly repairs. Therefore, the protection of the embankment slopes is a prime consideration. Slope protection is governed and thoroughly discussed in Appendix C of Corps of Engineers EM-1110-2-2300, entitled "Earth and Rock-fill Dams, General Design and Construction Considerations." Design Criteria Memorandum No. 4 (Minimum Dimensions of Dams and Embankments) dated 9 August 2005 also states the following: "Slope protection will be required for the CERP embankment Dams." As a result, soil cement armoring was considered for the interior slopes of the exterior embankments for both the C-11 and C-9 Impoundments.

Note that the original slope protection used in the feasibility study included soil cement plate (12" thick) with 12" stair steps. Using guidance from Appendix G (Use of Soil Cement for Levee Protection) of EM 1110-2-1913, 24-inch flat-plate soil-cement armoring would protect the interior slope. To protect the slope and the soil cement armoring from uplift forces encountered during an emergency rapid drawdown of the impoundment pool, 9 inches of fine drainage gravel would be placed beneath the soil cement. The slope protection features and typical sections are shown on *Plates G-15A* (for C-11) and *G-15B* (for C-9).

A.12.2.1.5 Instrumentation

All embankment dams shall have various types of instrumentation installed to monitor their safety, function and operation. Embankment instrumentation requirements are governed by EM-1110-2-1908, entitled "Instrumentation of Embankment Dams and Levees." Instrumentation is vital to monitoring the performance of embankment dams because of the construction materials involved and due to the design uncertainties of the embankment itself. While instrumentation is not intended to be the only means for examining the embankment, it is an important part of the embankment safety inspection and surveillance program. EM-1110-2-1908 lists the principal objectives of a geotechnical instrumentation plan. The objectives are sorted into four main categories: analytical assessment; prediction of future performance; legal evaluation; development and verification of future designs. Properly installed, located and monitored instrumentation can provide quality data to support the four objectives.

The main types of instrumentation under consideration for the BCWPA embankments are piezometers, groundwater-monitoring wells, inclinometers,

and possibly settlement gauges. Piezometers will be installed and screened within the embankment and foundation materials to monitor the water level at each location. Groundwater monitoring wells are to be installed along seepage collection canals and at adjacent properties to monitor groundwater level and groundwater quality. Inclinometers will be installed at a few locations to monitor embankment movement. These will be installed into the embankment foundation also in order to monitor relative movement between the embankment and foundation. Settlement gauges will be considered only for embankments constructed on top of loose sand deposits or over compressive fine-grained or organic soils. The final instrumentation program shall be determined during detailed design. It is important to note that all impoundments classified and constructed as dams shall be required to have both *annual* dam inspections and more extensive *periodic* dam safety inspections at intervals required by regulation. The Jacksonville District Geotechnical Branch along with the SFWMD will lead the inspection efforts.

A.12.2.1.6 Spillways

The design of emergency spillways is primarily under the purview of hydraulic design engineers. Geotechnical considerations mainly involve the type of spillway, erodability of the spillway or stilling basin, or uplift pressures that could occur beneath the spillway. Spillway design is governed by EM-1110-2-1603 entitled "Engineering and Design – Hydraulic Design of Spillways."

The C-9 and C-11 Impoundments will have some type of emergency spillway. The most current pertinent option is some type of chute spillway. It is envisioned that the chute spillway will be constructed over the embankment and shall be constructed of either poured concrete, articulated concrete mattresses, rock gabions or roller compacted concrete. The spillway should tie into competent bedrock on the downstream toe if possible. If competent bedrock is not available near the ground surface to tie into, downstream slope protection must be utilized for the spillway to prevent dangerous spillway toe erosion.

All of the final details should be reviewed during the design process. In addition, other alternative spillway designs may be considered during detailed design. Box inlet drop spillways may be an economical alternative to a chute spillway.

A.12.3 Regional Geology and Hydrogeology

A.12.3.1 Regional Geology

South Florida is underlain by Cenozoic-age rocks to a depth of approximately 5,000 feet below land surface (bls) and is comprised primarily of sand, limestone, clay and dolomite (Meyer, 1989). Geologic units exposed at the land surface in southern Florida have been mapped by Puri and Vernon (1964) and Brooks

(1981), and have been presented in detailed county maps by the Florida Geological Survey. The surficial geology is extremely important to environmental issues such as land use, waste disposal, surface and groundwater quality, drainage, ground water recharge, physiographic characteristics, and ecological zonation.

The lithology of geologic units that are at or near land surface plays a major role in determining the physiography by controlling drainage, elevation, soil development, recharge and runoff, and the dominant ecological environment. The regional geology has been broken up into sub-regions to focus the reader. These various sub-regions are described below.

A.12.3.2 Lower East Coast

Thin sand and the Miami Limestone underlie most of the Lower East Coast and form the highest elevations in the area corresponding to the Atlantic Coastal Ridge. These units are highly permeable and higher elevations are well drained. The oolitic facies of the Miami Limestone are breached by numerous shallow sloughs, further enhancing drainage. Coastal marshes formed at lower elevations and within the breaches created by the sloughs. The higher elevations of the Lower East Coast and Atlantic Coastal Ridge are composed of the more resistant cemented deposits of the Anastasia Formation to the north and the Miami Limestone to the south.

A.12.3.3 Hydrogeology

A.12.3.3.1 General Description and Background

Much of the work in identifying, mapping and describing the geologic units within southern Florida has been completed in an effort to understand the hydrologic resources of the area. The relation between the carbonate units and the interfingering siliciclastic sediments (quartz rich sand) controls numerous environmental aspects of the south Florida ecosystem mainly due to the profound influence these units have on the movement of water. Along with stratigraphic names, these units are also delineated as hydrologic units based on their hydraulic properties. As such, the top and base of that aquifer system may not always correspond with the top and base of any single geologic formation in any particular aquifer system. Table 1 of the WPA FS report presents preliminary hydrogeologic information within the study area.

Three major aquifer systems have been identified in South Florida; the Surficial Aquifer System (SAS), the Intermediate Aquifer System (IAS) and the Floridan Aquifer System (FAS) (Klein, et al. 1975; Causarus, 1985; Fernald and Patton, 1986; Southeastern Geological Society, 1986; Miller, 1986; Causarus, 1987; Johnston and Miller, 1988; Fish and Stewart, 1991; Miller 1997).

Separating the SAS from the FAS is the Intermediate Confining Unit (ICU), which isolates the aquifer systems. The ICU predominately consists of the Miocene age Hawthorn Group. The Hawthorn Group is variable in lithology and generally consists of interbedded sand, silt, clay, dolostone, and limestone, with characteristically high phosphate content. Scott (1988) upgraded the Hawthorn Formation to group status and described the group members throughout Florida.

In southern Florida, the Hawthorn Group is comprised of the Miocene age Peace River and the underlying Arcadia formations. The Peace River Formation consists of interbedded quartz sands, clays, and carbonates. The Arcadia Formation lies disconformably below the Peace River Formation, and consists predominantly of limestone and dolostone containing varying amounts of quartz sand, clay, and phosphate grains.

The IAS is contained within the Hawthorn Formation, as are a few minor aquifers of limited transmissivity and extent. In Dade and Broward Counties were the Broward WPA is located, the lower portion of the Miocene-Pliocene Tamiami Formation are included in the ICU because of its low permeability.

A.12.3.3.2 Surficial Aquifer System

In southern Florida, because the Floridan and intermediate aquifer systems are saline or have low yield, practically all municipal and irrigation water is obtained from the surficial aquifer system. The surficial aquifer system comprises all the rocks and sediments from land surface to the top of the intermediate confining unit and includes the Pleistocene Pamlico Sand, Anastasia Formation, Fort Thompson Formation, Miami Oolite, Key Largo Formation, Caloosahatchee Marl and the Pliocene Tamiami Formation.

These deposits consist of sands, sandy and shelly limestone, sandstone and silts. The discontinuous and locally productive nature of the shallow water bearing units reflects the complex interfingering of lithologic units throughout southern Florida (Causarus, 1985, 1987; Fish and Stewart, 1991; Weedman and others, 1997).

The thickness of the SAS varies from approximately 10 feet at some locations in the western part of the lower peninsula to greater than 400 feet along the Miami-Dade County coastline. Sediments of the SAS have a wide range of permeability and locally may be divided into distinct aquifers that are separated by less permeable or semi-confining units. As such, the SAS may exhibit both unconfined and semi-confined hydrogeologic characteristics.

Surficial aquifers of southern Florida include: the Biscayne aquifer, the undifferentiated surficial aquifer, the coastal aquifer of Palm Beach and Martin

Counties and the shallow aquifer of southwest Florida. As more mapping and hydrologic investigations are completed, it is likely that additional surficial aquifers will be delineated within this system.

The Biscayne aquifer is a highly productive unconfined aquifer capable of producing greater than 10 million gallons of water per day. It underlies parts of Miami-Dade, Broward, and southern Palm Beach Counties. It is wedge shaped, highly permeable, and is more than 200 feet thick in the Atlantic Coastal Ridge and thins to a feather edge about 35 to 40 miles west, deep in the Everglades. Several unconfined surficial aquifers have been identified within the surficial quartz sand and shelly beds of the Anastasia Formation, shelly limestone of the Tamiami Formation, and limestone units of the upper Hawthorn Group. Although these local, discontinuous, unconfined, shallow aquifers are not as productive as the Biscayne aquifer, they are an important source of water for counties to the north of Broward (Hyde, 1975). These aquifers have variable water quality and production rates varying from a few gallons per minute (gpm) to greater than 2000 gpm.

A.12.3.3.3 The Intermediate Aquifer System / Intermediate Confining Unit

The IAS consists of beds of sand, sandy limestone, limestone, and dolostone of Oligocene to Pliocene age that dip and thicken to the south and southwest. These aquifers are typically leaky artesian with moderate transmissivity and are located primarily in Polk, Sarasota, Highlands, Hardee and DeSoto Counties. The IAS includes the Tampa Member, the undifferentiated Arcadia Formation, and the Peace River Formation, all of the Hawthorn Group, and the Tamiami Formation.

A.12.3.3.4 The Floridan Aquifer System

The FAS is a thick sequence of Paleocene to Oligocene age carbonate units underlying the entire State of Florida. The Avon Park Formation (Eocene age), the Ocala Limestone (Eocene age), the Suwannee Limestone (Oligocene age), and the Arcadia Formation of the Hawthorn Group (Oligocene to Miocene age) are included in the FAS (Miller, 1986, 1997). Anhydrite beds in the lower Cedar Keys Formation constitute the base of the FAS.

The FAS is the primary source of water supply for the northern counties and is used as a source of supplemental irrigation water as far south as Martin County. The system receives direct recharge along a structural high, which occurs in the central part of the state. From this area, the FAS dips southward where it is overlain by clays and silts of the younger Hawthorn Group which form a confining layer over the FAS. The potentiometric surface is also highest in the north and decreases southward. In the vicinity of Lake Okeechobee, the potentiometric surface rises above the land surface, resulting in artesian

conditions with wells flowing freely up to 1,000 gallons per minute (gpm). Less permeable carbonate units, referred to as the middle confining unit, separate the system into two major aquifers called the Upper and Lower Floridan aquifers. North of Lake Okeechobee, the Floridan aquifer system yields freshwater although it is more mineralized (total dissolved solids are greater than 1,000 mg/L) along coastal areas and in southern Florida (Sprinkle 1989). In southern Florida, more than 600 feet of low permeability siliciclastic sediments confine this aquifer and create artesian conditions. Although the head gradient is upward, the low permeability units prevent significant upward migration of saline waters into the shallower aquifers.

Depth to the Floridan aquifer is approximately 400 feet near Naples and 900 feet in coastal Miami-Dade County (Klein and others, 1975). The transmissivity is generally less that 250,000 ft^2/d, generally decreasing to the south due to the presence of low permeability limestone. In the Upper East Coast, the Upper Floridan aquifer is used for drinking water supply. In the Lower East Coast, from Jupiter to south Miami, the Upper Floridan aquifer is being considered for storage of potable water within an aquifer storage and retrieval program.
In the Lower Floridan aquifer, there are zones of cavernous limestone and dolostone with transmissivities in excess of 3,000,000 ft^2 /d. However, because these zones produce saline water, they are not used for drinking water supply. Because of their depth and salinity, these deeper zones of the Lower Floridan aquifer are used primarily for injection of treated effluent wastewater. The deepest permeable zone of the Lower Floridan Aquifer contains a formation known as the Boulder Zone from a depth of about 3,000 to 3,500 feet.

The thickness of the FAS and the depth to its upper boundary vary according to location. In West Palm Beach, Broward and Dade Counties, the Upper Floridan Aquifer has a thickness of roughly 100 to 300 feet, and a depth to the upper boundary that varies from about 600 to 1,000 feet beneath the ground surface (Miller, 1990).

Estimated transmissivities of the Upper Floridan Aquifer vary between 10,000 and 50,000 sf/day in Palm Beach, Broward and Dade Counties, and between 100,000 and 250,000 sf/day in the regions just north and just east of Lake Okeechobee (Bush and Johnson, 1988). Bush and Johnson (1988) based these estimates on what they described as aquifer tests, geology, and simulation. These two authors provided a range for the storage coefficient for the upper FAS from 1.0×10^{-5} to 2.0×10^{-2}, with the most common values in the range of 10^{-3} to 10^{-4}.

A.12.4 Field Explorations Relating to the Geotechnical Design

A.12.4.1 General Description and Background

Some existing core borings were referenced in studying the project sites. In addition, a feasibility study level subsurface investigation took place, further enhancing the available information. Drilling techniques included the Standard Penetration Test (SPT) for soil and diamond tipped core drilling for rock. All core borings were surveyed and located by registered surveyors. All core boring locations are referenced to NAD 1983 horizontal grid and NGVD 1929 vertical datum. Core boring locations are shown in Attachment # 1 of Appendix C of the WPA FS report.

Core borings were drilled to depths ranging from 30 feet to 130 feet as discussed in later section.

A total of 15 recharge tests were performed within or in the proximity of the BCWPA sites at various elevations and strata. The recharge tests were performed by drilling to the bottom of the test depth, casing off the boring above this depth and creating a bentonite seal to create a 5-foot length of hole to be tested. Water was then pumped into the boring and the flow rate required to keep the water at the top of the casing was measured. The permeability was then calculated using equation 19.4 from Lambe and Whitman, case G (after Hvorslev).

Laboratory testing was performed on samples obtained from the core borings drilled at some of the various project sites. Laboratory tests included grain size analyses, natural moisture contents, Atterberg limits, organic contents, laboratory permeability tests and rock core unconfined compressive strength tests.

A.12.4.2 Field Explorations at the Broward WPA Design Region

A.12.4.2.1 WCA 3A and WCA 3B SMA Design Regions

No core borings were drilled within the 3A SMA or the 3B SMA areas during the feasibility study. However, core borings were drilled nearby for the C-11 Impoundment, the C-9 Impoundment and at the northern end of Lake Belt region.

Three initial soil borings were drilled for the C-11 Impoundment during the WPA FS phase. These were drilled along the C-11 Canal levee. More recently, an additional seven (7) borings were drilled around the perimeter of the impoundment, as shown in *Figure A-63*. The assumption is that these soil borings are generally representative of the conditions in the WCA 3A SMA

design region and the northern third of the WCA 3B SMA design region. In general, these soil borings depict overburden composed of peat and sands, slightly increasing in depth towards the west and varying in depth from 0 to 5 ft. The overburden is generally underlain by limestone of varying degrees of strength. This limestone, which may contain interbedded layers of sand or cemented sand (sandstone) extends to approximately 80 ft of depth, where it is underlain by a thick medium dense to dense sand stratum. Along the southern perimeter, the stratification within the upper 25 ft is more variable than within the rest of the C-11 Impoundment. The limestone appears to be outcrop at the eastern end and dips down towards the west. However, the differences arise in the presence of a clay stratum underlying the surficial rock at the eastern, which in turn, is underlain by a sand layer, both appear to diminish in the west direction. A more thorough description is provided in the upcoming section.

The core borings drilled for the C-9 Impoundment were drilled in an abandoned quarry just northeast of the Impoundment site. Together with the core borings drilled at the Opa-Locka West Airport of the North Lake Belt region and core boring CB-RS-S3 drilled in the Central Lake Belt region, these core borings were considered to be generally representative of the conditions in the southern two thirds of the WCA 3B SMA design region.

The materials encountered by these soil borings are described in the respective sections, with the exception of CB-RS-S3. The materials encountered in core boring CB-RS-S3 were sand in the upper 4.5 feet underlain by 1.5 feet of peat, which was in turn underlain by 1.5 feet of clay. This layer was followed by limestone to a depth of 93.0 feet and finally sand to the termination depth of the boring at 105.5 feet. Two thin layers of sand were interbedded in the limestone layer.

Four additional core borings were drilled in or near the southern end of the 3B SMA area in 1997. Only XY-coordinates were surveyed for these core borings. Elevations were not recorded. Therefore, the logs are only suitable for characterization of the types of materials and general stratification at the site.

These additional core borings are labeled CB-31 through CB-34. They were drilled to depths ranging from 21.2 to 40.1 feet. CB-31 was drilled just south of the Seepage Management Area WCA 3B region. CB-32 through CB-34 were drilled on Levee No. 33, which forms the west border of the 3B SMA.

CB-31 encountered 14.7 feet of limestone gravel followed by a 1.3-foot layer of peat underlain by limestone to the termination depth of the boring at 40.1 feet. Core borings CB-32 through CB-34 generally encountered about 15.0 feet of levee fill over seams of peat in thicknesses of 0.2 to 0.5 feet, underlain by limestone to the termination depths of the borings at depths ranging from 21.2

to 22.4 feet. The groundwater levels reported for the C-11 Canal borings were considered representative of the 3A SMA design region and the northern third of the 3B SMA design region. The groundwater levels reported for each area were close to the adjacent canal water levels.

The recharge tests performed in the C-11 Impoundment borings, CB-RS-Q1, Q2 and Q3, were considered representative for the 3A SMA region and the northern third of the 3B SMA region. The recharge tests performed in the C-9 Impoundment borings, CB-RS-R1, R2 and R3, were considered representative for the southern two thirds of the 3B SMA region. The results of these recharge tests are discussed in the respective sections of this report. Core borehole locations along with existing monitoring wells referenced in Table 1 of the WPA FS report, are shown on Plates 1 through 4 of Appendix C of the WPA FS report.

A.12.4.2.2 C-11 Impoundment Design Region

Three core borings were drilled during the WPA FS phase to depths of approximately 30.0 feet along the C-11 Canal borrow levee that forms the southern border of this site. A total of 6 recharge tests were performed; 2 in each core boring.

The site and its surrounding areas is relatively low and flat with natural ground elevation varying between +4.5 ft and +6 feet, according to the Cooper City SW, Florida quadrangle map and site point surveys. The site is bounded on the west by Route 27, which is at the approximate elevation of +12 to +13 feet, and on the south by the C-11 Canal and borrow levee. The elevation of the borrow levee is about +9.0 feet, according to the survey of the three core borings described above.

Generally, each core boring encountered sand in the upper few feet with limestone in the substrata. However, varying stratification was present. CB-RS-Q1 encountered interbedded layers of limestone and peat in the upper 8 feet while CB-RS-Q3 encountered a 5-foot clay layer beginning at a depth of 7.5 feet.

More specifically, CB-RS-Q1, the closest of the three to US 27, encountered sand and limestone fill in the upper three feet underlain by a 1.5-foot layer of peat that was in turn underlain by a limestone seam (~0.2 ft) and then a 2-foot layer of peat. The boring then encountered limestone to a depth of +15.0 feet in turn underlain by sand to a depth of +27.0 feet and then limestone again to the termination depth of the boring at +30.0 feet.

CB-RS-Q2 encountered sand in the upper 2.7 feet underlain by limestone to a depth of 13.5 feet in turn underlain by silty sand and sand to the termination depth of the boring at 30.0 feet. Finally, boring CB-RS-Q3 encountered sand in the upper 7.5 feet underlain by a 5-foot stratum of clay in turn underlain by

sand to a depth of 21.5 feet, limestone for the next 5.5 feet and, finally sand to the termination depth of the boring at 30.5 feet. Ground water was encountered in these soil borings at elevations of 2.1 and 4.2 feet, respectively.

Two recharge tests were performed in each of the 3 core borings drilled at this site. The depth ranges for the tests were from 5 to 10 feet and 25 to 30 feet for each core boring. The results of these tests were permeabilities (k) of between 0.7 and 16 ft/day with the lowest permeability indicated in a sand underlain by clay formation and the highest in a sand underlain by limestone formation. Locations for these soil borings, along with existing monitoring wells referenced in Table 1 of the WPA FS report, are shown on Plates 1 to 4 of Appendix C of the WPA FS report.

As stated in the previous section, an additional seven soil borings were drilled in the C-11 Impoundment design region. These were named CP05-BCWPA-CB-0001 through CB-0007. Their approximate location is presented in *Figure A-63*. All seven borings were sampled continuously to a depth of 25 ft, while CB-0007 extends to a depth of 100 ft. Most of these borings depicted overburden composed of peat and sand within the upper five (5) feet, underlain by limestone. Based on the borings, the limestone outcropped at two locations and during a site visit, was visible from the ground surface, although sporadically. The limestone is believed to extend to approximately 80 ft of depth, although it is interbedded with sand and cemented sand (sandstone) layers, occasionally, as much as 20 ft in thickness.

A.12.4.2.3 C-9 Impoundment Design Region

Six core borings were drilled for this project in proximity to this site. Three of these core borings were located to the northeast of this site and three to the south. Also, nine (9) recharge tests were performed; 2 in each of these 3 core borings drilled on the north side of this site and 1 in each of the core borings to the south.

The 3 borings to the north of this site, CB-RS-R1, R2 and R3, were located between ½ and 1 mile from the northern end of the C-9 Impoundment site in an area of an inactive quarry. These borings were drilled to depths of about 30.0 feet. The 3 soil borings drilled in proximity to the south of the site were labeled CB-RS-XX1, XX2 and XX3. Of these three, one was drilled on the C-9 Canal's northern levee at the south east corner of the site and two were drilled in the area of the Op-Locka West Airport between about ¼ and ½ mile south of the C-9 Canal. These borings were drilled to depths ranging from 95 to 102 feet.

Seven core borings from a previous project were also located on this site. However, survey elevations for these core borings were not taken, making them useful only for general site characterization.

Similarly to the C-11 Impoundment, the C-9 Impoundment site and its surrounding areas are relatively low and flat with elevations between about +4 and +5 feet, according to the Pennsuco, Florida quadrangle map. The site is bounded on the west by US 27, which is at the approximate elevation of +11.0 feet and on the south by the C-9 Canal and borrow levee. The elevation of the borrow levee is between about +5.5 and +7.0 feet, according to the survey of the core borings CB-RS-XX2 and CB-RS-XX3, respectively. Recent LIDAR survey data in the area reveals slightly lower elevations than shown in quadrangle maps.

The three soil borings drilled to the north of the site generally encountered limestone in the upper 12.5 to 15.0 feet underlain by a stratum of sand or silty sand between 1.5 and 4.5 feet in thickness. This was in turn underlain by limestone to the termination depths of the borings at about 30.0 feet.

The three soil borings to the south of the C-9 Impoundment site encountered very similar subsurface conditions. Each boring encountered limestone in the upper 71.5 to 73.0 feet underlain by sand and silty sand to depths of about 86.5 to 94.0 feet in turn underlain by silt and clayey silt to the termination depths of the borings at 95.0 to 102.0 feet.

Eight additional soil borings were drilled within and around the parameter of the C-9 Impoundment area in 1997. Only XY-coordinates were surveyed for these core borings. Elevations were not recorded. These additional borings were labeled CB-1, CB-19, CB-21 through CB-25 and CB-27. They were drilled to depths ranging from 8.3 to 26.5 feet. Typically, they encountered overburden layers of silty sand or limestone ranging in thickness from about 1.5 to 6.5 feet underlain by peat, organic silt or organic clay layers from about 0.5 to 2.0 feet in thickness. This overburden was generally underlain by limestone to the termination depths of the borings.

The ground water levels encountered by the three borings on the northeast of the site varied between elevations of +2.6 and +4.4 feet. The ground water levels encountered by the three borings to the south of the site varied between +3.2 and +4.7 feet.

Two recharge tests were performed in each of the 3 core borings drilled to the northeast of this site (CB-RS-R1, R2 and R3). The depth ranges for the tests were from 5 to 10 feet and 25 to 30 feet for each core boring. The results of these tests were hydraulic conductivities (k) between 8 and 306 ft/day.

The highest of these k values were measured in borings CB-RS-R1 and R2, which ranged from 129 to 306 ft/day. All four tests in these two borings were

done in limestone or limestone and gravel formations. The permeability coefficients measured in core boring CB-RS-R3 were 8 ft/day for the upper one and 22 ft/day for the lower. Both tests were performed in limestone formations.

The recharge tests performed in the core borings CB-RS-XX1, XX2 and XX3, to the south of the C-9 Impoundment site, were performed in the confining layer beneath the Biscayne aquifer. This was due to the fact that these 3 borings were drilled primarily for the purpose of studying this confining layer in relation to the feasibility of a future in-ground storage impoundment. Each of these tests were performed in a 5-foot recharge length in the core boring with top elevations of -91, -90 and -83 feet-NGVD in core borings CB-RS-XX1, XX2 and XX3 with the measured permeabilities being 34, 0.1 and 0.2 ft/day, respectively. Each test was performed in a strata of similar clayey silt material. Therefore, the resulting permeability of 34 ft/day from CB-RS-XX1 may be high due to possible experimental error. Core borehole locations along with existing monitoring wells referenced in Table 1 of the WPA FS report, are shown on Plates 1 to 4 of Appendix C of the WPA FS report.

A.12.5 Seepage Conceptual Model Development Methodology

A.12.5.1 General Description and Background

Seepage is of major consideration in the Broward WPA due to the regional hydrogeology. Seepage from the various impoundments and conveyance canals has been discussed in previous sections of this report. A conceptual hydrogeologic model was developed in the FS report to be used as building block, in order to aid evaluate the magnitude of the expected seepage.

Both two-dimensional and three-dimensional groundwater models were prepared for the various design regions. The SFWMD prepared three separate groundwater flow models for the FS report, utilizing the finite-difference code, Modflow (McDonald and Harbaugh, 1988). Further information on these models is available in the WPA FS report. During the Feasibility study, the COE Jacksonville District utilized the Modflow model information and available wells and core borings to prepare approximately 20 separate two-dimensional cross-section groundwater seepage models. These model cross-sections were located perpendicular to impoundment levees and seepage/conveyance canals. Three-dimensional modeling will be performed in the design phase of the project and will be provided when completed.

A.12.5.2 Hydrogeologic Conceptual Model Development

During the FS stage, it was decided that the conceptual model development should concentrate on the Surficial Aquifer System, after a review of the data and an evaluation of the function of the various WPA project features. The data

can be found in the FS report. Generally, the SAS comprises all the rocks and sediments from land surface to the top of the intermediate confining unit and includes the Pleistocene Pamlico Sand, Anastasia Formation, Fort Thompson Formation, Miami Oolite, Key Largo Formation, Caloosahatchee Marl and the Pliocene Tamiami Formation. The SAS can be sub-divided into numerous different units depending on the location and individual interpretation. For instance, past hydrogeologic conceptual models of Miami-Dade County have used only three layers to represent the SAS (Evans, 1999), while other authors have used up to six layers in other South Florida counties. Two approaches to developing a sub-divided conceptual model were initially considered and these are discussed below.

Two approaches to delineating separate layers in the conceptual model were considered: 1) define with close adherence (paralleling) to stratigraphy or 2) define layers hydrogeologically. The second approach was selected after considerable review because it allowed a logical layering from the "top down" with more continuity for the upper two layers.

A basic interpretation approach was decided upon and the available information was evaluated to separate the stratigraphy of the SAS into five hydrogeologic layers based on hydraulic conductivity (K) for use in the preparation of a numerical groundwater model. The interpretation centered upon the preparation of new hydrogeologic cross-sections. These sections were prepared in-house by the Jacksonville District staff and continued the work of Fish & Stewart (1991), and Fish (1988), to extrapolate the regional extent of various layers. The layers based on similar K values were extrapolated west to the Gulf of Mexico and north into Palm Beach County. The Jacksonville District staff initially adopted the K ranges proposed for Dade and Broward Counties by Fish & Stewart (1991) and Fish (1988) as a guide. The layers generally conform to cross-sections presented by Fish & Stewart.

However, for the Broward WPA, site specific hydrogeologic models were used to better represent local conditions, in addition to better predicting seepage out of the future impoundments. The differences consisted mostly in the actual values of the coefficient of permeability and the thickness of the strata.

A.12.5.3 Seepage Modeling

A.12.5.3.1 General Description and Background

As part of the WPA Feasibility Study, multiple numerical models were developed to evaluate seepage issues, natural systems, water quality, water supply and other important parameters. The SFWMD developed three distinct Modflow models concentrating on the three main South Florida counties that cover the study area; mainly, Miami-Dade County, Broward County and Palm Beach

County. These Modflow models are described in more detail in the WPA FS report. The Jacksonville District of the U.S. Army Corps of Engineers developed approximately 20 separate two-dimensional cross-section models utilizing the Groundwater Modeling System – "GMS" (WES, 1992). Specifically, the COE used GMS version 2.1b dated October 1994. The GMS is a modeling system graphical user interface that acts as both a pre and post-processor of various numerical models including FEMwater, Modflow, MT3D, SEEP2D and others.

SEEP2D is a two-dimensional finite-element model code that is ideal for evaluating seepage losses from impoundments or conveyance canals. SEEP2D can be applied to either unconfined or confined aquifers and can be utilized to determine total seepage flow per foot of section. A finite-element mesh was prepared at each cross-section location and then the various model inputs were applied to the model.

For the BCWPA PIR, additional modeling was performed using Plaxis (version 8.2) and SEEP/W (from the GeoStudio 2004 software suite, version 6.20) to model the project features.

A.12.5.3.2 Seepage Model Inputs

The most important model input for any seepage analysis software is the assumed hydrogeology of the two-dimensional cross-section. Most of the Finite Element cross-section models adopted the conceptual model hydrogeology discussed above unless more detailed site specific data was available that allowed further layer refinement. This was the case for both C-9 and C-11 impoundments, where site-specific data was available. Besides the geometry of the various hydrogeologic layers, additional model inputs included the assignment of hydraulic conductivities in the groundwater flow direction (horizontal K) and perpendicular direction (vertical K). Again, a majority of these were based upon the values chosen for the conceptual model, unless site specific information was readily available.

After the development of the geometry and the assignment of flow parameters, boundary conditions were placed upon the model. The boundaries represent sources or sinks for groundwater. The models mainly utilized constant head boundaries, flux boundaries, no-flow boundaries and flow boundaries. In general, the boundaries were varied over a reasonable range of impoundment total heads (source heads) and canal heads (sink heads) in order to develop groundwater flow nets. In some instances, the controlling source head was not in a conveyance canal or perimeter seepage canal; it may have been a local pond, wetland or other surface body of water. Also, at some locations, pumping wells could affect the location of boundary assignments. The section length corresponds to the location of a constant head boundary (seepage canal) or a groundwater divide (no-flow boundary). The final product of the modeling was to

determine seepage losses (or gains) from each area of interest. The seepage rate (in cubic feet per second per linear foot of section) was determined for a range of head differences to allow for more detailed design reviews. Also, besides the magnitude of the seepage, its direction was also revealed through modeling. In most cases impoundment seepage was collected or captured by perimeter seepage canals, however, in a few instances (e.g. C-9) the seepage bypassed the canals and may require other collection methods to be analyzed. The following sections describe the model results for each design region.

A.12.5.3.3 Seepage Management Areas 3A and 3B

Seepage from the two seepage management areas is anticipated to occur in short durations and should not constitute a major increase beyond what happens under existing conditions. Two SEEP2D cross-section models covered these design regions and the pertinent cross-sections can be found in Appendix C of the WPA FS report.

A.12.5.3.4 C-11 Impoundment

A.12.5.3.4.1 Model Description

For the C-11 Impoundment, two sections were modeled. The first section was oriented east-to-west and the second section north-to-south. All of the prominent surface features were incorporated into each section. For the east-to-west section, this included a portion of WCA 3A, a section through 3A SMA, US 27, the western C-11 Impoundment embankment and seepage canal, the central borrow lake, the eastern C-11 Impoundment embankment and seepage canal, and a portion of a subdivision located to the east of the proposed impoundment footprint. For the north-to-south section, the section included the northernmost Mitigation Area "A" embankment, one of the finger lakes, the embankments separating Mitigation Area "A" and the C-11 Impoundment, the central borrow lake, the southernmost C-11 Impoundment embankment, and the C-11 Canal (*Figure A-64*). The geology used for both sections was the same as that modeled by URS Corporation for Parsons Brinkerhoff Quade & Douglas, Inc. (see Reference 5). Hydraulic conductivity values (in both the X and Y direction) for each material layer were also taken from the Seepage Technical Memorandum prepared by URS Corporation for Parsons (see *Table A-98*). For each section, the geometry of the modeled canals and embankments is shown on *Plate G-11A through Plate G-11G*. The normal maximum pool was used in both sections and the water surface elevations elsewhere were modeled as given on *Plates G-11A through G-11G*. The central borrow lake and the finger lakes were modeled as being partially backfilled to elevation 0.0 feet and -20 feet, respectively, with spoil material producing an in-place hydraulic conductivity of 100 ft/day in the X direction.

A.12.5.3.4.2 Analysis Results

With respect to seepage, for the east-to-west section, the western seepage canal received approximately 2515 ft^3/day per linear foot. The eastern seepage canal received approximately 2224 ft^3/day per linear foot and captured approximately 97 percent of the seepage flow moving towards the east. For a length of 7200 feet for the western seepage canal and 14,000 feet for the eastern seepage canal, in terms of cubic feet per second of seepage flow captured, the numbers are 210 and 360 respectively. It should be noted that with a shallower western seepage canal, the potential for groundwater movement (upwelling) into the roadbase of US 27 exists as well as ponding adjacent to the roadway. As a result, the invert elevation for that canal was determined by iterative modeling to prevent the possibility of damage to the highway.

For the north-to-south section, C-11 Canal received approximately 1814 ft^3/day per linear foot. The seepage canal adjacent to SW 26th Street received approximately 25 ft^3/day per linear foot and the seepage canal located next to the northern property line received approximately 6.5 ft^3/day per linear foot. For a length of 4000 feet for C-11 Canal, 8000 feet for the SW 26th Street seepage canal, and 7770 feet for the northern most seepage canal, in terms of cubic feet per second of seepage flow captured, the numbers are 84, 2.3, and 0.6 respectively. Seepage flow south of C-11 Canal and north of the northern most seepage canal is negligible.

A.12.5.3.5 C-9 Impoundment

A.12.5.3.5.1 Model Description

The model domain selected for the C-9 Impoundment included three different cross-sections. All three had different orientations. Section 1 was oriented along a north/south axis and Sections 2 and 3 were oriented along an east/west axis (see Figure C17 of the WPA FS report). The length of each section (Sections 1 to 3) was 6000, 4600 and 5600 feet respectively.

Features included in the sections were as follows:

Section 1 – C-9 Canal, located along the southern toe of the modeled levee segment, 50-foot bottom width, invert elevation at –16.5 feet; Section 1 - a borrow area located along the northern toe of the modeled levee segment, 50-foot bottom width, invert elevation at –2 feet;

Section 2 – the C-509 Canal located along the eastern toe of the modeled levee segment, 20-foot bottom width, invert elevation at –4.5 feet; Section 2 – a borrow lake located to the east of C-509, bottom elevation at –70 feet;

Section 3 (from west to east) - a portion of SMA WCA-3B (3B SMA), Levee 502B, Canal 502B (130-foot bottom width, invert elevation at –11 feet), US 27, C-509 (10-foot bottom width, invert elevation at –1 feet), the westernmost section of the impoundment levee and a portion of the main impoundment area itself.

The hydrogeology for the section was based on data collected for the conceptual model. Specifically, well number G-2317 provided data in close proximity to the impoundment. Well number G-3294 was also considered in developing the seepage model, however, using the appropriate data from G-3294 would have resulted in a less conservative estimate of seepage losses. Interpretation of the G-2317 data through the conceptual model development resulted in two pertinent soil layers.

A.12.5.3.5.2 Analysis Results

Two soil layers were modeled below the impoundment levee template with bottom elevations at –11 feet and –70 feet respectively. The hydraulic conductivity for each layer (respectively) was assumed as 50 and 19,500 ft/d in the horizontal direction and 5 and 1,950 ft/day in the vertical direction.

With the first section, four different impoundment pool elevations were modeled starting with a normal pool elevation of +8.5 feet and ending with a surcharge pool elevation of +11.5 feet. In all four models, the water surface elevation in C-9 Canal was kept at +5 feet and the adjacent groundwater elevation (to the south) was modeled at +3 feet. The results from each model indicate that (on average) approximately 35 percent of the seepage flow leaving the impoundment will enter C-9 Canal, 9 percent will enter the adjacent area to the south and the remaining 56 percent will move south and out of the model domain. If the water surface elevation in C-9 Canal had been modeled at +3 feet as the adjacent groundwater elevation was, the percentage of seepage flow entering C-9 Canal would change to 90 percent. As shown by the modeled results, a higher water surface elevation in C-9 Canal is likely to retard seepage flow into the canal. For the head differences modeled with this section, the total flow rate ranged from 0.0324 cfs/ft to 0.0479 cfs/ft. Applied to the proposed length of the southernmost impoundment levee segment (approx. 7000 feet), these rates translate into 227 cfs and 335 cfs, respectively. Based upon the model results at this section, it appears that seepage control can be greatly enhanced when the stage of the C-9 Canal is at +3 feet NGVD or less. At times of high stage within the C-9 Canal and high pools in the impoundment, additional seepage collection methods may be warranted. Relief wells should be considered as one possible remedial measure. It is anticipated that a relief well system at the C-9 Impoundment would only operate for short periods of time during the year. The exact operations of any proposed system will require further study in the detailed

design phase. In addition, the possible addition of future ASR wells should be taken into consideration during detailed design.

With the second section, the same impoundment pool elevations were modeled. In all four models, the water surface elevation in the C-509 and the adjacent groundwater elevation (to the east) were kept at +3 feet. The results from each model indicate that approximately 5 percent of the seepage flow leaving the impoundment will enter C-509, 5 percent will enter the adjacent area to the east and the remaining 90 percent will move to the east and into the deep borrow lake modeled. For the head differences modeled, the total flow rate ranged from 0.0259 cfs/ft to 0.0401 cfs/ft. Applied to the proposed length of the impoundment levee included in this model (approx. 10,230 feet), these rates translate into 265 cfs and 410 cfs respectively. Again, the results in this section indicate that additional seepage control beyond just seepage canals may be warranted. The use of supplementary relief wells should be investigated further.

With the third section, the same impoundment pool elevations were modeled as indicated for the first section. In all four models, the water surface elevation in C-509, C-502B and 3B SMA were kept at +5, +5.75 and +6.5 feet, respectively. The results from each model indicate that approximately 2 percent of the seepage flow leaving the impoundment will enter the C-509, 95 percent will enter C-502B and the remaining 3 percent will enter the remaining area between Levees 509 and 502B. Even with a slightly higher water surface elevation than that modeled for C-509, C-502B captured nearly all of the seepage flow leaving the impoundment. The main reason for this was the modeled invert elevation of C-502B was the same as the top elevation of the lower, more permeable soil layer. Therefore, it appears that the C-502B Canal would be in direct hydraulic connection to the main seepage path (through the more permeable limestone). For the head differences modeled, the total flow rate ranged from 0.0205 cfs/ft to 0.0356 cfs/ft. Applied to the proposed length of the impoundment levee included in this model (approx. 10,300 feet), these rates translate into 211 cfs and 367 cfs, respectively. A summary of a portion of the model results is shown on Table 6 of Appendix C of the WPA FS report.

A.12.6 Slope Stability Analyses

A.12.6.1 Background

For the WPA FS, the embankment slopes were analyzed using Spencer's method of slices and the circular search routine of the UTEXAS-4 computer program. All cases were analyzed using consolidated-drained (S) shear strengths. This was done because of the predominance of granular materials encountered (particularly sand and limestone) by the core borings performed at each WPA site and the intent that this material be used for the construction of the WPA embankments. In addition, any existing surficial organic or highly plastic soils

encountered during embankment foundation preparation would be removed and backfilled with granular fill prior to embankment construction.

Note that the slope stability analyses performed during the WPA FS have been revised, as presented here, to include removal of the soil cement stair steps due to wildlife entrapment concerns. Stepped embankments are no longer considered to be a viable option for CERP impoundments. Both the C-9 and C-11 Impoundments were originally designed to have stepped embankments. Recent revisions were analyzed using Slope/W and Seep/W computer programs.

Uses original geometry and height provided in the feasibility study, but replaces the stair step soil cement with flat plate soil cement.

Typical sections depicting the geometry can be found on *Plate G-15A* for C-11 and *Plate G-15B* for C-9.

Maximum Pool and End of Construction (EOC) cases were considered for slope stability analysis. EOC slope stability was analyzed on the upstream and downstream sides of the embankment while the maximum pool was analyzed for stability on the downstream slope. For the maximum pool condition, pore water pressures and the phreatic surface was modeled under Steady State Seepage (SSS) conditions using SEEP/W. The pore water pressures were utilized in SLOPE/W for exterior slope stability, maximum pool condition.

The soil cement protection on the interior of the slope is considered a low permeable drainage barrier and during Rapid Draw Down (RDD) excessive uplift pressures could develop under the soil cement. To offset this effect, a drainage layer beneath the soil cement would allow for adequate pore pressure relief. RDD was not analyzed as a part of the PIR. During the detailed design phase, it is recommended this condition be further analyzed and accounted for.

The required factor of safety for the different design conditions described above was taken from Table 1 (Minimum Factors of Safety) in EM 1110-2-1902 (Engineering and Design Stability of Earth and Rock-Fill Dams), dated 1 April 1970. For the BCWPA PIR, Table 3-1 (Minimum Required Factors of Safety: New Earth and Rock-Fill Dams) of EM 1110-2-1902 (Slope Stability), dated 31 October 2003, was used for the minimum required factor of safety for each case analyzed.

A.12.6.2 C-11 Impoundment

For the C-11 Impoundment embankments, the original feasibility study geometry met the overwash requirements without the stair steps. A typical embankment cross section is shown on *Plate G-15A* and was analyzed for the End-of-Construction (EOC) and Steady State Seepage condition. The maximum,

100-yr surcharge pool was used for the SSS condition. The required minimum factor of safety for the EOC, and SSS with max surcharge pool condition is 1.3, and 1.4 respectively. The sections analyzed are shown on *Figure A-69* thru *Figure A-72*. The slope stability program SLOPE/W (from the GeoStudio 2004 software suite, Version 6.2) was used for the analyses with pore water pressures imported from SEEP/W when applicable. Shear strength parameters and unit weights for each soil/rock region modeled were obtained from references in paragraph A.12.8. Spencer's method of analysis was used along with a circular search routine.
For each case analyzed, the resulting minimum factor of safety is listed below:

Case	Factor of Safety
EOC – Interior Slope with no Pool	2.21
EOC – Exterior Slope with no Pool	2.65
SSS – Maximum Surcharge Pool, Exterior Slope	2.54

In each case, the resulting minimum factor of safety was greater than that required by EM 1110-2-1902. During the detailed design phase of the project, additional sections will be modeled and additional analyses performed for all applicable loading cases.

A.12.6.3 C-9 Impoundment

For the C-9 Impoundment embankments, typical embankment cross sections were selected and analyzed for the EOC and SSS condition. The original feasibility study geometry met the overwash requirements without the stair steps. The sections analyzed are shown on ***Figure A-73*** thru ***Figure A-76***.

The slope stability program SLOPE/W was used for the analyses with pore water pressures imported from SEEP/W when applicable. Shear strength parameters and unit weights for each soil/rock region modeled were obtained from references 6 and 7. Spencer's method of analysis was used along with a circular search routine.

For each case analyzed, the resulting minimum factor of safety is listed below:

Case	Factor of Safety
EOC – Interior Slope with no Pool	2.47
EOC – Exterior Slope with no Pool	2.77
SSS – Maximum Surcharge Pool, Exterior Slope	2.61

In each case, the resulting minimum factor of safety was greater than that required by EM 1110-2-1902. During the detailed design phase of the project, additional sections will be modeled and additional analyses performed for all applicable loading cases.

A.12.6.4 Seepage Management Areas

Embankments at the Seepage management areas are relatively small. Both WCA-3A and WCA-3B SMAs are expected to be constructed on similar foundation conditions and likely to be constructed of limestone fill. A 1V:3H slope assumed for the other design regions was considered suitable, safe and adequate for maintenance and serviceability purposes, although steeper slopes may be safe, as well, for this type of material, if properly compacted.

A.12.6.5 Foundation, Excavation, Construction and Dewatering Considerations for Structures at Specific Sites

Though site specific core borings will need to be drilled for each structure, it is anticipated that it will be possible to found all of the structures in this project on shallow foundations, except where high uplift forces are expected, as bearing capacity failures or high settlements are not expected.

Where uplift forces are expected, some form of anchoring system will need to be built in order to overcome the uplift. Options include rock anchors, augered cast-in-place (augercast) piles, mini-piles, and other technologies. Although augercast piles are highly recommended, all are suitable alternatives and as so, the final selection will be the most financially sound one.

In some cases, it is anticipated that dewatering for structure excavations may be required and may be possible with wellpoints or sumps and that the excavations can be made by cutback slopes. In other cases, dewatering will require a cofferdam and underwater concrete seal and rock or soil anchors or augered cast-

in-place deep foundations for each structure. Once flow into the excavation is sealed off in this way, sump pumps will be used to keep the excavation dry from seepage through the cofferdam or around the concrete seal.

The different design components that make up the BCWPA will require a tremendous amount of excavation and earthwork for embankment construction. Both overburden soils and limestone bedrock will require excavation and removal. In addition, much of the existing limestone encountered will require removal and processing afterwards for use as embankment fill. EM 1110-2-1911 entitled "Construction Control for Earth and Rock-filled Dams" provides guidance concerning various limitations or uses of earth moving equipment. Chapter 4 of the referenced EM discusses borrow areas and quarries, and as so, is particularly useful.

It is envisioned that a variety of earth-moving equipment will be required to complete the project. Where soil foundations and borrow sources are present, conventional equipment that can be utilized includes draglines, graders, scrapers and off-road dump trucks. Where high groundwater elevations are expected, which is the case for most WPA projects, especially BCWPA, draglines are recommended instead of power shovels. Typically, draglines can operate more efficiently in wet conditions. Also, since much of the overburden materials consist of sand and soft limestone, the use of a scraper may provide higher earthwork production than a grader. Additional subsurface investigations during the detailed design stage will help provide a better estimate of the volume of materials to be excavated and aid in the recommendations of earthwork equipment.

For BCWPA, excavation and special material handling is anticipated to be needed. For the proposed seepage collection canals, fish refugia, plunge pools and other type of large excavation features, drilling and associated rock removal may be required. Typically, the rock depth, expected hardness and required particle size to be generated control rock-removal method requirements. If used, blasting involves the installation of drill holes at spacing based upon designed explosive yield and the factors mentioned above. Closely spaced drill holes are required when local regulations limit the blasting vibrations or the rock is very hard. For instance, a gneiss rock may require more tightly packed drill holes than a weathered limestone or shale. The presence of voids in the rock may require special blasting techniques. The blasting Contractor shall be experienced in working with this type of material (vuggy limestone). The higher the number of drill holes required, the higher the costs of blasting operations. Also, more drill holes often result in lower excavation production for the project. The exact drill hole spacing, explosive requirements, depth, and required excavation limits will be determined during detailed design. Further subsurface investigations are required to determine all of these variables.

Once the rock is excavated, it must be processed, screened and transported to the proposed embankment rock-fill dam location. Since, the proposed embankment rock-fill dams will have gradation requirements, processing and screenings are very important. Processing the material may involve the removal of fines and oversized boulders; the latter can be re-processed and added to the gradation. It is envisioned that a grizzly processing plant or a shaking screen-processing plant will be utilized. Each of these can be utilized to assist with production of the appropriate rock-fill dam gradation. There is a possibility that several of these processing plants will be required for the project. Curent local ordinance does not allow blasting. This issue will be resolved during design phase.

Two main options were considered for material handling or transporting. First, the use of off-road dump trucks to haul the material over constructed haul roads was considered. End dumps are probably the most frequently used piece of equipment for this type of project since they can be operated at high speeds and have fairly good mobility. Another option for transportation from the processing center would be to utilize belt conveyors to transport the processed rock material to the project site. Belt conveyors are most suitable for transporting large quantities of materials over large distances where cost of building or maintaining haul roads is problematic. For the BCPWA, the basic infrastructure is believed to be already implemented as several paved and unpaved roads exist around the project site.

A.12.6.6 Geotechnical Considerations at Canal and Road Crossings

Canal Undercrossings for I-75 / US-27 Interchange were addressed by URS Group, Inc. in a report titled "Type, Size, and Location Report, I-75 / US-27 Interchange, Type, Size, and Location Study No. 1, Water Preserve Area Project, Delivery Order 0007, Broward County, Florida". This report reviewed and compared several alternatives for constructing 3 canal crossings; 2 under I-75 and 1 under US 27. Alternatives reviewed included the following:

- Bridges - Flat Slab Bridge, Prestressed (AASHTO) Beam Bridge
- Open Trench Culvert - Box Culvert Cast-in-Place, Box Culvert Cast-in-place, Con Span Culvert, Cast-in-place Circular Concrete Pipes
- Tunneling - Top-Down Box Culvert, Microtunneling Circular Pipes

An evaluation criterion was created to identify the most important factors involved with the proposed alternatives. The following seven (7) items were identify 1) Traffic Disruption, 2) Traffic Safety, 3) Construction Cost, 4) Construction Schedule, 5) Variable Subsurface Conditions, 6) Roadway Settlement, and 7) Risk of Construction were identified and weighed. The

analysis yielded traffic safety and construction cost as the two most important factors.
The conclusion of the URS Group, Inc. was that the Open Trench with Cast-in-place Box Culvert was the best alternative with the Con Span Culvert being second. This was due to the Open trench construction method being the quickest and most cost-effective approach. Safety was determined to be the same for each alternative with the exception of the Microtunneling alternative.

The Con Span Culvert is a very similar alternative to the Cast-in-place Box Culvert alternative. However, the Con Span Culvert is a proprietary, and potentially more economical, version of the same. URS Group's recommendation was, therefore, to accomplish the canal crossings using the Cast-in-place Box Culvert alternative but to also make an allowance in the Plans & Specs for a Contractor to propose a proprietary method similar or equivalent to the Con Span Culvert. In that way, the government can obtain the most competitive and cost-effective product. Construction of bridges and installation of pre-cast box culverts will need proper MOT which will be done during project design phase.

A.12.7 Comments, Recommendations and Miscellaneous

A.12.7.1 Additional Geotechnical Field Investigations

Additional subsurface investigations are recommended for all of the design components. The investigations should include, but not be limited to, installation of soil borings, installation of groundwater monitoring wells, aquifer performance tests, slug tests, test pits, soil and rock samples collection for testing, laboratory testing, field inspection, and others as necessary. The final spacing and layout of the program shall be determined once the embankment plan, canal layout and structure layout has been finalized at each design region. A preliminary detailed investigation plan has been estimated for this report. The preliminary plan assumes core borings at 500 to 1000 feet spacing along levee and canal center-lines. It also assumes some amount of soil overburden sampling and rock coring. Lastly, an attempt was made to estimate testing requirements at each design region. A detailed level of effort cost estimate is found in Appendix C of the WPA FS report.

A.12.7.2 Additional Analysis

The uncertainty in the actual values of the coefficient of permeability for the different soil layers leads to the recommendations made in the previous sections. The limestone formations in Florida, and especially in South Florida have been documented to be highly transmissive, with solution cavities (due to the Karstic nature) being responsible. The hydraulic conductivity can change significantly, in some cases by orders of magnitude within inches (both horizontally and vertically). The shear strength of the rock is of great variability as well, as has

been documented by many, and as was the case for this site based on the field explorations performed by Ardaman and Associates. The values used herein for the seepage analyses are general for the limestone. Laboratory permeability test results provide only an estimate of the lower boundary of the range of possible permeability of the rock as typically, a testable (intact) rock core is used. Field testing employing applicable technologies (tests) shall be employed for the final design to verify and confirm whether additional engineering alternatives would need to be used in order to minimize, reduce or perhaps capture, excessive seepage. It is convenient and financially advantageous and sound to have a final design that has covered all possible scenarios. Conditions not considered could become extremely costly, especially when dealing with uncontrolled seepage adjacent to urban development.

A.12.8 References

C-9 Impoundment Geotechnical Services Draft Geotechnical and Hydrogeological/Geophysical Report, prepared by Earth Tech, Inc. for the South Florida Water Management District, June 2006.

C-11 Impoundment Final Geotechnical Report, prepared by Parsons Brinkerhoff Quade & Douglas, Inc. for the South Florida Water Management District, July 2006.

C-11 Impoundment Initial Seepage Model Results Technical Memorandum (Draft), prepared by Parsons Brinkerhoff Quade & Douglas, Inc. in association with URS Corporation for the South Florida Water Management District, May 2006.

Design of Pile Foundations, US Army Corps of Engineers EM 1110-2-2906, 1991, Tables 4-6, *S-Case Shear Strengths* (for cohesive soils).

Foundations& Earth Structures, Design Manual 7.02, 1986, Naval Facilities Engineering Command, Table 1, *Typical Properties of Compacted Soils.*

Geotechnical Engineering Techniques and Practices, Roy E. Hunt, 1986, Table 3.5, *Common Properties of Cohesionless Soils* & Table 3.7, *Common Properties of Clay Soils.*

Soil Mechanics, Lambe, T. William and Robert V. Whitman, John Wiley & Sons, Inc., New York, 1969.

FIGURES

FIGURE A-63: OLDER AERIAL PHOTOGRAPH OF THE PROPOSED C-11 PROJECT AREA SHOWING THE LOCATIONS OF SUBSURFACE INVESTIGATIONS PERFORMED FOR THE PIR

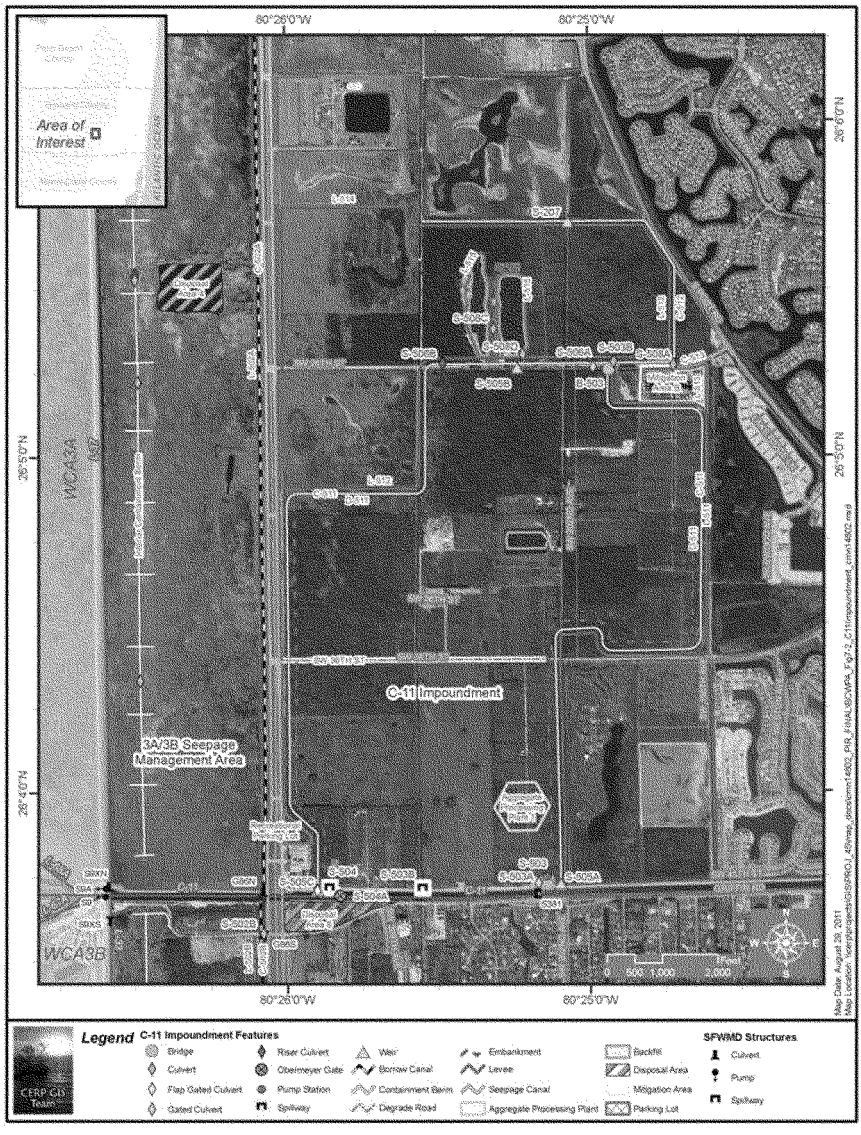


FIGURE A-64: MORE RECENT AERIAL PHOTOGRAPH OF THE PROPOSED C-11 PROJECT AREA

Note: The orientation and length of the seepage sections modeled are shown by the yellow lines

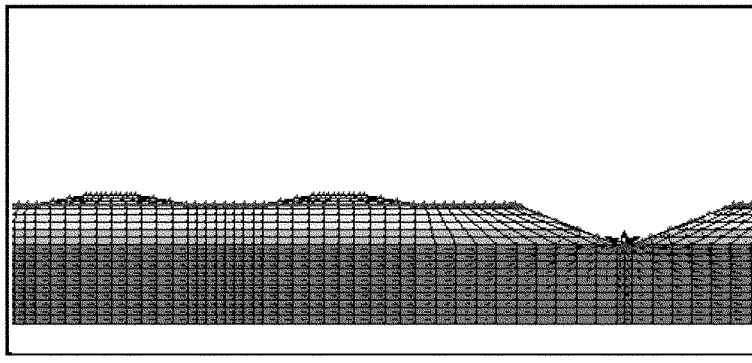


FIGURE A-65: US HIGHWAY 27 AND THE WESTERN SEEPAGE CANAL

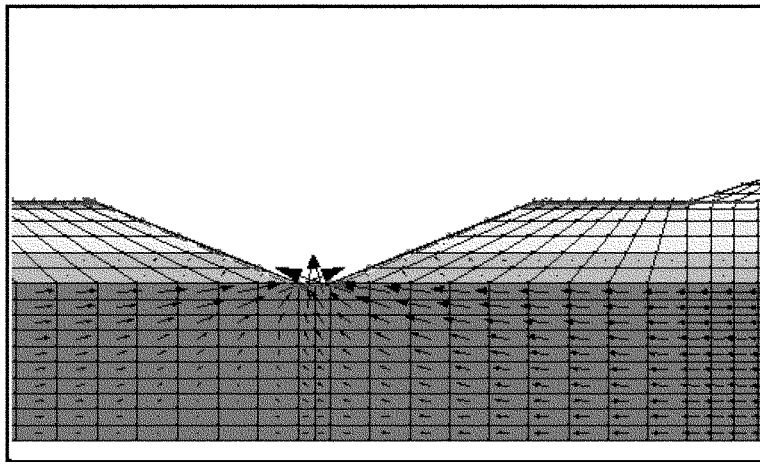


FIGURE A-66: SEEPAGE INTO THE WESTERN SEEPAGE CANAL FROM THE C-11 IMPOUNDMENT AND FLOW FROM THE WEST

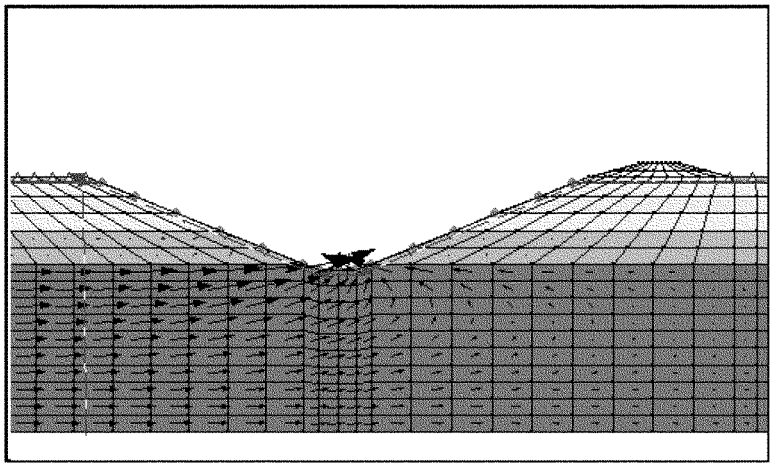


FIGURE A-67: SEEPAGE FLOW INTO THE EASTERN SEEPAGE CANAL

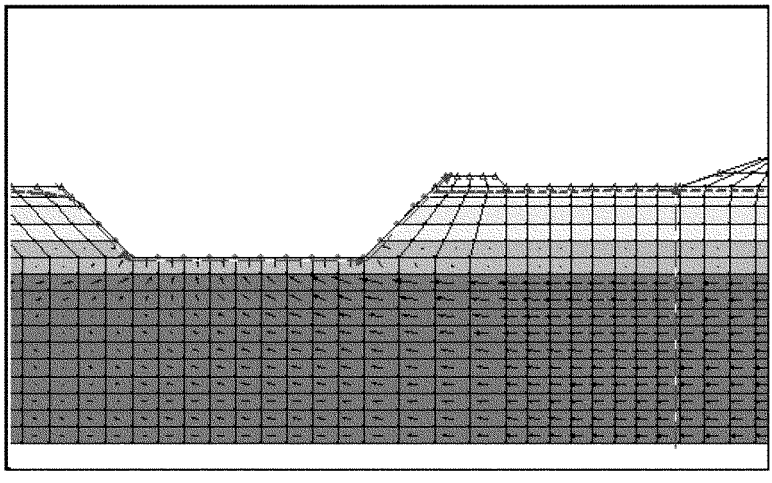


FIGURE A-68: SEEPAGE FLOW INTO C-11

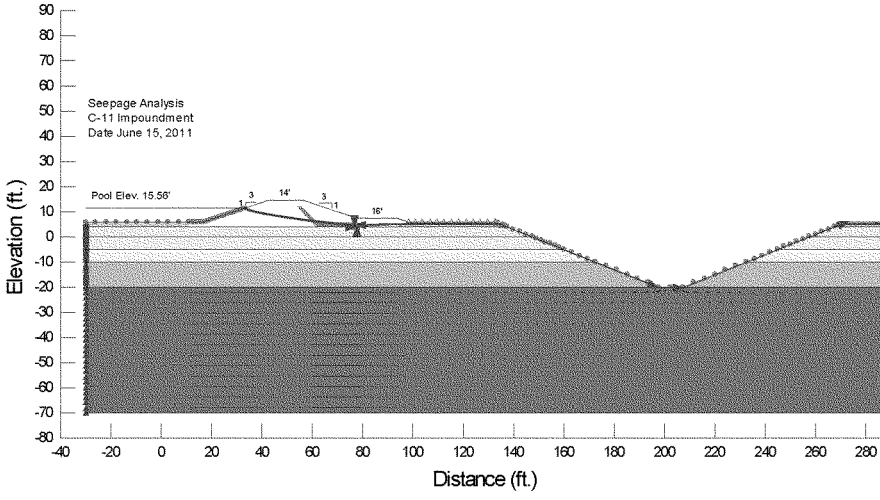


FIGURE A-69: SEEPAGE ANALYSIS FOR THE C-11 IMPOUNDMENT, MAXIMUM POOL

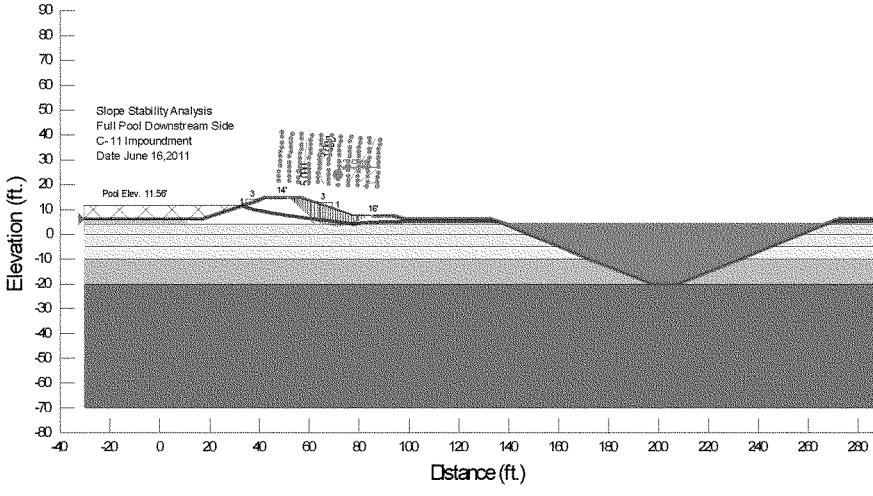


FIGURE A-70: SLOPE STABILITY FOR C-11 IMPOUNDMENT, EOC, EXTERIOR

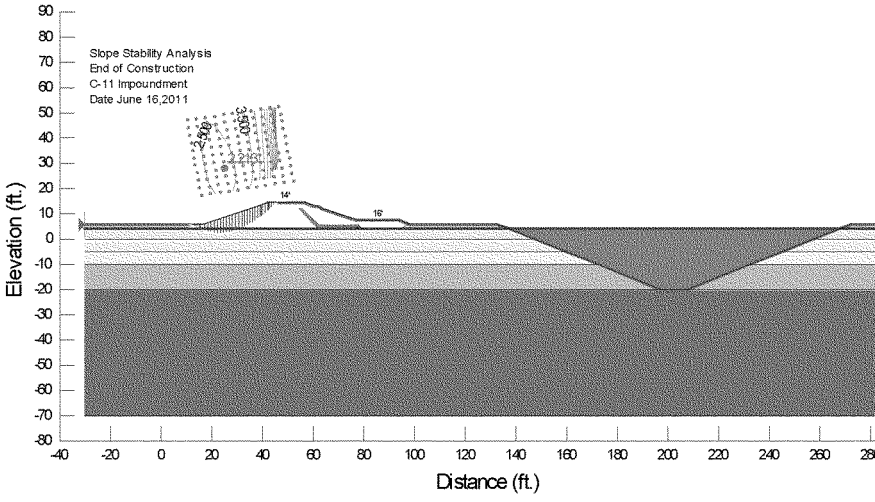


FIGURE A-71: SLOPE STABILITY FOR C-11 IMPOUNDMENT, EOC, INTERIOR

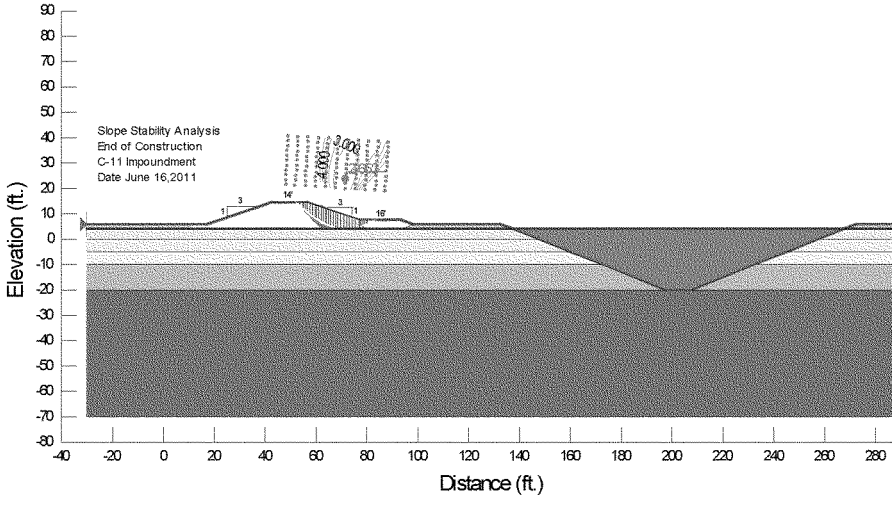


FIGURE A-72: SLOPE STABILITY FOR C-11 IMPOUNDMENT, MAXIMUM POOL, EXTERIOR

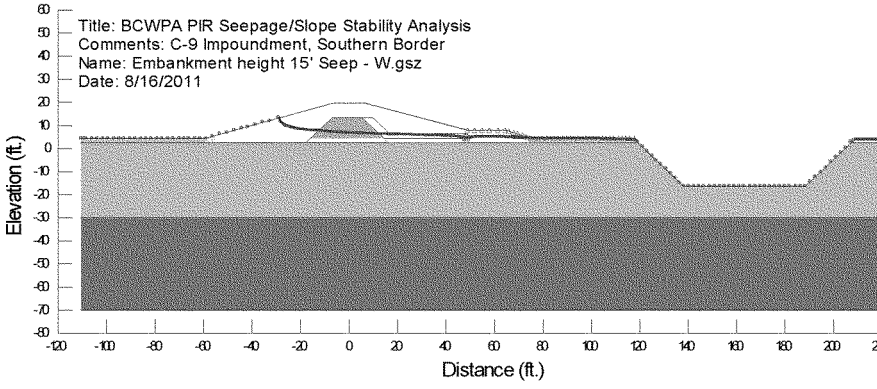


FIGURE A-73: SEEPAGE ANALYSIS FOR C-9 IMPOUNDMENT MAXIMUM POOL

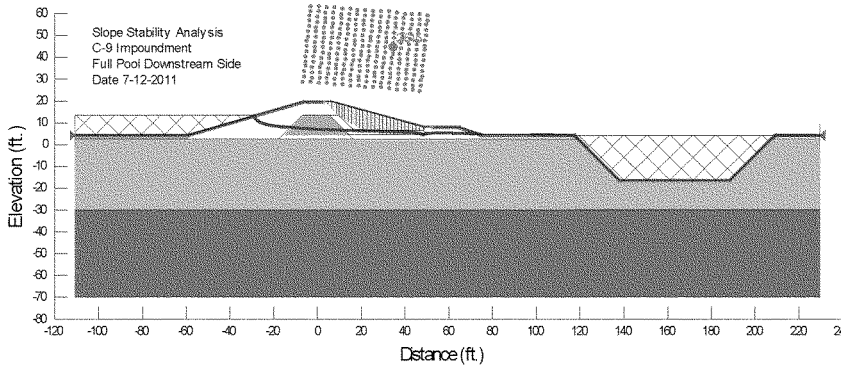


FIGURE A-74: SLOPE STABILITY FOR C-9 IMPOUNDMENT MAXIMUM POOL, DOWNSTREAM SIDE

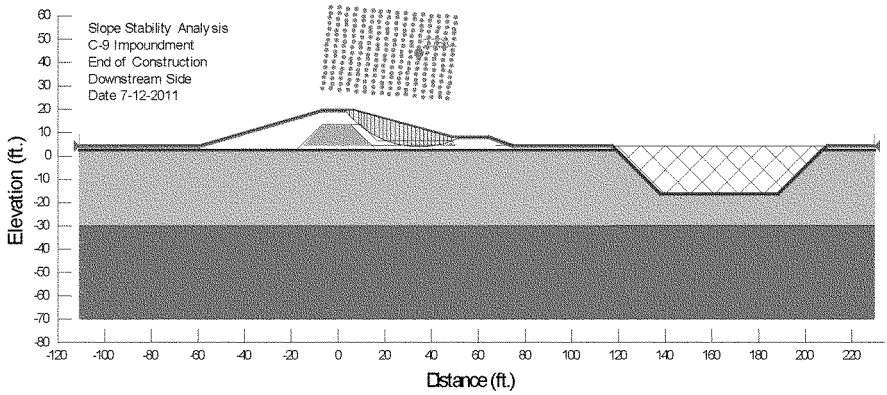


FIGURE A-75: SLOPE STABILITY FOR C-9 IMPOUNDMENT, EOC EXTERIOR

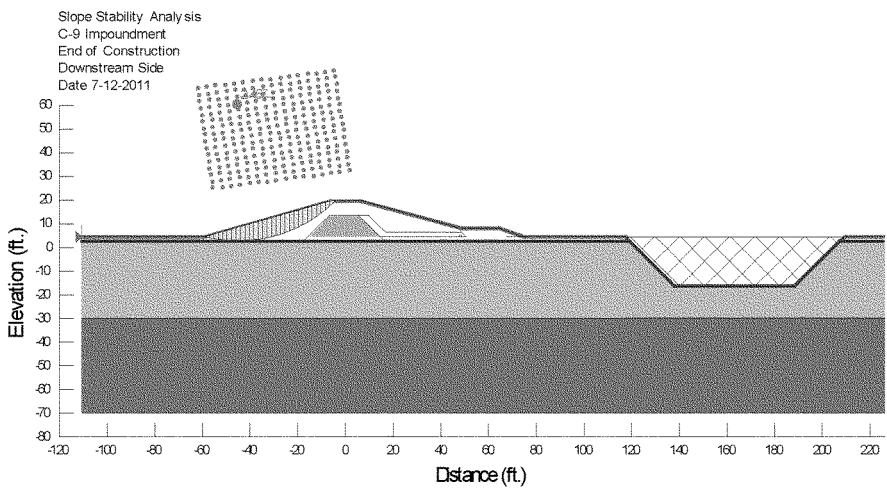


FIGURE A-76: SLOPE STABILITY ANALYSIS FOR C-9 IMPOUNDMENT, EOC INTERIOR

TABLES

TABLE A-101 HYDROGEOLOGIC PARAMETERS USED FOR C-11

Soil ID	Soil Type	Layer Bottom Elevation (ft)	Horizontal Hyd. Conductivity (ft/d)	Vertical Hyd. Conductivity (ft/d)
1	Embankment fill		15	5
2	Peat Layer	4	0.5	0.25
3	SP Layer	0	10	5
4	Limestone Layer 1	-5	10	5
5	Limestone Layer 2	-10	100	50
6	Limestone Layer 3	-20	1000	500
7	Limestone Layer 4	-70	22000	2200

TABLE A-102: HYDROGEOLOGIC PARAMETERS USED FOR C-9

Soil ID	Soil Type	Layer Bottom Elevation (ft)	Horizontal Hyd. Conductivity (ft/d)	Vertical Hyd. Conductivity (ft/d)
1	Limestone Fill		15	5
2	Peat	0	250	60
3	Upper Limestone	-14.5	700	200
4	Sandstone	-27	283	200
5	Lower Limestone	-79.5	350	70
6	Clean Sand	-102.5	2834	1500

A.13 ENGINEERING PLATES

A.13.1 Index to Plates

A.13.1.1 General/Civil/Site Design

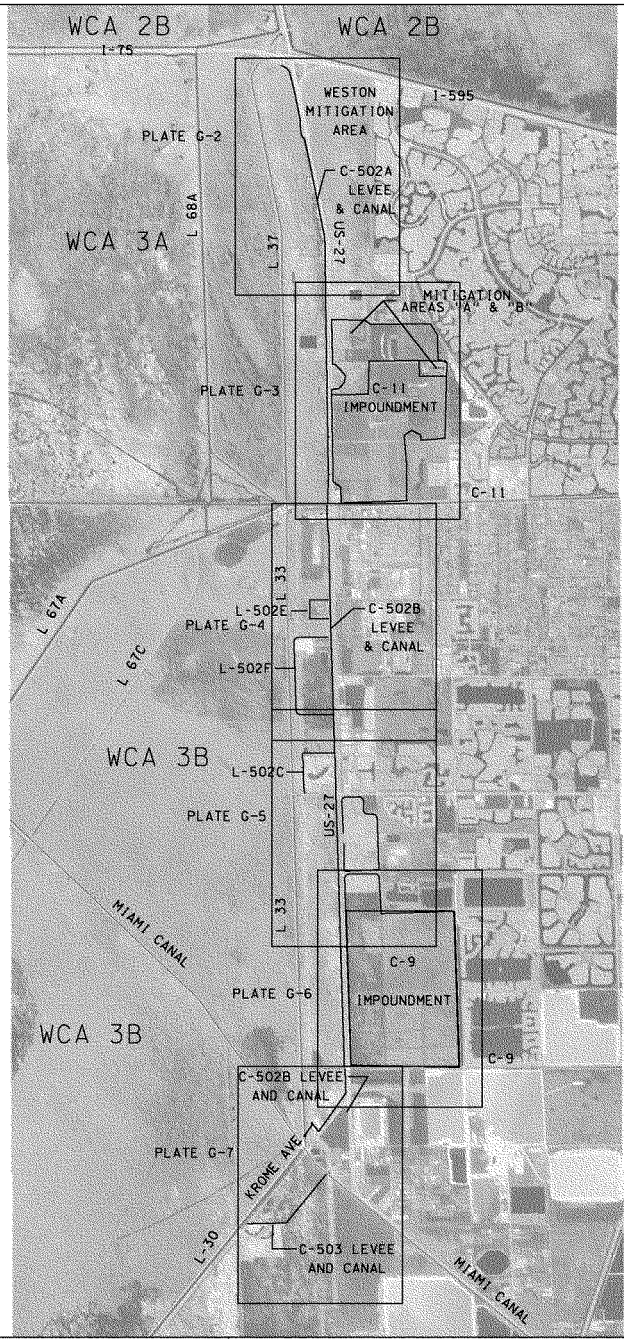
Plate No.	Plate Title
G-01	General Site Plan
G-02	C-502-A Reach 1 and 2
G-03	C-502-A Reach 2 and 3 and C-11 Impoundment
G-04	C-502-B Reach 1
G-05	C-502-B Reach 2 and 3 and Holly Lakes Community
G-06	C-502-B Reach 3 and 4 and C-9 Impoundment
G-07	C-502-A Reach 4 and 5
G-08	C-502-A Reaches 1 to 3 North of C-11 Canal – Typical Sections
G-09	C-502-B Reaches 1 to 3
G-10	C-502-B Reaches 4 and 5 – Typical Sections
G-11A	C-11 Impoundment – Typical Sections
G-11B	C-11 Impoundment – Typical Sections
G-11C	C-11 Impoundment – Typical Sections
G-11D	C-11 Impoundment – Typical Sections
G-11E	C-11 Impoundment – Typical Sections
G-11F	C-11 Impoundment – Typical Sections
G-11G	C-11 Impoundment – Typical Sections
G-12	C-9 Impoundment – Typical Sections
G-13	Random Fill Levee or Berm – Typical Section
G-14	2-Zone Levee or Berm, Typical Section
G-15A	Zone Impoundment Embankment, C-11 Typical Section
G-15B	Zone Impoundment Embankment, C-9 Typical Section

A.13.1.2 Structural

S-01	C-11 Impoundment S-503, S-503A and S-505A Site Plan
S-02	C-11 Impoundment S-503 Typical Sections
S-03	C-11 Impoundment S-503A Gated Culvert
S-04	C-11 Impoundment S-505A Weir and Sluice Gate
S-05	C-11 Impoundment S-504 Gated Culverts
S-06	C-11 Impoundment S-504B Overflow Spillways
S-07	C-11 Impoundment S-505B Weir
S-08	C-11 Impoundment S-505C Weir
S-09	C-11 Impoundment S-505E Bridge
S-10	C-11 Impoundment S-506A Gated Culvert
S-11	C-11 Impoundment S-506B Weir-gate Culvert
S-12	C-11 Impoundment S-507A-F Non-gated Culverts
S-13	C-11 Impoundment S-508A Non-gated Culvert
S-14	C-11 Impoundment S-508B Non-gated Culvert
S-15	C-9 Impoundment S-508 Non-gated Culvert
S-16	C-9 Impoundment S-508D Non-gated Culvert
S-17	C-9 Impoundment S-509 Pump Station (Plan)
S-18	C-9 Impoundment S-509 Pump Station (Section)
S-19	C-9 Impoundment S-510 Gated Culverts
S-20	C-9 Impoundment S-510A Overflow Spillway
S-21	C-9 Impoundment S-511 Gated Culverts
S-22	C-9 Impoundment S-512A Seepage Pump Station (Plan)
S-23	C-9 Impoundment S-512B & S-512C Gated (Flap) Culverts & Weir
S-24	C-9 Impoundment S-513A Gated Culverts
S-25	C-9 Impoundment S-513B Box Weir Culvert
S-26	3A and 3B Seepage Management Areas S-502B Gated Culverts
S-27	3A and 3B Seepage Management Areas S-515 Gated Culverts
S-28	3A and 3B Seepage Management Areas S-516A & S-516B Triangular Weir
S-29	3A and 3B Seepage Management Areas FPL 01-19

A.13.1.3 Electrical

E-1	S-503 Pumping Station Single Line Diagram
E-2	S-503 Pumping Station Scada System Diagram
E-3	Pumping Station S-503 Engine Control Panel
E-4	S-509 Pumping Station Single Line Diagram
E-5	S-509 Pumping Station Scada System Diagram
E-6	Pumping Station S-509 Engine Control Panel
E-7	S-512A Pumping Station Single Line Diagram
E-8	S-512A Pumping Station Scada System Diagram
E-9	Pumping Station S-512A Motor Control Panel
E-10	Vertical Lift Gate Single Line Diagram
E-11	Pneumatic Lift Gate Control Panel
E-12	Pneumatic Lift Gate Single Line Diagram



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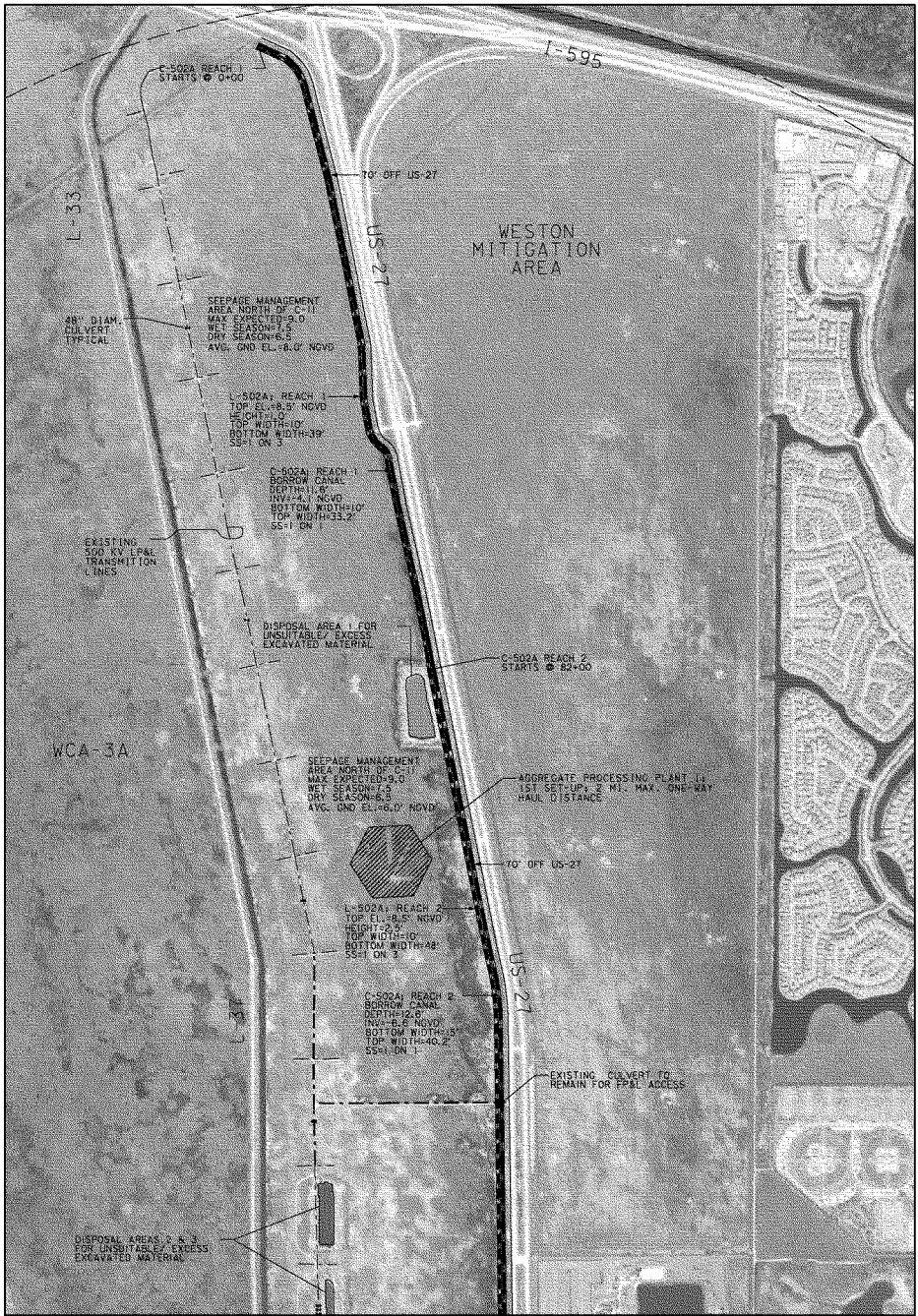
CENTRAL AND SOUTHERN FLORIDA PROJECT
BROWARD COUNTY WATER PRESERVE AREAS
PROJECT IMPLEMENTATION REPORT
GENERAL SITE PLAN

PLATE
G-1



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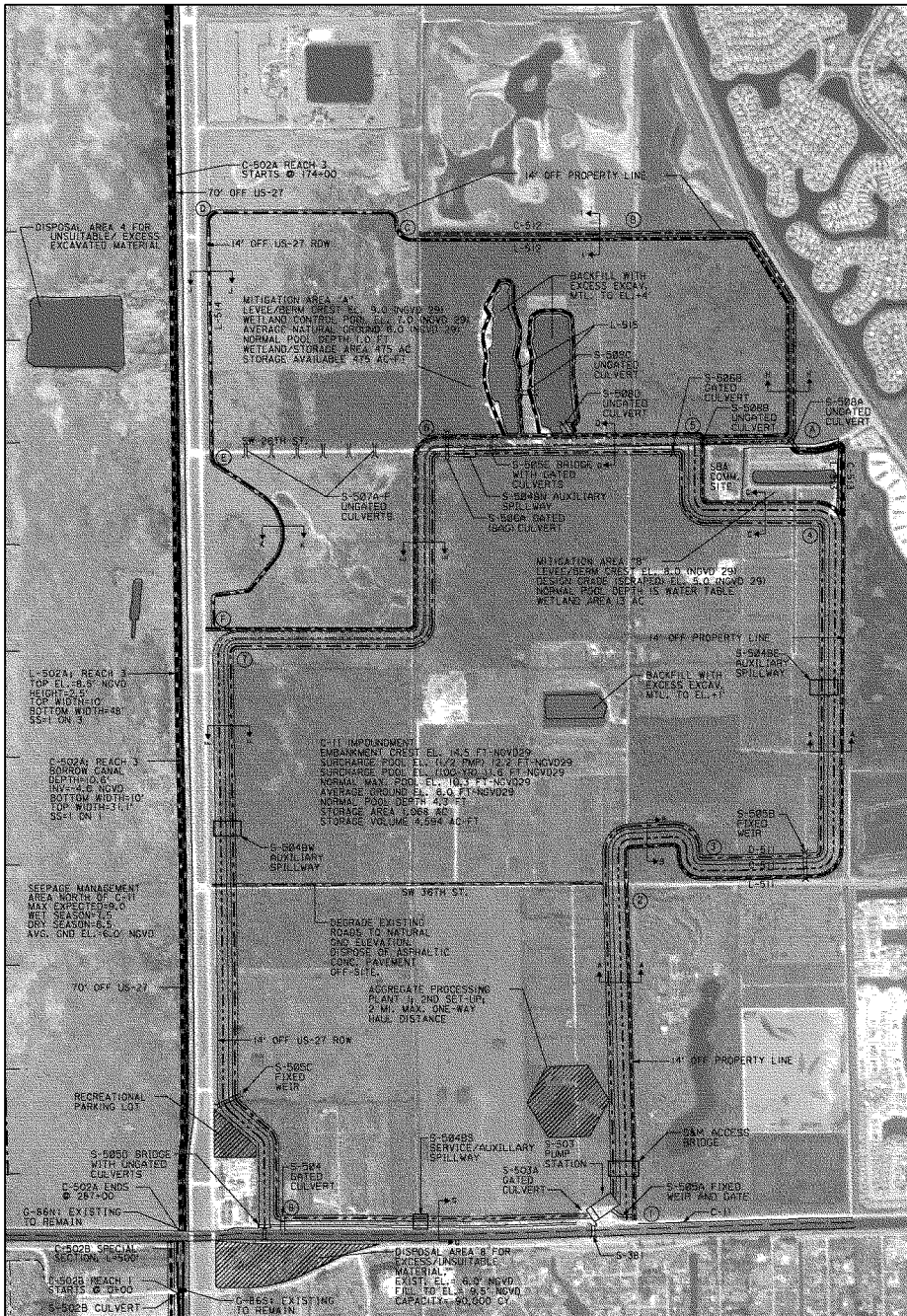

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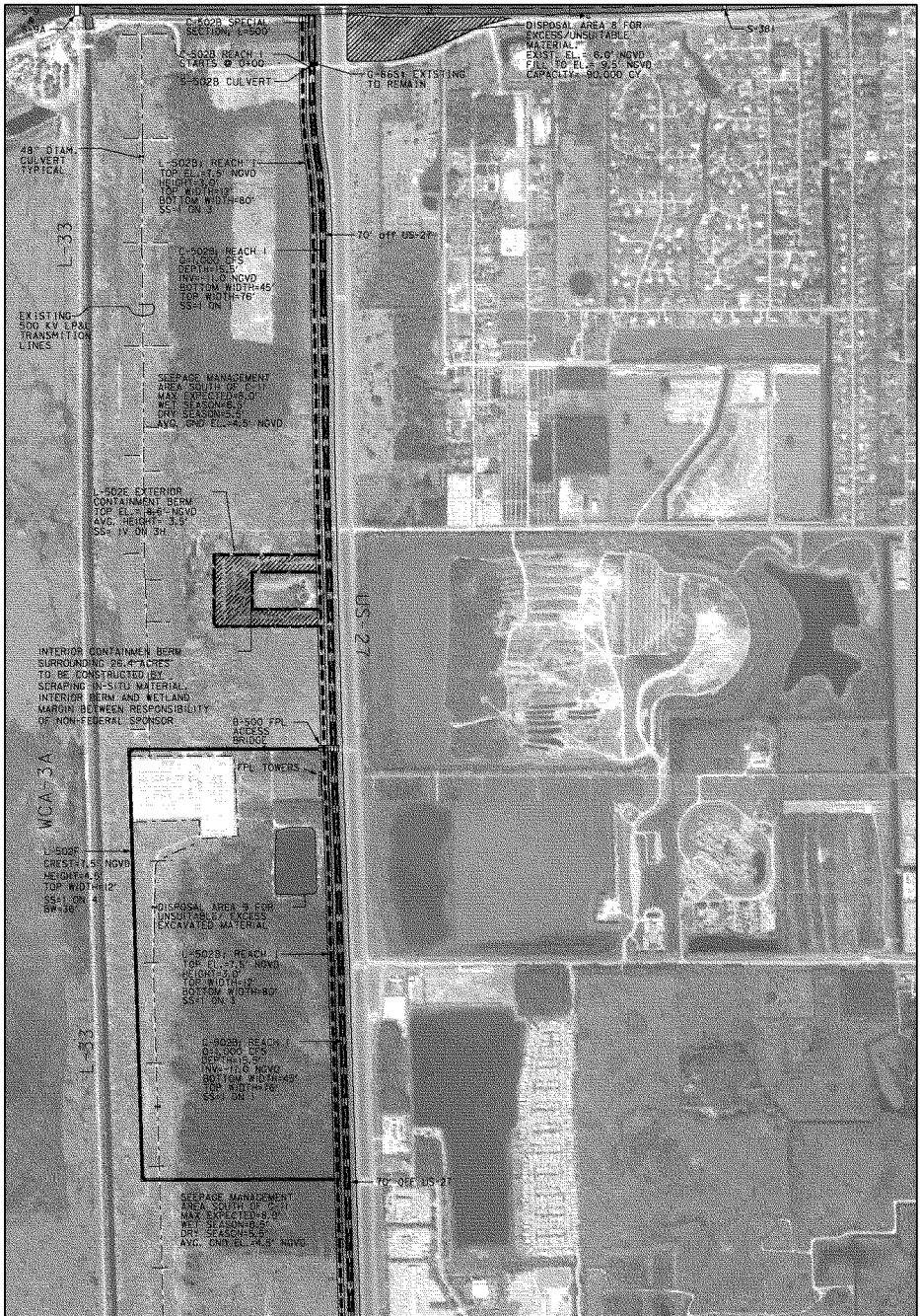
BROWARD COUNTY WATER PRESERVE AREAS
PROJECT IMPLEMENTATION REPORT
C-502A; REACH 2 & 3
AND C-11 IMPOUNDMENT

PLATE
G-3



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BROWARD COUNTY WATER PRESERVE AREAS

PROJECT IMPLEMENTATION REPORT
(MITIGATION OPTION)
C-502B: REACH 2 & 3 AND
HOLLEY LAKES COMMUNITY

PLATE
G-5

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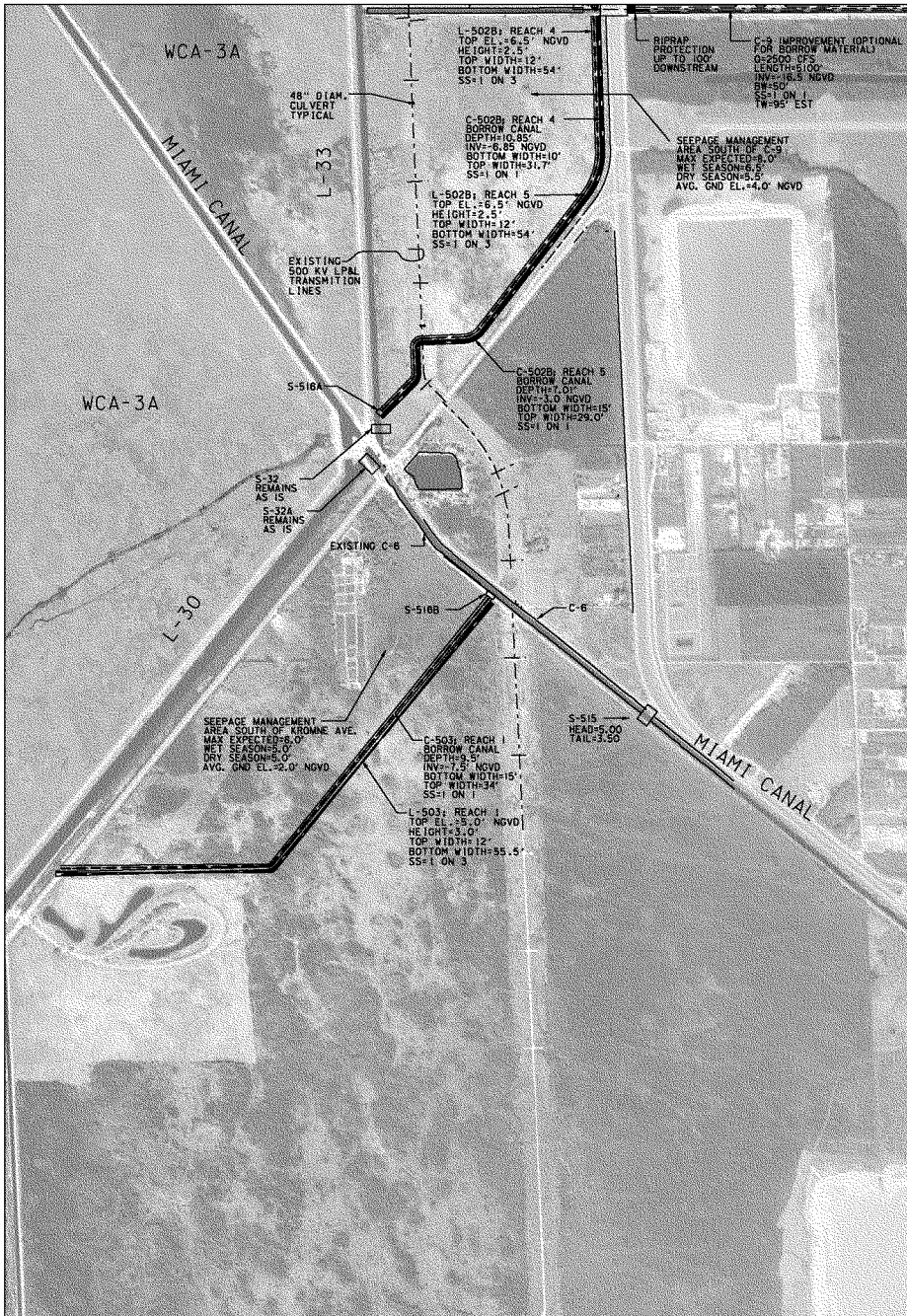

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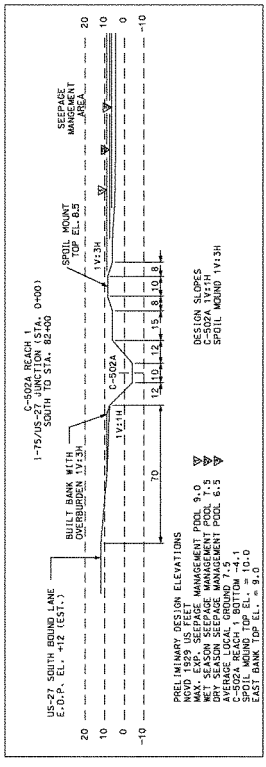

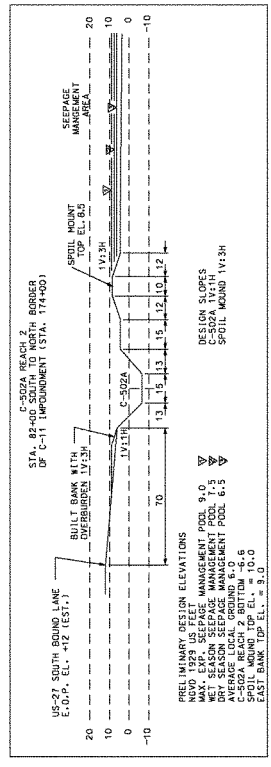

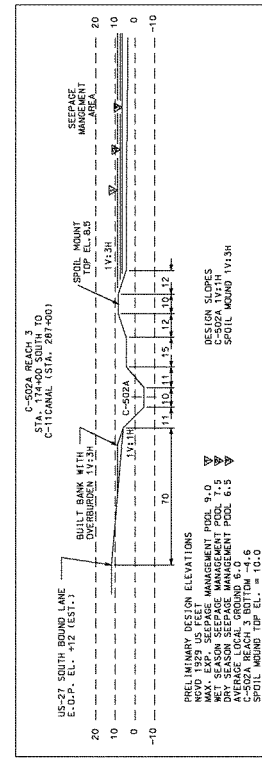

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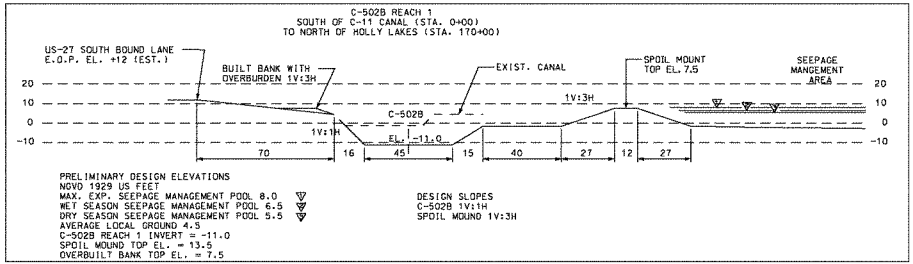

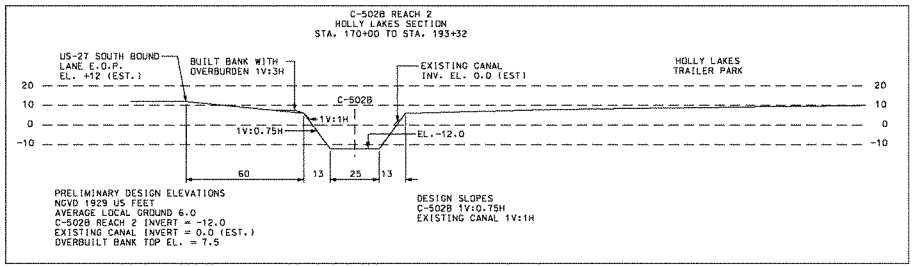

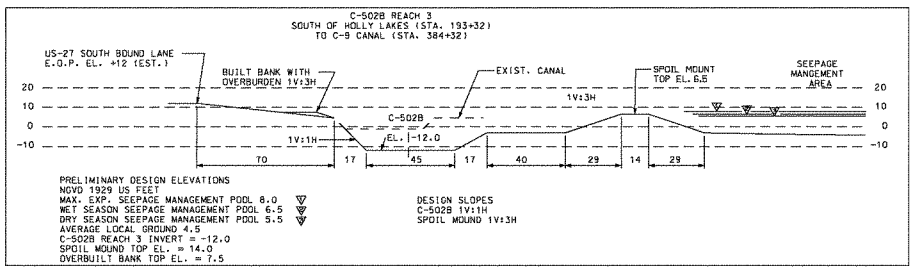

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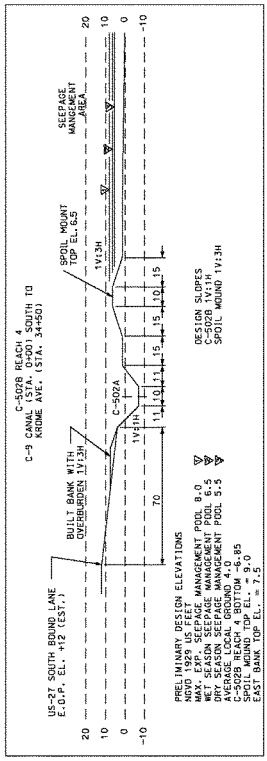
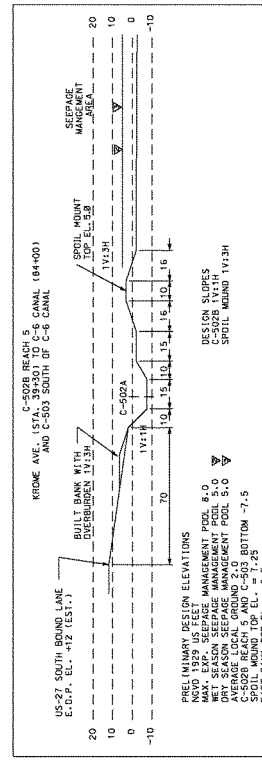
BROWARD COUNTY WATER PRESERVE AREAS
PROJECT IMPLEMENTATION REPORT
C502-B REACHES 1 TO 3
TYPICAL SECTIONS

PLATE
G-9





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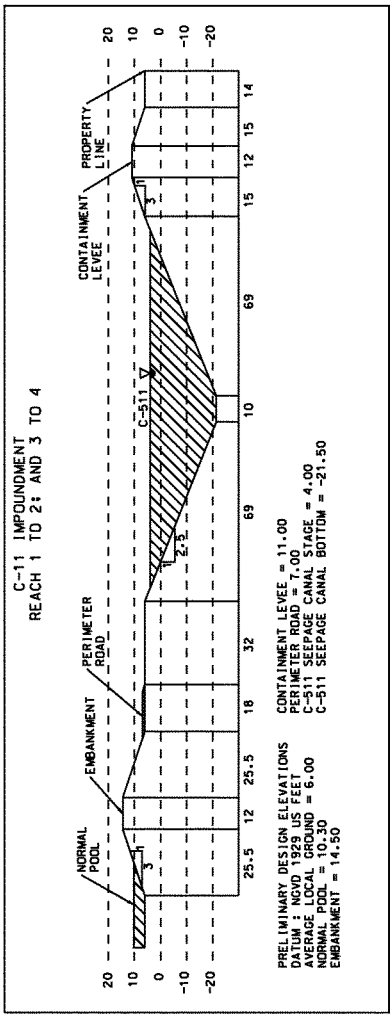

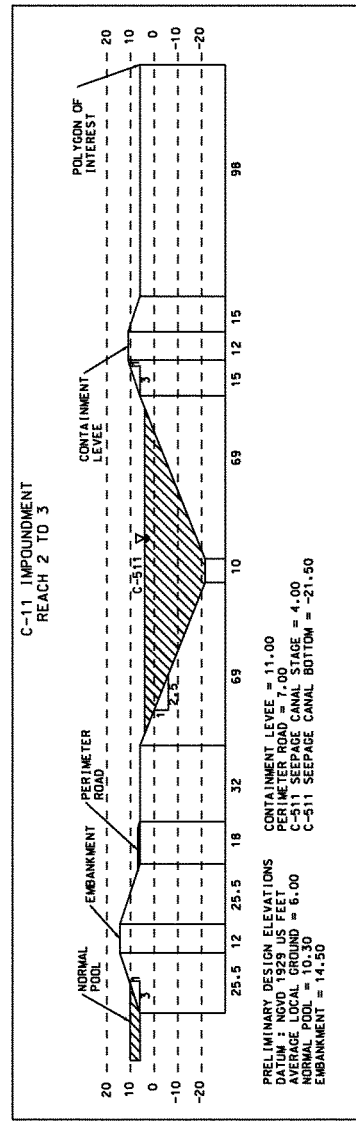

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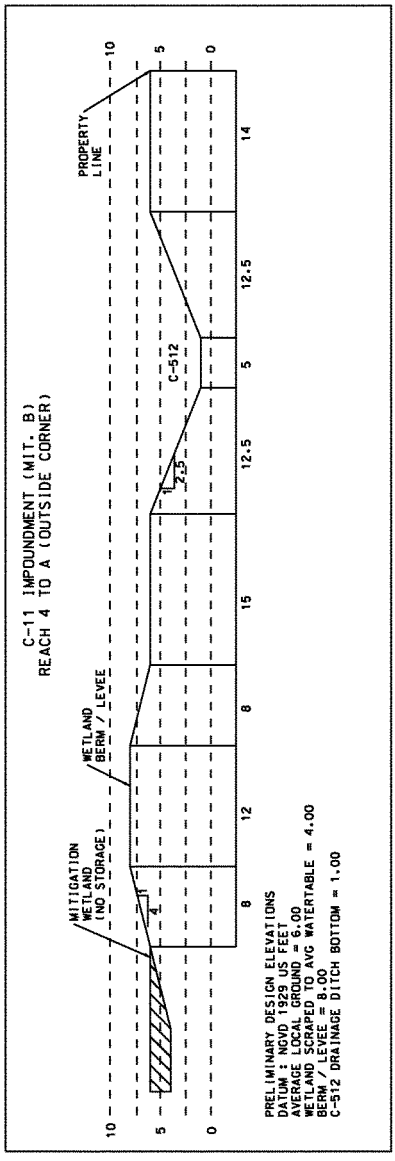
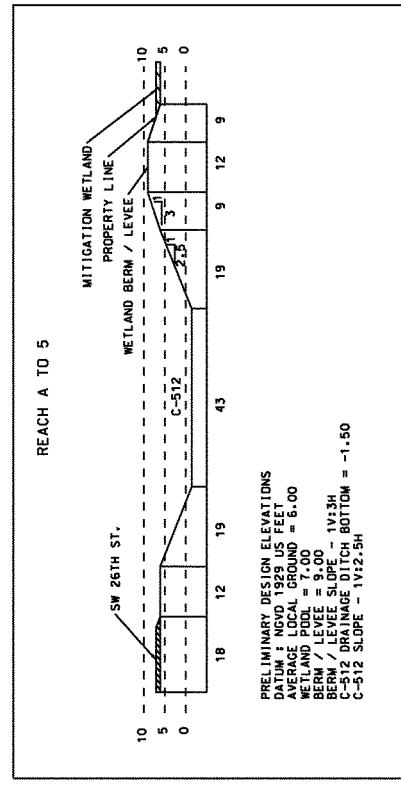
CENTRAL AND SOUTHERN FLORIDA PROJECT
BROWARD COUNTY WATER PRESERVE AREAS
PROJECT IMPLEMENTATION REPORT
C-11 IMPOUNDMENT
TYPICAL SECTIONS

PLATE
G-11A





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BROWARD COUNTY WATER PRESERVE AREAS
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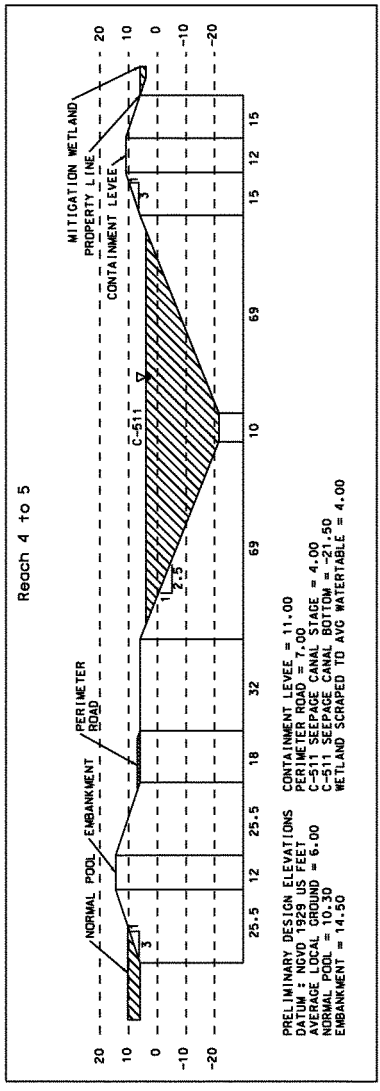
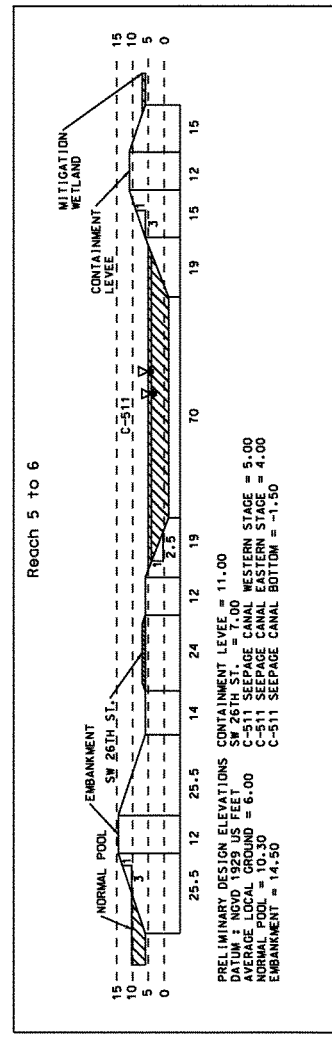
C-11 IMPOUNDMENT
TYPICAL SECTIONS

PLATE
G-11B





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CENTRAL AND SOUTHERN FLORIDA PROJECT
BROWARD COUNTY WATER PRESERVE AREAS
PROJECT IMPLEMENTATION REPORT
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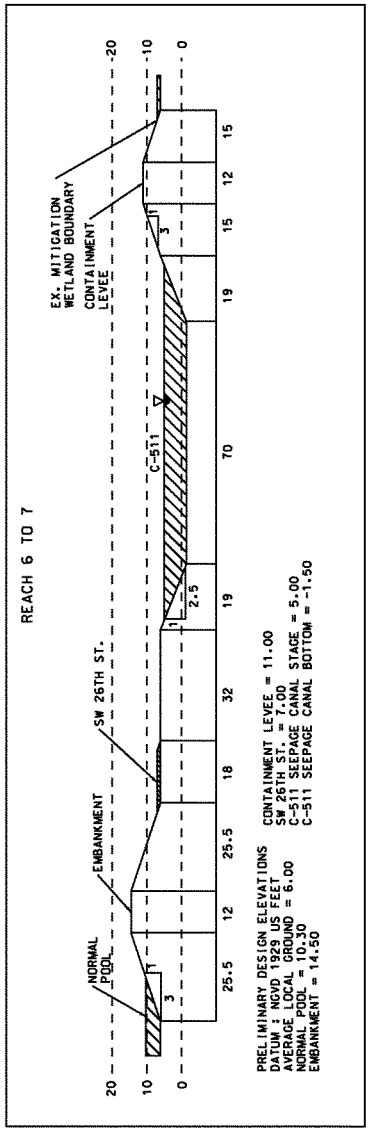
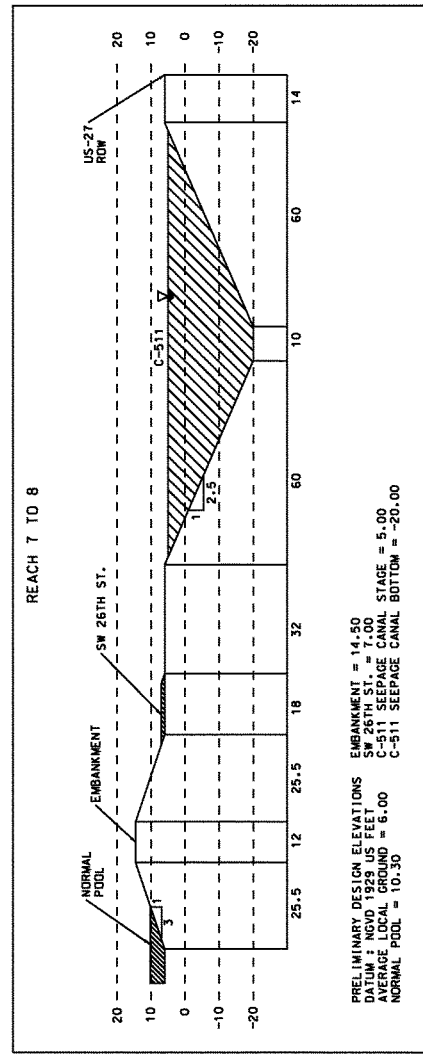
TYPICAL SECTIONS

PLATE
G-11C





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CENTRAL AND SOUTHERN FLORIDA PROJECT
BROWARD COUNTY WATER PRESERVE AREAS
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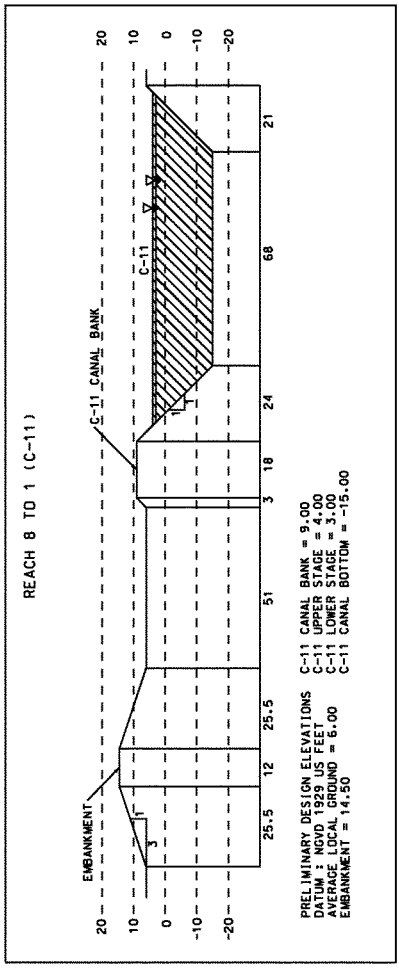
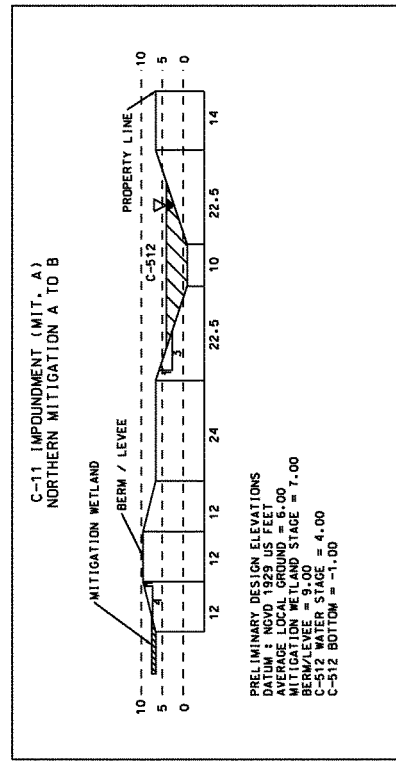
PLATE
G-11D



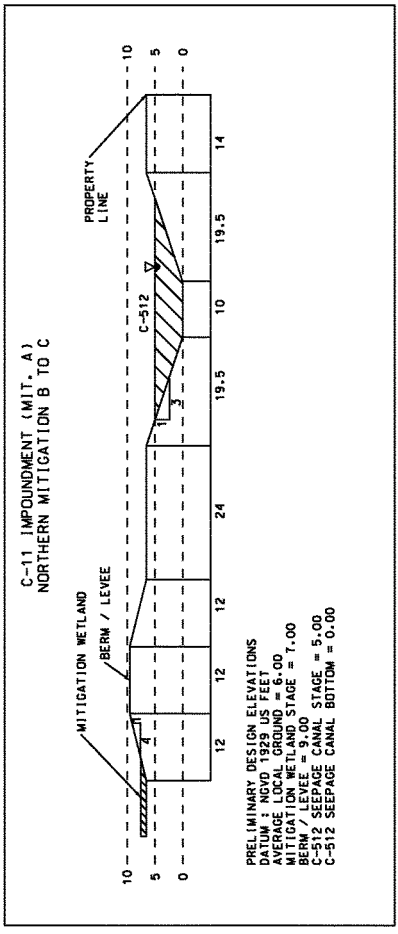


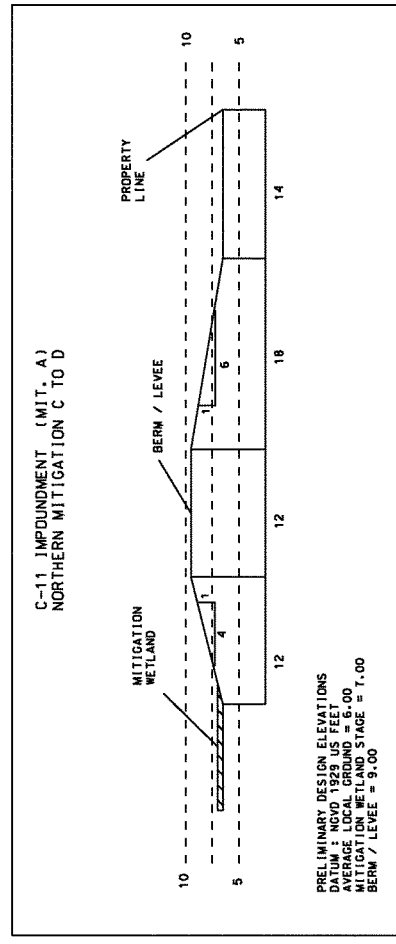
US Army Corps of Engineers
Jacksonville District

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

CENTRAL AND SOUTHERN FLORIDA PROJECT
BROWARD COUNTY WATER PRESERVE AREAS
PROJECT IMPLEMENTATION REPORT
C-11 IMPOUNDMENT
TYPICAL SECTIONS

PLATE
G-11E



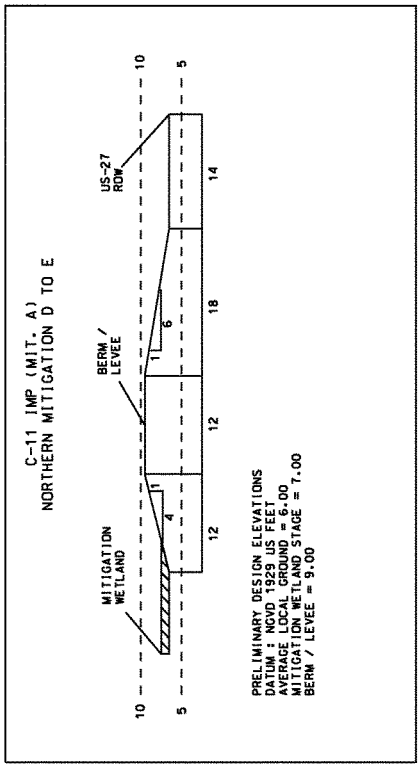


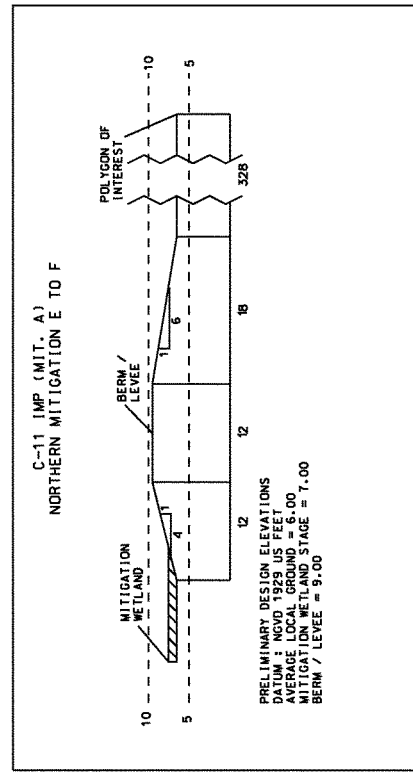
US Army Corps of Engineers
Jacksonville District

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

CENTRAL AND SOUTHERN FLORIDA PROJECT
BROWARD COUNTY WATER PRESERVE AREAS
PROJECT IMPLEMENTATION REPORT
C-11 IMPOUNDMENT
TYPICAL SECTIONS

PLATE
G-11F





US Army Corps of Engineers
Jacksonville District

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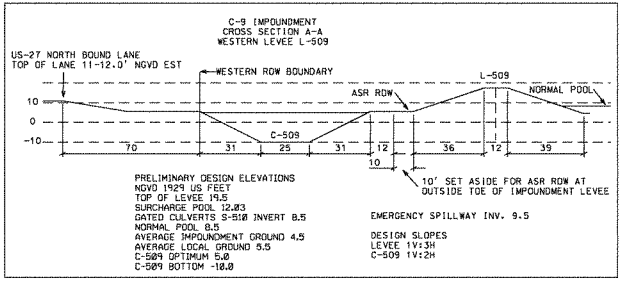
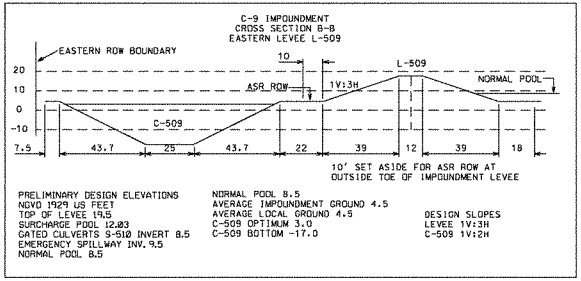
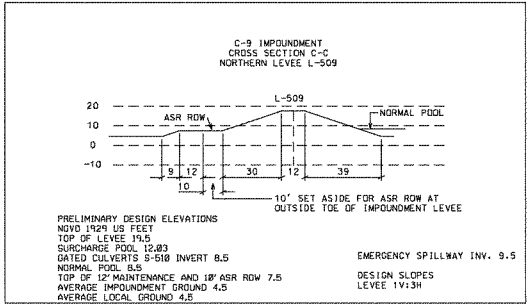
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

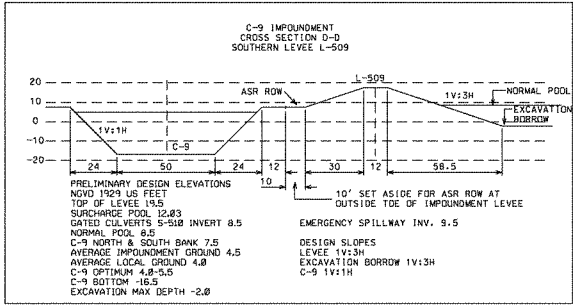
CENTRAL AND SOUTHERN FLORIDA PROJECT
BROWARD COUNTY WATER PRESERVE AREAS
PROJECT IMPLEMENTATION REPORT
C-11 IMPOUNDMENT
TYPICAL SECTIONS

PLATE
G-11G







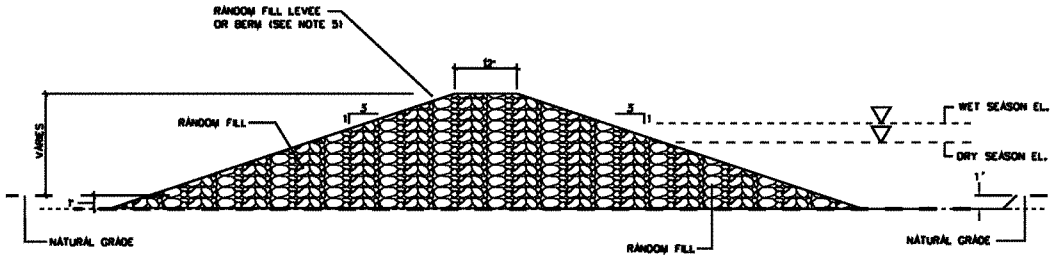


US Army Corps of Engineers
Jacksonville District

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

CENTRAL AND SOUTHERN FLORIDA PROJECT
BROWARD COUNTY WATER PRESERVE AREAS
PROJECT IMPLEMENTATION REPORT
C-9 IMPOUNDMENT
TYPICAL SECTIONS

PLATE
G-12



TYPICAL RANDOM FILL CROSS SECTION

APPLIES TO: L-502B (BETWEEN C-11 AND C-9)

AND L-502F (LP&L BERM)

DRAWING NOT TO SCALE

NOTES:

1. ALL ELEVATIONS AND HEIGHTS ARE REFERED TO HEIGHT ABOVE OR BELOW NATURAL GROUND.
2. TOP OF EMBANKMENT HEIGHT VARIES. REFER TO PREVIOUS CROSS SECTIONS
3. PEAT DEPTH VARIES 0' TO 5'
4. RANDOM FILL - BLASTED ROCK
5. APPLIES TO: L-502B (BETWEEN C-11 AND C-9), AND L-502F (LP&L BERM)

LEGEND:

WET SEASON - SEEPAGE MANAGEMENT AREA ELEV. (VARIES PER LOCATION)

DRY SEASON - SEEPAGE MANAGEMENT AREA ELEV. (VARIES PER LOCATION)

US Army Corps of Engineers Jacksonville District

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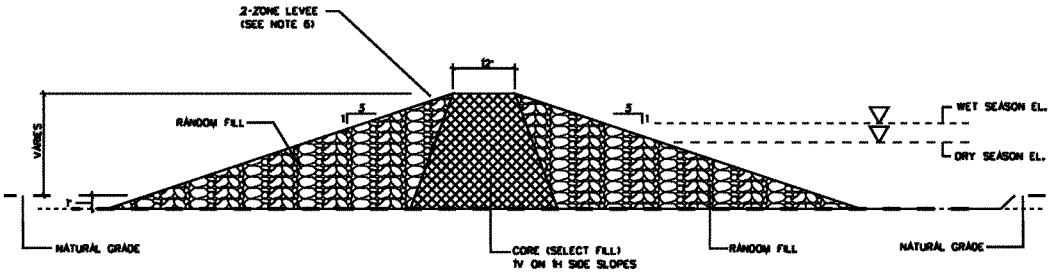
JACKSONVILLE, FLORIDA

CENTRAL AND SOUTHERN FLORIDA PROJECT
BROWARD COUNTY WATER PRESERVE AREAS
PROJECT IMPLEMENTATION REPORT
RANDOM FILL LEVEE OR BERM
TYPICAL SECTION

PLATE
G-13



TYPICAL 2-ZONE CROSS SECTION APPLIES TO:

L-502A, L-502B (SOUTH), L-503, L-509A & B, L-512, L-513, L-514,

L-502C (HOLLEY LAKES), L-502D (JONES PARK) AND L-502E (BISHOP/NIXON BERM)

NOTES:

1. ALL ELEVATIONS AND HEIGHTS ARE REFERED TO HEIGHT ABOVE OR BELOW NATURAL GROUND.
2. TOP OF EMBANKMENT HT. VARIES. REFER TO PREVIOUS CROSS SECTIONS
3. PEAT DEPTH VARIES 0' TO 5'
4. CORE - SELECT PROCESSED MATERIAL
5. RANDOM FILL - BLASTED ROCK
6. APPLIES TO: L-502A, L-502B (SOUTH), L-503, L-509A & B, L-512, L-513, L-514, L-502C (HOLLEY LAKES), L-502D (JONES PARK) AND L-502E (BISHOP/NIXON)

DRAWING NOT TO SCALE

LEGEND:

WET SEASON - SEEPAGE MANAGEMENT AREA ELEV. (VARIES PER LOCATION)

DRY SEASON - SEEPAGE MANAGEMENT AREA ELEV. (VARIES PER LOCATION)

US Army Corps of Engineers Jacksonville District

DEPARTMENT OF THE ARMY
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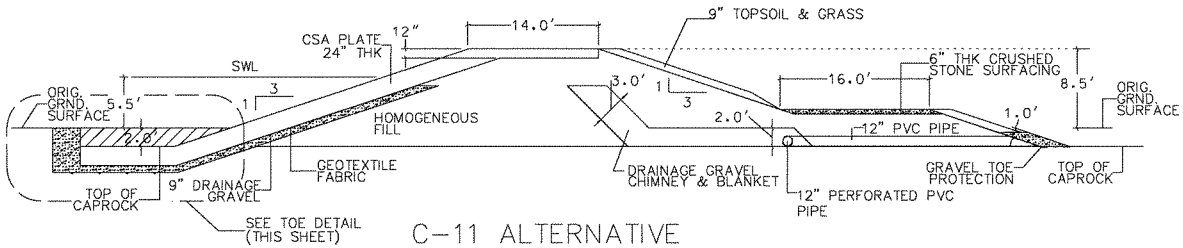
JACKSONVILLE, FLORIDA

CENTRAL AND SOUTHERN FLORIDA PROJECT
BROWARD COUNTY WATER PRESERVE AREAS
PROJECT IMPLEMENTATION REPORT
2-ZONE LEVEE OR BERM
TYPICAL SECTION

PLATE
G-14



C-11 ALTERNATIVE

DRAWING NOT TO SCALE

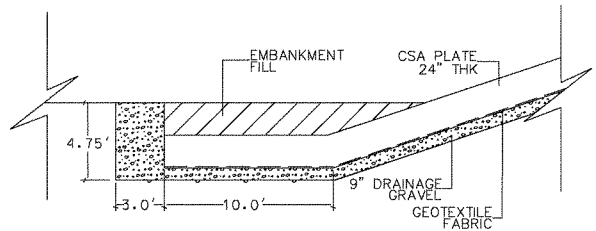
NOTES:

1. ALL ELEVATIONS AND HEIGHTS ARE REFERED TO HEIGHT ABOVE OR BELOW NATURAL GROUND.
2. ALL DIMENSION SHOWN ARE IN FEET, EXCEPT AS NOTED.
3. TOP OF EMBANKMENT HT. = 8.5'
4. PEAT DEPTH AVERAGES 2'
5. CSA = CEMENT STABILIZED AGGREGATE

LEGEND:

S.W.L. - MAX. SURCHARGE WATER LEVEL HT. = 5.5'

N.P.L. - NORMAL POOL LEVEL HT. = 4.3'



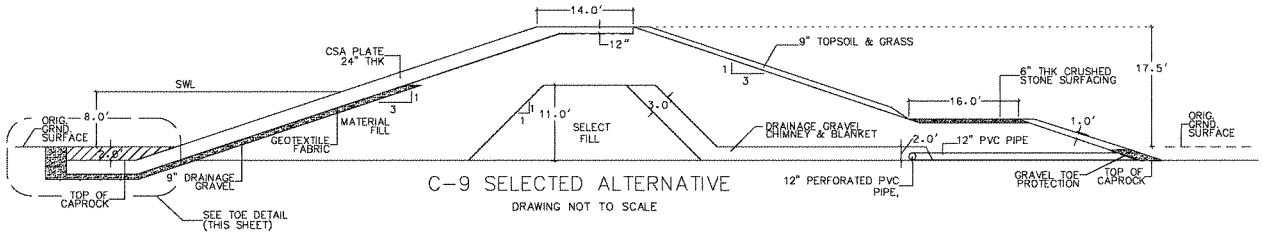
TOE DETAIL

US Army Corps of Engineers
Jacksonville District

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

CENTRAL AND SOUTHERN FLORIDA PROJECT
BROWARD COUNTY WATER PRESERVE AREAS
PROJECT IMPLEMENTATION REPORT
ZONE IMPOUNDMENT EMBANKMENT
C-11 TYPICAL SECTION

PLATE
G-15A



C-9 SELECTED ALTERNATIVE

DRAWING NOT TO SCALE

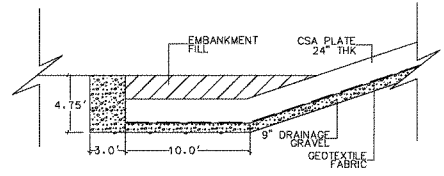
NOTES:

1. ALL ELEVATIONS AND HEIGHTS ARE REFERED TO HEIGHT ABOVE OR BELOW NATURAL GROUND.
2. ALL DIMENSION SHOWN ARE IN FEET, EXCEPT AS NOTED.
3. TOP OF EMBANKMENT HT. = 17.5'
4. PEAT DEPTH AVERAGES 2'
5. CSA = CEMENT STABILIZED AGGREGATE

LEGEND:

S.W.L. - MAX. SURCHARGE WATER LEVEL HT. = 8.0'

N.P.L. - NORMAL POOL LEVEL HT. = 4.3'



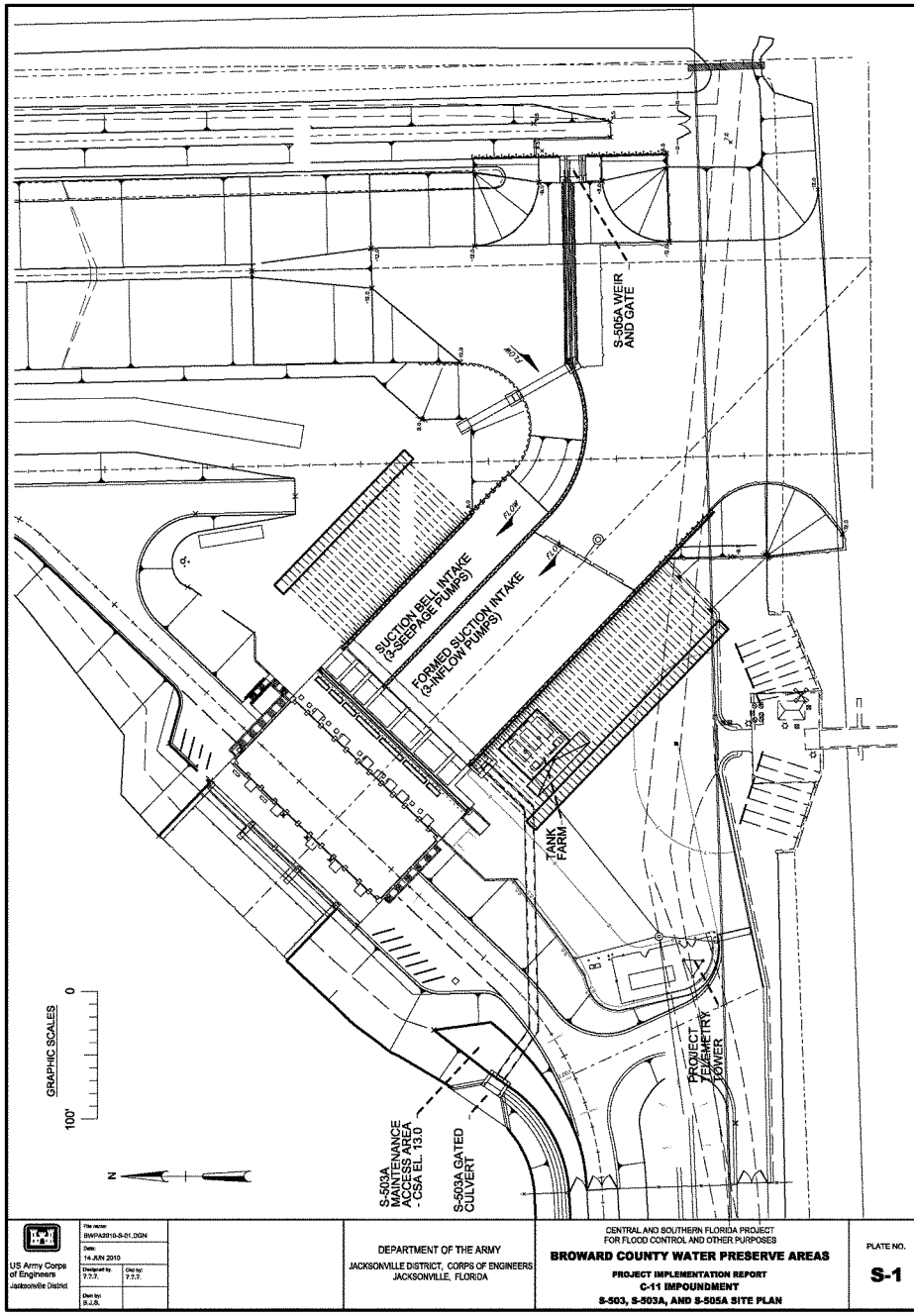
TOE DETAIL

US. Army Corps of Engineers Jacksonville District

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

CENTRAL AND SOUTHERN FLORIDA PROJECT
BROWARD COUNTY WATER PRESERVE AREAS
PROJECT IMPLEMENTATION REPORT
ZONE IMPOUNDMENT EMBANKMENT
C-9 TYPICAL SECTION

PLATE
G-15B



US Army Corps of Engineers
Jacksonville District

File name: BWPA2010-S-01.DGN
Date: 14 JUN 2010
Designed by: T.T.T.
Drawn by: T.T.T.
Chk by: B.J.S.

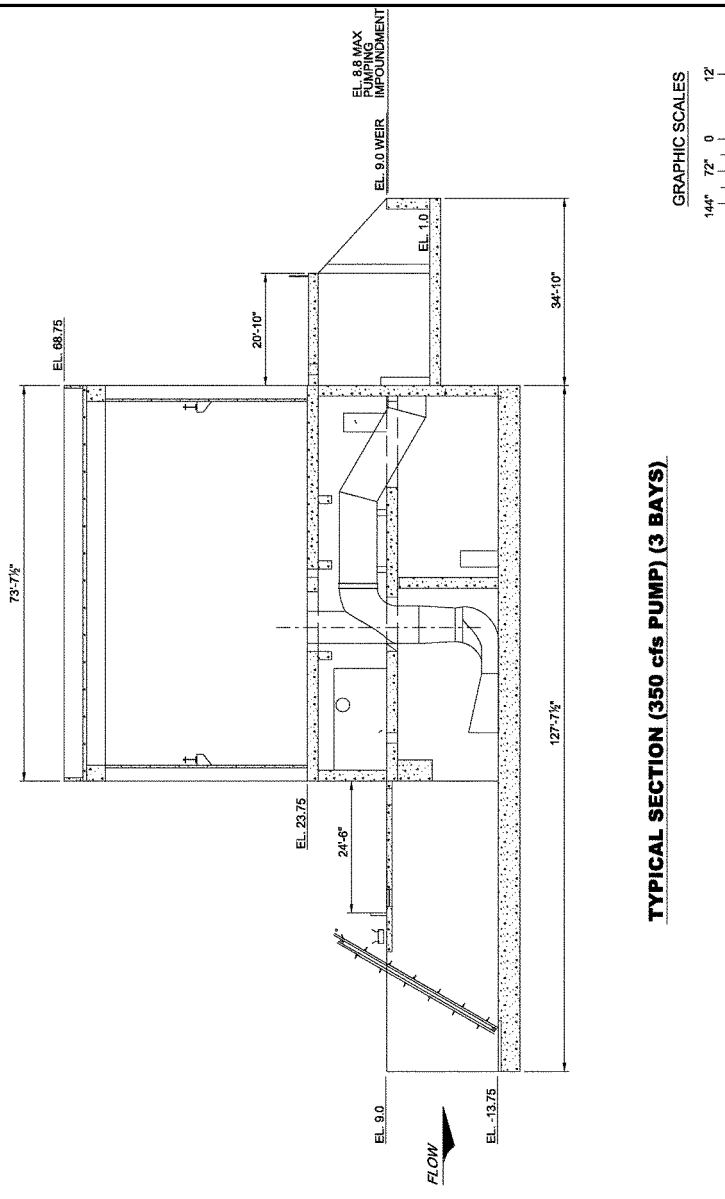
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

CENTRAL AND SOUTHERN FLORIDA PROJECT
FOR FLOOD CONTROL AND OTHER PURPOSES

BROWARD COUNTY WATER PRESERVE AREAS

PROJECT IMPLEMENTATION REPORT
C-11 IMPOUNDMENT
S-503, S-503A, AND S-505A SITE PLAN

PLATE NO.
S-1



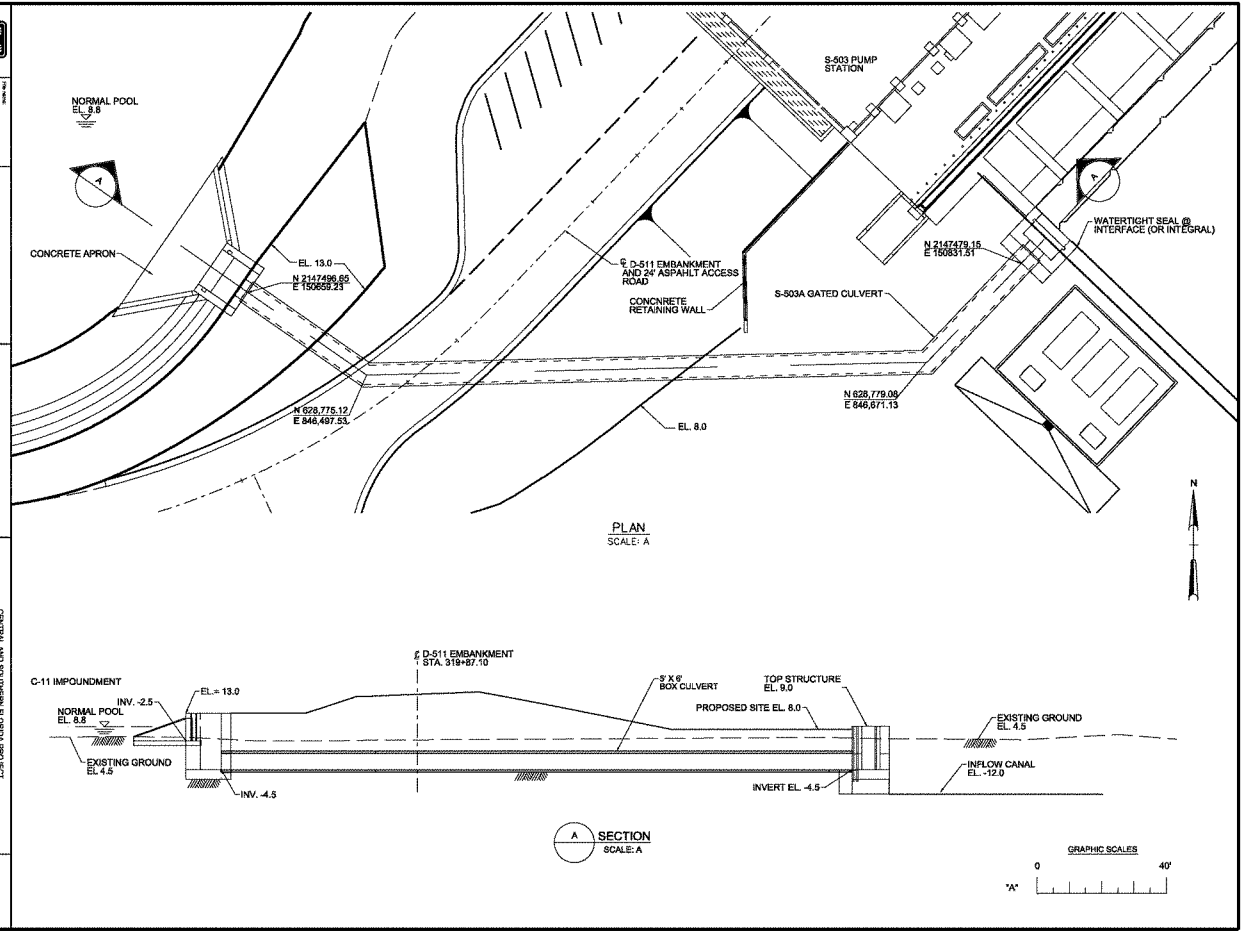
US Army Corps of Engineers
Jacksonville District

File name: BWPA2010-S-02.DGN
Date: 14 JUN 2010
Designed by: ?.?.?. Drawn by: ?.?.?.
Dwn by: S.J.K.

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

CENTRAL AND SOUTHERN FLORIDA PROJECT
FOR FLOOD CONTROL AND OTHER PURPOSES
BROWARD COUNTY WATER PRESERVE AREAS
PROJECT IMPLEMENTATION REPORT
C-11 IMPOUNDMENT
S-503 TYPICAL SECTION

PLATE NO.
S-2



US Army Corps of Engineers
Jacksonville District

Date: 11 AUG 2015
Checked by: ???
Drawn by: ???

File name: BWPR2015-SAT-LION

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

CENTRAL AND SOUTHERN FLORIDA PROJECT
FOR FLOOD CONTROL AND OTHER PURPOSES

BROWARD COUNTY WATER PRESERVE AREAS

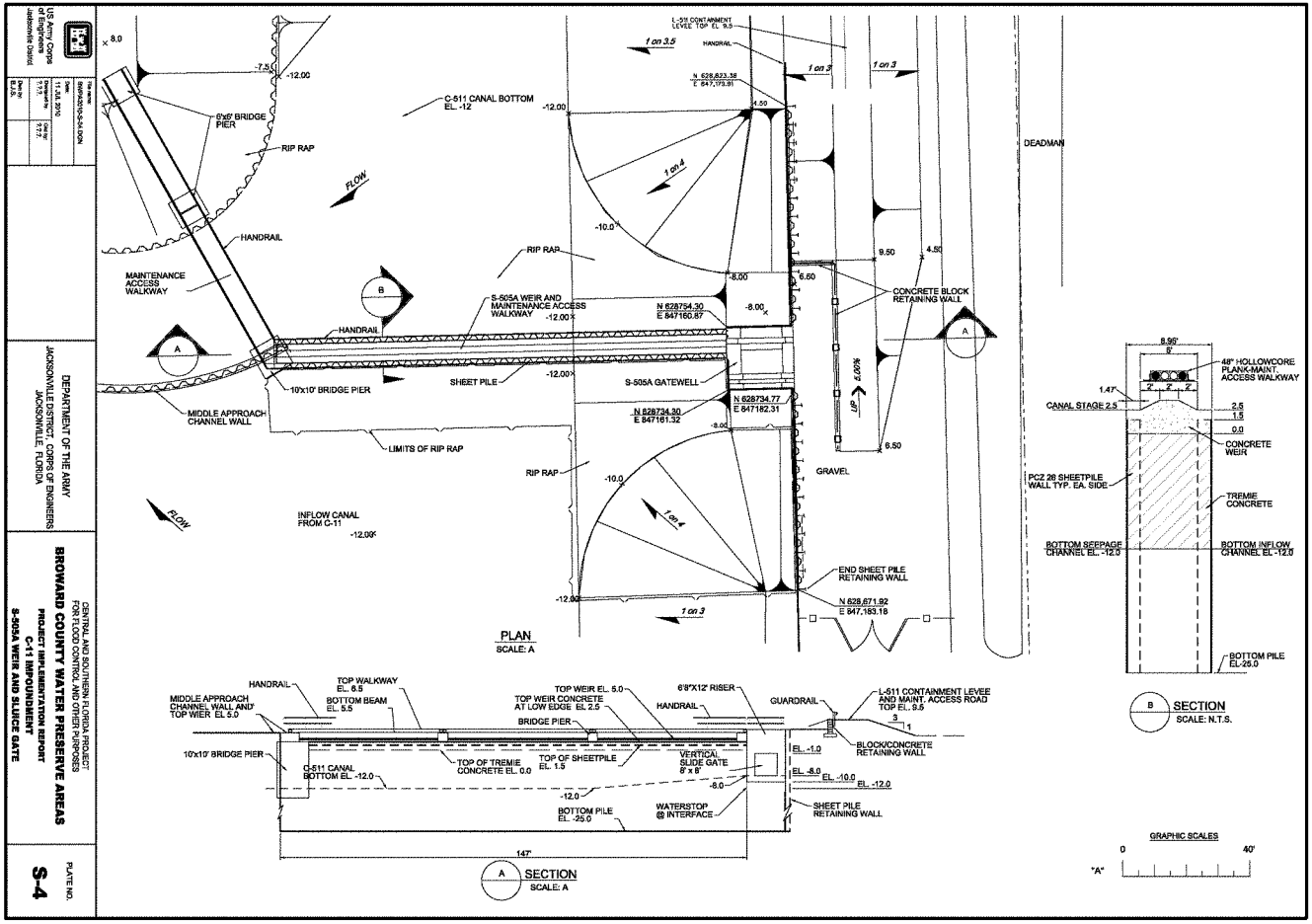
PROJECT IMPLEMENTATION REPORT

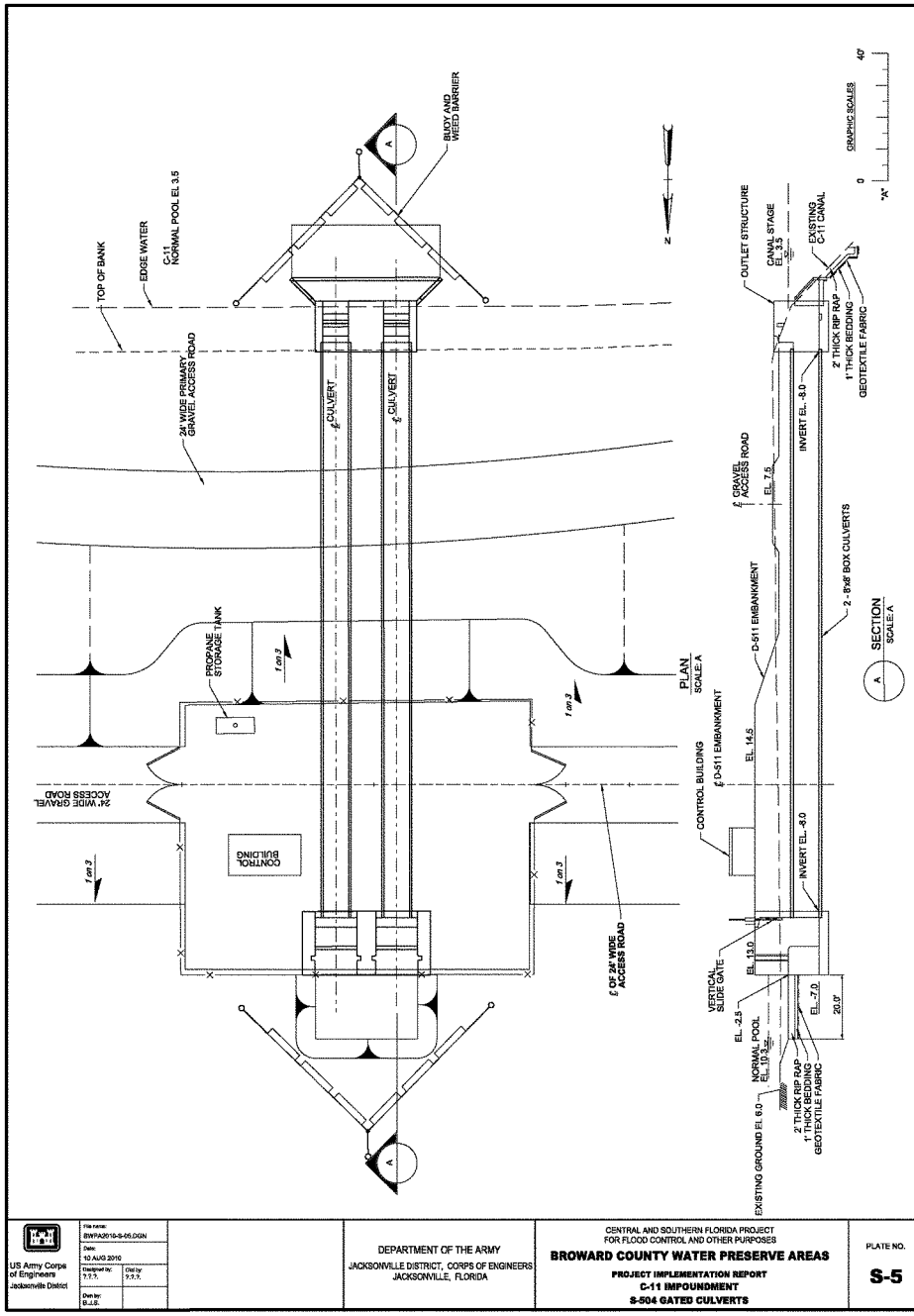
C-11 IMPOUNDMENT

S-503A GATED CULVERT

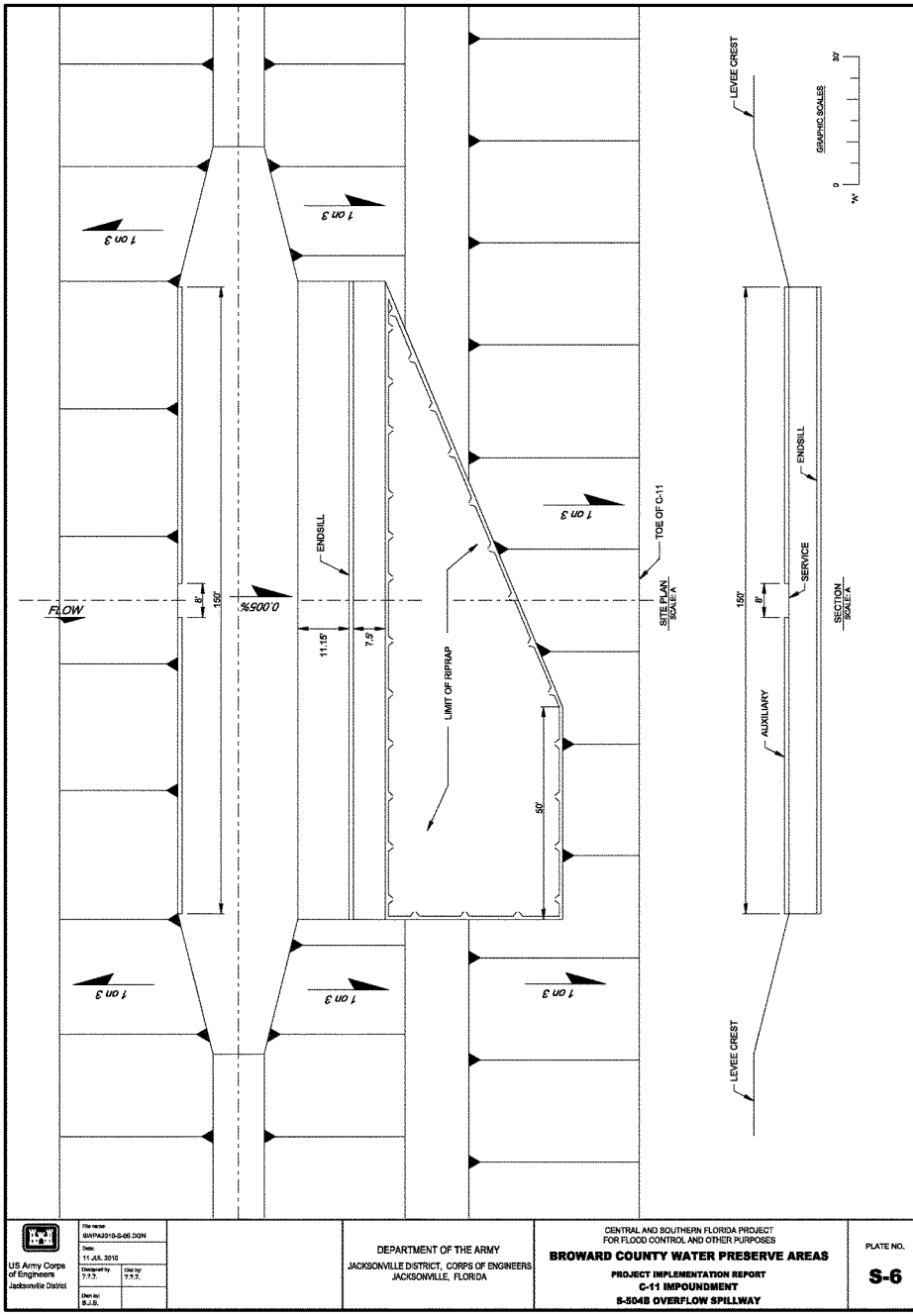
PLATE NO.

S-3


PLAN
SCALE: A
SECTION
SCALE: A
SECTION
SCALE: N.T.S.
GRAPHIC SCALES
0
40'
"A"
C-511 CANAL BOTTOM EL. -12
6'x6' BRIDGE PIER
RIP RAP
FLOW
HANDRAIL
MAINTENANCE ACCESS WALKWAY
S-505A WEIR AND MAINTENANCE ACCESS WALKWAY
10'x10' BRIDGE PIER
SHEET PILE
MIDDLE APPROACH CHANNEL WALL
LIMITS OF RIP RAP
INFLOW CANAL FROM C-11
S-505A GATEWELL
N 628734.30
E 847160.87
N 628734.77
E 847162.31
N 628734.30
E 847161.32
N 628,833.38
E 847,193.91
N 628,671.92
E 847,183.18
L-511 CONTAINMENT LEVEE TOP EL. 9.5
CONCRETE BLOCK RETAINING WALL
DEADMAN
GRAVEL
END SHEET PILE RETAINING WALL
1 on 3.5
1 on 3
1 on 4
48" HOLLOWCORE PLANK-MAINT. ACCESS WALKWAY
CANAL STAGE 2.5
CONCRETE WEIR
PCZ 26 SHEETPILE WALL TYP. EA. SIDE
TREMIE CONCRETE
BOTTOM SEEPAGE CHANNEL EL. -12.0
BOTTOM INFLOW CHANNEL EL. -12.0
BOTTOM PILE EL. -25.0
TOP WALKWAY EL. 6.5
BOTTOM BEAM EL. 5.5
MIDDLE APPROACH CHANNEL WALL AND TOP WIER EL 5.0
TOP WEIR EL. 5.0
TOP WEIR CONCRETE AT LOW EDGE EL 2.5
BRIDGE PIER
6'8"X12' RISER
GUARDRAIL
L-511 CONTAINMENT LEVEE AND MAINT. ACCESS ROAD TOP EL. 9.5
BLOCK/CONCRETE RETAINING WALL
TOP OF TREMIE CONCRETE EL. 0.0
TOP OF SHEETPILE EL. 1.5
VERTICAL SLIDE GATE 8' x 8'
C-511 CANAL BOTTOM EL. -12.0
BOTTOM PILE EL. -25.0
WATERSTOP @ INTERFACE
SHEET PILE RETAINING WALL
147'
US Army Corps of Engineers Jacksonville District
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
CENTRAL AND SOUTHERN FLORIDA PROJECT
FOR FLOOD CONTROL AND OTHER PURPOSES
BROWARD COUNTY WATER PRESERVE AREAS
PROJECT IMPLEMENTATION REPORT
C-11 IMPOUNDMENT
S-505A WEIR AND SLUICE GATE
PLATE NO.
S-4



US Army Corps of Engineers Jacksonville District	File name: BWPA2010-S-05.DGN Date: 10 AUG 2010 Designed by: ?.?.?. Drawn by: B.J.S.	DEPARTMENT OF THE ARMY JACKSONVILLE DISTRICT, CORPS OF ENGINEERS JACKSONVILLE, FLORIDA	CENTRAL AND SOUTHERN FLORIDA PROJECT FOR FLOOD CONTROL AND OTHER PURPOSES **BROWARD COUNTY WATER PRESERVE AREAS** **PROJECT IMPLEMENTATION REPORT** **C-11 IMPOUNDMENT** **S-504 GATED CULVERTS**	PLATE NO. **S-5**



US Army Corps of Engineers
Jacksonville District

File name: BWPA2010-S-06.DGN
Date: 11 JUL 2010
Designed by: ???
Dist by: ???
Chk by: B.J.B.

