114th Congress, 1st Session – – – – – – – – – – – – – – House Document 114–24

TRUCKEE MEADOWS, NEVADA: FINAL GENERAL REEVALUATION REPORT AND ENVIRONMENTAL IMPACT STATEMENT, MARCH 2014

COMMUNICATION

FROM

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

TRANSMITTING

THE PROPOSAL FOR AUTHORIZATION TO MODIFY THE TRUCKEE MEADOWS PROJECT ON THE TRUCKEE RIVER IN WASHOE COUNTY, NEVADA, FOR THE PURPOSES OF FLOOD RISK MANAGEMENT AND RECREATION

PART 1 OF 2

APRIL 13, 2015.—Referred to the Committee on Transportation and Infrastructure and ordered to be printed

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DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY
CIVIL WORKS
108 ARMY PENTAGON
WASHINGTON DC 20310-0108

MAR 27 2015

Honorable John Boehner
Speaker of the House of Representatives
U.S. Capitol Building, Room H-232
Washington, DC 20515-0001

Dear Mr. Speaker:

The Secretary of the Army recommends authorization to modify the Truckee Meadows project on the Truckee River in Washoe County, Nevada, for the purposes of flood risk management and recreation. The proposal is described in the enclosed report of the Chief of Engineers, dated April 11, 2014, which includes other reports and pertinent documents. The project was authorized in section 7002(2) 9 of the Water Resources Reform and Development Act of 2014. The Secretary plans to implement the project at the appropriate time, considering National priorities and the availability of funds.

The recommended flood risk management plan consists of constructing approximately 9,650 linear feet of floodwalls along the north bank and 31,000 linear feet of levees along the north and south banks of the Truckee River, and excavating a benched area along portions of the south bank. The project would reduce expected average annual damages from the Truckee River within the Truckee Meadows reach by approximately 40 percent. The annual exceedance probabilities for flooding would be reduced from approximately four to ten percent depending on location to approximately one percent.

The estimated total first cost for reducing flood risk is $270,851,000 based on October 2014 price levels. In accordance with section 103(a) of the Water Resources Development Act (WRDA) of 1986, as amended, the estimated Federal cost share is approximately $176,053,000 (65 percent) and the non-Federal cost share is approximately $94,798,000 (35 percent). The non-Federal sponsor, Truckee River Flood Management Authority, would provide all required lands, easements, rights-of-way, relocations, and excavated material disposal areas, a cost currently estimated to be $79,145,000. The sponsor would also be responsible for the operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) after construction in accordance with section 103(j) of the WRDA of 1986, a cost estimated at $700,000 per year.

Based on October 2014 price levels, a discount rate of 3.375 percent, and a 50-year period of analysis, the total equivalent average annual cost, including OMRR&R, is approximately $11,042,000. The average annual benefit for reducing flood damages is about $25,193,000 which provides net average annual benefits estimated at

$14,151,000 and a benefit cost ratio of about 2.3 to 1. The average annual residual flood damages would be about $37,069,000.

The project would increase the water surface elevations within the Truckee Meadows area along downstream reaches by four to eight inches for events between two percent and one percent annual chance exceedance. The increased flood elevations would be inconsistent with National Flood Insurance Program (NFIP) regulatory requirements that prevent communities from allowing floodplain encroachments that would cause increased base flood elevations in areas with existing structures. Compliance with the NFIP is a non-Federal responsibility and compliance costs estimated at $196,400,000 would be borne by non-Federal interests.

The recreation plan consists of one small group picnic shelter; one medium group picnic shelter, with parking, playground, and restrooms; 50 individual picnic areas; approximately 9,700 linear feet of paved trails; 8,900 linear feet of unpaved trails; four kayak and canoe input areas; and 13 fishing areas along the river. The estimated total first cost for recreation is $10,296,000 based on October 2014 price levels. In accordance with section 103(c) of the WRDA of 1986, as amended, the estimated Federal and non-Federal cost shares are both approximately $5,148,000 (50 percent). The non-Federal sponsor would also be responsible for the OMRR&R after construction, a cost estimated at $173,000 per year. The total equivalent average annual cost for recreation, including OMRR&R, would be approximately $611,000. The average annual benefit for recreation would be about $633,000, which would provide net average annual benefits estimated at $22,000 and a benefit cost ratio of about 1.04 to 1.

The estimated total project first cost at October 2014 price levels is $284,458,000. The total estimated Federal cost share would be approximately $184,044,000 (64.7 percent) and the total non-Federal cost share would be about $100,414,000 (35.3 percent). The total OMRR&R is an estimated $873,000 per year. The total equivalent average annual cost, including OMRR&R, is about $11,653,000. The average annual benefit is about $25,826,000, which provides net average annual benefits estimated at $14,173,000 and a benefit cost ratio of about 2.2 to 1. No compensatory mitigation is required. The recommended plan is the National Economic Development plan.

The sponsors may receive credit for an estimated $45,250,000 for the purchase of lands, easements and rights-of-way that are expected to be necessary for the recommended plan in accordance with section 113 of the Energy and Water Development Appropriations Act of 2006. No credit is included for water quality improvements or ecosystem restoration work because the recommended plan does not include such features; and no credit is included for recreation because the sponsor has not implemented any of the recommended recreation features. The sponsor may also receive credit estimated at about $2,406,000 for in-kind levee and floodwall construction for the Reno-Sparks Indian Colony in accordance with section 104 of the WRDA of 1986, as amended.

V

The Office of Management and Budget (OMB) advises that there is no objection to the submission of the report to Congress and concludes that the report recommendation is consistent with the policy and programs of the President. OMB also advises that the project would need to compete with other proposed investments in future budgets. A copy of OMB's letter, dated March 20, 2015, is enclosed. I am providing a copy of this transmittal and the OMB letter to the Subcommittee on Water Resources and Environment of the House Committee on Transportation and Infrastructure, and the Subcommittee on Energy and Water Development of the House Committee on Appropriations. I am providing an identical letter to the President of the Senate.

Very truly yours,

Jo-Ellen Darcy
Assistant Secretary of the Army
(Civil Works)

Enclosures

10 Enclosures

1. OMB Clearance Letter, March 20, 2015
2. Record of Decision, March 24, 2015
3. Report of the Chief of Engineers, April 11, 2014
4. Federal Emergency Management Agency (FEMA) letter, February 11, 2014
5. Environmental Protection Agency (EPA) letter, February 18, 2014
6. Pyramid Lake Paiute Tribe (PLPT) letter, February 18, 2014
7. Federal Aviation Administration (FAA) letter, February 24, 2014
8. Reno-Sparks Indian Colony letter, March 10, 2014
9. Project Slides
10. Final General Reevaluation Report and Environmental Impact Statement, March 2014

VII

March 20th 2015

The Honorable Jo-Ellen Darcy
Assistant Secretary of the Army (Civil Works)
108 Army Pentagon
Washington, DC 20310-0108

Dear Ms. Darcy:

As required by Executive Order 12322, the Office of Management and Budget has completed its review of the Corps' General Reevaluation Report for the Truckee Meadows Flood Control Project, Nevada that proposes construction of certain flood control features and associated recreation features at a total first cost of $281 million (October 2013 prices). Based on our review, we conclude that this project is consistent with the program and policies of the President.

The Office of Management and Budget does not object to your submitting this report to Congress. When you do so, please advise the Congress that the project would need to compete with other proposed investments for funding in future budgets.

Sincerely,

John Pasquantino
Deputy Associate Director
Energy, Science, and Water

RECORD OF DECISION

TRUCKEE MEADOWS, NEVADA

The Final General Reevaluation Report (GRR) and the Final Environmental Impact Statement (EIS) for the Truckee Meadows, Nevada Project, dated March 2014, along with the report of the Chief of Engineers, dated April 11, 2014, address flood risk management and recreation opportunities in Washoe County, Nevada. Based on these reports, the views of other Federal, State and local agencies, input from the public, and the review by my staff, I find the project recommended by the Chief of Engineers to be technically feasible, economically justified, in accordance with environmental statutes, and in the public interest. Thus, I approve the Truckee Meadows, Nevada Project for construction.

The GRR and the EIS, incorporated herein by reference, document the evaluation of a number of non-structural and structural alternatives to reduce flood risk along the Truckee River. The plan selected for implementation is Alternative 3-Floodplain Terrace Plan with recreation. The recommended plan is the national economic development plan and consists of the following features:

- Construction of 9,650 feet of floodwalls and 31,000 feet of levees along the north and south banks of the Truckee River;
- Construction of about 9,000 feet floodplain terraces along the south bank of Truckee River from Greg Street to East McCarran Boulevard and planting with native vegetation;
- Construction of concrete box culverts south of Interstate 80, including a 200-foot extension and placement of caps on two junction structures for Peoples' Drain;
- Construction of under-seepage remediation and interior drainage management features;
- Construction of scour protection along the stream banks and around three bridges;
- Realignment of existing recreational trails, and construction of 18,600 feet of new trails with associated trail access, 4 kayak/canoe access points, 13 fishing access locations, 50 picnic areas, a parking area, a playground, restrooms, and two picnic shelters; and
- Monitoring of water quality and revegetation success on floodplain terraces.

In addition to the "no action" plan, several conceptual flood risk management alternatives were identified. Alternative 1-Levees and Floodwalls Plan and a locally developed plan were considered but were eliminated due to significant adverse environmental effects, greater flooding effects to downstream communities, and/or substantial public opposition. A detailed analysis of Alternative 2-Detention Plan, a plan

similar to the authorized plan, is included in the GRR and EIS. All practicable means to avoid or minimize adverse environmental effects have been incorporated into the project.

The recommended plan is considered the environmentally preferable alternative. The recommended plan avoids or minimizes adverse impacts to water quality and biological resources to a greater extent than do the other alternatives, while meeting the flood risk management project purpose. Potential adverse environmental effects are predicted to be offset through project design, construction practices, regulatory requirements and best management practices. No compensatory mitigation is proposed for the recommended plan because the potential adverse impacts are predicted to be offset through the beneficial effects associated with project design elements.

Pursuant to the Endangered Species Act, the U.S. Fish and Wildlife Service provided a Biological Opinion for short-term adverse effects to the Lahontan cutthroat trout and cui-ui lake sucker. The project will implement all reasonable and prudent measures and the terms and conditions identified in the Biological Opinion. Mitigation measures for air quality impacts include updating the estimated annual project emissions during the preconstruction engineering and design phase, and including in construction specifications, measures that would further reduce potential emissions from construction equipment and vehicles based on this estimate. Mitigation measures for wildlife hazards to aviation safety will reduce to less than significant any potential hazards from flood risk management or recreation features. The measures include minimizing attractants to birds during construction and, to the extent possible, the use of structural designs that discourage loafing, burrowing, or nesting opportunities along levees and recreational facilities. Coordination with the Federal Aviation Administration and Reno-Tahoe Airport will continue during the design, construction and operation of the project.

Technical and economic criteria used in the formulation of alternative plans were those specified in the Water Resource Council's 1983 Economic and Environmental Principles and Guidelines for Water and Related Land Resource Implementation Studies. All applicable laws, executive orders, regulations and guidelines were considered in evaluation of alternatives and the selection of the recommended plan. Based on review of these evaluations, I find that the flood risk management and recreation benefits gained by construction of the recommended plan serve the public interest and outweigh any adverse effects. This Record of Decision completes the National Environmental Policy Act process.

March 27, 2015
Date

Jo-Ellen Darcy
Assistant Secretary of the Army
(Civil Works)

X

DEPARTMENT OF THE ARMY
CHIEF OF ENGINEERS
2600 ARMYPENTAGON
WASHINGTON, D.C. 20310-2600

DAEN

11 APR 2014

SUBJECT: Truckee Meadows, Nevada

THE SECRETARY OF THE ARMY

1. I submit for transmission to Congress my report on flood risk management for the Truckee Meadows area near the city of Reno, Nevada. It is accompanied by the report of the Sacramento District Engineer and the South Pacific Division Engineer. The Truckee Meadows Flood Control Project was authorized by Section 3(a) (10) of P.L. 100-676, the Water Resources Development Act (WRDA) of 1988. The Secretary of the Army received additional guidance regarding the preparation of the General Reevaluation Report (GRR) pursuant to the House Report 104-293 associated with P.L. 104-46, the Energy and Water Development Appropriations Act (EWDAA) of 1996, to consider additional flood protection along the Truckee River downstream of Reno as well as potential for environmental restoration along the Truckee River and tributaries in the Reno-Sparks area. Congress also gave direction as to the crediting of certain non-federal contributions in Section 113 of P.L. 109-103, the EWDAA of 2006.

2. The reporting officers recommend authorizing a plan to reduce flood risk by construction of floodwalls, levees, and floodplain terracing in the Truckee Meadows Reach and basic recreation features. The recommended plan includes approximately 9,650 linear feet of on-bank (6,500 feet) and in-channel (3,150 feet) floodwalls along the north bank and 31,000 linear feet of levees along the north and south banks in the Truckee Meadows Reach. The floodplain terracing feature involves excavating a benched area along portions of the south (right) bank of the Truckee River between Greg Street and McCarran Boulevard. Floodplain terracing would increase the flood flow channel capacity and thereby reduce water surface elevations in the Truckee Meadows area during a flood. The recommended plan for recreation consists of one small group picnic shelter; one medium group picnic shelter, with parking, playground, and restrooms; and 50 individual picnic areas located north of Mill Street between Greg Street and McCarran Boulevard. In addition, approximately 9,700 linear feet of paved trails and 8,900 linear feet of unpaved trails will be constructed linking the picnic areas with four kayak and canoe input areas and 13 fishing areas along the river. All recreation features would be located on lands required for flood risk management purposes. The estimated project first cost of the recommended plan is $280,820,000.

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SUBJECT: Truckee Meadows, Nevada

3. The recommended plan would reduce flood risk to the Truckee Meadows area. The project would reduce Expected Annual Damages (EAD) within Truckee Meadows by approximately 40 percent ($24,880,000). The residual EAD ($36,601,000) would be caused by flooding from the Truckee River for infrequent flood events and flooding from small tributaries. Annual Exceedance Probabilities (AEP) for flooding within Truckee Meadows would be reduced from approximately 4-10 percent (depending on location) to approximately 1 percent. The project would increase the water surface elevations within the Truckee Meadows area along the downstream reaches of Steamboat Creek, Boynton Slough, and the North Truckee Drain by 4-8 inches for events between 2 percent and 1 percent Annual Chance Exceedance (ACE). The increased 1 percent ACE flood elevations would be inconsistent with National Flood Insurance Program (NFIP) regulatory requirements that prevent communities from allowing floodplain encroachments that would cause increased base flood elevations in areas with existing structures. Under U.S. Army Corps of Engineers (USACE) policy, compliance with the NFIP is a non-federal responsibility and compliance costs would be borne by non-federal interests. These estimated additional costs for NFIP regulatory compliance are identified as regulatory requirement costs which are not included as economic costs of the project. The recommended plan would cause temporary and permanent losses of riparian habitat from construction activities affecting about 28 acres of native riparian habitat. The recommended plan would convert about 66 acres of prime farmland for levee construction. The potential adverse environmental effects would be reduced to a less than significant level through project design, construction practices, preconstruction surveys and analysis, regulatory requirements, and best management practices. No compensatory mitigation would be required.

4. The project first cost was estimated on the basis of October 2013 price levels and amounts to $280,820,000. The federal portion of the estimated first cost is $181,652,000. The non-federal portion of the estimated first cost is $99,168,000 including $78,572, 000 for lands, easements, rights-of-way, relocations, and dredged or excavated material disposal areas (LERRD). The Truckee River Flood Management Authority would also be responsible for the operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) of the project, a cost currently estimated at about $862,000 per year. The Authority is also responsible for the NFIP regulatory compliance requirements, currently estimated at $195,000,000. The NFIP regulatory compliance costs are not included in project first cost.

5. Based on a 3.5 percent discount rate and a 50-year period of analysis, the total equivalent average annual economic costs of the project (including OMRR&R) are estimated to be $11,823,000 ($11,211,000 for flood risk management and $612,000 for recreation). The recommended plan is estimated to be 95-99 percent reliable (depending on location) in providing flood risk management for the Truckee Meadows area, from a 2 percent ACE flood event. Total average annual economic benefits are estimated to be $25,505,000 ($24,880,000 for flood risk management and $625,000 for recreation); net average annual economic benefits are $13,682,000 ($13,669,000 for flood risk management and $13,000 for recreation). The overall benefit-to-cost ratio is 2.2 to 1 (1.0-to-1 for recreation).

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6. The goals and objectives included in the Campaign Plan of the USACE have been fully integrated into the Truckee Meadows study process. The recommended plan has been designed to avoid or minimize environmental impacts while maximizing future safety and economic benefits to the community. The recommended plan uses environmentally sustainable design including revegetation of floodplain terraces with native species. Environmental experts were consulted during the planning process, and coordination was conducted with a local community coalition to integrate project goals and public concerns.

7. An earlier USACE project, designated as the Truckee River and Tributaries Project, was authorized and constructed in this area pursuant to Section 203 of P.L. 83-780, the Flood Control Act (FCA) of 1954, and Section 203 of P.L. 87-874, the FCA of 1962. The reporting officers have recommended that the part of the existing Truckee River and Tributaries Project between Glendale Avenue and Vista be modified in accordance with the recommended plan for the Truckee Meadows Flood Control Project within that same reach. The Truckee River and Tributaries Project involved improvements at various reaches of the Truckee River between Lake Tahoe and Pyramid Lake. In the Truckee Meadows reach, maintained by the State of Nevada, the first project involved channel straightening and enlargement to provide a channel capacity of 6,000 cubic feet per second (cfs) of flow for flood risk management purposes. The proposed project will modify the Truckee River and Tributaries Project by increasing channel capacity, and by the placement of rip rap on banks and around bridge piers to avoid scouring. The operations and maintenance responsibility will be transferred from the State of Nevada to the present non-federal sponsor. This transfer of operations and maintenance responsibility for the Truckee River and Tributaries Project will ensure that the non-federal sponsor for the Truckee Meadows Flood Control Project has full and clear responsibility to the Department of the Army for OMRR&R of all federal flood risk management elements between Glendale Avenue and Vista. OMRR&R responsibilities for the parts of the Truckee River and Tributaries Project upstream of Glendale Avenue or downstream of Vista would not be changed by the recommended plan.

8. The reporting officers have further recommended additional studies to investigate further reduction of the residual flood risk to the Reno-Sparks area and/or ecosystem restoration opportunities along the Truckee River. Such studies could be part of a future comprehensive investigation of the Truckee River watershed, or a portion thereof. The previously authorized purpose of fish and wildlife enhancement (i.e., ecosystem restoration) may be retained for the Truckee Meadows Flood Control Project for potential future implementation.

9. In accordance with the Engineer Circular 1165-2-214, entitled "Civil Works Review", all technical, engineering and scientific work underwent an open, dynamic and vigorous review process to ensure technical quality. This included an Agency Technical Review (ATR), an Independent External Peer Review (IEPR) (Type I), and a USACE Headquarters policy and legal review. ATR concerns have been addressed and incorporated into the final report. The IEPR was completed by Battelle Memorial Institute. A total of 58 comments were documented. The IEPR comments identified significant concerns in areas of the explanation of the plan

formulation, hydraulic analysis, and environmental analyses. This resulted in expanded narratives throughout the report to support the decision-making process and justify the recommended plan. All comments from the above referenced reviews have been addressed and incorporated into the final documents. Overall the reviews resulted in improvements to the technical quality of the report. A safety assurance review (IEPR Type II) will be conducted during the design phase of the project.

10. The final GRR and EIS were published for State and Agency Review on 17 January 2014. Comments from other federal agencies generally requested minor clarifications and encouraged further cooperation through the project life. Two more extensive comment letters were received from the Pyramid Lake Paiute Tribe (PLPT) and Reno-Sparks Indian Colony (RSIC). The PLPT expressed concerns relating to tribal coordination and consultation, potential downstream impacts and impacts to the delta at Pyramid Lake, and cumulative impacts of other flood control projects. The PLPT also requested that ecosystem restoration work be included in this project. USACE responded to PLPT with commitments for further coordination and clarification on modeling analyses. Additional studies to investigate further ecosystem restoration opportunities are recommended in the report by the reporting officers. The RSIC letter expressed continued concern with not being a signatory to the Programmatic Agreement (PA) per Section 106 of the National Historic Preservation Act. The RSIC also requested revisions to the final EIS relating to Tribal claims, traditional cultural property (TCP) identification, and provision of funding for tribal monitors during construction. In the response letter sent to the RSIC, USACE committed to including RSIC as a signatory party to the PA and to abide by the stipulations of the PA, which will govern future activities to determine the presence of historic properties, including TCPs, and potential effects of the project.

11. Washington level review indicates that the project recommended by the reporting officers is technically sound, environmentally and socially acceptable, and economically justified. The plan complies with all essential elements of the 1983 U.S. Water Resources Council's Economic and Environmental Principles and Guidelines for Water and Land Related Resources Implementation Studies and complies with other administrative and legislative policies and guidelines. Also the views of interested parties, including federal, state and local agencies have been considered.

12. I concur in the findings, conclusions, and recommendations of the reporting officers. Accordingly, I recommend that the plan to reduce flood damage in the Truckee Meadows area near the City of Reno, Nevada, be authorized in accordance with the reporting officers' recommended plan at an estimated cost of $280,820,000 with such modifications as in the discretion of the Chief of Engineers may be advisable. My recommendation is subject to cost sharing, financing, and other applicable requirements of federal laws and policies, including Section 103 of P.L. 99-662, WRDA 1986, as amended (33 U.S.C. 2213). These requirements include, but are not limited to, the following items of local cooperation from the non-federal sponsor:

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a. Provide a minimum of 35 percent, but not to exceed 50 percent, of total flood risk management costs and 50 percent of total recreation costs as further specified below:

(1) Provide, during design, 35 percent of design costs allocated to flood risk management and 50 percent of design costs allocated to recreation.

(2) Pay, during the first year of construction, funds so its contribution equals 35 percent of the costs of the reevaluation report for the project.

(3) Pay, during construction, 5 percent of total flood risk management costs.

(4) Provide all lands, easements, and rights-of-way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material, and perform or ensure the performance of all relocations, as determined by the government to be required for the construction, operation, and maintenance of the project.

(5) During construction, pay any additional funds necessary to make its total contribution equal to at least 35 percent of total flood risk management costs and 50 percent of total recreation costs.

b. Provide, during construction, 100 percent of the total recreation costs that exceed 10 percent of the federal share of total flood risk management costs.

c. Inform affected interests, at least yearly, of the extent of protection afforded by the flood risk management features; participate in and comply with applicable federal floodplain management and flood insurance programs; comply with Section 402 of P.L. 99-662, the WRDA of 1986, as amended (33 U.S.C. 701b-12); and publicize floodplain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in adopting regulations, or taking other actions, to prevent unwise future development and to ensure compatibility with protection levels provided by the flood risk management features.

d. Prevent obstructions or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) such as any new developments on project lands, easements, and rights-of-way or the addition of facilities which might reduce the level of protection the flood risk management features afford, hinder operation and maintenance of the project, or interfere with the project's proper function.

e. Keep the recreation features, and access roads, parking areas, and other associated public use facilities, open and available to all on equal terms.

f. Operate, maintain, repair, rehabilitate, and replace the project, at no cost to the federal government, in a manner compatible with the project's authorized purposes and in accordance

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with applicable federal and state laws and regulations and any specific directions prescribed by the federal government.

g. Hold and save the United States free from all damages arising from the construction, operation, maintenance, repair, rehabilitation, and replacement of the project, except for damages due to the fault or negligence of the United States or its contractors.

h. Perform, or ensure performance of, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), P.L. 96-510, as amended (42 U.S.C. 9601-9675), that may exist in, on, or under lands, easements, or rights-of-way that the federal government determines to be required for construction, operation, and maintenance of the project.

i. Assume, as between the federal government and the non-federal sponsor, complete financial responsibility for all necessary cleanup and response costs of any hazardous substances regulated under CERCLA that are located in, on, or under lands, easements, or rights-of-way required for construction, operation, and maintenance of the project.

j. Agree, as between the federal government and the non-federal sponsor, that the non-federal sponsor shall be considered the operator of the project for the purpose of CERCLA liability, and to the maximum extent practicable, operate, maintain, repair, rehabilitate, and replace the project in a manner that will not cause liability to arise under CERCLA.