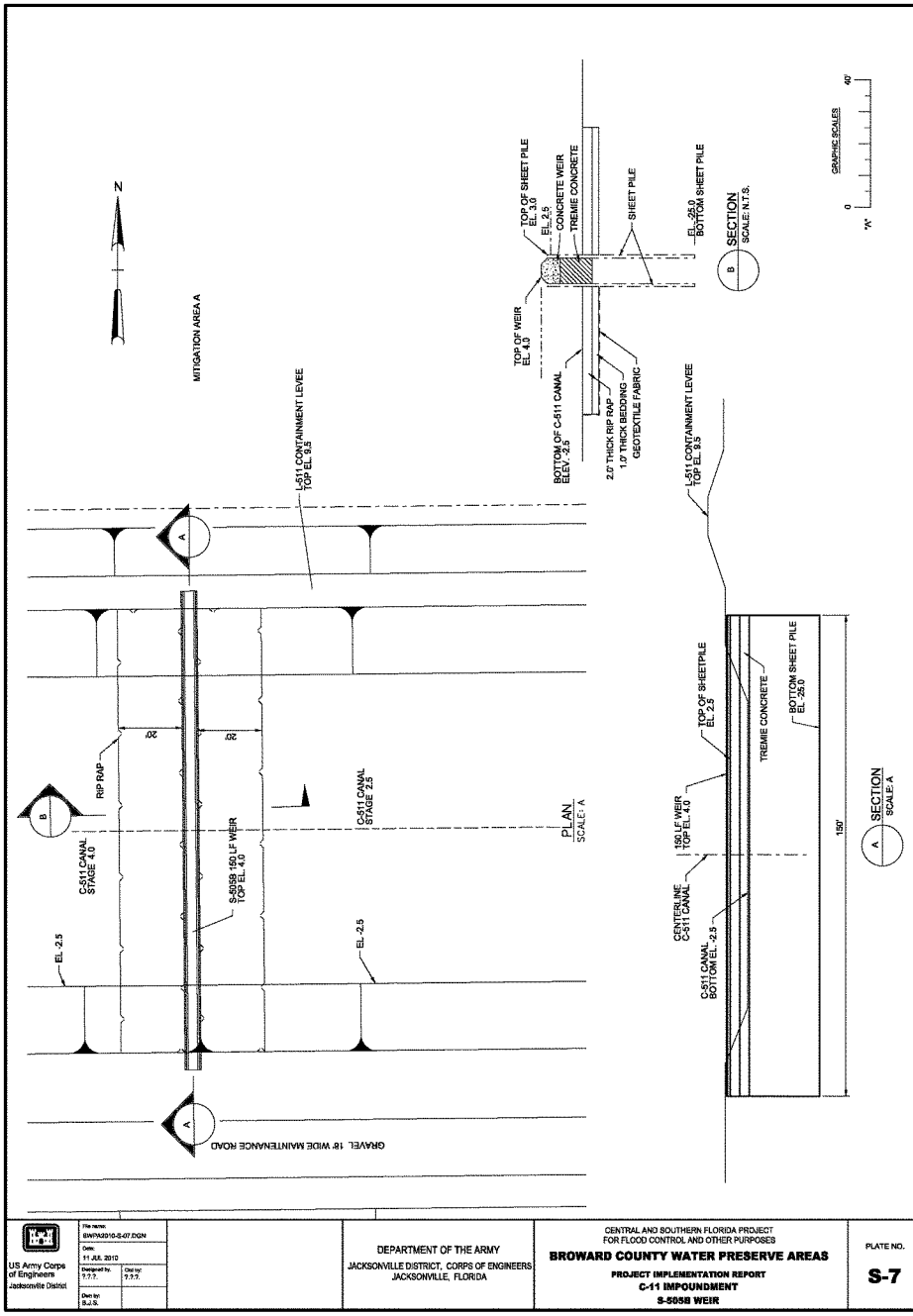
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

CENTRAL AND SOUTHERN FLORIDA PROJECT
FOR FLOOD CONTROL AND OTHER PURPOSES

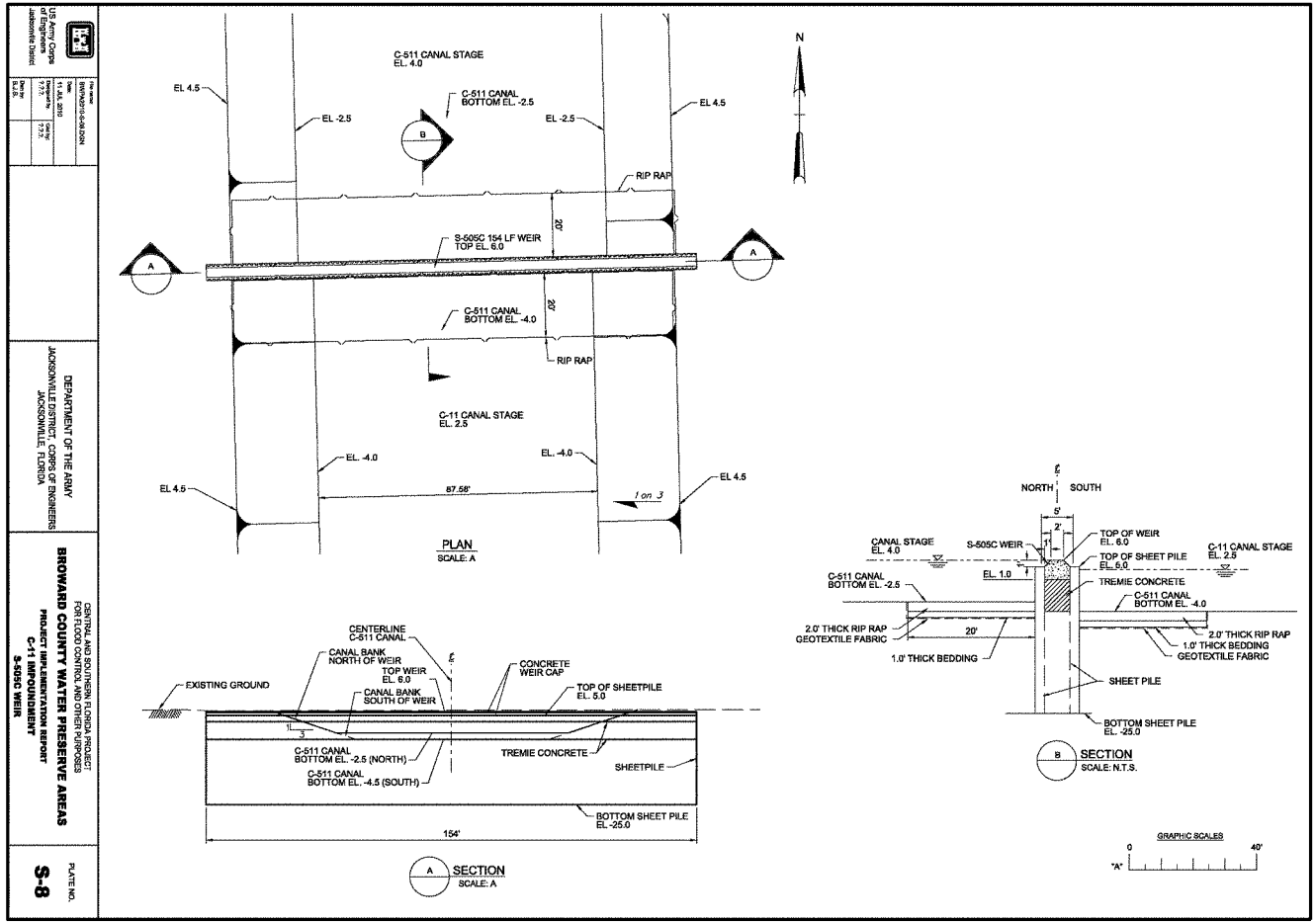
BROWARD COUNTY WATER PRESERVE AREAS

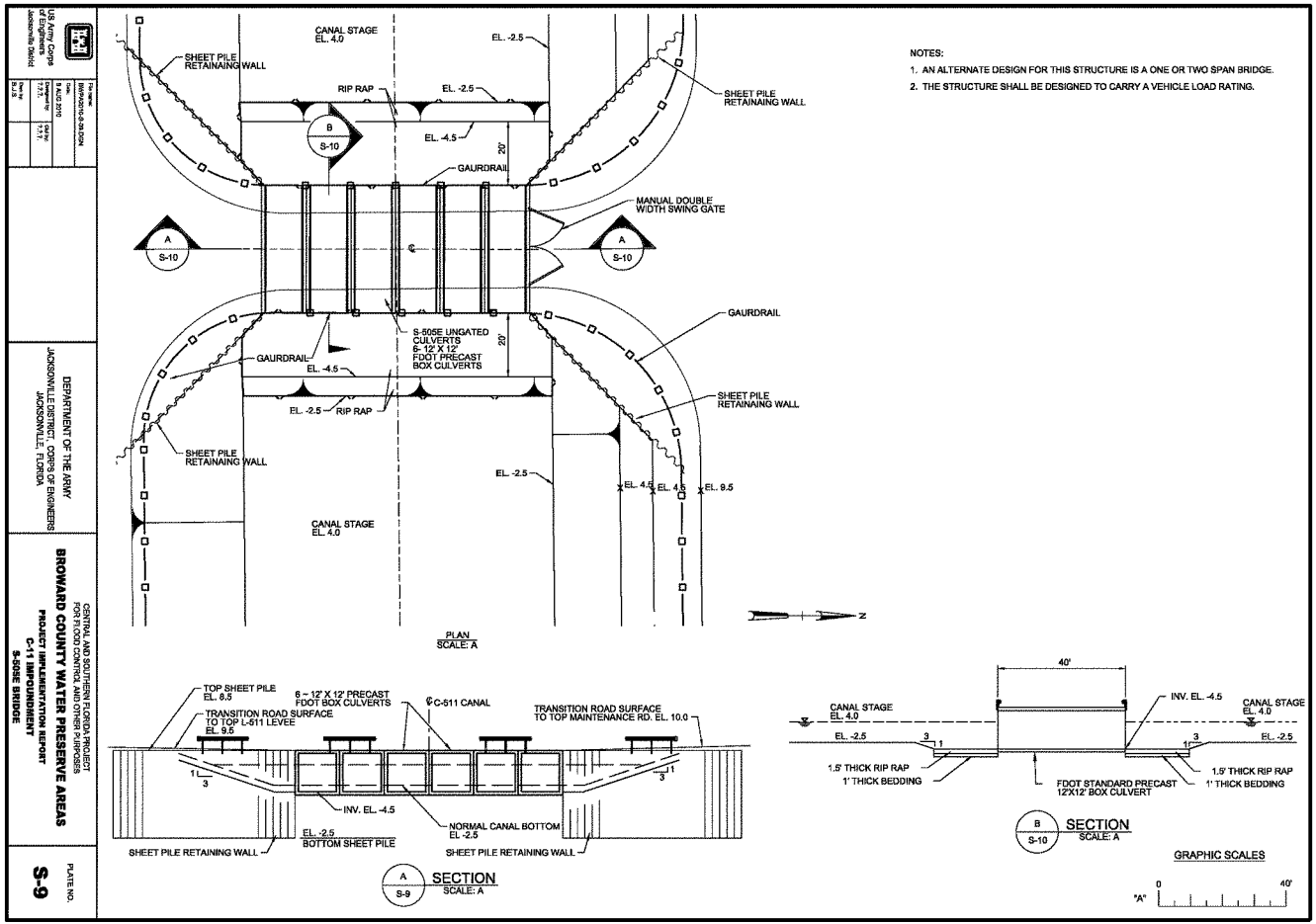
PROJECT IMPLEMENTATION REPORT
C-11 IMPOUNDMENT
S-504B OVERFLOW SPILLWAY

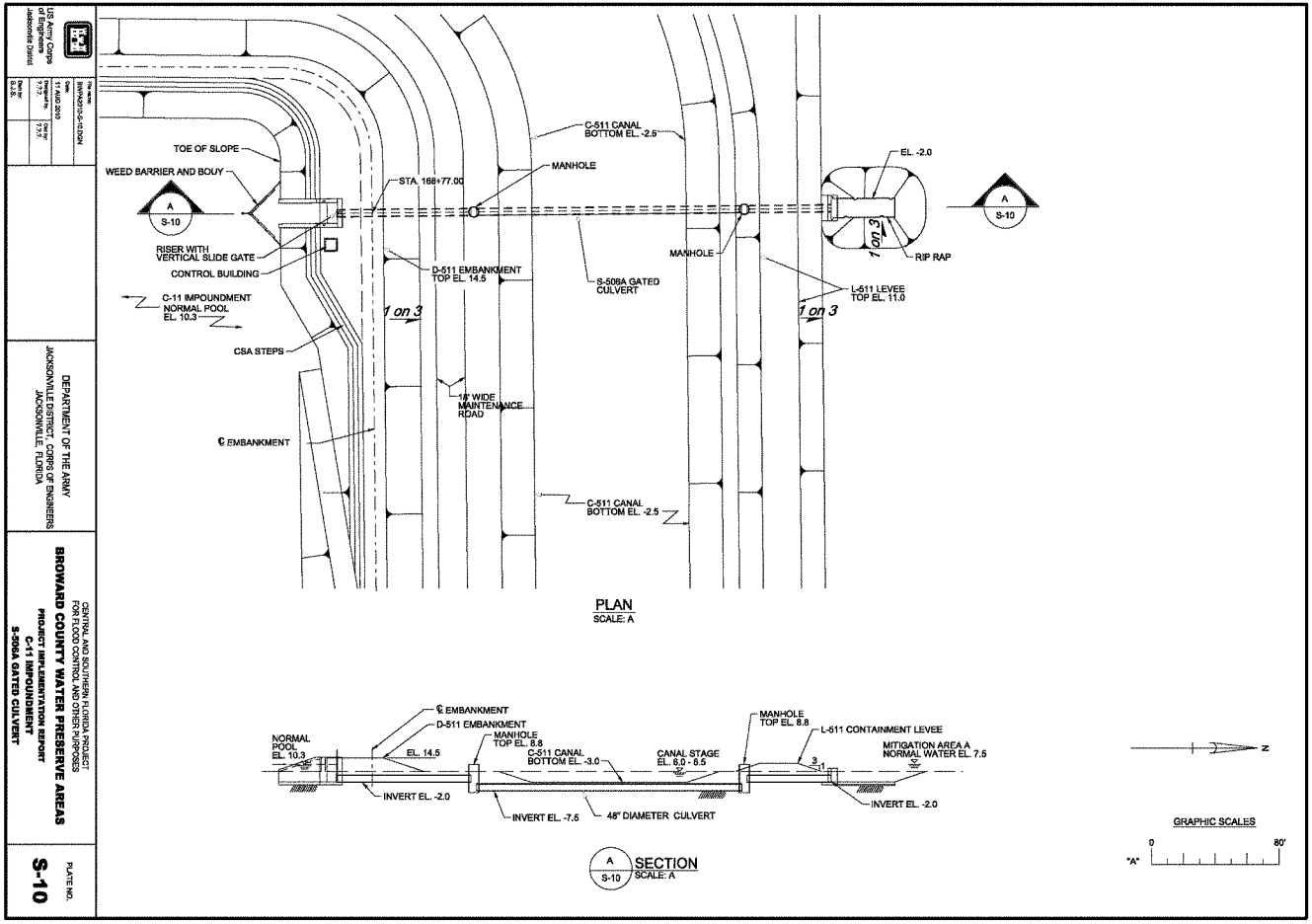
PLATE NO.
S-6

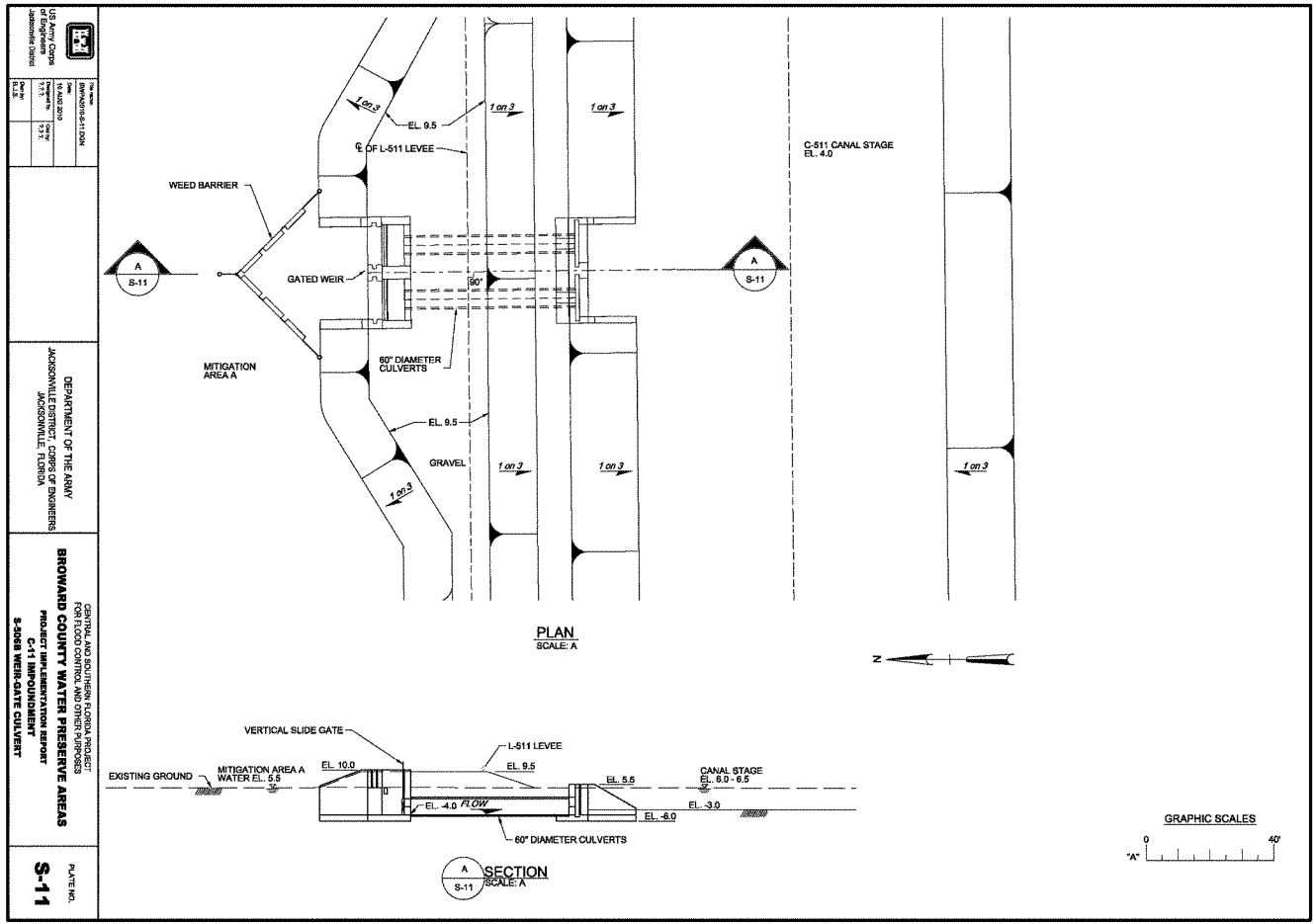


US Army Corps of Engineers Jacksonville District	File name: BWPA2010-S-07.DGN Date: 11 JUL 2010 Designed by: ??? Chk by: ??? Dwn by: S.J.S.	DEPARTMENT OF THE ARMY JACKSONVILLE DISTRICT, CORPS OF ENGINEERS JACKSONVILLE, FLORIDA	CENTRAL AND SOUTHERN FLORIDA PROJECT FOR FLOOD CONTROL AND OTHER PURPOSES **BROWARD COUNTY WATER PRESERVE AREAS** **PROJECT IMPLEMENTATION REPORT** **C-11 IMPOUNDMENT** **S-505B WEIR**	PLATE NO. **S-7**

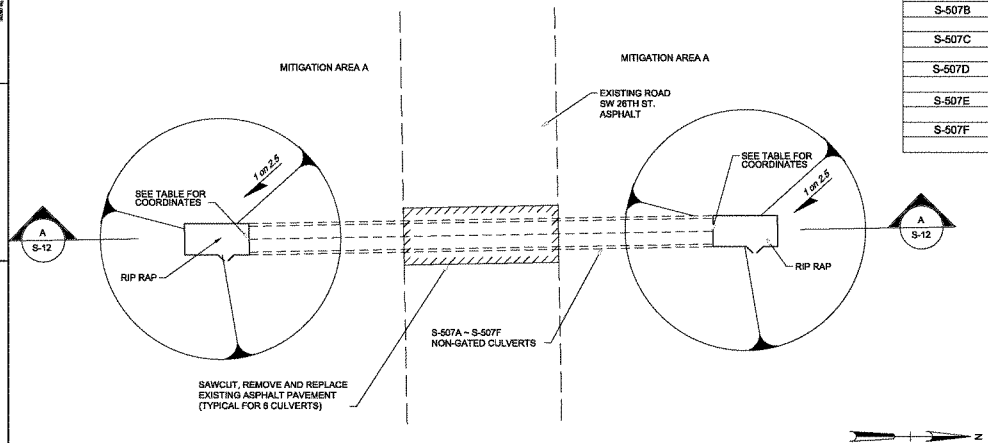

C-511 CANAL STAGE
EL. 4.0
EL 4.5
EL -2.5
C-511 CANAL
BOTTOM EL. -2.5
EL -2.5
EL 4.5
RIP RAP
S-505C 154 LF WEIR
TOP EL. 6.0
20'
20'
C-511 CANAL
BOTTOM EL. -4.0
RIP RAP
C-11 CANAL STAGE
EL. 2.5
EL. -4.0
EL. -4.0
EL 4.5
EL 4.5
87.58'
1 on 3
PLAN
SCALE: A
N
CENTERLINE
C-511 CANAL
CANAL BANK
NORTH OF WEIR
TOP WEIR
EL. 6.0
CANAL BANK
SOUTH OF WEIR
CONCRETE
WEIR CAP
TOP OF SHEETPILE
EL. 5.0
EXISTING GROUND
1
3
C-511 CANAL
BOTTOM EL. -2.5 (NORTH)
C-511 CANAL
BOTTOM EL. -4.5 (SOUTH)
TREMIE CONCRETE
SHEETPILE
BOTTOM SHEET PILE
EL. -25.0
154'
A SECTION
SCALE: A
NORTH
SOUTH
5'
2'
1'
CANAL STAGE
EL. 4.0
S-505C WEIR
TOP OF WEIR
EL. 6.0
TOP OF SHEET PILE
EL. 5.0
C-11 CANAL STAGE
EL. 2.5
EL. 1.0
C-511 CANAL
BOTTOM EL. -2.5
TREMIE CONCRETE
C-511 CANAL
BOTTOM EL. -4.0
2.0' THICK RIP RAP
GEOTEXTILE FABRIC
20'
2.0' THICK RIP RAP
1.0' THICK BEDDING
GEOTEXTILE FABRIC
1.0' THICK BEDDING
SHEET PILE
BOTTOM SHEET PILE
EL. -25.0
B SECTION
SCALE: N.T.S.
GRAPHIC SCALES
0
40'
"A"
US Army Corps of Engineers
Jacksonville District
File name: BWNA2010-6-MEZION
Date: 11-18-2010
Drawn by: ???
Checked by: ???
Dwn by: E.J.S.
Chkd by: ???
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
CENTRAL AND SOUTHERN FLORIDA PROJECT
FOR FLOOD CONTROL AND OTHER PURPOSES
BROWARD COUNTY WATER PRESERVE AREAS
PROJECT IMPLEMENTATION REPORT
C-11 IMPOUNDMENT
S-505C WEIR
PLATE NO.
S-8

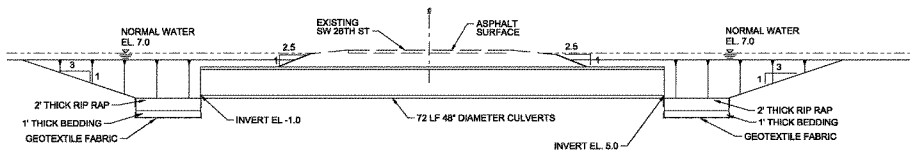

NOTES:
1. AN ALTERNATE DESIGN FOR THIS STRUCTURE IS A ONE OR TWO SPAN BRIDGE.
2. THE STRUCTURE SHALL BE DESIGNED TO CARRY A VEHICLE LOAD RATING.
CANAL STAGE EL. 4.0
EL. -2.5
SHEET PILE RETAINAING WALL
RIP RAP
EL. -4.5
GAURDRAIL
20'
MANUAL DOUBLE WIDTH SWING GATE
S-505E UNGATED CULVERTS 6-12' X 12' FDOT PRECAST BOX CULVERTS
EL. 4.5
EL. 9.5
PLAN
SCALE: A
TOP SHEET PILE EL. 8.5
6 ~ 12' X 12' PRECAST FDOT BOX CULVERTS
℄ C-511 CANAL
TRANSITION ROAD SURFACE TO TOP L-511 LEVEE EL. 9.5
TRANSITION ROAD SURFACE TO TOP MAINTENANCE RD. EL. 10.0
INV. EL. -4.5
NORMAL CANAL BOTTOM EL. -2.5
EL. -2.5 BOTTOM SHEET PILE
SHEET PILE RETAINING WALL
SECTION
SCALE: A
40'
INV. EL. -4.5
1.5' THICK RIP RAP
1' THICK BEDDING
FDOT STANDARD PRECAST 12'X12' BOX CULVERT
GRAPHIC SCALES
0
40'
"A"
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
CENTRAL AND SOUTHERN FLORIDA PROJECT
FOR FLOOD CONTROL AND OTHER PURPOSES
BROWARD COUNTY WATER PRESERVE AREAS
PROJECT IMPLEMENTATION REPORT
C-11 IMPOUNDMENT
S-505E BRIDGE
S-9
PLATE NO.


TOE OF SLOPE
WEED BARRIER AND BOUY
A
S-10
RISER WITH VERTICAL SLIDE GATE
CONTROL BUILDING
C-11 IMPOUNDMENT NORMAL POOL EL. 10.3
CSA STEPS
℄ EMBANKMENT
STA. 168+77.00
C-511 CANAL BOTTOM EL. -2.5
MANHOLE
D-511 EMBANKMENT TOP EL. 14.5
S-508A GATED CULVERT
1 on 3
18' WIDE MAINTENANCE ROAD
C-511 CANAL BOTTOM EL. -2.5
MANHOLE
EL. -2.0
1 on 3
RIP RAP
L-511 LEVEE TOP EL. 11.0
1 on 3
PLAN
SCALE: A
℄ EMBANKMENT
D-511 EMBANKMENT
NORMAL POOL EL. 10.3
EL. 14.5
MANHOLE TOP EL. 8.8
C-511 CANAL BOTTOM EL. -3.0
CANAL STAGE EL. 6.0 - 6.5
MANHOLE TOP EL. 8.8
L-511 CONTAINMENT LEVEE
MITIGATION AREA A NORMAL WATER EL. 7.5
INVERT EL. -2.0
INVERT EL. -7.5
48" DIAMETER CULVERT
INVERT EL. -2.0
SECTION
SCALE: A
GRAPHIC SCALES
0
80'
"A"
US Army Corps of Engineers Jacksonville District
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
CENTRAL AND SOUTHERN FLORIDA PROJECT
FOR FLOOD CONTROL AND OTHER PURPOSES
BROWARD COUNTY WATER PRESERVE AREAS
PROJECT IMPLEMENTATION REPORT
C-11 IMPOUNDMENT
S-508A GATED CULVERT
PLATE NO.
S-10


1 on 3
EL. 9.5
℄ OF L-511 LEVEE
WEED BARRIER
GATED WEIR
60"
60" DIAMETER CULVERTS
MITIGATION AREA A
GRAVEL
C-511 CANAL STAGE EL. 4.0
A S-11
PLAN
SCALE: A
N
VERTICAL SLIDE GATE
L-511 LEVEE
EXISTING GROUND
MITIGATION AREA A WATER EL. 5.5
EL. 10.0
EL. 9.5
EL. 5.5
CANAL STAGE EL. 6.0 - 6.5
EL. -4.0
FLOW
EL. -6.0
EL. -3.0
60" DIAMETER CULVERTS
SECTION
SCALE: A
GRAPHIC SCALES
0
40'
"A"
US Army Corps of Engineers Jacksonville District
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
CENTRAL AND SOUTHERN FLORIDA PROJECT
FOR FLOOD CONTROL AND OTHER PURPOSES
BROWARD COUNTY WATER PRESERVE AREAS
PROJECT IMPLEMENTATION REPORT
C-51 IMPOUNDMENT
S-309B WEIR-GATE CULVERT
PLATE NO.
S-11

CULVERT	NORTHING	EASTING	INVERT ELEV
S-507A	638,037.73	842,621.60	-1.0
	637,965.74	842,622.86	-1.0
S-507B	638,037.86	842,922.19	-1.0
	637,965.87	842,923.22	-1.0
S-507C	638,042.52	843,223.04	-1.0
	637,970.54	843,223.30	-1.0
S-507D	638,043.10	843,522.44	-1.0
	637,971.10	843,522.97	-1.0
S-507E	638,048.37	843,822.08	-1.0
	637,976.38	843,823.24	-1.0
S-507F	638,053.77	844,122.07	-1.0
	637,981.78	844,123.15	-1.0





A
S-12
SECTION
SCALE: A

GRAPHIC SCALES
0 20'
"A"

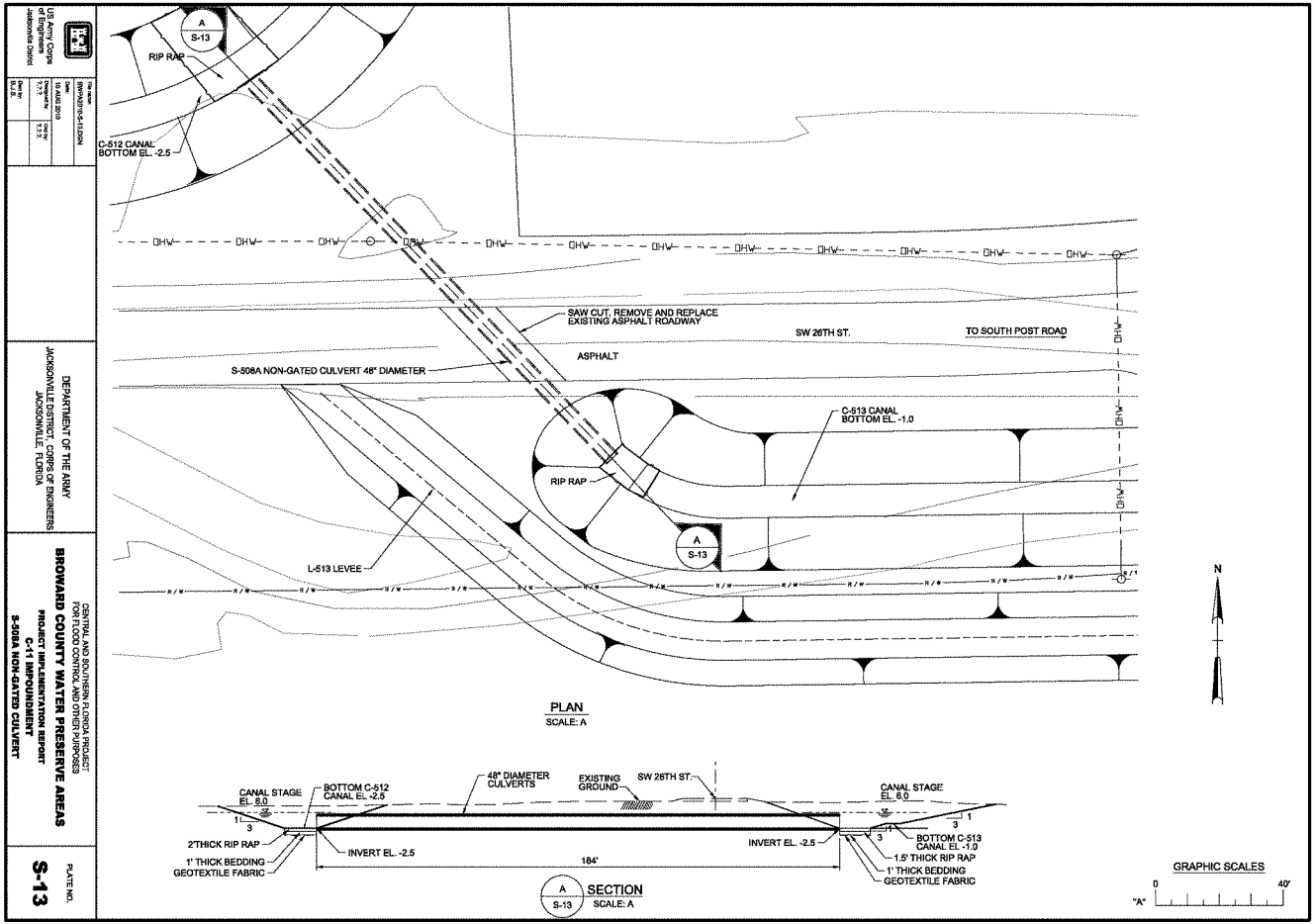
US Army Corps of Engineers Jacksonville District

File name: BWA3291a-S-12.DGN
Date: 12 AUG 2010
Time: 7:7:7
Dwn by: S.J.S.
Chk by: ? ? ?
Dsgn by: ? ? ?

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

CENTRAL AND SOUTHERN FLORIDA PROJECT
FOR FLOOD CONTROL AND OTHER PURPOSES
BROWARD COUNTY WATER PRESERVE AREAS
PROJECT IMPLEMENTATION REPORT
C-11 IMPOUNDMENT
S-507A-F NON-GATED CULVERTS

PLATE NO.
S-12



US Army Corps of Engineers
Jacksonville District

Date: 04 AUG 2003
Drawn by: T.T.T.
Checked by: T.T.T.
Dwg No: S-13
Dwg Nr: S.L.E.

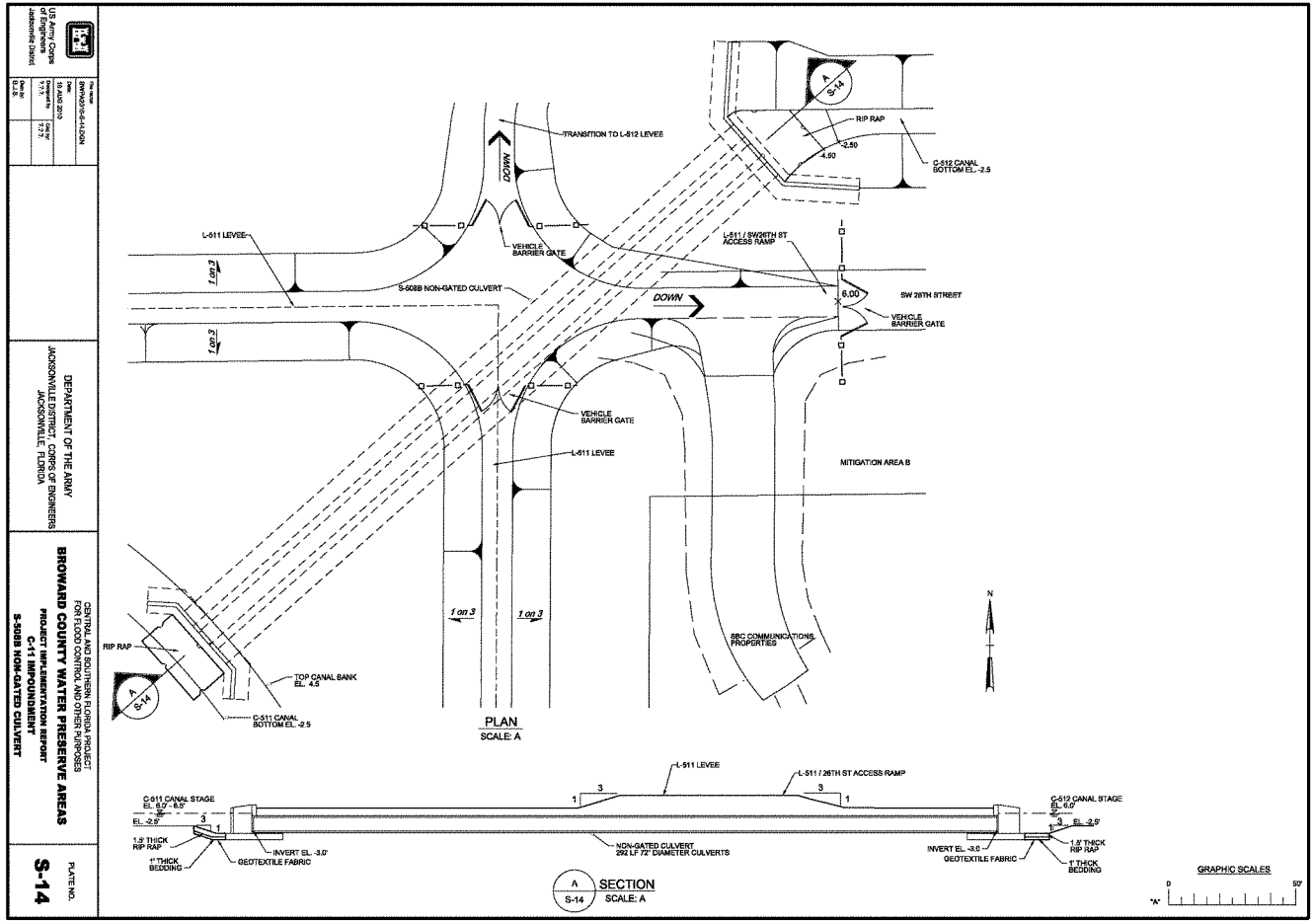
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

CENTRAL AND SOUTHERN FLORIDA PROJECT
FOR FLOOD CONTROL AND OTHER PURPOSES

BROWARD COUNTY WATER PRESERVE AREAS

PROJECT IMPLEMENTATION REPORT
C-11 IMPOUNDMENT
S-508A NON-GATED CULVERT

PLATE NO.
S-13



US Army Corps of Engineers
JACKSONVILLE DISTRICT

File name: BW1A3316-S-L-LDN
Date: 12 JUNE 2013
Drawn by: T.T.T.
Chkd by: T.T.T.
Dwn by: E.J.S.

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

CENTRAL AND SOUTHERN FLORIDA PROJECT
FOR FLOOD CONTROL AND OTHER PURPOSES

BROWARD COUNTY WATER PRESERVE AREAS

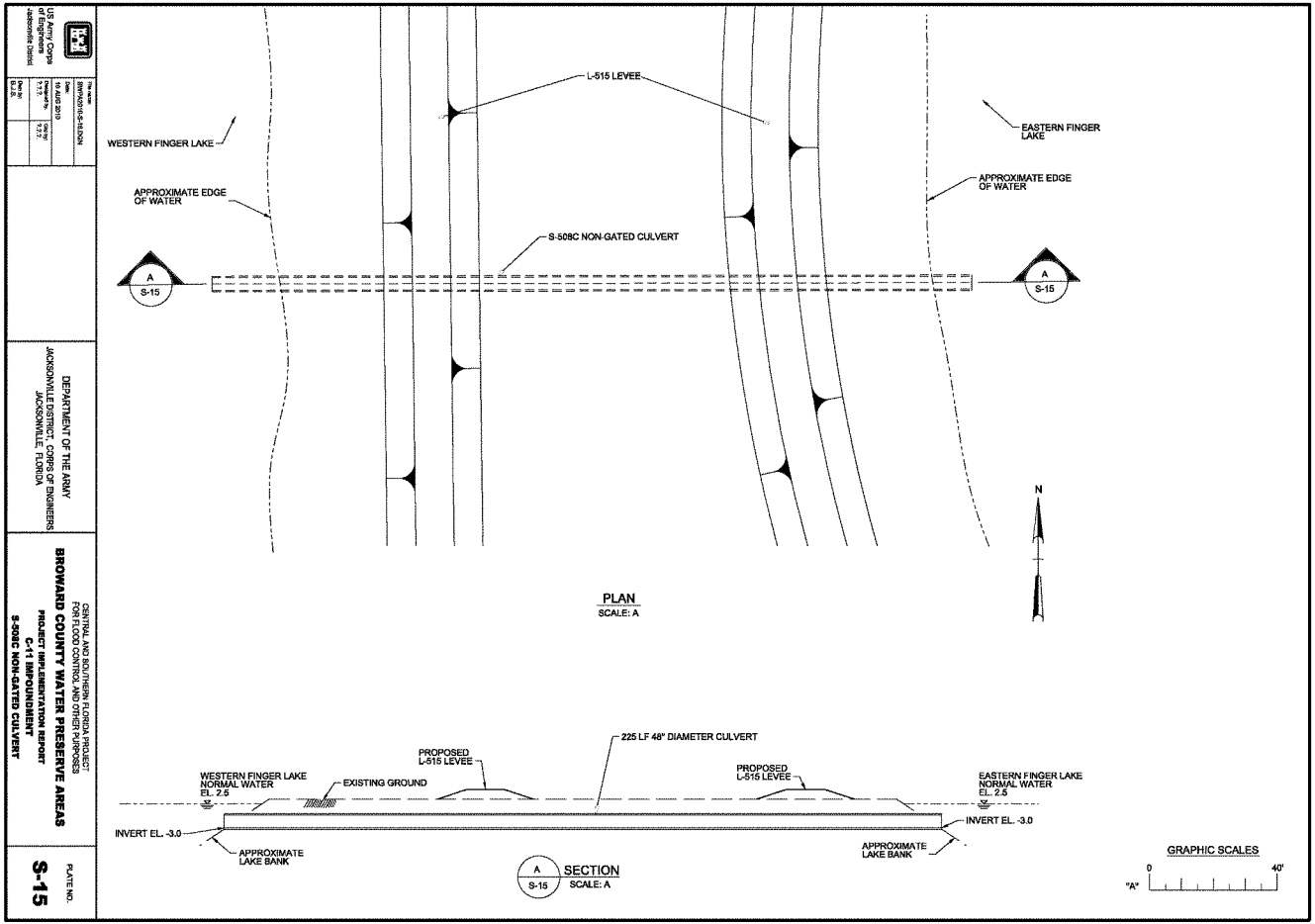
PROJECT IMPLEMENTATION REPORT

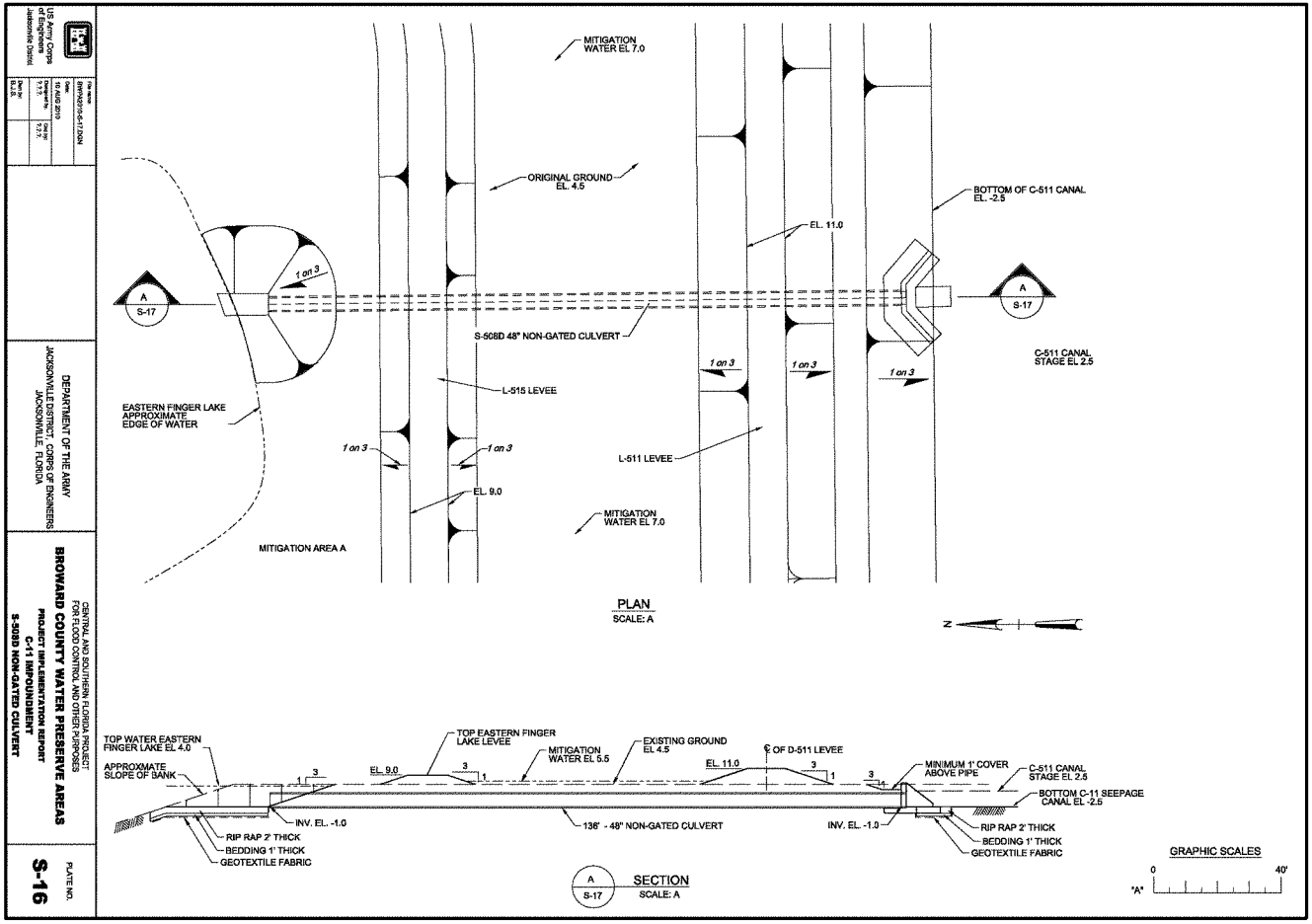
C-11 IMPOUNDMENT

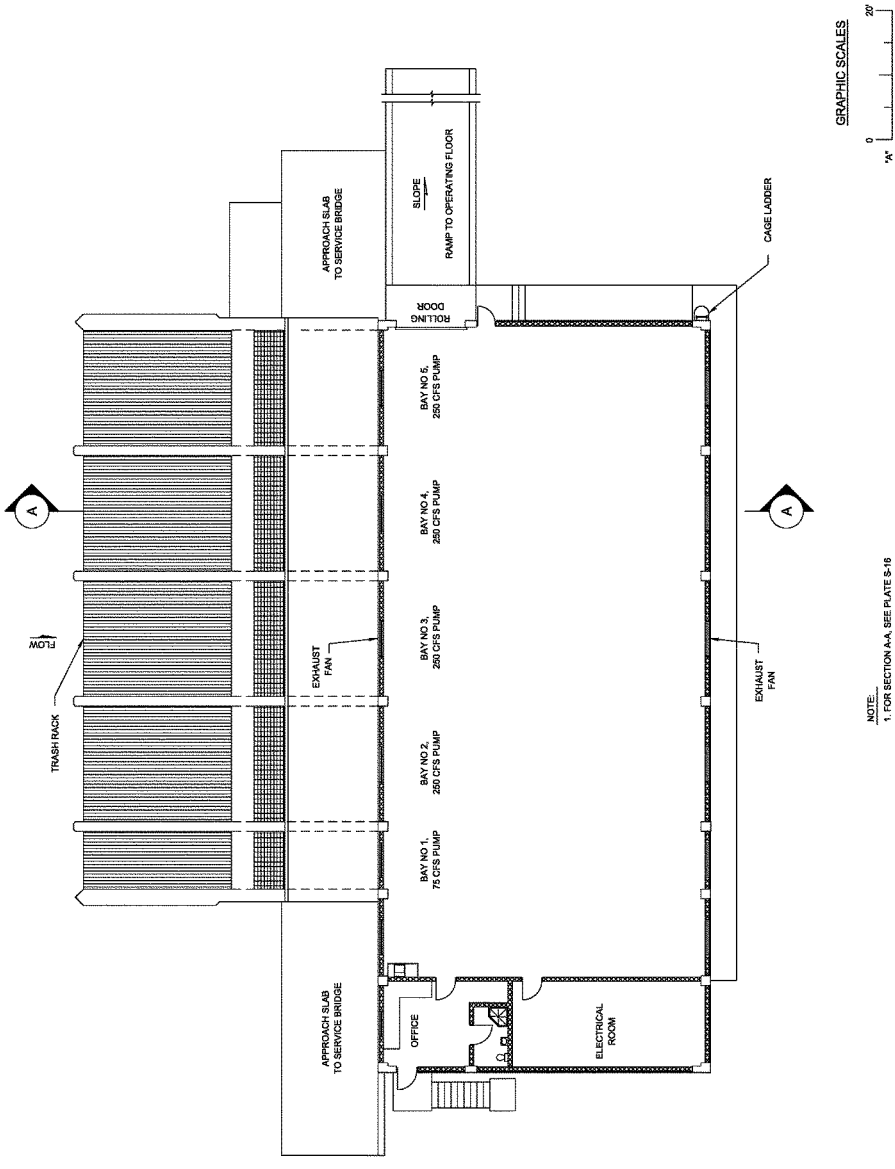
S-508B NON-GATED CULVERT

PLATE NO.

S-14


L-515 LEVEE
WESTERN FINGER LAKE
EASTERN FINGER LAKE
APPROXIMATE EDGE OF WATER
APPROXIMATE EDGE OF WATER
S-508C NON-GATED CULVERT
A
S-15
A
S-15
N
PLAN
SCALE: A
225 LF 48" DIAMETER CULVERT
PROPOSED L-515 LEVEE
PROPOSED L-515 LEVEE
WESTERN FINGER LAKE NORMAL WATER EL. 2.5
EXISTING GROUND
EASTERN FINGER LAKE NORMAL WATER EL. 2.5
INVERT EL. -3.0
INVERT EL. -3.0
APPROXIMATE LAKE BANK
APPROXIMATE LAKE BANK
A
S-15
SECTION
SCALE: A
GRAPHIC SCALES
0
40'
"A"
US Army Corps of Engineers
Jacksonville District
Date: 04-02-2013
Drawn by: T.T.T.
Checked by: T.T.T.
Chk'd by: T.T.T.
Date by: S.J.E.
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
CENTRAL AND SOUTHERN FLORIDA PROJECT
FOR FLOOD CONTROL AND OTHER PURPOSES
BROWARD COUNTY WATER PRESERVE AREAS
PROJECT IMPLEMENTATION REPORT
C-11 IMPOUNDMENT
S-508C NON-GATED CULVERT
PLATE NO.
S-15


MITIGATION WATER EL 7.0
ORIGINAL GROUND EL. 4.5
BOTTOM OF C-511 CANAL EL. -2.5
EL. 11.0
1 on 3
A S-17
S-508D 48" NON-GATED CULVERT
C-511 CANAL STAGE EL 2.5
L-515 LEVEE
EASTERN FINGER LAKE APPROXIMATE EDGE OF WATER
L-511 LEVEE
EL. 9.0
MITIGATION AREA A
PLAN
SCALE: A
N
TOP WATER EASTERN FINGER LAKE EL 4.0
APPROXIMATE SLOPE OF BANK
TOP EASTERN FINGER LAKE LEVEE
MITIGATION WATER EL 5.5
EXISTING GROUND EL 4.5
℄ OF D-511 LEVEE
MINIMUM 1' COVER ABOVE PIPE
C-511 CANAL STAGE EL 2.5
BOTTOM C-11 SEEPAGE CANAL EL -2.5
INV. EL. -1.0
RIP RAP 2' THICK
BEDDING 1' THICK
GEOTEXTILE FABRIC
136" - 48" NON-GATED CULVERT
SECTION
SCALE: A
GRAPHIC SCALES
0
40'
"A"
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
US Army Corps of Engineers Jacksonville District
CENTRAL AND SOUTHERN FLORIDA PROJECT
FOR FLOOD CONTROL AND OTHER PURPOSES
BROWARD COUNTY WATER PRESERVE AREAS
PROJECT IMPLEMENTATION REPORT
C-11 IMPOUNDMENT
S-508D NON-GATED CULVERT
PLATE NO.
S-16



US Army Corps of Engineers
Jacksonville District

File name: BWPA2010-S-17.DGN
Date: 16 AUG 2010
Designed by: ?.?.?.
Chd by: ?.?.?.
Dwn by: BJ.S.

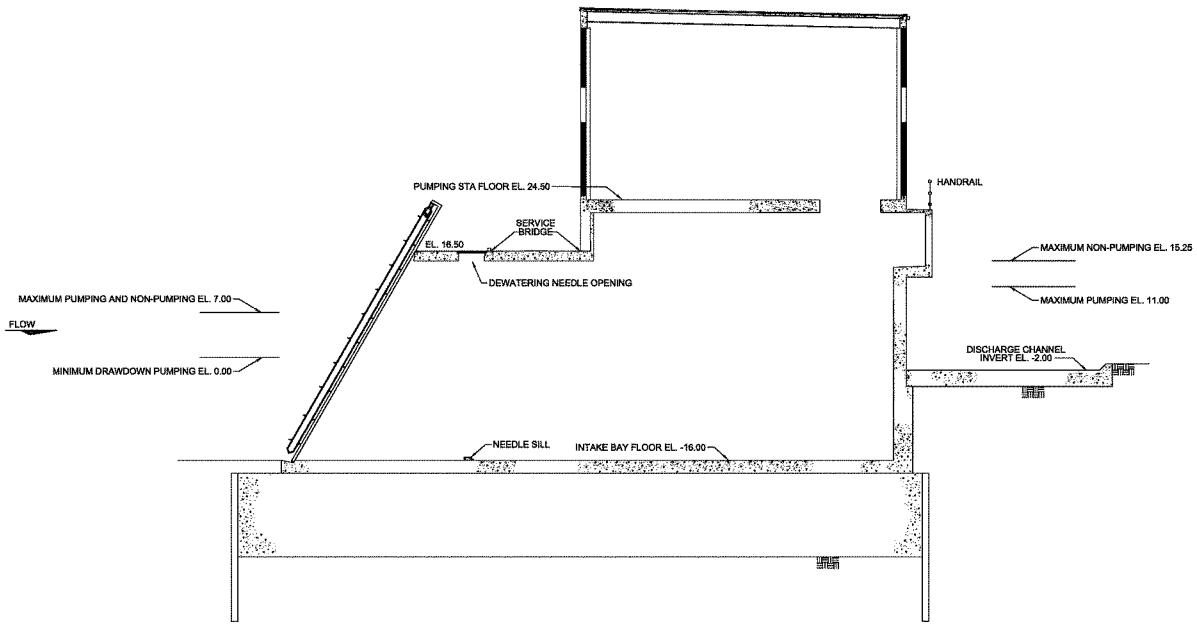
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

CENTRAL AND SOUTHERN FLORIDA PROJECT
FOR FLOOD CONTROL AND OTHER PURPOSES

BROWARD COUNTY WATER PRESERVE AREAS

PROJECT IMPLEMENTATION REPORT
C-9 IMPOUNDMENT
S-509 PUMP STATION (PLAN)

PLATE NO.
S-17



SECTION A-A
SCALE: A

NOTE:
1. FOR LOCATION OF SECTION A-A, SEE PLATE S-17

GRAPHIC SCALES
"A" 0 20'

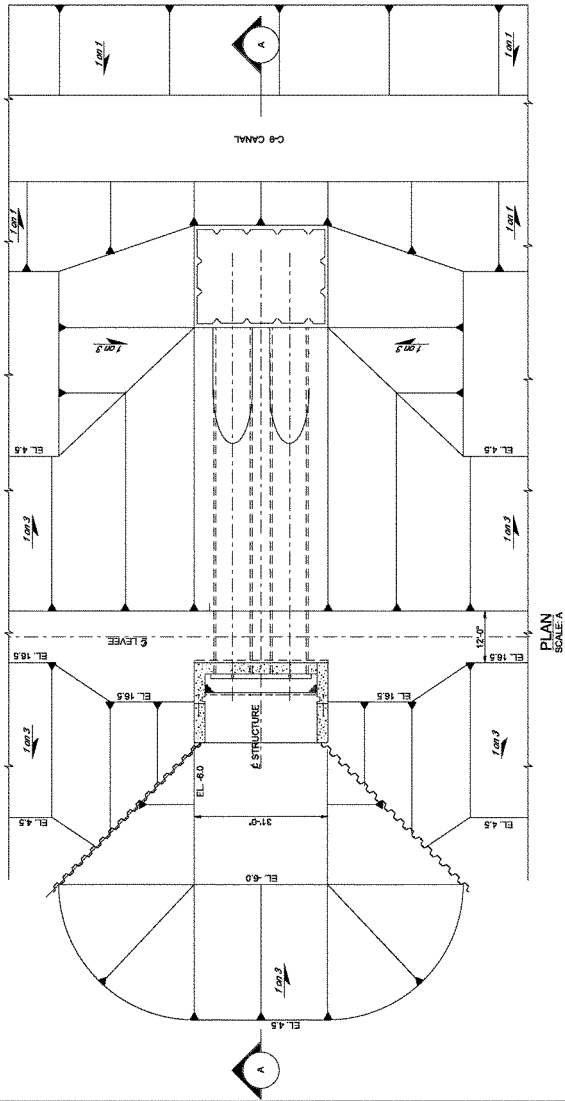
U.S. Army Corps of Engineers
Jacksonville District

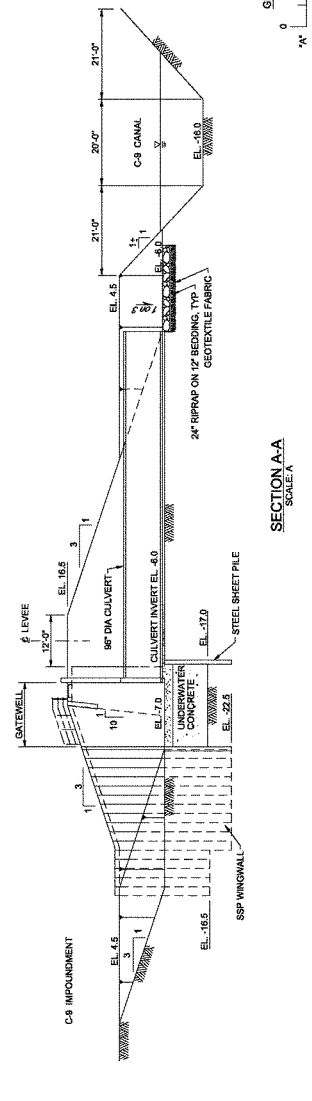
File name: BRPWQ015-S-18.dgn
Date: 17 AUG 2010
Designed by: T.T.T.
Drawn by: T.T.T.
Checked by: T.T.T.
Reviewed by: R.D.R.

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

CENTRAL AND SOUTHERN FLORIDA PROJECT
FOR FLOOD CONTROL AND OTHER PURPOSES
BROWARD COUNTY WATER PRESERVE AREAS
PROJECT IMPLEMENTATION REPORT
C-9 IMPOUNDMENT
S-509 PUMP STATION (SECTION)

PLATE NO.
S-18





US Army Corps of Engineers
Jacksonville District

File name: BWPA2010-S-19.DGN
Date: 17 AUG 2010
Designed by: T.T.T.
Det by: T.T.T.
Dwn by: B.J.S.

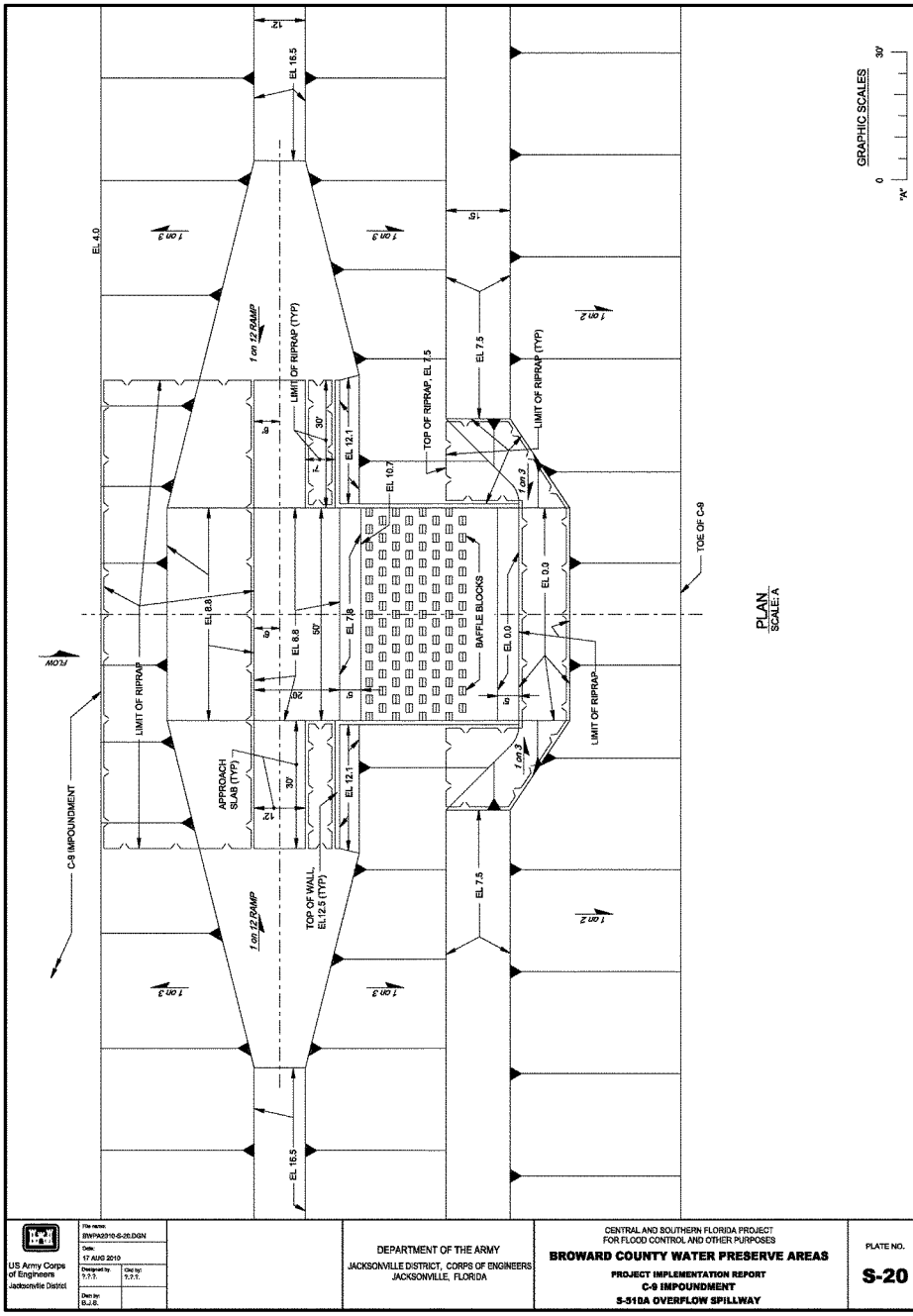
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

CENTRAL AND SOUTHERN FLORIDA PROJECT
FOR FLOOD CONTROL AND OTHER PURPOSES

BROWARD COUNTY WATER PRESERVE AREAS

PROJECT IMPLEMENTATION REPORT
C-9 IMPOUNDMENT
S-510 GATED CULVERT

PLATE NO.
S-19



US Army Corps of Engineers
Jacksonville District

File name: BWPA2010-S-20.DGN
Date: 17 AUG 2010
Designed by: ?.?.?.
Det by: ?.?.?.
Chkd by: B.J.B.

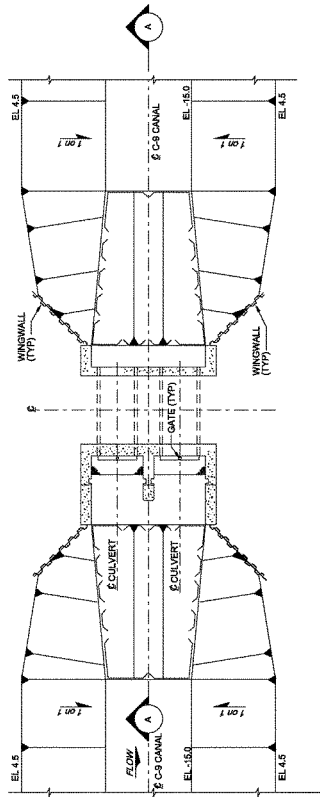
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

CENTRAL AND SOUTHERN FLORIDA PROJECT
FOR FLOOD CONTROL AND OTHER PURPOSES

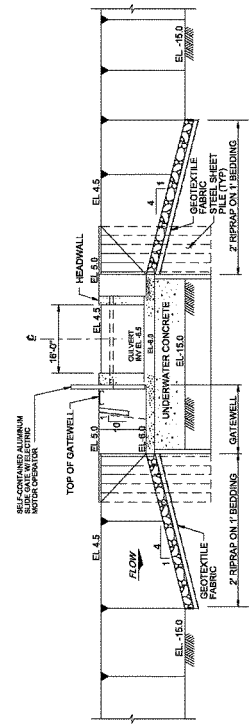
BROWARD COUNTY WATER PRESERVE AREAS

PROJECT IMPLEMENTATION REPORT
C-9 IMPOUNDMENT
S-510A OVERFLOW SPILLWAY

PLATE NO.
S-20



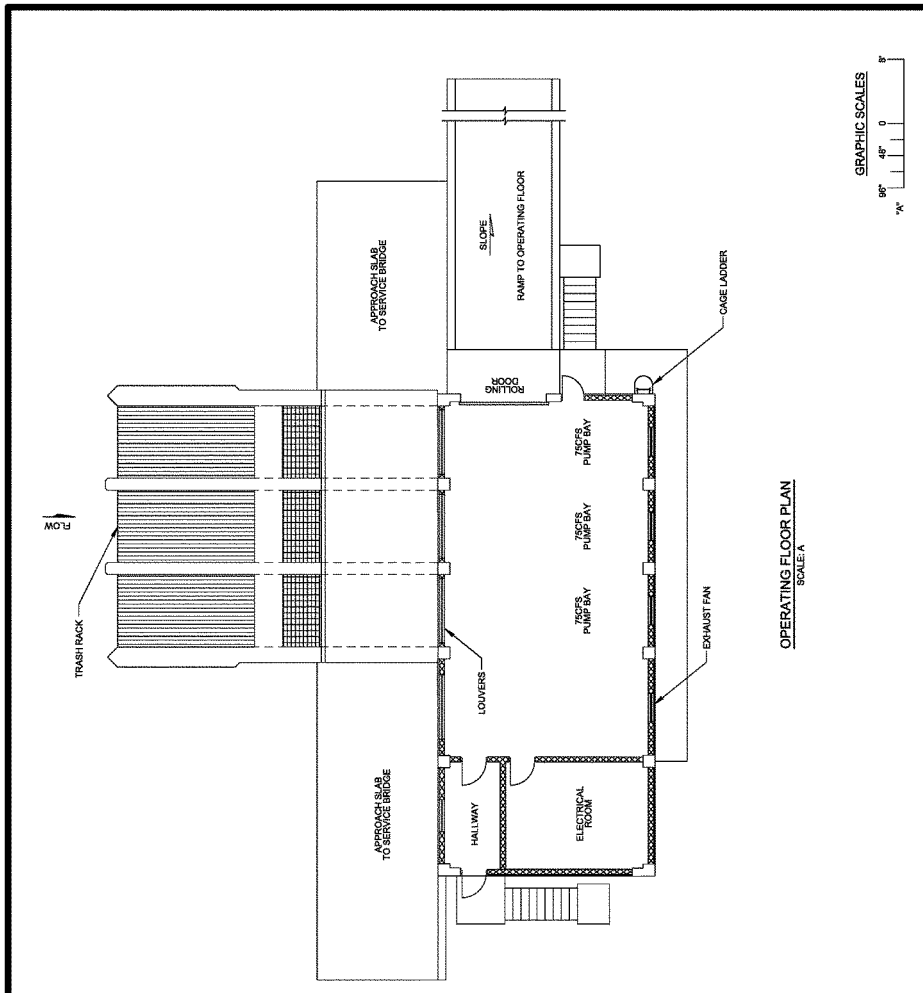
PLAN
SCALE: "A"



SECTION A-A
SCALE: "A"

GRAPHIC SCALES
0 30'
"A"

US Army Corps of Engineers Jacksonville District	File name: BWPA2010-S-21.DGN Date: 17 AUG 2010 Designed by: ?.?.? Checked by: ?.?.? Drawn by: B.J.S.	DEPARTMENT OF THE ARMY JACKSONVILLE DISTRICT, CORPS OF ENGINEERS JACKSONVILLE, FLORIDA	CENTRAL AND SOUTHERN FLORIDA PROJECT FOR FLOOD CONTROL AND OTHER PURPOSES **BROWARD COUNTY WATER PRESERVE AREAS** **PROJECT IMPLEMENTATION REPORT** **C-9 IMPOUNDMENT** **S-511 GATED CULVERTS**	PLATE NO. **S-21**



US Army Corps of Engineers
Jacksonville District

File name: BWPA2010-S-22.DGN
Date: 17 AUG 2010
Designed by: ?.?.?.
Chd by: ?.?.?.
Dwn by: B.J.S.

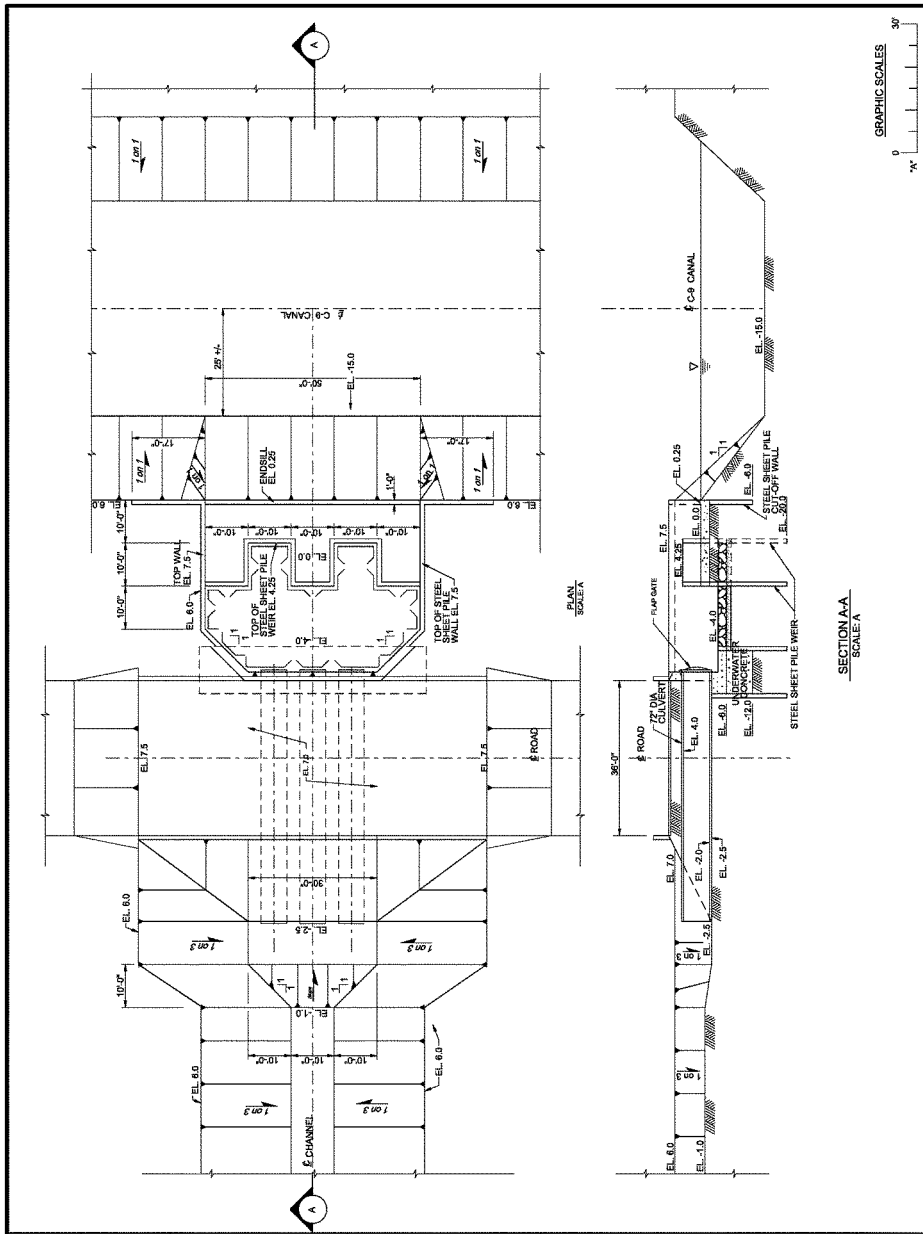
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

CENTRAL AND SOUTHERN FLORIDA PROJECT
FOR FLOOD CONTROL AND OTHER PURPOSES

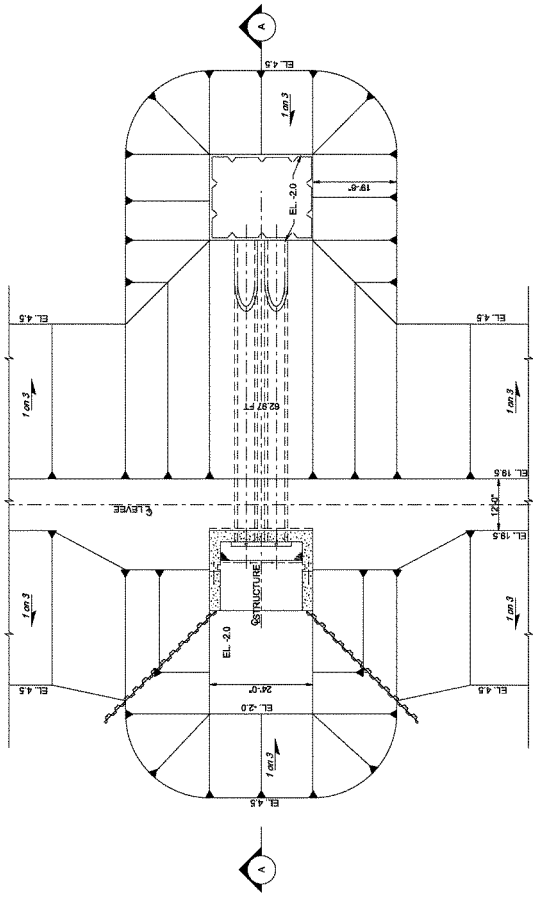
BROWARD COUNTY WATER PRESERVE AREAS

PROJECT IMPLEMENTATION REPORT
C-9 IMPOUNDMENT
S-512A SEEPAGE PUMP STATION (PLAN)

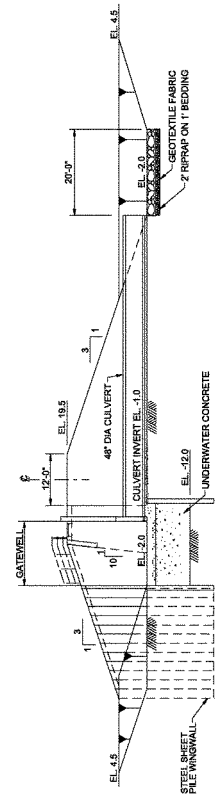
PLATE NO.
S-22



US Army Corps of Engineers Jacksonville District	File name: SWPA2010-S-23.DGN Date: 17 AUG 2010 Designed by: T.T.T. Drawn by: T.T.T. Chk by: T.T.T. Ver by: S.J.S.	DEPARTMENT OF THE ARMY JACKSONVILLE DISTRICT, CORPS OF ENGINEERS JACKSONVILLE, FLORIDA	CENTRAL AND SOUTHERN FLORIDA PROJECT FOR FLOOD CONTROL AND OTHER PURPOSES **BROWARD COUNTY WATER PRESERVE AREAS** **PROJECT IMPLEMENTATION REPORT** **C-9 IMPOUNDMENT** **S-512B AND S-512C GATED (FLAP) CULVERTS AND WEIR**
			PLATE NO. **S-23**



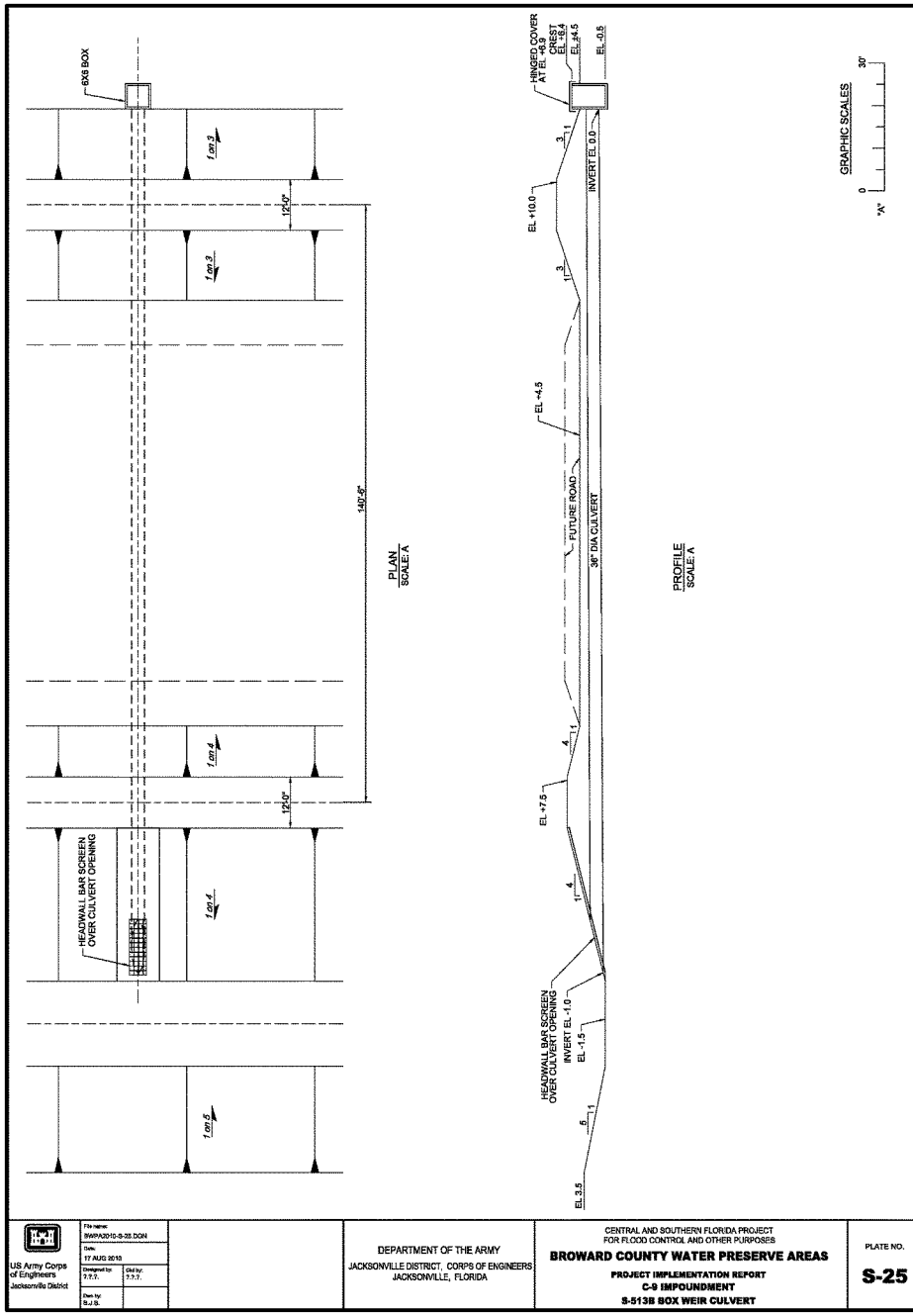
PLAN
SCALE: A



SECTION A-A
SCALE: A

GRAPHIC SCALES
0 30'
"A"

US Army Corps of Engineers Jacksonville District	File name: BWPA2010-S-24.DGN Date: 17 AUG 2010 Designed by: ?.?.?. Date by: ?.?.?. Drawn by: B.J.B.	DEPARTMENT OF THE ARMY JACKSONVILLE DISTRICT, CORPS OF ENGINEERS JACKSONVILLE, FLORIDA	CENTRAL AND SOUTHERN FLORIDA PROJECT FOR FLOOD CONTROL AND OTHER PURPOSES **BROWARD COUNTY WATER PRESERVE AREAS** **PROJECT IMPLEMENTATION REPORT** **C-9 IMPOUNDMENT** **S-513A GATED CULVERTS**	PLATE NO. **S-24**



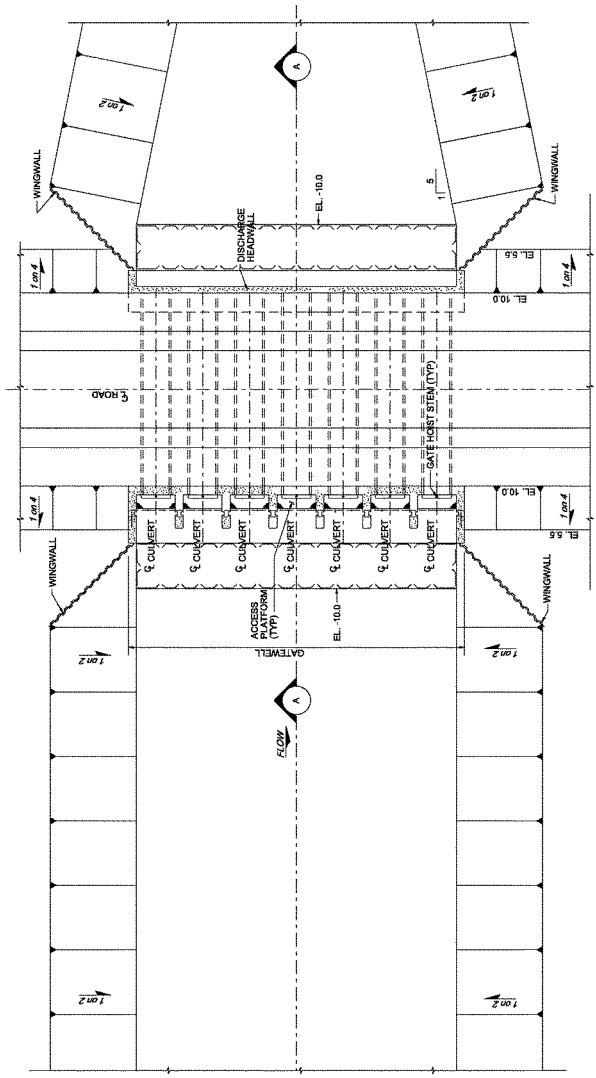
US Army Corps of Engineers
Jacksonville District

File name: BWPA2010-S-25.DGN
Date: 17 AUG 2010
Designed by: ?.?.?.
Chk by: ?.?.?.
Dwn by: S.J.S.

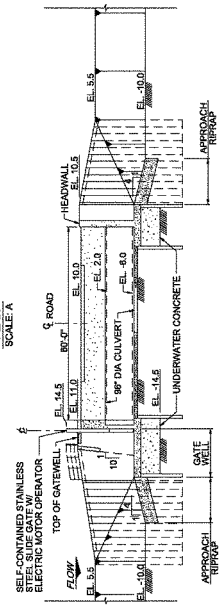
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

CENTRAL AND SOUTHERN FLORIDA PROJECT
FOR FLOOD CONTROL AND OTHER PURPOSES
BROWARD COUNTY WATER PRESERVE AREAS
PROJECT IMPLEMENTATION REPORT
C-9 IMPOUNDMENT
S-513B BOX WEIR CULVERT

PLATE NO.
S-25

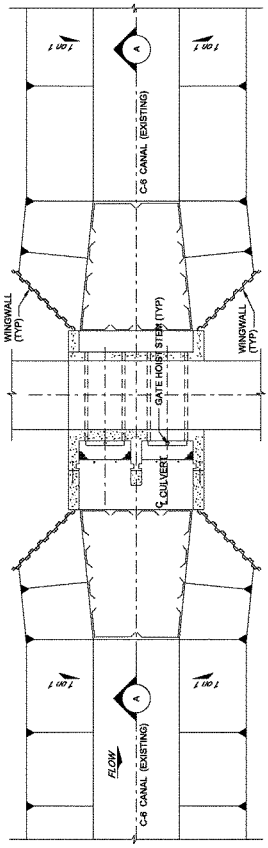


PLAN
SCALE: A

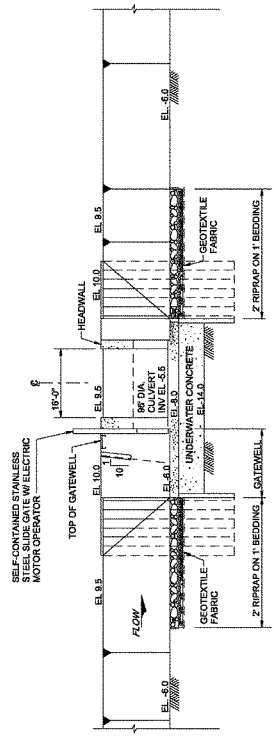


SECTION A-A
SCALE: A

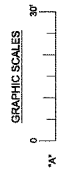
US Army Corps of Engineers Jacksonville District	File name: BWPA2010-S-26.DGN Date: 18 AUG 2010 Designed by: T.T.T. Date by: T.T.T. Dwn by: B.J.S.	DEPARTMENT OF THE ARMY JACKSONVILLE DISTRICT, CORPS OF ENGINEERS JACKSONVILLE, FLORIDA	CENTRAL AND SOUTHERN FLORIDA PROJECT FOR FLOOD CONTROL AND OTHER PURPOSES **BROWARD COUNTY WATER PRESERVE AREAS** **PROJECT IMPLEMENTATION REPORT** **3A AND 3B SEEPAGE MANAGEMENT AREAS** **S-502B GATED CULVERTS**
			PLATE NO. **S-26**



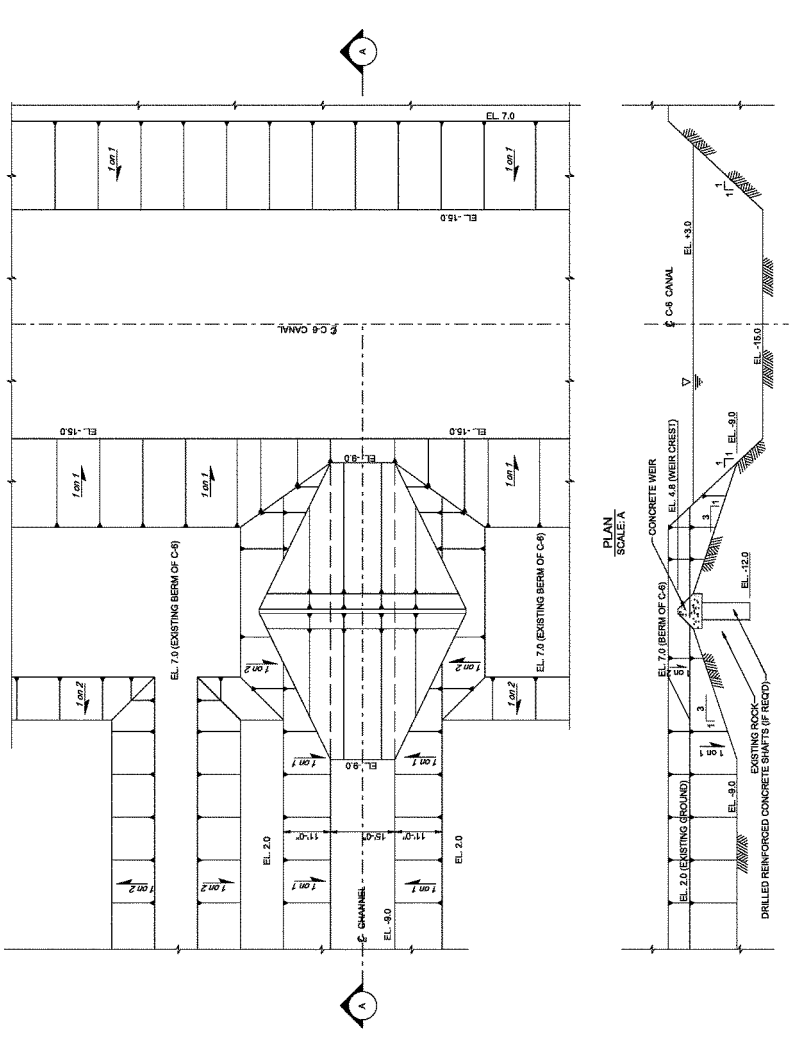
PLAN
SCALE: A



SECTION A-A
SCALE: A



US Army Corps of Engineers Jacksonville District	File name: BWPA3310-S-27.DGN Date: 18 AUG 2010 Designed by: ?.?.? Det by: ?.?.? Dwn by: B.J.S.	DEPARTMENT OF THE ARMY JACKSONVILLE DISTRICT, CORPS OF ENGINEERS JACKSONVILLE, FLORIDA	CENTRAL AND SOUTHERN FLORIDA PROJECT FOR FLOOD CONTROL AND OTHER PURPOSES **BROWARD COUNTY WATER PRESERVE AREAS** **PROJECT IMPLEMENTATION REPORT** **3A AND 3B SEEPAGE MANAGEMENT AREAS** **S-515 GATED CULVERTS**	PLATE NO. **S-27**



US Army Corps of Engineers
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File name: BWPA2010-S-28.DGN
Date: 16 AUG 2010
Designed by: ?.?.?. Dwn by: B.J.G.
Ckd by: ?.?.?.

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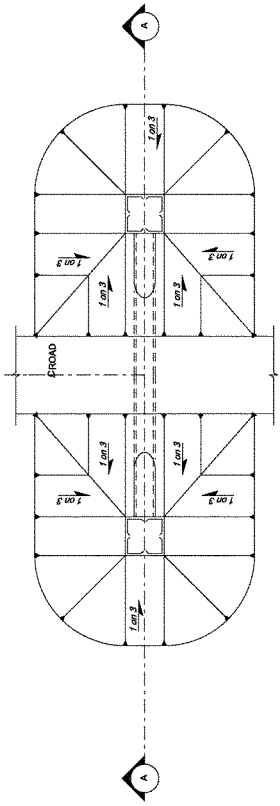
CENTRAL AND SOUTHERN FLORIDA PROJECT
FOR FLOOD CONTROL AND OTHER PURPOSES

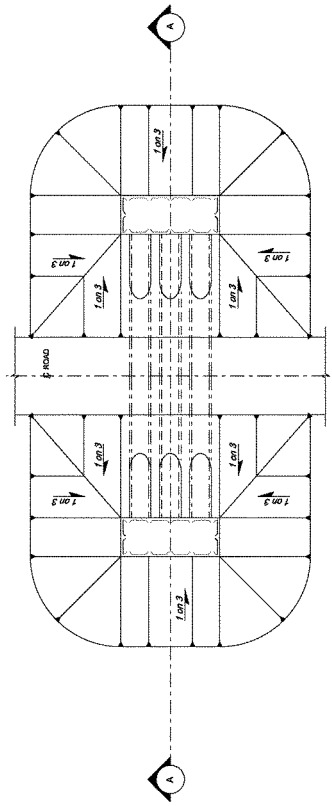
BROWARD COUNTY WATER PRESERVE AREAS

PROJECT IMPLEMENTATION REPORT
3A AND 3B SEEPAGE MANAGEMENT AREAS
S-516A AND S-516B TRIANGULAR WEIRS

PLATE NO.
S-28



PLAN - FPL 1-4, 7-19
SCALE: A



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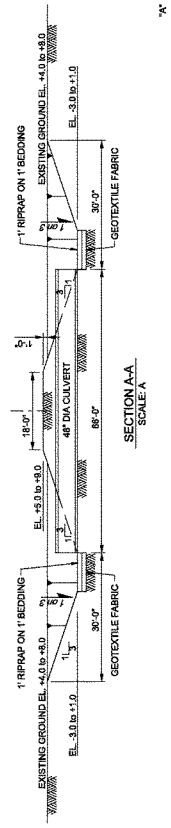

SECTION A-A
SCALE: A

GRAPHIC SCALES
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US Army Corps of Engineers
Jacksonville District

File name: BWPA3010-S-29.DGN
Date: 18 AUG 2010
Designed by: ?.?.?.
Det by: ?.?.?.
Dwn by: B.J.S.

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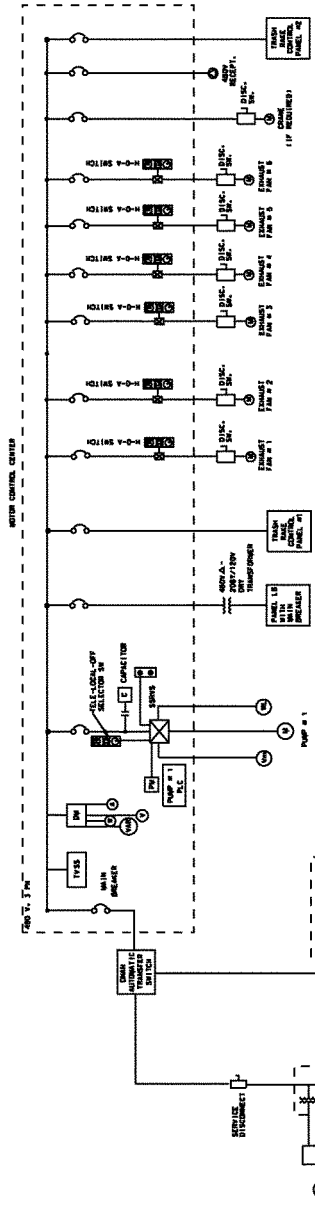
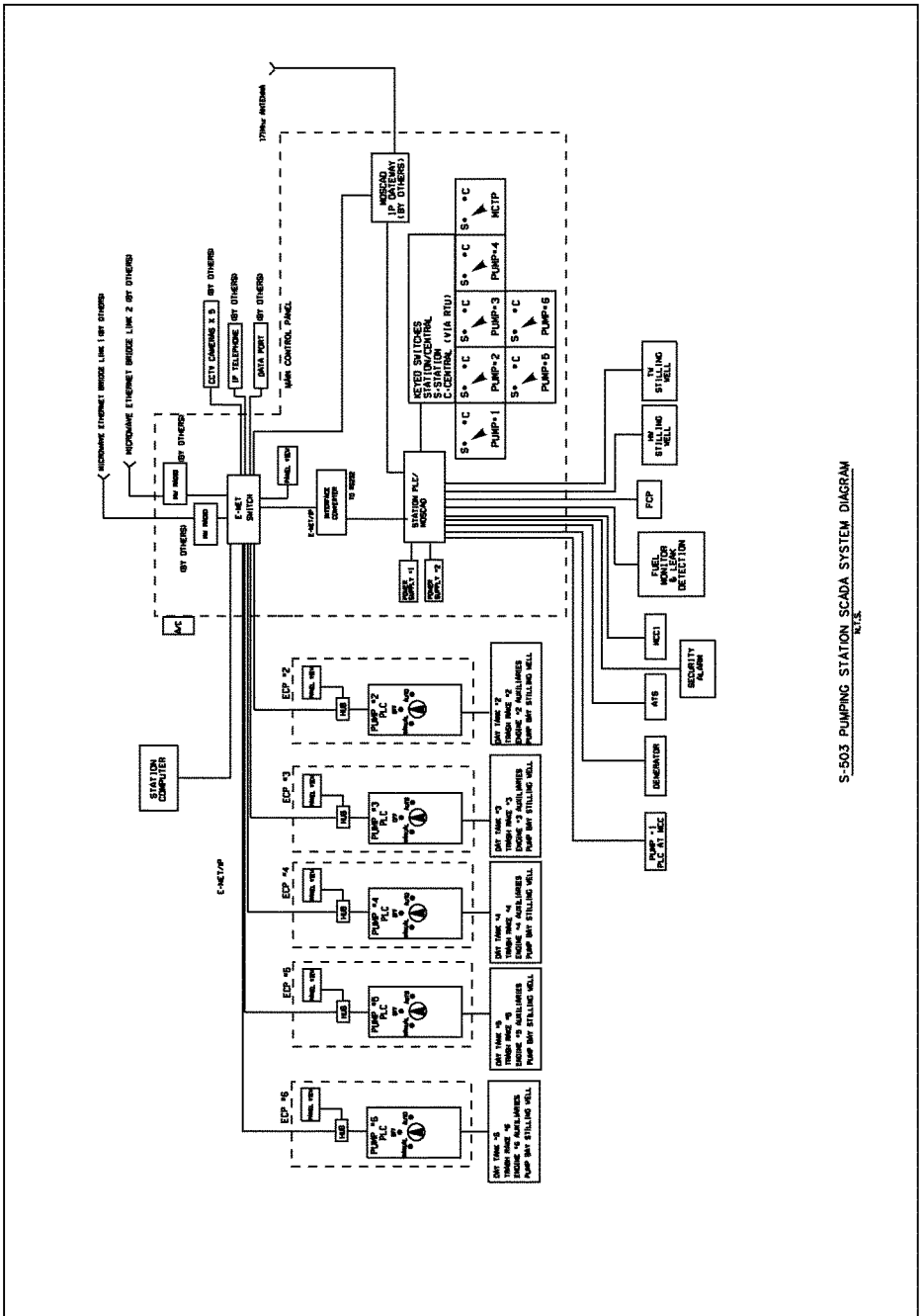
CENTRAL AND SOUTHERN FLORIDA PROJECT
FOR FLOOD CONTROL AND OTHER PURPOSES
BROWARD COUNTY WATER PRESERVE AREAS
PROJECT IMPLEMENTATION REPORT
3A AND 3B SEEPAGE MANAGEMENT AREAS
FPL 01-19

PLATE NO.
S-29

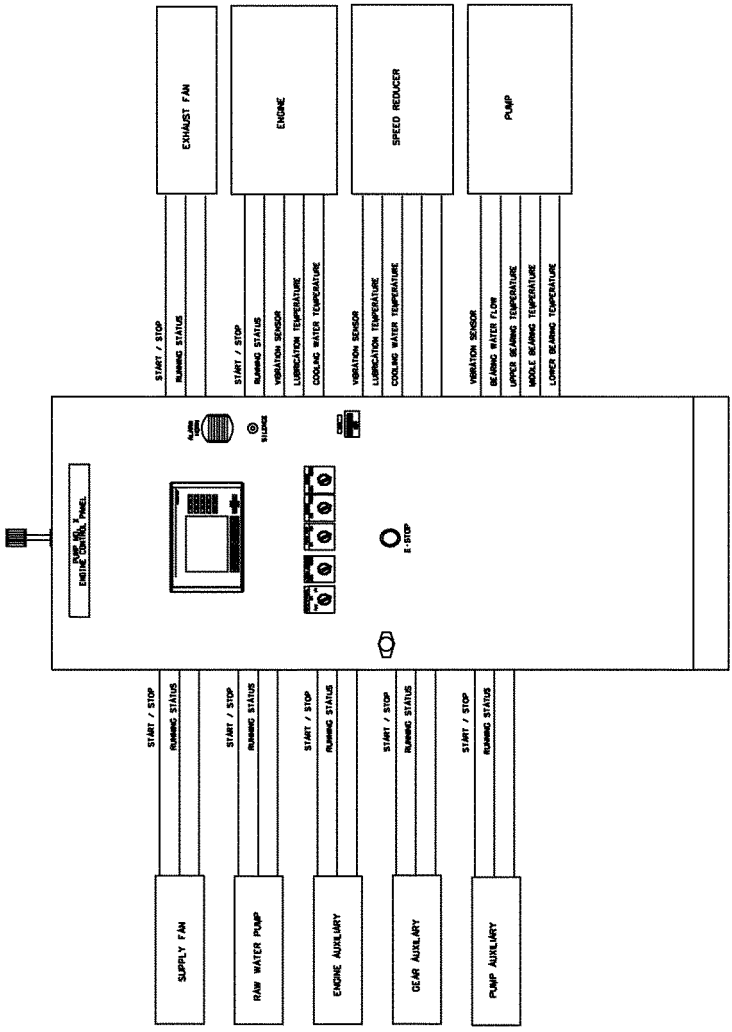


S-503 PUMPING STATION SINGLE LINE DIAGRAM
N.T.S.

US Army Corps of Engineers Jacksonville District	DEPARTMENT OF THE ARMY JACKSONVILLE DISTRICT, CORPS OF ENGINEERS JACKSONVILLE, FLORIDA	CENTRAL AND SOUTHERN FLORIDA PROJECT BROWARD COUNTY WATER PRESERVE AREAS PROJECT IMPLEMENTATION REPORT ELECTRICAL S-503 PUMPING STATION SINGLE LINE DIAGRAM	PLATE E-1



US Army Corps of Engineers Jacksonville District	DEPARTMENT OF THE ARMY JACKSONVILLE DISTRICT, CORPS OF ENGINEERS JACKSONVILLE, FLORIDA	CENTRAL AND SOUTHERN FLORIDA PROJECT BROWARD COUNTY WATER PRESERVE AREAS PROJECT IMPLEMENTATION REPORT ELECTRICAL S-503 PUMPING STATION SCADA SYSTEM DIAGRAM	PLATE E-2



PUMPING STATION S-503 ENGINE CONTROL PANEL (TYP. 1 OF 5)
N.T.S.

US Army Corps of Engineers
Jacksonville District

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JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
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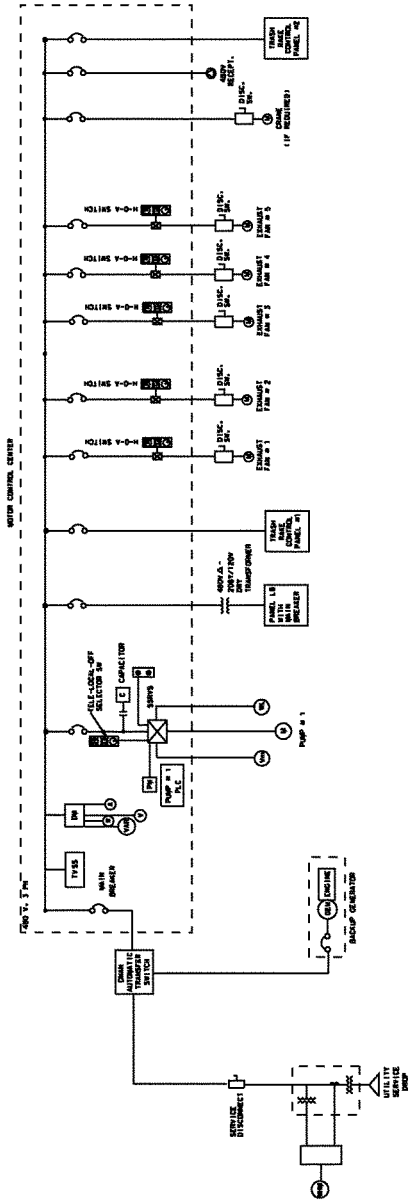
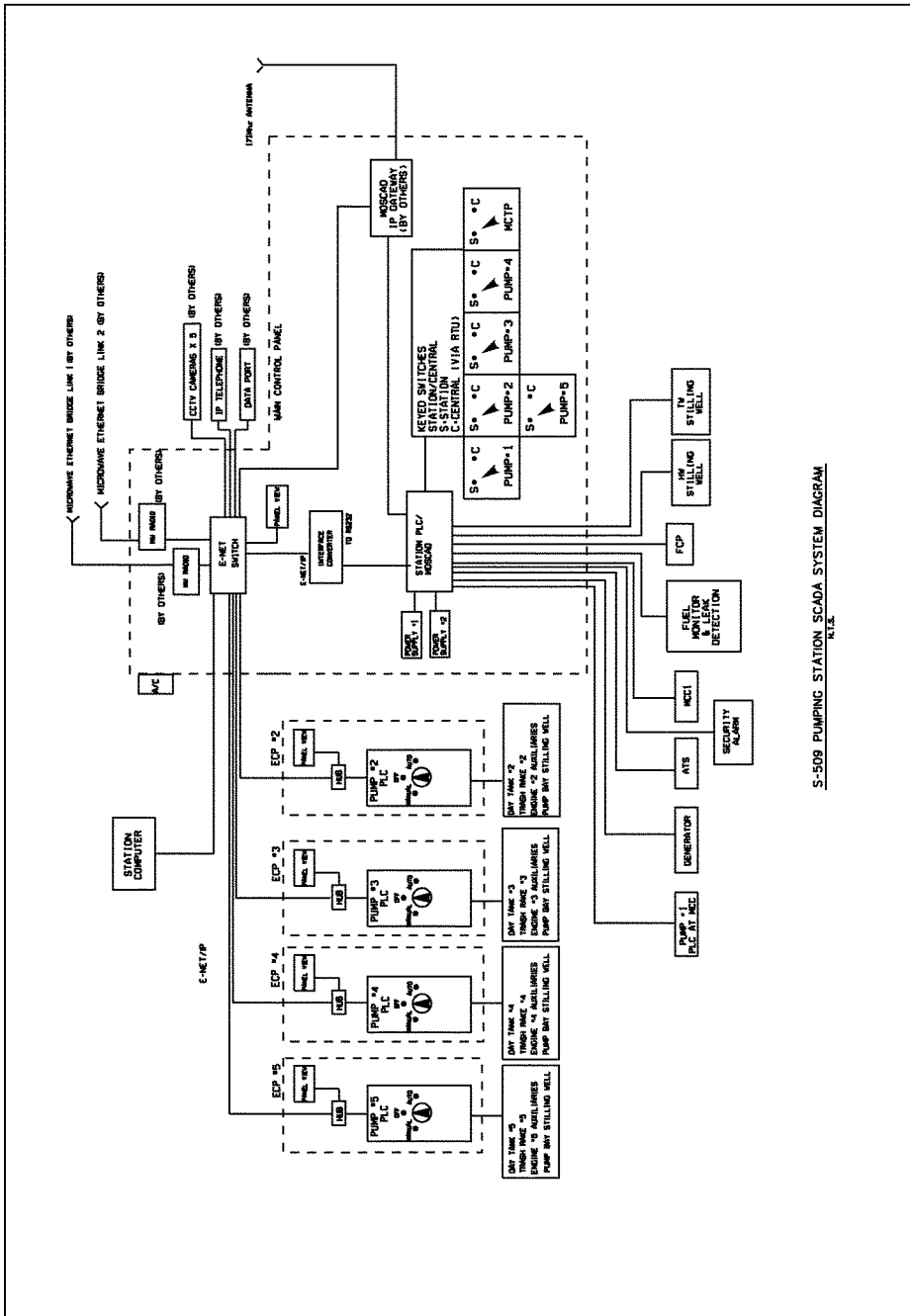
CENTRAL AND SOUTHERN FLORIDA PROJECT
BROWARD COUNTY WATER PRESERVE AREAS
PROJECT IMPLEMENTATION REPORT
ELECTRICAL
PUMPING STATION S-503 ENGINE CONTROL PANEL

PLATE
E-3

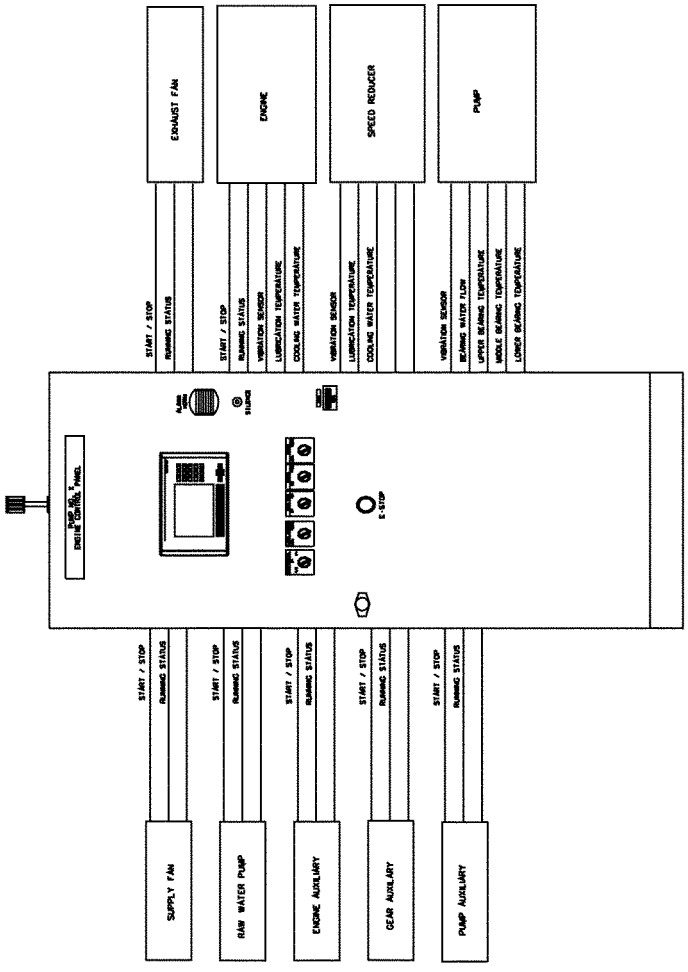


S-509 PUMPING STATION SINGLE LINE DIAGRAM
N.T.S.

US Army Corps of Engineers Jacksonville District	DEPARTMENT OF THE ARMY JACKSONVILLE DISTRICT, CORPS OF ENGINEERS JACKSONVILLE, FLORIDA	CENTRAL AND SOUTHERN FLORIDA PROJECT BROWARD COUNTY WATER PRESERVE AREAS PROJECT IMPLEMENTATION REPORT ELECTRICAL S-509 PUMPING STATION SINGLE LINE DIAGRAM	PLATE E-4



US Army Corps of Engineers Jacksonville District	DEPARTMENT OF THE ARMY JACKSONVILLE DISTRICT, CORPS OF ENGINEERS JACKSONVILLE, FLORIDA	CENTRAL AND SOUTHERN FLORIDA PROJECT BROWARD COUNTY WATER PRESERVE AREAS PROJECT IMPLEMENTATION REPORT ELECTRICAL S-509 PUMPING STATION SCADA SYSTEM DIAGRAM	PLATE E-5



PUMPING STATION S-509 ENGINE CONTROL PANEL (TYP. 1 OF 4)
N.T.S.

US Army Corps of Engineers
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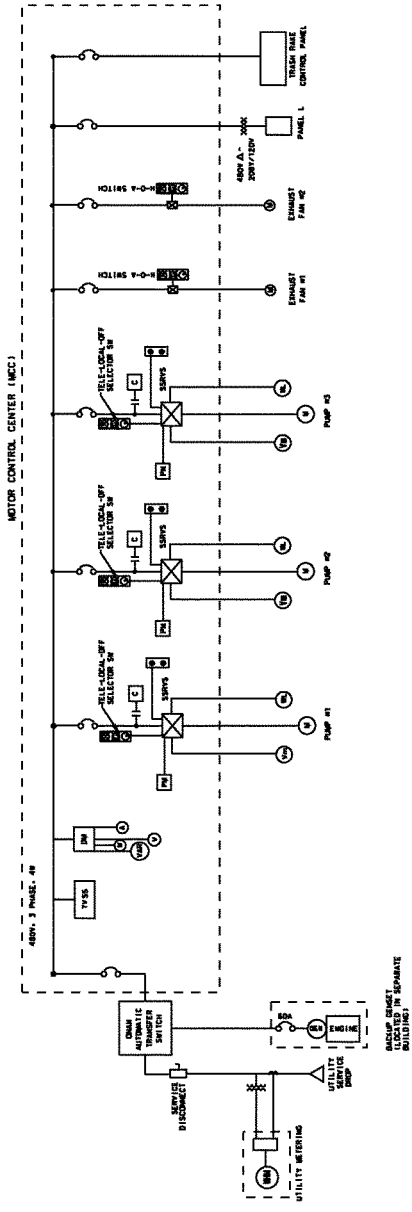
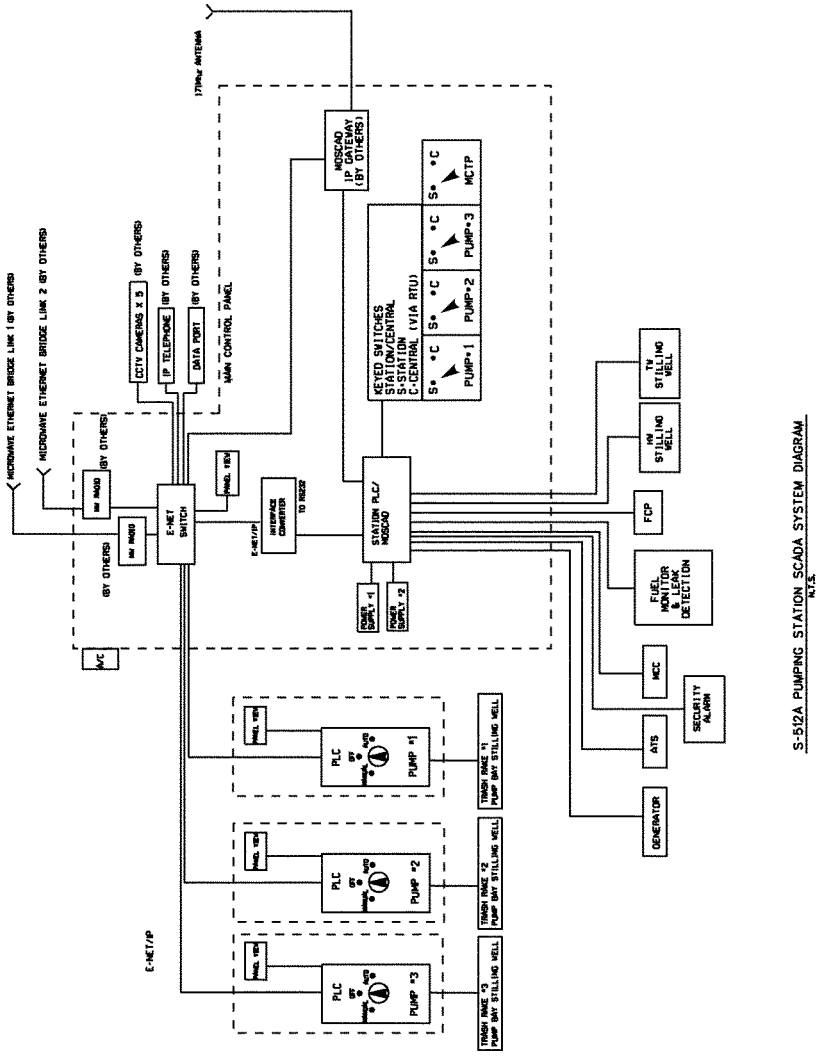
CENTRAL AND SOUTHERN FLORIDA PROJECT
BROWARD COUNTY WATER PRESERVE AREAS
PROJECT IMPLEMENTATION REPORT
ELECTRICAL
PUMPING STATION S-509 ENGINE CONTROL PANEL

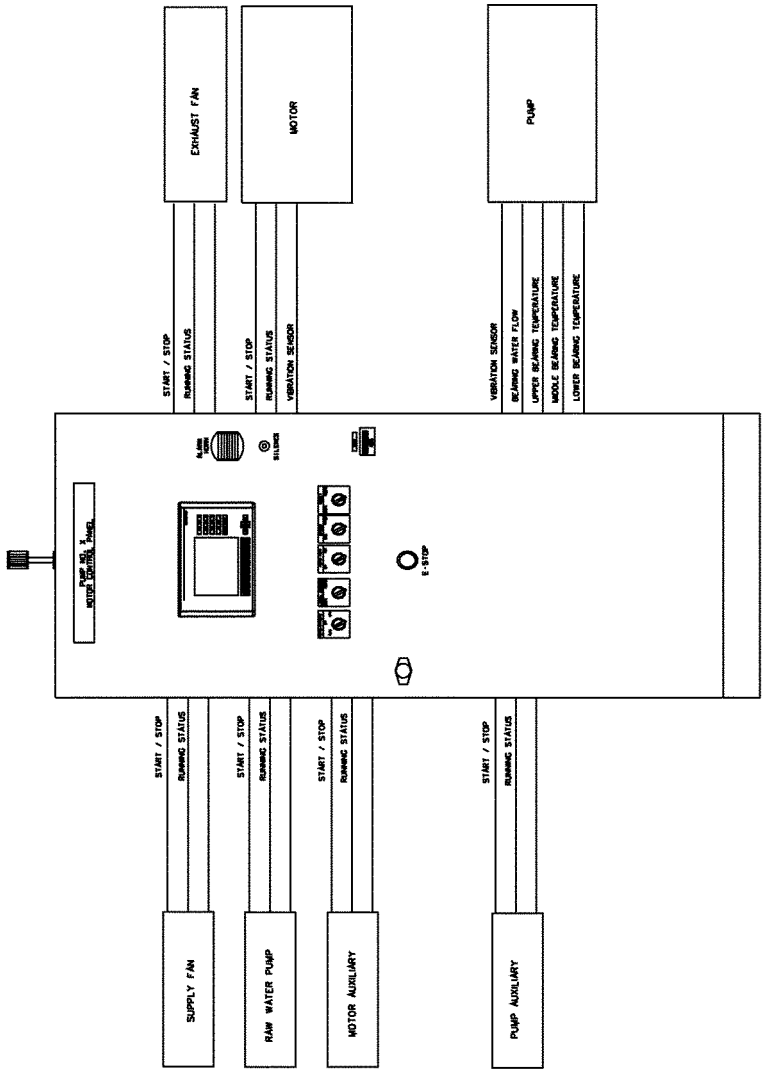
PLATE
E-6



US Army Corps of Engineers Jacksonville District	DEPARTMENT OF THE ARMY JACKSONVILLE DISTRICT, CORPS OF ENGINEERS JACKSONVILLE, FLORIDA	CENTRAL AND SOUTHERN FLORIDA PROJECT BROWARD COUNTY WATER PRESERVE AREAS PROJECT IMPLEMENTATION REPORT ELECTRICAL S-512A PUMPING STATION SINGLE LINE DIAGRAM	PLATE E-7

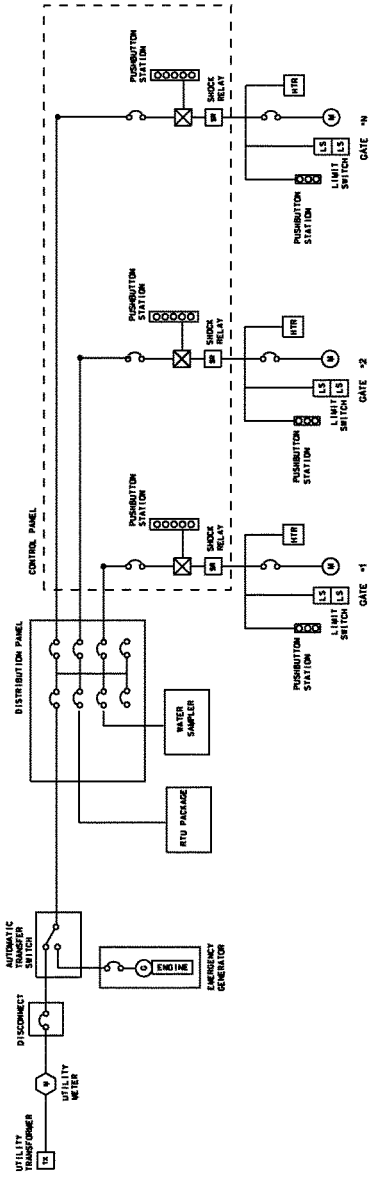


US Army Corps of Engineers Jacksonville District	DEPARTMENT OF THE ARMY JACKSONVILLE DISTRICT, CORPS OF ENGINEERS JACKSONVILLE, FLORIDA	CENTRAL AND SOUTHERN FLORIDA PROJECT BROWARD COUNTY WATER PRESERVE AREAS PROJECT IMPLEMENTATION REPORT ELECTRICAL S-512A PUMPING STATION SCADA SYSTEM DIAGRAM	PLATE E-8



PUMPING STATION S-512A MOTOR CONTROL PANEL (TYP. 1 OF 3)
N.T.S.

US Army Corps of Engineers Jacksonville District	DEPARTMENT OF THE ARMY JACKSONVILLE DISTRICT, CORPS OF ENGINEERS JACKSONVILLE, FLORIDA	CENTRAL AND SOUTHERN FLORIDA PROJECT BROWARD COUNTY WATER PRESERVE AREAS PROJECT IMPLEMENTATION REPORT ELECTRICAL PUMPING STATION S-512A MOTOR CONTROL PANEL	PLATE E-9



VERTICAL LIFT GATE SINGLE LINE DIAGRAM
N.T.S.

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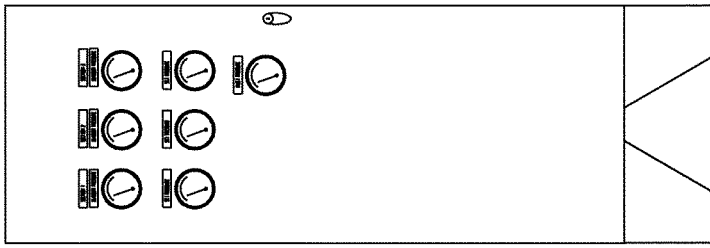
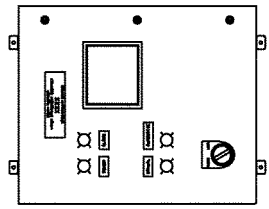


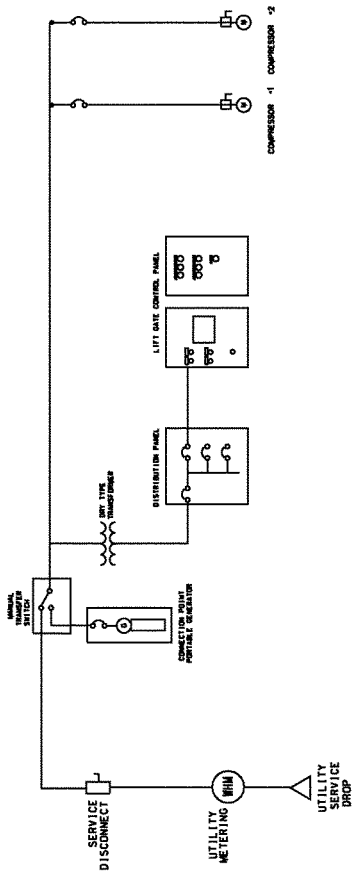
BLADDER PRESSURE CONTROL CABINET



PLC CONTROL CABINET

PNEUMATIC LIFT GATE CONTROL PANEL (TYP.)
N.T.S.

US Army Corps of Engineers Jacksonville District	DEPARTMENT OF THE ARMY JACKSONVILLE DISTRICT, CORPS OF ENGINEERS JACKSONVILLE, FLORIDA	CENTRAL AND SOUTHERN FLORIDA PROJECT BROWARD COUNTY WATER PRESERVE AREAS PROJECT IMPLEMENTATION REPORT ELECTRICAL PNEUMATIC LIFT GATE CONTROL PANEL	PLATE E-11



PNEUMATIC LIFT GATE SINGLE LINE DIAGRAM
N.T.S.

US Army Corps of Engineers Jacksonville District	DEPARTMENT OF THE ARMY JACKSONVILLE DISTRICT, CORPS OF ENGINEERS JACKSONVILLE, FLORIDA	CENTRAL AND SOUTHERN FLORIDA PROJECT BROWARD COUNTY WATER PRESERVE AREAS PROJECT IMPLEMENTATION REPORT ELECTRICAL PNEUMATIC LIFT GATE SINGLE LINE DIAGRAM	PLATE E-12

HYDROLOGY

A.14 HYDROLOGIC MODELING

Due to the vast amount of information available regarding hydrologic modeling, only the essential information was explicitly included in the appendix.

For detailed information on performance measures, please log on to www.evergladesplan.org and follow the links:

1. Projects
2. Feasibility Studies
3. Water Preserve Areas
4. WPA Performance Measures: Accept Terms

A.14.1 Project Benefits Modeling

A.14.1.1 Regional Model (SFWMM v3.5)

A.14.1.1.1 Description

NOTE: Information in this section was obtained from the Restudy, Appendix B, Modeling of Alternatives.

A.14.1.1.2 Process Modules

A.14.1.1.2.1 Domain

A.14.1.1.2.1.1 Background

The hydrology of South Florida is unique in response to flat topography, high water table, sandy soils, and an extremely transmissive surficial aquifer. Given the complexity of the Everglades system, computer simulation is perhaps the only way to devise long-range water management plans. These plans are needed for sustainable development and balancing the competing water needs of the environment, agriculture, and the urban communities. The South Florida Water Management Model (SFWMM) is the model utilized in simulating alternatives for the Restudy.

The SFWMM is an integrated surface water-groundwater model that simulates the hydrology and existing/proposed water management plans in the South Florida region. The model uses the climatic data for the time period 1965-1995. The model simulates the major components of the hydrologic cycle in South Florida that includes rainfall, evapotranspiration, overland flow, groundwater flow, canal flow, and seepage across levees. Additionally, the model simulates the operations of the C&SF system components including major wellfields in the urbanized east coast, impoundments, canals, pump stations and other water

control structures. The ability to simulate key water shortage policies effecting urban, agricultural, and environmental water demands allows the modeler to investigate trade-offs among different users and sub-regions. Two-dimensional regional hydrologic processes are simulated on a daily time step utilizing a mesh of 2-mile x 2-mile (3.22 km x 3.22 km) grid cells. The simulation produces an extensive output that can be summarized into numerous indicators and measures of performance for evaluating a plan. In addition, the model simulates inflows from Kissimmee Basin, runoff and managed discharges in the St. Lucie and Caloosahatchee Basins, and inflows to and outflows from Lake Okeechobee.

The most recent documentation for the model is available from the following reference: South Florida Water Management District. 1997. Draft Documentation for the South Florida Water Management Model. Hydrologic Systems Modeling Division, Planning Department, South Florida Water Management District, West Palm Beach, Florida. Additionally, it is currently available on at http://www.sfwmd.gov/org/pld/hsm/models/sfwmm.

A.14.1.1.2.2 Input Data and Model Setup

NOTE: Information in this section was obtained from the Restudy, Appendix B, Modeling of Alternatives.

A.14.1.1.2.2.1 Time Step

A fixed time step of one day is used in the model. The selection of this time step is consistent with the minimum time increment for which hydrologic data such as rainfall, evaporation and structure discharge are generally available. Rainfall and potential evapotranspiration (PET) are the primary driving processes. The longest total simulation time for the model is a function of the available historical rainfall and PET data. The model can be run for time periods ranging from one month to 31 years (between January 1, 1965 and December 31, 1995). The hydrologic processes are modeled sequentially within one time step. To simplify programming and reduce computational time, no iteration is performed between surface water and groundwater routines within a time step. Calculations for more transient phenomena (e.g. channel flow routing) are performed before less transient phenomena (e.g. groundwater flow). The total execution time for a typical Restudy alternative may run approximately 5 hours on a SunTM Ultra2.

A.14.1.1.2.2.2 Scale

The gridded portion of the model domain, south of Lake Okeechobee, describes the extent of the finite difference solution to the governing overland and groundwater flow equations. The network is comprised of 2-mile square grid cells that cover the large coastal urban areas of Palm Beach, Broward, and

Miami-Dade counties; the Everglades Agricultural Area (EAA); the Water Conservation Areas (WCAs); and Everglades National Park (ENP). The total coverage of the model is 1,746 grid cells. The model assumes homogeneity in physical as well as hydrologic characteristics within each grid cell.

The 2-mile discretization in the SFWMM is sufficiently fine to describe the solution to the overland and groundwater flow equations with reasonable resolution and to prevent excessive numerical errors (Lal, 1998b).

Other areas in the model (e.g. Lake Okeechobee and northern lake service areas) are conceptualized at a different level of detail due to varying degrees of data availability. The SFWMM employs both lumped and distributed modeling techniques. Specifics on these techniques can be found in SFWMD (1997).

A.14.1.1.2.2.3 Overland Flow

A diffusion wave approximation to the full equations for overland flow is utilized in the gridded portion of the model. Specifically, the components of the cell-to-cell flow are computed using the following expressions:

$$u = 1.49 \frac{h^{\frac{2}{3}}}{n\sqrt{S_n}} \frac{\partial H}{\partial x} \quad (1)$$

$$v = 1.49 \frac{h^{\frac{2}{3}}}{n\sqrt{S_n}} \frac{\partial H}{\partial y} \quad (2)$$

Where u and v are the velocity components in the x and y directions, respectively. Other variables defined: n is the overland flow roughness coefficient that depends on the depth of flow (according to the formula: n=A*hB); Sn is the maximum energy slope; and H is the water level above a given datum. An Alternating Direction Explicit (ADE) scheme with four six-hour time slices is utilized to solve for the overland flow from one cell to another.

A.14.1.1.2.2.4 Groundwater Flow

The following vertically-averaged, groundwater flow equation is solved:

$$\frac{\partial}{\partial x}\left(T_{xx}\frac{\partial h}{\partial x}\right) + \frac{\partial}{\partial y}\left(T_{yy}\frac{\partial h}{\partial y}\right) = S\frac{\partial h}{\partial t} - R \quad (3)$$

Where T is transmissivity, S is storage coefficient, and R is recharge to the groundwater table. The model utilizes a variation of the Saul'yev (1964) method to solve the above equation. This technique is unconditionally stable and

explicit. To minimize bias, the numerical formulation is solved in four different directions in four successive time steps. Highly concentrated groundwater flow across levees cannot be simulated with a 2-mile x 2-mile scale model; therefore separate regression equations were developed to simulate levee underseepage (SFWMD, 1997).

A.14.1.1.2.2.5 Canal/Structures Flow

Over 1,400 miles of levees and canals, 18 major pump stations, and more than 180 water control structures are simulated in the model. The SFWMM utilizes a mass balance approach to account for changes of storage in the canal due to inflows and outflows. The model computes flows into and out of canals via water control structures, interaction between the wetlands and the canals, and the groundwater seepage. Canals are assumed to pass through the center of a grid cell or group of grid cells and calculations are performed for each canal reach, i.e. a canal with known or calculated upstream inflow and outflow. A seasonal hydraulic gradient is assumed for each canal reach. For a given canal reach, the model calculates the end-of-day stage at the most downstream grid cell or node. Intermediate grid cells are assumed to have stages proportional to seasonal hydraulic gradient, according to their relative distance from the extreme nodes of the reach. A complex set of release and inflow rules are followed in the model (SFWMD, 1997) to regulate flow into and out of canals and storage areas.

A.14.1.1.2.2.6 Rainfall and ET

The SFWMM uses a time varying (daily), spatial database that has been preprocessed using rainfall records at more than 600 rain gages distributed throughout South Florida. In the absence of a more rigorous and practical spatial interpolation scheme, cell-by-cell rainfall has been estimated using a "nearest station" technique.

The algorithms to calculate actual ET in the model vary geographically. For Lake Okeechobee, the Penman-Monteith (Monteith, 1965) method is used to calculate open water and marsh zone ET. For the EAA, total ET is the sum of its components from the saturated, unsaturated, and open water zones. For the LEC urban area, unsaturated ET is pre-processed using the Agricultural Field-Scale Irrigation Requirements Simulation model (Smajstrla, 1990) that also computes the irrigation requirements for selected land cover types. The reference crop (turf grass) evapotranspiration, ET_0, for most areas of the model is computed utilizing the Penman-Monteith formula:

$$\lambda ET_0 = \frac{\Delta(R_n - G) + \rho C_p (e_a - e_d)\frac{1}{r_a}}{\Delta + \gamma\left(1 + \frac{r_c}{r_a}\right)} \qquad (4)$$

where,

ET0 = latent heat flux of evaporation, (KJ m-2 s-1);
ET0 = mass flux of evapotranspiration, (kg m-2 s-1);
□= latent heat of vaporization, (KJ kg-1);
□ = slope of vapor pressure curve, (kPa oC-1);
Rn = net radiation flux at surface, (KJ m-2 s-1);
G = soil heat flux, (KJ m-2 s-1);
= atmospheric density, (kg m-3);
Cp = specific heat of moist air, (KJ kg-1 oC-1);
ea = saturation vapor pressure at surface temperature, (kPa);
ed = actual ambient vapor pressure at dew point, (kPa);
(ea-ed) = vapor pressure deficit, (kPa);
= psychometric constant, (kPa oC-1);
rc = crop canopy resistance, (s m-1); and
ra = aerodynamic resistance, (s m-1).

Actual ET is related to ET0, as follows,

ET = K * ET0 (5)

Where K is an adjustment factor that takes into account depth of water above or below the ground surface, land cover type, and the depths of shallow and deep root zones.

A.14.1.1.2.2.7 Reservoirs

Water-holding facilities or reservoirs serve a variety of functions. The Holey Land can be modeled as an aboveground reservoir that acts as a wetland preserve. Examples of reservoirs in the Lower East Coast service areas are the West Palm Beach Catchment Area and the Indian Trails Water Control District reservoir. In the development of the Restudy alternatives two EAA reservoir compartments are proposed. One compartment stores EAA runoff and supplies water to the EAA during dry periods. The other compartment stores excess Lake Okeechobee water and helps meet environmental water supply demands in the Everglades. If a reservoir exist in the same EAA Basin, the SFWMM assumes that the reservoir receives runoff/LOK regulatory releases first while the remainder of the excess water goes directly to the reservoir for settlement.

Reservoirs in the Lower East Coast service areas are generally proposed as part of the Water Preserve Areas whose two functions are stated. First, store excess

water from a drainage basin that may result in improved flood control for the basin and reduced seepage volumes from the Water Conservation Areas. Second, release the stored water for water supply purposes and/or environmental enhancement to decrease the dependence of the LEC service areas on Water Conservation Area and Lake Okeechobee deliveries. ASR wells may accompany a reservoir to enhance the system's ability to store water and then use the excess water more effectively during times of demand.

All the reservoirs are assumed to have vertical walls for modeling purposes. The model identifies reservoirs by a hydrologic basin number that is assigned to appropriate grid cells. The model accounts for differences in the actual area of the reservoir and the area represented by the grid system, i.e. multiples of four square miles. Since rainfall and evapotranspiration depths are assumed to occur uniformly for each grid cell, their effect on reservoir stage is transformed by a proportionality factor relating reservoir area and the area of the grid cell(s) where the reservoir is located. For a given reservoir,

sfactor = total_reservoir_area / (no of grid cells * grid cell area)
change_reservoir_stage(t) = RF(t) - ET(t) + LSEEP(t) + GWIN(t) - [RF(t)-ET(t)] * [(1 - sfactor)]
where
RF(t) is rainfall into grid cell (ft);
ET(t) is evapotranspiration out of grid cell (ft);
LSEEP(t) is equivalent depth of levee seepage into grid cell; and
GWIN(t) is equivalent depth of net groundwater inflow into grid cell (ft).
reservoir_stage(t) = reservoir_stage(t-1) + change_reservoir_stage(t)

Reservoir_ stage is used in determining available storage in the reservoir. It is also the basis for calculating discharges through inlet and outlet structures of a reservoir. The outlet structures can be managed for water supply, flood control, or environmental enhancement.

A.14.1.1.2.3 Model Calibration and Verification

NOTE: Information and references to Sections, Equations, and Figures in this section of the Hydrology Appendix A were obtained from http://www.sfwmd.gov/org/pld/hsm/models/sfwmm/v3.5/wmmpdf.htm.

A.14.1.1.2.3.1 Calibration of the Everglades and the Lower East Cost

The goal of the Everglades/LEC calibration effort was to make simulated stages at selected monitoring/observation points and canals, and simulated discharges through selected structures match historical data as reasonably close as possible. All historical input data, including structure flows, were assumed to be

reliable. The model is calibrated on a regular basis to ensure that its history matching ability is maintained or improved after significant computer code changes have been made and/or data updates have been performed. It must be emphasized that calibration also enhances, but not guarantee, a model's predictive ability.

A.14.1.1.2.3.2 Methodology

A network of groundwater monitoring or observation wells is maintained by the District and the USGS. Observations from this network were used to make stage comparisons during calibration (***Figure A-81***). Although the simulation was performed on a daily basis, simulated water levels were compared with historical data on an end-of-week basis. Comparing historical data with simulated values on a daily basis was not justifiable because of several factors:

1. The spatial resolution of the model, 2 miles by 2 miles, is too coarse for modeling local phenomena such as wellfield drawdowns and levee seepage.
2. The time resolution of the model, 1 day, may not always satisfy certain assumptions in the model. For example, in the overland flow subroutine, in order to maintain stability in the solution procedure, volume constraints during some simulation days may override the assumption that overland flow is a diffusion type process.
3. The availability or lack of continuous flow and stage information preclude daily comparison of historical data and simulated values. Even if data is available, daily comparison is statistically noisier than weekly or monthly comparison.
4. The intended use of the model is to provide long-term planning-type guidance to water managers with regards to making water policy decisions. The model is not intended to estimate system responses to extreme conditions whose timing may be in the order of hours or even minutes (e.g. flood events). It is also not intended to be a prescriptive model that a field operator can use in making decisions on when and by how much to open a sluice gate, for instance, on a day-to-day basis.

Canal stages were also considered in the calibration. Due to the more dynamic nature of canal levels relative to groundwater levels, as well as the coarse representation of canals in the model (refer to ***Section 2.5***), a comparison of average monthly stages was selected.
In general, the time series of historical flows, where available and considered reliable, were input to the model. Discharges at some locations with sparse and/or unreliable historical data were compared to simulated values on monthly, seasonal and annual bases. Appendix F contains the full set of water level (ground water and surface water) calibration and verification/validation plots for

the Everglades and the Lower East Coast areas. Appendix G shows the calibration and verification/validation plots for canal stages, and Appendix H compares SFWMM-simulated structure flows against historical values.

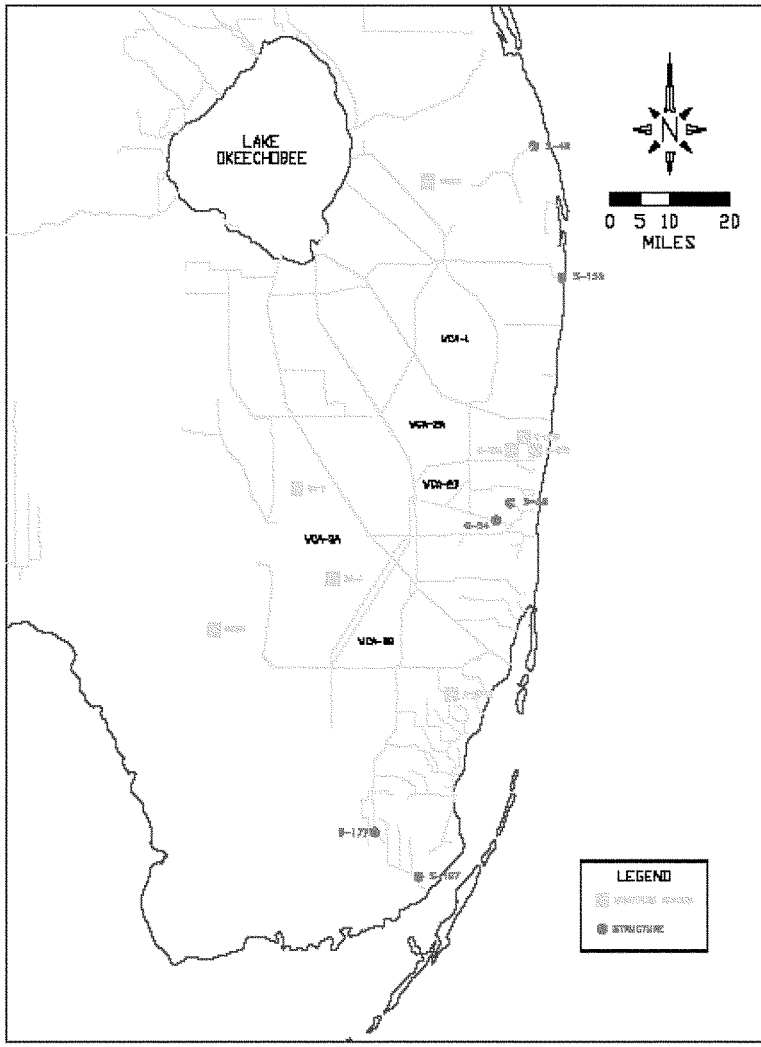


FIGURE A-81: LOCATION OF SELECTED GROUNDWATER LEVEL MONITORING OR OBSERVATION WELLS USED IN THE SOUTH FLORIDA

WATER MANAGEMENT MODEL CALIBRATION

Calibration for the majority of the model domain (LEC, WCA, ENP, and BCNP) was performed in an iterative fashion: (1) simulated stages were compared with historical stages at selected monitoring points and simulated flows were compared with historical flows at control structures; (2) appropriate calibration parameters were modified in order to make simulated values match historical values more closely; (3) the model was rerun with the revised parameters; and (4) step (1) was repeated until an acceptable match between simulated and historical values was obtained.

The use of historical flows as boundary conditions at certain structures, instead of actually simulating the discharge through those structures during calibration, allowed physical processes to be calibrated without being affected by possible changes to operating practices. One of the strengths of the SFWMM is its ability to show the response of groundwater levels to water resources management. Historical flows, which are determined by structure hydraulics as well as structure operating rules, insulate field-level decision making processes, which may deviate from what is specified in operating manuals.

Several parameters can be adjusted to calibrate the Everglades and LEC portions of the model domain. A breakdown of the most significant parameters used in the calibration procedure is given below.

A. Lower East Coast
1. Canal parameters:
a. channel - aquifer hydraulic conductivity coefficient [CHHC in Eq. (2.4.1)];
b. surface water - channel interaction [n in Sec. 2.5];
c. coefficients for operation of outlet structures;
2. Detention depths (refer to Sec. 2.3); and
3. ET coefficients (KVEG, DSRZ, DDRZ in Sec. 2.2).
B. Everglades (WCAs, ENP and BCNP)
1. ET coefficients (KVEG, DSRZ, DDRZ in Sec. 2.2);
2. Manning's n ($n = Ah^b$ for overland flow; mainly A is adjusted);
3. Levee seepage rate coefficients [β_0, β_1, β_2, in Eq. (2.4.2)];
4. Detention depths (refer to Sec. 2.3); and
5. Canal parameters (refer to Secs. 2.4 and 2.5).

The general guidelines used in calibrating the model were discussed in Chap. 4. Additional guidelines specific to the Everglades/LEC region are listed below.

1. The calibration period covered historical data consistent with a relatively static "plumbing" system and constant structure operating rules.

2. Local parameters such as canal properties and cell-based data were adjusted before regional parameters were adjusted. Regional parameters such as land use type have greater aerial influence. This procedure was followed to minimize the undesirable effect of the calibration getting better in some areas but negatively affecting other areas in the model domain.
3. Exact matching of historical data may not be desirable in some cells during the calibration process. The simulated stage represents the average water level computed for a 4-mile^2 area. Comparing historical stage, a point measurement, against simulated stage, an estimated aerial average, is a source of discrepancy in itself. Some monitoring points are located near a municipal wellfield, which can heavily influence the stage at that location. Since the model cannot accurately simulate wellfield drawdowns at such a small scale, matching stages at that particular location becomes a futile effort. Good engineering judgment must be used.
4. It was shown (Trimble, 1995a) that canals heavily influence groundwater levels within its immediate proximity. The monitoring point closest to the canal, assuming that several observation points exist within the cell where the canal is located, gets priority for the stage matching.
5. In addition to comparing seasonal and annual sums and means, the following statistical measures and their corresponding ranges were used to evaluate the status of the calibration after each parameter change.

Coefficient of determination or correlation coefficient, $\mathbf{R^2}$:

$$R^2 = \left[\frac{\sum_{i=1}^{n} (x_i - x_m)(\hat{x}_i - \hat{x}_m)}{\sqrt{\sum_{i=1}^{n} (x_i - x_m)^2 \sum_{i=1}^{n} (\hat{x}_i - \hat{x}_m)^2}} \right]^2 \quad ; \quad 0 \le R^2 \le +1 \qquad (4.2.1)$$

mean square error, mse :

$$mse = \frac{\sum_{i=1}^{n} (\hat{x}_i - x_i)^2}{n-1} \quad ; \quad 0 \le \text{mse} \le +\infty \qquad (4.2.2)$$

bias:

$$bias = \frac{\sum_{i=1}^{n} (\hat{x}_i - x_i)}{n} \quad ; \quad -\infty \le \text{bias} \le +\infty \qquad (4.2.3)$$

where: n = number of data points;
x_i = observed data point;
x_m = mean of observed data points;
$\hat{x}_i$ = simulated data point; and
$\hat{x}_m$ = mean of simulated data points.

The selected calibration period includes calendar years 1979 through 1990 and verification / validation years from 1991 through 1995. Because the South Dade Conveyance System (SDCS) was completed in 1982, the calibration during the first three years of the selected period was relaxed for that region of the model domain. All comparisons using the above statistical measures were performed by limiting the number of data points by the size of available historical data. In other words, simulated data with no corresponding historical data were not considered in all statistical calculations.

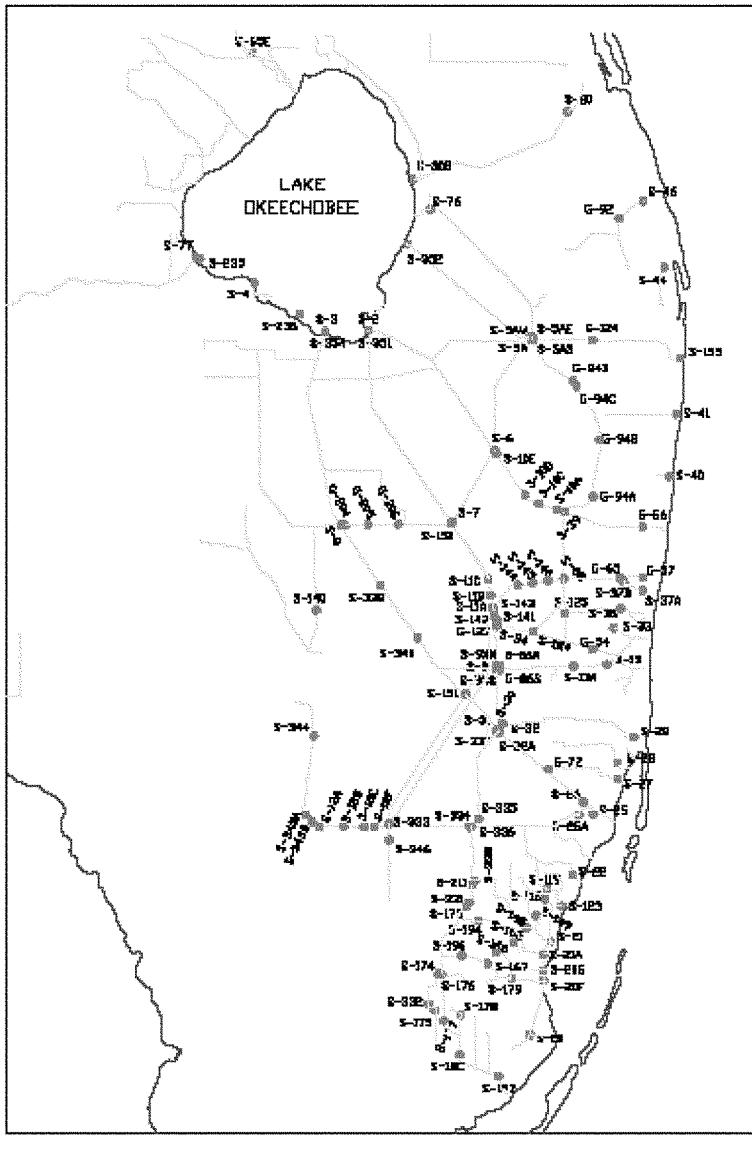


FIGURE A-82: LOCATION OF MAJOR CONTROL STRUCTURES SIMULATED IN THE SOUTH FLORIDA WATER MANAGEMENT MODEL

A.14.1.1.2.3.3 Everglades and LEC Calibration Results

Calibration results for the Everglades (WCAs and portions of the ENP and the BCNP) and LEC Service Areas are presented next. The figures that follow show representative comparisons of end-of-week stages for various monitoring points and monthly average stages for several canals throughout the model domain. Comparisons of simulated and historical monthly and annual flow volumes are also included for selected structures. ***Figure A-81*** and ***Figure A-82*** can be used to locate the gages referenced in the following discussion. Appendices F and G contain the full set (161 monitoring points and 22 canal locations, respectively) of calibration and verification plots based on SFWMM v3.5.

The effect of wellfields on the system is illustrated in ***Figure A-83*** and ***Figure A-84.*** G1074B (x,y: 31,20) is located within the cone of influence of the Alexander Orr, Jr. wellfield in Dade County, and G853 (x,y: 38,39) is situated in the same SFWMM grid cell where the Northeast wellfields of the city of Pompano Beach in Broward County are located. In both instances, the model is unable to track the wide fluctuations in groundwater levels at these two sites. This discrepancy could be reduced only if finer grid cells and/or finer time scales were used.

Another limitation of the model is related to one of the assumptions used to route water through canals: the water surface profile in a canal reach is assumed to have a constant slope, HDC (refer to Sec. 2.5). In ***Figure A-85*** and ***Figure A-86***, two gauging stations, G1315 (x,y: 37,40) and G1316 (x,y: 36,39), are located on opposite ends of one of the secondary canals maintained by the Deerfield Agricultural District just south of the Palm Beach-Broward county line. The model simulates stages in the upstream monitoring point (G1315) better than it does on the downstream end (G1316). Although the difficulty presented by these two gauging stations to the entire calibration effort do not occur frequently, suggested model improvements, in addition to better data collection, to offset it are: (1) include a time-varying HDC; or (2) revise the canal routing algorithm to be consistent with the more accurate distributed flow routing techniques.

The importance of regional parameters, such as ET parameters, which are functions of land use, is illustrated in ***Figure A-87*** and ***Figure A-88.*** PB831 (x,y: 29,60), located in northwestern Palm Beach County, and BR105 (x,y: 11,25), located in southeastern Collier County within the Big Cypress National Park, are both located in grid cells with the same land use classification: forest. During dry periods, PB831 tends to overestimate stages while BR105 tends to underestimate stages.

Since both monitoring points are located within the same type of "natural" areas, candidate parameters for calibration are limited to ET parameters. Adjusting such parameters will have conflicting effects at the two locations. A decision was

made to emphasize stage matching for PB831 since it is closer to urban development where related water management issues have to be made. This example illustrates that sometimes subjectivity may be required in model calibration.

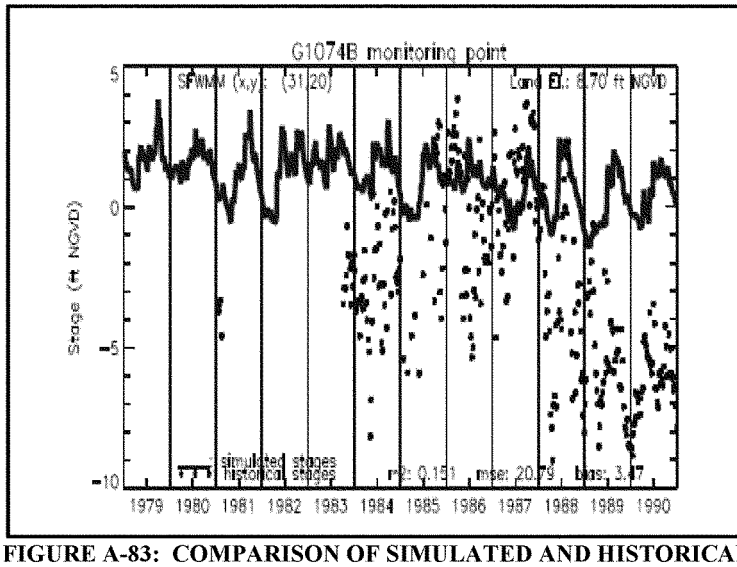


FIGURE A-83: COMPARISON OF SIMULATED AND HISTORICAL END-OF-WEEK STAGES AT GAGE LOCATION G107 FOR PERIOD OF RECORD 1979-1990

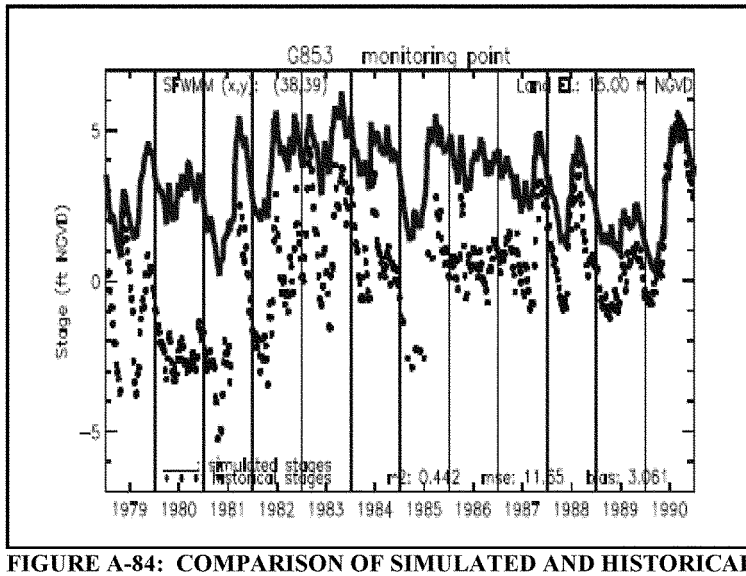


FIGURE A-84: COMPARISON OF SIMULATED AND HISTORICAL END-OF-WEEK STAGES AT GAGE LOCATION G853 FOR PERIOD OF RECORD 1979-1990

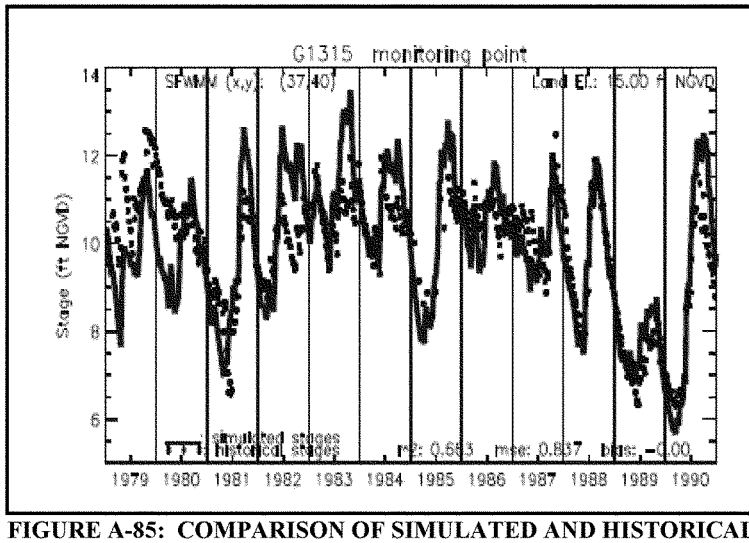


FIGURE A-85: COMPARISON OF SIMULATED AND HISTORICAL END-OF-WEEK STAGES AT GAGE LOCATION G135 FOR PERIOD OF RECORD 1979-1990

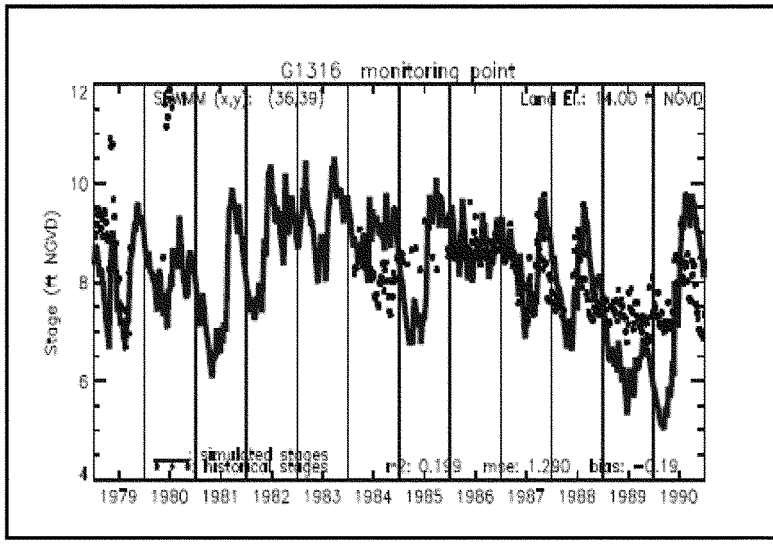


FIGURE A-86: COMPARISON OF SIMULATED AND HISTORICAL END-OF-WEEK STAGES AT GAGE LOCATION G136 FOR PERIOD OF RECORD 1979-1990

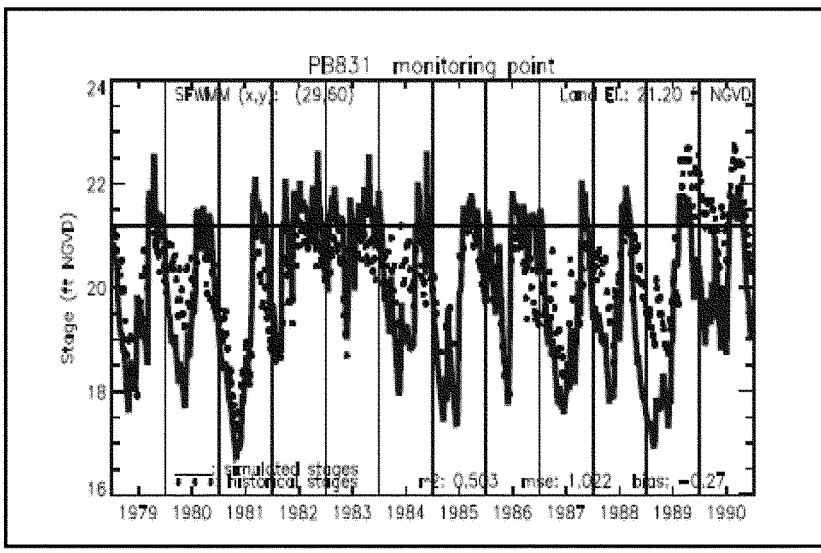


FIGURE A-87: COMPARISON OF SIMULATED AND HISTORICAL END-OF-WEEK STAGES AT GAGE LOCATION PB831 FOR PERIOD OF RECORD 1979-1990

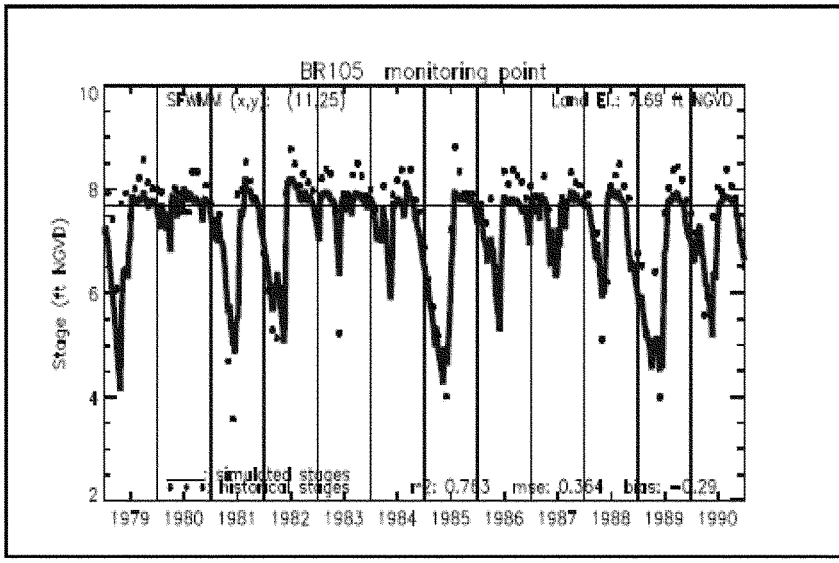


FIGURE A-88: COMPARISON OF SIMULATED AND HISTORICAL END-OF-WEEK STAGES AT GAGE LOCATION BR105 FOR PERIOD OF RECORD 1979-1990

Preferential stage matching in the model calibration may also be necessary in situations where a monitoring point is used to make operational decisions in the field. Gage 3A-4 (x,y: 21,29) is used as a basis for making regulatory discharges from WCA-3A. Additional effort was invested in improving the calibration at this location (***Figure A-90***), in terms of minimizing overestimation of highs and underestimation of lows, as compared to 3A-2 (x,y: 18,36), a gauging station less than ten miles away (***Figure A-89***) to the northwest of 3A-4. Both locations have the same vegetation type.

Historical values of canal stages measured at the headwater of the downstream structures (denoted by "Ref. Structure" in the calibration plots) are also compared to simulated stages during the calibration process. ***Figure A-91*** and ***Figure A-92*** are calibration plots for the upper C-103N Canal and the North New River Canal (NNRC). The model performs a fairly good simulation of canal stages for C-103N Canal but fails to trace wide fluctuations in NNRC stages. During wet periods the gates at G-54 are open full allowing the headwater stage to be quite low. During these times the slope of the water surface is relatively steep and nonlinear in geometry. Since the channel flow routing uses a mass balance approach and assumes a constant slope (linear) profile, the greatest error in the simulated stage along the North New River Canal would be at the

downstream structure: G-54. The linearity assumption on the water surface slope becomes more valid further upstream.

As mentioned earlier, the selection of the calibration period (1979-1990) was largely dictated by the completion of the infrastructure associated with the South Dade Conveyance System in 1982. ***Figure A-93*** and ***Figure A-95*** show the calibration of stages and flow volumes at S-177, one of the major structures in the SDCS. More emphasis was made in matching historical stages and flow volumes after 1982. Historical stages and flow volumes for 1989 and 1990 deviate significantly from simulated values. This discrepancy may be due to operational policies instituted for SDCS during those two drought years.

Another operational change that might explain substantial deviations between historical and simulated stages can be illustrated in ***Figure A-94***. Recorded low stages between 1982 and 1984 for the C-51 Canal imply that the gates at its downstream structure, S-155, were opened earlier than usual, i.e., the actual canal maintenance level is lower during this two-year period. The model assumes fixed operational policies during a given simulation period and therefore, does not capture deviations from the "normal" maintenance level. On a positive note, ***Figure A-96*** represents probably the best calibration information that the model can offer as far as matching historical flow volumes out of coastal structures. In general, flow volume trends on an annual, dry- and wet-season basis are sufficiently simulated by the model.

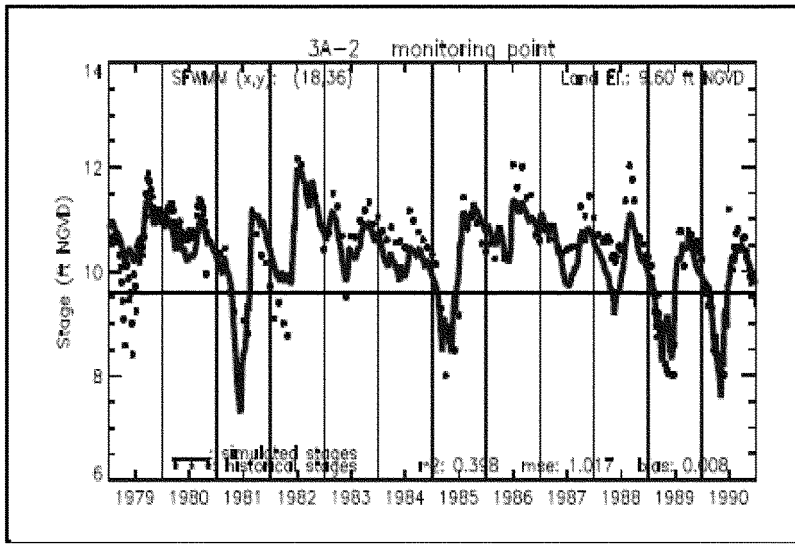


FIGURE A-89: COMPARISON OF SIMULATED AND HISTORICAL END-OF-WEEK STAGES AT GAGE LOCATION 3A-2 FOR PERIOD OF RECORD 1979-1990

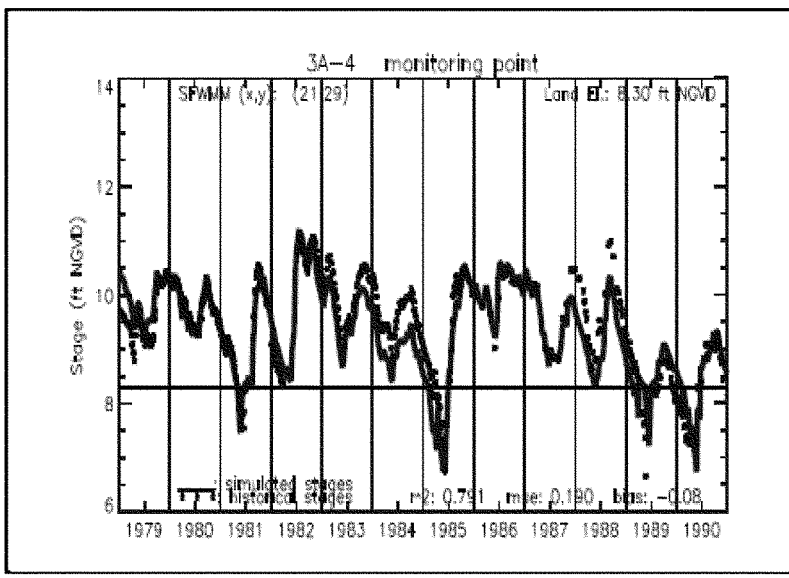


FIGURE A-90: COMPARISON OF SIMULATED AND HISTORICAL END-OF-WEEK STAGES AT GAGE LOCATION 3A-4 FOR PERIOD OF RECORD 1979-1990

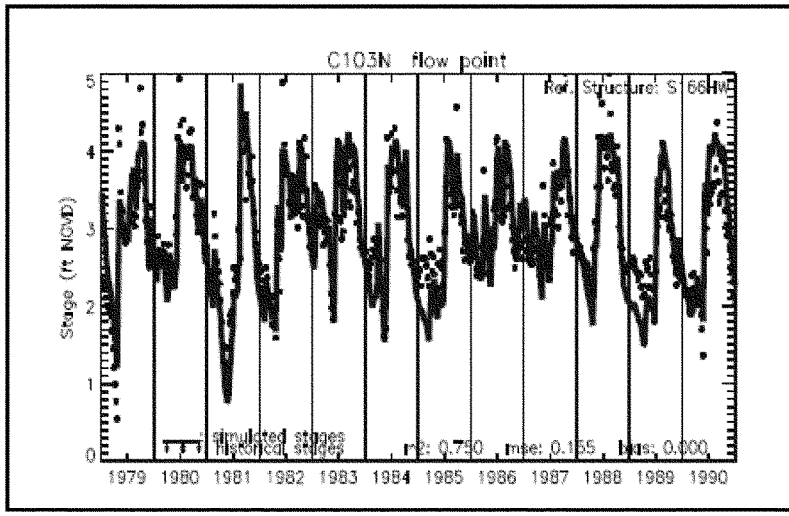


FIGURE A-91: COMPARISON OF SIMULATED AND HISTORICAL MEAN WEEKLY STAGES ALONG UPPER C-103N CANAL AT GAGING STATION S-166HW FOR PERIOD OF RECORD 1979-1990

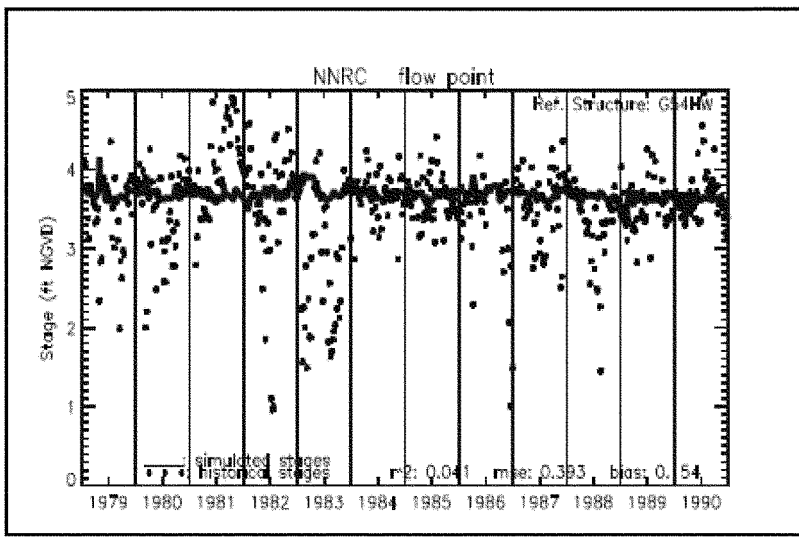


FIGURE A-92: COMPARISON OF SIMULATED AND HISTORICAL MEAN WEEKLY STAGES ALONG NORTH NEW RIVER CANAL AT GAGING STATION G-54HW FOR PERIOD OF RECORD 1979-1990

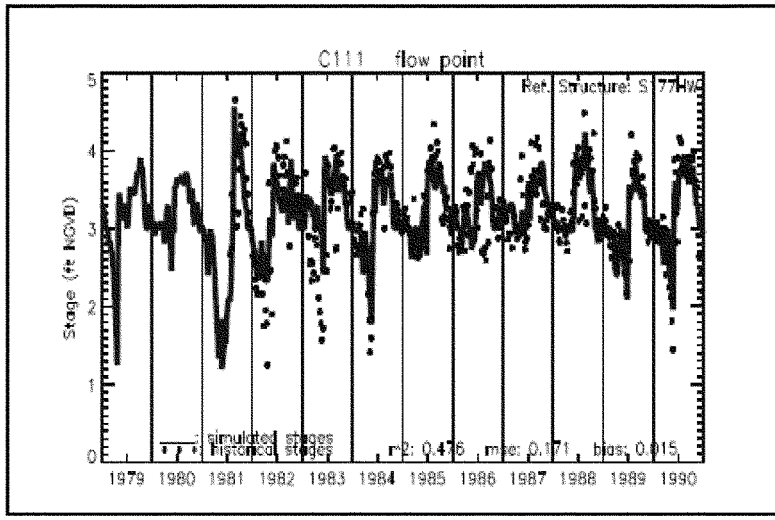


FIGURE A-93: COMPARISON OF SIMULATED AND HISTORICAL MEAN MONTHLY STAGES ALONG C-111 CANAL AT GAGING STATION S-177HW FOR PERIOD OF RECORD 1979-1990

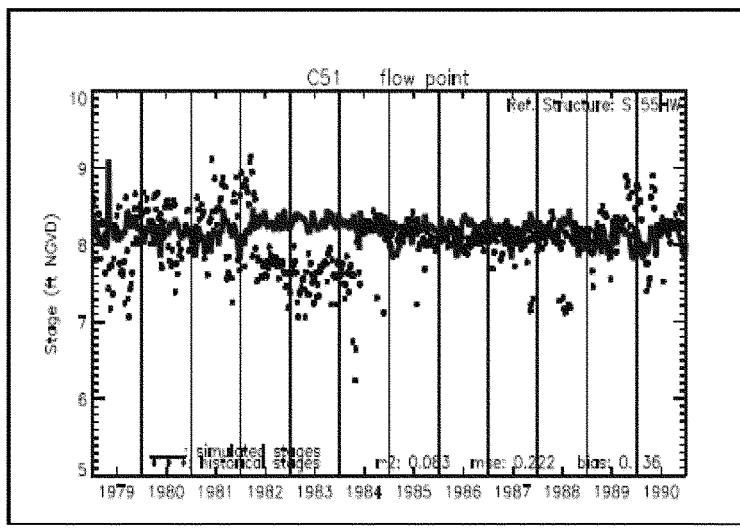


FIGURE A-94: COMPARISON OF SIMULATED AND HISTORICAL MEAN MONTHLY STAGES ALONG C-51 CANAL AT GAGING STATION S-155HW FOR PERIOD OF RECORD 1979-1990

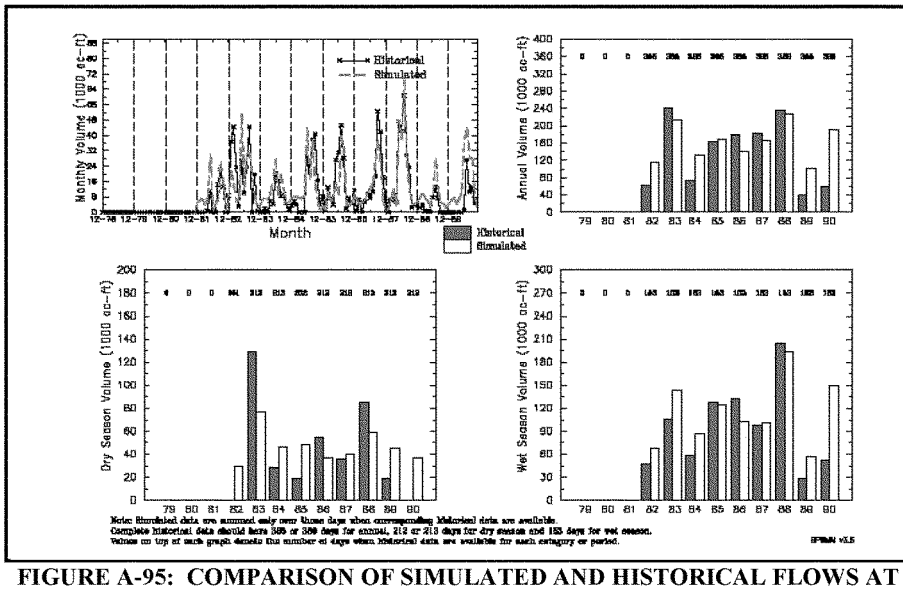


FIGURE A-95: COMPARISON OF SIMULATED AND HISTORICAL FLOWS AT STRUCTURE S-177 FOR PERIOD OF RECORD 1979-1990

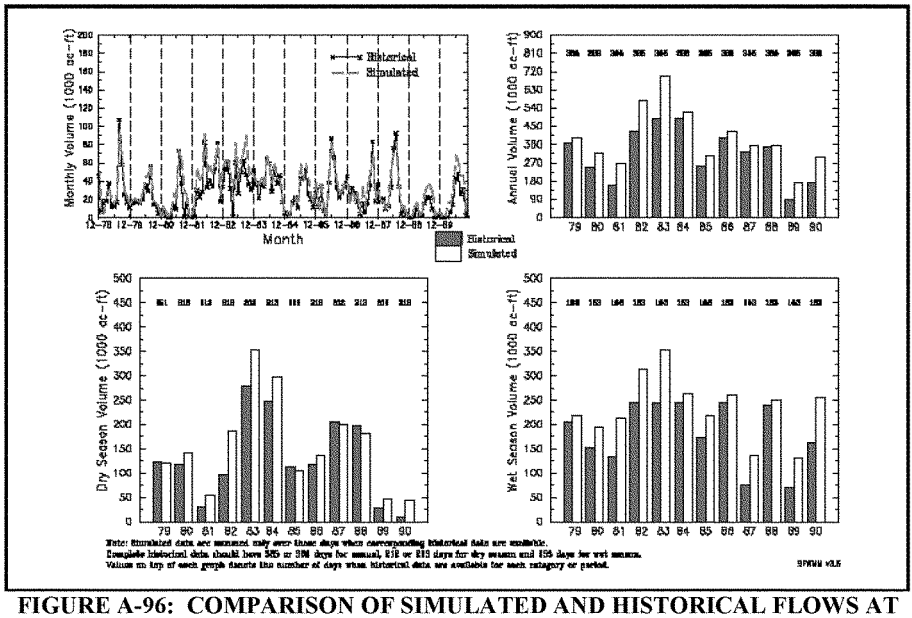


FIGURE A-96: COMPARISON OF SIMULATED AND HISTORICAL FLOWS AT STRUCTURE S-155 FOR PERIOD OF RECORD 1979-1990

A.14.1.1.2.4 Boundary Conditions

NOTE: Information and references to Sections, Equations, and Figures in this section of the Hydrology Appendix A were obtained from http://www.sfwmd.gov/org/pld/hsm/models/sfwmm/v3.5/maintext/chap2_6.pdf

A.14.1.1.2.4.1 Initial and Boundary Conditions

Initial and boundary conditions are prescribed in the form of discharges or stages. For Lake Okeechobee, historical stage is used at the start of simulation. For grid cells or nodes, the elevation of the water table and ponding depth, if applicable, are initialized as being equal to their historical values. In some areas where monitoring stations are not available, a horizontal pool is assumed as initial condition. For instance, historical gage reading for station 2A-17 applies to all cells within Water Conservation Area 2A. For canals, the initial water level is assumed to be equal to the maintenance level or the historical headwater level at the downstream structure. The choice between the two options does not really make any difference as far as inferences drawn from the model output since the model is intended to be run on a long-term (several years) basis. Boundary conditions refer to the time series of flows or stages at the peripheral grid cells of the model. The general southeasterly direction of both natural

(overland and groundwater flow) and man-controlled (structure discharge) flows in South Florida allows the northern boundary condition to be defined in terms of historical or independently simulated flows depending on the scenario simulated. In the 1990 base scenario for the Lower East Coast Regional Water Supply Plan (LECRWSP; see SFWMD, 1995), historical inflows through S-65E from the Kissimmee Basin prior to completion of the Kissimmee River Restoration Plan (Loftin, et al., 1990) define the boundary condition north of Lake Okeechobee. In the 2010 base scenario of LECRWSP, the Kissimmee River Restoration Plan is assumed to be in place and the corresponding inflows to Lake Okeechobee from Kissimmee Basin define a different northern boundary condition. The latter scenario was simulated by Krishnan (1994) using the CREAMS-WT model (Heatwole, et al., 1987).