13. The recommendation contained herein reflects the information available at this time and current departmental policies governing formulation of individual projects. It does not reflect program and budgeting priorities inherent in the formulation of a national civil works construction program or the perspective of higher review levels within the executive branch. Consequently, the recommendation may be modified before it is transmitted to the Congress as a proposal for authorization and implementation funding. However, prior to transmittal to Congress, the sponsor, the state, interested federal agencies, and other parties will be advised of any significant modifications and will be afforded an opportunity to comment further.

THOMAS P. BOSTICK
Lieutenant General, USA
Chief of Engineers

Truckee River Flood Management Authority

May 7, 2013

William J. Leady, P.E.
Sacramento District Commander
Department of the Army Corps of Engineers
1325 J Street
Sacramento, CA 95814-2922

RE: Truckee Meadows Flood Control Project (TMFCP)– Letter of Intent as the Non-Federal Sponsor

Dear Colonel Leady:

The Truckee River Flood Management Authority (TRFMA) is a joint powers authority with representatives from the City of Reno, the City of Sparks and Washoe County. TRFMA has been monitoring the progress made by the Corps, Sacramento District, on the development of the GRR/EIS on the above referenced project since completion of the formal Memorandum of Agreement dated August 22, 2012. We are pleased that the TMFCP is nearing the final stage of the Draft Feasibility Revaluation Report and Environmental Impact Statement.

TRFMA hereby confirms its intent to participate as a Non-Federal Sponsor for the design and construction of the proposed flood risk reduction project as described in the current document as Alternate 3 with 50-yr level of flood risk protection. TRFMA's continued sponsorship for the subsequent phase(s) is subject to development of a separate agreement for PED. We understand that this letter of intent is not a binding commitment by the TRFMA with the Army Corps of Engineers and does not financially commit TRFMA to future expenditures without a new and separate agreement.

In closing, TRFMA would like to reiterate our appreciation to the Corps for its continued work in helping to solve the flood control issue that impacts the economy of Northern Nevada, and threatens lives and property owners in Reno, Sparks and Washoe County. We look forward to completing this important Feasibility Phase and initiating dialogue regarding development of agreements for subsequent phases.

Warmest Regards,

Jay L. Aldean, P.E.
Executive Director

Cc: TRFMA Board of Directors
Josephine Axt, Planning Division Chief, Los Angeles District
Glen Reed, USACE Project Manager

Truckee River Flood Management Authority • 9635 Gateway Dr. Suite A • Reno, NV 89521 • 775-850-7460
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U.S. Department of Homeland Security
1111 Broadway, Suite 1200
Oakland, CA 94607-4052
FEMA

February 11, 2014

Theodore A. Brown, P.E.
U.S. Army Corps of Engineers, Headquarters
CECW-P (SA)
7701 Telegraph Road
Alexandria, VA 22315-3860

Dear Mr. Brown:

This is in response to your requested review of the proposed report of the Chief of Engineers and the report of the district engineer on the Truckee Meadows Flood Control Project, Nevada. We are happy to assist with this review and comment is provided below.

The recommended plan is to reduce risk by constructing floodwalls, levees and floodplain terracing. The proposed project would increase water surface elevations within the Truckee Meadows area and along downstream reaches of Steamboat Creek, Boynton Slough and North Truckee Drain by 4-8 inches for events between the 2% and 1% annual chance floods. Approximately 764 homes and 128 multiplex apartment buildings could be impacted by these increased flood elevations on the south side of the Truckee River.

The Cities of Reno and Sparks are participants in the National Flood Insurance Program (NFIP) and have adopted floodplain management requirements. These ordinances require that any development in a regulatory floodway cause no increase in flood levels during the occurrence of the base (1% annual chance) flood discharge. The area of proposed construction in the recommended plan is located within a regulatory floodway. We recognize that the report notes this criterion is a non-federal responsibility and compliance costs with flood projects are to be borne by local interests.

The report also highlights that the currently effective Flood Insurance Rate Map (FIRM) for Washoe County, Nevada does not reflect existing flood hazards. Specifically, the mapped floodplains under predict current conditions. My staff will be coordinating with local officials on this matter and we trust existing conditions hydraulic modeling and floodplain mapping can be provided when they are finalized.

Thank you for your efforts to reduce flood risk and the opportunity to review the proposed report. If you have any questions regarding this matter, please contact Mr. Eric Simmons, of my staff, by telephone at (510) 627-7029, or by email at Eric.Simmons@fema.dhs.gov.

Sincerely,

Sally Ziolkowski, Director
Mitigation Division

cc: Mr. Shaun Carey, City Manager, City of Sparks
Mr. Andrew Clinger, City Manager, City of Reno
Mr. Rob Palmer, Nevada State Floodplain Manager/NFIP Coordinator

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS
441 G STREET, NW
WASHINGTON, DC 20314-1000

REPLY TO
ATTENTION OF

Planning and Policy Division

APR 1 2014

Sally Ziolkowski
Department of Homeland Security
Federal Emergency Management Agency, Region IX
111 Broadway, Suite 1200
Oakland, CA 94607-4052

Dear Ms. Ziolkowski:

This letter is in response to your comments on the final General Reevaluation Report and Environmental Impact Statement for the Truckee Meadows Flood Control Project provided in a letter dated February 11, 2014. We appreciate your review of the reports. As noted in your letter, Sacramento District will coordinate with you regarding the existing conditions hydraulic modeling and floodplain mapping developed for this project.

If you have further questions or need additional information, please contact the study lead planner, Kim Carsell, at (916) 557-7635.

Sincerely,

Theodore A. Brown

Theodore A. Brown, P.E.
Chief, Planning and Policy Division
Directorate of Civil Works

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105-3901

February 18, 2014

Colonel William J. Leady, District Engineer
U.S. Army Corps of Engineers
Sacramento District
1325 J Street
Sacramento, California 95814-2922

Attention: Tyler Stalker

Subject: Final Environmental Impact Statement for the Truckee Meadows Flood Control Project, General Reevaluation Report (CEQ # 20140011)

The U.S. Environmental Protection Agency is providing comments on the subject Final Environmental Impact Statement. Our comments are provided pursuant to the National Environmental Policy Act, Council on Environmental Quality regulations (40 CFR Parts 1500-1508), and our NEPA review authority under Section 309 of the Clean Air Act.

EPA reviewed the Draft Environmental Impact Statement for the Truckee Meadows Project and provided comments in our July 8, 2013 letter. We rated the document EC-2, Environmental Concerns – Insufficient Information, based on our concerns regarding water resources, including restoration, and air quality

We remain concerned by the uncertainty of future restoration of the Truckee River. We understand that the high cost of the wildlife enhancement plan selected in the General Reevaluation Report -- preliminarily estimated at $47 million -- may be too costly for local stakeholders to support with matching funds. In responding to our comment, the FEIS states that the Corps will participate with federal agencies and local interests to seek restoration opportunities. EPA strongly supports restoration; therefore, we encourage the Corps and its partners to be diligent and creative in arriving at affordable and sustainable solutions.

In response to our comment on air quality, the FEIS states that an updated estimate of annual project emissions will be prepared for the preconstruction engineering and design phase of the project. Construction specifications for the project will include measures to further reduce potential emissions from construction equipment and vehicles. We ask that these commitments be incorporated into the Army Corps' Record of Decision as mitigation measures.

We appreciate the opportunity to review this FEIS. When the Record of Decision has been signed, please send one copy to the address above (mail code: ENF-4-2), If you have any questions about our letter, please contact Tom Kelly, the lead reviewer for this project, at kelly.thomasp@epa.gov or (415) 972-3856, or call me at (415) 972-3521.

Sincerely,

Kathleen Martyn Goforth, Manager
Environmental Review Section (ENF-4-2)

cc (via email): Caryn Huntt DeCarlo, U.S. Bureau of Reclamation
Beverly Harry, Pyramid Lake Piute Tribe
Danielle Henderson, Truckee River Flood Management Project

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS
441 G STREET, NW
WASHINGTON, DC 20314-1000

REPLY TO
ATTENTION OF

APR 1 2014

Planning and Policy Division

Kathleen Martyn Goforth
Environmental Review Section (ENF-4-2)
U.S. Environmental Protection Agency, Region IX
75 Hawthorne Street
San Francisco, CA 94105

Dear Ms. Goforth:

This letter is in response to your comments on the Truckee Meadows Flood Control Project, Final Environmental Impact Statement provided in a letter dated February 18, 2014. We acknowledge your concern about future restoration of the Truckee River and encouragement to find affordable and sustainable solutions. Regarding your comments on air quality, Sacramento District has added to the Record of Decision the commitments to include measures in construction specifications that would further reduce potential emissions from construction equipment and vehicles. The District has also confirmed the commitment to update the estimate of annual project emissions for the preconstruction engineering and design phase of the project.

Sacramento District project staff will provide the Record of Decision to your office upon its execution as you requested and continue to coordinate with the Environmental Protection Agency as the project moves forward. We trust that the above information sufficiently addresses your concerns. If you would like to discuss these issues further, please contact the study lead planner, Kim Carsell, at (916) 557-7635.

Sincerely,

Theodore A. Brown

Theodore A. Brown, P.E.
Chief, Planning and Policy Division
Directorate of Civil Works

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airport's Airport Operations Area and a hazardous wildlife attractant if the attractant could cause hazardous wildlife movement into or across approach or departure airspace.

As portions of the Truckee Meadows Flood Control Project are within 10,000 feet of the RNO Airport Operations Area, and within 5 miles of RNO approach/departure airspace, the proposed project revegetation plan should be developed and reviewed with the assistance of a wildlife biologist qualified to conduct wildlife hazard assessments. FAA standards for such wildlife biologists are included in FAA AC 150/5200-36B *Qualifications for Wildlife Biologist Conducting Wildlife Hazard Assessments and Training Curriculums for Airport Personnel Involved in Controlling Wildlife Hazards on Airports.* We also recommend that the RNO airport staff be included in the development and review of the proposed revegetation plan for areas near the airport. The overall goal of those reviews should be to ensure that revegetation completed within 10,000 feet of the RNO Airport Operations Area has the minimum attractiveness to hazardous wildlife, and that no areas are created that would encourage more hazardous wildlife to cross the RNO approach/departure airspace.

The FAA ACs mentioned in this letter are available at the FAA national website www.faa.gov. If you have any questions, please contact me, at 650-827-7601, or Doug Pomeroy, Environmental Protection Specialist, at 650-827-7612.

Sincerely,

Robin K. Hunt

Robin K. Hunt
Manager, San Francisco Airports District Office

Pyramid Lake Paiute Tribe
Post Office Box 256
Nixon, Nevada 89424
Telephone: (775) 574-1000 / 574-1001 / 574-1002
FAX (775) 574-1008

February 18, 2014

Via Email: spk-pao@usace.army.mil

U.S. Army Corps of Engineers
Sacramento District
Attn: Mr. Tyler Stalker
Public Affairs Specialist
1325 J Street
Sacramento, CA 95814

Re: Comments on the Final EIS for the Truckee Meadows Flood Control Project

Dear Mr. Stalker:

The Pyramid Lake Paiute Tribe (Tribe) appreciates the opportunity to provide comments on the Final Environmental Impact Statement (EIS) and General Reevaluation Report (GRR) on the Truckee Meadows Flood Control Project prepared by the U.S. Army Corps of Engineers (USACOE). The USACOE made both Final EIS and GRR available for review with a letter to all interested parties dated January 17, 2014. The 32-day public review period extends from January 18 to February 18, 2014.

The USACOE introduced the Tentatively Selected Plan (TSP) for the Truckee Meadows Flood Control Project at a meeting with the Tribe on April 16, 2013. This was the first time the Tribe was presented with the TSP. Prior to this meeting there was practically no government-to-government consultation of the TSP and scoping of the alternatives as presented in the May 2013 Draft EIS and December 2013 Final EIS. The USACOE also made a brief presentation of the TSP to the Pyramid Lake Tribal Council on May 15, 2013.

The Tribe would like to provide the following salient comments on the 2014 Final EIS and GRR prepared by the USACOE for the Truckee Meadows Flood Control Project.

1. The Tribe appreciates the early efforts by the USACE to consult with the Tribe. However, once there was a need for "refinements and corrections to the hydraulic and economic models being used" in early 2010, USACE basically discontinued the technical communications with the Tribe until April 2013, a month before the Draft EIS was to be released. This three-year hiatus up until the release of the Draft EIS is not considered

"regular," does not satisfy the intent of Executive Order 13175, and does not meet the standards for the United States fiduciary responsibilities to protect Tribal trust resources. It would have been helpful if the USACE had continued its consultation with the Tribe when the hydraulic and economic models were being revised. For example, it would have been helpful if the documentation report on the updated hydraulic model of the Truckee Meadows was made available to the Tribe for technical review when it was completed on April 11, 2011. It was not until later in 2013 that the Tribe became aware that all of the environmental restoration features of the project have been dropped. Even after the April 2013 meeting, USACE did not provide a "meaningful" consultation on the proposed project. For example, the Tribe would be interested in detention basin features of the proposed upstream flood control project, because detention basins tend to decrease the flood flows into the Lower Truckee River compared to other flood control features such as levees and terracing. However, the USACE has indicated that all detention basins are economically unfeasible, without providing the details to the Tribe.

2. The Tribe has learned that significant changes occur to the Lower Truckee River after large floods and after the previous flood control projects by the USACE, primarily in the 1960s. In particular, changes to the course of the river, severe erosion, and channel entrenchment have occurred, as witnessed after large flood events. This is why the Tribe is concerned about even modest increases in flood flows. These observed changes to the river are too large for ordinary flows, yet ordinary flows are only what this EIS focuses on. Currently, the Tentatively Selected Plan will increase flood flows by 5 to 10%, but the EIS determines no significant impacts to channel evolution and sediment dynamics based on no changes to ordinary flows. This finding does not agree with the Tribe's observations after flood events. The dynamic of channel changes resulting from high flow events needs to be incorporated into the project mitigation measures.

3. While the Final EIS mentions the Truckee River Flood Management Authority (TRFMA) Plan, the environmental impacts of the combined projects by USACOE and TRFMA are not analyzed. Particularly because both projects appear to be discounting the effects of increased flood flows in the Lower Truckee River, the combined impacts of both projects should be analyzed. The Federal (USACOE) and non-Federal (TRFMA) entities have been working closely together over the last fifteen years, and the impacts from their conjunctive flood control project should be addressed in the EIS.

4. The discussion in the EIS on impacts to the delta at Pyramid Lake is inadequate. The EIS reasons (p. 5-31), with no supporting analysis, that the project, which would increase flood flows, would decrease sedimentation at the Pyramid Lake delta relative to the no action alternative. Although the Tribe knows that larger floods cause erosion and carries more sediment load in the lake, this EIS reasons that an increase in flood flows will have the opposite effect on sediment load, which is counter intuitive. The increase in sedimentation will make it physically harder for cui-ui and Lahontan cutthroat trout (LCT) to make passage through the braided channels in the delta, particularly under lower flow conditions. The situation at Pyramid Lake is particularly sensitive because the lake level has dropped significantly due to upstream diversions.

5. The Tribe strongly urges USACOE to put the lower river restoration works back into the project and attenuate increases in flood flows in the Lower Truckee River whenever possible, as originally authorized by Congress.

In addition to the above comments, attached with this letter are additional comments by the Tribe, which include technical comments on the 2014 Final EIS and GRR by the USACOE for the Truckee Meadows Flood Control Project.

Based on the above comments, including the comments attached with this letter, the Tribe finds the process for the preparation of the environmental document and the 2014 Final EIS and 2013 Draft EIS for the Truckee Meadows Flood Control Project are significantly deficient. The Tribe strongly recommends the issuance of a revised environmental document by the USACOE for the Truckee Meadows Flood Control Project.

Thank you for the opportunity to provide comments on the 2014 Final EIS and GRR for the Truckee Meadows Flood Control Project.

Sincerely,

Elwood Lowery, Tribal Chairman
Pyramid Lake Paiute Tribe

Attachment
A hard copy of the comments is mailed via overnight mail (FedEx).

Cc list is on following page.

cc: Terence James
Albert John
Donna Noel
Don Springmeyer
Chris Mixson
Lisa Heki
Ali Shahroody
File

Attachment

Comments by Pyramid Lake Paiute Tribe on Final Environmental Impact Statement and General Reevaluation Report for the Truckee Meadows Flood Control Project Prepared by U.S. Army Corps of Engineers Sacramento District

The U.S. Army Corps of Engineers (USACE) made available the Final General Reevaluation Report (GRR) and Environmental Impact Statement (EIS) for the Truckee Meadows Flood Control Project (TMFCP) for public review on January 17, 2014. The public review period for the Final EIS extends from January 18 to February 18, 2014. The Draft EIS was issued on May 17, 2013, and the Tribe provided comments on the Draft EIS on July 8, 2013.

Unfortunately, the Pyramid Lake Paiute Tribe (Tribe) finds the USACE's responses to the Tribe's comments on the Draft EIS inadequate and still finds the 2013 DEIS and 2014 FEIS significantly deficient. The Tribe still strongly recommends the issuance of a revised environmental document by the USACE for the Truckee Meadows Flood Control Project before submittal of the Chief's Report on the project.

There are enough uncertainties and inadequacies in the current hydrologic, hydraulic, and geomorphic technical analyses, such that a lot of this work needs to be revised and expanded now, not later, in order to properly disclose the environmental impacts of the project. The Tribe empathizes with the USACE's desire to finish the project as quickly as possible. However, had the USACE not gone into a three-year hiatus in communications with the Tribe up until a month before the issuance of the Draft EIS, the Tribe's request to revise and expand the current hydrologic, hydraulic, and geomorphic analyses could have been avoided.

It is also unfortunate that the USACE in the GRR and EIS does not take at least partial responsibility for the channel incision and entrenchment effects in the Lower Truckee River. In particular, the USACE's earlier flood control efforts in the 1960s had a significant impact on the increase in channel incision in the Lower Truckee River and associated detrimental environmental effects. Currently, this important fact is discussed in only four sentences in the EIS (pg. 5-18 and 6-9):

> These alterations to the river included straightening and widening for flood control and construction of I-80, the Southern Pacific Railroad, and the Truckee Canal. Straightening the channel had the effect of increasing the sediment transport rate because all of the streamflow was held within the banks. This caused the channel slope and flow depth to increase, and result in higher stress on the channel bank and bed material. The result was a deeper channel cut and more bank erosion.

If the impacts regarding channel incision in the Lower Truckee River from past flood control projects are not properly explained and disclosed in detail, how is the Tribe to believe that impacts of the current project, which will basically do the same thing (increase flood flows in the Lower Truckee River), will have no impacts on the channel geomorphology.

While a 5 to 10% increase in flood flows may not sound like much, this is on top of previous channel degradation caused by previous increases in flood flows due to flood control projects. A channel that is incised has a greater likelihood of experiencing dramatic alterations in form and

function. This fact is also omitted in the EIS but is stated in other USACE general handbooks (i.e. "Review and Synopsis of Natural and Human Controls on Fluvial Channel Processes in the Arid West", Field and Lichvar, 2007). Why this evaluation was omitted in the EIS, which obviously applies to the Lower Truckee River based on previous impacts, is not known and it is indicative of an inadequate environmental analysis.

It is important to note that the USACE quotes the Nevada Department of Transportation geomorphic study by Miller in 1994 for the proposition that the Truckee River is stable and has been stable for decades (Final EIS pgs. 5-19 through 5-21; 6-10; and Appendix B: US Fish and Wildlife Coordination Report, p. 15). This may be cited in the EIS and GRR to imply that there should not be concerns about the geomorphic impacts of the project. However, the EIS and GRR fail to mention that the same study reissued by Nevada Department of Transportation in 2001 (NDOT, 2001) states that:

> The most significant unstable stream segments in terms of both lateral and vertical change are located (1) from roughly the I-80 bridge at Wadsworth downstream to Pyramid Lake, and (2) the reach extending from approximately Vista Reefs east of Sparks to just upstream of the East McCarran bridge. The exact cause(s) of instability are indeterminate, *but are probably related to base level lowering and channel modifications implemented primarily for flood control.*

The EIS also relies heavily on a sediment study performed the USACE Vicksburg, Mississippi River office (USACE, 2008). It is important to note that this Sediment Stability Assessment in 2008 was analyzed under a different alternative that already included environmental enhancement and mitigation measures in the Lower Truckee River. This is no longer an appropriate assumption because the Tentatively Selected Plan includes no environmental enhancement and mitigation measures in the Lower Truckee River. The conclusion of no significant geomorphic impacts from the Tentatively Selected Plan is largely derived from the effective discharge analysis in the USCACE 2008 study as described below (Final EIS, pgs. 30-31):

> However, sediment budget analyses carried out on Alternative 3(d) and the Locally Developed Plan, whose flood risk management features would induce flows in the Lower Truckee River reach up to 3,300 cfs greater than the No Action condition in a 1% ACE event, indicated minor changes to the average annual volume of sediment transport (or yield) along the Lower Truckee River resulting from Alternative 3(d) and the Locally Developed Plan (USACE, 2008b)..... In general, for both the No Action and Alternative 3(d) (as well as the Locally Developed Plan) conditions, the effective discharge between Vista and Marble Bluff Dam was estimated at around 3,000 cfs which roughly translates to approximately a 1/3 ACE event (i.e., about a 3-year event). Hydraulic modeling of the No Action and Floodplain Terrace Plan indicates no increases in flood discharges out of the Truckee Meadows for the 1/5 ACE event. Thus, significant long-term impacts in sedimentation due to the Floodplain Terrace Plan is considered unlikely since the effective discharge is not impacted by the project.

The effective discharge is the flow that transports the largest fraction of the average annual bed material load. However, the effective discharge concept does not deal directly with the subject of channel bed elevation stability. Rather, it is implied that the medium range floods move the most sediment downstream over time, and that the same amount of sediment is delivered from one location to another during the same time interval. A key assumption in effective discharge analysis is that the bed is in equilibrium, i.e. changes based on different amounts of sediment from upstream are not accounted for. Based on the effects of previous flood control projects on incision in the Lower Truckee River, the key issue of channel incision

that occurred during flood events and during non-equilibrium conditions caused by previous USCACE flood control projects should have been included in the analysis of the proposed project. Even USACE's own sediment study by the Vicksburg office (USACE, 2008), which this EIS relies upon, states: .

> The channel stability assessment addresses stability issues on a reach basis, ignoring river adjustments that will occur with non-equilibrium conditions. (pg. 2, USACE, 2008)...Bed elevation changes can be expected in both cases. The significance of these changes can only be determined with a non-equilibrium flow numerical model study. (pg. 8, USACE, 2008)

Relying predominantly upon effective discharge type analyses, even if done correctly (which it was not during this "feasibility" stage), is speculative at best for this study, particularly when channel incision and entrenchment is the key issue as it was for the previous USACE flood control projects in the Truckee Meadows. In the case of the Truckee River, after large flood events and after the previous flood control projects by the USACE, while floods were successfully reduced in the Reno-Sparks area, the Lower Truckee River experienced significant channel incision and downcutting.

Following the USACE's flood control projects, downcutting has been observed in the Lower Truckee River in connection with large flood events. See comments by Otis Bay and Desert Research Institute submitted previously in the Tribe's comments on the Draft EIS (pg. 8), which were ignored in the Final EIS. The notion that the proposed project makes "No change to effective discharge in the Lower Truckee River" should not preclude the examination of the impacts from the proposed flood control project in regard to "significant" changes that have occurred and are expected to continue to occur during flows higher than the effective discharge as evidenced already on the Lower Truckee River. Consistent with this type of explanation, the impacts of previous flood control projects should be documented and analyzed in more detail in the EIS (i.e. provide examples from Otis Bay and Desert Research Institute). The dynamic of channel changes during high flow events needs expansion and incorporation into the project mitigation measures.

While the science of channel stability is somewhat inexact, what is undisputable is that a higher peak in flood flows will be sent downstream to the Lower Truckee River under the proposed project, and this has resulted in significant channel degradation from past flood control projects. Restoration is needed to address the ecological damage (i.e. loss of sinuosity) caused by the past actions and will help attenuate the potential increase in erosive forces caused by the amplified flood peaks in the Lower Truckee River.