A no-flow boundary condition for both surface water and ground water is imposed on the northwestern and midwestern boundaries except for discharges statistically correlated to available rainfall records (Krishnan, 1993a and 1993b; Trimble, 1995c) through structures G-88, G-89, G-155 and G-136. The westernmost grid cells in this area of the model are assumed to define a hydrologic drainage divide between the Water Conservation Areas (WCAs) and the Big Cypress National Preserve (BCNP). The southwestern portion of the model domain, where the model cuts the western portion of the Everglades National Park, is defined as a no-flow boundary as far as groundwater movement is concerned. On the surface, a uniform overland flow condition is imposed, i.e., the hydraulic gradient or water surface profile is always assumed to be parallel to land surface. On the northeastern boundary along the Martin-Palm Beach county line a no-flow boundary condition is assumed for both overland flow and groundwater flow.

Along the Atlantic coastal boundary to the south and east, the boundary condition is defined in 55 terms of historical tidal data (Krishnan and Gove, 1993). Tidal data is preferred over a constant head (assumed to be 0.4 ft NGVD on the eastern seaboard of South Florida) because tidal levels in the southern tip of the Florida peninsula are generally higher than those found in higher latitudes. Based on available daily readings at six United States Geological Service (USGS) tidal stations along the Atlantic coast, six time series of mid-month long-term mean historical tidal values are read into the model. The data (12 values per station) is assumed to repeat every year of simulation. Individual boundary cell values are interpolated in time for calendar days between the middle of two successive months and in space for boundary cells in between two adjacent stations. These values are passed to the groundwater subroutine as known head boundary conditions. No overland flow is assumed to occur passed the eastern boundary cells.

A.14.1.1.2.5 Initial Conditions

NOTE: Information and references to Sections, Equations, and Figures in this section of the Hydrology Appendix A were obtained from
http://www.sfwmd.gov/org/pld/hsm/models/sfwmm/v3.5/maintext/chap2_6.pdf

See (1) Boundary Conditions above.

A.14.1.1.2.6 Calibration, Verification, and Validation

NOTE: Information and figures for this section of the Hydrology Appendix A can be obtained from
http://www.sfwmd.gov/org/pld/hsm/models/sfwmm/v3.5/appendices/appf.pdf for water level calibration/verification and
http://www.sfwmd.gov/org/pld/hsm/models/sfwmm/v3.5/appendices/appg.pdf for canal level calibration/verification.

The links above contain figures for calibration, verification, and validation.

A.14.1.1.3 Simulation Scenarios

A.14.1.1.3.1 Natural Systems Model (NSM)

NOTE: Information and references to Sections, Equations, and Figures in this section of the Hydrology Appendix A were obtained from
http://www.sfwmd.gov/org/pld/hsm/models/nsm/nsm45doc/nsm45.htm

A.14.1.1.3.1.1 Natural System Model (NSM) Version 4.5

A.14.1.1.3.1.1.1 Introduction

Prior to the major drainage activities that began early this century, the Everglades consisted of 3 million acres of subtropical wetlands that covered much of South Florida. The Everglades region was characterized by an extremely low gradient, heterogeneous lands mosaic that evolved over 5000 years (Science Sub Group Report, 1993). This immense wetland system south of Lake Okeechobee sprawled from the south shore of Lake Okeechobee to the mangrove estuaries of Florida Bay and Gulf of Mexico. The Immokalee Ridge to the west and the coastal ridges to the east generally mark the hydrologic boundaries of the historic Everglades, although numerous connections through the coastal ridge overflowed from the Everglades to the Atlantic Ocean. The primary characteristics of the pre-drainage wetland ecosystem in the Everglades were the hydrologic regime that featured slow sheetflow and natural recession due to storage, large spatial scale, and heterogeneity in habitat.

The Natural System Model (NSM) simulates the hydrologic response of a pre-drained Everglades system. The NSM does not attempt to simulate the pre-drained hydrology. Rather, more recent climatic data is used to simulate the pre-drained hydrologic response to current hydrologic input. Although one may wish to recreate the hydrologic conditions of the late 1800's or early 1900's, the input data necessary to perform such a simulation do not exist. The use of recent input data, e.g. rainfall, potential evapotranspiration, tidal and inflow boundaries, allows for meaningful comparisons between the current managed system and the natural system under identical climatic conditions.

The lands of present day south Florida has been greatly affected by the land reclamation, flood control and water management activities that have occurred since the early 1900's. The complex network of canals, structures and levees in the current system are replaced in the NSM with the rivers, creeks and transverse glades that were present prior to the construction of drainage canals. The vegetation and topography used by the NSM are based on pre-drainage conditions. The land cover simulated by the NSM is static, i.e. the model does not attempt simulate vegetation succession.

The use of the NSM is closely linked to the South Florida Water Management Model (SFWMM). The SFWMM is a regional scale hydrologic model that simulates the hydrology and highly managed water system in south Florida. The design of the SFWMM takes into consideration south Florida's unique hydrologic processes and geologic features, including the integrated surface and ground water hydrology and the operation of the Central and South Florida (C&SF) Project. The NSM uses the same climatic input, model parameters and computational methods as the SFWMM. Physical features, such as topography, vegetation type and river locations are adjusted to represent the pre-drainage condition. Since traditional calibration/verification methods cannot be applied to the NSM, model parameters are based on the calibrated and verified SFWMM.

A.14.1.1.3.1.1.2 Physical Data

The NSM encompasses an area from Lake Istokpoga to Florida Bay. The western boundary extends southward from Lake Istokpoga to near the Gulf of Mexico, and continues along the coastal marsh fringe, turning southward to Shark River Slough and Florida Bay. The eastern boundary extends across the northern Indian Prairie Region to the Kissimmee River, and continues around the northern rim of Lake Okeechobee and turning eastward to the Atlantic Ocean. The eastern boundary follows the coastline southward to Biscayne Bay and Florida Bay. The model domain is divided into 2328, 2-mile by 2-mile square mile grid cells. Vegetation class, land surface elevation and aquifer parameters are assigned to each cell and are assumed uniform within each cell.

The vegetation coverage is based on the estimated lands of the pre-drained Everglades by McVoy and Park. Eleven land use types are identified, based on an evaluation of hydrology (water depth, hydroperiod, flow direction and velocity), vegetation community, soil type and topographic relief. The NSM uses vegetation-based parameters to compute evapotranspiration (ET) and overland flow. The use of SFWMM parameters implies that the ET and flow characteristics of the current land uses are comparable to pre-drainage land uses and are transportable, e.g. parameters calibrated in the Everglades National Park can be applied to areas outside of the Park boundaries.

Of the eleven pre-drainage land use types, seven have been identified in the current system, including mangroves, forested uplands, marsh, sawgrass plains, wet prairie, shrubland and forested wetlands. Parameter values for the non-existent types (ridge and slough, marl marsh, edge marsh and grassland) are based on the land use they most closely resemble in the current system. The ET characteristics of the R&S land use most closely resemble the modified ridge and slough of central Water Conservation Area 3A, and the flow characteristics most closely resemble the modified ridge and sawgrass invaded slough in Shark River Slough. The vegetation and flow characteristics of the marl marshes on either side of Shark River Slough most closely resemble the marl prairie now found in those same areas. Edge marsh and grassland most closely resemble the wet prairie and shrubland land uses identified in the current system.

Surface elevations in the NSM approximate the pre-drainage topography in south Florida. In general, land surface elevations are consistent with current land surface elevations except in areas impacted by soil subsidence. Land surface elevations in the Eastern Flatwoods, Loxahatchee Slough, Atlantic Coastal Ridge, Miami Rock Ridge, Everglades National Park, Big Cypress and Lake Okeechobee are consistent with the SFWMM. Land surface elevations in other non-subsidence areas, including Immokalee Ridge, Caloosahatchee River basin, Fisheating Creek and Istokpoga / Indian Prairie regions are estimated from USGS and COE sources.

The most severe soil subsidence occurred along the Okeechobee Rim, Central Everglades and Northern Transverse Glades regions. Land surface elevations in these areas are based on land surface profiles that were surveyed during, or prior to the construction of the drainage canals.

Aquifer parameters (depth, permeability and soil storage coefficient) are consistent with the SFWMM. In areas outside the SFWMM boundaries, aquifer depth and permeability are based on published well log data.

The location of rivers, creeks and transverse glades is described through a series of x-y coordinates. The location of these pre-drainage flowways is based on

government survey plats (completed between 1855 and 1870) and the SFWMD Primary Hydrography Coverage. River cells and associated river segments are identified by the intersection of the grid cell mesh with the river coordinates.

A.14.1.1.3.1.1.3 Time Variant Data

The hydrology of south Florida is primarily rainfall driven, and highly influenced by other hydrologic processes, e.g. ET, overland and ground water flow. This phenomenon is simulated in the NSM by applying external stimuli (rainfall, potential ET and boundary flow) to affected cells and moving water between cells in response hydrologic processes.

The NSM utilizes a rainfall database that contains daily estimated rainfall for each cell in the respective model domains. Estimates for each cell are based on rainfall data collected at the station nearest to the cell center. Rainfall data from 671 stations in ten counties were used to develop the database.

Daily potential ET is computed for eleven stations using the modified Penman - Monteith Method (Giddings and Restrepo, 1994). An inverse distance method is used to weigh the contribution of each station to each cell.

Daily inflows along the northern boundary are defined by a series of inflow points into Lake Istokpoga and Lake Okeechobee. These flows represent the "natural" inflow that would have occurred under pre-drainage conditions. The Lake Istokpoga and Fisheating Creek basins have not been greatly altered by water management projects, such as lake regulation schedules, channelization, and impoundments. The rainfall-runoff relationship is assumed to be comparable to pre-drainage conditions, and natural inflows from these basins are approximated by observed flows at Arbuckle Creek, Josephine Creek, ungauged local inflow at Lake Istokpoga, and Fisheating Creek.

The Kissimmee River basin has been affected by a number of water management projects, including the connection and regulation of lakes in the upper basin, and channelization of the Kissimmee River. Natural inflow from the Kissimmee basin is estimated using a rainfall-runoff model, calibrated to the earliest available flow data (1934-1942). A set of synthetic flows is generated using 1965-1995 rainfall and potential ET data. Inflow from peripheral basins north of Lake Okeechobee (Nubbins Slough, Taylor Creek and S154), are assumed to be proportional to the lower Kissimmee basin runoff.

Tidal boundaries are effectively flow boundaries, in that water is removed or added as water levels are adjusted to coincide with the tidal stage. Tidal boundaries are established in ocean cells, which include cells along the Atlantic Ocean and Florida Bay. Tidal stages are based on long-term monthly average

tide data at six tidal gauging stations along the Atlantic Ocean, Biscayne Bay and Florida Bay.

A.14.1.1.3.1.1.4 Hydrologic Processes

Water is distributed within the model domain by a set of hydrologic processes. Processes are modeled independently within each time step, with more transient phenomena computed before less transient phenomena.

Vertical movement of water within a cell is simulated by infiltration and ET processes. The infiltration process simulates the downward movement of water from surface water ponding to the water table. The ET process simulates the release of water from surface water ponding and ground water table to the atmosphere through evaporation and plant transpiration, respectively.

The overland flow process simulates surface water movement between adjacent cells. The NSM uses an explicit, finite difference method to solve the overland flow equations. No-flow boundaries are established for the non-ocean cells along the northern, eastern, and most of the western limits of the model domain. Fixed head boundaries based on the tidal stage are imposed in ocean cells. Fixed gradient boundaries are imposed in cells along the southwest boundary. Lake Okeechobee, Lake Istokpoga and Lake Hicpochee are treated as level pools, wherein an "equalizing" function computes average stage for each lake and uniformly imposes this stage in the respective lake cells.

Ground water flow is simulated by solving for ground water level in a finite difference approximation of the linearized two-dimensional, transient, subsurface flow equation for unconfined aquifers. A zero gradient ground water boundary condition is established along the perimeter of the model domain. The head values in ocean cells coincide with stages established by the tidal boundary.

The river flow process simulates the influence of rivers on water levels. Rivers are represented as storage volumes in the model. Downstream discharge can be released to a cell, defined as inflow to another river, or removed from the model (tidal release). An iterative bisection technique is used to compute the river stage for which net inflow is equivalent to change in storage.

A.14.1.1.3.1.1.5 Results

The hydrology of the pre-drained Everglades is dominated by surface water processes, driven by rainfall and ET. Water generally moves as surface water slowly from north to south in response to the low land surface water gradient. The large storage capacity of Lake Okeechobee, coupled with its long overflow perimeter provides the buffering capacity required to transform large lake inflows into a slow moving, low gradient release to the south. Within the

Everglades boundary, the magnitude of the overland flow vectors is uniform with a south to southeast direction in the upper/central Everglades. The relative magnitude of the overland flow vectors begins to concentrate in what is now Water Conservation Area 2B. This concentration continues through the northern transverse glades area south to Shark River Slough and southwest towards the Gulf of Mexico.

Water levels are uniform throughout the upper and central Everglades with median ponding depths of 0.5 to 1.0 ft. Water levels are more variable in the lower Everglades with depths up to 4 ft in the northern transverse glades region, 2.0 ft in Shark River Slough, and 0.5 ft above to 0.5 ft below land surface in the marl wetlands in ENP. Outside the historic Everglades boundary, median water levels are generally near land surface to more than 4 ft below land surface along the Atlantic Coastal Ridge and the Highlands Ridge.

Water levels within the Everglades boundary generally fluctuate between 2.0 and 2.5 ft annually, with a somewhat smaller range (1.75 ft) in Lake Okeechobee, Hillsboro Lakes and Shark River Slough. Water levels in virtually all of the Everglades drop below land surface at some point during the simulation. Conversely, virtually all of the Everglades have extended periods (< 12 months) of inundation. Under these "wet" conditions, annual low water ponding depths of 0.5-1.0 ft and 2.0 ft persist in the upper/central Everglades and Shark River Slough, respectively.

Although much of the Everglades is subject to annual low water levels which drop below land surface, the duration of the dry down is very short. The median number of days of inundation per year or "hydroperiod" for the Everglades is generally greater than 330 days/year. Even under very dry conditions, hydroperiods in the upper/central Everglades are generally greater than 150 days/hr and hydroperiods in the Shark River Slough to the northern transverse glades area still exceed 335 days/yr.

A.14.1.1.3.2 Existing Conditions Model

NOTE: Information and figures in this section of the Hydrology Appendix A were obtained from http://www.sfwmd.gov/org/pld/restudy/hpm/index.html.

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C&SF Project Restudy – Existing (1995) and Future (2050) Without Project Condition Summaries

	Existing (1995) Condition	Future (2050) Without Project Condition
Climate	The 1965 to 1995 climatic record was used for evaluations of the Existing (1995) Condition. Rainfall and potential evapotranspiration are the key climatic inputs. The same climatic record is also used for the evaluation of the Future (2050) Without Project Condition and will be used in the evaluation of plan alternatives.	Just as for the Existing (1995) Condition, the 1965 to 1995 climatic record was used to evaluate the Future (2050) Without Project Condition. This same climatic record will be used for the evaluation of all plan alternatives. Rainfall and potential evapotranspiration are the key climatic inputs.
Sea Level	For the Existing (1995) Condition, sea level data from six long-term USGS stations were used to generate a historic record to use as sea level boundary conditions for the 1965 to 1995 evaluation period.	For the Future (2050) Without Project Condition the same sea level data as for the Existing (1995) Condition are being used. An evaluation has also been completed for the Future (2050) Without Project Condition utilizing a ½ foot rise in sea level so that the impacts of such a change on the performance of the water management system can be assessed.
Population and Socio-Economic Conditions	The Existing (1995) Condition reflects actual 1995 population and socio-economic conditions. Population and socio-economic conditions enter into and affect the Existing (1995) Condition analysis largely through their impact on water demands.	Projections of 2050 population and socio-economic conditions for all areas except Service Area 3 (most of Dade County) are those contained in Final Report Municipal and Industrial Water Use Forecast Lake Okeechobee Regulation Schedule Study prepared for the U.S. Army Corps of Engineers Jacksonville District, August 1996. The projections contained in that report that are based on those developed by the University of Florida, Bureau of Economic and Business Research were utilized. For Service Area 3, projections in the report cited above were increased to reflect Dade County's estimation of its future population growth as influenced by recent immigration legislation and other factors.
Land Use	• For the portions of the Coastal Basins Covered by the Water Preserve Area Land Suitability Analysis, land use data updated through 1994 were available and were used for the analysis of the Existing (1995) Condition. For the remaining portions of the Coastal Basins the latest data available were the 1988 land use data developed for the Draft Lower East Coast Regional Water Supply Plan. • Land use in the Everglades Agricultural Area represents the estimated conditions in 1990, as estimated for the Draft Lower East Coast Regional Water Supply Plan. • Land use conditions in the remainder of the Lake Okeechobee Service Area are accounted for through the evaluations of demands.	• For the Coastal Basins for 2050, land use projections were based on future land use maps (2010) from local government comprehensive plans. • In the Everglades Agricultural Area land use will be the same as for the Existing (1995) Condition except that the land to be used for stormwater treatment areas will be shifted to that use. • Impacts of changes in land use in the remainder of the Lake Okeechobee Service Area are accounted for through the evaluations of demands. (see below)
Natural Area Land Cover (Vegetation)	Recently updated information on vegetation classes and their spatial distribution prepared by the District was used for the natural areas. The updated information include improved classification of wetland land cover types and generally reflect conditions in the 1990 to 1995 period.	• The 2050 vegetation classes and spatial distribution will remain the same as those proposed for the Existing (1995) Condition.
Urban and Agricultural Water Demands	• For the analysis of the Existing (1995) Condition, historical 1995 data on public water supply wellfield pumpages were used. The same public water supply pumpages are used for each of the 31 years of the analysis. • Irrigation demands in the Coastal Basins were based on land use and the daily climatic data for the 31 years of the analysis. • Everglades Agricultural Area irrigation demands were based on historic use patterns and daily climatic data for the thirty-one years of the analysis. • Demands on Lake Okeechobee by the remainder of the Lake Okeechobee Service Area (other than the Everglades Agricultural Area) including those of the Caloosahatchee and St. Lucie Canal Basins were based on historical	• For all areas, except Service Area 3, the public water supply demands which will be used are those contained in Final Report Municipal and Industrial Water Use Forecast Lake Okeechobee Regulation Schedule Study prepared for the U.S. Army Corps of Engineers Jacksonville District, August 1996. The University of Florida Bureau of Economic and Business Research unrestricted demand set was used. These reflect University of Florida Bureau of Economic and Business Research generated population projections. For Service Area 3 the public water supply demands have been increased to reflect Dade County's estimation of its future population growth as influenced by recent immigration legislation and other factors.

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	Existing (1995) Condition	Future (2050) Without Project Condition
	records adjusted to reflect growth in demands over time due to development in these basins. • The St. Lucie Canal Basin demands include the existing Florida Power and Light reservoir at Indiantown. • The Upper East Coast rainfall runoff-relationship is the same as the runoff-relationship developed during the Indian River Lagoon Feasibility Study.	• Irrigation demands in the Lower East Coast Service Area are based on projected land use and climatic variables. • Irrigation demands for the Everglades Agricultural Area reflect the construction in the Stormwater Treatment Areas • Caloosahatchee River Basin demands increase by 40% from the Existing (1995) Condition based on Mazzotti's IFAS Citrus Study • St. Lucie Canal Basin demands remain the same as the Existing (1995) Condition based on projected land use and include the demand associated with the Florida Power and Light reservoir at Indiantown which will increase up to the existing permitted demand. • The Upper East Coast rainfall-runoff relationship will be the same as that used in the Existing (1995) Condition.
Physical Facilities & Operations - Lake Okeechobee & Lake Okeechobee Service Area	Existing (1995) water management system and practices including: • Lake Okeechobee Regulation Schedule Run-25 with: Lake Okeechobee regulatory discharges to Water Conservation Areas first, then to Caloosahatchee & St. Lucie if insufficient conveyance capacity exists through the Everglades Agricultural Area. Also Lake Okeechobee regulatory discharge to Water Conservation Areas allowed if Water Conservation Areas are below their regulation schedules. • Lake Okeechobee Supply Side management policy for Lake Okeechobee Service Area water restriction cutbacks • Interim Action Plan for reduced stormwater backpumping to Lake Okeechobee from Everglades Agricultural Area • No water supply backpumping to Lake Okeechobee from the Everglades Agricultural Area • Everglades Agricultural Area Best Management Practices • Everglades Agricultural Area Best Management Practices assumed to reduce runoff from Everglades Agricultural Area by ~18% per year • Everglades Agricultural Area Best Management Practices assumed to not reduce irrigation requirements from Lake Okeechobee • Replacement Water Deliveries per Everglades Forever Act(EFA)/SFWMD Rule • Historical Kissimmee River inflows to Lake Okeechobee.	Four changes are associated with the Everglades Construction Project as mandated by the Everglades Forever Act. They are: • Stormwater Treatment Areas • Northern L-8 water directed to Lake Okeechobee • Water quality entering Water Conservation Areas assumed to be that produced by Phase 2 of the Everglades Construction Project • Additional Everglades Agricultural Area lands previously draining to Lake Okeechobee now drains to the Everglades Protection Area More information on these components are described in the footnote.[1] Other changes are: • Deliveries to Water Conservation Areas up to annual average Best Management Practices Replacement Water Rule volumes • Kissimmee River Restoration and the Headwaters Revitalization Project, which will change the timing and amount of water flowing from the Kissimmee Basin into Lake Okeechobee.[2] • Strengthening of the Herbert Hoover Dike[3]
Physical Facilities & Operations – Water Conservation Areas, Holey Land Wildlife Management Area and	Existing (1995) water management system and practices including: • No net outflow from Water Conservation Areas (WCA) if water level is less than minimum operating criteria in canals of Loxahatchee National Wildlife Refuge (WCA-1): 14 ft., WCA-2A: 10.5ft., WCA-3A: 7.5 ft. • No regulatory releases to tide from Water Conservation Areas • C&SF Interim Regulation Schedule for the Loxahatchee National Wildlife Refuge (WCA-1) • Current WCA-2A & 3A regulation schedules • The topography in WCA-3B is consistent with the most recent USGS survey (USGS Report, December 1995) with the appropriate datum conversion from 1988 NAVD to 1929 NGVD.	1995 water management system and practices with the following changes: • No net outflow from Water Conservation Areas if water levels is less than Minimum Level marsh triggers or less than minimum operating criteria in canals of the Loxahatchee National Wildlife Refuge (WCA-1): 14 ft., WCA-2A: 10.5ft., WCA-3A: 7.5ft. Marsh level triggers will be those used in the Draft Lower East Coast Regional Water Supply Plan alternative 5. • Rainfall driven operational criteria for determining timing of deliveries to and discharges from WCA 2A and 3A with quantity adjusted to approximate Best Management Practices Replacement water quantities. • Structural modifications per federally authorized Modified Water Deliveries project[4] • Structural features of the Holey Land Wildlife Management Area are to be consistent with the Everglades Construction Project and operations

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	Existing (1995) Condition	Future (2050) Without Project Condition
Rotenberger Wildlife Management Area		consistent with the Existing (1995) Condition. • Operations of the Rotenberger WMA are to be consistent with the Everglades Construction Project (December 1997 design of STA 5 and STA 6). • The topography in WCA-3B will be the same as that used in the Existing (1995) Condition.
Physical Facilities & Operations – Everglades National Park	Existing (1995) water management system and practices including: • Water deliveries to Everglades National Park are based on the current Experimental Rainfall Delivery Plan for flows to Shark River Slough via S-12's and S-333 • Test 7 Phase 1 Operations of Experimental Program of Water Deliveries to Everglades National Park	1995 water management system and practices with the following changes: • The Federally authorized Modified Water Deliveries to Everglades National Park Project using a modified rainfall delivery plan to more closely replicate natural system like conditions consistent with WCA-3A rain-driven operations[4] • Federally authorized C-111 Project for Taylor Slough and East Panhandle.[5]
Physical Facilities & Operations – Lower East Coast Service Area	Existing (1995) water management system and practices including: • Existing C&SF system and operating rules in effect in 1995 • Existing secondary drainage/water supply system • Existing public water supply wellfields	1995 water management system and practices with the following changes: • Wellfield expansion in Service Areas 1, 2 and 3 based on the Lower East Coast Interim Plan [6] • Broward secondary canal recharge network based on the Lower East Coast Interim Plan [7] • Dade County utility aquifer storage and recovery based on the approved Lower East Coast Interim Plan [8] • Selected elements of L-8 project[9] • Northwest Dade Lake Belt area- assume that the conditions caused by the currently permitted mining exist and that the affects of any future mining are fully mitigated by industry. • Operational adjustments to try to maintain water levels in coastal canals to meet Minimum Levels in the Biscayne Aquifer as proposed in the Draft Lower East Coast Regional Water Supply Plan. • All projected service area demands will be reduced by 12% to account for the expected implementation of SFWMD's mandatory water conservation program (implementation of ultra-low flow fixtures and lawn sprinkler restrictions in residential and commercial land use).
Physical Facilities & Operations – Western Basins and Big Cypress	Existing (1995) water management system and practices including: • Estimated historical inflows from Western basins	1995 water management system and practices with the following changes: • Estimated inflows from Western basins according to Everglades Construction Project • Big Cypress Seminole Reservation irrigation demands increase reflecting the Seminole Compact.[10]
Region-wide Water Management and Related	• The analysis of the Existing (1995) Condition reflects the existing water shortage policies as reflected in South Florida Water Management District rule 40E-21. The impacts of declarations of water shortages on utility water use reflect assumptions contained in the Draft Lower East Coast Regional Water Supply Plan for the 2010 base case. These are that Phase 1 restrictions result in a 10% decrease in water use, while Phase 2 results in a	The assumptions for the Future (2050) Without Project Condition are the same as for the Existing (1995) Condition.

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	Existing (1995) Condition	Future (2050) Without Project Condition
Operations	25% decrease, Phase 3 a 40% decrease and Phase 4 a 55% decrease. • Implementation of supply side management in the Lake Okeechobee Service Area is evaluated to mimic existing District practices as detailed in the District publication Lake Okeechobee Supply-side Management Plan, September 1991.	

[1] The components of the Everglades Construction Project are:

- Stormwater Treatment Areas – These 6 areas will cover more than 40,000 acres and will reduce the amount of phosphorus and other constituents in stormwater runoff before it enters the Everglades Protection Area. Associated facilities will improve the distribution of water as it enters the Everglades Protection Area to help recreate sheet flow conditions. Other improvements include enhanced flood protection for the C-51 basin.
- Northern L-8 water directed to Lake Okeechobee – A divide structure in L-8 and a pump station and improved structures at Lake Okeechobee will be used to direct runoff from the northerly part of the L-8 basin (consisting primarily of the Dupuis Reserve and the J.W. Corbett Wildlife Management Area) to Lake Okeechobee.
- Water quality entering Water Conservation Areas assumed to be that produced by Phase 2 of the Everglades Construction Project – The Everglades Forever Act requires that future inflows to the Everglades Protection Area meet future established standards for phosphorus or a default standard of 10 parts per billion. Because it is not certain what the phosphorus standards will be or what will be implemented without the C&SF Restudy to achieve those standards, the Future (2050) Without Project Condition assumes water entering the Everglades Protection Area will be of the quality produced by the Stormwater Treatment Areas. The alternatives of the Restudy will include as components those additional facilities needed to achieve the best estimate of the future standards.
- Additional Everglades Agricultural Area basins previously draining to Lake Okeechobee now drain to the Everglades Protection Area. – As part of the requirements of the Everglades Forever Act, much of the water previously discharged to Lake Okeechobee from the East Beach, East Shore, 715 Farms and South Shore drainage districts will be routed to the Stormwater Treatment Areas and the Everglades Protection Area.

[2] The Kissimmee River Restoration Project will result in the backfilling of 29 miles of the C-38 Canal and the excavation of 11.6 miles of new river channel. This will restore a significant portion of the Kissimmee River and about 29,000 acres of wetlands. To provide the water in the timing and quantities needed for the restoration of the River, the Headwaters Revitalization Project is being undertaken. It includes modifications of the regulation schedules for the Upper Chain of Lakes and associated canal and water control structure modifications. The Headwaters Revitalization Project will also provide ecological benefits within the Upper Chain of Lakes Area. The impact of this project on Lake Okeechobee is that the timing of inflows to Lake Okeechobee will be changed and approximately 1.6% less water will enter the Lake from the Kissimmee River due to additional evapotranspiration upstream.

[3] These improvements will make the Herbert Hoover Dike less likely to fail under the existing regulation schedule and allow for slightly higher regulation schedules to be implemented without incurring additional costs. Such higher regulation schedules are not part of the Future (2050) Without Project Condition.

[4] The Modified Water Deliveries to Everglades National Park Project provides structural modifications to enable the restoration of more natural water flows to Shark River Slough in Everglades National Park. Components include structures to improve conveyance from WCA-3A to WCA-3 B and from WCA-3B to Everglades National Park, removal of an existing levee and canal (L-67 Extension) within Everglades National Park, a seepage control levee, canal and pump station to prevent additional flooding in the 8.5 square mile area, floodproofing of a Miccosukee Indian Camp and a pump station to return captured seepage water to Shark River Slough.

[5] The C-111 project consists of structural and non-structural modifications within the C-111 basin, which will improve hydroperiods in Taylor Slough, Shark River Slough and the eastern Panhandle areas of the Everglades. It will maintain flood protection within the agricultural areas adjacent to C-111. The C-111 Project Canal operations will be consistent with the authorized levels (aka Base '83) as recommended by SERA.

[6] This component is to be implemented as a result of the Lower East Coast Interim Plan and provides for relocation of future and some existing withdrawals from existing (1995) wellfields. Demands of the following utilities were evaluated assuming new wellfield locations: Lake Worth, Manalapan, Lantana, Boca Raton, Fort Lauderdale, Hollywood and Hallandale. The evaluations assumed that, for these utilities, demands shifted to new wellfields were the same as those identified in the Draft Lower East Coast Regional Water Supply Plan. Generally this means that 1995 levels of demands continued to be met from existing facilities while the portion of new demands beyond the 1995 levels were met from the newly expanded wellfields. The new wellfields were generally evaluated as being located along the western boundary of each utility's service area.

[7] This component is to be implemented as a result of the Lower East Coast Interim Plan and includes pump stations and structures which would maintain higher levels in secondary canals

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in eastern Broward County between the Hillsboro and the North New River Canals during the dry season. The selected canals are located where recharge from the canals would help to hold back the salt water front and protect the production capability of wellfields to the east.

[8] This component is to be implemented as a result of the approved Lower East Coast Interim Plan and includes ASR wells and related facilities that would be installed associated with wellfields of the Miami Dade Water and Sewer Authority Department. These facilities would be operated to store water in the Floridan Aquifer in the wet season and recover this water in the dry season. For the Future (2050) Without Project Condition the evaluations were for a daily injection and recovery capacity of 150 mgd, a maximum recovery percentage of injected water of 90% an annual injection period of 7 months and an annual recovery period of 5 months.

[9] This component is to be implemented as a result of the Lower East Coast Interim Plan. It includes a structure and pump station from C-18 to the Loxahatchee Slough, an improved structural connection from the West Palm Beach Water Catchment Area to the Loxahatchee Slough, aquifer storage and recovery wells at the West Palm Beach Water Catchment Area or the Indian Trails Improvement District impoundment and a coastal recharge delivery system.

[10] The estimated irrigation demands for the Big Cypress Seminole Reservation will be supplied by local sources first then by the regional system. While deliveries to this area to meet irrigation demands are increased as compared to the Existing (1995) Condition, no increase in runoff is assumed.

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A.14.1.1.4 Future With-Out Project Condition

See (2) Existing Conditions Model above.

A.14.1.1.5 Alternatives

A.14.1.1.5.1 WPA Alternative 2

A.14.1.1.5.1.1 Component O

Geographic Region: Water Preserve Area - Broward County

Component Title: Water Conservation Area (WCA) 3A and 3B Levee Seepage Management – SEE WPA COMPONENT MAPS 7 and 8

Purpose: Reduce seepage from WCAs 3A and 3B to improve hydropatterns within the Conservation Areas by allowing higher water levels in the borrow canals and longer inundation durations within the marsh areas that are located east of the WCAs and west of US Highway 27. Seepage from the WCAs and marshes is collected and directed south into the Central Lake Belt Storage Area. This maintains flood protection and the separation of seepage water from urban runoff originating in the C-11 Basin and Lake Okeechobee water supply deliveries.

Operation: The L-37 and L-33 borrow canals are held at higher stages as part of the WCA 2 seepage collection and conveyance system (Component YY). Seepage that is collected in the L-37 and L-33 borrow canals and from the marsh areas will be directed into the WCA 2 seepage collection and conveyance system and is directed south into the Central Lake Belt Storage Area or directly to the North East Shark River Slough.

Design: New levees are constructed west of US Highway 27 from the North New River Canal to the Miami (C-6) Canal to separate seepage water from the urban runoff collected in the C-11 Diversion Impoundment and Canal (Component Q).

The L-37 and L-33 borrow canals are controlled at higher stages, elevations 8.0 feet NGVD and 7.0 feet NGVD, respectively, as are the marshes east of the WCAs. A control structure is added in the L-37 borrow canal just north of the S-9 pump station. It consists of a gated spillway, which maintains the L-37 borrow canal at elevation 8.0 feet NGVD. Another control structure consisting of a gated spillway is added in L-33 borrow canal just north of its intersection with the C-6 Canal and maintains the L-33 borrow canal at elevation 7 feet NGVD.

A divide structure is added in the C-11 Canal, east of US Highway 27 to maintain a headwater stage of 4.0 feet NGVD and the separation of seepage

water from urban runoff. Water from the C-11 west basin is diverted south to the North Lake Belt Storage Area.

Location: Seepage that is collected in borrow canals along the existing eastern protective levees adjacent to WCA 3. Divide structure that is located in C-11 Canal east of US Highway 27.

Counties: Broward

Summary of modifications from Alternative 1: No change from Alternative 1

Assumptions and related considerations:

It is assumed that the seepage from the Water Conservation Areas meets the water quality standards necessary to achieve ecosystem restoration.

A.14.1.1.5.1.2 Component Q

Geographic Region: Water Preserve Area - Broward County

Component Title: Western C-11 Diversion Impoundment and Canal -- to North Lake Belt Storage Area - SEE WPA COMPONENT MAPS 7

Purpose: Divert untreated runoff from the western C-11 basin that is presently discharged into Water Conservation Area 3A into the C-11 Impoundment prior to sending it south to the North Lake Belt Storage Area (NLBSA).

Operation: Divert runoff previously backpumped into the Water Conservation Area 3A in the western C-11 Canal basin into the C-11 Impoundment until full, then send it to the C-9 Impoundment until full and finally to NLBSA. If storage capacity is not available in the C-11 Impoundment, C-9 Impoundment or NLBSA, then the S-9 pump station is used to provide flood protection for the western C-11 basin and runoff is pumped into WCA-3A. To improve groundwater elevations in the eastern C-11 Canal basin, the S-9 seepage divide structure operates to maintain the western C-11 Canal stage at elevation 3.5 feet NGVD. For Alternative 2, the impoundment depth increases to 6 feet. A shallower area along the eastern boundary is held at 2 feet to improve seepage control and allow the permitted mitigation areas to be relocated in it, out of the 6-foot deep area. A 7-foot high internal levee separates the west and east compartments. The two compartments interconnect to allow transfer of flows.

Design:

1. 2500 cfs diversion canal west of US Highway 27 between the C-11 and C-9 Canals and 2500 cfs conveyance capacity improvements to the C-9 Canal between S-30 and the diversion structure into NLBSA.

2. A 2500 cfs inflow pump station in the C-11 Canal to direct runoff to the C-11 Impoundment (pump on elevation 4.0 feet NGVD and pump off elevation 3.0 feet NGVD or when the impoundment reaches 4 feet deep).
3. 1734-acre impoundment is surrounded by an 11-foot high external levee. 1119 acres has a maximum depth of 6 feet and 615 acres has a maximum depth of 2 feet.
4. Seepage collection canals and pumps for C-11 Impoundment. Seepage collection canal system is maintained between elevations of:
   6.5 and 6.0 feet NGVD by a 25-cfs pump (northern section)
   5.0 and 5.3 feet NGVD by a 240-cfs pump (eastern section)
   and 8.0 feet NGVD by an 80-cfs pump (western section)
5. 2200 cfs discharge structure @ 4 feet of head to discharge from the impoundment to the US 27 west borrow canal.
6. A 7-foot high internal levee separates the western 6-foot deep storage area from the 2-foot deep eastern storage area. Transfer of flow is accomplished by 3 sets of gated culverts each consisting of two 60-foot long 72-inch diameter culverts.

Location: The diversion canal is located west of US Highway 27 between C-11 and C-9 Canals. The C-11 Impoundment is located northwest of the intersection of US Highway 27 and C-11 Canal.

Counties: Broward, Miami-Dade

Summary of modifications from Alternative 1: The impoundment depth increases to 6 feet. A shallower area along the eastern boundary will be held at 2 feet to improve seepage control and allow the permitted mitigation areas to be located in it, out of the 6- foot deep area. A 7-foot high internal levee separates the west and east compartments. The two compartments are interconnected to allow transfer of flows.

Assumptions and related considerations:
1. Flood protection component for FPL substation and mobile home park may be needed. For each facility, propose a 60 cfs pump with an on elevation of 6.0 feet NGVD and an off elevation of 5.0 feet NGVD.
2. Telemetry systems are required for all operable structures and pump stations.

A.14.1.1.5.1.3 Component R

Geographic Region: Water Preserve Area - Broward County

Component Title: C-9 Impoundment - SEE WPA COMPONENT MAP 8

Purpose: Treatment of water supply deliveries from the North Lake Belt Storage Area (NLBSA) to the C-9, C-6/C-7 and C-2/C-4 Canals. Runoff is backpumped into the NLBSA from the western C-9 Canal basin and the western C-11 Canal. The C-9 Impoundment provides settlement of urban runoff that is stored in the North Lake Belt Storage Area, groundwater recharge within the basin and seepage control of WCA 3 and buffer areas are located west of the impoundment.

Operation: In Alternative 2, the design and operation of the C-9 Impoundment are modified. Excess runoff from the C-11 Impoundment is pumped directly into the C-9 Impoundment from the US 27 west borrow canal (new pump). The C-9 Impoundment is divided into three compartments. The west compartment is held at a 6-foot maximum depth with two shallower step down areas located to the north and east. The north and east compartments will be held at a maximum depth of 2 feet. During dry periods, stormwater that is stored in the NLBSA is pumped into the C-9 Impoundment for settlement (if necessary) and then is released to provide water supply deliveries based on salinity control targets to the C-7, C-6, C-4 and C-2 Canals. Seepage from the C-9 Impoundment is collected and returned.

Design:

1. 2091-acre impoundment is divided into 3 compartments west, east and north. West (1232 acres) is held at a maximum of 6 feet deep, east (474 acres) is held at a maximum of 2 feet deep and north (385 acres) is held at a maximum of 2 feet deep.
2. Inflow structures: One, 1000 cfs pump from US 27 west borrow/delivery canal to C-9 Impoundment. (Pump on when the C-11 Impoundment is discharging and the depth in the impoundment is less than 4 feet above natural ground and pump off when discharge from the C-11 Impoundment is zero). One, 1000 cfs pump (from NLBSA, to be resized as needed) SEE COMPONENT XX. Pump on when water supply deliveries are needed to C-6, C-7, C-4 and C-2 and water level in the NLBSA is above –20.0 feet NGVD or when the depth in the impoundment is less than 4 feet above natural ground.
3. Outflow structures: Two gravity structures each with 1000 cfs capacity at 4 feet of head to C-6, C-7, C-4, and C-2 Canals for water supply deliveries. One is located in the western portion of the impoundment (6-foot depth) and the other is located in the eastern portion of the impoundment (2-foot depth).
4. Seepage Collection: A total of 300 cfs is recycled into the impoundment area. Seepage is collected along the western side of the impoundment by a 100-cfs pump with an on elevation of 8.0 feet and off elevation of 7.5 feet NGVD. Seepage is collected along the eastern side of the impoundment by

a 100-cfs pump with an on elevation of 3.0 feet and off elevation of 2.5 feet NGVD. Seepage is collected along the north side of the impoundment by a 100-cfs pump with an on elevation of 3.0 feet and off elevation of 2.5 feet NGVD.

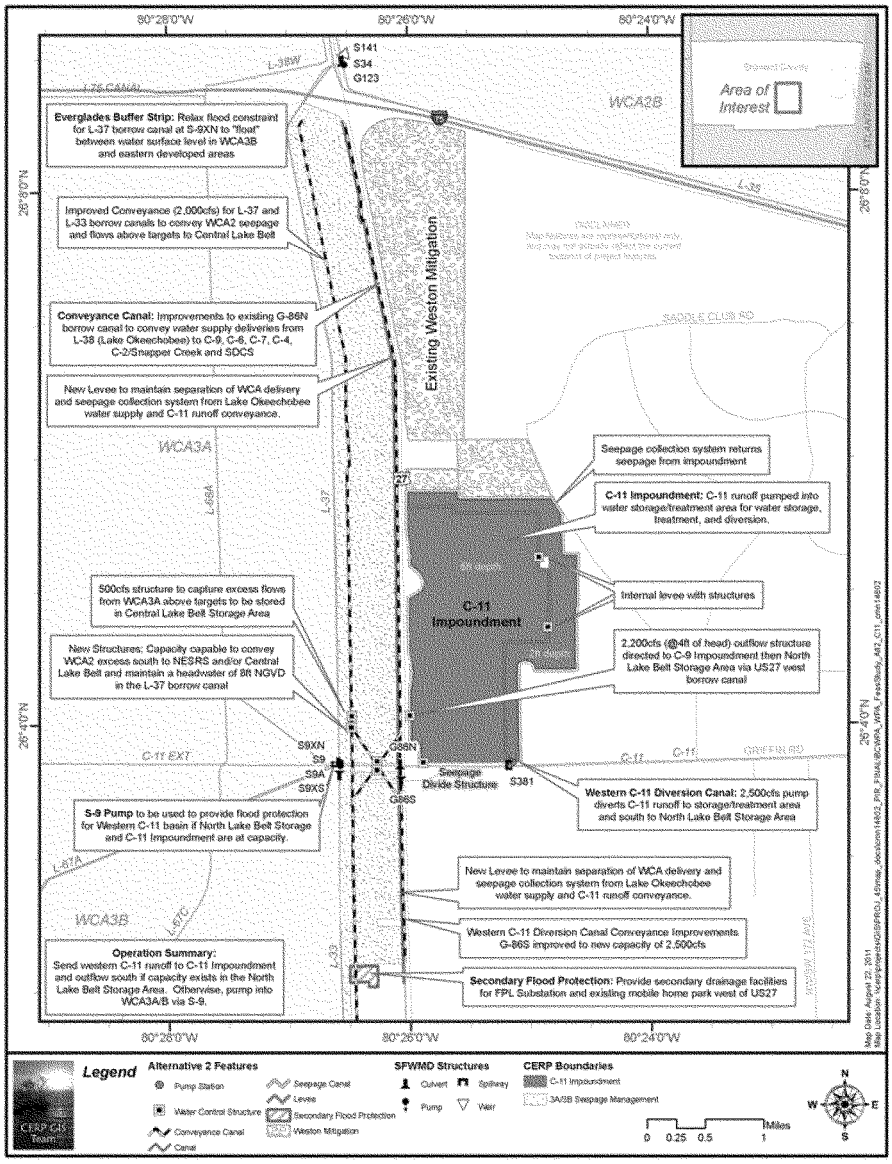
Location: Site identified by Water Preserve Area Land Suitability Analysis

Counties: Broward

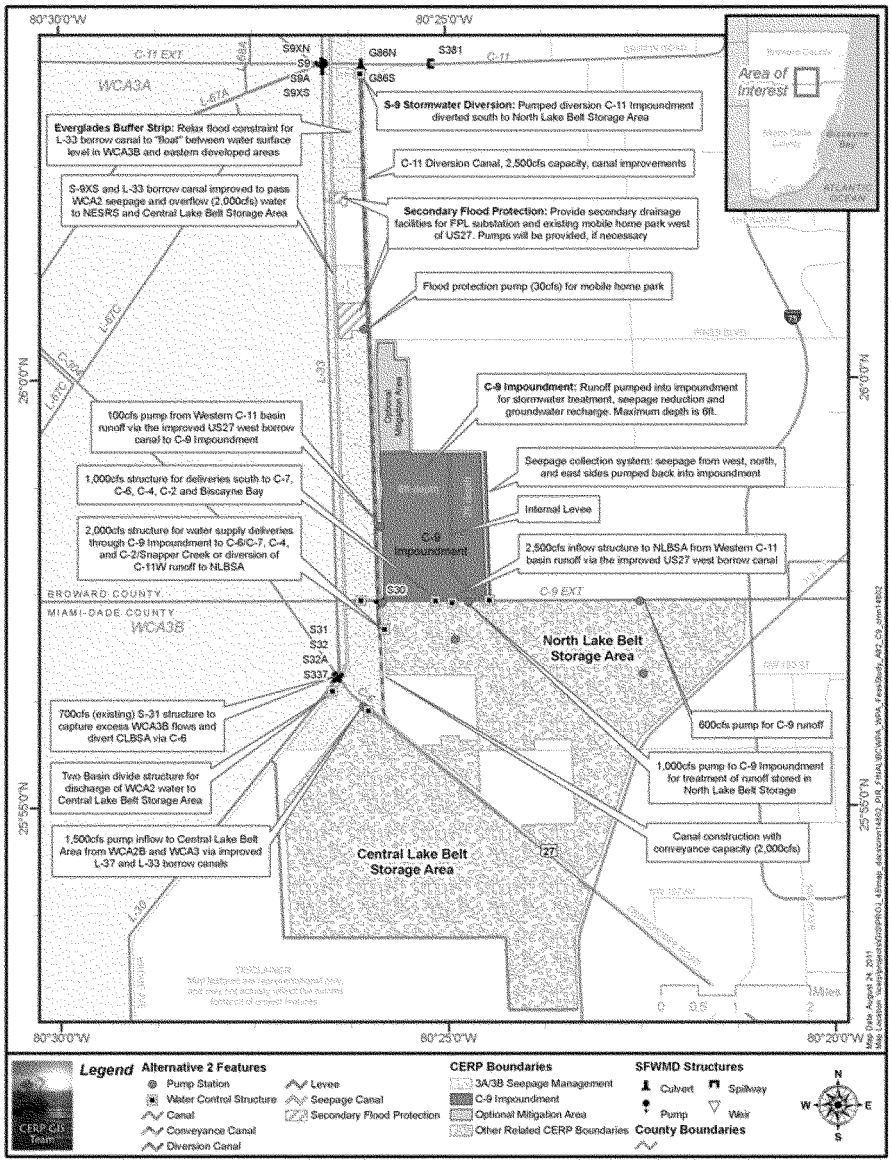
Summary of modifications from Alternative 1: The impoundment is divided into three compartments. The operation of the impoundment is modified. Additional mitigation areas are relocated to the north compartment. The internal levee was relocated. The seepage collection system and inflow pump operation is modified.

Assumptions and related considerations:

1. Additional settlement facility is needed if stored water is backpumped into Water Conservation Area 3A.
2. Telemetry systems are required for all operable structures and pump stations.



WPA FEASIBILITY STUDY – ALT 2 CENTRAL BROWARD AREA WPA COMPONENT MAP 7



WPA FEASIBILITY STUDY – ALT 2 SW BROWARD AREA WPA COMPONENT MAP 8

A.14.1.1.5.2 WPA Alternative 3

A.14.1.1.5.2.1 Component O

Geographic Region: Water Preserve Area - Broward County

Component Title: Water Conservation Area (WCA) 3A and 3B Levee Seepage Management – SEE WPA COMPONENT MAPS 7 and 8

Purpose: Reduce seepage from WCAs 3A and 3B to improve hydropatterns within the Water Conservation Areas by allowing higher water levels in the borrow canals and maintaining longer inundated durations within the marsh areas that are located east of the WCAs and west of US Highway 27. Seepage from the WCAs and marshes is collected and directed south into the Central Lake Belt Storage Area. This maintains flood protection and the separation of seepage water from urban runoff originating in the Western C-11 Basin and Lake Okeechobee water supply deliveries.

Operations Summary: The L-37 and L-33 borrow canals are held at higher stages as part of the WCA 3A and 3B seepage management system. Additionally, the borrow canals are also used to convey flows as part of the WCA-2B diversion flow system (Component YY). Seepage and canal flows collected in the L-37 and L-33 borrow canals are directed south to the North East Shark River Slough to meet its demands; to the Central Lake Belt Storage Area to store; or returned to WCA 3A through the proposed critical project pump S-9A.

Detailed Design and Operation: New canal with levees (US27W) are constructed west of US Highway 27 from the North New River Canal to the Miami (C-6) Canal. The canal and levees serve two purposes: (1) to separate seepage water from the urban runoff collected in the Western C-11 Diversion Impoundment and Canal (Component Q) and (2) maintain separation from Lake Okeechobee dry season delivery waters.

1. The L-37 and L-33 borrow canals are controlled at higher stages to control seepage from WCA 3A and 3B.
2. The northern Everglades Buffer Strip (a marsh area) has a controlled maximum elevation of 7.5 ft NGVD for the wet season and 6.5 ft NGVD for the dry season. A new 50 cfs gravity control structure in the L-37 Canal just east of the S-9 pump station is used to maintain these levels and provide operational flexibility. The discharge into the C-11 Canal is diverted or return pumped into WCA-3A by the S-9A pump station (critical project).
3. The southern Everglades Buffer Strip has a controlled maximum elevation of 6.5 ft NGVD for the wet season and 5.5 ft NGVD for the dry season. A 2000 cfs gated spillway is used to maintain these levels; as well

as to control WCA 2B, 3A and 3B flows to the south via the L-30 borrow canal or the Miami Canal (C-6).

4. A divide structure is added in the C-11 Canal, east of US Highway 27 to maintain a headwater stage of 5.0 feet NGVD and the separation of seepage water from urban runoff. Seepage water west of the divide structure is backpumped into WCA-3A by the new critical project pump station S-9A. Water from the C-11 West Basin, east of the divide structure is backpumped into the C-11 Impoundment and may be diverted south to the North Lake Belt Storage Area or indirectly to the C-9 Impoundment as storage availability exists.

Location: Seepage collects in borrow canals along the existing eastern protective levees adjacent to WCA 3. Divide structure is located in the C-11 Canal east of US Highway 27.

Counties: Broward

Summary of modifications from Alternative 2: Add 50 cfs fixed crest weir to transfer water from Everglades Buffer Strip to WCA 3A. Modify control elevations for L-33 and L-37 borrow canals to vary hydroperiod in the northern and southern Everglades Buffer Strips.

Assumptions and related considerations:

It is assumed that the seepage from the Water Conservation Areas meets the water quality standards necessary to achieve ecosystem restoration.

A.14.1.1.5.2.2 Component Q

Geographic Region: Water Preserve Area - Broward County

Component Title: Western C-11 Diversion Impoundment and Canal -- to North Lake Belt Storage Area - SEE WPA COMPONENT MAPS 7

Purpose: Divert untreated runoff from the C-11 West Basin that is presently discharged into Water Conservation Area 3A into the C-11 Impoundment prior to sending it south to the North Lake Belt Storage Area (NLBSA).

Operations Summary: Divert runoff previously pumped into WCA-3A from the C-11 West Basin into the C-11 Impoundment until full, then send it to the NLBSA. If storage capacity is not available in the C-11 Impoundment, the C-9 Impoundment or the NLBSA, then the S-9 pump station is used to provide existing flood protection by pumping runoff into WCA-3A. To improve groundwater elevations in the C-11 East Basin and Pond Apple Slough (east of

S-13AW) during dry seasons S-13AW is opened and deliveries from C-11 Impoundment are made when stage at S-13 is 3.5 ft NGVD. If water is not available from C-11 Impoundment, then deliveries are made by opening S-381 (critical project) and allowing seepage water to recharge the basin and prevent excessive dry-outs. The 1734-acre impoundment is divided into two compartments, east and west. 1) A 453-acre wetland buffer is located along the eastern boundary. Water is stored at less than 2 foot deep on average, but can store a maximum of 4 feet of water for short durations. 2) A western compartment (1281 acres) can store water to a maximum depth of 6 foot. The east compartment improves seepage control and allows the relocation of permitted mitigation areas from the 6-foot deep compartment. Excess water is released first from the eastern compartment, then from the western compartment. The western compartment fills prior to the eastern compartment.
Detailed Design and Operation:

1. 2500 cfs diversion canal west of US Highway 27 between the C-11 and C-9 Canals and 2500 cfs conveyance capacity improvements to the C-9 Canal between S-30 and the diversion structure into NLBSA.
2. 1734-acre impoundment is surrounded by an 11-foot high external levee. 1281 acres has a maximum depth of 6 feet and 452 acres has a maximum depth of 2 feet.
3. A 7-foot high internal levee separates the western 6-foot deep storage compartment from the wetland buffer. Transfer of flow is accomplished by 3 sets of gated culverts each consisting of two 60-foot long 72-inch diameter culverts.
4. Inflows: A 2500 cfs capacity inflow pump in the C-11 Canal directs runoff to the C-11 Impoundment's western compartment first
    - dry season pump on elevation 4.0 ft NGVD and pump off elevation 3.7 ft NGVD;
    - wet season pump on elevation 3.9 ft NGVD and pump off elevation 3.5 ft NGVD or when the impoundment reaches 6 feet of depth.
5. Discharges: 2500 cfs structure discharges from the impoundment to an improved US 27 West borrow canal when stages reach 4.0 ft NGVD. A gravity structure discharges water from the eastern compartment to the C-11 Extension Canal. When the impoundment at capacity, the eastern compartment discharges first and the western compartment discharges second.
6. Seepage collection canals is maintained by:
    - A 25 cfs seepage pump station (north and northeast boundary) operates at elevation 5.0 ft NGVD and ceases at 4.7 ft NGVD.
    - An 80 cfs seepage pump station (west boundary) operates at elevation 6.0 ft NGVD and ceases at 5.5 ft NGVD.
    - Southeastern boundary is controlled by the C-11 Extension Canal, an ungated canal from C-11 Canal.

7. The hydroperiod in the eastern compartment ranges between 1-1 ½ foot depth on average with dry down durations of not more than 2 months and water elevations dropping no more than 1 foot below natural grade for more than 1 month.
8. An emergency overflow spillway is designed as a lower section of the levee to maintain impoundment levee integrity. The emergency overflow spillway invert elevation is 1 foot above the maximum normal operating elevation. The spillway will discharge into the C-11 Canal.

Location: The diversion canal is located west of US Highway 27 between C-11 and C-9 Canals. The C-11 Impoundment is located northwest of the intersection of US Highway 27 and C-11 Canal.

Counties: Broward, Miami-Dade

Summary of modifications from Alternative 2: The east and west compartments locations have been modified. The eastern compartment has a maximum depth of 4 feet for temporary storage of large rain events. Its hydroperiod ranges between 1-1 ½ foot depth on average. The western, 6-foot deep compartment extends to the northern boundary. The western compartment fills first and the eastern buffer is drawn down first. The seepage canal along the southeastern boundary is improved and controlled at the same elevation as the C-11 Canal. Seepage canal elevations changed for the northeastern boundary. Revised operations for the C-11 Impoundment and S-13AW provide dry season flows to the eastern C-11 Basin and Pond Apple Slough.

Assumptions and related considerations:
1. Flood protection component for FPL substation and mobile home park may be needed. For each facility, propose a 60 cfs capacity pump station with an on elevation of 6.0 feet NGVD and an off elevation of 5.0 feet NGVD.
2. Telemetry systems are required for all operable structures and pump stations.

A.14.1.1.5.2.3 Component R

Geographic Region: Water Preserve Area - Broward County

Component Title: C-9 Impoundment - SEE WPA COMPONENT MAP 8

Purpose: Treatment of water supply deliveries from the NLBSA to the C-9, C-6/C-7 and C-2/C-4 canals. Runoff is backpumped into the NLBSA from the western C-9 Basin and diverted flows from the C-11 Impoundment. The C-9 Impoundment provides settlement of urban runoff stored in the North Lake Belt

Storage Area, groundwater recharge within the basin and seepage control of WCA 3 and buffer areas located west of the impoundment.

Operations Summary: In Alternative 3, the design and operation of the C-9 Impoundment are modified. Excess runoff diverted from the C-11 Impoundment is delivered directly into the North Lake Belt Storage Area from the US Highway 27 west borrow canal. The C-9 Impoundment is divided into three compartments. The west compartment can reach a 6-foot maximum depth with two shallower step down areas located to the north and east. The north and east compartments will store less than 2 foot of water on average and can store a maximum of 4 foot of water for short periods. During dry periods, stormwater stored in the NLBSA is pumped into the C-9 Impoundment for settlement (if necessary) and then released to provide water supply deliveries based on salinity control targets to the C-9, C-7, C-6, C-4 and C-2 canals. Seepage from the C-9 Impoundment is collected and returned to the impoundment or feed to ASR pumps.

Detailed Design and Operation:

2091-acre impoundment is divided into 3 compartments west, east and north. West (1232 acres) can store a maximum of 6 feet deep, east (474 acres) and north (385 acres) can store a maximum of 4-foot deep water for short durations of time.

Inflows: A 1000 cfs capacity pump station from NLBSA. SEE COMPONENT XX.

Pump operates when 1 of 3 conditions occur: (1) water supply deliveries are needed to C-9, C-6, C-7, C-4 and C-2 canals and water level in the NLBSA is above –15.0 ft NGVD; (2) when flows from C-11 Impoundment are directed to NLBSA and storage is available in C-9 Impoundment; or (3) when the water in the C-9 Impoundment is at or below ground surface.

Pump ceases to operate when 1 of 3 conditions occur: (1) water deliveries to C-9, C-6, C-7, C-4 and C-2 canals are met; (2) diversion from C-11 Impoundment is terminated; (3) C-9 Impoundment returns to 0.5-foot depth; or (4) the C-9 Impoundment is full.

Discharges: Two gravity structures with a total capacity of 1150 cfs to C-9, C-6, C-7, C-4, and C-2 canals for water supply deliveries. One (1000 cfs) is located in the western portion of the impoundment and the other (150 cfs) is located in the eastern portion of the impoundment. The east and north compartments discharge prior to the west compartment.

Seepage Collection: A total of 300 cfs is recycled into the impoundment.

Seepage collects along the western side of the impoundment by a 100-cfs capacity pump station that operates at 5.0 feet and ceases at 4.5 feet NGVD.

Seepage collects along the eastern side of the impoundment by a 100-cfs capacity pump station that operates at 3.0 feet and ceases at 2.5 feet NGVD.

Seepage collects along the north side of the impoundment by a 100-cfs capacity pump station that operates at 4.25 feet and ceases at 4.0 feet NGVD.

Add 40 MGD ASR and horizontal wells along eastern boundary. Water is injected when stages are greater than 1-foot deep in the impoundment and NLBSA is receiving flows from the C-11 Impoundment. Water is recovered when stages in C-9 Canal are below 3.5 ft NGVD.

Add hydroperiod operations to north and east compartments. The hydroperiod ranges between 1-1 ½ foot depth on average with dry down durations of not more than 2 months and water elevations dropping no more than 1 foot below natural grade for more than 1 month.

An emergency overflow spillway is designed as a lower section of the levee to maintain impoundment levee integrity. The emergency overflow spillway invert elevation is 1 foot above the maximum normal operating elevation. The spillway will discharge into the C-9 Canal.

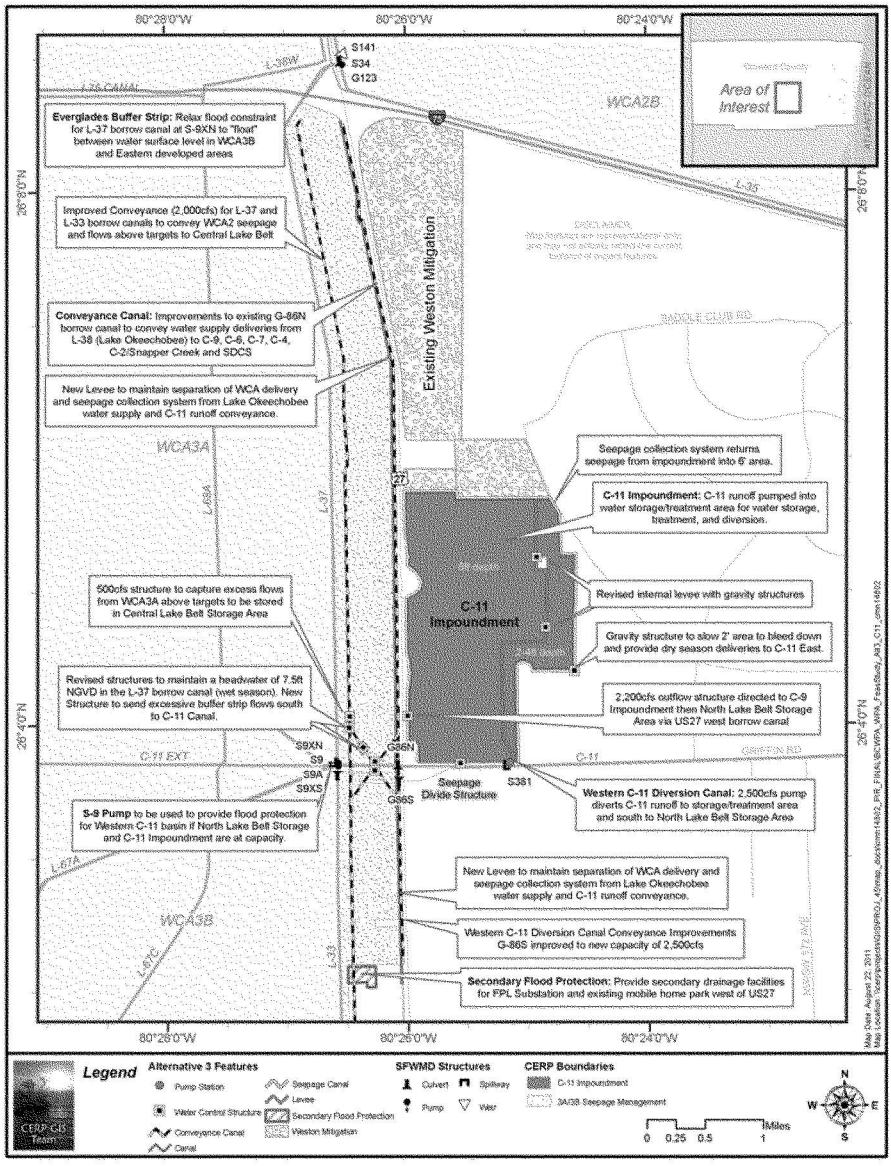
Location: Site identified by Water Preserve Area Land Suitability Analysis

Counties: Broward

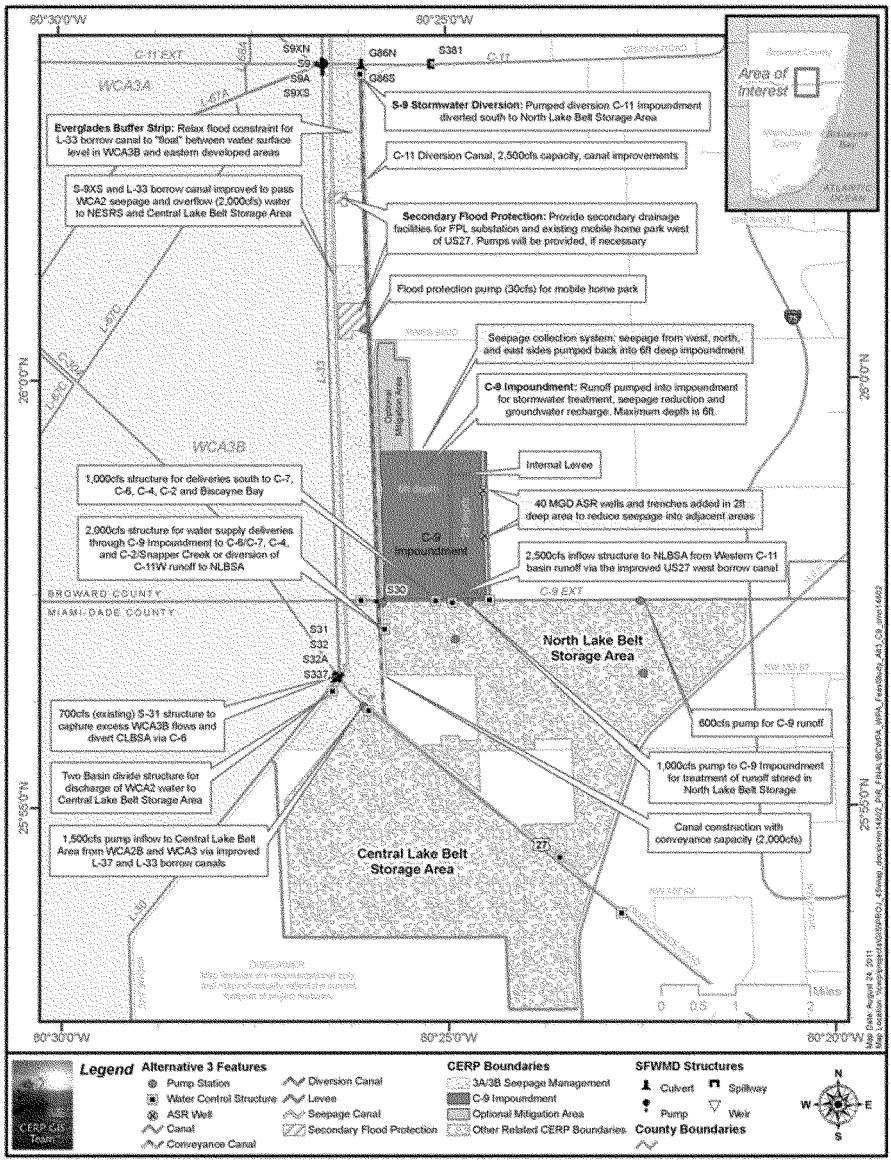
Summary of modifications from Alternative 2: The west compartment can store 6 foot maximum depth while the east and north compartments have a maximum depth of 4-foot for short durations. Inflow pumps operate when flows are diverted from C-11 Canal and there is available storage. Water deliveries into the east and north compartments follow a hydroperiod schedule. Horizontal ASR wells (40 MGD) are located in the east compartment). Water is recovered when stages in C-9 Canal are below 3.5 NGVD and water is not available from the NLBSA. Seepage on the western boundary changes to a maximum of 5.0 ft NGVD. Seepage pump operates at 5.0 ft NGVD and ceases at 4.5 ft NGVD.

Assumptions and related considerations:

1. Additional settlement facility is needed if stored water is backpumped into Water Conservation Area 3A.
2. Telemetry systems are required for all operable structures and pump stations.



WPA FEASIBILITY STUDY – ALT 3 CENTRAL BROWARD AREA WPA COMPONENT MAP 7



WPA FEASIBILITY STUDY – ALT 3 SW BROWARD AREA WPA COMPONENT MAP 8

A.14.1.1.5.3 WPA TSP (Tentative Selected Plan)

A.14.1.1.5.3.1 Component O

Geographic Region: Water Preserve Area - Broward County

Component Title: Water Conservation Area (WCA) 3A and 3B Levee Seepage Management – SEE WPA COMPONENT MAPS 7 and 8

Purpose: Reduce seepage from WCA 3A and 3B to improve hydropatterns within the WCAs by allowing higher water levels in the borrow canals and maintaining longer inundated duration within the marsh areas that are located east of the WCAs and west of US Highway 27. Seepage from the WCAs and marshes is collected and directed south into the Central Lake Belt Storage Area. This maintains flood protection and the separation of seepage water from urban runoff originating in the Western C-11 basin and Lake Okeechobee water supply deliveries.

Operations: The L-37 and L-33 borrow canals are held at higher stages as part of the WCA 3A and 3B seepage management system. The canals are also used to convey flows as part of the WCA 2B diversion flow system (Component YY). Seepage and canal flows collected in the L-37 and L-33 borrow canals are directed south to the Northeast Shark River Slough (NESRS) to meet its demands; to the Central Lake Belt Storage Area for storage; or returned to WCA 3A through the proposed critical project pump S-9A.

Design and operation detail:

New levees are constructed west of US Highway 27 from the North New River Canal to the Miami (C-6) Canal. This provides a separation of seepage water from the urban runoff.

The northern Everglades Buffer Strip, that runs parallel to the L-37 borrow canal, is controlled via a gated spillway at an elevation of 7.5 feet NGVD, wet season and 6.5 feet NGVD, dry season. A new 50 cfs gravity control structure directs water which can pond in the buffer strip near the C-11 Canal into the L-37 borrow canal just east of the S-9 pump station. The discharge into the C-11 Canal is diverted or returned to WCA 3A by the S-9A pump station (critical project).

The southern Everglades Buffer Strip, that runs parallel to the L-33 borrow canal, is controlled via a gated spillway at an elevation of 6.5 feet NGVD, wet season and 5.5 feet NGVD, dry season.

A divide structure is added in the C-11 Canal, east of US Highway 27 to maintain a headwater stage to reduce/control seepage from WCA 3A and to separate seepage water from urban runoff. Seepage water west of the divide structure is backpumped into WCA 3A by the new critical project pump station S-9A. Water from the C-11 west basin, east of the divide structure, is backpumped into the C-11 Impoundment and may be diverted south to the North Lake Belt Storage Area and C-9 Impoundment as storage availability exists in either facility.

Location: Seepage collected in borrow canals along the existing eastern protective levees adjacent to WCA 3. The divide structure is located in the C-11 Canal east of US Highway 27.

Counties: Broward

Assumptions and related considerations:
The seepage from the Water Conservation Areas meets the water quality standards necessary to achieve ecosystem restoration.

Telemetry systems are required for all operable structures and pump stations. Summary of modifications from D13R: Control elevations for L-33 and L-37 borrow canals are modified to improve the hydroperiod in the northern and southern Everglades Buffer Strip with the addition of two control structures. A control structure to transfer water from the Everglades Buffer Strip to WCA 3A via the S-9A pump is added.

A.14.1.1.5.3.2 Component Q

Geographic Region: Water Preserve Area - Broward County

Component Title: C-11 Impoundment - SEE WPA COMPONENT MAP 7

Purpose: Divert untreated runoff from the western C-11 basin that is presently discharged into Water Conservation Area (WCA) 3A into the C-11 Impoundment prior to sending it south to the North Lake Belt Storage Area (NLBSA).

Operation: Runoff in the western C-11 basin that was previously backpumped into Water Conservation Area 3A is diverted into the C-11 Impoundment and the NLBSA. If storage capacity is not available in the impoundment or NLBSA then the S-9 pump station is used to provide flood protection for the western C-11 basin and runoff is pumped into WCA 3A. The S-9 seepage divide structure (S-381) is operated to reduce the groundwater elevation fluctuations and reduce seepage in the western C-11 Canal.

Design and operation details:

Impoundment: 1730 acres divided into two compartments. The northern compartment is 209 acres in size with a maximum water depth of 2 feet. The 2-foot maximum water depth for this compartment is proposed to accommodate the relocation and consolidation of the mitigation areas for Arvida II, Arvida III and the City of Weston. The intent is to manage the northern compartment in such a way as to provide the wetland mitigation function. The southern compartment is 1507 acres in size with a maximum water depth of 4 feet. A perimeter levee surrounds the impoundment with a 7-foot high internal levee separating the two compartments. Transfer of flow between compartments is accomplished by 2 sets of gated culverts each consisting of two, 60-foot long, 72-inch diameter culverts. The buffer marsh/wetland enhancement area located north of the proposed impoundment will be used to mitigate seepage from the impoundment and provide a buffer between the impoundment and urban development.

Canal improvements: 2500 cfs diversion canal replaces the borrow canal located west of US Highway 27 between the C-11 and C-9 canals. Conveyance capacity improvements for the C-9 Canal are required between S-30 and the diversion structure into NLBSA.

Inflows: A 2500 cfs capacity inflow pump in the C-11 Canal directs runoff into the C-11 Impoundment. For dry season operation, the pump turns on at elevation 4.0 feet NGVD and turns off at elevation 3.7 feet NGVD or when the impoundment reaches 4 feet of depth. The wet season pump on elevation is 3.9 feet NGVD and off elevation is 3.5 feet NGVD or when the impoundment reaches 4 feet of depth.

Discharges: A 2500 cfs structure discharges from the impoundment into the improved, US Highway 27 west borrow canal when stages reach 4.0 feet NGVD. The northern 2-foot area discharges at a rate up to 100 cfs into the eastern seepage canal.

There are two operational scenarios:

> On-peak operations: Stormwater runoff that is currently backpumped into WCA 3A in the western C-11 basin is diverted into the C-11 Impoundment until full, then sent to the C-9 Impoundment until full and finally to NLBSA. If storage capacity is not available in the C-11 Impoundment, C-9 Impoundment or NLBSA, then the S-9 pump station is used to provide flood protection for the western C-11 basin and runoff is pumped into WCA 3A.

Off-peak operations: Water is supplied from the impoundment to maintain the western C-11 Canal and recharge south Broward County wellfields. To improve groundwater elevations in the eastern C-11 basin and Pond Apple Slough (at S-13AW) during dry seasons, S-13AW is opened and deliveries from the C-11 Impoundment are made when the stage at S-13 is less than 3.5 feet NGVD. If water is not available from the C-11 Impoundment, then deliveries are made by opening S-381 and allowing seepage water to recharge the basin and prevent excessive dry outs.

Seepage is collected and returned to the impoundment via a seepage collection system located on the north and west boundaries of the impoundment. Seepage east of the impoundment is controlled by the expansion of the eastern seepage canal that is directly connected to the C- 11 Canal.

An emergency overflow spillway is designed as a lower section of the levee to maintain impoundment levee integrity. The emergency overflow spillway invert elevation is 1 foot above the maximum normal operating elevation. The spillway discharges into the C-11 Canal west of the divide structure.

Location: The diversion canal is located west of US Highway 27 between the C-11 and the C-9 Canals. The C-11 Impoundment is located northeast of the intersection of US Highway 27 and C-11 Canal.

Counties: Broward, Miami-Dade

Assumptions and related considerations:
Flood protection component for FPL substation and mobile home park may be needed. For each facility, a 60 cfs pump with an on elevation of 6.0 feet NGVD and an off elevation of 5.0 feet NGVD is proposed.

Telemetry systems are required for all operable structures and pump stations.
Initially the C-11 Impoundment is operated as an impoundment. This operation continues until the NLBSA is functional. At which time, the intended use of the impoundment is to provide water settlement as necessary.

Summary of modifications from D13R: The impoundment footprint is modified and includes two interconnected compartments. The operation of the seepage collection system is modified. A new seepage collection canal and pump are added along the western perimeter of the impoundment east of US Highway 27. The seepage canal along the eastern boundary is connected to the C-11 Canal and helps improve seepage. The 2500 cfs outflow structure is relocated along the southwest side of the impoundment. The operations for the C-11 Impoundment and S-13AW are changed to provide dry season flows to the eastern C-11 basin and Pond Apple

Slough. Recharge to the South Broward County wellfields are provided from C-11 Canal.

A.14.1.1.5.3.3 Component R

Geographic Region: Water Preserve Area - Broward County

Component Title: C-9Impoundment – SEE WPA COMPONENT MAP 8

Purpose: Capture of stormwater to supply deliveries from the North Lake Belt Storage Area (NLBSA) to the C-9, C-6/C-7 and C-2/C-4 Canals. Runoff is backpumped into the NLBSA from the western C-9 basin and the western C-11 Canal. The C-9 Impoundment provides settlement of urban runoff that is stored in the North Lake Belt Storage Area, groundwater recharge within the basin and seepage control of WCA 3 and buffer areas located west of the impoundment.

Operation: Excess water from the C-11 and C-9 basins is distributed to the NLBSA and C-9 Impoundment when there is available storage. In the dry season, water supply deliveries are provided to the C-9, C-6/C-7 and C-2/C-4 canals and to Biscayne Bay. Seepage from the C-9 Impoundment is collected and returned to the impoundment. Aquifer Storage and Recovery (ASR) is proposed in conjunction with the impoundment to improve water supply during dry seasons and droughts. Twenty-five (25), 5-MGD ASR injection wells are included for a total of 125-MGD (194 cfs) capacity. Water from the C-9 Impoundment is injected into the ASR wells when stages in the impoundment are greater than 5.5 feet NGVD (1 foot of depth). Water is released from the impoundment and/or is recovered from the ASR wells to meet water supply demands.

Design and operation detail:

Impoundment: 1,641 interior acres with a maximum water depth of 4 feet. A levee surrounds the impoundment.

Inflow structure: 1000 cfs pump (from NLBSA, to be resized as needed) SEE COMPONENT XX. Pump on when water supply deliveries are needed to C-9, C-6/C-7 and C-2/C-4 canals and to Biscayne Bay when the water level in the NLBSA is above –15.0 feet NGVD.

Outflow structure: Gravity structure with 1000 cfs capacity discharges to the C-9 Canal for water supply deliveries to the C-6/C-7, C-2/C-4 canals and Biscayne Bay.

There are two operational scenarios:

On-peak operations: Flows from the western C-11 and C-9 basins are distributed to NLBSA and C-9 Impoundment where storage is available. Flows stop when the impoundment is full. The intent is to maximize the amount of water sent to the impoundment for storage in ASR.

Off-peak operations: Water supply deliveries from the impoundment and ASR storage system are provided to the C-9, C-6/C-7, C-2/C-4 canals and to Biscayne Bay.

Seepage Collection: Seepage canals are located on the north, east and west boundaries of the impoundment. Three, 100-cfs pumps are used to direct seepage back into the 4 foot deep impoundment area. The seepage collection canal system is maintained between elevations 2.5 and 3.0 feet NGVD for the east, 4.5 and 5.0 feet NGVD for the west and 4.0 and 4.3 feet NGVD for the north.

Twenty-five (25), 5-MGD ASR injection wells (total capacity 125-MGD or about 194 cfs) are located around the perimeter of the impoundment. Eight (8) additional wells have been added to increase the withdrawal capacity to 165-MGD (255 cfs) which improves the effectiveness if the ASR storage system. Water is supplied for injection into the ASR wells via horizontal supply wells and toe drains located inside the impoundment. Water from the horizontal supply wells injects into the ASR wells when stages in the impoundment are greater than 5.5 feet NGVD (1.0 foot of depth). Water is recovered when stages in C-9 Canal are below 3.5 feet NGVD.

An emergency overflow spillway is designed as a lower section of the levee to maintain impoundment levee integrity. The emergency overflow spillway invert elevation is 1 foot above the maximum normal operating elevation. The spillway will discharge into the C-9 Canal.

Location: Site identified by Water Preserve Area Land Suitability Analysis, east of US Highway 27 and north of the C-9 Canal.

Counties: Broward

Assumptions and related considerations:
Additional settlement facility needed if stored water is backpumped into Water Conservation Area 3.

Telemetry systems are required for all operable structures and pump stations.
Initially the C-9 Impoundment is operated as an impoundment. This operation continues until the NLBSA is functional.

Summary of modifications from D13R: The footprint is modified to 1739 acres. An ASR system is included. The seepage collection system and inflow pump operation are modified.
The following components have been identified as being located within the boundaries of the Water Preserve Areas. The component descriptions for the 2010 Recommended Plan have been modified from D13R (recommended plan for the C&SF Comprehensive Review Study) and from Other Project Elements (OPEs). These components have been outlined in the component descriptions in a very conceptual way. Some additional level of incidental design has been expended on several of the components in order to allow them to be included in the sub-regional models. It is noted all components described are recommended in the WPA Feasibility Study.

A.14.1.1.5.3.4 Component O

Geographic Region: Water Preserve Area - Broward County

Component Title: Water Conservation Area (WCA) 3A and 3B Levee Seepage Management – SEE WPA COMPONENT MAPS 5 and 6

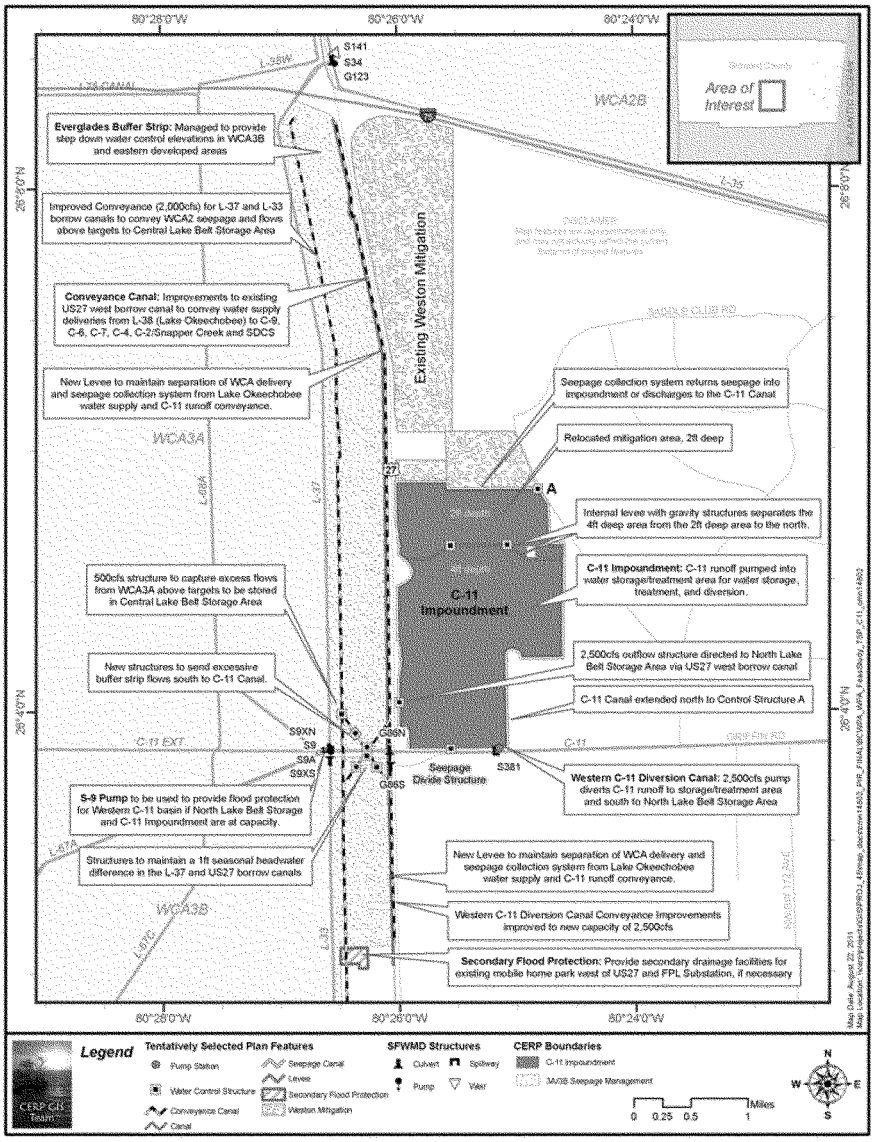
Purpose: Reduce seepage from WCA 3A and 3B to improve hydropatterns within the WCAs by allowing higher water levels in the borrow canals and maintaining longer inundated duration within the marsh areas that are located east of the WCAs and west of US Highway 27. Seepage from the WCAs and marshes is collected and directed south into the Central Lake Belt Storage Area. This maintains flood protection and the separation of seepage water from urban runoff originating in the Western C-11 basin and Lake Okeechobee water supply deliveries.

Operations: The L-37 and L-33 borrow canals are held at higher stages as part of the WCA 3A and 3B seepage management system. The canals are also used to convey flows as part of the WCA 2B diversion flow system (Component YY). Seepage and canal flows collected in the L-37 and L-33 borrow canals are directed south to the Northeast Shark River Slough (NESRS) to meet its demands; or returned to WCA 3A through the proposed critical project pump S-9A.

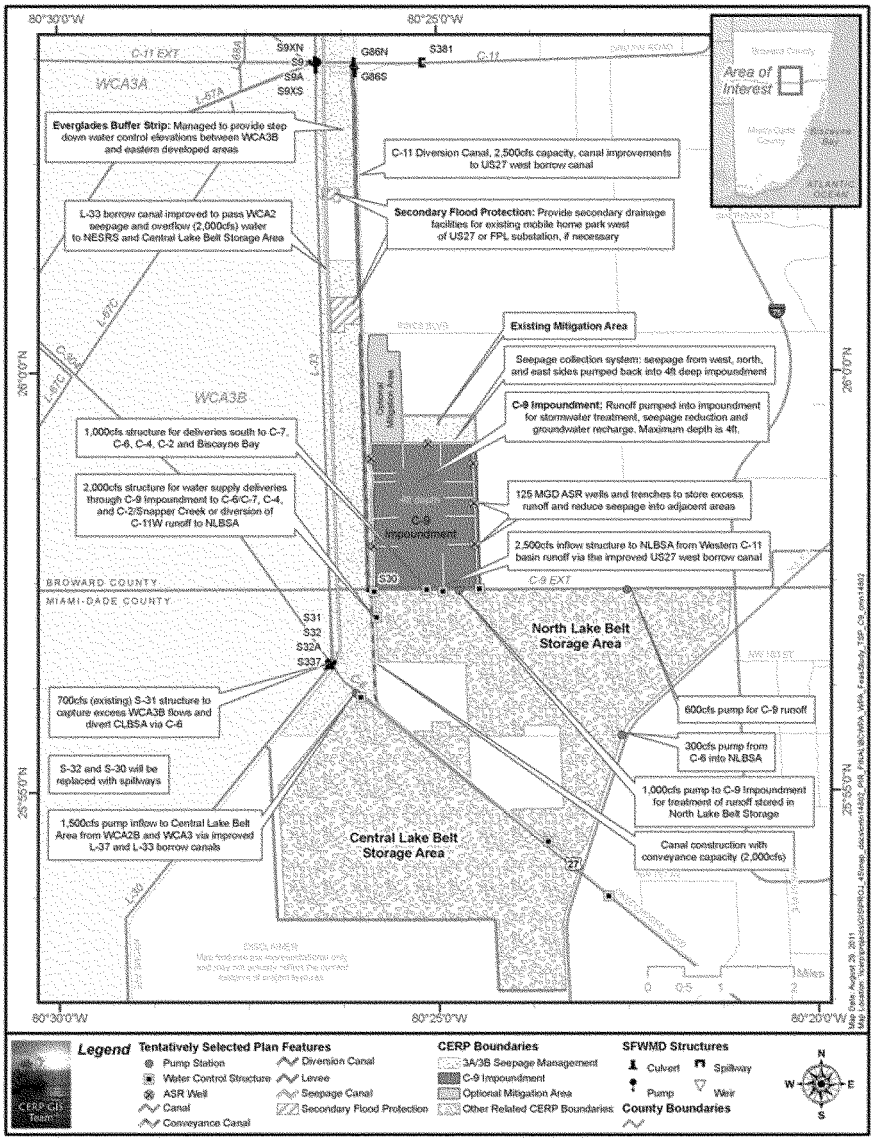
Design and operation detail:

New levees are constructed west of US Highway 27 from the North New River Canal to the Miami (C-6) Canal. This provides a separation of seepage water from the urban runoff.

The northern Everglades Buffer Strip, that runs parallel to the L-37 borrow canal, is controlled via a gated spillway at an elevation of 7.5 feet NGVD, wet



WPA FEASIBILITY STUDY – TENTATIVELEY SELECTED PLAN CENTRAL BROWARD AREA WPA COMPONENT MAP 5



WPA FEASIBILITY STUDY – TENTATIVELEY SELECTED PLAN SW BROWARD AREA WPA COMPONENET MAP 6

season and 6.5 feet NGVD, dry season. A new 50 cfs gravity control structure directs water which can pond in the buffer strip near the C-11 Canal into the L-37 borrow canal just east of the S-9 pump station. The discharge into the C-11 Canal is diverted or returned to WCA 3A by the S-9A pump station (critical project).

The southern Everglades Buffer Strip, that runs parallel to the L-33 borrow canal, is controlled via a gated spillway at an elevation of 6.5 feet NGVD, wet season and 5.5 feet NGVD, dry season.

A divide structure is added in the C-11 Canal, east of US Highway 27 to maintain a headwater stage to reduce/control seepage from WCA 3A and to separate seepage water from urban runoff (C-11 Critical Project). Seepage water west of the divide structure is backpumped into WCA 3A by the new critical project pump station S-9A. Water from the C-11 west basin, east of the divide structure, is backpumped into the C-11 Impoundment and C-9 Impoundment as storage availability exists in either facility.

Location: Seepage collected in borrow canals along the existing eastern protective levees adjacent to WCA 3. The divide structure is located in the C-11 Canal east of US Highway 27.

Counties: Broward

Assumptions and related considerations:
The seepage from the Water Conservation Areas meets the water quality standards necessary to achieve ecosystem restoration.

Telemetry systems are required for all operable structures and pump stations.

A.14.1.1.5.3.5 Component Q

Geographic Region: Water Preserve Area - Broward County

Component Title: C-11 Impoundment - SEE WPA COMPONENT MAP 5

Purpose: Divert untreated runoff from the western C-11 basin that is presently discharged into Water Conservation Area (WCA) 3A into the C-11 Impoundment prior to sending it south to the C-9 Impoundment.

Operation: Runoff in the western C-11 basin that was previously backpumped into Water Conservation Area 3A is diverted into the C-11 Impoundment. If storage is not available in the C-11 Impoundment then runoff is sent to the C-9 Impoundment if storage capacity is available. If storage capacity is not available

in the either of the impoundments and the C-9 Canal stages are not favorable to send excess to tide then the S-9 pump station is used to provide flood protection for the western C-11 basin and runoff is pumped into WCA 3A. If the C-9 Impoundment is full and the C-9 Canal elevations are favorable, then excess runoff can be sent to tide via the C-9 Canal. The S-9 seepage divide structure (S-381) is operated to reduce groundwater elevation fluctuations and reduce seepage in the western C-11 Canal.

Design and operation details:

Impoundment: 1730 acres divided into two compartments. The northern compartment is 209 acres in size with a maximum water depth of 2 feet. The 2-foot maximum water depth for this compartment is proposed to accommodate the relocation and consolidation of the mitigation areas for Arvida II, Arvida III and the City of Weston. The intent is to manage the northern compartment in such a way as to provide the wetland mitigation function. The southern compartment is 1507 acres in size with a maximum water depth of 4 feet. A perimeter levee surrounds the impoundment with a 7-foot high internal levee separating the two compartments. Transfer of flow between compartments is accomplished by 2 sets of gated culverts each consisting of two, 60-foot long, 72-inch diameter culverts. The buffer marsh/wetland enhancement area located north of the proposed impoundment will be used to mitigate seepage from the impoundment and provide a buffer between the impoundment and urban development.

Canal improvements: 2500 cfs diversion canal replaces the borrow canal located west of US Highway 27 between the C-11 and C-9 Canals. Conveyance capacity improvements for the C-9 Canal are required between S-30 and the inflow structure into for the C-9 Impoundment.

Inflows: A 2500 cfs capacity inflow pump in the C-11 Canal directs runoff into the C-11 Impoundment. For dry season operation, the pump turns on at elevation 4.0 feet NGVD and turns off at elevation 3.7 feet NGVD or when the impoundment reaches 4 feet of depth. The wet season pump on elevation is 3.9 feet NGVD and off elevation is 3.5 feet NGVD or when the impoundment reaches 4 feet of depth.

Discharges: A 2500 cfs structure discharges from the impoundment into the improved, US Highway 27 west borrow canal when stages reach 4.0 feet NGVD. The northern 2-foot area discharges at a rate up to 100 cfs into the eastern seepage canal.

There are two operational scenarios:

On-peak operations: Stormwater runoff that is currently backpumped into WCA 3A in the western C-11 basin is diverted into the C-11 Impoundment until full, then sent to the C-9 Impoundment until full. If storage capacity is not available in the C-11 Impoundment, or C-9 Impoundment and stages in the C-9 Canal are not favorable to send excess to tide, then the S-9 pump station is used to provide flood protection for the western C-11 basin and runoff is pumped into WCA 3A.

Off-peak operations: Water is supplied from the impoundment to maintain the western C-11 Canal and recharge south Broward County wellfields to improve groundwater elevations in the eastern C-11 basin during dry seasons. Seepage is collected and returned to the impoundment via a seepage collection system located on the north and west boundaries of the impoundment. Seepage east of the impoundment is controlled by the expansion of the eastern seepage canal which is directly connected to the C-11 Canal.

An emergency overflow spillway is designed as a lower section of the levee to maintain impoundment levee integrity. The emergency overflow spillway invert elevation is 1 foot above the maximum normal operating elevation. The spillway discharges into the C-11 Canal west of the divide structure.

Location: The diversion canal is located west of US Highway 27 between the C-11 and the C-9 Canals. The C-11 Impoundment is located northeast of the intersection of US Highway 27 and C-11 Canal.

Counties: Broward, Miami-Dade

Assumptions and related considerations:
Flood protection component for FPL the Holly Lake mobile home park may be needed. A 60 cfs pump with an on elevation of 6.0 feet NGVD and an off elevation of 5.0 feet NGVD is proposed.

Telemetry systems are required for all operable structures and pump stations. Interim Operations: Initially the C-11 Impoundment is operated as an impoundment. This operation continues until the NLBSA is functional.

A.14.1.1.5.3.6 Component R

Geographic Region: Water Preserve Area - Broward County

Component Title: C-9 Impoundment – SEE WPA COMPONENT MAP 6

Interim Purpose: C-9 Basin runoff is backpumped from the western C-9 basin and the western C-11 Canal into the impoundment. The C-9 Impoundment

provides storage of urban runoff, groundwater recharge within the basin and seepage control of WCA 3 and buffer areas located west of the impoundment.
Interim Operation: Excess water from the C-11 and C-9 basins is distributed to the C-9 Impoundment when there is available storage. In the dry season, water supply deliveries are provided to the C-9, C-6/C-7 and C-2/C-4 canals and to Biscayne Bay. Seepage from the C-9 Impoundment may be collected and returned to the impoundment.

Design and operation detail:

Impoundment: 1,641 interior acres with a maximum water depth of 4 feet. A levee surrounds the impoundment.

Inflow structure: 1000 cfs pump in the C-9 Canal directs runoff into the C-9 Impoundment. Pump on at elevation 3.2 ft NGVD and off at elevation 2.8 NGVD or when the impoundment reaches a 4-foot maximum depth.

Outflow structure: Gravity structure with 1000 cfs capacity discharges to the C-9 Canal for water supply deliveries to the C-6/C-7, C-2/C-4 canals and Biscayne Bay.

There are two operational scenarios:

> On-peak operations: Flows from the western C-11 and C-9 basins are distributed to C-9 Impoundment when storage is available. The intent is to maximize the amount of water sent to the impoundment for storage.
>
> Off-peak operations: Water supply deliveries from the impoundment are provided to the C-9, C-6/C-7, C-2/C-4 canals and to Biscayne Bay.

Seepage Collection: Seepage canals are located on the north, east and west boundaries of the impoundment. Three, 100-cfs pumps are used to direct seepage back into the 4 foot deep impoundment area. The seepage collection canal system is maintained between elevations 2.5 and 3.0 feet NGVD for the east, 4.5 and 5.0 feet NGVD for the west and 4.0 and 4.3 feet NGVD for the north.

An emergency overflow spillway is designed as a lower section of the levee to maintain impoundment levee integrity. The emergency overflow spillway invert elevation is 1 foot above the maximum normal operating elevation. The spillway will discharge into the C-9 Canal.

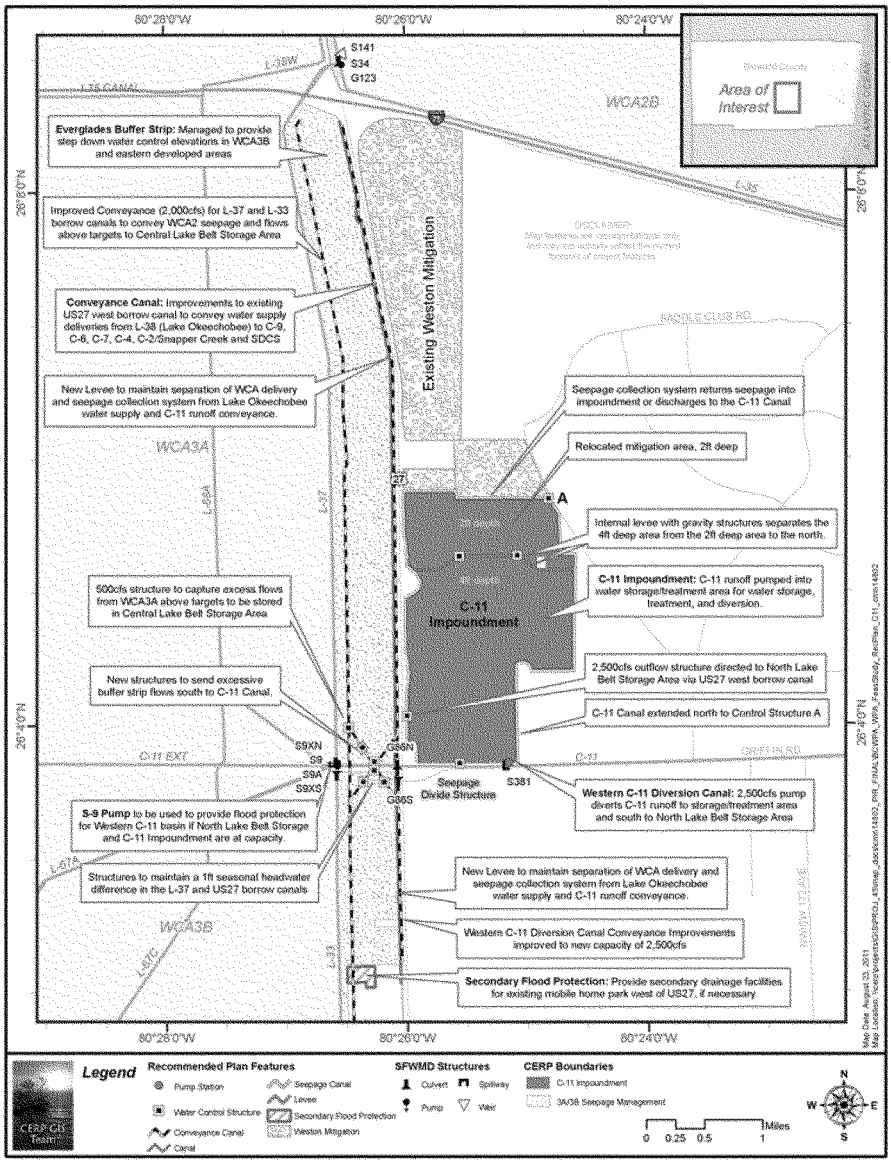
Location: Site identified by Water Preserve Area Land Suitability Analysis, east of US Highway 27 and north of the C-9 Canal.

Counties: Broward

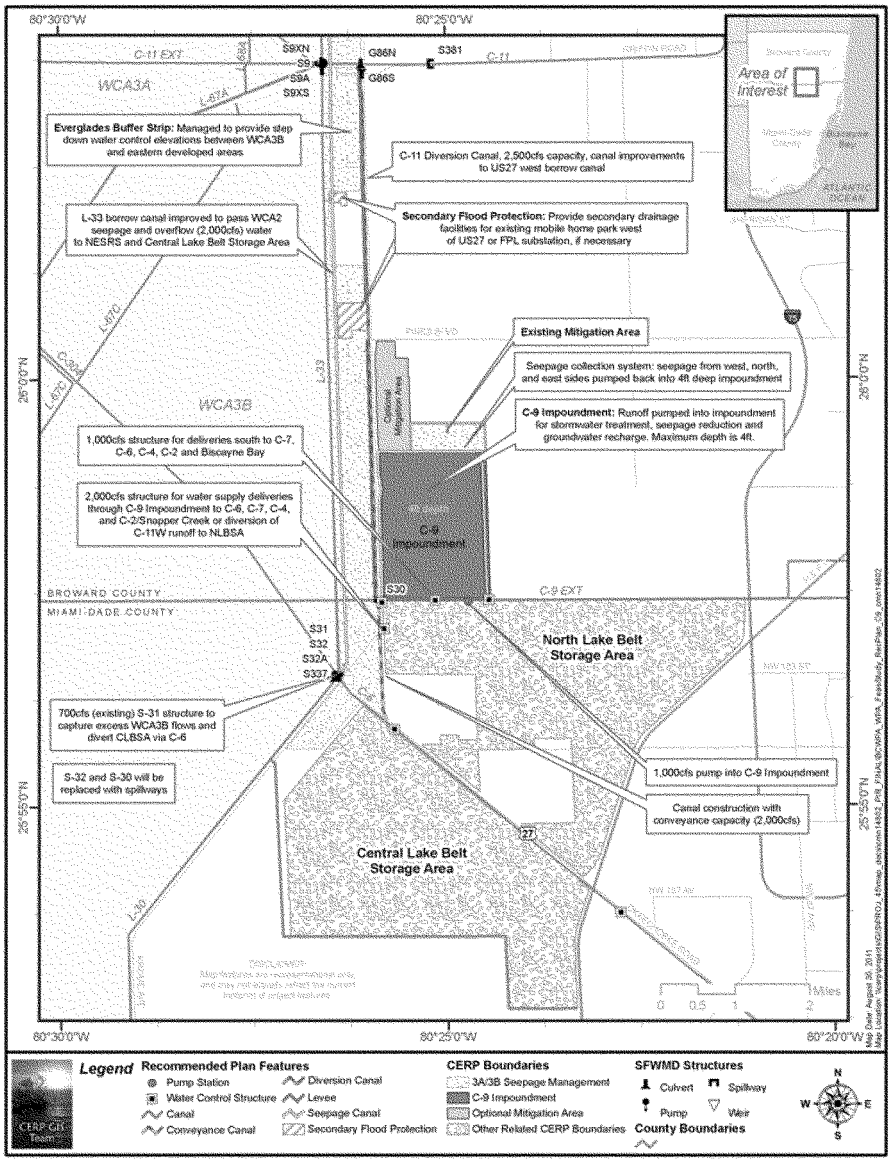
Assumptions and related considerations:

Additional settlement facility needed if stored water is backpumped into Water Conservation Area 3.
Telemetry systems are required for all operable structures and pump stations.

Interim Operations: Initially the C-9 Impoundment is operated as an impoundment. This operation continues until the NLBSA is functional.



WPA FEASIBILITY STUDY – RECOMMENDED PLAN CENTRAL BROWARD AREA WPA COMPONENT MAP 5



WPA FEASIBILITY STUDY – RECOMMENDED PLAN SW BROWARD AREA
WPA COMPONENT MAP 6

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WPA 2010 Base Case Summary
for WPA Interim Operations Simulations
February 14, 2001

	WPA Future Without Project Condition 2010 Base Case
Climate	Just as for the Existing (1995) Condition, the 1965 to 1995 climatic record was used to evaluate the Future (2010) Without Project Condition. This same climatic record will be used for the evaluation of all plan alternatives. Rainfall and potential evapotranspiration are the key climatic inputs.
Topography	
Sea Level	For the Future (2010) Without Project Condition the same sea level data as for the Existing (1995) Condition are being used.
Population and Socio-Economic Conditions	Projections of 2050 population and socio-economic conditions for all areas except Service Area 3 (most of Dade County) are those contained in Final Report Municipal and Industrial Water Use Forecast Lake Okeechobee Regulation Schedule Study prepared for the U.S. Army Corps of Engineers Jacksonville District, August 1996. The projections contained in that report are based on those developed by the University of Florida, Bureau of Economic and Business Research were utilized. For Service Area 3, projections in the report cited above were increased to reflect Dade County's estimation of its future population growth as influenced by recent immigration legislation and other factors. 2010 population projections are from the same report.
Land Use	• Same as 2050. • For the Coastal Basins for 2050, land use projections were based on local government comprehensive plans (which are based on 2010 land use). This is the same as used in the 2010 Restudy simulation. • In the Everglades Agricultural Area land use will be the same as for the Existing (1995) Condition except that the land to be used for stormwater treatment areas will be shifted to that use. • Impacts of changes in land use in the remainder of the Lake Okeechobee Service Area are accounted for through the evaluations of demands. (see below)
Natural Area Land Cover (Vegetation)	• The 2010 vegetation classes and spatial distribution will remain the same as those proposed for the Existing (1995) Condition. (version 3.5)
Urban and Agricultural Water Demands	• For all areas, except Service Area 3, the public water supply demands which will be used are those contained in Final Report Municipal and Industrial Water Use Forecast Lake Okeechobee Regulation Schedule Study prepared for the U.S. Army Corps of Engineers Jacksonville District, August 1996. The University of Florida Bureau of Economic and Business Research unrestricted demand set was used. These reflect University of Florida Bureau of Economic and Business Research generated population projections. For Service Area 3 the public water supply demands have been increased to reflect Dade County's estimation of its future population growth as influenced by recent immigration legislation and other factors. These projections included an

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	WPA Future Without Project Condition 2010 Base Case
	estimate for the population in 2010 and a per capita consumption rate, which is applied to the 2010 Base Case. The projected service area demands account for the expected implementation of water conservation (implementation of ultra-low flow fixtures and lawn sprinkler restrictions in residential and commercial land use). These are the same projections used in the Restudy 2010 Implementation Schedule simulations. • Irrigation demands in the Lower East Coast Service Area are based on projected land use and climatic variables. • Irrigation demands for the Everglades Agricultural Area reflect the construction in the Stormwater Treatment Areas • Caloosahatchee River Basin demands increase by 40% from the Existing (1995) Condition based on Mazzotti's IFAS Citrus Study (Same as 2010 Restudy) • St. Lucie Canal Basin demands remain the same as the Existing (1995) Condition based on projected land use and include the demand associated with the Florida Power and Light reservoir at Indiantown which will increase up to the existing permitted demand. (Same as 2010 Restudy.) • The Upper East Coast rainfall-runoff relationship will be the same as that used in the Existing (1995) Condition.
Physical Facilities & Operations - Lake Okeechobee & Lake Okeechobee Service Area	Four changes are associated with the Everglades Construction Project as mandated by the Everglades Forever Act. They are: • Stormwater Treatment Areas (Same as 2050) • No L-8 water directed to Lake Okeechobee • Water quality entering Water Conservation Areas assumed to be that produced by Phase 2 of the Everglades Construction Project • Additional Everglades Agricultural Area lands previously draining to Lake Okeechobee now drains to the Everglades Protection Area • LOK Schedule same as 2050 Base Case. • More information on these components are described in the footnote.[1] Other changes are: • Deliveries to Water Conservation Areas up to annual average Best Management Practices Replacement Water Rule volumes. • Kissimmee River Restoration and the Headwaters Revitalization Project, which will change the timing and amount of water flowing from the Kissimmee Basin into Lake Okeechobee.[2] • Strengthening of the Herbert Hoover Dike.
Physical Facilities & Operations –	1995 water management system and practices with the following changes: • No net outflow from Water Conservation Areas if water levels is less than Minimum Level marsh triggers or less than minimum operating criteria in canals of the Loxahatchee National Wildlife Refuge (WCA-1): 14 ft.,

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	WPA Future Without Project Condition 2010 Base Case
Water Conservation Areas, Holey Land Wildlife Management Area and Rotenberger Wildlife Management Area	WCA-2A: 10.5ft., WCA-3A: 7.5ft. Marsh level triggers will be those used in the Draft Lower East Coast Regional Water Supply Plan alternative 5. • Rainfall driven operational criteria for determining timing of deliveries to and discharges from WCA 2A and 3A with quantity adjusted to approximate Best Management Practices Replacement water quantities. • Structural modifications per federally authorized Modified Water Deliveries project (same as TSP and 2050) • Structural features of the Holey Land Wildlife Management Area are to be consistent with the Everglades Construction Project and operations consistent with the Existing (1995) Condition. • Operations of the Rotenberger WMA are to be consistent with the Everglades Construction Project (December 1997 design of STA 5 and STA 6). The topography in WCA-3B will be the same as that used in the Existing (1995) Condition.
Physical Facilities & Operations – Everglades National Park	1995 water management system and practices with the following changes: • The Federally authorized Modified Water Deliveries to Everglades National Park Project using S-12s, S-333 and S-355 to deliver water to meet NSM based targets in ENP. This is similar to 2050 Base Case operations. [3] • Federally authorized C-111 Project for Taylor Slough and East Panhandle.[4]
Physical Facilities & Operations – Lower East Coast Service Area	1995 water management system and practices with the following changes: • Wellfield expansion and locations in Service Areas 1, 2 and 3 based on the Lower East Coast Regional Water Supply Plan [5] • Broward secondary canal recharge network based on the Interim Lower East Coast Regional Water Supply Plan. Same as 2050 Base Case. [6] • Selected elements of L-8 project[7] • Northwest Dade Lake Belt area- assume that the conditions caused by the currently permitted mining exist and that the affects of any future mining are fully mitigated by industry. • Western C-4 Structure (S-380) Critical Project constructed. Operations differ for wet and dry seasons.[8] • Operational adjustments to try to maintain water levels in primary coastal canals at Minimum Levels in the Biscayne Aquifer as proposed in the Lower East Coast Regional Water Supply Plan. • C-11 Water Quality Treatment Critical Project (S-381 and S-9A)[9] • 55 MGD Miami-Dade County aquifer recharge facilities are included as per Miami-Dade Biscayne Aquifer Special Report. • C-4 Flood Mitigation Project. Includes 410 and 434+/- acre impoundments to store storm water from C-4 Basin.[10]
Physical Facilities &	1995 water management system and practices with the following changes: • Estimated inflows from Western basins according to Everglades Construction Project

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	WPA Future Without Project Condition 2010 Base Case
Operations – Western Basins and Big Cypress	• Big Cypress Seminole Reservation irrigation demands increase reflecting the Seminole Compact.[11]
Region-wide Water Management and Related Operations	The assumptions for the Future (2010) Without Project Condition are the same as for the Existing (1995) Condition.

[1] The components of the Everglades Construction Project are:

- Stormwater Treatment Areas – These 6 areas will cover more than 40,000 acres and will reduce the amount of phosphorus and other constituents in stormwater runoff before it enters the Everglades Protection Area. Associated facilities will improve the distribution of water as it enters the Everglades Protection Area to help recreate sheet flow conditions. Other improvements include enhanced flood protection for the C-51 basin,
- Water quality entering Water Conservation Areas assumed to be that produced by Phase 2 of the Everglades Construction Project – The Everglades Forever Act requires that future inflows to the Everglades Protection Area meet future established standards for phosphorus or a default standard of 10 parts per billion. Because it is not certain what the phosphorus standards will be or what will be implemented without the C&SF Restudy to achieve those standards, the Future (2050) Without Project Condition assumes water entering the Everglades Protection Area will be of the quality produced by the Stormwater Treatment Areas. The alternatives of the Restudy will include as components those additional facilities needed to achieve the best estimate of the future standards.
- Additional Everglades Agricultural Area basins previously draining to Lake Okeechobee now drain to the Everglades Protection Area – As part of the requirements of the Everglades Forever Act, much of the water previously discharged to Lake Okeechobee from the East Beach, East Shore, 715 Farms and South Shore drainage districts will be routed to the Stormwater Treatment Areas and the Everglades Protection Area.

[2] The Kissimmee River Restoration Project will result in the backfilling of 29 miles of the C-38 Canal and the excavation of 11.6 miles of new river channel. This will restore a significant portion of the Kissimmee River and about 29,000 acres of wetlands. To provide the water in the timing and quantities needed for the restoration of the River, the Headwaters Revitalization Project is being undertaken. It includes modifications of the regulation schedules for the Upper Chain of Lakes and associated canal and water control structure modifications. The Headwaters Revitalization Project will also provide ecological benefits within the Upper Chain of Lakes Area. The impact of this project on Lake Okeechobee is that the timing of inflows to Lake Okeechobee will be changed and approximately 1.6% less water will enter the Lake from the Kissimmee River due to additional evapotranspiration upstream.

[3] The Modified Water Deliveries to Everglades National Park Project provides structural modifications to enable the restoration of more natural water flows to Shark River Slough in Everglades National Park. Components include structures to improve conveyance from WCA-3A to WCA-3 B and from WCA-3B to Everglades National Park, removal of an existing levee and canal (L-67 Extension) within Everglades National Park, a seepage control levee, canal and pump station to prevent additional flooding in the 8.5 square mile area, floodproofing of a Miccosukee Indian Camp and a pump station to return captured seepage water to Shark River Slough.

[4] The C-111 project consists of structural and non-structural modifications within the C-111 basin, which will improve hydroperiods in Taylor Slough, Shark River Slough and the eastern Panhandle areas of the Everglades. It will maintain flood protection within the agricultural areas adjacent to C-111. The C-111 Project Canal operations will be consistent with the authorized levels (aka Base '83) as recommended by SERA.

[5] Lower East Coast Regional Water Supply Plan provides for relocation of future and some existing withdrawals from existing (1995) wellfields based on utility

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preferred locations. Demands shifted to new wellfields are identified in the Lower East Coast Regional Water Supply Plan (LEC-1R).

[6] This component is to be implemented as a result of the Interim Lower East Coast Regional Water Supply Plan and includes pump stations and structures which would maintain higher levels in secondary canals in eastern Broward County between the Hillsboro and the North New River Canals during the dry season. The selected canals are located where recharge from the canals would help to hold back the salt water front and protect the production capability of wellfields to the east.

[7] These projects will be implemented as a result of the Interim Lower East Coast Regional Water Supply Plan. It includes a structure and pump station from C-18n to the Loxahatchee Slough, an improved conveyance from the West Palm Beach's Water Catchment Area to the Loxahatchee Slough aquifer storage and recovery wells at the West Palm Beach Water Catchment Area or the Indian Trails Improvement District and a coastal recharge delivery system.

[8] S-380 dry season operations: at 4.2' NGVD gate open, at 4.0' NGVD gate is stationary, at 3.8' gate is closed. The optimum stage of 4.0 ft will allow for seepage reduction to be extended from G-119 to S-380. Also, when supplemental water supply deliveries from WCA 3 are made to supply water needs in eastern Dade Co via L-30 or L-29 canals, S-380 will be opened in conjunction with G-119 and water levels may vary from the optimum. During the wet season the gate is open to maintain control of this reach with G-119. If water levels are low, this structure may be operated for water supply even during the wet season months.

[9] S-9A operates when C-11 Canal is at 4.0 ft NGVD until stages reach 3.5 ft NGVD. The S-381 spillway divides the canal reach.

[10] C-4 Mitigation Project recommended by Miami-Dade Flood Task Force in 2001. Construction of two impoundments is expected to begin in 2002. The C-4 Canal will be backpumped when C-4 Canal (T-5)>5.0 ft NGVD and the maximum depth is 4.0 ft.

[11] The estimated irrigation demands for the Big Cypress Seminole Reservation will be supplied by local sources first then by the regional system. While deliveries to this area to meet irrigation demands are increased as compared to the Existing (1995) Condition, no increase in runoff is assumed.

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A.14.1.1.5.4 WPA PSP (Pre-Selected Plan)

A.14.1.1.5.4.1 Component O

Geographic Region: Water Preserve Area - Broward County

Component Title: Water Conservation Area (WCA) 3A and 3B Levee Seepage Management – SEE WPA COMPONENT MAPS 7 and 8

Purpose: Reduce seepage from WCA 3A and 3B to improve hydropatterns within the WCAs by allowing higher water levels in the borrow canals and maintaining longer inundated duration within the marsh areas that are located east of the WCAs and west of US Highway 27. Seepage from the WCAs and marshes is collected and directed south into the Central Lake Belt Storage Area. This maintains flood protection and the separation of seepage water from urban runoff originating in the Western C-11 basin and Lake Okeechobee water supply deliveries.

Operations: The L-37 and L-33 borrow canals are held at higher stages as part of the WCA 3A and 3B seepage management system. The canals are also used to convey flows as part of the WCA 2B diversion flow system (Component YY). Seepage and canal flows collected in the L-37 and L-33 borrow canals are directed south to the Northeast Shark River Slough (NESRS) to meet its demands; to the Central Lake Belt Storage Area for storage; or returned to WCA 3A through the proposed critical project pump S-9A.

Design and operation detail:

New levees are constructed west of US Highway 27 from the North New River Canal to the Miami (C-6) Canal. This provides a separation of seepage water from the urban runoff.

The northern Everglades Buffer Strip, that runs parallel to the L-37 borrow canal, is controlled via a gated spillway at an elevation of 7.5 feet NGVD, wet season and 6.5 feet NGVD, dry season. A new 50 cfs gravity control structure directs water which can pond in the buffer strip near the C-11 Canal into the L-37 borrow canal just east of the S-9 pump station. The discharge into the C-11 Canal is diverted or returned to WCA 3A by the S-9A pump station (critical project).

The southern Everglades Buffer Strip, that runs parallel to the L-33 borrow canal, is controlled via a gated spillway at an elevation of 6.5 feet NGVD, wet season and 5.5 feet NGVD, dry season.

A divide structure is added in the C-11 Canal, east of US Highway 27 to maintain a headwater stage to reduce/control seepage from WCA 3A and to separate seepage water from urban runoff. Seepage water west of the divide structure is backpumped into WCA 3A by the new critical project pump station S-9A. Water from the C-11 west basin, east of the divide structure, is backpumped into the C-11 Impoundment and may be diverted south to the North Lake Belt Storage Area and C-9 Impoundment as storage availability exists in either facility.

Location: Seepage collected in borrow canals along the existing eastern protective levees adjacent to WCA 3. The divide structure is located in the C-11 Canal west of US Highway 27.

Counties: Broward

Assumptions and related considerations:

The seepage from the Water Conservation Areas meets the water quality standards necessary to achieve ecosystem restoration.

Summary of modifications from D13R: Control elevations for L-33 and L-37 borrow canals are modified to improve the hydroperiod in the northern and southern Everglades Buffer Strip with the addition of two control structures. A control structure to transfer water from the Everglades Buffer Strip to WCA 3A via the S-9A pump is added.

A.14.1.1.5.4.2 Component Q

Geographic Region: Water Preserve Area - Broward County

Component Title: Western C-11 Diversion Impoundment and Canal -- to North Lake Belt Storage Area - SEE WPA COMPONENT MAPS 7

Purpose: Divert untreated runoff from the western C-11 basin that is presently discharged into Water Conservation Area (WCA) 3A into the C-11 Impoundment prior to sending it south to the North Lake Belt Storage Area (NLBSA).

Operation: Runoff in the western C-11 basin that was previously backpumped into Water Conservation Area 3A is diverted into the C-11 Impoundment and the NLBSA. If storage capacity is not available in the impoundment or NLBSA then the S-9 pump station is used to provide flood protection for the western C-11 basin and runoff is pumped into WCA 3A. To reduce groundwater elevations fluctuations in the eastern C-11 basin, the S-9 seepage divide structure (S-381) is operated to maintain the western C-11 Canal.

Design and operation details:

1730-acre impoundment is divided into two compartments. The northern compartment is 209 acres in size with a maximum water depth of 2 feet. The southern compartment consists of a 1507-acre storage area with a maximum depth of 4 feet. An 11-foot high levee surrounds the impoundment with a 7-foot high internal levee separating the two compartments. Transfer of flow between compartments is accomplished by 2 sets of gated culverts each consisting of two, 60-foot long, 72-inch diameter culverts.

Canal improvements: 2500 cfs diversion canal replaces the borrow canal located west of US Highway 27 between the C-11 and C-9 Canals. Conveyance capacity improvements for the C-9 Canal are required between S-30 and the diversion structure into NLBSA.

Inflows: A 2500 cfs capacity inflow pump in the C-11 Canal directs runoff into the C-11 Impoundment. For dry season operation, the pump turns on at elevation 4.0 feet NGVD and turns off at elevation 3.7 feet NGVD or when the impoundment reaches 4 feet of depth. The wet season pump on elevation is 3.9 feet NGVD and off elevation is 3.5 feet NGVD or when the impoundment reaches 4 feet of depth.

Discharges: A 2500 cfs structure discharges from the impoundment into the improved, US Highway 27 west borrow canal when stages reach 4.0 feet NGVD. The northern 2-foot area discharges at a rate up to 100 cfs into the eastern seepage canal.

There are two operational scenarios:

> On-peak operations: Stormwater runoff that is currently backpumped into WCA 3A in the western C-11 basin is diverted into the C-11 Impoundment until full, then sent to the C-9 Impoundment until full and finally to NLBSA. If storage capacity is not available in the C-11 Impoundment, C-9 Impoundment or NLBSA, then the S-9 pump station is used to provide flood protection for the western C-11 basin and runoff is pumped into WCA 3A.
>
> Off-peak operations: Water is supplied from the impoundment to maintain the western C-11 Canal and recharge south Broward County wellfields. To improve groundwater elevations in the eastern C-11 basin and Pond Apple Slough (at S-13AW) during dry seasons, S-13AW is opened and deliveries from the C-11 Impoundment are made when the stage at S-13 is less than 3.5 feet NGVD. If water is not available from the C-11

Impoundment, then deliveries are made by opening S-381 and allowing seepage water to recharge the basin and prevent excessive dry outs.

Seepage is collected and returned to the impoundment via a seepage collection system located on the north, east and west boundaries of the impoundment.

An emergency overflow spillway is designed as a lower section of the levee to maintain impoundment levee integrity. The emergency overflow spillway invert elevation is 1 foot above the maximum normal operating elevation. The spillway discharges into the C-11 Canal west of the divide structure.

Location: The diversion canal is located west of US Highway 27 between the C-11 and the C-9 Canals. The C-11 Impoundment is located northeast of the intersection of US Highway 27 and C-11 Canal.

Counties: Broward, Miami-Dade

Assumptions and related considerations:
Flood protection component for FPL substation and mobile home park may be needed. For each facility, a 60 cfs pump with an on elevation of 6.0 feet NGVD and an off elevation of 5.0 feet NGVD is proposed.

Telemetry systems are required for all operable structures and pump stations. Initially the C-11 Impoundment is operated as an impoundment. This operation continues until the NLBSA is functional. At which time, the intended use of the impoundment is to provide water settlement as necessary.

Summary of modifications from D13R: The impoundment footprint is modified and includes two interconnected compartments. The operation of the seepage collection system is modified. A new seepage collection canal and pump are added along the western perimeter of the impoundment east of US Highway 27. The seepage canal along the eastern boundary is connected to the C-11 Canal and helps improve seepage. The 2500 cfs outflow structure is relocated along the southwest side of the impoundment. The operations for the C-11 Impoundment and S-13AW are changed to provide dry season flows to the eastern C-11 basin and Pond Apple Slough. Recharge to the South Broward County wellfields are provided from C-11 Canal.

A.14.1.1.5.4.3 Component R

Geographic Region: Water Preserve Area - Broward County

Component Title: C-9 Impoundment – SEE WPA COMPONENT MAP 8

Purpose: Settlement of water supply deliveries from the North Lake Belt Storage Area (NLBSA) to the C-9, C-6/C-7 and C-2/C-4 Canals. Runoff is backpumped into the NLBSA from the western C-9 basin and the western C-11 Canal. The C-9 Impoundment provides settlement of urban runoff that is stored in the North Lake Belt Storage Area, groundwater recharge within the basin and seepage control of WCA 3 and buffer areas located west of the impoundment.

Operation: Excess water from the C-11 and C-9 basins is distributed to the NLBSA and C-9 Impoundment when there is available storage. In the dry season, water supply deliveries are provided to the C-9, C-6/C-7 and C-2/C-4 canals and to Biscayne Bay. Seepage from the C-9 Impoundment is collected and returned to the impoundment. Aquifer Storage and Recovery (ASR) is proposed in conjunction with the impoundment to improve water supply during dry seasons and droughts. Twenty-five (25), 5-MGD ASR injection wells are included for a total of 125-MGD (194 cfs) capacity. Water from the C-9 Impoundment is injected into the ASR wells when stages in the impoundment are greater than 5.5 feet NGVD (1 foot of depth). Water is released from the impoundment and is recovered from the ASR wells to meet demands when water levels in the impoundment are less than 5.5 feet NGVD (1 foot of depth).

Design and operation detail:

2124-acre impoundment is divided into a northern compartment (385 acres) with a maximum depth of 2 feet and a southern compartment (1739 acres) with a maximum depth of 4 feet. An 11-foot high levee surrounds the impoundment with a 7-foot high internal levee separating the two compartments. Transfer of flows between the compartments is accomplished with one gated culvert structure consisting of two 65-foot long, 72-inch diameter culverts.

Inflow structure: 1000 cfs pump (from NLBSA, to be resized as needed) SEE COMPONENT XX. Pump on when water supply deliveries are needed to C-9, C-6/C-7 and C-2/C-4 canals and to Biscayne Bay when the water level in the NLBSA is above –15.0 feet NGVD.

Outflow structure: Gravity structure with 1000 cfs capacity discharges to the C-9 Canal for water supply deliveries to the C-6/C-7, C-2/C-4 canals and Biscayne Bay.

There are two operational scenarios:

On-peak operations: Flows from the western C-11 and C-9 basins are distributed to NLBSA and C-9 Impoundment where storage is available. Flows stop when the impoundment is full. The intent is to

maximize the amount of water sent to the impoundment for storage in ASR.

Off-peak operations: Water supply deliveries from the impoundment and ASR storage system are provided to the C-9, C-6/C-7, C-2/C-4 canals and to Biscayne Bay.

Seepage Collection: Seepage canals are located on the north, east and west boundaries of the impoundment. Three, 100-cfs pumps are used to direct seepage back into the 4 foot deep impoundment area. The seepage collection canal system is maintained between elevations 2.5 and 3.0 feet NGVD for the east, 4.5 and 5.0 feet NGVD for the west and 4.0 and 4.3 feet NGVD for the 2-foot area.

Twenty-five (25), 5-MGD ASR injection wells (total capacity 125-MGD or about 194 cfs) are located around the perimeter of the impoundment. Eight (8) additional wells have been added to increase the withdrawal capacity to 165-MGD (255 cfs) which improves the effectiveness if the ASR storage system. Water is supplied for injection into the ASR wells via horizontal supply wells and toe drains located inside the impoundment. Water from the horizontal supply wells injects into the ASR wells when stages in the impoundment are greater than 5.5 feet NGVD (1.0 foot of depth). Water is recovered when stages in C-9 Canal are below 3.5 feet NGVD.

An emergency overflow spillway is designed as a lower section of the levee to maintain impoundment levee integrity. The emergency overflow spillway invert elevation is 1 foot above the maximum normal operating elevation. The spillway will discharge into the C-9 Canal. Location: Site identified by Water Preserve Area Land Suitability Analysis, east of US Highway 27 and north of the C-9 Canal.

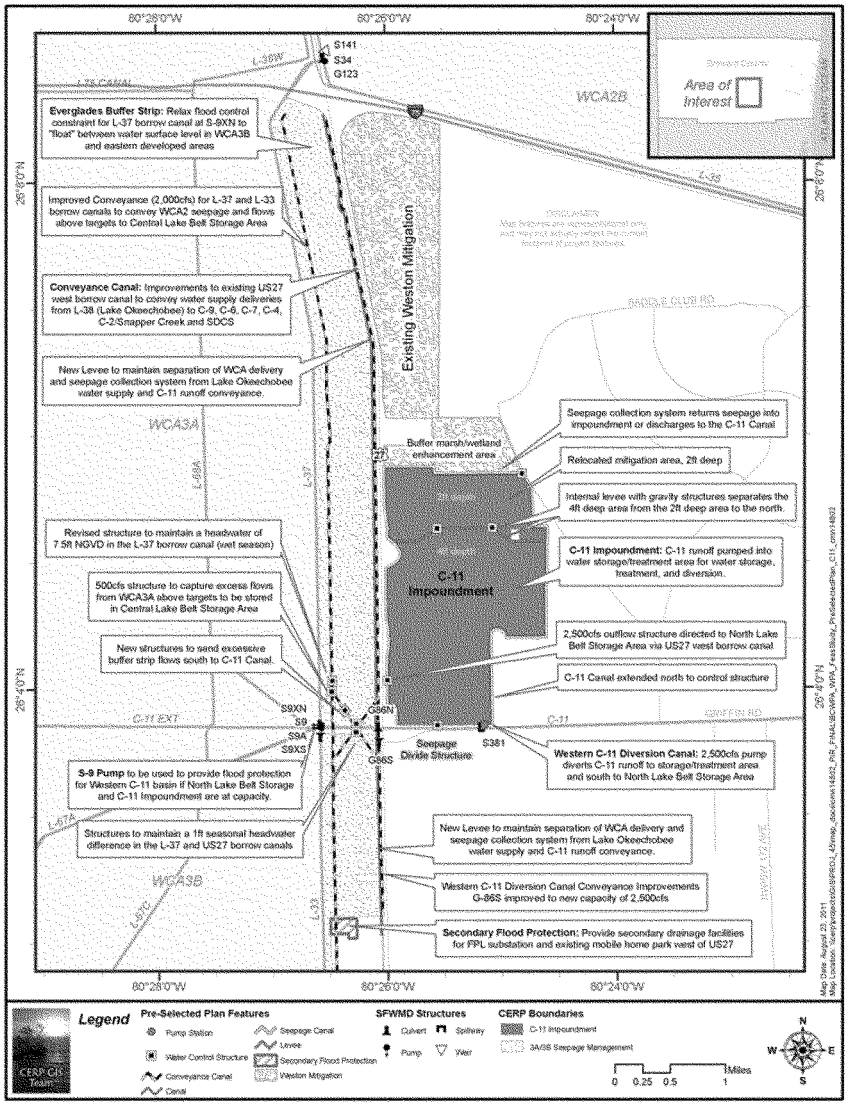
Counties: Broward

Assumptions and related considerations:
Additional settlement facility needed if stored water is backpumped into Water Conservation Area 3A.

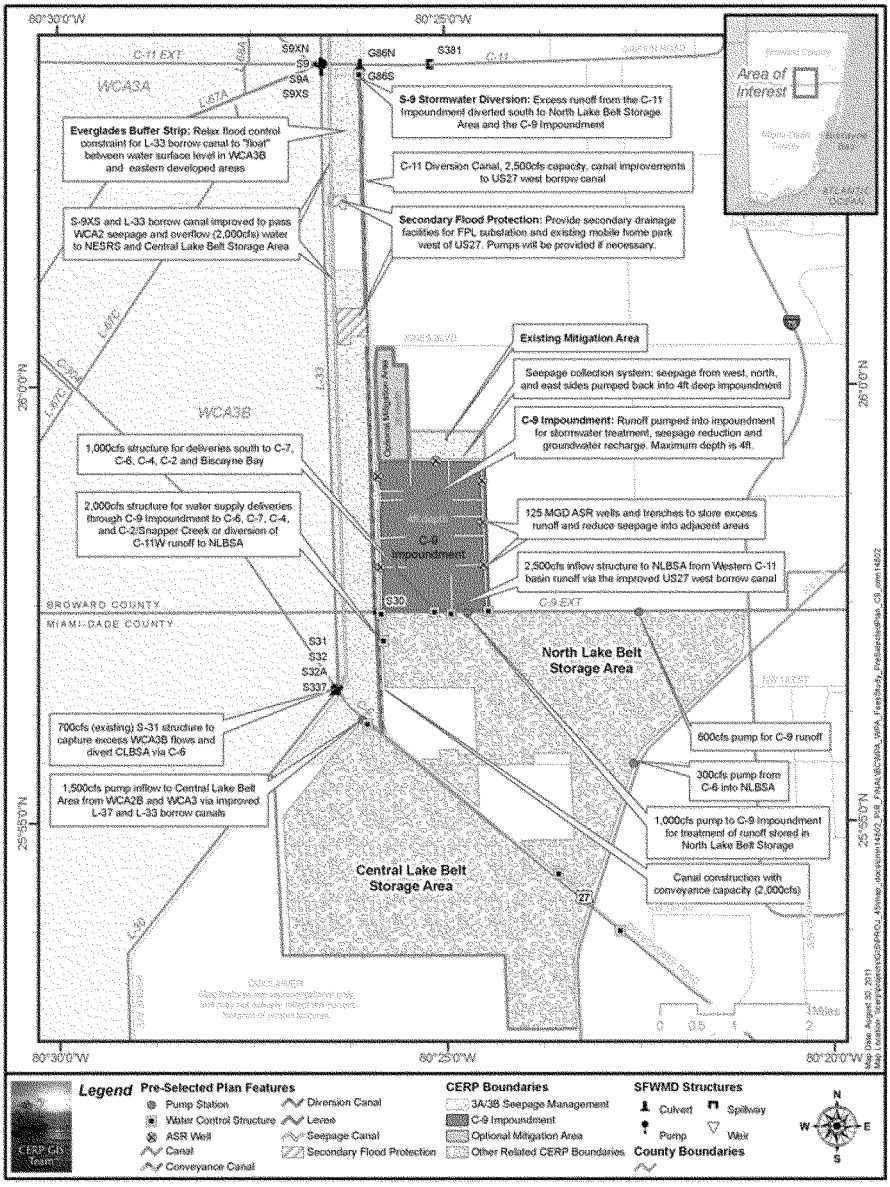
Telemetry systems are required for all operable structures and pump stations. Initially the C-9 Impoundment is operated as an impoundment. This operation continues until the NLBSA is functional. At which time, the intended use of the impoundment is to provide water settlement as necessary.

Summary of modifications from D13R: The footprint is modified and compartmentalized to include a 2-foot deep area to the north and a southern 4-foot deep area with a 7-foot high internal levee separating the compartments. An

ASR system is included. The seepage collection system and inflow pump operation are modified.



WPA FEASIBILITY STUDY – PRE-SELECTED PLAN CENTRAL BROWARD AREA WPA COMPONENT MAP 7



WPA FEASIBILITY STUDY – PRE-SELECTED PLAN SW BROWARD AREA WPA COMPONENT MAP 8

A.15 SUBREGIONAL MODEL (MODFLOW)

A.15.1 Description

The SFWMD used the U.S. Geological Survey (USGS) modular finite-difference groundwater flow model, commonly known as MODFLOW, in order to predict groundwater responses to various water management alternatives in Broward County, Southeastern Florida. The SFWMD enhanced the 1996 addition of the code (MODFLOW-96, Harbaugh and McDonald, 1996) by linking it together with the wetland module, Lake Module, Seepage Barrier Module, improved River Module, Trigger Module, Seepage Return Module, and a DSS Interface Module. MODFLOW is currently the most used numerical model in the USGS for groundwater flow problems.

MODFLOW is a three-dimensional finite-difference ground-water flow model. It has a modular structure that allows it to be easily modified to adapt the code for a particular application. Many new abilities have been added to the original model. Harbaugh and McDonald, 1996, document a general update to MODFLOW, which is called MODFLOW-96, in order to distinguish it from earlier versions.

MODFLOW simulates steady and unsteady flow in an irregularly shaped flow system in which aquifer layers can be confined, unconfined, or a combination of confined and unconfined. Flow from external stresses, such as flow to wells, aerial recharge, evapotranspiration, flow to drains, and flow through river beds, can be simulated. Hydraulic conductivities or transmissivities for any layer may differ spatially and be anisotropic, and the storage coefficient may be heterogeneous. The model requires input of the ratio of vertical hydraulic conductivity to distance between vertically adjacent block centers. Specified head and specified flux boundaries can be simulated as head dependent flux across the model's outer boundary that allows water to enter or exit the modeled area.

MODFLOW solves the ground-water flow equation using the finite-difference approximation. The flow region is considered to be subdivided into blocks in which the medium properties are assumed to be uniform. The plan view of rectangular discretization results from a grid of perpendicular lines. The vertical discretization transforms the modeled domain into a set of parallel "layers". Both horizontal and vertical discretization may be variably spaced. Several solvers are provided for solving the associated matrix problem. The user can choose the best solver for the particular problem. MODFLOW computes an overall mass balance for each time step and a cumulative mass balance for each source and sink.

A.15.1.1 Process Modules

The SFWMD applied code enhancements for analyzing the alternatives associated with the Water Preserve Areas. *Table A-100* presents a list of the original modules of the code used for this effort and the modules of the various enhancement packages. The SFWMD, its contractors, and other agencies provided the code enhancement. In particular, a key enhancement that was made to the MODFLOW-96 code was the development and implementation of the Wetland Module, which simulates the surface water levels and flows in large wetlands. The paragraphs below discuss the code enhancements.

A.15.1.1.1 Wetland Module

The SFWMD and Florida Atlantic University jointly developed this new module to simulate surface water movement in a wetland and its interaction with underlying aquifer and slough channels. The module combines a Manning's type equation for simulation of friction in flow through vegetative surfaces with the mathematical formulation of MODFLOW. The complete package includes flow routing, export and import of water, and evapotranspiration from wetlands. In addition, a comparison was made between the wetland module solution and a solution from a two-dimensional surface water model based on the diffusion-wave equation, which was published in a paper the September-October 1998 issue of Ground Water journal.

A.15.1.1.2 Lake Package

GeoTrans, Inc. modified the original version of the Lake Package for modeling the LEC. Notable improvements include modification of the steady-state solution of the lake stage, the input file structure and output options, and the ability to make the lake stage solution fully implicit. The latter modification precludes the need to use much finer time steps for the lake package as compared to the ground water model when using it in areas where there is considerable interaction between ground and surface water.

A.15.1.1.3 Seepage Barrier

The seepage barrier module is an official USGS package that was added to MODFLOW-96 after its original release.

A.15.1.1.4 New River Package

The SFWMD and Florida Atlantic University jointly modified the original river package to allow for dynamic simulation of the operational rules of numerous water control districts in the South Florida region. The model reads a series of operational rules at the beginning of the simulation period. It evaluates the

antecedent conditions at one or several predetermined nodes within the canal basin at the end of each stress period and determine the operational rules to be imposed for the next stress period.

A.15.1.1.5 Trigger Module

In 1992, the South Florida Water Management District initiated an effort to develop a "Trigger Module" for both MODFLOW code and the South Florida Water Management Model (SFWMM) code. The purpose of the trigger module was to simulate the implementation of water shortage policies in the form of water use cutbacks during periods when increased threat of salt water intrusion along the coastal belt of the Lower East Coast occurs. Because the current versions of the MODFLOW code being used at the SFWMD do not simulate the salt water intrusion along the coast directly, groundwater levels at selected "trigger locations" are used to indicate the threat of salt water intrusion and the possible implementation of water use cutbacks. The code was fully developed and implemented in the SFWMM and has been a valuable tool for many projects including the Lower East Coast Regional Water Supply Plan (LECRWSP) and the C&SF Project Review Study. Although the module was also developed and tested for the MODFLOW groundwater code, it has not yet been used for any major application prior to the sub-regional groundwater model.

A.15.1.1.6 Seepage Return Module

The Seepage Return module was developed for the purpose of allowing ground water flow captured by canals to be routed to specified active cells within the model domain. In particular, the initial intent is to use the module to simulate, as part of the initial WPA alternative, the return (via pumping) of captured reservoir seepage back into the reservoirs. This module is simply a modification of the original Drain Package where ground water flow removed from the ground water flow system by the drains is continually quantified during the simulation and routed to any set of user-specified active cells within the model domain (specified in the input data set for each canal reach).

A.15.1.1.7 DSS Interface

The primary purpose of this package is to allow the user to specify a period of time within the model simulation where heads at designated locations should be written in a format that can be readily imported into HEC-DSS. This database was developed and is used extensively by the U.S. Army Corps of Engineers for storing and retrieving hydrologic data. The DSS package operates independently from MODFLOW's existing output controls, so only heads at locations of interest are saved at the desired time steps as opposed to heads for the entire grid. Additionally, the module has an option of computing layer-based weighted

average heads at designated locations in order to enhance history matching at observation wells that are open to more than one model layer.

TABLE A-103: DESCRIPTION OF THE MODFLOW MODULES USED IN THE BROWARD COUNTY WPA SUBREGIONAL GROUNDWATER MODEL

Package	Description	Notes
Core Modules		
Basic and Output Control	Defines stress periods, time steps, starting heads, grid specifications, units, and output specifications	Handles the primary administrative tasks associated with a simulation
Block-Centered Flow	Specifies steady state vs. transient flag, cell sizes, anisotropy, layer types, and hydrogeologic data for each layer	Derived primarily from geologic data used to construct the model
Surface Water Stresses and Processes		
Recharge	Simulates aerially distributed recharge to a water table during each stress period	Preprocessed using an Agricultural Field-Scale Irrigation requirements Simulation (AFSIRS) based ET Recharge model
Evapotranspiration (ET)	Simulates removal of water from the water table via transpiration and direct evaporation	Preprocessed using an AFSIRS based ET-Recharge model; ET rate diminishes with increasing water table depth
River	Simulates ground water interchanges with canals that can either recharge or drain the aquifer	Canal stages are usually based on measured stages, control elevations, or stages extracted from SFWMM
Drain	Essentially the same as the River package except that canals can only drain the aquifer and water removed by the drains is removed permanently from the model	Canal stages are usually based on measured stages, control elevations, or stages extracted from SFWMM output
Canal	Essentially the same as the River package except it adds the abilities to limit the drainage rate to a specific rate and the recharge rates to a different rate, as well as allowing separate control levels for recharge and drainage	When applied in combination with the wetlands package the controlled discharge is the combined total of surface water runoff and ground water seepage. When applied without the Wetlands package, the controlled discharge is solely ground water seepage
Redirected Flow	Essentially the same as the Drain package except that it allows water to be redirected to another location in the model instead of being permanently removed from the model	
Lake	Simulates interaction between mining lakes (quarries) or reservoirs and the ground water system	Computes lake stages and performs an accounting of inflows/outflows; module was enhanced by District staff
Operations	Simulates the surface water transfer of water based on the availability of water	
Wetland	Simulates the overland flow in wetlands using the uppermost model layer	Enhanced to also simulate either specified or system dependant water diversions within wetlands

Package	Description	Notes
General Head Boundary	Simulates ground water exchange between selected cells and a specified boundary as a function of water level difference	Boundary stages are usually based on measured stages or stages computed by the SFWMM
Water Supply and Management		
Well	Simulates withdrawals from wells	Includes Public Water Supply (PWS), irrigation, and Aquifer Storage and Recovery (ASR) wells; enhanced by the District to read multiple input files
Pumpage Reduction	Simulates wellfield withdrawal cutbacks as a function of water level in trigger wells and in Lake Okeechobee; simulates LEC water shortage policy associated with saltwater intrusion	Cutback zones are based on SFWMM, refined to include more details; SFWMM simulates the timing of Lake Okeechobee cutbacks
Solution Algorithms		
Strongly Implicit Procedure (SIP)	A mathematical solution algorithm internal to the model	Usually used
Preconditioned Conjugate Gradient (PCG)	A mathematical solution algorithm internal to the model; more computationally rigorous than SIP	Used only occasionally when model experiences convergence problems

A.15.1.2 Domain

Figure A-103 depicts the model domain. The domain is bound by the intersection of the C-15 canal and the Intracoastal Waterway to the east and the southern limit is defined by the intersection of the C-7 and the Intracoastal Waterway. The buffer areas in Dade and Palm Beach counties were chosen to provide suitable boundary conditions for the model; however, the primary study area is within Broward County lines.

The model domain is discretized into 456 rows by 371 columns with a uniform cell size of 500 ft x 500 ft. It includes five horizontal layers representing lithologic zones within the surficial aquifer, one of the most transmissive aquifers in the world, sometimes ranging up to 300,000 ft^2/day.

One of the main advantages of this model is the ability to simulate hydroperiods within the wetland areas using the Wetland and Diversion packages. These packages have the ability to represent the wetland system on a daily basis, including levee interaction and sources/sinks. The use of these additional packages allows the model to represent the full hydrologic cycle within the wetland areas starting with the total precipitation as a driving force.

The modeled aquifer is a portion of the Biscayne aquifer. This aquifer is the principle source of freshwater in south Florida. This aquifer system is unconfined and receives recharge directly from infiltration of rainfall and through leakage from the numerous canals located in the region. The aquifer extends from near ground surface to depths in excess of 160 ft and generally occurs throughout Miami-Dade, Broward, and eastern Palm Beach Counties. The Biscayne aquifer is comprised chiefly of quaternary sediments. In places, the basal portion of the aquifer may include Pliocene to Miocene sediments (Fish and Stewart, 1991). The aquifer is principally composed of highly permeable Pleistocene limestones and sandstones (Causaras, 1987). This report describes the age estimates and stratigraphic framework of the quaternary sediments of south Florida along geochronologic lines utilizing the method originally proposed by Perkins (1977).

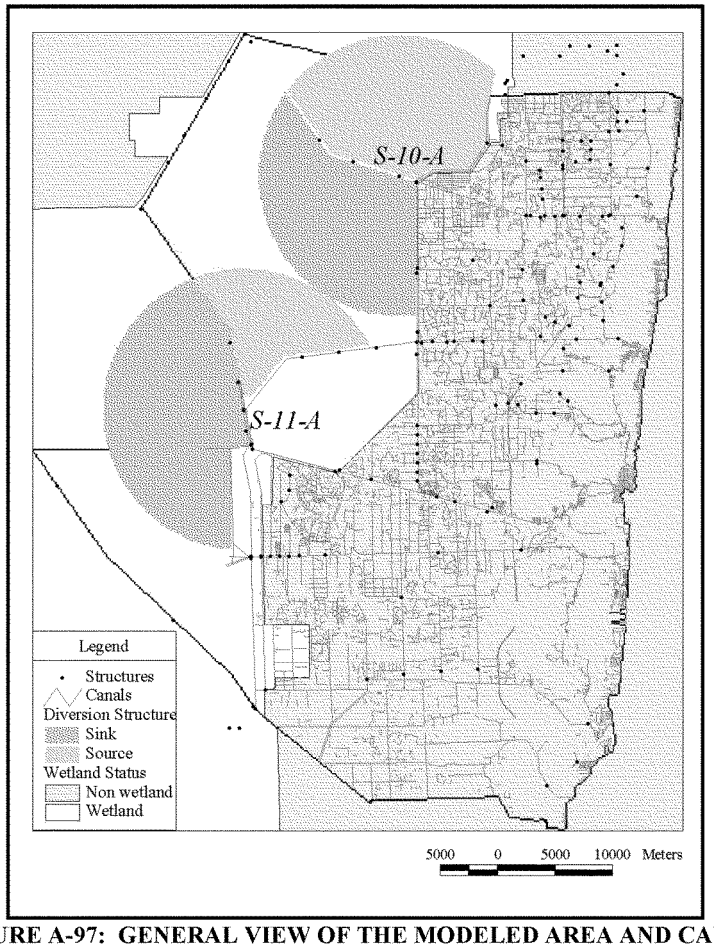


FIGURE A-97: GENERAL VIEW OF THE MODELED AREA AND CANAL SYSTEM

The Surficial Aquifer System in Broward County is an unconfined aquifer and includes all saturated sediments for ground surface down to the clay and marls of the impermeable Hawthorn Formation. The system is dominated by carbonate and clastic sediments ranging in age from the Holocene through the Miocene. The system can be sub-divided into two general zones: an upper zone comprising the highly productive Biscayne aquifer and a lower zone comprising the gray limestone aquifer. The Biscayne aquifer general comprises all quaternary sediments including the Fort Thompson Formation, the Anastasia Formation and the Miami Limestone Formation (Fish and Stewart, 1991). The grey

limestone is a permeable zone within the Tamiami Formation of Pliocene to Miocene age (Fish and Stewart, 1991). In western Broward County, the Biscayne aquifer is separated from the lower grey limestone aquifer by a semi-confining unit of the upper Tamiami Formation, while the two aquifers merge into a single hydrologic unit along the coast.

There are many primary and secondary canals within the study area. Understanding the function of these canals and their relation to the groundwater levels is essential in developing an effective model for the study area. Water levels in the primary canals are maintained by the SFWMD using pump stations and control structures. During dry periods, water is transported via primary canals from Lake Okeechobee and the Water Conservation Areas (WCA's) into the study area to maintain adequate water levels in the canals, and to prevent salt-water intrusion. During wet periods, water is either discharged to the ocean or pumped into the WCA's in order to reduce the potential for flooding. The secondary canals are used to maintain the water levels by the 26 local districts (e.g., water control districts, drainage districts, or improvement districts).

The Basins of Broward County are divided into sub areas based on control elevations and/or on the operational rules of each drainage district. The county-operated Water Central District (WCD) and other drainage districts obtain water usage permits to withdraw water from SFWMD canals to maintain water levels and to supply water to wellfields within their respective drainage districts. Some districts have pumps that are able of bringing water into their systems. The recharge systems for other districts consist of free flow from or to the SFWMD canals, with the flow direction being dependent upon the difference in water levels between the individual drainage districts and the SFWMD canals. In some cases, the drainage district canals are allowed free flow only when SFWMD canal elevations are higher than the local districts canals.

In the past, there were several farms located within the Pinetree, Cocomar, and Turtle Run WCD's. These farmers use a pump on the Hillsboro Canal and a canal that runs parallel to US 441 to supply water to the farm ditches. Due to the interconnection of the canals in the area and the hydraulic connection between the canals and the aquifer, the pumpage from the farmers helped recharge the aquifer throughout most of north central Broward County. By agreement between the farmers and the local drainage districts, the average water level in the main canal is 11.6 ft NGVD. However, the water level in the main canal can rise as high as 12 ft NGVD during the growing season and can drop to 11 ft NGVD at other times. The farmers attempt to maintain the levels in the irrigation ditches between 12 and 14 ft NGVD. The growing season usually begins in November and ends in April, although it can begin as early as September and end as early as January. The highest water levels occur in

November, at the beginning of the dry season. The farmers lower the water level an average of two ft during the remainder of the growing season in order to protect the crop roots. The irrigated acreage within the farm areas decreased from about 2,700 acres in 1982 to about 850 acres by 1989. Many of the farmers moved out between 1980 and 1985.

A.16 INPUT DATA AND MODEL SETUP

A.16.1 Model Discretization

The model uses a uniform spatial discretization of 500 ft long by 500 ft wide (250,000 ft^2 cells). The model's grid includes 169,176 cells (456 rows and 371 columns), and five layers that were determined by geological features (four zones of the surficial aquifer plus the lower boundary layer with the Floridan aquifer). The grid limits in US State Plane Florida East NAD 27 are x_{min} = 620,250; x_{max} = 805,750; y_{min} = 550,000 and y_{max} = 778,000 for a total area of 42,294 million square ft. This discretization allows an adequate accuracy while managing the time required processing model input/output and executing the model.

In the time discretization for the transient model, each day from January 1988 to December 1990 was treated as one stress period. During this interval, the region has had a mean annual precipitation of 52, 39 and 53 inches/year respectively, which comprise average and dry precipitation conditions (NOAA, 1988, 1989, 1990).

Of the five model layers, the top layer corresponds to the Holocene sediments, soils and the youngest Pleistocene marine unit deposited in the region (Q5 of Perkins, 1977). This layer generally extends from the land surface to an elevation of -5 to -20 ft NGVD. The layer contains most of rivers, drains, recharge, evapotranspiration cells and wetlands. The thickness of this layer was set to mainly portray the soil conditions while avoiding the drying of cells during model simulations. The second layer consists of the next two marine Pleistocene deposits (Q3 and Q4 of Perkins, 1977) and contains some deep canals and lakes. The third layer encompasses the main production zone of the Biscayne aquifer and corresponds to the older Pleistocene deposits of the Fort Thompson and Anastasia Formations (Q2 and Q1 of Perkins, 1977). The fourth layer encompasses the upper unit of the Tamiami Formation. The fifth and bottom layer encompasses the Gray Limestone aquitard in the west and its coastal equivalent. *Figure A-98* provides a general description of the model vertical discretization.

FIGURE A-98: MAIN STATISTICS FOR THE TOP ELEVATION SURFACE FOR EACH LAYER (FT)

	Topo	Layer 1*	Layer 2	Layer 3	Layer 4	Layer 5
Maximum (NGVD)	35.48	-5	-13	-32	-70	-122
Minimum (NGVD)	0.0	-31	-73	-145	-194	-244
Average (NGVD)	8.01	-6.12	-37.98	-79.71	-122.31	-162.11
Maximum thickness		40.48	67.0	85	89	97
Minimum thickness		6.06	8.0	13	11	9
Average thickness		14.14	31.85	41.72	42.59	39.79

* Water Table

A.16.2 Domain Data

The model uses two types of domain data. One type is the bottom and top elevation of each of the model layers, and the other is the hydrogeological properties of each layer.

A.16.2.1 Surface Elevation

The model uses the surface elevation to estimate the depth to the water table in order to estimate the evapotranspiration rate. *Figure A-99* illustrates the topography of the modeled area. The elevations are based on the NGVD 29 and revised to reflect recent permitting decisions.

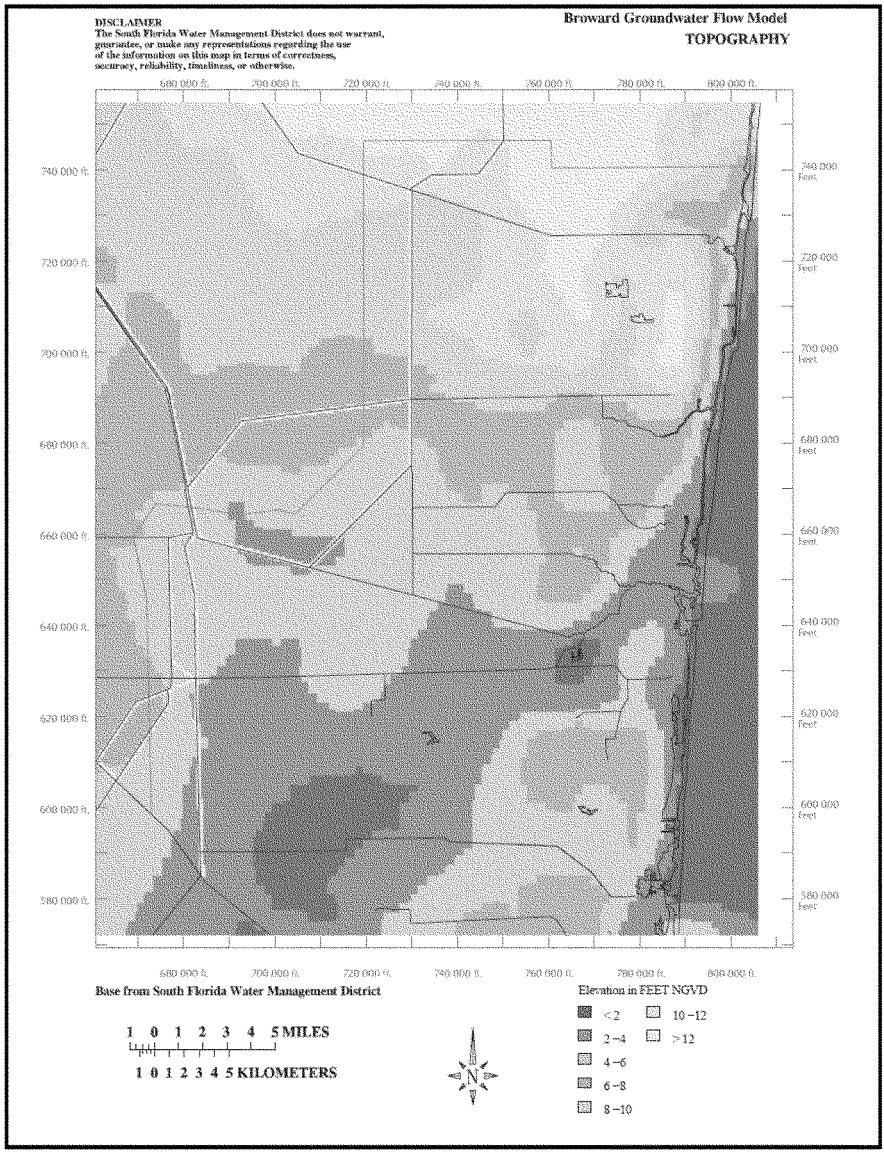


FIGURE A-99: SURFACE ELEVATION USED FOR THE BROWARD COUNTY SUB-REGIONAL GROUNDWATER MODEL

A.16.2.2 Layers Bottom Elevations

Geologic layers bottom elevations are based on boring logs throughout the county.

A.16.2.3 Hydrological Properties

Pre-calibration hydraulic conductivities for all layers in the model were initially based on estimates of hydraulic conductivities from various reports, pump tests and core analysis completed in the study area. The principle sources for determining the hydraulic characteristics of the Surficial Aquifer System are reports from Fish (1991) and Causarus (1975) with supplemental information from independent aquifer performance tests conducted by the SFWMD and specific capacity tests reported to the SFWMD from various users. The horizontal hydraulic conductivity of the top layer was estimated based on the average vertical hydraulic conductivity of the soil profile, using data obtained from the latest Soil Conservation Service soil surveys of Miami-Dade County (Pendleton et al., 1976), Broward (Pendleton et al., 1976) and Palm Beach (McCollum, 1978), and on SFWMD aquifer tests in the upper zone of the surficial aquifer system.

A.16.2.3.1 Horizontal Hydraulic Conductivity

The surficial aquifer system of the study area is a semi confined system. The main statistics of the calibrated values for the hydraulic conductivity for the upper zone of the surficial aquifer system are shown in *Table A-104.*

TABLE A-104: MAIN STATISTICS OF HORIZONTAL HYDRAULIC CONDUCTIVITY FOR EACH LAYER (FT/DAY)

	Layer 1	Layer 2	Layer 3	Layer 4	Layer 5
Maximum	15,213	39,764	39,732	1,580	990
Minimum	13	10	6	3	5
Average	389	3,584	6,228	236	308

A.16.2.3.2 Vertical Conductance

Within the MODFLOW model, vertical flow between layers is controlled by the vertical conductance coefficient (Vcont) that is a composite term expressed in units of ft2/day. It is calculated for the two nodes located at vertically adjacent geohydrologic units using the equation:

$$V_{CONT} = \frac{1}{\frac{b_u}{2K_{hu}A_{vh}} + \frac{b_l}{2K_{hu}A_{vh}}} \qquad (2)$$

In Equation (1), b_u and b_l are the thickness of the upper and lower layers (ft), K_{hu} and K_{hl} are the horizontal hydraulic conductivities for the upper and lower layers (ft/day), and A_{vh} is the ratio of vertical to horizontal hydraulic conductivities (the vertical anisotropy factor) for each layer in consideration (dimensionless). The factor A_{vh} was adjusted non-uniformly during the calibration process.

Calibrated values of the Vcont factor are shown in *Table A-105*. Layer 2 appears to be semi-confined unit. It is characterized by high values of hydraulic conductivity in any direction. Although those values appeared to be lower, it was found to yield acceptable results.

TABLE A-105: MAIN STATISTICS OF VERTICAL CONDUCTANCE FOR EACH LAYER (FT^2/DAY)

	Layer 1-2	Layer 2-3	Layer 3-4	Layer 4-5
Maximum	48	147	8	2
Minimum	0.03	0.02	0.01	0.007
Average	1.73	7.46	1.12	0.34

A.16.2.3.3 Specific Yield and Storage Coefficient

The specific yield values in all of the model layers are set to 0.25, a typical value for unconfined aquifers (Walton, 1987). Pre-Calibrated storage coefficients in layers 2 through 4 are set equal to the specific storage value of 1x10-5 (Restrepo et al 1992) multiplied by the aquifer thickness (ft). The final storage coefficient values varied as shown in *Table A-106*.

TABLE A-106: MAIN STATISTICS OF STORAGE COEFFICIENT CHARACTERISTICS FOR EACH LAYER

	Layer 2	Layer 3	Layer 4	Layer 5
Maximum	0.00034	0.00043	0.00044	0.00049
Minimum	0.00004	0.00007	0.00006	0.00005
Average	0.00016	0.00021	0.00021	0.00020

A.16.3 Boundary Conditions

The model considers the following boundary conditions: sources and sinks at the top, specified head and flow from lateral boundaries, and no flow at the bottom of the aquifer. Sources and sinks at the top include infiltrated rain, evapotranspiration, seepage interchange with wetlands, canals and rivers, and infiltration from irrigation.

A.16.3.1 Infiltration from Rainstorms and Irrigation, and Evapotranspiration

Aquifer recharge from rainstorm is a function of rainstorm intensity, duration, drainage conditions, direct evaporation, and the permeability of the soils from the water table to the soil surface.

The model uses maximum potential evapotranspiration rates, soil surface elevation, depth to water table, and maximum depth from which evapotranspiration may occur (extinction depths) to estimate the evapotranspiration rate. The extinction depth is based on representative root zone depths for each type of vegetation land cover found within the model domain. Maximum evapotranspiration rates were estimated by conducting a daily water balance on the root zone for each unique combination of land cover and soil type, as outlined in Restrepo and Giddings (1994). This water balance analysis also yielded daily amounts of infiltrated rainfall that reached the water table. These data were used to construct the arrays depicting rainfall recharge to the water table and provide input to the model using the recharge package. The evapotranspiration/recharge values were carefully developed at the beginning and were not modified during the calibration process.

Data from a recent report on Melaleuca evapotranspiration rates Information (Chin 1996) were used to select appropriate parameters for modeling evapotranspiration from Melaleuca in both the regional model and the local model. Chin (1996) noted that the interception losses can be significant. In addition, in this analysis it was assumed that the evapotranspiration extinction depth for the root zone should be about 36 inches.

Evapotranspiration from the saturated zone was accounted in the model through the MODFLOW ET package. This package input data requirements include an evapotranspiration surface array depicting the elevations at which evapotranspiration from the water table occurs at a maximum rate, an array containing maximum evapotranspiration rates, and an extinction depth array that represents the depth where evapotranspiration rates from the water table become negligible. The evapotranspiration surface and extinction depth arrays were based on land surface elevations as well as representative shallow and deep root zone depths, respectively, for all vegetative land covers found within the model domain. The maximum evapotranspiration rates were estimated by

conducting a daily water balance on the root zone for each unique combination of land cover and soil type, as outlined in Restrepo and Giddings (1994). This water balance analysis also yielded daily amounts of infiltrated rainfall reaching the water table. These results were used to construct the arrays depicting rainfall recharge to the water table and were input to the model using the Recharge package.

A.16.3.2 Land Use

Land use describes the land coverage, which is a useful data to estimate runoff/precipitation relationships, and Manning coefficient of roughness for overland flow. Land use includes the type of use, such as natural area, agricultural area, and urban area, and the type of vegetation in each land use and the fraction of impervious areas, such as buildings and roadways. The type of vegetation is used to determine the Manning coefficient of roughness for channel and overland flow. In addition, land use data were used to determine the locations of preferred flow paths adjacent to wetlands; as the presence of rockpits, levees, and channels are represented for example, as roads, borrow areas and waterways, repeatedly.

A land use cover map was obtained for this model from the SFWMD's GIS library, CD-ROM #1. This map was used to select attributes from the associated tables. *Figure A-100* illustrates the distribution of land use over the modeled domain.

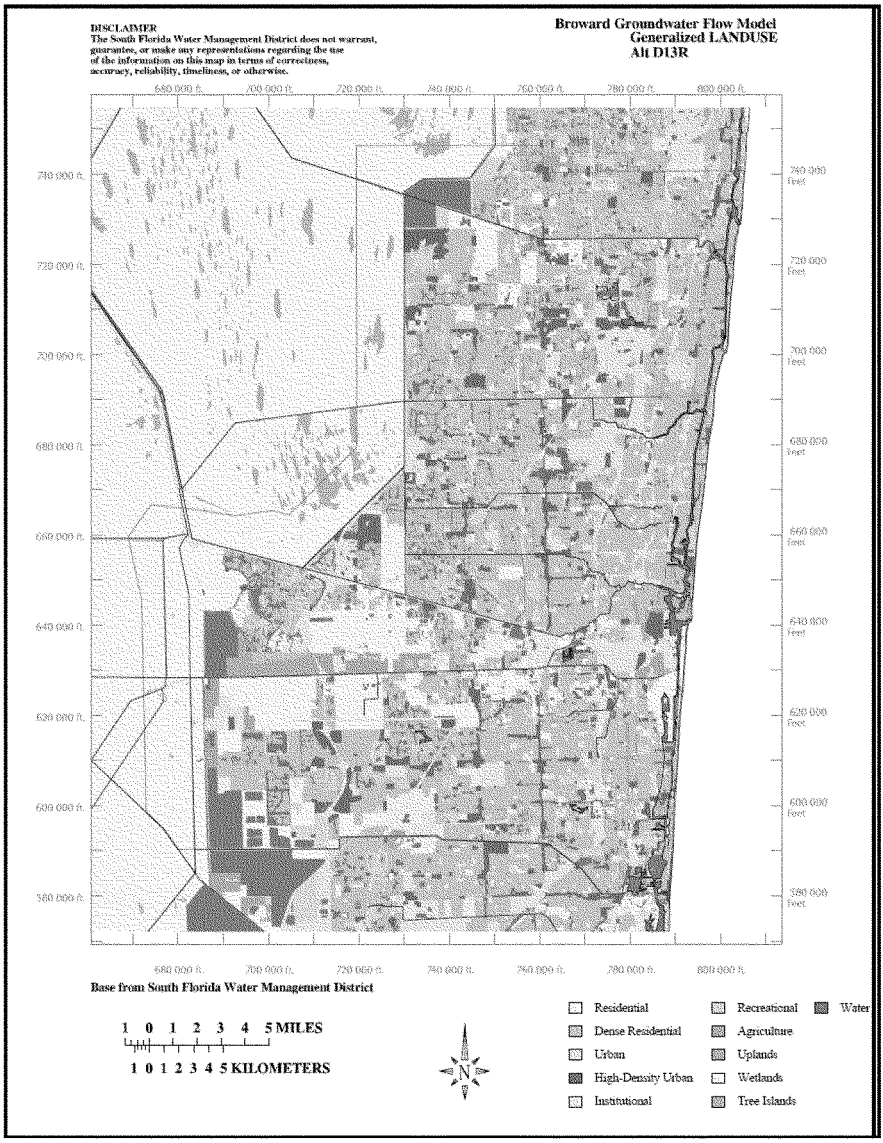


FIGURE A-100: LAND USE MAP FOR THE MODELED DOMAIN

To obtain discretized land use values by row and columns for the model, the user overlaid the land use map onto the model grid map containing. In this operation,

the user excluded isolated small, wetland areas to minimize numerical instabilities in the numerical model.

A.16.3.3 Wetlands

Table A-107 depicts the ILOC flag MODFLOW uses for each cell in the wetland areas to indicate waterways or interfaces with levees or channels. The features, ILOC, in the Wetland Package is defined as a flag for each cell, which indicates waterways (rivers and canals) or interfaces with levees or channels as the orientation of flow in the wetland, with different values of conductivity. To avoid numerical instabilities, the modeler placed the levees in the model 500 ft away from the associated canal to allow an intermediate cell between the barrier and the waterway.

TABLE A-107: WETLAND FEATURES USED IN THE MODEL

ILOC	Land Use	Observation
0	Isolated Wetland	
1	Regular Slough Channel	
2	Airboat Trail	
3	Wetland-Channel	C-4 and other canals / Spoil areas - canal - spoil areas, roads
4	Levee-Slough Channel	Road – canal / Spoil areas – canal / Canal - road
5	Levee	
6	Levee-Lake	Not found
7	Lake	Wetland delimited by circular canal

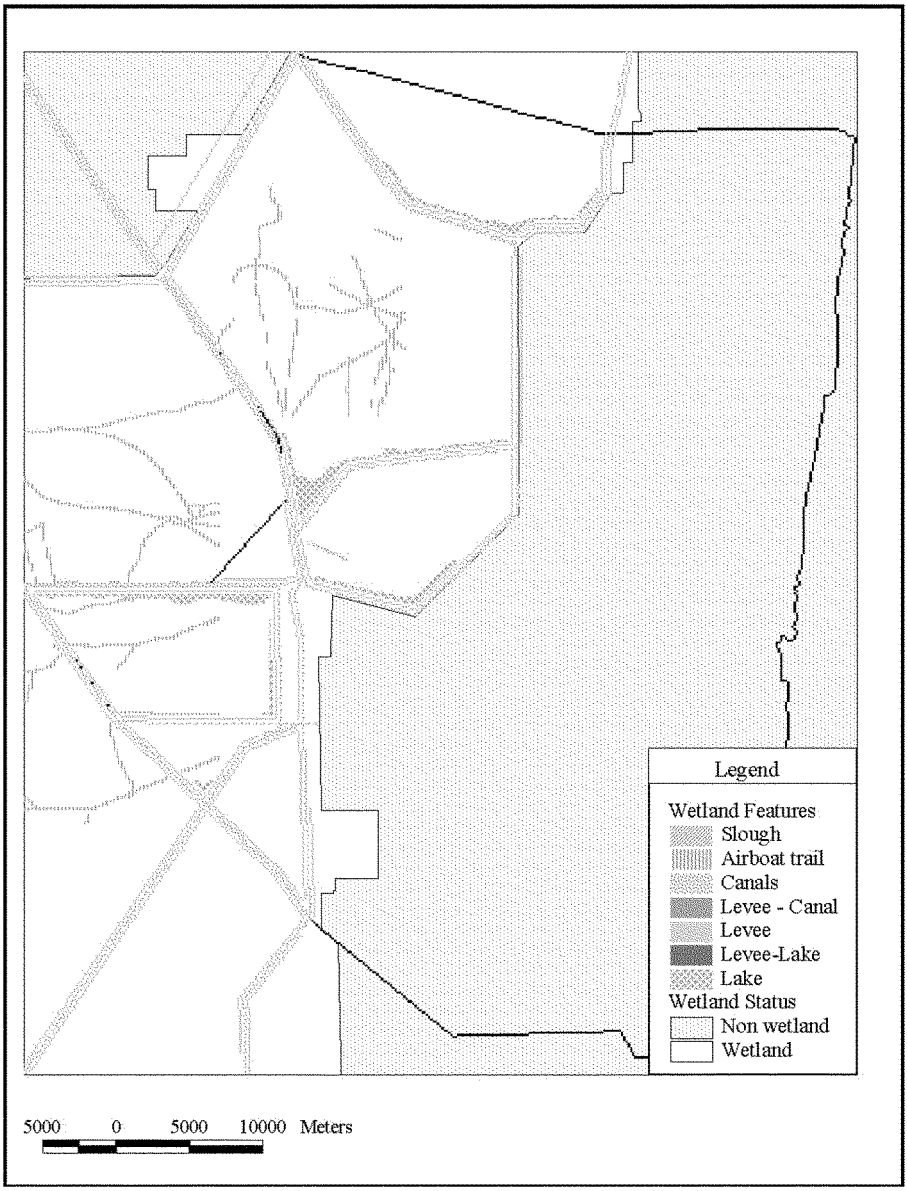


FIGURE A-101: WETLAND SYSTEM, WATERWAYS, AND NO-WETLAND AREAS OF THE BROWARD COUNTY MODEL

A.16.3.4 Levees

MODFLOW considers levees in the simulations through information about orientation of flow given in the FACES parameters. There are two types of FACES: FACE1 – a primary face of orientation, and FACE2 – a secondary face of orientation. For the levees, the faces are set perpendicular to the orientation of the structure, i.e. if the levee is oriented NS, face 1 or 3, in the cases when the levee is not completely horizontal or vertical, the faces that represent the barrier are selected. For the channel or slough, the faces are set toward the direction of flow, (i.e. if the slough is oriented NS, the faces will be 2 and 4).

MODFLOW uses the LEVEE parameter as a parameter to locate each levee in the grid model. The Broward county model contains levees along the following canals: C-11, C-13, C-304, I-75, L-30, L-33, L-35A, L-35B, L-37, L-38W, L-39, L-40, L-5, L-6, L-67A, L-68A, MIAMI, and New River as NS-C-9EXT.

A.16.3.5 Canals

The basis for the canals location in the model was the 7.5-Minute USGS Hydrography Overlay. All canals and lakes from the original map were converted into linear features. In order to check and update the USGS spatial features, the file was compared to a 10-meter resolution enhanced SPOT image (satellite imagery covering Broward, Miami-Dade, and the southern end of Palm Beach counties). Most small canals were checked using 1:300 aerial photographs (TRW REDI Reality Atlas, 1995). On-screen digitizing was performed using ArcView with the degree of zoom set to 1 inch on the screen equaling approximately 2000 ft on the georectified image. In this way, the smallest lake able of being digitized was approximately 250ft by 250ft. Lakes interconnected with flow canals having a top width of less than approximately 250ft were digitized as line features and where the width increased, polygons with a centerline were used. The centerlines of all digitized lakes allow for the easy transition from lake to canal at any point in the River and Drain Packages generation.

It is important to note that the USGS canal features do not precisely match with the SPOT image features. The loss in accuracy could be due to problems with the image georeferencing or a loss of precision during the change from NAD 83 to NAD 27 coordinate system. Overall, the USGS file is considered more accurate than the SPOT image.

The modeler obtained canal bottom elevations from the U.S. Army Corps of Engineers canal profile records, SFWMD's records, drainage districts records, information obtained in this project, or estimated when no other information was available. Average daily canal stages were determined from the SFWMD

database and/or these records. The data associated with each of the canal segments are depicted in *Table A-108.*

TABLE A-108: DATA ASSOCIATED WITH EACH OF THE CANALS SEGMENTS

Reach feature	Field Name	Data Type
Reach id	ID	Integer
Hydraulic conductivity at the bottom of the reach	HYDR_CON D	real
Bottom thickness	BOT_THICK	real
Slope of the canal reach	CSLOPE	real
Name of the water body	CAN_NAME	string
Width at the top of the stream	TOP_WIDTH	real
Width at the bottom of the stream	BOTWIDTH	real
Sediment thickness at the side of the canal	SIDE_THICK	Real
Slope at the side of the canal	SIDE_SLOPE	Real
If the cross section of the canal has field data	XSEC	y/n
If the reach is active or inactive	FUNCTION	on/off
Type of the stream (canal, lake or culvert)	TYPE	string
Length of the reach	LENGTH	real
Elevation of the bottom of the stream	BOT_ELEV	real

MODFLOW wetland module uses the IDIV flag for each cell to indicate waterway diversions and interconnection between wetlands and waterways. The flag indicates presence of an extraction well or a canal structure in a wetland area. *Table A-109* provides the IDIV flags used in the model.

TABLE A-109: WATERWAYS DIVERSION OPTIONS

IDIV	Waterway diversion
1	Historical and target diversions or pumping flow is known or provided.
2	Drain structure computed using an analytical function for the ratting curve
3	Drain structure with lag of one time step

Table A-110 lists the station names of the waterways structures in the model and their physical attributes. The table links the station names to a spreadsheet containing a "time series of flow data", i.e. S-10-B, S-11-A, etc. The flow type is a character field used to specify if the cell at the diversion zone of influence is a source of water or is a sink. The modeler created a buffer around each station with maximum distance between a diversion cell and the structure of about 18,000 ft. This value was based on a daily flow velocity of 0.2 ft/s. The buffer

radius could vary when the number of source cells does not match the number of sink cells.

The model treats the flow in/out to/from the model domain by a canal by placing a set of sink/source cells in the input data set. This sink/source cells in wetland areas have been placed at the top layer of the model.

TABLE A-110: STRUCTURE CHARACTERISTICS ASSOCIATED WITH THE IDIV PARAMETERS

Name	Flow type	Control	Canal	Design Q	Discharge. rate cfs	Function	Description	IDIV
S-11-A	spillway	Gate	L38W	5570	2685	Control stages at WCA2A	Not normally required: WCA2A discharging into canal L38W	3
S-11-B	spillway	gate	L-38-W	5570	2194	Regulation WCA2	Not normally required	3
S-11-C	spillway	gate	L-38-W	5570	3408	Regulation WCA2	Not normally required	3
S-38	culvert	gate	L-36	500	586	Regulation WCA2	Supply water to C-13 and C-14 during low natural flow periods and when stages at WCA2A are above schedule discharge to tidewater.	3
S-7	spillway	Pump and gate	North New River	2490	2790	Gravity flow to maintain stage at the canal	Discharges water from the canal to WCA2A when the stage at the canal exceeds 12.5 ft	3
S-144 S-145 S-146	culvert	gated	L-35-B	210		Regulation WCA2A	connecting WCA2A to WCA2B, controls stages at WCA2A discharging into WCA2B and WCA3A	3
S-10-A	spillway	Gate	L 39	4680	3158	Control stages at WCA1	WCA1 discharge at L 39	3
S-10-C	spillway	Gate	L 39	4680	2661	Maintain stage WCA1		3
S-10-D	spillway	Gate	L 39	4680	2508	Maintain stage WCA1		3
S-39	spillway	gate	Hillsboro	800	800	Maintain stage at Hillsboro	Optimum stage at Hillsboro and when stage at WCA1 is over discharge to tide water by the canal	3
S-6	pump		Hillsboro	2920	2925	Maintain stage at Hillsboro	Pumps from Hillsboro Canal to WCA1, when stage at canal exceeds 12.5 ft until 10 ft. Also from Lake Okeechobee.	1
S-9	pump		C-11	2060	2880	Maintain stage at C-11	Water discharged from the Miami Canal to WCA3A when stage at canal exceeds 12.5 ft	1
S-141	Sheet pile overflow weir	Flash board	L-38-E	435		Regulate stage at WCA2B	Releases from WCA2B to the New River Canal	2
Culvert2 Culvert3 Culvert4 Control3	culvert	gated				Regulate stage at WCA3A	Located at the SR 84 road to maintain the flow into the WCA3A	3

A.16.3.6 Drainage Parameters

The basis of the model drainage information is the current SFWMD basins map as shown in Cooper and Lane (1987). The modeler updated the computer operation rules database prior to calibrating the model using the information given by each Drainage District and the Department of Natural Resources Protection of Broward County in order to reveal the actual water management division.

The areas in the model that are not under a Drainage District control were named with the character string FAU followed by the acronym of the sub-basin location. For instance, FAUIS-SB1 is a sub basin named at FAU, located close to the Intracoastal Waterway at the southern part of the County. SB1 indicates that this sub-basin is the first subdivision of a management area ("District"). The criteria used to determine the subdivisions were the presence of a structure (e.g., gate, pump, weird, and plugs). *Table A-111* shows the database fields and design for the basins.

TABLE A-111: DATA ASSOCIATED WITH EACH OF THE SUB-BASINS POLYGONS

Reach feature	Field Name	Data Type
District ID	DRDIST95_ID	Integer
Sub basins ID within each drainage district	BASINS_ID	Integer
Sub basin Area	AREA_SB	Real
Name of the district	DIST_NAME	String
Acronym for the full name of the drainage district	DIS_CODE	String
Sub-basin name	SUB_BASIN	String
Source of surface water input from adjacent drainage districts/sub-basins	IN_BASINS	y/n
Adjacent district/sub-basin that functions as a sink for surface water losses	EF_BASINS	y/n
ID for the influent sub-basin	ASC_INBAS	String
ID for a second influent sub-basin	ASC_INBAS2	String
ID for the effluent sub-basin	ASC_EFBAS	String
ID for a second effluent sub-basin	ASC_EFBAS2	String
Optimum water level in the sub-basin	OPT_LEVEL*	Real
Condition indicating if there exists an external recharge source via either gravity, free-flow or pumping	RCH_PROJEC	y/n
Source of water for the recharge project	SOURCES	String
Source class: canal, wetland, reservoir or ASR	SOURCE_CLS	String
Source type: gravity or pump	SOURCE_TYPE	String
Stage at which recharge starts to maintain the optimum level	ON_LEV_RCH	Real
Stage at which recharge stops to maintain the optimum level	OF_LEV_RCH	Real
Condition indicating if there exists an external drainage sink via either gravity, free-flow or pumping	DRN_PROJEC	y/n
Sink of water for the drain project	SINK	String
Sink class: canal, wetland, reservoir, or ASR	SINK_CLS	String
Sink type: gravity or pump	SINK_TYPE	String
Stage at which drainage starts to maintain the optimum level	ON_LEV_DRN	Real
Stage at which drainage stops to maintain the optimum level	OF_LEV_DRN	Real
Level above the optimum level which is maintained for extra storage during DRY conditions	DRY_XSTORE	Real
Time when the extra storage is active	TIME_ON	String
Road crown elevation, used to estimate canal bottom when data is not available	RD_CROWN	real
Calculated as ROAD_CROWN – 5 minus the average canal depth as reported by each district	CANAL_BOT	real
Calculated as ROAD_CROWN – 5 minus the average lake depth as reported by each district	LAKES_BOT	real
Structure that controls the level in the sub-basin	STRUCTURE	string
Sub-basin is active during the modeling process	BASIN_FTN	string

*The optimum level of the free-flow basins that have historical data is set to 999.

The modeler obtained drainage basin data for each cell of the model grid by overlaying the model grid on the drainage basin map. This operation assigned a row and column for each drainage coverage characteristic length for each canal

reach. The information in the new canal coverage is crossed with the information in the basin coverage to get the full description of the operation rule of each canal. *Figure A-102* shows the operation of the structure associated with each canal reach in order to maintain the optimum level (OPTLEV), where ONLEVD is the stage at which the canal starts to drain, OFLEVD is the stage at which the canal stops draining, ONLEVR is the stage at which the canal starts to recharge and OFLEVR is the stage at which the canal stops recharging the aquifer. It is important to say that the behavior of the basins ID # 65, 179, 186, 187, 188, 190, 194 and 195 changed their function from drain to river around May of 1989, stress period 500 (Fran Henderson. Broward County Office of Environmental Services, personal communication, 2000).

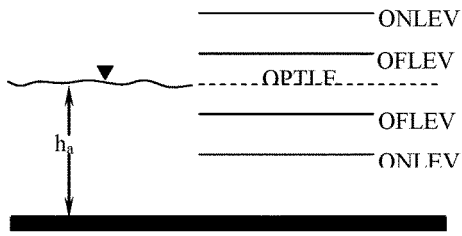


FIGURE A-102: DIAGRAM ILLUSTRATING THE RELATIVE POSITIONS OF TARGET MANAGEMENT LEVELS FOR WATER DISTRICT OPERATION

A.17 MODEL CALIBRATION AND VERIFICATION

A.17.1 Calibration

SFWMD calibrated the model by a trial and error process. The model was run for small simulation periods in transient in transient mode until the model predicted relatively stable conditions in the aquifer systems were achieved (i.e. head levels were realistic and showed reasonable variation over time). The model input parameters were adjusted as necessary to match model predictions with observed values. The modeler performed parameter adjustments for the following parameters: general head boundary conditions, horizontal hydraulic conductivity, aquifer vertical conductance, storage coefficients, and conductance coefficients of canals, rivers, and drains.

The period of record selected for history matching was 1988-1995. This period of record includes a severe drought (1988-1990), an average condition (1992-1993), and an extreme wet condition (1994-1995). The primary objective for the history matching was to compare measured and computed water levels at monitoring

sites and adjust model parameters as appropriate to reduce errors to an acceptable level.
The modeler compared daily water levels computed by the model to measured daily water levels at well locations. The modeler considered that the model was calibrated at a given well location when the average difference between the measured and computed water levels was less than 1.0 ft, unless there was some apparent physical condition that would prevent a close match from occurring. *Figure A-103* illustrates the locations of the observation wells.

Table A-112 lists the differences between computed and observed water levels. The table provides the mean, minimum, and maximum errors for each observation well. The model has not been calibrated yet for the eastern Boca Raton area along the Atlantic Ocean coast.

It is important to note that the statistics for each gage are based on the measured water level data available at that site within the calibration period of record. At some gages, data only exist over a fraction of the total period of record and result in statistics that may not be indicative of model accuracy over the entire period of record. Furthermore, the measured ground water levels are the daily maximum values (the only ground water levels published by the USGS) at each site and may not always be close to observed end-of-day ground water levels. In contrast, the model computes water levels at the end of each time step, which, in this case, is the end of each day. Additionally, one can generally not expect a finite-difference based model to replicate ground water levels observed in the immediate vicinity of a pumping well due to limitations imposed by the spatial resolution of the model. Finally, it should be emphasized that the calibration results depicted in *Table A-112* reflect the current status of the model and are subject to change as improvements to the model are made.

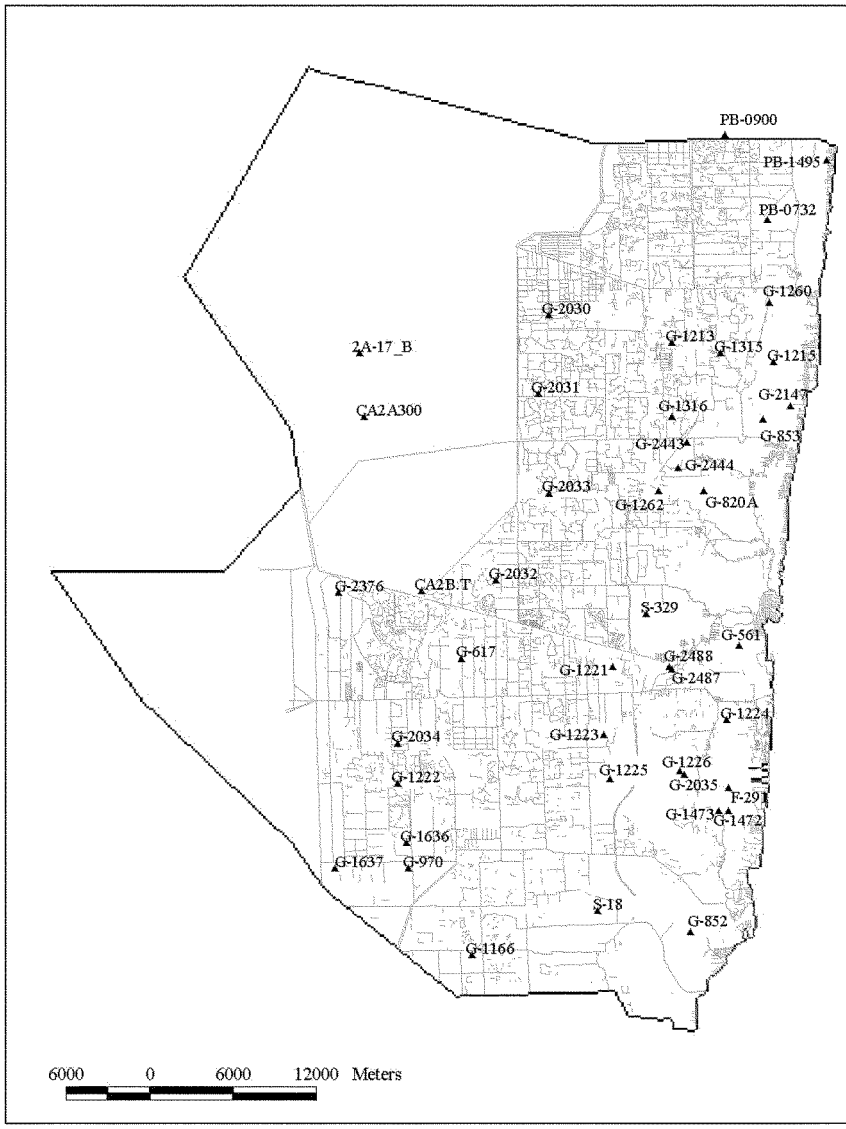


FIGURE A-103: LOCATION AND WELL NAME FOR THE HISTORICAL OBSERVATION

TABLE A-112: CALIBRATION STATISTICS FOR THE PERIOD 1988–1991 (FREQUENCY WITHIN A 1 FT MARGIN OF ERROR AND STANDARD DEVIATION)

STATION	Minimum Difference	Average Difference	Maximum Difference	Frequency within a 1 ft margin of error
G-260	0	1.234	3.69	44.95
G-2030	0	0.3916	1.92	94.087
G-2739	0	0.3696	2.4	96.7438
G-213	0	0.7065	5.24	70.9022
G-616	0	0.6586	4.3	80.2497
G-315	0	0.9017	2.91	60.7533
G-215	0	1.2699	4.9	50.4383
G-2031	0	0.3876	2.07	96.2377
G-2147	0	0.8442	2.95	60.5865
G-1316	0	0.5788	2.57	89.8757
G- 853	0	1.147	3.58	45.5946
G-2443	0	0.3285	2.01	97.479
G-2444	0	1.1182	8.59	53.52
G-2395	0	1.35	4.69	42.9821
G- 820A	0.02	1.4157	3.9	24.2903
G-2033	0	0.4002	3.39	95.292
G-2032	0	0.3639	2.86	95.3366
G-1220	0	0.431	2.64	92.9142
G-2376	0	0.7072	1.87	74.5623
S-329	0	0.8324	4.15	64.1571
G-561	0	0.8809	3.49	62.6502
G-617	0	0.2951	2.3	97.2279
G-2494	0	0.3486	1.5	96.0674
G-2490	0	0.413	1.65	88.5942
G-221	0	0.2503	4.89	96.7067
G-2488	0	0.6764	1.98	76.584
G-2487	0.01	0.6109	2.04	75
G-2491	0	0.4695	1.73	83.5106
G-2493	0	0.3266	1.19	96.2766
G-2492	0	0.3332	1.22	93.883
G-1224	0	0.7474	3.36	72.1079
G-1322	0	0.3564	1.39	97.0769
G-1223	0	0.4111	3.18	96.3976
G-2495	0	0.5801	1.97	87.381
G-2034	0	0.4525	2.46	91.761
G-2854	0.41	0.9081	1.67	63.8554
G-2615	0.34	0.7954	1.51	63.8554
G-2856	0.39	0.8787	1.44	58.6957
G-2614	0.16	0.7457	1.56	63.8554
G-1226	0	0.4904	7.87	91.2806

STATION	Minimum Difference	Average Difference	Maximum Difference	Frequency within a 1 ft margin of error
G-2035	0	0.4712	3.88	91.4968
G-1225	0	0.5557	3.15	86.0888
G-1222	0	0.5006	2.4	89.6467
F-291	0	0.4916	3.87	87.3575
G-1473	0	0.3636	3.52	93.2759
G-1472	0	0.4582	3.06	87.6667
G-1636	0	0.3191	2.18	97.5009
G-970	0	0.3552	2.58	98.9183
G-1637	0	0.4488	1.79	93.7478
G-3571	0.01	0.5444	3.9	90.6801
S-18	0	0.2469	2.32	99.2662
G- 852	0	0.2715	2.94	97.6349
G-1166	0	0.2358	2.31	98.3635
CA2B.T	0	1.5231	5.02	33.2188
CA2A300	0.02	1.0553	2.19	47.1976
2A-17_B	0	0.6866	1.89	75.9754
WCA2F1	0	0.8642	1.74	56.4815
WCA2F4	0	0.5317	1.3	92.8241
WCA2E4	0.01	0.4615	1.18	96.5358
WCA2U1	0	0.3433	1.24	96.0739
WCA2RT	0	0.3082	1.15	98.7245
WCA2E1	0.01	0.7699	1.49	63.109
2-15	0	0.5126	1.1	98.2911
2-17	0	0.8124	1.94	66.3317
3-63	0	0.343	1.76	97.2871
3-76	0	0.2799	1.11	99.4859
1-9	0	0.3175	1.17	96.1063
PB-0732	0	0.5067	2.17	87.3835
PB-1661	0	0.3231	3.13	95.8739
PB-1680	0	0.5655	2.88	86.1718
PB-1684	0.26	0.9488	2.79	67.5134
PB-0490	0	0.45	1.88	90
PB-0492	0.03	0.6194	3.7	84.058
PB-0567	0	0.5566	2.41	82.3529
PB-0948	0	0.5185	1.44	89.7436
PB-1006	0.01	0.3967	1.64	93.0233
PB-1063	0	0.5914	1.88	83.908
PB-0897	0.04	0.7574	2.38	69.7674

The computed water levels represent the average water level over a model cell. Since actual levels can vary across the 500 by 500 ft cell, monitored well data may not closely match the average model predicted water level. This problem

mostly occurs in areas of public water supply wellfields and where local steep gradients form around the wells. In other areas, however, the gradient across a model cell is sufficiently small that the monitored well represents groundwater elevation for the entire cell. Published reports do not describe model validation efforts.

A.17.2 Model Verification

The model was calibrated with the entire set of recorded data without setting aside data for model verification.

A.17.3 Boundary Conditions

The General Head Boundary package is applied at all of the cells located along the ground water model boundaries. Water levels are therefore needed to simulate fluxes during all stress periods into and out of the model domain across the northern, eastern, southern, and western faces of boundary cells in all layers. Generally, the eastern face includes all of the coastal boundary cells and the water levels along this boundary are computed from the nearest tidal station with measured data.

A correction is made to the computed head to account for the density difference between the salt water and fresh water along the eastern boundary of the model. In addition, conductance associated with the general head boundary implementation is progressively reduced with depth (using a quadratic formula) to indirectly force the movement of fresh water towards the upper layers at the freshwater/saltwater interface. This is an approximation for the complex three-dimensional nature of flow dynamics that typically occurs near the interface.

The water levels from the remaining faces of the model boundary (northern, western, and southern) are estimated from the SFWMM for all stress periods. For example, the water levels in the ground water model boundary cells located in the Water Conservation Areas (WCAs) are estimated from the corresponding water levels computed in the SFWMM simulation. Again, the same water level is assumed for boundary cells in all vertical layers. In some cases, a primary canal simulated by the SFWMM corresponds to the ground water model boundary. Where this occurs, the canal water levels resulting from the SFWMM run are used to define the heads at this boundary.

A.17.4 Initial Conditions

SFWMD used the results of the SFWMM simulation to set up the initial water level conditions for January 1, 1988. They have used the Geographic Information System (GIS) ARC/INFO FOCALMEAN function to smooth the discrete two miles by two miles SFWMM prediction results over the Broward

County groundwater model in order to assign water levels from the corresponding SFWMM cells to each of ground water model cells. The SFWMD assumed hydrostatic distribution of the water head in setting up the model initial conditions.

A.18 SIMULATION SCENARIOS

A.18.1 Project Assurances

A.18.1.1 Regional Model (SFWMM v5.4)

A.18.1.1.1 Differences between v5.4 and v3.5

NOTE: Additional information for this section may be obtained at http://www.sfwmd.gov/org/pld/hsm/models/sfwmm/index.html

The following list represents major included in SFWMM v5.5 since the last peer review and documentation (since SFWMD v3.5, April, 1999)

Simulation period extended from 31 years (1965-1995) to 36 years (1965-2000)

- S12 A, B, C and D structures are simulated separately
- Time dependent (calendar based) minimum threshold (instead of fixed value) for delivering water from Lake Okeechobee to meet Caloosahatchee and St. Lucie estuarine demands
- Update of modified delta storage based on new S236 basin demand and runoff and the S-4 basin demand time series
- BMP makeup water and regulatory discharge from Lake Okeechobee to the WCAs are subject to high water constraints in WCA canals
- Full implementation of WSE operational schedule for Lake Okeechobee
- Miscellaneous operational modifications for structures or gages
- Able to simulate canal drawdown during anticipated storms
- Ability to send ASR recovery water directly to grid cells
- Ability to simulate SSM as per Water Shortage Rules 40E-21/40E-22
- Modifications to the way 298 Districts runoff is handled in LOSA
- Added generic code so as to provide increased flexibility in modeling of scenarios.
- Ability to run model in continuous (used for long-term planning) mode or position analysis mode
- Enhanced model to do forward pumping (in addition to gravity flow) through S354, S351 and S352 when Lake Okeechobee is sufficiently low
- Deviations from Lake Okeechobee operational schedule (e.g. drought conditions) can be specified
- Ability to send Lake Okeechobee regulatory discharge to LEC tidewater even if WCAs are below schedule

- Days of week specification for Lake Okeechobee WS deliveries to EAA and LEC
- v5.4 compared against NSM v4.6 and NMS v4.6.2 (earlier versions typically compared against NSM v4.5)
- Included separate Lake Istokpoga demands and runoff time series
- Slope of water surface along selected canals can vary daily
- Operational modifications to several structures to better match structure operational rules
- Small reservoirs can be modeled within and across cells as independent entities
- Calendar-based WCA floor elevations
- Tidal Creek flows from ENP to Whitewater Bay and Florida Bay are explicitly simulated
- v5.5 based on v5.4 SFWMM calibration

A.18.1.1.2 Input Data and Model Setup

NOTE: Information and Figures in this section of the Hydrology Appendix A were obtained from http://pmviewer.cerpzone.org/cerp_recover/showDocument.do?documentID=97

A.18.2 CERP (2000) Existing Condition Assumptions for the Initial CERP Update September 19 DRAFT

A.18.2.1 Review and Discussion Phase Begins

The Initial CERP Update is being undertaken by an interagency, interdisciplinary team of the RECOVER program in CERP. The purpose of the update is to incorporate new information gained since the C&SF Comprehensive Review Study was released (July 1999). The scope of this effort is to:

Update planning conditions from the 1995 data used in the Restudy to 2000 data, such as land use, population, and water use.
Update structural, operational and regulation schedule changes to the water management system.

Update forecasts of 2050 conditions based on new data since the Restudy
Evaluate the performance of the Comprehensive Plan using the latest updated versions of the South Florida Water Management Model (SFWMM) and the Natural System Model (NSM).

Document all findings in a technical report.

Planning for water resources purposes in South Florida relies strongly upon a computer simulation tool called the South Florida Water Management Model,

which is able of simulating the daily hydrology and operations of the water management system. The model requires input data, termed "assumptions", that govern the results, or outputs, of a given model simulation. Use of this modeling tool allows informed discussion as to what assumptions appear reasonable as input data. In addition to the use of new data, the SFWMM and NSM have undergone updating and improvements to increase accuracy of predictions.

The first updated model run for the 2000 Existing Condition will be posted on the web at http://modeling.cerpzone.org/cerp_recover/pmviewer/pmviewer.jsp for agency and public review. In the planning process, conditions that exist at the time of the investigation, or study, are collectively called the "existing condition." The existing condition is a reasonable depiction of current, relevant circumstances in the planning area.

Planning by its nature is iterative. This web posting begins the review and discussion of the assumptions for the 2000 Existing Condition. These assumptions may change over time, as the review process proceeds. Additionally, as external review of the calibration/verification of the SFWMM goes forward, there is the potential that the outputs (results) of the model may be refined as well.

The assumptions for the 2000 Existing Condition as currently modeled for the Initial CERP Update are to be used for planning purposes only and are presented in the table below.

CERP Existing (2000) Condition Assumptions Summary

September 19 DRAFT

Feature	Assumptions
	Regional Input Data
Climate	• The climatic period of record is from 1965 to 2000. • Rainfall estimates have been revised and updated for 1965-2000. • Revised evapotranspiration methods have been used for 1965-2000.
Topography	Updated November 2001 and September 2003 using latest available information (in NGVD 29 datum). Nov 2001 update (Documented in November 2001 SFWMD memorandum from M. Hinton to K. Tarboton) includes: • USGS High Accuracy Elevation data from helicopter surveys collected 1999-2000 for Everglades National Park and Water Conservation Area (WCA) 3 south of Alligator Alley • USGS Lidar data (May 1999) for WCA-3A north of Alligator Alley • Lindahl, Browning, Ferrari & Helstrom 1999 survey for Rotenberger Wildlife Management Area. • Stormwater Treatment Area surveys from 1990s • Aerometric Corp. 1986 survey of the 8-1/2 square mile area • Includes estimate of Everglades Agricultural Area subsidence • Other data as in SFWMM v3.7 • FWC survey 1992 for the Holey Land Wildlife Management Area. September 2003 update includes: • Reverting to FWC 1992 survey data for Rotenberger Wildlife Management Area. • DHI gridded data from Kimley –Horn contracted survey of EAA, 2002-2003. Regridded to 2x2 scale for EAA outside of STAs and WMAs.
Sea Level	• Sea level data from six long-term NOAA stations were used to generate a historic record to use as sea level boundary conditions for the 1965 to 2000 evaluation period.
Land Use	• All land use has been updated using most recent FLUCCS data (1995), modified in the Lower East Coast urban areas using 2000 aerial photography (2x2 scale). (Documented in August 2003 SFWMD memorandum from J. Barnes and K. Tarboton to J. Obeysekera).
Natural Area Land Cover (Vegetation)	Vegetation classes and their spatial distribution in the natural areas comes from the following data: • Walsh 1995 aerial photography in Everglades National Park • Rutchey 1995 classification in WCA-3B, WCA-3A north of Alligator Alley and the Miami Canal, WCA-2A & 2B • Richardson 1990 data for Loxahatchee National Wildlife Refuge • FLUCCS 1995 for Big Cypress National Preserve, Holey Land & Rotenberger Wildlife Management Areas & WCA-3A south of Alligator Alley and the Miami

CERP Existing (2000) Condition Assumptions Summary

September 19 DRAFT

Feature	Assumptions
	Canal. (Documented in August 2003 SFWMD memorandum from J. Barnes and K. Tarboton to J. Obeysekera).
	Lake Okeechobee Service Area
LOSA Basins	• Lower Istokpoga, S-4, North Lake Shore and Northeast Lake Shore demands and runoff based on AFSIRS modeling.
Lake Okeechobee	• Lake Okeechobee Regulation Schedule WSE according to WSE decision trees. • Lake Okeechobee Supply Side management policy for Lake Okeechobee Service Area water restriction cutbacks as per rule 40E-21 and 40E-22 (13.5 – 11.0 ft. trigger line). A 67% maximum cutback will be implemented. • Emergency flood control backpumping to Lake Okeechobee from the Everglades Agricultural Area. • Kissimmee River inflows based on interim schedule for Kissimmee Chain of Lakes using the UKISS model. • Best Management Practices runoff reduction assumed to be 0%. BMP Makeup water (Replacement Water Rule) target has an average of 102 KAF per year for the 36-yr period. Actual deliveries can be less due to conveyance limitations, WCAs above schedule and suspension of makeup water deliveries due to SSM.
Caloosahatchee River Basin	• Caloosahatchee River Basin irrigation demands and runoff were estimated using the AFSIRS method based on existing planted acreage. • Public water supply daily intake from the river is included in the analysis.
St. Lucie Canal Basin	• St. Lucie Canal Basin demands estimated using the AFSIRS method based on existing planted acreage. • Basin demands include the Florida Power & Light reservoir at Indiantown.
Seminole Brighton Reservation	• Brighton Reservation demands were estimated using the AFSIRS method based on existing planted acreage. • Demands are in agreement with the entitlement quantities as per Table 7, Agreement 41-21 (Nov 92). • Supply-side management applies to this agreement.
Seminole Big Cypress Reservation	• Big Cypress Reservation irrigation demands and runoff were estimated using the AFSIRS method based on existing planted acreage. • The 1 in 5 demand is in agreement with the Seminole Compact (Work Plan = 2606 MGM, Model = 2659 MGM) . • Supply-side management applies to the Compact.
Everglades Agricultural Area	• Everglades Agricultural Area irrigation demands are simulated using climatic data for the 36 year period of record and a soil moisture accounting algorithm, with parameters calibrated to match historical regional supplemental deliveries from Lake Okeechobee.

CERP Existing (2000) Condition Assumptions Summary

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Feature	Assumptions
	• Best Management Practices assumed to reduce runoff 0% annually.
Everglades Construction Project Stormwater Treatment Areas	• Stormwater Treatment Areas 1W, 5 & 6 operational. • Stormwater Treatment Area 2 complete but not connected to the regional system. • Operation of Stormwater Treatment Areas assumes 6" minimum depth during periods of drought.
Holey Land Wildlife Management Area	• As per Memorandum of Agreement between the FWC and the District.
Rotenberger Wildlife Management Area	• Interim Operational Schedule as defined in the Operation Plan for Rotenberger (SFWMD Jan 2001).
Water Conservation Areas	
Water Conservation Area 1 (ARM Loxahatchee National Wildlife Refuge)	• Current C&SF Regulation Schedule. Includes regulatory releases to tide through LEC canals. • No net outflow to maintain minimum stages in the LEC Service Area canals (salinity control), if water levels are less than minimum operating criteria of 14 ft. The bottom floor of the schedule (Zone C) is the area below 14 ft. Any water supply releases below the floor will be matched by an equivalent volume of inflow from Lake Okeechobee.
Water Conservation Area 2 A&B	• Current C&SF regulation schedule. Includes regulatory releases to tide through LEC canals. • No net outflow to maintain minimum stages in the LEC Service Area canals (salinity control), if water levels in WCA-2A are less than minimum operating criteria of 10.5 ft. Any water supply releases below the floor will be matched by an equivalent volume of inflow from Lake Okeechobee.
Water Conservation Area 3 A&B	• Current C&SF regulation schedule. Includes regulatory releases to tide through LEC canals. • No net outflow to maintain minimum stages in the LEC Service Area canals (salinity control), if water levels are less than minimum operating criteria of 7.5 ft in WCA-3A. Any water supply releases below the floor will be matched by an equivalent volume of inflow from Lake Okeechobee.
Lower East Coast Service Areas	
Public Water Supply and Irrigation	• Public water supply wellfield pumpages and locations are based on actual pumpage data for calendar year 2000 (includes Miami-Dade County Water and Sewer Department West Wellfield Aquifer Storage and Recovery system). • Irrigation demands are based upon existing land use and calculated using AFSIRS, reduced to account for landscape and golf course areas irrigated using reuse water and landscape areas irrigated using public water supply.

CERP Existing (2000) Condition Assumptions Summary

September 19 DRAFT

Feature	Assumptions
Seminole Hollywood Reservation	• Hollywood Reservation demands are set forth under VI.C of the Water Rights Compact.
Natural Areas	• For the Northwest Fork of the Loxahatchee River, the District operates the G-92 structure and associated structures to provide approximately 50 cfs over Lainhart Dam to the Northwest Fork, when the District determines that water supplies are available. • Flows to Pond Apple Slough through S-13A are adjusted in the model to approximate measured flows at the structure. • Flows to Biscayne Bay are simulated through Snake Creek, North Bay, the Miami River, Central Bay and South Bay.
Canal Operations	• C&SF system and operating rules in effect in 2000. • Includes operations to meet control elevations in the primary coastal canals for the prevention of saltwater intrusion. • Includes existing secondary drainage/water supply system. • Excludes portions of the South Dade Conveyance System that follow rules for Test 7 Phase 1 water deliveries to Everglades National Park, as per Restudy 1995 Existing Condition
	Western Basins and Big Cypress National Preserve
Western Basins	• Estimated and updated historical inflows from western basins at two locations: G-136 and G-406. The G-406 location represents potential inflow from the C-139 Basin into STA 5. Data for the period 1978 - 2000 is the same as the data used for the C-139 Basin Rule development. (Documented in June 2002 SFWMD memorandum from L. Cadavid and L. Brion to J. Obeysekera).
Big Cypress	• The northern end of Big Cypress receives flows from S-190. • Tamiami Trail culverts are not modeled in SFWMM due to the coarse (2x2 mile) model resolution.
	Everglades National Park and Florida Bay
Everglades National Park	• Water deliveries to Everglades National Park are based on Test 7 Phase 1 as per Restudy 1995 Existing Condition.
	Region-wide Water Management and Related Operations
Water Management Rules	• The existing condition reflects the existing water shortage policies in 2000 as reflected in South Florida Water Management District rule 40E-21. • The impacts of declarations of water shortages on utility water use reflect assumptions contained in the Lower East Coast Regional Water Supply Plan (May 2000).

NOTE: Information for items (1) through (7) below in this section of the Hydrology Appendix A can be obtained from http://pmviewer.cerpzone.org/cerp_recover/showDocument.do?documentID=295

A.18.2.1.1 Model Calibration and Verification

NOTE: Information in this section of the Hydrology Appendix A was obtained from http://www.sfwmd.gov/org/pld/hsm/models/sfwmm/v5.4/sfwmm_v54_cal_ver.pdf

SFWMM V5.4 Calibration/Verification April 2004

This document describes modifications made in the Calibration and Verification of the South Florida Water Management Model (SFWMM) with V5.4 of the model, which updates the previous Calibration and Verification simulations run with V5.0 in October 2003. The main features and reasons for this revision are described below:

- New Calibration/Verification simulations were required due to several source code modifications from V5.0 to V5.4 of the SFWMM.
- Changes in the topographic elevation introduced in the update to the CERP existing conditions (2000B2) simulation were included in the V5.4 Calibration/Verification.
- The Everglades Agricultural Area was recalibrated using different time periods. 1984-1995 was considered as the calibration period and 1979-1983 and 1996-2000 as verification periods, to be consistent with the calibration and verification periods for the rest of the SFWMM domain. Also, soil storage coefficients were allowed to differ between the three major EAA basins in the calibration.
- The Lower East Coast cutback trigger module was made inactive during the calibration and verification simulations, since historically imposed cutbacks are reflected in the historical Public Water Supply Utility data used as input to the model.
- New data became available to estimate more appropriate values for the following static parameters affecting irrigation, on a cell by cell basis, in the LEC Urban Areas:
-
    - FLI: Fraction of land use irrigation receiving water from Public Water Supply Utility well fields.
    - FLR: Fraction of land use irrigation receiving water from treated waste water
    - FGI: Fraction of golf course irrigation receiving water from treated waste water

- SFWMM V5.0 used anisotropy factors other than one (1.0) for flow resistance in the N-E, E-W direction for the Ridge and Slough II land use

type. These factors were reset to one (1.0) in the V5.4 Calibration/Verification.

- In order to simulate increased flow resistance across bridges and culverts underneath the Alligator Alley (I-75) corridor, roughness coefficient s for cells located nearby were increased by a factor of five in the SFWMM V5.0. For SFWMM V5.4 Calibration and Verification, this factor was reset to one in cells where it had been changed previously.
- Other than the above changes, all parameter values remained the same as in the V5.0 Calibration/Verification.

A.18.2.1.2 Calibration, Verification, and Validation

NOTE: Information, graphs, and figures for this section of the Hydrology Appendix A can be found at http://www.sfwmd.gov/org/pld/hsm/models/sfwmm/v5.4/flow/flow_sites.pdf for flows and http://www.sfwmd.gov/org/pld/hsm/models/sfwmm/v5.4/stage/stage_sites.pdf for stages.

A.18.2.1.3 Simulation Scenarios

Natural Systems Model (NSM)

NOTE: Information in this section of the Hydrology Appendix A was obtained from http://pmviewer.cerpzone.org/cerp_recover/ModelRunInfo.do?modelrunID=75
The link has now been changed to
http://pmviewer.cerpzone.org/pmviewer/ModelRunInfo.do?modelrunID=43

Description

The Natural System Model (NSM) simulates the hydrologic response of an Everglades watershed in its pre-drainage condition. Recent climatic data is used to simulate the pre-drainage hydrologic response to current hydrologic input allowing for meaningful comparisons between SFWMM simulations and NSM simulations. Vegetation, topography, and river courses used by the NSM are based on pre-drainage conditions.

NSM Version 4.6.2 uses the same climatic input, computational methods, and model parameters calibrated and verified by the SFWMMv5.4 (e.g. ET, Manning's "n") including:

- Updated tidal boundary stations
- New rainfall based on "10-tin" interpolation
- Reformulated PET dataset

- Modified land use coverage
- Updated soil storage coefficients
- Updated ET and Manning's coefficients
- Revised topography
- Updated inflow boundary flows into Lake Okeechobee and Lake Istokpoga (dbhydro changes)
- Expanded period of record through 2000

2000 Conditions Modeling

NOTE: Information and figures in this section of the Hydrology Appendix A was obtained from http://pmviewer.cerpzone.org/cerp_recover/showDocument.do?documentID=295

The link has now been changed to http://pmviewer.cerpzone.org/pmviewer/showDocument.do?documentID=89

April 5, 2004 DRAFT

CERP 2000B2 Existing Conditions and 2050B2
Future Without Project Modeling Modifications

The table below documents modeling assumption changes to those documented in the CERP Existing (2000) Condition Assumptions Summary (September 19, 2003) modeled in 2000B1 (posted Oct 7, 2003) and CERP Future Without Project (2050) Condition Summary (December 5, 2003) modeled in 2050B1 (posted Dec 7, 2003). Changes common to both the 2000B2 and 2050B2 as well as changes unique to each simulation are listed.

Feature	Assumptions Change for 2000B2 and 2050B2
	Regional Input Data
Topography	**2000B2:** STA3/4 lowered topo values to be consistent with the 2050B1 STA5 increased topo value (one cell) to be consistent with 2050B1 **2000B2 & 2050B2:** New areas of USGS High Accuracy Elevation data have become available and interpolation of data in areas where new data not available was revisited. Topo was modified as follows:

Row	Col	Previous Elevation (feet)	Current Elevation (feet)	Comments
44	25	9.90	9.31	STA-2 (*)
44	26	11.29	10.65	STA-2 (*)
24	28	4.93	5.50	
23	28	4.68	5.50	
23	11	6.72	6.92	
23	12	7.04	7.14	
23	13	7.37	7.57	
23	14	7.91	7.65	
7	13	0.00	0.39	
7	14	0.60	0.82	
6	13	0.00	0.31	
6	14	0.50	0.40	
5	13	0.20	0.59	
5	14	0.30	0.35	
4	13	0.00	1.01	
4	14	0.50	1.27	

(*) Data modified by SFWMD ECP staff.

The above changes make 2000B2 & 2050B2 topo consistent with each other and with the SFWMMv5.4 calibration/verification except where different due to 2050 development (e.g. Mined Lake Belt areas).

	Lake Okeechobee Service Area
Lake Okeechobee	**2000B2:** Revised pump capacity for 298 District pump stations sending runoff from the 298 Districts to the Lake. Also, the connectivity between the 298

<table>
<tr><th>Feature</th><th>Assumptions Change for 2000B2 and 2050B2</th></tr>
<tr><td></td><td>Districts and the STA's was revised to make it consistent with improvements made in the 2050B1 simulation.
2000B2: Stage Break Point Line for minimum Lake stage in order to make deliveries to maintain STA depths
-Values updated so that the line is approximately 0.5ft below the Supply Side Management Line from Oct – May. The line was original set to – 99 for each month.</td></tr>
<tr><td>St. Lucie Canal Basin</td><td>2000B2 & 2050B2: Time series of non C-44 basin runoff entering the St. Lucie estuary were updated. These are used in the post processing of results for the St. Lucie Estuary and do not affect simulation results.</td></tr>
<tr><td>Everglades Agricultural Area</td><td>2000B2 & 2050B2: New parameters derived from a revised EAA Calibration/Verification effort were introduced in the 2000B2 & 2050B2 simulations. In the new EAA calibration, soil storage coefficient values were made different among the three major EAA basins. Also, the EAA Calibration and Verification periods were redefined to 1984-1995 and 1979-1983/1996-2000, to be consistent to the calibration of the rest of the system (Everglades and LEC Urban Areas).</td></tr>
<tr><td>Everglades Construction Project Stormwater Treatment Areas</td><td>2050B2: Total inflow capacity into STA-2 was increased from 2925 to 3375 cfs to account for the new G-329 structure.
2050B2: Effective treatment areas for the STA's were updated with the most current values provided by ECP staff, as follows:
<table>
<tr><th>STA</th><th>Previous Area (acres)</th><th>Current Area (acres)</th></tr>
<tr><td>STA 1E</td><td>6050</td><td>5132</td></tr>
<tr><td>STA 1W</td><td>6670</td><td>6236</td></tr>
<tr><td>STA 2</td><td>6430</td><td>6340</td></tr>
<tr><td>STA 3/4</td><td>16660</td><td>16543</td></tr>
<tr><td>STA 5</td><td>4118 (2 x 2059)</td><td>4110 (2 x 2055)</td></tr>
<tr><td>STA 6</td><td>2421</td><td>2282</td></tr>
</table>
2050B2: To better deal with elevation gradients inside the STA's, STA 1E and STA 2 were each split into two interconnected smaller reservoirs, oriented in the East-West direction for both cases. Using this approach, flow exchange between the small reservoirs (cells) is controlled by hydraulic structures and not by overland flow.</td></tr>
<tr><td>Rotenberger Wildlife Management Area</td><td>2000B2: Rotenbeger Schedule consistent with 2050B1 &2050B2 introduced in the 2000B2 simulation. This schedule is lower than the 2000B1 which used an interim (higher) schedule.</td></tr>
</table>

Feature	Assumptions Change for 2000B2 and 2050B2
	Water Conservation Areas
Water Conservation Area 2 A&B	**2050B2:** Import and export stage targets for rain driven operations were based on the NSM 4.6.2. **2000B2 & 2050B2:** Structure S10E connecting WCA-1 to the North-Eastern portion of WCA-2A is no longer considered part of the simulated regional system.
Water Conservation Area 3 A&B	**2000B2:** WCA-3A Regulatory schedule -Zone D line modified to match the Zone C line near the beginning and end of the year. (Zone D line was original modified to follow IOP) -Maximum Desired Stage line for flood control releases to WCA3A was modified to match the Zone D line **2050B2:** Import and export stage targets for rain driven operations were based on the NSM 4.6.2. **2000B2 & 2050B2:** In order to simulate increased flow resistance across bridges and culverts underneath the Alligator Alley (I-75) corridor, flow transmissivity across nearby cells located was decreased by a factor of five in the previous 2000B1 and 2050B1 simulations. For the 2000B2 & 2050B2 simulations, this factor was reduced to one, which makes transmissivity the same for all cells. **2000B2 & 2050B2:** The previous simulations (2000B1 & 2050B1) used anisotropy factors other than one (1.0) for flow resistance in the N-E, E-W direction for the Ridge and Slough 2 land use type. These factors were made equal to one (1.0) for the 2000B2 & simulation.
	Everglades National Park
	2050B2: Import and export stage targets for rain driven operations were based on the NSM 4.6.2.
	Lower East Coast Service Areas
Public Water Supply and Irrigation	**2000B2 & 2050B2:** Several iterations were performed, corrections were made, and new data become available in estimating more appropriate values for the following static parameters affecting irrigation on a cell by cell basis in the LEC Urban Areas: -FLI: Fraction of landscape irrigation receiving water from Public Water Supply Utility well fields. -FLR: Fraction of landscape irrigation receiving water from treated waste water -FGI: Fraction of golf course irrigation receiving water from treated waste water -BLU: Land use type index (2000B2, one cell) **2050B2:** Lake Belt -Additional permitted acreage for the Lake Belt Project in the Miami-Dade area was identified and included in the simulation. Consequently, the acreage for certain types of irrigation (landscape, nursery, agricultural overhead and other agricultural) in this area changed, affecting local demand calculations. However, the blue print defined by

Feature	Assumptions Change for 2000B2 and 2050B2
	the basic land use did not increase. -Due also to the expansion of the Lake Belt blue print, irrigation demands for the LEC Urban areas were computed again. This was prompted also by some land use codes which were found missing in the previous computation. **2000B2:** The input file to the SFWMM providing data on LEC Urban Areas Public Water Supply pumpage was revised for North Palm Beach County. **2050B2:** The input file to the SFWMM providing data on LEC Urban Areas Public Water Supply pumpage volumes underwent several revisions. Some of the reasons prompting these revisions were: Modification of well field allocation volumes, changes in well field redistributions, inclusion of additional utility ASR facilities, changes in utility ASR efficiencies, etc. **2050B2:** The Hillsboro Utility ASR capacity changed from 5.0 to 4.0 MGD. Other Utility ASR capacity are as follows:

Utility Name	Permit Number	ASR Capacity
Palm Beach County Utilities	50-00135-W	12 mgd
City of Delray Beach	50-00177-W	2 mgd
City of Boynton Beach	50-00499-W	6mgd
City of West Palm Beach	50-00615-W	8mgd
City of Sunrise	06-00120-W	2 mgd
City of Fort Lauderdale	06-00123-W	2 mgd
Broward Wellfield 2A	06-00142-W	2 mgd
Fl. Keys Aqueduct Auth.	13-00005-W	4 mgd
MDWASA Alexander Orr	13-00017-W	25 mgd
MDWASA Hialeah-Preston	13-00037-W	10 mgd

Canal Operations	**2000B2:** • G123 -Changed location of head water to be consistent with the 2050B1 and 2050B2 simulations. -Added canal stage triggers for determination of flood control discharges -Increased Manning's n coefficient for canal flow • L-8 to M-Canal (S2 pump to M-canal) -Pump efficiency changed to 1 to be consistent with the 2050B1 • ACMEA & ACMEB -Switched order of ACMEA and ACMEB canals for water supply purposes • PLMEC7 & PLMEC4 -Corrected PLMEC4 name (PLMEC4 was named incorrectly) • C13 canal -Modified input file so the C-13 would be a maintained canal • NNRC -Increased Manning's N coefficient for canal flow from 0.26 to 0.46

Feature	Assumptions Change for 2000B2 and 2050B2
	2050B2: • Stages triggering flood control operations for some structures in the C-6 canal were increased by 0.2 ft. Also, C111E maintenance stage was lowered by 0.3ft. These modifications were introduced to make the 2050B2 simulation consistent with current and future expected operational practices. • S-8 Pump Station is used in the 2050B2 simulation to pass water supply deliveries from Lake Okeechobee or the EAA to the Miami-Dade Urban Area. • Simulation and routing of flood control releases from ACME Basin B into the C-51W and C51 canals was improved.

A.18.2.1.4 Future Without Project Condition

NOTE: Information and figures in this section of the Hydrology Appendix A was obtained from
http://pmviewer.cerpzone.org/pmviewer/showDocument.do?documentID=89
The information for this section is included in the above section.

A.18.2.1.5 Selected Plan Condition

Savings Clause (Level of Service of Flood Protection):

The Broward County Water Preserve Areas (WPA) project includes three principal components:

- The C-11 Impoundment
- The C-9 Impoundment
- The WCA3A/3B Levee Seepage Management Projects

These components were recommended as a part of the Central and Southern Florida Comprehensive Review Study Feasibility Report and Integrated EIS in April of 1999 (the Restudy). In a related and complimentary effort, the WPA Feasibility Study was initiated. The WPA study region included multiple CERP components in the area east of the Water Conservation Areas in Palm Beach, Broward, and Dade Counties. The findings and recommendations of the Feasibility Study are presented in the October 2001 Central and Southern Florida Project, Water Preserve Areas; Draft Integrated Feasibility Report and Supplemental Environmental Impact Statement (the Feasibility Study). The Broward County WPA Project, a separable element of the Comprehensive Everglades Restoration Plan authorized under Section 601 of the Water Resources Development Act of 2000, includes buffer marsh areas, canals, levees,

water control structures and above-ground improvements with a total storage capacity of approximately 4,594 acre-feet located in the western C-11 Canal basin and 7,052 acre-feet located in the western C-9 Canal Basin in western Broward County.

Programmatic regulations developed for CERP responsive to the "savings clause" of WRDA 2000 include requirements that the level of flood protection following implementation of CERP projects not be reduced from that existing in December 2000. To assist the PIR team, Burns & McDonnell Engineering Co., Inc. under SFWMD Work Order No. C-C20104P-WO03 was retained to investigate in more detail the effect of the Broward County WPA Project on the level of flood protection in the western C-11 and C-9 drainage basins. Those analyses conducted include:

- Review and analysis of historic stage/discharge relationships;
- Review of existing groundwater model data and results;
- Hydraulic analysis of canal water surface profiles with and without the CERP project;
- Review of the conceptual design and planned operations of the project for potential impacts on flood protection;
- Development of recommendations for operational and/or structural changes to the current plan necessary to mitigate any adverse impacts on flood protection under future "with project" conditions;
- Identification of such further operational and/or structural changes to the current plan as might be appropriate to minimize stormwater pumping from the western C-11 drainage basin into WCA 3A.

The analyses are specific to conditions anticipated to exist in 2010 upon completion of the presently authorized Broward County WPA project. Future separable elements of CERP, such as the North and Central Lake Belt Storage Areas, were not included in the analyses as the intention is to not rely on these elements to maintain the current level of flood protection. Specifically, the analyses considers the C-11 Impoundment, C-9 Impoundment and WCA 3A and WCA 3B Seepage Management Areas complete as described in the WPA Feasibility Study, together with at least the following elements of the North New River Improvements Project necessary to transfer water between the two impoundments:

- Canal C-502A between Structure S-504 and the C-11 Canal;
- Canal C-502B between the C-11 Canal and Structure S-30;
- Gated culvert S-502C.

The "with project" condition considered includes certain features authorized under Section 528 of the Water Resources Development Act of 1996 as the

Western C-11 Water Quality Treatment Project, one of 34 "critical projects" authorized in that Act. The Western C-11 Water Quality Project includes the construction of Pumping Station S-9A and Structure S-381.

The completed findings of the analyses are included below. Based upon the information in the report, the SFWMD is providing reasonable assurance through structural and operational modifications to the WPA design that existing levels of service for flood protection will not be diminished through implementation of the BCWPA Project.

A.19 DISCUSSION OF SOILS IMPACTED WITH SELENIUM

A.19.1 Objective

The purpose of this section is to provide a summary of past and ongoing investigations of selenium impacted soils and the actions that may be necessary to ensure the protection of environmental resources. This information supports some of the data requirements of the September 2011 ASA(CW) policy for Agricultural Chemicals on CERP project lands. Upon the completion of agricultural soil impacts on project lands, a Soil Management Plan (SMP) will be developed to layout out the environmental construction specifications associated with handling and isolating soils impacted by past agricultural activities. SMP's frequently include field-screening protocols, special work procedures, waste handling and staging and waste re-use and disposal provisions. The SMP will be presented for proposal and concurrence from the appropriate regulatory agencies.

A.19.2 Extent of Selenium Impacted Soils

The land within the footprint of the Broward County WPA Project is undeveloped with portions of the C-11 and C-9 Impoundment previously used for mixed agricultural uses including tree and plant nurseries. Legal use of agrochemicals has potentially caused increased soil concentrations of selenium and to a lesser extent barium, within the cultivated soils at concentrations above the FDEPs advisory Sediment Quality Assessment Guidelines (SQAGs) or USFWS recommendations. The SFWMD determined that barium concentrations were indicative of natural background concentrations and thus less of an ecological concern since they exist in nearby wetlands at similar concentrations. Subsequent site investigations and studies by the USFWS have focused on selenium as the sole residual agricultural chemical that poses a potential ecological risk under post-project conditions where the lands are converted to aquatic restoration features. The following residual agricultural chemical related documents are attachments to Section A.19:

USFWS letter to the SFWMD dated 8/6/2010 regarding environmental sampling completed and the USFWS concerns about the selenium levels in the C-9 and C-11 Impoundments and potential need for additional assessments (Appendix A. Section A.19, Attachment A).
Letter from HQUSACE to SFWMD dated 30 June 2010. Subject is Agrichemical contaminants and soil management plans associated with the IRL-South Lagoon and C-111 Spreader Canal Project. (Appendix A. Section A.19, Attachment B).
USFWS letter to the SFWMD dated 6/29/2011 regarding review of additional assessment completed and the USFWS recommended ecological screening level for protection of aquatic community receptors (Appendix A. Section A.19. Attachment C).
CERP Residual Agricultural Chemical Policy memorandum dated September 14, 2011. (Appendix A. Section A.19, Attachment D).
East Coast Buffer – Regional Selenium Project. Study commissioned by SFWMD to investigate extent of selenium impacted soil (Appendix A, Section A.19, Attachment E).
Draft Additional Assessment for East Coast Buffer – Regional Selenium Project. Study commissioned by SFWMD to address USFWS comments provided 8/6/2010 (Appendix A. Section A.19, Attachment F).

In addition to these reports, an electronic archive file of BCWPA project environmental audits provided by the SFWMD is maintained by the USACE. Electronic copies of these documents are available upon request.

Impacted soils are soils with "elevated levels" of selenium that resulted from agricultural operations. "Elevated levels" are defined either by exceedance of Soil Quality Assessment Guidelines (SQAGs) for Florida Inland Waters as referenced by the FDEP or in consultation with the USFWS in regards to endangered species protection Currently no SQAGs exist for selenium. The USFWS has established a preliminary screening concentration for selenium of 2 mg/Kg based on periodic research to assess risk to trust species. Based on previous assessments, approximately 5,700 of the 7,700 acres acquired are not impacted by selenium or other agricultural chemicals. Non-impacted soils include all soils located in grids in which composite testing results indicate residual chemical concentrations within the composite sample are below concentrations of concern.

The composite sample selenium concentrations in approximately 40 fifty-acre grid cells (2,000 acres) exceeded the USFWS' interim ecological restoration target (2.0 milligrams per kilogram (mg/kg) for selenium at several sampling locations in the southern portion of the C-11 Impoundment and several locations in the C-9 Impoundment. The sampling locations are shown in ***Figures A-106*** and ***A-107***. Locations where sample results showed selenium concentrations exceed 2 mg/kg are shown in, ***Figures A-108*** and ***A-109***. (Note that the USFWS

reviewed these maps and determined that there are additional areas that should be shown as having selenium concentrations above 2 mg/kg). A discussion of selenium concentrations by feature follows.

A.19.2.1 Soil Selenium Concentrations by Feature

A.19.2.1.1 Water Conservation Area 3A/3B Seepage Management Area

The 95% Upper Confidence Limit (UCL) for selenium in soils within WCA 3A/3B is estimated to be 1.35 mg/kg. The concentration of residual pesticides and metals detected in the surficial soil within this section of the project area does not pose an unacceptable risk to the USFWS trust species. Based on the regional concentration of selenium detected and the previous ecological risk assessments conducted in this area, no additional assessment or response action is warranted.

A.19.2.1.2 C-11 Impoundment

As part of the analysis, 31 discrete samples were collected and analyzed within the C-11 Impoundment for selenium. Selenium concentrations ranged from 0.12 parts per million (ppm) to 6.4 ppm with a mean value of 1.58 ppm. ***Figure A-109*** shows exceedance locations identified in the May 2010 East Coast Buffer Selenium Study Report included in Attachment E of this appendix. The 95% UCL for selenium in soils within the C-11 footprint is estimated to be 2.62 mg/kg. Based on the desorption study and risk analysis conducted for the project area, the calculated concentration was characterized to pose a low risk potential to future waterfowl that may use the areas for feeding and breeding purposes, although the USFWS expressed potential concerns for several selenium impacted areas within the C-11 Impoundment and potential risks to Federal trust resources. Additional soil characterization and post-construction water quality sampling was recommended in order to demonstrate minimum ecological risk in the C-11 Impoundment. The necessity for corrective action would be determined upon completion of the proposed additional assessment.

A.19.2.1.3 C-9 Impoundment

The C-9 project area was divided into two areas for sampling and analysis of selenium concentrations. The first area was an approximately 1,600 acre, squarely configured area, located to the south. The second area was an approximately 400 acre rectangular area located to the north (FDOT Optional Mitigation Area). As part of assessment of the 1,600 acre area, 34 discrete samples were collected for selenium analysis. The 95% UCL for selenium in soils within the 1,600 acre C-9 Impoundment project area was calculated to be 2.19 mg/kg. Although previous assessments concluded with recommendations of no additional corrective actions for the 1,600 acre area of the C-9 Impoundment,

the USFWS expressed concerns that minimal risk has not been adequately demonstrated. Additional soil characterization and post-construction water quality sampling may be required in order to demonstrate minimum ecological risk in the 1,600 acre area. The necessity for corrective action would be determined upon completion of the proposed additional assessment.

The 95% UCL for selenium in soils within the 400 acre northern portion of the C-9 referred to as the FDOT Optional Mitigation Area was calculated to be 4.57 mg/kg. Based upon the desorption study and risk analysis conducted for this project, the detected concentration in the surficial soils may pose an unacceptable risk to waterfowl that use this area for feeding and breeding purposes. Additional assessment and/or corrective actions are warranted in this area prior to construction. These additional activities may include further ecological analysis of soil/sediment to develop a site specific remediation goal. Corrective action which may include scrapping/inverting or capping the area could also be necessary to minimize the potential ecological risk to trust resources. The necessity for corrective action would be determined upon completion of the proposed additional assessment.

A.19.3 Discussion

In 2010, the USFWS determined that the density and type of soil samples previously collected from the C-9 and C-11 Impoundments were not completed in accordance with the Protocol for Assessment, Remediation and Post-Remediation Monitoring for Environmental Contaminants on Everglades Restoration Projects (Protocol) and was inadequate for evaluating ecological risk upon project implementation (USFWS letter dated August 6, 2010). The Protocol recommends a sampling density of 1 sample per 20 acres. Sampling densities for the C-11 Impoundment were 1 sample per 44 acres and the C-9 Impoundment 1 sample for every 47 acres as reported in the "East Coast Buffer Regional Selenium Project report (May 10, 2011). In May of 2011, the SFWMD completed additional selenium sampling in C-9 and C-11 impoundment areas to address USFWS concerns regarding sampling density. Attachments E is the "East Coast Regional Selenium Project" Report, and **Attachment F** is the "Additional Assessment For East Coast Buffer Regional Selenium Project Report"

The USFWS concurs that the sampling efforts completed were adequate to determine that the WCA 3A/3B Seepage Management Area is unlikely to present risk to trust resources and requires no further assessment or corrective action. The USFWS remains concerned that the 400 acres identified as the FDOT Optional Mitigation Area of the C-9 Impoundment and southern portions of the C-9 Impoundment and C-11 Impoundment pose potential risk to aquatic feeding avian fauna. The USFWS has requested that the SFWMD conduct selenium bioaccumulation studies using site soils to determine if the selenium is

toxic to invertebrates within the selenium impacted areas. Prior desorption studies were deemed inconclusive. If minimal risk cannot be demonstrated within these areas, a full scale ecological risk assessment may be necessary, including bioaccumulation studies, toxicity testing, and food web modeling, as detailed in the Protocol.

The SFWMD has secured funding to complete additional sampling and characterization of soils/sediments, including toxicity testing for FY 12, within the areas of ecological concern proposed by the USFWS. This study will help USFWS determine if and to what extent corrective action may be required to protect USFWS trust resources under post-project conditions. If toxicity testing shows an unacceptable risk to Federal trust resources, additional corrective action or exclusion of the C-9 FDOT optional mitigation areas and other areas may be necessary to move forward with project implementation.

A.19.4 Corrective Actions

Completion of selenium toxicity testing will help to determine if corrective actions will be necessary in order to construct project features of the C-9 and C-11 Impoundments. Additional testing and risk studies may result in the following scenarios:

1) USFWS determines that residual soil selenium concentrations on project lands do not pose a significant risk to avian species. No special soil handling/encapsulation will be required and no selenium related post construction water quality sampling will be required.

2) USFWS determines that residual soil selenium concentrations on project lands pose potentially acceptable but unknown risk to avian species. The Service requests post-construction water quality monitoring for selenium be conducted in the C-9 and C-11 Impoundments. The Service would require corrective actions if water column selenium concentrations are found to exceed ecological targets.

3) USFWS determines that residual soil selenium concentrations on project lands pose an unacceptable risk to avian species. The Service requests that soils containing elevated concentrations of selenium be isolated from the inundated areas by either encapsulating the soils under 6 to 12 inches of clean soils or removing the impacted soils from the inundated areas of the project.

The most likely outcome is that the USFWS will recommend water quality monitoring with the potential for post-construction corrective actions to isolate the most impacted soils from the water column. If corrective action was recommended by the USFWS either as a potential post-construction action or as

a condition of constructing the impoundments, it is most likely that this would require the isolation or removal of impacted soils primarily from the 400 acre FDOT Optional Mitigation Area of the C-9 impoundment where the average selenium concentration exceeds 4 mg/Kg. There are other areas within the C-9 and C-11 impoundments with elevated selenium concentrations above 4 mg/Kg; however, they present less of an ecological risk because these areas are smaller in size than the FDOT optional mitigation Area and the overall site selenium concentrations for these areas are around 2 mg/Kg. The USFWS recommendation for the C-9 and C-11 canals is likely to focus on additional WQ monitoring with corrective actions required on only a small fraction of the total acreage in these two impoundments; however, to address the possibility of a worse case outcome, cost estimates prepared for the Residual Agricultural Chemical writeup (Section 7.11) assume all areas with selenium above 2 mg/kg require corrective action.

In accordance with the USFWS letter dated August 6, 2010 (**Attachment A**), several options may be viable if additional testing does not confirm acceptable e risk to USFWS trust resources; 1) Impacted soils can be encapsulated into impoundment levees so no contact with impacted soils would occur, this can be done as long as the engineering properties of the impacted soil are suitable for inclusion in levees; 2) Impacted soil unsuitable for inclusion in levee or access roadways can be to be moved offsite; and 3) Soil blending, blend or mixing of the upper strata of the soil with un-contaminated soil at lower depths can be done in order to bring the soil to suitable selenium levels.

Per USACE policy for HTRW on civil works project lands (USACE Engineering and Design For Civil Works Projects, ER 1110-2-1150, Dated 31 August 1999), the cost of special handling or disposal of impacted soils is not cost-sharable and must be paid for by the SFWMD. Since most of the lands likely to require corrective action lie within the C-9 FDOT Optional mitigation area, the SFWMD may choose to avoid this corrective action by acquiring replacement wetland mitigation credits at another location rather than using the FDOT Optional Mitigation Area lands. This approach is further discussed in Section 7.3. A final decision regarding the use of the C-9 FDOT Optional Mitigiation Area lands will depend upon the outcome of the final ecological risk assessment report (to be completed in 2012) and the availability and cost of alternative wetland mitigation credits.

Additional coordination between the NFS, the DEP, the USFWS, and the Corps will continue to be done to ensure that the C-9 and C-11 site soils are fully characterized and that proposed remedial actions are reviewed by all parties and are carried out in a legal and cost effective manner. Complete characterization and understanding of ecological risks associated with the C-9 and C-11

Impoundments will be fully realized and implemented prior to construction of project features currently scheduled for 2015 or later.

A.19.5 REFERENCES

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U.S. Army Corps of Engineers, June 2010. Memorandum for Mr. James Dalton, CECW-CE, HQUSACE.

United States Department of the Interior, letter dated August 6, 2010 [to Mr. Taylor, South Florida Water Management District].

USFWS letter to SFWMD dated June 29, 2011 [to Mr. Taylor, South Florida Water Management District].

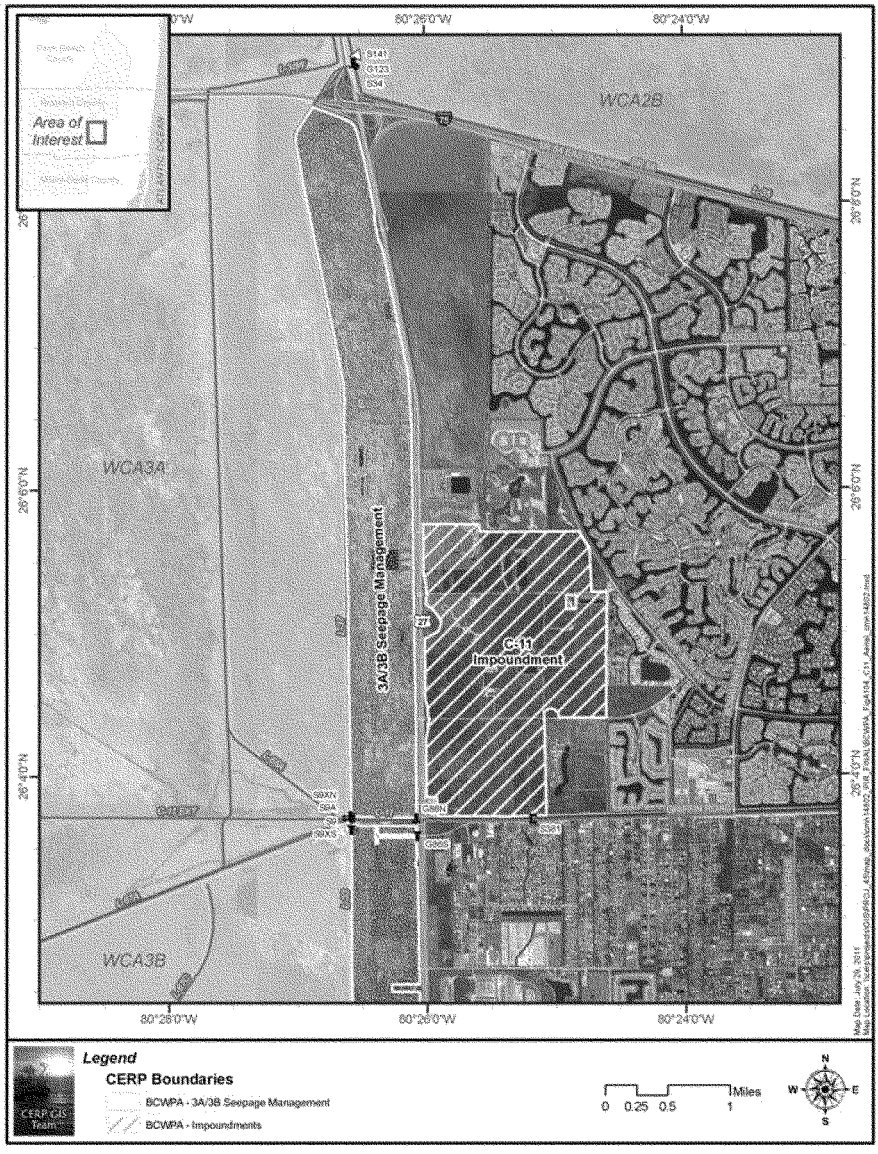

FIGURE A-104: C-11 IMPOUNDMENT AND WCA 3A/3B SMA PROJECT AREAS

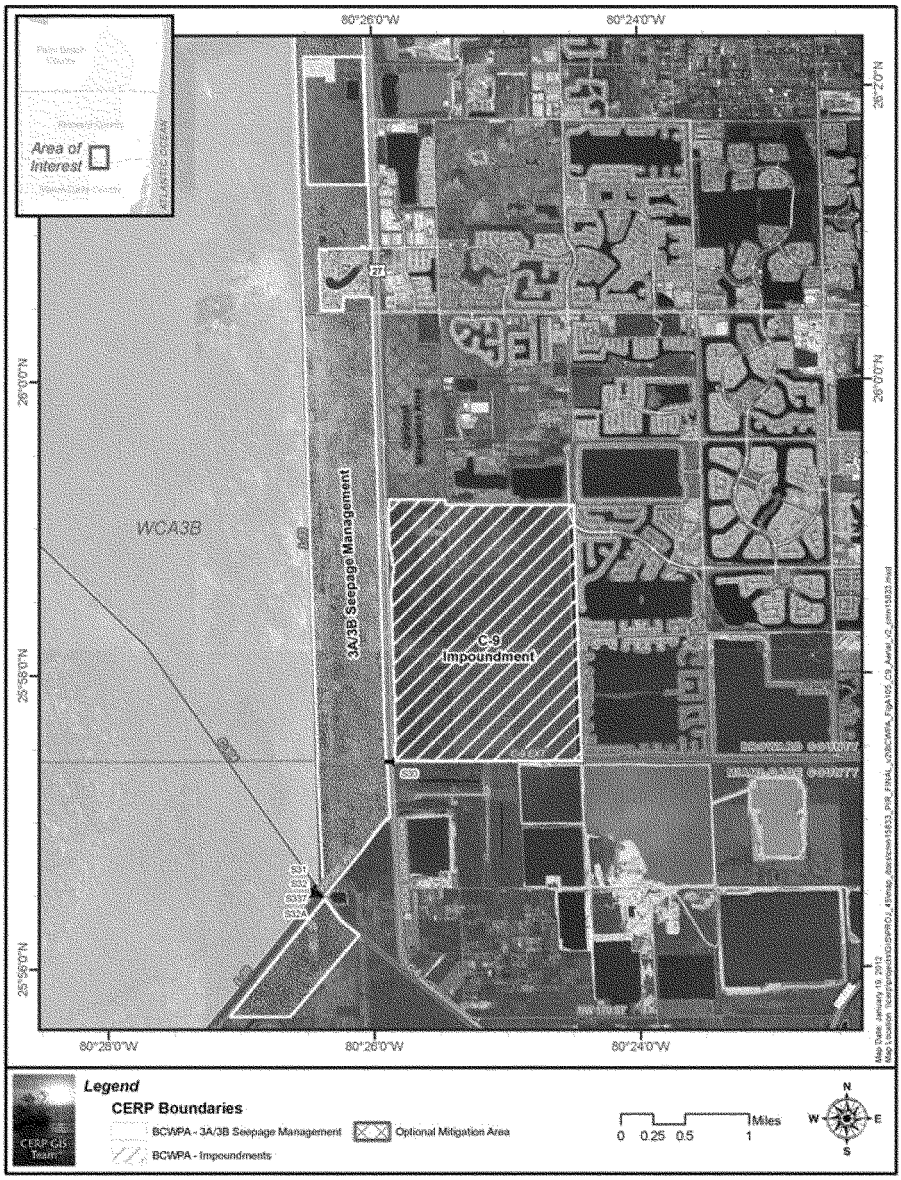

FIGURE A-105: C-9 IMPOUNDMENT AND WCA 3A/3B SMA PROJECT AREAS

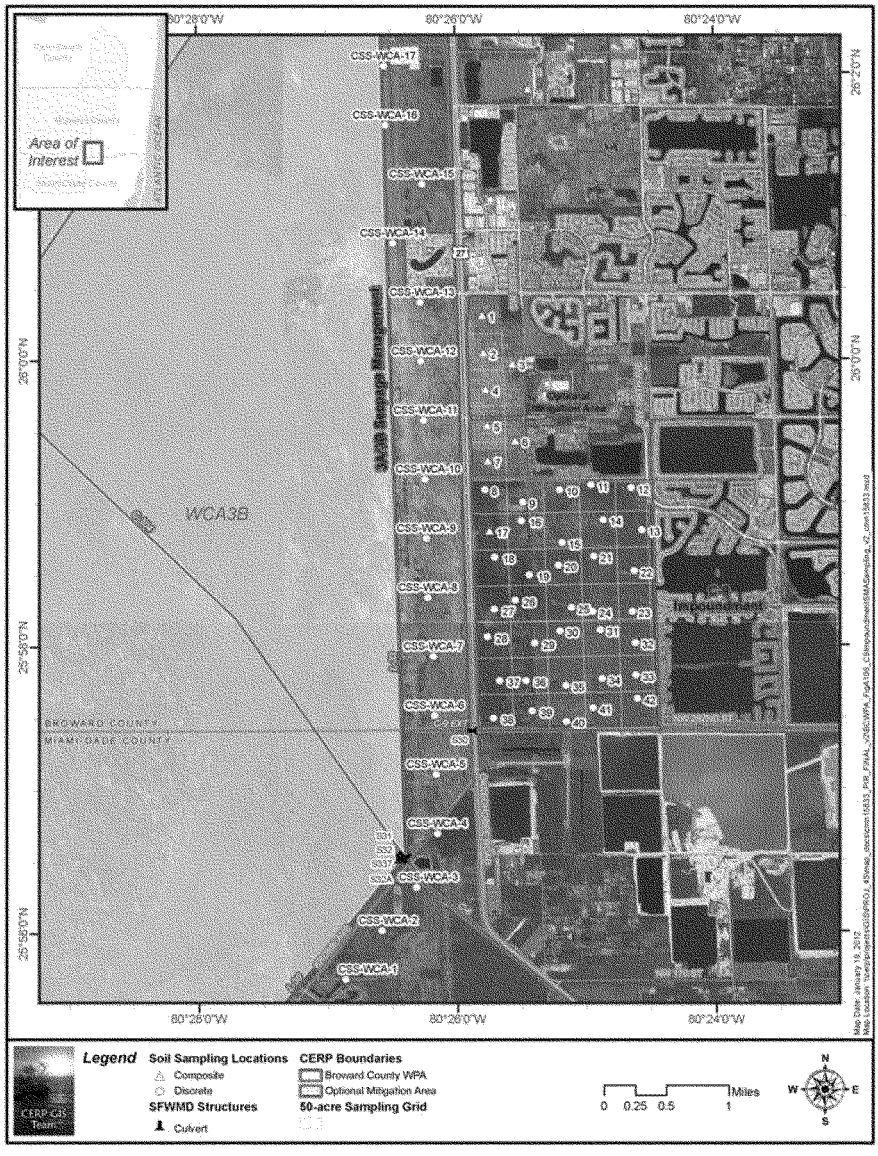

FIGURE A-106: C-9 IMPOUNDMENT AND WCA 3A/3B SMA SAMPLING LOCATIONS

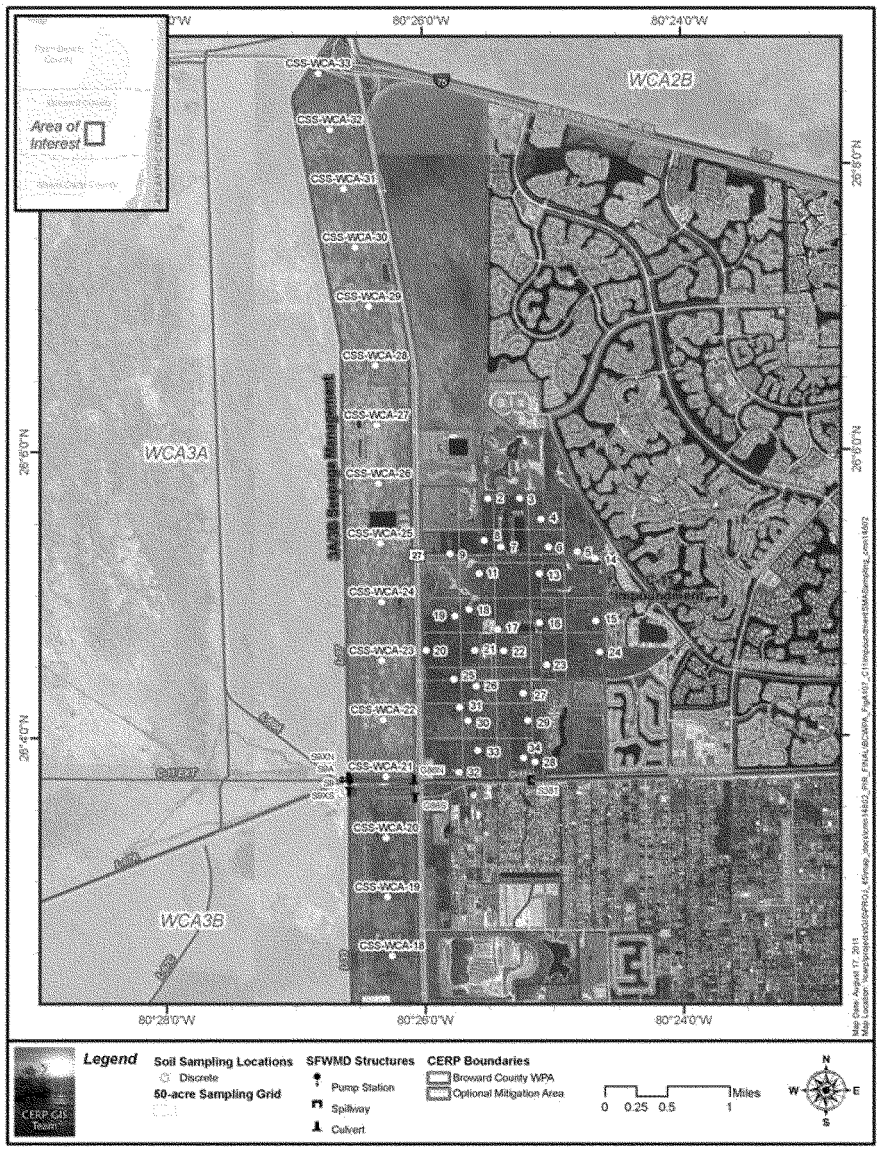

FIGURE A-107: C-11 IMPOUNDMENT AND WCA 3A/3B SMA SAMPLING LOCATIONS

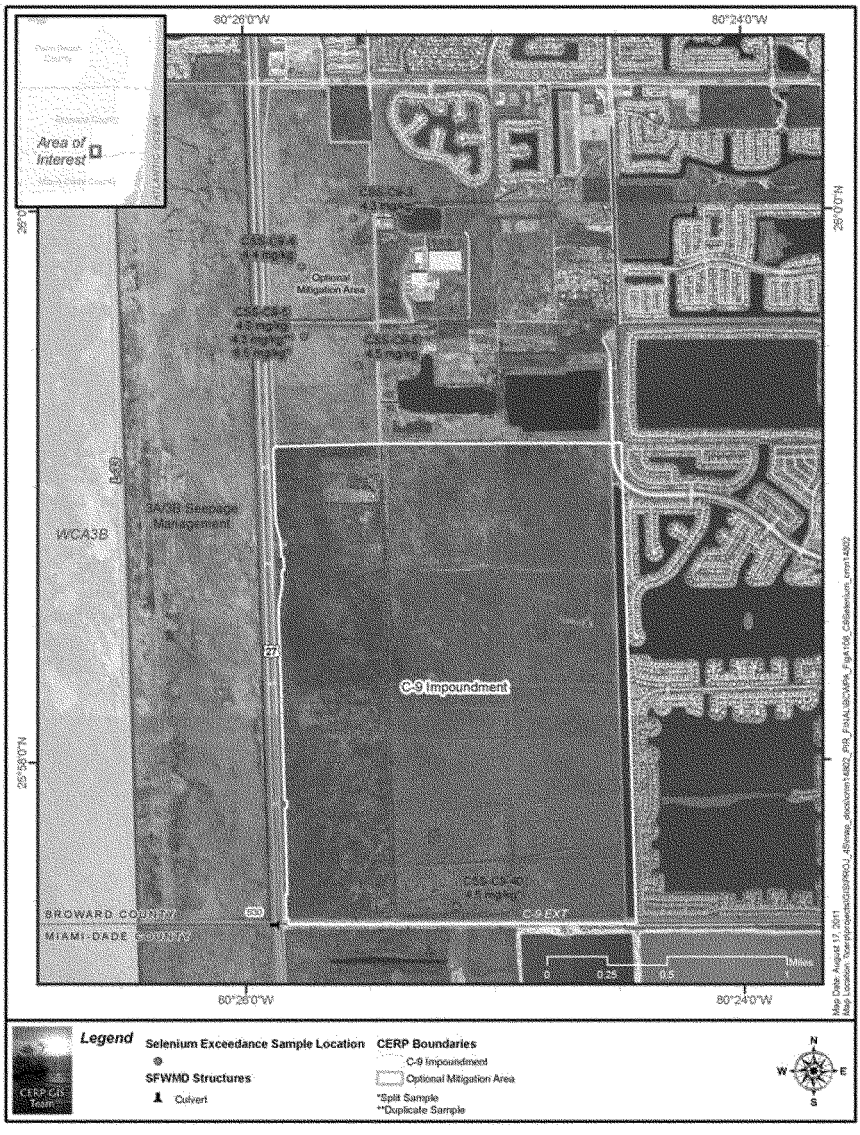

FIGURE A-108: C-9 IMPOUNDMENT SELENIUM EXCEEDANCE

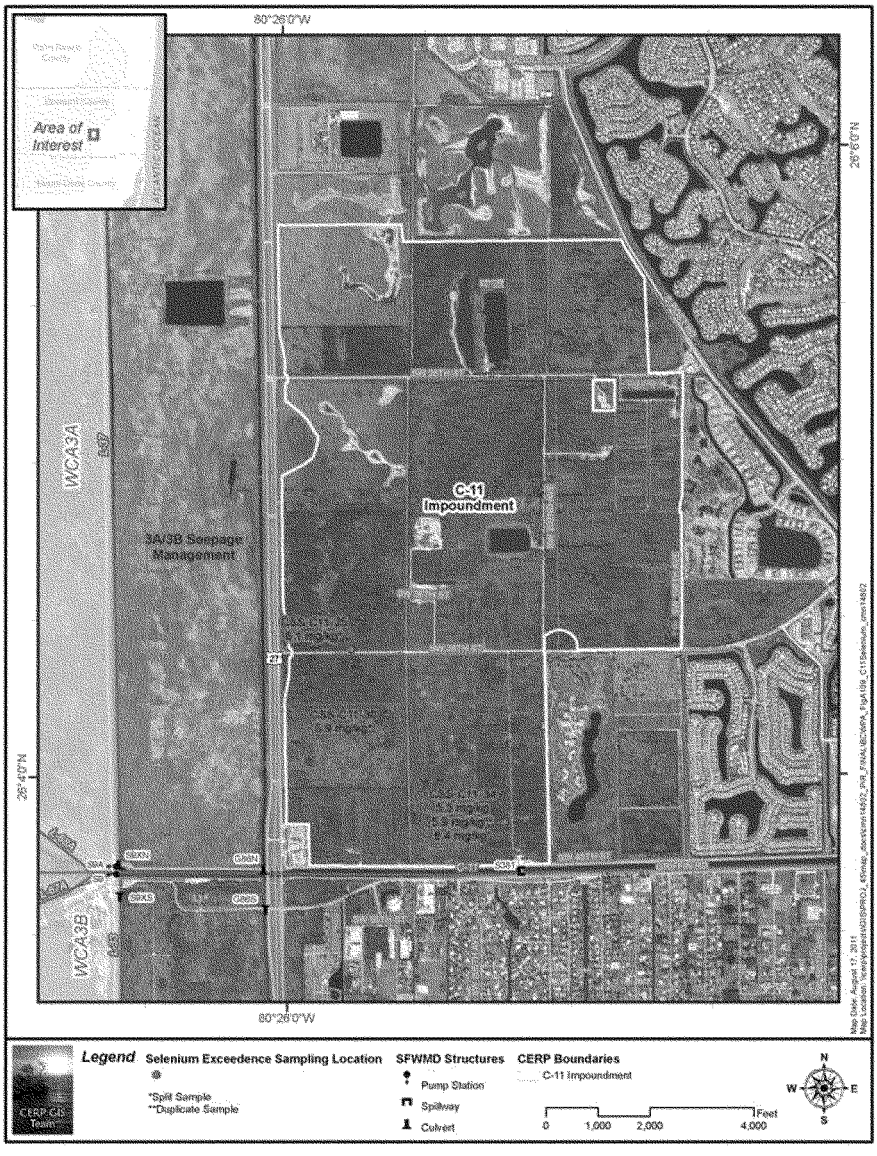

FIGURE A-109: C-11 IMPOUNDMENT SELENIUM EXCEEDANCE

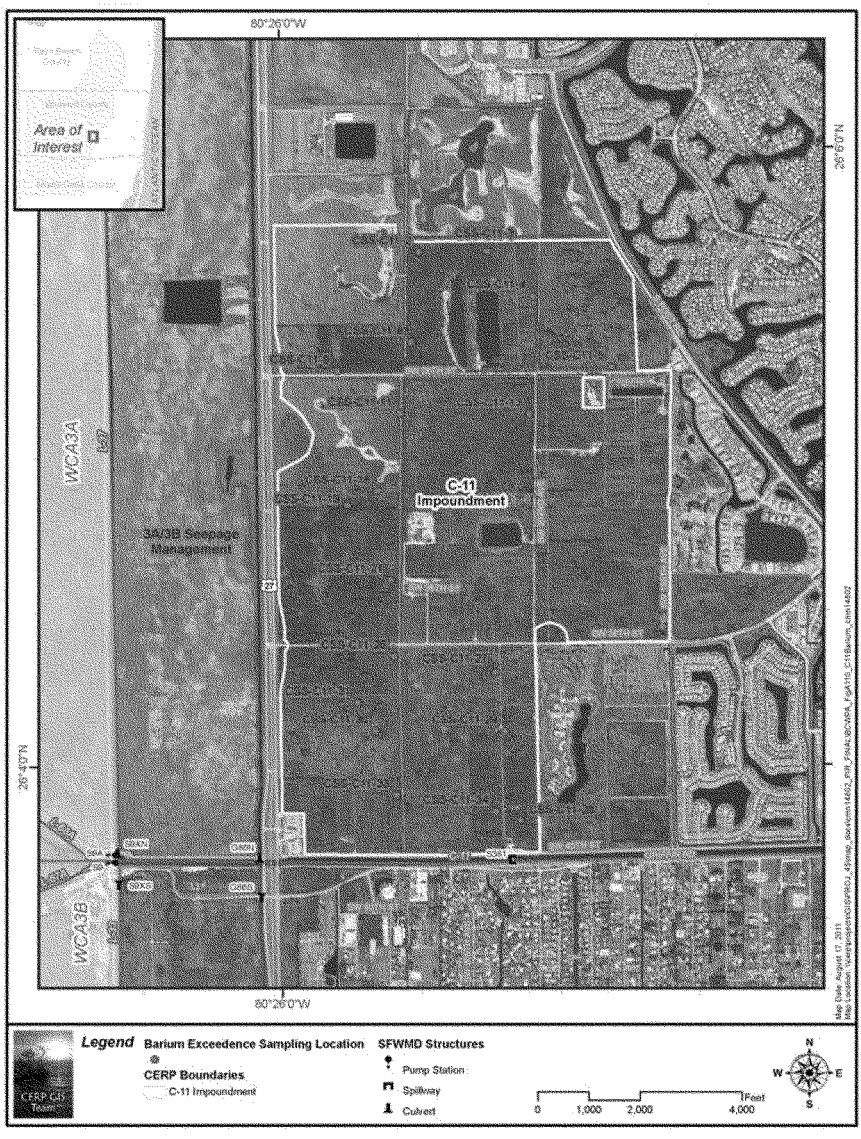

FIGURE A-110: C-11 IMPOUNDMENT BARIUM EXCEEDANCE

Attachment A: August 6, 2010 U.S. Fish and Wildlife Service Letter

United States Department of the Interior

FISH AND WILDLIFE SERVICE
South Florida Ecological Services Office
1339 20th Street
Vero Beach, Florida 32960

August 6, 2010

Robert Taylor
South Florida Water Management District
3301 Gun Club Road
West Palm Beach, Florida 33406

Dear Mr. Taylor:

The Fish and Wildlife Service (Service) has reviewed the East Coast Buffer Regional Selenium Project: Ecological Risk of Selenium in the Proposed East Coast Buffer Project Area, prepared by Environmental Consulting and Technology, Incorporated (ECT). The East Coast Buffer Project area consists of the C-9 and C-11 impoundments and the Water Conservation Area (WCA) 3A/3B seepage area. Previous soil sampling from the project area detected selenium concentrations in excess of the Service's recommended interim screening value (2 mg/kg), ranging from less than 1 to 7.7 mg/kg. The present document reports the results from additional soil and surface water sampling conducted throughout the project area.

Proposed soil sampling in the C-9 and C-11 impoundments included taking composite samples within 50-acre grids; however, due to access issues with wetland conditions and vegetative cover, sampling was modified. Discrete samples within a 50-acre grid were collected when conditions prevented composite sampling. A total of 31 discrete soil samples were collected from the 1,700-acre C-11 impoundment. Within the approximately 2,000-acre C-9 impoundment, 8 composite and 34 discrete samples were collected. The WCA 3A/3B seepage area (5,500 acres), which had no history of agriculture, had 34 discrete samples collected. Soil sampling results were used to calculate 95 percent upper confidence levels (UCL) for selenium. As a prediction of future surface water quality, surface water samples were collected from canals within the C-9 and C-11 impoundments at three locations each, near soil selenium concentrations in excess of 4 mg/kg.

Results

C-11 soils had a calculated 95 percent UCL of 2.6 mg/kg. The calculated 95 percent UCL for selenium from the northern seven contiguous composite samples from the C-9 impoundment was 4.57 mg/kg. The 34 discrete samples from the C-9 impoundment had a 95 percent UCL of 2.19 mg/kg. Concentrations of selenium in the surface water from both the C-9 and C-11 impoundments were below the laboratory detection limit (0.5 μg/l). Selenium concentrations from the WCA 3A/3B seepage area ranged from 0.05 to 3.4 mg/kg, with a 95 percent UCL of 1.35 mg/kg. ECT recommended no further assessment or corrective action for soils within the WCA 3A/3B seepage area or the C-11 impoundment. Since the selenium concentration in the northern 400 acres of the C-9 impoundment indicated a potential risk to aquatic feeding avian fauna, additional assessment and/or corrective actions were recommended. To obtain additional data regarding the mobility of selenium within the C-11 impoundment, two quarters of post-construction surface water quality monitoring were proposed.

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Robert Taylor Page 2

Service Comments

- Pages 2-1 – 2-2 - The density and type of soil samples collected from the C-9 and C-11 Impoundments was not in accordance with the Protocol for Assessment, Remediation and Post-Remediation Monitoring for Environmental Contaminants on Everglades Restoration Projects (protocol) and was inadequate for evaluating ecological risk upon project implementation. For discrete sampling, the protocol recommends a minimum sample density of 1 sample per 20 acres. For the C-11 Impoundment, approximately 1 sample was collected per 55 acres. In the southern portion of the C-9 Impoundment, sample density was approximately 1 sample for every 47 acres.

- A great deal of previous sampling has occurred in the C-9 and C-11 project area, including work by BEM, Shaw, and the Corps of Engineers. We would like to have seen a discussion of the current sampling results compared to the previous sampling that has been conducted in the project area, including a calculation of the 95 percent UCL for all of the sampling results in the C-9 and C-11 impoundments. All sampling results should be summarized in one table and /or figure.

- Page 1-3, 1st paragraph – In previous assessments by Shaw (2007), nearly 20 percent of the soil samples collected had selenium concentrations at or above 5 mg/kg. No comparison is made between Shaw's results and the most recent sampling results by ECT. We would like to have an explanation of the differences.

- The conclusion section of the subject report states that the majority of the C-9 and C-11 areas have not been used for agricultural purposes. However, previous assessment reports reviewed by the Service for the WCA 3A/3B seepage areas and C-9 and C-11 impoundments indicated historical use for agricultural purposes. The exact historical use of the project area surrounding the sampling locations is unclear. In order to evaluate the potential risk associated with the proposed use of the project area, a detailed description and maps of the land use must be provided.

- Page 3-2, 3rd paragraph – It is not clear how the calculated correlation between the soil selenium and TOC concentrations is being used in this assessment. Please provide a conclusion regarding the observed correlation.

- Pages 3-1, 4-2 and 4-3 – It is unclear how the desorption study by NewFields was used to demonstrate low risk in the southern portion of the C-9 and C-11 Impoundments. No calculation was provided. The 4 mg/kg selenium screening value from the New Fields desorption and risk assessment studies, was based on a TOC that was considerably higher (21 to 47 % TOC) than the TOC from the current sampling results (2 to 4.6 % TOC). No explanation was provided on this disparity. Based on the TOC of soils from the current sampling event, it is likely that more selenium would leach from the soil than was shown in the desorption study.

Robert Taylor Page 3

- The surface water samples that were collected from the canals are not likely to be representative of conditions after the proposed project implementation.

- The Service concurs that the WCA 3A/3B seepage area is unlikely to present risk to Service trust resources and requires no further assessment or corrective action.

- Page 4-1 and 4-3 – There is a discrepancy between ECT's recommended length of water quality monitoring, four quarters versus two quarters.

- The Service concurs with the conclusion that the northern 400 acres of the C-9 impoundment present potential risk to aquatic feeding avian fauna, and agree with ECT's recommendation to perform additional assessment and/or corrective actions within this selenium impacted area.

- We are not convinced that low risk to ecological receptors has been established for the remaining portions of the C-9 Impoundment and the entire C-11 Impoundment. If minimal risk cannot be demonstrated in these areas, a full scale ecological risk assessment may be necessary, including bioaccumulation studies, toxicity testing, and food web modeling, as detailed in the protocol.

In summary, the Service still has concerns about the selenium levels in both the C-9 and C-11 project areas. The subject report, although it provided additional information on selenium levels, did not remove all of our concerns. Sampling densities were too low and did not follow the protocol. No risk calculations were provided to support the conclusion of low risk to Federal trust resources. Finally, the report did not include a summary and comparison with earlier results.

Thank you for the opportunity to provide comments regarding the East Coast Buffer Regional Selenium Project. If you have any questions, please contact Emily Bauer at 772-562-3909, extension 335.

Sincerely yours,

Robert Drake

for Paul Souza
Field Supervisor
South Florida Ecological Services Office

cc: electronic only
Corps, West Palm Beach, Florida (Lisa Gued, Tori White)
DEP, West Palm Beach, Florida (Joe Lurix)
ECT, Fort Lauderdale, Florida (Marc Lefebvre)
Service, Vero Beach, Florida (Liberta Scotto)

Attachment B: June 30, 2010 U.S. Department of the Army Letter

DEPARTMENT OF THE ARMY
SOUTH ATLANTIC DIVISION, CORPS OF ENGINEERS
ROOM 10M15, 60 FORSYTH ST, S.W.
ATLANTA, GEORGIA 30303-3490

REPLY TO
ATTENTION OF:

CESAD-PDS-P

30 June 2010

MEMORANDUM FOR MR. JAMES DALTON, CECW-CE, HQUSACE

SUBJECT: Agrochemical Contaminants and Soil Management Plans Associated With the Indian River Lagoon South and C-111 Spreader Canal Projects

1. References

a. Memorandum, CECW-PC, 11 June 2010, Subject: Policy Compliance Review for the CERP, C-111 Spreader Canal Western Project Final Integrated Project Implementation Report and Environmental Impact Statement, dated November 2009.

b. ASA (CW) letter, 4 June 2010, addressed to Carol Ann Wehle, Executive Director, South Florida Water Management District (SFWMD).

2. Policy guidance included with the referenced documents contains direction to coordinate with regulatory agencies on proposed treatment. Reference 1a included specific direction to coordinate with EPA Region IV. Upon further investigation it has been determined that EPA Region IV has delegated this regulatory program responsibility to Florida Department of Environmental Protection (FDEP) for these agriculture chemicals. EPA Region IV is not exercising regulatory authority in this matter. Coordination for the proposed soil management with FDEP and Fish and Wildlife Service (FWS) are or will soon be complete. Consequently, further coordination with EPA Region IV in this instance would provide no additional value. Accordingly, as FDEP has the EPA-delegated regulatory authority for this soil management plan, we intend to provide evidence of their concurrence in response to reference 1a.

3. I coordinated with Stan Meiburg, Regional Administrator, today on this issue and he confirmed that he does not want to review individual soil management plans for each project and prefers that clean up measures for agrochemicals be coordinated with FDEP. As a result, I have directed Jacksonville District to complete any remaining coordination required on these and other affected CERP projects with FDEP and FWS to ensure compliance with the intent of the policy guidance.

4. My staff point of contact on this issue is Mike Magley, (404) 562-5206.

TODD T. SEMONITE
Major General, USA
Commanding

Attachment C: June 29, 2011 U.S. Fish and Wildlife Service Letter

United States Department of the Interior

FISH AND WILDLIFE SERVICE
South Florida Ecological Services Office
1339 20th Street
Vero Beach, Florida 32960

June 29, 2011

Robert Taylor
South Florida Water Management District
3301 Gun Club Road
West Palm Beach, Florida 33406

Dear Mr. Taylor:

The U.S. Fish and Wildlife Service (Service) has reviewed the additional assessment for the East Coast Buffer Regional Selenium Project: Ecological Risk of Selenium in the Proposed East Coast Buffer Project Area, prepared by Environmental Consulting and Technology, Incorporated (ECT). The East Coast Buffer Project area consists of the C-9 and C-11 impoundments and the Water Conservation Area (WCA) 3A/3B seepage area. Previous soil sampling from the project area detected selenium concentrations in excess of the Service's recommended interim screening value (2 mg/kg) (see Enclosure), ranging from less than 1 to 7.7 mg/kg. The present document reports the results from additional soil sampling conducted at former agricultural sites within the project area.

A total of 36 five-point discrete samples were collected from the proposed C-9 and C-11 impoundments. Ten of those samples were collected from the northern 400 acres of the C-9 impoundment. A 95 percent upper confidence limit (UCL) of 6 mg/kg was calculated for this 400-acre area. Only one sample, which had a concentration of 4.5 mg/kg selenium, was collected from the remaining portion (1,600 acres) of the C-9 impoundment. The 25 soils samples collected from the C-11 impoundment had a calculated 95 percent UCL of 3.1 mg/kg selenium. Based on the results, ECT recommended conducting an ecological risk assessment, including a bioaccumulation study and toxicity testing.

Service Comments

- Page 4-1, section 4.1, last paragraph – The text incorrectly references Figure 3, instead of Figure 4, as illustrating the sampling locations.
- Table 2 – Data is not presented for sampling locations SE-34, SE-35, and SE-36.
- Page 5-2, section 5.2.1 – The text incorrectly references Appendix C, instead of Appendix B, as including the 95 percent UCL calculations.
- Figures 7 and 8 – Both figures should also include areas identified in previous sampling events with selenium concentrations above the 2 mg/kg screening level. Once all the available data is combined, a more accurate determination on areas of concern can be made. As presented in the figures, individual discrete samples are being used to base potential remediation decisions. As stated in the assessment protocol, one sample is not sufficient as a basis for remediation decisions. Since much sampling has already occurred in the C-9 and

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Robert Taylor Page 2

C-11 impoundments, we feel kriging or some other method of interpolation would be best for determining where corrective actions are needed.

- While ECT did provide a written discussion and tabular data on previous sampling events that have been conducted on the subject site, they did not provide figures displaying all of the detected selenium concentrations from these assorted studies. Without graphic representation of where elevated selenium concentrations have been identified, it is difficult to determine the area of the subject site that presents a potential ecological concern.

- Pages 5.2 - 5.3, section 5.2.1 – The Service does not feel that the 1,600-acre area in the C-9 impoundment is free from potential risk to Service trust resources. Based on current and previous sampling events, it is clear the southern portion of the C-9 impoundment has elevated selenium concentrations that are not consistent with the northern part of the 1,600-acre area.

- Page 6.1, 1st paragraph – The 313-acre area of selenium impacts in the C-11 is underestimated, since it does not include areas of selenium impacts that were identified in former sampling events.

In summary, the current assessment at the C-9 and C-11 detention areas confirms the elevated selenium concentrations identified in earlier sampling events, which exceed the Service's recommended ecological screening level for the protection of aquatic community receptors. While the Service concurs with ECT's recommendation for an ecological risk assessment (ERA) using soils from the C-9 and C-11 impoundments, including a bioaccumulation study, toxicity testing, and food web modeling, we feel the acreage (720 acres) of elevated selenium presented in the report is underestimated. ECT failed to include the areas of elevated selenium identified in previous sampling events. All selenium data collected on the subject site must be considered, whether or not it was from a known formerly cultivated area. Once an ERA is complete the data can then be used to determine a site-specific remediation goal and help to develop remedial options, as necessary.

Thank you for the opportunity to provide comments regarding the East Coast Buffer Regional Selenium Project. If you have any questions, please contact Emily Bauer at 772-469-4335.

Sincerely yours,

Robert Trahan

for Spencer Simon
Acting Field Supervisor
South Florida Ecological Services Office

Enclosure

2

Attachment D: September 14, 2011 Department of the Army Letter

DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY
CIVIL WORKS
108 ARMY PENTAGON
WASHINGTON DC 20310-0108

SEP 14 2011

MEMORANDUM FOR DEPUTY COMMANDING GENERAL FOR CIVIL AND EMERGENCY OPERATIONS

SUBJECT: Comprehensive Everglades Restoration Plan (CERP) - Residual Agricultural Chemicals

1. Generally, it is Civil Works program policy that the responsibility for the cost of all necessary response actions at project lands is a non-Federal responsibility.[1] Thus, the non-Federal sponsor (NFS) is expected to take all actions that are necessary to respond to the presence of residual agricultural chemicals[2] prior to construction of the federal project and to pay 100% of the costs of such response action.

2. As part of CERP implementation, clarification was requested concerning the certification of project lands containing residual agricultural chemicals. This policy addresses only residual agricultural chemicals under the following circumstances:

- Residual agricultural chemicals are present on lands that cannot be avoided, meaning that alternative lands are not available and/or not suitable for CERP project purposes;
- Residual agricultural chemicals must have resulted from the use of commercially available products that were lawfully applied for their intended purpose to enhance agricultural production;[3]
- The actions to address residual agricultural chemicals are necessary because the project lands are being converted from agricultural production to an aquatic restoration purpose,[4] in order to meet the goals of the authorized project; and

[1] *See* Engineer Regulation (ER) 1165-2-132.
[2] The term residual agricultural chemicals means those chemicals found in formerly cultivated soils that were legally applied, in accordance with their Environmental Protection Agency (EPA) registration, any Federal, state or local legal requirements, any labeling or other instructions, and which over time remain in the soil.
[3] This policy applies only to residual agricultural chemicals that were lawfully applied. Residual agricultural chemicals that were spilled or resulted from waste management are not covered by this memorandum and shall be addressed under ER 1165-2-132.
[4] In most instances aquatic restoration occurs when the land is being inundated with water.

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(2)

- The NFS is responsible for ensuring that the development and execution of Federal, state, and/or locally required response actions to address residual agricultural chemicals are accomplished at 100 percent non-project cost. The NFS will regularly update the Jacksonville District Commander regarding its progress in the development and execution of the required response actions.

3. Normally, lands certification and construction shall not be undertaken until response actions have been completed on impacted lands; however, in some circumstances, economic efficiencies may be achieved if the response action is performed during the construction phase. Accordingly, the Jacksonville District Commander, with concurrence of Headquarters, U.S. Army Corps of Engineers (HQUSACE), may: (a) at the NFS' explicit request and expense, conduct the response action to address residual agricultural chemicals for the NFS during the construction phase; and/or (b) at the NFS' explicit request and expense, allow soils containing residual agricultural chemicals to remain on project lands as part of an approved response action only under the following conditions:

- the residual agricultural chemicals were commercially available products that were lawfully applied for their intended purpose to enhance agricultural production;

- there is adequate documentation of regulatory approval(s) of the NFS' proposed response actions relating to the presence of residual agricultural chemicals;

- the use of project lands and/or U.S. Army Corps of Engineers (USACE) contractors acting for the NFS are determined to be a cost effective option;

- the engineering and other risks associated with using or leaving soils containing residual agricultural chemicals on project lands are determined to be adequately assessed and acceptable;

- the NFS provides for 100% of the costs for all response actions taken regarding the residual agricultural chemicals and ensures the development, planning, and execution of Federal, state, and/or locally required response actions to address residual agricultural chemicals. Such response actions include any soil management activities required by Federal, state or local regulatory agencies to address residual agricultural chemicals; and

- the NFS agrees that any future costs associated with the presence of residual agricultural chemicals remaining on Federal project lands are a

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(3)

100% NFS cost and responsibility, including any potential liability related to their presence.

4. To fulfill the above requirements, on a case by case basis, when a CERP project includes lands that contain, or are reasonably expected to contain, residual agricultural chemicals, the CERP Project Implementation Report (PIR) should include the following additional topics in a section entitled "Residual Agricultural Chemicals" and, if necessary, a corresponding appendix. The NFS should request in writing the inclusion of this section and provide the information for the below sections. The Jacksonville District should verify, approve and make recommendations in the PIR, as appropriate. If necessary, the District may review prior project guidance on this issue. For authorized projects, such as IRL-S C-44, equivalent documentation shall be submitted to HQUSACE in advance of construction. For projects that are not yet authorized, but have existing ASA(CW) guidance, such as C-111 Spreader Canal, Site 1 and C-43 Reservoir, the project shall follow this guidance.

Residual Agricultural Chemicals: Provide an explanation and documentation supporting why it has been determined the residual agricultural chemicals were commercially available products that were legally applied for their intended purpose to enhance agricultural production. Explain the nature and extent of the residual agricultural chemicals. Explain why avoidance of the lands containing the chemicals was not practicable. Demonstrate that any actions taken concerning residual agricultural chemicals are necessary because the project property is being converted from agricultural production to an aquatic restoration purpose, which inundates the land with water in order to meet federal project goals.

Regulatory Coordination: Include adequate documentation of any regulatory approval(s) of the NFS' proposed actions or explain the steps being taken by the NFS to obtain regulatory approval(s) and the NFS' current proposed plan. The Jacksonville District will obtain adequate documentation from the NFS and provide it to HQUSACE prior to project construction. This will include written documentation of regulatory approval for any response action and for the soils containing residual agricultural chemicals remaining on project lands.

Soils Removed: At sites where residual agricultural chemicals remain or are suspected to be present, soils from the project lands must be tested to determine if any hazardous waste characteristic under the Resource Conservation and Recovery Act (RCRA) is exhibited. If any of the soils are hazardous waste under these criteria, then they shall be removed from the project lands by the NFS and properly disposed of and managed in compliance with applicable laws. In these circumstances, the USACE shall not conduct the work for the NFS.

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(4)

Cost Comparison for Soils Containing Residual Agricultural Chemicals Remaining on Project Lands: As an initial step, the PIR should compare incorporating the soils containing residual agricultural chemicals on the project lands with the cost of removing the soils containing residual agricultural chemicals from the project lands.[5] In order to be considered a cost effective approach, the cost of incorporating the impacted soils into project features or leaving these materials on the project site in a disposal unit must be the least expensive option and all current and future responsibility for the disposal unit must be assumed by the NFS. If this is the case, the PIR should then include a final determination, which takes into account the above required comparison and evaluates the possibility of any future releases that may result in liability concerns. The final determination may also take into account other factors relevant to the project. The costs for items that are part of normal engineering and construction activities will not be considered a response action cost, provided these are the same activities required to implement the project features absent the presence of residual agricultural chemicals in the soil. Such normal engineering and construction activities will remain a part of total project cost even if the actions coincidentally assist in the response actions related to the residual agricultural chemicals. Any activities undertaken solely due to the presence of residual agricultural chemicals in the soils may not be cost shared or credited towards the NFS share of project costs.

Cost Comparison for the USACE Acting as the Construction Agency and Performing the non–RCRA Response Action for the NFS: As an initial step, the PIR should compare the cost of the USACE performing the response action for the NFS with the cost of the NFS performing the response action prior to USACE beginning construction of the Federal project. In order to be considered a cost effective approach, the cost of having the USACE be the sole party performing the construction and response action must be the least expensive option. If this is the case, the PIR should then include a final determination, which takes into account the above required comparison and evaluates the possibility of any future releases that may result in liability concerns. The final determination may also take into account other factors relevant to the project. When the NFS conducts the construction and response action, it can realize the efficiencies of performing both activities. Thus, a comparison of the costs is not necessary and should not be included in the PIR.

Engineering and Other Risks: Provide an adequate description and explanation identifying and addressing any engineering or other risks associated with using or leaving soils containing residual agricultural chemicals on project lands. Provide a determination, in consultation with an expert familiar with

[5] As noted in paragraph 4, Soils Removed, soils that are hazardous waste will be removed at 100% NFS cost, may not remain on the project lands and USACE may not conduct the work for the sponsor. As such, these activities should not be included in the cost comparison.

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(5)

environmental remediation, as to whether the risks have been adequately evaluated. Documentation stating that the risks have been adequately evaluated and recommending a risk management decision must be provided to HQUSACE prior to project construction. The determination should consider that any future release of the materials from the project lands may result in liability concerns.

NFS Responsibility: Provide a clear statement that the NFS is 100% responsible for the cost of all actions taken due to the presence of residual agricultural chemicals, at no expense to the Federal Government and that any future costs associated with the presence of residual agricultural chemicals at the Federal project site are a 100% NFS cost and responsibility. The costs for characterization of the project lands in preparation for conducting a response action for the residual agricultural chemicals and removal of soils that are hazardous waste shall be included as 100% NFS responsibility. The Jacksonville District shall not conduct actions to address residual agricultural chemicals for the NFS during the operation and maintenance, repair, replacement and rehabilitation (OMRR&R) phase of the project.

5. Because the cost of actions addressing residual agricultural chemicals is not included in the total project cost for the CERP project, compliance with this policy should never result in increasing project costs. However, a reduction in the total cost of the project for both the NFS and the Federal government may result due to the efficiencies created by permitting the soils to remain on site and/or utilizing one contractor for construction of the project and the response action.

6. Until otherwise notified, HQUSACE, in its concurrence role in paragraph 3 or prior to submission of the PIR in paragraph 4, shall inform this office of any CERP project determined to be ineligible for application of this policy. HQUSACE shall also inform this office of any issues arising from the application of this policy to the project partnership agreement of the affected CERP project. No deviation from this policy is permitted without the express written approval from this office.

Jo-Ellen Darcy
Assistant Secretary of the Army
(Civil Works)

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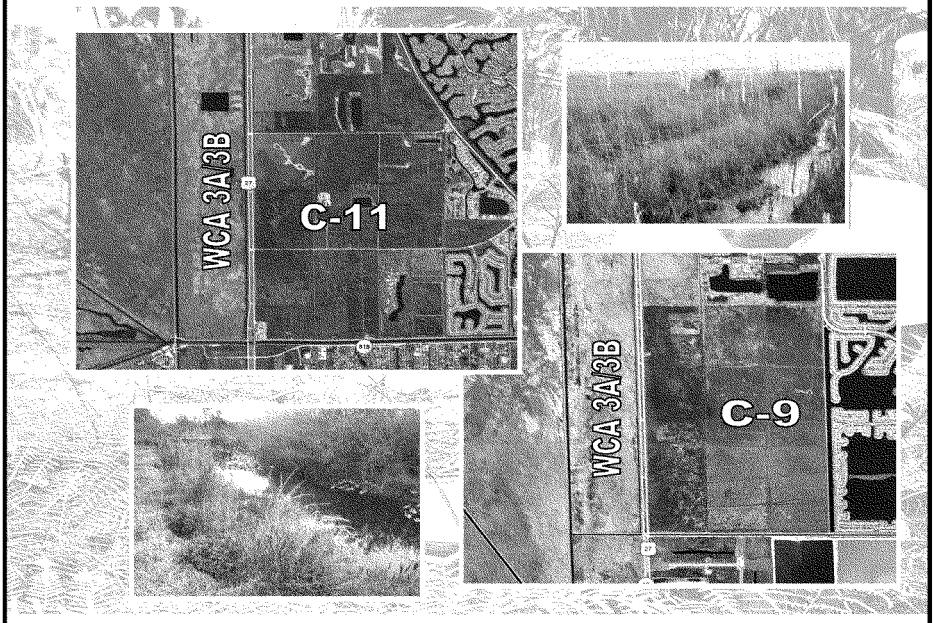
Attachment E: East Coast Buffer Regional Selenium Project Report, May 2010

East Coast Buffer Regional Selenium Project



Ecological Risk of Selenium in the Proposed East Coast Buffer Project Area

PREPARED FOR:

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

ECT Environmental Consulting & Technology, Inc.

Providing Environmental Solutions

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EXECUTIVE SUMMARY

The East Coast Buffer project area has been slated for construction by the South Florida Water Management District (District) and Army Corps of Engineers as part of Comprehensive Everglades Restoration Program. This project consists of areas C-11, C-9 and WCA3A/3B. Sampling and analysis from August 2006 in the C-11 project area indicate selenium concentrations in sediments ranging from less than 1 to 7.7 mg/Kg. The US Fish & Wildlife Service (USFWS) has expressed concern that restoration of the project areas may release selenium into the overlying water column resulting in elevated levels of risk to ecological receptors that may inhabit the area following restoration.

Additional sampling was conducted in the WCA 3A/3B, C-9 and C-11 areas to better define the mean selenium concentrations within each area. Discrete, or close composite, soil samples were collected in the linear WCA 3A/3B at 2,500 foot intervals. Much of the C-9 area was sampled at a rate of one close proximity discrete sample per 50 acres due to access limitations. Seven 50-acre grid cells within C-9 were sampled using a 10-point composite approach. C-11 was sampled at the rate of one discrete sample per 50-acres with no composite samples collected due to access issues.

The upper 95% UCL soil selenium concentrations calculated for discrete C-9, C-11 and WCA 3A/3B samples are 2.19 mg/kg, 2.63 mg/kg and 1.35 mg/kg respectively. The 95% UCL of composite soil samples from the northern portion of the C-9 was equal to 4.57 mg/kg. A batch leach test C-11 sediment samples indicates that less than 3 percent of the total selenium mass present in sediments were mobilized to the water and that selenium concentrations in surface waters that contact these sediments are expected to remain below the Florida surface water quality selenium standard of 0.005 mg/l for Class III fresh water (NewFields 2007). Additionally, the NewFields study indicated a very low probability that bioaccumulation of selenium in the food chain would result in reproductive effects to waterfowl that may inhabit the area and use it for breeding purposes after construction.

While NewFields' leaching study and the additional sample data collected suggests that the potential for risks to the environment due to selenium exposure are low, the presence of several areas of elevated selenium concentrations in surface soils in the southwest corner of the C-11 area and in the northern rectangular portion of C-9 are indicates the need for limited monitoring of surface water data following construction.

ECT also collected wetland area surface water samples in the vicinity of the high soil concentration areas. All six surface water samples reported non-detects (method detection limit of 0.5 ug/l). These concentrations are likely to reflect post-flooding conditions.

ECT, therefore, recommends the following, by project area.

WCA 3A/3B

The 95% UCL for selenium in soils within WCA 3A/3B is estimated to be 1.35 mg/kg. The concentration of residual pesticides and metals detected in the surficial soil within this section of the project area does not pose and unacceptable risk to the USFWS trustee species. Based on the regional concentration of selenium detected and the previous ecological risk assessments conducted in this area, no additional assessment or corrective actions are warranted.

C-9

The C-9 project area was divided into two areas for sampling and analysis of selenium concentrations. The first area was an approximately 1,600 hundred acre, squarely configured area located to the south. The second area was an approximately 400 acre rectangular area located to the north.

1,600 Acre Area

As part of the 1,600 acre area assessment, 34 discrete samples were collected for selenium analysis. The 95% UCL for selenium in soils within C-9 was calculated to be 2.19 mg/kg. Based upon previous discussions and coordination with the USFWS, the site specific selenium screening level concentration has a range of 2 mg/kg to approximately

4 mg/kg. In accordance with the site specific ecological risk assessment, the calculated selenium concentration of 2.19 mg/kg does not pose an unacceptable risk to the USFWS trustee species. Based upon the site specific conditions in this area, no further assessment or corrective action is warranted within this section of the project footprint.

400 Acre Area

The confirmation sampling included the collection of eight (8) composite soil samples from the 400-acre area. The 95% UCL for selenium in soils within the northern portion of the C-9 400-acre footprint was calculated to be 4.57 mg/kg. Based upon the desorption study and risk analysis conducted for this project, the detected concentration in the surficial soils may pose an unacceptable risk to waterfowl that may use this area for feeding and breeding purposes. Additional assessment and/or corrective action are warranted in this area prior to construction. These additional activities may include further ecological analysis of soil/sediment to develop a site specific remediation goal. Corrective action, which may include scraping/inverting or capping the area, could also be necessary to minimize the potential ecological risk to trust resources. The necessity for corrective action would be determined upon completion of the proposed additional assessment.

C-11

This assessment included the collection and analysis of 31 samples. The 95% UCL for selenium in soils within the C-11 footprint is estimated to be 2.63 mg/kg. Based on the desorption study and risk analysis conducted for the project area, the calculated concentration poses a low risk potential to future waterfowl that may use the areas for feeding and breeding purposes.

To further evaluate the potential impact of selenium, surface water samples were collected from onsite canal/ditches. The results of surface water samples collected for analysis did not indicate significant selenium concentrations. Based on the site specific conditions no further assessment or corrective action is warranted within this section of the project footprint.

In an effort to obtain additional data regarding the mobility of selenium within the environment, it is recommended that two quarters of post-construction surface water quality monitoring be conducted. It is anticipated that the concentration of selenium detected will be low and not pose risk to USFWS Trust species.

1.0 INTRODUCTION

1.1 PURPOSE

Phase I/II environmental assessments were completed as part of the District's pre-acquisition activities in the East Coast Buffer Project Area. The results of the pre-acquisition assessment and follow up studies have identified the presence of elevated concentrations of selenium in the surface soil. USFWS has indicated that the detection of selenium above 2 mg/kg may pose a potential for ecological risk to USFWS trustee species.

The initial assessment within the project areas identified concentrations ranging from less than 1 mg/kg to in excess of 7mg/kg. A desorption study and additional assessment of potential ecological risks from selenium were prepared indicating that only a small possibility of effects to waterfowl that may inhabit the area in the future exists at the upper levels of selenium concentrations (NewFields 2008). USFWs expressed concern that under conditions in which water in the area of elevated selenium concentrations was assumed to be stagnant for an extended period of time that the desorption study results indicated a possibility for effects to breeding waterfowl. In an effort to address concerns raised by the USFWS regarding the risk to waterfowl additional soil sampling was conducted. ECT proposed additional regional selenium sampling to demonstrate to the USFWS that comprehensive start up sampling and annual surface water quality monitoring for selenium may not be warranted. Subsequent communications between the USFWS and the District indicated that many of these concerns could be remedied by additional soil sampling within the project footprint to obtain a site wide average concentration for selenium. Based on BEM Systems, Inc. (BEM's) Phase II assessment data, barium was also analyzed since it exceeded initial screening values within the project footprint (BEM 2004) but is much less of a concern as an ecological risk than selenium. **Figures 1 and 2** illustrate the general ECB area and the project boundaries.

1.2 PROJECT BACKGROUND

The elevated selenium concentrations in the project area have been identified by a series of assessments and follow up studies. Currently no soil quality assessment guideline (SQAG) exists for selenium. USFWS has used varying screening concentrations based on periodic research to assess risk to trustee species. A brief summary of the relevant assessments and studies and their results is included below.

1.2.1 PHASE II ASSESSMENT

BEM conducted a Phase II Environmental Site Assessment (ESA) on behalf of the District at the East Coast Buffer Canal 11 (C-11) properties. The Phase II ESA was conducted to assess potential recognized environmental conditions associated with the properties noted in BEM's Phase I ESA, and information provided to BEM in a Phase I ESA prepared by CRB Geological & Environmental Services, Inc. (CRB) on behalf of the law firm representing the land owners in the condemnation process (Brigham Moore).

Selenium was reported in 13 of the 26 composite soil samples and in both of the duplicate soil samples that were collected at the C-11 properties. The maximum concentration of 1.4 mg/kg was found at the Bukele property. Selenium concentrations for the Lauderhill soil type in Broward County range from 2.45 mg/kg to 4.03 mg/kg (University of Florida 1999). The concentrations of selenium encountered in the discrete and composite soil samples collected during the C-11 Phase II ESA falls below this range. BEM presented the data and results of the UF study to the USFWS for review.

On December 5, 2002, BEM, USFWS and SFWMD met to discuss the results of the UF study and to determine if the range of selenium reported for the Lauderhill soil could be applied for this assessment as a natural background concentration for the soil samples, and on review of the data, it was agreed that it could. Because of the findings of the UF study and the approval of the USFWS of the background concentration of selenium, selenium was not considered to be a chemical of concern at the C-11 properties.

1.2.2 ECB SOIL SELENIUM ASSESSMENT

Shaw Environmental, Inc., (Shaw) conducted a selenium soil assessment on behalf of the District at ten tracts located within the 3A/3B, C-9, and C-11 project areas (Shaw 2007) in response to recommendations in the USFWS letter dated February 3, 2006. The analytical results of the 115 samples collected at the 10 tracts indicated that 73 soil samples had selenium concentrations at or above the 1.0 mg/kg interim guidance concentration. Forty-two of the samples were below the 1.0 mg/kg interim guidance concentration. Thirty-nine of these samples were listed as non-detect, but the laboratory's reporting limits were above the 1.0 mg/kg guidance concentration. Twenty-two of the samples had selenium concentrations at or above the 5.0 mg/kg, with the highest concentration at 7.7 mg/kg. Shaw contracted NewFields to conduct a 95% Upper Confidence Limit (UCL) on the mean selenium concentrations. NewFields calculated a UCL of 2.58 mg/kg.

1.2.3 LEACH TEST AND DESORPTION STUDY

NewFields conducted a batch leach testing of sediment samples collected from the C-11 project area to evaluate whether these sediments could release selenium by desorption or dissolution reactions, and to evaluate the selenium leaching potential. The batch leach test data indicated that the amount of selenium leached from C-11 sediments during these tests was less than 3 percent of the total selenium mass initially present, and the selenium concentrations in surface water that comes into contact with these sediments are expected to remain below the Florida surface water quality standard for selenium (0.005 mg/l for Class III fresh water).

Based on discussions with USFWS, NewFields conducted an expanded test consisting of aquarium sediment leaching for the evaluation of selenium in C-11 project area soils. This follow-up study allowed for a more direct estimate of selenium concentrations in surface water overlying soil/sediments from the site. The new methodology placed soils from the site into aquaria and incubated them with water for up to 98 days. Concentrations of selenium remained below Florida water quality standards and USFWS screening levels throughout the incubation period and the additional assessment indicated that reproductive risks to waterfowl were low.

1.3 SCOPE OF WORK

A scope of work was developed to conduct soil sampling within the project footprint to obtain a site wide average selenium concentration. The scope of work consisted of the following:

1.3.1 C-9 AND C-11 RESERVOIR

For project planning purposes, the C-11 project area was divided into 34 50-acre grids. The C-9 project area was divided into 42 50-acre grids. The assessment of the regional selenium impacts included the collection of ten discrete soil samples within five acre grids. Each soil sample was to be collected and combined into one sample representing a 50 acre composite sample. Each sampling coordinate was predetermined using GIS. The sampling locations were downloaded into a GPS for use in the field. It should be noted that this sampling plan could not be adhered to due to site conditions that are described in detail in section 2.0 of this report.

1.3.2 WCA 3A/3B SEEPAGE AREA

Water Conservation Area (WCA) 3A/3B is located on the west side of US Highway 27, and is the eastern edge of the WCA. The project area consists of approximately 5,500 acres. The majority of the property is undeveloped. No significant agricultural or industrial areas are located within the project footprint. There are several point source areas that have been excluded from the project footprint. Based on past limited agricultural use the District proposed to collect a close proximity sample at each 2,500 foot interval. Each close proximity composite sample consisted of five discrete samples. Each sampling coordinate was predetermined using GIS. The sampling locations were downloaded into a GPS unit for use in the field. In the event that they were relocated in the field, all actual sampling locations were recorded with a GPS unit.

1.3.3 SURFACE WATER SAMPLING

Surface water sampling was also conducted within specific areas of C9 and C11 where relatively higher selenium concentrations were observed. The surface water sampling was

conducted in the wetland or surface water bodies close to the high concentration selenium samples to observe the aqueous selenium concentration above soils with an elevated selenium concentration. A total of six (6), three within each C-9 and C-11, samples were collected to evaluate these areas.

1.3.4 QA/QC SAMPLING

Twenty percent of the soil samples were collected for quality assurance/quality control (QA/QC) measures. Ten percent of the QA/QC samples were submitted to the primary laboratory (Accutest) as duplicate samples. The remaining ten percent of the soil samples were submitted to Pace Analytical and Columbia Analytical Services.

1.3.5 DATA EVALUATION AND STATISTICAL DATA ANALYSIS

ECT prepared an ADaPT library and transmitted to the contract laboratory stating the District's project expectations with respect to reporting limits and lab QA/QC statistical limits on blank spikes, matrix spikes, lab duplicates, matrix spikes, etc. The analytical results were validated using ADaPT, and they were compared to sediment quality assessment guidelines and FDEP 62-777 groundwater and soil cleanup target levels. Tables were prepared to tabulate soil and groundwater quality on the property.

ECT conducted a statistical analysis of the data collected from the project areas. Summary statistics and a 95 % upper confidence limit of the mean were calculated for each site. This data was used in conjunction with the earlier selenium work conducted in the project areas to assess risk. A detailed description of the statistical analysis is included in Section 3 and the results and conclusions from these analyses are included in Section 4.

2.0 INVESTIGATIVE METHODOLOGIES

This section describes the sampling methodologies followed in C-11, C-9 and WCA 3A/3B. The sampling methods varied slightly in each of the three areas and are described in detail in a separate subsection.

2.1 SOIL BORING INSTALLATION

Soil borings were installed in each of three East Coast Buffer areas as described below. Soil sampling was conducted on February 17, 2010 for the WCA 3A/3B area, February 19, 24 and 25, 2010 for the C9 area, and February 23 and 26, 2010 at the C11 area.

2.1.1 C-11 AREA

A total of 34 50-acre grids were prepared during project planning. Soil samples were collected from zero to six (0-6") inches below land surface (bls) in 31 discrete sample locations in 50-acre increments in accordance with the *Protocol for Assessment, Remediation and Post-Remediation Monitoring for Environmental Contaminants on Everglades Restoration Projects* dated March 14, 2008, developed jointly with the USFWS, and approved by the FDEP. The proposal originally called for soil samples collected within every 5-acre grid and composited into one sample representing a 50-acre composite sample. This sampling plan could not be adhered to because of field conditions. It was jointly determined by ECT and the District project manager that 50-acre composite sampling would not be possible because of the presence of thick vegetation, access issues, and other environmental factors including wetland conditions and vegetative GPS signal disruption. It was concluded that one 50-acre discrete sample would be collected to represent the regional selenium and barium concentrations within the approximate 1,700 acres of area that encompasses the C-11 project boundary area. Wherever possible the actual sampling locations were recorded into a GPS unit, which the field team chose within the pre-programmed 50-acre grid. On other occasions where the GPS unit was unable to detect satellite signal because of environmental conditions, the field team chose a point along the line where the signal was last receivable and walked to a known distance to collect a sample. This was done to avoid collection of non-

representative samples which lay along the neighboring access road. The sampling point was noted in the field book by means of the distance from the reference point in the preprogrammed grid.

Figure 3 illustrates the actual sample locations within each 50-acre grid. It should also be noted that no access, either by road or on foot, was available to collect a sample within three (3) of the 34 50-acre grids. The soil borings were collected with a stainless steel trowel, marked 6 inches from the tip to allow sample collection to an exact depth. Care was taken to ensure that a soil column of uniform diameter was collected such that the sample was representative of average concentration of soil throughout the entire 6 inches, rather than weighting the sample with more soil from one end. The samples were collected in stainless steel bowls, mixed thoroughly, placed in pre-cleaned containers for transport to the laboratory, and placed on ice.

2.1.2 C-9 AREA

In areas where there was access to every 5-acre grid, soil samples were collected as a 50-acre composite sample. This resulted in a total of 8 composite samples representing the northern rectangular portion of the C-9 area. The remaining 34 soil samples were collected as 50-acre close-proximity discrete samples because of access issues similar to those described in the C-11 project area. The discrete samples represented a 50-acre grid with a soil sample collected at one location within that grid. The 50-acre composite samples were labeled CSS-C9-1 through CSS-C9-7 and the 50-acre discrete samples are labeled CSS-C9-17.

Figure 4 illustrates the sampling locations within this area. The Soil borings were collected with a stainless steel trowel, marked 6 inches from the tip to allow sample collection to an exact depth. Care was taken to ensure that a soil column of uniform diameter was collected such that the sample was representative of average concentration of soil throughout the entire 6 inches, rather than weighting the sample with more soil from either end. The samples were collected into stainless steel bowls, mixed thoroughly, placed in pre-cleaned containers for transport to the laboratory, and placed on ice. The primary soil samples were

sent to Accutest, and the split samples were sent to Columbia Analytical Services, Inc. (Columbia).

2.1.3 WCA 3A/3B AREA

The soil samples collected in WCA 3A/3B represented a close proximity discrete sample every 2,500 feet, as per the District proposal. Based on the sampling scheme a total of 34 discrete samples were collected representing the eastern edge of the WCA that lies west of US Highway 27. The project area consists of approximately 5,500 acres. The soil borings were collected with a stainless steel trowel, marked 6 inches from the tip to allow sample collection to an exact depth. Care was taken to ensure that a soil column of uniform diameter was collected such that the sample was representative of average concentration of soil throughout the entire 6 inches, rather than weighting the sample with more soil from either end. Five samples, starting with a central sample followed by four evenly spaced samples distributed radially at five foot intervals, were collected and homogenized to represent one close proximity sample. The samples were collected into stainless steel bowls, mixed thoroughly, placed in pre-cleaned containers for transport to the laboratory, and placed on ice.

2.2 SURFACE WATER SAMPLE COLLECTION

Surface water samples were collected by quiescent sampling techniques using a peristaltic pump and appropriate tubing. The length of the tubing was extended by connecting it to a 5' long PVC pipe so that the standing water was not disturbed during the approach to the sampling point. The pump was operated under low flow conditions at about 0.1 gallons per minute to collect a 500 ml aqueous selenium sample. Six (6) samples were collected to represent the surface water concentrations in the vicinity of six soil samples. The samples were sent to Pace to be analyzed for selenium using EPA method 6020.

2.3 SAMPLE CUSTODY, LABORATORY PROCEDURES AND ANALYSES

All sample transmittal forms were placed in waterproof bags and sealed in transport containers with the samples. Chain-of-custody seals were applied after the containers (coolers) were secured. All shipping bills from common carriers were kept with the forms.

All samples that were submitted to a laboratory were accompanied by a sample transmittal or chain-of-custody record.

2.4 QUALITY ASSURANCE/QUALITY CONTROL PROCEDURES

Quality assurance procedures used during this assessment included compliance with the FDEP SOP for Laboratory Operation and Sample Collection Activities. Specific quality assurance protocols and procedures for the analytical methodologies performed during this assessment were in accordance with FDEP SOP for laboratory analysis. Twenty percent of the soil samples were split for quality assurance/quality control (QA/QC) measures. Ten percent of the QA/QC samples were submitted to the primary laboratory as duplicate samples, whereas the remaining ten percent were submitted to two secondary laboratories, Pace and Columbia. This QA/QC procedure complies with the September 19, 2002 memorandum by Mr. Robert Kukleski and Mr. Robert Taylor of the District's Land Acquisition Support Division.

3.0 RESULTS

This section presents the results and conclusions from the sampling activities conducted within the East Coast Buffer project area. The soil samples were analyzed by Accutest Laboratories as the prime and by Pace and Columbia as the QA/QC split lab. Laboratory analytical reports are attached as **Appendix A**. The sample results from all three laboratories were verified using ADaPT 4.5.2. No critical errors were found during the error check. The results from the ADaPT error checks are included as **Appendix B**.

3.1 C-11 RESULTS

The 31 discrete samples collected within the C-11 area were analyzed for selenium, barium and total organic carbon (TOC). Selenium and barium were analyzed for all samples whereas TOC was analyzed for eight or approximately 25% of the total samples. 20% of the total samples were also analyzed for QA/QC purposes as duplicates and splits. Selenium and barium was analyzed using method 6020 as opposed to 6010, the later is known to be prone to matrix interference. A 95% upper confidence level (UCL) of the sample mean was calculated for selenium and barium. 95% UCL was calculated using FL UCL which is an Excel add-in tool developed by FDEP and the University of Florida to calculate the average concentration levels of a potential contaminate for a study site. Selenium concentrations ranged from 0.12 ppm to 6.4 ppm with a mean of 1.58 ppm. When a duplicate and split sample above detection limit existed, the mean was taken to calculate the UCL. When the lab returned split sample data that was below detection limits in one sample and within the quantifiable range in the other sample, only the quantifiable data was considered for calculations.

The 95% UCL values for selenium and barium are 2.62 ppm and 39.24 ppm respectively. Neither of these concentrations is above the FDEP mandated soil clean up target levels (SCTLs). The 95% UCL for selenium is lower than 4 mg/kg which is considered as a conservative risk assessment screening value based on the NewFields desorption and risk assessment studies. The 95% UCL for barium is above the sediment quality assessment guideline (SQAG) threshold effects concentrations (TECs) as developed by FDEP.

Review of the SQAG guidance document provides no information regarding the derivation of the TEC and PEC benchmarks for barium. The barium SQAGs are not representative of the typical consensus-based benchmarks provided for most of the metal contaminants in the guidance and no discussion regarding the underlying assumptions behind the benchmark is provided. A review of the referenced source for the benchmarks indicates that the author of the benchmark guidance obtained the benchmarks from a secondary source which was itself a draft document (SAIC 1991). Neither the secondary nor the primary US EPA sources (US EPA 1977) were located after an extensive search for both documents. Some information on the barium benchmarks was located in the Washington State Sediment Quality Guidelines document (WADOE 1997). The Washington document indicated that the benchmarks cited in the US EPA (1977) guidance developed by US EPA Region V in order to classify Great Lakes harbor sediments. The document notes that the values are 'somewhat arbitrary and are not well founded scientifically' and that they were only adequate for 'determining the suitability of dredged material for open water disposal'. The barium benchmarks appear to be based not on benthic toxicity but on an unknown general 'contamination classification' scheme.

Based on the lack of PEC exceedances, the marginal exceedance of the TEC by the 95% UCL and the lack of scientific evidence that supports the use of the barium SQAGs for assessing ecological risk, it is highly unlikely that barium in the site soils would cause significant risk to a future aquatic community.

A correlation coefficient was calculated for the selenium and the TOC data. A significantly high positive correlation coefficient of 0.97 exists between these two data sets. A tabulation of the C-11 data is provided in **Table 1** and the 95% UCL calculations are attached as **Appendix C**. A figure showing the selenium exceeding 4 mg/kg and above FDEP SQAG TEC for barium are illustrated as **Figure 5**. **Figure 7** illustrates the barium exceedances in terms of the SQAGs.

Three surface water samples were collected from areas close to the discrete soil samples

CSS-C11-25, CSS-C11-30 and CSS-C11-34. All three samples reported concentrations lower than the 0.5 ug/l method detection limit. It is noteworthy that FDEP freshwater water quality standard for selenium is 5 ug/l. The surface water sample locations are illustrated as **Figure 8** and the analytical results are tabulated as **Table 4**.

3.2 C-9 RESULTS

The C-9 data, composed of eight 5-acre composite samples and 34 50-acre discrete samples, were analyzed for selenium, and ten samples were also analyzed for TOC. Consistent with the District protocol, QA/QC samples were also collected at the specified frequency described earlier. Due to the differences in sample collection protocol and the different scope of potential contamination measured by the two sampling techniques, separate 95% UCLs were calculated. As shown on **Figure 4**, the composite samples were geographically grouped with the exception of sample CSS-C9-17, all of the composite samples were collected within the 350 acre rectangular extension of the main C-9 area. Segregating the composite samples from the discrete samples allows for the statistically valid calculation of 95% UCLs in both areas. Results from sample CSS-C9-17 were excluded from both analyses because the sample was physically separated from the other composite samples. Selenium was not, however, detected in CSS-C9-17 indicating that its removal from the dataset did not negatively affect the statistical analysis.

FL UCL was used for data analysis of the discrete samples and US EPA software, ProUCL, was used for calculating the UCLs for the composite samples. ProUCL was used because FL UCL does not permit fewer than nine subsamples to be analyzed, however, due to the nature of collection and the average area concentration that they are intended to represent, it is reasonable to calculate a valid 95% UCL using a smaller number of composite samples.

The 34 discrete sample selenium concentrations ranged from 0.03 ppm to 6.50 ppm with a mean of 1.88 ppm. The 95 % UCL concentration was calculated to be 2.19 ppm for the discrete samples. ProUCL reported a concentration of 4.57 ppm for the 8 composite samples. A tabulation of the C-9 data is provided in **Table 2** and the 95% UCL

calculations are attached as Appendix A. **Figure 6** shows the selenium exceedances in relation to the 4 ppm screening level.

Since the composite samples from the northern portion of C-9 exhibited higher concentrations compared to the discrete samples collected in the remaining portion, two surface water samples were collected as representative of aqueous concentrations in relation to soil samples CSS-C9-4 and CSS-C9-5. These samples reported selenium concentrations lower than the MDL of 0.5 ug/l. Another surface water sample was collected as representative of aqueous concentrations in relation to soil sample CSS-C9-40. This sample also reported below the MDL (0.5 ug/l) for selenium. The sample locations are shown in **Figure 8**.

3.3 WCA 3A/3B Results

Thirty four close proximity discrete samples were collected from WCA 3A/3B which is used as a power transmission corridor west of US HWY 27. All the samples were analyzed for selenium and six samples were also analyzed for TOC. Additional samples were also collected as requested to comply with District QA/QC protocols. The selenium concentrations within this area ranged from 0.05 ppm to 3.40 ppm. The 95% UCL of the mean selenium concentration was calculated to be 1.35 ppm. The concentrations reported in this area were, in general, lower than the other two areas. No significant correlation coefficient relationship was observed for the selenium and TOC data. WCA 3A/3B data is provided in **Table 3** and the 95% UCL calculations are attached as Appendix B. No surface water samples were collected from this area.

3.4 DATA VALIDATION

All the three laboratories provided ECT with the ADaPT electronic data deliverables (EDDs) along with the reports and error logs. Upon receipt of the EDD with accompanying error log, ECT personnel imported the EDD into ADaPT, reviewed the error log generated by the laboratory's error check determine whether the comments were acceptable. ECT then re-ran the error check to confirm that no errors were present that had not been observed and commented on by the laboratory. The results from the ADaPT error checks are included as **Appendix B**.

4.0 CONCLUSIONS

The selenium concentrations observed at the C-11, C-9 and WCA 3A/3B are consistent with previous assessment results conducted within this area. None of the soils in the assessed project areas pose a human health risk. Calculated 95% UCL concentrations of selenium were 2.63 mg/kg, 2.19 mg/kg and 1.35 mg/kg in C-11, C-9 and WCA 3A/3B respectively. The selenium concentration in the northern portion of the C-9 impoundment was calculated separately because composite sampling was used. A 95% UCL of 4.57 mg/kg was reported for this area. It is ECT's belief that the concentrations observed in these areas may be indicative of background levels[1] since no anthropogenic point source could be attributed as a factor. The majority of the C-11 and C-9 areas have not been used for agricultural, commercial or industrial use and currently remain undeveloped.

Relatively higher concentrations of selenium were observed in the southwest section of C-11 and a north section of C-9. If the surface water concentrations that naturally exist at these areas are lower than state and federal water quality criteria, the release of contaminants will not likely occur after flooding these areas. This may also limit the need for any monitoring requirements following construction. Since the District's future project plans consists of inundating these areas to create surface water storage and seepage management areas, ECT conducted surface water sampling in these areas to demonstrate the existing selenium concentrations that exists in these areas that are in contact with the soil. Without such data and based on the results of this assessment, four quarters of post-construction surface water monitoring is recommended. Further sampling of standing water within the areas of elevated selenium concentration may result in lesser monitoring requirements.

[1] Geometric mean (GM) concentration of selenium in Histosol soil order: 0.967 ± 3.6 mg/kg; GM concentration in Entisol soil order: 0.081 ± 5.5 mg/kg; GM concentration in Spodosol soil order: 0.041 ± 5.1 mg/kg (Chen, et al, 1999).

ECT recommends the following, by project area.

WCA 3A/3B

The 95% UCL for selenium in soils within WCA 3A/3B is estimated to be 1.35 mg/kg. The concentration of residual pesticides and metals detected in the surficial soil within this section of the project area does not pose and unacceptable risk to the USFWS trustee species. Based on the regional concentration of selenium detected and the previous ecological risk assessments conducted in this area, no additional assessment or corrective actions are warranted.

C-9

The C-9 project area was divided into two areas for sampling and analysis of selenium concentrations. The first area was an approximately 1,600 hundred acre squarely configured area located to the south. The second area was an approximately 400 acre rectangular area located to the north.

1,600 Acre Area

As part of assessment of the 1,600 acre area, 34 discrete samples were collected for selenium analysis. The 95% UCL for selenium in soils within the C-9 was calculated to be 2.19 mg/kg. Based upon previous discussions and coordination with the USFWS, the site specific selenium concentration has a range of 2 mg/kg to approximately 4 mg/kg. In accordance with the site specific ecological risk assessment, the calculated selenium concentration of 2.19 mg/kg does not pose an unacceptable risk to the USFWS trustee species. Based upon the site specific conditions in this area, no further assessment or corrective action is warranted within this section of the project footprint.

400 Acre Area

The confirmation sampling included the collection of eight (8) composite soil samples from the 400 acre area. The 95% UCL for selenium in soils within the northern portion of the C-9 400-acre footprint was calculated to be 4.57 mg/kg. Based upon the desorption study and risk analysis conducted for this project, the detected concentration in the

surficial soils may pose an unacceptable risk to waterfowl that may use this area for feeding and breeding purposes. Additional assessment and/or corrective action are warranted in this area prior to construction. These additional activities may include further ecological analysis of soil/ sediment to develop a site specific remediation goal. Corrective action which may include scrapping/ inverting or capping the area could also be necessary to minimize the potential ecological risk to trust resources. The necessity for corrective action would be determined upon completion of the proposed additional assessment.

C-11

This assessment included the collection and analysis of 31 samples. The 95% UCL for selenium in soils within the C-11 footprint is estimated to be 2.63 mg/kg. Based on the desorption study and risk analysis conducted for the project area , the calculated concentration poses a low risk potential to future waterfowl that may use the areas for feeding and breeding purposes.

To further evaluate the potential impact of selenium surface water samples were collected from onsite canal /ditches. The results of surface water samples collected for analysis did not indicate insignificant selenium concentrations. Based on the site specific conditions no further assessment or corrective action is warranted within this section of the project footprint.

In an effort to obtain additional data regarding the mobility of selenium within the environment, it is recommended that two quarters of post-construction surface water quality monitoring should be conducted. It is anticipated that the concentration of selenium detected will be low and not pose a risk to UFWS trustee species.

5.0 REFERENCES

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2) BEM Systems. November 2002. Phase II Environmental Site Assessment East Coast Buffer Canal 11 26 Condemnation Properties.

3) Shaw Environmental. June 2007. Additional Selenium Sampling Assessment Results.

4) NewFields, LLC. January 2007. Selenium Leaching Potential of Sediment: C-11 Project Area.

5) Lemly, D.A. and Skorupa, J.A. 2007. "Technical Issues Affecting the Implementation of US Environmental Protection Agency's Proposed Fish Tissue-Based Aquatic Criterion for Selenium." Integrated Environmental Assessment and Management. Vol 3 (4), pp. 552-558.

6) NewFields, LLC. August 2008. Aquarium Sediment Leaching Studies Data Report, Broward County Water Protection Area, C-11 Impoundment.

7) FDEP. Chapter 62-302. Florida Surface Water Quality Standards.

TABLES

TABLE 1: SOIL BORING ANALYTICAL SUMMARY

Facility Name: C 11

Sample Designation	Sample Date	Depth To Water (ft)	Sample Interval	Selenium (mg/kg)	Selenium Qualifier	Barium (mg/kg)	TOC (mg/kg)
CSS-C11-2	2/26/2010	NA	0-6"	0.95		**22**	12800
CSS-C11-3	2/26/2010	NA	0-6"	1.3		**24.2**	NA
CSS-C11-4	2/26/2010	NA	0-6"	**2**		**55.6**	NA
CSS-C11-5	2/26/2010	NA	0-6"	**2**		**34.1**	21800
CSS-C11-5D	2/26/2010	NA	0-6"	1.5		**22.8**	NA
CSS-C11-5*	2/26/2010	NA	0-6"	**2.8**		**29.9**	NA
CSS-C11-6	2/26/2010	NA	0-6"	**2.4**		**50.5**	NA
CSS-C11-7	2/26/2010	NA	0-6"	0.12	I	4.9	NA
CSS-C11-8	2/26/2010	NA	0-6"	0.55		**33**	NA
CSS-C11-9	2/26/2010	NA	0-6"	0.41	I	**29.2**	NA
CSS-C11-11	2/26/2010	NA	0-6"	0.66		**36.5**	NA
CSS-C11-13	2/26/2010	NA	0-6"	**3.4**		**64.5**	NA
CSS-C11-14	2/26/2010	NA	0-6"	0.63		19.2	NA
CSS-C11-15	2/26/2010	NA	0-6"	0.46	I	10.5	9620
CSS-C11-15 D	2/26/2010	NA	0-6"	0.8	I	15.1	NA
CSS-C11-15*	2/26/2010	NA	0-6"	0.88		11.2	NA
CSS-C11-16	2/26/2010	NA	0-6"	0.67		18.1	NA
CSS-C11-17	2/26/2010	NA	0-6"	0.33	I	11	9000
CSS-C11-17D	2/26/2010	NA	0-6"	0.24	I	12.5	9310
CSS-C11-17*	2/26/2010	NA	0-6"	0.34	I	9.6	91400
CSS-C11-18	2/23/2010	NA	0-6"	**2.5**		**30.5**	NA
CSS-C11-19	2/23/2010	NA	0-6"	1.8		**25.8**	NA
CSS-C11-20	2/23/2010	NA	0-6"	0.069	U	5	3590
CSS-C11-20D	2/23/2010	NA	0-6"	0.072	I	4.4	NA
CSS-C11-20**	2/23/2010	NA	0-6"	0.6	U	NA	8300
CSS-C11-21	2/23/2010	NA	0-6"	1.1		**30**	NA
CSS-C11-22	2/26/2010	NA	0-6"	0.17	I	12.3	NA
CSS-C11-23	2/26/2010	NA	0-6"	0.2	I	12.9	NA
CSS-C11-24	2/26/2010	NA	0-6"	0.22	I	11.9	NA
CSS-C11-25	2/23/2010	NA	0-6"	**2.4**		**40**	36600
CSS-C11-25D	2/23/2010	NA	0-6"	**3.2**		**46.4**	NA
CSS-C11-25**	2/23/2010	NA	0-6"	**6.1**	I	NA	NA
CSS-C11-26	2/23/2010	NA	0-6"	**2**		**33.3**	NA
CSS-C11-27	2/23/2010	NA	0-6"	**2.3**		**37.1**	NA
CSS-C11-28	2/23/2010	NA	0-6"	**2**		**22.8**	NA
CSS-C11-29	2/23/2010	NA	0-6"	**2.2**		**31.9**	NA
CSS-C11-30	2/23/2010	NA	0-6"	**3.1**		**40.1**	38900
CSS-C11-30D	2/23/2010	NA	0-6"	**3.4**		**65.6**	NA
CSS-C11-30**	2/23/2010	NA	0-6"	**5.9**	I	NA	NA
CSS-C11-31	2/23/2010	NA	0-6"	1.7		**27.5**	NA
CSS-C11-32	2/26/2010	NA	0-6"	0.16	I	17.4	9540
CSS-C11-33	2/23/2010	NA	0-6"	**2**		**36.7**	NA
CSS-C11-34	2/23/2010	NA	0-6"	**5.3**		**71.6**	NA
CSS-C11-34D	2/23/2010	NA	0-6"	**5.9**		**71.2**	NA
CSS-C11-34**	2/23/2010	NA	0-6"	**6.4**	I	NA	NA
[1]Residential SCTL				440		120	
[2]Industrial SCTL				11,000		130,000	
[3] Groundwater Leachability SCTL				5.5		1,600	
[4]SQAG TEC						20.0	
[4]SQAG PEC						60.0	
[5] Other Standard				4.0			

1 Soil Cleanup Target Level, Direct Exposure, Residential Use, Chapter 62-777, FAC

2 Soil Cleanup Target Level, Direct Exposure, Commercial/Industrial Use, Chapter 62-777, FAC

3 Leachability Based on Groundwater Criteria, Chapter 62-777, FAC

4 Sediment Quality Assessment Guideline, Techincal Report, January 2003

5 Interim Screening Level Applied by USFWS, Protective of Avian Receptors

NA = Not Analyzed

I = Analyte detected but could not be quantified with certainty, value lies between MDL and PQL

U = Below MDL

Suffix "**D**" are Duplicate Samples

* Analyzed by Pace Analytical as Split Samples

** Analyzed by Columbia Analytical Services, Inc.

TABLE 2: SOIL BORING ANALYTICAL SUMMAR

Facility Name: C 9

Sample Designation	Sample Date	Depth To Water (ft)	Sample Interval	Selenium (mg/kg)	Qualifer	TOC (mg/kg)
CSS-C9-1	2/19/2010	NA	0-6"	**3.7**	I	28200
CSS-C9-2	2/19/2010	NA	0-6"	**3.8**		NA
CSS-C9-3	2/19/2010	NA	0-6"	**4.3**		NA
CSS-C9-4	2/19/2010	NA	0-6"	**4.4**		NA
CSS-C9-5	2/19/2010	NA	0-6"	**4**		26000
CSS-C9-5D	2/19/2010	NA	0-6"	**4.6**		39200
CSS-C9-5*	2/19/2010	NA	0-6"	**6.5**		180000
CSS-C9-6	2/19/2010	NA	0-6"	**4.5**		NA
CSS-C9-7	2/25/2010	NA	0-6"	**3.4**		NA
CSS-C9-8	2/24/2010	NA	0-6"	0.094	I	NA
CSS-C9-9	2/24/2010	NA	0-6"	0.068	U	NA
CSS-C9-10	2/24/2010	NA	0-6"	0.065	U	NA
CSS-C9-10D	2/24/2010	NA	0-6"	0.059	I	NA
CSS-C9-10*	2/24/2010	NA	0-6"	0.5	I	NA
CSS-C9-11	2/25/2010	NA	0-6"	**2.2**		2460
CSS-C9-12	2/25/2010	NA	0-6"	1.5		NA
CSS-C9-13	2/25/2010	NA	0-6"	1.6		NA
CSS-C9-14	2/25/2010	NA	0-6"	**2.6**		NA
CSS-C9-15	2/24/2010	NA	0-6"	0.34	I	12100
CSS-C9-15D	2/24/2010	NA	0-6"	0.48		NA
CSS-C9-15*	2/24/2010	NA	0-6"	1	I	NA
CSS-C9-16	2/24/2010	NA	0-6"	0.42	I	NA
CSS-C9-17	2/24/2010	NA	0-6"	0.56		NA
CSS-C9-18	2/24/2010	NA	0-6"	0.45		NA
CSS-C9-19	2/25/2010	NA	0-6"	0.4	I	NA
CSS-C9-20	2/24/2010	NA	0-6"	0.087	I	17900
CSS-C9-20D	2/24/2010	NA	0-6"	0.08	I	17200
CSS-C9-20*	2/24/2010	NA	0-6"	0.6	I	7700
CSS-C9-21	2/25/2010	NA	0-6"	1.9		NA
CSS-C9-22	2/25/2010	NA	0-6"	1.8		NA
CSS-C9-23	2/25/2010	NA	0-6"	**2.3**		NA
CSS-C9-24	2/25/2010	NA	0-6"	1.7	I	NA
CSS-C9-25	2/25/2010	NA	0-6"	**2.1**		33500
CSS-C9-25D	2/25/2010	NA	0-6"	1.9		NA
CSS-C9-25*	2/25/2010	NA	0-6"	**2.6**	I	NA
CSS-C9-26	2/25/2010	NA	0-6"	1.7		NA
CSS-C9-27	2/25/2010	NA	0-6"	1.7		NA
CSS-C9-28	2/25/2010	NA	0-6"	1.5		NA
CSS-C9-29	2/25/2010	NA	0-6"	1.7		NA
CSS-C9-30	2/25/2010	NA	0-6"	1.9		24000
CSS-C9-30D	2/25/2010	NA	0-6"	**2.1**		33000
CSS-C9-30*	2/25/2010	NA	0-6"	**3**	I	100000
CSS-C9-31	2/25/2010	NA	0-6"	**3.1**		NA
CSS-C9-32	2/25/2010	NA	0-6"	**3.2**		NA
CSS-C9-33	2/25/2010	NA	0-6"	**3.8**		NA
CSS-C9-34	2/25/2010	NA	0-6"	**3.2**		NA
CSS-C9-35	2/24/2010	NA	0-6"	1.6		20900
CSS-C9-35D	2/24/2010	NA	0-6"	**2**		NA
CSS-C9-35*	2/24/2010	NA	0-6"	**2.8**	I	NA
CSS-C9-36	2/24/2010	NA	0-6"	**2.7**		NA
CSS-C9-37	2/24/2010	NA	0-6"	**2.2**		NA
CSS-C9-38	2/24/2010	NA	0-6"	**2.2**		NA
CSS-C9-39	2/24/2010	NA	0-6"	**3**		NA
CSS-C9-40	2/25/2010	NA	0-6"	**2.3**		39300
CSS-C9-40D	2/25/2010	NA	0-6"	**3.5**		31000
CSS-C9-40*	2/25/2010	NA	0-6"	**4.5**	I	NA
CSS-C9-41	2/25/2010	NA	0-6"	**3**		NA
CSS-C9-42	2/25/2010	NA	0-6"	**2.7**		33400
[1]Residential SCTL				440		
[2]Industrial SCTL				11,000		
[3] Groundwater Leachability SCTL				5.5		
[4]SQAG TEC						
[4]SQAG PEC						
[5] Other Standard				4.0		

1 Soil Cleanup Target Level, Direct Exposure, Residential Use, Chapter 62-777, FAC

2 Soil Cleanup Target Level, Direct Exposure, Commercial/Industrial Use, Chapter 62-777, FAC

3 Leachability Based on Groundwater Criteria, Chapter 62-777, FAC

4 Sediment Quality Assessment Guideline, Techincal Report, January 2003

5 Interim Screening Level Applied by USFWS, Protective of Avian Receptors

NA = Not Analyzed

I = Analyte detected but could not be quantified with certainty, value lies between MDL and PQL

U = Below MDL

Suffix "**D**" are Duplicate Samples

* Analyzed by Columbia Analytical Services, Inc. as Split Samples

TABLE 3: SOIL BORING ANALYTICAL SUMMARY

Facility Name: Water Conservation Area 3A/3B

Sample Designation	Sample Date	Depth To Water (ft)	Sample Interval	Selenium (mg/kg)	Qualifer	TOC (mg/kg)
CSS-WCA-1	2/17/2010	NA	0-6"	1.5	I	NA
CSS-WCA-2	2/17/2010	NA	0-6"	1	I	NA
CSS-WCA-3	2/17/2010	NA	0-6"	**2**	I	NA
CSS-WCA-4	2/17/2010	NA	0-6"	1.1	I	NA
CSS-WCA-5	2/17/2010	NA	0-6"	1.9		48700
CSS-WCA-5D	2/17/2010	NA	0-6"	**2.6**		NA
CSS-WCA-5*	2/17/2010	NA	0-6"	**2.8**		NA
CSS-WCA-6	2/17/2010	NA	0-6"	1.1	I	NA
CSS-WCA-7	2/17/2010	NA	0-6"	0.1	U	NA
CSS-WCA-8	2/17/2010	NA	0-6"	0.13	U	NA
CSS-WCA-9	2/17/2010	NA	0-6"	1.9		NA
CSS-WCA-10	2/17/2010	NA	0-6"	0.38	I	30200
CSS-WCA-10D	2/17/2010	NA	0-6"	0.65	I	NA
CSS-WCA-10*	2/17/2010	NA	0-6"	1.2		NA
CSS-WCA-11	2/17/2010	NA	0-6"	1.3		NA
CSS-WCA-12	2/17/2010	NA	0-6"	0.093	U	NA
CSS-WCA-13	2/17/2010	NA	0-6"	0.13	I	NA
CSS-WCA-14	2/17/2010	NA	0-6"	1.4	I	NA
CSS-WCA-15	2/17/2010	NA	0-6"	0.16	U	20900
CSS-WCA-15D	2/17/2010	NA	0-6"	0.55	I	NA
CSS-WCA-15*	2/17/2010	NA	0-6"	1.4		NA
CSS-WCA-16	2/17/2010	NA	0-6"	1.8		NA
CSS-WCA-17	2/17/2010	NA	0-6"	1.9		NA
CSS-WCA-18	2/17/2010	NA	0-6"	0.2	U	NA
CSS-WCA-19	2/17/2010	NA	0-6"	0.55	I	NA
CSS-WCA-20	2/17/2010	NA	0-6"	1.6		44800
CSS-WCA-20D	2/17/2010	NA	0-6"	**2.4**		30500
CSS-WCA-20*	2/17/2010	NA	0-6"	**3.4**		236000
CSS-WCA-21	2/17/2010	NA	0-6"	0.32	I	NA
CSS-WCA-22	2/17/2010	NA	0-6"	1.5		NA
CSS-WCA-23	2/17/2010	NA	0-6"	0.23	I	NA
CSS-WCA-24	2/17/2010	NA	0-6"	0.15	I	NA
CSS-WCA-25	2/17/2010	NA	0-6"	**3.3**		31600
CSS-WCA-25D	2/17/2010	NA	0-6"	**2.3**		NA
CSS-WCA-25*	2/17/2010	NA	0-6"	**3.4**		NA
CSS-WCA-26	2/17/2010	NA	0-6"	1.3		NA
CSS-WCA-27	2/17/2010	NA	0-6"	1		NA
CSS-WCA-28	2/17/2010	NA	0-6"	1		NA
CSS-WCA-29	2/17/2010	NA	0-6"	0.9		NA
CSS-WCA-30	2/17/2010	NA	0-6"	0.64		30600
CSS-WCA-30D	2/17/2010	NA	0-6"	0.65	I	22600
CSS-WCA-30*	2/17/2010	NA	0-6"	1		74500
CSS-WCA-31	2/17/2010	NA	0-6"	**2**		NA
CSS-WCA-32	2/17/2010	NA	0-6"	0.42	I	NA
CSS-WCA-32D	2/17/2010	NA	0-6"	0.56	I	NA
CSS-WCA-32*	2/17/2010	NA	0-6"	0.89		NA
CSS-WCA-33	2/17/2010	NA	0-6"	1.7		NA
CSS-WCA-34	2/17/2010	NA	0-6"	1.1		NA
[1]Residential SCTL				440		
[2]Industrial SCTL				11,000		
[3] Groundwater Leachability SCTL				5.5		
[4]SQAG TEC						
[4]SQAG PEC						
[5] Other Standard				4.0		

1 Soil Cleanup Target Level, Direct Exposure, Residential Use, Chapter 62-777, FAC

2 Soil Cleanup Target Level, Direct Exposure, Commercial/Industrial Use, Chapter 62-777, FAC

3 Leachability Based on Groundwater Criteria, Chapter 62-777, FAC

4 Sediment Quality Assessment Guideline, Techincal Report, January 2003

5 Interim Screeninng Level Applied by USFWS, Protective of Avian Receptors

NA = Not Analyzed

I = Analyte detected but could not be quantified with certainty, value lies between MDL and PQL

U = Below MDL

Suffix "**D**" are Duplicate Samples

* Analyzed by Pace Analytical as Split Samples

TABLE 4: SURFACE WATER ANALYTICAL SUMMARY

Facility Name: East Coast Buffer

Sample Designation	Sample Date	Depth To Water (ft)	Sample Interval	Selenium (ug/L)	Qualifer
SW-C11-1	4/14/2010	NA	NA	0.5	U
SW-C11-2	4/14/2010	NA	NA	0.5	U
SW-C11-3	4/14/2010	NA	NA	0.5	U
SW-C9-1	4/14/2010	NA	NA	0.5	U
SW-C9-2	4/14/2010	NA	NA	0.5	U
SW-C9-3	4/14/2010	NA	NA	0.5	U
[1]Groundwater Criteria				50	
[2]Freshwater Surface Water Criteria				5	
[3] Marine Surface Water Criteria				71.0	
[4] Groundwater of Low Yield/Poor Quality Criteria				500.00	

1 Groundwater and Surface Water Cleanup Target Levels, Chapter 62-777, FAC
2 Groundwater and Surface Water Cleanup Target Levels, Chapter 62-777, FAC
3 Groundwater and Surface Water Cleanup Target Levels, Chapter 62-777, FAC
4 Groundwater and Surface Water Cleanup Target Levels, Chapter 62-777, FAC
U = Below MDL

FIGURES

Figure:	CREATED BY: CTM	C-11 AND WCA 3A/3B	ECT
	CHECKED BY: BDW	PROJECT AREA	Environmental Consulting & Technology, Inc.
1	SCALE: AS NOTED		
	DATE: 3/2/2010		

Figure: 2	CREATED BY: CTM CHECKED BY: BDW SCALE: AS NOTED DATE: 3/2/2010	**C-9 AND WCA 3A/3B** PROJECT AREA	ECT Environmental Consulting & Technology, Inc.