The GRR and EIS should also address the full environmental impacts of the entire project (not just the Federal portion), which in this case includes additional flood control measures that will be part of the non-Federal sponsors undertaken by the Truckee River Flood Management Authority (TRFMA) in coordination with the USACE's project. The Federal and non-Federal entities have been working together over the last fifteen years, and the impacts from the conjunctive flood control project should be addressed in the EIS. The USACE was not responsive to this comment as responded in item #27 which states,

> See section 3.5.4 for a discussion on TRFMA's proposed revisions to the locally developed plan. Based on USACE's review, TRFMA's revised locally developed plan is not a substantially different alternative than those already considered in this EIS.

Section 3.5.4 relates to "**Alternatives not Considered Further**". The Tribe is not requesting that the Locally Developed Plan be chosen as a separate alternative, but rather that the environmental effects from combined projects for flood control by the Federal and non-Federal entities be evaluated together in order to avoid piecemeal treatment and review of significant impacts to downstream parties.

What is even more problematic in the EIS is that the Locally Developed Plan (LDP) is becoming more like Alternative 3C, which is also similar to Alternative 3D, previously the USACE preferred plan for the "117-year event" (1997 storm) in the Truckee Meadows. Both Alternatives 3C and 3D plans include large volumes of terracing at the Vista Narrows (which acts as a natural bottleneck for the passage of flood flows from the Truckee Meadows to the Lower Truckee River). This proposed terracing by opening the Vista Narrows could have significant environmental consequences in downstream areas. The response in item #27 is incorrect by implying that the TRFMA plan, Alternative 3C, or Alternative 3D is "within the range of project scales" of the Tentatively Selected Plan (TSP) by the USACE. These plans (TRFMA, Alternative 3C and Alternative 3D) would definitely have more severe environmental impacts in the Lower Truckee River compared to the TSP. The impacts would be similar to the previous USACE project which involved dredging of the Vista Reef in the late 1950s and early 1960s. Even the USACE felt the need to add hydraulic mitigation and restoration projects in the Lower Truckee River under the original plan. However, in order to save money, as stated in the EIS: "TRFMA's revised plan does not include downstream bank stabilization as part of the initial construction, as anticipated by the USACE for mitigation from a similar increase in peak flows, but does include acquiring access easements for potential future scour remediation." This approach to cut environmental restoration projects in the Lower Truckee River and at the same time increase the peak flood flows in the Lower Truckee River is very concerning to the Tribe.

The Tribe strongly urges the inclusion of lower river restoration works into the project as originally included, and the attenuation of increases in flood flows in the Lower Truckee River whenever possible, as originally authorized by Congress and expanded upon in later settlement agreements. The direction that the flood control project in the Truckee Meadows appears to be heading based on this GRR and EIS is to avoid restoration works in the Lower Truckee River and not to be concerned about increasing flood flows downstream in the Lower Truckee River due to economic factors. This type of benefit analysis is at the expense of Tribe's trust resources. The analysis simply discounts the environmental damage from the increase in flood flows by the past and future projects. The Tribe understands the need for flood protection in the Truckee Meadows, but believes it should be done without further damaging the trust resources on the Pyramid Lake Indian Reservation, even if this means higher economic costs.

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Specific comments on the USACE responses to the Tribe's comments are provided below and they are identified by the USACE numbering system. It should be noted that the USACE was not responsive to many of the Tribe's comments to the Draft EIS.

#21 and #22

The Tribe appreciates the early efforts by the USACE to consult with the Tribe. However, once there was a need for "refinements and corrections to the hydraulic and economic models being used" in early 2010, USACE basically discontinued the technical communications with the Tribe until April 2013, a month before the Draft EIS was to be released. This three-year hiatus up until the release of the Draft EIS is not considered "regular," does not satisfy the intent of Executive Order 13175, and does not meet the standards for the United States fiduciary responsibilities to protect Tribal trust resources. It would have been helpful if the USACE had continued its consultation with the Tribe when the hydraulic and economic models were being revised. For example, it would have been helpful if the documentation report on the updated hydraulic model of the Truckee Meadows was made available to the Tribe for technical review when it was completed on April 11, 2011. It was not until later in 2013 that the Tribe became aware that all of the environmental restoration features of the Project have been dropped. Even after the April 2013 meetings, USACE did not provide a "meaningful" consultation on the proposed project. For example, the Tribe would be interested in detention basin features of the proposed upstream flood control project, because detention basins tend to decrease the flood flows into the Lower Truckee River compared to other flood control features such as levees and terracing. However, the USACE has indicated that all detention basins are economically unfeasible, without providing the details to the Tribe.

#23

It is not clear which comments of the Tribe are responded to by the USACE under this item. Sometimes the order of the responses by the USACE are not consistent and do not address all of the components of Tribe's comments.

#24, #25 and #26

Please see comments above on items #21 and #22 regarding consultation with the Tribe.

#27

The response in item #27 states,

> "See section 3.5.4 for a discussion on TRFMA's proposed revisions to the locally developed plan. Based on USACE's review, TRFMA's revised locally developed plan is not a substantially different alternative than those already considered in this EIS."

Please see Tribe's comments above on this item.

#28

Please see comments above (pages 1-3).

#29

Please see comments above on items #21 and #22.

#30

The EIS does not meet the project's authorized purpose and need which included "fish and wildlife enhancement" features.

#31

Response noted. However, the Tribe is still concerned about the accuracy of the hydrologic and hydraulic models. The Tribe requested model sensitivity analyses but has not been provided by the USACE.

#32

Please see comments above on item #27.

#33

Please see comments above on item #28. The baseline condition in this case is particularly important because a channel that is incised has a greater likelihood of experiencing alterations in form and function which is not addressed in the EIS.

#34a

The USACE's response does not address why the working hydraulic model was abandoned and an entirely new model was created and why there was a "concern with the hydraulic and economic models" (underline added for emphasis).

#34b

The Tribe is still concerned about the calibration of these models. The calibration should be expanded to include years other than 1997. It is preferred to have the expanded calibration performed before the EIS is certified but not in the Preconstruction and Engineering Design (PED) stage. This is important because currently the EIS relies on analysis of other flows besides the 1997 flood event, but the accuracy of this analysis is not known. It is common engineering practice to calibrate models to several different storm events not just one. Also the same level of calibration effort should be applied to the Lower Truckee River models, not just the Truckee Meadows model.

#34c

This part of the model still needs further review. For example, the USACE stated in the May 2013 Draft EIS that "The existing conditions flow frequency for the Truckee Meadows area is uncertain due to complex backwater interactions and significant overbank storage." Maybe some additional simplified diagrams would help explain the hydraulic uncertainties in the reach between McCarran Bridge and Vista.

#34d

Please see comments above on item #34c. It would also be helpful to know the exact feedback (input and output) between HEC-RAS and FLO-2d models.

#35a

Response noted. Due to potential effects of error propagation between models, requested sensitivity analyses would be appreciated.

#35b

The issue is not the dynamic attenuation but the modeling of flow losses during a 117-yr event. Please review the figure in Tribe's comments to the Draft EIS. This may affect Table 25 of Attachment B – Hydraulic Design as well.

#35c

The problems with the geometric data identified by the USACE in the existing conditions HEC-RAS model should be updated now rather than later during the PED stage. The EIS should be based on the best available data. The level of effort used on the models of the Lower Truckee River to determine environmental impacts is not equal to the efforts used on the Truckee Meadows model for planning of the flood project features.

#35d

The model documentation should be updated now than later during the PED stage. The level of modeling efforts to determine environmental impacts in the Lower Truckee River is not equal to the efforts used on the Truckee Meadows model for the planning of flood project features.

#36a

Please see above comments on item #35a.

#36b

Please see above comments on item #35c.

#36c

The Wadsworth to Pyramid Lake model should be updated now rather than later during the PED stage. The EIS should be based on the best available data.

#36d

Please see above comments on item #36c.

#37a

Response noted. Thank you for modifying the project to lessen the impacts to the Lower Truckee River. Please see comments above on items #27 and #28 regarding other impacts.

#37b

The Sediment Stability Assessment in 2008 was analyzed under a completely different alternative which included environmental enhancement and mitigation measures for the Lower Truckee River. Under the original framework and level of funding, the authors of the 2008 study could have assumed any additional changes to mitigation measures could be absorbed by the

original funding and scope. This is no longer an appropriate assumption because the Tentatively Selected Plan includes no environmental enhancement and mitigation measures.

#37c

Response noted. According to the 2008 USACE report, there would be an increase in aggradation (5,100 tons) in the lower Truckee Meadows and an increase in peak flows into the Lower Truckee River. This would indicate that sediment deficient flows entering into the Lower Truckee River during large flood events would increase the potential for further erosion in the downstream reaches.

#37d

Please see comments above (pages 1-3). The determination of no significant impacts to channel geomorphology with increasing peak flood flows in the Lower Truckee River based on the model that was not calibrated or verified is questionable.

#37e

Please see comments above (pages 1-3). Even the early promoters of the effective discharge concepts, Wolman and Miller, did not rely entirely on effect discharge analysis for geomorphic evaluation. For example as stated in their seminal work:

> In the preceding discussion it has been argued that forces of moderate magnitude and frequency have greater net effect on land-form development than do intense short-lived forces associated with catastrophic events. Clearly, such a general conclusion requires qualification to the extent that catastrophic events produce results that are (1) unique in some respect because of magnitude or (2) different in kind from effects of more ordinary occurrences .....Changes in dimension and position of stream channels commonly occur during large floods.... Where stresses generated by frequent events are incompetent to transport available materials, less frequent ones of greater magnitude are obviously required. Closer observation of many geomorphic processes is required before the relative importance of different processes and of events of differing magnitude and frequency in the formation of given features of the landscape can be adequately evaluated. ("Magnitude and Frequency of Forces in Geomorphic Processes", Wolman and Miller, Johns Hopkins University and Harvard University Manuscript, May 4, 1959).

#37e

Please see comments above (pages 1-3). The expansion of text in Chapter 6 is inadequate and does not recognize the impacts of channel incision caused by previous USACE flood control projects.

#37f

Please see comments above (pages 1-3).

#37g

Please see comment #37d. This response does not address the Tribe's comment on the DEIS.

#37h

Please see comments above (pages 1-3).

#38

Thank you for expanding the text in the EIS on the Pyramid Lake delta. However, the discussion and analysis of impacts on the Pyramid Lake delta are still inadequate. Please see Tribe's comments submitted on the Draft EIS and comments within this transmittal. Inadequacies in the current hydrologic, hydraulic, and geomorphic analyses are cumulative when determining impacts on the Pyramid Lake delta. The expected increase in channel incision upstream will most likely cause additional sedimentation at the delta under the proposed project compared to no action conditions. The impacts of entrenchment due to flood control projects has a unique feature on the Truckee River because all the induced erosion and increased sediment supply that occurs from the incised channels ends up at the delta of Pyramid Lake. The increase in sedimentation makes it harder for cui-ui and LCT to make passage through the braided channels in the delta, particularly under lower flow conditions. The situation at Pyramid Lake is particularly sensitive because the lake level has dropped significantly due to upstream diversions.

#39

Response noted. Thank you.

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WASHINGTON, DC 20314-1000

REPLY TO
ATTENTION OF

Planning and Policy Division

APR 8 2014

Elwood Lowery
Tribal Chairman
Pyramid Lake Paiute Tribe
PO Box 256
Nixon, Nevada 89424

Dear Mr. Lowery:

This letter is in response to your comments on the Truckee Meadows General Reevaluation Report (GRR) and Final Environmental Impact Statement (EIS) provided in a letter dated February 18, 2014. We appreciate your review of these documents. All resolutions from the Pyramid Lake Paiute Tribe's previous comments received on the Draft EIS were incorporated into the Final EIS.

Regarding concerns about consultation with the Tribe, the Corps takes its consultation responsibilities very seriously and has endeavored to involve the Tribe on an ongoing basis in the development of the project. As noted in the Final EIS, our collaboration, consultation, and coordination with the Tribe extends back many years and has resulted in several adjustments to project alternatives. Government-to-Government consultation for the Truckee Meadows project was initiated in 2005. Regular meetings were conducted with the Tribe's technical team to discuss hydraulic models and outputs, as wells as alternatives and methods to minimize downstream flows. In late 2010 through September 2011, the Corps focused efforts on the preparation of Alternative Formulation Briefing documentation, and, as no new information was being produced, no meetings were held with the technical team during that time. From September 2011 to January 2012, there was no formal communication with the Tribe as the project was inactive due to a number of issues such as project funding. Consultation was resumed in 2012 once the issues were resolved, including a meeting in February 2012 and a meeting in August 2012 where updates on project re-evaluation and a revised tentatively selected plan were provided. In late 2012, regular technical meetings with the Tribe were again put on hold as the Corps prepared the draft GRR and EIS for public release. Meetings were then resumed with the Tribe in April and May 2013. Coordination with the Tribe is important to the Corps and we are committed to our fiduciary responsibility to protect tribal treaty rights, lands, assets and resources. As demonstrated above, we have been diligent in bringing new information to the Tribe in meeting the intent and obligations of Executive Order 13175. In order to conduct regular and meaningful consultation and collaboration, we have ensured that the Tribe is included in relevant technical discussions and maintained communication during project development. We remain committed to maintaining relations and consultation with you as the project moves forward and will do so through open communication and meetings between the Tribe and the Sacramento District's tribal liaison and District Engineer.

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Both the Draft and Final EIS for the project provide a complete and comprehensive fulfillment of the requirements of the National Environmental Policy Act. Both documents provided a discussion of the purpose and need for the action, alternatives, the affected environment, and also the environmental consequences of the proposed action. The Final EIS provides a full and fair discussion of significant environmental impacts, reasonable alternatives and also includes a substantial cumulative effects analysis that addresses projects beginning with the Truckee River and Tributaries, California and Nevada Flood Control Project that was completed in 1964. The Final EIS includes a full summary of comments and responses that were received from circulation of the Draft EIS, including reasons why some comments did not warrant further agency response. The Final EIS also incorporates changes and/or corrections resulting from the assessment of comments on the Draft EIS, including those received from the Tribe.

We value and respect your concerns about any potential increases in flood flows, channel stability, and sedimentation in the Lower Truckee River. The Corps concurs that large episodic events can result in increased amounts of erosion and channel instability; however, the relatively minor change in flow rates (for the 1-percent annual chance exceedence event, for example) between the with- and without-project conditions result in approximately the same amounts of erosion and scour. Therefore, conclusions of the Final EIS focused on the effective discharge, which is the factor that has the greatest effect on long term channel stability. In the case of the Lower Truckee River, the effective discharge is not impacted by the Recommended Plan. Regarding concern about using the 2008 Sediment Stability Assessment, the assessment provided the best available data to accurately and comprehensively evaluate project effects in the lower Truckee River. The assessment has undergone internal quality control review, technical review from Corps experts outside of the Sacramento District and has also undergone Independent External Peer Review by a panel of experts without Corps affiliation. Additionally, the models used for this study, HEC-RAS and HEC-FDA, have both been certified as a result of process to review, improve and validate analytical tools and models for Corps Civil Works business programs. Both models have been peer reviewed and have been utilized for numerous studies both in and outside of the Corps. As stated in the EIS, the Corps will consider the need for more detailed modeling during future phases of the project. If outputs from this model indicate substantial differences from the feasibility-level modeling, further evaluation of changes to sediment dynamics may be warranted.

Regarding the Tribe's concerns about the potential cumulative impacts of other constructed or proposed Truckee River Flood Management Authority (TRFMA) flood control projects, both the GRR and EIS took account of such potential impacts. Those documents included a thorough description of the effects of previous flood control projects in and along the Truckee River, in order to support plan formulation and environmental evaluation of the Recommended Plan to reduce flood risk in the Truckee Meadows area. In addition, due to comments received on the Draft EIS, Chapter 6 of the Final EIS was revised to more thoroughly discuss any potential cumulative effects of the Recommended Plan combined with other planned projects at this time.

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The EIS indicates that the effects on Indian Trust assets from the project alternatives would represent a minor contribution to the cumulative effects and would not significantly change the existing condition of these resources.

Regarding potential impacts to the delta at Pyramid Lake, the feasibility-level hydraulic and sediment budget analyses incorporated into the GRR and EIS indicates that there would be minimal effects on depositional conditions of the delta. Additionally, a biological opinion (BO) for short-term, construction-related effects on Lahontan cutthroat trout and cui-ui was issued by U.S. Fish and Wildlife Service (FWS) on December 4, 2013. The FWS concurred that the project is not likely to have long-term adverse effects to those fish species. All reasonable and prudent measures and the terms and conditions identified in the BO would be implemented by the Corps to minimize any project effects.

We appreciate your request and support for including ecosystem restoration work along the Lower Truckee River in the project, and we understand your concerns about past work within the Truckee River basin. The past projects were designed and constructed to perform according to standards at that time. The current project has been planned to meet much more stringent criteria for ecological performance, as new guidelines and methodologies have been developed to guide water resources projects. Ecosystem restoration was considered in the GRR, including the restoration of fish passage on the Truckee River. In 2012 the Corps and the non-Federal sponsor, TRFMA, decided to provide an interim response to the project authority and focus on the single-project purpose of flood risk management in order to expedite completion of the study consistent with Administration and sponsor priorities. Nevertheless, this does not preclude future ecosystem restoration planning efforts in the study area, and we will continue to look for opportunities to partner with the Pyramid Lake Paiute Tribe and/or non-Federal sponsors to conduct these future investigations.

Again, we thank you for the commentary that you have provided. If you would like to discuss these issues further, please contact the study planner, Kim Carsell, at (916) 557-7635.

Sincerely,

Theodore A. Brown, P.E.
Chief, Planning and Policy Division
Directorate of Civil Works

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U.S. Department
of Transportation
**Federal Aviation
Administration**

Western-Pacific Region
San Francisco Airports District Office

1000 Marina Blvd., Suite 220
Brisbane, CA 94005-1835

February 24, 2014

Mr. Theodore A. Brown, P.E.
Headquarters
U. S. Army Corps of Engineers
CECW-P (SA)
7701 Telegraph Road
Alexandria, VA 22315-3860

Subject: Comments on Final Environmental Impact Statement for the Truckee Meadows Flood Control Project, Nevada, General Reevaluation Report

Dear Mr. Brown:

Per your request, we have reviewed the Truckee Meadows Flood Control Project Report, and provide the following comments. The Reno-Tahoe International Airport (RNO) is located within the project area of the proposed United States Army Corps of Engineers Truckee Meadows Flood Control Project.

RNO has received a number of federal grants through the Airport Improvement Program to make capital improvements at the airport. Flood protection measures that reduce the risk of flooding of RNO would also serve to protect capital improvements at the airport, and therefore benefit civil aviation. However, I would like to make you aware of several factors that should be considered during project implementation.

Both the 3-Floodplain Terrance Plan (Recommended Plan) and the 2-Detention Plan alternatives propose to provide habitat mitigation for areas disturbed by the project flood control alternatives. The FAA recognizes revegetation measures may be required by existing environmental regulations and regulatory agencies to protect water quality and compensate for losses of habitat and aquatic resources. Such revegetation efforts should be consistent with the 2003 Memorandum of Agreement (MOA) between the FAA, U.S. Air Force, U.S. Army, U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, and U.S. Department of Agriculture to Address Aircraft-Wildlife Strikes (wildlife-aircraft strike hazards). The MOA recognizes that some habitats are more of an attractant to hazardous wildlife than others, and encourages signatory agencies to follow FAA Advisory Circular (AC) 150/5200-33B *Hazardous Wildlife Attractants on or Near Airports* to minimize the risk of wildlife striking aircraft.

AC 150/5200-33B discusses which wildlife species represent the most serious risks to aircraft and identifies the minimum separation distances between attractants to wildlife and existing airports. AC 150/5200-33B recommends a separation distance of at least 10,000 feet between airports serving turbine-powered (jet) aircraft and potential hazardous wildlife attractants. AC 150/5200-33B also recommends a separation distance of 5 miles between the edge of an

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REPLY TO
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Planning and Policy Division

APR 1 2014

Robin K. Hunt, Manager
U.S. Department of Transportation
Federal Aviation Administration
San Francisco Airports District Office
1000 Marina Boulevard, Suite 220
Brisbane, CA 94005-1835

Dear Ms. Hunt:

This letter is in response to your comments on the Truckee Meadows Flood Control Project General Reevaluation Report and Final Environmental Impact Statement (EIS) provided in a letter dated February 24, 2014. We appreciate your review of the reports and your recognition of the benefits the flood risk management project would have on protecting capital improvements at the Reno-Tahoe International Airport (RNO).

As was stated in the Final EIS, we acknowledge the need for consistency with the 2003 Memorandum of Agreement (MOA) between the Federal Aviation Administration (FAA), U.S. Air Force, U.S. Army, U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, and U.S. Department of Agriculture to Address Aircraft-Wildlife Strikes. The FAA Advisory Circular (AC) 150/5200-33B also has been considered, and the Sacramento District will continue to reference the AC to minimize the risk of wildlife striking aircraft. The Sacramento District also will continue coordination with RNO, U.S. Department of Agriculture Animal Plant Health Inspection Service airport biologists, and FAA staff as project designs and revegetation plans are refined to ensure consistency with the MOA and AC.

If you have further questions or need additional information, please contact the study lead planner, Kim Carsell, at (916) 557-7635.

Sincerely,

Theodore A. Brown

Theodore A. Brown, P.E.
Chief, Planning and Policy Division
Directorate of Civil Works

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March 10, 2014

RENO-SPARKS
INDIAN COLONY
TRIBAL COUNCIL
98 COLONY ROAD
RENO, NEVADA
89502
(775) 329-2936
FAX:
(775) 329-8710

Mr. Dan Artho, Senior Environmental Manager
United Sates Army Corps of Engineers
Sacramento District
CESPK-PD
1325 J Street
Sacramento, CA 95814

RE: Truckee Meadows Flood Control Project in the City of Reno & Sparks Washoe County, Nevada

Dear Mr. Ortho:

The Reno-Sparks Indian Colony (RSIC) appreciates the ongoing participation and opportunity to comment on the Final Environmental Impact Statement (EIS) and the Final General Reevaluation Report (GRR), dated December 2013, regarding the Truckee Meadows Flood Control Project (Project). The RSIC understands the Project was authorized by the Water Resources Development Act of 1988, and that the purpose of the EIS is to evaluate the potential effects of the Project and its alternatives, which will address the flood risk management and recreation alternatives in the Truckee Meadows along the 60 miles of the Truckee River. As we understand, the EIS will meet the federal water resources project planning guidelines. The RSIC further understands that the GRR is to address the potential modifications to the Truckee Meadows Flood Control Project.

In reference to Chapter 5 (Affected Environment, Environmental Consequences and Mitigation) of the EIS, specifically Section 5.18 (Cultural Resources) and Section 5.19.2 (Environmental Consequences-*Coordination and Consultation)*, the RSIC is, by way of this letter, providing its comments. On pages 5-229 and 5-241 of the Native American Consultation Section, the RSIC Cultural Resource Manager/THPO is Michon R. Eben; my last name in these sections is misspelled. In this same section, on pages 5-229 and 5-241, the EIS remarks on the Tribe's non committal of signing the Programmatic Agreement (PA). From the RSIC's perspective, signing this PA delegated us to the status of a concurring party. The concurring status was merely to agree with the document and not have any authority in executing, amending or terminating the PA. The appropriate level of dealing with our Native American ancestral cultural items, remains and funerary objects is at the signatory level.

The RSIC applauds the Army Corps of Engineers (ACE), and its contractors' efforts in finalizing the Ethnography (*The People and Places of the Truckee Meadows: An Ethnohistory of a Portion of the Truckee Meadows Flood Control Project, Washoe County, Nevada*) for the Project. The ethnographic study was to focus on identifying

potential Traditional Cultural Properties within the Truckee Meadows which could be affected by the Project, and to evaluate these places for federal eligibility. On page 5-230 (Chapter 5) there are statements that the RSIC believes are inaccurate and must be clarified or removed from the EIS. The first sentence beginning with "Prevailing thinking says that the Truckee Meadows was exclusively....." requires identification as to who the "prevailing" thinkers are; if that is not possible, RSIC requests that the sentence be deleted. The next sentence, beginning with "The original basis for the study was to conduct ethnographic.....to attempt to determine if one tribe had a legitimate claim to the Truckee Meadows as their ancestral homelands" is problematic. The RSIC participated in the ethnographic interviews, field trips, and studies because it has the closest affiliation to the Project, and is representative of members and descendants of the Washoe, Paiute and Shoshone Tribes. The RSIC's participation was not to determine Tribal legitimacy to the Truckee Meadows. We are requesting that this sentence be deleted because it is inconsistent with the Project's ethnographic study objectives. In addition, please delete the similar statement that "an ethnohistoric study was conducted to attempt to determine the ancestral homeland claims of the Washoe Tribe and Northern Paiute Tribe in the Truckee Meadows" (page 5-241, second paragraph). These types of statements by federal and state agencies may set precedence, or perpetuate a conflict amongst Tribes. The sharing of cultural and spiritual elements of a Tribe with ethnographers is in jeopardy when the use of the ethnographic study exceeds the original intent of the study. The RSIC participated in the ethnographic study with the understanding that our elders and Tribal Members were providing their knowledge on traditional cultural landscapes, habitation areas and land uses for informational purposes, and not to perpetuate competing interests over past Tribal affiliations.