Figure: 3	CREATED BY: CTM CHECKED BY: SDW SCALE: AS NOTED DATE: 3/2/2010	**C-9 / C-11 / WCA 3A/3B** SAMPLING LOCATION	ECT *Environmental Consulting & Technology, Inc.*

Figure: 4	CREATED BY: CTM CHECKED BY: RDW SCALE: AS NOTED DATE: 9/2/2010	**C-9 / C-11 / WCA 3A/3B** SAMPLING LOCATION	ECT *Environmental Consulting & Technology, Inc.*

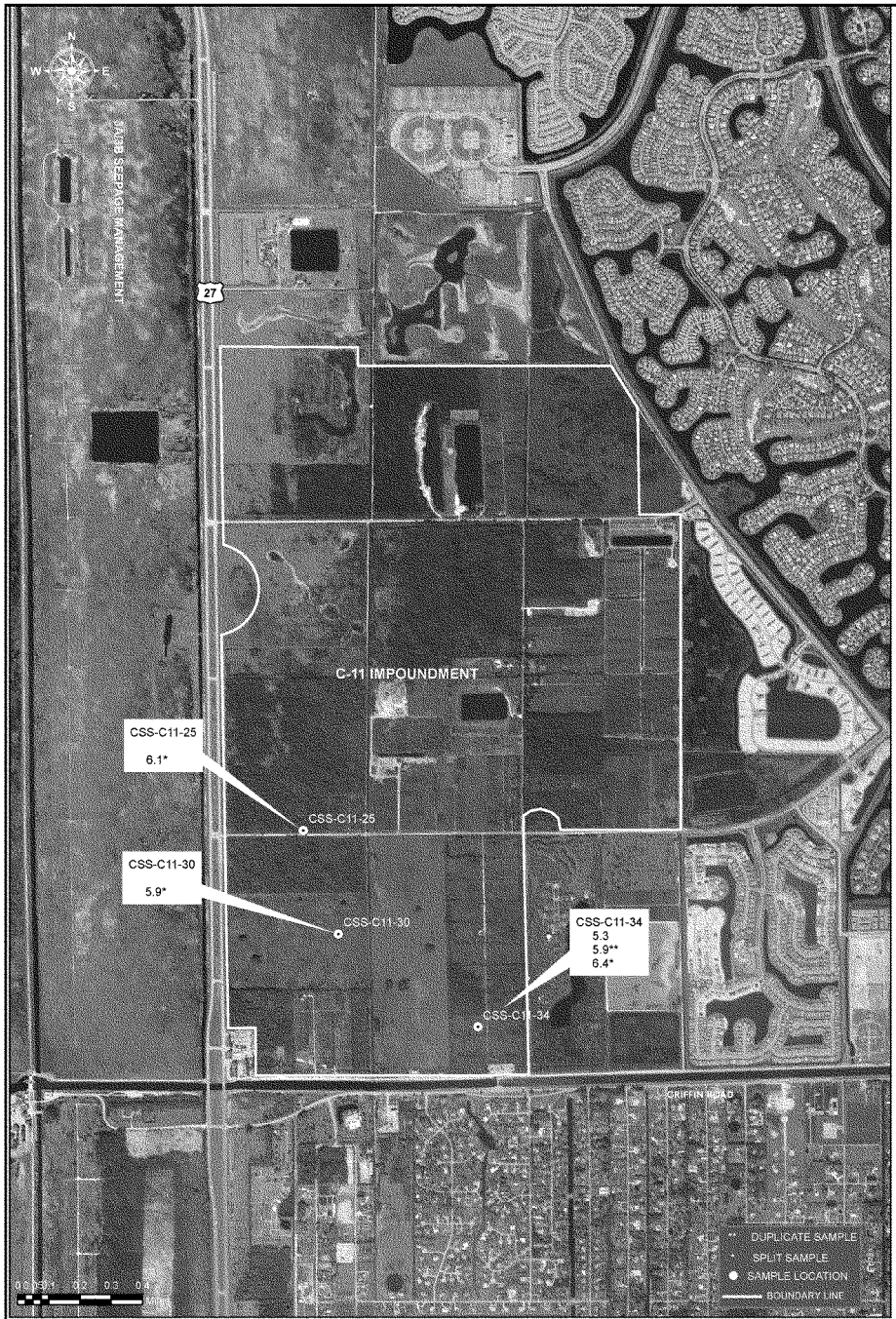

Figure:	CREATED BY: PA CHECKED BY: SDW SCALE: AS NOTED DATE: 4/7/2010	**C-11 IMPOUNDMENT** SELENIUM EXCEEDANCE	ECT Environmental Consulting & Technology, Inc.
5			

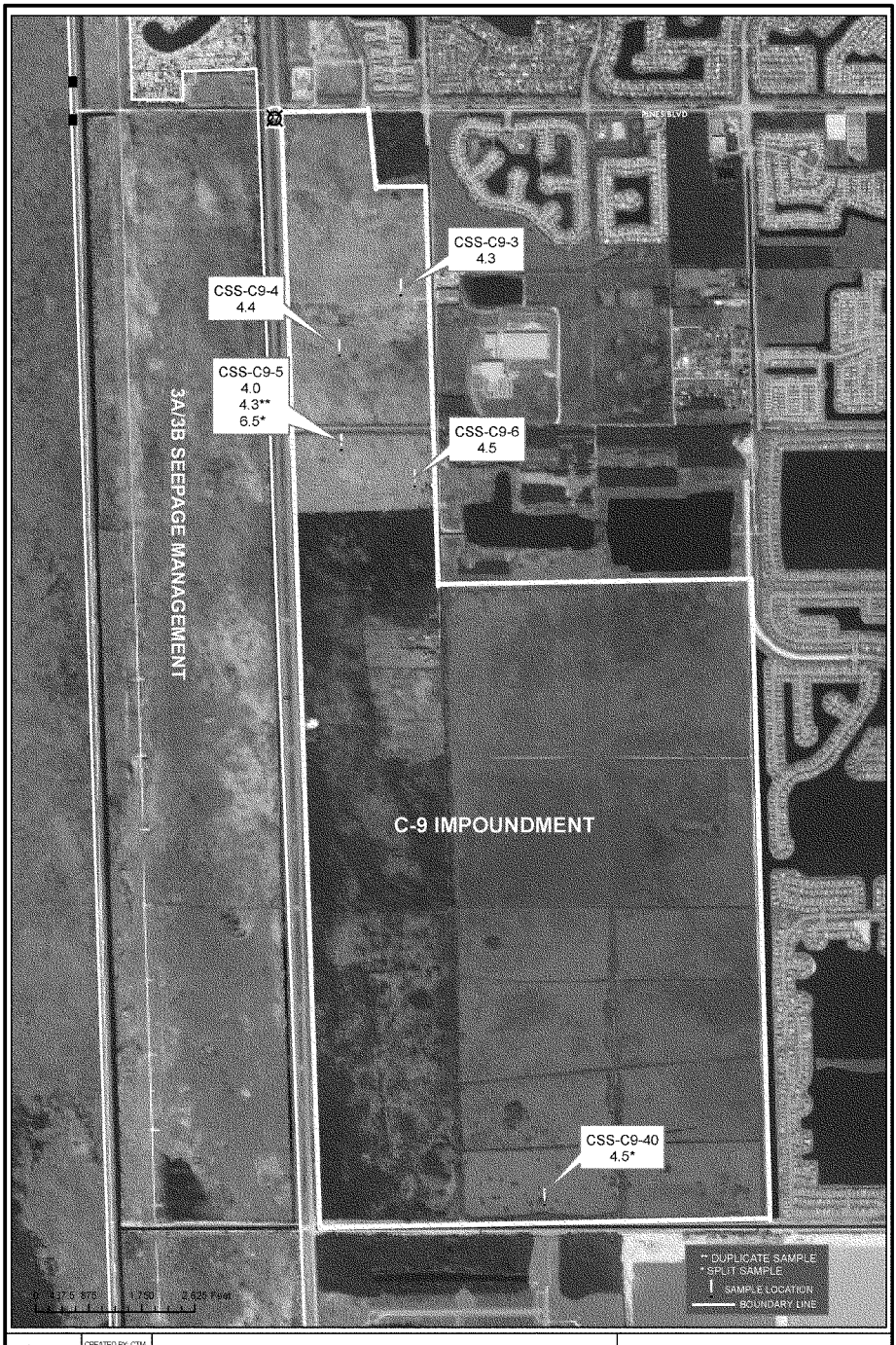

Figure: 6	CREATED BY: CTM CHECKED BY: BDW SCALE: AS NOTED DATE: 5/20/10	**C-9 IMPOUNDMENT** SELENIUM EXCEEDANCE	ECT *Environmental Consulting & Technology, Inc.*

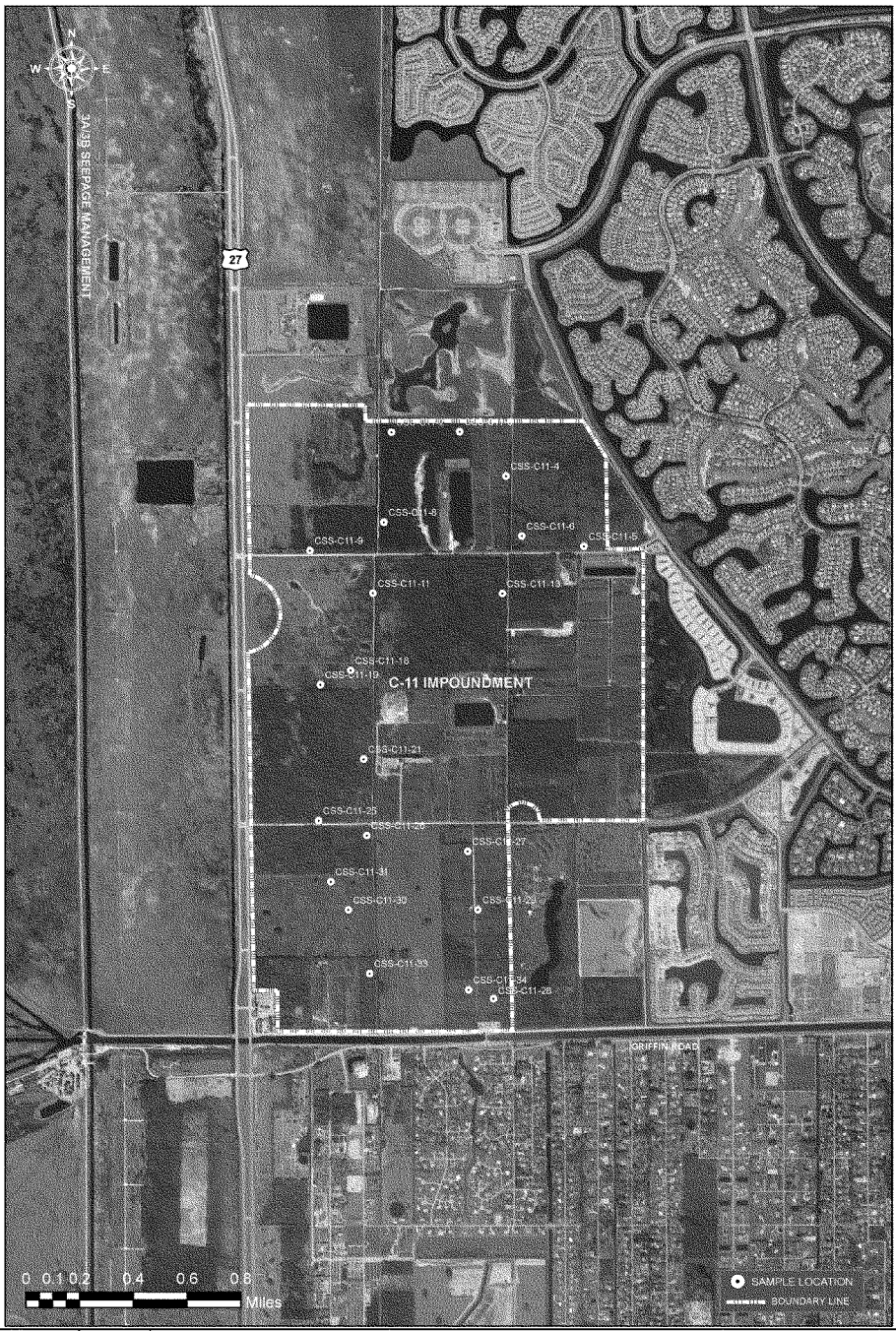

Figure: 7

CREATED BY: PA	
CHECKED BY: BDW	
SCALE: AS NOTED	
DATE: 4/7/2010	

C-11 IMPOUNDMENT

BARIUM EXCEEDANCE

ECT
Environmental Consulting & Technology, Inc.

Figure: 8	CREATED BY: CTM CHECKED BY: BDW SCALE: AS NOTED DATE: 3/2/2010	**SURFACE WATER SAMPLE LOCATIONS** EAST COAST BUFFER	ECT Environmental Consulting & Technology, Inc.

APPENDIX A

LABORATORY ANALYTICAL DATA

e-Hardcopy 2.0
Automated Report

Southeast ACCUTEST Laboratories

IT'S ALL IN THE CHEMISTRY

03/19/10

Technical Report for

ECT

C-11 Speciation Sampling, Broward Co, FL

10-0096

Accutest Job Number: F71678

Sampling Dates: 02/19/10 - 02/25/10

Report to:

ECT
6300 NE 1st St Suite 100
Ft Lauderdale, FL 33334
padak@ectinc.com

ATTN: Probas Adak

Total number of pages in report: 121

ACCUTEST LABORATORIES 50 YEARS 1956-2006

ACCREDITED IN ACCORDANCE WITH nelac

Test results contained within this data package meet the requirements of the National Environmental Laboratory Accreditation Conference and/or state specific certification programs as applicable.

Harry Behzadi, Ph.D.
Laboratory Director

Client Service contact: Sue Bell 407-425-6700

Certifications: FL (DOH E83510), NC (573), NJ (FL002), MA (FL946), IA (366), LA (03051), KS (E-10327), SC, AK
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Accutest Laboratories

Sample Summary

ECT

Job No: F71678

C-11 Speciation Sampling, Broward Co, FL
Project No: 10-0096

Sample Number	Collected Date	Time	By	Received	Matrix Code	Type	Client Sample ID
F71678-1	02/23/10	14:25	MCD	02/27/10	SO	Soil	CSS-C11-18
F71678-2	02/23/10	14:45	MCD	02/27/10	SO	Soil	CSS-C11-19
F71678-3	02/23/10	14:05	MCD	02/27/10	SO	Soil	CSS-C11-20
F71678-4	02/23/10	13:45	MCD	02/27/10	SO	Soil	CSS-C11-21
F71678-5	02/23/10	11:02	MCD	02/27/10	SO	Soil	CSS-C11-25
F71678-6	02/23/10	09:05	MCD	02/27/10	SO	Soil	CSS-C11-26
F71678-7	02/23/10	11:32	MCD	02/27/10	SO	Soil	CSS-C11-27
F71678-8	02/23/10	12:35	MCD	02/27/10	SO	Soil	CSS-C11-28
F71678-9	02/23/10	11:55	MCD	02/27/10	SO	Soil	CSS-C11-29
F71678-10	02/23/10	09:35	MCD	02/27/10	SO	Soil	CSS-C11-30
F71678-11	02/23/10	10:05	MCD	02/27/10	SO	Soil	CSS-C11-31
F71678-12	02/23/10	10:20	MCD	02/27/10	SO	Soil	CSS-C11-33
F71678-13	02/23/10	12:15	MCD	02/27/10	SO	Soil	CSS-C11-34

Soil samples reported on a dry weight basis unless otherwise indicated on result page.

Accutest Laboratories

Sample Summary
(continued)

ECT

Job No: F71678

C-11 Speciation Sampling, Broward Co, FL
Project No: 10-0096

Sample Number	Collected Date	Time By	Received	Matrix Code	Matrix Type	Client Sample ID
F71678-14	02/24/10	07:09 MCD	02/27/10	SO	Soil	CSS-C9-8
F71678-15	02/24/10	07:38 MCD	02/27/10	SO	Soil	CSS-C9-9
F71678-16	02/24/10	07:52 MCD	02/27/10	SO	Soil	CSS-C9-10
F71678-17	02/24/10	08:14 MCD	02/27/10	SO	Soil	CSS-C9-15
F71678-18	02/24/10	08:32 MCD	02/27/10	SO	Soil	CSS-C9-16
F71678-19	02/24/10	09:17 MCD	02/27/10	SO	Soil	CSS-C9-17
F71678-20	02/24/10	09:52 MCD	02/27/10	SO	Soil	CSS-C9-18
F71678-21	02/24/10	10:19 MCD	02/27/10	SO	Soil	CSS-C9-19
F71678-22	02/24/10	10:46 MCD	02/27/10	SO	Soil	CSS-C9-20
F71678-23	02/24/10	11:15 MCD	02/27/10	SO	Soil	CSS-C9-25
F71678-24	02/24/10	11:39 MCD	02/27/10	SO	Soil	CSS-C9-26
F71678-25	02/24/10	12:19 MCD	02/27/10	SO	Soil	CSS-C9-27
F71678-26	02/24/10	12:50 MCD	02/27/10	SO	Soil	CSS-C9-28

Soil samples reported on a dry weight basis unless otherwise indicated on result page.

Accutest Laboratories

Sample Summary
(continued)

ECT

Job No: F71678

C-11 Speciation Sampling, Broward Co, FL
Project No: 10-0096

Sample Number	Collected Date	Time	By	Received	Matrix Code	Type	Client Sample ID
F71678-27	02/24/10	13:22	MCD	02/27/10	SO	Soil	CSS-C9-29
F71678-28	02/24/10	13:50	MCD	02/27/10	SO	Soil	CSS-C9-30
F71678-29	02/24/10	14:15	MCD	02/27/10	SO	Soil	CSS-C9-35
F71678-30	02/24/10	14:48	MCD	02/27/10	SO	Soil	CSS-C9-36
F71678-31	02/24/10	15:26	MCD	02/27/10	SO	Soil	CSS-C9-37
F71678-32	02/24/10	15:55	MCD	02/27/10	SO	Soil	CSS-C9-38
F71678-33	02/24/10	16:20	MCD	02/27/10	SO	Soil	CSS-C9-39
F71678-34	02/25/10	07:39	MCD	02/27/10	SO	Soil	CSS-C9-11
F71678-35	02/25/10	07:15	MCD	02/27/10	SO	Soil	CSS-C9-12
F71678-36	02/25/10	08:15	MCD	02/27/10	SO	Soil	CSS-C9-13
F71678-37	02/25/10	08:46	MCD	02/27/10	SO	Soil	CSS-C9-14
F71678-38	02/25/10	09:34	MCD	02/27/10	SO	Soil	CSS-C9-21
F71678-39	02/25/10	09:17	MCD	02/27/10	SO	Soil	CSS-C9-22

Soil samples reported on a dry weight basis unless otherwise indicated on result page.

Accutest Laboratories

Sample Summary
(continued)

ECT

Job No: F71678

C-11 Speciation Sampling, Broward Co, FL
Project No: 10-0096

Sample Number	Collected Date	Time By	Received	Matrix Code	Matrix Type	Client Sample ID
F71678-40	02/25/10	09:56 MCD	02/27/10	SO	Soil	CSS-C9-23
F71678-41	02/25/10	10:19 MCD	02/27/10	SO	Soil	CSS-C9-24
F71678-42	02/25/10	10:48 MCD	02/27/10	SO	Soil	CSS-C9-32
F71678-43	02/25/10	11:18 MCD	02/27/10	SO	Soil	CSS-C9-31
F71678-44	02/25/10	12:19 MCD	02/27/10	SO	Soil	CSS-C9-33
F71678-45	02/25/10	12:40 MCD	02/27/10	SO	Soil	CSS-C9-34
F71678-46	02/25/10	13:10 MCD	02/27/10	SO	Soil	CSS-C9-40
F71678-47	02/25/10	13:45 MCD	02/27/10	SO	Soil	CSS-C9-41
F71678-48	02/25/10	14:18 MCD	02/27/10	SO	Soil	CSS-C9-42
F71678-49	02/19/10	11:29 MCD	02/27/10	SO	Soil	CSS-C9-1
F71678-50	02/19/10	12:43 MCD	02/27/10	SO	Soil	CSS-C9-2
F71678-51	02/19/10	09:52 MCD	02/27/10	SO	Soil	CSS-C9-3
F71678-52	02/19/10	13:16 MCD	02/27/10	SO	Soil	CSS-C9-4

Soil samples reported on a dry weight basis unless otherwise indicated on result page.

Accutest Laboratories

Sample Summary
(continued)

ECT

Job No: F71678

C-11 Speciation Sampling, Broward Co, FL
Project No: 10-0096

Sample Number	Collected Date	Time	By	Received	Matrix Code	Type	Client Sample ID
F71678-53	02/19/10	14:03	MCD	02/27/10	SO	Soil	CSS-C9-5
F71678-54	02/19/10	10:48	MCD	02/27/10	SO	Soil	CSS-C9-6
F71678-55	02/25/10	15:08	MCD	02/27/10	SO	Soil	CSS-C9-7
F71678-56	02/25/10	00:00	MCD	02/27/10	SO	Soil	CSS-C9-43
F71678-57	02/25/10	00:00	MCD	02/27/10	SO	Soil	CSS-C9-44

Soil samples reported on a dry weight basis unless otherwise indicated on result page.

Sample Results

Report of Analysis

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C11-18		
Lab Sample ID:	F71678-1	**Date Sampled:**	02/23/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	40.7
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed By	Method	Prep Method
Barium [a]	30.5	0.42	0.032	mg/kg	5	03/10/10	03/10/10 ANJ	SW846 6020 [1]	SW846 3050B [2]
Selenium [a]	2.5	0.42	0.048	mg/kg	5	03/10/10	03/10/10 ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23956
(2) Prep QC Batch: N:MP51789

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C11-19		
Lab Sample ID:	F71678-2	**Date Sampled:**	02/23/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	62.3
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed By	Method	Prep Method
Barium [a]	25.8	0.43	0.033	mg/kg	5	03/10/10	03/10/10 ANJ	SW846 6020 [1]	SW846 3050B [2]
Selenium [a]	1.8	0.43	0.050	mg/kg	5	03/10/10	03/10/10 ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23956
(2) Prep QC Batch: N:MP51789

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C11-20		
Lab Sample ID:	F71678-3	**Date Sampled:**	02/23/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	83.1
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Barium [a]	5.0	0.59	0.045	mg/kg	5	03/10/10	03/10/10	ANJ	SW846 6020 [1]	SW846 3050B [2]
Selenium [a]	0.069 U	0.59	0.069	mg/kg	5	03/10/10	03/10/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23956
(2) Prep QC Batch: N:MP51789

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C11-20		
Lab Sample ID:	F71678-3	**Date Sampled:**	02/23/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	83.1
Project:	C-11 Speciation Sampling, Broward Co, FL		

General Chemistry

Analyte	Result	RL	MDL	Units	DF	Analyzed	By	Method
Solids, Percent	83.1			%	1	03/02/10	CP	SM19 2540B M
Total Organic Carbon	3590	1200	600	mg/kg	1	03/16/10 14:01	SD	SW846 9060A MOD

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C11-21		
Lab Sample ID:	F71678-4	**Date Sampled:**	02/23/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	44.0
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Barium [a]	30.0	0.55	0.042	mg/kg	5	03/10/10	03/10/10	ANJ	SW846 6020 [1]	SW846 3050B [2]
Selenium [a]	1.1	0.55	0.064	mg/kg	5	03/10/10	03/10/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23956
(2) Prep QC Batch: N:MP51789

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C11-25		
Lab Sample ID:	F71678-5	**Date Sampled:**	02/23/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	33.4
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Barium [a]	40.0	0.50	0.038	mg/kg	5	03/10/10	03/10/10	ANJ	SW846 6020 [1]	SW846 3050B [2]
Selenium [a]	2.4	0.50	0.058	mg/kg	5	03/10/10	03/10/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23956
(2) Prep QC Batch: N:MP51789

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C11-25		
Lab Sample ID:	F71678-5	**Date Sampled:**	02/23/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	33.4
Project:	C-11 Speciation Sampling, Broward Co, FL		

General Chemistry

Analyte	Result	RL	MDL	Units	DF	Analyzed	By	Method
Solids, Percent	33.4			%	1	03/02/10	CP	SM19 2540B M
Total Organic Carbon	36600	3000	1500	mg/kg	1	03/16/10 14:27	SD	SW846 9060A MOD

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C11-26		
Lab Sample ID:	F71678-6	**Date Sampled:**	02/23/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	29.2
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed By	Method	Prep Method
Barium [a]	33.3	0.58	0.044	mg/kg	5	03/10/10	03/10/10 ANJ	SW846 6020 [1]	SW846 3050B [2]
Selenium [a]	2.0	0.58	0.067	mg/kg	5	03/10/10	03/10/10 ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23956
(2) Prep QC Batch: N:MP51789

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C11-27		
Lab Sample ID:	F71678-7	**Date Sampled:**	02/23/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	41.2
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Barium [a]	37.1	0.58	0.044	mg/kg	5	03/10/10	03/10/10	ANJ	SW846 6020 [1]	SW846 3050B [2]
Selenium [a]	2.3	0.58	0.067	mg/kg	5	03/10/10	03/10/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23956
(2) Prep QC Batch: N:MP51789

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C11-28		
Lab Sample ID:	F71678-8	**Date Sampled:**	02/23/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	34.2
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed By		Method	Prep Method
Barium [a]	22.8	0.49	0.038	mg/kg	5	03/10/10	03/10/10	ANJ	SW846 6020 [1]	SW846 3050B [2]
Selenium [a]	2.0	0.49	0.057	mg/kg	5	03/10/10	03/10/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23956
(2) Prep QC Batch: N:MP51789

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C11-29		
Lab Sample ID:	F71678-9	**Date Sampled:**	02/23/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	58.2
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed By		Method	Prep Method
Barium [a]	31.9	0.43	0.033	mg/kg	5	03/10/10	03/10/10	ANJ	SW846 6020 [1]	SW846 3050B [2]
Selenium [a]	2.2	0.43	0.050	mg/kg	5	03/10/10	03/10/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23956
(2) Prep QC Batch: N:MP51789

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C11-30		
Lab Sample ID:	F71678-10	**Date Sampled:**	02/23/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	35.3
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Barium [a]	40.1	0.55	0.042	mg/kg	5	03/10/10	03/10/10	ANJ	SW846 6020 [1]	SW846 3050B [2]
Selenium [a]	3.1	0.55	0.064	mg/kg	5	03/10/10	03/10/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23956
(2) Prep QC Batch: N:MP51789

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C11-30		
Lab Sample ID:	F71678-10	**Date Sampled:**	02/23/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	35.3
Project:	C-11 Speciation Sampling, Broward Co, FL		

General Chemistry

Analyte	Result	RL	MDL	Units	DF	Analyzed	By	Method
Solids, Percent	35.3			%	1	03/02/10	CP	SM19 2540B M
Total Organic Carbon	38900	2800	1400	mg/kg	1	03/16/10 14:45	SD	SW846 9060A MOD

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C11-31		
Lab Sample ID:	F71678-11	**Date Sampled:**	02/23/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	54.4
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed By		Method	Prep Method
Barium [a]	27.5	0.46	0.035	mg/kg	5	03/10/10	03/10/10	ANJ	SW846 6020 [1]	SW846 3050B [2]
Selenium [a]	1.7	0.46	0.053	mg/kg	5	03/10/10	03/10/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23956
(2) Prep QC Batch: N:MP51789

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C11-33		
Lab Sample ID:	F71678-12	**Date Sampled:**	02/23/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	51.8
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Barium [a]	36.7	0.49	0.037	mg/kg	5	03/10/10	03/10/10	ANJ	SW846 6020 [1]	SW846 3050B [2]
Selenium [a]	2.0	0.49	0.057	mg/kg	5	03/10/10	03/10/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23956
(2) Prep QC Batch: N:MP51789

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C11-34		
Lab Sample ID:	F71678-13	**Date Sampled:**	02/23/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	25.6
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Barium [a]	71.6	0.67	0.051	mg/kg	5	03/10/10	03/10/10	ANJ	SW846 6020 [1]	SW846 3050B [2]
Selenium [a]	5.3	0.67	0.078	mg/kg	5	03/10/10	03/10/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23956
(2) Prep QC Batch: N:MP51789

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-8		
Lab Sample ID:	F71678-14	**Date Sampled:**	02/24/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	90.3
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	0.094 I	0.58	0.067	mg/kg	5	03/10/10	03/10/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23956
(2) Prep QC Batch: N:MP51789

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-9		
Lab Sample ID:	F71678-15	**Date Sampled:**	02/24/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	89.0
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed By		Method	Prep Method
Selenium [a]	0.068 U	0.58	0.068	mg/kg	5	03/10/10	03/10/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23956
(2) Prep QC Batch: N:MP51789

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-10		
Lab Sample ID:	F71678-16	**Date Sampled:**	02/24/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	88.3
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	0.065 U	0.56	0.065	mg/kg	5	03/10/10	03/10/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23956
(2) Prep QC Batch: N:MP51789

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-10		
Lab Sample ID:	F71678-16	**Date Sampled:**	02/24/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	88.3
Project:	C-11 Speciation Sampling, Broward Co, FL		

General Chemistry

Analyte	Result	RL	MDL	Units	DF	Analyzed	By	Method
Solids, Percent	88.3			%	1	03/02/10	CP	SM19 2540B M
Total Organic Carbon	2460	1100	570	mg/kg	1	03/16/10 15:18	SD	SW846 9060A MOD

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-15		
Lab Sample ID:	F71678-17	**Date Sampled:**	02/24/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	53.4
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	0.34 I	0.48	0.056	mg/kg	5	03/10/10	03/10/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23956
(2) Prep QC Batch: N:MP51789

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-15		
Lab Sample ID:	F71678-17	**Date Sampled:**	02/24/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	53.4
Project:	C-11 Speciation Sampling, Broward Co, FL		

General Chemistry

Analyte	Result	RL	MDL	Units	DF	Analyzed	By	Method
Solids, Percent	53.4			%	1	03/02/10	CP	SM19 2540B M
Total Organic Carbon	12100	1900	940	mg/kg	1	03/16/10 17:58	SD	SW846 9060A MOD

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-16		
Lab Sample ID:	F71678-18	**Date Sampled:**	02/24/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	54.1
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	0.42 I	0.46	0.054	mg/kg	5	03/10/10	03/10/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23956
(2) Prep QC Batch: N:MP51789

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-17		
Lab Sample ID:	F71678-19	**Date Sampled:**	02/24/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	57.2
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	0.56	0.36	0.042	mg/kg	5	03/10/10	03/10/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23956
(2) Prep QC Batch: N:MP51789

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-18		
Lab Sample ID:	F71678-20	**Date Sampled:**	02/24/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	56.4
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	0.45	0.44	0.051	mg/kg	5	03/10/10	03/10/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23956
(2) Prep QC Batch: N:MP51789

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-19		
Lab Sample ID:	F71678-21	**Date Sampled:**	02/24/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	55.2
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	0.40 I	0.51	0.059	mg/kg	5	03/10/10	03/10/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23956
(2) Prep QC Batch: N:MP51790

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-20		
Lab Sample ID:	F71678-22	**Date Sampled:**	02/24/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	88.1
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	0.087 I	0.59	0.068	mg/kg	5	03/10/10	03/10/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23956
(2) Prep QC Batch: N:MP51790

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-20		
Lab Sample ID:	F71678-22	**Date Sampled:**	02/24/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	88.1
Project:	C-11 Speciation Sampling, Broward Co, FL		

General Chemistry

Analyte	Result	RL	MDL	Units	DF	Analyzed	By	Method
Solids, Percent	88.1			%	1	03/02/10	CP	SM19 2540B M
Total Organic Carbon	17900	1100	570	mg/kg	1	03/16/10 18:31	SD	SW846 9060A MOD

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-25		
Lab Sample ID:	F71678-23	**Date Sampled:**	02/24/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	31.6
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	2.1	1.0	0.12	mg/kg	10	03/10/10	03/10/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23956
(2) Prep QC Batch: N:MP51790

(a) Elevated detection limit due to dilution required for matrix interference. Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-25		
Lab Sample ID:	F71678-23	**Date Sampled:**	02/24/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	31.6
Project:	C-11 Speciation Sampling, Broward Co, FL		

General Chemistry

Analyte	Result	RL	MDL	Units	DF	Analyzed	By	Method
Solids, Percent	31.6			%	1	03/02/10	CP	SM19 2540B M
Total Organic Carbon	33500	3200	1600	mg/kg	1	03/17/10 11:44	SD	SW846 9060A MOD

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-26		
Lab Sample ID:	F71678-24	**Date Sampled:**	02/24/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	34.0
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	1.7	1.0	0.12	mg/kg	10	03/10/10	03/10/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23956
(2) Prep QC Batch: N:MP51790

(a) Elevated detection limit due to dilution required for matrix interference. Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-27		
Lab Sample ID:	F71678-25	**Date Sampled:**	02/24/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	33.4
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed By	Method	Prep Method
Selenium [a]	1.7	0.53	0.062	mg/kg	5	03/10/10	03/10/10 ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23956
(2) Prep QC Batch: N:MP51790

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-28		
Lab Sample ID:	F71678-26	**Date Sampled:**	02/24/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	40.3
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	1.5	0.95	0.11	mg/kg	10	03/10/10	03/10/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23956
(2) Prep QC Batch: N:MP51790

(a) Elevated detection limit due to dilution required for matrix interference. Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-29		
Lab Sample ID:	F71678-27	**Date Sampled:**	02/24/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	44.4
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	1.7	0.50	0.059	mg/kg	5	03/10/10	03/10/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23956
(2) Prep QC Batch: N:MP51790

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-30		
Lab Sample ID:	F71678-28	**Date Sampled:**	02/24/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	33.0
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	1.9	1.0	0.12	mg/kg	10	03/10/10	03/10/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23956
(2) Prep QC Batch: N:MP51790

(a) Elevated detection limit due to dilution required for matrix interference. Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-30		
Lab Sample ID:	F71678-28	**Date Sampled:**	02/24/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	33.0
Project:	C-11 Speciation Sampling, Broward Co, FL		

General Chemistry

Analyte	Result	RL	MDL	Units	DF	Analyzed	By	Method
Solids, Percent	33			%	1	03/02/10	CP	SM19 2540B M
Total Organic Carbon	24000	3000	1500	mg/kg	1	03/17/10 12:18	SD	SW846 9060A MOD

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-35		
Lab Sample ID:	F71678-29	**Date Sampled:**	02/24/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	37.8
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	1.6	0.98	0.11	mg/kg	10	03/10/10	03/10/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23956
(2) Prep QC Batch: N:MP51790

(a) Elevated detection limit due to dilution required for matrix interference. Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-35		
Lab Sample ID:	F71678-29	**Date Sampled:**	02/24/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	37.8
Project:	C-11 Speciation Sampling, Broward Co, FL		

General Chemistry

Analyte	Result	RL	MDL	Units	DF	Analyzed	By	Method
Solids, Percent	37.8			%	1	03/02/10	CP	SM19 2540B M
Total Organic Carbon	20900	2600	1300	mg/kg	1	03/17/10 13:24	SD	SW846 9060A MOD

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-36		
Lab Sample ID:	F71678-30	**Date Sampled:**	02/24/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	33.8
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	2.7	0.49	0.057	mg/kg	5	03/10/10	03/10/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23956
(2) Prep QC Batch: N:MP51790

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-37		
Lab Sample ID:	F71678-31	**Date Sampled:**	02/24/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	29.0
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	2.2	0.99	0.12	mg/kg	10	03/10/10	03/10/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23956
(2) Prep QC Batch: N:MP51790

(a) Elevated detection limit due to dilution required for matrix interference. Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-38		
Lab Sample ID:	F71678-32	**Date Sampled:**	02/24/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	31.0
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	2.2	0.50	0.058	mg/kg	5	03/10/10	03/10/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23956
(2) Prep QC Batch: N:MP51790

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-39		
Lab Sample ID:	F71678-33	**Date Sampled:**	02/24/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	22.8
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	3.0	1.1	0.13	mg/kg	10	03/10/10	03/15/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23970
(2) Prep QC Batch: N:MP51790

(a) Elevated detection limit due to dilution required for matrix interference (indicated by failing internal standard on original analysis). Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-11		
Lab Sample ID:	F71678-34	**Date Sampled:**	02/25/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	31.2
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	2.2	0.50	0.058	mg/kg	5	03/10/10	03/10/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23956
(2) Prep QC Batch: N:MP51790

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-12		
Lab Sample ID:	F71678-35	**Date Sampled:**	02/25/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	43.6
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed By		Method	Prep Method
Selenium [a]	1.5	0.49	0.057	mg/kg	5	03/10/10	03/10/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23956
(2) Prep QC Batch: N:MP51790

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-13		
Lab Sample ID:	F71678-36	**Date Sampled:**	02/25/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	39.3
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	1.6	0.53	0.062	mg/kg	5	03/10/10	03/10/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23956
(2) Prep QC Batch: N:MP51790

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-14		
Lab Sample ID:	F71678-37	**Date Sampled:**	02/25/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	31.8
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	2.6	0.53	0.062	mg/kg	5	03/10/10	03/10/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23956
(2) Prep QC Batch: N:MP51790

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-21		
Lab Sample ID:	F71678-38	**Date Sampled:**	02/25/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	33.2
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	1.9	0.49	0.058	mg/kg	5	03/10/10	03/10/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23956
(2) Prep QC Batch: N:MP51790

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-22		
Lab Sample ID:	F71678-39	**Date Sampled:**	02/25/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	35.8
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed By		Method	Prep Method
Selenium [a]	1.8	0.50	0.059	mg/kg	5	03/10/10	03/10/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23956
(2) Prep QC Batch: N:MP51790

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-23		
Lab Sample ID:	F71678-40	**Date Sampled:**	02/25/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	30.5
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	2.3	0.53	0.061	mg/kg	5	03/10/10	03/10/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23956
(2) Prep QC Batch: N:MP51790

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-24		
Lab Sample ID:	F71678-41	**Date Sampled:**	02/25/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	29.1
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	1.7 I	2.3	0.27	mg/kg	20	03/11/10	03/12/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23965
(2) Prep QC Batch: N:MP51801

(a) Elevated detection limit due to dilution required for matrix interference (indicated by failing internal standard on original analysis). Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-32		
Lab Sample ID:	F71678-42	**Date Sampled:**	02/25/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	44.9
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	3.2	0.56	0.066	mg/kg	5	03/11/10	03/12/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23965
(2) Prep QC Batch: N:MP51801

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-31		
Lab Sample ID:	F71678-43	**Date Sampled:**	02/25/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	43.9
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	3.1	0.58	0.067	mg/kg	5	03/11/10	03/12/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23965
(2) Prep QC Batch: N:MP51801

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-33		
Lab Sample ID:	F71678-44	**Date Sampled:**	02/25/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	44.2
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	3.8	1.1	0.13	mg/kg	10	03/11/10	03/15/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23970
(2) Prep QC Batch: N:MP51801

(a) Elevated detection limit due to dilution required for matrix interference (indicated by failing internal standard on original analysis). Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-34		
Lab Sample ID:	F71678-45	**Date Sampled:**	02/25/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	45.1
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	3.2	0.56	0.065	mg/kg	5	03/11/10	03/12/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23965
(2) Prep QC Batch: N:MP51801

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-40		
Lab Sample ID:	F71678-46	**Date Sampled:**	02/25/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	41.2
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	2.3	0.48	0.056	mg/kg	5	03/11/10	03/12/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23965
(2) Prep QC Batch: N:MP51801

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-40		
Lab Sample ID:	F71678-46	**Date Sampled:**	02/25/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	41.2
Project:	C-11 Speciation Sampling, Broward Co, FL		

General Chemistry

Analyte	Result	RL	MDL	Units	DF	Analyzed	By	Method
Solids, Percent	41.2			%	1	03/02/10	CP	SM19 2540B M
Total Organic Carbon	39300	2400	1200	mg/kg	1	03/17/10 14:07	SD	SW846 9060A MOD

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-41		
Lab Sample ID:	F71678-47	**Date Sampled:**	02/25/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	45.1
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	3.0	0.55	0.064	mg/kg	5	03/11/10	03/12/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23965
(2) Prep QC Batch: N:MP51801

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-42		
Lab Sample ID:	F71678-48	**Date Sampled:**	02/25/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	44.9
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	2.7	0.57	0.067	mg/kg	5	03/11/10	03/12/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23965
(2) Prep QC Batch: N:MP51801

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-42		
Lab Sample ID:	F71678-48	**Date Sampled:**	02/25/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	44.9
Project:	C-11 Speciation Sampling, Broward Co, FL		

General Chemistry

Analyte	Result	RL	MDL	Units	DF	Analyzed	By	Method
Solids, Percent	44.9			%	1	03/02/10	CP	SM19 2540B M
Total Organic Carbon	33400	2200	1100	mg/kg	1	03/17/10 14:37	SD	SW846 9060A MOD

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-1		
Lab Sample ID:	F71678-49	**Date Sampled:**	02/19/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	31.3
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	3.7	1.1	0.13	mg/kg	10	03/11/10	03/12/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23965
(2) Prep QC Batch: N:MP51801

(a) Elevated detection limit due to dilution required for matrix interference (indicated by failing internal standard on original analysis). Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-1		
Lab Sample ID:	F71678-49	**Date Sampled:**	02/19/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	31.3
Project:	C-11 Speciation Sampling, Broward Co, FL		

General Chemistry

Analyte	Result	RL	MDL	Units	DF	Analyzed	By	Method
Solids, Percent	31.3			%	1	03/02/10	CP	SM19 2540B M
Total Organic Carbon	28200	3200	1600	mg/kg	1	03/17/10 14:57	SD	SW846 9060A MOD

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-2		
Lab Sample ID:	F71678-50	**Date Sampled:**	02/19/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	26.3
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed By	Method	Prep Method
Selenium [a]	3.8	1.0	0.12	mg/kg	10	03/11/10	03/12/10 ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23965
(2) Prep QC Batch: N:MP51801

(a) Elevated detection limit due to dilution required for matrix interference (indicated by failing internal standard on original analysis). Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-3		
Lab Sample ID:	F71678-51	**Date Sampled:**	02/19/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	24.7
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	4.3	1.0	0.12	mg/kg	10	03/11/10	03/12/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23965
(2) Prep QC Batch: N:MP51801

(a) Elevated detection limit due to dilution required for matrix interference (indicated by failing internal standard on original analysis). Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-4		
Lab Sample ID:	F71678-52	**Date Sampled:**	02/19/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	23.9
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed By		Method	Prep Method
Selenium [a]	4.4	1.1	0.12	mg/kg	10	03/11/10	03/12/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23965
(2) Prep QC Batch: N:MP51801

(a) Elevated detection limit due to dilution required for matrix interference (indicated by failing internal standard on original analysis). Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-5		
Lab Sample ID:	F71678-53	**Date Sampled:**	02/19/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	31.3
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	4.0	1.1	0.12	mg/kg	10	03/11/10	03/12/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23965
(2) Prep QC Batch: N:MP51801

(a) Elevated detection limit due to dilution required for matrix interference (indicated by failing internal standard on original analysis). Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-5		
Lab Sample ID:	F71678-53	**Date Sampled:**	02/19/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	31.3
Project:	C-11 Speciation Sampling, Broward Co, FL		

General Chemistry

Analyte	Result	RL	MDL	Units	DF	Analyzed	By	Method
Solids, Percent	31.3			%	1	03/02/10	CP	SM19 2540B M
Total Organic Carbon	26000	3200	1600	mg/kg	1	03/17/10 15:16	SD	SW846 9060A MOD

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-6		
Lab Sample ID:	F71678-54	**Date Sampled:**	02/19/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	29.0
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	4.5	1.1	0.13	mg/kg	10	03/11/10	03/12/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23965
(2) Prep QC Batch: N:MP51801

(a) Elevated detection limit due to dilution required for matrix interference (indicated by failing internal standard on original analysis). Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-7		
Lab Sample ID:	F71678-55	**Date Sampled:**	02/25/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	33.2
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	3.4	1.0	0.12	mg/kg	10	03/11/10	03/12/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23965
(2) Prep QC Batch: N:MP51801

(a) Elevated detection limit due to dilution required for matrix interference (indicated by failing internal standard on original analysis). Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-43		
Lab Sample ID:	F71678-56	**Date Sampled:**	02/25/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	52.7
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	2.8	0.48	0.056	mg/kg	5	03/11/10	03/15/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23970
(2) Prep QC Batch: N:MP51801

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-44		
Lab Sample ID:	F71678-57	**Date Sampled:**	02/25/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	45.1
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	3.5	0.57	0.066	mg/kg	5	03/11/10	03/12/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23965
(2) Prep QC Batch: N:MP51801

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-C9-44		
Lab Sample ID:	F71678-57	**Date Sampled:**	02/25/10
Matrix:	SO - Soil	**Date Received:**	02/27/10
		Percent Solids:	45.1
Project:	C-11 Speciation Sampling, Broward Co, FL		

General Chemistry

Analyte	Result	RL	MDL	Units	DF	Analyzed	By	Method
Solids, Percent	45.1			%	1	03/02/10	CP	SM19 2540B M
Total Organic Carbon	32600	2200	1100	mg/kg	1	03/17/10 15:39	SD	SW846 9060A MOD

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Misc. Forms

Custody Documents and Other Forms

Includes the following where applicable:

- Certification Exceptions
- Chain of Custody

Accutest Laboratories Southeast
Chain of Custody

ACCUTEST.

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Accutest JOB # F71678 PAGE 1 OF 4
Accutest Quote # F71678

Client / Reporting Information

Company Name: ECT
Address: 6300 NE 1st Ave #100
City: Ft Lauderdale State: FL Zip: 33334
Project Contact: Barry Wolstenkark
Phone: 954-771-0444
Sampler(s) Name(s) (Printed): AER MCD

Project Information

Project Name: CA #C11
Street: US 27
City: Broward Co State: FL
Project #: 10-0096
Fax #: 954-771-8118
Client Purchase Order #:

Accutest Sample #	Field ID / Point of Collection	Collection Date	Collection Time	Sampled By	Matrix	Total # of Bottles	Container Information: Contains	HCAS	HCl	NaOH	HNO3	H2SO4	NaOH/ZNAC	NaHSO4	None	Se	Ba	TOC								Matrix Codes / Lab Use Only
1	CSS-C11-18	2/23/10			SO	1	✓									✓	✓									
2	CSS-C11-19					1	✓									✓	✓									
3	CSS-C11-20					2	✓									✓	✓	✓								
4	CSS-C11-21					1	✓									✓	✓									
5	CSS-C11-25					2	✓									✓	✓	✓								
6	CSS-C11-26					1	✓									✓	✓									
7	CSS-C11-27					1	✓									✓	✓									
8	CSS-C11-28					1	✓									✓	✓									
9	CSS-C11-29					1	✓									✓	✓									
10	CSS-C11-30					2	✓									✓	✓	✓								
11	CSS-C11-31					1	✓									✓	✓									
12	CSS-C11-33	2/23/10			SO	1	✓									✓	✓									

Matrix Codes: DW - Drinking Water; GW - Ground Water; WW - Water; SW - Surface Water; SD - Soil; SL - Sludge; OI - Oil; LIQ - Other Liquid; AIR - Air; SOL - Other Solid; WP - Wipe

TURNAROUND TIME (Business Days)

- [x] 10 Days Standard
- [ ] 7 Day RUSH
- [ ] 5 Day RUSH
- [ ] 3 Day EMERGENCY
- [ ] 2 Day EMERGENCY
- [ ] 1 Day EMERGENCY
- [ ] OTHER

Approved By: / Rush Code

Emergency or Rush T/A Data Available VIA Email or Labtrak

Data Deliverable Information

- [ ] COMMERCIAL "A" (RESULTS ONLY)
- [ ] COMMERCIAL "B" (RESULTS PLUS QC)
- [ ] REDT1 (EPA LEVEL 3)
- [ ] FULT1 (EPA LEVEL 4)
- [ ] EDD'S

Comments / Remarks

Sample Custody must be documented below each time samples change possession, including courier delivery.

Relinquished by Sampler:	Date Time:	Received By:	Relinquished by:	Date Time:	Received By:
1 ECT	2/26	2 (Mtx) 2/26/10 15:00	3 (Mtx)		4 Accutest
Relinquished by: 5	Date Time:	Received By: 6	Relinquished by: 7	Date Time:	Received By: 8 03-27-10 08:00

Lab Use Only: Custody Seal in Place: Y N Temp Blank Provided: Y N Preserved where Applicable: Y N Total # of Coolers: Cooler Temperature (s) Celsius: 2.0

F71678: Chain of Custody
Page 1 of 14

Accutest Laboratories Southeast
Chain of Custody

ACCUTEST.

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TEL. 407-425-6700 • FAX: 407-425-0707
www.accutest.com

Accutest JOB # F71678 PAGE 2 OF 4
Accutest Quote # Date Rec'd

Client / Reporting Information
Company Name: ECT
Address:
City: Ft Lauderdale State: FL Zip:
Project Contact: Wesselink
Phone: 954-771-0444 Fax #: 954-771-8118
Sampler(s) Name(s) Printed: AK + MD

Project Information
Project Name: I-95 & C-11
Street: 115 27
City: BROWARD CO State: FL
Project #: 10-0096
Client Purchase Order #:

Analytical Information: SM, BOD, TOC

Matrix Codes: GW - Drinking Water; GW - Ground Water; WW - Water; SW - Surface Water; SO - Soil; SL - Sludge; OI - Oil; LIQ - Other Liquid; AIR - Air; SOL - Other Solid; WP - Wipe

Accutest Sample #	Field ID / Point of Collection	Collection Date	Time	Sampled By	Matrix	Total # of Bottles	Preserv.	H2O	MeOH	DI H2O	NaOH	HCl	NaTiO3	DI Water	Weight	SM	BOD	TOC								Lab Use Only
13	C33-C11-34	2/23			SO	1	✓									✓	✓									
14	C33-C9-8	2/24				1	✓									✓										
15	C33-C9-9					1	✓									✓										
16	C33-C9-10					2	✓									✓		✓								
17	C33-C9-15					2	✓									✓		✓								
18	C33-C9-16					1	✓									✓										
19	C33-C9-17					1	✓									✓										
20	C33-C9-18					1	✓									✓										
21	C33-C9-19					1	✓									✓										
22	C33-C9-20					2	✓									✓		✓								
23	C33-C9-25	↓			↓	2	✓									✓		✓								
24	C33-C9-26	2/24			SO	1	✓									✓										

TURNAROUND TIME (Business Days)
Approved By: / Rush Code
- [x] 10 Days Standard
- [ ] 7 Day RUSH
- [ ] 5 Day RUSH
- [ ] 3 Day EMERGENCY
- [ ] 2 Day EMERGENCY
- [ ] 1 Day EMERGENCY
- [ ] OTHER

Emergency or Rush T/A Data Available VIA Email or Lablink

Data Deliverable Information
- [ ] COMMERCIAL "A" (RESULTS ONLY)
- [ ] COMMERCIAL "B" (RESULTS PLUS QC)
- [ ] REDT1 (EPA LEVEL 3)
- [ ] FULT1 (EPA LEVEL 4)
- [ ] EDD'S

Comments / Remarks

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Relinquished by Sampler:	Date Time:	Received By:	Relinquished by:	Date Time:	Received By:
1	2/26	2	3		4
Relinquished by:	Date Time:	Received By:	Relinquished by:	Date Time:	Received By:
5		6	7		8

Lab Use Only: Custody Seal in Place: Y N Temp Blank Provided: Y N Preserved where Applicable: Y N Total # of Coolers: Cooler Temperature (s) Celsius:

F71678: Chain of Custody
Page 2 of 14

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www.accutest.com

Accutest JOB # F71678 PAGE 3 OF 4
Accutest Quote #

Client / Reporting Information

Company Name: ECT
Address:
City: Ft Laud State: FL Zip:
Project Contact: Barry Westbrook E-mail:
Phone: 954-771-0444
Sampler(s) Name(s): Cole + McD

Project Information

Project Name: C9 & C11
Street: US 27
City: Broward Co State: FL
Project #: 10-0696
Fax #: 954-771-8118
Client Purchase Order #:

Analytical Information

Accutest Sample #	Field ID / Point of Collection	Collection Date	Collection Time	Sampled By	Matrix	Total # of Bottles	Preservative: HCl	Preservative: NaOH	Preservative: HNO3	Preservative: H2SO4	Preservative: NaHSO4	Preservative: NaO3/NaOH	Preservative: Methanol	Preservative: None	Sx	Ba	TOC								Lab Use Only
27	CSS-C9-27	2/24/10			SO	1		✓							✓										
28	CSS-C9-28					1		✓							✓										
29	CSS-C9-29					1		✓							✓										
30	CSS-C9-30					2		✓							✓		✓								
31	CSS-C9-35					2		✓							✓		✓								
32	CSS-C9-36					1		✓							✓										
33	CSS-C9-37					1		✓							✓										
34	CSS-C9-38					1		✓							✓										
35	CSS-C9-39	2/24/10			SO	1		✓							✓										
36	CSS-C9-11	2/25						✓							✓										
37	CSS-C9-12							✓							✓										
38	CSS-C9-13	2/25			SO			✓							✓										

Matrix Codes: DW - Drinking Water; GW - Ground Water; WW - Water; SW - Surface Water; SO - Soil; SL - Sludge; OI - Oil; LIQ - Other Liquid; AIR - Air; SOL - Other Solid; WP - Wipe

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- [ ] FULT1 (EPA LEVEL 4)
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Comments / Remarks

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Relinquished by Sampler:	Date Time:	Received By:	Relinquished by:	Date Time:	Received By:
	2/26	2/26/10 15:20	2		Accutest
Relinquished by: 5	Date Time:	Received By: 6	Relinquished by: 7	Date Time:	Received By: 8 02-27-10 08:00

Lab Use Only: Custody Seal in Place: Y N Temp Blank Provided: Y N Preserved where Applicable: Y N Total # of Coolers: Cooler Temperature (s) Celsius: L.D

F71678: Chain of Custody
Page 3 of 14

Accutest Laboratories Southeast
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www.accutest.com

Accutest JOB # F71678 PAGE 4 OF 4
Accutest Quote #

Client / Reporting Information

Company Name: ECT
Address:
City: Ft Laud. State: FL Zip: 33554
Project Manager: Kevin Hinzek
E-mail:
Phone: 954-771-0444
Sampler(s) Name(s) (Printed): MATT CAR

Project Information

Project Name: C9 & C11
Street: US 27
City: BROWARD CO State: FL
Project #: 10-0096
Fax #: 954-771-8118
Client Purchase Order #:

Analytical Information

Accutest Sample #	Field ID / Point of Collection	Collection Date	Collection Time	Sampled By	Matrix	Total # of Bottles	Preservation Codes: None	HCl	HNO3	H2SO4	NaOH	NaOH+ZnAc	S2O3/NH4	MeOH	SV	TDS									Matrix Codes / LAB USE ONLY
37	CSS-C9-14	2/25			SO	1		✓							✓										
38	CSS-C9-21					1		✓							✓										
39	CSS-C9-22					1		✓							✓										
40	CSS-C9-23					1		✓							✓										
41	CSS-C9-24					1		✓							✓										
42	CSS-C9-32					1		✓							✓										
43	CSS-C9-31					1		✓							✓										
44	CSS-C9-33					1		✓							✓										
45	CSS-C9-34					1		✓							✓										
46	CSS-C9-40					2		✓							✓	✓									
47	CSS-C9-41	↓			↓	1		✓							✓										
48	CSS-C9-42	2/25			SO	2		✓							✓	✓									

Matrix Codes: DW - Drinking Water; GW - Ground Water; WW - Water; SW - Surface Water; SO - Soil; SL - Sludge; OI - Oil; LIQ - Other Liquid; AIR - Air; SOL - Other Solid; WP - Wipe

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Approved By: / Rush Code

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- [ ] 1 Day EMERGENCY
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Emergency or Rush T/A Data Available VIA Email or Labink

Data Deliverable Information

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- [ ] REDT1 (EPA LEVEL 3)
- [ ] FULT1 (EPA LEVEL 4)
- [ ] EDO'S

Comments / Remarks

Sample Custody must be documented below each time samples change possession, including/courier delivery.

Relinquished by Sampler:	Date Time:	Received By:	Relinquished by:	Date Time:	Received By:
1 ECT	2/26	2 [signature] 2/26/10 15:00	3 [signature]		4 Accutest
Relinquished by: 5	Date Time:	Received By: 6	Relinquished by: 7	Date Time:	Received By: 8 02-27-10 08:00

Lab Use Only: Custody Seal in Place: Y N Temp Blank Provided: Y N Preserved where Applicable: Y N Total # of Coolers: Cooler Temperature (s) Celsius: 2.0

F71678: Chain of Custody
Page 4 of 14

ACCUTEST LABORATORIES SAMPLE RECEIPT CONFIRMATION

ACCUTEST'S JOB NUMBER: F71678 CLIENT: ECT PROJECT: C9 + C11

DATE/TIME RECEIVED: 02-27-10 08:00 (MM/DD/YY 24:00) NUMBER OF COOLERS RECEIVED: 1

METHOD OF DELIVERY: FEDEX UPS ACCUTEST COURIER GREYHOUND DELIVERY OTHER

AIRBILL NUMBERS:

COOLER INFORMATION

- [ ] CUSTODY SEAL NOT PRESENT OR NOT INTACT
- [ ] CHAIN OF CUSTODY NOT RECEIVED (COC)
- [ ] ANALYSIS REQUESTED IS UNCLEAR OR MISSING
- [ ] SAMPLE DATES OR TIMES UNCLEAR OR MISSING
- [ ] TEMPERATURE CRITERIA NOT MET
- [ ] WET ICE PRESENT

TRIP BLANK INFORMATION

- [ ] TRIP BLANK PROVIDED
- [X] TRIP BLANK NOT PROVIDED
- [X] TRIP BLANK NOT ON COC
- [ ] TRIP BLANK INTACT
- [ ] TRIP BLANK NOT INTACT
- [ ] RECEIVED WATER TRIP BLANK
- [ ] RECEIVED SOIL TRIP BLANK

MISC. INFORMATION

NUMBER OF ENCORES ? Ø

NUMBER OF 5035 FIELD KITS ? Ø

NUMBER OR LAB FILTERED METALS ? Ø

TEMPERATURE INFORMATION

- [ ] IR THERM ID 3 CORR. FACTOR Ø
- [ ] OBSERVED TEMPS: 2.0
- [ ] CORRECTED TEMPS: 2.0

SAMPLE INFORMATION

- [ ] SAMPLE LABELS PRESENT ON ALL BOTTLES
- [ ] INCORRECT NUMBER OF CONTAINERS USED
- [ ] SAMPLE RECEIVED IMPROPERLY PRESERVED
- [ ] INSUFFICIENT VOLUME FOR ANALYSIS
- [ ] DATES/TIMES ON COC DO NOT MATCH SAMPLE LABEL
- [ ] ID'S ON COC DO NOT MATCH LABEL
- [ ] VOC VIALS HAVE HEADSPACE (MACRO BUBBLES)
- [X] BOTTLES RECEIVED BUT ANALYSIS NOT REQUESTED
- [X] NO BOTTLES RECEIVED FOR ANALYSIS REQUESTED
- [ ] UNCLEAR FILTERING OR COMPOSITING INSTRUCTIONS
- [ ] SAMPLE CONTAINER(S) RECEIVED BROKEN
- [ ] % SOLIDS JAR NOT RECEIVED
- [ ] 5035 FIELD KIT FROZEN WITHIN 48 HOUR'S
- [ ] RESIDUAL CHLORINE PRESENT

(APPLICABLE TO EPA 600 SERIES OR NORTH CAROLINA ORGANICS)

SUMMARY OF COMMENTS: Samp #5 only received 1 jar Se,Ba no TOC, Samp #11 recieved 1 jar TOC not on coc Samples 14-57 have no time/date on coc or label Samp 1-13 time on labels ① 1415, ② 1445, ③ 1405, ④ 1345, ⑤ 1102, ⑥ 905, ⑦ 1132, ⑧ 1335, ⑨ 1157, ⑩ 935, ⑪ 1005, ⑫ 1020, ⑬ 1215, received 9 jars not on coc see back for jar info ⟶, Samp 34-36 1 jar received

TECHNICIAN SIGNATURE/DATE E.T. 02.27.10 REVIEWER SIGNATURE/DATE CB 2/27/10

NF 10/09 RECEIPT CONFIRMATION 100609 (2).xls

F71678: Chain of Custody
Page 5 of 14

Sample #	ID	Analysis
49	CSS-C9-1	Se, TOC (2 jars)
50	CSS-C9-2	Se (1 jar)
51	CSS-C9-3	Se (1 jar)
52	CSS-C9-4	Se (1 jar)
53	CSS-C9-5	Se, TOC (2 jars)
54	CSS-C9-6	Se (1 jar)
55	CSS-C9-7	Se (1 jar)
56	CSS-C9-43	Se (1 jar)
57	CSS-C9-44	Se (1 jar)

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TEL: 407-425-6700 • FAX: 407-425-0707
www.accutest.com

Accutest JOB # F71678 PAGE 1 OF 4

Accutest Quote # | SKIFF#

Client / Reporting Information

Company Name: E.C.T.
Address: 300 NE 1st Ave #100
City: Ft Lauderdale State: FL Zip: 33301
Project Contact: Bob Wintermark Email:
Phone: 954-771-0444 Fax: 954-771-2118
State where Samples Taken: FLORIDA

Project Information

Project Name: 29 St C11
Street: US 27
City: BROWARD CO State: FL
Project #: 15-0096
Client Purchase Order #:

Analytical Information

| Accutest Sample # | Field ID / Point of Collection | Date | Time | Sampled By | Matrix | Total # of Bottles | Chlorides | Sulfate | Nitrate | Nitrite | Ortho P | Total P | Total Kjeldahl Nitrogen | Ammonia | Total Dissolved Solids | Total Suspended Solids | Turbidity | Alkalinity | Total Hardness | Calcium Hardness | Chlorophyll A | Chlorophyll B | Chlorophyll C | Phaeophytin | Total Organic Carbon | Total Phosphorus | Total Nitrogen | Total Organic Carbon | Total Phosphorus | Total Nitrogen | Total Organic Carbon | Total Phosphorus | Total Nitrogen

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TEL: 407-425-6700 • FAX: 407-425-0707
www.accutest.com

Accutest JOB # PAGE 2 OF 4
Accutest Quote # SKIFF#

Client / Reporting Information

Company Name: ECT
Address: 115 27
City: Ft Lauderdale State: FL Zip:
Project Contact: Barry Westbrook Email:
Phone#: 954-771-0444 Fax #: 954-771-8118
Sampled by (Name/Initials): BRK MCB

Project Information

Project Name: 09 & C11
Street: 115 27
City: DAVIE State: FL
Project #: 10-0096
Client Purchase Order #:

Analytical Information

Accutest Sample #	Field ID / Point of Collection	DATE	TIME	SAMPLED BY	MATRIX	TOTAL # OF BOTTLES	VOC	BOD	TOC							Matrix Codes / LAB USE ONLY
	C33-C11-34	1/23	1215		SO	1	✓	✓								
	C35-C9-8	1/24	709			1	✓									
	C35-C9-9		738			1	✓									
	C35-C9-10		752			2	✓		✓							
	C35-C9-15		814			2	✓		✓							
	C35-C9-16		832			1	✓									
	C35-C9-17		917			1	✓									
	C35-C9-18		952			1	✓									
	C35-C9-19		1019			1	✓									
	C35-C9-20		1046			2	✓		✓							
	C35-C9-25		1115			2	✓		✓							
	C35-C9-26	1/24	1139		SO	1	✓									

Matrix Codes: DW - Drinking Water; GW - Ground Water; WW - Water; SW - Surface Water; SO - Soil; SL - Sludge; OI - Oil; LIQ - Other Liquid; AIR - Air; SOL - Other Solid; WP - Wipe

TURNAROUND TIME (Business Days)

Approved By: / Rush Code

- [x] 10 Days Standard
- [ ] 7 Day RUSH
- [ ] 5 Day RUSH
- [ ] 3 Day EMERGENCY
- [ ] 2 Day EMERGENCY
- [ ] 1 Day EMERGENCY
- [ ] OTHER

Emergency or Rush T/A Data Available VIA Email or Labtink

Data Deliverable Information

- [ ] COMMERCIAL "A" (RESULTS ONLY)
- [ ] COMMERCIAL "B" (RESULTS PLUS QC)
- [ ] REDT1 (EPA LEVEL 3)
- [ ] FULT1 (EPA LEVEL 4)
- [ ] EDD'S

Comments / Remarks

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Relinquished by Sampler:	Date Time:	Received By:	Relinquished by:	Date Time:	Received By:
1	2	3	4		
Relinquished by:	Date Time:	Received By:	Relinquished by:	Date Time:	Received By:
5		6	7		8

Lab Use Only: Custody Seal in Place: Y N Temp Blank Provided: Y N Preserved where Applicable: Y N Total # of Coolers: Cooler Temperature (s) Celsius:

F71678: Chain of Custody
Page 8 of 14

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www.accutest.com

Accutest JOB # | PAGE 3 OF 4
Accutest Quote # | SKIFF#

Client / Reporting Information

Company Name: ECT
Address:
City: Ft Laud State: FL Zip:
Report Contact: Barry Westbrook Email:
Phone: 954-771-0444
Sampler(s) Name(s) (Printed): Chris + HCD

Project Information

Project Name: C-9 & C11
Street: 113 27
City: BROWARD CO State: FL
Project #: 10-0696
Fax #: 954-771-8118
Client Purchase Order #:

Analytical Information

Accutest Sample #	Field ID / Point of Collection	DATE	TIME	SAMPLED BY	MATRIX	TOTAL # OF CONTAINERS	OTHER	HCL	NaOH	H2SO4	HNO3	NaTHIO	ZnOAc	Fe	Oil & Grease	TOC									Matrix Codes / LAB USE ONLY
	C33-09-27	7/24/16	1219	SD		1	✓									✓									
	C35-09-28		1250			1	✓									✓									
	C33-09-29		1322			1	✓									✓									
	C33-09-30		1350			2	✓									✓	✓								
	C33-09-35		1415			2	✓									✓	✓								
	C33-09-36		1448			1	✓									✓									
	C33-09-37		1526			1	✓									✓									
	C33-09-38		1555			1	✓									✓									
	C33-09-39	7/24/16	1620		SD	1	✓									✓									
	C33-09-11	7/25	739				✓									✓									
	C33-09-12		915				✓									✓									
	C33-09-13	7/25	815		SD		✓									✓									

Matrix Codes: DW - Drinking Water; GW - Ground Water; WW - Water; SW - Surface Water; SO - Soil; SL - Sludge; OI - Oil; LIQ - Other Liquid; AIR - Air; SOL - Other Solid; WP - Wipe

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- [ ] FULT1 (EPA LEVEL 4)
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Comments / Remarks

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Relinquished by Sampler:	Date-Time:	Received By:	Relinquished by:	Date Time:	Received By:
	7/25/16	[illegible] 7/25/16 15:00	3		4
Relinquished by:	Date Time:	Received By:	Relinquished by:	Date Time:	Received By:
5		6	7		8

Lab Use Only: Custody Seal in Place: Y N Temp Blank Provided: Y N Preserved where Applicable: Y N Total # of Coolers: Cooler Temperature (s) Celsius:

F71678: Chain of Custody
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www.accutest.com

Accutest JOB # PAGE 4 OF 4

Accutest Quote # SKIFF#

Client / Reporting Information

Company Name: ECT
Address:
City: Ft Laud State: FL Zip: 33334
Project Contact: Robert W. Stinnett Email:
Phone: 954-771-0444 Fax: 954-771-5118
Sampler(s) Name(s) (Printed): MATT CAR

Project Information

Project Name: C9 #011
Street: US 27
City: BROWARD State: FL
Project #: 10-00916
Client Purchase Order #:

Analytical Information

TOC

Matrix Codes

DW - Drinking Water
GW - Ground Water
WW - Water
SW - Surface Water
SO - Soil
SL - Sludge
S - Oil
LIQ - Other Liquid
AIR - Air
SOL - Other Solid
WP - Wipe

Accutest Sample #	Field ID / Point of Collection	Collected Date	Collected Time	Sampled By	Matrix	Total # of Bottles	Preservation: Other	HCl	NaOH	HNO3	H2SO4	NaHSO4	NaOH+ZnAc	Methanol	TOC	Lab Use Only
	CSS-C9-14	3/25	940		SO	1	✓								✓	
	CSS-C9-31		934			1	✓								✓	
	CSS-C9-22		917			1	✓								✓	
	CSS-C9-33		956			1	✓								✓	
	CSS-C9-24		1009			1	✓								✓	
	CSS-C9-32		1048			1	✓								✓	
	CSS-C9-31		1118			1	✓								✓	
	CSS-C9-33		1219			1	✓								✓	
	CSS-C9-34		1242			1	✓								✓	
	CSS-C9-41		1310			2	✓								✓ ✓	
	CSS-C9-41		1345			1	✓								✓	
	CSS-C9-42	3/25	1418		SO	2	✓								✓ ✓	

TURNAROUND TIME (Business Days)

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- [x] 10 Days Standard
- [ ] 7 Day RUSH
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Relinquished by Sampler:	Date Time:	Received By:	Relinquished by:	Date Time:	Received By:
1 [signature] ECT	3/26	2 [signature]	3		4
Relinquished by:	Date Time:	Received By:	Relinquished by:	Date Time:	Received By:
5		6	7		8

Lab Use Only: Custody Seal In Place: Y N Temp Blank Provided: Y N Preserved where Applicable: Y N Total # of Coolers: Cooler Temperature (s) Celsius:

F71678: Chain of Custody
Page 10 of 14

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www.accutest.com

Accutest JOB # PAGE 1 OF 1

Accutest Quote # SKIFF#

Client / Reporting Information

Company Name: ECT
Address: 300 NE 1st Ave #100
City: Ft Lauderdale State: FL Zip: 33334
Project Contact (Email): Mary Westmark
Phone: 954-771-0444
Sampler(s) Name(s) (Initials): Pete + MCD

Project Information

Project Name: C9 & C11
Street: US 27
City: Bordentown CO State: FL
Project #: 10-0096
Po #:
Client Purchase Order #:

Analytical Information

Accutest Sample #	Field ID / Point of Collection	Date	Time	Sampled By	Matrix	Total # of Bottles	Other	None	HCl	HNO3	H2SO4	NaOH	Na2S2O3	NaHSO4	DI Water	Methanol	Sulfuric	Methyl	SE 6020	TOC
	CSS-C9-1	2/19/10	1129		SO	2													✓	✓
	CSS-C9-2		1249			1													✓	
	CSS-C9-3		952			1													✓	
	CSS-C9-4	2/19	1316			1													✓	
	CSS-C9-5		1403			2													✓	✓
	CSS-C9-6		1048			1													✓	
	CSS-C9-7	2/19/10	1508		SO	1													✓	

Matrix Codes: DW - Drinking Water; GW - Ground Water; WW - Water; SW - Surface Water; SO - Soil; SL - Sludge; OI - Oil; LIQ - Other Liquid; AIR - Air; SOL - Other Solid; WP - Wipe

LAB USE ONLY

TURNAROUND TIME (Business Days)

Approved By: / Rush Code

- [X] 10 Days Standard
- [ ] 7 Day RUSH
- [ ] 5 Day RUSH
- [ ] 3 Day EMERGENCY
- [ ] 2 Day EMERGENCY
- [ ] 1 Day EMERGENCY
- [ ] OTHER

Emergency or Rush T/A Data Available VIA Email or Labtrk

Data Deliverable Information

- [ ] COMMERCIAL "A" (RESULTS ONLY)
- [ ] COMMERCIAL "B" (RESULTS PLUS QC)
- [ ] REDT1 (EPA LEVEL 3)
- [ ] FULT1 (EPA LEVEL 4)
- [ ] EDD'S

Comments / Remarks

Sample Custody must be documented below each time samples change possession, including courier delivery.

Relinquished by Sampler:	Date Time:	Received By:	Relinquished by :	Date Time:	Received By:
1 [signature]	2/19/10 1630	2	3		4
Relinquished by:	**Date Time:**	**Received By:**	**Relinquished by:**	**Date Time:**	**Received By:**
5		6	7		8

Lab Use Only: Custody Seal in Place: Y N Temp Blank Provided: Y N Preserved where Applicable: Y N Total # of Coolers: Cooler Temperature (s) Celsius:

3-1

Job Change Order: F71678_3/1/2010

Requested Date:	3/1/2010	**Received Date:**	2/27/2010
Account Name:	ECT	**Due Date:**	3/15/2010
Project Description:	C-11 Speciation Sampling, Broward Co, FL	**Deliverable:**	COMMB
CSR:	SB	**TAT (Days):**	14

Sample #: F71678-5 — **Change:** Per Crystal @ ECT via e-mail 03.01.10, run SEMS, BAMS and TOC on this sample, despite what bottles we received.

CSS-C11-25

Sample #: F71678-11 — **Change:** Per Crystal @ ECT via e-mail 03.01.10, run SEMS and BAMS on this sample, despite what bottles we received.

CSS-C11-31

Sample #: F71678-49-55 — **Change:** NO coc received with samples. COC received from Crystal @ ECT via e-mail 03.01.10.

Sample #: F71678-49 — **Change:** Per Crystal @ ECT via e-mail 03.01.10, run SEMS and TOC on this sample.

CSS-C9-1

Sample #: F71678-50 — **Change:** Per Crystal @ ECT via e-mail 03.01.10, run SEMS on this sample.

CSS-C9-2

Sample #: F71678-51 — **Change:** Per Crystal @ ECT via e-mail 03.01.10, run SEMS on this sample.

CSS-C9-3

Above Changes Crystal @ ECT **Date:** 3/1/2010

To Client: This Change Order is confirmation of the revisions, previously discussed with the Accutest Client Service Representative.

Page 1 of 3

Job Change Order: F71678_3/1/2010

Requested Date:	3/1/2010	**Received Date:**	2/27/2010
Account Name:	ECT	**Due Date:**	3/15/2010
Project Description:	C-11 Speciation Sampling, Broward Co, FL	**Deliverable:**	COMMB
CSR:	SB	**TAT (Days):**	14

Sample #: F71678-52 **Change:** Per Crystal @ ECT via e-mail 03.01.10, run SEMS on this sample.

CSS-C9-4

Sample #: F71678-53 **Change:** Per Crystal @ ECT via e-mail 03.01.10, run SEMS and TOC on this sample.

CSS-C9-5

Sample #: F71678-54 **Change:** Per Crystal @ ECT via e-mail 03.01.10, run SEMS on this sample.

CSS-C9-6

Sample #: F71678-55 **Change:** Per Crystal @ ECT via e-mail 03.01.10, run SEMS on this sample.

CSS-C9-7

Sample #: F71678-56 **Change:** Per Crystal @ ECT via e-mail 03.01.10, run SEMS on this sample.

CSS-C9-43

Sample #: F71678-57 **Change:** Per Crystal @ ECT via e-mail 03.01.10, run SEMS and TOC on this sample.

CSS-C9-44

Above Changes Crystal @ ECT **Date:** 3/1/2010

To Client: This Change Order is confirmation of the revisions, previously discussed with the Accutest Client Service Representative.

Page 2 of 3

Job Change Order: F71678_3/1/2010

Requested Date:	3/1/2010	**Received Date:**	2/27/2010
Account Name:	ECT	**Due Date:**	3/15/2010
Project Description:	C-11 Speciation Sampling, Broward Co, FL	**Deliverable:**	COMMB
CSR:	SB	**TAT (Days):**	14

Sample #: F71678-56 **Change:** No coc received with this sample. COC requested from client.

CSS-C9-43

Sample #: F71678-57 **Change:** No coc received with this sample. COC requested from client.

CSS-C9-44

Sample #: F71678-1-13 **Change:** No sample collection times on coc. Collections times logged in per the sample labels.

Sample #: F71678-1-13 **Change:** Revised coc with sample collections times submitted. All sample collections times on revised coc matched bottles, except as noted below.

Sample #: F71678-9 **Change:** Collection time on bottle was 1157, revised coc is 1155. Sample logged in per revised coc.

CSS-C11-29

Sample #: F71678-14-48 **Change:** No sample collection times on coc or sample bottle labels. A revised coc was submitted from Crystal @ ECT via e-mail 03.01.10, with collection times.

Above Changes Crystal @ ECT **Date:** 3/1/2010

To Client: This Change Order is confirmation of the revisions, previously discussed with the Accutest Client Service Representative.

Page 3 of 3

General Chemistry

QC Data Summaries

Includes the following where applicable:

- Method Blank and Blank Spike Summaries
- Duplicate Summaries
- Matrix Spike Summaries

METHOD BLANK AND SPIKE RESULTS SUMMARY
GENERAL CHEMISTRY

Login Number: F71678
Account: ECTFLLAU - ECT
Project: C-11 Speciation Sampling, Broward Co, FL

Analyte	Batch ID	RL	MB Result	Units	Spike Amount	BSP Result	BSP %Recov	QC Limits
Total Organic Carbon	GP14492/GN38879	1000	0.0	mg/kg	20000	21300	106.5	88-114%
Total Organic Carbon	GP14493/GN38878	1000	0.0	mg/kg	20000	21100	105.5	88-114%
Total Organic Carbon	GP14503/GN38908	1000	0.0	mg/kg	20000	21300	106.5	88-114%

Associated Samples:
Batch GP14492: F71678-10, F71678-16, F71678-3, F71678-5
Batch GP14493: F71678-17, F71678-22
Batch GP14503: F71678-23, F71678-28, F71678-29, F71678-46, F71678-48, F71678-49, F71678-53, F71678-57
(*) Outside of QC limits

DUPLICATE RESULTS SUMMARY
GENERAL CHEMISTRY

Login Number: F71678
Account: ECTFLLAU - ECT
Project: C-11 Speciation Sampling, Broward Co, FL

Analyte	Batch ID	QC Sample	Units	Original Result	DUP Result	RPD	QC Limits
Solids, Percent	GN38643	F71678-1	%	40.7	46.3	12.9*	0-10%
Solids, Percent	GN38644	F71678-3	%	83.1	22.3	115.4*	0-10%
Solids, Percent	GN38645	F71678-23	%	31.6	34.7	9.4	0-10%
Solids, Percent	GN38648	F71678-43	%	43.9	46.8	6.4	0-10%
Total Organic Carbon	GP14492/GN38879	F71796-5	mg/kg	33000	26600	21.5	0-36%
Total Organic Carbon	GP14493/GN38879	F71678-17	mg/kg	12100	11600	4.2	0-36%
Total Organic Carbon	GP14503/GN38908	F71678-23	mg/kg	33500	26400	23.7	0-36%

Associated Samples:
Batch GN38643: F71678-1, F71678-2
Batch GN38644: F71678-10, F71678-11, F71678-12, F71678-13, F71678-14, F71678-15, F71678-16, F71678-17, F71678-18, F71678-19, F71678-20, F71678-21, F71678-22, F71678-3, F71678-4, F71678-5, F71678-6, F71678-7, F71678-8, F71678-9
Batch GN38645: F71678-23, F71678-24, F71678-25, F71678-26, F71678-27, F71678-28, F71678-29, F71678-30, F71678-31, F71678-32, F71678-33, F71678-34, F71678-35, F71678-36, F71678-37, F71678-38, F71678-39, F71678-40, F71678-41, F71678-42
Batch GN38648: F71678-43, F71678-44, F71678-45, F71678-46, F71678-47, F71678-48, F71678-49, F71678-50, F71678-51, F71678-52, F71678-53, F71678-54, F71678-55, F71678-56, F71678-57
Batch GP14492: F71678-10, F71678-16, F71678-3, F71678-5
Batch GP14493: F71678-17, F71678-22
Batch GP14503: F71678-23, F71678-28, F71678-29, F71678-46, F71678-48, F71678-49, F71678-53, F71678-57
(*) Outside of QC limits

MATRIX SPIKE RESULTS SUMMARY
GENERAL CHEMISTRY

Login Number: F71678
Account: ECTFLLAU - ECT
Project: C-11 Speciation Sampling, Broward Co, FL

Analyte	Batch ID	QC Sample	Units	Original Result	Spike Amount	MS Result	%Rec	QC Limits
Total Organic Carbon	GP14492/GN38879	F71796-5	mg/kg	33000	55200	75500	76.9N(a)	88-114%
Total Organic Carbon	GP14493/GN38879	F71678-17	mg/kg	12100	37500	48900	98.3	88-114%
Total Organic Carbon	GP14503/GN38908	F71678-23	mg/kg	33500	63300	91600	91.8	88-114%

Associated Samples:
Batch GP14492: F71678-10, F71678-16, F71678-3, F71678-5
Batch GP14493: F71678-17, F71678-22
Batch GP14503: F71678-23, F71678-28, F71678-29, F71678-46, F71678-48, F71678-49, F71678-53, F71678-57
(*) Outside of QC limits
(N) Matrix Spike Rec. outside of QC limits
(a) Spike recovery indicates possible matrix interference and/or sample nonhomogeneity.

Misc. Forms

5

Custody Documents and Other Forms

(Accutest New Jersey)

Includes the following where applicable:

- Chain of Custody

Accutest Southeast Subcontract Chain of Custody

ACCUTEST Laboratories

4405 Vineland Road, Suite C-15 Orlando, Fl 32811
TEL. 407-425-6700 • FAX: 407-425-0707

PAGE 1 OF 5

FX 7984 3786 5495

Client / Reporting Information

Company Name: Accutest Laboratories Southeast
Address: 4405 Vineland Road Suite C-15
City: Orlando State: Fl Zip: 32811
Project Contact: E-mail:
Phone#: 407-425-6700 Fax #: 407-425-0707
Lab Technician Printed Name:

Project Information

Accutest Job Number: F71678
Street
City
Project #
Fax #
Client Purchase

Please send report to dawnd@accutest.com

For any other issues contact
mamam@accutest.com

Analytical Information

BAMS, SEMS

Matrix Codes

DW - Drinking Water
GW - Ground Water
WW - Waste Water
SW - Surface Water
SO - Soil
SL - Sludge
O - Oil
LIQ - Other Liquid
AIR - Air
SOL - Other Solid

Lab ID #	Client ID / Accutest Sample ID	Collection DATE	Collection TIME	SAMPLED BY	MATRIX	TOTAL # OF BOTTLES	Container/Preservation OTHER	NONE	HCl	NaOH	HNO3	H2SO4	NaHSO4	ZnAc	BAMS, SEMS	LAB USE ONLY
	F71678-1	03.23	1405		SO	1		X							X	
	-2		1405													~~HEPC~~
	-3		1405													MEZ8
	-4		1045													
	-5		1102													
	-6		0905													
	-7		1132													
	-8		1215													
	-9		1155													
	-10		0905													
	-11		1005													
	-12		1030													

TURNAROUND TIME (Business Days)

Approved By:

Standard 10 Business Days
7 Day RUSH
5 Day RUSH — Due
3 Day EMERGENCY — 03-15-10
2 Day EMERGENCY
1 Day EMERGENCY
OTHER

Data Deliverable Information

- [ ] COMMERCIAL "A" (RESULTS ONLY)
- [x] COMMERCIAL "B" (RESULTS PLUS QC)
- [ ] REDT1 (EPA LEVEL 3)
- [ ] FULLT1 (EPA LEVEL 4)
- [ ] EDD'S

Comments / Remarks

Ship to Laboratory- AMS
Approved By- Munar Mohammed

Sample Custody must be documented below each time samples change possession, including courier delivery.

Relinquished by/Affiliation	Date Time:	Received By/Affiliation	Relinquished by/Affiliation	Date Time	Received By/Affiliation
1	03.10 1200	2	3	3-3-10 9:45	4
Relinquished by/Affiliation 5	Date Time:	Received By/Affiliation 6	Relinquished by/Affiliation 7	Date Time:	Received By/Affiliation 8

Lab Use Only: Custody Seal in Place: Y N Temp Blank Provided: Y N Preserved Where Applicable: Y N Total # of Coolers: 1 Cooler Temperature (s) Celsius: 2.6°C

F71678: Chain of Custody
Page 1 of 5
Accutest New Jersey

ACCUTEST Laboratories

Accutest Southeast Subcontract Chain of Custody

4405 Vineland Road, Suite C-15 Orlando, Fl 32811
TEL: 407-425-6700 • FAX: 407-425-0707

PAGE 2 OF 5

Client / Reporting Information

Company Name: Accutest Laboratories Southeast
Address: 4405 Vineland Road Suite C-15
City: Orlando State: Fl Zip: 32811
Project Contact: E-mail
Phone#: 407-425-6700 Fax #: 407-425-0707
Lab Technician Printed Name:

Project Information

Accutest Job Number: F71678
Street
City
Project #
Fax #
Client Purchase Order

Please send report to dawnd@accutest.com

For any other issues contact munani@accutest.com

Analytical Information

Lab ID	Client ID / Accutest Sample ID	Collection Date	Collection Time	Sampled By	Matrix	Total # of Bottles	Cl-Hg	NPW	PET	PAON	PAO3	PAO2	NON-DNC	ETHER	HCN	8 Aromatics + 5 Esters	5 Esters							Lab Use Only
	F71678-13	02-23	1115		SO	1		X								X	X							
	-14	02-24	0739														X							
	-15		0738																					
	-16		0752																					
	-17		0814																					
	-18		0832																					
	-19		0917																					
	-20		0952																					
	-21		1019																					
	-22		1046																					
	-23		1115																					
	-24		1139																					

Matrix Codes

DW - Drinking Water
GW - Ground Water
WW - Water
SW - Surface Water
SO - Soil
SL - Sludge
OI - Oil
LIQ - Other Liquid
AIR - Air
SOL - Other Solid

TURNAROUND TIME (Business Days)

Approved By:

- Standard 10 Business Days
- 7 Day RUSH
- 5 Day RUSH — Dwi
- 3 Day EMERGENCY
- 2 Day EMERGENCY — 03-15-10
- 1 Day EMERGENCY
- OTHER

Data Deliverable Information

- [ ] COMMERCIAL "A" (RESULTS ONLY)
- [X] COMMERCIAL "B" (RESULTS PLUS QC)
- [ ] REDT1 (EPA LEVEL 3)
- [ ] FULLT1 (EPA LEVEL 4)
- [ ] EDD'S

Comments / Remarks

Ship to Laboratory-
Approved By- Muna Mohammad

Sample Custody must be documented below each time samples change possession, including courier delivery.

Relinquished by/Affiliation	Date Time	Received By/Affiliation	Relinquished by/Affiliation	Date Time	Received By/Affiliation
1	03-02-10 1700	2	3	3-3-10 9:45	4
Relinquished by/Affiliation 5	Date Time	Received By/Affiliation 6	Relinquished by/Affiliation 7	Date Time	Received By/Affiliation 8

Lab Use Only: Custody Seal in Place: Y N Temp Blank Provided: Y N Preserved Where Applicable: Y N Total # of Coolers: Cooler Temperature (s) Celsius:

5.1 5

F71678: Chain of Custody
Page 2 of 5

ACCUTEST Laboratories

Accutest Southeast Subcontract Chain of Custody

4405 Vineland Road, Suite C-15 Orlando, Fl 32811
TEL: 407-425-6700 • FAX: 407-425-0707

PAGE 3 OF 5

Client / Reporting Information

Company Name: Accutest Laboratories Southeast
Address: 4405 Vineland Road Suite C-15
City: Orlando State: Fl Zip: 32811
Project Contact: E-mail
Phone#: 407-425-6700 Fax #: 407-425-0707
Lab Technician Printed Name:

Project Information

Accutest Job Number: F71678
Street
City
Project #
Fax #
Client Purchase O

Please send report to dawnd@accutest.com
For any other issues contact mariam@accutest.com

Analytical Information: SEMS

Matrix Codes: GW - Drinking Water; GW - Ground Water; WW - Water; SW - Surface Water; SO - Soil; SL - Sludge; OI - Oil; LIQ - Other Liquid; AIR - Air; SOL - Other Solid

Lab ID #	Client ID / Accutest Sample ID	DATE	TIME	SAMPLED BY	MATRIX	TOTAL # OF BOTTLES	SEMS									LAB USE ONLY
	F71678-25	02-24	1129		SO	1	X								X	
	-26		1158													
	-27		1322													
	-28		1350													
	-29		1415													
	-30		1448													
	-31		1526													
	-32		1555													
	-33		1600													
	-34	02-25	0739													
	-35		0715													
	-36		0845													

TURNAROUND TIME (Business Days) — Approved By:
Standard 10 Business Days
7 Day RUSH
5 Day RUSH — Due:
3 Day EMERGENCY — 02-15-10
2 Day EMERGENCY
1 Day EMERGENCY
OTHER

Data Deliverable Information
- [ ] COMMERCIAL "A" (RESULTS ONLY)
- [x] COMMERCIAL "B" (RESULTS PLUS QC)
- [ ] REDT1 (EPA LEVEL 3)
- [ ] FULLT1 (EPA LEVEL 4)
- [ ] EDD'S

Comments / Remarks

Ship to Laboratory- AMJ
Approved By- Mariam Manuel

Sample Custody must be documented below each time samples change possession, including courier delivery.

Relinquished by LabTechnician	Date Time:	Received By/Affiliation	Relinquished by/Affiliation	Date Time:	Received By/Affiliation
Accutest	02-23-10 1730	2	3	3-3-10 9:45	
Relinquished by/Affiliation	Date Time:	Received By/Affiliation	Relinquished by/Affiliation	Date Time:	Received By/Affiliation
5		6	7		8

Lab Use Only: Custody Seal in Place: Y N Temp Blank Provided: Y N Preserved Where Applicable: Y N Total # of Coolers: Cooler Temperature (s) Celsius:

F71678: Chain of Custody
Page 3 of 5

Accutest Southeast Subcontract Chain of Custody

ACCUTEST Laboratories

4405 Vineland Road, Suite C-15 Orlando, Fl 32811
TEL: 407-425-6700 • FAX: 407-425-0707

PAGE 4 OF 5

Client / Reporting Information

Company Name: Accutest Laboratories Southeast
Address: 4405 Vineland Road Suite C-15
City: Orlando State: FL Zip: 32811
Project Contact: E-mail:
Phone#: 407-425-6700 Fax #: 407-425-0707
Lab Technician Printed Name:

Project Information

Accutest Job Number: F71678
Street
City
Project #
Fax #
Client Purchase Order

Please send report to dawnd@accutest.com

For any other issues contact munam@accutest.com

Analytical Information: SVOCS

Matrix Codes: DW - Drinking Water; GW - Ground Water; WW - Water; SW - Surface Water; SO - Soil; SL - Sludge; OI - Oil; LIQ - Other Liquid; AIR - Air; SOL - Other Solid

Lab ID #	Client ID / Accutest Sample ID	Collection Date	Collection Time	Sampled By	Matrix	Total # of Bottles	Other	Other	HCl	NaOH	H2SO4	HNO3	NaHSO4	NaOH+Zn	None	SVOCS	Lab Use Only
	F71678-37	03-15	0936		SO	1		X								X	
	-38		0944														
	-39		0917														
	-40		0956														
	-41		1019														
	-42		1043														
	-43		1118														
	-44		1149														
	-45		1240														
	-46		1310														
	-47		1345														
	-48		1418														

TURNAROUND TIME (Business Days)

Approved By:
Standard 10 Business Days
7 Day RUSH
5 Day RUSH Due:
3 Day EMERGENCY
2 Day EMERGENCY 03-15-10
1 Day EMERGENCY
OTHER

Data Deliverable Information

- [ ] COMMERCIAL "A" (RESULTS ONLY)
- [x] COMMERCIAL "B" (RESULTS PLUS QC)
- [ ] REDT1 (EPA LEVEL 3)
- [ ] FULLT1 (EPA LEVEL 4)
- [ ] EDD'S

Comments / Remarks

Ship to Laboratory- AINS
Approved By:- Muna Mohanna

Sample Custody must be documented below each time samples change possession, including courier delivery.

Relinquished by LabTechnician:	Date Time:	Received By/Affiliation	Relinquished by/Affiliation	Date Time:	Received By/Affiliation
Accutest	03-15-10 DW	2	3	3-3-10 9:45	4
Relinquished by/Affiliation	Date Time:	Received By/Affiliation	Relinquished by/Affiliation	Date Time:	Received By/Affiliation
5		6	7		8

Lab Use Only: Custody Seal In Place: Y N Temp Blank Provided: Y N Preserved Where Applicable: Y N Total # of Coolers: Cooler Temperature (s) Celsius:

F71678: Chain of Custody
Page 4 of 5

Accutest Southeast Subcontract Chain of Custody

ACCUTEST Laboratories

4405 Vineland Road, Suite C-15 Orlando, Fl 32811
TEL: 407-425-6700 • FAX: 407-425-0707

PAGE 5 OF 5

Client / Reporting Information

Company Name: Accutest Laboratories Southeast
Address: 4405 Vineland Road Suite C-15
City: Orlando State: Fl Zip: 32811
Project Contact: E-mail
Phone#: 407-425-6700 Fax #: 407-425-0707
Lab Technician Printed Name:

Project Information

Accutest Job Number: F71678
Street
City
Project #
Fax #
Client Purchase

Please send report to dawnd@accutest.com

For any other issues contact mmunn@accutest.com

Analytical Information: SEMS

Matrix Codes: DW - Drinking Water; GW - Ground Water; WW - Water; SW - Surface Water; SO - Soil; SL - Sludge; OI - Oil; LQ - Other Liquid; AIR - Air; SOL - Other Solid

Lab ID #	Client ID / Accutest Sample ID	DATE	TIME	SAMPLED BY	MATRIX	TOTAL # OF BOTTLES	OH SDS	HNO3	HCl	NaOH	H2SO4	NaHSO4	DI WATER	NaOH	SEMS	LAB USE ONLY
	F71678-49	03-19	1129		SO	1		X							X	
	-50		1243													
	-51		0952													
	-52		1316													
	-53		1403													
	-54		1048													
	-55	03-20	1508													
	-56		—													
	-57		—													

TURNAROUND TIME (Business Days) — Approved By:

- Standard 10 Business Days
- 7 Day RUSH
- 5 Day RUSH: DWL
- 3 Day EMERGENCY
- 2 Day EMERGENCY: 03-15-10
- 1 Day EMERGENCY
- OTHER

Data Deliverable Information

- [ ] COMMERCIAL "A" (RESULTS ONLY)
- [x] COMMERCIAL "B" (RESULTS PLUS QC)
- [ ] REDT1 (EPA LEVEL 3)
- [ ] FULLT1 (EPA LEVEL 4)
- [ ] EDD'S

Comments / Remarks

Ship to Laboratory- AIVE

Approved By: Nuna Mohamed

Sample Custody must be documented below each time samples change possession, including courier delivery.

Relinquished by/Affiliation	Date Time	Received By/Affiliation	Relinquished by/Affiliation	Date Time	Received By/Affiliation
1	03-10 1700	2	3	03-16 9:45	4
Relinquished by/Affiliation	Date Time:	Received By/Affiliation	Relinquished by/Affiliation	Date Time:	Received By/Affiliation
5		6	7		8

Lab Use Only: Custody Seal in Place: Y N Temp Blank Provided: Y N Preserved Where Applicable: Y N Total # of Coolers: Cooler Temperature (s) Celsius:

F71678: Chain of Custody
Page 5 of 5

Metals Analysis

QC Data Summaries

(Accutest New Jersey)

Includes the following where applicable:

- Method Blank Summaries
- Matrix Spike and Duplicate Summaries
- Blank Spike and Lab Control Sample Summaries
- Serial Dilution Summaries

BLANK RESULTS SUMMARY
Part 2 - Method Blanks

Login Number: F71678
Account: ALSE - Accutest Laboratories Southeast, Inc.
Project: ECTFLLAU: C-11 Speciation Sampling, Broward Co, FL

QC Batch ID: MP51789 Methods: SW846 6020
Matrix Type: SOLID Units: mg/kg

Prep Date: 03/10/10

Metal	RL	IDL	MDL	MB raw	final
Aluminum	25	.34	.52		
Antimony	0.25	.019	.022		
Arsenic	0.50	.074	.11		
Barium	0.50	.013	.038	0.038	<0.50
Beryllium	0.25	.007	.03		
Boron	2.5	.29	.25		
Cadmium	0.25	.011	.016		
Calcium	130	3	3.1		
Chromium	2.0	.038	.29		
Cobalt	0.25	.0015	.016		
Copper	2.0	.13	.036		
Iron	25	.68	1.9		
Lead	0.25	.003	.012		
Magnesium	130	.27	1.4		
Manganese	0.25	.006	.02		
Molybdenum	0.50	.024	.096		
Nickel	2.0	.095	.026		
Potassium	130	1.4	3.9		
Selenium	0.50	.039	.058	-0.027	<0.50
Silver	1.0	.01	.022		
Sodium	130	.56	1.3		
Strontium	0.50	.004	.0082		
Thallium	0.25	.002	.0051		
Tin	0.50	.025			
Titanium	0.50	.027	.27		
Uranium	0.50				
Vanadium	2.0	.27	.79		
Zinc	2.0	.39	.91		

Associated samples MP51789: F71678-1, F71678-2, F71678-3, F71678-4, F71678-5, F71678-6, F71678-7, F71678-8, F71678-9, F71678-10, F71678-11, F71678-12, F71678-13, F71678-14, F71678-15, F71678-16, F71678-17, F71678-18, F71678-19, F71678-20

Results < IDL are shown as zero for calculation purposes
(*) Outside of QC limits
(anr) Analyte not requested

MATRIX SPIKE AND DUPLICATE RESULTS SUMMARY

Login Number: F71678
Account: ALSE - Accutest Laboratories Southeast, Inc.
Project: ECTFLLAU: C-11 Speciation Sampling, Broward Co, FL

QC Batch ID: MP51789
Matrix Type: SOLID

Methods: SW846 6020
Units: mg/kg

Prep Date: 03/10/10

Metal	F71678-15 Original	MS	Spikelot MPIRS1	% Rec	QC Limits
Aluminum					
Antimony					
Arsenic					
Barium	5.3	444	463	94.7	75-125
Beryllium					
Boron					
Cadmium					
Calcium					
Chromium					
Cobalt					
Copper					
Iron					
Lead					
Magnesium					
Manganese					
Molybdenum					
Nickel					
Potassium					
Selenium	0.0	476	463	102.7	69-125
Silver					
Sodium					
Strontium					
Thallium					
Tin					
Titanium					
Uranium					
Vanadium					
Zinc					

Associated samples MP51789: F71678-1, F71678-2, F71678-3, F71678-4, F71678-5, F71678-6, F71678-7, F71678-8, F71678-9, F71678-10, F71678-11, F71678-12, F71678-13, F71678-14, F71678-15, F71678-16, F71678-17, F71678-18, F71678-19, F71678-20

Results < IDL are shown as zero for calculation purposes
(*) Outside of QC limits
(N) Matrix Spike Rec. outside of QC limits
(anr) Analyte not requested

MATRIX SPIKE AND DUPLICATE RESULTS SUMMARY

Login Number: F71678
Account: ALSE - Accutest Laboratories Southeast, Inc.
Project: ECTFLLAU: C-11 Speciation Sampling, Broward Co, FL

QC Batch ID: MP51789
Matrix Type: SOLID

Methods: SW846 6020
Units: mg/kg

Prep Date: 03/10/10

Metal	F71678-15 Original	MSD	Spikelot MPIRS1	% Rec	MSD RPD	QC Limit
Aluminum						
Antimony						
Arsenic						
Barium	5.3	424	454	92.2	4.6	20
Beryllium						
Boron						
Cadmium						
Calcium						
Chromium						
Cobalt						
Copper						
Iron						
Lead						
Magnesium						
Manganese						
Molybdenum						
Nickel						
Potassium						
Selenium	0.0	458	454	100.9	3.9	20
Silver						
Sodium						
Strontium						
Thallium						
Tin						
Titanium						
Uranium						
Vanadium						
Zinc						

Associated samples MP51789: F71678-1, F71678-2, F71678-3, F71678-4, F71678-5, F71678-6, F71678-7, F71678-8, F71678-9, F71678-10, F71678-11, F71678-12, F71678-13, F71678-14, F71678-15, F71678-16, F71678-17, F71678-18, F71678-19, F71678-20

Results < IDL are shown as zero for calculation purposes
(*) Outside of QC limits
(N) Matrix Spike Rec. outside of QC limits
(anr) Analyte not requested

SPIKE BLANK AND LAB CONTROL SAMPLE SUMMARY

Login Number: F71678
Account: ALSE - Accutest Laboratories Southeast, Inc.
Project: ECTELLAU: C-11 Speciation Sampling, Broward Co, FL

QC Batch ID: MP51789
Matrix Type: SOLID

Methods: SW846 6020
Units: mg/kg

Prep Date: 03/10/10

Metal	BSP Result	Spikelot MPIRS1	% Rec	QC Limits
Aluminum				
Antimony				
Arsenic				
Barium	393	400	98.3	80-120
Beryllium				
Boron				
Cadmium				
Calcium				
Chromium				
Cobalt				
Copper				
Iron				
Lead				
Magnesium				
Manganese				
Molybdenum				
Nickel				
Potassium				
Selenium	420	400	105.0	80-120
Silver				
Sodium				
Strontium				
Thallium				
Tin				
Titanium				
Uranium				
Vanadium				
Zinc				

Associated samples MP51789: F71678-1, F71678-2, F71678-3, F71678-4, F71678-5, F71678-6, F71678-7, F71678-8, F71678-9, F71678-10, F71678-11, F71678-12, F71678-13, F71678-14, F71678-15, F71678-16, F71678-17, F71678-18, F71678-19, F71678-20

Results < IDL are shown as zero for calculation purposes
(*) Outside of QC limits
(anr) Analyte not requested

SERIAL DILUTION RESULTS SUMMARY

Login Number: F71678
Account: ALSE - Accutest Laboratories Southeast, Inc.
Project: ECTFLLAU: C-11 Speciation Sampling, Broward Co, FL

QC Batch ID: MP51789 Methods: SW846 6020
Matrix Type: SOLID Units: ug/l

Prep Date: 03/10/10

Metal	F71678-15 Original	SDL 5:25	%DIF	QC Limits
Aluminum				
Antimony				
Arsenic				
Barium	45.5	53.9	18.5*(a)	0-10
Beryllium				
Boron				
Cadmium				
Calcium				
Chromium				
Cobalt				
Copper				
Iron				
Lead				
Magnesium				
Manganese				
Molybdenum				
Nickel				
Potassium				
Selenium	0.00	4.63		0-10
Silver				
Sodium				
Strontium				
Thallium				
Tin				
Titanium				
Uranium				
Vanadium				
Zinc				

Associated samples MP51789: F71678-1, F71678-2, F71678-3, F71678-4, F71678-5, F71678-6, F71678-7, F71678-8, F71678-9, F71678-10, F71678-11, F71678-12, F71678-13, F71678-14, F71678-15, F71678-16, F71678-17, F71678-18, F71678-19, F71678-20

Results < IDL are shown as zero for calculation purposes
(*) Outside of QC limits
(anr) Analyte not requested
(a) Serial dilution indicates possible matrix interference.

BLANK RESULTS SUMMARY
Part 2 - Method Blanks

Login Number: F71678
Account: ALSE - Accutest Laboratories Southeast, Inc.
Project: ECTFLLAU: C-11 Speciation Sampling, Broward Co, FL

QC Batch ID: MP51790
Matrix Type: SOLID

Methods: SW846 6020
Units: mg/kg

Prep Date: 03/10/10

Metal	RL	IDL	MDL	MB raw	final
Aluminum	25	.34	.52		
Antimony	0.25	.019	.022		
Arsenic	0.50	.074	.11		
Barium	0.50	.013	.038		
Beryllium	0.25	.007	.03		
Boron	2.5	.29	.25		
Cadmium	0.25	.011	.016		
Calcium	130	3	3.1		
Chromium	2.0	.038	.29		
Cobalt	0.25	.0015	.016		
Copper	2.0	.13	.036		
Iron	25	.68	1.9		
Lead	0.25	.003	.012		
Magnesium	130	.27	1.4		
Manganese	0.25	.006	.02		
Molybdenum	0.50	.024	.096		
Nickel	2.0	.095	.026		
Potassium	130	1.4	3.9		
Selenium	0.50	.039	.058	-0.044	<0.50
Silver	1.0	.01	.022		
Sodium	130	.56	1.3		
Strontium	0.50	.004	.0082		
Thallium	0.25	.002	.0051		
Tin	0.50	.025			
Titanium	0.50	.027	.27		
Uranium	0.50				
Vanadium	2.0	.27	.79		
Zinc	2.0	.39	.91		

Associated samples MP51790: F71678-21, F71678-22, F71678-23, F71678-24, F71678-25, F71678-26, F71678-27, F71678-28, F71678-29, F71678-30, F71678-31, F71678-32, F71678-33, F71678-34, F71678-35, F71678-36, F71678-37, F71678-38, F71678-39, F71678-40

Results < IDL are shown as zero for calculation purposes
(*) Outside of QC limits
(anr) Analyte not requested

MATRIX SPIKE AND DUPLICATE RESULTS SUMMARY

Login Number: F71678
Account: ALSE - Accutest Laboratories Southeast, Inc.
Project: ECTFLLAU: C-11 Speciation Sampling, Broward Co, FL

QC Batch ID: MP51790
Matrix Type: SOLID

Methods: SW846 6020
Units: mg/kg

Prep Date: 03/10/10

Metal	F71678-22 Original	MS	Spikelot MPIRS1	% Rec	QC Limits
Aluminum					
Antimony					
Arsenic					
Barium					
Beryllium					
Boron					
Cadmium					
Calcium					
Chromium					
Cobalt					
Copper					
Iron					
Lead					
Magnesium					
Manganese					
Molybdenum					
Nickel					
Potassium					
Selenium	0.087	480	478	100.4	69-125
Silver					
Sodium					
Strontium					
Thallium					
Tin					
Titanium					
Uranium					
Vanadium					
Zinc					

Associated samples MP51790: F71678-21, F71678-22, F71678-23, F71678-24, F71678-25, F71678-26, F71678-27, F71678-28, F71678-29, F71678-30, F71678-31, F71678-32, F71678-33, F71678-34, F71678-35, F71678-36, F71678-37, F71678-38, F71678-39, F71678-40

Results < IDL are shown as zero for calculation purposes
(*) Outside of QC limits
(N) Matrix Spike Rec. outside of QC limits
(anr) Analyte not requested

MATRIX SPIKE AND DUPLICATE RESULTS SUMMARY

Login Number: F71678
Account: ALSE - Accutest Laboratories Southeast, Inc.
Project: ECTFLLAU: C-11 Speciation Sampling, Broward Co, FL

QC Batch ID: MP51790 Methods: SW846 6020
Matrix Type: SOLID Units: mg/kg

Prep Date: 03/10/10

Metal	F71678-22 Original	MSD	Spikelot MPIRS1	% Rec	MSD RPD	QC Limit
Aluminum						
Antimony						
Arsenic						
Barium						
Beryllium						
Boron						
Cadmium						
Calcium						
Chromium						
Cobalt						
Copper						
Iron						
Lead						
Magnesium						
Manganese						
Molybdenum						
Nickel						
Potassium						
Selenium	0.087	453	454	99.8	5.8	20
Silver						
Sodium						
Strontium						
Thallium						
Tin						
Titanium						
Uranium						
Vanadium						
Zinc						

Associated samples MP51790: F71678-21, F71678-22, F71678-23, F71678-24, F71678-25, F71678-26, F71678-27, F71678-28, F71678-29, F71678-30, F71678-31, F71678-32, F71678-33, F71678-34, F71678-35, F71678-36, F71678-37, F71678-38, F71678-39, F71678-40

Results < IDL are shown as zero for calculation purposes
(*) Outside of QC limits
(N) Matrix Spike Rec. outside of QC limits
(anr) Analyte not requested

SPIKE BLANK AND LAB CONTROL SAMPLE SUMMARY

Login Number: F71678
Account: ALSE - Accutest Laboratories Southeast, Inc.
Project: ECTFLLAU: C-11 Speciation Sampling, Broward Co, FL

QC Batch ID: MP51790
Matrix Type: SOLID

Methods: SW846 6020
Units: mg/kg

Prep Date: 03/10/10

Metal	BSP Result	Spikelot MPIRS1	% Rec	QC Limits
Aluminum				
Antimony				
Arsenic				
Barium				
Beryllium				
Boron				
Cadmium				
Calcium				
Chromium				
Cobalt				
Copper				
Iron				
Lead				
Magnesium				
Manganese				
Molybdenum				
Nickel				
Potassium				
Selenium	394	400	98.5	80-120
Silver				
Sodium				
Strontium				
Thallium				
Tin				
Titanium				
Uranium				
Vanadium				
Zinc				

Associated samples MP51790: F71678-21, F71678-22, F71678-23, F71678-24, F71678-25, F71678-26, F71678-27, F71678-28, F71678-29, F71678-30, F71678-31, F71678-32, F71678-33, F71678-34, F71678-35, F71678-36, F71678-37, F71678-38, F71678-39, F71678-40

Results < IDL are shown as zero for calculation purposes
(*) Outside of QC limits
(anr) Analyte not requested

SERIAL DILUTION RESULTS SUMMARY

Login Number: F71678
Account: ALSE - Accutest Laboratories Southeast, Inc.
Project: ECTFLLAU: C-11 Speciation Sampling, Broward Co, FL

QC Batch ID: MP51790
Matrix Type: SOLID

Methods: SW846 6020
Units: ug/l

Prep Date: 03/10/10

Metal	F71678-22 Original	SDL 5:25	%DIF	QC Limits
Aluminum				
Antimony				
Arsenic				
Barium				
Beryllium				
Boron				
Cadmium				
Calcium				
Chromium				
Cobalt				
Copper				
Iron				
Lead				
Magnesium				
Manganese				
Molybdenum				
Nickel				
Potassium				
Selenium	0.743	0.00	100.0(a)	0-10
Silver				
Sodium				
Strontium				
Thallium				
Tin				
Titanium				
Uranium				
Vanadium				
Zinc				

Associated samples MP51790: F71678-21, F71678-22, F71678-23, F71678-24, F71678-25, F71678-26, F71678-27, F71678-28, F71678-29, F71678-30, F71678-31, F71678-32, F71678-33, F71678-34, F71678-35, F71678-36, F71678-37, F71678-38, F71678-39, F71678-40

Results < IDL are shown as zero for calculation purposes
(*) Outside of QC limits
(anr) Analyte not requested
(a) Percent difference acceptable due to low initial sample concentration (< 50 times IDL).

BLANK RESULTS SUMMARY
Part 2 - Method Blanks

Login Number: F71678
Account: ALSE - Accutest Laboratories Southeast, Inc.
Project: ECTFLLAU: C-11 Speciation Sampling, Broward Co, FL

QC Batch ID: MP51801
Matrix Type: SOLID

Methods: SW846 6020
Units: mg/kg

Prep Date:					03/11/10		03/11/10
Metal	RL	IDL	MDL	MB raw	final	MB raw	final
Aluminum	25	.34	.52				
Antimony	0.25	.019	.022				
Arsenic	0.50	.074	.11				
Barium	0.50	.013	.038				
Beryllium	0.25	.007	.03				
Boron	2.5	.29	.25				
Cadmium	0.25	.011	.016				
Calcium	130	3	3.1				
Chromium	2.0	.038	.29				
Cobalt	0.25	.0015	.016				
Copper	2.0	.13	.036				
Iron	25	.68	1.9				
Lead	0.25	.003	.012				
Magnesium	130	.27	1.4				
Manganese	0.25	.006	.02				
Molybdenum	0.50	.024	.096				
Nickel	2.0	.095	.026				
Potassium	130	1.4	3.9				
Selenium	0.50	.039	.058	0.038	<0.50	0.085	<0.50
Silver	1.0	.01	.022				
Sodium	130	.56	1.3				
Strontium	0.50	.004	.0082				
Thallium	0.25	.002	.0051				
Tin	0.50	.025					
Titanium	0.50	.027	.27				
Uranium	0.50						
Vanadium	2.0	.27	.79				
Zinc	2.0	.39	.91				

Associated samples MP51801: F71678-41, F71678-42, F71678-43, F71678-44, F71678-45, F71678-46, F71678-47, F71678-48, F71678-49, F71678-50, F71678-51, F71678-52, F71678-53, F71678-54, F71678-55, F71678-56, F71678-57

Results < IDL are shown as zero for calculation purposes
(*) Outside of QC limits
(anr) Analyte not requested

MATRIX SPIKE AND DUPLICATE RESULTS SUMMARY

Login Number: F71678
Account: ALSE - Accutest Laboratories Southeast, Inc.
Project: ECTFLLAU: C-11 Speciation Sampling, Broward Co, FL

QC Batch ID: MP51801
Matrix Type: SOLID

Methods: SW846 6020
Units: mg/kg

Prep Date: 03/11/10

Metal	F71678-56 Original	MS	Spikelot MPIRS1	% Rec	QC Limits
Aluminum					
Antimony					
Arsenic					
Barium	anr				
Beryllium					
Boron					
Cadmium					
Calcium					
Chromium					
Cobalt					
Copper					
Iron					
Lead					
Magnesium					
Manganese					
Molybdenum					
Nickel					
Potassium					
Selenium	2.8	362	387	92.8	69-125
Silver					
Sodium					
Strontium					
Thallium					
Tin					
Titanium					
Uranium					
Vanadium					
Zinc					

Associated samples MP51801: F71678-41, F71678-42, F71678-43, F71678-44, F71678-45, F71678-46, F71678-47, F71678-48, F71678-49, F71678-50, F71678-51, F71678-52, F71678-53, F71678-54, F71678-55, F71678-56, F71678-57

Results < IDL are shown as zero for calculation purposes
(*) Outside of QC limits
(N) Matrix Spike Rec. outside of QC limits
(anr) Analyte not requested

MATRIX SPIKE AND DUPLICATE RESULTS SUMMARY

Login Number: F71678
Account: ALSE - Accutest Laboratories Southeast, Inc.
Project: ECTFLLAU: C-11 Speciation Sampling, Broward Co, FL

QC Batch ID: MP51801
Matrix Type: SOLID

Methods: SW846 6020
Units: mg/kg

Prep Date: 03/11/10

Metal	F71678-56 Original	MSD	Spikelot MPIRS1	% Rec	MSD RPD	QC Limit
Aluminum						
Antimony						
Arsenic						
Barium	anr					
Beryllium						
Boron						
Cadmium						
Calcium						
Chromium						
Cobalt						
Copper						
Iron						
Lead						
Magnesium						
Manganese						
Molybdenum						
Nickel						
Potassium						
Selenium	2.8	370	389	94.3	2.2	20
Silver						
Sodium						
Strontium						
Thallium						
Tin						
Titanium						
Uranium						
Vanadium						
Zinc						

Associated samples MP51801: F71678-41, F71678-42, F71678-43, F71678-44, F71678-45, F71678-46, F71678-47, F71678-48, F71678-49, F71678-50, F71678-51, F71678-52, F71678-53, F71678-54, F71678-55, F71678-56, F71678-57

Results < IDL are shown as zero for calculation purposes
(*) Outside of QC limits
(N) Matrix Spike Rec. outside of QC limits
(anr) Analyte not requested

SPIKE BLANK AND LAB CONTROL SAMPLE SUMMARY

Login Number: F71678
Account: ALSE - Accutest Laboratories Southeast, Inc.
Project: ECTELLAU: C-11 Speciation Sampling, Broward Co, FL

QC Batch ID: MP51801
Matrix Type: SOLID

Methods: SW846 6020
Units: mg/kg

Prep Date:			03/11/10				03/11/10	
Metal	BSP Result	Spikelot MPIRS1	% Rec	QC Limits	BSP Result	Spikelot MPIRS1	% Rec	QC Limits
Aluminum								
Antimony								
Arsenic								
Barium	anr							
Beryllium								
Boron								
Cadmium								
Calcium								
Chromium								
Cobalt								
Copper								
Iron								
Lead								
Magnesium								
Manganese								
Molybdenum								
Nickel								
Potassium								
Selenium	447	400	111.8	80-120	474	400	118.5	80-120
Silver								
Sodium								
Strontium								
Thallium								
Tin								
Titanium								
Uranium								
Vanadium								
Zinc								

Associated samples MP51801: F71678-41, F71678-42, F71678-43, F71678-44, F71678-45, F71678-46, F71678-47, F71678-48, F71678-49, F71678-50, F71678-51, F71678-52, F71678-53, F71678-54, F71678-55, F71678-56, F71678-57

Results < IDL are shown as zero for calculation purposes
(*) Outside of QC limits
(anr) Analyte not requested

SERIAL DILUTION RESULTS SUMMARY

Login Number: F71678
Account: ALSE - Accutest Laboratories Southeast, Inc.
Project: ECTFLLAU: C-11 Speciation Sampling, Broward Co, FL

QC Batch ID: MP51801 Methods: SW846 6020
Matrix Type: SOLID Units: ug/l

Prep Date: 03/11/10

Metal	F71678-56 Original	SDL 5:25	%DIF	QC Limits
Aluminum				
Antimony				
Arsenic				
Barium	anr			
Beryllium				
Boron				
Cadmium				
Calcium				
Chromium				
Cobalt				
Copper				
Iron				
Lead				
Magnesium				
Manganese				
Molybdenum				
Nickel				
Potassium				
Selenium	28.7	33.1	15.2*(a)	0-10
Silver				
Sodium				
Strontium				
Thallium				
Tin				
Titanium				
Uranium				
Vanadium				
Zinc				

Associated samples MP51801: F71678-41, F71678-42, F71678-43, F71678-44, F71678-45, F71678-46, F71678-47, F71678-48, F71678-49, F71678-50, F71678-51, F71678-52, F71678-53, F71678-54, F71678-55, F71678-56, F71678-57

Results < IDL are shown as zero for calculation purposes
(*) Outside of QC limits
(anr) Analyte not requested
(a) Serial dilution indicates possible matrix interference.

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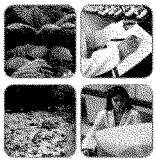
Automated Report

Southeast ACCUTEST Laboratories

IT'S ALL IN THE CHEMISTRY

04/02/10



Technical Report for

ECT

C9/C11 Selenium; Weston, FL

10-0096

Accutest Job Number: F71708

Sampling Date: 02/26/10

Report to:

ECT

padak@ectinc.com

ATTN: Probas Adak

Total number of pages in report: 45

ACCUTEST LABORATORIES 50 YEARS 1956-2006

ACCREDITED IN ACCORDANCE WITH nelac

Test results contained within this data package meet the requirements of the National Environmental Laboratory Accreditation Conference and/or state specific certification programs as applicable.

Harry Behzadi, Ph.D.
Laboratory Director

Client Service contact: Sue Bell 407-425-6700

Certifications: FL (DOH E83510), NC (573), NJ (FL002), MA (FL946), IA (366), LA (03051), KS (E-10327), SC, AK
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Sample Summary

ECT

Job No: F71708

C9/C11 Selenium; Weston, FL
Project No: 10-0096

Sample Number	Collected Date	Time By	Received	Matrix Code	Type	Client Sample ID
F71708-1	02/26/10	11:57 PA	03/02/10	SO	Soil	CSS-C11-2
F71708-2	02/26/10	12:20 PA	03/02/10	SO	Soil	CSS-C11-3
F71708-3	02/26/10	12:42 PA	03/02/10	SO	Soil	CSS-C11-4
F71708-4	02/26/10	13:20 PA	03/02/10	SO	Soil	CSS-C11-5
F71708-5	02/26/10	13:05 PA	03/02/10	SO	Soil	CSS-C11-6
F71708-6	02/26/10	14:05 PA	03/02/10	SO	Soil	CSS-C11-7
F71708-7	02/26/10	11:35 PA	03/02/10	SO	Soil	CSS-C11-8
F71708-8	02/26/10	11:15 PA	03/02/10	SO	Soil	CSS-C11-9
F71708-9	02/26/10	10:42 PA	03/02/10	SO	Soil	CSS-C11-11
F71708-10	02/26/10	09:45 PA	03/02/10	SO	Soil	CSS-C11-13
F71708-11	02/26/10	13:40 PA	03/02/10	SO	Soil	CSS-C11-14
F71708-12	02/26/10	14:55 PA	03/02/10	SO	Soil	CSS-C11-15
F71708-13	02/26/10	09:58 PA	03/02/10	SO	Soil	CSS-C11-16

Soil samples reported on a dry weight basis unless otherwise indicated on result page.

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Sample Summary
(continued)

ECT

Job No: F71708

C9/C11 Selenium; Weston, FL
Project No: 10-0096

Sample Number	Collected Date	Time By	Received	Matrix Code	Matrix Type	Client Sample ID
F71708-14	02/26/10	15:30 PA	03/02/10	SO	Soil	CSS-C11-17
F71708-15	02/26/10	15:05 PA	03/02/10	SO	Soil	CSS-C11-22
F71708-16	02/26/10	10:18 PA	03/02/10	SO	Soil	CSS-C11-23
F71708-17	02/26/10	14:30 PA	03/02/10	SO	Soil	CSS-C11-24
F71708-18	02/26/10	14:40 PA	03/02/10	SO	Soil	CSS-C11-32

Soil samples reported on a dry weight basis unless otherwise indicated on result page.

Sample Results

Report of Analysis

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Report of Analysis

Client Sample ID:	CSS-C11-2		
Lab Sample ID:	F71708-1	**Date Sampled:**	02/26/10
Matrix:	SO - Soil	**Date Received:**	03/02/10
		Percent Solids:	57.3
Project:	C9/C11 Selenium; Weston, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed By	Method	Prep Method
Barium [a]	22.0	0.50	0.038	mg/kg	5	03/09/10	03/09/10 ANJ	SW846 6020 [1]	SW846 3050B [2]
Selenium [a]	0.95	0.50	0.058	mg/kg	5	03/09/10	03/09/10 ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23949
(2) Prep QC Batch: N:MP51777

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

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Report of Analysis

Client Sample ID:	CSS-C11-2		
Lab Sample ID:	F71708-1	**Date Sampled:**	02/26/10
Matrix:	SO - Soil	**Date Received:**	03/02/10
		Percent Solids:	57.3
Project:	C9/C11 Selenium; Weston, FL		

General Chemistry

Analyte	Result	RL	MDL	Units	DF	Analyzed	By	Method
Solids, Percent	57.3			%	1	03/02/10	CP	SM19 2540B M
Total Organic Carbon	12800	1700	870	mg/kg	1	03/15/10 17:25	SD	SW846 9060A MOD

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

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Report of Analysis

Client Sample ID:	CSS-C11-3		
Lab Sample ID:	F71708-2	**Date Sampled:**	02/26/10
Matrix:	SO - Soil	**Date Received:**	03/02/10
		Percent Solids:	49.7
Project:	C9/C11 Selenium; Weston, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed By		Method	Prep Method
Barium [a]	24.2	0.50	0.038	mg/kg	5	03/09/10	03/09/10	ANJ	SW846 6020 [1]	SW846 3050B [2]
Selenium [a]	1.3	0.50	0.058	mg/kg	5	03/09/10	03/09/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23949
(2) Prep QC Batch: N:MP51777

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

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Report of Analysis

Client Sample ID:	CSS-C11-4		
Lab Sample ID:	F71708-3	**Date Sampled:**	02/26/10
Matrix:	SO - Soil	**Date Received:**	03/02/10
		Percent Solids:	31.5
Project:	C9/C11 Selenium; Weston, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Barium [a]	55.6	0.50	0.038	mg/kg	5	03/09/10	03/09/10	ANJ	SW846 6020 [1]	SW846 3050B [2]
Selenium [a]	2.0	0.50	0.059	mg/kg	5	03/09/10	03/09/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23949
(2) Prep QC Batch: N:MP51777

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

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Report of Analysis

Client Sample ID:	CSS-C11-5		
Lab Sample ID:	F71708-4	**Date Sampled:**	02/26/10
Matrix:	SO - Soil	**Date Received:**	03/02/10
		Percent Solids:	42.2
Project:	C9/C11 Selenium; Weston, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed By	Method	Prep Method
Barium [a]	34.1	0.50	0.038	mg/kg	5	03/09/10	03/09/10 ANJ	SW846 6020 [1]	SW846 3050B [2]
Selenium [a]	2.0	0.50	0.059	mg/kg	5	03/09/10	03/09/10 ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23949
(2) Prep QC Batch: N:MP51777

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

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Report of Analysis

Client Sample ID:	CSS-C11-5		
Lab Sample ID:	F71708-4	**Date Sampled:**	02/26/10
Matrix:	SO - Soil	**Date Received:**	03/02/10
		Percent Solids:	42.2
Project:	C9/C11 Selenium; Weston, FL		

General Chemistry

Analyte	Result	RL	MDL	Units	DF	Analyzed	By	Method
Solids, Percent	42.2			%	1	03/02/10	CP	SM19 2540B M
Total Organic Carbon	21800	2400	1200	mg/kg	1	03/15/10 17:06	SD	SW846 9060A MOD

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

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Report of Analysis

Client Sample ID:	CSS-C11-6		
Lab Sample ID:	F71708-5	**Date Sampled:**	02/26/10
Matrix:	SO - Soil	**Date Received:**	03/02/10
		Percent Solids:	42.5
Project:	C9/C11 Selenium; Weston, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed By	Method	Prep Method
Barium [a]	50.5	0.51	0.039	mg/kg	5	03/09/10	03/09/10 ANJ	SW846 6020 [1]	SW846 3050B [2]
Selenium [a]	2.4	0.51	0.060	mg/kg	5	03/09/10	03/09/10 ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23949
(2) Prep QC Batch: N:MP51777

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

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Report of Analysis

Client Sample ID:	CSS-C11-7		
Lab Sample ID:	F71708-6	**Date Sampled:**	02/26/10
Matrix:	SO - Soil	**Date Received:**	03/02/10
		Percent Solids:	83.2
Project:	C9/C11 Selenium; Weston, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Barium [a]	4.9	0.51	0.039	mg/kg	5	03/09/10	03/09/10	ANJ	SW846 6020 [1]	SW846 3050B [2]
Selenium [a]	0.12 I	0.51	0.059	mg/kg	5	03/09/10	03/09/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23949
(2) Prep QC Batch: N:MP51777

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

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Report of Analysis

Client Sample ID:	CSS-C11-8		
Lab Sample ID:	F71708-7	**Date Sampled:**	02/26/10
Matrix:	SO - Soil	**Date Received:**	03/02/10
		Percent Solids:	55.1
Project:	C9/C11 Selenium; Weston, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Barium [a]	33.0	0.51	0.039	mg/kg	5	03/09/10	03/09/10	ANJ	SW846 6020 [1]	SW846 3050B [2]
Selenium [a]	0.55	0.51	0.059	mg/kg	5	03/09/10	03/09/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23949
(2) Prep QC Batch: N:MP51777

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

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Report of Analysis

Client Sample ID:	CSS-C11-9		
Lab Sample ID:	F71708-8	**Date Sampled:**	02/26/10
Matrix:	SO - Soil	**Date Received:**	03/02/10
		Percent Solids:	29.9
Project:	C9/C11 Selenium; Weston, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Barium [a]	29.2	0.51	0.039	mg/kg	5	03/09/10	03/09/10	ANJ	SW846 6020 [1]	SW846 3050B [2]
Selenium [a]	0.41 I	0.51	0.059	mg/kg	5	03/09/10	03/09/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23949
(2) Prep QC Batch: N:MP51777

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

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Report of Analysis

Client Sample ID:	CSS-C11-11		
Lab Sample ID:	F71708-9	**Date Sampled:**	02/26/10
Matrix:	SO - Soil	**Date Received:**	03/02/10
		Percent Solids:	44.2
Project:	C9/C11 Selenium; Weston, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed By	Method	Prep Method
Barium [a]	36.5	0.51	0.039	mg/kg	5	03/09/10	03/09/10 ANJ	SW846 6020 [1]	SW846 3050B [2]
Selenium [a]	0.66	0.51	0.059	mg/kg	5	03/09/10	03/09/10 ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23949
(2) Prep QC Batch: N:MP51777

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

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Report of Analysis

Client Sample ID:	CSS-C11-13		
Lab Sample ID:	F71708-10	**Date Sampled:**	02/26/10
Matrix:	SO - Soil	**Date Received:**	03/02/10
		Percent Solids:	20.9
Project:	C9/C11 Selenium; Weston, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Barium [a]	64.5	0.51	0.039	mg/kg	5	03/09/10	03/09/10	ANJ	SW846 6020 [1]	SW846 3050B [2]
Selenium [a]	3.4	0.51	0.060	mg/kg	5	03/09/10	03/09/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23949
(2) Prep QC Batch: N:MP51777

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

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Report of Analysis

Client Sample ID:	CSS-C11-14		
Lab Sample ID:	F71708-11	**Date Sampled:**	02/26/10
Matrix:	SO - Soil	**Date Received:**	03/02/10
		Percent Solids:	42.6
Project:	C9/C11 Selenium; Weston, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Barium [a]	19.2	0.50	0.038	mg/kg	5	03/09/10	03/09/10	ANJ	SW846 6020 [1]	SW846 3050B [2]
Selenium [a]	0.63	0.50	0.058	mg/kg	5	03/09/10	03/09/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23949
(2) Prep QC Batch: N:MP51777

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

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Report of Analysis

Client Sample ID:	CSS-C11-15		
Lab Sample ID:	F71708-12	**Date Sampled:**	02/26/10
Matrix:	SO - Soil	**Date Received:**	03/02/10
		Percent Solids:	81.3
Project:	C9/C11 Selenium; Weston, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Barium [a]	10.5	0.51	0.039	mg/kg	5	03/09/10	03/09/10	ANJ	SW846 6020 [1]	SW846 3050B [2]
Selenium [a]	0.461	0.51	0.060	mg/kg	5	03/09/10	03/09/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23949
(2) Prep QC Batch: N:MP51777

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest LabLink@101081 15:41 02-Apr-2010

Report of Analysis

Client Sample ID:	CSS-C11-15		
Lab Sample ID:	F71708-12	**Date Sampled:**	02/26/10
Matrix:	SO - Soil	**Date Received:**	03/02/10
		Percent Solids:	81.3
Project:	C9/C11 Selenium; Weston, FL		

General Chemistry

Analyte	Result	RL	MDL	Units	DF	Analyzed	By	Method
Solids, Percent	81.3			%	1	03/02/10	CP	SM19 2540B M
Total Organic Carbon	9620	1200	620	mg/kg	1	03/15/10 16:44	SD	SW846 9060A MOD

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

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Report of Analysis

Client Sample ID:	CSS-C11-16		
Lab Sample ID:	F71708-13	**Date Sampled:**	02/26/10
Matrix:	SO - Soil	**Date Received:**	03/02/10
		Percent Solids:	63.0
Project:	C9/C11 Selenium; Weston, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Barium [a]	18.1	0.51	0.039	mg/kg	5	03/09/10	03/09/10	ANJ	SW846 6020 [1]	SW846 3050B [3]
Selenium [a]	0.67	0.51	0.059	mg/kg	5	03/09/10	03/10/10	ANJ	SW846 6020 [2]	SW846 3050B [3]

(1) Instrument QC Batch: N:MA23949
(2) Instrument QC Batch: N:MA23956
(3) Prep QC Batch: N:MP51777

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

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Report of Analysis

Client Sample ID:	CSS-C11-17		
Lab Sample ID:	F71708-14	**Date Sampled:**	02/26/10
Matrix:	SO - Soil	**Date Received:**	03/02/10
		Percent Solids:	77.4
Project:	C9/C11 Selenium; Weston, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Barium [a]	11.0	0.52	0.040	mg/kg	5	03/09/10	03/09/10	ANJ	SW846 6020 [1]	SW846 3050B [3]
Selenium [a]	0.33 I	0.52	0.060	mg/kg	5	03/09/10	03/10/10	ANJ	SW846 6020 [2]	SW846 3050B [3]

(1) Instrument QC Batch: N:MA23949
(2) Instrument QC Batch: N:MA23956
(3) Prep QC Batch: N:MP51777

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest LabLink@101081 15:41 02-Apr-2010

Report of Analysis

Client Sample ID:	CSS-C11-17		
Lab Sample ID:	F71708-14	**Date Sampled:**	02/26/10
Matrix:	SO - Soil	**Date Received:**	03/02/10
		Percent Solids:	77.4
Project:	C9/C11 Selenium; Weston, FL		

General Chemistry

Analyte	Result	RL	MDL	Units	DF	Analyzed	By	Method
Solids, Percent	77.4			%	1	03/02/10	CP	SM19 2540B M
Total Organic Carbon	9000	1300	650	mg/kg	1	03/15/10 13:39	SD	SW846 9060A MOD

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest LabLink@101081 15:41 02-Apr-2010

Report of Analysis

Client Sample ID:	CSS-C11-22		
Lab Sample ID:	F71708-15	**Date Sampled:**	02/26/10
Matrix:	SO - Soil	**Date Received:**	03/02/10
		Percent Solids:	71.4
Project:	C9/C11 Selenium; Weston, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Barium [a]	12.3	0.52	0.040	mg/kg	5	03/09/10	03/09/10	ANJ	SW846 6020 [1]	SW846 3050B [3]
Selenium [a]	0.171	0.52	0.060	mg/kg	5	03/09/10	03/10/10	ANJ	SW846 6020 [2]	SW846 3050B [3]

(1) Instrument QC Batch: N:MA23949
(2) Instrument QC Batch: N:MA23956
(3) Prep QC Batch: N:MP51777

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest LabLink@101081 15:41 02-Apr-2010

Report of Analysis

Client Sample ID:	CSS-C11-23		
Lab Sample ID:	F71708-16	**Date Sampled:**	02/26/10
Matrix:	SO - Soil	**Date Received:**	03/02/10
		Percent Solids:	63.9
Project:	C9/C11 Selenium; Weston, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Barium [a]	12.9	0.51	0.039	mg/kg	5	03/09/10	03/09/10	ANJ	SW846 6020 [1]	SW846 3050B [3]
Selenium [a]	0.20 I	0.51	0.060	mg/kg	5	03/09/10	03/10/10	ANJ	SW846 6020 [2]	SW846 3050B [3]

(1) Instrument QC Batch: N:MA23949
(2) Instrument QC Batch: N:MA23956
(3) Prep QC Batch: N:MP51777

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

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Report of Analysis

Client Sample ID:	CSS-C11-24		
Lab Sample ID:	F71708-17	**Date Sampled:**	02/26/10
Matrix:	SO - Soil	**Date Received:**	03/02/10
		Percent Solids:	71.4
Project:	C9/C11 Selenium; Weston, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Barium [a]	11.9	0.50	0.039	mg/kg	5	03/09/10	03/09/10	ANJ	SW846 6020 [1]	SW846 3050B [3]
Selenium [a]	0.22 I	0.50	0.059	mg/kg	5	03/09/10	03/10/10	ANJ	SW846 6020 [2]	SW846 3050B [3]

(1) Instrument QC Batch: N:MA23949
(2) Instrument QC Batch: N:MA23956
(3) Prep QC Batch: N:MP51777

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest LabLink@101081 15:41 02-Apr-2010

Report of Analysis

Client Sample ID:	CSS-C11-32		
Lab Sample ID:	F71708-18	**Date Sampled:**	02/26/10
Matrix:	SO - Soil	**Date Received:**	03/02/10
		Percent Solids:	81.9
Project:	C9/C11 Selenium; Weston, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Barium [a]	17.4	0.52	0.040	mg/kg	5	03/09/10	03/09/10	ANJ	SW846 6020 [1]	SW846 3050B [2]
Selenium [a]	0.161	0.52	0.060	mg/kg	5	03/09/10	03/09/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23949
(2) Prep QC Batch: N:MP51777

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest LabLink@101081 15:41 02-Apr-2010

Report of Analysis

Client Sample ID:	CSS-C11-32		
Lab Sample ID:	F71708-18	**Date Sampled:**	02/26/10
Matrix:	SO - Soil	**Date Received:**	03/02/10
		Percent Solids:	81.9
Project:	C9/C11 Selenium; Weston, FL		

General Chemistry

Analyte	Result	RL	MDL	Units	DF	Analyzed	By	Method
Solids, Percent	81.9			%	1	03/02/10	CP	SM19 2540B M
Total Organic Carbon	9540	1200	610	mg/kg	1	03/15/10 16:19	SD	SW846 9060A MOD

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Misc. Forms

Custody Documents and Other Forms

Includes the following where applicable:

- Certification Exceptions
- Chain of Custody

Accutest Laboratories Southeast
Chain of Custody

ACCUTEST.

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TEL: 407-425-6700 • FAX: 407-425-0707
www.accutest.com

Accutest JOB # F71708 PAGE 1 OF 2
Accutest Quote #

Client / Reporting Information

Company Name: ICT
Address: 6200 NW 1st Ave #100
City: Ft L State: FL Zip: 33334
Project Contact: Barry Wickenden
E-mail:
Phone: 954-371-0444
Sampler(s) Name(s) (Printed): Rod Adair

Project Information

Project Name: C9/C11 Selenium
Street:
City: Weston State: FL
Project #:
Fax #:
Client Purchase Order #:

Analytical Information

Accutest Sample #	Field ID / Point of Collection	Date	Time	Sampled By	Matrix	Total # of Bottles	Cooler	VOA	AMBER	PLASTIC	MEDICAL	PLASTIC/PREC	SUMMER	MISC	Se, Br	TOC										
1	CSS-C11-2	2/24	1155	PA	SO	2										X										
2	CSS-C11-3		1220			1																				
3	CSS-C11-4		1242			1																				
4	CSS-C11-5		1320			2										X										
5	CSS-C11-6		1305			1																				
6	CSS-C11-7		1405			1																				
7	CSS-C11-8		1155			1																				
8	CSS-C11-9		1115			1																				
9	CSS-C11-11		1042			1																				
10	CSS-C11-13		945			1																				
11	CSS-C11-14		1340			1																				
12	CSS-C11-15	↓	1455	↓	↓	2										↓ X										

Matrix Codes: DW - Drinking Water; GW - Ground Water; WW - Water; SW - Surface Water; SO - Soil; SL - Sludge; OI - Oil; LIQ - Other Liquid; AIR - Air; SOL - Other Solid; WP - Wipe

LAB USE ONLY

TURNAROUND TIME (Business Days)

Approved By: / Rush Code

- [x] 10 Days Standard
- [ ] 7 Day RUSH
- [ ] 5 Day RUSH
- [ ] 3 Day EMERGENCY
- [ ] 2 Day EMERGENCY
- [ ] 1 Day EMERGENCY
- [ ] OTHER

Emergency or Rush T/A Data Available VIA Email or Labink

Data Deliverable Information

- [ ] COMMERCIAL "A" (RESULTS ONLY)
- [ ] COMMERCIAL "B" (RESULTS PLUS QC)
- [ ] REDT1 (EPA LEVEL 3)
- [ ] FULT1 (EPA LEVEL 4)
- [x] EDD'S ADAPT

Comments / Remarks

Sample Custody must be documented below each time samples change possession, including courier delivery.

Relinquished by Sampler:	Date Time:	Received By:	Relinquished By:	Date Time:	Received By:
1 Rod Adair		2 [illegible] 03/02/10	3 [illegible]		4 [illegible] Accutest
Relinquished by:	Date Time:	Received By:	Relinquished by:	Date Time:	Received By: 03-03-10 08:10
5		6	7		8

Lab Use Only: Custody Seal in Place: Y N Temp Blank Provided: Y N Preserved where Applicable: Y N Total # of Coolers: Cooler Temperature (s) Celsius: 7.4

F71708: Chain of Custody
Page 1 of 3

Accutest Laboratories Southeast
Chain of Custody

ACCUTEST.

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TEL. 407-425-6700 • FAX: 407-425-0707
www.accutest.com

Accutest JOB # F71708 PAGE 2 OF 2
Accutest Quote #

Client / Reporting Information

Company Name: GCT
Address: 6260 NE 1st Ave #100
City: FTL State: FL Zip: 33334
Project Contact: Barry Wittmann
Email:
Phone#: 954-771-0944
Fax #:
Sampler(s) Name(s) (Printed): Paul Adele

Project Information

Project Name: CG/CII Selenium
Street:
City: Weston State: FL
Project #:
Client Purchase Order #:

Analytical Information

Accutest Sample #	Field ID / Point of Collection	Date	Time	Sampled By	Matrix	Total # of Bottles	Other	Acids	NaOH	Hexane	Acetone	Methanol/DI	Na2S2O3	Sel. Se	TOC
13	CSS-CII-16	2/16	958	PA	SO	1									
14	CSS-CII-17	2/16	1520	PA	SO	2									X
15	CSS-CII-22		1525			1									
16	CSS-CII-23		1048			1									
17	CSS-CII-24		1450			1									
18	CSS-CII-32		1440			2									X

Matrix Codes: DW - Drinking Water; GW - Ground Water; WW - Water; SW - Surface Water; SO - Soil; SL - Sludge; OI - Oil; LIQ - Other Liquid; AIR - Air; SOL - Other Solid; WIP - Wipe

LAB USE ONLY

TURNAROUND TIME (Business Days)

Approved By: / Rush Code

- [X] 10 Days Standard
- [ ] 7 Day RUSH
- [ ] 5 Day RUSH
- [ ] 3 Day EMERGENCY
- [ ] 2 Day EMERGENCY
- [ ] 1 Day EMERGENCY
- [ ] OTHER

Emergency or Rush T/A Data Available VIA Email or Labtrk

Data Deliverable Information

- [ ] COMMERCIAL "A" (RESULTS ONLY)
- [ ] COMMERCIAL "B" (RESULTS PLUS QC)
- [ ] REDT1 (EPA LEVEL 3)
- [ ] FULT1 (EPA LEVEL 4)
- [X] EDD'S ASAPT

Comments / Remarks

Sample Custody must be documented below each time samples change possession, including courier delivery.

Relinquished by Sampler:	Date Time:	Received By:	Relinquished by:	Date Time:	Received By:
1 Paul Adele		2 Paul Adele (ASE) 3/11/10	3 Paul Adele (ASE) 3/11/10 15:55		4 Accutest
Relinquished by:	Date Time:	Received By:	Relinquished by:	Date Time:	Received By:
5		6	7		8

Lab Use Only: Custody Seal in Place: Y N Temp Blank Provided: Y N Preserved where Applicable: Y N Total # of Coolers: Cooler Temperature (s) Celsius: 2.4

3.1 3

F71708: Chain of Custody
Page 2 of 3

ACCUTEST LABORATORIES SAMPLE RECEIPT CONFIRMATION

ACCUTEST'S JOB NUMBER: F71708 CLIENT: ECT PROJECT: C9/C11

DATE/TIME RECEIVED: 03-02-10 08:00 (MM/DD/YY 24:00) NUMBER OF COOLERS RECEIVED: 1

METHOD OF DELIVERY: FEDEX UPS ACCUTEST COURIER GREYHOUND DELIVERY OTHER

AIRBILL NUMBERS:

COOLER INFORMATION

- [ ] CUSTODY SEAL NOT PRESENT OR NOT INTACT
- [ ] CHAIN OF CUSTODY NOT RECEIVED (COC)
- [ ] ANALYSIS REQUESTED IS UNCLEAR OR MISSING
- [ ] SAMPLE DATES OR TIMES UNCLEAR OR MISSING
- [ ] TEMPERATURE CRITERIA NOT MET
- [ ] WET ICE PRESENT

TRIP BLANK INFORMATION

- [ ] TRIP BLANK PROVIDED
- [x] TRIP BLANK NOT PROVIDED
- [x] TRIP BLANK NOT ON COC
- [ ] TRIP BLANK INTACT
- [ ] TRIP BLANK NOT INTACT
- [ ] RECEIVED WATER TRIP BLANK
- [ ] RECEIVED SOIL TRIP BLANK

MISC. INFORMATION

NUMBER OF ENCORES ? 0

NUMBER OF 5035 FIELD KITS ? 0

NUMBER OR LAB FILTERED METALS ? 0

TEMPERATURE INFORMATION

- [ ] IR THERM ID 2 CORR. FACTOR Ø
- [ ] OBSERVED TEMPS: 2-4
- [ ] CORRECTED TEMPS: 2-4

SAMPLE INFORMATION

- [ ] SAMPLE LABELS PRESENT ON ALL BOTTLES
- [ ] INCORRECT NUMBER OF CONTAINERS USED
- [ ] SAMPLE RECEIVED IMPROPERLY PRESERVED
- [ ] INSUFFICIENT VOLUME FOR ANALYSIS
- [ ] DATES/TIMES ON COC DO NOT MATCH SAMPLE LABEL
- [ ] ID'S ON COC DO NOT MATCH LABEL
- [ ] VOC VIALS HAVE HEADSPACE (MACRO BUBBLES)
- [ ] BOTTLES RECEIVED BUT ANALYSIS NOT REQUESTED
- [ ] NO BOTTLES RECEIVED FOR ANALYSIS REQUESTED
- [ ] UNCLEAR FILTERING OR COMPOSITING INSTRUCTIONS
- [ ] SAMPLE CONTAINER(S) RECEIVED BROKEN
- [ ] % SOLIDS JAR NOT RECEIVED
- [ ] 5035 FIELD KIT FROZEN WITHIN 48 HOUR'S
- [ ] RESIDUAL CHLORINE PRESENT

(APPICABLE TO EPA 600 SERIES OR NORTH CAROLINA ORGANICS)

SUMMARY OF COMMENTS:

TECHNICIAN SIGNATURE/DATE E.T. 03-02-10 REVIEWER SIGNATURE/DATE VC 03-02-10

NF 10/09 RECEIPT CONFIRMATION 100609 (2).xls

F71708: Chain of Custody
Page 3 of 3

General Chemistry

QC Data Summaries

Includes the following where applicable:

- Method Blank and Blank Spike Summaries
- Duplicate Summaries
- Matrix Spike Summaries

METHOD BLANK AND SPIKE RESULTS SUMMARY
GENERAL CHEMISTRY

Login Number: F71708
Account: ECTFLLAU - ECT
Project: C9/C11 Selenium; Weston, FL

Analyte	Batch ID	RL	MB Result	Units	Spike Amount	BSP Result	BSP %Recov	QC Limits
Total Organic Carbon	GP14481/GN38846	1000	0.0	mg/kg	20000	21300	106.5	88-114%

Associated Samples:
Batch GP14481: F71708-1, F71708-12, F71708-14, F71708-18, F71708-4
(*) Outside of QC limits

DUPLICATE RESULTS SUMMARY
GENERAL CHEMISTRY

Login Number: F71708
Account: ECTFLLAU - ECT
Project: C9/C11 Selenium; Weston, FL

Analyte	Batch ID	QC Sample	Units	Original Result	DUP Result	RPD	QC Limits
Solids, Percent	GN38642	F71706-1	%	78.1	77.1	1.3	0-10%
Solids, Percent	GN38742	F71862-9	%	78.1	75.2	3.8	0-10%
Total Organic Carbon	GP14481/GN38846	F71708-14	mg/kg	9000	9280	3.1	0-36%

Associated Samples:
Batch GN38642: F71708-1, F71708-10, F71708-11, F71708-12, F71708-13, F71708-14, F71708-15, F71708-16, F71708-17, F71708-18, F71708-2, F71708-3, F71708-4, F71708-5, F71708-6, F71708-7, F71708-8
Batch GN38742: F71708-9
Batch GP14481: F71708-1, F71708-12, F71708-14, F71708-18, F71708-4
(*) Outside of QC limits

MATRIX SPIKE RESULTS SUMMARY
GENERAL CHEMISTRY

Login Number: F71708
Account: ECTFLLAU - ECT
Project: C9/C11 Selenium; Weston, FL

Analyte	Batch ID	QC Sample	Units	Original Result	Spike Amount	MS Result	%Rec	QC Limits
Total Organic Carbon	GP14481/GN38846	F71708-14	mg/kg	9000	25800	35100	101.0	88-114%

Associated Samples:
Batch GP14481: F71708-1, F71708-12, F71708-14, F71708-18, F71708-4
(*) Outside of QC limits
(N) Matrix Spike Rec. outside of QC limits

Misc. Forms

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Custody Documents and Other Forms

(Accutest New Jersey)

Includes the following where applicable:

- Chain of Custody

Accutest Southeast Subcontract Chain of Custody

ACCUTEST Laboratories

4405 Vineland Road, Suite C-15 Orlando, Fl 32811
TEL. 407-425-6700 • FAX 407-425-0707

PAGE 1 OF 2

FX 7984 3786 5495

Client / Reporting Information

Company Name: Accutest Laboratories Southeast
Address: 4405 Vineland Road Suite C-15
City: Orlando State: Fl Zip: 32811
Project Contact: E-mail:
Phone#: 407-425-6700 Fax #: 407-425-0707
Lab Technician Printed Name:

Project Information

Accutest Job Number: F71708
Street
City
Project #
Fax #
Client Purchase

Please send report to dnwnd@accutest.com

For any other issues contact munam@accutest.com

Analytical Information

Sludge Sludge

Matrix Codes

DW - Drinking Water
GW - Ground Water
WS - Water
SW - Surface Water
SO - Soil
SL - Sludge
OI - Oil
LIQ - Other Liquid
AIR - Air
SOL - Other Solid

Lab ID #	Client ID / Accutest Sample ID	Collection DATE	Collection TIME	Sampled by	Matrix	Total # of Bottles	Chlorine	Sulfide	HCl	HNO3	H2SO4	NaOH	NaHSO4	ZnAcO2	NaOH	Sludge	LAB USE ONLY
	F71708-1	02 Mar	1157		SO	1	X									X	
	-2		1200														
	-3		1145														
	-4		1200														
	-5		1115														
	-6		1405														
	-7		1135														
	-8		1115														
	-9		1047														
	-10		0945														
	-11		1240														
	-12		1405														

TURNAROUND TIME (Business Days)

Approved By:

Standard 10 Business Days
7 Day RUSH
5 Day RUSH Due
3 Day EMERGENCY
2 Day EMERGENCY 03-12-10
1 Day EMERGENCY
OTHER

Data Deliverable Information

- [ ] COMMERCIAL "A" (RESULTS ONLY)
- [x] COMMERCIAL "B" (RESULTS PLUS QC)
- [ ] REDT1 (EPA LEVEL 3)
- [ ] FULLT1 (EPA LEVEL 4)
- [ ] EDD 3

Comments / Remarks

Ship to Laboratory- AINJ
Approved By: Munam Khanna

Sample Custody must be documented below each time samples change possession, including courier delivery.

Relinquished by/Technician	Date Time:	Received By/Affiliation	Relinquished by/Affiliation	Date Time:	Received By/Affiliation
1	03-10-10	2	3	3-3-10 9:45	4
Relinquished by/Affiliation	Date Time:	Received By/Affiliation	Relinquished by/Affiliation	Date Time:	Received By/Affiliation
5		6	7		8

Lab Use Only: Custody Seal In Place: Y (N) Temp Blank Provided: (Y) N Preserved Where Applicable: Y N Total # of Coolers: 1 Cooler Temperature (s) Celsius: 3.6°C

5.1 5

F71708: Chain of Custody
Page 1 of 2
Accutest New Jersey

Accutest Southeast Subcontract Chain of Custody

ACCUTEST Laboratories

4405 Vineland Road, Suite C-15 Orlando, Fl 32811
TEL: 407-425-6700 • FAX: 407-425-0707

PAGE 2 OF 2

Client / Reporting Information

Company Name: Accutest Laboratories Southeast
Address: 4405 Vineland Road Suite C-15
City: Orlando State: Fl Zip: 32811
Project Contact: Email:
Phone#: 407-425-6700 Fax #: 407-425-0707
Lab Technician Printed Name:

Project Information

Accutest Job Number: F71708
Street:
City:
Project #:
Fax #:
Client Purchase Order #:

Please send report to dawnd@accutest.com
For any other issues contact mouam@accutest.com

Analytical Information

Bacs, Jems

Matrix Codes

DW - Drinking Water
GW - Ground Water
WW - Waste Water
SW - Surface Water
SO - Soil
SL - Sludge
O - Oil
LIQ - Other Liquid
AIR - Air
SOL - Other Solid

Lab ID #	Client ID / Accutest Sample ID	DATE	TIME	SAMPLED BY	MATRIX	TOTAL # OF BOTTLES	CONTAINER INFORMATION: HCL	NaOH	HNO3	H2SO4	NaS2O3	NaHSO4	DI H2O	Bacs, Jems	LAB USE ONLY
	F71708-13	03-10	0958		SO	1	X							X	
	-14		1530												
	-15		1035												
	-16		1018												
	-17		1470												
	-18		1440												

TURNAROUND TIME (Business Days)

Approved By:

- Standard 10 Business Days
- 7 Day RUSH
- 5 Day RUSH — Date
- 3 Day EMERGENCY
- 2 Day EMERGENCY — 03-12-10
- 1 Day EMERGENCY
- OTHER

Data Deliverable Information

- [ ] COMMERCIAL "A" (RESULTS ONLY)
- [x] COMMERCIAL "B" (RESULTS PLUS QC)
- [ ] REDT1 (EPA LEVEL 3)
- [ ] FULLT1 (EPA LEVEL 4)
- [ ] EDD'S

Comments / Remarks

Ship to Laboratory- AIJ
Approved By- Munar Mohammed

Sample Custody must be documented below each time samples change possession, including courier delivery.

Relinquished by/Lab Technician	Date Time:	Received By/Affiliation	Relinquished by/Affiliation	Date Time:	Received By/Affiliation
1	03-10 1730	2	3	3-3-10 9:45	4
Relinquished by/Affiliation	Date Time:	Received By/Affiliation	Relinquished by/Affiliation	Date Time:	Received By/Affiliation
5		6	7		8

Lab Use Only: Custody Seal in Place: Y N Temp Blank Provided: Y N Preserved Where Applicable: Y N Total # of Coolers: ____ Cooler Temperature (s) Celsius: ____

5.1 5

F71708: Chain of Custody
Page 2 of 2

Metals Analysis

6

QC Data Summaries

(Accutest New Jersey)

Includes the following where applicable:

- Method Blank Summaries
- Matrix Spike and Duplicate Summaries
- Blank Spike and Lab Control Sample Summaries
- Serial Dilution Summaries

BLANK RESULTS SUMMARY
Part 2 - Method Blanks

Login Number: F71708
Account: ALSE - Accutest Laboratories Southeast, Inc.
Project: ECTELLAU: C9/C11 Selenium; Weston, FL

QC Batch ID: MP51777
Matrix Type: SOLID

Methods: SW846 6020
Units: mg/kg

Prep Date: 03/09/10

Metal	RL	IDL	MDL	MB raw	final
Aluminum	25	.34	.52		
Antimony	0.25	.019	.022		
Arsenic	0.50	.074	.11		
Barium	0.50	.013	.038	-0.0056	<0.50
Beryllium	0.25	.007	.03		
Boron	2.5	.29	.25		
Cadmium	0.25	.011	.016		
Calcium	130	3	3.1		
Chromium	2.0	.038	.29		
Cobalt	0.25	.0015	.016		
Copper	2.0	.13	.036		
Iron	25	.68	1.9		
Lead	0.25	.003	.012		
Magnesium	130	.27	1.4		
Manganese	0.25	.006	.02		
Molybdenum	0.50	.024	.096		
Nickel	2.0	.095	.026		
Potassium	130	1.4	3.9		
Selenium	0.50	.039	.058	-0.0050	<0.50
Silver	1.0	.01	.022		
Sodium	130	.56	1.3		
Strontium	0.50	.004	.0082		
Thallium	0.25	.002	.0051		
Tin	0.50	.025			
Titanium	0.50	.027	.27		
Uranium	0.50				
Vanadium	2.0	.27	.79		
Zinc	2.0	.39	.91		

Associated samples MP51777: F71708-1, F71708-2, F71708-3, F71708-4, F71708-5, F71708-6, F71708-7, F71708-8, F71708-9, F71708-10, F71708-11, F71708-12, F71708-13, F71708-14, F71708-15, F71708-16, F71708-17, F71708-18

Results < IDL are shown as zero for calculation purposes
(*) Outside of QC limits
(anr) Analyte not requested

MATRIX SPIKE AND DUPLICATE RESULTS SUMMARY

Login Number: F71708
Account: ALSE - Accutest Laboratories Southeast, Inc.
Project: ECTFLLAU: C9/C11 Selenium; Weston, FL

QC Batch ID: MP51777
Matrix Type: SOLID

Methods: SW846 6020
Units: mg/kg

Prep Date: 09/09/10

Metal	F71708-18 Original	MS	Spikelot MPIRS1	% Rec	QC Limits
Aluminum					
Antimony					
Arsenic					
Barium	17.4	403	404	95.5	75-125
Beryllium					
Boron					
Cadmium					
Calcium					
Chromium					
Cobalt					
Copper					
Iron					
Lead					
Magnesium					
Manganese					
Molybdenum					
Nickel					
Potassium					
Selenium	0.16	381	404	94.4	69-125
Silver					
Sodium					
Strontium					
Thallium					
Tin					
Titanium					
Uranium					
Vanadium					
Zinc					

Associated samples MP51777: F71708-1, F71708-2, F71708-3, F71708-4, F71708-5, F71708-6, F71708-7, F71708-8, F71708-9, F71708-10, F71708-11, F71708-12, F71708-13, F71708-14, F71708-15, F71708-16, F71708-17, F71708-18

Results < IDL are shown as zero for calculation purposes
(*) Outside of QC limits
(N) Matrix Spike Rec. outside of QC limits
(anr) Analyte not requested

MATRIX SPIKE AND DUPLICATE RESULTS SUMMARY

Login Number: F71708
Account: ALSE - Accutest Laboratories Southeast, Inc.
Project: ECTFLLAU: C9/C11 Selenium; Weston, FL

QC Batch ID: MP51777
Matrix Type: SOLID

Methods: SW846 6020
Units: mg/kg

Prep Date: 03/09/10

Metal	F71708-18 Original	MSD	Spikelot MPIRS1	% Rec	MSD RPD	QC Limit
Aluminum						
Antimony						
Arsenic						
Barium	17.4	419	407	98.7	3.9	20
Beryllium						
Boron						
Cadmium						
Calcium						
Chromium						
Cobalt						
Copper						
Iron						
Lead						
Magnesium						
Manganese						
Molybdenum						
Nickel						
Potassium						
Selenium	0.16	389	407	95.5	2.1	20
Silver						
Sodium						
Strontium						
Thallium						
Tin						
Titanium						
Uranium						
Vanadium						
Zinc						

Associated samples MP51777: F71708-1, F71708-2, F71708-3, F71708-4, F71708-5, F71708-6, F71708-7, F71708-8, F71708-9, F71708-10, F71708-11, F71708-12, F71708-13, F71708-14, F71708-15, F71708-16, F71708-17, F71708-18

Results < IDL are shown as zero for calculation purposes
(*) Outside of QC limits
(N) Matrix Spike Rec. outside of QC limits
(anr) Analyte not requested

SPIKE BLANK AND LAB CONTROL SAMPLE SUMMARY

Login Number: F71708
Account: ALSE - Accutest Laboratories Southeast, Inc.
Project: ECTFLLAU: C9/C11 Selenium; Weston, FL

QC Batch ID: MP51777
Matrix Type: SOLID

Methods: SW846 6020
Units: mg/kg

Prep Date: 03/09/10

Metal	BSP Result	Spikelot MPIRS1	% Rec	QC Limits
Aluminum				
Antimony				
Arsenic				
Barium	410	400	102.5	80-120
Beryllium				
Boron				
Cadmium				
Calcium				
Chromium				
Cobalt				
Copper				
Iron				
Lead				
Magnesium				
Manganese				
Molybdenum				
Nickel				
Potassium				
Selenium	442	400	110.5	80-120
Silver				
Sodium				
Strontium				
Thallium				
Tin				
Titanium				
Uranium				
Vanadium				
Zinc				

Associated samples MP51777: F71708-1, F71708-2, F71708-3, F71708-4, F71708-5, F71708-6, F71708-7, F71708-8, F71708-9, F71708-10, F71708-11, F71708-12, F71708-13, F71706-14, F71708-15, F71708-16, F71708-17, F71708-18

Results < IDL are shown as zero for calculation purposes
(*) Outside of QC limits
(anr) Analyte not requested

SERIAL DILUTION RESULTS SUMMARY

Login Number: F71708
Account: ALSE - Accutest Laboratories Southeast, Inc.
Project: ECTFLLAU: C9/C11 Selenium; Weston, FL

QC Batch ID: MP51777
Matrix Type: SOLID

Methods: SW846 6020
Units: ug/l

Prep Date: 03/09/10

Metal	F71708-18 Original	SDL 5:25	%DIF	QC Limits
Aluminum				
Antimony				
Arsenic				
Barium	168	165	1.7	0-10
Beryllium				
Boron				
Cadmium				
Calcium				
Chromium				
Cobalt				
Copper				
Iron				
Lead				
Magnesium				
Manganese				
Molybdenum				
Nickel				
Potassium				
Selenium	1.55	3.58	131.0(a)	0-10
Silver				
Sodium				
Strontium				
Thallium				
Tin				
Titanium				
Uranium				
Vanadium				
Zinc				

Associated samples MP51777: F71708-1, F71708-2, F71708-3, F71708-4, F71708-5, F71708-6, F71708-7, F71708-8, F71708-9, F71708-10, F71708-11, F71708-12, F71708-13, F71708-14, F71708-15, F71708-16, F71708-17, F71708-18

Results < IDL are shown as zero for calculation purposes
(*) Outside of QC limits
(anr) Analyte not requested
(a) Percent difference acceptable due to low initial sample concentration (< 50 times IDL).

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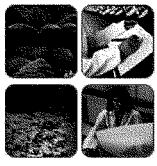
Automated Report

Southeast ACCUTEST Laboratories

IT'S ALL IN THE CHEMISTRY

03/15/10



Technical Report for

ECT

C-11 Speciation Sampling, Broward Co, FL

10-0096

Accutest Job Number: F71511

Sampling Date: 02/17/10

Report to:

ECT
6300 NE 1st St Suite 100
Ft Lauderdale, FL 33334
padak@ectinc.com

ATTN: Probas Adak

Total number of pages in report: **73**

ACCUTEST LABORATORIES 50 YEARS 1956-2006

ACCREDITED IN ACCORDANCE WITH nelac

Test results contained within this data package meet the requirements of the National Environmental Laboratory Accreditation Conference and/or state specific certification programs as applicable.

Harry Behzadi, Ph.D.
Laboratory Director

Client Service contact: Sue Bell 407-425-6700

Certifications: FL (DOH E83510), NC (573), NJ (FL002), MA (FL946), IA (366), LA (03051), KS (E-10327), SC, AK
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Accutest Laboratories

Sample Summary

ECT

Job No: F71511

C-11 Speciation Sampling, Broward Co, FL
Project No: 10-0096

Sample Number	Collected Date	Time	By	Received	Matrix Code	Type	Client Sample ID
F71511-1	02/17/10	09:15	CRMD	02/20/10	SO	Soil	CSS-WCA-1
F71511-2	02/17/10	09:41	CRMD	02/20/10	SO	Soil	CSS-WCA-2
F71511-3	02/17/10	10:01	CRMD	02/20/10	SO	Soil	CSS-WCA-3
F71511-4	02/17/10	10:23	CRMD	02/20/10	SO	Soil	CSS-WCA-4
F71511-5	02/17/10	10:54	CRMD	02/20/10	SO	Soil	CSS-WCA-5
F71511-6	02/17/10	11:16	CRMD	02/20/10	SO	Soil	CSS-WCA-6
F71511-7	02/17/10	11:49	CRMD	02/20/10	SO	Soil	CSS-WCA-7
F71511-8	02/17/10	12:09	CRMD	02/20/10	SO	Soil	CSS-WCA-8
F71511-9	02/17/10	12:31	CRMD	02/20/10	SO	Soil	CSS-WCA-9
F71511-10	02/17/10	12:52	CRMD	02/20/10	SO	Soil	CSS-WCA-10
F71511-11	02/17/10	13:18	CRMD	02/20/10	SO	Soil	CSS-WCA-11
F71511-12	02/17/10	13:39	CRMD	02/20/10	SO	Soil	CSS-WCA-12
F71511-13	02/17/10	14:02	CRMD	02/20/10	SO	Soil	CSS-WCA-13

Soil samples reported on a dry weight basis unless otherwise indicated on result page.

Accutest Laboratories

Sample Summary
(continued)

ECT

Job No: F71511

C-11 Speciation Sampling, Broward Co, FL
Project No: 10-0096

Sample Number	Collected Date	Time	By	Received	Matrix Code	Type	Client Sample ID
F71511-14	02/17/10	14:20	CRMD	02/20/10	SO	Soil	CSS-WCA-14
F71511-15	02/17/10	14:37	CRMD	02/20/10	SO	Soil	CSS-WCA-15
F71511-16	02/17/10	14:55	CRMD	02/20/10	SO	Soil	CSS-WCA-16
F71511-17	02/17/10	15:15	CRMD	02/20/10	SO	Soil	CSS-WCA-17
F71511-18	02/17/10	15:35	CRMD	02/20/10	SO	Soil	CSS-WCA-18
F71511-19	02/17/10	15:59	CRMD	02/20/10	SO	Soil	CSS-WCA-19
F71511-20	02/17/10	16:10	CRMD	02/20/10	SO	Soil	CSS-WCA-20
F71511-21	02/17/10	16:29	CRMD	02/20/10	SO	Soil	CSS-WCA-21
F71511-22	02/17/10	19:54	CRMD	02/20/10	SO	Soil	CSS-WCA-22
F71511-23	02/17/10	17:12	CRMD	02/20/10	SO	Soil	CSS-WCA-23
F71511-24	02/17/10	17:41	CRMD	02/20/10	SO	Soil	CSS-WCA-24
F71511-25	02/17/10	17:53	CRMD	02/20/10	SO	Soil	CSS-WCA-25
F71511-26	02/17/10	18:12	CRMD	02/20/10	SO	Soil	CSS-WCA-26

Soil samples reported on a dry weight basis unless otherwise indicated on result page.

Accutest Laboratories

Sample Summary
(continued)

ECT

Job No: F71511

C-11 Speciation Sampling, Broward Co, FL
Project No: 10-0096

Sample Number	Collected Date	Time	By	Received	Matrix Code	Type	Client Sample ID
F71511-27	02/17/10	18:30	CRMD	02/20/10	SO	Soil	CSS-WCA-27
F71511-28	02/17/10	18:46	CRMD	02/20/10	SO	Soil	CSS-WCA-28
F71511-29	02/17/10	19:09	CRMD	02/20/10	SO	Soil	CSS-WCA-29
F71511-30	02/17/10	08:02	CRMD	02/20/10	SO	Soil	CSS-WCA-30
F71511-31	02/17/10	08:34	CRMD	02/20/10	SO	Soil	CSS-WCA-31
F71511-32	02/17/10	08:42	CRMD	02/20/10	SO	Soil	CSS-WCA-32
F71511-33	02/17/10	08:26	CRMD	02/20/10	SO	Soil	CSS-WCA-33
F71511-34	02/17/10	08:18	CRMD	02/20/10	SO	Soil	CSS-WCA-34

Soil samples reported on a dry weight basis unless otherwise indicated on result page.

Sample Results

Report of Analysis

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-WCA-1		
Lab Sample ID:	F71511-1	**Date Sampled:**	02/17/10
Matrix:	SO - Soil	**Date Received:**	02/20/10
		Percent Solids:	10.2
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed By		Method	Prep Method
Selenium [a]	1.51	2.4	0.28	mg/kg	5	03/04/10	03/04/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23932
(2) Prep QC Batch: N:MP51723

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-WCA-2		
Lab Sample ID:	F71511-2	**Date Sampled:**	02/17/10
Matrix:	SO - Soil	**Date Received:**	02/20/10
		Percent Solids:	9.0
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed By	Method	Prep Method
Selenium [a]	1.0 I	1.8	0.21	mg/kg	5	03/04/10	03/04/10 ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23932
(2) Prep QC Batch: N:MP51723

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-WCA-3		
Lab Sample ID:	F71511-3	**Date Sampled:**	02/17/10
Matrix:	SO - Soil	**Date Received:**	02/20/10
		Percent Solids:	7.7
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed By	Method	Prep Method
Selenium [a]	2.01	3.2	0.37	mg/kg	5	03/04/10	03/04/10 ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23932
(2) Prep QC Batch: N:MP51723

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-WCA-4		
Lab Sample ID:	F71511-4	**Date Sampled:**	02/17/10
Matrix:	SO - Soil	**Date Received:**	02/20/10
		Percent Solids:	8.2
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	I.1.1	2.0	0.24	mg/kg	5	03/04/10	03/04/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23932
(2) Prep QC Batch: N:MP51723

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-WCA-5		
Lab Sample ID:	F71511-5	**Date Sampled:**	02/17/10
Matrix:	SO - Soil	**Date Received:**	02/20/10
		Percent Solids:	13.4
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	1.9	1.9	0.22	mg/kg	5	03/04/10	03/04/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23932
(2) Prep QC Batch: N:MP51723

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-WCA-5		
Lab Sample ID:	F71511-5	**Date Sampled:**	02/17/10
Matrix:	SO - Soil	**Date Received:**	02/20/10
		Percent Solids:	13.4
Project:	C-11 Speciation Sampling, Broward Co, FL		

General Chemistry

Analyte	Result	RL	MDL	Units	DF	Analyzed	By	Method
Solids, Percent	13.4			%	1	02/23/10	CP	SM19 2540B M
Total Organic Carbon	48700	7500	3700	mg/kg	1	03/10/10 14:10	SD	SW846 9060A MOD

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-WCA-6		
Lab Sample ID:	F71511-6	**Date Sampled:**	02/17/10
Matrix:	SO - Soil	**Date Received:**	02/20/10
		Percent Solids:	11.2
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed By	Method	Prep Method
Selenium [a]	1.11	2.2	0.26	mg/kg	5	03/04/10	03/04/10 ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23932
(2) Prep QC Batch: N:MP51723

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-WCA-7		
Lab Sample ID:	F71511-7	**Date Sampled:**	02/17/10
Matrix:	SO - Soil	**Date Received:**	02/20/10
		Percent Solids:	28.1
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	0.10 U	0.87	0.10	mg/kg	5	03/04/10	03/04/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23932
(2) Prep QC Batch: N:MP51723

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-WCA-8		
Lab Sample ID:	F71511-8	**Date Sampled:**	02/17/10
Matrix:	SO - Soil	**Date Received:**	02/20/10
		Percent Solids:	15.1
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	0.13 U	1.1	0.13	mg/kg	5	03/04/10	03/04/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23932
(2) Prep QC Batch: N:MP51723

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-WCA-9		
Lab Sample ID:	F71511-9	**Date Sampled:**	02/17/10
Matrix:	SO - Soil	**Date Received:**	02/20/10
		Percent Solids:	17.0
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	1.9	0.96	0.11	mg/kg	5	03/04/10	03/04/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23932
(2) Prep QC Batch: N:MP51723

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-WCA-10		
Lab Sample ID:	F71511-10	**Date Sampled:**	02/17/10
Matrix:	SO - Soil	**Date Received:**	02/20/10
		Percent Solids:	19.4
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	0.38 I	0.85	0.10	mg/kg	5	03/04/10	03/04/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23932
(2) Prep QC Batch: N:MP51723

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-WCA-10		
Lab Sample ID:	F71511-10	**Date Sampled:**	02/17/10
Matrix:	SO - Soil	**Date Received:**	02/20/10
		Percent Solids:	19.4
Project:	C-11 Speciation Sampling, Broward Co, FL		

General Chemistry

Analyte	Result	RL	MDL	Units	DF	Analyzed	By	Method
Solids, Percent	19.4			%	1	02/23/10	CP	SM19 2540B M
Total Organic Carbon	30200	5200	2600	mg/kg	1	03/10/10 14:55	SD	SW846 9060A MOD

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-WCA-11		
Lab Sample ID:	F71511-11	**Date Sampled:**	02/17/10
Matrix:	SO - Soil	**Date Received:**	02/20/10
		Percent Solids:	19.3
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	1.3	0.85	0.099	mg/kg	5	03/04/10	03/04/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23932
(2) Prep QC Batch: N:MP51723

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-WCA-12		
Lab Sample ID:	F71511-12	**Date Sampled:**	02/17/10
Matrix:	SO - Soil	**Date Received:**	02/20/10
		Percent Solids:	30.9
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	0.093 U	0.80	0.093	mg/kg	5	03/04/10	03/04/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23932
(2) Prep QC Batch: N:MP51723

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-WCA-13		
Lab Sample ID:	F71511-13	**Date Sampled:**	02/17/10
Matrix:	SO - Soil	**Date Received:**	02/20/10
		Percent Solids:	26.9
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	0.13 I	0.91	0.11	mg/kg	5	03/04/10	03/04/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23932
(2) Prep QC Batch: N:MP51723

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-WCA-14		
Lab Sample ID:	F71511-14	**Date Sampled:**	02/17/10
Matrix:	SO - Soil	**Date Received:**	02/20/10
		Percent Solids:	16.7
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	1.41	1.5	0.17	mg/kg	5	03/04/10	03/04/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23932
(2) Prep QC Batch: N:MP51723

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-WCA-15		
Lab Sample ID:	F71511-15	**Date Sampled:**	02/17/10
Matrix:	SO - Soil	**Date Received:**	02/20/10
		Percent Solids:	18.0
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	0.16 U	1.4	0.16	mg/kg	5	03/04/10	03/04/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23932
(2) Prep QC Batch: N:MP51723

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-WCA-15		
Lab Sample ID:	F71511-15	**Date Sampled:**	02/17/10
Matrix:	SO - Soil	**Date Received:**	02/20/10
		Percent Solids:	18.0
Project:	C-11 Speciation Sampling, Broward Co, FL		

General Chemistry

Analyte	Result	RL	MDL	Units	DF	Analyzed	By	Method
Solids, Percent	18			%	1	02/23/10	CP	SM19 2540B M
Total Organic Carbon	20900	5600	2800	mg/kg	1	03/10/10 15:45	SD	SW846 9060A MOD

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-WCA-16		
Lab Sample ID:	F71511-16	**Date Sampled:**	02/17/10
Matrix:	SO - Soil	**Date Received:**	02/20/10
		Percent Solids:	17.8
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	1.8	0.92	0.11	mg/kg	5	03/04/10	03/04/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23932
(2) Prep QC Batch: N:MP51723

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-WCA-17		
Lab Sample ID:	F71511-17	**Date Sampled:**	02/17/10
Matrix:	SO - Soil	**Date Received:**	02/20/10
		Percent Solids:	14.8
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed By	Method	Prep Method
Selenium [a]	1.9	1.1	0.13	mg/kg	5	03/04/10	03/04/10 ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23932
(2) Prep QC Batch: N:MP51723

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-WCA-18		
Lab Sample ID:	F71511-18	**Date Sampled:**	02/17/10
Matrix:	SO - Soil	**Date Received:**	02/20/10
		Percent Solids:	14.0
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	0.20 U	1.8	0.20	mg/kg	5	03/04/10	03/04/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23932
(2) Prep QC Batch: N:MP51723

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-WCA-19		
Lab Sample ID:	F71511-19	**Date Sampled:**	02/17/10
Matrix:	SO - Soil	**Date Received:**	02/20/10
		Percent Solids:	20.8
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	0.55 I	1.2	0.14	mg/kg	5	03/04/10	03/04/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23932
(2) Prep QC Batch: N:MP51723

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-WCA-20		
Lab Sample ID:	F71511-20	**Date Sampled:**	02/17/10
Matrix:	SO - Soil	**Date Received:**	02/20/10
		Percent Solids:	19.8
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	1.6	1.2	0.15	mg/kg	5	03/04/10	03/04/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23932
(2) Prep QC Batch: N:MP51723

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-WCA-20		
Lab Sample ID:	F71511-20	**Date Sampled:**	02/17/10
Matrix:	SO - Soil	**Date Received:**	02/20/10
		Percent Solids:	19.8
Project:	C-11 Speciation Sampling, Broward Co, FL		

General Chemistry

Analyte	Result	RL	MDL	Units	DF	Analyzed	By	Method
Solids, Percent	19.8			%	1	02/23/10	CP	SM19 2540B M
Total Organic Carbon	44800	5100	2500	mg/kg	1	03/11/10 16:17	SD	SW846 9060A MOD

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-WCA-21		
Lab Sample ID:	F71511-21	**Date Sampled:**	02/17/10
Matrix:	SO - Soil	**Date Received:**	02/20/10
		Percent Solids:	11.1
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	0.32 I	0.60	0.070	mg/kg	5	03/05/10	03/05/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23938
(2) Prep QC Batch: N:MP51739

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-WCA-22		
Lab Sample ID:	F71511-22	**Date Sampled:**	02/17/10
Matrix:	SO - Soil	**Date Received:**	02/20/10
		Percent Solids:	18.0
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	1.5	0.61	0.071	mg/kg	5	03/05/10	03/05/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23938
(2) Prep QC Batch: N:MP51739

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-WCA-23		
Lab Sample ID:	F71511-23	**Date Sampled:**	02/17/10
Matrix:	SO - Soil	**Date Received:**	02/20/10
		Percent Solids:	20.4
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	0.23 I	0.56	0.066	mg/kg	5	03/05/10	03/05/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23938
(2) Prep QC Batch: N:MP51739

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-WCA-24		
Lab Sample ID:	F71511-24	**Date Sampled:**	02/17/10
Matrix:	SO - Soil	**Date Received:**	02/20/10
		Percent Solids:	26.9
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	0.151	0.51	0.060	mg/kg	5	03/05/10	03/05/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23938
(2) Prep QC Batch: N:MP51739

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-WCA-25		
Lab Sample ID:	F71511-25	**Date Sampled:**	02/17/10
Matrix:	SO - Soil	**Date Received:**	02/20/10
		Percent Solids:	17.4
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	3.3	0.56	0.066	mg/kg	5	03/05/10	03/05/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23938
(2) Prep QC Batch: N:MP51739

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-WCA-25		
Lab Sample ID:	F71511-25	**Date Sampled:**	02/17/10
Matrix:	SO - Soil	**Date Received:**	02/20/10
		Percent Solids:	17.4
Project:	C-11 Speciation Sampling, Broward Co, FL		

General Chemistry

Analyte	Result	RL	MDL	Units	DF	Analyzed	By	Method
Solids, Percent	17.4			%	1	02/23/10	CP	SM19 2540B M
Total Organic Carbon	31600	5700	2900	mg/kg	1	03/11/10 16:43	SD	SW846 9060A MOD

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-WCA-26		
Lab Sample ID:	F71511-26	**Date Sampled:**	02/17/10
Matrix:	SO - Soil	**Date Received:**	02/20/10
		Percent Solids:	25.5
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	1.3	0.56	0.066	mg/kg	5	03/05/10	03/05/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23938
(2) Prep QC Batch: N:MP51739

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-WCA-27		
Lab Sample ID:	F71511-27	**Date Sampled:**	02/17/10
Matrix:	SO - Soil	**Date Received:**	02/20/10
		Percent Solids:	12.7
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	1.0	0.74	0.086	mg/kg	5	03/05/10	03/05/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23938
(2) Prep QC Batch: N:MP51739

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-WCA-28		
Lab Sample ID:	F71511-28	**Date Sampled:**	02/17/10
Matrix:	SO - Soil	**Date Received:**	02/20/10
		Percent Solids:	10.6
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	1.0	0.58	0.068	mg/kg	5	03/05/10	03/05/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23938
(2) Prep QC Batch: N:MP51739

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-WCA-29		
Lab Sample ID:	F71511-29	**Date Sampled:**	02/17/10
Matrix:	SO - Soil	**Date Received:**	02/20/10
		Percent Solids:	11.0
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	0.90	0.59	0.069	mg/kg	5	03/05/10	03/05/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23938
(2) Prep QC Batch: N:MP51739

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-WCA-30		
Lab Sample ID:	F71511-30	**Date Sampled:**	02/17/10
Matrix:	SO - Soil	**Date Received:**	02/20/10
		Percent Solids:	18.5
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	0.64	0.45	0.052	mg/kg	5	03/05/10	03/05/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23938
(2) Prep QC Batch: N:MP51739

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-WCA-30		
Lab Sample ID:	F71511-30	**Date Sampled:**	02/17/10
Matrix:	SO - Soil	**Date Received:**	02/20/10
		Percent Solids:	18.5
Project:	C-11 Speciation Sampling, Broward Co, FL		

General Chemistry

Analyte	Result	RL	MDL	Units	DF	Analyzed	By	Method
Solids, Percent	18.5			%	1	02/23/10	CP	SM19 2540B M
Total Organic Carbon	30600	5400	2700	mg/kg	1	03/11/10 17:23	SD	SW846 9060A MOD

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-WCA-31		
Lab Sample ID:	F71511-31	**Date Sampled:**	02/17/10
Matrix:	SO - Soil	**Date Received:**	02/20/10
		Percent Solids:	18.6
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	2.0	0.58	0.067	mg/kg	5	03/05/10	03/05/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23938
(2) Prep QC Batch: N:MP51739

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-WCA-32		
Lab Sample ID:	F71511-32	**Date Sampled:**	02/17/10
Matrix:	SO - Soil	**Date Received:**	02/20/10
		Percent Solids:	18.3
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed By		Method	Prep Method
Selenium [a]	0.42 I	0.48	0.056	mg/kg	5	03/05/10	03/05/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23938
(2) Prep QC Batch: N:MP51739

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-WCA-33		
Lab Sample ID:	F71511-33	**Date Sampled:**	02/17/10
Matrix:	SO - Soil	**Date Received:**	02/20/10
		Percent Solids:	15.9
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	1.7	0.54	0.063	mg/kg	5	03/05/10	03/05/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23938
(2) Prep QC Batch: N:MP51739

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest Laboratories

Report of Analysis

Client Sample ID:	CSS-WCA-34		
Lab Sample ID:	F71511-34	**Date Sampled:**	02/17/10
Matrix:	SO - Soil	**Date Received:**	02/20/10
		Percent Solids:	9.1
Project:	C-11 Speciation Sampling, Broward Co, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	1.1	0.66	0.077	mg/kg	5	03/05/10	03/05/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23938
(2) Prep QC Batch: N:MP51739

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Misc. Forms

Custody Documents and Other Forms

Includes the following where applicable:

- Certification Exceptions
- Chain of Custody

Accutest Laboratories Southeast
Chain of Custody

ACCUTEST.

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www.accutest.com

Accutest JOB # F71511 PAGE 1 OF 3
Accutest Quote # SDG # 32961

Client / Reporting Information

Company Name: FCT
Address: 6300 NE 1st Ave. #100
City: Ft Lauderdale State: FL Zip: 33334
Project Contact: Barry Westmark E-mail:
Phone: 954-771-6444
Sampler(s) Name(s) (Print): Cal Elico

Project Information

Project Name: C9-C11
Street: 115-27
City: Broward Co. State: FL
Project #: 10-0096
Fax #: 954-771-8118
Client Purchase Order #:

Analytical Information

6020 Sec Tot

Matrix Codes

DW - Drinking Water
GW - Ground Water
WW - Water
SW - Surface Water
SO - Soil
SL - Sludge
OI - Oil
LIQ - Other Liquid
AIR - Air
SOL - Other Solid
WP - Wipe

Accutest Sample #	Field ID / Point of Collection	Collection Date	Collection Time	Sampled By	Matrix	Total # of Bottles	Container Type	HCL	NaOH	HNO3	H2SO4	NaHSO4	DI WATER	6020	Sec	Tot									Lab Use Only
1	CSS-WCA-1	2/17/10			SO	1	1							✓											
2	CSS-WCA-2					1	1							✓											
3	CSS-WCA-3					1	1							✓											
4	CSS-WCA-4					1	1							✓											
5	CSS-WCA-5					2	1							✓	✓										
6	CSS-WCA-6					1	1							✓											
7	CSS-WCA-7					1	1							✓											
8	CSS-WCA-8					1	1							✓											
9	CSS-WCA-9					1	1							✓											
10	CSS-WCA-10					2	1							✓	✓										
11	CSS-WCA-11	✓			✓	1	1							✓											
12	CSS-WCA-12	2/17/10			SO	1	1							✓											

Turnaround Time (Business Days)

Approved By: / Rush Code

- [x] 10 Days Standard
- [ ] 7 Day RUSH
- [ ] 5 Day RUSH
- [ ] 3 Day EMERGENCY
- [ ] 2 Day EMERGENCY
- [ ] 1 Day EMERGENCY
- [ ] OTHER

Emergency or Rush T/A Data Available VIA Email or Lablink

Data Deliverable Information

- [ ] COMMERCIAL "A" (RESULTS ONLY)
- [ ] COMMERCIAL "B" (RESULTS PLUS QC)
- [ ] REDT1 (EPA LEVEL 3)
- [ ] FULT1 (EPA LEVEL 4)
- [ ] EDD'S

Comments / Remarks

Sample Custody must be documented below each time samples change possession, including courier delivery.

Relinquished by Sampler:	Date Time:	Received By:	Relinquished by:	Date Time:	Received By:
1		2 [illegible] 2/19/10 14:30	3 [illegible]		4 [illegible] 02-23-10 0900
Relinquished by: 5 [illegible]	Date Time: 2/19/10 19:00	Received By:	Relinquished by: 7	Date Time:	Received By: 8

Lab Use Only: Custody Seal in Place: Y N Temp Blank Provided: Y N Preserved where Applicable: Y N Total # of Coolers: Cooler Temperature (s) Celsius: 3.6

3.1 3

F71511: Chain of Custody
Page 1 of 5

ACCUTEST.

Accutest Laboratories Southeast
Chain of Custody

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www.accutest.com

Accutest JOB # F71511 PAGE 2 OF 3
Accutest Quote # SDG #

Client / Reporting Information

Company Name: ECT
Address:
City: Ft Laud. State: FL Zip:
Project Contact: Kerry Westmark Email:
Phone#: 954-771-6444
Sampler(s) Name(s) (Printed): CAR + MCD

Project Information

Project Name: C9-C11
Street: US 27
City: Broward Co State: FL
Project #: 10-0096
Fax #:
Client Purchase Order #:

Analytical Information: 6020 SL; TOC

Matrix Codes: DW - Drinking Water; GW - Ground Water; WW - Water; SW - Surface Water; SO - Soil; SL - Sludge; OI - Oil; LIQ - Other Liquid; AIR - Air; SOL - Other Solid; WP - Wipe

Accutest Sample #	Field ID / Point of Collection	Collection Date	Time	Sampled By	Matrix	Total # of Bottles	Container Preservation: Other	None	HCl	NaOH	HNO3	H2SO4	NaHSO4	Methanol	Encore	Water	6020 SL	TOC								Lab Use Only
13	CSS-WCA-13	2/17			SO	1		1									✓									
14	CSS-WCA-14					1		1									✓									
15	CSS-WCA-15					2		2									✓	✓								
16	CSS-WCA-16					1		1									✓									
17	CSS-WCA-17					1		1									✓									
18	CSS-WCA-18					1		1									✓									
19	CSS-WCA-19					1		1									✓									
20	CSS-WCA-20					2		2									✓	✓								
21	CSS-WCA-21					1		1									✓									
22	CSS-WCA-22					1		1									✓									
23	CSS-WCA-23	↓			↓	1		1									✓									
24	CSS-WCA-24	2/17			SO	1		1									✓									

Turnaround Time (Business Days)

Approved By: / Rush Code

- [x] 10 Days Standard
- [ ] 7 Day RUSH
- [ ] 5 Day RUSH
- [ ] 3 Day EMERGENCY
- [ ] 2 Day EMERGENCY
- [ ] 1 Day EMERGENCY
- [ ] OTHER!

Emergency or Rush T/A Data Available VIA Email or Lablink

Data Deliverable Information

- [ ] COMMERCIAL "A" (RESULTS ONLY)
- [ ] COMMERCIAL "B" (RESULTS PLUS QC)
- [ ] REDT1 (EPA LEVEL 3)
- [ ] FULT1 (EPA LEVEL 4)
- [ ] EDD'S

Comments / Remarks

Sample Custody must be documented below each time samples change possession, including courier delivery.

Relinquished by Sampler:	Date Time:	Received By:	Relinquished by:	Date Time:	Received By:
1		2 (ALS6) 2/19/10 14:30	3 (ALS6)		4 ACCUTEST
Relinquished by: 5	Date Time: 2/19/10 19:00	Received By:	Relinquished by: 7	Date Time:	Received By: 8 02-20-10 0900

Lab Use Only: Custody Seal in Place: Y N Temp Blank Provided: Y N Preserved where Applicable: Y N Total # of Coolers: Cooler Temperature (s) Celsius: 7.6

3.1 3

F71511: Chain of Custody
Page 2 of 5

ACCUTEST.

Accutest Laboratories Southeast
Chain of Custody

4405 Vineland Road, Suite C-15 Orlando, Fl 32811
TEL. 407-425-6700 • FAX: 407-425-0707
www.accutest.com

Accutest JOB # F71511 PAGE 3 OF 3
Accutest Quote # SUIFF

Client / Reporting Information
Company Name: ECT
Address:
City: Ft Lauderdale State: FL Zip:
Project Contact: Barry Wadsmark
Phone: 954-771-0444
Sampler(s) Name(s) (Printed): CHRIS MCA

Project Information
Project Name: C9-011
Street: US 27
City: BROWARD CO State: FL
Project #: 10-00916
Fax #:
Client Purchase Order #:

Analytical Information: Sec 6020; TDC

Matrix Codes: DW - Drinking Water; GW - Ground Water; WW - Water; SW - Surface Water; SO - Soil; SL - Sludge; OI - Oil; LIQ - Other Liquid; AIR - Air; SOL - Other Solid; WP - Wipe

Accutest Sample #	Field ID / Point of Collection	Collection Date	Collection Time	Sampled By	Matrix	Total # of Bottles	Preservation Other	Preservation None	HCl	HNO3	H2SO4	NaOH	NaOH/ZnAc	Sec 6020	TDC	Matrix	Lab Use Only
25	CSS-WCA-25	2/17			SO	2		2						✓	✓		
26	CSS-WCA-26					1		1						✓			
27	CSS-WCA-27					1		1						✓			
28	CSS-WCA-28					1		1						✓			
29	CSS-WCA-29					1		1						✓			
30	CSS-WCA-30					2		2						✓	✓		
31	CSS-WCA-31					1		1						✓			
32	CSS-WCA-32					1		1						✓			
33	CSS-WCA-33					1		1						✓			
34	CSS-WCA-34	2/17			SO	1		1						✓			

TURNAROUND TIME (Business Days)
Approved By: / Rush Code
- [x] 10 Days Standard
- [ ] 7 Day RUSH
- [ ] 5 Day RUSH
- [ ] 3 Day EMERGENCY
- [ ] 2 Day EMERGENCY
- [ ] 1 Day EMERGENCY
- [ ] OTHER

Emergency or Rush T/A Data Available VIA Email or Labtrek

Data Deliverable Information
- [ ] COMMERCIAL "A" (RESULTS ONLY)
- [ ] COMMERCIAL "B" (RESULTS PLUS QC)
- [ ] REDT1 (EPA LEVEL 3)
- [ ] FULT1 (EPA LEVEL 4)
- [ ] EDDYS

Comments / Remarks

Sample Custody must be documented below each time samples change possession, including courier delivery.

Relinquished by Sampler:	Date Time:	Received By:	Relinquished by:	Date Time:	Received By:
1		2 [signature] 2/19/10 14:30	3 [signature]		4 [signature] Accutest
Relinquished by: 5 [signature]	Date Time: 2/19/10 14:30	Received By:	Relinquished by: 7	Date Time:	Received By: 8 2-20-10 0800

Lab Use Only: Custody Seal in Place: Y N Temp Blank Provided: Y N Preserved where Applicable: Y N Total # of Coolers: Cooler Temperature (s) Celsius: 3.6

F71511: Chain of Custody
Page 3 of 5

ACCUTEST LABORATORIES SAMPLE RECEIPT CONFIRMATION

ACCUTEST'S JOB NUMBER: F71511 CLIENT: ECT PROJECT: C9-C11

DATE/TIME RECEIVED: 02-20-10 0800 {MM/DD/YY 24:00} NUMBER OF COOLERS RECEIVED: 1

METHOD OF DELIVERY: FEDEX UPS ACCUTEST COURIER GREYHOUND DELIVERY OTHER

AIRBILL NUMBERS:

COOLER INFORMATION

- [ ] CUSTODY SEAL NOT PRESENT OR NOT INTACT
- [ ] CHAIN OF CUSTODY NOT RECEIVED (COC)
- [ ] ANALYSIS REQUESTED IS UNCLEAR OR MISSING
- [ ] SAMPLE DATES OR TIMES UNCLEAR OR MISSING
- [ ] TEMPERATURE CRITERIA NOT MET
- [ ] WET ICE PRESENT

TRIP BLANK INFORMATION

- [ ] TRIP BLANK PROVIDED
- [x] TRIP BLANK NOT PROVIDED
- [x] TRIP BLANK NOT ON COC
- [ ] TRIP BLANK INTACT
- [ ] TRIP BLANK NOT INTACT
- [ ] RECEIVED WATER TRIP BLANK
- [ ] RECEIVED SOIL TRIP BLANK

MISC. INFORMATION

NUMBER OF ENCORES ? Ø

NUMBER OF 5035 FIELD KITS ? Ø

NUMBER OR LAB FILTERED METALS ? Ø

TEMPERATURE INFORMATION

- [ ] IR THERM ID 3 CORR. FACTOR Ø
- [ ] OBSERVED TEMPS: 3.6
- [ ] CORRECTED TEMPS: 3.6

SAMPLE INFORMATION

- [ ] SAMPLE LABELS PRESENT ON ALL BOTTLES
- [ ] INCORRECT NUMBER OF CONTAINERS USED
- [ ] SAMPLE RECEIVED IMPROPERLY PRESERVED
- [ ] INSUFFICIENT VOLUME FOR ANALYSIS
- [ ] DATES/TIMES ON COC DO NOT MATCH SAMPLE LABEL
- [ ] ID'S ON COC DO NOT MATCH LABEL
- [ ] VOC VIALS HAVE HEADSPACE (MACRO BUBBLES)
- [ ] BOTTLES RECEIVED BUT ANALYSIS NOT REQUESTED
- [ ] NO BOTTLES RECEIVED FOR ANALYSIS REQUESTED
- [ ] UNCLEAR FILTERING OR COMPOSITING INSTRUCTIONS
- [ ] SAMPLE CONTAINER(S) RECEIVED BROKEN
- [ ] % SOLIDS JAR NOT RECEIVED
- [ ] 5035 FIELD KIT FROZEN WITHIN 48 HOUR'S
- [ ] RESIDUAL CHLORINE PRESENT

{APPICABLE TO EPA 600 SERIES OR NORTH CAROLINA ORGANICS}

SUMMARY OF COMMENTS:

TECHNICIAN SIGNATURE/DATE ET 02-20-10 REVIEWER SIGNATURE/DATE CL 2/20/10

NF 10/09 RECEIPT CONFIRMATION 100609 (2).xls

F71511: Chain of Custody
Page 4 of 5

3.1
3

Job Change Order: F71511_3/2/2010

Requested Date:	3/2/2010	**Received Date:**	2/20/2010
Account Name:	ECT	**Due Date:**	3/8/2010
Project Description:	C-11 Speciation Sampling, Broward Co, FL	**Deliverable:**	COMMB
CSR:	SB	**TAT (Days):**	14

Sample #: F71511-all

Change: Revised coc sent in from Crystal @ ECT via e-mail 03.01.10. The coc has collections times.

Above Changes Crystal @ ECT **Date:** 3/2/2010

To Client: This Change Order is confirmation of the revisions, previously discussed with the Accutest Client Service Representative.

Page 1 of 1

F71511: Chain of Custody
Page 5 of 5

General Chemistry

QC Data Summaries

Includes the following where applicable:

- Method Blank and Blank Spike Summaries
- Duplicate Summaries
- Matrix Spike Summaries

METHOD BLANK AND SPIKE RESULTS SUMMARY
GENERAL CHEMISTRY

Login Number: F71511
Account: ECTFLLAU - ECT
Project: C-11 Speciation Sampling, Broward Co, FL

Analyte	Batch ID	RL	MB Result	Units	Spike Amount	BSP Result	BSP %Recov	QC Limits
Total Organic Carbon	GP14463/GN38784	1000	0.0	mg/kg	20000	21000	105.0	88-114%
Total Organic Carbon	GP14469/GN38794	1000	0.0	mg/kg	20000	21000	105.0	88-114%

Associated Samples:
Batch GP14463: F71511-10, F71511-15, F71511-5
Batch GP14469: F71511-20, F71511-25, F71511-30
(*) Outside of QC limits

DUPLICATE RESULTS SUMMARY
GENERAL CHEMISTRY

Login Number: F71511
Account: ECTFLLAU - ECT
Project: C-11 Speciation Sampling, Broward Co, FL

Analyte	Batch ID	QC Sample	Units	Original Result	DUP Result	RPD	QC Limits
Solids, Percent	GN38560	F71511-1	%	10.2	9.9	3.0	0-10%
Solids, Percent	GN38561	F71511-21	%	11.1	10.3	7.5	0-10%
Total Organic Carbon	GP14463/GN38784	F71511-5	mg/kg	48700	36400	28.9	0-36%
Total Organic Carbon	GP14469/GN38794	F71511-20	mg/kg	44800	40500	10.1	0-36%

Associated Samples:
Batch GN38560: F71511-1, F71511-10, F71511-11, F71511-12, F71511-13, F71511-14, F71511-15, F71511-16, F71511-17, F71511-18, F71511-19, F71511-2, F71511-20, F71511-3, F71511-4, F71511-5, F71511-6, F71511-7, F71511-8, F71511-9
Batch GN38561: F71511-21, F71511-22, F71511-23, F71511-24, F71511-25, F71511-26, F71511-27, F71511-28, F71511-29, F71511-30, F71511-31, F71511-32, F71511-33, F71511-34
Batch GP14463: F71511-10, F71511-15, F71511-5
Batch GP14469: F71511-20, F71511-25, F71511-30
(*) Outside of QC limits

MATRIX SPIKE RESULTS SUMMARY
GENERAL CHEMISTRY

Login Number: F71511
Account: ECTFLLAU - ECT
Project: C-11 Speciation Sampling, Broward Co, FL

Analyte	Batch ID	QC Sample	Units	Original Result	Spike Amount	MS Result	%Rec	QC Limits
Total Organic Carbon	GP14463/GN38784	F71511-5	mg/kg	48700	149000	191000	95.3	88-114%
Total Organic Carbon	GP14469/GN38794	F71511-20	mg/kg	44800	101000	140000	94.2	88-114%

Associated Samples:
Batch GP14463: F71511-10, F71511-15, F71511-5
Batch GP14469: F71511-20, F71511-25, F71511-30
(*) Outside of QC limits
(N) Matrix Spike Rec. outside of QC limits

Misc. Forms

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Custody Documents and Other Forms

(Accutest New Jersey)

Includes the following where applicable:

- Chain of Custody

ACCUTEST Laboratories

Accutest Southeast Subcontract Chain of Custody

4405 Vineland Road, Suite C-15 Orlando, Fl 32811
TEL. 407-425-6700 • FAX: 407-425-0707

PAGE 1 OF 3

Client / Reporting Information

Company Name: Accutest Laboratories Southeast
Address: 4405 Vineland Road Suite C-15
City: Orlando State: Fl Zip: 32811
Project Contact: E-mail
Phone#: 407-425-6700 Fax #: 407-425-0707
Lab Tech/Acct. Printed Name:

Project Information

Accutest Job Number: F71511
Street
City
Project #
Fax #
Client Purchase Order #

Please send report to dawnd@accutest.com

For any other issues contact munam@accutest.com

Analytical Information

Matrix Codes: DW - Drinking Water; GW - Ground Water; WW - Waste Water; SW - Surface Water; SO - Soil; SL - Sludge; OI - Oil; LIQ - Other Liquid; AIR - Air; SOL - Other Solid

Lab ID #	Client ID / Accutest Sample ID	Collection Date	Time	Sampled By	Matrix	Number of Containers	Container Information: Other	Glass	PO	Plastic	Encore	Methanol	Sodium Bisulfate	Sodium Hydroxide	Zinc Acetate	Water	SEMS	LAB USE ONLY
	F71511-1				SO	1		X								X		48FL
	-2					1		X								X		
	-3					1		X								X		
	-4					1		X								X		
	-5					1		X								X		
	-6					1		X								X		
	-7					1		X								X		
	-8					1		X								X		
	-9					1		X								X		
	-10					1		X								X		
	-11					1		X								X		
	-12					1		X								X		

TURNAROUND TIME (Business Days)

Approved By: 3/8/10

- Standard 10 Business Days
- 7 Day RUSH
- 5 Day RUSH
- 3 Day EMERGENCY
- 2 Day EMERGENCY
- 1 Day EMERGENCY
- OTHER

Data Deliverable Information

- [ ] COMMERCIAL "A" (RESULTS ONLY)
- [x] COMMERCIAL "B" (RESULTS PLUS QC)
- [ ] REDT1 (EPA LEVEL 3)
- [ ] FULLT1 (EPA LEVEL 4)
- [ ] EDD'S

Comments / Remarks

Ship to Laboratory- ALNJ
Approved By- Muna Mohammed
• 2 202 Dass Rec'd All WAB Soils
BC. 2-24-10

Sample Custody must be documented below each time samples change possession, including courier delivery.

Relinquished by/Affiliation	Date Time:	Received By/Affiliation	Relinquished by/Affiliation	Date Time:	Received By/Affiliation
1	2-23-10 1710	2 Fed Ex	3 Fed Ex	4 2-24-10	
Relinquished by/Affiliation	Date Time:	Received By/Affiliation	Relinquished by/Affiliation	Date Time:	Received By/Affiliation
5		6	7		8

Lab Use Only: Custody Seal in Place: Y N Temp Blank Provided: Y N Preserved Where Applicable: Y N Total # of Coolers: 1 Cooler Temperature (s) Celsius: 2.1°c

F71511: Chain of Custody
Page 1 of 4
Accutest New Jersey

ACCUTEST Laboratories

Accutest Southeast Subcontract Chain of Custody

4405 Vineland Road, Suite C-15 Orlando, Fl 32811
TEL: 407-425-6700 • FAX: 407-425-0707

PAGE 2 OF 3

Client / Reporting Information

Company Name: Accutest Laboratories Southeast
Address: 4405 Vineland Road Suite C-15
City: Orlando State: Fl Zip: 32811
Project Contact: E-mail
Phone#: 407-425-6700 Fax #: 407-425-0707
Lab Technician Printed Name:

Project Information

Accutest Job Number: F71511
Street
City
Project #
Fax #
Client Purchase Order #

Please send report to dawnd@accutest.com

For any other issues contact
miranm@accutest.com

Analytical Information

Lab ID #	Client ID / Accutest Sample ID	Collection Date	Collection Time	Sampled By	Matrix	Total # of Bottles	Other	VOC	SVOC	PCB	PEST	RCRA	Metals/Hg	Cr(VI)	VOP	SEMS	Lab Use Only
	F71511-13				SO	1		X								X	
	-14					1		X								X	
	-15					1		X								X	
	-16					1		X								X	
	-17					1		X								X	
	-18					1		X								X	
	-19					1		X								X	
	-20					1		X								X	
	-21					1		X								X	
	-22					1		X								X	
	-23					1		X								X	
	-24				V	1		X								X	

Matrix Codes: DW - Drinking Water; GW - Ground Water; WW - Water; SW - Surface Water; SO - Soil; SL - Sludge; O - Oil; LIQ - Other Liquid; AIR - Air; SOL - Other Solid

TURNAROUND TIME (Business Days)

Approved By:
Standard 10 Business Days
7 Day RUSH
5 Day RUSH 3/8/10
3 Day EMERGENCY
2 Day EMERGENCY
1 Day EMERGENCY
OTHER

Data Deliverable Information

- [ ] COMMERCIAL "A" (RESULTS ONLY)
- [x] COMMERCIAL "B" (RESULTS PLUS QC)
- [ ] REDT1 (EPA LEVEL 3)
- [ ] FULLT1 (EPA LEVEL 4)
- [ ] EDD/S

Comments / Remarks

Ship to Laboratory-ALNJ
Approved By-Muram Mohammed

Sample Custody must be documented below each time samples change possession, including courier delivery.

Relinquished by/Affiliation	Date Time	Received By/Affiliation	Relinquished by/Affiliation	Date Time	Received By/Affiliation
1	2-27-10 1700	2 Fed Ex	3 Fed Ex	2-27-10 945	4
Relinquished by/Affiliation	Date Time	Received By/Affiliation	Relinquished by/Affiliation	Date Time	Received By/Affiliation
5		6	7		8

Lab Use Only: Custody Seal in Place: Y N Temp Blank Provided: Y N Preserved Where Applicable: Y N Total # of Coolers: Cooler Temperature (s) Celsius:

5.1 5

F71511: Chain of Custody
Page 2 of 4

Accutest Southeast Subcontract Chain of Custody

ACCUTEST Laboratories

4405 Vineland Road, Suite C-15 Orlando, Fl 32811
TEL: 407-425-6700 • FAX: 407-425-0707

PAGE 3 OF 3

Client / Reporting Information

Company Name: Accutest Laboratories Southeast
Address: 4405 Vineland Road Suite C-15
City: Orlando State: Fl Zip: 32811
Project Contact: E-mail:
Phone#: 407-425-6700 Fax #: 407-425-0707
Lab Technician Printed Name:

Project Information

Accutest Job Number:
Street:
City:
Project #:
Fax #:
Client Purchase Order #:

Please send report to dawnd@accutest.com

For any other issues contact munam@accutest.com

Analytical Information

Lab ID #	Client ID / Accutest Sample ID	Date	Time	Sampled By	Matrix	Total # of Bottles	Chlorides	Sulfate	TKN	Nitrate	Nitrite	Ammonia	Phosphorus	Ortho P	SEMS						LAB USE ONLY
	F71511-25 •				SO	1		X							X						
	-26					1		X							X						
	-27					1		X							X						
	-28					1		X							X						
	-29					1		X							X						
	-30 •					1		X							X						
	-31					1		X							X						
	-32					1		X							X						
	-33					1		X							X						
	-34					1		X							X						

Matrix Codes: DW - Drinking Water; GW - Ground Water; WW - Water; SW - Surface Water; SO - Soil; SL - Sludge; OIl - Oil; LIQ - Other Liquid; AIR - Air; SOL - Other Solid

TURNAROUND TIME (Business Days)

Approved By:
Standard 10 Business Days
7 Day RUSH
5 Day RUSH
3 Day EMERGENCY 3/8/10
2 Day EMERGENCY
1 Day EMERGENCY
OTHER

Data Deliverable Information

- [ ] COMMERCIAL "A" (RESULTS ONLY)
- [x] COMMERCIAL "B" (RESULTS PLUS QC)
- [ ] REDT1 (EPA LEVEL 3)
- [ ] FULLT1 (EPA LEVEL 4)
- [ ] EDD'S

Comments / Remarks

Ship to Laboratory-ALNS
Approved By- Munam Chaudhry

Sample Custody must be documented below each time samples change possession, including courier delivery.

Relinquished by/Affiliation	Date Time:	Received By/Affiliation	Relinquished by/Affiliation	Date Time:	Received By/Affiliation
1	1000	2	3	9/53	4
8-23-10		Red Ea	Fed Ex		
Relinquished by/Affiliation	Date Time:	Received By/Affiliation	Relinquished by/Affiliation	Date Time:	Received By/Affiliation
5		6	7		8

Lab Use Only: Custody Seal In Place: Y N Temp Blank Provided: Y N Preserved Where Applicable: Y N Total # of Coolers: Cooler Temperature (s) Celsius:

F71511: Chain of Custody
Page 3 of 4

ACCUTEST Laboratories

Accutest Laboratories Sample Receipt Summary

Accutest Job Number: F71511 Client: Immediate Client Services Action Required: No

Date / Time Received: 2/24/2010 Delivery Method: Client Service Action Required at Login: No

Project: No. Coolers: 1 Airbill #'s:

Cooler Security	Y	or	N		Y	or	N
1. Custody Seals Present:	☑		☐	3. COC Present:	☑		☐
2. Custody Seals Intact:	☑		☐	4. Smpl Dates/Time OK	☑		☐

Cooler Temperature	Y	or	N
1. Temp criteria achieved:	☑		☐
2. Cooler temp verification:	Infared gun		
3. Cooler media:	Ice (bag)		

Quality Control Preservatio	Y	or	N	N/A
1. Trip Blank present / cooler:	☐		☐	☑
2. Trip Blank listed on COC:	☐		☐	☑
3. Samples preserved properly:	☑		☐	
4. VOCs headspace free:	☐		☐	☑

Sample Integrity - Documentation	Y	or	N
1. Sample labels present on bottles:	☑		☐
2. Container labeling complete:	☑		☐
3. Sample container label / COC agree:	☑		☐

Sample Integrity - Condition	Y	or	N
1. Sample recvd within HT:	☑		☐
2. All containers accounted for:	☑		☐
3. Condition of sample:	Intact		

Sample Integrity - Instructions	Y	or	N	N/A
1. Analysis requested is clear:	☑		☐	
2. Bottles received for unspecified tests	☐		☑	
3. Sufficient volume recvd for analysis:	☑		☐	
4. Compositing instructions clear:	☐		☐	☑
5. Filtering instructions clear:	☐		☐	☑

Comments

Accutest Laboratories
V:732.329.0200

2235 US Highway 130
F: 732.329.3499

Dayton, New Jersey
www.accutest.com

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F71511: Chain of Custody
Page 4 of 4

Metals Analysis

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QC Data Summaries

(Accutest New Jersey)

Includes the following where applicable:

- Method Blank Summaries
- Matrix Spike and Duplicate Summaries
- Blank Spike and Lab Control Sample Summaries
- Serial Dilution Summaries

BLANK RESULTS SUMMARY
Part 2 - Method Blanks

Login Number: F71511
Account: ALSE - Accutest Laboratories Southeast, Inc.
Project: ECTELLAU: C-11 Speciation Sampling, Broward Co, FL

QC Batch ID: MP51723
Matrix Type: SOLID

Methods: SW846 6020
Units: mg/kg

Prep Date: 03/04/10

Metal	RL	IDL	MDL	MB raw	final
Aluminum	25	.34	.52		
Antimony	0.25	.019	.022		
Arsenic	0.50	.074	.11		
Barium	0.50	.013	.038		
Beryllium	0.25	.007	.03		
Boron	2.5	.29	.25		
Cadmium	0.25	.011	.016		
Calcium	130	3	3.1		
Chromium	2.0	.038	.29		
Cobalt	0.25	.0015	.016		
Copper	2.0	.13	.036		
Iron	25	.68	1.9		
Lead	0.25	.003	.012		
Magnesium	130	.27	1.4		
Manganese	0.25	.006	.02		
Molybdenum	0.50	.024	.096		
Nickel	2.0	.095	.026		
Potassium	130	1.4	3.9		
Selenium	0.50	.039	.058	-0.032	<0.50
Silver	1.0	.01	.022		
Sodium	130	.56	1.3		
Strontium	0.50	.004	.0082		
Thallium	0.25	.002	.0051		
Tin	0.50	.025			
Titanium	0.50	.027	.27		
Uranium	0.50				
Vanadium	2.0	.27	.79		
Zinc	2.0	.39	.91		

Associated samples MP51723: F71511-1, F71511-2, F71511-3, F71511-4, F71511-5, F71511-6, F71511-7, F71511-8, F71511-9, F71511-10, F71511-11, F71511-12, F71511-13, F71511-14, F71511-15, F71511-16, F71511-17, F71511-18, F71511-19, F71511-20

Results < IDL are shown as zero for calculation purposes
(*) Outside of QC limits
(anr) Analyte not requested

MATRIX SPIKE AND DUPLICATE RESULTS SUMMARY

Login Number: F71511
Account: ALSE - Accutest Laboratories Southeast, Inc.
Project: ECTFLLAU: C-11 Speciation Sampling, Broward Co, FL

QC Batch ID: MP51723
Matrix Type: SOLID

Methods: SW846 6020
Units: mg/kg

Prep Date: 03/04/16

Metal	F71511-19 Original	MS	Spikelot MPIRS1	% Rec	QC Limits
Aluminum					
Antimony					
Arsenic					
Barium					
Beryllium					
Boron					
Cadmium					
Calcium					
Chromium					
Cobalt					
Copper					
Iron					
Lead					
Magnesium					
Manganese					
Molybdenum					
Nickel					
Potassium					
Selenium	0.55	959	956	100.3	69-125
Silver					
Sodium					
Strontium					
Thallium					
Tin					
Titanium					
Uranium					
Vanadium					
Zinc					

Associated samples MP51723: F71511-1, F71511-2, F71511-3, F71511-4, F71511-5, F71511-6, F71511-7, F71511-8, F71511-9, F71511-10, F71511-11, F71511-12, F71511-13, F71511-14, F71511-15, F71511-16, F71511-17, F71511-18, F71511-19, F71511-20

Results < IDL are shown as zero for calculation purposes
(*) Outside of QC limits
(N) Matrix Spike Rec. outside of QC limits
(anr) Analyte not requested

MATRIX SPIKE AND DUPLICATE RESULTS SUMMARY

Login Number: F71511
Account: ALSE - Accutest Laboratories Southeast, Inc.
Project: ECTFLLAU: C-11 Speciation Sampling, Broward Co, FL

QC Batch ID: MP51723
Matrix Type: SOLID

Methods: SW846 6020
Units: mg/kg

Prep Date: 03/04/10

Metal	F71511-19 Original	MSD	Spikelot MPIRS1	% Rec	MSD RPD	QC Limit
Aluminum						
Antimony						
Arsenic						
Barium						
Beryllium						
Boron						
Cadmium						
Calcium						
Chromium						
Cobalt						
Copper						
Iron						
Lead						
Magnesium						
Manganese						
Molybdenum						
Nickel						
Potassium						
Selenium	0.55	956	946	101.0	0.3	20
Silver						
Sodium						
Strontium						
Thallium						
Tin						
Titanium						
Uranium						
Vanadium						
Zinc						

Associated samples MP51723: F71511-1, F71511-2, F71511-3, F71511-4, F71511-5, F71511-6, F71511-7, F71511-8, F71511-9, F71511-10, F71511-11, F71511-12, F71511-13, F71511-14, F71511-15, F71511-16, F71511-17, F71511-18, F71511-19, F71511-20

Results < IDL are shown as zero for calculation purposes
(*) Outside of QC limits
(N) Matrix Spike Rec. outside of QC limits
(anr) Analyte not requested

SPIKE BLANK AND LAB CONTROL SAMPLE SUMMARY

Login Number: F71511
Account: ALSE - Accutest Laboratories Southeast, Inc.
Project: ECTFLLAU: C-11 Speciation Sampling, Broward Co, FL

QC Batch ID: MP51723
Matrix Type: SOLID

Methods: SW846 6020
Units: mg/kg

Prep Date: 03/04/10

Metal	BSP Result	Spikelot MPIRS1	% Rec	QC Limits
Aluminum				
Antimony				
Arsenic				
Barium				
Beryllium				
Boron				
Cadmium				
Calcium				
Chromium				
Cobalt				
Copper				
Iron				
Lead				
Magnesium				
Manganese				
Molybdenum				
Nickel				
Potassium				
Selenium	432	400	108.0	80-120
Silver				
Sodium				
Strontium				
Thallium				
Tin				
Titanium				
Uranium				
Vanadium				
Zinc				

Associated samples MP51723: F71511-1, F71511-2, F71511-3, F71511-4, F71511-5, F71511-6, F71511-7, F71511-8, F71511-9, F71511-10, F71511-11, F71511-12, F71511-13, F71511-14, F71511-15, F71511-16, F71511-17, F71511-18, F71511-19, F71511-20

Results < IDL are shown as zero for calculation purposes
(*) Outside of QC limits
(anr) Analyte not requested

SERIAL DILUTION RESULTS SUMMARY

Login Number: F71511
Account: ALSE - Accutest Laboratories Southeast, Inc.
Project: ECTFLLAU: C-11 Speciation Sampling, Broward Co, FL

QC Batch ID: MP51723
Matrix Type: SOLID

Methods: SW846 6020
Units: ug/l

Prep Date: 03/04/10

Metal	F71511-19 Original	SDL 5:25	%DIF	QC Limits
Aluminum				
Antimony				
Arsenic				
Barium				
Beryllium				
Boron				
Cadmium				
Calcium				
Chromium				
Cobalt				
Copper				
Iron				
Lead				
Magnesium				
Manganese				
Molybdenum				
Nickel				
Potassium				
Selenium	2.33	0.00	100.0(a)	0-10
Silver				
Sodium				
Strontium				
Thallium				
Tin				
Titanium				
Uranium				
Vanadium				
Zinc				

Associated samples MP51723: F71511-1, F71511-2, F71511-3, F71511-4, F71511-5, F71511-6, F71511-7, F71511-8, F71511-9, F71511-10, F71511-11, F71511-12, F71511-13, F71511-14, F71511-15, F71511-16, F71511-17, F71511-18, F71511-19, F71511-20

Results < IDL are shown as zero for calculation purposes
(*) Outside of QC limits
(anr) Analyte not requested
(a) Percent difference acceptable due to low initial sample concentration (< 50 times IDL).

BLANK RESULTS SUMMARY
Part 2 - Method Blanks

Login Number: F71511
Account: ALSE - Accutest Laboratories Southeast, Inc.
Project: ECTFLLAU: C-11 Speciation Sampling, Broward Co, FL

QC Batch ID: MP51739
Matrix Type: SOLID

Methods: SW846 6020
Units: mg/kg

Prep Date: 03/05/10

Metal	RL	IDL	MDL	MB raw	final
Aluminum	10	.14	.21		
Antimony	0.10	.0076	.0086		
Arsenic	0.20	.03	.044		
Barium	0.20	.005	.015		
Beryllium	0.10	.0028	.012		
Boron	1.0	.11	.1		
Cadmium	0.10	.0044	.0063		
Calcium	50	1.2	1.2		
Chromium	0.80	.015	.12		
Cobalt	0.10	.0006	.0063		
Copper	0.80	.051	.015		
Iron	10	.27	.77		
Lead	0.10	.0012	.0046		
Magnesium	50	.11	.56		
Manganese	0.10	.0024	.0078		
Molybdenum	0.20	.0096	.038		
Nickel	0.80	.038	.01		
Potassium	50	.56	1.5		
Selenium	0.20	.016	.023	0.018	<0.20
Silver	0.40	.004	.0089		
Sodium	50	.22	.52		
Strontium	0.20	.0016	.0033		
Thallium	0.10	.0008	.002		
Tin	0.20	.0098			
Titanium	0.20	.011	.11		
Uranium	0.20				
Vanadium	0.80	.11	.32		
Zinc	0.80	.16	.37		

Associated samples MP51739: F71511-21, F71511-22, F71511-23, F71511-24, F71511-25, F71511-26, F71511-27, F71511-28, F71511-29, F71511-30, F71511-31, F71511-32, F71511-33, F71511-34

Results < IDL are shown as zero for calculation purposes
(*) Outside of QC limits
(anr) Analyte not requested

MATRIX SPIKE AND DUPLICATE RESULTS SUMMARY

Login Number: F71511
Account: ALSE - Accutest Laboratories Southeast, Inc.
Project: ECTFLLAU: C-11 Speciation Sampling, Broward Co, FL

QC Batch ID: MP51739 Methods: SW846 6020
Matrix Type: SOLID Units: mg/kg

Prep Date: 03/05/10

Metal	F71511-26 Original	MS	Spikelot MPIRS1	% Rec	QC Limits
Aluminum					
Antimony					
Arsenic					
Barium					
Beryllium					
Boron					
Cadmium					
Calcium					
Chromium					
Cobalt					
Copper					
Iron					
Lead					
Magnesium					
Manganese					
Molybdenum					
Nickel					
Potassium					
Selenium	1.3	408	456	89.2	69-125
Silver					
Sodium					
Strontium					
Thallium					
Tin					
Titanium					
Uranium					
Vanadium					
Zinc					

Associated samples MP51739: F71511-21, F71511-22, F71511-23, F71511-24, F71511-25, F71511-26, F71511-27, F71511-28, F71511-29, F71511-30, F71511-31, F71511-32, F71511-33, F71511-34

Results < IDL are shown as zero for calculation purposes
(*) Outside of QC limits
(N) Matrix Spike Rec. outside of QC limits
(anr) Analyte not requested

MATRIX SPIKE AND DUPLICATE RESULTS SUMMARY

Login Number: F71511
Account: ALSE - Accutest Laboratories Southeast, Inc.
Project: ECTFLLAU: C-11 Speciation Sampling, Broward Co, FL

QC Batch ID: MP51739
Matrix Type: SOLID

Methods: SW846 6020
Units: mg/kg

Prep Date: 03/05/10

Metal	F71511-26 Original	MSD	Spikelot MPIRS1	% Rec	MSD RPD	QC Limit
Aluminum						
Antimony						
Arsenic						
Barium						
Beryllium						
Boron						
Cadmium						
Calcium						
Chromium						
Cobalt						
Copper						
Iron						
Lead						
Magnesium						
Manganese						
Molybdenum						
Nickel						
Potassium						
Selenium	1.3	391	455	85.7	4.3	20
Silver						
Sodium						
Strontium						
Thallium						
Tin						
Titanium						
Uranium						
Vanadium						
Zinc						

Associated samples MP51739: F71511-21, F71511-22, F71511-23, F71511-24, F71511-25, F71511-26, F71511-27, F71511-28, F71511-29, F71511-30, F71511-31, F71511-32, F71511-33, F71511-34

Results < IDL are shown as zero for calculation purposes
(*) Outside of QC limits
(N) Matrix Spike Rec. outside of QC limits
(anr) Analyte not requested

SPIKE BLANK AND LAB CONTROL SAMPLE SUMMARY

Login Number: F71511
Account: ALSE - Accutest Laboratories Southeast, Inc.
Project: ECTFLLAU: C-11 Speciation Sampling, Broward Co, FL

QC Batch ID: MP51739
Matrix Type: SOLID

Methods: SW846 6020
Units: mg/kg

Prep Date: 03/05/10

Metal	BSP Result	Spikelot MPIRS1	% Rec	QC Limits
Aluminum				
Antimony				
Arsenic				
Barium				
Beryllium				
Boron				
Cadmium				
Calcium				
Chromium				
Cobalt				
Copper				
Iron				
Lead				
Magnesium				
Manganese				
Molybdenum				
Nickel				
Potassium				
Selenium	430	400	107.5	80-120
Silver				
Sodium				
Strontium				
Thallium				
Tin				
Titanium				
Uranium				
Vanadium				
Zinc				

Associated samples MP51739: F71511-21, F71511-22, F71511-23, F71511-24, F71511-25, F71511-26, F71511-27, F71511-28, F71511-29, F71511-30, F71511-31, F71511-32, F71511-33, F71511-34

Results < IDL are shown as zero for calculation purposes
(*) Outside of QC limits
(anr) Analyte not requested

SERIAL DILUTION RESULTS SUMMARY

Login Number: F71511
Account: ALSE - Accutest Laboratories Southeast, Inc.
Project: ECTFLLAU: C-11 Speciation Sampling, Broward Co, FL

QC Batch ID: MP51739 | Methods: SW846 6020
Matrix Type: SOLID | Units: ug/l

Prep Date: 03/05/10

Metal	F71511-26 Original	SDL 5:25	%DIF	QC Limits
Aluminum				
Antimony				
Arsenic				
Barium				
Beryllium				
Boron				
Cadmium				
Calcium				
Chromium				
Cobalt				
Copper				
Iron				
Lead				
Magnesium				
Manganese				
Molybdenum				
Nickel				
Potassium				
Selenium	11.6	16.2	39.8 [a]	0-10
Silver				
Sodium				
Strontium				
Thallium				
Tin				
Titanium				
Uranium				
Vanadium				
Zinc				

Associated samples MP51739: F71511-21, F71511-22, F71511-23, F71511-24, F71511-25, F71511-26, F71511-27, F71511-28, F71511-29, F71511-30, F71511-31, F71511-32, F71511-33, F71511-34

Results < IDL are shown as zero for calculation purposes
(*) Outside of QC limits
(anr) Analyte not requested
(a) Percent difference acceptable due to low initial sample concentration (< 50 times IDL).

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Automated Report

Southeast ACCUTEST Laboratories

IT'S ALL IN THE CHEMISTRY

04/02/10

Technical Report for

ECT

C9/C11 Selenium; Weston, FL

10-0096

Accutest Job Number: F71796

Sampling Dates: 02/23/10 - 02/25/10

Report to:

ECT

padak@ectinc.com

ATTN: Probas Adak

Total number of pages in report: **37**

Test results contained within this data package meet the requirements of the National Environmental Laboratory Accreditation Conference and/or state specific certification programs as applicable.

Harry Behzadi, Ph.D.
Laboratory Director

Client Service contact: Sue Bell 407-425-6700

Certifications: FL (DOH E83510), NC (573), NJ (FL002), MA (FL946), IA (366), LA (03051), KS (E-10327), SC, AK
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Test results relate only to samples analyzed.

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Accutest LabLink@101046 08:56 02-Apr-2010

Sample Summary

ECT

Job No: F71796

C9/C11 Selenium; Weston, FL
Project No: 10-0096

Sample Number	Collected Date	Time By	Received	Matrix Code	Type	Client Sample ID
F71796-1	02/24/10	07:52 CAR	03/04/10	SO	Soil	CSS-C9-10D
F71796-2	02/24/10	08:14 CAR	03/04/10	SO	Soil	CSS-C9-15D
F71796-3	02/24/10	10:46 CAR	03/04/10	SO	Soil	CSS-C9-20D
F71796-4	02/24/10	11:15 CAR	03/04/10	SO	Soil	CSS-C9-25D
F71796-5	02/24/10	13:50 CAR	03/04/10	SO	Soil	CSS-C9-30D
F71796-6	02/24/10	14:15 CAR	03/04/10	SO	Soil	CSS-C9-35D
F71796-7	02/25/10	13:10 CAR	03/04/10	SO	Soil	CSS-C9-40D
F71796-8	02/23/10	14:05 CAR	03/04/10	SO	Soil	CSS-C11-20D
F71796-9	02/23/10	11:02 CAR	03/04/10	SO	Soil	CSS-C11-25D
F71796-10	02/23/10	12:15 CAR	03/04/10	SO	Soil	CSS-C11-34D
F71796-11	02/23/10	09:35 CAR	03/04/10	SO	Soil	CSS-C11-30D
F71796-12	02/24/10	00:00 CAR	03/04/10	SO	Soil	CSS-C9-5D

Soil samples reported on a dry weight basis unless otherwise indicated on result page.

Sample Results

Report of Analysis

Accutest LabLink@101046 08:56 02-Apr-2010

Report of Analysis

Client Sample ID:	CSS-C9-10D		
Lab Sample ID:	F71796-1	**Date Sampled:**	02/24/10
Matrix:	SO - Soil	**Date Received:**	03/04/10
		Percent Solids:	92.3
Project:	C9/C11 Selenium; Weston, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	0.059 I	0.27	0.031	mg/kg	5	03/11/10	03/12/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23965
(2) Prep QC Batch: N:MP51802

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest LabLink@101046 08:56 02-Apr-2010

Report of Analysis

Client Sample ID:	CSS-C9-15D		
Lab Sample ID:	F71796-2	**Date Sampled:**	02/24/10
Matrix:	SO - Soil	**Date Received:**	03/04/10
		Percent Solids:	56.8
Project:	C9/C11 Selenium; Weston, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	0.48	0.44	0.051	mg/kg	5	03/11/10	03/12/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23965
(2) Prep QC Batch: N:MP51802

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest LabLink@101046 08:56 02-Apr-2010

Report of Analysis

Client Sample ID:	CSS-C9-20D		
Lab Sample ID:	F71796-3	**Date Sampled:**	02/24/10
Matrix:	SO - Soil	**Date Received:**	03/04/10
		Percent Solids:	88.6
Project:	C9/C11 Selenium; Weston, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	0.0801	0.29	0.033	mg/kg	5	03/11/10	03/12/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23965
(2) Prep QC Batch: N:MP51802

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest LabLink@101046 08:56 02-Apr-2010

Report of Analysis

Client Sample ID:	CSS-C9-20D		
Lab Sample ID:	F71796-3	**Date Sampled:**	02/24/10
Matrix:	SO - Soil	**Date Received:**	03/04/10
		Percent Solids:	88.6
Project:	C9/C11 Selenium; Weston, FL		

General Chemistry

Analyte	Result	RL	MDL	Units	DF	Analyzed	By	Method
Solids, Percent	88.6			%	1	03/10/10 11:25	LT	SM19 2540B M
Total Organic Carbon	17200	1100	560	mg/kg	1	03/15/10 18:08	SD	SW846 9060A MOD

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest LabLink@101046 08:56 02-Apr-2010

Report of Analysis

Client Sample ID:	CSS-C9-25D		
Lab Sample ID:	F71796-4	**Date Sampled:**	02/24/10
Matrix:	SO - Soil	**Date Received:**	03/04/10
		Percent Solids:	37.2
Project:	C9/C11 Selenium; Weston, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	1.9	0.67	0.078	mg/kg	5	03/11/10	03/12/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23965
(2) Prep QC Batch: N:MP51802

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest LabLink@101046 08:56 02-Apr-2010

Report of Analysis

Client Sample ID:	CSS-C9-30D		
Lab Sample ID:	F71796-5	**Date Sampled:**	02/24/10
Matrix:	SO - Soil	**Date Received:**	03/04/10
		Percent Solids:	36.2
Project:	C9/C11 Selenium; Weston, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed By	Method	Prep Method
Selenium [a]	2.1	0.69	0.081	mg/kg	5	03/11/10	03/12/10 ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23965
(2) Prep QC Batch: N:MP51802

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest LabLink@101046 08:56 02-Apr-2010

Report of Analysis

Client Sample ID:	CSS-C9-30D		
Lab Sample ID:	F71796-5	**Date Sampled:**	02/24/10
Matrix:	SO - Soil	**Date Received:**	03/04/10
		Percent Solids:	36.2
Project:	C9/C11 Selenium; Weston, FL		

General Chemistry

Analyte	Result	RL	MDL	Units	DF	Analyzed	By	Method
Solids, Percent	36.2			%	1	03/10/10 11:25	LT	SM19 2540B M
Total Organic Carbon	33000	2800	1400	mg/kg	1	03/16/10 10:29	SD	SW846 9060A MOD

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest LabLink@101046 08:56 02-Apr-2010

Report of Analysis

Client Sample ID:	CSS-C9-35D		
Lab Sample ID:	F71796-6	**Date Sampled:**	02/24/10
Matrix:	SO - Soil	**Date Received:**	03/04/10
		Percent Solids:	34.4
Project:	C9/C11 Selenium; Weston, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	2.0	0.74	0.086	mg/kg	5	03/11/10	03/12/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23965
(2) Prep QC Batch: N:MP51802

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest LabLink@101046 08:56 02-Apr-2010

Report of Analysis

Client Sample ID:	CSS-C9-40D		
Lab Sample ID:	F71796-7	**Date Sampled:**	02/25/10
Matrix:	SO - Soil	**Date Received:**	03/04/10
		Percent Solids:	45.9
Project:	C9/C11 Selenium; Weston, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed By	Method	Prep Method
Selenium [a]	3.5	0.55	0.064	mg/kg	5	03/11/10	03/15/10 ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23970
(2) Prep QC Batch: N:MP51802

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest LabLink@101046 08:56 02-Apr-2010

Report of Analysis

Client Sample ID:	CSS-C9-40D		
Lab Sample ID:	F71796-7	**Date Sampled:**	02/25/10
Matrix:	SO - Soil	**Date Received:**	03/04/10
		Percent Solids:	45.9
Project:	C9/C11 Selenium; Weston, FL		

General Chemistry

Analyte	Result	RL	MDL	Units	DF	Analyzed	By	Method
Solids, Percent	45.9			%	1	03/10/10 11:25	LT	SM19 2540B M
Total Organic Carbon	31000	2200	1100	mg/kg	1	03/16/10 10:52	SD	SW846 9060A MOD

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest LabLink@101046 08:56 02-Apr-2010

Report of Analysis

Client Sample ID:	CSS-C11-20D		
Lab Sample ID:	F71796-8	**Date Sampled:**	02/23/10
Matrix:	SO - Soil	**Date Received:**	03/04/10
		Percent Solids:	83.4
Project:	C9/C11 Selenium; Weston, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Barium [a]	4.4	0.30	0.023	mg/kg	5	03/11/10	03/12/10	ANJ	SW846 6020 [1]	SW846 3050B [2]
Selenium [a]	0.072 I	0.30	0.035	mg/kg	5	03/11/10	03/12/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23965
(2) Prep QC Batch: N:MP51802

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest LabLink@101046 08:56 02-Apr-2010

Report of Analysis

Client Sample ID:	CSS-C11-25D		
Lab Sample ID:	F71796-9	**Date Sampled:**	02/23/10
Matrix:	SO - Soil	**Date Received:**	03/04/10
		Percent Solids:	24.8
Project:	C9/C11 Selenium; Weston, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Barium [a]	46.4	1.0	0.080	mg/kg	5	03/11/10	03/12/10	ANJ	SW846 6020 [1]	SW846 3050B [2]
Selenium [a]	3.2	1.0	0.12	mg/kg	5	03/11/10	03/12/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23965
(2) Prep QC Batch: N:MP51802

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest LabLink@101046 08:56 02-Apr-2010

Report of Analysis

Client Sample ID:	CSS-C11-34D		
Lab Sample ID:	F71796-10	**Date Sampled:**	02/23/10
Matrix:	SO - Soil	**Date Received:**	03/04/10
		Percent Solids:	23.5
Project:	C9/C11 Selenium; Weston, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Barium [a]	71.2	1.1	0.082	mg/kg	5	03/11/10	03/12/10	ANJ	SW846 6020 [1]	SW846 3050B [2]
Selenium [a]	5.9	1.1	0.13	mg/kg	5	03/11/10	03/12/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23965
(2) Prep QC Batch: N:MP51802

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest LabLink@101046 08:56 02-Apr-2010

Report of Analysis

Client Sample ID:	CSS-C11-30D		
Lab Sample ID:	F71796-11	**Date Sampled:**	02/23/10
Matrix:	SO - Soil	**Date Received:**	03/04/10
		Percent Solids:	37.1
Project:	C9/C11 Selenium; Weston, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Barium [a]	65.6	0.68	0.052	mg/kg	5	03/11/10	03/12/10	ANJ	SW846 6020 [1]	SW846 3050B [2]
Selenium [a]	3.4	0.68	0.080	mg/kg	5	03/11/10	03/12/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23965
(2) Prep QC Batch: N:MP51802

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest LabLink@101046 08:56 02-Apr-2010

Report of Analysis

Client Sample ID:	CSS-C9-5D		
Lab Sample ID:	F71796-12	**Date Sampled:**	02/24/10
Matrix:	SO - Soil	**Date Received:**	03/04/10
		Percent Solids:	34.9
Project:	C9/C11 Selenium; Weston, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	4.6	0.73	0.086	mg/kg	5	03/11/10	03/12/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23965
(2) Prep QC Batch: N:MP51802

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest LabLink@101046 08:56 02-Apr-2010

Report of Analysis

Client Sample ID:	CSS-C9-5D		
Lab Sample ID:	F71796-12	**Date Sampled:**	02/24/10
Matrix:	SO - Soil	**Date Received:**	03/04/10
		Percent Solids:	34.9
Project:	C9/C11 Selenium; Weston, FL		

General Chemistry

Analyte	Result	RL	MDL	Units	DF	Analyzed	By	Method
Solids, Percent	34.9			%	1	03/10/10 11:25	LT	SM19 2540B M
Total Organic Carbon	39200	2900	1400	mg/kg	1	03/16/10 11:11	SD	SW846 9060A MOD

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Misc. Forms

Custody Documents and Other Forms

Includes the following where applicable:

- Certification Exceptions
- Chain of Custody

ACCUTEST

CHAIN OF CUSTODY
4405 Vineland Rd., Suite C15
Orlando, FL 32811
407.425.6700, fax 407.425.0707

Accutest Job #: F71796
Accutest Control #:

Client Information

Name: ECT
Address: 6300 NE 18T AVE.
City: FT LAUDERDALE State: FL Zip: 33334
Send Report to:
Phone #: 9547710444 FAX #:

Facility Information

Project Name: C9 AND C11
Location: FL
Project No.: 10-0096

Analytical Information

	Field ID / Point of Collection	Collection Date	Time	Sampled By	Matrix	# of bottles	Preservation: HCL	NaOH	HNO3	None	Se (By 6020)	TOC	Ba
1	CSS-C9-10D	2/24/2010	752	CAR/MS	SO	1					X		
2	CSS-C9-15D	2/24/2010	814	CAR/MS	SO	1					X		
3	CSS-C9-20D	2/24/2010	1046	CAR/MS	SO	1					X	X	
4	CSS-C9-25D	2/24/2010	1115	CAR/MS	SO	2					X		
5	CSS-C9-30D	2/24/2010	1350	CAR/MS	SO	1					X	X	
6	CSS-C9-35D	2/24/2010	1415	CAR/MS	SO	2					X		
7	CSS-C9-40D	2/25/2010	1310	CAR/MS	SO	1					X	X	
8	CSS-C11-20D	2/23/2010	1405	PA	SO	1					X		X
9	CSS-C11-25D	2/23/2010	1102	PA	SO	1					X		X
10	CSS-C11-34D	2/23/2010	1215	PA	SO	1					X		X
11	CSS-C11-30D	2/23/2010	935	PA	SO	1					X		X

Turnaround Information

- [X] 14 Day Standard — Approved By:
- [ ] 7 days
- [ ] 24 hour
- [ ] Other _____ (Days)

RUSH TAT is for FAX data
Data unless previously approved.

Data Deliverable Information

- [ ] NJ Reduced
- [ ] NJ Full
- [ ] FULL CLP
- [ ] Disk Deliverable
- [X] Other (Specify) ADAPT EDD
- [ ] Commercial "A"
- [ ] Commercial "B"
- [ ] ASP Category B
- [ ] State Forms

Comments / Remarks

CSS-C9-5. Should be logged in for Selenium & TOC analysis. Ok 3/3/10
2/24/10 0000

Sample Custody must be documented below each time samples change possession, including courier delivery.

Relinquished by Sampler:	Date Time:	Received By:	Relinquished By:	Date Time:	Received By:
1		1	2		2
Relinquished by Sampler:	Date Time:	Received By:	Relinquished By:	Date Time:	Received By:
3	2/24/10 9:00	3	4		4
Relinquished by Sampler:	Date Time:	Received By:	Seal #	Preserved where applic:	On Ice:
5		5			3.0

3/3/10 1430

3.1 3

F71796: Chain of Custody
Page 1 of 3

ACCUTEST LABORATORIES SAMPLE RECEIPT CONFIRMATION

ACCUTEST'S JOB NUMBER: F71796 CLIENT: ECT PROJECT: C9 and C11

DATE/TIME RECEIVED: 3/4/10 9:50 (MM/DD/YY 24:00) NUMBER OF COOLERS RECEIVED: 1

METHOD OF DELIVERY: (FEDEX) UPS ACCUTEST COURIER GREYHOUND DELIVERY OTHER

AIRBILL NUMBERS: 8510 8882 8841

COOLER INFORMATION

- [ ] CUSTODY SEAL NOT PRESENT OR NOT INTACT
- [ ] CHAIN OF CUSTODY NOT RECEIVED (COC)
- [ ] ANALYSIS REQUESTED IS UNCLEAR OR MISSING
- [ ] SAMPLE DATES OR TIMES UNCLEAR OR MISSING
- [ ] TEMPERATURE CRITERIA NOT MET
- [ ] WET ICE PRESENT

TRIP BLANK INFORMATION

- [ ] TRIP BLANK PROVIDED
- [X] TRIP BLANK NOT PROVIDED
- [X] TRIP BLANK NOT ON COC
- [ ] TRIP BLANK INTACT
- [ ] TRIP BLANK NOT INTACT
- [ ] RECEIVED WATER TRIP BLANK
- [ ] RECEIVED SOIL TRIP BLANK

MISC. INFORMATION

NUMBER OF ENCORES ? 0

NUMBER OF 5035 FIELD KITS ? 0

NUMBER OR LAB FILTERED METALS ? 0

TEMPERATURE INFORMATION

- [ ] IR THERM ID IR3 CORR. FACTOR +0
- [ ] OBSERVED TEMPS: 3.0
- [ ] CORRECTED TEMPS: 3.0

SAMPLE INFORMATION

- [ ] SAMPLE LABELS PRESENT ON ALL BOTTLES
- [ ] INCORRECT NUMBER OF CONTAINERS USED
- [ ] SAMPLE RECEIVED IMPROPERLY PRESERVED
- [ ] INSUFFICIENT VOLUME FOR ANALYSIS
- [ ] DATES/TIMES ON COC DO NOT MATCH SAMPLE LABEL
- [ ] ID'S ON COC DO NOT MATCH LABEL
- [ ] VOC VIALS HAVE HEADSPACE (MACRO BUBBLES)
- [X] BOTTLES RECEIVED BUT ANALYSIS NOT REQUESTED
- [ ] NO BOTTLES RECEIVED FOR ANALYSIS REQUESTED
- [ ] UNCLEAR FILTERING OR COMPOSITING INSTRUCTIONS
- [ ] SAMPLE CONTAINER(S) RECEIVED BROKEN
- [ ] % SOLIDS JAR NOT RECEIVED
- [ ] 5035 FIELD KIT FROZEN WITHIN 48 HOUR'S
- [ ] RESIDUAL CHLORINE PRESENT

(APPICABLE TO EPA 600 SERIES OR NORTH CAROLINA ORGANICS)

SUMMARY OF COMMENTS: Received 1 extra 2oz jar labeled CSS-C9-5D

TECHNICIAN SIGNATURE/DATE [illegible] 3/4/10 REVIEWER SIGNATURE/DATE [illegible] 03-04-10

NF 10/09 RECEIPT CONFIRMATION 100609 (2).xls

3.1 3

F71796: Chain of Custody
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3.1
3

Job Change Order: F71796_3/4/2010

Requested Date:	3/4/2010	**Received Date:**	3/4/2010
Account Name:	ECT	**Due Date:**	3/15/2010
Project Description:	C9/C11 Selenium; Weston, FL	**Deliverable:**	COMMB
CSR:	SB	**TAT (Days):**	14

Sample #: F71796-CSS-C9-5D

Change: Per Probas @ ECT via phone 03.0.10, run this sample for Se and TOC.

Above Changes Probas @ ECT **Date:** 3/4/2010

To Client: This Change Order is confirmation of the revisions, previously discussed with the Accutest Client Service Representative.

Page 1 of 1

F71796 Chain of Custody
Page 3 of 3

General Chemistry

QC Data Summaries

Includes the following where applicable:

- Method Blank and Blank Spike Summaries
- Duplicate Summaries
- Matrix Spike Summaries

METHOD BLANK AND SPIKE RESULTS SUMMARY
GENERAL CHEMISTRY

Login Number: F71796
Account: ECTFLLAU - ECT
Project: C9/C11 Selenium; Weston, FL

Analyte	Batch ID	RL	MB Result	Units	Spike Amount	BSP Result	BSP %Recov	QC Limits
Total Organic Carbon	GP14481/GN38846	1000	0.0	mg/kg	20000	21300	106.5	88-114%
Total Organic Carbon	GP14492/GN38879	1000	0.0	mg/kg	20000	21300	106.5	88-114%

Associated Samples:
Batch GP14481: F71796-3
Batch GP14492: F71796-12, F71796-5, F71796-7
(*) Outside of QC limits

DUPLICATE RESULTS SUMMARY
GENERAL CHEMISTRY

Login Number: F71796
Account: ECTFLLAU - ECT
Project: C9/C11 Selenium; Weston, FL

Analyte	Batch ID	QC Sample	Units	Original Result	DUP Result	RPD	QC Limits
Solids, Percent	GN38758	F71730-1	%	81.1	80.5	0.7	0-10%
Total Organic Carbon	GP14481/GN38846	F71708-14	mg/kg	9000	9280	3.1	0-36%
Total Organic Carbon	GP14492/GN38879	F71796-5	mg/kg	33000	26600	21.5	0-36%

Associated Samples:
Batch GN38758: F71796-1, F71796-10, F71796-11, F71796-12, F71796-2, F71796-3, F71796-4, F71796-5, F71796-6, F71796-7, F71796-8, F71796-9
Batch GP14481: F71796-3
Batch GP14492: F71796-12, F71796-5, F71796-7
(*) Outside of QC limits

MATRIX SPIKE RESULTS SUMMARY
GENERAL CHEMISTRY

Login Number: F71796
Account: ECTFLLAU - ECT
Project: C9/C11 Selenium; Weston, FL

Analyte	Batch ID	QC Sample	Units	Original Result	Spike Amount	MS Result	%Rec	QC Limits
Total Organic Carbon	GP14481/GN38846	F71708-14	mg/kg	9000	25800	35100	101.0	88-114%
Total Organic Carbon	GP14492/GN38879	F71796-5	mg/kg	33000	55200	75500	76.8N(a)	88-114%

Associated Samples:
Batch GP14481: F71796-3
Batch GP14492: F71796-12, F71796-5, F71796-7
(*) Outside of QC limits
(N) Matrix Spike Rec. outside of QC limits
(a) Spike recovery indicates possible matrix interference and/or sample nonhomogeneity.

Misc. Forms

Custody Documents and Other Forms

(Accutest New Jersey)

Includes the following where applicable:

- Chain of Custody

ACCUTEST Laboratories

Accutest Southeast Subcontract Chain of Custody

4405 Vineland Road, Suite C-15 Orlando, Fl 32811
TEL: 407-425-6700 • FAX: 407-425-0707

AB# 798454289 0378

PAGE 1 OF 1

Client / Reporting Information

Company Name: Accutest Laboratories Southeast
Address: 4405 Vineland Road Suite C15
City: Orlando State: Fl Zip: 32811
Project Contact: E-mail:
Phone#: 407-425-6700 Fax #: 407-425-0707
Lab Technician Printed Name:

Project Information

Accutest Job Number: F71796
Street
City
Project #
Fax #
Client Purchase Order #

Please send report to dawnd@accutest.com

For any other issues contact munam@accutest.com

Analytical Information

Lab ID #	Client ID / Accutest Sample ID	Collection Date	Collection Time	Sampled By	Matrix	Total # of Bottles	Other	Metals	HCl	NaOH	HNO3	H2SO4	NaHSO4	NaO2S2O3	SEMS	PAHS							Lab Use Only
	F71796-1				SO	1		X							X								NE
	-2					1		X							X								48FL
	-3					1		X							X								
	-4					1		X							X								
	-5					1		X							X								
	-6					1		X							X								
	-7					1		X							X								
	-8					1		X							X	X							
	-9					1		X							X	X							
	-10					1		X							X	X							
	-11					1		X							X	X							
	-12				W	1		X							X								

Matrix Codes: DW - Drinking Water; GW - Ground Water; WW - Water; SW - Surface Water; SO - Soil; SL - Sludge; OI - Oil; LIQ - Other Liquid; AIR - Air; SOL - Other Solid

TURNAROUND TIME (Business Days)

Approved By: 3/15/10

- Standard 10 Business Days
- 7 Day RUSH
- 5 Day RUSH
- 3 Day EMERGENCY
- 2 Day EMERGENCY
- 1 Day EMERGENCY
- OTHER

Data Deliverable Information

- COMMERCIAL "A" (RESULTS ONLY)
- [X] COMMERCIAL "B" (RESULTS PLUS QC)
- REDT1 (EPA LEVEL 3)
- FULLT1 (EPA LEVEL 4)
- EDD'S

Comments / Remarks

Ship to Laboratory-ALNJ

Approved By-Muna Mohammad

Sample Custody must be documented below each time samples change possession, including courier delivery.

Relinquished by Lab Technician	Date Time:	Received By/Affiliation	Relinquished by/Affiliation	Date Time:	Received By/Affiliation
1	3/12/10 1200	2 Fed Ex	3 Fed Ex	3-9-10 930	4
Relinquished by/Affiliation	Date Time:	Received By/Affiliation	Relinquished by/Affiliation	Date Time:	Received By/Affiliation
5		6	7		8

Lab Use Only: Custody Seal in Place: Y N Temp Blank Provided: Y N Preserved Where Applicable: Y N Total # of Coolers: Cooler Temperature (s) Celsius: 2-2 c.

F71796: Chain of Custody
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Accutest New Jersey

ACCUTEST Laboratories

Accutest Laboratories Sample Receipt Summary

Accutest Job Number: F71796 Client: Immediate Client Services Action Required: No

Date / Time Received: 3/9/2010 Delivery Method: Client Service Action Required at Login: No

Project: No. Coolers: 1 Airbill #'s:

Cooler Security	Y	or	N		Y	or	N
1. Custody Seals Present:	☑		☐	3. COC Present:	☑		☐
2. Custody Seals Intact:	☑		☐	4. Smpl Dates/Time OK	☑		☐

Cooler Temperature	Y	or	N
1. Temp criteria achieved:	☑		☐
2. Cooler temp verification:	Infared gun		
3. Cooler media:	Ice (bag)		

Quality Control Preservatio	Y	or	N	N/A
1. Trip Blank present / cooler:	☐		☐	☑
2. Trip Blank listed on COC:	☐		☐	☑
3. Samples preserved properly:	☑		☐	
4. VOCs headspace free:	☐		☐	☑

Sample Integrity - Documentation	Y	or	N
1. Sample labels present on bottles:	☑		☐
2. Container labeling complete:	☑		☐
3. Sample container label / COC agree:	☑		☐

Sample Integrity - Condition	Y	or	N
1. Sample recvd within HT:	☑		☐
2. All containers accounted for:	☑		☐
3. Condition of sample:	Intact		

Sample Integrity - Instructions	Y	or	N	N/A
1. Analysis requested is clear:	☑		☐	
2. Bottles received for unspecified tests	☐		☑	
3. Sufficient volume recvd for analysis:	☑		☐	
4. Compositing instructions clear:	☐		☐	☑
5. Filtering instructions clear:	☐		☐	☑

Comments

Accutest Laboratories
V:732.329.0200

2235 US Highway 130
F: 732.329.3489

Dayton, New Jersey
www.accutest.com

F71796: Chain of Custody
Page 2 of 2

Metals Analysis

6

QC Data Summaries

(Accutest New Jersey)

Includes the following where applicable:

- Method Blank Summaries
- Matrix Spike and Duplicate Summaries
- Blank Spike and Lab Control Sample Summaries
- Serial Dilution Summaries

BLANK RESULTS SUMMARY
Part 2 - Method Blanks

Login Number: F71796
Account: ALSE - Accutest Laboratories Southeast, Inc.
Project: ECTFLLAU: C9/C11 Selenium; Weston, FL

QC Batch ID: MP51802
Matrix Type: SOLID

Methods: SW846 6020
Units: mg/kg

Prep Date: 03/11/10

Metal	RL	IDL	MDL	MB raw	final
Aluminum	10	.14	.21		
Antimony	0.10	.0076	.0086		
Arsenic	0.20	.03	.044		
Barium	0.20	.005	.015	0.066	<0.20
Beryllium	0.10	.0028	.012		
Boron	1.0	.11	.1		
Cadmium	0.10	.0044	.0063		
Calcium	50	1.2	1.2		
Chromium	0.80	.015	.12		
Cobalt	0.10	.0006	.0063		
Copper	0.80	.051	.015		
Iron	10	.27	.77		
Lead	0.10	.0012	.0046		
Magnesium	50	.11	.56		
Manganese	0.10	.0024	.0078		
Molybdenum	0.20	.0096	.038		
Nickel	0.80	.038	.01		
Potassium	50	.56	1.5		
Selenium	0.20	.016	.023	0.017	<0.20
Silver	0.40	.004	.0089		
Sodium	50	.22	.52		
Strontium	0.20	.0016	.0033		
Thallium	0.10	.0008	.002		
Tin	0.20	.0098			
Titanium	0.20	.011	.11		
Uranium	0.20				
Vanadium	0.80	.11	.32		
Zinc	0.80	.16	.37		

Associated samples MP51802: F71796-1, F71796-2, F71796-3, F71796-4, F71796-5, F71796-6, F71796-7, F71796-8, F71796-9, F71796-10, F71796-11, F71796-12

Results < IDL are shown as zero for calculation purposes
(*) Outside of QC limits
(anr) Analyte not requested

MATRIX SPIKE AND DUPLICATE RESULTS SUMMARY

Login Number: F71796
Account: ALSE - Accutest Laboratories Southeast, Inc.
Project: ECTFLLAU: C9/C11 Selenium; Weston, FL

QC Batch ID: MP51802
Matrix Type: SOLID

Methods: SW846 6020
Units: mg/kg

Prep Date: 03/11/10

Metal	F71797-2 Original	MS	Spikelot MPIRS1	% Rec	QC Limits
Aluminum					
Antimony					
Arsenic					
Barium	81.3	984	883	102.2	75-125
Beryllium					
Boron					
Cadmium					
Calcium					
Chromium					
Cobalt					
Copper					
Iron					
Lead					
Magnesium					
Manganese					
Molybdenum					
Nickel					
Potassium					
Selenium	0.65	908	883	102.0	69-125
Silver					
Sodium					
Strontium					
Thallium					
Tin					
Titanium					
Uranium					
Vanadium					
Zinc					

Associated samples MP51802: F71796-1, F71796-2, F71796-3, F71796-4, F71796-5, F71796-6, F71796-7, F71796-8, F71796-9, F71796-10, F71796-11, F71796-12

Results < IDL are shown as zero for calculation purposes
(*) Outside of QC limits
(N) Matrix Spike Rec. outside of QC limits
(anr) Analyte not requested

MATRIX SPIKE AND DUPLICATE RESULTS SUMMARY

Login Number: F71796
Account: ALSE - Accutest Laboratories Southeast, Inc.
Project: ECTFLLAU: C9/C11 Selenium; Weston, FL

QC Batch ID: MP51802 Methods: SW846 6020
Matrix Type: SOLID Units: mg/kg

Prep Date: 03/11/10

Metal	F71797-2 Original	MSD	Spikelot MPIRS1	% Rec	MSD RPD	QC Limit
Aluminum						
Antimony						
Arsenic						
Barium	81.3	1100	923	110.3	11.1	20
Beryllium						
Boron						
Cadmium						
Calcium						
Chromium						
Cobalt						
Copper						
Iron						
Lead						
Magnesium						
Manganese						
Molybdenum						
Nickel						
Potassium						
Selenium	0.65	1020	923	110.4	11.6	20
Silver						
Sodium						
Strontium						
Thallium						
Tin						
Titanium						
Uranium						
Vanadium						
Zinc						

Associated samples MP51802: F71796-1, F71796-2, F71796-3, F71796-4, F71796-5, F71796-6, F71796-7, F71796-8, F71796-9, F71796-10, F71796-11, F71796-12

Results < IDL are shown as zero for calculation purposes
(*) Outside of QC limits
(N) Matrix Spike Rec. outside of QC limits
(anr) Analyte not requested

SPIKE BLANK AND LAB CONTROL SAMPLE SUMMARY

Login Number: F71796
Account: ALSE - Accutest Laboratories Southeast, Inc.
Project: ECTFLLAU: C9/C11 Selenium; Weston, FL

QC Batch ID: MP51802
Matrix Type: SOLID

Methods: SW846 6020
Units: mg/kg

Prep Date: 03/11/10

Metal	BSP Result	Spikelot MPIRS1	% Rec	QC Limits
Aluminum				
Antimony				
Arsenic				
Barium	438	400	109.5	80-120
Beryllium				
Boron				
Cadmium				
Calcium				
Chromium				
Cobalt				
Copper				
Iron				
Lead				
Magnesium				
Manganese				
Molybdenum				
Nickel				
Potassium				
Selenium	444	400	111.0	80-120
Silver				
Sodium				
Strontium				
Thallium				
Tin				
Titanium				
Uranium				
Vanadium				
Zinc				

Associated samples MP51802: F71796-1, F71796-2, F71796-3, F71796-4, F71796-5, F71796-6, F71796-7, F71796-8, F71796-9, F71796-10, F71796-11, F71796-12

Results < IDL are shown as zero for calculation purposes
(*) Outside of QC limits
(anr) Analyte not requested

ACCUTEST Laboratories

SERIAL DILUTION RESULTS SUMMARY

Login Number: F71796
Account: ALSE - Accutest Laboratories Southeast, Inc.
Project: ECTFLLAU: C9/C11 Selenium; Weston, FL

QC Batch ID: MP51802
Matrix Type: SOLID

Methods: SW846 6020
Units: ug/l

Prep Date: 03/11/10

Metal	F71797-2 Original	SDL 5:25	%DIF	QC Limits
Aluminum				
Antimony				
Arsenic				
Barium	368	368	0.1	0-10
Beryllium				
Boron				
Cadmium				
Calcium				
Chromium				
Cobalt				
Copper				
Iron				
Lead				
Magnesium				
Manganese				
Molybdenum				
Nickel				
Potassium				
Selenium	2.93	6.16	110.6(a)	0-10
Silver				
Sodium				
Strontium				
Thallium				
Tin				
Titanium				
Uranium				
Vanadium				
Zinc				

Associated samples MP51802: F71796-1, F71796-2, F71796-3, F71796-4, F71796-5, F71796-6, F71796-7, F71796-8, F71796-9, F71796-10, F71796-11, F71796-12

Results < IDL are shown as zero for calculation purposes
(*) Outside of QC limits
(anr) Analyte not requested
(a) Percent difference acceptable due to low initial sample concentration (< 50 times IDL).

Columbia Analytical Services™ 9143 Philips Highway, Suite 200 | Jacksonville, FL 32256 | 904-739-2277 | 904-739-2011 fax | www.caslab.com

March 10, 2010

Service Request No: J1000934

Barry Westmark
Environmental Consulting & Technology, Inc.
6300 Northeast First Avenue, Suite 100
Fort Lauderdale, FL 33334

Laboratory Results for: C9 & C11/10-0096

Dear Barry:

Enclosed are the results of the sample(s) submitted to our laboratory on February 27, 2010. For your reference, these analyses have been assigned our service request number **J1000934**.

All analyses were performed according to our laboratory's quality assurance program. The test results meet requirements of the NELAP standards except as noted in the case narrative report. All results are intended to be considered in their entirety, and Columbia Analytical Services, Inc. (CAS) is not responsible for use of less than the complete report. Results apply only to the items submitted to the laboratory for analysis and individual items (samples) analyzed, as listed in the report.

Please contact me if you have any questions. My extension is 4409. You may also contact me via email at CMyers@caslab.com.

Respectfully submitted,

Columbia Analytical Services, Inc.

Craig Myers
Project Manager

CAS Jacksonville is NELAC-accredited by the State of Florida, #E82502. Other state accreditations include: Georgia, #958; Kentucky, #63; Louisiana, #02086; North Carolina, #527; South Carolina, #96021001; Texas, #T104704197-09-TX.

Florida DEP Data Qualifiers

B Results based upon colony counts outside the acceptable range.

D Measurement was made in the field.

H Value based on field kit determination; results may not be accurate.

i The reported value is between the laboratory method detection limit and the laboratory practical quantitation limit.

J Estimated value (one of the following reasons is discussed in the project case narrative).
1. The result may be inaccurate because the surrogate recovery limits have been exceeded.
2. No known quality control criteria exists for the component.
3. The reported value failed to meet the established quality control criteria for either precision or accuracy.
4. The sample matrix interfered with the ability to make any accurate determination (e.g., primary and confirmation results show greater than 40% RPD).
5. The data is questionable because of improper laboratory or field protocols (e.g., GC/MS Tune did not meet method criteria).

K Off scale low. The value is less than the lowest calibration standard but greater than the method reporting limit (MRL).

L Off scale high. The analyte is above the upper limit of the linear calibration range.

M The MDL/MRL has been elevated because the analyte could not be accurately quantified due to matrix interference.

N Presumptive evidence of the analyte. Confirmation was not performed.

Q Sample held beyond the accepted holding time.

T Value reported is less than the laboratory method detection limit. The value is reported for informational purposes only.

U Indicates that the compound was analyzed for but not detected.

V Indicates that the analyte was detected in both the sample and the associated method blank.

Y The laboratory analysis was from an improperly preserved sample.

Z Too many colonies were present (TNTC). The numeric value represents the filtration volume.

Acronyms

ASTM	American Society for Testing and Materials
A2LA	American Association for Laboratory Accreditation
CARB	California Air Resources Board
CAS Number	Chemical Abstract Service registry Number
CFC	Chlorofluorocarbon
CFU	Colony-Forming Unit
DEC	Department of Environmental Conservation
DEQ	Department of Environmental Quality
DHS	Department of Health Services
DOE	Department of Ecology
DOH	Department of Health
EPA	U. S. Environmental Protection Agency
ELAP	Environmental Laboratory Accreditation Program
GC	Gas Chromatography
GC/MS	Gas Chromatography/Mass Spectrometry
LUFT	Leaking Underground Fuel Tank
M	Modified
MCL	Maximum Contaminant Level is the highest permissible concentration of a substance allowed in drinking water as established by the USEPA.
MDL	Method Detection Limit
MPN	Most Probable Number
MRL	Method Reporting Limit
NA	Not Applicable
NC	Not Calculated
NCASI	National Council of the Paper Industry for Air and Stream Improvement
ND	Not Detected
NIOSH	National Institute for Occupational Safety and Health
PQL	Practical Quantitation Limit
RCRA	Resource Conservation and Recovery Act
SIM	Selected Ion Monitoring
TPH	Total Petroleum Hydrocarbons
tr	Trace level is the concentration of an analyte that is less than the PQL but greater than or equal to the MDL.

Client: Environmental Consulting & Technology, Inc.
Project: C9 & C11/10-0096

Service Request: J1000934

SAMPLE CROSS-REFERENCE

SAMPLE #	CLIENT SAMPLE ID	DATE	TIME
J1000934-001	CSS-C9-10	2/24/10	00:00
J1000934-002	CSS-C9-15	2/24/10	00:00
J1000934-003	CSS-C9-20	2/24/10	00:00
J1000934-004	CSS-C9-25	2/24/10	00:00
J1000934-005	CSS-C9-30	2/24/10	00:00
J1000934-006	CSS-C9-35	2/24/10	00:00
J1000934-007	CSS-C9-40	2/25/10	00:00
J1000934-008	CSS-C11-20	2/23/10	14:05
J1000934-009	CSS-C11-25	2/23/10	11:02
J1000934-010	CSS-C11-30	2/23/10	09:35
J1000934-011	CSS-C11-34	2/23/10	12:15
J1000934-012	CSS-C9-5	2/24/10	00:00

COLUMBIA ANALYTICAL SERVICES, INC.

Analytical Report

Client:	Environmental Consulting & Technology, Inc.	**Service Request:**	J1000934
Project:	C9 & C11/10-0096	**Date Collected:**	2/23/10 - 2/25/10
Sample Matrix:	Soil	**Date Received:**	2/27/10
Prep Method:	EPA 3050B	**Units:**	mg/Kg
Analysis Method:	6020	**Basis:**	Dry

Selenium, Total

Sample Name	Lab Code	Result	Q	MRL	MDL	Dilution Factor	Date Extracted	Date Analyzed
CSS-C9-10	J1000934-001	**0.5**	I	2.3	0.5	1	3/ 3/10	3/4/10 15:12
CSS-C9-15	J1000934-002	**1.0**	I	3.3	0.7	1	3/ 3/10	3/4/10 15:17
CSS-C9-20	J1000934-003	**0.6**	I	2.2	0.5	1	3/ 3/10	3/4/10 15:48
CSS-C9-25	J1000934-004	**2.6**	I	5.2	1.1	1	3/ 3/10	3/4/10 15:53
CSS-C9-30	J1000934-005	**3.0**	I	5.6	1.2	1	3/ 3/10	3/4/10 16:14
CSS-C9-35	J1000934-006	**2.8**	I	5.5	1.2	1	3/ 3/10	3/4/10 16:19
CSS-C9-40	J1000934-007	**4.5**	I	4.6	1.0	1	3/ 3/10	3/4/10 16:24
CSS-C11-20	J1000934-008	ND	U	2.7	0.6	1	3/ 3/10	3/4/10 16:29
CSS-C11-25	J1000934-009	**6.1**	I	8.4	1.7	1	3/ 3/10	3/4/10 16:34
CSS-C11-30	J1000934-010	**5.9**	I	9.2	1.9	1	3/ 3/10	3/4/10 16:39
CSS-C11-34	J1000934-011	**6.4**	I	6.5	1.4	1	3/ 3/10	3/4/10 16:44
CSS-C9-5	J1000934-012	**6.5**		6.1	1.3	1	3/ 3/10	3/4/10 16:49
Method Blank	J1000934-MB	ND	U	2.0	0.4	1	3/ 3/10	3/4/10 14:16

Comments:

COLUMBIA ANALYTICAL SERVICES, INC.

Analytical Report

Client : Environmental Consulting & Technology, Inc.
Project Name : C9 & C11
Project Number : 10-0096
Sample Matrix : SOIL

Service Request : J1000934
Date Collected : 02/23,24/10
Date Received : 02/27/10

Carbon, Total Organic

Units : mg/Kg (ppm)
Basis : Dry

Analysis Method : S1D, S3
Test Notes :

Sample Name	Lab Code	MRL	MDL	Dilution Factor	Date/Time Analyzed	Result	Result Notes
CSS-C9-20	J1000934-003	300	55	1	03/03/10 17:00	7700	
CSS-C9-30	J1000934-005	300	55	1	03/03/10 17:00	100000	
CSS-C11-20	J1000934-008	300	55	1	03/03/10 17:00	8300	
CSS-C9-5	J1000934-012	300	55	1	03/03/10 17:00	180000	
Method Blank	J1000934-MB	300	55	1	03/03/10 17:00	U	

Report By:Palimi

COLUMBIA ANALYTICAL SERVICES, INC.

Analytical Report

Client : Environmental Consulting & Technology, Inc.
Project Name : C9 & C11
Project Number : 10-0096
Sample Matrix : SOIL

Service Request : J1000934
Date Collected : 02/23-25/10
Date Received : 02/27/10

Solids, Total

Units : PERCENT
Basis : NA

Analysis Method : 160.3 MOD
Test Notes :

Sample Name	Lab Code	MRL	MDL	Dilution Factor	Date/Time Analyzed	Result	Result Notes
CSS-C9-10	J1000934-001	0.1	0.1	1	03/02/10 17:30	89	
CSS-C9-15	J1000934-002	0.1	0.1	1	03/02/10 17:30	57	
CSS-C9-20	J1000934-003	0.1	0.1	1	03/02/10 17:30	89	
CSS-C9-25	J1000934-004	0.1	0.1	1	03/02/10 17:30	36	
CSS-C9-30	J1000934-005	0.1	0.1	1	03/02/10 17:30	35	
CSS-C9-35	J1000934-006	0.1	0.1	1	03/02/10 17:30	34	
CSS-C9-40	J1000934-007	0.1	0.1	1	03/02/10 17:30	43	
CSS-C11-20	J1000934-008	0.1	0.1	1	03/02/10 17:30	78	
CSS-C11-25	J1000934-009	0.1	0.1	1	03/02/10 17:30	23	
CSS-C11-30	J1000934-010	0.1	0.1	1	03/02/10 17:30	22	
CSS-C11-34	J1000934-011	0.1	0.1	1	03/02/10 17:30	31	
CSS-C9-5	J1000934-012	0.1	0.1	1	03/02/10 17:30	32	

COLUMBIA ANALYTICAL SERVICES, INC.

QA/QC Report

Client:	Environmental Consulting & Technology, Inc.	**Service Request:**	J1000934
Project:	C9 & C11/10-0096	**Date Collected:**	2/24/10
Sample Matrix:	Soil	**Date Received:**	2/27/10
		Date Analyzed:	3/ 4/10

Matrix Spike Summary
Selenium, Total, by Inductively Coupled Plasma/Mass Spectrometry

Sample Name:	CSS-C9-15	**Units:**	mg/Kg
Lab Code:	J1000934-002	**Basis:**	Dry

Analytical Method: 6020
Prep Method: EPA 3050B

		Matrix Spike J1000934-MS			Duplicate Matrix Spike J1000934-DMS					
Analyte Name	**Sample Result**	**Result**	**Amount**	**% Rec**	**Result**	**Amount**	**% Rec**	**% Rec Limits**	**RPD**	**RPD Limit**
Selenium, Total	1.0	157	170	92	157	167	94	75 - 125	0	20

Comments:

COLUMBIA ANALYTICAL SERVICES, INC.

QA/QC Report

Client: Environmental Consulting & Technology, Inc.
Project: C9 & C11/10-0096
Sample Matrix: Soil

Service Request: J1000934
Date Analyzed: 3/ 4/10

Lab Control Sample Summary
Selenium, Total, by Inductively Coupled Plasma/Mass Spectrometry

Units: mg/Kg
Basis: Dry

Analyte Name	Method	Lab Control Sample J1000934-LCS Result	Expected	% Rec	% Rec Limits
Selenium, Total	6020	**99.2**	103	96	80 - 120

Comments:

COLUMBIA ANALYTICAL SERVICES, INC.

QA/QC Report

Client :	Environmental Consulting & Technology, Inc.	**Service Request :**	J1000934
Project Name :	C9 & C11	**Date Collected :**	02/24/10
Project Number :	10-0096	**Date Received :**	02/27/10
Sample Matrix :	SOIL	**Date Extracted :**	NA
		Date Analyzed :	03/02/10

Duplicate Summary
Inorganic Parameters

Sample Name : CSS-C9-10
Lab Code : J1000934-001DUP
Test Notes :

Basis : NA

Analyte	Units	Analysis Method	MRL	Sample Result	Duplicate Sample Result	Average	Relative Percent Difference	Result Notes
Solids, Total	PERCENT	160.3 MOD	0.1	89	89	89	<1	

COLUMBIA ANALYTICAL SERVICES, INC.

QA/QC Report

Client :	Environmental Consulting & Technology, Inc.	**Service Request :**	J1000934
Project Name :	C9 & C11	**Date Collected :**	02/23/10
Project Number :	10-0096	**Date Received :**	02/27/10
Sample Matrix :	SOIL	**Date Extracted :**	NA
		Date Analyzed :	03/02/10

Duplicate Summary
Inorganic Parameters

Sample Name : CSS-C11-34
Lab Code : J1000934-011DUP
Test Notes :

Basis : NA

Analyte	Units	Analysis Method	MRL	Sample Result	Duplicate Sample Result	Average	Relative Percent Difference	Result Notes
Solids, Total	PERCENT	160.3 MOD	0.1	31	38	34.5	20	

COLUMBIA ANALYTICAL SERVICES, INC.

QA/QC Report

Client :	Environmental Consulting & Technology, Inc.	**Service Request :**	J1000934
Project Name :	C9 & C11	**Date Collected :**	NA
Project Number :	10-0096	**Date Received :**	NA
Sample Matrix :	SOIL	**Date Extracted :**	NA
		Date Analyzed :	03/03/10

Laboratory Control Sample Summary
Inorganic Parameters

Sample Name : Laboratory Control Sample
Lab Code : J1000934-LCS
Test Notes :

Basis : Dry

Analyte	Units	Analysis Method	True Value	Result	Percent Recovery	CAS Percent Recovery Acceptance Limits	Result Notes
Carbon, Total Organic	mg/Kg (ppm)	S1D, S3	14200	16755	118	20-120	

Report By: Palimi

Columbia Analytical Services, Inc.
Cooler Receipt Form

Client: ECT Service Request #: J1000834
Project: C9+C11

Cooler received on 3-1-10 and opened on 3-1-10 by SC

COURIER: CAS UPS FEDEX Client Other Blue Streak Airbill #

1	Were custody seals on outside of cooler?	Yes	(No)	
	If yes, how many and where?	#:___ on lid	other	
2	Were seals intact and signature and date correct?	Yes	No	(N/A)
3	Were custody papers properly filled out?	(Yes)	No	N/A
4	Temperature of cooler(s) upon receipt (Should be 4 +/- 2 degrees C) 3.5			
5	Thermometer ID T13			
6	Temperature Blank Present?	Yes	(No)	
7	Were Ice or Ice Packs present	(Ice)	Ice Packs	No
8	Did all bottles arrive in good condition (unbroken, etc....)?	(Yes)	No	N/A
9	Type of packing material present			
10	Were all bottle labels complete (sample ID, preservation, etc....)?	(Yes)	No	N/A
11	Did all bottle labels and tags agree with custody papers?	Yes	(No)	N/A
12	Were the correct bottles used for the tests indicated?	(Yes)	No	N/A
13	Were all of the preserved bottles received with the appropriate preservative? HNO3 pH<2 H2SO4 pH<2 ZnAc2/NaOH pH>9 NaOH pH>12 HCl pH<2 Preservative additions noted below	Yes	No	(N/A)
14	Were all samples received within analysis holding times?	(Yes)	No	N/A
15	Were VOA vials checked for absence of air bubbles? If present, note below	Yes	No	(N/A)
16	Where did the bottles originate?	(CAS)	Client	

Sample ID	Reagent	Lot #	ml added	Initials Date/Time

Additional comments and/or explanation of all discrepancies noted above:

additional sample CSS-C9-5 was included but not listed on COC, no date or time given.
no sample times listed on COC for all C9 samples

Client approval to run samples if discrepancies noted: Date:

Columbia Analytical Services™

Jacksonville Laboratory
Condition Upon Receipt - Sample pH

SR # J1000934 Date: 3/1/10 Initials: SC

Note that pH is check and meets the required pH criterion listed in the column heading unless otherwise noted on the cooler receipt form.

	Bottle Code																													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
	40mL	40mL	40mL	125mL	125mL	125mL	125mL	250mL	250mL	250mL	250mL	250mL	250mL	250mL	500mL	500mL	500mL	500mL	500mL	1L	1L	1L	1L	1L	2oz	4oz	8oz	16oz	100ml	Ziplock	Misc.	
Container	G	G	G	P	P	P	P	P	P	P	P	P	G	G	P	P	P	P	G	P	P	G	G	C	G	G	G	G	P	P	Misc.	
Pres.		HCl	Na2S2O3		HCl	H2SO4	HNO3		H2SO4	HNO3	ZnAc2 NaOH	NaOH		HNO3		HCl	H2SO4	HNO3			HNO3		HCl	H2SO4					Sodium Thiosulfate			
Req. pH	N/A	<2	N/A	N/A	<2	<2	<2	N/A	<2	<2	>9	>12	N/A	<2	N/A	<2	<2	<2	N/A	N/A	<2	N/A	<2	<2	N/A	N/A	N/A	N/A	N/A		N/A	
Sample #	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	
-001																										1						-001
-002																										1						-002
-003																										2						-003
-004																										1						-004
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-006																										1						-006
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NOTE: VOA pH checks are performed by the analytical area, not sample control

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CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

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PAGE 1 OF 2

SR # J1000934

CAS Contact

Project Name: C9 & C11

Project Number: 10-0096

Project Manager: Barry Westmark

Email Address:

Company/Address: ECT, 6300 NE 1st Ave #100, Ft Lauderdale FL 33334

Phone #: 954-771-0444

FAX#: 954-771-9118

Sampler's Signature: CAR

Sampler's Printed Name: CAR & MCD

ANALYSIS REQUESTED (Include Method Number) [redacted]

PRESERVATIVE: 0

NUMBER OF CONTAINERS: Se, Ba, TOC

0. NONE
1. HCL
2. HNO_3
3. H_2SO_4
4. NaOH
5. Zn Acetate
6. MeOH
7. $NaHSO_4$
8. Other _____

CLIENT SAMPLE ID	LAB ID	SAMPLING DATE	SAMPLING TIME	MATRIX	Se	Ba	TOC	REMARKS/ ALTERNATE DESCRIPTION
CSS-C9-10		2/24/10		SO	✓			
CSS-C9-15					✓			
CSS-C9-20					✓	✓		
CSS-C9-25					✓			
CSS-C9-30					✓	✓		
CSS-C9-35		2/24/10			✓			
CSS-C9-40		2/25/10		SO	✓			
CSS-C11-20		2/23/10	1405		✓	✓		
CSS-C11-25		2/23/10	1102		✓			
CSS-C11-30		2/23/10	0935	SO	✓			

SPECIAL INSTRUCTIONS/COMMENTS

No Barium analysis required per Mike Dwall 2/3/10 [illegible]

See QAPP ☐

TURNAROUND REQUIREMENTS

___ RUSH (SURCHARGES APPLY)

X STANDARD

REQUESTED FAX DATE _____

REQUESTED REPORT DATE _____

REPORT REQUIREMENTS

___ I. Results Only

___ II. Results + QC Summaries (LCS, DUP, MS/MSD as required)

___ III. Results + QC and Calibration Summaries

___ IV. Data Validation Report with Raw Data

___ V. Specialized Forms / Custom Report

Edata ___ Yes ___ No

INVOICE INFORMATION

PO#

BILL TO:

SAMPLE RECEIPT: CONDITION/COOLER TEMP: _____ CUSTODY SEALS: Y N

RELINQUISHED BY	RECEIVED BY	RELINQUISHED BY	RECEIVED BY	RELINQUISHED BY	RECEIVED BY
Signature: [illegible] /ECT	Signature: [illegible]	Signature: BLUE	Signature: [illegible]	Signature	Signature
Printed Name	Printed Name	Printed Name: STREAK	Printed Name: Silver Streak	Printed Name	Printed Name
Firm	Firm	Firm	Firm: CAS	Firm	Firm
Date/Time	Date/Time: 2/26/10 1:53	Date/Time	Date/Time: 2/27/10 0905	Date/Time	Date/Time

Distribution: White - Return to Originator; Yellow - Retained by Client

JSCOC-06/20/06

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Columbia Analytical Services

CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

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SR # J10000934

[redacted]

Project Name: C9 & C11	Project Number: 10-0096
Project Manager: Barry Westmark	Email Address:
Company/Address: ECT, 6300 NE 1st Ave #100, Ft Lauderdale FL 33334	
Phone #: 954-771-0444	FAX#: 954-771-8118
Sampler's Signature: CAK	Sampler's Printed Name: CAK/MCA

ANALYSIS REQUESTED (Include Method Numbe[redacted]

PRESERVATIVE: 0

NUMBER OF CONTAINERS: 5/TOC

Preservative Key: 0. NONE; 1. HCL; 2. HNO_3; 3. H_2SO_4; 4. NaOH; 5. Zn Acetate; 6. MeOH; 7. $NaHSO_4$; 8. Other _____

CLIENT SAMPLE ID	LAB ID	SAMPLING DATE	SAMPLING TIME	MATRIX			REMARKS/ ALTERNATE DESCRIPTION
CSS-C11-34		2/23/10	1215	SO	✓		
CSS-C9-5 *		2/24/10		SO	✓	✓	

SPECIAL INSTRUCTIONS/COMMENTS

* Added per Probas Adak 3/3/10 CK

See QAPP ☐

TURNAROUND REQUIREMENTS
____ RUSH (SURCHARGES APPLY)
X STANDARD
REQUESTED FAX DATE
REQUESTED REPORT DATE

REPORT REQUIREMENTS
____ I. Results Only
____ II. Results + QC Summaries (LCS, DUP, MS/MSD as required)
____ III. Results + QC and Calibration Summaries
____ IV. Data Validation Report with Raw Data
____ V. Specialized Forms / Custom Report
Edata ____ Yes ____ No

INVOICE INFORMATION
PO#
BILL TO:

SAMPLE RECEIPT: CONDITION/COOLER TEMP: _____ CUSTODY SEALS: Y N

RELINQUISHED BY	RECEIVED BY	RELINQUISHED BY	RECEIVED BY	RELINQUISHED BY	RECEIVED BY
S. Thomas/ECT	[signature]	BLUE STREAK	[signature]		
Signature	Signature	Signature	Signature	Signature	Signature
Printed Name	Printed Name	Printed Name	Printed Name: Steven Ostrom	Printed Name	Printed Name
Firm	Firm	Firm	Firm: OAS	Firm	Firm
Date/Time: 2/26/10 1:53	Date/Time: 2/26/10 1:53	Date/Time	Date/Time: 2/27/10 0905	Date/Time	Date/Time

Distribution: White - Return to Originator; Yellow - Retained by Client

JSCOC-05/20/08

1028

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Ormond Beach, FL 32174
(386)672-5668

March 16, 2010

Mr. Barry Westmark
ECT, Inc.
6300 NE 1st Avenue #100
Fort Lauderdale, FL 33334

RE: Project: C9/C11 Selenium
Pace Project No.: 358199

Dear Mr. Westmark:
Enclosed are the analytical results for sample(s) received by the laboratory on March 02, 2010. The results relate only to the samples included in this report. Results reported herein conform to the most current NELAC standards, where applicable, unless otherwise narrated in the body of the report.

If you have any questions concerning this report, please feel free to contact me.

Sincerely,

Martha Montero

martha.montero@pacelabs.com
Project Manager

Enclosures

cc: Mr. Probas Adak, ECT, Inc.
Mark Lefebvre, ECT, Inc.

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ACCREDITED IN ACCORDANCE WITH nelac

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CERTIFICATIONS

Project: C9/C11 Selenium
Pace Project No.: 358199

Minnesota Certification IDs

Tennessee Certification #: 02818
New Jersey Certification #: MN-002
Montana Certification #: MT CERT0092
Minnesota Certification #: 027-053-137
Michigan DEQ Certification #: 9909
Maine Certification #: 2007029
Louisiana Certification #: 03086
Louisiana Certification #: LA080009
Kansas Certification #: E-10167
Iowa Certification #: 368
Illinois Certification #: 200011
Florida/NELAP Certification #: E87605
California Certification #: 01155CA
Arizona Certification #: AZ-0014
North Carolina Certification #: 530
North Dakota Certification #: R-036
Oregon Certification #: MN200001
Pennsylvania Certification #: 68-00563
New York Certification #: 11647
Washington Certification #: C754
Wisconsin Certification #: 999407970
1700 Elm Street SE, Suite 200 Minneapolis, MN 55414
Alaska Certification #: UST-078

Green Bay Certification IDs

1241 Bellevue Street Green Bay, WI 54302
Wisconsin DATCP Certification #: 105-444
Wisconsin Certification #: 405132750
South Carolina Certification #: 83006001
North Dakota Certification #: R-150
North Carolina Certification #: 503
California Certification #: 09268CA
New York Certification #: 11887
Minnesota Certification #: 055-999-334
Louisiana Certification #: 04168
Kentucky Certification #: 82
Illinois Certification #: 200050
Florida/NELAP Certification #: E87948
New York Certification #: 11888

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SAMPLE SUMMARY

Project: C9/C11 Selenium
Pace Project No.: 358199

Lab ID	Sample ID	Matrix	Date Collected	Date Received
358199001	**CSS-C11-5**	Solid	02/26/10 13:20	03/02/10 12:00
358199002	**CSS-C11-15**	Solid	02/26/10 14:55	03/02/10 12:00
358199003	**CSS-C11-17**	Solid	02/26/10 15:30	03/02/10 12:00

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SAMPLE ANALYTE COUNT

Project: C9/C11 Selenium
Pace Project No.: 358199

Lab ID	Sample ID	Method	Analysts	Analytes Reported	Laboratory
358199001	**CSS-C11-5**	EPA 6020	RJS	2	PASI-M
		% Moisture	JDL	1	PASI-M
358199002	**CSS-C11-15**	EPA 6020	RJS	2	PASI-M
		% Moisture	JDL	1	PASI-M
358199003	**CSS-C11-17**	EPA 6020	RJS	2	PASI-M
		ASTM D2974-87	KAM	1	PASI-G
		EPA 9060 Modified	DJR	3	PASI-G

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PROJECT NARRATIVE

Project: C9/C11 Selenium
Pace Project No.: 358199

Method: **EPA 6020**
Description: 6020 MET ICPMS
Client: ECT, Inc.
Date: March 16, 2010

General Information:
3 samples were analyzed for EPA 6020. All samples were received in acceptable condition with any exceptions noted below.

Hold Time:
The samples were analyzed within the method required hold times with any exceptions noted below.

Initial Calibrations (including MS Tune as applicable):
All criteria were within method requirements with any exceptions noted below.

Continuing Calibration:
All criteria were within method requirements with any exceptions noted below.

Internal Standards:
All internal standards were within QC limits with any exceptions noted below.

Method Blank:
All analytes were below the report limit in the method blank with any exceptions noted below.

Laboratory Control Spike:
All laboratory control spike compounds were within QC limits with any exceptions noted below.

Matrix Spikes:
All percent recoveries and relative percent differences (RPDs) were within acceptance criteria with any exceptions noted below.

Duplicate Sample:
All duplicate sample results were within method acceptance criteria with any exceptions noted below.

Additional Comments:

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PROJECT NARRATIVE

Project: C9/C11 Selenium
Pace Project No.: 358199

Method: **% Moisture**
Description: Dry Weight
Client: ECT, Inc.
Date: March 16, 2010

General Information:
2 samples were analyzed for % Moisture. All samples were received in acceptable condition with any exceptions noted below.

Hold Time:
The samples were analyzed within the method required hold times with any exceptions noted below.

Initial Calibrations (including MS Tune as applicable):
All criteria were within method requirements with any exceptions noted below.

Continuing Calibration:
All criteria were within method requirements with any exceptions noted below.

Internal Standards:
All internal standards were within QC limits with any exceptions noted below.

Surrogates:
All surrogates were within QC limits with any exceptions noted below.

Method Blank:
All analytes were below the report limit in the method blank with any exceptions noted below.

Laboratory Control Spike:
All laboratory control spike compounds were within QC limits with any exceptions noted below.

Matrix Spikes:
All percent recoveries and relative percent differences (RPDs) were within acceptance criteria with any exceptions noted below.

Duplicate Sample:
All duplicate sample results were within method acceptance criteria with any exceptions noted below.

Additional Comments:

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PROJECT NARRATIVE

Project: C9/C11 Selenium
Pace Project No.: 358199

Method: **EPA 9060 Modified**
Description: Total Organic Carbon
Client: ECT, Inc.
Date: March 16, 2010

General Information:
1 sample was analyzed for EPA 9060 Modified. All samples were received in acceptable condition with any exceptions noted below.

Hold Time:
The samples were analyzed within the method required hold times with any exceptions noted below.

Initial Calibrations (including MS Tune as applicable):
All criteria were within method requirements with any exceptions noted below.

Continuing Calibration:
All criteria were within method requirements with any exceptions noted below.

Method Blank:
All analytes were below the report limit in the method blank with any exceptions noted below.

Laboratory Control Spike:
All laboratory control spike compounds were within QC limits with any exceptions noted below.

Matrix Spikes:
All percent recoveries and relative percent differences (RPDs) were within acceptance criteria with any exceptions noted below.

Duplicate Sample:
All duplicate sample results were within method acceptance criteria with any exceptions noted below.

Additional Comments:

This data package has been reviewed for quality and completeness and is approved for release.

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ANALYTICAL RESULTS

Project: C9/C11 Selenium
Pace Project No.: 358199

Sample: CSS-C11-5 **Lab ID: 358199001** Collected: 02/26/10 13:20 Received: 03/02/10 12:00 Matrix: Solid

Results reported on a "dry-weight" basis

Parameters	Results	Units	PQL	MDL	DF	Prepared	Analyzed	CAS No.	Qual
6020 MET ICPMS	Analytical Method: EPA 6020								
Barium	**29.9**	mg/kg	0.66	0.11	20	03/08/10 14:51	03/09/10 16:43	7440-39-3	
Selenium	**2.8**	mg/kg	1.1	0.55	20	03/08/10 14:51	03/09/10 16:43	7782-49-2	
Dry Weight	Analytical Method: % Moisture								
Percent Moisture	**58.6**	%	0.10	0.10	1		03/05/10 00:00		

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ANALYTICAL RESULTS

Project: C9/C11 Selenium
Pace Project No.: 358199

Sample: CSS-C11-15 **Lab ID: 358199002** Collected: 02/26/10 14:55 Received: 03/02/10 12:00 Matrix: Solid

Results reported on a "dry-weight" basis

Parameters	Results	Units	PQL	MDL	DF	Prepared	Analyzed	CAS No.	Qual
6020 MET ICPMS	Analytical Method: EPA 6020								
Barium	**11.2**	mg/kg	0.46	0.077	20	03/08/10 14:51	03/09/10 17:04	7440-39-3	
Selenium	**0.88**	mg/kg	0.77	0.39	20	03/08/10 14:51	03/09/10 17:04	7782-49-2	
Dry Weight	Analytical Method: % Moisture								
Percent Moisture	**42.2**	%	0.10	0.10	1		03/05/10 00:00		

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ANALYTICAL RESULTS

Project: C9/C11 Selenium
Pace Project No.: 358199

Sample: CSS-C11-17 **Lab ID: 358199003** Collected: 02/26/10 15:30 Received: 03/02/10 12:00 Matrix: Solid

Results reported on a "dry-weight" basis

Parameters	Results	Units	PQL	MDL	DF	Prepared	Analyzed	CAS No.	Qual
6020 MET ICPMS	Analytical Method: EPA 6020								
Barium	**9.6**	mg/kg	0.38	0.063	20	03/08/10 14:51	03/09/10 17:25	7440-39-3	
Selenium	**0.34 I**	mg/kg	0.63	0.32	20	03/08/10 14:51	03/09/10 17:25	7782-49-2	
Percent Moisture	Analytical Method: ASTM D2974-87								
Percent Moisture	**32.0**	%	0.10	0.10	1		03/05/10 07:48		
Total Organic Carbon	Analytical Method: EPA 9060 Modified								
Total Organic Carbon	**107000**	mg/kg	33300	9330	1		03/15/10 12:39	7440-44-0	
Total Organic Carbon	**75800**	mg/kg	33300	9330	1		03/15/10 12:43	7440-44-0	
Mean Total Organic Carbon	**91400**	mg/kg	33300	9330	1		03/15/10 12:43	7440-44-0	

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QUALITY CONTROL DATA

Project: C9/C11 Selenium
Pace Project No.: 358199

QC Batch: ICPM/19470 Analysis Method: EPA 6020
QC Batch Method: EPA 6020 Analysis Description: 6020 MET
Associated Lab Samples: 358199001, 358199002, 358199003

METHOD BLANK: 755844 Matrix: Solid
Associated Lab Samples: 358199001, 358199002, 358199003

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Barium	mg/kg	0.047U	0.28	03/09/10 16:09	
Selenium	mg/kg	0.23U	0.47	03/09/10 16:09	

LABORATORY CONTROL SAMPLE: 755845

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Barium	mg/kg	19.2	19.3	101	75-125	
Selenium	mg/kg	19.2	18.8	98	75-125	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 755846 755847

Parameter	Units	5035041001 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Barium	mg/kg	21.3	22.7	24.4	44.8	47.0	103	106	70-130	5	20	
Selenium	mg/kg	2.2	22.7	24.4	26.7	28.3	108	107	70-130	6	20	

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QUALITY CONTROL DATA

Project: C9/C11 Selenium
Pace Project No.: 358199

QC Batch: MPRP/19458
QC Batch Method: % Moisture
Analysis Method: % Moisture
Analysis Description: Dry Weight/Percent Moisture
Associated Lab Samples: 358199001, 358199002

SAMPLE DUPLICATE: 755588

Parameter	Units	358199001 Result	Dup Result	RPD	Max RPD	Qualifiers
Percent Moisture	%	58.6	59.4	1	30	

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QUALITY CONTROL DATA

Project: C9/C11 Selenium
Pace Project No.: 358199

QC Batch: PMST/3680
QC Batch Method: ASTM D2974-87
Associated Lab Samples: 358199003

Analysis Method: ASTM D2974-87
Analysis Description: Dry Weight/Percent Moisture

SAMPLE DUPLICATE: 270976

Parameter	Units	4028987001 Result	Dup Result	RPD	Max RPD	Qualifiers
Percent Moisture	%	9.5	9.7	2	10	

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QUALITY CONTROL DATA

Project: C9/C11 Selenium
Pace Project No.: 358199

QC Batch: WETA/5901
QC Batch Method: EPA 9060 Modified
Associated Lab Samples: 358199003

Analysis Method: EPA 9060 Modified
Analysis Description: 9060 TOC Average

METHOD BLANK: 274704 Matrix: Solid
Associated Lab Samples: 358199003

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Mean Total Organic Carbon	mg/kg	70.0U	250	03/15/10 12:17	

LABORATORY CONTROL SAMPLE: 274705

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Mean Total Organic Carbon	mg/kg	1000	1040	104	80-120	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 274706 274707

Parameter	Units	358199003 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Mean Total Organic Carbon	mg/kg	91400	66700	66700	156000	162000	97	106	50-150	4	30	

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QUALIFIERS

Project: C9/C11 Selenium
Pace Project No.: 358199

DEFINITIONS

DF - Dilution Factor, if reported, represents the factor applied to the reported data due to changes in sample preparation, dilution of the sample aliquot, or moisture content.
ND - Not Detected at or above adjusted reporting limit.
MDL - Adjusted Method Detection Limit.
S - Surrogate
1,2-Diphenylhydrazine (8270 listed analyte) decomposes to Azobenzene.
Consistent with EPA guidelines, unrounded data are displayed and have been used to calculate % recovery and RPD values.
LCS(D) - Laboratory Control Sample (Duplicate)
MS(D) - Matrix Spike (Duplicate)
DUP - Sample Duplicate
RPD - Relative Percent Difference
NC - Not Calculable.
Pace Analytical is NELAP accredited. Contact your Pace PM for the current list of accredited analytes.
U - Indicates the compound was analyzed for, but not detected.

LABORATORIES

PASI-G	Pace Analytical Services - Green Bay
PASI-M	Pace Analytical Services - Minneapolis

ANALYTE QUALIFIERS

I	The reported value is between the laboratory method detection limit and the laboratory practical quantitation limit.

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QUALITY CONTROL DATA CROSS REFERENCE TABLE

Project: C9/C11 Selenium
Pace Project No.: 358199

Lab ID	Sample ID	QC Batch Method	QC Batch	Analytical Method	Analytical Batch
358199001	**CSS-C11-5**	EPA 6020	ICPM/19470	EPA 6020	ICPM/7986
358199002	**CSS-C11-15**	EPA 6020	ICPM/19470	EPA 6020	ICPM/7986
358199003	**CSS-C11-17**	EPA 6020	ICPM/19470	EPA 6020	ICPM/7986
358199001	**CSS-C11-5**	% Moisture	MPRP/19458		
358199002	**CSS-C11-15**	% Moisture	MPRP/19458		
358199003	**CSS-C11-17**	ASTM D2974-87	PMST/3680		
358199003	**CSS-C11-17**	EPA 9060 Modified	WETA/5901		
358199003	**CSS-C11-17**	EPA 9060 Modified	WETA/5902		

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CHAIN-OF-CUSTODY / Analytical Request Document

The Chain-of-Custody is a LEGAL DOCUMENT. All relevant fields must be completed accurately.

358199

Page: 1 of 1

1283664

Section A Required Client Information:

Company: ECT
Address: 6300 NE 1st Ave
Ft L, FL 33334
Email To: Barry Westmoreland
Phone: Fax:
Requested Due Date/TAT: Regular

Section B Required Project Information:

Report To: Barry Westmoreland
Copy To: Probas Adale
Purchase Order No.:
Project Name: CA/CII Selenium
Project Number:

Section C Invoice Information:

Attention: Barry Westmoreland
Company Name: ECT
Address: On file
Pace Quote Reference:
Pace Project Manager:
Pace Profile #:

REGULATORY AGENCY: NPDES, GROUND WATER, DRINKING WATER, UST, RCRA, OTHER

Site Location STATE: Weston FL

Section D Required Client Information

Matrix Codes MATRIX / CODE: Drinking Water DW, Water WT, Waste Water WW, Product P, Soil/Solid SL, Oil OL, Wipe WP, Air AR, Tissue TS, Other OT

SAMPLE ID (A-Z, 0-9 / ,-) Sample IDs MUST BE UNIQUE

Requested Analysis Filtered (Y/N)

ITEM #	SAMPLE ID	MATRIX CODE (see valid codes to left)	SAMPLE TYPE (G=GRAB C=COMP)	COLLECTED COMPOSITE START DATE	COLLECTED COMPOSITE START TIME	COLLECTED COMPOSITE END/GRAB DATE	COLLECTED COMPOSITE END/GRAB TIME	SAMPLE TEMP AT COLLECTION	# OF CONTAINERS	Unpreserved	H_2SO_4	HNO_3	HCl	NaOH	$Na_2S_2O_3$	Methanol	Other	Analysis Test (Y/N)	Se, B, Cl, Tot	Residual Chlorine (Y/N)	Pace Project No./ Lab I.D.
1	CSS-CII-5	SO		2/26	1320				1												
2	CSS-CII-15	↓		↓	1455				↓												
3	CSS-CII-17	↓		↓	1530				↓										X		
4																					
5																					
6																					
7																					
8																					
9																					
10																					
11																					
12																					

ADDITIONAL COMMENTS	RELINQUISHED BY / AFFILIATION	DATE	TIME	ACCEPTED BY / AFFILIATION	DATE	TIME	SAMPLE CONDITIONS
Samples	[signature]	2/26/10	16:15	[signature]	3/01	11:31 Am	
	Probas Adale/ECT	3/1/10	11:30am	[signature]	3/2/10	12:00	09 Y

ORIGINAL

SAMPLER NAME AND SIGNATURE
PRINT Name of SAMPLER: PROBAS ADALE
SIGNATURE of SAMPLER: Probas Adale DATE Signed (MM/DD/YY): 2/26/10

Temp in °C | Received on Ice (Y/N) | Custody Sealed Cooler (Y/N) | Samples Intact (Y/N)

*Important Note: By signing this form you are accepting Pace's NET 30 day payment terms and agreeing to late charges of 1.5% per month for any invoices not paid within 30 days.

F-ALL-Q-020rev.07, 15-May-2007

1045

Sample Condition Upon Receipt Form (SCUR)

Table Number: 25

Pace Analytical

Client Name: ECT Project # 358199

Courier: ☑ Fed Ex ☐ UPS ☐ USPS ☐ Client ☐ Commercial ☐ Pace ☐ B&B ☐ Other

Tracking # 8714 7658 5345

Custody Seal on Cooler/Box Present: ☐ yes ☑ no Seals intact: ☐ yes ☐ no

Packing Material: ☐ Bubble Wrap ☑ Bubble Bags ☐ None ☐ Other

Thermometer Used (L4) L5 L6 **Type of Ice** (Wet) Blue None

Cooler Temperature 0.9 **(Actual)** (Temp should be above freezing to 6°C)

Date and Initials of person examining contents: 3/2/10 EW

Secondary Review Initials:

Receipt of samples satisfactory: ☑ Yes ☐ No **Rush TAT requested on COC:** ☐

If yes, then all conditions below were met:	If no, then mark box & describe issue (use comments area if necessary):
Chain of Custody Present	☐
Chain of Custody Filled Out	☐
Relinquished Signature & Sampler Name COC	☐
Samples Arrived within Hold Time	☐
Sufficient Volume	☐
Correct Containers Used	☐
Containers Intact	☐
Sample Labels match COC (sample IDs & date/time of collection)	☐ No Labels: ☐ No Time/Date on Labels: ☐
All containers needing preservation are found to be in compliance with EPA recommendation.	☐
No Headspace in VOA Vials (>6mm):	☐

Client Notification/ Resolution:

Person Contacted: _____ Date/Time: _____

Comments/ Resolution (use back for additional comments): _____

Project Manager Review: _____ **Date:** _____

Finished Product Information Only

F.P. Sample ID: _____

Production Code: _____

Date/Time Opened: _____

Number of Unopened Bottles Remaining: _____

Extra Sample in Shed: Yes No

Size & Qty of Bottles Received

_____ x 5 Gal
_____ x 2.5 Gal
_____ x 1 Gal
_____ x 1 Liter
_____ x 500 mL
_____ x 250 mL
_____ x Other: _____

Sample																	
A	1	2	3														

A B C D

Container Acode	Size	Type		Preservative	
GJ / 12GU	Gal - 1/2Gal	Plastic		Cool	**Wet Chem***
BP1U / BP1S	1 Liter	Plastic	FF	Cool - H2SO4	
AP1U	1 Liter	Plastic Amber		Cool	
12GZ / BP4Z	1/2Gal - 1Liter	Plastic		ZnAc - NaOH	
AG1U / AG1S	1 Liter	Amber Glass		Cool - H2SO4	BOD / CBOD 48hr (Wed & Fri only)
BP2U / BP2S	500 mL	Plastic	FF	Cool - H2SO4	Chloramines 24hr
AG2U / AG2S	500 mL	Amber Glass		Cool - H2SO4	Chlorine Dioxide 24hr
BP3U / BP3C	250 mL	Plastic	FF	Cool - NaOH	Residual Chlorine 24hr
BP3H / BP3S	250 mL	Plastic		HCL - H2SO4	Chlorophyll A (unfiltered) 48hr
AG3U / AG3E	250 mL	Amber Glass		Cool - EDA	Dissolved Oxygen 28hr
AG3S	250 mL	Amber Glass		H2SO4	Nitrate / Nitrite / NOX 48hr
BP4U / BP4C	125 mL	Plastic	FF	Cool - NaOH	Odor / pH 24hr
BP4H / BP4S	125 mL	Plastic		HCL - H2SO4	OP (Low) / OP (High) 48hr
VG9U / VG9E / VG9H	40 mL	Glass		Cool-EDA-HCL	MBAS (Foaming Agents) 48hr
DG9U / DG9E / DG9H	40 mL	Amber Glass		Cool-EDA-HCL	Turbidity / UV254 / Color 48hr

Containers requiring short-hold analysis (to be used when container is the same as container with non-short hold analysis

BP1N / BP1U	1 Liter	Plastic	FF	HNO3 - Cool	**Metals***
BP2N / BP2U	500 mL	Plastic	FF	HNO3 - Cool	
BP3N / BP3U	250 mL	Plastic	FF	HNO3 - Cool	
					Hex Chrome 24hr
AG3U	250 mL	Amber Glass		Cool	**Extractions**
AG2U	500 mL	Amber Glass		Cool	
AG24 / AG34	500 mL	Amber Glass		NH4CL	
AG1S	1 Liter	Amber Glass		H2SO4	
AG1U	1 Liter	Amber Glass		Cool	
AG1H	1 Liter	Amber Glass		HCL	
AP1S / AP1U	1 Liter	Amber Plastic		H2SO4 - Cool	
VG9U / DG9U	40 mL	Glass Vial		Cool	
VG9U	40 mL	Glass Vial		Cool	**Semi Volatiles**
VG9M	40 mL	Glass Vial		MCAA	
VG9U / VG9H	40 mL	Glass Vial		Cool - HCL	**Volatiles**
WG43	40 mL	Soil Vials		Cool	
WG20 / WG40	2 / 4 oz	Glass (Soil)		Cool	
T	1 Liter	Tedlar Bag		Cool	
WG9D / WG40	4oz	Glass/plastic		Cool	**Soil Cooler**
		Glass/plastic		Cool/H2SO4/HNO3	
SP5U	100 mL	Micro Bottle		Cool	**Microbiology***
					SPC/HPC 8 hr — MMO-MUG (DW) 30hr
					Total MF 6 hr — Fecal MF 6hr
					Fecal MPN (solid) 24 hr
AG1U	1 Liter	Amber Glass		Cool	**Subouts**
BP1U	1 Liter	Plastic		Cool	
BP1N	1 Liter	Plastic		HNO3	
1 1 2					
1 1 1					

* All Short-hold analysis must be circled and copy of SCUR given to Laboratory section

Additional comments from front page: _____

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March 22, 2010

Mr. Barry Westmark
ECT, Inc.
6300 NE 1st Avenue #100
Fort Lauderdale, FL 33334

RE: Project: 10-0096/C9 & C11
Pace Project No.: 357830

Dear Mr. Westmark:
Enclosed are the analytical results for sample(s) received by the laboratory on February 23, 2010. The results relate only to the samples included in this report. Results reported herein conform to the most current NELAC standards, where applicable, unless otherwise narrated in the body of the report.

If you have any questions concerning this report, please feel free to contact me.

Sincerely,

Martha Montero

martha.montero@pacelabs.com
Project Manager

Enclosures

cc: Mr. Probas Adak, ECT, Inc.
Mark Lefebvre, ECT, Inc.

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CERTIFICATIONS

Project: 10-0096/C9 & C11
Pace Project No.: 357830

Minnesota Certification IDs
Tennessee Certification #: 02818
New Jersey Certification #: MN-002
Montana Certification #: MT CERT0092
Minnesota Certification #: 027-053-137
Michigan DEQ Certification #: 9909
Maine Certification #: 2007029
Louisiana Certification #: 03086
Louisiana Certification #: LA080009
Kansas Certification #: E-10167
Iowa Certification #: 368
Illinois Certification #: 200011
Florida/NELAP Certification #: E87605
California Certification #: 01155CA
Arizona Certification #: AZ-0014
North Carolina Certification #: 530
North Dakota Certification #: R-036
Oregon Certification #: MN200001
Pennsylvania Certification #: 68-00563
New York Certification #: 11647
Washington Certification #: C754
Wisconsin Certification #: 999407970
1700 Elm Street SE, Suite 200 Minneapolis, MN 55414
Alaska Certification #: UST-078

Green Bay Certification IDs
1241 Bellevue Street Green Bay, WI 54302
Wisconsin DATCP Certification #: 105-444
Wisconsin Certification #: 405132750
South Carolina Certification #: 83006001
North Dakota Certification #: R-150
North Carolina Certification #: 503
California Certification #: 09268CA
New York Certification #: 11887
Minnesota Certification #: 055-999-334
Louisiana Certification #: 04168
Kentucky Certification #: 82
Illinois Certification #: 200050
Florida/NELAP Certification #: E87948
New York Certification #: 11888

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SAMPLE SUMMARY

Project: 10-0096/C9 & C11
Pace Project No.: 357830

Lab ID	Sample ID	Matrix	Date Collected	Date Received
357830001	CSS-WCA-5	Solid	02/17/10 08:00	02/23/10 10:00
357830002	CSS-WCA-10	Solid	02/17/10 08:00	02/23/10 10:00
357830003	CSS-WCA-15	Solid	02/17/10 08:00	02/23/10 10:00
357830004	CSS-WCA-20	Solid	02/17/10 08:00	02/23/10 10:00
357830005	CSS-WCA-25	Solid	02/17/10 08:00	02/23/10 10:00
357830006	CSS-WCA-30	Solid	02/17/10 08:00	02/23/10 10:00
357830007	CSS-WCA-32	Solid	02/17/10 08:00	02/23/10 10:00

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SAMPLE ANALYTE COUNT

Project: 10-0096/C9 & C11
Pace Project No.: 357830

Lab ID	Sample ID	Method	Analysts	Analytes Reported	Laboratory
357830001	**CSS-WCA-5**	EPA 6020	RJS	1	PASI-M
		ASTM D2974-87	LTI	1	PASI-G
357830002	**CSS-WCA-10**	EPA 6020	RJS	1	PASI-M
		ASTM D2974-87	LTI	1	PASI-G
357830003	**CSS-WCA-15**	EPA 6020	RJS	1	PASI-M
		ASTM D2974-87	LTI	1	PASI-G
357830004	**CSS-WCA-20**	EPA 6020	RJS	1	PASI-M
		ASTM D2974-87	LTI	1	PASI-G
		EPA 9060 Modified	DJR	3	PASI-G
357830005	**CSS-WCA-25**	EPA 6020	RJS	1	PASI-M
		ASTM D2974-87	LTI	1	PASI-G
357830006	**CSS-WCA-30**	EPA 6020	RJS	1	PASI-M
		ASTM D2974-87	LTI	1	PASI-G
		EPA 9060 Modified	DJR	3	PASI-G
357830007	**CSS-WCA-32**	EPA 6020	RJS	1	PASI-M
		ASTM D2974-87	LTI	1	PASI-G

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PROJECT NARRATIVE

Project: 10-0096/C9 & C11
Pace Project No.: 357830

Method: **EPA 6020**
Description: 6020 MET ICPMS
Client: ECT, Inc.
Date: March 22, 2010

General Information:
7 samples were analyzed for EPA 6020. All samples were received in acceptable condition with any exceptions noted below.

Hold Time:
The samples were analyzed within the method required hold times with any exceptions noted below.

Initial Calibrations (including MS Tune as applicable):
All criteria were within method requirements with any exceptions noted below.

Continuing Calibration:
All criteria were within method requirements with any exceptions noted below.

Internal Standards:
All internal standards were within QC limits with any exceptions noted below.

Method Blank:
All analytes were below the report limit in the method blank with any exceptions noted below.

Laboratory Control Spike:
All laboratory control spike compounds were within QC limits with any exceptions noted below.

Matrix Spikes:
All percent recoveries and relative percent differences (RPDs) were within acceptance criteria with any exceptions noted below.

Duplicate Sample:
All duplicate sample results were within method acceptance criteria with any exceptions noted below.

Additional Comments:

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PROJECT NARRATIVE

Project: 10-0096/C9 & C11
Pace Project No.: 357830

Method: **EPA 9060 Modified**
Description: Total Organic Carbon
Client: ECT, Inc.
Date: March 22, 2010

General Information:
2 samples were analyzed for EPA 9060 Modified. All samples were received in acceptable condition with any exceptions noted below.

Hold Time:
The samples were analyzed within the method required hold times with any exceptions noted below.

Initial Calibrations (including MS Tune as applicable):
All criteria were within method requirements with any exceptions noted below.

Continuing Calibration:
All criteria were within method requirements with any exceptions noted below.

Method Blank:
All analytes were below the report limit in the method blank with any exceptions noted below.

Laboratory Control Spike:
All laboratory control spike compounds were within QC limits with any exceptions noted below.

Matrix Spikes:
All percent recoveries and relative percent differences (RPDs) were within acceptance criteria with any exceptions noted below.

QC Batch: WETA/5812

A matrix spike and matrix spike duplicate (MS/MSD) were performed on the following sample(s): 357830006

J(M0): Estimated Value. Matrix spike recovery was outside laboratory control limits.

- MS (Lab ID: 269685)
  - Mean Total Organic Carbon
- MSD (Lab ID: 269686)
  - Mean Total Organic Carbon

Duplicate Sample:
All duplicate sample results were within method acceptance criteria with any exceptions noted below.

Additional Comments:

This data package has been reviewed for quality and completeness and is approved for release.

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ANALYTICAL RESULTS

Project: 10-0096/C9 & C11
Pace Project No.: 357830

Sample: CSS-WCA-5 **Lab ID: 357830001** Collected: 02/17/10 08:00 Received: 02/23/10 10:00 Matrix: Solid

Results reported on a "dry-weight" basis

Parameters	Results	Units	PQL	MDL	DF	Prepared	Analyzed	CAS No.	Qual
6020 MET ICPMS	Analytical Method: EPA 6020								
Selenium	**2.8**	mg/kg	0.82	0.41	20	03/01/10 09:50	03/01/10 21:54	7782-49-2	
Percent Moisture	Analytical Method: ASTM D2974-87								
Percent Moisture	**84.9**	%	0.10	0.10	1		03/01/10 07:47		

REPORT OF LABORATORY ANALYSIS

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ANALYTICAL RESULTS

Project: 10-0096/C9 & C11
Pace Project No.: 357830

Sample: CSS-WCA-10 **Lab ID: 357830002** Collected: 02/17/10 08:00 Received: 02/23/10 10:00 Matrix: Solid

Results reported on a "dry-weight" basis

Parameters	Results	Units	PQL	MDL	DF	Prepared	Analyzed	CAS No.	Qual
6020 MET ICPMS	Analytical Method: EPA 6020								
Selenium	**1.2**	mg/kg	0.70	0.35	20	03/01/10 09:50	03/01/10 21:42	7782-49-2	
Percent Moisture	Analytical Method: ASTM D2974-87								
Percent Moisture	**82.5**	%	0.10	0.10	1		03/01/10 07:47		

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ANALYTICAL RESULTS

Project: 10-0096/C9 & C11
Pace Project No.: 357830

Sample: CSS-WCA-15 **Lab ID: 357830003** Collected: 02/17/10 08:00 Received: 02/23/10 10:00 Matrix: Solid

Results reported on a "dry-weight" basis

Parameters	Results	Units	PQL	MDL	DF	Prepared	Analyzed	CAS No.	Qual
6020 MET ICPMS	Analytical Method: EPA 6020								
Selenium	**1.4**	mg/kg	0.67	0.33	20	03/01/10 09:50	03/01/10 21:50	7782-49-2	
Percent Moisture	Analytical Method: ASTM D2974-87								
Percent Moisture	**81.3**	%	0.10	0.10	1		03/01/10 07:47		

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ANALYTICAL RESULTS

Project: 10-0096/C9 & C11
Pace Project No.: 357830

Sample: CSS-WCA-20 **Lab ID: 357830004** Collected: 02/17/10 08:00 Received: 02/23/10 10:00 Matrix: Solid

Results reported on a "dry-weight" basis

Parameters	Results	Units	PQL	MDL	DF	Prepared	Analyzed	CAS No.	Qual
6020 MET ICPMS	Analytical Method: EPA 6020								
Selenium	**3.4**	mg/kg	1.1	0.54	20	03/01/10 09:50	03/01/10 22:32	7782-49-2	
Percent Moisture	Analytical Method: ASTM D2974-87								
Percent Moisture	**88.7**	%	0.10	0.10	1		03/01/10 07:47		
Total Organic Carbon	Analytical Method: EPA 9060 Modified								
Total Organic Carbon	**227000**	mg/kg	50000	14000	1		03/02/10 10:35	7440-44-0	
Total Organic Carbon	**252000**	mg/kg	100000	28000	1		03/02/10 10:38	7440-44-0	
Mean Total Organic Carbon	**236000**	mg/kg	66700	18700	1		03/02/10 10:38	7440-44-0	

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ANALYTICAL RESULTS

Project: 10-0096/C9 & C11
Pace Project No.: 357830

Sample: CSS-WCA-25 **Lab ID: 357830005** Collected: 02/17/10 08:00 Received: 02/23/10 10:00 Matrix: Solid

Results reported on a "dry-weight" basis

Parameters	Results	Units	PQL	MDL	DF	Prepared	Analyzed	CAS No.	Qual
6020 MET ICPMS	Analytical Method: EPA 6020								
Selenium	**3.4**	mg/kg	0.82	0.41	20	03/01/10 09:50	03/01/10 22:36	7782-49-2	
Percent Moisture	Analytical Method: ASTM D2974-87								
Percent Moisture	**84.9**	%	0.10	0.10	1		03/01/10 07:47		

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ANALYTICAL RESULTS

Project: 10-0096/C9 & C11
Pace Project No.: 357830

Sample: CSS-WCA-30 **Lab ID: 357830006** Collected: 02/17/10 08:00 Received: 02/23/10 10:00 Matrix: Solid

Results reported on a "dry-weight" basis

Parameters	Results	Units	PQL	MDL	DF	Prepared	Analyzed	CAS No.	Qual
6020 MET ICPMS	Analytical Method: EPA 6020								
Selenium	**1.0**	mg/kg	0.67	0.33	20	03/01/10 09:50	03/01/10 22:40	7782-49-2	
Percent Moisture	Analytical Method: ASTM D2974-87								
Percent Moisture	**81.5**	%	0.10	0.10	1		03/01/10 07:47		
Total Organic Carbon	Analytical Method: EPA 9060 Modified								
Total Organic Carbon	**74700**	mg/kg	11100	3110	1		03/02/10 10:45	7440-44-0	
Total Organic Carbon	**74300**	mg/kg	12500	3500	1		03/02/10 10:52	7440-44-0	
Mean Total Organic Carbon	**74500**	mg/kg	11800	3290	1		03/02/10 10:52	7440-44-0	J(M0)

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ANALYTICAL RESULTS

Project: 10-0096/C9 & C11
Pace Project No.: 357830

Sample: CSS-WCA-32 **Lab ID: 357830007** Collected: 02/17/10 08:00 Received: 02/23/10 10:00 Matrix: Solid

Results reported on a "dry-weight" basis

Parameters	Results	Units	PQL	MDL	DF	Prepared	Analyzed	CAS No.	Qual
6020 MET ICPMS	Analytical Method: EPA 6020								
Selenium	**0.89**	mg/kg	0.69	0.34	20	03/01/10 09:50	03/01/10 22:45	7782-49-2	
Percent Moisture	Analytical Method: ASTM D2974-87								
Percent Moisture	**82.1**	%	0.10	0.10	1		03/01/10 07:47		

REPORT OF LABORATORY ANALYSIS

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QUALITY CONTROL DATA

Project: 10-0096/C9 & C11
Pace Project No.: 357830

QC Batch: ICPM/19390 Analysis Method: EPA 6020
QC Batch Method: EPA 6020 Analysis Description: 6020 MET
Associated Lab Samples: 357830001, 357830002, 357830003, 357830004, 357830005, 357830006, 357830007

METHOD BLANK: 753349 Matrix: Solid
Associated Lab Samples: 357830001, 357830002, 357830003, 357830004, 357830005, 357830006, 357830007

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Selenium	mg/kg	0.062U	0.12	03/01/10 21:34	

LABORATORY CONTROL SAMPLE: 753350

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Selenium	mg/kg	4.9	5.2	106	75-125	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 753351 753352

Parameter	Units	357830001 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Selenium	mg/kg	2.8	32.5	32.5	34.9	37.4	99	106	70-130	7	20	

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QUALITY CONTROL DATA

Project: 10-0096/C9 & C11
Pace Project No.: 357830

QC Batch: PMST/3663 Analysis Method: ASTM D2974-87
QC Batch Method: ASTM D2974-87 Analysis Description: Dry Weight/Percent Moisture
Associated Lab Samples: 357830001, 357830002, 357830003, 357830004, 357830005, 357830006, 357830007

SAMPLE DUPLICATE: 269120

Parameter	Units	4028810001 Result	Dup Result	RPD	Max RPD	Qualifiers
Percent Moisture	%	6.2	6.1	2	10	

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QUALITY CONTROL DATA

Project: 10-0096/C9 & C11
Pace Project No.: 357830

QC Batch: WETA/5812 — Analysis Method: EPA 9060 Modified
QC Batch Method: EPA 9060 Modified — Analysis Description: 9060 TOC Average
Associated Lab Samples: 357830004, 357830006

METHOD BLANK: 269683 — Matrix: Solid
Associated Lab Samples: 357830004, 357830006

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Mean Total Organic Carbon	mg/kg	70.0U	250	03/02/10 09:55	

LABORATORY CONTROL SAMPLE: 269684

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Mean Total Organic Carbon	mg/kg	1000	922	92	80-120	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 269685 — 269686

Parameter	Units	357830006 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Mean Total Organic Carbon	mg/kg	74500	80000	66700	215000	192000	176	176	50-150	11	30	J(M0)

REPORT OF LABORATORY ANALYSIS

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QUALIFIERS

Project: 10-0096/C9 & C11
Pace Project No.: 357830

DEFINITIONS

DF - Dilution Factor, if reported, represents the factor applied to the reported data due to changes in sample preparation, dilution of the sample aliquot, or moisture content.

ND - Not Detected at or above adjusted reporting limit.

MDL - Adjusted Method Detection Limit.

S - Surrogate

1,2-Diphenylhydrazine (8270 listed analyte) decomposes to Azobenzene.

Consistent with EPA guidelines, unrounded data are displayed and have been used to calculate % recovery and RPD values.

LCS(D) - Laboratory Control Sample (Duplicate)

MS(D) - Matrix Spike (Duplicate)

DUP - Sample Duplicate

RPD - Relative Percent Difference

NC - Not Calculable.

Pace Analytical is NELAP accredited. Contact your Pace PM for the current list of accredited analytes.

U - Indicates the compound was analyzed for, but not detected.

LABORATORIES

PASI-G	Pace Analytical Services - Green Bay
PASI-M	Pace Analytical Services - Minneapolis

ANALYTE QUALIFIERS

J(M0)	Estimated Value. Matrix spike recovery was outside laboratory control limits.

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QUALITY CONTROL DATA CROSS REFERENCE TABLE

Project: 10-0096/C9 & C11
Pace Project No.: 357830

Lab ID	Sample ID	QC Batch Method	QC Batch	Analytical Method	Analytical Batch
357830001	**CSS-WCA-5**	EPA 6020	ICPM/19390	EPA 6020	ICPM/7940
357830002	**CSS-WCA-10**	EPA 6020	ICPM/19390	EPA 6020	ICPM/7940
357830003	**CSS-WCA-15**	EPA 6020	ICPM/19390	EPA 6020	ICPM/7940
357830004	**CSS-WCA-20**	EPA 6020	ICPM/19390	EPA 6020	ICPM/7940
357830005	**CSS-WCA-25**	EPA 6020	ICPM/19390	EPA 6020	ICPM/7940
357830006	**CSS-WCA-30**	EPA 6020	ICPM/19390	EPA 6020	ICPM/7940
357830007	**CSS-WCA-32**	EPA 6020	ICPM/19390	EPA 6020	ICPM/7940
357830001	**CSS-WCA-5**	ASTM D2974-87	PMST/3663		
357830002	**CSS-WCA-10**	ASTM D2974-87	PMST/3663		
357830003	**CSS-WCA-15**	ASTM D2974-87	PMST/3663		
357830004	**CSS-WCA-20**	ASTM D2974-87	PMST/3663		
357830005	**CSS-WCA-25**	ASTM D2974-87	PMST/3663		
357830006	**CSS-WCA-30**	ASTM D2974-87	PMST/3663		
357830007	**CSS-WCA-32**	ASTM D2974-87	PMST/3663		
357830004	**CSS-WCA-20**	EPA 9060 Modified	WETA/5812		
357830004	**CSS-WCA-20**	EPA 9060 Modified	WETA/5813		
357830006	**CSS-WCA-30**	EPA 9060 Modified	WETA/5812		
357830006	**CSS-WCA-30**	EPA 9060 Modified	WETA/5813		

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Price E

357830

Columbia Analytical Services

CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

SR #

CAS Contact

9143 Philips Highway, Ste 200 • Jacksonville, FL 32256 (904) 739-2277 • 800-695-7222 x06 • FAX (904) 739-2011 PAGE 1 OF 1

www.caslab.com

Project Name: C9#C11

Project Number: 10-0096

Project Manager: Barry Westmark

Email Address: bwestmark@ectinc.com

Company/Address: ECT, 6300 NE 1st Ave #100, Ft Lauderdale FL 33334

Phone #: 954-771-0444

FAX#: 954-771-8118

Sampler's Signature: CAR

Sampler's Printed Name: CAR + MCD

ANALYSIS REQUESTED (Include Method Number and Container Preservative)

CLIENT SAMPLE ID	LAB ID	SAMPLING DATE	SAMPLING TIME	MATRIX	NUMBER OF CONTAINERS	8260	TOC													REMARKS/ ALTERNATE DESCRIPTION
PRESERVATIVE						0	0													
CSS-WCA-5	001	2/17/10		SO	1	✓												1-4oz cg		must be
CSS-WCA-10	002	↓		↓	1	✓												↓ 2-4oz cg		run by
CSS-WCA-15	003				1	✓												1-4oz cg		method
CSS-WCA-20	004				~~2~~	✓	✓											↓		8020 only
CSS-WCA-25	005				1	✓														
CSS-WCA-30	006	↓		↓	~~2~~	✓	✓											2-4oz cg		
CSS-WCA-32	007	2/17/10		SO	~~2~~	✓												1-4oz cg		

Preservative Key
0. NONE
1. HCL
2. HNO_3
3. H_2SO_4
4. NaOH
5. Zn. Acetate
6. MeOH
7. $NaHSO_4$
8. Other _____

SPECIAL INSTRUCTIONS/COMMENTS

See QAPP ☐

TURNAROUND REQUIREMENTS
____ RUSH (SURCHARGES APPLY)
_X_ STANDARD
REQUESTED FAX DATE
REQUESTED REPORT DATE

REPORT REQUIREMENTS
____ I. Results Only
____ II. Results + QC Summaries (LCS, DUP, MS/MSD as required)
____ III. Results + QC and Calibration Summaries
____ IV. Data Validation Report with Raw Data
____ V. Specialized Forms / Custom Report
Edata ____ Yes ____ No

INVOICE INFORMATION
PO#
BILL TO:

SAMPLE RECEIPT: CONDITION/COOLER TEMP: _____ CUSTODY SEALS: Y N

RELINQUISHED BY	RECEIVED BY	RELINQUISHED BY	RECEIVED BY	RELINQUISHED BY	RECEIVED BY
Signature: [signature]	Signature: [signature]	Signature: Fed Ex	Signature: K Meiki	Signature	Signature
Printed Name: Jack Hubbard	Printed Name: [illegible]	Printed Name	Printed Name	Printed Name	Printed Name
Firm: ECT	Firm: [illegible]	Firm	Firm	Firm	Firm
Date/Time: 2/22/10 13:42	Date/Time: 2/22/10 13:42	Date/Time: 2/23/10 1000	Date/Time: 2-23-10 1000	Date/Time	Date/Time

Distribution: White - Return to Originator; Yellow - Retained by Client

JSCOC-06/20/06

1066

e-Hardcopy 2.0
Automated Report

Southeast ACCUTEST Laboratories

IT'S ALL IN THE CHEMISTRY

04/02/10

Technical Report for

ECT

C9/C11 Selenium; Weston, FL

10-0096

Accutest Job Number: F71797

Sampling Dates: 02/17/10 - 02/26/10

Report to:

ECT

padak@ectinc.com

ATTN: Probas Adak

Total number of pages in report: 38

ACCREDITED IN ACCORDANCE WITH nelac

Test results contained within this data package meet the requirements of the National Environmental Laboratory Accreditation Conference and/or state specific certification programs as applicable.

Harry Behzadi, Ph.D.
Laboratory Director

Client Service contact: Sue Bell 407-425-6700

ACCUTEST LABORATORIES 50 YEARS 1956-2006

Certifications: FL (DOH E83510), NC (573), NJ (FL002), MA (FL946), IA (366), LA (03051), KS (E-10327), SC, AK
This report shall not be reproduced, except in its entirety, without the written approval of Accutest Laboratories.
Test results relate only to samples analyzed.

Accutest Laboratories is the sole authority for authorizing edits or modifications to this document. Unauthorized modification of this report is strictly prohibited.