Consistent with Native American tradition, the entire Truckee River is a significant cultural resource. While not formally designated, it has all the elements associated with, and it appears to be eligible as, a Traditional Cultural Property. Several Native American Generations (past, current and future) continue to utilize and depend on the Truckee River. In the past several years, the RSIC has experienced unanticipated discoveries of Native American human remains, funerary objects, and cultural resource items in areas associated with the Truckee River. These areas were not identified as sensitive, therefore the Truckee River and associated areas have the potential of containing buried cultural resources and/or human remains and funerary objects, even if the area has been previously disturbed or recorded. To this extent, the RSIC (as the closest affiliated Tribe) has an interest in Native American cultural resource protection and management of the Project. Therefore, the RSIC is requesting a detailed "Estimated First Cost of the Recommended Plan" as is outlined in the GRR (Page 6-13, Cost Estimate). According to Table 6-3 (Page 6-13), cultural resources is a cost estimate which, we believe, must include costs associated with ensuring that a qualified Native American Tribal Monitor, or Monitors, be on site during all earth moving activities (construction, data recovery, etc.) and that such Monitor(s) are appropriately compensated from the Project budget. Because the RSIC is the closest affiliated and Federally Recognized Tribe with a federally designated Tribal Historic Preservation Office (THPO), the RSIC is further requesting that our Unanticipated Discovery Plan be included in the Project as follows:

Discovery of Cultural Resources

- The RSIC is requesting that Monitors be on site during any and all initial ground disturbance. Monitor(s) shall be present during the initial ground disturbance, and on-site prior to and throughout any initial surface ground disturbance.
- The RSIC and Monitor(s) shall be included as authorized representatives who are permitted to halt all activities in a discovery situation. The RSIC Cultural Resource Program shall be notified within 1 hour of the discovery.
- If any Native American cultural resources are discovered during the initial ground disturbance activity, or excavations throughout the project, Monitor(s) shall be allowed to inspect all cultural resources (along with the qualified project staff and archaeologist) and the site to determine the extent of the discovery.
- The Monitor(s) shall be present during all undertaking related activities.
- In addition to the qualified cultural resource contractor, Monitor(s) shall be included in all the evaluating of the Native American cultural resources found during the ground disturbance and construction activities of the Project.
- Monitor(s) shall be included in all discoveries along with the Archaeologist, and shall be included in all areas of concern regarding Native American cultural resources.
- Monitor(s) shall assess all mitigation measures, comments and solutions with the Project staff.
- Data recovery shall be observed by the Monitor(s).
- There shall be no scientific study or destructive analysis on any Native American cultural resources which are discovered or removed from the Project site.
- Notwithstanding applicable laws, the RSIC shall have the opportunity to remove and secure ownership of any Native American cultural resources for the purpose of preservation and education.
- Work can resume upon completion of removal of Native American cultural resources consistent with the process outlined above.

Discovery of Human Remains

- In the event that Native American human remains and associated funerary objects are discovered, the RSIC THPO/Cultural Resource Program shall be notified within one (1) hour of the discovery. It shall be presumed that any human remains and associated funerary objects are Native American, unless preliminary evidence clearly establishes otherwise.
- Monitor(s) and the RSIC THPO/Cultural Resource Program shall be a part of the initial discussions with any State, County, Federal and local representatives regarding any discoveries.

- In the event that Native American human remains and associated funerary objects must be recovered or removed, the RSIC shall be permitted to participate in the removal so that it is done in a culturally sensitive manner, in accordance with all State, Federal and Tribal laws. This will ensure that the RSIC's spiritual and cultural responsibilities, and respect to the human remains and associated funerary objects, are met, and will ensure confidentiality of the reburial.
- There shall be no scientific study or destructive analysis on any human remains and associated funerary objects that are discovered or removed from the Project site.
- Pictures and drawings of any discovered Native American human remains and associated funerary are prohibited.

The RSIC understands and appreciates the efforts made to improve flood control management in the Reno-Sparks metropolitan area. The RSIC looks forward to our continued collaboration with the Project staff. If you have any questions or need additional information, please contact me at (775) 785-1363 extension 5402 or (775) 636-3242, or via email at meben@rsic.org.

Sincerely,

Michon R. Eben
THPO

CC: Mr. Mark Gilfillan, ACE District Tribal Liaison-Grand Junction, Colorado
Ms. Melissa Montag, ACE Archaeologist-Sacramento, California
Mr. Andy Hummel, City of Sparks, Nevada
Mr. Eric Scheetz, Truckee River Flood Control Project-Reno, Nevada
RSIC Tri Basin Cultural Committee

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REPLY TO
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Planning and Policy Division

APR 8 2014

Michon R. Eben, THPO
Cultural Resource Manager
Reno-Sparks Indian Colony
98 Colony Road
Reno, Nevada 89502

Dear Ms. Eben:

This letter is in response to your comments on the Truckee Meadows Flood Control Project General Reevaluation Report (GRR) and Final Environmental Impact Statement (EIS) provided in a letter to Mr. Dan Artho, dated March 10, 2014. Thank you for your review of these documents. We apologize for the incorrect spelling of your name in the EIS. The correct spelling has been incorporated into the EIS.

In regards to the Reno-Sparks Indian Colony's (the Colony) position on the Programmatic Agreement (PA), we understand your concern with being a concurring party to the PA rather than a signatory. The existing PA already requires continual tribal involvement and consultation, an obligation to which we are firmly committed. Because the Truckee Meadows Flood Control Project includes features that will be constructed on lands owned by the Colony, the Sacramento District will provide the PA to the Colony to sign as a signatory party.

We appreciate the Colony's overall support for, and participation in, the ethnohistoric and ethnographic surveys. Thank you for the clarifications provided in your comments. The references in the EIS and ethnohistory report pertain to the conclusions provided by the Indian Claims Commission (ICC) pursuant to Dockets 87 and 288. The EIS and ethnographic report also note that the ICC conclusions did not consider additional testimony from the Northern Paiutes regarding use of the Truckee Meadows. The ethnographic report and EIS reiterate that, at the time of Euroamerican intrusion, the Truckee Meadows was important to both the Washoe and Northern Paiute peoples. However, the ethnohistory report was never intended to determine legitimacy of Tribal claims to the Truckee Meadows. Statements alluding to that objective in the EIS have been corrected or deleted, as appropriate. The ethnohistory report does not contain any such statements.

You also indicated support for identification of the Truckee River as a traditional cultural property (TCP). You further suggest that since the Truckee River is a TCP, and because of the high potential for significant buried cultural resources, funding should be provided for tribal monitors during construction. We recognize the significance of the Truckee River to the local tribes. At this time we have not determined if a TCP will be established. The PA will govern future activities to determine the presence of historic properties, including TCPs, and potential

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effects of the project. The Sacramento District will coordinate with the Colony during the pre-construction engineering and design phase of the project regarding the future activities associated with design and construction of the project.

As you requested, the Total Project Cost Summary is enclosed. The detailed project costs associated with cultural resources for identification and evaluation of cultural resources and potential monitoring for the project will be developed during our pre-construction engineering and design phase. As noted in the above paragraph, at this time we have not made a determination of the extent, if any, that monitoring will be required. This will be determined when more detailed identification of significant cultural resources has taken place and potential adverse effects to historic properties are assessed during the design phase and in coordination with the State Historic Preservation Officer and the Colony.

The EIS summarized a geoarcheological study indicating high potential for buried archeological sites along the river. Further efforts to identify these resources and develop an archaeological monitoring plan, all in consultation with the Colony, would occur during the design phase of project implementation. For these and related purposes, the suggestions for monitoring and discovery plans you provided us are very valuable. The Sacramento District will continue to review and consider these issues as the Section 106 consultation continues.

Again, we thank you for the commentary that you have provided. If you would like to discuss these issues further, please contact the study lead planner, Kim Carsell, at (916) 557-7635.

Sincerely,

Theodore A. Brown

Theodore A. Brown, P.E.
Chief, Planning and Policy Division
Directorate of Civil Works

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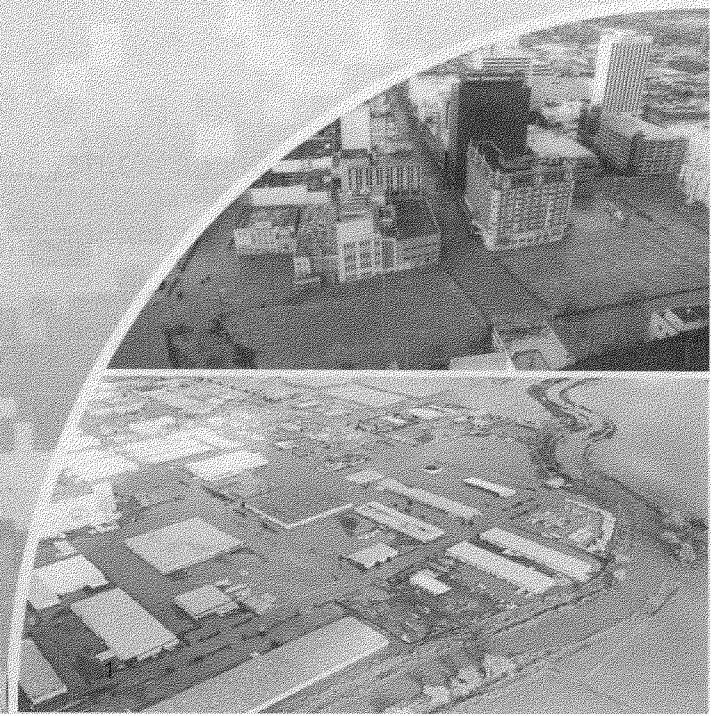
Truckee Meadows, NV

General Reevaluation Report and EIS



US Army Corps of Engineers

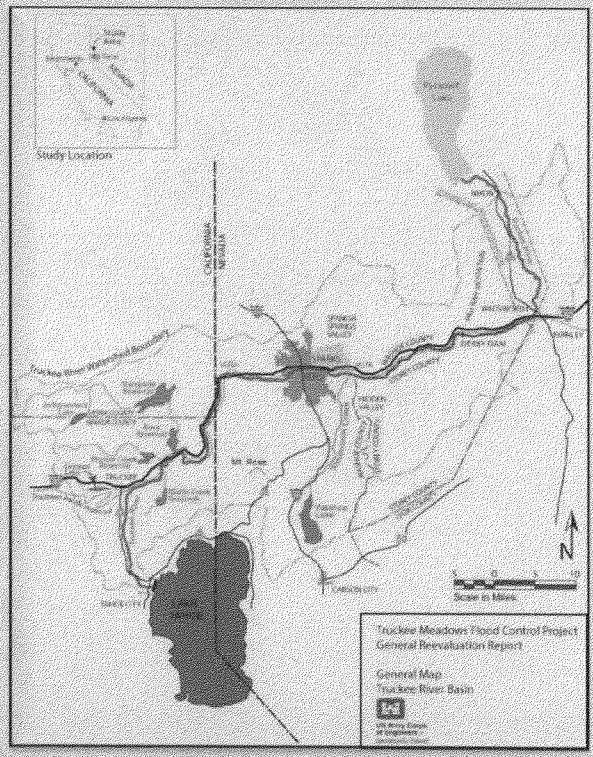
BUILDING STRONG®

Legislative Authority

- Flood Control Act, 1954 & 1962
- Water Resources Development Act, 1988
- Fallon Paiute Shoshone Indian Tribes Water Rights Settlement Act of 1990
- Energy and Water Development Appropriations Act, 1996
- Energy and Water Development Appropriations Act, 2006, Section 113

Truckee River Watershed

- Watershed: 3,060 sq miles
- Major upstream reservoirs:
  - Lake Tahoe
  - Stampede
  - Boca
  - Prosser
  - Martis
- Major urban areas:
  - Reno, NV
  - Sparks, NV
- Study area includes approximately 60 miles of the Truckee River – from upstream of Reno to Pyramid Lake



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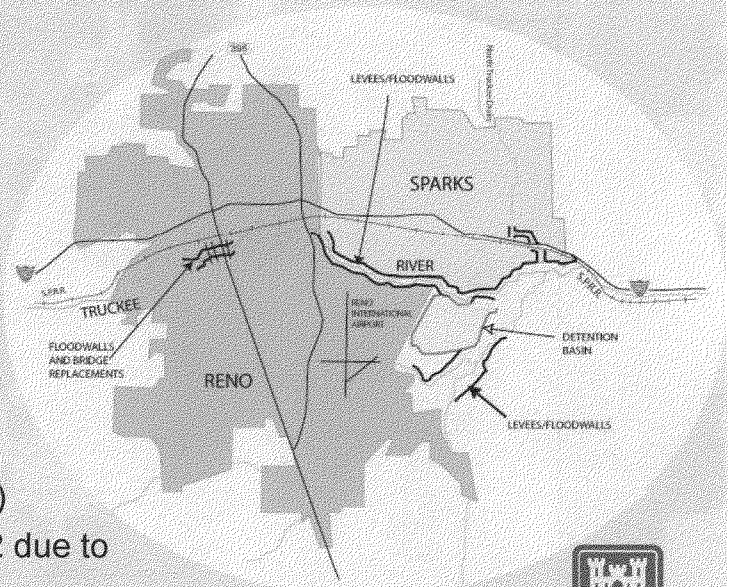
1988 Authorized Plan

- Features –
  - 12 miles of levees/floodwalls
  - 6 bridge replacements
  - 900-acre detention basin
  - Channel excavation
  - 31 acres habitat mitigation
  - Fish/Wildlife Enhancement
  - Recreation features



- BCR – 1.8 to 1
- Cost – $78.4 M (unadjusted)
- Deferred during PED in 1992 due to increased real estate costs

Study Purpose

Re-evaluation of previously authorized project to determine continued Federal interest.

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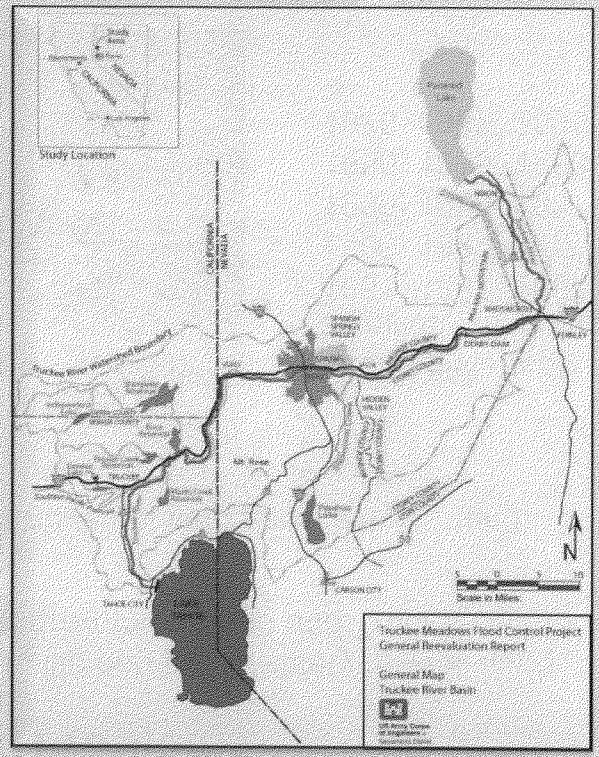
Non-Federal Sponsor

- Truckee River Flood Management Authority (TRFMA), which is a tax funded board representing local government:
  - City of Sparks
  - City of Reno
  - Washoe County

Truckee River Watershed

- Watershed: 3,060 sq miles
- Major upstream reservoirs:
  - Lake Tahoe
  - Stampede
  - Boca
  - Prosser
  - Martis
- Major urban areas:
  - Reno, NV
  - Sparks, NV
- Study area includes approximately 60 miles of the Truckee River – from upstream of Reno to Pyramid Lake



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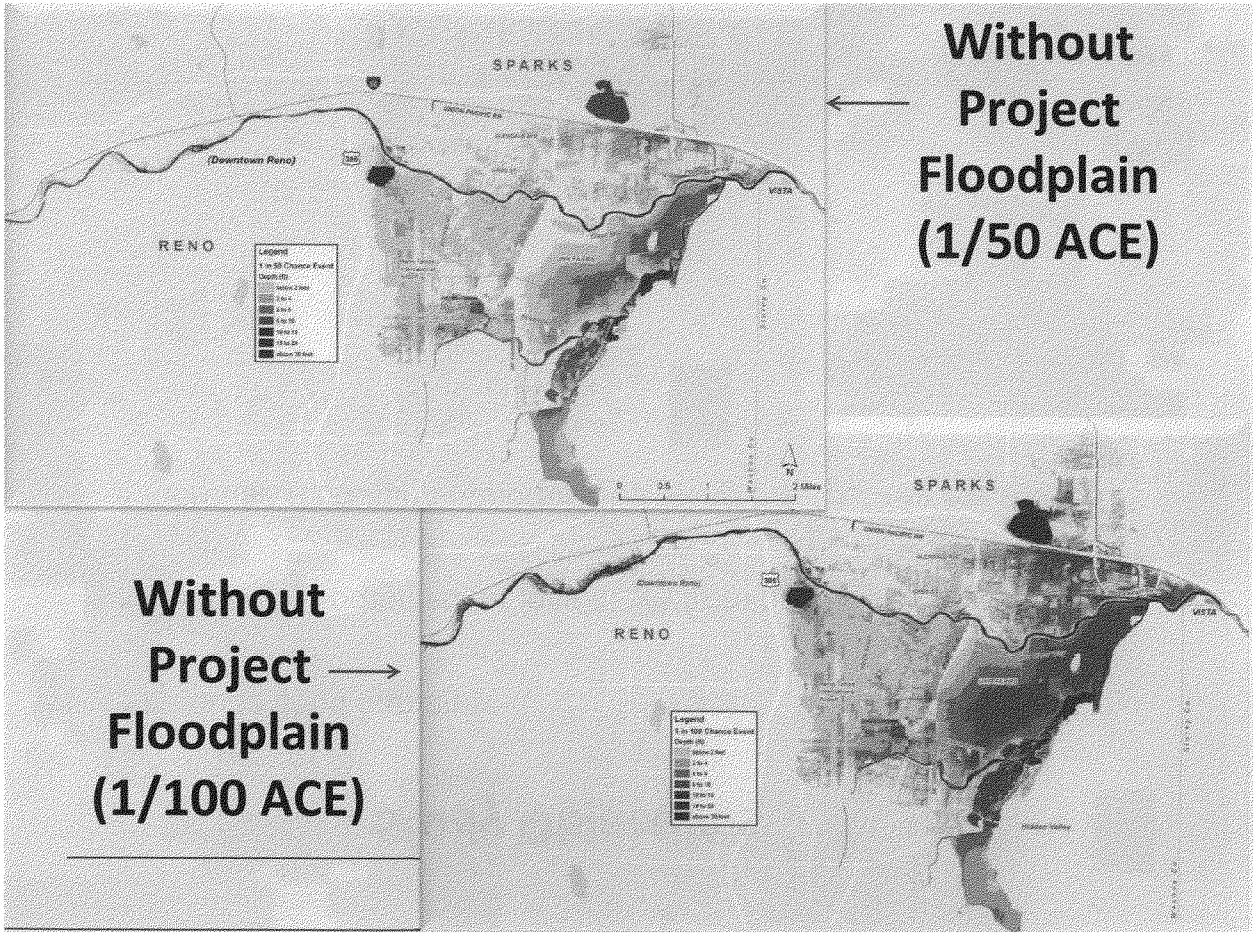
Problems

- Flood Risk: Poses a risk to life and public safety as well as to structures and contents in downtown Reno and Truckee Meadows.

- Recreation: Opportunities have not kept pace with demand.

• Long history of significant flooding – 1861, 1862, 1867, 1886, 1890,1907, 1909, 1928, 1937, 1950, 1955, 1963, 1986, **1997**, 2005.


Without Project Floodplain (1/50 ACE)
SPARKS
(Downtown Reno)
RENO
VISTA
Legend
1 in 50 Chance Event
Depth (ft)
0 0.5 1 2 Miles
Without Project Floodplain (1/100 ACE)
SPARKS
RENO
VISTA
Legend
1 in 100 Chance Event
Depth (ft)

Study Objectives

- Reduce flood damages
- Reduce the potential for loss of life from flooding
- Increase recreation opportunities along the Truckee River

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Preliminary Alternatives

- **Downtown Reno**
  - 7 alternatives consisting of: bridge modification, floodwalls, and non-structural (all eliminated during screening)
- **Truckee Meadows Reach**
  - 11 alternatives consisting of: levees, floodwalls, detention basin, and non-structural (narrowed to 3)
- **Recreation in Truckee Meadows Reach**
  - 3 alternatives

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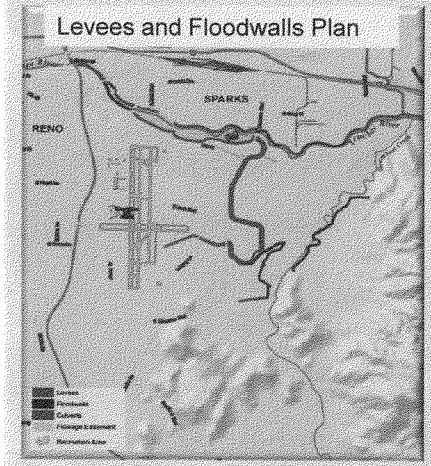
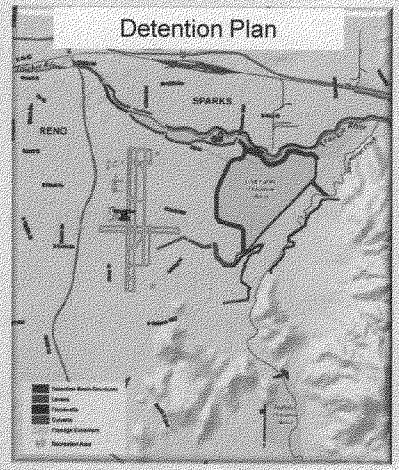
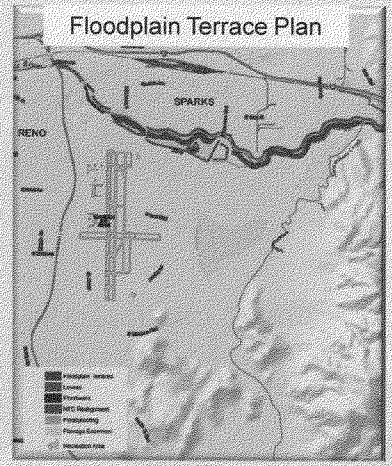
Final Array of Alternatives

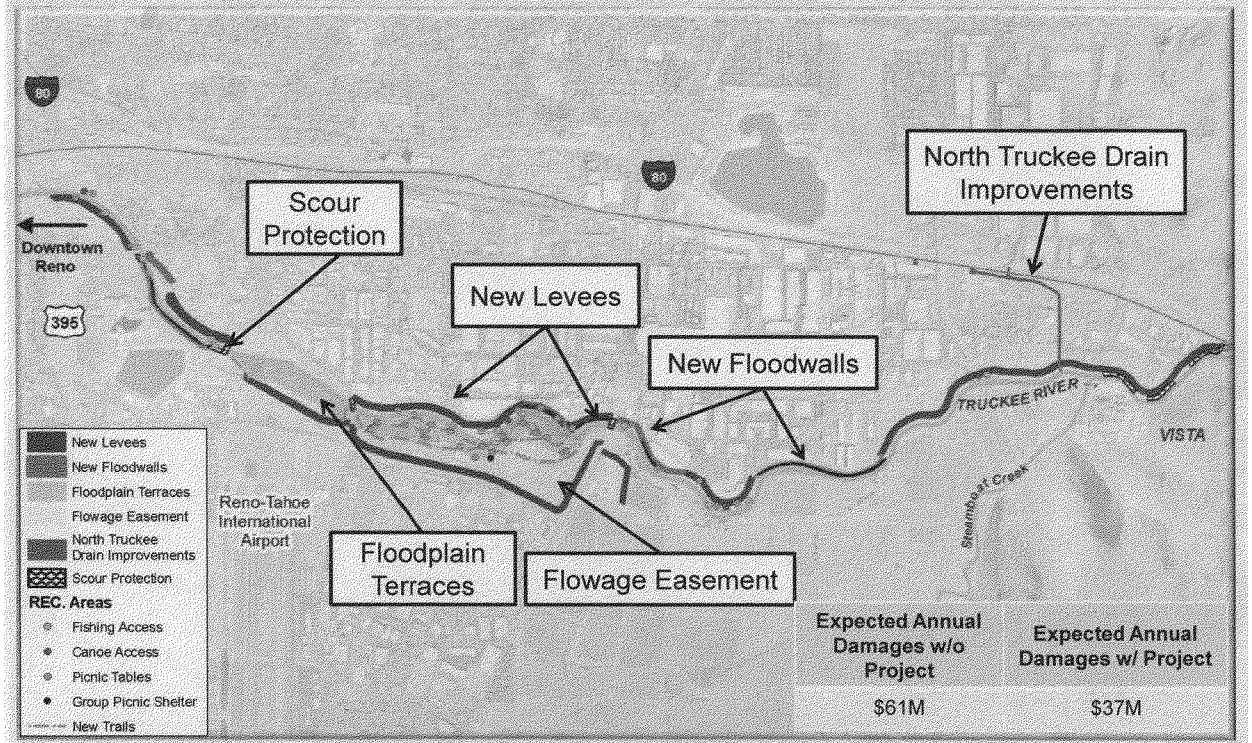






- All have reduced footprint from the authorized project.
- Each scaled to perform at 3 flood event levels.
- Non-structural features included.
- Floodplain Management Plan will be developed and implemented by sponsor.

NED (Recommended) Plan Features



Expected Annual Damages w/o Project	Expected Annual Damages w/ Project
$61M	$37M

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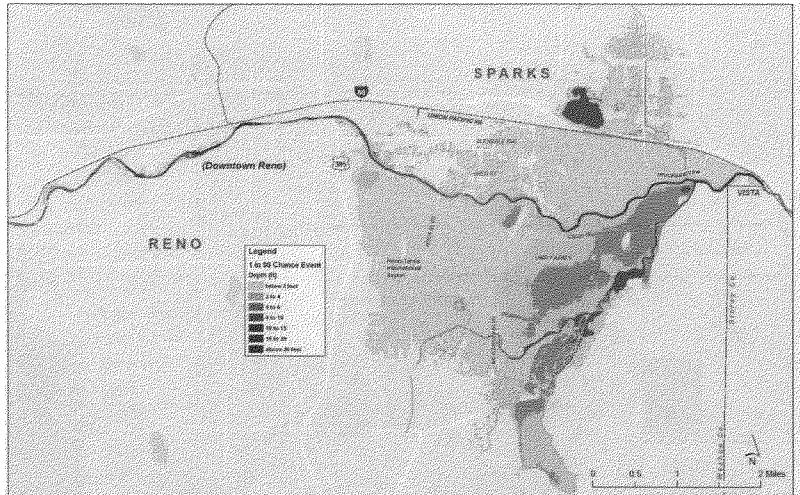
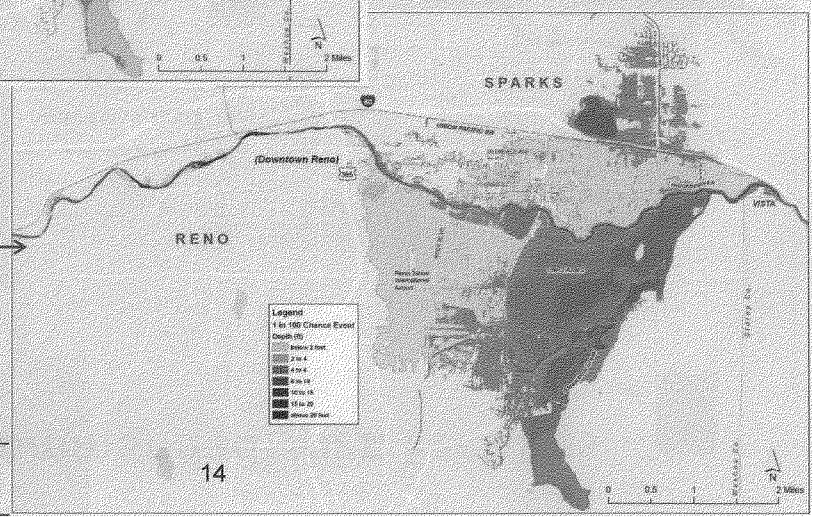


Residual Floodplain (1/50 ACE)

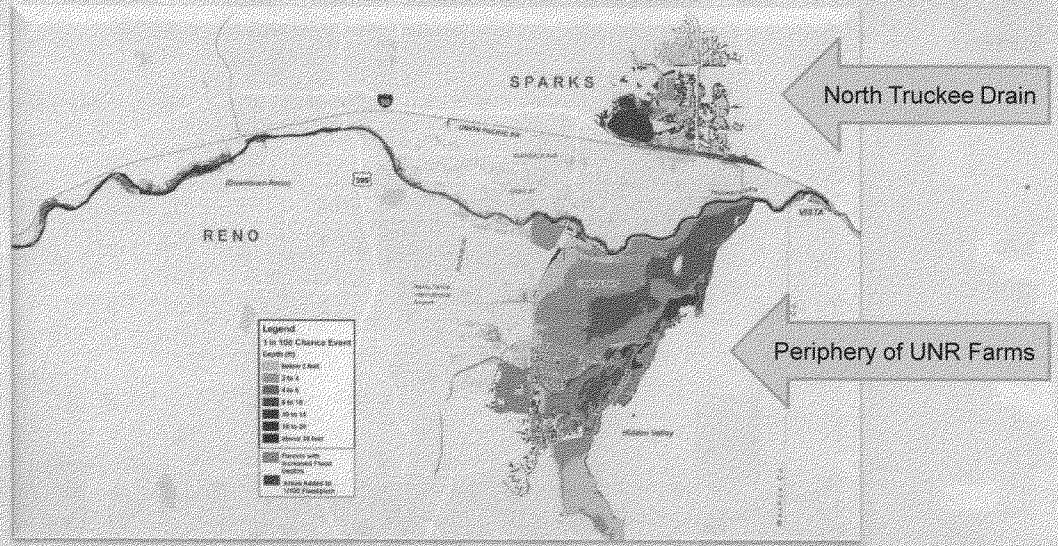
Structures in the Floodplain	Without Project	With Project
Total	**717**	**299**

Residual Floodplain (1/100 ACE)

Structures in the Floodplain	Without Project	With Project
Total	**1,786**	**1,307**



FEMA National Flood Insurance Program Compliance



Area	Impacts	Least Cost Option
North Truckee Drain Area	Up to 1 foot increase affecting ~240 structures	Pump station
Periphery of UNR Farms	Up to 7 inch increase affecting ~1075 structures	•Elevate 892 residential structures •Floodproof 7 non-residential structures

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Recommended Plan
Economic Summary

Economic Summary	
Item	**NED Plan ($1,000)**
Investment Costs	
First Costs[1]	$234,891
Interest During Construction	22,205
Total	**257,096**
Annual Cost	**11,823**
Annual Benefits	**25,505**
Net Annual Benefits	**13,682**
Benefit to Cost Ratio (3.5%)	**2.2**
Benefit to Cost Ratio (7%)	**1.3**

[1] Excludes PED sunk costs ($42,200,000), cultural resources data recovery costs ($1,817,000), and Section 113 financial costs ($1,912,000).

Recommended Plan
Federal and non-Federal Cost Shares

Total Project First Cost: $280,820,000

Project Purposes	Federal	Non-Federal
Flood Risk Management	$175M	$94M
Percentages	65%	35%
Recreation	$5M	$5M
Percentages	50%	50%
Cultural Resource Data Recovery	$1.8M	
TOTAL COST-SHARE	$182M	$99M[1]

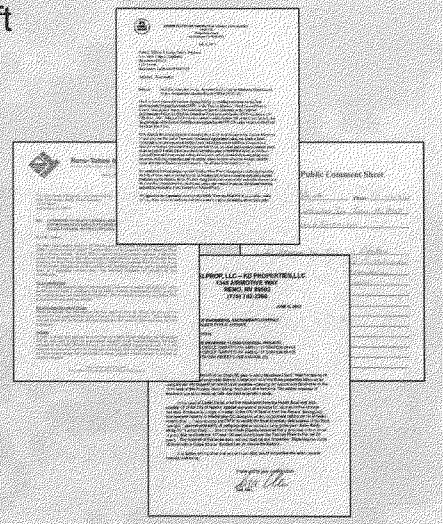
1. Federal Emergency Management Agency National Flood Insurance Program regulatory compliance costs of $195M are required. These costs are to be borne by Non-Federal sponsor and are not included in the total project cost.

Recommended Plan
Environmental Compliance

- NEPA compliance is complete for CWRB.
  - Received EPA EC-2 rating (Environmental Concerns and Requests Additional Information in FEIS); water resources, air quality, and public health concerns are addressed in the FEIS.
- Section 7 Endangered Species Act Consultation – ESA compliance with USFWS is complete (Lahontan cutthroat trout and cui-ui), 5 December 2013.
- Section 106 National Historic Preservation Act – Programmatic Agreement executed with SHPO on August 23, 2005, amended April 29, 2010.
- Compliant with all applicable Laws, Executive Orders and Federal regulations.
- Government to Government has been undertaken for this study with the Pyramid Lake Paiute Tribe and the Reno-Sparks Indian Colony.

Recommended Plan
Public Coordination

- 45-day public review of draft report and draft EIS – May 24, 2013
- Public meetings – June 12 and 19, 2013
- Public/agency comments received from: 6 individuals, 1 tribe, 8 agencies
- Primary concerns:
  - Increase in peak flows downstream affecting fisheries and inducing flooding
  - Cumulative effects of local roadway project



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Project Implementation

- Completed local work eligible for Section 104 credit
  - Approved by ASA(CW) in 2008
  - Reno Sparks Indian Colony project consists of approximately 2,200 linear feet of floodwall/levee on the south bank of Truckee River
  - Estimated credit $2.4 M

- Pre-construction Engineering and Design: 2 years
- Construction Phase: 5 years
- Plant Establishment Period: 3 years post construction

Study Team Members
(SPK/SPL)

- Project Management
- Planning
  - Plan Formulation
  - Environmental
  - Economics
  - Cultural Resources
- Engineering
  - Hydraulics
  - Hydrology
  - Geotechnical
  - Cost Engineering
  - Value Engineering
  - Environmental Engineering
  - Civil Design
- Real Estate
- Review Team
  - DST
  - RIT
  - OWPR
  - ATR
- Sponsor: TRFMA
- Office of Counsel
- Public Affairs Office

Truckee Meadows Schedule

- Feb 2013 – AFB and PGM
- May through August 2013
  - Release Draft GRR/EIS
  - Public Meetings
  - Division Engineers Transmittal Memo
- Dec 2013 – CWRB
- Jan/Feb 2014 – Final Public/State/Agency Review
- Apr 2014 – Chief's Report
- 2015 – 2016 – PED
- 2017 – 2020 – Construction

Civil Works Review Board

- 17 December 2013
- OMB Attendees: Mr. Alex Hettinger, Ms. Andrea Leung
- Result:
  - Board members voted unanimously to release the report for State and Agency review, contingent upon resolution of the National Flood Insurance Policy compliance cost decision.
  - Meeting held on December 18, 2013 with USACE and Office of ASA(CW). Determined that the NFIP compliance cost should not be included as part of the project economics.
  - The District was directed to modify the report accordingly and release it for State and Agency Review.

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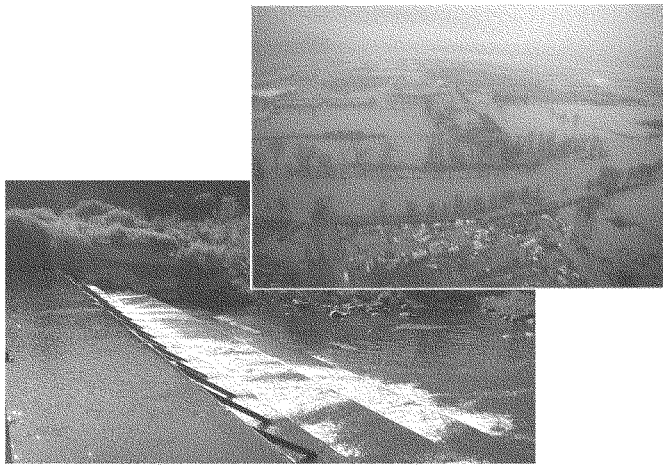
TRUCKEE MEADOWS FLOOD CONTROL PROJECT, NEVADA

FINAL GENERAL REEVALUATION REPORT

Revised March 2014



US Army Corps of Engineers ®
Sacramento District

Truckee Meadows Flood Control Project, Nevada

Final General Reevaluation Report

Revised March 2014

Prepared by
U.S. Army Corps of Engineers
Sacramento District

ADDENDUM TO TRUCKEE MEADOWS FLOOD CONTROL PROJECT, NEVADA
FINAL GENERAL REEVALUATION REPORT
14 MAY 2014

The following information is provided in response to policy review comments by the Administration and is intended to provide further information supporting the ranking of Truckee Meadows alternatives. This information is provided as an addendum to Section 5.3.1 of the Final General Reevaluation Report (pages 5-1 and 5-2) and Section 4.2.1 of the Economics Appendix (pages 45 and 46). The table below shows the expected annual benefits and net benefits for Truckee Meadows Alternatives. The table was included in previous District Quality Control and Agency Technical Review but had been simplified for the draft and final reports to focus on the rankings.

The three alternatives in the final array were evaluated at three comparative levels of project performance (90% assurance in passing the 1/50 ACE, 1/100 ACE and 1/117 ACE events) to economically optimize flood risk management. Preliminary benefits and costs for each level of project performance were developed to identify the plan with the maximum net benefits. The cost estimates were preliminary in nature using conceptual designs, historic bid information, and professional judgment. These estimates were only used for screening. Ranking of the alternatives based on preliminary net benefits is shown in the table below (1 = highest rank).

Comparison of Flood Risk Management Plans

Alternative (nominal level of performance[1])	Expected Annual Benefits	Annual Costs	B/C Ratio	Net Benefits	Ranking
No-Action	0	0	0	0	8
Alternative 1a (50)	26,800	21,100	1.27	5,700	4
Alternative 1b (100)	33,600	33,000	1.02	600	7
Alternative 1c (117)	36,600	35,700	1.02	900	6
Alternative 2a (50)	25,500	20,700	1.2	4,800	5
Alternative 2b (100)	31,300	38,400	0.81	-7,100	10
Alternative 2c (117)	33,900	39,400	0.86	-5,500	9
Alternative 3a (50)	32,600	21,300	1.53	11,300	2
Alternative 3c (100)	42,100	31,200	1.4	10,900	3
Alternative 3d (117)	45,600	31,500	1.32	14,100	1

[1] Nominal level of performance = 90% assurance of safely containing indicated event water surface elevation behind the lines of protection. For example, alternative 1a would safely contain the 2% (1/50) ACE water surface elevation 90% of the time.

Based on the net benefits of alternatives displayed above, it is clear that Alternative 3 produces far superior outputs at all three levels of project performance when compared to Alternatives 1 and 2. The lowest net benefit produced by Alternative 3 at any level of project performance exceeded the highest net benefit produced by either Alternative 1 or 2. Due to this order of magnitude superiority, Alternative 3 was the only alternative carried forward for refined H&H modeling, as the H&H refinements would not have changed the relative rankings of alternatives. Therefore, Alternative 3 was identified as the most cost effective and highest output plan, with Alternative 3d tentatively identified as the optimal plan for the Truckee Meadows Reach.

TRUCKEE MEADOWS FLOOD CONTROL PROJECT, NEVADA
FINAL GENERAL REEVALUATION REPORT

ERRATA SHEET
March 2014

The following corrections are made to the final General Reevaluation Report:

1. Executive Summary, Major Conclusions section, page S-12.

   Replaced the word deauthorization in sentence regarding Truckee River and Tributaries Project: "To ensure that the sponsor has full and clear responsibility for all Federal flood risk management features in the Truckee Meadows reach, deauthorization of the features of the Truckee River and Tributaries Project (authorized by FCA 1954, § 203 and FCA 1962, § 203) in the Truckee Meadows reach, which are currently maintained by the State of Nevada, is recommended."

   With the word modification: "To ensure that the sponsor has full and clear responsibility for all Federal flood risk management features in the Truckee Meadows reach, modification of the features of the Truckee River and Tributaries Project (authorized by FCA 1954, § 203 and FCA 1962, § 203) in the Truckee Meadows reach, which are currently maintained by the State of Nevada, is recommended."

2. Chapter 6, section 6.1.10 Operation, Maintenance, Repair, Replacement, and Rehabilitation, page 6-10.

   Replaced the word deauthorization in the subheading: "Deauthorization of a Portion of the Truckee River and Tributaries Project"

   With the word modification: "Modification of a Portion of the Truckee River and Tributaries Project"

3. Chapter 6, section 6.1.10 Operation, Maintenance, Repair, Replacement, and Rehabilitation, page 6-10.

   Replaced the word deauthorization in sentence regarding Truckee River and Tributaries Project: "In Chapter 9, this GRR recommends deauthorization of the Glendale Avenue to Vista Reach of Truckee River and Tributaries Project to ensure that the sponsor for the Truckee Meadows Flood Control Project has full and clear responsibility, as between USACE and the sponsor, for OMRR&R of all USACE flood risk management elements between Glendale Avenue and Vista."

   With the word modification: "In Chapter 9, this GRR recommends modification of the Glendale Avenue to Vista Reach of Truckee River and Tributaries Project to ensure that the sponsor for the Truckee Meadows Flood Control Project has full and clear responsibility, as between USACE and the sponsor, for OMRR&R of all USACE flood risk management elements between Glendale Avenue and Vista."

4. Chapter 9, section 9.4 Recommendations, page 9-5.

Replaced the paragraph regarding Truckee River and Tributaries Project: "I also recommend that the part of the existing Truckee River and Tributaries Project between Glendale Avenue and Vista be deauthorized upon completion and transfer to the sponsor of all elements of the Recommended Plan for the Truckee Meadows Flood Control Project within that same reach. Deauthorization of the obsolete part of the Truckee River and Tributaries Project (which is currently maintained by the State of Nevada) will ensure that the non-Federal sponsor for the Truckee Meadows Flood Control Project has full and clear responsibility, as between the Department of the Army and the sponsor, for operation, maintenance, repair, replacement and rehabilitation (OMRR&R) of all Federal flood risk management elements between Glendale Avenue and Vista. OMRR&R responsibilities for the parts of the Truckee River and Tributaries Project upstream of Glendale Avenue or downstream of Vista would not be changed by the Recommended Plan."

With: "I also recommend that the part of the existing Truckee River and Tributaries Project between Glendale Avenue and Vista be modified in accordance with the Recommended Plan for the Truckee Meadows Flood Control Project within that same reach. Modification of that part of the Truckee River and Tributaries Project (which is currently maintained by the State of Nevada) will ensure that the non-Federal sponsor for the Truckee Meadows Flood Control Project has full and clear responsibility, as between the Department of the Army and the sponsor, for operation, maintenance, repair, replacement and rehabilitation (OMRR&R) of all Federal flood risk management elements between Glendale Avenue and Vista. OMRR&R responsibilities for the parts of the Truckee River and Tributaries Project upstream of Glendale Avenue or downstream of Vista would not be changed by the Recommended Plan."

EXECUTIVE SUMMARY

This General Reevaluation Report (GRR) addresses potential modifications to the Congressionally-authorized Truckee Meadows Flood Control Project in the cities of Reno and Sparks in Washoe County, Nevada. The study area for this report extends along the Truckee River from upstream of the City of Reno to Pyramid Lake. This report: (1) assesses the risks of flooding; (2) analyzes ecosystem problems within the study area; (3) evaluates a range of alternatives to reduce flood risks in the cities of Reno and Sparks; (4) evaluates opportunities for fish passage improvements; and (5) identifies the Recommended Plan. The Recommended Plan includes flood risk management and associated recreation measures along the Truckee River within the Truckee Meadows area.

This final GRR will be submitted to United States Army Corps of Engineers (USACE) Headquarters. A Chief's Report based on the GRR will be developed and provided to the Assistant Secretary of the Army for Civil Works (ASA(CW)) and the Office of Management and Budget for review and approval. It will then be transmitted to Congress for potential project authorization and funding of the Federal share of the Recommended Plan.

BACKGROUND

The Truckee Meadows Flood Control Project[1] was authorized by the Water Resources Development Act of 1988, Pub. L. No. 100-676, § 3(a)(10), 102 Stat. 4012 (1988), (WRDA 1988, §3(a)(10)), which reads:

> The project for flood control, Truckee Meadows, Nevada: Report of the Chief of Engineers, dated July 25, 1986, at a total cost of $78,400,000, with an estimated first Federal cost of $39,200,000 and an estimated first non-Federal cost of $39,200,000; except that the Secretary is authorized to carry out fish and wildlife enhancement as a purpose of such project, including fish and wildlife enhancement measures described in the District Engineer's Report, dated July 1985, at an additional total cost of $4,140,000.

Construction of the authorized project was deferred during the Pre-construction Engineering and Design (PED) phase, in or around 1992, when changes in real estate costs made the project economically infeasible. The Fallon Paiute Shoshone Indian Tribes Water Rights Settlement Act, Pub. L. 101-618, § 207, 104 Stat. 3289 (1990) (Tribes Water Rights Settlement Act, § 207), provided direction regarding the conduct of a general reevaluation as follows:

[1] A previous USACE project was authorized and constructed pursuant to the Flood Control Act of 1954, Pub. L. 83-780, § 203, 68 Stat. 1256, 1264 (1954) (FCA 1954, § 203) and the Flood Control Act of 1962, Pub. L. 87-874, § 203, 76 Stat. 1180, 1191 (1962) (FCA 1962, § 203).

> The Secretary of the Army, in consultation with and with the assistance of the Pyramid Lake Tribe, State of Nevada, Environmental Protection Agency, the Secretary [of Interior], and other interested parties, is authorized and directed to incorporate into its ongoing reconnaissance level study of the Truckee River, a study of the rehabilitation of the lower Truckee River to and including the river terminus delta at Pyramid Lake, for the benefit of the Pyramid Lake fishery. Such study shall analyze, among other relevant factors, the feasibility of:
>
> - Restoring riparian habitat and vegetative cover
> - Stabilizing the course of the Truckee River to minimize erosion
> - Improving spawning and migratory habitat for the cui-ui
> - Improving spawning and migratory habitat for the Lahontan cutthroat trout
> - Improving or replacing existing facilities, or creating new facilities, to enable the efficient passage of cui-ui and Lahontan cutthroat trout through or around the delta at the mouth of the Truckee River, and to upstream reaches above Derby Dam, to obtain access to upstream spawning habitat.

In 1996, local communities requested that flooding problems in Truckee Meadows be reevaluated. The Secretary of the Army also received guidance regarding USACE's conduct of the GRR pursuant to the House Report, H.R. Rep. No. 104-293, at 14 (1995), associated with the Energy and Water Development Appropriations Act of 1996, Pub. L. 104-46, 109 Stat. 402 (1996) (EWDAA 1996). A major flood event in January 1997 exceeded all previous records and caused $450 million (unadjusted) in reported damages.

During the current general reevaluation, the Energy and Water Development Appropriations Act of 2006, Pub. L. 109-103, § 113, 119 Stat. 2247, 2254 (2005) (EWDAA 2006, § 113) was passed. Section 113 of EWDAA 2006 states:

> Truckee Meadows Flood Control Project, Nevada: The non-Federal funds expended for purchase of lands, easements and rights-of-way, implementation of project monitoring and assessment, and construction and implementation of recreation, ecosystem restoration, and water quality improvement features, including the provision of 6,700 acre-feet of water rights no later than the effective date of the Truckee River Operating Agreement for revegetation, reestablishment and maintenance of riverine and riparian habitat of the lower Truckee River and Pyramid Lake, whether expended prior to or after the signing of the Project Cooperation Agreement (PCA), shall be fully credited to the non-Federal sponsor's share of costs for the project: Provided, that for the purposes of benefit-cost ratio calculations in the General Reevaluation Report (GRR), the Truckee Meadows Nevada Flood Control Project shall be defined as a single unit and non-separable.