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Accutest LabLink@101046 08:53 02-Apr-2010

Sample Summary

ECT

Job No: F71797

C9/C11 Selenium; Weston, FL
Project No: 10-0096

Sample Number	Collected Date	Time By	Received	Matrix Code	Type	Client Sample ID
F71797-1	02/17/10	10:54 CAR	03/04/10	SO	Soil	CSS-WCA-5D
F71797-2	02/17/10	12:52 CAR	03/04/10	SO	Soil	CSS-WCA-10D
F71797-3	02/17/10	14:37 CAR	03/04/10	SO	Soil	CSS-WCA-15D
F71797-4	02/17/10	16:10 CAR	03/04/10	SO	Soil	CSS-WCA-20D
F71797-5	02/17/10	17:53 CAR	03/04/10	SO	Soil	CSS-WCA-25D
F71797-6	02/17/10	08:02 CAR	03/04/10	SO	Soil	CSS-WCA-30D
F71797-7	02/17/10	08:42 CAR	03/04/10	SO	Soil	CSS-WCA-32D
F71797-8	02/26/10	13:20 CAR	03/04/10	SO	Soil	CSS-C11-5D
F71797-9	02/26/10	14:55 CAR	03/04/10	SO	Soil	CSS-C11-15D
F71797-10	02/26/10	15:30 CAR	03/04/10	SO	Soil	CSS-C11-17D

Soil samples reported on a dry weight basis unless otherwise indicated on result page.

Sample Results

Report of Analysis

Accutest LabLink@101046 08:53 02-Apr-2010

Report of Analysis

Client Sample ID:	CSS-WCA-5D		
Lab Sample ID:	F71797-1	**Date Sampled:**	02/17/10
Matrix:	SO - Soil	**Date Received:**	03/04/10
		Percent Solids:	19.2
Project:	C9/C11 Selenium; Weston, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed By	Method	Prep Method
Selenium [a]	2.6	1.3	0.15	mg/kg	5	03/11/10	03/12/10 ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23965
(2) Prep QC Batch: N:MP51802

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest LabLink@101046 08:53 02-Apr-2010

Report of Analysis

Client Sample ID:	CSS-WCA-10D		
Lab Sample ID:	F71797-2	**Date Sampled:**	02/17/10
Matrix:	SO - Soil	**Date Received:**	03/04/10
		Percent Solids:	22.1
Project:	C9/C11 Selenium; Weston, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed By	Method	Prep Method
Selenium [a]	0.65 I	1.1	0.13	mg/kg	5	03/11/10	03/12/10 ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23965
(2) Prep QC Batch: N:MP51802

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest LabLink@101046 08:53 02-Apr-2010

Report of Analysis

Client Sample ID:	CSS-WCA-15D		
Lab Sample ID:	F71797-3	**Date Sampled:**	02/17/10
Matrix:	SO - Soil	**Date Received:**	03/04/10
		Percent Solids:	20.5
Project:	C9/C11 Selenium; Weston, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed By	Method	Prep Method
Selenium [a]	0.55 I	1.2	0.14	mg/kg	5	03/11/10	03/12/10 ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23965
(2) Prep QC Batch: N:MP51802

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest LabLink@101046 08:53 02-Apr-2010

Report of Analysis

Client Sample ID:	CSS-WCA-20D		
Lab Sample ID:	F71797-4	**Date Sampled:**	02/17/10
Matrix:	SO - Soil	**Date Received:**	03/04/10
		Percent Solids:	19.4
Project:	C9/C11 Selenium; Weston, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Selenium [a]	2.4	1.3	0.15	mg/kg	5	03/11/10	03/12/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23965
(2) Prep QC Batch: N:MP51802

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest LabLink@101046 08:53 02-Apr-2010

Report of Analysis

Client Sample ID:	CSS-WCA-20D		
Lab Sample ID:	F71797-4	**Date Sampled:**	02/17/10
Matrix:	SO - Soil	**Date Received:**	03/04/10
		Percent Solids:	19.4
Project:	C9/C11 Selenium; Weston, FL		

General Chemistry

Analyte	Result	RL	MDL	Units	DF	Analyzed	By	Method
Solids, Percent	19.4			%	1	03/11/10 12:53	LT	SM19 2540B M
Total Organic Carbon	30500	5200	2600	mg/kg	1	03/16/10 12:37	SD	SW846 9060A MOD

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest LabLink@101046 08:53 02-Apr-2010

Report of Analysis

Client Sample ID:	CSS-WCA-25D		
Lab Sample ID:	F71797-5	**Date Sampled:**	02/17/10
Matrix:	SO - Soil	**Date Received:**	03/04/10
		Percent Solids:	19.9
Project:	C9/C11 Selenium; Weston, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed By	Method	Prep Method
Selenium [a]	2.3	1.3	0.15	mg/kg	5	03/11/10	03/12/10 ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23965
(2) Prep QC Batch: N:MP51802

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest LabLink@101046 08:53 02-Apr-2010

Report of Analysis

Client Sample ID:	CSS-WCA-30D		
Lab Sample ID:	F71797-6	**Date Sampled:**	02/17/10
Matrix:	SO - Soil	**Date Received:**	03/04/10
		Percent Solids:	22.1
Project:	C9/C11 Selenium; Weston, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed By	Method	Prep Method
Selenium [a]	0.65 I	1.1	0.13	mg/kg	5	03/11/10	03/12/10 ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23965
(2) Prep QC Batch: N:MP51802

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest LabLink@101046 08:53 02-Apr-2010

Report of Analysis

Client Sample ID:	CSS-WCA-30D		
Lab Sample ID:	F71797-6	**Date Sampled:**	02/17/10
Matrix:	SO - Soil	**Date Received:**	03/04/10
		Percent Solids:	22.1
Project:	C9/C11 Selenium; Weston, FL		

General Chemistry

Analyte	Result	RL	MDL	Units	DF	Analyzed	By	Method
Solids, Percent	22.1			%	1	03/11/10 12:53	LT	SM19 2540B M
Total Organic Carbon	22600	4500	2300	mg/kg	1	03/16/10 12:57	SD	SW846 9060A MOD

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest LabLink@101046 08:53 02-Apr-2010

Report of Analysis

Client Sample ID:	CSS-WCA-32D		
Lab Sample ID:	F71797-7	**Date Sampled:**	02/17/10
Matrix:	SO - Soil	**Date Received:**	03/04/10
		Percent Solids:	21.9
Project:	C9/C11 Selenium; Weston, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed By	Method	Prep Method
Selenium [a]	0.56 I	1.1	0.13	mg/kg	5	03/11/10	03/12/10 ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23965
(2) Prep QC Batch: N:MP51802

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest LabLink@101046 08:53 02-Apr-2010

Report of Analysis

Client Sample ID:	CSS-C11-5D		
Lab Sample ID:	F71797-8	**Date Sampled:**	02/26/10
Matrix:	SO - Soil	**Date Received:**	03/04/10
		Percent Solids:	55.8
Project:	C9/C11 Selenium; Weston, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Barium [a]	22.8	0.45	0.034	mg/kg	5	03/11/10	03/12/10	ANJ	SW846 6020 [1]	SW846 3050B [2]
Selenium [a]	1.5	0.45	0.052	mg/kg	5	03/11/10	03/12/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23965
(2) Prep QC Batch: N:MP51802

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest LabLink@101046 08:53 02-Apr-2010

Report of Analysis

Client Sample ID:	CSS-C11-15D		
Lab Sample ID:	F71797-9	**Date Sampled:**	02/26/10
Matrix:	SO - Soil	**Date Received:**	03/04/10
		Percent Solids:	61.1
Project:	C9/C11 Selenium; Weston, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed By	Method	Prep Method
Barium [a]	15.1	0.41	0.031	mg/kg	5	03/11/10	03/12/10 ANJ	SW846 6020 [1]	SW846 3050B [2]
Selenium [b]	0.80 I	0.82	0.095	mg/kg	10	03/11/10	03/12/10 ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23965
(2) Prep QC Batch: N:MP51801

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.
(b) Elevated detection limit due to dilution required for matrix interference (indicated by failing internal standard on original analysis). Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest LabLink@101046 08:53 02-Apr-2010

Report of Analysis

Client Sample ID:	CSS-C11-17D		
Lab Sample ID:	F71797-10	**Date Sampled:**	02/26/10
Matrix:	SO - Soil	**Date Received:**	03/04/10
		Percent Solids:	72.4
Project:	C9/C11 Selenium; Weston, FL		

Metals Analysis

Analyte	Result	RL	MDL	Units	DF	Prep	Analyzed	By	Method	Prep Method
Barium [a]	12.5	0.34	0.026	mg/kg	5	03/11/10	03/12/10	ANJ	SW846 6020 [1]	SW846 3050B [2]
Selenium [a]	0.24 I	0.34	0.039	mg/kg	5	03/11/10	03/12/10	ANJ	SW846 6020 [1]	SW846 3050B [2]

(1) Instrument QC Batch: N:MA23965
(2) Prep QC Batch: N:MP51801

(a) Analysis performed at Accutest Laboratories, Dayton, NJ.

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Accutest LabLink@101046 08:53 02-Apr-2010

Report of Analysis

Client Sample ID:	CSS-C11-17D		
Lab Sample ID:	F71797-10	**Date Sampled:**	02/26/10
Matrix:	SO - Soil	**Date Received:**	03/04/10
		Percent Solids:	72.4
Project:	C9/C11 Selenium; Weston, FL		

General Chemistry

Analyte	Result	RL	MDL	Units	DF	Analyzed	By	Method
Solids, Percent	72.4			%	1	03/11/10 12:53	LT	SM19 2540B M
Total Organic Carbon	9310	1400	690	mg/kg	1	03/16/10 13:20	SD	SW846 9060A MOD

RL = Reporting Limit = PQL
MDL = Method Detection Limit

U = Indicates a result < MDL
I = Indicates a result >= MDL but < RL

Misc. Forms

Custody Documents and Other Forms

Includes the following where applicable:

- Certification Exceptions
- Chain of Custody

(3/3/2010) Adam Smith - Accutest COC DUPLICATES C9 C11 THRU PACE.pdf Page 1

F71797

ACCUTEST.

CHAIN OF CUSTODY

4405 Vineland Rd., Suite C15
Orlando, FL 32811
407-425-6700, fax 407-425-0707

Accutest Job #:
Accutest Contact #:

Client Information

Name: EST
Address: 6300 NE 1ST AVE.
City: FT LAUDERDALE State: FL Zip: 33334
Send Report to:
Phone #: 9647710444

Facility Information

Project Name: C9 AND C11
Location: FL
Project No.: 10-0096
FAX #:

Analytical Information

	Field ID / Point of Collection	Collection Date	Time	Sampled By	Matrix	# of bottles	Preservative: None	HCl	HNO3	H2SO4	NaOH	Na2S2O3	C9 (By 6020)	TOC	Bz
1	CSS-WCA-5D	2/17/2010	1054	CAR/ASO		1							X		
2	CSS-WCA-10D	2/17/2010	1252	CAR/ASO		1							X		
3	CSS-WCA-15D	2/17/2010	1437	CAR/ASO		1							X		
4	CSS-WCA-20D	2/17/2010	1610	CAR/ASO		2							X	X	
5	CSS-WCA-25D	2/17/2010	1753	CAR/ASO		1							X		
6	CSS-WCA-30D	2/17/2010	802	CAR/ASO		2							X	X	
7	CSS-WCA-35D	2/17/2010	842	CAR/ASO		1							X		
8	CSS-C11-5D	2/26/2010	1320	PA	SO	1							X		X
9	CSS-C11-15D	2/26/2010	1455	PA	SO	1							X		X
10	CSS-C11-17D	2/26/2010	1630	PA	SO	1							X	X	X

Turnaround Information

- 14 Day Standard — Approved By:
- 7 days
- 24 hour
- Other _____ (Days)

RUSH TAT is for FAX date
Data unless previously approved.

Data Deliverable Information

- Std Reduced
- NJ Full
- FULL CLP
- Disk Deliverable
- Other (Specify)
- Commercial "A"
- Commercial "B"
- ASP Category B
- State Forms

Comments / Remarks

Sample Custody must be documented below each time samples change possession, including courier delivery.

Relinquished by Sampler:	Date Time:	Received By:	Relinquished By:	Date Time:	Received By:
1		1	2		
Relinquished by Sampler:	Date Time:	Received By:	Relinquished By:	Date Time:	Received By:
3	3/4/10 9:00	3	4 PACE	3/3/10 10:30	
Relinquished by Sampler:	Date Time:	Received By:			
5		6			

Cooler # | Preserved where applicable: ☐ | On Ice: 3.2 2.0

F71797: Chain of Custody
Page 1 of 2

ACCUTEST LABORATORIES SAMPLE RECEIPT CONFIRMATION

ACCUTEST'S JOB NUMBER: F71797 CLIENT: ECT PROJECT: C9 and 11

DATE/TIME RECEIVED: 3/4/10 9:00 (MM/DD/YY 24:00) NUMBER OF COOLERS RECEIVED: 2

METHOD OF DELIVERY: (FEDEX) UPS ACCUTEST COURIER GREYHOUND DELIVERY OTHER

AIRBILL NUMBERS: 9846 4620 3401

COOLER INFORMATION

- [ ] CUSTODY SEAL NOT PRESENT OR NOT INTACT
- [ ] CHAIN OF CUSTODY NOT RECEIVED (COC)
- [ ] ANALYSIS REQUESTED IS UNCLEAR OR MISSING
- [ ] SAMPLE DATES OR TIMES UNCLEAR OR MISSING
- [ ] TEMPERATURE CRITERIA NOT MET
- [ ] WET ICE PRESENT

TRIP BLANK INFORMATION

- [ ] TRIP BLANK PROVIDED
- [X] TRIP BLANK NOT PROVIDED
- [X] TRIP BLANK NOT ON COC
- [ ] TRIP BLANK INTACT
- [ ] TRIP BLANK NOT INTACT
- [ ] RECEIVED WATER TRIP BLANK
- [ ] RECEIVED SOIL TRIP BLANK

MISC. INFORMATION

NUMBER OF ENCORES ? 0

NUMBER OF 5035 FIELD KITS ? 0

NUMBER OR LAB FILTERED METALS ? 0

TEMPERATURE INFORMATION

- [ ] IR THERM ID IR3 CORR. FACTOR +0
- [ ] OBSERVED TEMPS: 2.2 2.0
- [ ] CORRECTED TEMPS: 3.2 2.0

SAMPLE INFORMATION

- [ ] SAMPLE LABELS PRESENT ON ALL BOTTLES
- [ ] INCORRECT NUMBER OF CONTAINERS USED
- [ ] SAMPLE RECEIVED IMPROPERLY PRESERVED
- [ ] INSUFFICIENT VOLUME FOR ANALYSIS
- [ ] DATES/TIMES ON COC DO NOT MATCH SAMPLE LABEL
- [X] ID'S ON COC DO NOT MATCH LABEL
- [ ] VOC VIALS HAVE HEADSPACE (MACRO BUBBLES)
- [ ] BOTTLES RECEIVED BUT ANALYSIS NOT REQUESTED
- [ ] NO BOTTLES RECEIVED FOR ANALYSIS REQUESTED
- [ ] UNCLEAR FILTERING OR COMPOSITING INSTRUCTIONS
- [ ] SAMPLE CONTAINER(S) RECEIVED BROKEN
- [ ] % SOLIDS JAR NOT RECEIVED
- [ ] 5035 FIELD KIT FROZEN WITHIN 48 HOUR'S
- [ ] RESIDUAL CHLORINE PRESENT

(APPICABLE TO EPA 600 SERIES OR NORTH CAROLINA ORGANICS)

SUMMARY OF COMMENTS: All samples are missing a "D" at the end of each ID see COC for correct IDs.

TECHNICIAN SIGNATURE/DATE 3/4/10 REVIEWER SIGNATURE/DATE 03-04-10

NF 10/09 RECEIPT CONFIRMATION 100609 (2).xls

F71797: Chain of Custody
Page 2 of 2

General Chemistry

QC Data Summaries

Includes the following where applicable:

- Method Blank and Blank Spike Summaries
- Duplicate Summaries
- Matrix Spike Summaries

METHOD BLANK AND SPIKE RESULTS SUMMARY
GENERAL CHEMISTRY

Login Number: F71797
Account: ECTFLLAU - ECT
Project: C9/C11 Selenium; Weston, FL

Analyte	Batch ID	RL	MB Result	Units	Spike Amount	BSP Result	BSP %Recov	QC Limits
Total Organic Carbon	GP14492/GN38879	1000	0.0	mg/kg	20000	21300	106.5	88-114%

Associated Samples:
Batch GP14492: F71797-10, F71797-4, F71797-6
(*) Outside of QC limits

DUPLICATE RESULTS SUMMARY
GENERAL CHEMISTRY

Login Number: F71797
Account: ECTFLLAU - ECT
Project: C9/C11 Selenium; Weston, FL

Analyte	Batch ID	QC Sample	Units	Original Result	DUP Result	RPD	QC Limits
Solids, Percent	GN38780	F71947-1	%	93.9	93.5	0.4	0-10%
Total Organic Carbon	GP14492/GN38879	F71796-5	mg/kg	33000	26600	21.5	0-36%

Associated Samples:
Batch GN38780: F71797-1, F71797-10, F71797-2, F71797-3, F71797-4, F71797-5, F71797-6, F71797-7, F71797-9
Batch GP14492: F71797-10, F71797-4, F71797-6
(*) Outside of QC limits

MATRIX SPIKE RESULTS SUMMARY
GENERAL CHEMISTRY

Login Number: F71797
Account: ECTFLLAU - ECT
Project: C9/C11 Selenium; Weston, FL

Analyte	Batch ID	QC Sample	Units	Original Result	Spike Amount	MS Result	%Rec	QC Limits
Total Organic Carbon	GP14492/GN38879	F71796-5	mg/kg	33000	55200	75500	78.9N(a)	88-114%

Associated Samples:
Batch GP14492: F71797-10, F71797-4, F71797-6
(*) Outside of QC limits
(N) Matrix Spike Rec. outside of QC limits
(a) Spike recovery indicates possible matrix interference and/or sample nonhomogeneity.

Misc. Forms

Custody Documents and Other Forms

(Accutest New Jersey)

Includes the following where applicable:

- Chain of Custody

ACCUTEST Laboratories

Accutest Southeast Subcontract Chain of Custody

AR# 7984954990878

4405 Vineland Road, Suite C-15 Orlando, Fl 32811
TEL: 407-425-6700 • FAX: 407-425-0707

PAGE 1 OF 1

Client / Reporting Information

Company Name: Accutest Laboratories Southeast
Address: 4405 Vineland Road Suite C-15
City: Orlando State: Fl Zip: 32811
Project Contact: E-mail
Phone#: 407-425-6700 Fax #: 407-425-0707
Lab Technician Printed Name:

Project Information

Accutest Job Number: F71797
Street
City
Project #
Fax #
Client Purchase Order #

Please send report to dnavad@accutest.com

For any other issues contact mmam@accutest.com

Analytical Information

Matrix Codes: DW - Drinking Water; GW - Ground Water; WW - Water; SW - Surface Water; SO - Soil; SL - Sludge; OIL - Oil; LIQ - Other Liquid; AIR - Air; SOL - Other Solid

Lab ID #	Client ID / Accutest Sample ID	DATE	TIME	SAMPLED BY	MATRIX	TOTAL # OF BOTTLES	OTHER	HCL	NA	NaOH	HNO3	H2SO4	NONE	ZnAc/ NaOH	H2O2	SEMS	PAHS	LAB USE ONLY
	F71797-1				SO	1		X								X		NE
	-2					1		X								X		48hr
	-3					1		X								X		
	-4					1		X								X		
	-5					1		X								X		
	-6					1		X								X		
	-7					1		X								X		
	-8					1		X								X	X	
	-9					1		X								X	X	
	-10					1		X								X	X	

TURNAROUND TIME (Business Days)

Approved By: 3/15/10

- Standard 10 Business Days
- 7 Day RUSH
- 5 Day RUSH
- 3 Day EMERGENCY
- 2 Day EMERGENCY
- 1 Day EMERGENCY
- OTHER

Data Deliverable Information

- COMMERCIAL "A" (RESULTS ONLY)
- [X] COMMERCIAL "B" (RESULTS PLUS QC)
- REDT1 (EPA LEVEL 3)
- FULLT (EPA LEVEL 4)
- EDD'S

Comments / Remarks

Ship to Laboratory- ALNJ

Approved By- Muna Mohammad

Sample Custody must be documented below each time samples change possession, including courier delivery.

Relinquished by/Sampler	Date Time:	Received By/Affiliation	Relinquished by/Affiliation	Date Time:	Received By/Affiliation
1 [signature]	3/18/10 1700	2 Fed Ex	3 Fed Ex	3-19-10 930	4 [signature]
Relinquished by/Affiliation	Date Time:	Received By/Affiliation	Relinquished by/Affiliation	Date Time:	Received By/Affiliation
5		6	7		8

Lab Use Only: Custody Seal in Place: Y N Temp Blank Provided: Y N Preserved Where Applicable: Y N Total # of Coolers: Cooler Temperature (s) Celsius: 2.2.2

F71797: Chain of Custody
Page 1 of 2
Accutest New Jersey

ACCUTEST Laboratories

Accutest Laboratories Sample Receipt Summary

Accutest Job Number: F71797 Client: Immediate Client Services Action Required: No

Date / Time Received: 3/9/2010 Delivery Method: Client Service Action Required at Login: No

Project: No. Coolers: 1 Airbill #'s:

Cooler Security	Y	or	N		Y	or	N
1. Custody Seals Present:	☑		☐	3. COC Present:	☑		☐
2. Custody Seals Intact:	☑		☐	4. Smpl Dates/Time OK	☑		☐

Cooler Temperature	Y	or	N
1. Temp criteria achieved:	☑		☐
2. Cooler temp verification:	Infared gun		
3. Cooler media:	Ice (bag)		

Quality Control Preservatio	Y	or	N	N/A
1. Trip Blank present / cooler:	☐		☐	☑
2. Trip Blank listed on COC:	☐		☐	☑
3. Samples preserved properly:	☑		☐	
4. VOCs headspace free:	☐		☐	☑

Sample Integrity - Documentation	Y	or	N
1. Sample labels present on bottles:	☑		☐
2. Container labeling complete:	☑		☐
3. Sample container label / COC agree:	☑		☐

Sample Integrity - Condition	Y	or	N
1. Sample recvd within HT:	☑		☐
2. All containers accounted for:	☑		☐
3. Condition of sample:	Intact		

Sample Integrity - Instructions	Y	or	N	N/A
1. Analysis requested is clear:	☑		☐	
2. Bottles received for unspecified tests	☐		☑	
3. Sufficient volume recvd for analysis:	☑		☐	
4. Compositing instructions clear:	☐		☐	☑
5. Filtering instructions clear:	☐		☐	☑

Comments

Accutest Laboratories
V:732.329.0200
2235 US Highway 130
F: 732.329.3499
Dayton, New Jersey
www.accutest.com

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F71797: Chain of Custody
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Metals Analysis

6

QC Data Summaries

(Accutest New Jersey)

Includes the following where applicable:

- Method Blank Summaries
- Matrix Spike and Duplicate Summaries
- Blank Spike and Lab Control Sample Summaries
- Serial Dilution Summaries

BLANK RESULTS SUMMARY
Part 2 - Method Blanks

Login Number: F71797
Account: ALSE - Accutest Laboratories Southeast, Inc.
Project: ECTFLLAU: C9/C11 Selenium; Weston, FL

QC Batch ID: MP51801
Matrix Type: SOLID

Methods: SW846 6020
Units: mg/kg

Prep Date:					03/11/10		03/11/10
Metal	RL	IDL	MDL	MB raw	final	MB raw	final
Aluminum	25	.34	.52				
Antimony	0.25	.019	.022				
Arsenic	0.50	.074	.11				
Barium	0.50	.013	.038	0.25	<0.50	0.24	<0.50
Beryllium	0.25	.007	.03				
Boron	2.5	.29	.25				
Cadmium	0.25	.011	.016				
Calcium	130	3	3.1				
Chromium	2.0	.038	.29				
Cobalt	0.25	.0015	.016				
Copper	2.0	.13	.036				
Iron	25	.68	1.9				
Lead	0.25	.003	.012				
Magnesium	130	.27	1.4				
Manganese	0.25	.006	.02				
Molybdenum	0.50	.024	.096				
Nickel	2.0	.095	.026				
Potassium	130	1.4	3.9				
Selenium	0.50	.039	.058	0.038	<0.50	0.085	<0.50
Silver	1.0	.01	.022				
Sodium	130	.56	1.3				
Strontium	0.50	.004	.0082				
Thallium	0.25	.002	.0051				
Tin	0.50	.025					
Titanium	0.50	.027	.27				
Uranium	0.50						
Vanadium	2.0	.27	.79				
Zinc	2.0	.39	.91				

Associated samples MP51801: F71797-9, F71797-10

Results < IDL are shown as zero for calculation purposes
(*) Outside of QC limits
(anr) Analyte not requested

ACCUTEST Laboratories

MATRIX SPIKE AND DUPLICATE RESULTS SUMMARY

Login Number: F71797
Account: ALSE - Accutest Laboratories Southeast, Inc.
Project: ECTFLLAU: C9/C11 Selenium; Weston, FL

QC Batch ID: MP51801
Matrix Type: SOLID

Methods: SW846 6020
Units: mg/kg

Prep Date: 03/11/10

Metal	F71678-56 Original	MS	Spikelot MPIRS1	% Rec	QC Limits
Aluminum					
Antimony					
Arsenic					
Barium	52.4	433	387	98.3	75-125
Beryllium					
Boron					
Cadmium					
Calcium					
Chromium					
Cobalt					
Copper					
Iron					
Lead					
Magnesium					
Manganese					
Molybdenum					
Nickel					
Potassium					
Selenium	2.8	362	387	92.8	69-125
Silver					
Sodium					
Strontium					
Thallium					
Tin					
Titanium					
Uranium					
Vanadium					
Zinc					

Associated samples MP51801: F71797-9, F71797-10

Results < IDL are shown as zero for calculation purposes
(*) Outside of QC limits
(N) Matrix Spike Rec. outside of QC limits
(anr) Analyte not requested

MATRIX SPIKE AND DUPLICATE RESULTS SUMMARY

Login Number: F71797
Account: ALSE - Accutest Laboratories Southeast, Inc.
Project: ECTFLLAU: C9/C11 Selenium; Weston, FL

QC Batch ID: MP51801
Matrix Type: SOLID

Methods: SW846 6020
Units: mg/kg

Prep Date: 03/11/10

Metal	F71678-56 Original	MSD	Spikelot MPIRS1	% Rec	MSD RPD	QC Limit
Aluminum						
Antimony						
Arsenic						
Barium	52.4	452	389	102.7	4.3	20
Beryllium						
Boron						
Cadmium						
Calcium						
Chromium						
Cobalt						
Copper						
Iron						
Lead						
Magnesium						
Manganese						
Molybdenum						
Nickel						
Potassium						
Selenium	2.8	370	389	94.3	2.2	20
Silver						
Sodium						
Strontium						
Thallium						
Tin						
Titanium						
Uranium						
Vanadium						
Zinc						

Associated samples MP51801: F71797-9, F71797-10

Results < IDL are shown as zero for calculation purposes
(*) Outside of QC limits
(N) Matrix Spike Rec. outside of QC limits
(anr) Analyte not requested

SPIKE BLANK AND LAB CONTROL SAMPLE SUMMARY

Login Number: F71797
Account: ALSE - Accutest Laboratories Southeast, Inc.
Project: ECTFLLAU: C9/C11 Selenium; Weston, FL

QC Batch ID: MP51801
Matrix Type: SOLID

Methods: SW846 6020
Units: mg/kg

Prep Date: 03/11/10 03/11/10

Metal	BSP Result	Spikelot MPIRS1	% Rec	QC Limits	BSP Result	Spikelot MPIRS1	% Rec	QC Limits
Aluminum								
Antimony								
Arsenic								
Barium	429	400	107.3	80-120	467	400	116.8	80-120
Beryllium								
Boron								
Cadmium								
Calcium								
Chromium								
Cobalt								
Copper								
Iron								
Lead								
Magnesium								
Manganese								
Molybdenum								
Nickel								
Potassium								
Selenium	447	400	111.8	80-120	474	400	118.5	80-120
Silver								
Sodium								
Strontium								
Thallium								
Tin								
Titanium								
Uranium								
Vanadium								
Zinc								

Associated samples MP51801: F71797-9, F71797-10

Results < IDL are shown as zero for calculation purposes
(*) Outside of QC limits
(anr) Analyte not requested

SERIAL DILUTION RESULTS SUMMARY

Login Number: F71797
Account: ALSE - Accutest Laboratories Southeast, Inc.
Project: ECTFLLAU: C9/C11 Selenium; Weston, FL

QC Batch ID: MP51801
Matrix Type: SOLID

Methods: SW846 6020
Units: ug/l

Prep Date: 03/11/10

Metal	F71678-56 Original	SDL 5:25	%DIF	QC Limits
Aluminum				
Antimony				
Arsenic				
Barium	542	609	12.4*(a)	0-10
Beryllium				
Boron				
Cadmium				
Calcium				
Chromium				
Cobalt				
Copper				
Iron				
Lead				
Magnesium				
Manganese				
Molybdenum				
Nickel				
Potassium				
Selenium	28.7	33.1	15.2*(a)	0-10
Silver				
Sodium				
Strontium				
Thallium				
Tin				
Titanium				
Uranium				
Vanadium				
Zinc				

Associated samples MP51801: F71797-9, F71797-10

Results < IDL are shown as zero for calculation purposes
(*) Outside of QC limits
(anr) Analyte not requested
(a) Serial dilution indicates possible matrix interference.

6.1.4 9

BLANK RESULTS SUMMARY
Part 2 - Method Blanks

Login Number: F71797
Account: ALSE - Accutest Laboratories Southeast, Inc.
Project: ECTFLLAU: C9/C11 Selenium; Weston, FL

QC Batch ID: MP51802
Matrix Type: SOLID

Methods: SW846 6020
Units: mg/kg

Prep Date: 03/11/10

Metal	RL	IDL	MDL	MB raw	final
Aluminum	10	.14	.21		
Antimony	0.10	.0076	.0086		
Arsenic	0.20	.03	.044		
Barium	0.20	.005	.015	0.066	<0.20
Beryllium	0.10	.0028	.012		
Boron	1.0	.11	.1		
Cadmium	0.10	.0044	.0063		
Calcium	50	1.2	1.2		
Chromium	0.80	.015	.12		
Cobalt	0.10	.0006	.0063		
Copper	0.80	.051	.015		
Iron	10	.27	.77		
Lead	0.10	.0012	.0046		
Magnesium	50	.11	.56		
Manganese	0.10	.0024	.0078		
Molybdenum	0.20	.0096	.038		
Nickel	0.80	.038	.01		
Potassium	50	.56	1.5		
Selenium	0.20	.016	.023	0.017	<0.20
Silver	0.40	.004	.0089		
Sodium	50	.22	.52		
Strontium	0.20	.0016	.0033		
Thallium	0.10	.0008	.002		
Tin	0.20	.0098			
Titanium	0.20	.011	.11		
Uranium	0.20				
Vanadium	0.80	.11	.32		
Zinc	0.80	.16	.37		

Associated samples MP51802: F71797-1, F71797-2, F71797-3, F71797-4, F71797-5, F71797-6, F71797-7, F71797-8

Results < IDL are shown as zero for calculation purposes
(*) Outside of QC limits
(anr) Analyte not requested

MATRIX SPIKE AND DUPLICATE RESULTS SUMMARY

Login Number: F71797
Account: ALSE - Accutest Laboratories Southeast, Inc.
Project: ECTFLLAU: C9/C11 Selenium; Weston, FL

QC Batch ID: MP51802
Matrix Type: SOLID

Methods: SW846 6020
Units: mg/kg

Prep Date: 03/11/10

Metal	F71797-2 Original	MS	Spikelot MPIRS1	% Rec	QC Limits
Aluminum					
Antimony					
Arsenic					
Barium	81.3	984	883	102.2	75-125
Beryllium					
Boron					
Cadmium					
Calcium					
Chromium					
Cobalt					
Copper					
Iron					
Lead					
Magnesium					
Manganese					
Molybdenum					
Nickel					
Potassium					
Selenium	0.65	908	883	102.8	69-125
Silver					
Sodium					
Strontium					
Thallium					
Tin					
Titanium					
Uranium					
Vanadium					
Zinc					

Associated samples MP51802: F71797-1, F71797-2, F71797-3, F71797-4, F71797-5, F71797-6, F71797-7, F71797-8

Results < IDL are shown as zero for calculation purposes
(*) Outside of QC limits
(N) Matrix Spike Rec. outside of QC limits
(anr) Analyte not requested

MATRIX SPIKE AND DUPLICATE RESULTS SUMMARY

Login Number: F71797
Account: ALSE - Accutest Laboratories Southeast, Inc.
Project: ECTFLLAU: C9/C11 Selenium; Weston, FL

QC Batch ID: MP51802
Matrix Type: SOLID

Methods: SW846 6020
Units: mg/kg

Prep Date: 03/11/10

Metal	F71797-2 Original	MSD	Spikelot MPIRS1	% Rec	MSD RPD	QC Limit
Aluminum						
Antimony						
Arsenic						
Barium	81.3	1100	923	110.3	11.1	20
Beryllium						
Boron						
Cadmium						
Calcium						
Chromium						
Cobalt						
Copper						
Iron						
Lead						
Magnesium						
Manganese						
Molybdenum						
Nickel						
Potassium						
Selenium	0.65	1020	923	110.4	11.6	20
Silver						
Sodium						
Strontium						
Thallium						
Tin						
Titanium						
Uranium						
Vanadium						
Zinc						

Associated samples MP51802: F71797-1, F71797-2, F71797-3, F71797-4, F71797-5, F71797-6, F71797-7, F71797-8

Results < IDL are shown as zero for calculation purposes
(*) Outside of QC limits
(N) Matrix Spike Rec. outside of QC limits
(anr) Analyte not requested

SPIKE BLANK AND LAB CONTROL SAMPLE SUMMARY

Login Number: F71797
Account: ALSE - Accutest Laboratories Southeast, Inc.
Project: ECTFLLAU: C9/C11 Selenium; Weston, FL

QC Batch ID: MP51802
Matrix Type: SOLID

Methods: SW846 6020
Units: mg/kg

Prep Date: 03/11/10

Metal	BSP Result	Spikelot MPIRS1	% Rec	QC Limits
Aluminum				
Antimony				
Arsenic				
Barium	438	400	109.5	80-120
Beryllium				
Boron				
Cadmium				
Calcium				
Chromium				
Cobalt				
Copper				
Iron				
Lead				
Magnesium				
Manganese				
Molybdenum				
Nickel				
Potassium				
Selenium	444	400	111.0	80-120
Silver				
Sodium				
Strontium				
Thallium				
Tin				
Titanium				
Uranium				
Vanadium				
Zinc				

Associated samples MP51802: F71797-1, F71797-2, F71797-3, F71797-4, F71797-5, F71797-6, F71797-7, F71797-8

Results < IDL are shown as zero for calculation purposes
(*) Outside of QC limits
(anr) Analyte not requested

6.2.3

6

SERIAL DILUTION RESULTS SUMMARY

Login Number: F71797
Account: ALSE - Accutest Laboratories Southeast, Inc.
Project: ECTFLLAU: C9/C11 Selenium; Weston, FL

QC Batch ID: MP51802
Matrix Type: SOLID

Methods: SW846 6020
Units: ug/l

Prep Date: 03/11/10

Metal	F71797-2 Original	SDL 5:25	%DIF	QC Limits
Aluminum				
Antimony				
Arsenic				
Barium	368	368	0.1	0-10
Beryllium				
Boron				
Cadmium				
Calcium				
Chromium				
Cobalt				
Copper				
Iron				
Lead				
Magnesium				
Manganese				
Molybdenum				
Nickel				
Potassium				
Selenium	2.93	6.16	110.6(a)	0-10
Silver				
Sodium				
Strontium				
Thallium				
Tin				
Titanium				
Uranium				
Vanadium				
Zinc				

Associated samples MP51802: F71797-1, F71797-2, F71797-3, F71797-4, F71797-5, F71797-6, F71797-7, F71797-8

Results < IDL are shown as zero for calculation purposes
(*) Outside of QC limits
(anr) Analyte not requested
(a) Percent difference acceptable due to low initial sample concentration (< 50 times IDL).

APPENDIX B

ADaPT ERROR CHECKS

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-WCA-10
Sample Date : 02/17/2010
Lab Sample ID: 357830002

Lab Report Batch : 357830
Analysis Type: ***RES (TOT)***

Lab ID : E87605
Sample Matrix : SOLID

Reviewed By / Date : .....

Approved By / Date : .....

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***				**Dilution:** ***20***												
Selenium	TOT	1.2	mg/kg		YES											

1106

Project Number and Name: **10-0096 - C9 & C11**

Library Used: **SFWMDCompLibraryVer06**

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-WCA-15
Sample Date : 02/17/2010
Lab Sample ID: 357830003

Lab Report Batch : 357830
Analysis Type: ***RES (TOT)***

Lab ID : E87605
Sample Matrix : SOLID

Reviewed By / Date :

Approved By / Date :

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***					**Dilution:** ***20***											
Selenium	TOT	1.4	mg/kg		YES											

1107

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-WCA-20
Sample Date : 02/17/2010
Lab Sample ID: 357830004

Lab Report Batch : 357830
Analysis Type: ***RES (TOT)***

Lab ID : E87605
Sample Matrix : SOLID

Reviewed By / Date : .....

Approved By / Date : .....

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***				**Dilution:** ***20***												
Selenium	TOT	3.4	mg/kg		YES											
Analysis Method : ***EPA 9060M***				**Dilution:** ***1***												
Carbon- Total Organic	TOT	236000	mg/kg		YES											

1108

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-WCA-25
Sample Date : 02/17/2010
Lab Sample ID: 357830005

Lab Report Batch : 357830
Analysis Type: ***RES (TOT)***

Lab ID : E87605
Sample Matrix : SOLID

Reviewed By / Date : .....

Approved By / Date : .....

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***					**Dilution:** ***20***											
Selenium	TOT	3.4	mg/kg		YES											

1109

Project Number and Name: **10-0096 - C9 & C11**

Library Used: **SFWMDCompLibraryVer06**

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-WCA-30
Sample Date : 02/17/2010
Lab Sample ID: 357830006

Lab Report Batch : 357830
Analysis Type: ***RES (TOT)***

Lab ID : E87605
Sample Matrix : SOLID

Reviewed By / Date : .....

Approved By / Date : .....

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***				**Dilution:** ***20***												
Selenium	TOT	1	mg/kg		YES											
Analysis Method : ***EPA 9060M***				**Dilution:** ***1***												
Carbon- Total Organic	TOT	74500	mg/kg	J	YES											

1110

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-WCA-32
Sample Date : 02/17/2010
Lab Sample ID: 357830007

Lab Report Batch : 357830
Analysis Type: ***RES (TOT)***

Lab ID : E87605
Sample Matrix : SOLID

Reviewed By / Date : .....

Approved By / Date : .....

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***					**Dilution:** ***20***											
Selenium	TOT	0.89	mg/kg		YES											

1111

Project Number and Name: **10-0096 - C9 & C11**

Library Used: **SFWMDCompLibraryVer06**

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-WCA-5
Sample Date : 02/17/2010
Lab Sample ID: 357830001

Lab Report Batch : 357830
Analysis Type: *RES (TOT)*

Lab ID : E87605
Sample Matrix : SOLID

Reviewed By / Date : .....

Approved By / Date : .....

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***				**Dilution:** ***20***												
Selenium	TOT	2.8	mg/kg		YES											

1112

Project Number and Name: **10-0096 - C9 & C11**

Library Used: **SFWMDCompLibraryVer06**

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : 5035041001
Sample Date : 02/24/2010
Lab Sample ID: 5035041001

Lab Report Batch : 358199
Analysis Type: ***RES (TOT)***

Lab ID : E87605
Sample Matrix : SOLID

Reviewed By / Date : .....

Approved By / Date : .....

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***					**Dilution:** ***20***											
Barium	TOT	21.3	mg/kg		YES											
Selenium	TOT	2.2	mg/kg		YES											

1113

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-C11-15
Sample Date : 02/26/2010
Lab Sample ID: 358199002

Lab Report Batch : 358199
Analysis Type: *RES (TOT)*

Lab ID : E87605
Sample Matrix : SOLID

Reviewed By / Date : .....

Approved By / Date : .....

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***				**Dilution:** ***20***												
Barium	TOT	11.2	mg/kg		YES											
Selenium	TOT	0.88	mg/kg		YES											

1114

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-C11-17
Sample Date : 02/26/2010
Lab Sample ID: 358199003

Lab Report Batch : 358199
Analysis Type: ***RES (TOT)***

Lab ID : E87605
Sample Matrix : SOLID

Reviewed By / Date : .....

Approved By / Date : .....

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***				**Dilution:** ***20***												
Barium	TOT	9.6	mg/kg		YES											
Selenium	TOT	0.34	mg/kg	I	YES											
Analysis Method : ***EPA 9060M***				**Dilution:** ***1***												
Carbon- Total Organic	TOT	91400	mg/kg		YES											

1115

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-C11-5
Sample Date : 02/26/2010
Lab Sample ID: 358199001

Lab Report Batch : 358199
Analysis Type: *RES (TOT)*

Lab ID : E87605
Sample Matrix : SOLID

Reviewed By / Date : .....

Approved By / Date : .....

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***				**Dilution:** ***20***												
Barium	TOT	29.9	mg/kg		YES											
Selenium	TOT	2.8	mg/kg		YES											

1116

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-C11-11
Sample Date : 02/26/2010
Lab Sample ID: F71708-9

Lab Report Batch : F71708
Analysis Type: ***RES (TOT)***

Lab ID : E83510
Sample Matrix : SOLID

Reviewed By / Date : pa 05/10/2010

Approved By / Date : pa 5/10/2010

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***					**Dilution:** ***5.00***											
Barium	TOT	36.5	mg/kg		YES											
Selenium	TOT	0.66	mg/kg		YES											

1117

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-C11-13
Sample Date : 02/26/2010
Lab Sample ID: F71708-10

Lab Report Batch : F71708
Analysis Type: *RES (TOT)*

Lab ID : E83510
Sample Matrix : SOLID

Reviewed By / Date : pa 05/10/2010

Approved By / Date : pa 5/10/2010

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***				**Dilution:** ***5.00***												
Barium	TOT	64.5	mg/kg		YES											
Selenium	TOT	3.4	mg/kg		YES											

1118

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-C11-14
Sample Date : 02/26/2010
Lab Sample ID: F71708-11

Lab Report Batch : F71708
Analysis Type: ***RES (TOT)***

Lab ID : E83510
Sample Matrix : SOLID

Reviewed By / Date : pa 05/10/2010

Approved By / Date : pa 5/10/2010

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***					**Dilution:** ***5.00***											
Barium	TOT	19.2	mg/kg		YES											
Selenium	TOT	0.63	mg/kg		YES											

1119

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-C11-15
Sample Date : 02/26/2010
Lab Sample ID: F71708-12

Lab Report Batch : F71708
Analysis Type: ***RES (TOT)***

Lab ID : E83510
Sample Matrix : SOLID

Reviewed By / Date : pa 05/10/2010

Approved By / Date : pa 5/10/2010

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***				**Dilution:** ***5.00***												
Barium	TOT	10.5	mg/kg		YES											
Selenium	TOT	0.46	mg/kg	I	YES											
Analysis Method : ***EPA 9060M***				**Dilution:** ***1.00***												
Carbon- Total Organic	TOT	9620	mg/kg		YES											

1120

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-C11-16
Sample Date : 02/26/2010
Lab Sample ID: F71708-13

Lab Report Batch : F71708
Analysis Type: ***RE (TOT)***

Lab ID : E83510
Sample Matrix : SOLID

Reviewed By / Date : pa 05/10/2010

Approved By / Date : pa 5/10/2010

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***					**Dilution:** ***5.00***											
Selenium	TOT	0.67	mg/kg		YES											

1121

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-C11-16
Sample Date : 02/26/2010
Lab Sample ID: F71708-13

Lab Report Batch : F71708
Analysis Type: ***RES (TOT)***

Lab ID : E83510
Sample Matrix : SOLID

Reviewed By / Date : pa 05/10/2010

Approved By / Date : pa 5/10/2010

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***				**Dilution:** ***5.00***												
Barium	TOT	18.1	mg/kg		YES											

1122

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-C11-17
Sample Date : 02/26/2010
Lab Sample ID: F71708-14

Lab Report Batch : F71708
Analysis Type: ***RE (TOT)***

Lab ID : E83510
Sample Matrix : SOLID

Reviewed By / Date : pa 05/10/2010

Approved By / Date : pa 5/10/2010

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***					**Dilution:** ***5.00***											
Selenium	TOT	0.33	mg/kg	I	YES											

1123

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-C11-17
Sample Date : 02/26/2010
Lab Sample ID: F71708-14

Lab Report Batch : F71708
Analysis Type: ***RES (TOT)***

Lab ID : E83510
Sample Matrix : SOLID

Reviewed By / Date : pa 05/10/2010

Approved By / Date : pa 5/10/2010

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***				**Dilution:** ***5.00***												
Barium	TOT	11.0	mg/kg		YES											
Analysis Method : ***EPA 9060M***				**Dilution:** ***1.00***												
Carbon- Total Organic	TOT	9000	mg/kg		YES											

1124

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-C11-2
Sample Date : 02/26/2010
Lab Sample ID: F71708-1

Lab Report Batch : F71708
Analysis Type: ***RES (TOT)***

Lab ID : E83510
Sample Matrix : SOLID

Reviewed By / Date : pa 05/10/2010

Approved By / Date : pa 5/10/2010

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***				**Dilution:** ***5.00***												
Barium	TOT	22.0	mg/kg		YES											
Selenium	TOT	0.95	mg/kg		YES											
Analysis Method : ***EPA 9060M***				**Dilution:** ***1.00***												
Carbon- Total Organic	TOT	12800	mg/kg		YES											

1125

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-C11-22
Sample Date : 02/26/2010
Lab Sample ID: F71708-15

Lab Report Batch : F71708
Analysis Type: ***RE (TOT)***

Lab ID : E83510
Sample Matrix : SOLID

Reviewed By / Date : pa 05/10/2010

Approved By / Date : pa 5/10/2010

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***				**Dilution:** ***5.00***												
Selenium	TOT	0.17	mg/kg	I	YES											

1126

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-C11-22
Sample Date : 02/26/2010
Lab Sample ID: F71708-15

Lab Report Batch : F71708
Analysis Type: ***RES (TOT)***

Lab ID : E83510
Sample Matrix : SOLID

Reviewed By / Date : pa 05/10/2010

Approved By / Date : pa 5/10/2010

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***					**Dilution:** ***5.00***											
Barium	TOT	12.3	mg/kg		YES											

1127

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-C11-23
Sample Date : 02/26/2010
Lab Sample ID: F71708-16

Lab Report Batch : F71708
Analysis Type: ***RE (TOT)***

Lab ID : E83510
Sample Matrix : SOLID

Reviewed By / Date : pa 05/10/2010

Approved By / Date : pa 5/10/2010

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***				**Dilution:** ***5.00***												
Selenium	TOT	0.20	mg/kg	I	YES											

1128

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-C11-23
Sample Date : 02/26/2010
Lab Sample ID: F71708-16

Lab Report Batch : F71708
Analysis Type: ***RES (TOT)***

Lab ID : E83510
Sample Matrix : SOLID

Reviewed By / Date : pa 05/10/2010

Approved By / Date : pa 5/10/2010

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***					**Dilution:** ***5.00***											
Barium	TOT	12.9	mg/kg		YES											

1129

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-C11-24
Sample Date : 02/26/2010
Lab Sample ID: F71708-17

Lab Report Batch : F71708
Analysis Type: ***RE (TOT)***

Lab ID : E83510
Sample Matrix : SOLID

Reviewed By / Date : pa 05/10/2010

Approved By / Date : pa 5/10/2010

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***				**Dilution:** ***5.00***												
Selenium	TOT	0.22	mg/kg	I	YES											

1130

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-C11-24
Sample Date : 02/26/2010
Lab Sample ID: F71708-17

Lab Report Batch : F71708
Analysis Type: ***RES (TOT)***

Lab ID : E83510
Sample Matrix : SOLID

Reviewed By / Date : pa 05/10/2010

Approved By / Date : pa 5/10/2010

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***					**Dilution:** ***5.00***											
Barium	TOT	11.9	mg/kg		YES											

1131

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-C11-3
Sample Date : 02/26/2010
Lab Sample ID: F71708-2

Lab Report Batch : F71708
Analysis Type: *RES (TOT)*

Lab ID : E83510
Sample Matrix : SOLID

Reviewed By / Date : pa 05/10/2010

Approved By / Date : pa 5/10/2010

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***				**Dilution:** ***5.00***												
Barium	TOT	24.2	mg/kg		YES											
Selenium	TOT	1.3	mg/kg		YES											

1132

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-C11-32
Sample Date : 02/26/2010
Lab Sample ID: F71708-18

Lab Report Batch : F71708
Analysis Type: ***RES (TOT)***

Lab ID : E83510
Sample Matrix : SOLID

Reviewed By / Date : pa 05/10/2010

Approved By / Date : pa 5/10/2010

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***				**Dilution:** ***5.00***												
Barium	TOT	17.4	mg/kg		YES											
Selenium	TOT	0.16	mg/kg	I	YES											
Analysis Method : ***EPA 9060M***				**Dilution:** ***1.00***												
Carbon- Total Organic	TOT	9540	mg/kg		YES											

1133

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-C11-4
Sample Date : 02/26/2010
Lab Sample ID: F71708-3

Lab Report Batch : F71708
Analysis Type: *RES (TOT)*

Lab ID : E83510
Sample Matrix : SOLID

Reviewed By / Date : pa 05/10/2010

Approved By / Date : pa 5/10/2010

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***				**Dilution:** ***5.00***												
Barium	TOT	55.6	mg/kg		YES											
Selenium	TOT	2.0	mg/kg		YES											

1134

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-C11-5
Sample Date : 02/26/2010
Lab Sample ID: F71708-4

Lab Report Batch : F71708
Analysis Type: ***RES (TOT)***

Lab ID : E83510
Sample Matrix : SOLID

Reviewed By / Date : pa 05/10/2010

Approved By / Date : pa 5/10/2010

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***				**Dilution:** ***5.00***												
Barium	TOT	34.1	mg/kg		YES											
Selenium	TOT	2.0	mg/kg		YES											
Analysis Method : ***EPA 9060M***				**Dilution:** ***1.00***												
Carbon- Total Organic	TOT	21800	mg/kg		YES											

1135

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-C11-6
Sample Date : 02/26/2010
Lab Sample ID: F71708-5

Lab Report Batch : F71708
Analysis Type: *RES (TOT)*

Lab ID : E83510
Sample Matrix : SOLID

Reviewed By / Date : pa 05/10/2010

Approved By / Date : pa 5/10/2010

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***				**Dilution:** ***5.00***												
Barium	TOT	50.5	mg/kg		YES											
Selenium	TOT	2.4	mg/kg		YES											

1136

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-C11-7
Sample Date : 02/26/2010
Lab Sample ID: F71708-6

Lab Report Batch : F71708
Analysis Type: ***RES (TOT)***

Lab ID : E83510
Sample Matrix : SOLID

Reviewed By / Date : pa 05/10/2010

Approved By / Date : pa 5/10/2010

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***				**Dilution:** ***5.00***												
Barium	TOT	4.9	mg/kg		YES											
Selenium	TOT	0.12	mg/kg	I	YES											

1137

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-C11-8
Sample Date : 02/26/2010
Lab Sample ID: F71708-7

Lab Report Batch : F71708
Analysis Type: ***RES (TOT)***

Lab ID : E83510
Sample Matrix : SOLID

Reviewed By / Date : pa 05/10/2010

Approved By / Date : pa 5/10/2010

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***				**Dilution:** ***5.00***												
Barium	TOT	33.0	mg/kg		YES											
Selenium	TOT	0.55	mg/kg		YES											

1138

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-C11-9
Sample Date : 02/26/2010
Lab Sample ID: F71708-8

Lab Report Batch : F71708
Analysis Type: ***RES (TOT)***

Lab ID : E83510
Sample Matrix : SOLID

Reviewed By / Date : pa 05/10/2010

Approved By / Date : pa 5/10/2010

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***				**Dilution:** ***5.00***												
Barium	TOT	29.2	mg/kg		YES											
Selenium	TOT	0.41	mg/kg	I	YES											

1139

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-C11-20D
Sample Date : 02/23/2010
Lab Sample ID: F71796-8

Lab Report Batch : F71796
Analysis Type: *RES (TOT)*

Lab ID : E83510
Sample Matrix : SOLID

Reviewed By / Date : .....

Approved By / Date : .....

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***				**Dilution:** ***5.00***												
Barium	TOT	4.4	mg/kg		YES											
Selenium	TOT	0.072	mg/kg	I	YES											

1140

Project Number and Name: **10-0096 - C9/C11 Selenium**

Library Used: **SFWMDCompLibraryVer06**

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-C11-25D
Sample Date : 02/23/2010
Lab Sample ID: F71796-9

Lab Report Batch : F71796
Analysis Type: ***RES (TOT)***

Lab ID : E83510
Sample Matrix : SOLID

Reviewed By / Date : .....

Approved By / Date : .....

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***					**Dilution:** ***5.00***											
Barium	TOT	46.4	mg/kg		YES											
Selenium	TOT	3.2	mg/kg		YES											

1141

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-C11-30D
Sample Date : 02/23/2010
Lab Sample ID: F71796-11

Lab Report Batch : F71796
Analysis Type: ***RE (TOT)***

Lab ID : E83510
Sample Matrix : SOLID

Reviewed By / Date : .....

Approved By / Date : .....

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***				**Dilution:** ***5.00***												
Selenium	TOT	3.4	mg/kg		YES											

1142

Project Number and Name: **10-0096 - C9/C11 Selenium**

Library Used: **SFWMDCompLibraryVer06**

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-C11-30D
Sample Date : 02/23/2010
Lab Sample ID: F71796-11

Lab Report Batch : F71796
Analysis Type: ***RES (TOT)***

Lab ID : E83510
Sample Matrix : SOLID

Reviewed By / Date : .....

Approved By / Date : .....

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***					**Dilution:** ***5.00***											
Barium	TOT	65.6	mg/kg		YES											

1143

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-C11-34D
Sample Date : 02/23/2010
Lab Sample ID: F71796-10

Lab Report Batch : F71796
Analysis Type: *RES (TOT)*

Lab ID : E83510
Sample Matrix : SOLID

Reviewed By / Date : .....

Approved By / Date : .....

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***				**Dilution:** ***5.00***												
Barium	TOT	71.2	mg/kg		YES											
Selenium	TOT	5.9	mg/kg		YES											

1144

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-C9-10D
Sample Date : 02/24/2010
Lab Sample ID: F71796-1

Lab Report Batch : F71796
Analysis Type: ***RES (TOT)***

Lab ID : E83510
Sample Matrix : SOLID

Reviewed By / Date : .....

Approved By / Date : .....

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***					**Dilution:** ***5.00***											
Selenium	TOT	0.059	mg/kg	I	YES											

1145

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-C9-15D
Sample Date : 02/24/2010
Lab Sample ID: F71796-2

Lab Report Batch : F71796
Analysis Type: ***RES (TOT)***

Lab ID : E83510
Sample Matrix : SOLID

Reviewed By / Date : .....

Approved By / Date : .....

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***				**Dilution:** ***5.00***												
Selenium	TOT	0.48	mg/kg		YES											

1146

Project Number and Name: **10-0096 - C9/C11 Selenium**

Library Used: **SFWMDCompLibraryVer06**

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-C9-20D
Sample Date : 02/24/2010
Lab Sample ID: F71796-3

Lab Report Batch : F71796
Analysis Type: ***RES (TOT)***

Lab ID : E83510
Sample Matrix : SOLID

Reviewed By / Date : .....

Approved By / Date : .....

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***				**Dilution:** ***5.00***												
Selenium	TOT	0.080	mg/kg	I	YES											
Analysis Method : ***EPA 9060M***				**Dilution:** ***1.00***												
Carbon- Total Organic	TOT	17200	mg/kg		YES											

1147

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-C9-25D
Sample Date : 02/24/2010
Lab Sample ID: F71796-4

Lab Report Batch : F71796
Analysis Type: ***RES (TOT)***

Lab ID : E83510
Sample Matrix : SOLID

Reviewed By / Date : .....

Approved By / Date : .....

Analysis Method : ***EPA 6020*** **Dilution:** ***5.00***

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Selenium	TOT	1.9	mg/kg		YES											

1148

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-C9-30D
Sample Date : 02/24/2010
Lab Sample ID: F71796-5

Lab Report Batch : F71796
Analysis Type: ***RES (TOT)***

Lab ID : E83510
Sample Matrix : SOLID

Reviewed By / Date : .....

Approved By / Date : .....

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***				**Dilution:** ***5.00***												
Selenium	TOT	2.1	mg/kg		YES											
Analysis Method : ***EPA 9060M***				**Dilution:** ***1.00***												
Carbon- Total Organic	TOT	33000	mg/kg		YES											

1149

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-C9-35D
Sample Date : 02/24/2010
Lab Sample ID: F71796-6

Lab Report Batch : F71796
Analysis Type: ***RES (TOT)***

Lab ID : E83510
Sample Matrix : SOLID

Reviewed By / Date : .....

Approved By / Date : .....

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***				**Dilution:** ***5.00***												
Selenium	TOT	2.0	mg/kg		YES											

1150

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-C9-40D
Sample Date : 02/25/2010
Lab Sample ID: F71796-7

Lab Report Batch : F71796
Analysis Type: ***RES (TOT)***

Lab ID : E83510
Sample Matrix : SOLID

Reviewed By / Date : .....

Approved By / Date : .....

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***				**Dilution:** ***5.00***												
Selenium	TOT	3.5	mg/kg		YES											
Analysis Method : ***EPA 9060M***				**Dilution:** ***1.00***												
Carbon- Total Organic	TOT	31000	mg/kg		YES											

1151

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-C9-5D
Sample Date : 02/24/2010
Lab Sample ID: F71796-12

Lab Report Batch : F71796
Analysis Type: ***RES (TOT)***

Lab ID : E83510
Sample Matrix : SOLID

Reviewed By / Date : .....

Approved By / Date : .....

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***				**Dilution:** ***5.00***												
Selenium	TOT	4.6	mg/kg		YES											
Analysis Method : ***EPA 9060M***				**Dilution:** ***1.00***												
Carbon- Total Organic	TOT	39200	mg/kg		YES											

1152

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-C11-15D
Sample Date : 02/26/2010
Lab Sample ID: F71797-9

Lab Report Batch : F71797
Analysis Type: ***DL (TOT)***

Lab ID : E83510
Sample Matrix : SOLID

Reviewed By / Date : .....

Approved By / Date : .....

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***					**Dilution:** ***10.00***											
Selenium	TOT	0.80	mg/kg	I	YES											

1153

Project Number and Name: **10-0096 - C9/C11 Selenium**

Library Used: **SFWMDCompLibraryVer06**

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-C11-15D
Sample Date : 02/26/2010
Lab Sample ID: F71797-9

Lab Report Batch : F71797
Analysis Type: *RES (TOT)*

Lab ID : E83510
Sample Matrix : SOLID

Reviewed By / Date : .....

Approved By / Date : .....

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***				**Dilution:** ***5.00***												
Barium	TOT	15.1	mg/kg		YES											

1154

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-C11-17D
Sample Date : 02/26/2010
Lab Sample ID: F71797-10

Lab Report Batch : F71797
Analysis Type: ***RES (TOT)***

Lab ID : E83510
Sample Matrix : SOLID

Reviewed By / Date : _____

Approved By / Date : _____

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***				**Dilution:** ***5.00***												
Barium	TOT	12.5	mg/kg		YES											
Selenium	TOT	0.24	mg/kg	I	YES											
Analysis Method : ***EPA 9060M***				**Dilution:** ***1.00***												
Carbon- Total Organic	TOT	9310	mg/kg		YES											

1155

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-C11-5D
Sample Date : 02/26/2010
Lab Sample ID: F71797-8

Lab Report Batch : F71797
Analysis Type: *RES (TOT)*

Lab ID : E83510
Sample Matrix : SOLID

Reviewed By / Date : .....

Approved By / Date : .....

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***				**Dilution:** ***5.00***												
Barium	TOT	22.8	mg/kg		YES											
Selenium	TOT	1.5	mg/kg		YES											

1156

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-WCA-10D
Sample Date : 02/17/2010
Lab Sample ID: F71797-2

Lab Report Batch : F71797
Analysis Type: ***RES (TOT)***

Lab ID : E83510
Sample Matrix : SOLID

Reviewed By / Date : .....

Approved By / Date : .....

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***					**Dilution:** ***5.00***											
Selenium	TOT	0.65	mg/kg	I	YES											

1157

Project Number and Name: **10-0096 - C9/C11 Selenium**

Library Used: **SFWMDCompLibraryVer06**

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-WCA-15D
Sample Date : 02/17/2010
Lab Sample ID: F71797-3

Lab Report Batch : F71797
Analysis Type: ***RES (TOT)***

Lab ID : E83510
Sample Matrix : SOLID

Reviewed By / Date :

Approved By / Date :

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***				**Dilution:** ***5.00***												
Selenium	TOT	0.55	mg/kg	I	YES											

1158

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-WCA-20D
Sample Date : 02/17/2010
Lab Sample ID: F71797-4

Lab Report Batch : F71797
Analysis Type: ***RES (TOT)***

Lab ID : E83510
Sample Matrix : SOLID

Reviewed By / Date :

Approved By / Date :

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***				**Dilution:** ***5.00***												
Selenium	TOT	2.4	mg/kg		YES											
Analysis Method : ***EPA 9060M***				**Dilution:** ***1.00***												
Carbon- Total Organic	TOT	30500	mg/kg		YES											

1159

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-WCA-25D
Sample Date : 02/17/2010
Lab Sample ID: F71797-5

Lab Report Batch : F71797
Analysis Type: ***RES (TOT)***

Lab ID : E83510
Sample Matrix : SOLID

Reviewed By / Date : .....

Approved By / Date : .....

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***				**Dilution:** ***5.00***												
Selenium	TOT	2.3	mg/kg		YES											

1160

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-WCA-30D
Sample Date : 02/17/2010
Lab Sample ID: F71797-6

Lab Report Batch : F71797
Analysis Type: ***RES (TOT)***

Lab ID : E83510
Sample Matrix : SOLID

Reviewed By / Date : .....

Approved By / Date : .....

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***				**Dilution:** ***5.00***												
Selenium	TOT	0.65	mg/kg	I	YES											
Analysis Method : ***EPA 9060M***				**Dilution:** ***1.00***												
Carbon- Total Organic	TOT	22600	mg/kg		YES											

1161

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-WCA-32D
Sample Date : 02/17/2010
Lab Sample ID: F71797-7

Lab Report Batch : F71797
Analysis Type: ***RES (TOT)***

Lab ID : E83510
Sample Matrix : SOLID

Reviewed By / Date : .....

Approved By / Date : .....

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***				**Dilution:** ***5.00***												
Selenium	TOT	0.56	mg/kg	I	YES											

1162

Sample Qualification Report with Reason Codes (All Results sorted by Client Sample ID)

Client Sample ID : CSS-WCA-5D
Sample Date : 02/17/2010
Lab Sample ID: F71797-1

Lab Report Batch : F71797
Analysis Type: ***RES (TOT)***

Lab ID : E83510
Sample Matrix : SOLID

Reviewed By / Date : .....

Approved By / Date : .....

Analyte Name	Total or Diss.	Result	Result Units	Lab Quals	Reportable Result	Overall Val Qual	HT	MB	LCS	MS	Lab Dup	Surr	Det Limit	Field QC	Replicate RSD	Reason Codes
Analysis Method : ***EPA 6020***					**Dilution:** ***5.00***											
Selenium	TOT	2.6	mg/kg		YES											

1163

APPENDIX C

UCL CALCULATIONS

FDEP UCL Calculator Version 1.0 **5/11/10**

Summary Statistics for	
Number of Samples	34
Number of Censored Data	4
Minimum	0.0465
Maximum	3
Mean	1.121662
Median	1.05
Standard Deviation	0.775298
Variance	0.601087
Coefficient of Variation	0.691205
Skewness	0.413915

95% UCL (Assuming Normal Data)	
Student's-t	1.346682

95% UCL (Adjusted for Skewness)	
Adjusted-CLT	1.350472
Modified-t	1.348255

95% Non-parametric UCL	
CLT	1.340385
Jackknife	NA
Standard Bootstrap	1.305281
Bootstrap-t	1.378995
Chebyshev (Mean, Std)	1.701245

Summary Statistics for ln()	
Minimum	-3.0683
Maximum	1.098612
Mean	-0.31739
Standard Deviation	1.174892
Variance	1.380371

Goodness-of-Fit Results	
Distribution Recommended	Normal
Distribution Used	Normal

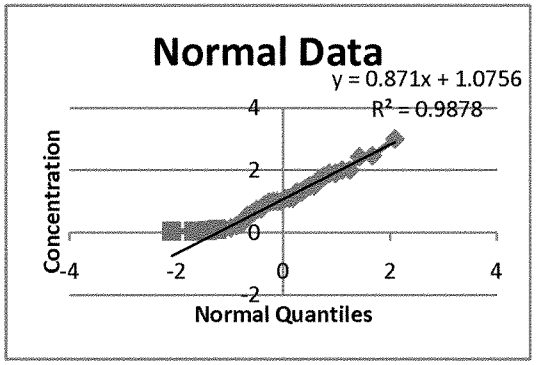
Estimates Assuming Lognormal Distribution	
MLE Mean	1.451785
MLE Standard Deviation	2.504645
MLE Median	0.728045
MLE Coefficient of Variation	1.725218
MVUE Estimate of Mean	1.39955
MVUE Estimate of Std. Dev.	2.117503
MVUE Estimate of SE	0.357257
MVUE Coefficient of Variation	1.512988

UCL Assuming Lognormal Distribution	
95% H-UCL	2.495259
95% Chebyshev (MVUE) UCL	2.956798
99% Chebyshev (MVUE) UCL	4.954222

FDEP Recommended UCL to Use:
1.346682

FDEP UCL Calculator Version 1.0

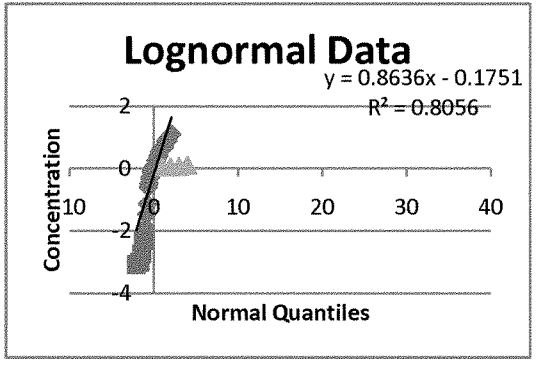
Goodness-of-fit test results



Shapiro-Francia Results (Adjust for Censoring)

SF for Normal Distribution	0
SF for LogNormal Distribution	0
Shapiro-Francia critical value for p<0.05	0.963484

Test stat > critical value indicates a reasonable fit



Shapiro-Wilk's Test Results for All Data (BDL replaced with 1/2 DL)

SW test statistic for Normal Distribution	0.951
SW test statistic for LogNormal Distribution	0.840
Shapiro-Wilk's critical value for p<0.05	0.933

Test stat > critical value indicates a reasonable fit

Based on the results of the Shapiro-Wilk's test
Distribution is best described as: Normal

Normal

FDEP UCL Calculator Version 1.0 **5/11/10**

Summary Statistics for	
Number of Samples	34
Number of Censored Data	1
Minimum	0.034
Maximum	3.8
Mean	1.880529
Median	2.015
Standard Deviation	1.05242
Variance	1.107588
Coefficient of Variation	0.55964
Skewness	-0.27787

95% UCL (Assuming Normal Data)	
Student's-t	2.185981

95% UCL (Adjusted for Skewness)	
Adjusted-CLT	2.168241
Modified-t	2.184548

95% Non-parametric UCL	
CLT	2.177433
Jackknife	NA
Standard Bootstrap	2.236621
Bootstrap-t	2.117131
Chebyshev (Mean, Std)	2.667279

Summary Statistics for ln()	
Minimum	-3.38139
Maximum	1.335001
Mean	0.292466
Standard Deviation	1.094252
Variance	1.197388

Goodness-of-Fit Results	
Distribution Recommended	Normal
Distribution Used	Normal

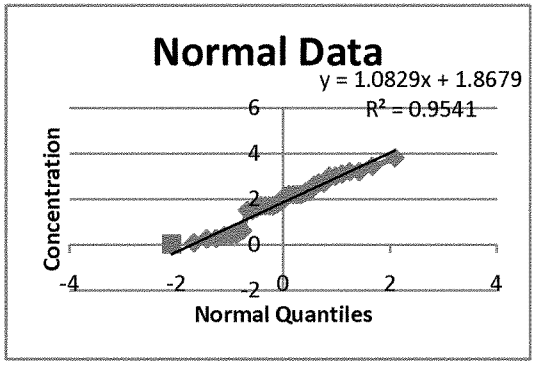
Estimates Assuming Lognormal Distribution	
MLE Mean	2.437955
MLE Standard Deviation	3.706539
MLE Median	1.339727
MLE Coefficient of Variation	1.520347
MVUE Estimate of Mean	2.371464
MVUE Estimate of Std. Dev.	3.26051
MVUE Estimate of SE	0.532247
MVUE Coefficient of Variation	1.374893

UCL Assuming Lognormal Distribution	
95% H-UCL	3.961061
95% Chebyshev (MVUE) UCL	4.691475
99% Chebyshev (MVUE) UCL	7.667267

FDEP Recommended UCL to Use:
2.185981

FDEP UCL Calculator Version 1.0

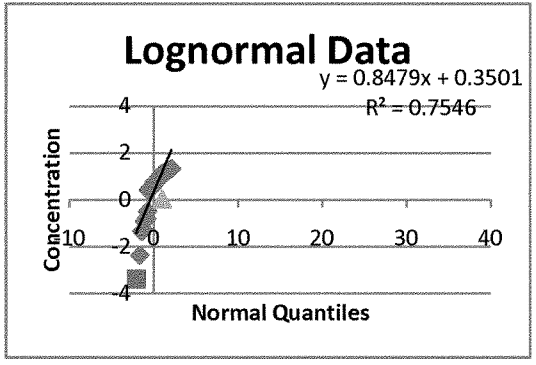
Goodness-of-fit test results



Shapiro-Francia Results (Adjust for Censoring)

SF for Normal Distribution	0
SF for LogNormal Distribution	0
Shapiro-Francia critical value for p<0.05	0.966138

Test stat > critical value indicates a reasonable fit



Shapiro-Wilk's Test Results for All Data (BDL replaced with 1/2 DL)

SW test statistic for Normal Distribution	0.939
SW test statistic for LogNormal Distribution	0.767
Shapiro-Wilk's critical value for p<0.05	0.933

Test stat > critical value indicates a reasonable fit

Based on the results of the Shapiro-Wilk's test
Distribution is best described as: Normal

Normal

FDEP UCL Calculator Version 1.0 **5/11/10**

Summary Statistics for	
Number of Samples	32
Number of Censored Data	0
Minimum	4.7
Maximum	71.4
Mean	29.59531
Median	28.825
Standard Deviation	16.33795
Variance	266.9286
Coefficient of Variation	0.552045
Skewness	0.765291

95% UCL (Assuming Normal Data)	
Student's-t	34.49226

95% UCL (Adjusted for Skewness)	
Adjusted-CLT	34.76391
Modified-t	34.55738

95% Non-parametric UCL	
CLT	34.34635
Jackknife	NA
Standard Bootstrap	32.81659
Bootstrap-t	37.42817
Chebyshev (Mean, Std)	42.18484

Summary Statistics for ln()	
Minimum	1.547562
Maximum	4.268298
Mean	3.213338
Standard Deviation	0.651719
Variance	0.424737

Goodness-of-Fit Results	
Distribution Recommended	Lognormal
Distribution Used	Lognormal

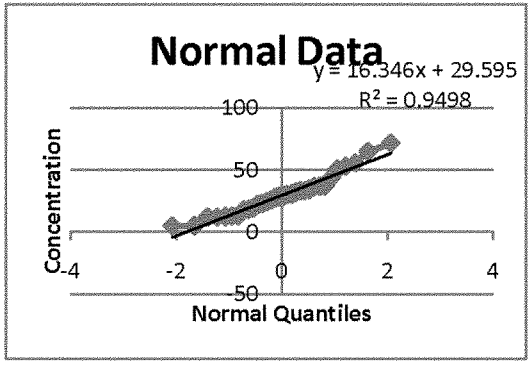
Estimates Assuming Lognormal Distribution	
MLE Mean	30.74435
MLE Standard Deviation	22.36509
MLE Median	24.86193
MLE Coefficient of Variation	0.727454
MVUE Estimate of Mean	30.50245
MVUE Estimate of Std. Dev.	21.55053
MVUE Estimate of SE	3.772158
MVUE Coefficient of Variation	0.706518

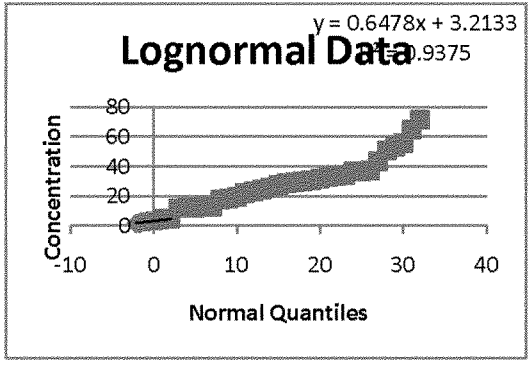
UCL Assuming Lognormal Distribution	
95% H-UCL	39.24075
95% Chebyshev (MVUE) UCL	46.9449
99% Chebyshev (MVUE) UCL	68.03504

FDEP Recommended UCL to Use:
39.24075

FDEP UCL Calculator Version 1.0

Goodness-of-fit test results





Shapiro-Francia Results (Adjust for Censoring)

SF for Normal Distribution	0
SF for LogNormal Distribution	0
Shapiro-Francia critical value for p<0.05	NA

Test stat > critical value indicates a reasonable fit

Shapiro-Wilk's Test Results for All Data (BDL replaced with 1/2 DL)

SW test statistic for Normal Distribution	0.945
SW test statistic for LogNormal Distribution	0.935
Shapiro-Wilk's critical value for p<0.05	0.93

Test stat > critical value indicates a reasonable fit

Based on the results of the Shapiro-Wilk's test
Distribution is best described as: Lognormal

Lognormal

FDEP UCL Calculator Version 1.0 **5/11/10**

Summary Statistics for	
Number of Samples	32
Number of Censored Data	0
Minimum	0.072
Maximum	5.87
Mean	1.578813
Median	1.5
Standard Deviation	1.362044
Variance	1.855165
Coefficient of Variation	0.862702
Skewness	1.241182

95% UCL (Assuming Normal Data)	
Student's-t	1.987056

95% UCL (Adjusted for Skewness)	
Adjusted-CLT	2.031349
Modified-t	1.995861

95% Non-parametric UCL	
CLT	1.974892
Jackknife	NA
Standard Bootstrap	1.836711
Bootstrap-t	2.220848
Chebyshev (Mean, Std)	2.628363

Summary Statistics for ln()	
Minimum	-2.63109
Maximum	1.769855
Mean	-0.03047
Standard Deviation	1.151588
Variance	1.326154

Goodness-of-Fit Results	
Distribution Recommended	Neither
Distribution Used	Neither

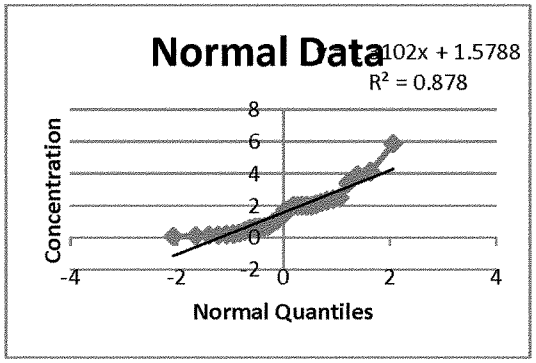
Estimates Assuming Lognormal Distribution	
MLE Mean	1.88252
MLE Standard Deviation	3.131176
MLE Median	0.969994
MLE Coefficient of Variation	1.663289
MVUE Estimate of Mean	1.822048
MVUE Estimate of Std. Dev.	2.693053
MVUE Estimate of SE	0.441403
MVUE Coefficient of Variation	1.478036

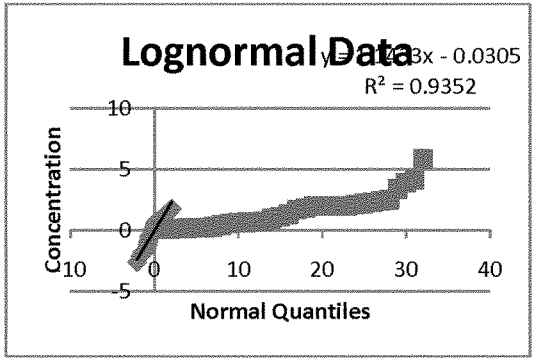
UCL Assuming Lognormal Distribution	
95% H-UCL	3.251274
95% Chebyshev (MVUE) UCL	3.74608
99% Chebyshev (MVUE) UCL	6.213964

FDEP Recommended UCL to Use:
2.628363

FDEP UCL Calculator Version 1.0

Goodness-of-fit test results





Shapiro-Francia Results (Adjust for Censoring)

SF for Normal Distribution	0
SF for LogNormal Distribution	0
Shapiro-Francia critical value for p<0.05	NA

Test stat > critical value indicates a reasonable fit

Shapiro-Wilk's Test Results for All Data (BDL replaced with 1/2 DL)

SW test statistic for Normal Distribution	0.879
SW test statistic for LogNormal Distribution	0.926
Shapiro-Wilk's critical value for p<0.05	0.93

Test stat > critical value indicates a reasonable fit

Based on the results of the Shapiro-Wilk's test
Distribution is best described as: Neither

Neither

Normal UCL Statistics for Full Data Sets

User Selected Options	
From File	P:\S F W M D\WCA 3A-3B\WO 65 C-11 Selenium Protocol Sampling\Data\C-9 Composite.wst
Full Precision	OFF
Confidence Coefficient	95%

se

Number of Valid Observations	7
Number of Missing Values	1
Number of Distinct Observations	7
Minimum	3.4
Maximum	5.03
Mean	4.161
Median	4.3
SD	0.558
Variance	0.311
Coefficient of Variation	0.134
Skewness	0.166

Warning: A sample size of 'n' = 7 may not adequate enough to compute meaningful and reliable test statistics and estimates!

It is suggested to collect at least 8 to 10 observations using these statistical methods!
If possible compute and collect Data Quality Objectives (DQO) based sample size and analytical results.

Shapiro Wilk Test Statistic	0.965
5% Shapiro Wilk Critical Value	0.803
Data appear Normal at 5% Significance Level	

95% UCL (Assuming Normal Distribution)

Student's-t UCL	4.571

Potential UCL to Use

Student's-t UCL	4.571

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6300 NE 1st Avenue, Suite 100

Fort Lauderdale, Florida, 33411

Phone: (954) 771-0444

Fax : (954) 771-8118

www.ectinc.com

Attachment F: Additional Assessment for East Coast Buffer Regional Selenium Report May 2011.

DRAFT ADDITIONAL ASSESSMENT
FOR

EAST COAST BUFFER
REGIONAL SELENIUM PROJECT
Ecological Risk Selenium in the Proposed East Coast Buffer Project Area

PREPARED FOR:

SOUTH FLORIDA WATER MANAGEMENT DISTRICT
3301 GUN CLUB ROAD, B-1 BLDG
WEST PALM BEACH, FLORIDA 33406

PREPARED BY:

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Environmental Consulting & Technology, Inc.

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ECT No. 11-0268-0100
MAY 2011

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EXECUTIVE SUMMARY

The East Coast Buffer project area has been slated for construction by the South Florida Water Management District (District) and Army Corps of Engineers as part of Comprehensive Everglades Restoration Program. The US Fish & Wildlife Service (USFWS) has expressed concern that restoration of the project areas may release selenium into the overlying water column resulting in elevated levels of risk to ecological receptors that may inhabit the area following restoration. The elevated selenium concentrations in the project area have been identified by a series of assessments and follow up studies. Currently no soil quality assessment guideline (SQAG) exists for selenium. An interim screening level of 2 parts per million (ppm) has been accepted by the USFWS. The USFWS has used varying screening concentrations based on periodic research to assess risk to trustee species. An interim screening level of 2 parts per million (ppm) has been accepted by the USFWS. Based on the results of the previous assessment, the USFWS requested additional samples for analysis from the C-9 and C-11 project areas.

The results of the additional assessment indicated selenium concentrations observed at the C-9 and C-11 impoundment areas were consistent with the previous assessment results in the area. The 95 % UCL for the C-9 400 acre chimney area was 5.98 ppm which was previously 4.57 in 2010. The one discrete samples from the C-9 1600 acre area was 4.5 ppm although the area wide 95% UCL 2.19% in 2010. The 95 % UCL for the C-11 area was 3.11 ppm which was previously 2.63 in 2010. Of the approximately 920 acres reviewed in this assessment the entire 400 acres in the Chimney and a former landscaping business area of C-9 have Selenium impacts greater than 2 ppm and 313 acres of the formerly cultivated tracts on C-11 have Selenium impacts greater than 2 ppm.

Based on ECT's evaluation of soil use options, ECT recommends an ecological risk assessment be conducted to modify the current screening level of 2 ppm for selenium. This will require a bioaccumulation study, toxicity test, and food web modeling as

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described in the USFWS protocol. The selenium screeningconcentration could be elevated as high as 7.0 ppm, if successful. In accordance with the literature survey and previously developed values for USSC muck soils, this would preclude most areas from requiring remediation. In addition, the soil blending option may also be considered viable if used in conjunction with the risk assessment.

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1.0 INTRODUCTION

The East Coast Buffer project area has been slated for construction by the South Florida Water Management District (District) and Army Corps of Engineers as part of Comprehensive Everglades Restoration Program. This project consists of areas C-11, C-9 and WCA3A/3B. Sampling and analysis from August 2006 in the C-11 project area indicate selenium concentrations in sediments ranging from less than 1 to 7.7 mg/Kg. The US Fish & Wildlife Service (USFWS) has expressed concern based on historical work at the site that restoration of the project areas may release selenium into the overlying water column resulting in elevated levels of risk to ecological receptors that may inhabit the area following restoration.

Additional sampling was conducted in the WCA 3A/3B, C-9 and C-11 areas to better define the mean selenium concentrations within each area. Discrete or close composite, soil samples were collected in the linear WCA 3A/3B at 2,500 foot intervals. Much of the C-9 area was sampled at a rate of one close proximity discrete sample per 50 acres due to access limitations. Seven 50-acre grid cells within C-9 were sampled using a 10-point composite approach. C-11 was sampled at the rate of one discrete sample per 50-acres with no composite samples collected due to access issues. The results of this sampling effort were presented in ECT's May 13, 2010 report titled "East Coast Buffer Regional Selenium Project: Ecological Risk of Selenium in the Proposed East Coast Buffer Project Area." In response to USFWS August 6, 2010 letter, ECT conducted additional sampling within the C-9/C-11 footprint.

On August 16, 2010, ECT overlaid property boundaries of former agricultural properties within the C-9 and C-11 footprint on its sample location map and forwarded the drawings to the USFWS for discussion. ECT described the difficulty of collecting composite samples in most locations within the C-9 and C-11 project footprint and requested that discrete samples be employed instead. The USFWS indicated it would like to see more focused sampling in those locations on which it is known that cultivation occurred. ECT agreed to increase the sample density to one sample per 20 acres in the former cultivated

areas and attempt to reduce the sample density in the background (non-cultivated) areas.

The results of these activities proposed by ECT are provided in the following sections and were intended to satisfy USFWS concerns regarding the low density of selenium data within cultivated portions of the C-9 and C-11 footprints. Options for risk assessment work to raise the selenium screening value and soil blending as a means of reducing the selenium concentrations in the site, are also presented in this report.

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2.0 PROJECT BACKGROUND

The elevated selenium concentrations in the project area have been identified by a series of assessments and follow up studies. Currently no soil quality assessment guideline (SQAG) exists for selenium. USFWS has used varying screening concentrations based on periodic research to assess risk to trustee species. A brief summary of the relevant assessments and studies and their results is included below.

2.1 OVERVIEW

Phase I/II environmental assessments were completed as part of the District's pre-acquisition activities in the East Coast Buffer Project Area. The results of the pre-acquisition assessment and follow up studies have identified the presence of elevated concentrations of selenium in the surface soil. USFWS has indicated that the detection of selenium above 2 mg/kg may pose a potential for ecological risk to USFWS trustee species.

The initial assessment within the project areas identified concentrations ranging from less than 1 mg/kg to in excess of 7 mg/kg. A desorption study and additional assessment of potential ecological risks from selenium were prepared indicating that only a small possibility of effects to waterfowl that may inhabit the area in the future exists at the upper levels of selenium concentrations (NewFields 2008). USFWs expressed concern that under conditions in which water in the area of elevated selenium concentrations was assumed to be stagnant for an extended period of time that the desorption study results indicated a possibility for effects to breeding waterfowl. In an effort to address concerns raised by the USFWS regarding the risk to waterfowl additional soil sampling was conducted. ECT proposed additional regional selenium sampling to demonstrate to the USFWS that comprehensive start up sampling and annual surface water quality monitoring for selenium may not be warranted. Subsequent communications between the USFWS and the District indicated that many of these concerns could be remedied by additional soil sampling within the project footprint to obtain a site wide average concentration for selenium. Based on BEM Systems, Inc. (BEM's) Phase II assessment

data, barium was also analyzed since it exceeded initial screening values within the project footprint (BEM 2004) but is much less of a concern as an ecological risk than selenium.

2.1.1 PHASE II ASSESSMENT

BEM conducted a Phase II Environmental Site Assessment (ESA) on behalf of the District at the East Coast Buffer Canal 11 (C-11) properties. The Phase II ESA was conducted to assess potential recognized environmental conditions associated with the properties noted in BEM's Phase I ESA, and information provided to BEM in a Phase I ESA prepared by CRB Geological & Environmental Services, Inc. (CRB) on behalf of the law firm representing the land owners in the condemnation process (Brigham Moore).

Selenium was reported in 13 of the 26 composite soil samples and in both of the duplicate soil samples that were collected at the C-11 properties. The maximum concentration of 1.4 mg/kg was found at the Bukele property. Selenium concentrations for the Lauderhill soil type in Broward County range from 2.45 mg/kg to 4.03 mg/kg (University of Florida 1999). The concentrations of selenium encountered in the discrete and composite soil samples collected during the C-11 Phase II ESA falls below this range. BEM presented the data and results of the UF study to the USFWS for review.

On December 5, 2002, BEM, USFWS and SFWMD met to discuss the results of the UF study and to determine if the range of selenium reported for the Lauderhill soil could be applied for this assessment as a natural background concentration for the soil samples, and on review of the data, it was agreed that it could. Because of the findings of the UF study and the approval of the USFWS of the background concentration of selenium, selenium was not considered to be a chemical of concern at the C-11 properties.

2.1.2 ECB SOIL SELENIUM ASSESSMENT

Shaw Environmental, Inc., (Shaw) conducted a selenium soil assessment on behalf of the District at ten tracts located within the 3A/3B, C-9, and C-11 project areas (Shaw 2007) in response to recommendations in the USFWS letter dated February 3, 2006. The

analytical results of the 115 samples collected at the 10 tracts indicated that 73 soil samples had selenium concentrations at or above the 1.0 mg/kg interim guidance concentration. Forty-two of the samples were below the 1.0 mg/kg interim guidance concentration. Thirty-nine of these samples were listed as non-detect, but the laboratory's reporting limits were above the 1.0 mg/kg guidance concentration. Twenty-two of the samples had selenium concentrations at or above the 5.0 mg/kg, with the highest concentration at 7.7 mg/kg. Shaw contracted NewFields to conduct a 95% Upper Confidence Limit (UCL) on the mean selenium concentrations. NewFields calculated a UCL of 2.58 mg/kg.

2.1.3 LEACH TEST AND DESORPTION STUDY

NewFields conducted a batch leach testing of sediment samples collected from the C-11 project area in January 2007 to evaluate whether these sediments could release selenium by desorption or dissolution reactions, and to evaluate the selenium leaching potential. The batch leach test data indicated that the amount of selenium leached from C-11 sediments during these tests was less than 3 percent of the total selenium mass initially present, and the selenium concentrations in surface water that comes into contact with these sediments are expected to remain below the Florida surface water quality standard for selenium (0.005 mg/l for Class III fresh water).

Based on discussions with USFWS, NewFields conducted an expanded test consisting of aquarium sediment leaching for the evaluation of selenium in C-11 project area soils. This follow-up study allowed for a more direct estimate of selenium concentrations in surface water overlying soil/sediments from the site. The new methodology placed soils from the site into aquaria and incubated them with water for up to 98 days. Concentrations of selenium remained below Florida water quality standards and USFWS screening levels throughout the incubation period and the additional assessment indicated that reproductive risks to waterfowl were low.

2.1.4 EAST COAST BUFFER REGIONAL SELENIUM PROJECT

ECT conducted selenium soil assessment on behalf of the District at the East Coast

Buffer properties in February 2010, as reported in ECT's report "East Coast Buffer Regional Selenium Project: Ecological Risk of Selenium in the Proposed East Coast Buffer Project Area, dated August 6, 2010. The C-9 project area was divided into two areas for sampling and analysis of selenium concentrations. The first area was an approximately 1,600 hundred acre, squarely configured area located to the south (the 1,600 acre property will not be discussed here). The second area was an approximately 400 acre rectangular area located to the north.

The confirmation sampling included the collection of eight (8) composite soil samples from the 400-acre area. The 95% UCL for selenium in soils within the northern portion of the C-9 400-acre footprint was calculated to be 4.57 mg/kg. Based upon the desorption study and risk analysis conducted for this project, the report concluded that the detected concentration in the surficial soils may pose an unacceptable risk to waterfowl that may use this area for feeding and breeding purposes. Additional assessment and/or corrective actions were warranted in this area prior to construction. These additional activities may have included further ecological analysis of soil/sediment to develop a site specific remediation goal. Corrective action, which may include scraping/inverting or capping the area, could also be necessary to minimize the potential ecological risk to trust resources. The necessity for corrective action would be determined upon completion of the proposed additional assessment.

To address the concerns raised by the USFWS, this assessment was performed which included the collection and analysis of 31 samples. The 95% UCL for selenium in soils within the C-11 footprint was estimated to be 2.63 mg/kg. Based on the desorption study and risk analysis conducted for the project area, the calculated concentration poses a low risk potential to future waterfowl that may use the areas for feeding and breeding purposes.

To further evaluate the potential impact of selenium, surface water samples were collected from onsite canal/ditches. The results of surface water samples collected for analysis did not indicate significant selenium concentrations. Based on the site specific

conditions no further assessment or corrective action is warranted within this section of the project footprint.

In an effort to obtain additional data regarding the mobility of selenium within the environment, it was recommended that two quarters of post-construction surface water quality monitoring be conducted. It was anticipated that the concentration of selenium detected would be low and not pose an unacceptable risk to USFWS Trust species.

The results of this sampling effort were presented in ECT's May 13, 2010 report titled "East Coast Buffer Regional Selenium Project: Ecological Risk of Selenium in the Proposed East Coast Buffer Project Area." In response, USFWS wrote in their August 6, 2010 comments letter that they had concerns regarding Selenium levels in both C-9 and C-11 areas, which predicated the need to implement this study.

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3.0 SCOPE OF WORK

Based on the results of the previous assessment, the USFWS requested additional samples for analysis from the C-9 and C-11 project areas. **Figure 1** illustrates the general project area boundaries for the additional selenium assessment of C-9 and C-11. **Figure 2** and **Figure 3** illustrate the Selenium sample location from the 2010 assessment. A scope of work was developed to conduct additional soil sampling within the project footprint to increase the sample density to approximately one (1) sample for every twenty (20) acres and to resample areas in excess of 2.0 mg/kg selenium.

3.1 C-9 AND C-11 RESERVOIR

For project planning purposes, ECT mapped out draft sample locations within the former cultivated portions of the C-9 and C-11 footprint that satisfy the objective of decreasing sample density to one sample per 20 acres within the former cultivated areas taken in total (as opposed to each individual parcel). The draft sample locations were provided to the Service for comment and modification as necessary. Ten (10) discrete samples were proposed to be collected for the northern portion (400 acre area) and one sample from the southern 1600 acres of the C-9 parcel and twenty-six (26) discrete samples were proposed for the southwestern portion of the C-11 parcel. **Figure 4** provides an overview of the C-9 and C-11 sample locations.

ECT proposed to employ GPS and line of sight reckoning (where the tree canopy prevented GPS signals) to target pre-programmed sample locations for reference purposes. ECT used enhanced sample techniques, including close proximity sampling, wading, machete, and non-destructive mechanical equipment to access sample locations. At each sample location, ECT recorded the actual sample location by GPS. During the sampling event, care was taken to ensure that the samples were collected away from any historical roads, tracts or trails to reduce or eliminate the potential for any anthropogenic influence.

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3.2 QA/QC SAMPLING

Twenty percent of the soil samples were collected for quality assurance/quality control (QA/QC) measures. Ten percent of the QA/QC samples were submitted to the primary laboratory (Accutest) as duplicate samples. The remaining ten percent of the soil samples were submitted to Energy Laboratories, Inc.

3.3 DATA EVALUATION AND STATISTICAL DATA ANALYSIS

ECT prepared an ADaPT library and transmitted to the contract laboratory stating the District's project expectations with respect to reporting limits and lab QA/QC statistical limits on blank spikes, matrix spikes, lab duplicates, matrix spikes, etc. The analytical results were validated using ADaPT, and they were compared to sediment quality assessment guidelines and FDEP 62-777 soil cleanup target levels. Tables were prepared to tabulate the soil quality on the property.

ECT conducted a statistical analysis of the data collected from the project areas. Summary statistics and a 95 % upper confidence limit of the mean were calculated for each site. This data was used in conjunction with the earlier selenium work conducted in the project areas to assess risk. A detailed description of the statistical analysis and the results and conclusions from these analyses are provided in the following Sections.

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4.0 INVESTIGATIVE METHODOLOGIES

This section describes the sampling methodology followed in C-9 and C-11. Soil sampling was conducted between April 8, 2011 and April 15, 2011.

4.1 SOIL SAMPLING

A total of (36) 20-acre grids were prepared during project planning. Soil samples were collected from zero to six (0-6") inches below land surface (bls) in 36 discrete sample locations in accordance with the *Protocol for Assessment, Remediation and Post-Remediation Monitoring for Environmental Contaminants on Everglades Restoration Projects* dated March 14, 2008, developed jointly with the USFWS, and approved by the FDEP. Wherever possible, locations were recorded into a GPS unit, which the field team chose within the pre-programmed 20-acre grid. ECT collected a five point composite sample from each location that was selected for sampling. Soil samples were collected from a depth of 0-6 inches bls using a stainless steel sample barrel. The sampler consisted of a 6 inch long steel sample barrel with a disposable plastic interior sample sleeve. The sampler could not easily be pushed to a depth deeper than 6 inches, so the depth of sampling was carefully controlled.

In a few areas the depth to cap rock was less than 6 inches, so the sample location was relocated within the grid to obtain a 6 inch sample. Each sub-sample consisted of four aliquots, which were collected approximately 5 feet apart, in cardinal locations of the center sample. The sample aliquots were removed from the sampling sleeves using a stainless steel rod. The aliquots were placed in a stainless steel bowl and thoroughly mixed. The soil was further homogenized and a composite sample was collected in the appropriate laboratory-provided containers and placed on ice. Figure 3 illustrates the actual sample locations within each 20-acre grid.

4.2 SAMPLE CUSTODY, LABORATORY PROCEDURES AND ANALYSES

All sample transmittal forms were placed in waterproof bags and sealed in transport containers with the samples. Chain-of-custody seals were applied after the containers

(coolers) were secured. All shipping bills from common carriers were kept with the forms. All samples that were submitted to a laboratory were accompanied by a sample transmittal or chain-of-custody record.

4.3 QUALITY ASSURANCE/QUALITY CONTROL PROCEDURES

Quality assurance procedures used during this assessment included compliance with the FDEP SOP for Laboratory Operation and Sample Collection Activities. Specific quality assurance protocols and procedures for the analytical methodologies performed during this assessment were in accordance with FDEP SOP for laboratory analysis. Twenty percent of the soil samples were split for quality assurance/quality control (QA/QC) measures. Ten percent of the QA/QC samples were submitted to the primary laboratory as duplicate samples, whereas the remaining ten percent were submitted to a secondary laboratory, Energy Laboratories, Inc. This QA/QC procedure complies with the September 19, 2002 memorandum by Mr. Robert Kukleski and Mr. Robert Taylor of the District's Land Acquisition Support Division.

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5.0 DISCUSSION OF RESULTS

This section provides a review of the historical analytical data for the C-9 and C-11 impoundments. In addition, an evaluation of the current analytical data is also provided. The soil samples were analyzed by Accutest Laboratories as the prime and Energy as the QA/QC split lab. Laboratory analytical reports are attached as **Appendix A**. The sample results from two laboratories were verified using ADaPT 4.5.2. (RESULTS PENDING)

5.1 HISTORIC SELENIUM DATA DISCUSSION

A table showing the selenium concentrations that were reported during various assessments by District consultants and the Corps of Engineers is attached (Table 1). Selenium was detected in samples during the Phase II assessment and later during follow up sampling conducted by BEM Systems (BEM). The sampling was conducted to target point source areas within C-9 and C-11 project footprint. The highest concentration reported by BEM was 4.7 ppm and the period of sampling ranged from 2002 (Phase II ESA) to 2005 (Livestock Pen Evaluations). The District requested Shaw Environmental (Shaw) to conduct further assessment within the tracts assessed previously by BEM and provide additional delineation samples within these areas. In 2006, Shaw reported several samples exceeding the 2 ppm screening level with concentrations ranging from non-detect to 6.1 ppm. In 2008 the US Army Corps of Engineers (USACE) collected soil samples at several tracts within C-11 and reported selenium concentrations ranging from non- detect to 1.9 ppm. ECT conducted area wide sampling in 2010 dividing the entire project footprints of C-9 and C-11 in 50 acre grids. A detailed QA/QC procedure was followed which included duplicate and spilt samples for 20% of the samples. ECT reported a 95% upper confidence level (UCL) for southern portion of C-9 (1600 acres) at 2.19 ppm and northern portion of C-9 (Chimney area) at 4.6 ppm. 95% UCL for C-11 was calculated to be 2.6 ppm. Based on ECT's 2010 results and subsequent discussions with USFWS and the District, the former landscape use areas along with the chimney areas were sampled with a smaller grid size, the results of which are discussed in the following sections.

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5.2 ADDITIONAL C-9/ C-11 SELENIUM DATA DISCUSSION

This section provides a brief discussion of the soil sampling results obtained from sampling at the C-9 and C-11 areas. 95% UCL was calculated for the two areas and compared with the results from the previous sampling event in 2010.

5.2.1 C-9 IMPOUNDMENT

The C-9 project area was divided into two areas for sampling and analysis of selenium concentrations. The first area was an approximately 1,600 hundred acre squarely configured area located to the south. The second area was an approximately 400 acre rectangular area located to the north.

400 ACRE AREA (Chimney Area)

The C-9 soil sample data was composed of ten discrete samples collected at the northern portion of the C-9 area which is also referred to as the chimney area. Consistent with the District protocol, QA/QC samples were also collected at the specified frequency described earlier. **Figure 5** illustrates the soil sample locations for C-9. All the samples collected in the C-9 area were above the USFWS screening level of 2 ppm. The discrete selenium sample concentrations ranged from 2.3 ppm to 8.9 ppm with a mean of 4.8 ppm. The 95 % UCL concentration was calculated to be 5.98 ppm for the selenium samples. A tabulation of the C-9 chimney area 2010 and 2011 data is provided in **Table 2** and the 95% UCL calculations are attached as Appendix (C). The chimney area previously indicated a 95% UCL of 4.57 ppm for the composite samples that were collected in 2010. Options to address this area are discussed in Section 6 of this report.

1600 ACRE AREA

Based on discussions with the Service, the site specific selenium screening level can range from 2 mg/kg to approximately 4 kg/mg depending on specific soil properties. As part of a limited study, the site specific ecological risk assessment value of 2 ppm was developed and approved for the site. In accordance with the initial sampling event, the area wide 95% UCL was calculated at 2.19 mg/kg. This calculated value was within the acceptable range and determined not to pose an unacceptable risk to the USFWS trustee

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species. One sample (SE-26) was collected from a parcel in the southwest portion of C-9 which was historically used for landscaping business. This was collected to satisfy the USFWS comment regarding the need to correlate agricultural use with elevated selenium impacts. The discrete sample selenium concentration was 4.5 ppm which is above the USFWS screening level of 2 ppm. A tabulation of the C-9 1600 2010 and 2011 acre area of data is provided in **Table 3** and **Figure 5** illustrates the soil sample location. Since the mean and 95% UCL of the mean for this area is close to the 2 ppm screening level, no remediation is proposed. Options to address this area through risk assessment are discussed in Section 6.0 of this report.

5.2.2 C-11 IMPOUNDMENT RESULTS

The 25 discrete samples collected within the C-11 area were analyzed for selenium using method 6020. An additional three (3) samples were collected as duplicate samples and three more samples were sent to Energy Laboratories for split samples. A 95% upper confidence level (UCL) of the sample mean was calculated for selenium for the 28 samples analyzed by Accutest. Selenium concentrations ranged from 0.59 ppm to 5.1 ppm with a mean of 2.36 ppm. Sixteen (16) of the twenty-five (25) samples reported concentrations above the USFWS screening level of 2.0 ppm. All the samples analyzed by Accutest were above the detection limit.

The 95% UCL values for selenium is 3.1 ppm which is comparable but slightly higher than the value obtained during the previous sampling event. Neither of these concentrations is above the FDEP soil clean up target level of 5.2 mg/kg *(Leacgbility baseon Groundwater Crtetera Chapter 62-777 FAC* A tabulation of the C-11 area 2010 and 2011 data is provided in **Table 4** and **Figure 6** illustrates the soil sample location. The 95% UCL calculations are attached as **Appendix (B).** Options to address this area are discussed in Section 6.0 of this report.

5.3 DATA VALIDATION

The two laboratories provided ECT with the ADaPT electronic data deliverables (EDDs)

along with the reports and error logs. Upon receipt of the EDD with accompanying error log, ECT personnel imported the EDD into ADaPT, reviewed the error log generated by the laboratory's error check determine whether the comments were acceptable. ECT then re-ran the error check to confirm that no errors were present that had not been observed and commented on by the laboratory. The results from the ADaPT error checks are **(PENDING)**.

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6.0 SOIL OPTIONS FOR SELENIUM IMPACTED SOILS

Based on the results of the C-9 and C-11 soil analytical data, ECT evaluated a number of options for use of Selenium impacted soil. Of the approximately 920 acres reviewed in this assessment the entire 400 acres in the Chimney and a former landscaping business area of C-9 have Selenium impacts greater than 2 ppm and 313 acres of the formerly cultivated tracts on C-11 have Selenium impacts greater than 2 ppm. **Figure 7** and **Figure 8** illustrates the areas of Selenium impacted soil in C-9 and C-11, respectively. The following paragraphs present a summary of the soil use or risk assessment options.

6.1 NO CORRECTIVE ACTION WITH MONITORING AFTER PROJECT

The District's future plans consist of inundating these areas to create surface water seepage management areas. This option would consist of surface water monitoring in the areas of elevated selenium impacted sediments. As a result, ECT would propose four quarters of post construction surface water monitoring. Further sampling of standing water within these areas of elevated selenium concentrations may result in lesser monitoring requirements. However, this scenario would involve monitoring after the fact and would have the disadvantage of reducing the potential for corrective actions, if required. ECT would not recommend this option.

6.2 OFFSITE DISPOSAL

The offsite disposal option would require scraping the impacted soils down to the caprock. Assuming an estimated 12 inches of selenium impacted muck over approximately 720 acres, the total volume of soil would be an estimated 1.5 million tons of soil. Therefore, based on the large volume of soil that would require offsite disposal, this option is cost prohibitive. ECT would not recommend this option.

6.3 SOIL INVERSION

Due to the shallow depth of caprock, the lack of unimpacted soils for inversion, and the presence of limestone outcroppings at the C9/C11 project area, this option is not viable. Disk plows or pan scrapers would not be effective in this inversion process due to these

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limitations. ECT would not recommend this option.

6.4 SOIL CAPPING

Similar to offsite disposal, the cost of soil capping would be prohibitive. An estimated 12 inches of clean soil would need to be transported to the C-9/C-11 project area to cover or cap the selenium impacted muck over approximately 720 acres. The total volume of clean soil would be an estimated 1.5 million tons. Therefore, based on the large volume of soil that would be required and associated costs, ECT would not recommend this option.

6.5 SOIL BLENDING/GEOTECHNICAL EVALUATION

The soil blending option proposes that the muck soil and the clean soil could be used onsite. A geotechnical evaluation of the selenium impacted soil and clean soil should be conducted. The clean soil would be used to blend with selenium organic rich soils onsite. The muck soil would be blended at a one (1-3) part clean soil to a one (1) part muck soils ratio in order to lower the selenium concentration in the soil. ECT anticipates, by using this mix ratio, the selenium concentration in the blended materials would meet the existing or revised selenium screening level. Once the soils have been blended in this pre-determined ratio, this material will be used for berms or other features. This option should be used in conjunction with the ecological risk assessment option to minimize the volume of soil that would need to be blended.

ECT recommends completion of a bench test study to confirm the selenium concentrations using various mix ratios. The bench study would consist of the actual blending of one part muck soil with one to three parts clean soil and submitting these samples for analysis for selenium. ECT understands that soil analysis will take 7-10 days before the testing is complete. Once the soil data is received, ECT would review the data and evaluate if the proposed mix ratios will achieve the lower selenium concentrations. The cost for completing this feasibility study would be on the order of $30,000. ECT recommends implementing the soil blending pilot study.

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6.6 ECOLOGICAL RISK ASSESSMENT

An ecological risk assessment may be necessary to modify the current screening level of 2 ppm for selenium. This will require a bioaccumulation study, toxicity test, and food web modeling as described in the USFWS protocol. The selenium concentration could be elevated to the 7 ppm range, if successful. This would preclude most areas if not all areas from requiring remediation. The estimated cost for implementing this option would be $80,000. The soil blending options could be used with this option if the new screening level is in the 2-7 ppm range. ECT recommends implementing the ecological risk assessment study for this project.

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7.0 CONCLUSIONS

Based on the results of the additional assessment the selenium concentrations observed at the C-9 and C-11 impoundment areas were consistent with the previous assessment results in the area. The 95 % UCL for the C-9 400 acre chimney area was 5.98 ppm and was previously 4.57 ppm in 2010; the discrete sample from the C-9 1600 acre area was 4.5 ppm and the 95 % UCL for the C-11 area was 3.11 ppm and was previously 2.63 in 2010.

Based on ECT evaluation of soil options, ECT recommends an ecological risk assessment and soil blending pilot study be conducted to modify the current screening level of 2 ppm for selenium and evaluate the efficacy of soil blending. The ecological risk assessment will require a bioaccumulation study, toxicity test, and food web modeling as described in the USFWS protocol. The selenium concentration could be elevated to the 3-7 ppm range if successful. Based on literature survey and previously developed values for USSC muck soils, this would preclude most areas from requiring remediation. In addition, the soil blending option may also be considered to supplement any newly developed screening level derived from the ecological risk assessment.

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8.0 REFERENCES

1) University of Florida Soil and Water Science Department. 1999. Background Concentrations of Trace Metals in Florida Surface Soils: Taxonomic and Geographical Distributions of Total-total and Total-recoverable Concentrations of Selected Trace Metals. Florida Center for Solid and Hazardous Waste Management Report #99-7.

2) BEM Systems. November 2002. Phase II Environmental Site Assessment East Coast Buffer Canal 11 26 Condemnation Properties.

3) Shaw Environmental. June 2007. Additional Selenium Sampling Assessment Results.

4) NewFields, LLC. January 2007. Selenium Leaching Potential of Sediment: C-11 Project Area.

5) Lemly, D.A. and Skorupa, J.A. 2007. "Technical Issues Affecting the Implementation of US Environmental Protection Agency's Proposed Fish Tissue-Based Aquatic Criterion for Selenium." Integrated Environmental Assessment and Management. Vol 3 (4), pp. 552-558.

6) NewFields, LLC. August 2008. Aquarium Sediment Leaching Studies Data Report, Broward County Water Protection Area, C-11 Impoundment.

7) FDEP. Chapter 62-302. Florida Surface Water Quality Standards.

DRAFT

FIGURES

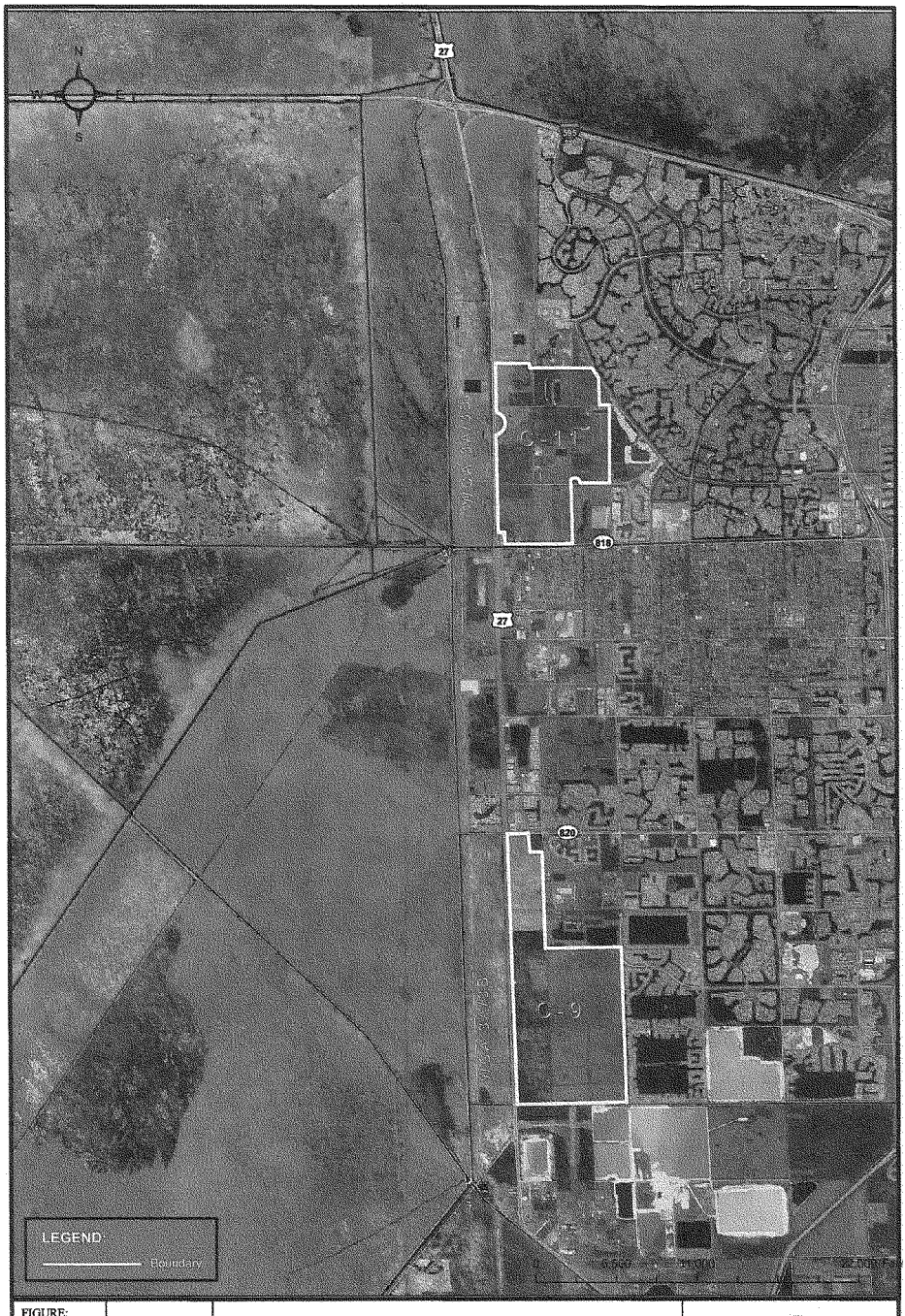

FIGURE: 1	CREATED BY: CTM CHECKED BY: BDW SCALE: AS NOTED DATE: 4/2011	C-9 / C-11 IMPOUNDMENT AREA LOCATION MAP	ECT Environmental Consulting & Technology, Inc.

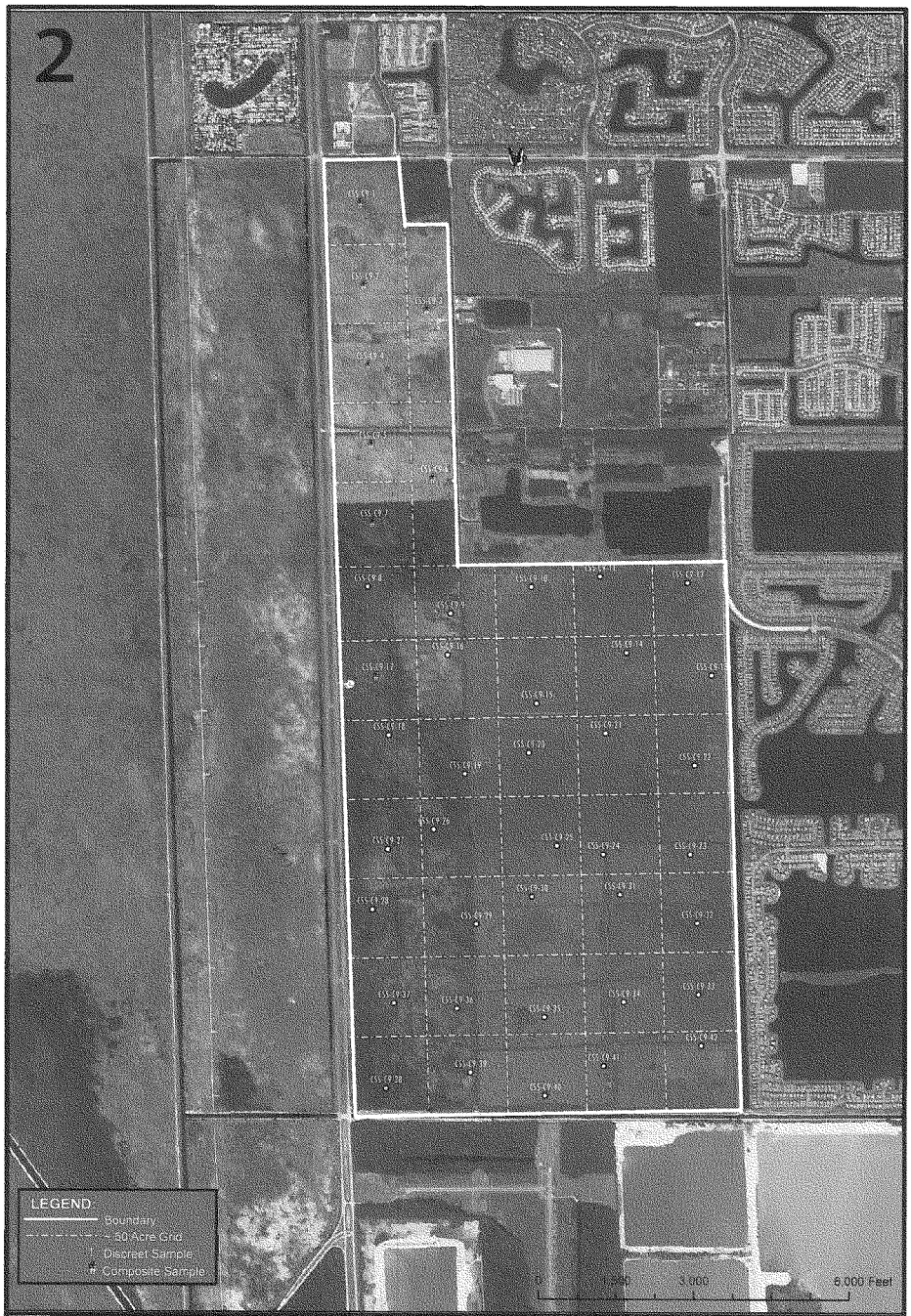

FIGURE: 2	CREATED BY: CTM CHECKED BY: BDW SCALE: AS NOTED DATE: 4/2011	C-9 IMPOUNDMENT SELENIUM SAMPLE LOCATION (FEBRUARY 19, 24, 25, 2010)	ECT Environmental Consulting & Technology, Inc.

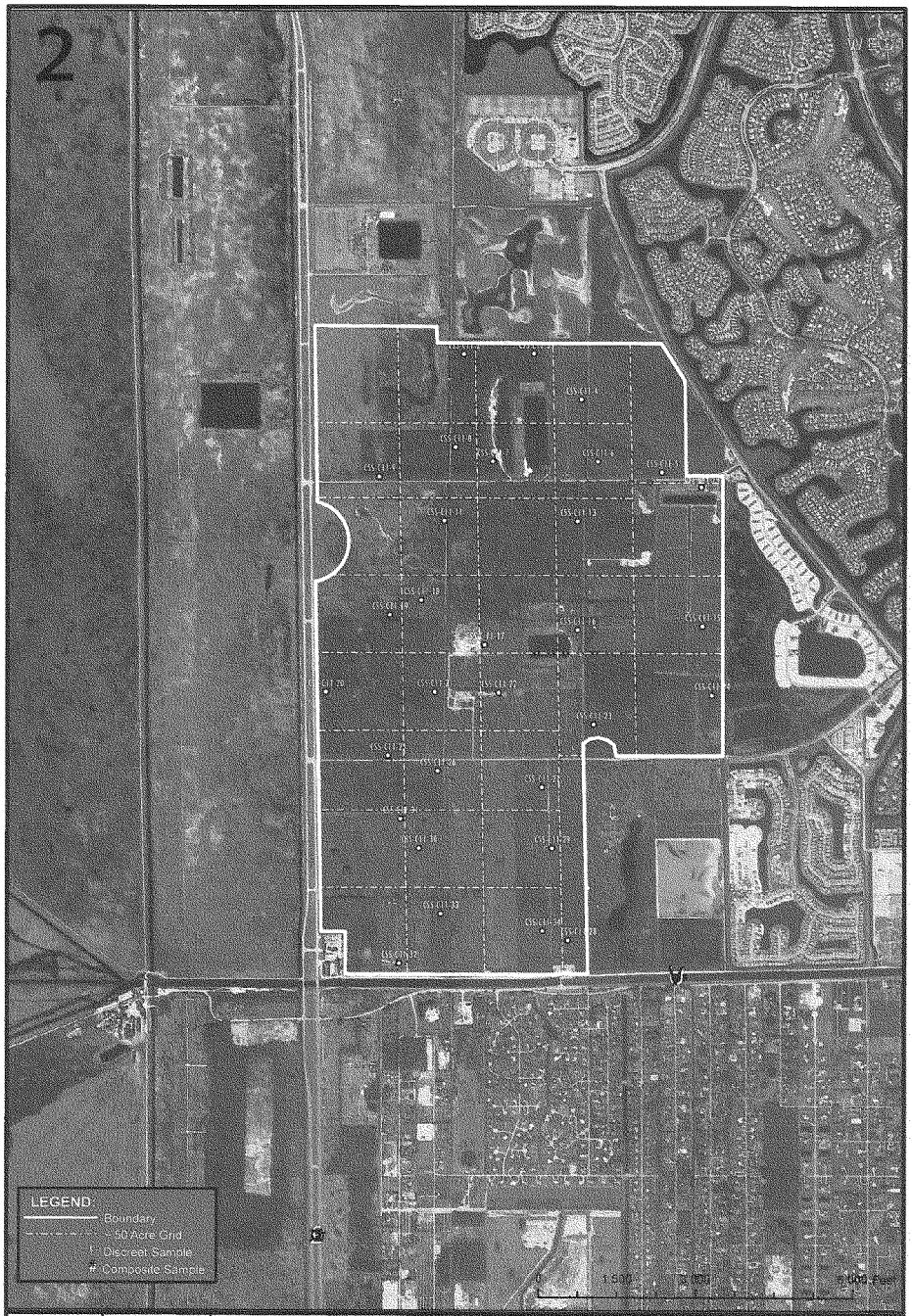

FIGURE: 3	CREATED BY: CTM CHECKED BY: BDW SCALE: AS NOTED DATE: 4/2011	C-11 IMPOUNDMENT SELENIUM SAMPLE LOCATION (FEBRUARY 23-26, 2010)	ECT Environmental Consulting & Technology, Inc.

FIGURE: 4	CREATED BY: CTM CHECKED BY: BDW SCALE: AS NOTED DATE: 4/2011	C-9 / C-11 IMPOUNDMENT AREA SELENIUM SAMPLE LOCATION	ECT Environmental Consulting & Technology, Inc.

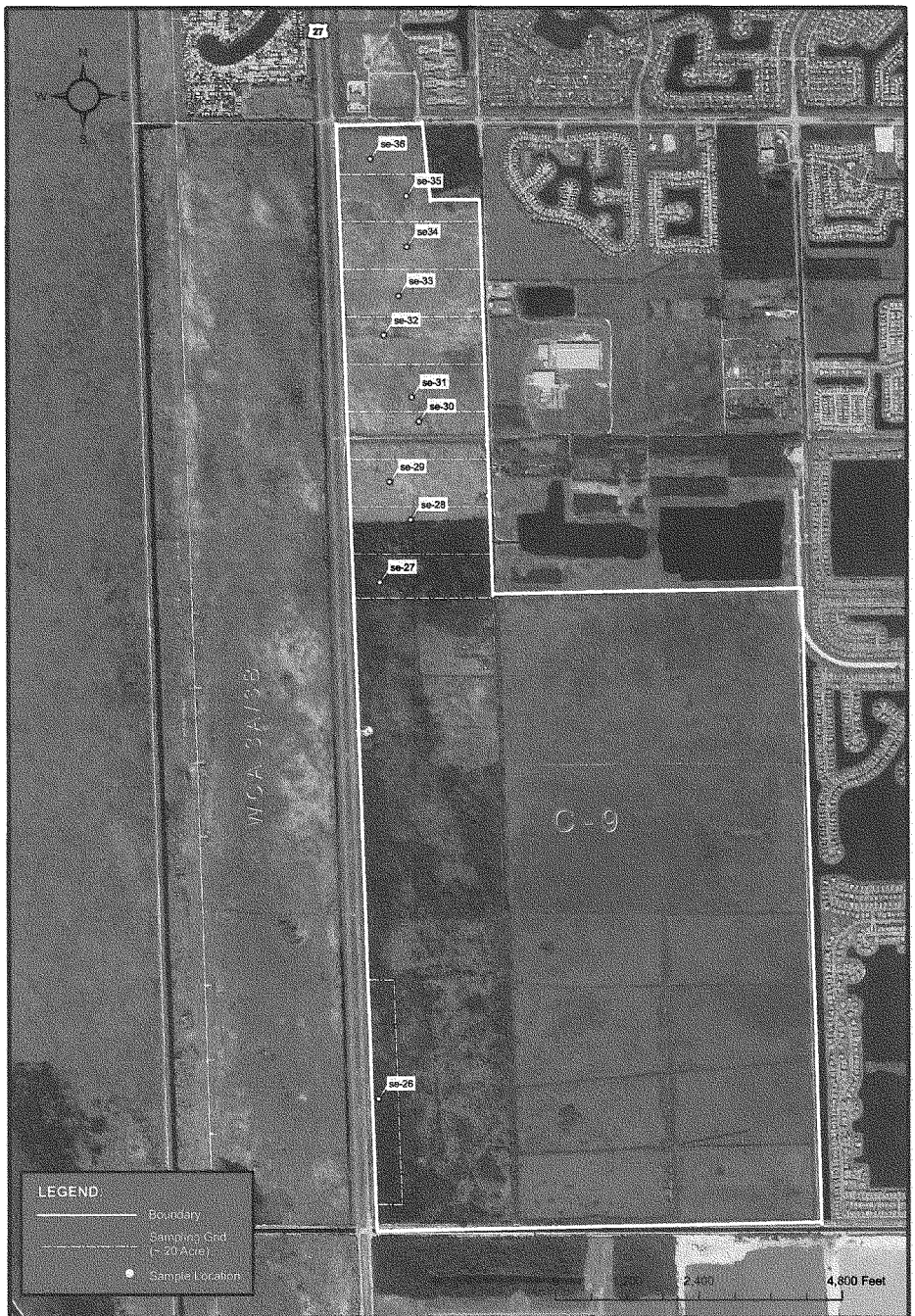

FIGURE: 5	CREATED BY: CTM CHECKED BY: BDW SCALE: AS NOTED DATE: 4/2011	C-9 IMPOUNDMENT AREA SELENIUM SAMPLE LOCATION	ECT Environmental Consulting & Technology, Inc.

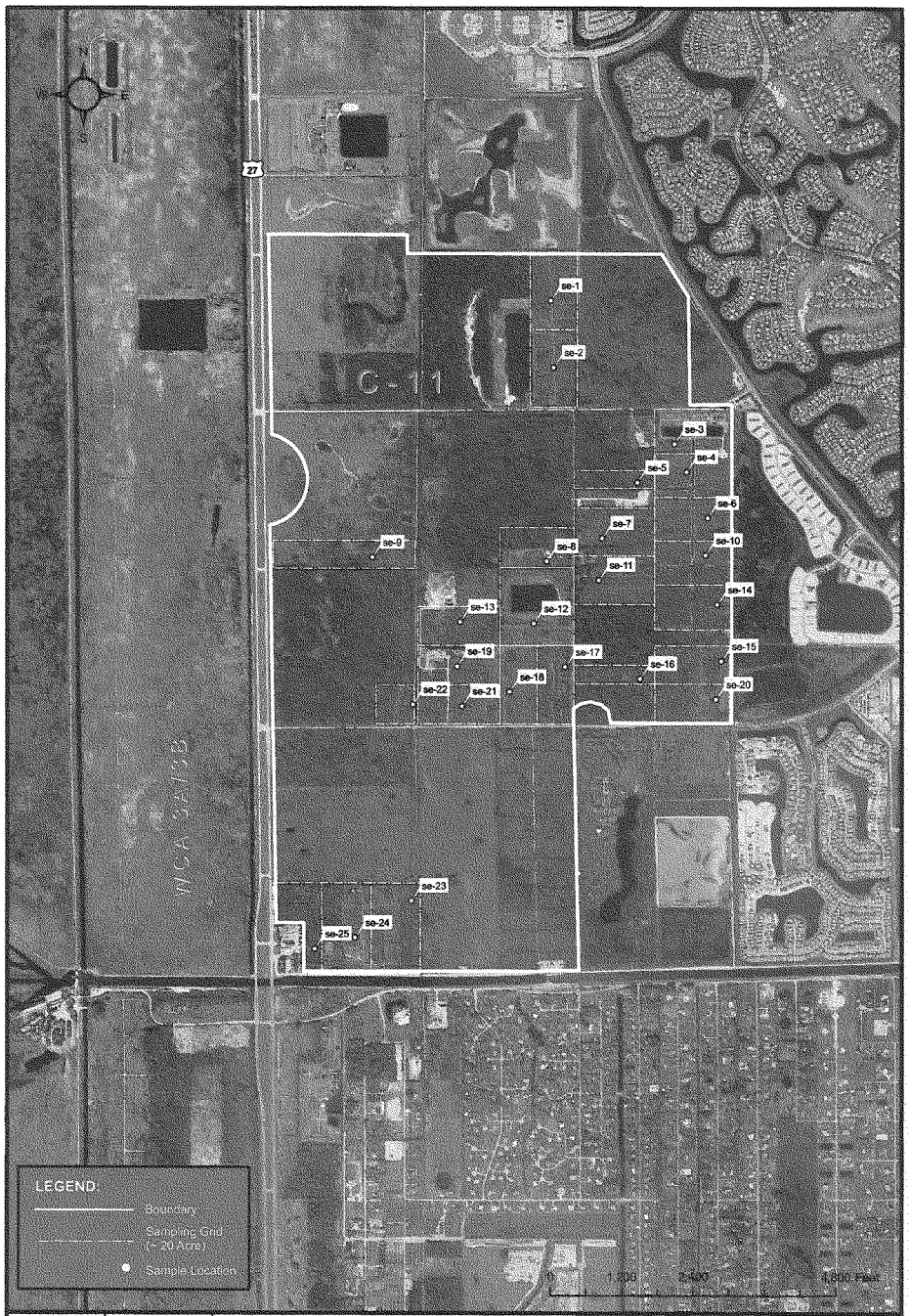

FIGURE: 6	CREATED BY: CTM CHECKED BY: BDW SCALE: AS NOTED DATE: 4/2011	C-11 IMPOUNDMENT AREA SELENIUM SAMPLE LOCATION	ECT Environmental Consulting & Technology, Inc.

FIGURE: 7	CREATED BY: CTM CHECKED BY: BDW SCALE: AS NOTED DATE: 4/2011	C-9 IMPOUNDMENT AREA SELENIUM SAMPLE LOCATION	ECT Environmental Consulting & Technology, Inc.

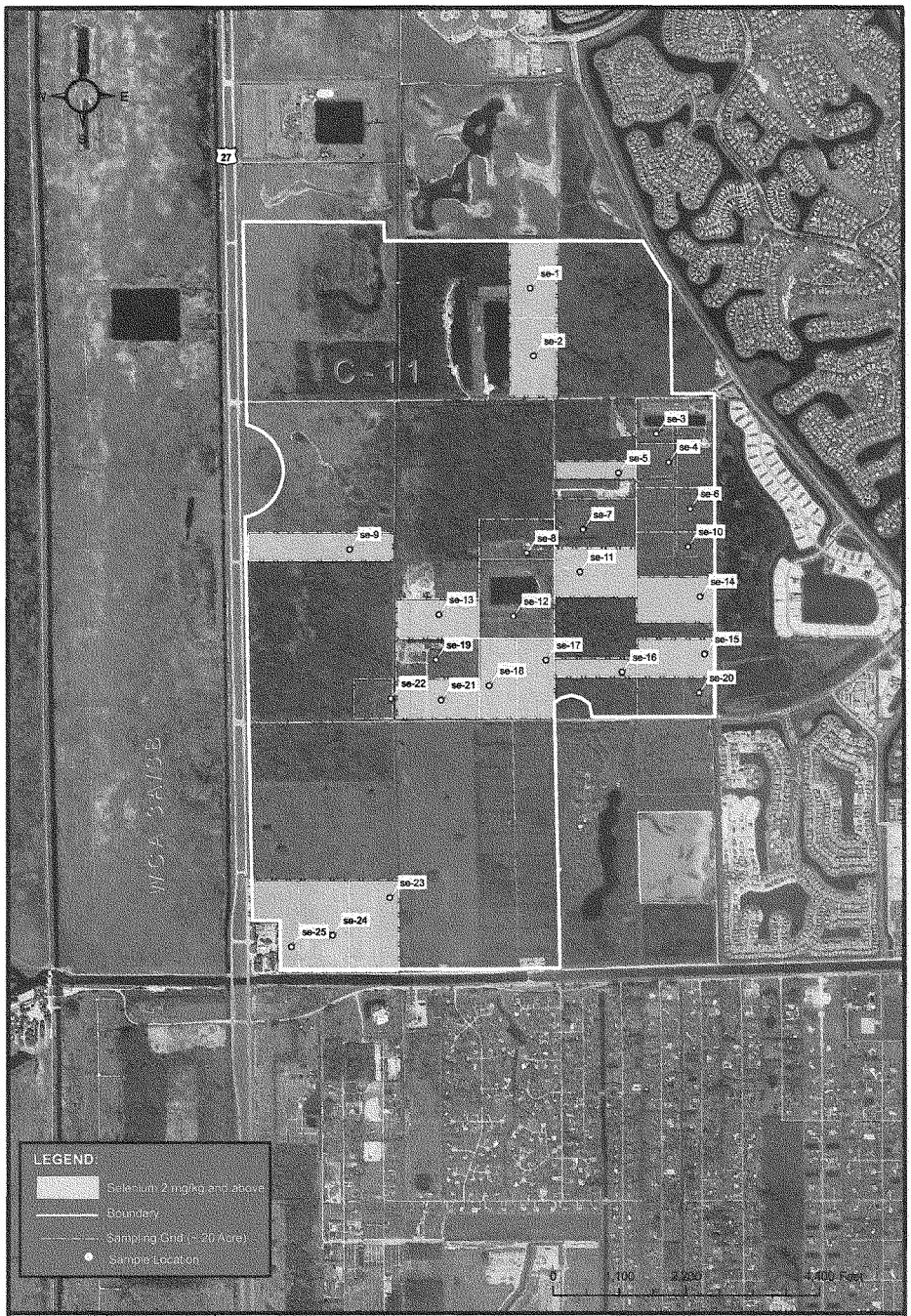

FIGURE: 8	CREATED BY: CTM CHECKED BY: BDW SCALE: AS NOTED DATE: 4/2011	C-11 IMPOUNDMENT AREA SELENIUM SAMPLE LOCATION	ECT Environmental Consulting & Technology, Inc.

TABLES

TABLE 1: HISTORIC SOIL SELENIUM DATA

PROJECT SITE: C 11

ECT DATA

Sample Designation	Sample Date	Selenium (mg/kg)
CSS-C11-2	2/28/2010	0.95
CSS-C11-3	2/28/2010	1.3
CSS-C11-4	2/28/2010	2
CSS-C11-5	2/28/2010	2
CSS-C11-5D	2/28/2010	1.5
CSS-C11-5*	2/28/2010	2.8
CSS-C11-6	2/28/2010	2.4
CSS-C11-7	2/28/2010	0.12 I
CSS-C11-8	2/28/2010	0.55
CSS-C11-9	2/28/2010	0.41 I
CSS-C11-11	2/28/2010	0.69
CSS-C11-13	2/28/2010	3.4
CSS-C11-14	2/28/2010	0.83
CSS-C11-15	2/28/2010	0.46 I
CSS-C11-15 D	2/28/2010	0.81
CSS-C11-16*	2/28/2010	0.88
CSS-C11-16	2/28/2010	0.67
CSS-C11-17	2/28/2010	0.33 I
CSS-C11-17D	2/28/2010	0.24 I
CSS-C11-17*	2/28/2010	0.34 I
CSS-C11-18	2/23/2010	2.8
CSS-C11-19	2/23/2010	1.8
CSS-C11-20	2/23/2010	0.069 U
CSS-C11-20D	2/23/2010	0.072 I
CSS-C11-20**	2/23/2010	0.6 U
CSS-C11-21	2/23/2010	1.1
CSS-C11-22	2/26/2010	0.17 I
CSS-C11-23	2/26/2010	0.2 I
CSS-C11-24	2/26/2010	0.22 I
CSS-C11-25	2/23/2010	2.4
CSS-C11-25D	2/23/2010	3.2
CSS-C11-25**	2/23/2010	6.1
CSS-C11-26	2/23/2010	2
CSS-C11-27	2/23/2010	2.3
CSS-C11-28	2/23/2010	2
CSS-C11-29	2/23/2010	2.2
CSS-C11-30	2/23/2010	3.1
CSS-C11-30D	2/23/2010	3.4
CSS-C11-30**	2/23/2010	8.9 I
CSS-C11-31	2/23/2010	1.7
CSS-C11-32	2/26/2010	0.16 I
CSS-C11-33	2/23/2010	2
CSS-C11-34	2/23/2010	5.3
CSS-C11-34D	2/23/2010	5.9
CSS-C11-34**	2/23/2010	6.4 I

[1]Residential SCTL	440
[1]Industrial SCTL	11,000
[2]Groundwater Leachability SCTL	5.5
[3]SQAG TEC	
[3]SQAG PEC	
[4]Other Standard	4.0

Sample Designation	Sample Date	Selenium (mg/kg)
SE-1	4/14/2011	2.3
SE-2	4/14/2011	4
SE-3	4/13/2011	1.5
SE-4	4/13/2011	1.1
SE-5	4/13/2011	5.1
SE-6	4/14/2011	1.8
SE-7	4/13/2011	1.4
SE-7D	4/13/2011	1.2
SE-8	4/13/2011	0.71
SE-9	4/12/2011	3.6
SE-10	4/14/2011	1.5
SE-11	4/13/2011	2.6
SE-12	4/12/2011	0.86
SE-13	4/12/2011	4.4
SE-13D	4/12/2011	1.8
SE-14	4/14/2011	3.3
SE-15	4/14/2011	4.9
SE-16	4/13/2011	3.2
SE-17	4/12/2011	3.1
SE-18	4/12/2011	3.1
SE-19	4/12/2011	0.62
SE-20	4/14/2011	0.59
SE-21	4/12/2011	2
SE-22	4/12/2011	1.2
SE-23	4/12/2011	2.9
SE-24	4/12/2011	3.5
SE-25	4/8/2011	2.1
SE-25D	4/8/2011	2.4

SHAW DATA

Sample Designation	Sample Date	Selenium (mg/kg)
908-SB01-T	8/2/2006	1.8 U
908-SB01-N	8/2/2006	2.1 U
908-SB01-E	8/2/2006	4.30
908-SB01-S	8/2/2006	1.3 U
908-SB01-W	8/2/2006	3.1 U
908-SB02-T	8/2/2006	3.8 U
908-SB02-N	8/2/2006	4.1 U
908-SB02-E	8/2/2006	5.1 U
908-SB02-S	8/2/2006	4.0 U
908-SB02-W	8/2/2006	4.3 U
062-SB01-T	8/2/2006	1.1 U
062-SB01-N	8/2/2006	1.2 U
062-SB01-E	8/2/2006	1.1 U
062-SB01-S	8/2/2006	1.1 U
062-SB01-W	8/2/2006	5.80
062-SB02-T	8/2/2006	4.70
062-SB02-N	8/2/2006	1.5 U
062-SB02-E	8/2/2006	2.50
062-SB02-S	8/2/2006	0.92
062-SB02-W	8/2/2006	1.1 U
062-SB03-T	8/2/2006	1.4 U
062-SB03-N	8/2/2006	1.7 U
062-SB03-E	8/2/2006	1.4 U
062-SB03-S	8/2/2006	1.5 U
062-SB03-W	8/2/2006	1.5 U
963-SB02-T	8/2/2006	1.1 U
963-SB02-N	8/2/2006	0.91 U
963-SB02-E	8/2/2006	0.88 U
963-SB02-S	8/2/2006	0.92 U
963-SB02-W	8/2/2006	0.99 U
963-SB03-T	8/2/2006	0.99 U
963-SB03-N	8/2/2006	0.90 U
963-SB03-E	8/2/2006	0.87 U
963-SB03-S	8/2/2006	0.87 U
963-SB03-W	8/2/2006	0.89 U
110-SB01-T	8/2/2006	0.99 U
110-SB01-N	8/2/2006	1.0 U
110-SB01-E	8/2/2006	0.95 U
110-SB01-S	8/2/2006	1.0 U
110-SB01-W	8/2/2006	1.80
110-SB02-T	8/2/2006	5.90
110-SB02-N	8/2/2006	5.80
110-SB02-E	8/2/2006	4.60
110-SB02-S	8/2/2006	4.50
110-SB02-W	8/2/2006	3.60
109-SB01-T	8/2/2006	0.92 U
109-SB01-N	8/2/2006	1.0 U
109-SB01-E	8/2/2006	0.91 U
109-SB01-S	8/2/2006	0.96 U
109-SB01-W	8/2/2006	0.99 U
109-SB02-T	8/2/2006	5.40
109-SB02-N	8/2/2006	5.60
109-SB02-E	8/2/2006	2.80
109-SB02-S	8/2/2006	3.60
109-SB02-W	8/2/2006	5.30

BEM DATA

Sample Designation	Sample Date	Selenium (mg/kg)
963-SB01	11/22/2005	0.46 U
963-SB02	11/22/2005	0.97 I
963-SB03	11/22/2005	2.3

USACE DATA

Sample Designation	Sample Date	Selenium (mg/kg)
C11-1-1	7/1/2008	0.8
C11-1-2	7/1/2008	<0.24
C11-1-3	7/1/2008	1.6
C11-1-4	7/1/2008	0.22
C11-1-5	7/1/2008	0.62
C11-2-1	7/1/2008	<0.36
C11-2-2	7/1/2008	<0.35
C11-2-3	7/1/2008	<0.29
C11-2-4	7/1/2008	<0.25
C11-2-5	7/1/2008	1.9
C11-2-6	7/1/2008	<0.46

PROJECT SITE: C 9

ECT DATA

Sample Designation	Sample Date	Selenium (mg/kg)
CSS-C9-1	2/19/2010	3.7 I
CSS-C9-2	2/19/2010	3.8
CSS-C9-3	2/19/2010	4.3
CSS-C9-4	2/19/2010	4.4
CSS-C9-5	2/19/2010	4
CSS-C9-5D	2/19/2010	4.6
CSS-C9-5*	2/19/2010	6.5
CSS-C9-6	2/19/2010	4.5
CSS-C9-7	2/19/2010	3.4
CSS-C9-8	2/24/2010	0.094 I
CSS-C9-9	2/24/2010	0.068 U
CSS-C9-10	2/24/2010	0.065 U
CSS-C9-10D	2/24/2010	0.059 I
CSS-C9-10*	2/24/2010	0.5 I
CSS-C9-11	2/25/2010	2.2
CSS-C9-12	2/25/2010	1.5
CSS-C9-13	2/25/2010	1.8
CSS-C9-14	2/25/2010	2.6
CSS-C9-15	2/24/2010	0.34 I
CSS-C9-15D	2/24/2010	0.48
CSS-C9-15*	2/24/2010	1 I
CSS-C9-16	2/24/2010	0.42 I
CSS-C9-17	2/24/2010	0.58
CSS-C9-18	2/24/2010	0.45
CSS-C9-19	2/25/2010	0.4 I
CSS-C9-20	2/24/2010	0.097 I
CSS-C9-20D	2/24/2010	0.08 I
CSS-C9-20*	2/24/2010	0.8 I
CSS-C9-21	2/25/2010	1.9
CSS-C9-22	2/25/2010	1.8
CSS-C9-23	2/25/2010	2.3
CSS-C9-24	2/25/2010	1.7 I
CSS-C9-25	2/25/2010	2.1
CSS-C9-25D	2/25/2010	1.9
CSS-C9-25*	2/25/2010	2.6 I
CSS-C9-26	2/25/2010	1.7
CSS-C9-27	2/25/2010	1.7
CSS-C9-28	2/25/2010	1.5
CSS-C9-29	2/25/2010	1.7
CSS-C9-30	2/25/2010	1.9
CSS-C9-30D	2/25/2010	2.1
CSS-C9-30*	2/25/2010	3 I
CSS-C9-31	2/25/2010	3.1
CSS-C9-32	2/25/2010	3.2
CSS-C9-33	2/25/2010	3.8
CSS-C9-34	2/25/2010	3.2
CSS-C9-35	2/24/2010	1.6
CSS-C9-35D	2/24/2010	2
CSS-C9-35*	2/24/2010	2.8 I
CSS-C9-36	2/24/2010	2.7
CSS-C9-37	2/24/2010	2.2
CSS-C9-38	2/24/2010	2.2
CSS-C9-39	2/24/2010	3
CSS-C9-40	2/25/2010	2.3
CSS-C9-40D	2/25/2010	3.5
CSS-C9-40*	2/25/2010	4.5 I
CSS-C9-41	2/25/2010	3
CSS-C9-42	2/25/2010	2.7
SE-26	4/11/2011	4.5
SE-27	4/11/2011	3.3
SE-28	4/11/2011	5.1
SE-29	4/11/2011	4.2
SE-30	4/11/2011	4.2
SE-31	4/11/2011	6.3
SE-31D	4/11/2011	4
SE-32	4/11/2011	2.3
SE-33	4/11/2011	8.9
SE-34	4/11/2011	3.3
SE-35	4/11/2011	4.7
SE-36	4/11/2011	8.4

SHAW DATA

Sample Designation	Sample Date	Selenium (mg/kg)
919-SB01-T	8/2/2006	4.00
919-SB01-N	8/2/2006	3.3 U
919-SB01-E	8/2/2006	3.1 U
919-SB01-S	8/2/2006	4.20
919-SB01-W	8/2/2006	3.90
919-SB02-T	8/2/2006	6.0 U
919-SB02-N	8/2/2006	8.60
919-SB02-E	8/2/2006	5.30
919-SB02-S	8/2/2006	5.4 U
919-SB02-W	8/2/2006	6.00
919-SB03-T	8/2/2006	7.1 U
919-SB03-N	8/2/2006	7.4 U
919-SB03-E	8/2/2006	6.1
919-SB03-S	8/2/2006	5.9
919-SB03-W	8/2/2006	5.5 U
901-SB01-T	8/2/2006	1.6 U
901-SB01-N	8/2/2006	2.00
901-SB01-E	8/2/2006	1.2 U
901-SB01-S	8/2/2006	1.90
901-SB01-W	8/2/2006	3.30
901-SB02-T	8/2/2006	1.1 U
901-SB02-N	8/2/2006	1.0 U
901-SB02-E	8/2/2006	1.0 U
901-SB02-S	8/2/2006	1.1 U
901-SB02-W	8/2/2006	0.92 U
901-SB03-T	8/2/2006	1.9 U
901-SB03-N	8/2/2006	2.90
901-SB03-E	8/2/2006	2.0 U
901-SB03-S	8/2/2006	2.60
901-SB03-W	8/2/2006	2.60

BEM DATA

Sample Designation	Sample Date	Selenium (mg/kg)
901-SB01	11/22/2005	1.5 I
901-SB02	11/22/2005	2.9 I
901-SB03	11/22/2005	4.7
902-SB01	11/22/2005	0.54 U
902-SB02	11/22/2005	0.49 U
902-SB03	11/22/2005	0.49 U
902-SB02	11/22/2005	0.48 U
902-SB03	11/22/2005	0.48 U

1 Soil Cleanup Target Level, Direct Exposure, Residential Use, Chapter 62-777, FAC
2 Soil Cleanup Target Level, Direct Exposure, Commercial/Industrial Use, Chapter 62-777, FAC
3 Leachability Based on Groundwater Criteria, Chapter 62-777, FAC
4 Sediment Quality Assessment Guideline, Technical Report, January 2003
5 Interim Screening Level Applied by USFWS, Protective of Avian Receptors
N/A = Not Analyzed
I = Analyte detected but could not be quantified with certainty, value lies between MDL and PQL
U = Below MDL
Suffix "D" are Duplicate Samples
* Analyzed by Pace Analytical as Split Samples
** Analyzed by Columbia Analytical Services, Inc.

table 1 Compiled Se Data.xls

Table 3 C-9 1600 Acres Selenium Data

2010 DATA			2011 DATA*		
95% UCL: 2.19 mg/kg					
Sample Designation	Sample Date	Selenium (mg/kg)	Sample Designation	Sample Date	Selenium (mg/kg)
CSS-C9-8	2/24/2010	0.094 I	SE-26	4/11/2011	**4.5**
CSS-C9-9	2/24/2010	0.068 U			
CSS-C9-10	2/24/2010	0.065 U			
CSS-C9-10D	2/24/2010	0.059 I			
CSS-C9-10*	2/24/2010	0.5 I			
CSS-C9-11	2/25/2010	**2.2**			
CSS-C9-12	2/25/2010	1.5			
CSS-C9-13	2/25/2010	1.6			
CSS-C9-14	2/25/2010	**2.6**			
CSS-C9-15	2/24/2010	0.34 I			
CSS-C9-15D	2/24/2010	0.48			
CSS-C9-15*	2/24/2010	1 I			
CSS-C9-16	2/24/2010	0.42 I			
CSS-C9-17	2/24/2010	0.56			
CSS-C9-18	2/24/2010	0.45			
CSS-C9-19	2/25/2010	0.4 I			
CSS-C9-20	2/24/2010	0.087 I			
CSS-C9-20D	2/24/2010	0.08 I			
CSS-C9-20*	2/24/2010	0.6 I			
CSS-C9-21	2/25/2010	1.9			
CSS-C9-22	2/25/2010	1.8			
CSS-C9-23	2/25/2010	**2.3**			
CSS-C9-24	2/25/2010	1.7 I			
CSS-C9-25	2/25/2010	**2.1**			
CSS-C9-25D	2/25/2010	1.9			
CSS-C9-25*	2/25/2010	**2.6 I**			
CSS-C9-26	2/25/2010	1.7			
CSS-C9-27	2/25/2010	1.7			
CSS-C9-28	2/25/2010	1.5			
CSS-C9-29	2/25/2010	1.7			
CSS-C9-30	2/25/2010	1.9			
CSS-C9-30D	2/25/2010	**2.1**			
CSS-C9-30*	2/25/2010	**3 I**			
CSS-C9-31	2/25/2010	**3.1**			
CSS-C9-32	2/25/2010	**3.2**			
CSS-C9-33	2/25/2010	**3.8**			
CSS-C9-34	2/25/2010	**3.2**			
CSS-C9-35	2/24/2010	1.6			
CSS-C9-35D	2/24/2010	**2**			
CSS-C9-35*	2/24/2010	**2.8 I**			
CSS-C9-36	2/24/2010	**2.7**			
CSS-C9-37	2/24/2010	**2.2**			
CSS-C9-38	2/24/2010	**2.2**			
CSS-C9-39	2/24/2010	**3**			
CSS-C9-40	2/25/2010	**2.3**			
CSS-C9-40D	2/25/2010	**3.5**			
CSS-C9-40*	2/25/2010	**4.5 I**			
CSS-C9-41	2/25/2010	**3**			
CSS-C9-42	2/25/2010	**2.7**			

*Only one sample was collected from the 1600 acres which was designated as previous landscape foliage use

Table 2 C-9 400 Acre (Chimney) Selenium Data

2010 DATA			2011 DATA		
95% UCL: 4.57 mg/kg			95% UCL: 5.98 mg/kg		
Sample Designation	Sample Date	Selenium (mg/kg)	Sample Designation	Sample Date	Selenium (mg/kg)
CSS-C9-1	2/19/2010	3.7 I			
CSS-C9-2	2/19/2010	3.8	SE-27	4/11/2011	3.3
CSS-C9-3	2/19/2010	4.3	SE-28	4/11/2011	5.1
CSS-C9-4	2/19/2010	4.4	SE-29	4/11/2011	4.2
CSS-C9-5	2/19/2010	4	SE-30	4/11/2011	4.2
CSS-C9-5D	2/19/2010	4.6	SE-31	4/11/2011	6.3
CSS-C9-5*	2/19/2010	6.5	SE-31D	4/11/2011	4
CSS-C9-6	2/19/2010	4.5	SE-32	4/11/2011	2.3
CSS-C9-7	2/25/2010	3.4	SE-33	4/11/2011	8.9

Table 4 C-11 Selenium Data

2010 DATA				2011 DATA		
95% UCL : 2.63 mg/kg				95% UCL: 3.11 mg/kg		
Sample Designation	Sample Date	Selenium (mg/kg)	Qualifier	Sample Designation	Sample Date	Selenium (mg/kg)
CSS-C11-2	2/26/2010	0.95		SE-1	4/14/2011	**2.3**
CSS-C11-3	2/26/2010	1.3		SE-2	4/14/2011	**4**
CSS-C11-4	2/26/2010	**2**		SE-3	4/13/2011	1.5
CSS-C11-5	2/26/2010	**2**		SE-4	4/13/2011	1.1
CSS-C11-5D	2/26/2010	1.5		SE-5	4/13/2011	**5.1**
CSS-C11-5*	2/26/2010	**2.8**		SE-6	4/14/2011	1.8
CSS-C11-6	2/26/2010	**2.4**		SE-7	4/13/2011	1.4
CSS-C11-7	2/26/2010	0.12 I	I	SE-7D	4/13/2011	1.2
CSS-C11-8	2/26/2010	0.55		SE-8	4/13/2011	0.71
CSS-C11-9	2/26/2010	0.41 I	I	SE-9	4/12/2011	**3.6**
CSS-C11-11	2/26/2010	0.66		SE-10	4/14/2011	1.5
CSS-C11-13	2/26/2010	**3.4**		SE-11	4/13/2011	**2.6**
CSS-C11-14	2/26/2010	0.63		SE-12	4/12/2011	0.86
CSS-C11-15	2/26/2010	0.46 I	I	SE-13	4/12/2011	**4.4**
CSS-C11-15 D	2/26/2010	0.8 I	I	SE-13D	4/12/2011	1.6
CSS-C11-15*	2/26/2010	0.88		SE-14	4/14/2011	**3.3**
CSS-C11-16	2/26/2010	0.67		SE-15	4/14/2011	**4.6**
CSS-C11-17	2/26/2010	0.33 I	I	SE-16	4/13/2011	**3.2**
CSS-C11-17D	2/26/2010	0.24 I	I	SE-17	4/12/2011	**3.1**
CSS-C11-17*	2/26/2010	0.34 I	I	SE-18	4/12/2011	**3.1**
CSS-C11-18	2/23/2010	**2.5**		SE-19	4/12/2011	0.62
CSS-C11-19	2/23/2010	1.8		SE-20	4/14/2011	0.59
CSS-C11-20	2/23/2010	0.069 U	U	SE-21	4/12/2011	**2**
CSS-C11-20D	2/23/2010	0.072 I	I	SE-22	4/12/2011	1.2
CSS-C11-20**	2/23/2010	0.6 U	U	SE-23	4/12/2011	**2.9**
CSS-C11-21	2/23/2010	1.1		SE-24	4/12/2011	**3.5**
CSS-C11-22	2/26/2010	0.17 I	I	SE-25	4/8/2011	**2.1**
CSS-C11-23	2/26/2010	0.2 I	I	SE-25D	4/8/2011	**2.4**
CSS-C11-24	2/26/2010	0.22 I	I			
CSS-C11-25	2/23/2010	**2.4**				
CSS-C11-25D	2/23/2010	**3.2**				
CSS-C11-25**	2/23/2010	**6.1**	I			
CSS-C11-26	2/23/2010	**2**				
CSS-C11-27	2/23/2010	**2.3**				
CSS-C11-28	2/23/2010	**2**				
CSS-C11-29	2/23/2010	**2.2**				
CSS-C11-30	2/23/2010	**3.1**				
CSS-C11-30D	2/23/2010	**3.4**				
CSS-C11-30**	2/23/2010	**5.9 I**	I			
CSS-C11-31	2/23/2010	1.7				
CSS-C11-32	2/26/2010	0.16 I	I			
CSS-C11-33	2/23/2010	**2**				
CSS-C11-34	2/23/2010	**5.3**				
CSS-C11-34D	2/23/2010	**5.9**				
CSS-C11-34**	2/23/2010	**6.4 I**	I			

APPENDIX A

LABORATORY ANALYTICAL DATA

APPENDIX B

UCL CALCULATIONS

APPENDIX C

ADaPT ERROR CHECKS

Attachment G: SFWMD Letter Requesting Inclusion of a Section Entitled "Residual Agricultural Chemicals" within the Broward County Water Preserve Area Final Integrated Project Implementation Report and Environmental Impact Statement, March 09, 2012.

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

March 09, 2012

Mr. David S. Hobbie
Deputy District Engineer, Jacksonville District
Programs and Project Management Division
U. S. Army Corps of Engineers
701 San Marco Blvd.
Jacksonville, FL 32207-8175

Dear Mr. Hobbie:

Subject: Request for Inclusion of a Section Entitled "Residual Agricultural Chemicals" within the Broward County Water Preserve Area Final Integrated Project Implementation Report and Environmental Impact Statement

I am writing on behalf of the South Florida Water Management District (SFWMD) to request inclusion of a section entitled "Residual Agricultural Chemicals" to the Broward County Water Preserve Area Final Integrated Project Implementation Report and Environmental Impact Statement (BCWPA). This request is in accordance with Paragraph 4 of the Comprehensive Everglades Restoration Plan (CERP) – Residual Agricultural Chemicals Memorandum issued September 14, 2011 from the Assistant Secretary of the Army for Civil Works. In accordance with the policy guidance, SFWMD requests that soils containing residual agricultural chemicals remain on project lands, and that the Jacksonville District handle these soils during construction efforts for the Project.

SFWMD has provided information to the Jacksonville District to fulfill the applicable requirements set forth in Paragraph 4 of the policy guidance for BCWPA Project and will work with the Jacksonville District to complete this new section in the 2012 revisions to BCWPA Final Project Implementation Report.

If you have any questions concerning this request, please contact Tom Teets, Federal Policy Chief, at 561-682-6993.

Sincerely,

Ernie Barnett
Director
Office of Everglades Policy and Coordination

EB/pv

c: Alan C. Bruns, USACE
Howard H. Gonzales, Jr., USACE
Mark Shafer, USACE
Kimberley A. Taplin, P.E., USACE
Tom Teets, SFWMD

3301 Gun Club Road, West Palm Beach, Florida 33406 • (561) 686-8800 • FL WATS 1-800-432-2045
Mailing Address: P.O. Box 24680, West Palm Beach, FL 33416-4680 • www.sfwmd.gov

A.20 VALUE ENGINEERING

US Army Corps of Engineers

U.S. ARMY CORPS OF ENGINEERS
JACKSONVILLE DISTRICT

FINAL VALUE ENGINEERING STUDY REPORT FOR

114627 Broward County Water Preserve Area (PIR)

Broward County, Florida

Sponsored By: South Florida Water Management District and U.S. Army Engineering District, Jacksonville

SEPTEMBER 2010

VALUE ENGINEERING TEAM STUDY

DOD SERVICE: USACE **VALUE ENGINEERING OFFICER:** Fred McAuley
CONTROL NO: CESAD-VE-10-008C

Final Value Engineering Report for

114627 Broward County Water Preserve Area (PIR)
Broward County, Florida

SEPTEMBER 2010

STUDY SPONSORS: South Florida Water Management District and USACE, Jacksonville District

VALUE ENGINEERING FIRM: Jacksonville District
ADDRESS: 701 San Marco Blvd
Jacksonville, FL 32232-0019
TELEPHONE: (904) 232-1903

VALUE ENGINEERING STUDY TEAM LEADER: Fred McAuley

VALUE ENGINEERING STUDY TEAM MEMBERS:
USACE: Alan Bruns, Rob Tucker, Gerald Deloach, Lisa Gued, Simon Jackson, Ali Rezaie, Lisa Eckert, Lori Hadley, Christyn Wiederhold, Kevin Larrimore, Krutarth Mehta, Amy Thompson, Rudy Wynn, Elizabeth Carwell

SFWMD: Jeff Neddle, Jose Guardiario, Gregory Coffelt, Jane LaBombard

USFWS: Steve Schubert, Darla Fousek

Florida DEP: Tracy Robb

VALUE ENGINEERING TEAM STUDY

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VALUE ENGINEERING TEAM STUDY

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PERMA-ZYME road stabilization

VALUE ENGINEERING TEAM STUDY

PROJECT DESCRIPTION AND BACKGROUND

PROJECT TITLE:	Broward County Water Preserve Area
PROJECT LOCATION:	Broward County, Florida

Broward County WPA (BCWPA) is located along the eastern edge of the remaining Everglades ecosystem and on the western edge of Ft. Lauderdale and its suburbs. The BCWPA Project Implementation Report (PIR) carries forward the planning and project implementation of the C-11 and C-9 Impoundments and the Levee Seepage Management Area (SMA) components.

This project was authorized by the Water Resources Development Act of 2000 (WRDA 2000) Section 601(2)(c). The study area consists of the proposed project site, WCA 3, and the affected drainage basins. The C-11 and C-9 drainage basins are located entirely within a portion of Broward County west of Fort Lauderdale. These two drainage areas approximate the cities of Weston, Davie, Southwest Ranches, Cooper City, Pembroke Pines, and Miramar. Western C-11 Basin drainage basins established by local drainage districts that reside, partially and wholly within the project study area include: the South Broward Drainage District, Central Broward Drainage District, and Indian Trace Drainage District. Local drainage districts located along the C&SF C-9 include: South Broward Drainage District and various municipalities that provide some control over incorporated limits.

The proposed project is located from the northern boundary of the North New River Canal to the southern boundary of the C-6 canal. The three components of the BCWPA project footprint are the C-11 Impoundment, the C-9 Impoundment, and WCAs 3A and 3B Levee Seepage Management, which will provide an interconnected series of marshlands, impoundments, STAs, conveyance, and aquifer recharge areas. These components and other related projects are depicted in Figure 1.

The BCWPA Project addresses loss of ecosystem function within the Everglades as a result of 1) damaging discharges of runoff from developed areas in western Broward County into the Everglades (Water Conservation Area 3A); 2) excessive nutrient loading to the Everglades and; 3) excessive seepage of water out of the Everglades to developed areas in western Broward County. The project addresses insufficient quantities of water available in the regional water management system during dry periods to meet municipal, agricultural, and environmental water supply demands. The selected plan reflects an optimization of reservoir configuration, storage volume, and seepage management features. The selected plan includes two above-ground impoundments and associated pumps and water control structures: the C-11 Impoundment with an effective interior storage of 1,068 acres and two wetland marsh mitigation areas north of the C-11 Impoundment with 488 acres of wetland marsh; the C-9 Impoundment with an effective interior storage of 1,641 acres and two wetland marsh mitigation areas north of the C-9 Impoundment with 339 acres of wetland marsh; canal conveyance improvements to connect the two impoundments; and an approximately 4,633 acre seepage management area east of the Water Conservation Areas.

Furthermore, natural system water within the Everglades seeps (via groundwater movement into the adjacent canal system) out of the Everglades into developed areas due to the highly transmissive aquifer underlying the project area, and the construction of the C&SF Project and associated secondary and tertiary drainage features. Since seepage effects are increased during dry periods when water is withdrawn from the natural system for water supply and protection against saltwater intrusion into drinking water aquifers, seepage of water out of the natural system also contributes to decline of ecosystem function in the project area. The BCWPA project is planned and designed primarily to perform two functions: 1) reduce seepage loss from WCA 3 to the C-9 and C-11 basins; and 2) capture and store excess surface water runoff from the Western C-11 Basin that is currently discharged untreated into WCA 3, thus reducing nutrient loading to the natural system.

The C-11 and C-9 impoundment components also aid the WCA 3A and 3B Seepage Management Area (3A/3B SMA) project component in reducing seepage from WCA 3A and WCA 3B by reducing the water level difference between WCA 3 and the drained areas immediately to the east. The impoundments will also assist in maintaining existing levels of flood protection that resulted from discharges at the S-9 pump station.

Everglades National Park (ENP) will benefit from changes to the current system. The timing and distribution of water to WCAs 3A and 3B would be changed to moderate extremes in seasonal water levels. Reduction in S-9 pumping would reduce flows and nutrients to the L-67 Canal in WCA 3A. The 3A/3B SMA would also reduce seepage of high quality natural system water from leaving WCA 3 that would eventually flow to the park. These changes in the timing, distribution, quality and quantity of water will benefit the Everglades Protection Area including fish and wildlife habitat in ENP. Northern Biscayne Bay will also benefit by increased incidental freshwater flows through the C-9 Canal during the dry season as the water stored in the C-9 Impoundment is released to prepare for the next storm event.