USACE initially sought to identify a comprehensive solution for flood, ecosystem, and recreation problems, including detailed evaluation of a locally-developed plan resulting from a community coalition process. Despite several attempts, those efforts did not result in a plan that USACE could recommend. The primary purpose of the reevaluation study is to assess the feasibility of modifying the Congressionally-authorized project to reduce flood damages in the Truckee Meadows project area while avoiding or minimizing adverse effects.

AUTHORIZED PLAN

The flood control features authorized in WRDA 1988, § 3(a)(10), begin near Booth Street in downtown Reno, extend downstream along the Truckee River to the Truckee Meadows Wastewater Reclamation Facility (TMWRF), and continue up Steamboat Creek for approximately two miles. Features include floodwalls, setback levees, reconstruction/ replacement of six bridges in downtown Reno, channel excavation, reconstruction of the TMWRF diversion dam, backwater levees on the North Truckee Drain, a large detention basin at Nevada Agricultural Experiment Station (also known as UNR Farms), and levees along Steamboat Creek and Boynton Slough with an additional bridge modification. These project features were designed to provide "100-year flood protection" based on then-current (1988) hydrology and design standards. Authorized recreation features include a new pedestrian/bike bridge, bike lanes on bridges, pedestrian/bike paths, and new access sites and improvements in downtown Reno. The authorized project includes riparian habitat plantings as compensatory fish and wildlife mitigation. Fish and wildlife "enhancement" features, consisting of riparian plantings, marsh habitat preservation, and fish habitat improvements, were also specifically authorized.

CONSIDERATION OF ALTERNATIVE PLANS

During the general reevaluation, the Federal water resources planning process established by the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (1983) was used to identify a recommended plan. Following definition of problems and opportunities related to flooding, ecosystems, and recreation (Chapter 3), specific planning objectives and constraints were identified (Chapter 4). Next, various structural and non-structural management measures were identified to achieve the planning objectives and avoid the planning constraints. Management measures were screened based on how well they met the study objectives and formulation criteria, and some measures were dropped from further consideration at that point. The retained management measures were combined to form preliminary alternative plans.

Flood Risk Management

The study area includes approximately 60 miles of the Truckee River. Because of the size of the land area and number of river miles the study area was divided into general reaches for analysis.

For Downtown Reno reach (Figure 2-2), which includes the Truckee River area from about Booth Street to U.S Highway 395, seven preliminary flood risk management alternatives, including a non-structural alternative, were evaluated. The structural alternatives focused on the modification of multiple bridges, along with increases in channel capacity, levees, and floodwalls. None of the preliminary alternatives were found to be economically justified, so no plan was carried forward for detailed evaluation.

For the Truckee Meadows reach (Figure 2-6), which includes the Truckee River area from U.S. Highway 395 to the Vista, three preliminary alternatives representing different strategies were initially evaluated. All three alternatives included levees and floodwalls along portions of the Truckee River between Highway 395 and Vista. Alternative 1 was limited to levees and floodwalls as the primary features. Alternative 2 also included detention facilities at Huffaker Hills, UNR Farms, and Mustang Ranch. Alternative 3 included floodplain terracing in addition to levees and floodwalls. In response to stakeholder input, eight additional preliminary alternatives focused on increasing storage opportunities at Huffaker Hills, UNR Farms, and Upper Lockwood were also evaluated. The preliminary alternatives were developed to a level of detail to allow a basic comparison of costs and benefits. None of the eight additional storage alternatives were found to be economically justified. Of the three initial alternatives, Alternative 3 was ranked the highest, but had not yet been demonstrated to be the National Economic Development (NED) plan for flood risk management. Alternative 3 was the focus of a reformulation workshop with the non-Federal sponsor, Truckee River Flood Management Authority (TRFMA), and USACE vertical team members held in November 2011 to identify a Federally-supportable flood risk management plan. The reformulation workshop assessed the incremental costs and benefits of the various elements of Alternative 3 to ensure that each added element was incrementally justified. The workshop resulted in more focused evaluation of the 2% Annual Chance Exceedance (ACE) scale of Alternative 3 with high assurance (2% event is also commonly called the 1:50, 1/50, or "50-year" event). Previous analysis had identified maximum net benefits at this relative scale. Terracing downstream of Steamboat Creek was eliminated from Alternative 3, and capping of People's Drain outlets was added, as a result of the workshop.

Federal policy requires USACE to recommend the plan that reasonably maximizes net economic benefits consistent with protecting the Nation's environment (the National Economic Development or NED Plan), unless an exception is granted by the ASA(CW). The 2% ACE scale of the reformulated Alternative 3 was identified as the plan that reasonably maximized net economic benefits consistent with protecting the environment.

Recreation

Three alternative recreation plans composed of policy-compliant basic recreation features were formulated based on the opportunities provided by the flood risk management NED Plan. All three recreation plans included picnic areas, fishing access, non-motorized watercraft launches, and trails. The two larger-scale plans also included a playground and group picnic shelters. The largest-scale plan (Recreation Alternative C) is economically justified and would provide the maximum net recreation benefits and was therefore included in the NED Plan.

Ecosystem Restoration

The Truckee Meadows project was authorized by Congress in WRDA 1988, §3(a)(10), for flood control and fish and wildlife enhancement purposes. Since the 1990's, there has been a strong local interest in reestablishing a "living river" corridor to convey flood flows, reestablish native habitat and restore fish passage along the Truckee River. Fish and wildlife enhancement was considered during USACE's general reevaluation of the project. In 2012, USACE and the Administration, in coordination with the sponsor, decided to give priority to flood risk reduction to expedite completion of the study. As a result, habitat restoration was deferred. Measures to avoid or minimize adverse effects on existing habitats and sensitive species, including revegetation, landscaping, and erosion protection on project lands, have been included in the Recommended Plan. The District Engineer's recommendation in Chapter 9 includes retaining the existing authorized fish and wildlife enhancement (i.e., ecosystem restoration) purpose of the Truckee Meadows Flood Control Project for potential future implementation.

Restoration of fish passage on the Truckee River was evaluated in detail pursuant to the 1990 Tribes Water Rights Settlement Act, § 207. USACE's Engineer Research and Development Center (ERDC) developed measures to address upstream and downstream fish passage problems at 18 barriers between Pyramid Lake and Fleisch diversion dam in California. The measures considered included diversion structure removal or modification, installing or modifying fish ladders, installing a bypass channel, replacing a diversion structure with a pump diversion, and installing fish screens. A total of 54 system-wide plans providing a wide range of output were evaluated using a fishery quality/quantity scoring system and Cost Effectiveness and Incremental Cost Analyses. Three best buy plans were identified, including the most cost effective plan, which would restore fish access to approximately 90 miles of the Truckee River at a preliminary estimated cost of $47 million. In 2012, USACE and the Administration, in coordination with the sponsor, decided to refocus plan selection on the primary project purpose of flood risk management to expedite completion of the study consistent with Administration and sponsor priorities. Federal interest in a plan for the restoration of fish passage has been established, but that plan is not being recommended for implementation by USACE at this time.

National Economic Development Plan (Floodplain Terrace Plan)

The National Economic Development (NED) plan is the Floodplain Terrace Plan (also identified as Alternative 3 in this GRR). The Floodplain Terrace Plan efficiently reduces flood damages in high-value commercial and industrial areas near the Truckee River, including the Reno-Tahoe International Airport, by containing flood flows with levees and floodwalls, enlarging the existing channel with floodplain terracing, and by detaining peak flows in a designated overflow area. The designated overflow area is on the south side of the river near the mouth of Steamboat Creek and is largely occupied by the Nevada Agricultural Experiment Station (also known as UNR Farms). The NED Plan provides 90% assurance of safely passing the 2% ACE in major damage areas and includes basic recreation features that are compliant with USACE policy.

Increased Depth of Flooding from NED Plan in Two Areas

Feasibility-level hydraulic modeling of the NED Plan found that the 1% ACE flood elevations (also commonly referred to as 1/100, 1:100, or 100-year flood) increase between 0.0 and 0.6 foot in several areas near the downstream end of the project compared to the without-project condition. (There is some level of uncertainty in any hydraulic model. In this case, the actual without- and with-project water surface elevations could be 0.5 foot lower or higher than estimated.)

- UNR Farms and southern periphery: The flood elevation increase in the UNR Farms area is up to 0.6 foot. The USACE estimated with-project 1% ACE flood elevations would exceed the first floor elevations of an estimated 900 existing structures (mostly single-family residences and multiplex apartment buildings) on the southern periphery of the UNR Farms area that are also within the USACE without-project 1% ACE floodplain. An estimated additional 175 residences that are outside of the USACE without-project 1% ACE floodplain would be within the limits of the with-project floodplain, but it is estimated that their first floors would still be above the with-project flood elevation. However, the estimated increase in the 2% ACE flood elevations would affect about 22 existing structures south of UNR Farms, most of which would have an estimated increase of 0.2 to 0.4 foot.

- North Truckee Drain (NTD): The 1% ACE flood elevation on both sides of the North Truckee Drain (NTD) immediately north of I-80 would be increased by approximately 0.5 to 1 foot due to backwater effects in the NTD.

Figure 5-4 shows the areas in the estimated without- and with-project 1% ACE floodplains.

USACE policy allows mitigation for induced flooding to be recommended as a project feature when it is economically justified or there are overriding reasons of safety, economic, or social concerns, or a determination of a real estate taking has been made (ER 1105-2-100, para.3-3.b.(5)). Potential mitigation measures for induced flooding were considered by the District, but none were found to be economically justified. The structural and non-structural measures considered for the south side of the Truckee River were: raising or wet flood-proofing existing residential and commercial structures; levees and floodwalls to protect existing structures; a detention basin with perimeter levees in the UNR Farms area; excavation of the hydraulic constriction downstream of Truckee Meadows including downstream hydraulic and environmental mitigation; or purchase/removal of the affected structures. The structural and non-structural measures considered for the north side of the Truckee River were: a pump station; ring levees; or raising/wet flood-proofing existing residential and commercial structures. Raising/flood-proofing structures on the south side and a pump station on the north side were found to be the least costly options that could be added to the NED Plan, based on rough cost estimates for each measure by District civil design and cost engineering staff using their professional experience. The average annual flood risk management benefits for those measures were found to be far less than required to justify their costs. Any increase in flooding will be an important concern for adversely affected property owners. However, because of the small

increase in flood elevations and the low recurrence frequency of induced flooding, those concerns are not considered to be overriding safety, economic, or social concerns under USACE policy, and no real estate taking would occur specifically due to the increase in water surface elevation in the vicinity of the North Truckee Drain or University of Nevada Reno Farms. Therefore, mitigation for induced flooding is not proposed as a project feature of the Federally-funded NED Plan.

Additional costs for non-Federal interests to comply with the NFIP were estimated by USACE. The NFIP compliance costs are not based on specific features proposed by the sponsor. The estimated NFIP compliance costs are based on the least-cost features that could be added to the NED Plan by local interests, without modifying the NED Plan, to achieve NFIP compliance.

USACE has considered several options for NFIP compliance and determined that non-structural methods including house raising would likely be the least-cost option on the south side of the Truckee River. Based on feasibility-level hydraulic modeling, approximately 764 homes and 128 multiplex apartment buildings would need to be raised in the area south of the river. An additional four commercial structures and three public buildings would also need to be raised or "wet flood-proofed" with closures and sealing. The preliminary cost estimate to raise and flood-proof structures for NFIP compliance on the south side of the Truckee River is $172 million. For the north side of the Truckee River, a 400-cfs capacity pump station on the North Truckee Drain with an outfall to the Truckee River would be the least-cost option. The estimated first cost for the pump station is $23 million including contingencies. Because compliance with the NFIP is a non-Federal responsibility, the affected NFIP communities could develop their own plan for compliance with the NFIP and would not be required to implement the specific assumed least-cost features. The estimated NFIP compliance costs are subject to change based on more detailed hydraulic analysis during final design of the project, including the results of NFIP hydraulic modeling assumptions and methods, and more detailed surveys of the elevations of existing structures.

Federal cost sharing will be based on the NED Plan and all additional costs for NFIP compliance will be non-Federal costs.

RECOMMENDED PLAN

The Recommended Plan is the NED plan for flood risk management (Alternative 3 – Floodplain Terrace Plan) and recreation (Alternative C). The principal features of the Recommended Plan are (1) construction of floodwalls, levees, and floodplain terracing in the Truckee Meadows reach, and (2) basic recreation features in the Truckee Meadows. Features are summarized below and shown in Figures 6.2 and 6.3.

- Levees: 31,000 lineal feet (lf) on north/south banks of Truckee River.
- Floodwalls (on-bank): 6,500 lf on north and south banks of Truckee River.
- Floodwalls (in-channel): 3,150 lf on north and south banks of Truckee River.

- Floodplain terrace: 150-200 ft to the landside of the south bank of the Truckee River. A higher bench would be extended approximately 50-70 feet to the landside of the low bench.
- Box culverts: 2 box culverts on North Truckee Drain (NTD) for approximately 3,100 lf. Includes a 200 lf extension to the existing People's Drain. Cap 2 junction structures of People's Drain.
- Interior drainage: 14 cfs pumping station and new flap gates and vertical sluice gates.
- Seepage prevention: Berms, drainage blankets, and relief wells.
- Bridge pier and scour protection: 11,600 lf rock scour protection. Pier protection at 3 bridges between US Hwy 395 and Vista.
- Picnic areas: 50 individual picnic areas, 1 small and 1 medium group picnic shelter, with parking, playground and restrooms.
- Water recreation access: 4 kayak/canoe input areas and 13 fishing areas.
- Trails: 18,800 lf of paved and unpaved trails.

The Recommended Plan will require new congressional authorization because the Section 902 cost limit would be exceeded. Additional information about the Recommended Plan can be found in Chapter 6.

ENVIRONMENTAL EFFECTS

An evaluation of environmental effects determined that the proposed action has the potential for adverse effects on a number of environmental resources.

Construction of the flood risk management features for the Recommended Plan would detrimentally affect fish and wildlife habitat. The Recommended Plan would cause temporary and permanent losses of riparian habitat from construction activities required for excavations, floodwalls, and levees, affecting 28.3 acres of native riparian habitat.

Removal of riparian habitat that shades the river would also potentially increase water temperatures, which would be detrimental to fish spawning activities and egg and young survival. The Recommended Plan would remove about 7,200 linear feet of riparian river shading. However, the plan would avoid long-term effects to water temperature through revegetation of floodplain terraces and implementation of bioengineering techniques in scour protection features. Formal consultation with the U.S. Fish and Wildlife Service (USFWS) under Section 7 of the Endangered Species Act is complete and USACE received a Biological Opinion (BO) on December 5th, 2013. In addition, a Coordination Act Report from the Service was finalized on December 12th, 2013. Coordination with USFWS to implement the terms and conditions of the BO and recommendations from the Coordination Act Report will continue through PED and Construction.

The Recommended Plan would remove approximately 1.1 acres of existing wetland habitat primarily associated with Pioneer Ditch and the North Truckee Drain. However, the

Recommended Plan would reestablish connection of the river to its historic floodplain through excavation and revegetation of floodplain terraces that are exposed to seasonal inundation.

In-channel construction activities would represent a temporary disturbance to fisheries habitat. Construction of in-channel floodwalls and scour protection features for the Recommended Plan would involve temporary disturbance of 3.7 acres of river bottom and the permanent loss of approximately 2.5 acres of open water habitat along the river margin and the North Truckee Drain. However, following completion of construction activities, river bottom habitat conditions are expected to be similar to existing conditions. Bottom dwelling organisms should repopulate to pre-project levels within 6 months.

In-channel construction would also temporarily increase turbidity levels causing spawning gravel spaces to fill in, which contributes to low dissolved oxygen levels, and can cause gill damage. Increases in turbidity levels during construction would be avoided or minimized by use of cofferdams to divert flows around the construction area, timing construction during low flows, installing silt screens, and monitoring turbidity levels to avoid exceeding significance thresholds.

Increased turbidity levels and water temperatures also represent a potential effect to the threatened Lahontan cutthroat trout and endangered cui-ui. While the Lahontan cutthroat trout, extirpated from the Truckee River in the 20th century, was recently reintroduced to the river, existing water temperature conditions prohibit the presence of a self-sustaining population of the species in and downstream of the project area. Cui-ui populations are present only downstream of the project area, below Derby Dam. While changes in water temperature and turbidity could represent an indirect adverse effect to cui-ui, measures to control turbidity levels during construction and reestablishment of riparian vegetation on floodplain terraces and scour protection features would avoid or minimize adverse long-term effects to this species. The limited increase in downstream flows induced by the Recommended Plan are not expected to generate a measurable change in sediment aggradation or degradation within the Lower Truckee river.

The Recommended Plan would convert about 30 acres of prime and unique farmland and 19 acres of farmland with statewide and local importance for levee construction. While the overall acreage of land available for agriculture would be reduced in portions of the Truckee Meadows reach, the conversion of land for flood risk management would reduce the danger of catastrophic floods and benefit the remaining agricultural land by improving groundwater recharge and nutrient exchange through construction of the floodplain terraces.

In all cases the potential adverse environmental effects would be reduced to a less than significant level through project design, construction practices, preconstruction surveys and analysis, regulatory requirements, and best management practices. No compensatory mitigation would be required. A National Pollutant Discharge Elimination System (NPDES) general construction permit would be required. A Storm Water Pollution Prevention Plan (SWPPP) and Spill Prevention Control and Countermeasures Plan (SPCCP) would be developed by the contractor prior to construction.

ECONOMIC EVALUATION

Investment costs, annual costs, and annual benefits are displayed in Table S-1 below, both with- and without the associated economic costs and benefits for NFIP compliance.

Table S-1. Comparison of Total Annual Benefits and Costs for the NED Plan (with and without associated economic costs and benefits for NFIP compliance) [1,2]

Item	NED Plan without NFIP ($1,000)	NED Plan with NFIP ($1,000)	Difference ($1,000)
Investment Costs			
Flood Risk Management First Costs[2]	$224,778	$224,778	$0
Associated Cost NFIP Compliance[3]	0	195,000	$195,000
Recreation First Costs	10,113	10,113	$0
Interest During Construction	22,205	25,828	$3,623
Total	257,096	455,719	$198,623
Annual Cost			
Interest and Amortization	$10,961	$19,428	
OMRR&R[4]	862	862	
Total	11,823	20,290	$ 8,467
Annual Benefits	25,505	26,524	$1,019
Net Annual Benefits	13,682	6,234	($7,448)
Benefit to Cost Ratio	2.2	1.3	

[1] October 2013 price levels, 3.5 percent rate of interest, and a 50-year period of analysis.
[2] Excludes PED sunk costs ($42,200,000), cultural resources data recovery costs ($1,817,000), and Section 113 financial costs ($1,912,000).
[3] Minimum additional cost for non-Federal compliance with National Flood Insurance Program regulations.
[4] Operation, Maintenance, Repair, Replacement, and Rehabilitation.

COST-SHARING REQUIREMENTS

A summary of cost sharing responsibilities is presented in Table S-2. The estimated total first cost for the Recommended Plan is $280,820,000. Federal costs for the Recommended Plan would be limited to the Federal share of the NED plan, which is estimated to be $181,652,000. The estimated costs in Table S-2 include additional financial costs for LER due to Section 113 of the Energy and Water Development Appropriations Act of 2006 (see Section 1.3), as is explained in Sections 6.2 and 6.5.

Table S-2. Summary of Cost Sharing Responsibilities for Recommended Plan[1]

Item	Federal ($1,000)	Non-Federal ($1,000)	Total ($1,000)
Flood Risk Management			
Construction[2,5]	$187,912	$2,406	$190,318
LERRD[3]	1,496	77,076	78,572
Minimum Cash Contribution (5%)	-13,445	13,445	
Additional Cash Contribution	-1,185	1,185	
Sub-total Flood Risk Management	174,779	94,112	268,890
Recreation			
Construction[2]	9,923		9,923
LERRD[3,4]	32	158	190
Cash Contribution	-4,899	4,899	
Sub-total Recreation	5,057	5,057	10,113
Cultural Resources Data Recovery	1,817		1,817
Total	**$181,652**	**$99,168**	**$280,820**

[1] October 2013 price levels; Includes estimated Section 104 credit for RSIC levee.
[2] Construction costs include PED and Construction Management costs.
[3] Federal costs on this line are administrative costs. Non-Federal costs include Section 113 credit for expenditures to date.
[4] Recreation LERRD limited to upgrade of FRM easements to fee title.
[5] Non-Federal Construction includes estimated creditable cost for completed Sec 104 work ($2,406,000).

UNCERTAINTY

Each aspect of flood risk assessment must account for uncertainty. This includes hydrologic and hydraulic analysis, geotechnical analysis, economics, and the impacts of future local projects in the study area. USACE risk assessment procedures were followed in this study that account for uncertainty in the information to the extent practicable. However, the public should recognize that in all studies, even with the risk assessment procedures, there is some project performance uncertainty. Additional information about uncertainty is included in Chapters 3 and 5.

MAJOR CONCLUSIONS

The recommendation of the District Engineer of the Sacramento District, USACE is that the Recommended Plan (NED Plan) be authorized for implementation as a Federal project. The estimated first cost of the Recommended Plan is $280,820,000 and the estimated average annual Operation, Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R) cost is $862,000 (October 2013 price levels). The Federal portion of the estimated first cost is $181,652,000. The estimated fully funded total project cost is $307,100,000.

The non-Federal sponsor portion of the estimated first cost is $99,168,000. An additional $195,000,000 is estimated as the minimum cost for non-Federal interests to comply with National Flood Insurance Program requirements by avoiding induced flooding of existing structures. The non-Federal sponsor will agree to provide all lands, easements, rights-of-way,

relocations, and suitable borrow and disposal areas. The non-Federal sponsor will also assume responsibility for OMRR&R. To ensure that the sponsor has full and clear responsibility for all Federal flood risk management features in the Truckee Meadows reach, modification of the features of the Truckee River and Tributaries Project (authorized by FCA 1954, § 203 and FCA 1962, § 203) in the Truckee Meadows reach, which are currently maintained by the State of Nevada, is recommended. The non-Federal sponsor will publicize floodplain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in adopting regulations, or taking other actions, to prevent unwise future development and to ensure compatibility with protection levels provided by the project. The non-Federal sponsor will continue to participate in and comply with applicable Federal floodplain management and flood insurance programs.

SUMMARY OF POST AUTHORIZATION CHANGES

The following provides a summary comparison of the Recommended Plan to the Authorized Project in the 16-item format of a Post-Authorization Change Report (ER 1105-2-100, Appendix G, Amendment #1, June 2004). The GRR is a post-authorization change report that addresses these items in more detail.

1. Description of Authorized Project

The authorized flood control features begin near Booth Street in downtown Reno, extend downstream along the Truckee River to the Truckee Meadows Wastewater Reclamation Facility (TMWRF), and continue up Steamboat Creek for approximately two miles. Features include floodwalls, setback levees, reconstruction/replacement of six bridges in downtown Reno, channel excavation, reconstruction of the TMWRF diversion dam, backwater levees on the North Truckee Drain, a large detention basin at UNR Farms, and levees along Steamboat Creek and Boynton Slough with an additional bridge modification. These project features were designed to provide "100-year flood protection" as defined in 1988. Authorized recreation features include a new pedestrian/bike bridge, bike lanes on bridges, pedestrian/bike paths, and new access sites and improvements in downtown Reno. The authorized project includes 31.4 acres of riparian habitat plantings as compensatory fish and wildlife mitigation. Fish and wildlife "enhancement" features, consisting of 9.5 acres of riparian plantings, 300 acres of marsh habitat preservation and improvement, and fish habitat improvement, were also specifically authorized. The authorized project would require 2,094 acres of lands and permanent easements. The non-Federal cost-share for the authorized project was estimated to be 50%, including credit for Lands, Easements, Rights-of-Way, Relocations and Disposal sites (LERRD).

2. Authorization

The Truckee Meadows Flood Control Project[2] was authorized by WRDA 1988, § 3(a)(10). Construction of the authorized project was deferred during the Pre-construction Engineering and Design (PED) phase when changes in real estate costs made the project economically infeasible. The Tribes Water Rights Settlement Act, § 207, provided direction regarding the conduct of a general reevaluation that had been undertaken by USACE. The Secretary of the Army also received guidance regarding USACE's conduct of the GRR pursuant to the House Report associated with the EWDAA 1996.

3. Funding Since Authorization

Federal funds:	$40,799,653	FY1988-2013
Non-federal funds:	1,400,000	FY2012 only
Total	$42,199,653	

[2] A previous USACE project was authorized and constructed pursuant to the FCA 1954, § 203 and the FCA 1962, § 203.

Federal funding is summarized below.

Years Funded	Amount
1988-1994	$3,787,530
1994-1998	$0
1998-2002	$5,071,800
2003-2007	$11,394,000
2008-2012	$20,546,323

Non-Federal funds were provided for completion of the GRR pursuant to a Memorandum of Agreement dated 22 August 2012 (August 2012 MOA) between USACE and TRFMA, which is the potential non-Federal sponsor of the Recommended Plan. Prior to the August 2012 MOA, no cost-sharing agreements had been executed with any non-Federal entity for sponsorship of the reevaluation, which had been fully federally funded.

4. Changes in Scope of Authorized Project

USACE guidance (ER 1105-2-100, Appendix G, paragraph G-12.c.) defines changes in scope as "increases or decreases in the outputs for the authorized purposes of a project. Outputs are the physical effects which (usually) have associated benefits."

The scope of the Recommended Plan has been reduced from the Authorized Project based on current economic analysis, planning policies, and budget considerations (See Table S-3).

Table S-3. Percentage of Change of Authorized Project and Recommended Plan

PROJECT PURPOSE and SCOPE PARAMETERS	1988 AUTHORIZED PROJECT	RECOMMENDED PLAN	PERCENTAGE OF CHANGE
Flood Risk Management			
Design Discharge	18,500 cfs	13,700 cfs	- 26%
Floodplain Affected	Downtown/Meadows	Meadows only	n/a
Recreation			
Annual Use Days	750,000	115,640	- 85%
Fish & Wildlife Enhancement Acres of Habitat	310 acres	None	- 100%

a. FRM project performance has been reduced from 1% ACE with freeboard to greater than 90% assurance of safely conveying a 2% ACE flood event for the primary damage areas. The reduction in FRM project performance was driven by the need to identify an economically justified plan that reasonably maximized net economic benefits.

b. Anticipated recreation output has been significantly reduced from 750,000 annual recreation days for the Authorized Project to 115,640 days for the Recommended Plan. Reduced recreation scope is consistent with the reduced scope of the FRM features.

c. No fish and wildlife enhancement is included in the Recommended Plan. Ecosystem restoration is not included in the Recommended Plan.

The Recommended Plan will require new congressional authorization because the Section 902 cost limit would be exceeded, as shown in item 9 below.

5. Changes in Project Purpose

The Authorized Project included fish and wildlife enhancement as a project purpose. No fish and wildlife enhancement or ecosystem restoration is included in the Recommended Plan.

6. Changes in Local Cooperation Requirements

In the 1986 Chief of Engineers Report for the Authorized Project, the recommended cost-sharing requirements required a non-Federal sponsor contribution between 25% and 50% in accordance with the Water Resources Development Act of 1986, Pub. L. No. 99-662, § 101, 100 Stat. 4082 (1986) (WRDA 1986, § 101). The project was authorized in WRDA 1988, § 3(a)(10), with those cost-sharing requirements. Cost-sharing for new flood damage reduction projects was modified in WRDA 1996 Pub. L. No. 104-303, § 201, 110 Stat. 3658, 3671 (1996) (WRDA 1996, § 201) to require a minimum non-Federal share of 35%. The Recommended Plan will require reauthorization, which will make the cost-sharing provisions of WRDA 1996 applicable, including a 35 to 50% non-Federal cost-share for structural flood risk management. Cost apportionment for the Recommended Plan has been calculated based on the requirements of WRDA 1996, § 201.

7. Change in Location of Project

The features of the Recommended Plan are located along the Truckee River within the extent of the Authorized Project. The Recommended Plan is more limited in its extent than the Authorized Project because some of the features of the Authorized Project were found to no longer be economically efficient. The Recommended Plan does not include features in Downtown Reno (upstream of Highway 395) and in the Steamboat Creek, Boynton Slough and UNR Farms area that were included in the Authorized Project. The Recommended Plan does not include separable lands for recreation, or for fish and wildlife mitigation or enhancement that were included in the Authorized Project.

8. Design Changes

See Table S-4 for a summary of major design differences between the Authorized Project and the Recommended Plan. These design changes are the result of the changes in scope and project purposes described in items 4 and 5, above.

Table S-4. Comparison of Authorized Plan and Recommended Plan

PARAMETER	1988 AUTHORIZED PROJECT		RECOMMENDED PLAN
COSTS	**1984 Price Level**	**2013 Price Level †**	**2013 Price Level**
Total Project First Costs	$74,720,000	$169,305,000	$280,820,000
Authorized Cost	$78,400,000 (Note1)	$177,643,000	n/a
BENEFITS (Annual)	**1984 Price Level**	**2013 Price Level***	**2013 Price Level**
Flood Risk Management	$9,717,000	$21,572,000	$24,880,000
Recreation	$2,395,000	$5,317,000	$625,000
Fish and Wildlife Enhancement	$1,153,000	$2,560,000	n/a
Total Annual Benefits	$13,265,000	$29,449,000	$25,505,000
BENEFIT TO COST RATIO	**1988 AUTHORIZED PROJECT**		**RECOMMENDED PLAN**
Flood Risk Management	1.6 to 1 (50 yrs; 8.375%)		2.2 to 1 (50 yrs; 3.5%)
Recreation	4.7 to 1		1.0 to 1
OVERALL DESIGN	**1988 AUTHORIZED PROJECT**		**RECOMMENDED PLAN**
Location	Booth St (Downtown Reno) to Vista; also includes Steamboat Creek, Boynton Slough and UNR Farms area		Highway 395 to Vista
Length (mainstem only)	8.3 miles		6 miles
Design Level of Performance	100-year with freeboard		1:50 Annual Chance Exceedance (>90% assurance) for primary damage areas
Design Discharge	18,500 cfs		13,700 cfs (between Rock Blvd. & McCarran Blvd.)
BRIDGES	Reconstruct/replace 6 bridges in Downtown Reno; elevate footbridge at Wingfield Park; modify Pembroke Dr. bridge on Steamboat Ck.		Pier/scour protection at 4 existing bridges in Truckee Meadows Reach

Note 1. Authorized cost includes additional $4,140,000 for fish and wildlife enhancement.
* Benefits escalated based on Consumer Price Index
† Costs escalated based on construction cost index

PARAMETER	1988 AUTHORIZED PROJECT	RECOMMENDED PLAN
CONVEYANCE FEATURES		
Downtown Reno	1.0 mile of floodwalls and channel excavation between Booth St. and Lake St.	None
Truckee Meadows Reach		
Levees (Truckee River)	7 miles	31,000 feet (5.9 mi)
Floodwalls (Truckee River)	3.3 miles	9,650 feet (1.8 mi)
Floodplain Terrace	5.6 ac at Glendale Park	60 ac south bank Greg St. to McCarran Blvd.
North Truckee Drain	Backwater levees from river to north of I-80	3,200 lf box culverts; extend Peoples Drain 200 lf; cap Peoples Drain junction structures
UNR Farms	900-acre detention basin with perimeter levees; 1000-ft wide overflow weir; and outlet structure	Flowage easements
Steamboat Creek and Boynton Slough	Backwater levees	None
INTERIOR DRAINAGE	Ditches and culverts with flapgates	14 cfs pump station near Glendale Ave.; gravity drain at UNR; flap/sluice gates on storm drains
SEEPAGE PREVENTION	None specified	Seepage berms, drainage blankets, impervious berms and relief wells
RECREATION		
Trails	14.4 miles of new pedestrian/bike paths; pedestrian/bike bridge at Mill St. Park;	9,700 lf paved trails; 8,900 lf unpaved trails (3.5 mi total)
River access	80 picnic sites, 3 group picnic shelters, restrooms and parking (9 sites)	50 picnic sites, 2 group picnic shelters, playground, 13 fishing areas, restrooms and parking (1 main site)
Boat access	6 raft/tube access sites	4 kayak/canoe access sites
FISH AND WILDLIFE MITIGATION	31.4 acres riparian plantings	None
FISH AND WILDLIFE ENHANCEMENT	10 acres of riparian plantings; 300 acres of marsh habitat preservation; fish habitat improvements	None

9. Changes in Total Project First Costs

As shown in Table S-5, the estimated Authorized Project costs were $74,720,000 at October 1984 price levels. The authorized project cost in WRDA 1988, § 3(a)(10), was $78,400,000, including an additional $4,140,000 authorized for fish and wildlife enhancement. The current preliminary estimated cost limit for the Authorized Project is $184,249,000 (not including fish and wildlife enhancement) in accordance with 33 U.S.C. § 2280 (Section 902). The project first costs for the Recommended Plan are currently estimated at $280,820,000 (Oct 2013 price level).

Because the estimated total project first costs of the Recommended Plan would exceed the Section 902 limit for the Authorized Project, additional Congressional authorization will be required.

Table S-5. Comparison of Total Project First Costs ($1000)

Item	1988 Authorized Project		Last Reported to Congress	Recommended Plan
	Oct. 1984 Prices	Oct. 2013 Prices	FY 2006 Budget Submittal	Oct. 2013 Prices
Construction/PED/CM	$30,550	$69,222	$18,500[1]	$202,058
LERRD	$44,170	$100,083	n/a	$78,762
Total Project First Costs	$74,720	$169,305	n/a	$280,820

[1] For PED to Chiefs Report only; price level not adjusted; no report to Congress since FY2006

Reasons for cost changes and attributed percentage of the total increase since authorization (Recommended Plan compared to Authorized Project 1984 price):

a. Downtown Reno Reach removed: -10%

   Includes Construction, LERRD, PED, Construction Management (CM), fish and wildlife mitigation, and cultural resources mitigation.

b. Levees in UNR Farm area removed: -10%

   Includes Construction, LERRD, PED, CM, fish and wildlife mitigation, and cultural resources mitigation for levees at UNR Farms, Steamboat Creek and Boynton Slough.

c. Recreation in Downtown Reno and UNR Farms area removed: -1%

   Includes Construction, LERRD, PED, and CM.

d. Price escalation: +24%

   For items f. through j., below, Oct 1984 to Oct 2013

e. Sunk PED costs: +23%

   For general reevaluation study, since authorization.

f. Increase in LERRD costs: +19%

Net increase includes increase in real costs and reduction in project scale for Truckee Meadows Reach.

g. Increase in FRM Construction costs: +42%

Net increase includes increase in real construction costs and reduction in project scale for Truckee Meadows Reach.

h. Increase in Recreation Construction costs: +2%

Net increase includes increase in real construction costs and reduction in project scale for Truckee Meadows Reach.

i. Increase in remaining PED costs: +7%

Net increase includes increase in real costs and reduction in project scale for Truckee Meadows Reach.

j. Increase in Construction Management costs: +4%

Net increase includes increase in real costs and reduction in project scale for Truckee Meadows Reach.

10. Changes in Project Benefits

Table S-6 shows a summary comparison of benefits for the Authorized Project and the Recommended Plan. Benefits are discussed in detail in the GRR and Economic Appendix. Annual benefits for the authorized project have increased by $16,184,000 (122%) as a result of price level increases. Compared to the Authorized Project, the Recommended Plan has lower flood risk management benefits, significantly reduced recreation benefits, and no fish and wildlife enhancement benefits.

11. Benefit-to-Cost Ratio

For the benefit-cost analysis in this GRR, the project costs were amortized over the 50-year period of analysis using the current Federal discount rate of 3.5 percent. See Table S-6 for a comparison of the Authorized Project and the Recommended Plan.

Table S-6. Comparison of Economic Results

Category	1985 Feasibility Report Authorized Project		Last Reported to Congress	Recommended Plan
	Oct. 1984 Prices	Oct. 2013 Prices	FY2006 Budget Submittal[1]	Oct. 2013 Prices
Interest Rate	8.375%	3.5%	n/a	3.5%
Period of Analysis	50 Year	50 Year	n/a	50 Year
Annual Benefits	$13,265,000	$29,449,000	n/a	$25,505,000
Annual Costs	$7,041,000	$8,367,000	n/a	$11,823,000
Net Benefits	$6,224,000	$21,082,000	n/a	$13,682,000
Benefit-to-Cost Ratio	1.9	3.5	n/a	2.2

Note 1: No estimate of benefits or annual costs included; no report to Congress since FY2006

12. Changes in Cost Allocation

Table S-7 compares the allocation of cost among the project purposes for the Authorized Project and the Recommended Plan.

13. Changes in Cost Apportionment

Table S-7 shows changes in the apportionment of costs between the Federal Government and the non-Federal sponsor.

Table S-7. Cost Allocation and Cost Apportionment Comparison of Authorized Project and Recommended Plan ($1000)

Item	Authorized Project (1984 Prices)			Authorized Project (2013 Prices)			Recommended Plan (2013 Prices) (with Sec 104 credit)		
	Federal	Non-Federal	Total	Federal	Non-Federal	Total	Federal	Non-Federal	Total
Flood Risk Management Construction (includes PED/Const Mgt)	$26,600		$26,600	$60,271		$60,271	$187,912	$2,406	$190,318
LERRD		$43,200	$43,200		$97,885	$97,885	$1,496	$77,076	$78,572
Total First Cost (FRM)	$26,600	$43,200	$69,800	$60,271	$97,885	$158,156	$189,408	$79,482	$268,890
Minimum 5% Cash	n/a	n/a		n/a	n/a		($13,445)	$13,445	
Additional Cash Contribution	$8,300	($8,300)		$18,806	($18,806)		($1,185)	$1,185	
Cost-Shared Total (FRM)	**$34,900**	**$34,900**	***93.4%*** **$69,800**	**$79,078**	**$79,078**	***93.4%*** **$158,156**	**$174,779**	**$94,112**	***95.8%*** **$268,890**
Cost-share Percentages	*50%*	*50%*		*50%*	*50%*		*65%*	*35%*	
Recreation Const, LERRD,PED,CM	**$2,260**	**$2,260**	***6.0%*** **$4,520**	**$5,121**	**$5,121**	***6.0%*** **$10,242**	**$5,057**	**$5,057**	***3.6%*** **$10,113**
Cost-Share Percentages	*50%*	*50%*		*50%*	*50%*		*50%*	*50%*	
Cultural Resource Data Recovery	**$400**		***0.5%*** **$400**	**$906**		***0.5%*** **$906**	**$1,817**		***0.6%*** **$1,817**
TOTAL PROJECT FIRST COST	**$37,560**	**$37,160**	**$74,720**	**$85,105**	**$84,200**	**$169,305**	**$181,652**	**$99,168**	**$280,820**

Note: Percentages of Total Project First Cost allocated to each project purpose are shown in ***bold italics***

14. Environmental Considerations in Recommended Changes

An EIS has been prepared to address the proposed modifications to the Authorized Project and new circumstances and information relevant to the environmental concerns previously identified in the EIS prepared with the 1985 Feasibility Report. The new EIS will supersede the 1985 EIS.

15. Public Involvement

The public and concerned resource agencies have been invited to participate in all phases of the Truckee Meadows Flood Control Project since the initiation of the General Reevaluation Study in 1996. This has included opportunities to comment on the 1997 Reconnaissance Report, the Notice of Initiation, the Public Scoping Meeting conducted in 1999, and public workshops in 2000, 2003, 2005, and 2013. Additional efforts included disseminating information through a project web site and publishing a monthly newsletter. Public involvement encouraged the consideration of setback levees and floodplain terracing as flood risk management measures that would minimize the physical isolation of the river from the surrounding community. Public involvement also influenced the types of recreation features included in the Recommended Plan.

16. Project History

The Truckee Meadows Flood Control Project was authorized by the WRDA 1988, § 3(a)(10), which authorized construction of the project as described in the Chief of Engineer's report dated July 25, 1986. In fiscal year 1988, the Preconstruction Engineering and Design (PED) phase for the authorized project was initiated. In addition to further technical studies, the PED phase included evaluating the project based on changes in existing conditions, laws, and requirements since the project was initially studied and authorized. In particular, WRDA 1986 was enacted after completion of the feasibility report and before Congressional authorization. Several changes in USACE guidance that resulted from WRDA 1986 affected the Truckee Meadows project including changes to cost-sharing requirements, real estate valuation rules, and revised project benefits. Application of these changes to the authorized plan resulted in a benefit-cost ratio below unity. Because the project appeared to lack economic justification, it was placed in a deferred status.

In 1996, local communities requested a reevaluation of flood problems in Truckee Meadows. A general reevaluation study of the Truckee River was initially funded by appropriations received through EWDAA 1996. A reconnaissance report was completed in 1997 and the GRR was initiated in 1998. See the GRR main text for additional detailed information regarding the project history.

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CHAPTER 1
INTRODUCTION

This General Reevaluation Report (GRR) addresses potential modifications to the Congressionally authorized Truckee Meadows Flood Control Project in the cities of Reno and Sparks in Washoe County, Nevada. These potential modifications include flood risk management and recreation measures along the Truckee River within the Truckee Meadows.

1.1 Purpose and Scope

The Truckee Meadows Flood Control Project was authorized under the WRDA 1988, § 3(a)(1), , but was deferred in or around 1992 during the Pre-construction Engineering and Design (PED) phase when changes in real estate costs made the project economically infeasible. In 1996, local communities requested that flooding problems in Truckee Meadows be reevaluated. As a result of consultations with local communities at that time, a decision was made to expand the study area beyond Truckee Meadows downstream to Pyramid Lake and to consider ecosystem restoration as a project purpose.

This GRR analyzes the flood and ecosystem problems in the study area, and develops alternatives to reduce flood risks, restore environmental resources, and increase recreational opportunities. The alternatives include the no-action plan and various combinations of structural and nonstructural measures. The Recommended Plan is identified after the engineering, economic, and environmental feasibility of the alternatives is evaluated. Since the recommended plan is not consistent with the authorized plan it will need to be reauthorized by Congress.

This GRR summarizes the plan formulation process for a comprehensive solution to water resources problems in the Truckee River watershed. The USACE planning process initially sought to identify a comprehensive solution for flood, ecosystem, and recreation problems including detailed evaluation of a locally developed plan resulting from a community coalition process. Despite several iterative attempts, those efforts did not result in a project that USACE could recommend. Therefore, in 2012, in coordination with the sponsor, the study was re-scoped to focus plan formulation on flood risk management with basic recreation features. The primary purpose of the reevaluation study is to assess the feasibility of modifying the Federally-authorized project to reduce flood damages in the Truckee Meadows project area while avoiding or minimizing adverse effects.

Within the primary purpose, the specific goal of this study is to identify a complete plan that will yield an economically justified and environmentally sustainable project that accomplishes the following:

- Reduces flood damages to populated areas
- Provides access and recreation to the public, as feasible
- Avoids and minimizes effects to riparian and aquatic habitats

- Complies with pertinent planning and environmental laws, regulations, and policy
- Complements other Federal, state, and local plans and projects for the Truckee River and vicinity

1.2 Location of Study Area

The study area includes approximately 60 miles of the Truckee River beginning just upstream of Reno, passing through Sparks and the Truckee Meadows, and ending at the river's terminus, Pyramid Lake, on Pyramid Lake Paiute tribal lands (see Figure 1-1). The results of the reconnaissance study focused the general reevaluation study from the entire length of the Truckee River to the current study area. Because of the size of the land area and the number of river miles, the study area was divided into four general reaches: Verdi Reach, Downtown Reno Reach, Truckee Meadows Reach, and Lower Truckee River Reach (see Figure 1-2).

The Verdi Reach extends from the Fleish diversion dam to Booth Street in Reno's central business district. The Downtown Reno Reach extends from Booth Street downstream to Highway 395. The Truckee Meadows Reach encompasses an area bordered by Highway 395 on the west, Vista and the Virginia and Pah Rah Mountain Ranges to the east, south along Steamboat Creek to Huffaker Hills, and north to Sparks. The Lower Truckee River Reach extends from Vista downstream to the river's terminus at Pyramid Lake.

1.3 Project Authorization

The Truckee Meadows Flood Control Project[1] was authorized by WRDA 1988, § 3(a)(10), which reads:

> Truckee Meadows, Nevada.--The project for flood control, Truckee Meadows, Nevada: Report of the Chief of Engineers, dated July 25, 1986, at a total cost of $78,400,000, with an estimated first Federal cost of $39,200,000 and an estimated first non-Federal cost of $39,200,000; except that the Secretary is authorized to carry out fish and wildlife enhancement as a purpose of such project, including fish and wildlife enhancement measures described in the District Engineer's Report, dated July 1985, at an additional total cost of $4,140,000.

After a general reevaluation of the authorized project was initiated, the 1990 Tribes Water Rights Settlement Act, § 207, provided direction regarding the conduct of the study as follows:

[1] A previous USACE project was authorized and constructed pursuant to the FCA 1954, § 203, and the FCA 1962, § 203.

> The Secretary of the Army, in consultation with and with the assistance of the Pyramid Lake Tribe, State of Nevada, Environmental Protection Agency, the Secretary [of Interior], and other interested parties, is authorized and directed to incorporate into its ongoing reconnaissance level study of the Truckee River, a study of the rehabilitation of the lower Truckee River to and including the river terminus delta at Pyramid Lake, for the benefit of the Pyramid Lake fishery. Such study shall analyze, among other relevant factors, the feasibility of:
>
> - Restoring riparian habitat and vegetative cover
> - Stabilizing the course of the Truckee River to minimize erosion
> - Improving spawning and migratory habitat for the cui-ui
> - Improving spawning and migratory habitat for the Lahontan cutthroat trout
> - Improving or replacing existing facilities, or creating new facilities, to enable the efficient passage of cui-ui and Lahontan cutthroat trout through or around the delta at the mouth of the Truckee River, and to upstream reaches above Derby Dam, to obtain access to upstream spawning habitat.

The Secretary of the Army received additional guidance regarding USACE's conduct of the GRR pursuant to the House Report associated with EWDAA 1996, providing:

> The Secretary of the Army is directed to initiate a general reevaluation report for the Truckee Meadows Flood Control project, Nevada, authorized in the Water Resources Development Act of 1988. Of the $400,000 provided in the conference agreement for the lower Truckee River, Nevada, project, $50,000 is appropriated for this investigation. The report will consider additional flood protection at and below Reno, Nevada, through levee/channel improvements, local impoundments, and potential reoperation of existing reservoirs in the watershed. The report will also consider the potential for environmental restoration along the Truckee River and tributaries in the Reno-Sparks area.

During the current general reevaluation, EWDAA 2006, § 113, was passed, which states:

> Truckee Meadows Flood Control Project, Nevada: The non-Federal funds expended for purchase of lands, easements and

rights-of-way, implementation of project monitoring and assessment, and construction and implementation of recreation, ecosystem restoration, and water quality improvement features, including the provision of 6,700 acre-feet of water rights no later than the effective date of the Truckee River Operating Agreement for revegetation, reestablishment and maintenance of riverine and riparian habitat of the lower Truckee River and Pyramid Lake, whether expended prior to or after the signing of the Project Cooperation Agreement (PCA), shall be fully credited to the non-Federal sponsor's share of costs for the project: Provided, that for the purposes of benefit-cost ratio calculations in the General Reevaluation Report (GRR), the Truckee Meadows Nevada Flood Control Project shall be defined as a single unit and non-separable.