Approximate cost for construction of the project components are under development for the reissued PIR. A PIR update estimating action will follow in September 2010. For use in the Value Engineering Study, the following project features construction costs (in FY2010 $'s) are identified (Construction cost excluding real estate):

C-11 Impoundment Features:	$459.5 Million
C-9 Impoundment Features:	$214.2 Million
WCA 3A/3B Seepage Management Features:	$247.0 Million

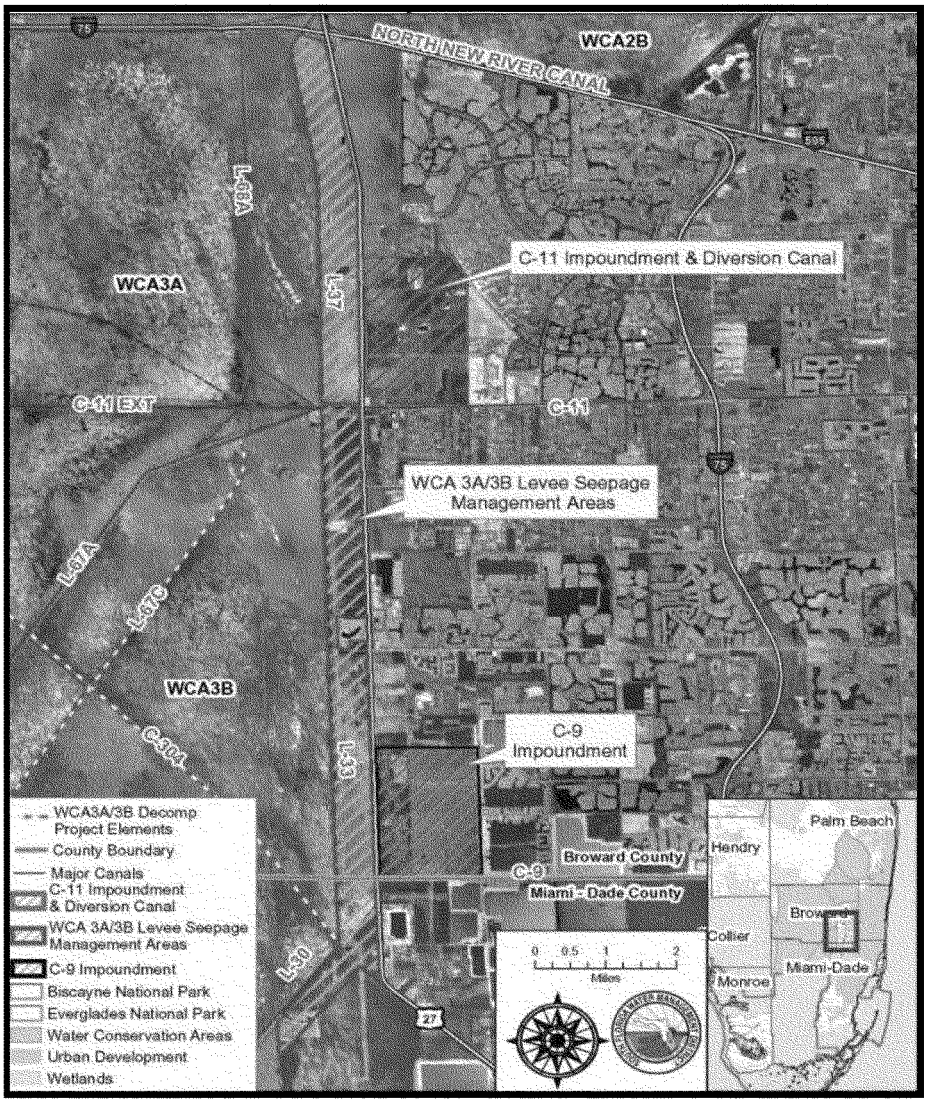
The Supporting Documents Appendices provides the names of Value Engineering Team Members, the Speculation List, Cost Models, and Function Analysis System List (a logic listing identifying project functions) and Function Analysis System Technique diagram (a logic diagram identifying project functions). The following Figures provide project views and supporting details for a quick reference to the project features:

VALUE ENGINEERING TEAM STUDY

PROJECT DESCRIPTION AND BACKGROUND

PROJECT TITLE: Broward County Water Preserve Area
PROJECT LOCATION: Broward County, Florida

FIGURE 1: BROWARD COUNTY WPA SITE MAP



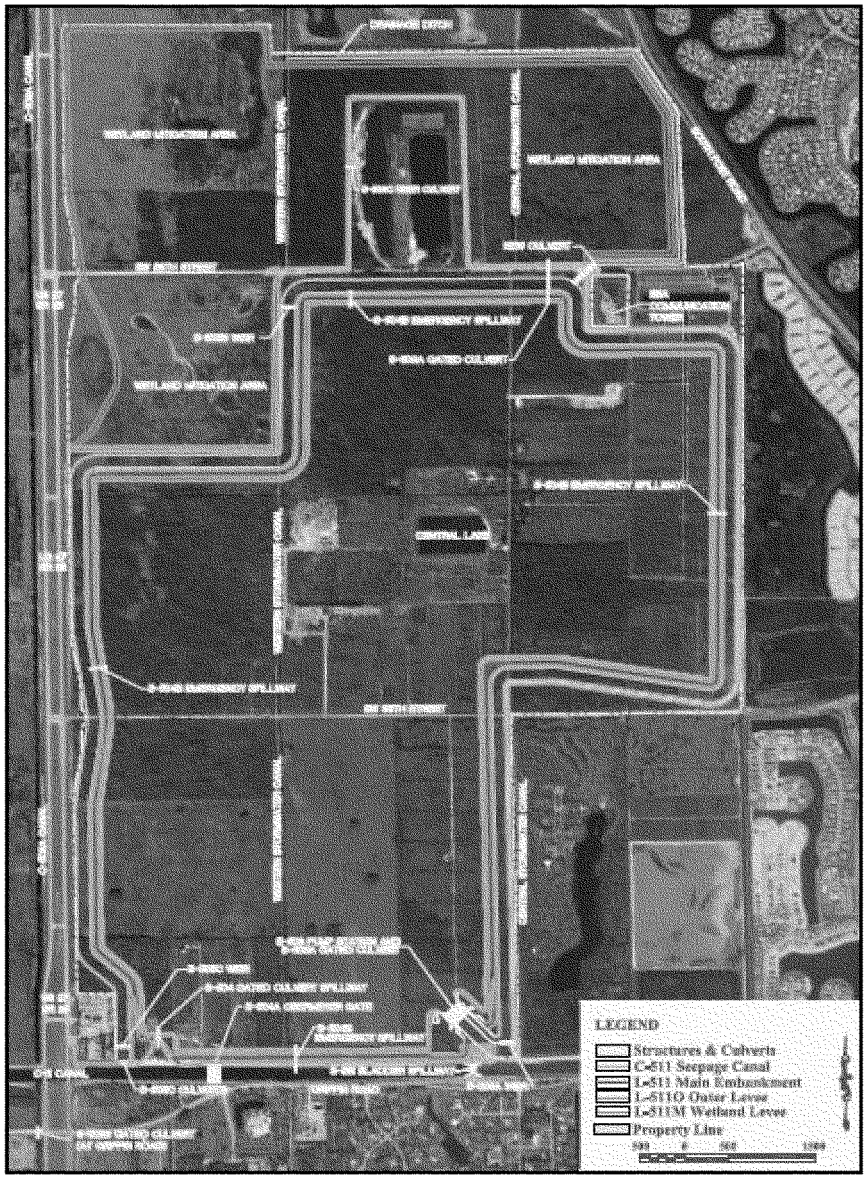
VALUE ENGINEERING TEAM STUDY

PROJECT DESCRIPTION AND BACKGROUND

PROJECT TITLE: Broward County Water Preserve Area

PROJECT LOCATION: Broward County, Florida

FIGURE 2: C-11 IMPOUNDMENT AND FEATURES



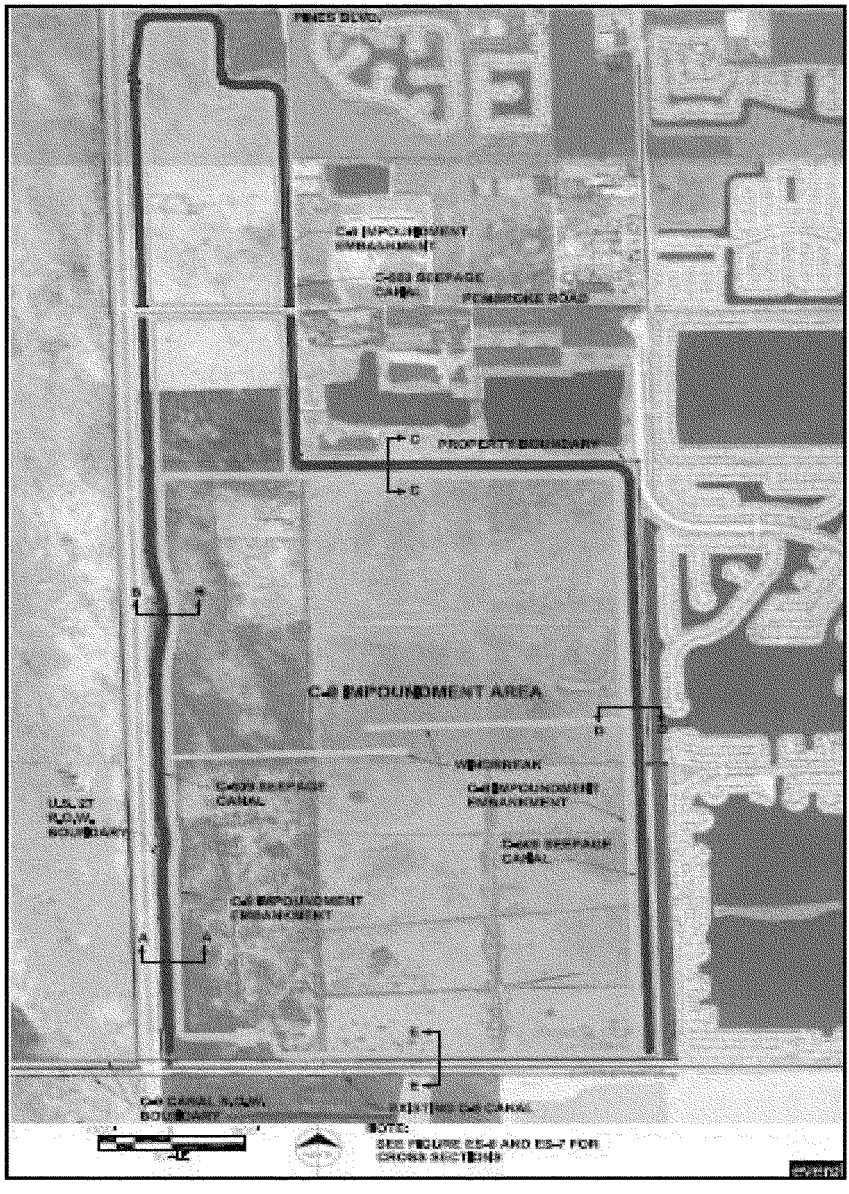
VALUE ENGINEERING TEAM STUDY

PROJECT DESCRIPTION AND BACKGROUND

PROJECT TITLE: Broward County Water Preserve Area

PROJECT LOCATION: Broward County, Florida

FIGURE 3: C-9 IMPOUNDMENT AND FEATURES

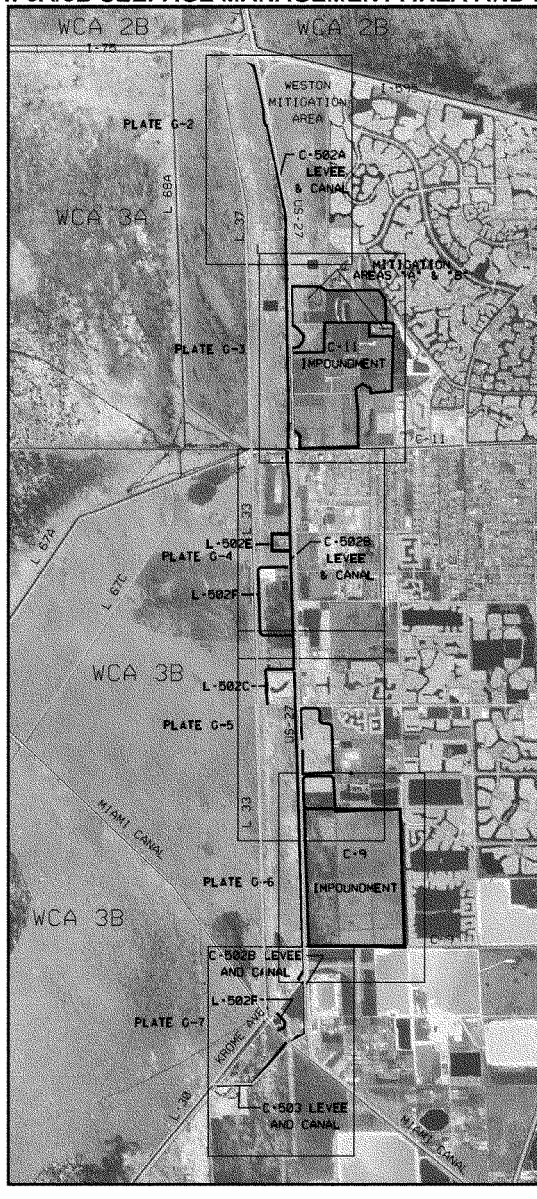


VALUE ENGINEERING TEAM STUDY

PROJECT DESCRIPTION AND BACKGROUND

PROJECT TITLE: Broward County Water Preserve Area
PROJECT LOCATION: Broward County, Florida

FIGURE 4: 3A/3B SEEPAGE MANAGEMENT AREA AND FEATURES



VALUE ENGINEERING TEAM STUDY
EXECUTIVE SUMMARY

The formal VE study process was conducted on 22 July 2010. The purpose for the VE activity was to conduct a Value Engineering study session to identify opportunities for design refinements and improvement to operations that could realize efficiency and economy within the project. The participants included members of the Florida Department of Environmental Protection, South Florida Water Management District Project and Jacksonville District Development Team (PDT) members.

The project was studied using the Corps of Engineers standard Value Engineering (VE) methodology, consisting of six phases:

Information Phase: The Team was presented plans, descriptions of project work, and cost estimates to fully understand the work to be performed and the project objectives to be achieved. Cost Models (see Appendix C) were compared to determine areas of relative high cost to ensure that the team focused on those parts of the project that offered the most potential for cost savings.

Function Analysis Phase: Value Engineering (VE) is a process used to study the functions a project is to accomplish. As a result, the VE team takes a critical look at how these functions are being met, and it identifies alternative ways to achieve the equivalent function while increasing the value, and the cost ratio of the project.

Creativity Phase: The Team speculated by conducting brainstorming sessions to generate ideas for alternative designs. All team members contributed ideas and critical analysis of the ideas was discouraged (see Appendix B).

Evaluation Phase: Evaluation, testing and critical analysis of all ideas generated during speculation was performed to determine potential for savings and possibilities for risk. Ideas were ranked by priority for development. Ideas that did not survive critical analysis were deleted.

Development Phase: VE team members developed the selected priority ideas identified during analysis into written proposals. Proposal descriptions and possible impacts to schedule and funding were identified for each item discussed. Savings were estimated where realized.

Presentation Phase: The draft VE Study Report is distributed for review and coordination by Project Development Team, including the project Sponsor, for determination of recommended action for each Proposal. A formal Presentation session will be conducted and actions for each proposal will be annotated on Summary of Proposals/Recommended Action. The VE report will be annotated with the recommended actions for each Proposal, and the report will be used with redesign and repackaging of PIR and future DDR documents. Final coordination will include a detailed review as part of the BCOE review for actions taken on specific VE proposals, and a determination of cost avoidance/saving realized with implementation of all VE proposals in the final design.

VALUE ENGINEERING TEAM STUDY

SUMMARY OF PROPOSALS / RECOMMENDED ACTION

PROPOSAL NUMBER	DESCRIPTION	POTENTIAL SAVINGS	RECOMMENED ACTION
C-1*	Use Profile High Density Polyethylene (HDPE) for precast culverts and pipes	$1,566,000*	**Analyze in Design Phase**
C-2*	Remove levee material and culvert between Finger Lakes in Mitigation Area A of the C-11 Impoundment	$ 365,000*	**Analyze in Design Phase**
C-3*	Alternative C-3A - Use existing berms in Weston for north perimeter levee L512 for Mitigation Area A of the C-11 Impoundment	$ 286,000*	**Analyze in Design Phase**
	Alternative C-3B - Move L-512 north to property line	($ 186,000)	**Analysis in Design Phase**
C-4	Add automating S-13 Pump Stations to BC WPA project scope	(Cost Increase TBD)	**Analyze in PIR**
C-5	Develop C-9 impoundment conversion to STA for future conditions	(No Cost Savings)	**Analyze in Design Phase**
C-6*	Use Buried Cellular Confinement Systems (to protect the C-9 Impoundment levees from overwash erosion - Shown in Life Cycle Present Worth)		**Analyze in**
	Vs. Soil Cement (LC PW)	($ 148,000)	**PIR&Design**
	Vs. TRM (LC PW)	($ 558,000)	**PIR&Design**
	Vs. 17.5 Foot Height (LC PW)	$4,106,000*	**PIR&Design**
	Vs. 15 Foot with Berm (LC PW)	$3,506,000	**PIR&Design**
C-7*	Use existing Sunset Lakes Canal for seepage management along eastern C-9 Impoundment boundary	($ 762,000)	**Analyze in Design Phase**
C-8*	Combine storage for C-9 and C-11 at C-11 Impoundment	(No Cost Savings)	**Reject**
C-9	Reorder the construction schedules for C-9 and 3A/3B Seepage Management Area	(No Cost Savings)	**Analyze in PIR**
C-10	Reduce Size of WCA 3A/3B SMA from 14 miles total length	(No Cost Savings)	**Reject**
Estimated Total Cost Savings		**$6,323,000**	

**Proposals identified by asterisk are potentially additive proposals to arrive at Estimated Potential Total First Cost Savings. No savings are claimed as C-10 remains possible future project requirement under Adaptive Management.*

VALUE ENGINEERING PROPOSAL

PROPOSAL NO: C-1 (Idea 23) PAGE NO: 1 OF 8

DESCRIPTION: Use Profile High Density Polyethylene (HDPE) for precast culverts and pipes

ORIGINAL CONDITION: Current culvert systems identify both Reinforced Concrete Pipe (Class IV and V) and precast FDOT Standard box culverts for water conveyance and control structures in the three features of the project - C-9 and C-11 Impoundments, and 3A/3B Seepage Management Area. Specific materials and structures are identified to an early PIR level of detail. Consideration is also being given to use of cast in place box culverts. PIR cost estimates are developed using the above culvert materials. See Table 1 - Broward County WPA Water Conveyance and Control Structures (C-11, C-9 and 3A/3B Seepage Management Area Structure Summary and Details).

PROPOSED CONDITION: It is recommended that all structures be considered for design using Profile High Density Polyethylene (HDPE). The HDPE pipe system is available to 120 Inch diameters and is readily adaptable to precast or cast in place gated structures and manholes as well as headwall systems. It is available in variable RSC (Ring Stiffness coefficient) specifying the pipe's load carrying capacity.

ADVANTAGES:

- Available in various dimensions and stiffness ratings for most project structures.
- Thermally fused to full structural length, the HDPE has no joints for leakage.
- Lower Manning's "n" will reduce many structures by one or more diameter or sizes.
- Cost of HDPE material pipes may initially appear be equal, or slightly more expensive than concrete, but on-site constructability advantages will result in faster construction and less cost for installation to net significant savings.

DISADVANTAGES:

- Coordination through MSC and HQ is still required for use of HDPE pipe through levees and reservoirs (See EM 1110-2-2902).

JUSTIFICATION: The Profile HDPE culvert pipe being evaluated is a flexible pipe such as Weholite, manufactured by KWH, and the KRAH profile HDPE pipe as manufactured by Krah Pipe Systems LLC, in South Carolina. The HDPE material is chemically inert, light weight; and it is essentially a single thermally welded pipe with no joints. It will deflect rather than crack under stress. HDPE offers greater resistance to corrosion and abrasion than concrete pipe. Concrete pipe is limited to sites where the pH is greater than 5.0; whereas HDPE can function with a pH as low as 2.0. HDPE pipe is stabilized with carbon black, an effective ultraviolet stabilizer (UV), and is suitable for use for exposure to sunlight. Smooth interior surface ("design" Manning's "n" = 0.009) can carry greater flows with smaller pipe diameters due to reduced friction losses. A broad range of RSC's, which specifies the pipe's load carrying capacity, is available. HDPE pipe simplifies handling and Installation; provides reduced weight for transportation and "telescoping" small pipes within larger ones for more pipe lengths per shipment; and most importantly quick installation and reduced dewatering costs.

The pipe comes in 20 to 50 ft. lengths, and therefore can be installed in long pipe sections very quickly. The pipe is connected by thermal fusion (heat fusion) and is pressure tested for leakage before backfilling occurs. HDPE pipes perform well when installed under roadways (RSC 250 may be recommended for under roadways). Specifications should refer to ASTM-F894 and specifically call for "fully fused/fully restrained" extrusion welded and/or electro-fused for the joining the pipe sections. Further engineering analysis should be performed to determine appropriate RSC level. Under the FDOT culvert life analysis program, HDPE is currently recognized as having a 100 year life service. Weholite Profile HDPE pipe was used for the Seminole Big Cypress Contract 1 siphon consisting of two – 60 Inch diameter HDPE siphon pipes, approximately 400 feet long. Two, 120 Foot – 60 Inch diameter HDPE pipe was also used for the gated control structure at Three Forks Marsh Conservation Area project.

The use of HDPE pipe is proposed for consideration in all three project components, C-9 and C-11 Impoundments, and 3A/3B Seepage Management features. This proposal should be carried into the design phase for determination which pipe and box culvert system may be appropriate for development using Profile HDPE pipe. C-11 and C-9 Impoundments and the 3A/3B SMA has approximately 6,200 LF and 48 culverts that may be evaluated for use of Profile HDPE pipe. Potential saving are estimated for both material and installation for specific structures identified in the detailed cost estimate. Estimated combined savings using HDPE pipe for the 48 selected culver conveyance structures is approximately $1,566,000.

Table 1 - Broward County WPA Water Conveyance and Control Structures (C-11, C9 and 3A/3B Seepage Management Area Structure Summary and Details):

Broward County WPA Water Conveyance and Control Structures						
Structure Summary and Details:						
C-11 Site Structures	Culvert Type	Pipe Diameter (In)/ Culvert Dimension (FT)	Culvert Design (cfs)	Culvert Length	Total Culvert Length	As HDPE Pipe (In)
S-500N	RCP Class IV	2 Ea. 72	250	166	332	66
S-500E	RCP Class IV	2 Ea. 72	250	170	340	66
S-500S	RCP Class IV	2 Ea. 72	250	236	472	66
S-500W	RCP Class IV	2 Ea. 72	250	170	340	66
S-501	RCP Class IV	48	Min.	164	164	42
S-503A	FDOT Std Box	5 X 6	200	266	266	66
S-504	FDOT Std Box	2 Ea. 8 X 8	1000	180	360	96
S-505E	RCP Class IV	3 Ea. 72	750	71	213	66
S-506A	RCP Class V	48	55	310	310	42
S-506B	RCP Class IV	72	358	292	292	66
S-506C	RCP Class IV	2 Ea. 60	75	60	120	54
S-507A - F	RCP Class IV	6 Ea. 48	Min.	72	432	42
S-508A	RCP Class IV	48	Min.	225	225	42
S-508B	RCP Class IV	48	Min.	200	200	42
Total					4066	

VALUE ENGINEERING PROPOSAL

PROPOSAL NO: C-1 PAGE NO: 3 OF 8

Broward County WPA Water Conveyance and Control Structures						
Structure Summary and Details:						
PIR C-9 Site Structures	Culvert Type	Pipe Diameter (In)/ Culvert Dimension (FT)	Culvert Design (cfs)	Culvert Length	Total Culvert Length	As HDPE Pipe (In)
S-510	RCP Class IV	2 Ea. 96	500	75	150	96
S-511	RCP Class IV	2 Ea. 96	500	60	120	96
S-512B*	RCP Class IV	3 Ea. 72	150	40	120	66
S-512C*	RCP Class IV	3 Ea. 72	150	40	120	66
S-513A	RCP Class IV	2 Ea. 48	50	125	250	42
S-513B	RCP Class IV	36	25	180	180	30
Total					940	

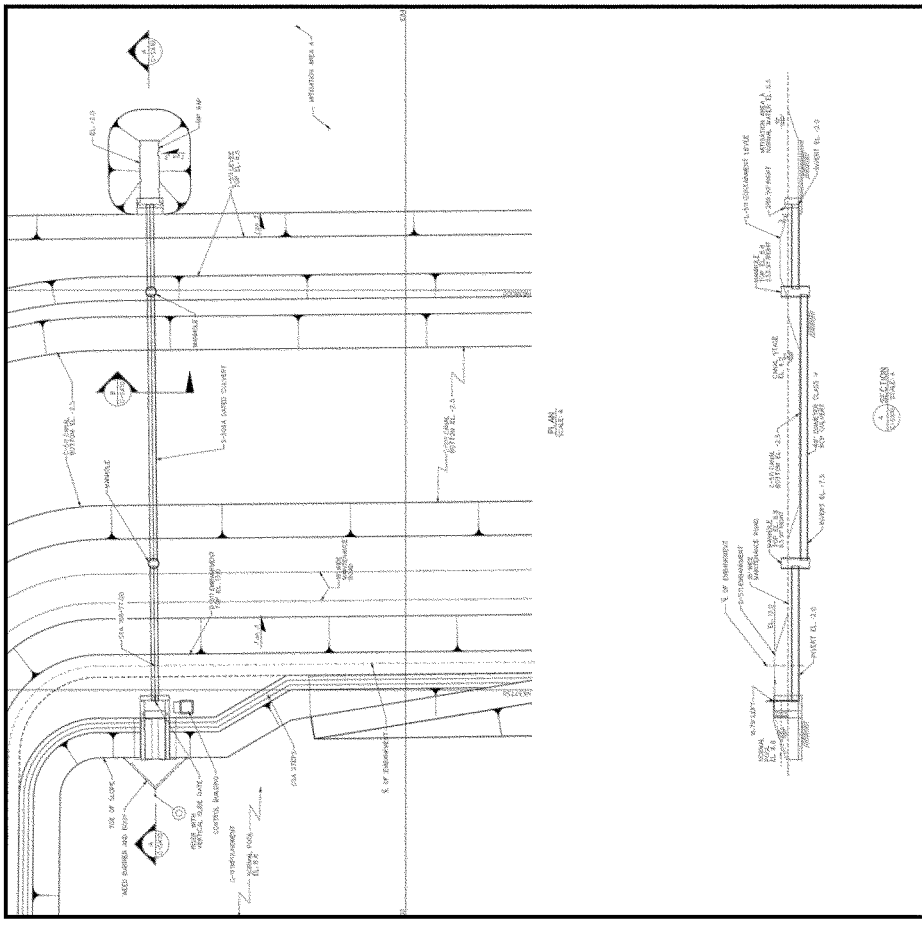
Broward County WPA Water Conveyance and Control Structures						
Structure Summary and Details:						
PIR 3A/3B SMA Site Structures	Culvert Type	Pipe Diameter (In)/ Culvert Dimension (FT)	Culvert Design (cfs)	Culvert Length	Total Culvert Length	As HDPE Pipe (In)
S-502B	RCP Class IV	7 Ea. 96	1000	60	420	96
S-515	RCP Class IV	2 Ea. 96	600	60	120	96
FPL 1-4,FPL 7-19	Single CAP	17 Ea. 48	>1	30	510	42
FPL 5,FPL 6	Double CAP	2X2 Ea. 48	>1	30	120	42
Total					1170	

VALUE ENGINEERING PROPOSAL

PROPOSAL NO: C-1 PAGE NO: 4OF 8

Current Typical PIR Feature

(C-11, S-506A - 48-Inch Class V RCP – Gated (Sag) Culvert)

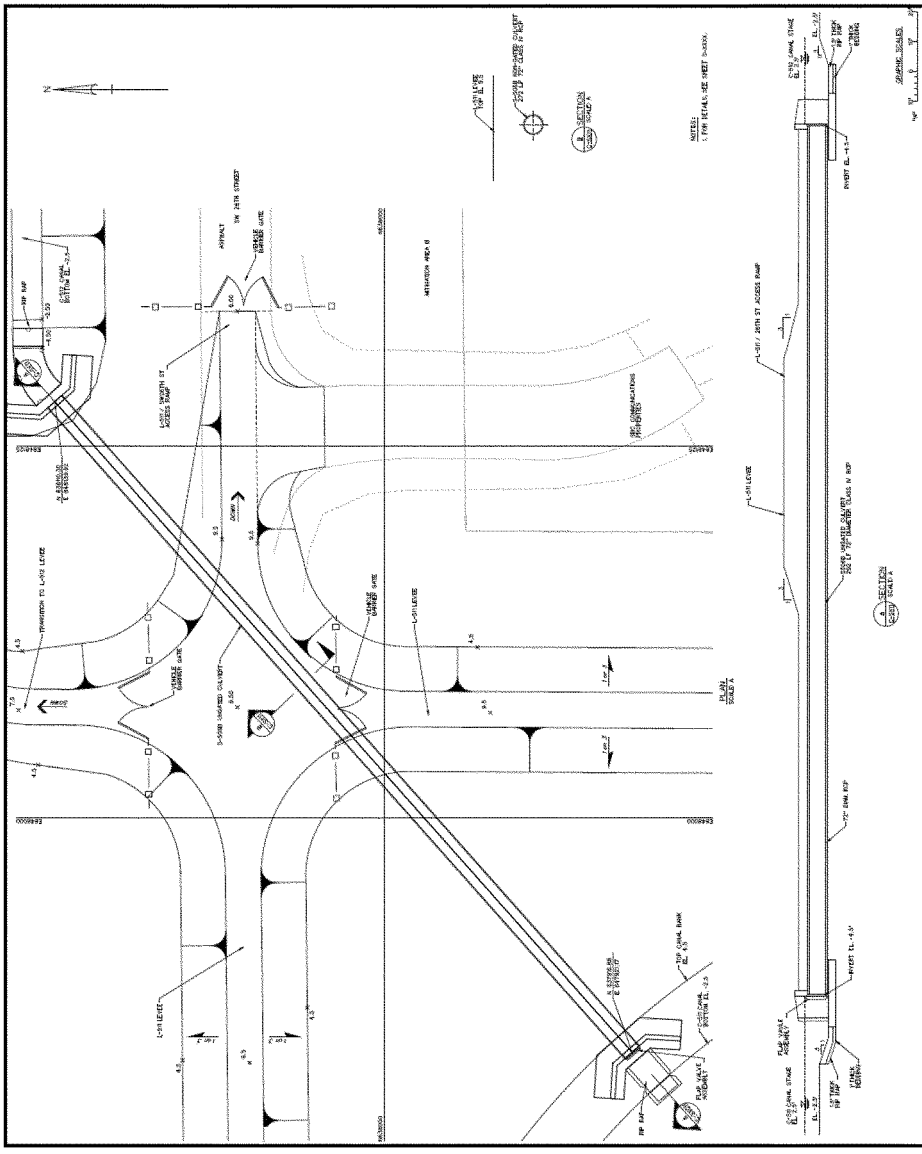


VALUE ENGINEERING PROPOSAL

PROPOSAL NO: C-1 PAGE NO: 5 OF8

Current Typical PIR Feature

(C-11, S-506B - 72-Inch Class IV RCP – Gated Culvert)

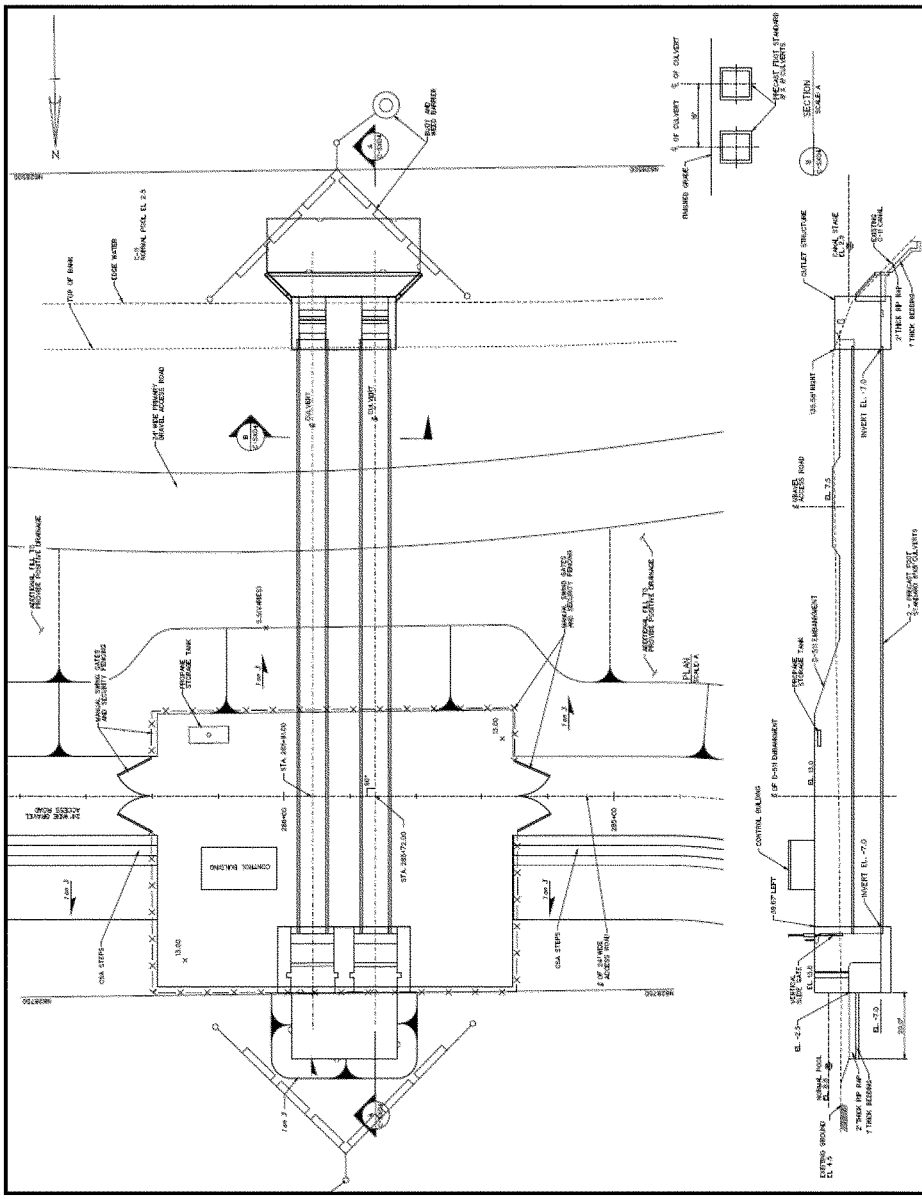


VALUE ENGINEERING PROPOSAL

PROPOSAL NO: C-1 PAGE NO: 6 OF 8

Current Typical PIR Feature

(C-11, S-504 - 2 Each 8 FT X 8 FT – Precast FDOT Std. Box Culvert)



VALUE ENGINEERING PROPOSAL

PROPOSAL NO: C-1 PAGE NO: 7 OF 8

Cost Estimate 1 of 2

COST ESTIMATE WORKSHEET

C-1 PROPOSAL DESCRIPTION: Use Profile High Density Polyethylene (HDPE) - Page 1/2

DELETIONS

	ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
C-11	S-500 N-E-S-W (4 X 2-72" RCP)	LF	1,400	$612.34	$857,276
	S-501 (1-48" RCP)	LF	164	$364.60	$59,794
	S-503A (5' X 6' CIP Box)	LF	266	$1,143.85	$304,263
	S-504 (2-8' X 8' CIP Box)	LF	360	$2,118.08	$762,510
	S-505E (3-72" RCP)	LF	213	$612.34	$130,428
	S-506A (1-48" RCP)	LF	304	$389.39	$118,376
	S-506B (1-72" RCP)	LF	292	$612.34	$178,803
	S-506C (2-60" RCP)	LF	108	$518.38	$55,985
	S-507A-F (6 X 1-48" RCP)	LF	432	$359.13	$155,144
	S-508A (1-48" RCP)	LF	225	$359.12	$80,802
	S-508B (1-48" RCP)	LF	200	$359.13	$71,826
					$0
			Total Deletions		$2,775,207

ADDITIONS

	ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
C-11	S-500 N-E-S-W (4 X 2-66" HDPE)	LF	1,400	$601.58	$842,209
	S-501 (1-42" HDPE)	LF	164	$302.93	$49,681
	S-503A (1-66" HDPE)	LF	266	$601.58	$160,020
	S-504 (2-96" HDPE)	LF	360	$859.35	$309,366
	S-505E (3-66" HDPE)	LF	213	$601.58	$128,136
	S-506A (1-42" HDPE)	LF	304	$309.51	$94,091
	S-506B (3-66" HDPE)	LF	292	$601.58	$175,661
	S-506C (2-54" HDPE)	LF	108	$430.78	$46,524
	S-507A-F (6 X 1-48" HDPE)	LF	432	$302.93	$130,866
	S-508A (1-42" HDPE)	LF	225	$302.93	$68,159
	S-508B (1-42" HDPE)	LF	200	$302.93	$60,586
					$0
			Total Additions		$2,065,299
		Net Cost Decrease/Increase			$709,908
	*	Mark-ups	132.85%		$943,099
		Total Cost Decrease/Increase			$1,653,007
	Roll Up C-11, C-9 and 3A/3B SMA	Total Cost Decrease/Increase			$1,566,190

* Mark-ups: Gen. Contractor Mark-up - 84.8% (Field Office/Home Office/Profit/Bond); Contingencies - 26.0% = 132.8%

VALUE ENGINEERING PROPOSAL

PROPOSAL NO: C-1 PAGE NO: 8 OF 8

Cost Estimate 2 of 2

COST ESTIMATE WORKSHEET

C-1 PROPOSAL DESCRIPTION: Use Profile High Density Polyethylene (HDPE) - Page 2/2

DELETIONS

	ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
C-9	S-510 (2-96" RCP)	LF	150	$735.90	$110,385
	S-501 (1-48" RCP)	LF	120	$735.90	$88,308
	S-512B (3-72" RCP)	LF	120	$612.34	$73,481
	S-512C (3-72" RCP)	LF	120	$612.34	$73,481
	S-513A (2-48" RCP)	LF	250	$359.13	$89,782
	S-513B (1-36" RCP)	LF	180	$295.03	$53,106
SMA	S-502B (7-96" RCP)	LF	420	$735.90	$309,078
	S-515 (2-96" RCP)	LF	120	$735.90	$88,308
	FPL 1-4 & 7-19 (17-48" RCP)	LF	510	$355.13	$181,118
	FPL 5 & 6 (2 X 2-48" RCP)	LF	120	$355.13	$42,616
					$0
					$0
			Total Deletions		$1,109,663

ADDITIONS

	ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
C-9	S-510 (2-96" HDPE)	LF	150	$859.35	$128,902
	S-501 (1-42" HDPE)	LF	120	$859.35	$103,122
	S-512B (3-66" HDPE)	LF	120	$601.58	$72,189
	S-512C (3-72" HDPE)	LF	120	$601.58	$72,189
	S-513A (2-42" HDPE)	LF	250	$302.93	$75,732
	S-513B (1-36" HDPE)	LF	180	$221.77	$39,919
SMA	S-502B (7-96" HDPE)	LF	420	$859.35	$360,927
	S-515 (2-96" HDPE)	LF	120	$859.35	$103,122
	FPL 1-4 & 7-19 (17-42" HDPE)	LF	510	$302.93	$154,494
	FPL 5 & 6 RCP (2 X 2-42" HDPE)	LF	120	$302.93	$36,352
					$0
					$0
			Total Additions		$1,146,948

		Net Cost Decrease/Increase		-$37,285
	*	Mark-ups	132.85%	-$49,532
		Total Cost Decrease/Increase		-$86,817
	Roll Up C-11, C-9 and 3A/3B SMA	Total Cost Decrease/Increase		$1,566,190

* Mark-ups: Gen. Contractor Mark-up - 84.8% (Field Office/Home Office/Profit/Bond); Contingencies - 26.0% = 132.8%

VALUE ENGINEERING PROPOSAL

PROPOSAL NO: C-2 (Idea 22) PAGE NO: 1 OF 4

DESCRIPTION: Remove levee material and culvert between Finger Lakes in Mitigation Area A of the C-11 Impoundment

ORIGINAL CONDITION: Current plans in the PIR propose an ungated culvert connection (S-508C) within Mitigation Area A between two existing borrow lakes identified as the Western and Eastern Finger Lakes. The size and length of this culvert varies in the PIR; however, in the Intermediate Design Plans, it is specified as a 225 ft. long 48" RCP identified as S-508A (Naming convention change). There is also an area between the lakes that is being considered as part of the mitigation area acreage. At this time, the proposal for Mitigation Area A is enhancement of the property through removal of exotic vegetation with maintenance and natural recruitment thereafter along with improved hydrology. Small levees (L-515) are proposed completely around both Finger Lakes with the intent to maintain water levels in the mitigation area slightly above the water level in the lakes. Recreational boating, presumably non-motorized, is limited to one lake at a time. Both lakes are long and somewhat narrow (hence "finger lakes").

PROPOSED CONDITION: It is recommended that two channels be constructed connecting the lakes, one at the north end and one south, along with elimination of the S-508A culvert. The levees between the lakes will be replaced with a shorter segment along the north side, making the levee contiguous to both lakes. Additionally, lowering the area between the lakes to an elevation slightly above the normal level in the lakes will provide a littoral shelf for wildlife and wetland plants. Alternatively, depending on the vegetation conditions and mitigation requirements, this area can just be left in its current state to become a bird rookery once it becomes an "island", or it can be completely excavated, creating one large lake. Material may be used for construction

ADVANTAGES:

- Eliminates the cost of the culvert installation and future maintenance.
- Improves wildlife and recreational use of the existing lakes.
- Reduces the length of berms required around the lakes.
- Creates a natural feature for wildlife and public interest.

DISADVANTAGES:

- Changes design plans for C-11 project.
- Additional excavation required for second connection.
- May decrease mitigation area acreage.
- May generate more unsuitable (organic) material for disposal.

JUSTIFICATION: Removing the culvert and providing open connections eliminates most of the costs associated with installation of this pipe. This culvert is identified on design plans as 225 feet of 48" reinforced concrete pipe installed approximately 8 feet below existing ground. Additional cost savings will also be realized through the reduction of approximately 3,200 lf of levees around the Finger Lakes. Recreational use will be improved by allowing boating access to both lakes from a single launch point, presumably near the recreational area by the Western Finger Lake and a longer route that circumnavigates the lakes.

VALUE ENGINEERING PROPOSAL

PROPOSAL NO: C-2 (Idea 22) PAGE NO: 3 OF 4

The proposed width of the channel openings is roughly 30 feet with a depth of around 6 feet below existing ground and side slopes of 1:2, or possibly steeper given the rock conditions. With respect to the mitigation area acreage, the creation of this natural feature on the 7.3+ acres should still provide mitigation credits even without the desired hydroperiod if the area is appropriately lowered by about 1 foot. If left natural and outside of the Mitigation Area A, which is expected to have an improved hydrology, the area may be considered upland.

Wildlife benefits are realized by elimination of predatory hiding common within culvert structures and gaining full open light connection for species to move between the two finger lakes.

This change can be evaluated for incorporation into the PIR or to defer it to the future design phase. Potential savings for this proposal is estimated as $365,000.

Material Quantity Calculations:

Deduct

1. S-508C Culvert 225 lf of 48" RCP
2. L-515 Levee 3,200 lf

Add

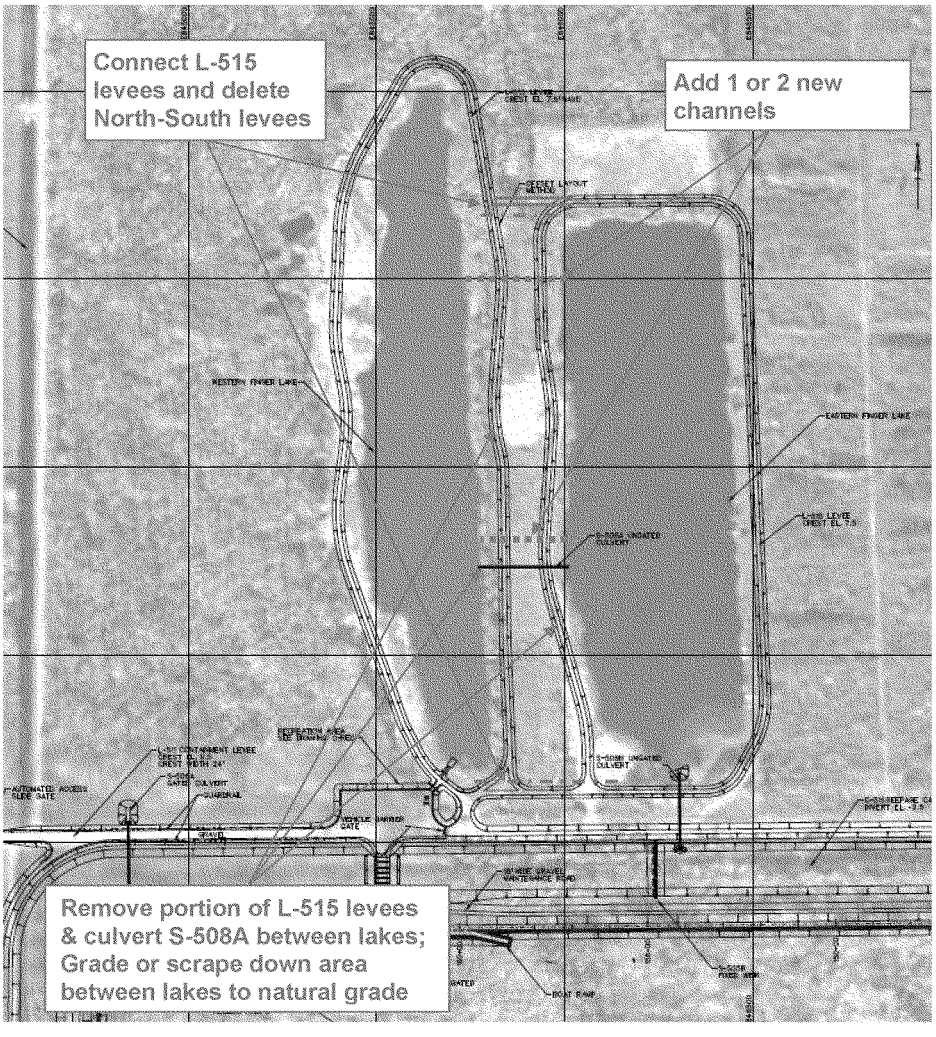
1. Excavation for Channels 2 @ 1,500 CY
   (225 lf x 30 ft wide x 6 ft deep)
2. Scrape down Area 12,000 CY
   (Lower 7.3 acres by 1 foot)This activity is not recommended, but is estimated in description of estimate. It was not used to reduce net savings.

VALUE ENGINEERING PROPOSAL

PROPOSAL NO: C-2 (Idea 22) PAGE NO: 3 OF 4

Current and Proposed PIR Feature

(C-11 Mitigation Area A with S-508A 48" RCP and Proposed changes)



VALUE ENGINEERING PROPOSAL

PROPOSAL NO: C-2 (Idea 22) PAGE NO: 5 OF4

Cost Estimate

COST ESTIMATE WORKSHEET

C-2 PROPOSAL DESCRIPTION: Remove levee material and culvert between Finger Lakes in C-11 Mitigation Area A

DELETIONS

ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
S-508A 48" RCP	LF	225	$364.60	$82,035
Portion of L-515 Levee	LF	3,200	$15.18	$48,576
L-515 Agg Surface Course	CY	1,067	$88.35	$94,240
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
		Total Deletions		$224,851

ADDITIONS

ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
Channel Excavation (30' W X 6' D X 225' L)	CY	1,500	$10.57	$15,855
Grade and Stockpile (7.3 Acres X 1')	CY	12,000	$4.34	$52,080
(Grading and Stockpile is required				$0
12,000 CY X $4.34 = $52,560)				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
		Total Additions		$67,935

	Net Cost Decrease/Increase		$156,916
*	Mark-ups	132.85%	$208,463
	Total Cost Decrease/Increase		$365,379

* Mark-ups: Gen. Contractor Mark-up - 84.8% (Field Office/Home Office/Profit/Bond); Contingencies - 26.0% = 132.8%

VALUE ENGINEERING PROPOSAL

PROPOSAL NO: C-3 (Idea 10) PAGE NO: 1 OF 6

DESCRIPTION: Use existing berms in Weston for north perimeter levee L512 for Mitigation Area A of the C-11 Impoundment or move L-512 north to property line

ORIGINAL CONDITION: Current plan in the PIR proposes construction of a levee L-512 and canal C-512 along the north property line. The purpose of this canal is for seepage management and stormwater conveyance. These features will be located between two mitigation areas: Mitigation Area A, which is proposed as part of the BCWPA project and an existing mitigation area maintained by the Village of Weston. The proposed water level for Mitigation Area A is 1 foot higher than Weston's mitigation area.

PROPOSED CONDITION: It is recommended the C-512 Canal along the north property line be eliminated from the project. For the L-512 Levee, it can be constructed immediately adjacent to the existing berm located along the south side of Weston's mitigation area (Alternative C-3a). Access can be over the new levee or alternatively, over Weston's levee berm through acquisition of an easement. Or, it may be offset 15 feet from BCWPA property line as is levee L-514(Alternative C-3b).

ADVANTAGES:

- Reduces costs for the canal and possibly levee.
- Eliminates concerns about the operational level of the C-512 seepage canal.
- Increases the acreage for Mitigation Area A by over 9 acres.

DISADVANTAGES:

- Changes design plans for C-11 project.
- Requires inclusion of access easement or fee title over existing levee berm in agreement between District and Weston or levee must remain of project property.
- Potential seepage impacts when Mitigation Area A is used for additional storage.

JUSTIFICATION: During the initial planning and design phases for C-11, there were concerns about the elimination of the existing western stormwater canal which resulted in the continuation of the C-512 canal along the northern project boundary. After researching the existing stormwater permits for the Village of Weston, it was determined that the canal was not intended to serve the residential outparcel and mitigation sites to the north. The areas north of the project discharge by gravity eastward through several control structures and into Weston's stormwater management system. Therefore, this canal is not needed for stormwater conveyance.

With respect to seepage, approximately 3,800 lf of the C-512 canal is proposed between two mitigation areas. The desired water elevation in Mitigation Area A is one foot higher than the elevation of the existing mitigation area immediately to the north and 0.5 feet higher that the other existing mitigation areas in the vicinity. Historically, the existing mitigation site just to the north has been too dry. If a seepage canal is constructed between the two areas, there is a potential for it to create a "drain". Given the minimal differential between the sites during normal operational levels, the seepage canal would likely be more detrimental to the wetlands in the area that beneficial.

One concern is the possibility of off-site seepage impacts when Mitigation Area A is used for additional storage, which could add an additional 1.5 feet to the water levels. This infrequent operational scenario is expected only during a major storm event when the impoundment is at capacity and for a short duration due to concerns with survival of the mitigation vegetation. Seepage to the north of the project should not result in adverse impacts to the existing mitigation area.

For the L-512 levee, it was envisioned that the existing levee berm constructed as part of Weston's mitigation area could be also utilized for Mitigation Area A, both for containment and access (Alternative C-3a). . According to the design plans, it appears to have sufficient height. It also has a wide stabilized access road. Potentially, the width of the levee section could be reduced through the negotiation of an access easement over the existing levee berm. However, it is unlikely that this existing berm was constructed to levee standards that would be acceptable to the Corps and improving the adequacy of the berm would be required (50% is estimated for new levee random fill to improve the existing levee). Further testing could better identify the level of improvement and if improvement needed.

Normally Federal projects are required to have independent facilities that are located on lands held by the local sponsor. Therefore, for the proposed alternative, a new levee can be constructed immediately adjacent to the existing levee berm on District lands (Alternative C-3b) with the height and construction requirements specified under this project to meet levee standards. It may be constructed 15 feet south of the C-11 property line as is levee L-514.

By eliminating the canal and minimizing the L-512 levee construction, the acreage for Mitigation Area A may be increased by up to 9 acres. This change can be evaluated for incorporation into the PIR or to defer it to the future design phase. Potential savings for this proposal as described under Alternative C-3a is estimated as $286,000. Potential cost as described under Alternative C-3b is estimated as -$186,000. Any cost for Real Estate actions with Weston is unknown and is not included in the construction estimates.

Material Quantity Calculations:

Deduct

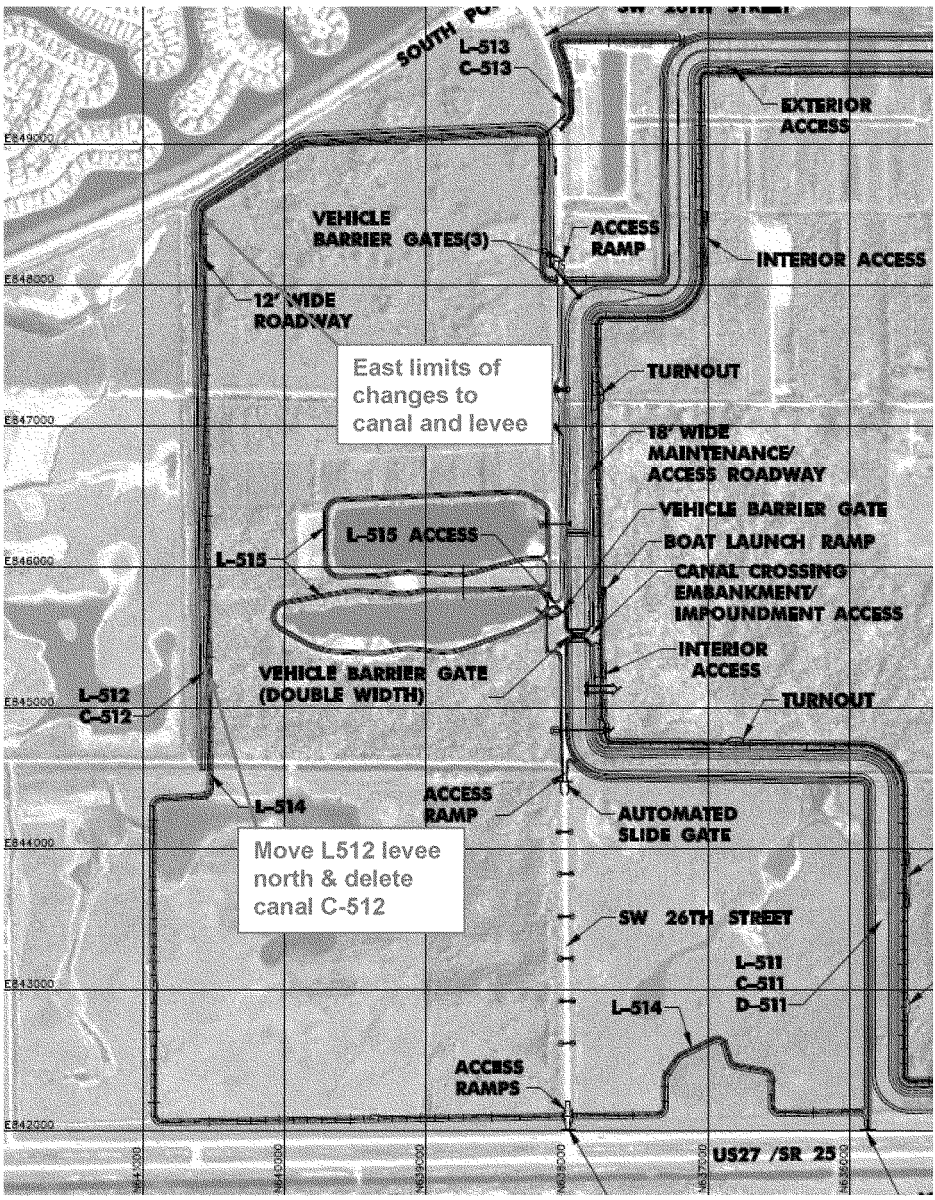
1. Delete C-512 Canal 3,800 lf
2. Delete or Relocate L-512 Levee 3,800 lf
   (If incorporated into existing Weston levee, a 50% reduction is assumed. If relocated to 15 FT of north C-11 property line, no quantity reduction is assumed.)

VALUE ENGINEERING PROPOSAL

PROPOSAL NO: C-3 (Idea 10) PAGE NO: 3 OF 6

Current and Proposed PIR Feature

(C-11Mitigation Area A, C-512 Seepage Canal & L-512 Levee)

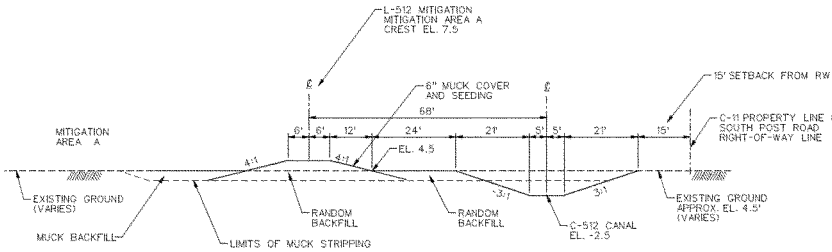


VALUE ENGINEERING PROPOSAL

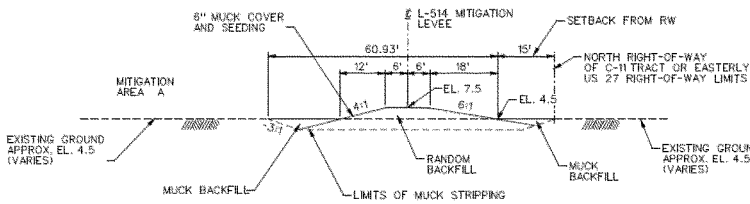
PROPOSAL NO: C-3 (Idea 10) PAGE NO: 4 OF 6

Proposed Typical PIR Feature

(C-11 Mitigation Area A – L-512 Levee Revision to Follow L-514 Levee Section)



TYPICAL SECTION 8 – 8
MITIGATION AREA A
STATION 0+00 TO STATION 78+10



TYPICAL SECTION 9 – 9
MITIGATION AREA A
STATION 78+10 TO STATION END

Alternative C-3a: Use existing Weston Perimeter Levee or Alternative C-3b: Replace L-512 Levee Typical Section 8-8 from Station ~40+00 to ~78+10

VALUE ENGINEERING PROPOSAL

PROPOSAL NO: C-3 (Idea 10) PAGE NO: 5 OF 6

Cost Estimate C-3a

COST ESTIMATE WORKSHEET

C-3a PROPOSAL DESCRIPTION: Use existing berms in Weston for north perimeter levee L512 for Mitigation Area A of the C-11 Impoundment (Use Weston levee plus 50% random fill required)

DELETIONS

	ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
C-11	Canal C-512	CY	30,500	$10.57	$322,385
					$0
					$0
					$0
					$0
					$0
					$0
					$0
					$0
					$0
					$0
					$0
			Total Deletions		$322,385

ADDITIONS

	ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
C-11	Bulk borrow L-512 - 50% levee random fill	CY	13,150	$15.18	$199,617
	(Within C-11 same as L-514)				$0
					$0
					$0
					$0
					$0
					$0
					$0
					$0
					$0
					$0
					$0
			Total Additions		$199,617

	Net Cost Decrease/Increase		$122,768
*	Mark-ups	132.85%	$163,097
	Total Cost Decrease/Increase		$285,865

* Mark-ups: Gen. Contractor Mark-up - 84.8% (Field Office/Home Office/Profit/Bond); Contingencies - 26.0% = 132.8%

VALUE ENGINEERING PROPOSAL

PROPOSAL NO: C-3 (Idea 10) PAGE NO: 5 OF 6

Cost Estimate C-3b

COST ESTIMATE WORKSHEET

C-3b PROPOSAL DESCRIPTION: Use existing berms in Weston for north perimeter levee L512 for Mitigation Area A of the C-11 Impoundment (Move new L-512 levee north to property line - 100% random fill required)

DELETIONS

	ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
C-11	Canal C-512	CY	30,500	$10.57	$322,385
					$0
					$0
					$0
					$0
					$0
					$0
					$0
					$0
					$0
					$0
			Total Deletions		$322,385

ADDITIONS

	ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
C-11	Bulk borrow L-512 -100% levee random fill	CY	26,500	$15.18	$402,270
	(Within C-11 same as L-514)				$0
					$0
					$0
					$0
					$0
					$0
					$0
					$0
					$0
					$0
			Total Additions		$402,270
		Net Cost Decrease/Increase			-$79,885
	*	Mark-ups	132.85%		-$106,127
		Total Cost Decrease/Increase			-$186,012

* Mark-ups: Gen. Contractor Mark-up - 84.8% (Field Office/Home Office/Profit/Bond); Contingencies - 26.0% = 132.8%

VALUE ENGINEERING PROPOSAL

PROPOSAL NO: C-4 (Idea 31) PAGE NO: 1 OF 1

DESCRIPTION: Add automating S-13 Pump Stations to BC WPA project scope

ORIGINAL CONDITION: Currently S-13 forward pumps are used when tides are high in Port Everglades and the Eastern C-11 basin stormwater needs to be discharged, and the head needed to push the water through the gated structures are not sufficient to provide flood protection.

PROPOSED CONDITION: This proposal is to automate the pumps with telemetry to allow for more frequent use of the pumps. This would allow for a bleed down of the proposed C-11 impoundment whenever bleed down is required without scheduling in advance to bring in a crew to operate the S-13 pumps.

ADVANTAGES:

- Automation of the S-13 pumps would give much increased bleed down capabilities of the C-11 impoundment without advanced scheduling crews for manual operation of pumps.
- More bleed down of the impoundment allows for more diversion of stormwater from the Western C-11 Basin away from WCA 3A, and thus increases benefits from the project.

DISADVANTAGES:

- Initial cost will be increased to provide telemetry and pumping automation.

JUSTIFICATION: Increased benefits to the project will be realized with more effective pumping the Eastern C-11 basin of stormwater. The S-13 forward pumps are manually operated so an operational crew is required to be sent to operate the structure every time pumping operations are needed. Scheduling crews to operate pumps is no longer required with pump station automation. Lower operational crew labor cost can eventually offset added cost for the automation of S-13 pumps.

This is an improvement to the S-13 pump station feature and it should be considered for inclusion into the PIR project scope description and cost estimate. This is considered a "Qualitative Value Engineering Proposal". There are no estimated VE savings, but added project benefits and offset labor cost will be realized with S-13 automation. A decision is required to add this component to the PIR. Associated costs will need to be developed based on a scope of work to be further defined.

VALUE ENGINEERING PROPOSAL

PROPOSAL NO: C-5 (Idea 25) PAGE NO: 1 OF 1

DESCRIPTION: Develop C-9 impoundment conversion to STA for future conditions

ORIGINAL CONDITION: The current design is for a 4.3 foot full pool above ground impoundment to store excess stormwater from the C-11 Western basin in order to divert that stormwater from Water Conservation Area 3A. When the North Lake Belt Storage Area (NLBSA) comes on line, (in 2036 as per the original CERP planning horizon), it was anticipated that the C-9 impoundment would be converted to an STA to provide pre or post treatment (depending on future permit requirements) storage for NLBSA. The NLBSA has adequate storage to hold all of Western C-11 stormwater, so C-9 impoundment will not be needed for storage - if and when NLBSA comes on line.

PROPOSED CONDITION: During the current planning phase, identify the design features for converting the above ground storage impoundment to an STA during the design phase. Design features include smaller inflow pumps, and internal redistribution levees and water control structures.

ADVANTAGES:

- Avoid redesign and more construction in 2036 when the STA may be needed to provide treatment for NBLSA.

DISADVANTAGES:

- 2036 is 26 years into the future. NLBSA may not be implemented at that time due to (1) cost, or (2) failure of the pilot project, or (3) reduced demands for water deliveries along the Lower East Coast (LEC) because of more consistent hydroperiods maintained in the Everglades due to restoration efforts.
- Internal levees within the storage impoundment will take up storage capacity and have increased cost.

JUSTIFICATION: The PIR states "Future CERP projects requiring water quality treatment will address conversion of the C-11 and C-9 impoundments to STAs." As a minimum, identification of future STA features required for converting the above ground storage impoundment to an STA should be considered during the design that will include additional new smaller STA inflow pumps and internal redistribution levees and structures. Future STA pumping requirements could be used in developing the current storage capacities for the C-9 pump station structure, but using a different mix of pumps sized such as 3- 75 cfs electric pumps and 3-280 cfs diesel engines, or 4-75 cfs electric pumps and 3-260 cfs diesel engines. Original pump equipment will be past its service life, but the pump station structure will be ready for conversion. More grading refinements to the impoundment bottom may be required also. Allowance for dimensioning of these features could influence the initial design of the impoundments and placement of structures and future internal levees.

Incorporation of conversion features for future operations as a STA may need to be addressed with a designated point for action – in PIR, or later in design of plans and Specs. This idea should be cost neutral to the current project which addresses future flexibility for another function, and no savings are identified at this time.

VALUE ENGINEERING PROPOSAL

PROPOSAL NO: C-6 (Idea 3) PAGE NO: 1 OF 9

DESCRIPTION: Use Buried Cellular Confinement Systems (Geocells) to protect the C-9 Impoundment levees from overwash erosion

ORIGINAL CONDITION: The current alternatives consist of armoring the backside of the levee with a Turf Reinforcement Mat (TRM) or buried soil-cement. The local sponsor (SFWMD) has expressed concern over the long term durability of the TRM and would prefer another alternative. The buried soil cement is considered a maintenance risk as severe wet conditions from rain and overwash could result in sloughing of top soil, requiring regrading and regrassing of embankment slopes. C-9 could also be developed with a wave bench and reduced 15 FT crest height.

PROPOSED CONDITION: It is recommended that the use of buried cellular confinement systems (Geocell system with geotextile filter cloth) be considered for armoring the backside of the levee. The 8 inch thick Geocells will be buried under at least one foot of topsoil, covered with sod. The buried Geocells offer comparable reliability and costs to buried soil cement, without some of the maintenance issues associated with the buried soil cement should erosion occur.

ADVANTAGES:

- Proven system, invented over 30 years ago by USACE and Presto Geosystems.
- The systems allows for a direct drainage path under the sod, which allows for a stronger and more robust root system. (An advantage over the buried soil cement)

DISADVANTAGES:

- May need dedicated QA/QC with the contractor's placement to ensure proper installation during construction.

JUSTIFICATION: The target crest height of 15 feet will require backside armoring. Geocells were invented by USACE and Presto Geosystems to develop a stable road system in unstable soft soils. Since that time, the Geocells have been used to provide an inexpensive solution to slope protection, channel protection, and erosion control. The cells within the system provide a form to contain soil, vegetation, and/or concrete, stabilizing the lateral movement of the infill.

For this application, Geocells will prevent erosion from overwash. The Geocells will be buried under at least one foot of topsoil and covered with sod. The Geocells will be filled with granular stone drain material. Sod works well with the Geocells as the roots provide an extensive mesh that will be able to work their way through the top soil to the cells. Extra stability is obtained when the roots grow into the perforations. The grass will be the primary barrier against overwash. Should the grass allow gullies and rills in the 1-foot thick layer of topsoil on the embankment, the secondary barrier (Geocells) will provide sufficient protection against overwash erosion. Protected by the one foot thick top soil, the Geocells do not have direct exposure from mowing and maintenance vehicle loading. They will confine the soil to prevent lateral movement and rutting below vehicles. The soil provides the support for construction equipment and lawn

maintenance mowers can adequately drive across the soil covered and grassed Geocells without damage to the product.

Cost comparisons were developed for conceptual embankment sections, crests heights and armoring systems using following:

C-6a: 15 FT Crest Height with soil cement and 24 inch top soil and sod.
C-6b: 15 FT Crest Height with TRM with sod.
C-6c: Raising the crest height from 15 feet to 17.5 feet (No armoring required).
C-6d: 15 FT Crest Height with added wave bench.

The proposed section using buried a Geocell Cellular Confinement System was defined as having a 15 FT Crest Height with 12 inch soil and sod. Each system was compared to the Geocell system cost for first cost impact. Finally, a Present Worth Life Cycle Cost comparison was developed for each when compared with the Geocell system.

First cost estimates indicate an increased cost for the Geocell system by approximately -$4,829,000, when compared to the buried soil-cement system. This followed preliminary cost comparisons for Site 1, D-525 levee embankment where buried soil cement priced better in a first cost analysis. However, C-9 life cycle cost netted a Present Worth reduced cost for the Geocell section, but total net Present Worth remains estimates as -$148,000, or $148,000 more than the buried soil cement section.

When Geocells were compared to a TRM section, the Geocell system indicates a reduced first cost by approximately $1,055,000. Present Worth life cycle cost for the Geocell section is estimated as -$558,000, or $558,000 more than the TRM section.

Cost comparison for raising the crest height from 15 feet with the Geocell system to 17.5 feet crest height is approximately $6,275,000 with the advantage to Geocells. A disadvantage would be reduction in storage capacity and more site development restraints for a larger embankment footprint. Present Worth life cycle cost for the Geocell section is estimated as $4,106,000.

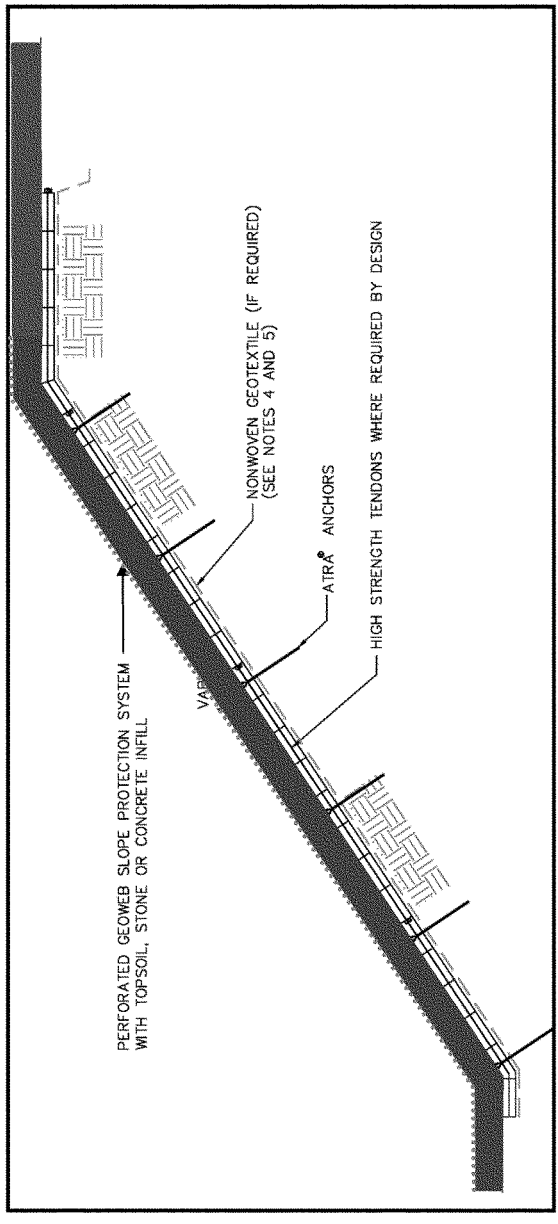
Life cycle cost analysis for each of the above comparisons used annual maintenance activities ranging from 5% to 15% for annual repairs to sloped embankments from erosion damage. Damage could come from overwash or heavy rain events such as a hurricane. The buried soil cement was rated as having a 15% area damage for sloped surface area annually, the TRM systems was rated as having a 5%, and the 17.5 FT crest, the 15 FT crest with wave berm and the Geocell system was rated as having a 10% area damage. Life cycle spreadsheets are provided in Supporting Documents, Appendix E.

This will be both a PIR embankment system selection and Design Phase embankment material selection with design refinements for overwash, erosion containment, and cost estimating of the C-9 Impoundment. Continued design development should assure the best system is integrated and the solution is economically executed .

VALUE ENGINEERING PROPOSAL

PROPOSAL NO: C-6 (Idea 3) PAGE NO: 3 OF 9

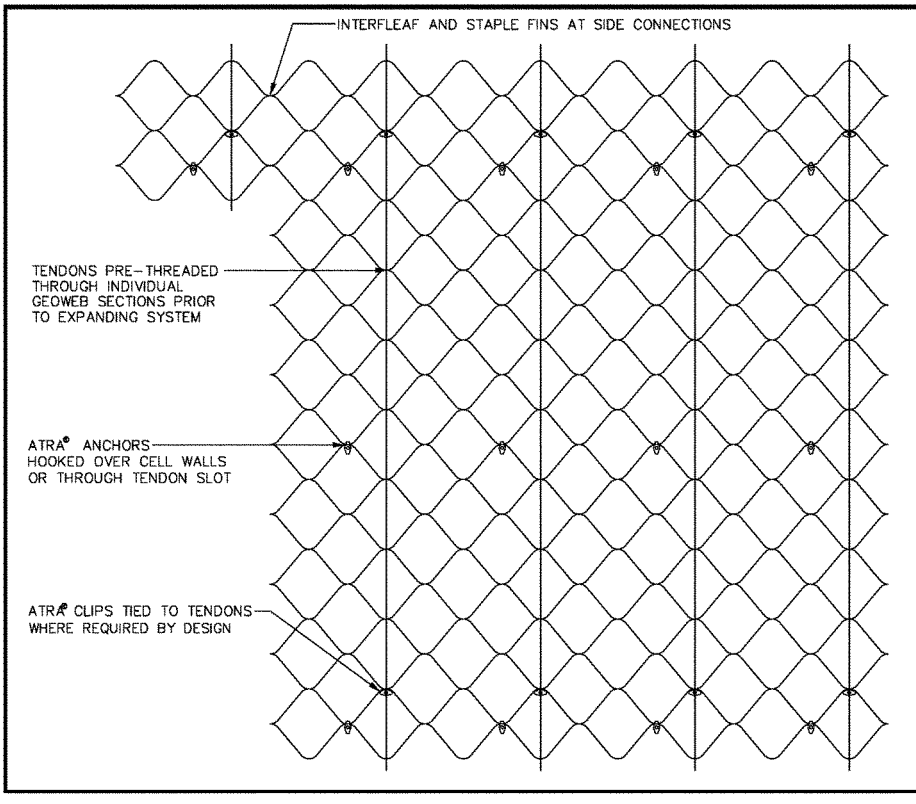
Cross Section of Typical Geocell Slope Protection System



VALUE ENGINEERING PROPOSAL

PROPOSAL NO: C-6 (Idea 3) PAGE NO: 4 OF 9

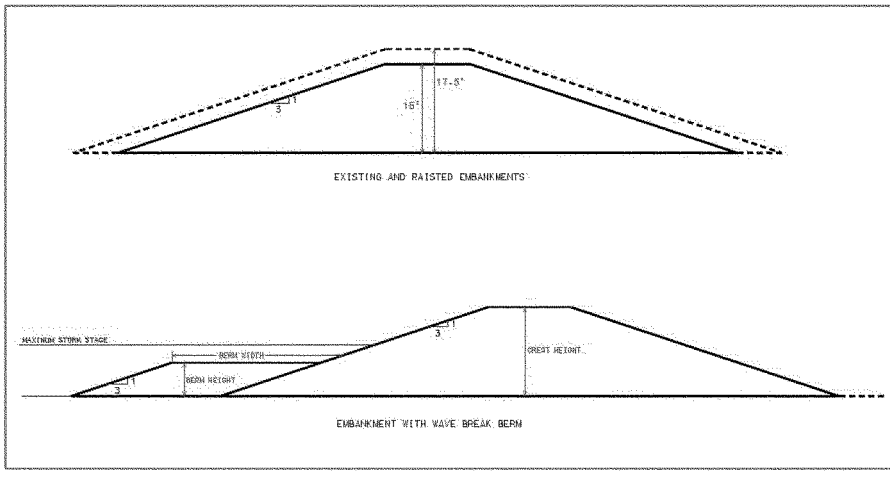
Typical Plan View of Geocell System



VALUE ENGINEERING PROPOSAL

PROPOSAL NO: C-6 (Idea 3) PAGE NO: 5 OF 9

Alternative C-9 Impoundment Conceptual Cross-Sections



Embankment Alternative: Smooth Armor	Height (ft)	Elevation (ft – NGVD)	Overwash Rate (cfs/lf)	Flow Velocity (fps)	Area (sf)	Notes:
High Hazard - PMP Storm						
Existing Crest	15.0	19.5	0.677	8.0	885	Will require backside armor
Raised Crest	17.5	22.0	0.094	3.6	1,164	No backside armor required
Wave Break Berm	14-16	18.0-20.5	0.100	3.8	967-1,101	Wave berm must be armored; No backside armor required
*Allowable Overwash Rate 0.1 cfs/lf						

VALUE ENGINEERING PROPOSAL

PROPOSAL NO: C-6 (Idea 3) PAGE NO: 6 OF 9

Cost Estimate

COST ESTIMATE WORKSHEET

C-6a PROPOSAL DESCRIPTION: Use Buried Cellular Confinement Systems (Geocells) to protect the C-9 impoundment levees from overwash erosion (vs. 8" Soil-Cement w/ 24" Top Soil)

DELETIONS

	ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
C-9	8" Soil-Cement w/ 24" Top Soil:				
	Soil-Cement (8" Thick)	CY	47,837	$53.62	$2,564,994
	Top Soil (4" Thick)	CY	23,561	$29.51	$695,293
	Random Fill (20" Thick)	CY	119,234	$15.26	$1,819,515
	Sod - Bahia	SY	214,193	$5.64	$1,208,050
					$0
					$0
					$0
					$0
					$0
					$0
					$0
			Total Deletions		$6,287,852

ADDITIONS

	ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
C-9	Buried Cellular Confinement System:				
	Geocell System (Geoweb w/ Geotextile)	SY	214,193	$14.64	$3,135,790
	Granular Fill (8" Thick)	CY	47,837	$31.42	$1,503,023
	Random Fill (8"+ 8" Thick)	CY	119,234	$15.26	$1,819,515
	Top Soil (4" Thick)	CY	23,561	$29.51	$695,293
	Sod - Bahia	SY	214,193	$5.64	$1,208,050
					$0
					$0
					$0
					$0
					$0
					$0
			Total Additions		$8,361,672

	Net Cost Increase		-$2,073,820
*	Mark-ups	132.85%	-$2,755,070
	Total Cost Increase		-$4,828,890
	Total Life Cycle Savings - Present Worth, First Cost Increase and O&M Cost Decrease:		-$148,000

* Mark-ups: Gen. Contractor Mark-up - 84.8% (Field Office/Home Office/Profit/Bond); Contingencies - 26.0% = 132.8%

VALUE ENGINEERING PROPOSAL

PROPOSAL NO: C-6 (Idea 3) PAGE NO: 7 OF 9

Cost Estimate

COST ESTIMATE WORKSHEET

C-6b PROPOSAL DESCRIPTION: Use Buried Cellular Confinement Systems (Geocells) to protect the C-9 impoundment levees from overwash erosion (vs. TRM w/ Sod)

DELETIONS

	ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
C-9	Turf Reinforcement Mat w/ Anchors:				
	Turf Reinforcement Mat w/ Anchors	SY	214,193	$20.41	$4,371,686
	Top Soil (4" Thick)	CY	23,561	$29.51	$695,293
	Random Fill (8" + 8" Thick)	CY	95,673	$15.16	$1,450,403
	Sod - Bahia	SY	214,193	$5.64	$1,208,050
					$0
					$0
					$0
					$0
					$0
					$0
					$0
			Total Deletions		$7,725,432

ADDITIONS

	ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
C-9	Buried Cellular Confinement System:				
	Geocell System (Geoweb w/ Geotextile)	SY	214,193	$14.64	$3,135,790
	Granular Fill (8" Thick)	CY	47,837	$31.42	$1,503,023
	Random Fill (8" Thick)	CY	47,837	$15.26	$729,985
	Top Soil (4" Thick)	CY	23,561	$29.51	$695,293
	Sod - Bahia	SY	214,193	$5.64	$1,208,050
					$0
					$0
					$0
					$0
					$0
					$0
			Total Additions		$7,272,142

	Net Cost Decrease		$453,290
*	Mark-ups	132.85%	$602,196
	Total Cost Decrease		$1,055,486
	Total Life Cycle Savings - Present Worth, First Cost Decrease and O&M Cost Increase:		-$558,000

* Mark-ups: Gen. Contractor Mark-up - 84.8% (Field Office/Home Office/Profit/Bond); Contingencies - 26.0% = 132.8%

VALUE ENGINEERING PROPOSAL

PROPOSAL NO: C-6 (Idea 3) PAGE NO: 8 OF 9

Cost Estimate

COST ESTIMATE WORKSHEET

C-6c PROPOSAL DESCRIPTION: Use Buried Cellular Confinement Systems (Geocells) to protect the C-9 impoundment levees from overwash erosion (With 15FT Crest vs. 17.5 FT Crest Height)

DELETIONS

	ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
C-9	17.5 FT Crest Height (No Armor):				
	Random Fill (From 15' to 17.5')	CY	349,160	$15.16	$5,293,268
	Soil-Cement (24" Thick)	CY	20,041	$53.62	$1,074,624
	Gravel Base (9" Thick)	SY	7,516	$31.42	$236,139
	Random Fill (8"+ 8" Thick)	CY	95,673	$15.26	$1,459,970
	Top Soil (4" Thick)	CY	23,561	$29.51	$695,293
	Sod - Bahia	SY	214,193	$5.64	$1,208,050
					$0
					$0
					$0
					$0
					$0
			Total Deletions		$9,967,345

ADDITIONS

	ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
C-9	Buried Cellular Confinement System:				
	Geocell System (Geoweb w/ Geotextile)	SY	214,193	$14.64	$3,135,790
	Granular Fill (8" Thick)	CY	47,837	$31.42	$1,503,023
	Random Fill (8" Thick)	CY	47,837	$15.26	$729,985
	Top Soil (4" Thick)	CY	23,561	$29.51	$695,293
	Sod - Bahia	SY	214,193	$5.64	$1,208,050
					$0
					$0
					$0
					$0
					$0
					$0
			Total Additions		$7,272,142
		Net Cost Decrease			$2,695,203
	*	Mark-ups	132.85%		$3,580,577
		Total Cost Decrease			$6,275,780
	Total Life Cycle Savings - Present Worth, First Cost Decrease and O&M Cost Decrease:				$4,106,000

* Mark-ups: Gen. Contractor Mark-up - 84.8% (Field Office/Home Office/Profit/Bond);
Contingencies - 26.0% = 132.8%

VALUE ENGINEERING PROPOSAL

PROPOSAL NO: C-6 (Idea 3) PAGE NO: 9 OF 9

Cost Estimate

COST ESTIMATE WORKSHEET

C-6d PROPOSAL DESCRIPTION: Use Buried Cellular Confinement Systems (Geocells) to protect the C-9 impoundment levees from overwash erosion (vs. Bench w/ 15 FT Crest Height)

DELETIONS

	ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
C-9	Bench w/ 15 FT Crest:				
	Random Fill (Add for Bench w/ 15 FT Crest)	CY	186,636	$15.16	$2,829,406
	Soil-Cement (Add for Bench 24" Thick)	CY	62,630	$53.62	$3,358,201
	Gravel Base (Add for Bench 9" Thick)	SY	23,486	$31.42	$737,934
	Sod - Bahia	SY	214,193	$5.64	$1,208,050
	Random Fill (8" + 8" Thick)	CY	71,398	$15.16	$1,082,390
	Top Soil (4" Thick)	CY	23,561	$29.51	$695,293
					$0
					$0
					$0
					$0
					$0
			Total Deletions		$9,911,274

ADDITIONS

	ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
C-9	Buried Cellular Confinement System:				
	Geocell System (Geoweb w/ Geotextile)	SY	214,193	$14.64	$3,135,790
	Granular Fill (8" Thick)	CY	47,837	$31.42	$1,503,023
	Random Fill (8" Thick)	CY	47,837	$15.26	$729,985
	Top Soil (4" Thick)	CY	23,561	$29.51	$695,293
	Sod - Bahia	SY	214,193	$5.64	$1,208,050
					$0
					$0
					$0
					$0
					$0
					$0
			Total Additions		$7,272,142
		Net Cost Decrease			$2,639,132
	*	Mark-ups	132.85%		$3,506,087
		Total Cost Decrease			$6,145,219
	Total Life Cycle Savings - Present Worth, First Cost Decrease and O&M Equal Cost:				$3,506,000

* Mark-ups: Gen. Contractor Mark-up - 84.8% (Field Office/Home Office/Profit/Bond); Contingencies - 26.0% = 132.8%

VALUE ENGINEERING PROPOSAL

PROPOSAL NO: C-7 (Idea 6) PAGE NO: 1 OF 5

DESCRIPTION: Use existing Sunset Lakes Canal for seepage management along eastern impoundment boundary

ORIGINAL CONDITION: The current design is to construct a seepage canal (C-509E) along the eastern boundary of the impoundment adjacent to the eastern levee (L-509E).

PROPOSED CONDITION: Eliminate the eastern seepage canal from the design and utilize the existing canal that runs along the western boundary of the Sunset Lakes Community for seepage management.

ADVANTAGES:

- Eliminates the construction costs associated with the seepage canal.
- Eliminates the need for intensive excavation construction within close proximity to existing residential homes (+/- 275').
- Allow for increased storage capacity in the impoundment by the moving the eastern levee (L-509E) east by approximately 120'.

DISADVANTAGES:

- Will need to find alternative borrow source for the approximate 664,444 CY of suitable fill material currently anticipated to come out of the excavation of the eastern seepage canal.
- Will need to construct a seepage pump to return seepage to the impoundment, or control structure on the south side of the existing canal to allow excess water to discharge into C-9.
- Will need an agreement/memorandum of understanding with Sunset Lakes and South Broward Drainage District to remove that section of the surface water management system from Sunset lakes development and have it owned and/or operated by SFWMD.
- Construction of a Water Control Structure to separate the proposed seepage collection ditch and the remaining surface water management system of Sunset Lakes is needed (see the point of the "existing canal" arrow for structure location).

JUSTIFICATION: The City of Miramar has an ordinance that prohibits all blasting within their city limits. If a variance to this ordinance is not attainable, then the only option would be to "rip" the rock material encountered during the excavation of the eastern seepage canal. This means of construction would add a significant expense to the project and would require a longer construction duration adjacent to the existing residential community. PIR estimates will require adjustments for excavation without blasting for the C-9 impoundment.

Alternatives to construction of the seepage canal include offsite borrow for embankment construction materials planned to come from the seepage canal. Offsite borrow could be excavated and processed before delivery; however, higher material cost are likely. Other expenses would be incurred for a new seepage pump station and water control structure to manage the eastern exposure of the C-9 Impoundment.

VALUE ENGINEERING PROPOSAL

PROPOSAL NO: C-7 PAGE NO: 2 OF 5

The Sunset Lakes Community has expressed a desire to have more water in their lakes. This proposal will allow their lakes to be raised and controlled at a certain elevation. An agreement/memorandum of understanding with Sunset Lakes and South Broward Drainage District to remove that section of the surface water management system from Sunset Lakes development and have it owned and/or operated by SFWMD.

This will be a PIR C-9 component selection option with further development required during design phase. Cost comparisons will be developed for "ripping" the rock material encountered for borrow from and construction of the C-509 seepage canal vs. use of the existing canal, addition of water control structure, pump station and offsite borrow. The cost for offsite borrow is potentially much less than ripping and on site excavation for the seepage canal. It is the addition of seepage weir and pump station that adds to the cost for this concept. If further refinements in pumping and water control can be made, this may be desirable for this location to use the existing Sunset Lakes canal. The estimated cost for the VE concept is approximately $762,000 more than the current plan. Negative savings are -$762,000.

VALUE ENGINEERING PROPOSAL

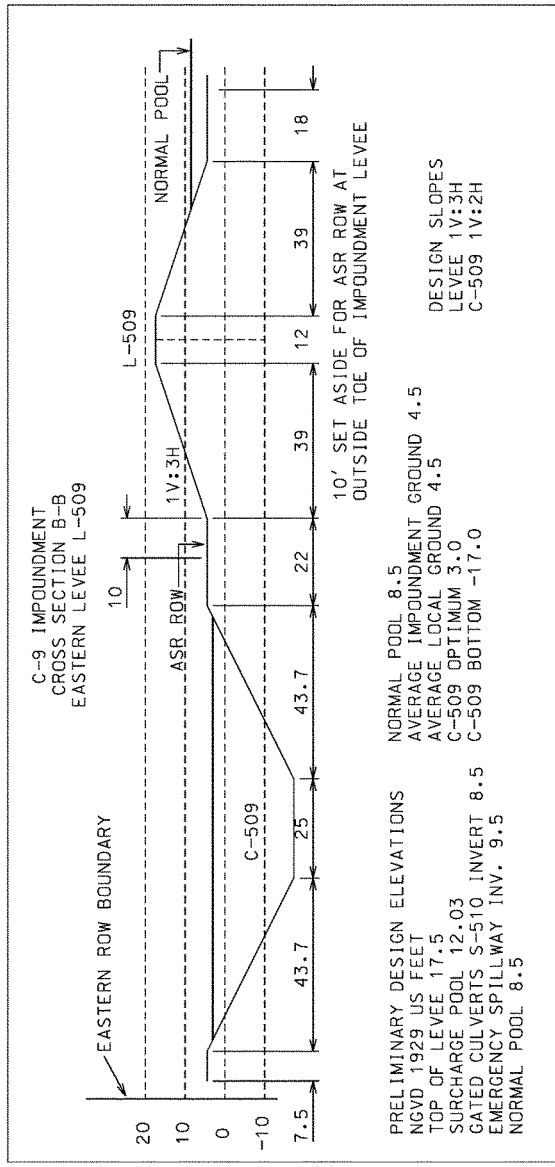
PROPOSAL NO: C-7 PAGE NO: 3 OF 5

Aerial View of Proposed Impoundment and Sunset Lakes

VALUE ENGINEERING PROPOSAL

PROPOSAL NO: C-7 PAGE NO: 4 OF 5

Typical Cross Section of Proposed Eastern Seepage Canal (C-509)



VALUE ENGINEERING PROPOSAL

PROPOSAL NO: C-7 PAGE NO: 5 OF 5

Cost Estimate

COST ESTIMATE WORKSHEET

C-7 PROPOSAL DESCRIPTION: Use existing Sunset lakes Canal for seepage management along eastern boundary

DELETIONS

	ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
C-9	C-509E Canal Excavation (5,000LF)	CY	255,000	$14.53	$3,705,150
	Drill and Blast	CY	255,000	$3.12	$795,600
	Adjustment for Ripping w/o Blasting	CY	255,000	$14.53	$3,705,150
	(Ripping is estimated to be double the cost for excavation with blasting)				$0
	Haul Suitable Material to Levee	CY	175,000	$2.49	$435,750
					$0
					$0
					$0
					$0
					$0
					$0
					$0
			Total Deletions		$8,641,650

ADDITIONS

	ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
C-9	Off Site Borrow for L-509E (5,000LF)	CY	175,000	$10.00	$1,750,000
	Seepage Pump Station (Same as S-512A)	LS	1	$5,931,612	$5,931,612
	Control Weir (Same as S-512B)	LS	1	$1,287,356	$1,287,356
					$0
					$0
					$0
					$0
					$0
					$0
					$0
					$0
			Total Additions		$8,968,968

	Net Cost Increase		-$327,318
*	Mark-ups	132.85%	-$434,842
	Total Cost Increase		-$762,160

* Mark-ups: Gen. Contractor Mark-up - 84.8% (Field Office/Home Office/Profit/Bond); Contingencies - 26.0% = 132.8%

VALUE ENGINEERING PROPOSAL

PROPOSAL NO: C-8 (Idea 30) PAGE NO: 1 OF 2

DESCRIPTION: Combine storage for C-9 and C-11 at C-11 Impoundment

ORIGINAL CONDITION: Current plan has the C-11 Impoundment with 1,000 acres of storage 4.3 ft deep, and has 500 acres of mitigation. The C-9 Impoundment has 1,500 acres of storage at 4.3 ft deep. Parts of existing 404 mitigated wetlands in C-9 footprint are relocated to C-11.

PROPOSED CONDITION: Combine storage of C-9 with C-11 impoundment and move portions of the existing C-11 404 mitigated wetlands to C-9.

ADVANTAGES:

- C-11 impoundment as now has limited capability with small area and shallow design. Combining the 2 impoundments as one will accelerate benefits from the project by 10 years.
- The C-11 project area is surrounded by opposing land uses with opposing interests that may be better served (See listing below).
- Lessens necessary canal improvement and new structural requirements for conveyance control in SMA between C-11 and C-9.
- Establishes C-9 now as a STA (STA with no Phosphorus target, not targeted for natural system) with all mitigation wetlands versus 25 years, for northern Biscayne Bay estuarine environmental discharges.

DISADVANTAGES:

- Capital cost for liner and installation as this proposal will require (However, the liner does not have to have a perfect seal; holes, open seams, small discontinuous areas would be acceptable).
- C-11 Impoundment will have a higher embankment with a relabeling from Low HPC to High HPC (But C-9 Impoundment as an STA would be Low HPC now versus High HPC).
- Complete re-design effort, hard hit on C-11 schedule, but already noted C-9 acceleration.

JUSTIFICATION: C-11 impoundment as now has limited capability with small area and shallow design. Combining the 2 impoundments as one will accelerate benefits from the project by 10 years. The C-11 project area is surrounded by opposing land uses with opposing interests.

(1) Weston now has a raised controlled water table, yet flood impact prone with new church site.
(2) Existing wetlands to north that need drainage, but not too much.
(3) Southwest Ranches susceptible to flooding, extremely high potential for litigation with project implementation as is.
(4) US 27 and Truck Stop on west boundary.

VALUE ENGINEERING PROPOSAL

By Consent Decree, additional diversion storage is need now. With all the opposing issues and potential for litigation, this change may not be as hard of a hit on C-11 and the overall BC WPA schedule as it initially appears to be.

This is a substantial departure from the current project plan. This change would be a PIR phase action item with further efforts required for detailed development and costing. Reconfiguring all storage within C-11 would require a deeper pool for storage and seepage control likely including significant impoundment lining and continuous cutoff seepage wall. A rough order magnitude estimate to line C-11 impoundment identified approximately $50 million for seepage management of a deeper pool. A cutoff wall, if required could potentially cost $60/SF, and if a deep wall is required estimated cost could be between $5 and $6 million per 1,000 LF ($170,000,000 for the current C-11 perimeter). Currently a low hazard classification, C-11 would become a high hazard classification impoundment. Current mitigation would likely be lost to storage and mitigation would move to C-9. The C-9 site would remain a planned or future STA (See Proposal C-5). Real estate actions to commit or purchase have taken place for the current plan for both C-9 and C-11.

No further detailed cost estimates were developed for this concept as it is so broad and demands more effort and details for quantifying items to be changed and related cost applied to changed components. It could possibly result in significant additional cost for the BC WPA storage requirement. The long term assessment is that combining the 2 impoundments as one could possibly accelerate benefits from the project by as much as 10 years. There would be much revision to the developing PIR and the PIR completion could be delayed by one or more years.

VALUE ENGINEERING PROPOSAL

PROPOSAL NO: C-9 (Idea 9) PAGE NO: 1 OF 3

DESCRIPTION: Reorder the construction schedules for C-9 and 3A/3B Seepage Management Area

ORIGINAL CONDITION: The current order of construction was to be the C-11 Impoundment, to be followed by the construction of C-9 Impoundment, and last WCA 3A/3B Seepage Management Area (SMA).

PROPOSED CONDITION: The proposed order of construction would be the C-11 Impoundment to be constructed first, followed by the WCA 3A/3B Seepage Management Area (SMA) and then followed by construction of the C-9 Impoundment.

ADVANTAGES:

- The conveyance canal between the C-11 impoundment and the C-9 impoundment falls within the design and construction purview of the SMA component. Without SMA constructed, conveyance of western C-11 basin stormwater to the C-9 impoundment will not be possible.
- Seepage reduction will occur sooner from WCA 3A and 3B if SMA is constructed before C-9 Impoundment rather than later.

DISADVANTAGES:

- C-9 basin stormwater will not be captured as soon if SMA is constructed before C-9 Impoundment rather than later
- Rescheduling annual budget appropriations for the more expensive C-9 impoundment would lock it in for a later construction window only.

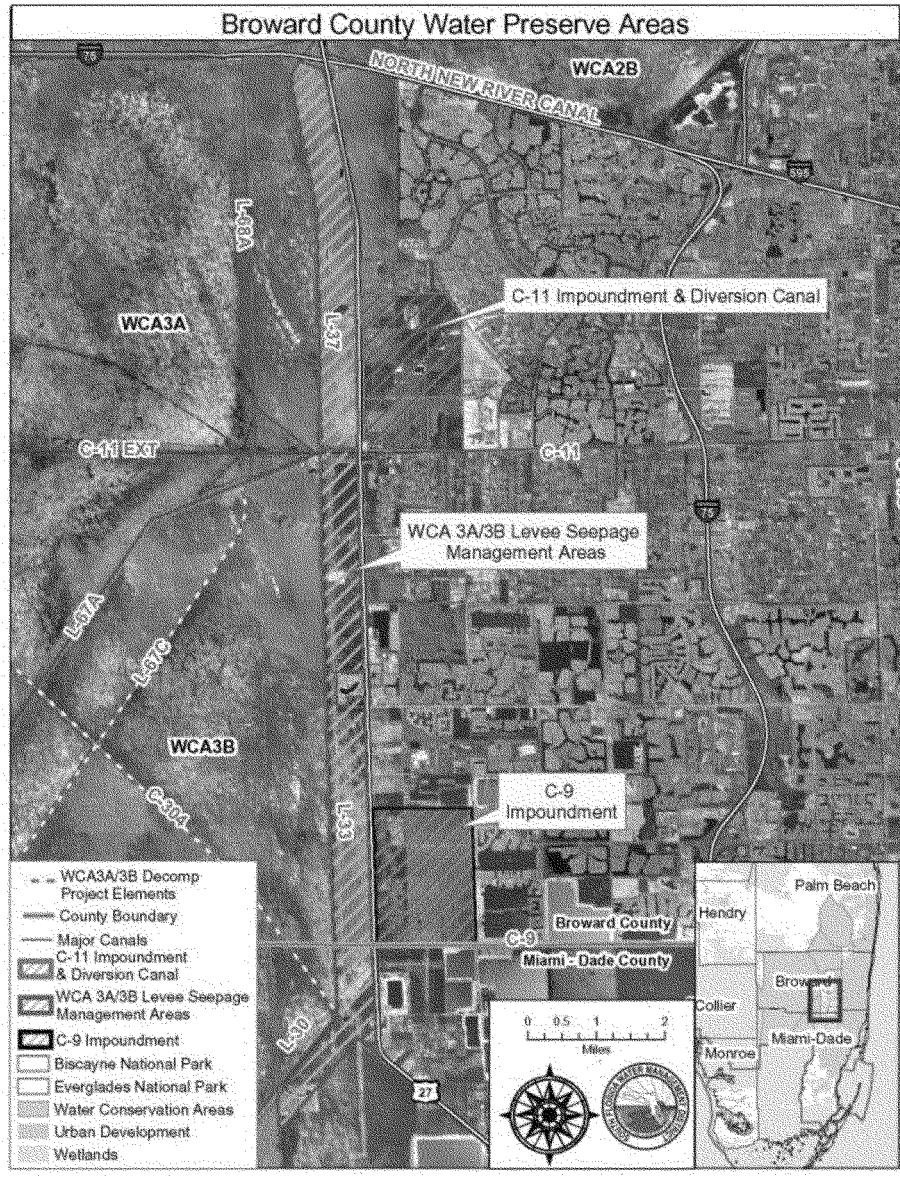
JUSTIFICATION: Conveyance of western C-11 basin stormwater to the C-9 impoundment will not be possible without SMA features constructed. The conveyance canal between the C-11 impoundment and the C-9 impoundment currently falls within the design and construction of the SMA components. Revising the order of construction with the SMA features being placed before the construction of C-9 will result in earlier seepage reduction from WCA 3A and 3B. There appears to be no real down side to this change.

This proposal is a PIR phase decision item. It does not have significant monetary impacts to the project construction other than escalation and planning for project funding distributions by execution year. The VE proposal is considered a "Quality Based VE" improvement in project execution.

VALUE ENGINEERING PROPOSAL

PROPOSAL NO: C-9 PAGE NO: 2 OF 3

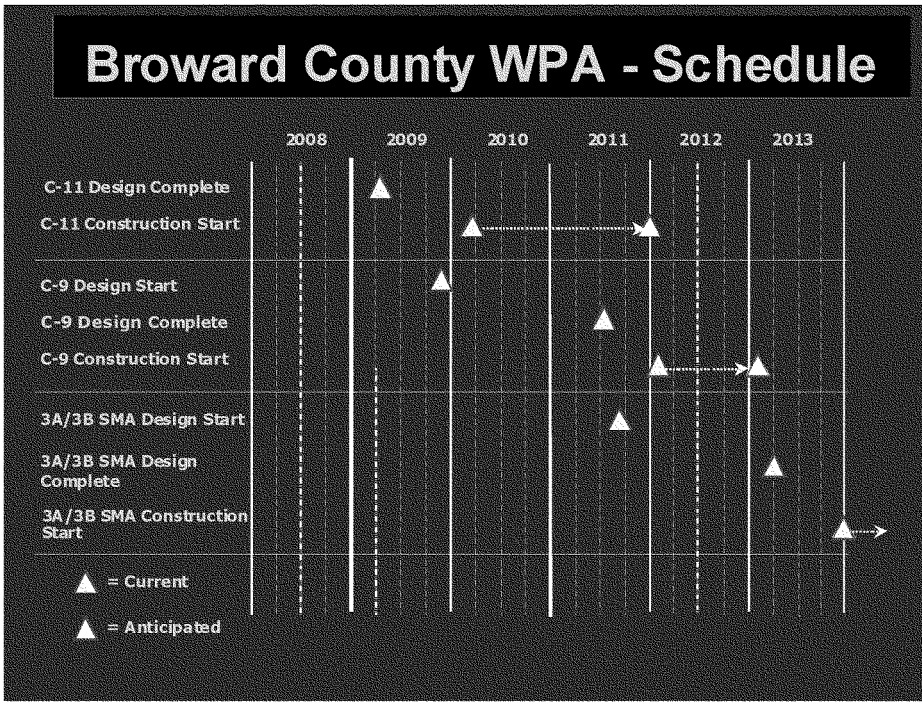
Proposed PIR BCWPA Features



VALUE ENGINEERING PROPOSAL

PROPOSAL NO: C-9 PAGE NO: 3 OF 3

Current PIR Construction Phasing Schedule



VALUE ENGINEERING PROPOSAL

PROPOSAL NO: C-10 (Idea 18) PAGE NO: 1 OF 5
DESCRIPTION: Reduce Size of WCA 3A/3B SMA from 14 miles total length

ORIGINAL CONDITION: Current plan has the 3A/3B SMA extending approximately 14 miles from I-75 (Alligator Alley) to the former public park south of Miami Canal (C-6).

PROPOSED CONDITION: Two options are proposed to reduce the 3A/3B SMA area to an effective project feature with a smaller footprint. Alternative A: Eliminate SMA improvements from I-595 to C-11 Canal (3A SMA). Alternative B: Eliminate SMA from C-6 Canal to former public park (portion of 3B SMA).

ADVANTAGES:
- The advantage of Alternate A is less impact to existing wetlands found in this segment.
- The advantage of Alternate B is less cost for a relatively small area.

DISADVANTAGES:
- The disadvantage of Alternate A is that there is no guarantee that the current wetland conditions will remain the same in the future with no "infrastructure" to provide flexibility.
- The disadvantage of Alternate B is that it shortens continuity of length in SMA implemented. Also, this section establishes a buffer from developments on other side of Krome Ave (though they are proposed for land acquisition).
- The water level head difference between the WCA and the developed area at C-6 canal is 6 feet and the project would lose the benefits of seepage reduction in this location.

JUSTIFICATION: For Alternate A, eliminate SMA from I-75 to C-11 Canal (3A SMA) and allow that area be monitored and implemented if necessary under Adaptive Management principles. The existing wooded/wetlands conditions in this area are very favorable for continuing without the PIR improvements. The PIR proposed sections for L-502A and C-502A would held for construction until they are determined to be required, and then would be implemented as Adaptive Management changes.

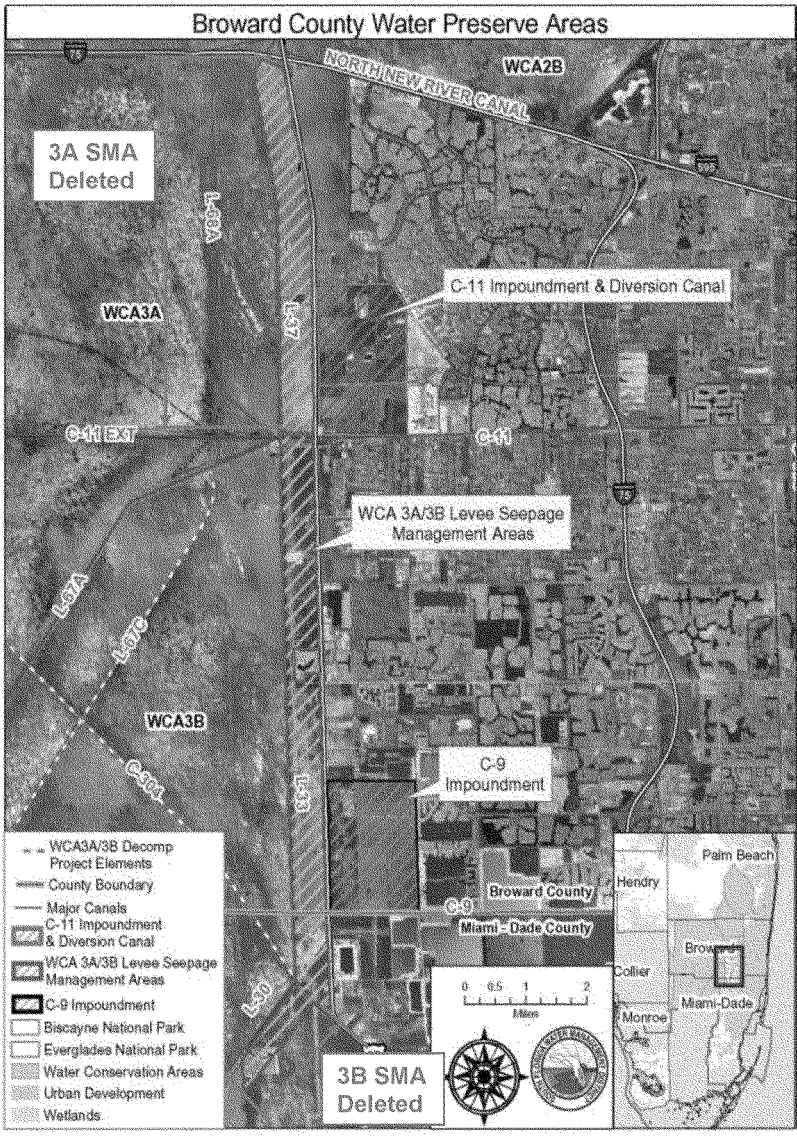
For Alternative B, leave in the plan provisions to maintain a buffer from developments across Krome Ave. S-516B and L-503/C-503 would be deferred as identified in Alternative B.

These actions may be considered for evaluation and assessment during PED phase. If omitted from the PIR, authorization would be lost and future placement of either would be difficult under Adaptive Management. Cost avoidance is identified, but may not be counted as VE savings as potentially loss of function may occur and eventually the future placement of SMA features may be required. No savings are shown as these WCA 3A/3B SMA components remain possible future project requirement under Adaptive Management.

VALUE ENGINEERING PROPOSAL

PROPOSAL NO: C-10 PAGE NO: 2 OF 5

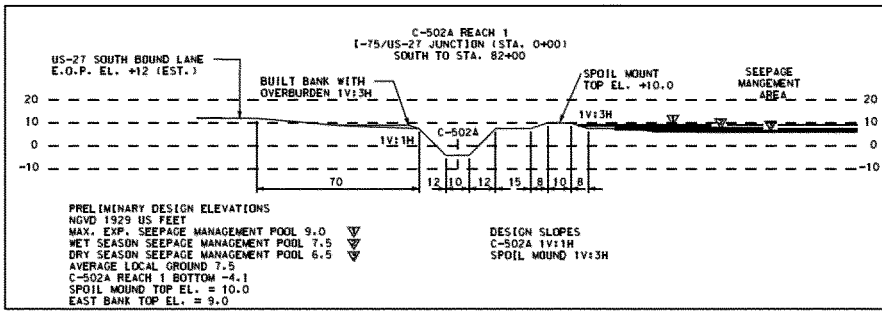
Current 3A/3B Seepage management Area PIR Feature
(Modified SMA Segments for Evaluation and Deletion form PIR)

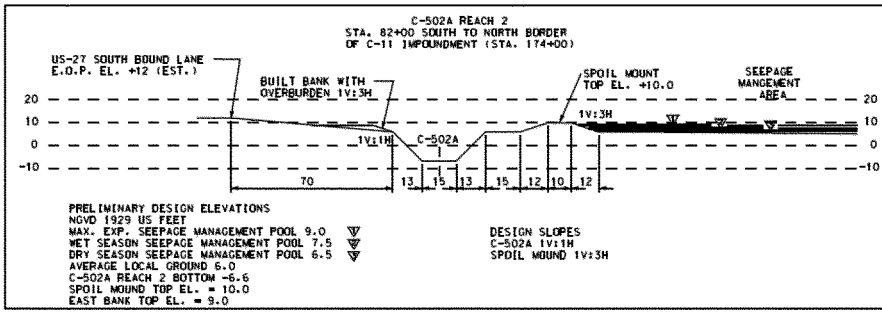


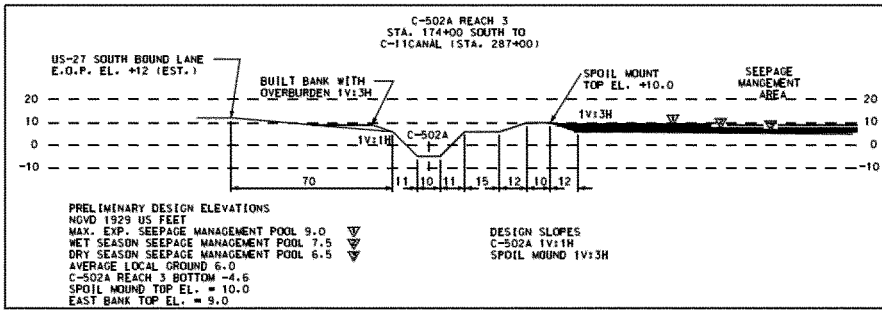
VALUE ENGINEERING PROPOSAL

PROPOSAL NO: C-10 PAGE NO: 3 OF 5

Current 3A SMA PIR Feature
C-502A Reach 1, 2 and 3 to Canal C-11



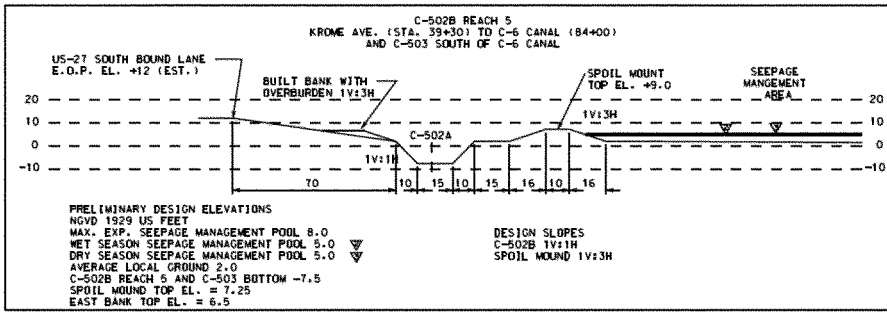




VALUE ENGINEERING PROPOSAL

PROPOSAL NO: C-10 PAGE NO: 4 OF 5

Current 3B SMA PIR Feature
C-502B Reach 5 and L-503 South of Canal 6



VALUE ENGINEERING PROPOSAL

PROPOSAL NO: C-10 PAGE NO: 5 OF 5

Cost Estimate

C-10 PROPOSAL DESCRIPTION: Reduce Size of WCA 3A/3B SMA from 14 miles total length

DELETIONS

	ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
3A	C-502A Reach 1, 2 and 3 to Canal C-11	LS	1	$3,418,464.00	$3,418,464
3B	C-502B Reach 5 - L-503 South of Canal 6	LS	1	$1,458,044.00	$1,458,044
3A	L-502A Reach 1, 2 and 3 to Canal C-11	LS	1	$1,952,356.00	$1,952,356
3B	L-502B Reach 5 - L-503 South of Canal 6	LS	1	$656,302.00	$656,302
3B	S-516B Weir	LS	1	$253,962.00	$253,962
					$0
					$0
					$0
					$0
					$0
					$0
					$0
			Total Deletions		$7,739,128

ADDITIONS

	ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
					$0
					$0
					$0
					$0
					$0
					$0
					$0
					$0
					$0
					$0
					$0
					$0
			Total Additions		$0

	Net Cost Decrease/Increase	$7,739,128
*	Mark-ups 16.63%	$1,287,017
	Total Cost Decrease/Increase	$9,026,145

* Mark-ups: Gen. Contractor Mark-up - Included in Unit Prices (Field Office/Home Office/Profit/Bond); Contingencies - 16.63%

VALUE ENGINEERING TEAM STUDY
VALUE ENGINEERING COMMENTS

1. **Eliminate barriers to wildlife movement (Speculation Item 1)** - Certain barriers create wildlife hazards and may lead to entrapment to many forms of wildlife including, but not limited to, birds and reptiles. The use of steps, or any vertical structure, for control of reservoir and impoundment overwash creates a continuous entrapment condition. While this condition is being corrected, other features may also pose new hazards. Structures with vertical pits, pump discharge drop structures, curbs, and fencing placed at ground level also create wildlife entrapment conditions.

2. **Optimize soil cement mixing plant; look for options other than batch plat such as continuous feed pugmill mixers (Speculation Item 20)** - Soil cement is typically prepared by 2 methods: continuous feed and batch. In continuous feed plants, ingredients are delivered from a hopper to a conveyor through a continuous ribbon of material and are then mixed for a predetermined time. The materials are then conveyed out of the pugmill mixer and into a truck for delivery to the construction site. In batch plants, each ingredient in the soil cement is weighed separately and dumped into a mixer (typically pugmill or rotary drum). Batch plants provide lower production rates than continuous feed plants; however, they provide tighter tolerances on ingredients and a much higher degree of quality assurance.

In continuous feed plants materials are delivered to the conveyor by adjusting gate openings on material hoppers. The mix time is then controlled by belt speed, shaft speed and mixing paddle pitch. The mix time can be adjusted in continuous feed pugmills; however, the mix time has maximum limits (approximately 7 seconds max on most pugmills). This could result in non-homogeneous soil cement mixes that could result in an array of problems. Additionally ingredients delivered to continuous feed plants can be subject to clogging at the point of discharge. This can result in variable mixes. Generally, ingredients can be controlled to within 4 to 5 percent of the specified value. Because the specified cement content is normally the minimum required to achieve strength and durability requirements, the result in the inaccuracy of the continuous feed plant is a mix tolerance of 0 to +5 percent cement. This additional cement will drive up cost somewhat offsetting the higher initial cost required for a batch plant. Furthermore, when dealing with sandy soil, such as are predominate in Florida, cement contents required for strength and durability are generally 11 percent or higher (the high end of the scale for normal soil cement production). As typical cement contents are already high in these soils, the required tolerance of 0 to +5 percent can result in cement contents of 16 percent or higher. This can significantly affect the frequency and magnitude of shrinkage cracking in the final product.

Batch type plants generally have a higher front end cost and have a lower production rates than continuous feed plants. However, because these plants weigh ingredients entered into the mix, they provide much greater quality control of the mix and ensure a better product. These plants also allow the product to be mixed as long as necessary to become homogeneous. Batch plants will also use 2 to 3 percent less cement throughout the overall project resulting in less shrinkage cracking of the final product.

Because the ultimate goal is to have a strong durable end product, it is the opinion of SAJ-EN-GS that batch type plants should be specified on all major projects. POC is John Kendall, P.E., SAJ-EN-GS (904) 232-2078.

3. Develop native species and wildflower planting plan for selected project areas (Speculation Item 32) - Many native grasses and wildflowers do have erosion prevention characteristic, and the use of more native planting and wildflowers could save on mowing, insecticide / herbicide costs and would definitely bloom and look better than turf. Wildflowers only need to be mowed once a year which could produce a life-cycle cost savings that far exceed additional seed costs. Frequently closely mower turf can quickly become stressed with dry periods following a mowing cycle. Repair to damages areas and regrassing may occur more frequently than with natives and wildflowers.

The average cost for seed mix applications in current project specifications are typically for 10 pounds of Bahia and 2 pounds of Bermuda (both in #/1000 SF and respectively 435.6 and 87.1 pounds per acre) with an average cost of $1,500 per acre – just for seed in the bag. Adding cost for more frequent watering to establish suitable grass and soil treatment with chemicals, average cost for grassing ranges from $3,500 to $6,000 per acre. Using sod, cost ranges to the higher of these costs per acre. Annual mowing, vegetation maintenance and chemicals costs are estimated as $240 per acre for grass.

One native species grass is Purple Love Grass (*Eragrostis spectabilis (Pursh) Steud.*). It is recommended as a native species that can supplement the current mix with a low cost and drought tolerant grass. Purple Love Grass is a native, warm-season, perennial bunch grass. The height is between 1 and 3 feet. The leaf blade is 8 to 18 inches long; densely hairy; stiffly ascending when young; tapers to fine point. The leaf sheath is longer than internodes; covered with long, gray hair. The ligule is hairy. The seed head is open panicle 1 to 2 feet long and about as wide. It is recommended to be added at the rate of about 3 to 5 pounds per acre (0.06 to 0.12 #/1000 SF). Seed cost is about $1.10 per acre. Below are some potential wildflowers for consideration:
GROUNDCOVERS (for surface soil retention): Achillea millefolium, Yarrow P/R/W – full sun or part shade; spreads Baccharis pilularis 'Twin Peaks' or 'Pigeon Point', Dwarf Coyote Brush W Ceanothus griseus horizontalis 'Yankee Point' B Grasses with tough fibrous root systems (many choices) Mimulus spp., Monkey Flower O/P/R/Y Salvia spp., Groundcover Sage Varieties such as 'Gracias,' 'Pt. Sal,' 'Bees Bliss'
Epilobium canum and E. canum latifolia, California Fuchsia. Source:
http://www.theodorepayne.org/plants/plants_for_erosion_control.htm

Reservoir and impoundment slopes and canal slopes may require more closely mowed and managed grassing species for monitoring and response management of repair efforts should erosion or other repair become necessary. There remains many acres of project areas that would be appropriate for development of a native species and wildflower planting scheme.

Additional benefits would be realized for wildlife habitat from food sources, and shading and cover from exposure to heat and predators which would particularly benefit juveniles of many species. POC is Paul C. Stevenson, ASLA, CESAJ-PD-PR, 904.232.3747.

4. Identify and coordinate solutions to FPL access and transmission poles (Speculation Item 14) – The improvements to the Seepage Management Area for access and maintenance by FP&L is somewhat described and quantified, but will require additional development and coordination for approval by FP&L. Much of this effort is needed to be included in the PIR. Possible items of concern may include foundation protection for transmission structures, service road reliability with higher stages and locations of drainage structures. Final details will continue development with the planning and design phase.

5. Use existing mining operations for alternative borrow source for C-9 (Speculation Item 29) - The original design calls for approximately 1,271,231 CY of suitable fill material to be excavated onsite. Approximately 878,845 CY of the onsite excavation was assumed to come from blasted rock and the remainder to come from loose fill material.

The City of Miramar has an ordinance in place which prohibits blasting within the city limits. Since blasting is prohibited, a variance to the ordinance will need to be requested, or ripping of the rock will be required. This rock will need to be processed onsite to produce the desired aggregate size, as opposed to using the excavated blasted rock for "random" fill material as in the original design.

An option to avoid the processing of the "ripped" rock would be to purchase the required fill material from an offsite source. An existing quarry operation (White Rock Quarry) is located adjacent to the C-9 impoundment, on the south side of the C-9 canal. The close proximity of this quarry to the C-9 impoundment may provide a benefit over the onsite processing.

6. Identify new technology to replace soil cement for reservoir crest pavement, access roads and ramps, and eventually embankment armoring (Speculation Items 4, 5, 13 and 19) – A new road pavement technology is being employed using enzyme stabilized soil techniques that develops a cementitious property for road base materials. It is also being applied as the finish paving systems for some remote applications, such as public and staff park service access roads, parking and hiking trails to control erosion and wear from vehicle use, when other traditional pavement materials is undesirable in sensitive natural environments. Heavy use applications include mining, intermodal storage operations, logging operations, airstrips and rural roads in developing countries where permanent pavement is not affordable or practical.

The enzyme is environmentally friendly and is considered to be “Green” resulting in use by the California Parks Department for public parks for parking, trails and walkways, including ADA handicap accessibility. It avoids use of concretes, lime stabilizers or petro-chemicals such as tar and asphalt.

When mixed with water and applied prior to compaction, the enzyme reacts with organic fines contained in the soil through a catalytic bonding process, producing a strong "cementation" action. Unlike inorganic or petroleum based products which temporarily hold soil materials together, enzyme bonding causes the soil to bond during compaction into a dense permanent base which resists water penetration, weathering and wear.

The enzyme product is easy to apply and requires normal highway construction equipment and procedures. It can be used to recycle roadbed by mixing with scarifing machines, or applied with placement of new materials. It should be used with soils that contain approximately 20% cohesive fines. It is mixed with water used for compaction during normal road building techniques. A typical application to stabilize a 6-inch layer of existing or new road base uses approximately 1 gallon of enzyme with 1,000 gallons of water. This application rate typically brings 150 to 165 CY of earth material up to optimum moisture. For Florida projects clay will likely be hauled in from some distant sources. It is also effectively with soils containing limestone (CaO) and Calcite (CaO3), a fine grain limestone which are available regionally.

The process takes 72 hours to setup under ideal conditions. In addition to creating a new and better way of building and maintaining road surfaces, it is being used successfully in construction of mine leach pads, ponds and earth enclosures for waste containment where there is a need to increase the load-bearing capacity of the soil and to reduce plasticity and permeability. Economies maybe be realized ranging to 40% .

The enzyme-soil stabilization applications will add bonding and strength to earth fill embankments and potentially crest pavements, ramps and service access roads presently using soil cement. Embankments may be developed with reduced seepage impacts, and this may be extended for some distance beyond the interior or exterior toe for projects. With further development and understanding of potential applications the enzyme stabilized soils applications may continue to be more widely integrated into reservoir project replacing soil cement for armoring, road surfacing and soil sealing of porous reservoir bottoms. Possible applications of enzyme soil stabilization for projects with erosive soil embankments are being considered with future reservoir embankment testing through ERDC. In addition to CERP reservoirs embankments and service roads, DMMA's and possibly other large Civil Works project's applications may be developed and applied. Visit some of the following web sites for more information:
http://www.globalzyme.com/global-zyme.htm
http://www.pavmax.com/
http://www.itstoyou.com/sites/internationalenzymes/perma-zyme/

7. <u>Use local regional stone for rip rap where sufficient durability can be achieved for locations suitable this class of stone (Speculation Item 21)</u> - The selection of the riprap with stone characteristic, size and specification are dependent on the hydraulics of the systems where it is to be used, and this will be designed during plans and specs design phase of the project. For purposes of the PIR, rip rap is assumed to be 165 pound per cubic foot stone, typically granite coming from existing quarries such as north to middle Georgia. Opportunities for use of regional limestone will require assessment that the stone is available from on site excavation or from regional quarries. Specific locations will need to be identified and quantities of regional stone can be identified. The stone prices for the two classes are approximately $35 and $85 per ton. Transportation is approximately half of the cost for non-regional 165 pound stone.

8. <u>Use rock fragmentation blasting for construction vs. ripping (Conduct a demonstration project for fragmentation by blasting) (Speculation Items 15 and 16)</u> – Current PIR estimates include blasting for both excavation of significant structures and canals. Blasting is either too restrictive to execute, due to previous restraints seen of the last 8.5 Square Mile contract, or will be outright prohibited as it is in the city of Miramar. This impacts cost for obtaining all borrow construction in efficient manor using mechanical excavation, lengthens construction and extends noise and inconvenience to neighboring project areas which will likely be adversely impacted. It is recommended that further coordination be initiated with the project to include a demonstration projects to demonstrate the minimal risk using controlled blasting so that blasting can be used with the construction of project features.

See the following comments addressing blasting issues for BC WPA prepared by the SAJ Subject Mater Expert:

Comments on C-11 and C-9, For PIR purposes:

1. Due to the rock condition in South Florida (from very hard to soft) both projects shall included blasting for rock removal.
2. Rock removal can be performed with mechanical means with increased in cost for rock removal.
3. Some counties as well local agencies banned the use of explosives within their perimeter.
4. The material from both sites shall be processed for construction purposes. The utilization of blasting shall reduced the cost for rock processing. The material will be used for soil-cement mix.
5. The C-11 site was very large with approximate dimensions of three miles long by two miles wide. The test program was spread out along the perimeter of the site. A series of ten test pits were completed for the purpose of determining the depth to top of rock, thickness of rock, the excavatability of the rock and the suitability of the materials as borrow t o be used for the purpose of levee construction. A large track mounted excavator was used for the purpose of determining the excavatability of the subsurface materials for canal construction and the suitability of the recovered materials for proposed levee embankments.

6. Site C-11 was excavated with a large trackhoe and the material produced during the excavation demonstrate that the rock is not good for rip-rap material. No information pertaining to C-9 was obtained but experience dictate that material obtained from this site is not recommended to be used as rip-rap material.
7. Deep excavation will be performed (25' deep) in C-11 site. Past experience dictate that the rock in south Florida varies considerable from one area to another (in terms of meters), sometimes from very soft very hard material. Due to the depth of the material special equipment is mandatory to replace the blasting operations. Some of the equipment as a heavy chisel can be used to break the rock . This type of equipment can produce more vibrations than the one produced during blasting operations.
8. In order to removed the hard rock , the experience dictate that the utilization of blasting is the best method for rock removal. Due to the regulations some areas are within areas in which blasting is prohibited. In order to overcome this situation, a comprehensive study (test blast, and project advantages for the community) in which the community participate clearly open the doors for the utilization of explosives in the area. The test blast for the community shall be performed before completion of the plans and specifications. In case that the blasting issue is not resolved with the community, excavation shall be performed with the utilization of mechanical means at high cost. Apparently C-11 area can excavated with the utilization large equipment increasing time and cost for project completion.

SUPPORTING DOCUMENTS

CONTACT DIRECTORY

Broward County WPA
Value Engineering Team and Contact List

22-Jul-10

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SPECULATION LIST

VALUE ENGINEERING TEAM STUDY
APPENDIX B: SPECULATION LIST

Broward County WPA
Value Engineering Creative Brainstorming Action Items

22-Jul-10

Proposal	No.	D = Develop Idea; X = Eliminate Idea; C = Comment on Idea	Action:	Assigned To:	Notes:
C-6	3	Evaluate Geocells for outside embankment (not needed for C-11, may be considered for C-9)	D	Kevin	
C-7	6	Use Sunset Lakes lake for seepage management - excavation area needed, rock fragmentation	D	Jeff, Christie, Kevin	
C-9	9	Reorder construction placing Seepage Management second and C-9 third	D	Rob, Jeff	
C-3	10	Use existing berms in Weston for perimeter berms in mitigation area	D	Tracy, Christie	
C-10	18	Reduce size of Seepage Management Area from 14 miles - focus on south	D	Jeff, Rob	
C-2	22	Remove material and culvert between existing lakes Mit Area C-11	D	Tracy, Jane, Christie	
C-1	23	Use Profile HDPE for precast culverts and pipes	D	Fred	
C-8	25	Develop conversion to STA for future conditions	D	Jeff, Greg	
C-4	30	Combine storage for C-9 and C-11 at C-11, and move all mitigation to C-9	D	Rob	
C-5	31	Automate the S-13 forward pumps with telemetry	D	Jeff	
	1	Eliminate barriers to wildlife movement	C	Darla, Liberta	
	4	Identify new technology to replace soil cement	C	Fred, Jose	
	14	Identify and coordinate solutions to FPL access and transmission poles	C	Susan, Don	
	21	Use local rock for rip rap	C	Ali	
	29	Look for alternative borrow sources for C-9 - existing mining operations vs.	C	Kevin	
	32	Use native grasses and wildflowers for erosion management and control	C	Paul	
	15	Use rock fragmentation blasting for construction (vs. ripping)	C	Rafael Rios	
	20	Optimize soil cement mixing plant - look to options other than batch plant, i.e; pugmill	C	Ali, John K	
	27	Connect Finger Lakes with canal instead of culvert (508A)	See 22	Tracy, Jane, Christie	
	16	Conduct demo project for rock fragmentation	See 15	Rob	
	5	Use enzyme soil stabilization for embankment erosion control	See 4	Fred, Jose	
	13	Use enzyme soil stabilization for access roads, ramps and crest	See 4	Fred, Jose	
	19	Develop pilot project for enzyme applications - roads, embankments	See 4	Fred, Jose	
	11	Eliminate bridge over seepage canal C-11 (See Site 1)	X	Gerald, Rob	Delete - See 12 for comment
	17	Identify alternate comm. link vs. new tower	X	Gerald	supports line of sight or cable
	12	Separate seepage and inflow pump stations C-11	X	Susan, Don	Delete - Requires splitting single pump station into inflow and seepage pump stations. Undistributed land may impact secondary containment.
	2	Deepen reservoir excavation to increase storage (remove muck only)	X		Existing bottom helps w/ seepage losses
	7	Reduce berm crest width to 12 feet	X		DCM Std is 14FT
	8	Change slope to 2.5 to 1	X		Higher crest ht.
	24	Evaluate use as an STA now and only construct as an STA	X		Storage is required now
	26	Develop as STA with future development as impoundment	X		See 24
	28	Line bottom of impoundment and go deeper for increased storage	X		Lining is too costly

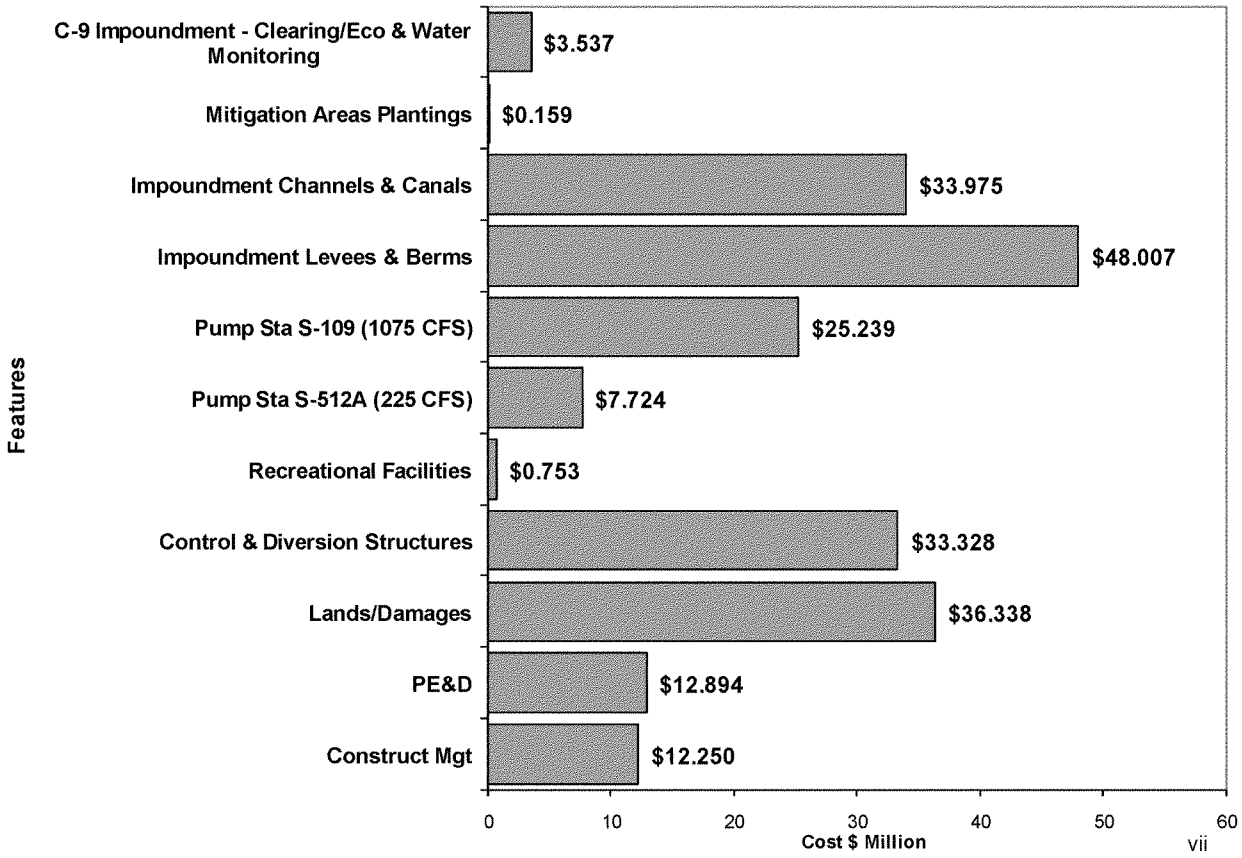
COST MODELS

Cost Model 1: C-11 Impoundment

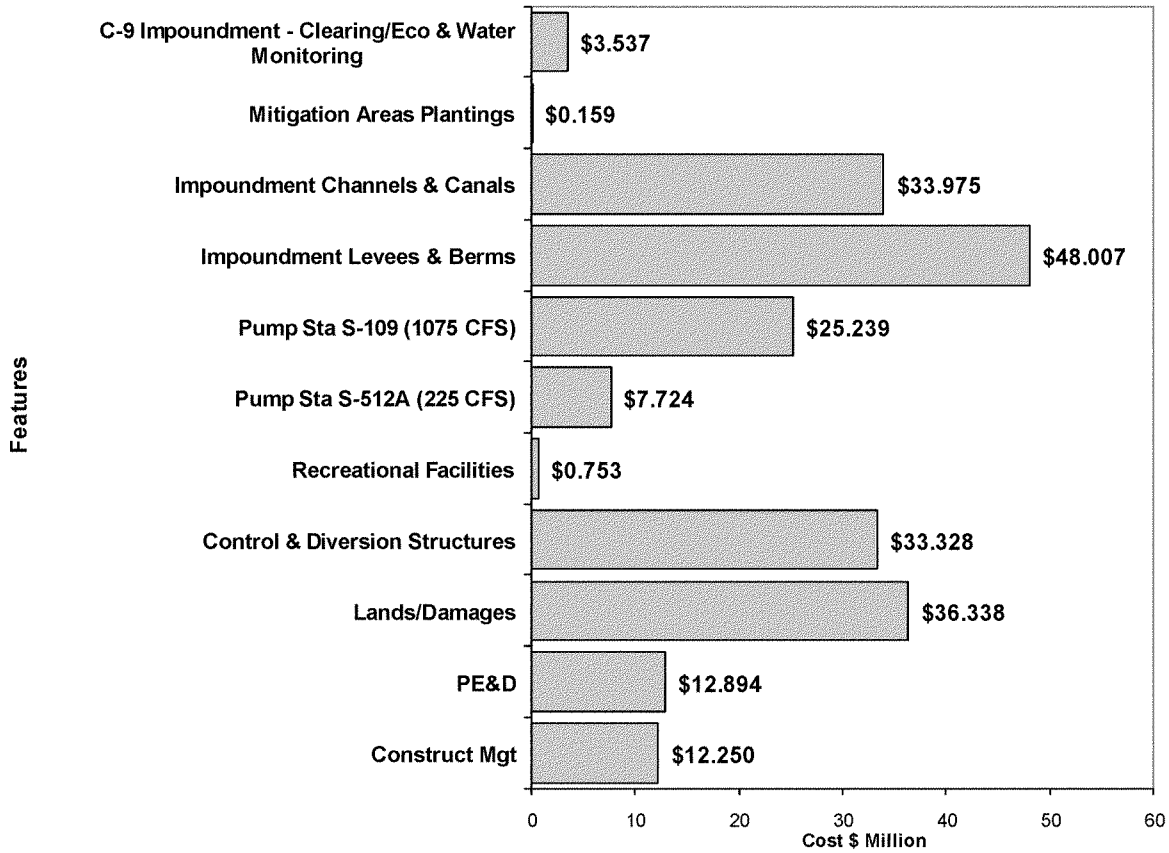
Cost Model 2: C-9 Impoundment

Cost Model 3: WCA 3A/3B SMA

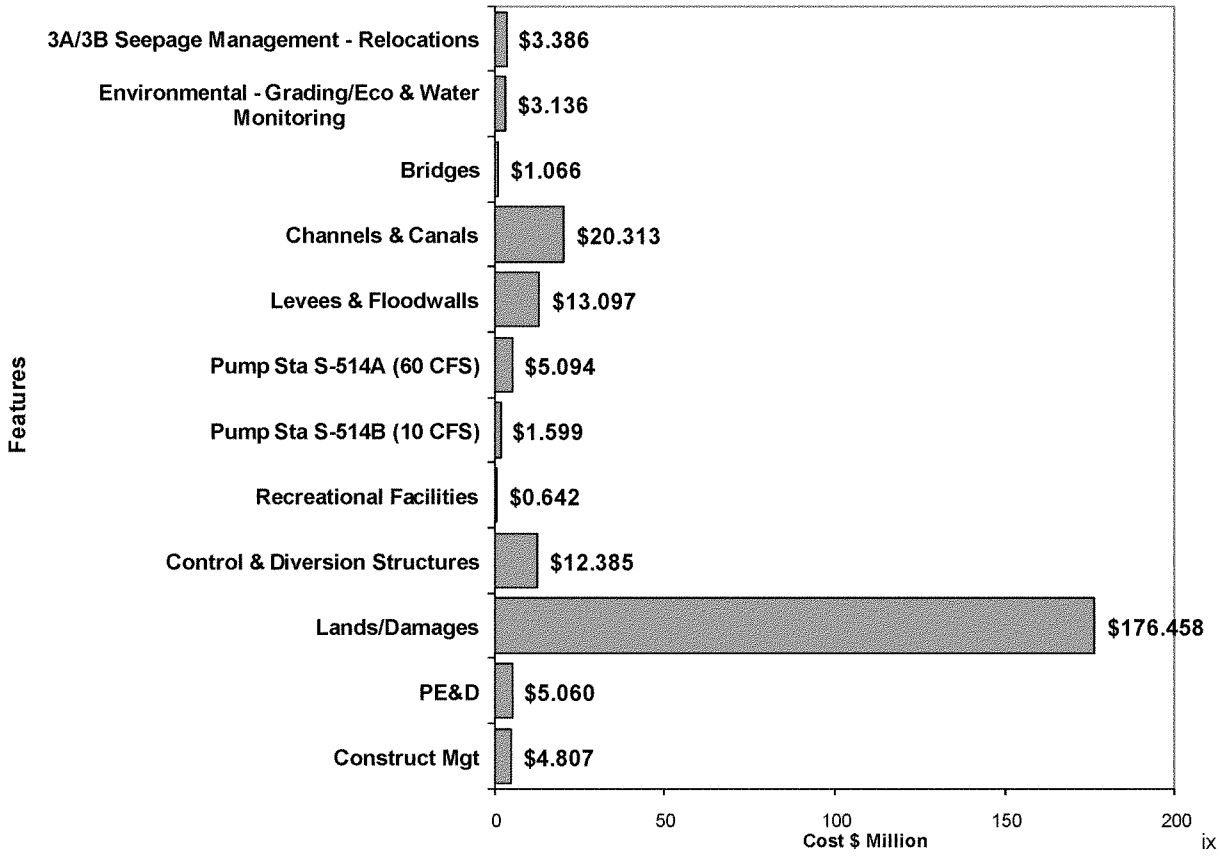
Cost Model 1: Broward County WPA C-11 Impoundment
Total Construction Estimate - $459.5 Million



Cost Model 2: Broward County WPA C-9 Impoundment
Total Construction Estimate - $214.2 Million



Cost Model 3: Broward County WPA 3A/3B Seepage Management
Total Construction Estimate - $247.0 Million

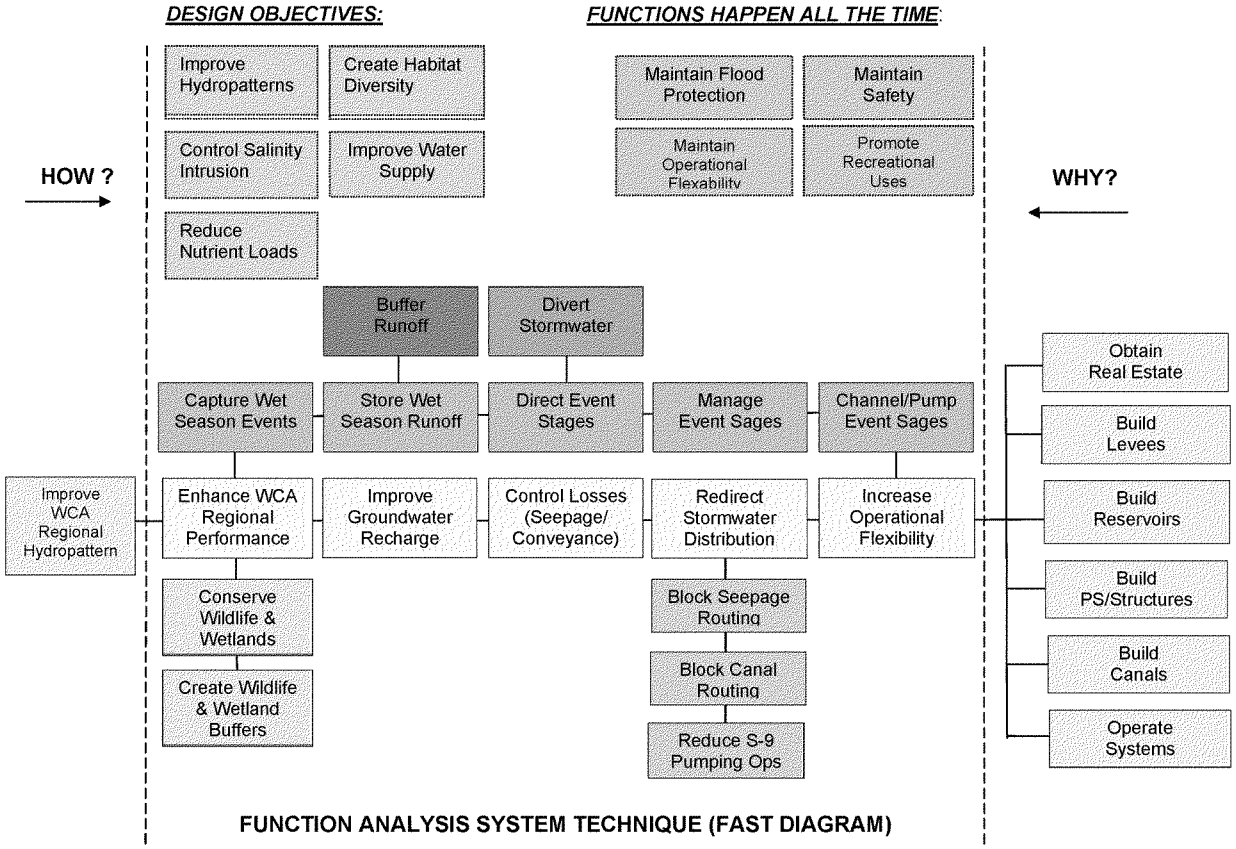


FUNCTION ANALYSIS SYSTEM TECHNIQUE LIST (FASTL)

FUNCTION ANALYSIS SYSTEM TECHNIQUE (FAST) DIAGRAM

Broward County WPA Project Function Analysis List

	Project Functions as Action Verb and Noun:	Being Met? (Y/N/?)
1	**Improve Hydropatterns**	Y
2	Control Seepage	Y
3	Enhance groundwater recharge	Y
4	Store water	Y
5	Enhance Wetlands	Y
6	Promote Recreational Use	Y
7	Conserve Wildlife	Y
8	Reduce Nutrient Loads	Y
9	Increase habitat function/diversity	Y
10	Maintain Flood Protection	Y
11	Create Wildlife Buffer	Y
12	Enhance Estuary Performance	Y
13	Increase operational Flexibility	Y
14	Manage costs (Construction/O&M)	Y
15	Control Saltwater Intrusion	Y
16	Divert Stormwater	Y
17	Buffer Runoff	Y
18	Control Water	Y
19	Pump Water	Y
20	Reduction of S-9 Pumping Operations	Y
1	**Address constructability**	Y
2	Acqure Real Estate	Y
3	Address downstream effects	Y
4	Address sequencing	Y
5	Care of water - storm/seasonal during construction	Y
6	Develop wide range of materials	Y
7	Identify material availably	Y
8	Plan material deliveries	Y
9	Procurement strategy - IFB/RFP	Y
10	Protect environment	Y
11	Maintain safety	Y
12	Manage costs	Y
13	Involve communities/public	Y
14	Obtain permits	Y
15	Deliver to schedules	Y



FUNCTION ANALYSIS SYSTEM TECHNIQUE (FAST DIAGRAM)

Broward County Water Preserve Area

SUPPORTING INFORMATION

VALUE ENGINEERING TEAM STUDY

APPENDIX E:

Page 1

Life Cycle Cost Analysis for Proposal C-6: Use Buried Cellular Confinement Systems (Geocells) to protect the C-9 Impoundment levees from overwash erosion

LIFE CYCLE COST ESTIMATE WORKSHEET						
Broward County WPA C-9 Impoundment Embankment Alternatives						
ALTERNATIVES: ***15' Smooth Embankment w/ Buried Soil-Cement vs. 15' Smooth Embankment w/ Buried Geocell***						
(Systems Service Life: 100-Years)						
ANNUAL PERCENTAGE RATE: ***4.375%***						
			Alternative 1 Design		***Alternative 4 Design***	
INITIAL COST			PRESENT WORTH		PRESENT WORTH	
Alternative 1 Capital Cost: Smooth Embankment w/ Buried Soil-Cement, 2 FT Top Soil and Sod			***$8,353,411***			
Alternative 4 Capital Costs: 15' Smooth Embankment w/ Buried Geocell, 1 FT Top Soil and Sod					***$11,108,481***	
SUBTOTAL			***$8,353,411***		***$11,108,481***	
(Given: i = 4.375%)		PRESENT				
SINGLE	YEAR	WORTH		PRESENT		PRESENT
EXPENDITURE		FACTOR	ESTIMATE	WORTH	ESTIMATE	WORTH
	25	***0.34284***	***$0***	***$0***	***$0***	***$0***
	50	***0.11754***	***$0***	***$0***	***$0***	***$0***
	75	***0.04030***	***$0***	***$0***	***$0***	***$0***
	100	***0.01382***	***$0***	***$0***	***$0***	***$0***
SALVAGE VALUE	***0***	***0***	***$0***	***$0***	***$0***	***$0***
SUBTOTAL				***$0***		***$0***
(Given: i = 4.375%)		UNIT PMT				
ANNUAL	YEAR	PW		PRESENT		PRESENT
EXPENDITURE		FACTOR	ESTIMATE	WORTH	ESTIMATE	WORTH
	25	***15.02087***	***$0***	***$0***	***$0***	***$0***
Annual O&M	***50***	***20.17058***	***$325,067***	***$6,557,000***	***$195,844***	***$3,950,000***
	75	***21.93609***	***$0***	***$0***	***$0***	***$0***
	100	***22.54137***	***$0***	***$0***	***$0***	***$0***
SUBTOTAL				***$6,557,000***		***$3,950,000***
TOTAL PRESENT WORTH				***$14,910,411***		***$15,058,000***
TOTAL LIFE CYCLE SAVINGS				***$147,589***		***-$147,589***
Annual O&M reflects annual cost. Future major maintenance/replacement are identified as Single Expenditure and is not factored into annual expenditure.						
*USACE / USTD Established discount rates in October each year. FY 2010 is 4.375%.						

VALUE ENGINEERING TEAM STUDY

APPENDIX E:

Page 2

Life Cycle Cost Analysis for Proposal C-6: Use Buried Cellular Confinement Systems (Geocells) to protect the C-9 Impoundment levees from overwash erosion

Broward County WPA C-9 Impoundment Embankment Alternatives
Operation and Maintenance Forecast

Alternative 1 Capital Cost: Smooth Embankment w/ Buried Soil-Cement, 2 FT Top Soil and Sod

No.	O&M Activity/Action	Unit	Unit Cost	Quantity	Total
1	Mowing - Slope	Ac	$110.73	44.25	$4,900
2	Grading (~15% Annually)	CY	$3.42	21,419	$73,254
3	Vegetation Maint	Ac	$80.00	44.25	$3,540
4	Chemicals	Ac	$50.00	44.25	$2,213
5	Grass/Sod (~15% Annually)	SY	$7.51	32,129	$241,161
6	Other				$0
7	Total				$325,067

No.	Replacement Activity/Action	Unit	Unit Cost	Quantity	Total
1	NA				$0
2	NA				$0
3	Total				$0

Alternative 4 Capital Costs: 15' Smooth Embankment w/ Buried Geocell, 1 FT Top Soil and Sod

No.	O&M Activity/Action	Unit	Unit Cost	Quantity	Total
1	Mowing - Slope	Ac	$110.73	44.25	$4,900
2	Grading (~10% Annually)	CY	$3.42	7,139.8	$24,418
3	Vegetation Maint	Ac	$80.00	44.25	$3,540
4	Chemicals	Ac	$50.00	44.25	$2,213
5	Grass/Sod (~10% Annually)	SY	$7.51	21,419	$160,774
6	Other				$0
7	Total				$195,844

No.	Replacement Activity/Action*	Unit	Unit Cost	Quantity	Total
1	NA				$0
2	NA				$0
3	Total				$0

NOTES:

1 O&M activity unit cost from SFWMD Operation and Maintenance Forecast dated Jan 2009.
2 New unit price developed for grading on sloped embankment from Site 1 using levee fill by scraper or dozer $1.31/CY, grade and compact $2.12/CY = $3.42/CY
3 O&M quantity and cost is limited to items influenced by alternative systems being compared.
4 Less slope repair and regrassing would be necessary for Geogrid (reduced by 1/3).
5 Federal discount rate for FY 2010 is 4.375% for 50 and 100-years.
6 Plan formulation LCC are developed for 50 Year Service Life per ER 1105-2-100
7 PED LCC are developed for 100 Year Service Life per ER111-2-8-159

VALUE ENGINEERING TEAM STUDY

APPENDIX E:

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Life Cycle Cost Analysis for Proposal C-6: Use Buried Cellular Confinement Systems (Geocells) to protect the C-9 Impoundment levees from overwash erosion

LIFE CYCLE COST ESTIMATE WORKSHEET						
Broward County WPA C-9 Impoundment Embankment Alternatives						
ALTERNATIVES: ***15' Smooth Embankment w/ Anchored TRM vs. 15' Smooth Embankment w/ Buried Geocell***						
(Systems Service Life: 100-Years)						
ANNUAL PERCENTAGE RATE: ***4.375%***						
			Alternative 2 Design		***Alternative 4 Design***	
INITIAL COST			PRESENT WORTH		PRESENT WORTH	
Alternative 2 Capital Cost: Smooth Embankment w/ Anchored TRM and Sod			***$10,263,236***			
Alternative 4 Capital Costs: 15' Smooth Embankment w/ Buried Geocell, Top Soil and Sod						***$9,661,041***
SUBTOTAL			***$10,263,236***			***$9,661,041***
(Given: i = 4.375%)		PRESENT				
SINGLE	YEAR	WORTH		PRESENT		PRESENT
EXPENDITURE		FACTOR	ESTIMATE	WORTH	ESTIMATE	WORTH
	25	***0.34284***	***$0***	***$0***	***$0***	***$0***
Replace Anchored TRM/Grass	***50***	***0.11754***	***$7,415,525***	***$871,601***	***$0***	***$0***
	75	***0.04030***	***$0***	***$0***	***$0***	***$0***
	100	***0.01382***	***$0***	***$0***	***$0***	***$0***
SALVAGE VALUE	***0***	***0***	***$0***	***$0***	***$0***	***$0***
SUBTOTAL				***$871,601***		***$0***
(Given: i = 4.375%)		UNIT PMT				
ANNUAL	YEAR	PW		PRESENT		PRESENT
EXPENDITURE		FACTOR	ESTIMATE	WORTH	ESTIMATE	WORTH
	25	***15.02087***	***$0***	***$0***	***$0***	***$0***
Annual O&M	***50***	***20.17058***	***$95,068***	***$1,918,000***	***$195,844***	***$3,950,000***
	75	***21.93609***	***$0***	***$0***	***$0***	***$0***
	100	***22.54137***	***$0***	***$0***	***$0***	***$0***
SUBTOTAL				***$1,918,000***		***$3,950,000***
TOTAL PRESENT WORTH				***$13,052,837***		***$13,611,000***
TOTAL LIFE CYCLE SAVINGS				***$558,163***		***-$558,163***
Annual O&M reflects annual cost. Future major maintenance/replacement are identified as Single Expenditure and is not factored into annual expenditure.						
*USACE / USTD Established discount rates in October each year. FY 2010 is 4.375%.						
Plan formulation LCC are developed for 50 Year Service Life per ER 1105-2-100						22-Sep-10

VALUE ENGINEERING TEAM STUDY

APPENDIX E:

Life Cycle Cost Analysis for Proposal C-6: Use Buried Cellular Confinement Systems (Geocells) to protect the C-9 Impoundment levees from overwash erosion

Broward County WPA C-9 Impoundment Embankment Alternatives

Operation and Maintenance Forecast

Alternative 2 Capital Cost: Smooth Embankment w/ Anchored TRM and Sod

No.	O&M Activity/Action	Unit	Unit Cost	Quantity	Total
1	Mowing - Slope	Ac	$110.73	44.25	$4,900
2	Grading (~5% Annually)	CY	$3.42	1,178	$4,029
3	Vegetation Maint	Ac	$80.00	44.25	$3,540
4	Chemicals	Ac	$50.00	44.25	$2,213
5	Grass/Sod (~5% Annually)	SY	$7.51	10,710	$80,387
6	Other				$0
7	Total				$95,068

No.	Replacement Activity/Action	Unit	Unit Cost	Quantity	Total
1	Anchored High Performance TRM	SY	$27.11	214,193.33	$5,807,785
2	Grass/Sod	SY	$7.51	214,193.33	$1,607,741
3	Total *(By Construction Contract)				$7,415,525

Alternative 4 Capital Costs: 15' Smooth Embankment w/ Buried Geocell, Top Soil and Sod

No.	O&M Activity/Action	Unit	Unit Cost	Quantity	Total
1	Mowing - Slope	Ac	$110.73	44.25	$4,900
2	Grading (~10% Annually)	CY	$3.42	7,139.8	$24,418
3	Vegetation Maint	Ac	$80.00	44.25	$3,540
4	Chemicals	Ac	$50.00	44.25	$2,213
5	Grass/Sod (~10% Annually)	SY	$7.51	21,419	$160,774
6	Other				$0
7	Total				$195,844

No.	Replacement Activity/Action*	Unit	Unit Cost	Quantity	Total
1	NA				$0
2	NA				$0
3	Total				$0

NOTES:

1 O&M activity unit cost from SFWMD Operation and Maintenance Forecast dated Jan 2009.

2 New unit price developed for grading on sloped embankment from Site 1 using levee fill by scraper or dozer $1.31/CY, grade and compact $2.12/CY = $3.42/CY

3 O&M quantity and cost is limited to items influenced by alternative systems being compared.

4 Less slope repair and regrassing would be necessary for TRM (reduced by 1/2).

5 Replacement of the Anchored High Performance TRM and regrassing is scheduled for year 50.

6 Federal discount rate for FY 2010 is 4.375% for 50 and 100-years.

7 Plan formulation LCC are developed for 50 Year Service Life per ER 1105-2-100

8 PED LCC are developed for 100 Year Service Life per ER111-2-8-159

VALUE ENGINEERING TEAM STUDY

APPENDIX E:

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Life Cycle Cost Analysis for Proposal C-6: Use Buried Cellular Confinement Systems (Geocells) to protect the C-9 Impoundment levees from overwash erosion

LIFE CYCLE COST ESTIMATE WORKSHEET						
Broward County WPA C-9 Impoundment Embankment Alternatives						
ALTERNATIVES: ***17.5' Smooth Embankment (No Armor) vs. 15' Smooth Embankment w/ Buried Geocell***						
(Systems Service Life: 100-Years)						
ANNUAL PERCENTAGE RATE: ***4.375%***			***Alternative 3 Design***		***Alternative 4 Design***	
INITIAL COST			PRESENT WORTH		PRESENT WORTH	
Alternative 3 Capital Cost: 17.5' Smooth Embankment (No Armor) and Sod			***$13,241,618***			
Alternative 4 Capital Costs: 15' Smooth Embankment w/ Buried Geocell, Top Soil and Sod					***$9,661,041***	
SUBTOTAL			***$13,241,618***		***$9,661,041***	
(Given: i = 4.375%)		PRESENT				
SINGLE	YEAR	WORTH		PRESENT		PRESENT
EXPENDITURE		FACTOR	ESTIMATE	WORTH	ESTIMATE	WORTH
	25	***0.34284***	***$0***	***$0***	***$0***	***$0***
	50	***0.11754***	***$0***	***$0***	***$0***	***$0***
	75	***0.04030***	***$0***	***$0***	***$0***	***$0***
	100	***0.01382***	***$0***	***$0***	***$0***	***$0***
SALVAGE VALUE	***0***	***0***	***$0***	***$0***	***$0***	***$0***
SUBTOTAL				***$0***		***$0***
(Given: i = 4.375%)		UNIT PMT				
ANNUAL	YEAR	PW		PRESENT		PRESENT
EXPENDITURE		FACTOR	ESTIMATE	WORTH	ESTIMATE	WORTH
	25	***15.02087***	***$0***	***$0***	***$0***	***$0***
Annual O&M	***50***	***20.17058***	***$221,836***	***$4,475,000***	***$195,844***	***$3,950,000***
	75	***21.93609***	***$0***	***$0***	***$0***	***$0***
	100	***22.54137***	***$0***	***$0***	***$0***	***$0***
SUBTOTAL				***$4,475,000***		***$3,950,000***
TOTAL PRESENT WORTH				***$17,716,618***		***$13,611,000***
TOTAL LIFE CYCLE SAVINGS				***-$4,105,618***		***$4,105,618***
Annual O&M reflects annual cost. Future major maintenance/replacement are identified as Single Expenditure and is not factored into annual expenditure.						
*USACE / USTD Established discount rates in October each year. FY 2010 is 4.375%.						
Plan formulation LCC are developed for 50 Year Service Life per ER 1105-2-100						22-Sep-10

Life Cycle Cost Analysis for Proposal C-6: Use Buried Cellular Confinement Systems (Geocells) to protect the C-9 Impoundment levees from overwash erosion

Broward County WPA C-9 Impoundment Embankment Alternatives
Operation and Maintenance Forecast

Alternative 3 Capital Cost: 17.5' Smooth Embankment (No Armor) and Sod

No.	O&M Activity/Action	Unit	Unit Cost	Quantity	Total
1	Mowing - Slope	Ac	$110.73	44.25	$4,900
2	Grading (~10% Annually)	CY	$3.42	8,142	$27,845
3	Vegetation Maint	Ac	$80.00	44.25	$3,540
4	Chemicals	Ac	$50.00	44.25	$2,213
5	Grass/Sod (~10% Annually)	SY	$7.51	24,426	$183,339
6	Other				$0
7	Total				$221,836

No.	Replacement Activity/Action	Unit	Unit Cost	Quantity	Total
1	NA				$0
2	NA				$0
3	Total				$0

Alternative 4 Capital Costs: 15' Smooth Embankment w/ Buried Geocell, Top Soil and Sod

No.	O&M Activity/Action	Unit	Unit Cost	Quantity	Total
1	Mowing - Slope	Ac	$110.73	44.25	$4,900
2	Grading (~10% Annually)	CY	$3.42	7,140	$24,418
3	Vegetation Maint	Ac	$80.00	44.25	$3,540
4	Chemicals	Ac	$50.00	44.25	$2,213
5	Grass/Sod (~10% Annually)	SY	$7.51	21,419	$160,774
6	Other				$0
7	Total				$195,844

No.	Replacement Activity/Action*	Unit	Unit Cost	Quantity	Total
1	NA				$0
2	NA				$0
3	Total				$0

NOTES:

1 O&M activity unit cost from SFWMD Operation and Maintenance Forecast dated Jan 2009.
2 New unit price developed for grading on sloped embankment from Site 1 using levee fill by scraper or dozer $1.31/CY, grade and compact $2.12/CY = $3.42/CY
3 O&M quantity and cost is limited to items influenced by alternative systems being compared.
4 Slope repair and regrassing would be equal.
5 Federal discount rate for FY 2010 is 4.375% for 50 and 100-years.
6 Plan formulation LCC are developed for 50 Year Service Life per ER 1105-2-100
7 PED LCC are developed for 100 Year Service Life per ER111-2-8-159

VALUE ENGINEERING TEAM STUDY

APPENDIX E:

Life Cycle Cost Analysis for Proposal C-6: Use Buried Cellular Confinement Systems (Geocells) to protect the C-9 Impoundment levees from overwash erosion

LIFE CYCLE COST ESTIMATE WORKSHEET						
Broward County WPA C-9 Impoundment Embankment Alternatives						
ALTERNATIVES: ***15' Smooth Embankment (With Bench and No Armor) vs. 15' Smooth Embankment w/ Buried Geocell***						
(Systems Service Life: 100-Years)						
ANNUAL PERCENTAGE RATE: ***4.375%***			***Alternative 4 Design***		***Alternative 5 Design***	
INITIAL COST			PRESENT WORTH		PRESENT WORTH	
Alternative 4 Capital Cost: 15' Smooth Embankment (With Bench and No Armor) and Sod			***$13,167,128***			
Alternative 5 Capital Costs: 15' Smooth Embankment w/ Buried Geocell, Top Soil and Sod					***$9,661,041***	
SUBTOTAL			***$13,167,128***		***$9,661,041***	
(Given: i = 4.375%)		PRESENT				
SINGLE	YEAR	WORTH		PRESENT		PRESENT
EXPENDITURE		FACTOR	ESTIMATE	WORTH	ESTIMATE	WORTH
	25	***0.34284***	***$0***	***$0***	***$0***	***$0***
	50	***0.11754***	***$0***	***$0***	***$0***	***$0***
	75	***0.04030***	***$0***	***$0***	***$0***	***$0***
	100	***0.01382***	***$0***	***$0***	***$0***	***$0***
SALVAGE VALUE	***0***	***0***	***$0***	***$0***	***$0***	***$0***
SUBTOTAL				***$0***		***$0***
(Given: i = 4.375%)		UNIT PMT				
ANNUAL	YEAR	PW		PRESENT		PRESENT
EXPENDITURE		FACTOR	ESTIMATE	WORTH	ESTIMATE	WORTH
	25	***15.02087***	***$0***	***$0***	***$0***	***$0***
Annual O&M	***50***	***20.17058***	***$195,844***	***$3,950,000***	***$195,844***	***$3,950,000***
	75	***21.93609***	***$0***	***$0***	***$0***	***$0***
	100	***22.54137***	***$0***	***$0***	***$0***	***$0***
SUBTOTAL				***$3,950,000***		***$3,950,000***
TOTAL PRESENT WORTH				***$17,117,128***		***$13,611,000***
TOTAL LIFE CYCLE SAVINGS				***-$3,506,128***		***$3,506,128***
Annual O&M reflects annual cost. Future major maintenance/replacement are identified as Single Expenditure and is not factored into annual expenditure.						
*USACE / USTD Established discount rates in October each year. FY 2010 is 4.375%.						
Plan formulation LCC are developed for 50 Year Service Life per ER 1105-2-100						22-Sep-10

VALUE ENGINEERING TEAM STUDY

APPENDIX E:

Life Cycle Cost Analysis for Proposal C-6: Use Buried Cellular Confinement Systems (Geocells) to protect the C-9 Impoundment levees from overwash erosion

Broward County WPA C-9 Impoundment Embankment Alternatives

Operation and Maintenance Forecast

Alternative 4 Capital Cost: 15' Smooth Embankment (With Bench and No Armor) and Sod

No.	O&M Activity/Action	Unit	Unit Cost	Quantity	Total
1	Mowing - Slope	Ac	$110.73	44.25	$4,900
2	Grading (~10% Annually)	CY	$3.42	7,140	$24,418
3	Vegetation Maint	Ac	$80.00	44.25	$3,540
4	Chemicals	Ac	$50.00	44.25	$2,213
5	Grass/Sod (~10% Annually)	SY	$7.51	21,419	$160,774
6	Other				$0
7	Total				$195,844

No.	Replacement Activity/Action	Unit	Unit Cost	Quantity	Total
1	NA				$0
2	NA				$0
3	Total				$0

Alternative 5 Capital Costs: 15' Smooth Embankment w/ Buried Geocell, Top Soil and Sod

No.	O&M Activity/Action	Unit	Unit Cost	Quantity	Total
1	Mowing - Slope	Ac	$110.73	44.25	$4,900
2	Grading (~10% Annually)	CY	$3.42	7,140	$24,418
3	Vegetation Maint	Ac	$80.00	44.25	$3,540
4	Chemicals	Ac	$50.00	44.25	$2,213
5	Grass/Sod (~10% Annually)	SY	$7.51	21,419	$160,774
6	Other				$0
7	Total				$195,844

No.	Replacement Activity/Action*	Unit	Unit Cost	Quantity	Total
1	NA				$0
2	NA				$0
3	Total				$0

NOTES:

1 O&M activity unit cost from SFWMD Operation and Maintenance Forecast dated Jan 2009.

2 New unit price developed for grading on sloped embankment from Site 1 using levee fill by scraper or dozer $1.31/CY, grade and compact $2.12/CY = $3.42/CY

3 O&M quantity and cost is limited to items influenced by alternative systems being compared.

4 Slope repair and regrassing would be equal.

5 Federal discount rate for FY 2010 is 4.375% for 50 and 100-years.

6 Plan formulation LCC are developed for 50 Year Service Life per ER 1105-2-100

7 PED LCC are developed for 100 Year Service Life per ER111-2-8-159

PERMA-ZYME road stabilization:

PERMA-ZYME is a unique, soil-stabilizing product with the potential to significantly reduce your overall costs for road construction and maintenance. PERMA-ZYME is a non-toxic formulation of enzyme-rich materials that is manufactured through a natural fermentation process using only sugars and other 100% natural, organic compounds.

When mixed with water and applied during compaction, PERMA-ZYME acts upon the soil's organic fines through a catalytic bonding process producing a strong cementation effect. The result is a durable and water-resistant mix that can be used in any climatic environment as a sub-base or as a primary surface. Typically, the bonding process will be sufficiently cured within 72 hours to permit a road's use by normal traffic.

The product is both safe and convenient to handle. It is highly concentrated and is available in handy 5-gallon containers. Only 15 gallons of PERMA-ZYME are needed for a one-mile road surface, 25-feet wide and 6-inches deep. No special construction or handling equipment is required to apply PERMA-ZYME, only a blade or mixer/reclaimer, a water truck and a roller.

Because the enzymes in PERMA-ZYME interact with a wide variety of soil materials, maximum use can be made of existing soils. This minimizes the need to haul in additional materials. And because it is mixed on site, construction crews will encounter no storage or waste problems. Perma-Zyme works well with all organic soils. It will increase the bonding of the fines (-200 mesh) and allow greater moisture penetration to facilitate compaction. Perma-Zyme has been used successfully in roads containing Limestone (CaO). Calcite (CaCO3), a fine grain limestone or soft earthy clay, also reacts positively with Perma-Zyme, however the use of clays should be minimized in road building - usually less than 30% -200 mesh.

All these factors make PERMA-ZYME highly economical with considerable cost savings of 3-5 times when compared with conventional road construction methods.

For additional information on Perma-zyme, including Environmental and Toxicological Analysis Report, visit the website:
http://www.itstoyou.com/sites/internationalenzymes/perma-zyme/

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Pictures of a typical process application are provided on the following pages:

Typical Road Stabilization Equipment

Typical Soil and Enzyme-Water Mixing Equipment

Grading Equipment

Compaction Equipment (Smooth Roller may also be used)

FOR CONTINUATION OF HOUSE DOCUMENT 112-154

CENTRAL AND SOUTHERN FLORIDA PROJECT
BROWARD COUNTY WATER PRESERVE AREAS
INTEGRATED PROJECT IMPLEMENTATION REPORT AND
ENVIRONMENTAL IMPACT STATEMENT

SEE PART 3