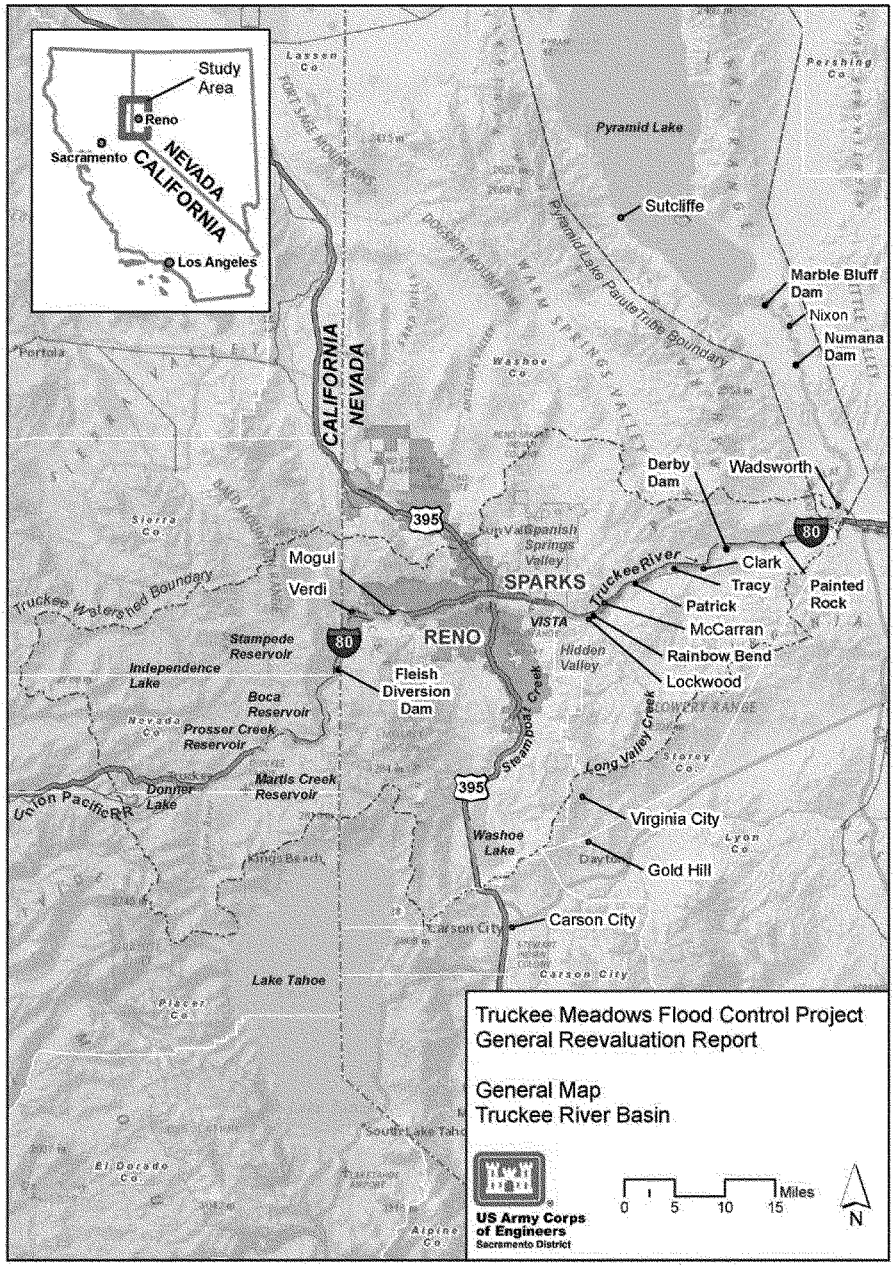

Figure 1-1. Truckee River Basin

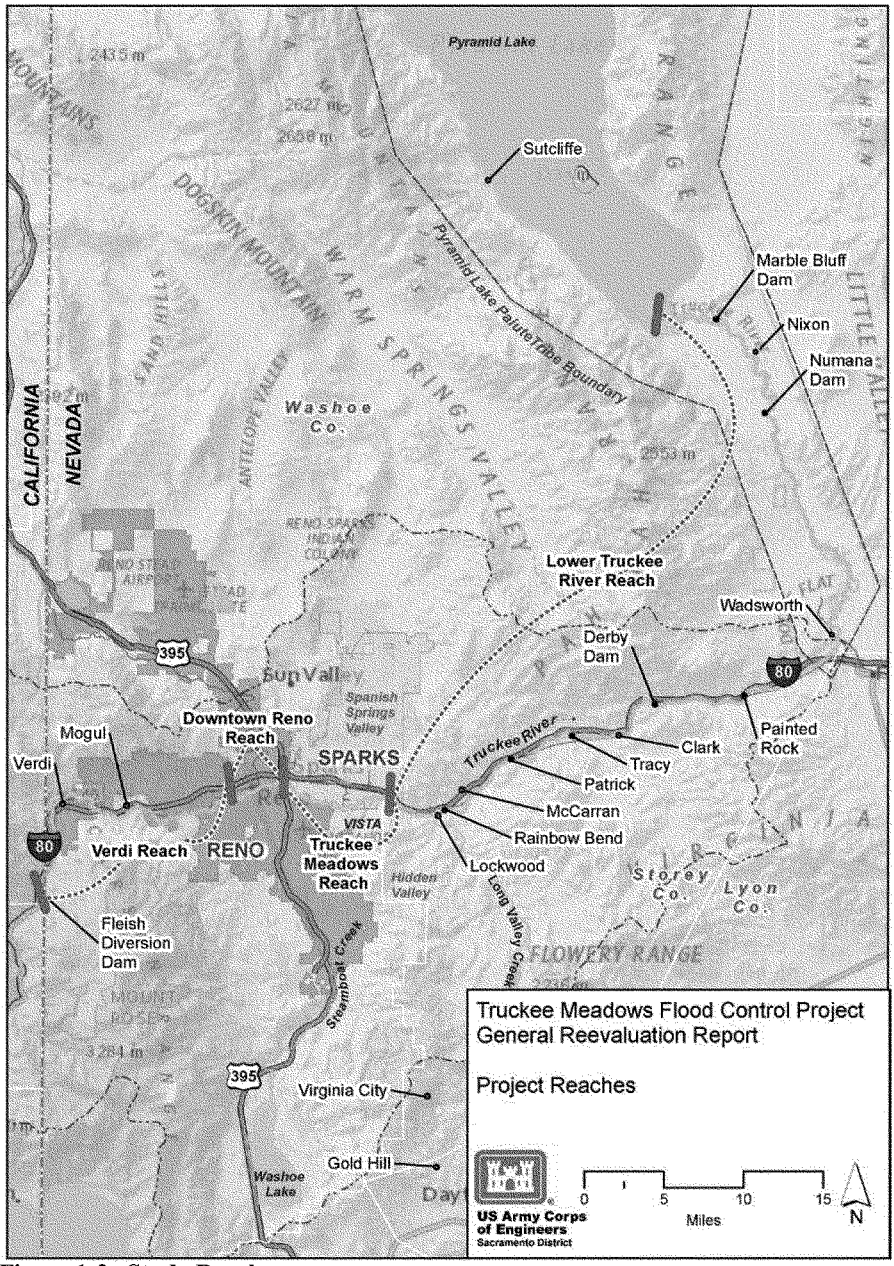

Figure 1-2. Study Reaches

1.4 History of the Truckee River Investigations

Congress authorized the Truckee River and Tributaries, California and Nevada, Project in the FCA of 1954, § 203, and the FCA of 1962, § 203. The project included work at several locations along the Truckee River from Lake Tahoe to Pyramid Lake. Work included channel enlargement near Lake Tahoe; channel improvements along 7.5 miles of the Truckee River below Reno; and clearing and snagging, channel enlargement, and straightening from Vista to Wadsworth to accommodate additional flows created by the construction work upstream. Construction began in 1959 and was completed in 1968.

USACE involvement with the Truckee River continued in 1965 as a result of local requests for additional flood control, which prompted a USACE study. The Truckee Meadows (Reno-Sparks metropolitan area), Nevada, investigation proposed a flood control plan consisting of storage facilities on the Truckee River at Verdi, interceptor facilities on Steamboat Creek, and channel improvements in Truckee Meadows. Due to opposition to the dam proposal at Verdi, that portion of the plan was dropped. Since there was no local support for the proposed plan, the study was suspended in 1970.

In 1974, Washoe County requested that the USACE investigate the feasibility of lowering the Vista Reefs and channelizing the Truckee River. A year later, USACE determined that the channel enlargement was feasible. In late 1976, Washoe County and the cities of Sparks and Reno requested that USACE determine the feasibility of flood control within the Truckee Meadows. In response, the USACE prepared and approved a reconnaissance report in 1977, which determined that channel modification between U.S. Highway 395 and Vista might be feasible. In June 1978, the Washoe Council of Governments gave their vote of approval for USACE to proceed with a feasibility study.

USACE completed the Truckee Meadows (Reno-Sparks Metropolitan Area), Nevada Feasibility Report and Environmental Impact Statement in 1985. The feasibility report identified a project designed to pass a flow of 18,500 cubic feet per second (cfs) (identified in the report as the estimated "100-year" event) through Reno. The flood control features of the project included construction of approximately 5 miles of floodwalls and 7 miles of levees, and replacement of six bridges along the Truckee River. The project also included channel excavation and a 900-acre detention basin and levees to mitigate potential increases in downstream flooding due to upstream flood control features. Adverse effects on fish and wildlife would be mitigated by planting riparian vegetation on 31 acres along the Truckee River and Steamboat Slough.

The total estimated first cost of the project was $78.4 million, and the estimated first Federal cost was $39.2 million (unadjusted 1986 dollars). Annual benefits included $9.7 million for flood control and $2.4 million for recreation. Authorized by Congress in WRDA 1988, § 3(a)(10), the project was to be carried out in accordance with the Truckee Meadows, Nevada: Report of the Chief of Engineers, dated July 25, 1986. The authorization included flood control, recreation, and fish and wildlife enhancement purposes.

In fiscal year 1988, the Preconstruction Engineering and Design (PED) phase for the authorized project was initiated. In addition to further technical studies, the PED phase included evaluating the project based on changes in existing conditions, laws, and requirements since the project was initially studied and authorized. In particular, WRDA 1986, a significant piece of legislation, was enacted between completion of the feasibility report and congressional authorization:

- WRDA 1986 changed the cost-sharing requirements for USACE projects.
- Guidance implementing WRDA 1986 required that all lands, including publicly owned lands, must be included in the project cost estimate at fair market value, regardless of ownership. As a result, the estimation of real estate values changed, and real estate cost estimates significantly increased from the 1985 feasibility report.

Several additional factors affected the Truckee Meadows project:

- The assumptions for determination of project benefits were revised. Assumptions changed about area growth, future flood proofing of structures, and the level of flooding for which project benefits were captured. As a result, project benefits decreased.
- Washoe County, one of the local sponsors, requested that the proposed detention basin at the University of Nevada Agricultural Experiment Station (UNR Farms) be replaced with a detention basin at the Huffaker Hills site.

Application of these changes to the authorized plan resulted in a revised benefit-cost ratio less than 1.0 to 1, based on the information available at that time. Because the project appeared to lack economic feasibility, in or around 1992 it was placed in a deferred status.

1.4.1 Current Study Effort

In 1996, local communities requested a reevaluation of flood problems in Truckee Meadows. In response, USACE received funding with guidance to conduct a reevaluation of the authorized project (see House Report associated with EWDAA 1996) and potential flood and related problems and needs in mid-1996. The Truckee Meadows, Nevada; Reconnaissance Reevaluation Report was completed in August 1997. The conclusions of the study were that: (1) there continues to be a substantial demonstrated flood problem in the study area; (2) in addition to flood control, there is a need for environmental restoration and recreation features along the river consistent with any plan to reduce the risk of flooding; (3) plans to help reduce flood problems and enhance recreation and environmental opportunities in the area appear economically feasible and locally desirable; and (4) Washoe County and the cities of Reno and Sparks support

increased flood protection in the area and support continuing PED studies, with the first step being to conduct a GRR.

During the completion of the reconnaissance report, USACE conducted a post-flood assessment of damages along the entire Truckee River from a major flood event in January 1997. The evaluation identified 40 sites with damage. USACE proposed debris removal, channel clearing, and erosion fill at all 40 sites. This work is completed for the without-project condition for the current study.

1.5 Description of 1988 Authorized Plan

This section describes the plan authorized in 1988. The authorized plan is discussed in more detail in the Truckee Meadows (Reno-Sparks Metropolitan Area), Nevada, Feasibility Report and Environmental Impact Statement, February 1985.

1.5.1 Flood Control Features

Authorized flood control features begin near Booth Street Bridge and extend downstream to the Truckee Meadows Wastewater Reclamation Facility (TMWRF), and then continue up Steamboat Creek through the UNR Farms south of Truckee River for approximately two miles (Figure 1-3). Features include:

- Floodwalls and setback floodwalls constructed or reconstructed along the north bank of the Truckee River between Lake Street and Booth Street, and on the south bank between Lake Street and 1,400 feet upstream of Arlington Avenue. Floodwalls and setback floodwalls would average 2 to 4 feet in height.

- Bridges reconstructed and/or replaced at or above grade at Arlington Avenue, and Booth, Virginia, Lake, Sierra, and Center streets. The foot bridges at Wingfield Park were also identified to be elevated. However, the foot bridges have since been upgraded.

- Channel excavation along the north bank of the Truckee River in the vicinity of Booth Street Bridge, and excavation through the stream channel to a maximum depth of 1.5 feet from just above Arlington Avenue Bridge to just above Sierra Street Bridge. The total river distance involved is approximately 1,600 feet.

- Setback floodwalls (south bank only, 4 to 7 feet in height) from U.S. Highway 395 to Glendale Avenue.

- A reconstructed and realigned TMWRF diversion dam just above Glendale Avenue.

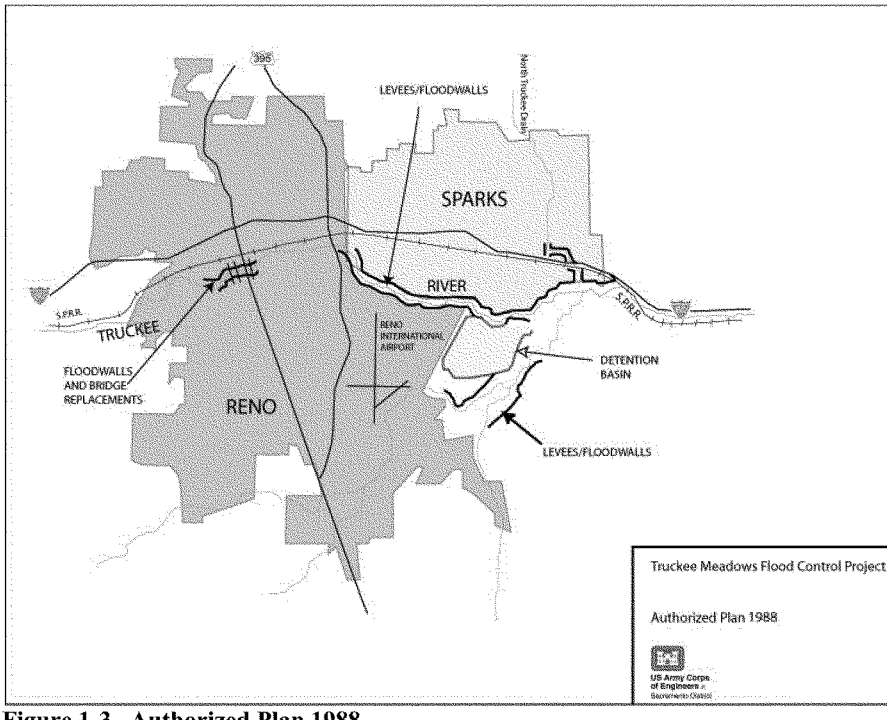

Figure 1-3. Authorized Plan 1988

- Setback floodwalls and setback levees (5 to 8 feet high) between Glendale Avenue and South Rock Boulevard

- Setback floodwalls, floodwalls at the river's edge, and setback levees (5 to 8 feet high) between South Rock Boulevard and South McCarran Boulevard.

- 5.6 acres along the north bank in the area of Glendale Park excavated above the water surface elevation of the Truckee River associated with 1,000 cfs discharge (estimated average annual flow).

- Setback levees constructed on both sides of the river between South McCarran Boulevard and the east end of the project at Vista. These levees would be about 11 feet high and 82 to 90 feet wide at the base.

- Backwater levees with an average height of 5 feet constructed on North Truckee Drain from the confluence with the Truckee River to approximately 900 feet north of Interstate 80 (I-80). This levee also extends along the Southern Pacific Railroad alignment to Peoples Drain.

- A 1,000-foot overflow weir built immediately east of the UNR Farms on South McCarran Boulevard and approximately 7 acres excavated from the south bank of the Truckee River and adjacent agricultural land.

- 10-foot levees surrounding the UNR Farms serving as an overflow area to temporarily store peak flows of floods greater than a 35-year event. This is intended to preclude increased flood peaks for areas downstream of the project. An overflow weir and low-level outlet structure would be located along the east side levee to release flows back into the Truckee River.

- Levees with an average height of 10.5 feet constructed along Steamboat Creek and Boynton Slough. Pembroke Drive Bridge over Steamboat Creek would be raised and lengthened to provide for more flow under the bridge.

1.5.2 Recreation Features

Authorized recreation features included a new pedestrian/bike bridge, bike lanes on bridges, pedestrian/bike paths, and new access sites and improvements to Riverside Park and the Riverwalk area in downtown Reno. Of the approximately 22.7 miles of existing and proposed pedestrian/bike paths, 14.4 miles would be new paths. Access and improvements would include ten sets of steps leading to the river, four observation decks, ten locator or interpretive signs, and six rafting/tubing launch/exits along the Truckee River.

1.5.3 Fish and Wildlife Features

The authorized plan includes about 31.4 acres of riparian habitat plantings as compensatory fish and wildlife mitigation for habitat losses due to construction of the flood risk management features.

Fish and wildlife enhancement features, consisting of 10 acres of riparian plantings, 300 acres of marsh habitat preservation, and fish habitat improvements, were also presented in the 1985 feasibility report. Fish and wildlife features were not included in the recommended plan because of a lack of local sponsorship, but were specifically authorized by Congress.

1.5.4 Costs and Benefits

The estimated first costs of the authorized plan (excluding fish and wildlife enhancement) were $74,720,000 with an annual cost of $6,628,000 (unadjusted 1984 dollars; 8 3/8%). With average annual benefits of $12,112,000, the plan's benefit-cost ratio was 1.8 to 1. The updated cost for the authorized project using October 2012 prices is $167,810,000 (not including fish and wildlife enhancement). Congress also authorized fish and wildlife enhancement at an additional cost of $4,140,000 (unadjusted 1984 dollars).

1.5.5 Reevaluation of Authorized Project

The authorized project is included in the array of alternatives analyzed for a GRR. In the case of Truckee Meadows, the authorized project was based on hydrology developed prior to the 1997 flood event, which exceeded all previous records. USACE estimated 1% ACE peak flow for the Truckee River at Reno was increased by almost 12% after the 1997 event. Therefore, the authorized project would not perform as Report of the Chief of Engineers, July 25, 1986, based on the 1985 feasibility report. To accommodate this change in conditions, USACE formulated a plan for the Truckee Meadows reach that consists of most of the authorized plan features. That plan is identified in this document as Alternative 2 - Detention Plan.

1.6 Study Coordination

The reevaluation study is being accomplished with close coordination with the potential non-federal sponsor, the TRFMA. The planning process is being coordinated with the U.S. Fish and Wildlife Service (USFWS), Nevada State Historic Preservation Office, Nevada Department of Transportation (NDOT), Pyramid Lake Paiute Tribe, and other stakeholders in the affected community.

1.7 Related Studies and Reports

The following is a list of related studies and reports that were consulted as part of the reevaluation of the flood problems and environmental problems of the Truckee River in the study area. This is not intended to be an exhaustive list, but instead to provide a sense of the scope of studies that were consulted.

1.7.1 Federal

- U.S. Army Corps of Engineers, Truckee Meadows, Nevada, Reconnaissance Reevaluation Report, August 1997.

- U.S. Army Corps of Engineers, Truckee Meadows, Reno-Sparks Metropolitan Area, Nevada, Office Report, May 1991.

- U.S. Army Corps of Engineers, Truckee Meadows, Nevada: Report of the Chief of Engineers, dated July 25, 1986.

- U.S. Army Corps of Engineers, Truckee Meadows, Reno-Sparks Metropolitan Area, Nevada, Feasibility Report, February 1985.

- U.S. Army Corps of Engineers, Water Control Manual, Truckee River Basin Reservoirs, Truckee River, Nevada and California, July 1985.

- U.S. Army Corps of Engineers, Truckee Meadows, Reno-Sparks Metropolitan Area, Nevada, Documentation Report, October 1983.

- Federal Emergency Management Agency, Flood Insurance Study, Washoe County, Nevada, 1994.

- U.S. Geological Survey, Environmental and Hydrologic Settings of the Las Vegas Valley Area and the Carson and Truckee River Basins, Nevada and California, Water Resources Investigations Report 96-4087, 1996.

- U.S. Bureau of Reclamation, Truckee-Carson River Basin Study, Western Water Policy Review Advisory Commission, March 1997.

- U.S. Bureau of Reclamation, Phase III Project Information Report, Truckee River, Nevada Emergency Flood Restoration, October 1997.

- U.S. Bureau of Reclamation, P.L. 84-99 Flood Restoration Work for Portions of the Truckee River from the Nevada State Line East to Wadsworth, Nevada, October 1997.

- U.S. Department of the Interior, Bureau of Reclamation, Fish and Wildlife Service, Bureau of Indian Affairs, and State of California, Department of Water Resources, Revised Draft Environmental Impact Statement/ Environmental Impact Report, Truckee River Operating Agreement, California and Nevada, August 2004.

1.7.2 Local

- Washoe County Department of Comprehensive Planning, Washoe County Comprehensive Plan, Volumes 1 and 2, Reno, Nevada, 1996.

- Nevada Department of Water Resources, 1995-2015 Washoe County Comprehensive Regional Water Management Plan, Washoe County, Nevada, November 1996.

- City of Reno Redevelopment Agency, Downtown Riverfront District Plan, August 1997.

1.8 Report Organization

This report documents the study process and its results. The report chapters are as follows:

Chapter 1, Introduction, provides background information concerning the purpose of and need for the project modification, project authorization, and project status, as well as the scope of the reevaluation study. This chapter also notes linkages with other related studies and reports.

Chapter 2, Existing Conditions, describes the current conditions and future without-project conditions for important resources within the study area. This provides the baseline for the evaluation of effects each alternative may have on those resources.

Chapter 3, Problems and Needs, describes the first step in the USACE planning process. This chapter identifies the problems and needs for the project purposes of flood risk management, ecosystem restoration, and recreation.

Chapter 4, Development of Alternative Plans, describes the second and third steps in the USACE planning process. In this chapter, planning goals are set, objectives are established, and constraints are identified. This chapter also identifies a range of potential management measures that address specific problems identified in Chapter 3 and identifies various combinations of preliminary alternative plans that have the potential to address the goals and objectives. A discussion is also provided for why some preliminary alternatives were eliminated from further consideration.

Chapter 5, Evaluation and Comparison of Alternative Plans, describes the fourth, fifth, and sixth steps in the USACE planning process. This chapter qualitatively and quantitatively describes potential costs and benefits as a result of implementation of the alternative plans relative to existing conditions.

Chapter 6, Details of Tentatively Recommended Plan, summarizes the environmental, economic, and social benefits and costs of the recommended plan.

Chapter 7, Public Involvement, describes the numerous coordination and public involvement activities conducted throughout the course of the reevaluation study. These activities include information workshops, status reports, informal briefings, presentations, and correspondence with various resource agencies.

Chapter 8, Remaining Reviews, Approvals, Plan Implementation, and Schedule, identifies the estimated project timeline for future actions, defines commitments and responsibilities, and verifies the fulfillment of procedural notice and review requirements.

Chapter 9, Conclusions and Recommendation, presents the study conclusions and recommendations by the District Engineer.

1.9 Technical Appendices

Appendix A, Historical Photographs, includes photographs of flood events from the past 100 years.

Appendix B, Real Estate, provides the Preliminary Real Estate Plan, which presents the baseline real estate cost estimates based on the analysis and assumptions made during the process of formulating and developing the alternatives.

Appendix C, Economics, presents information regarding the social and economic resources that exist in the vicinity of the project area. This appendix also analyzes the with-project benefits as well as flood damages for both the with- and without-project conditions.

Appendix D, Engineering Appendix, presents a summary of hydraulic analysis, floodplain development, an assessment of geomorphology and sediment transport, design, and cost of alternatives completed for this document.

CHAPTER 2
EXISTING AND FUTURE WITHOUT-PROJECT CONDITIONS

This chapter identifies the existing conditions in the study area and the forecast for those conditions into the future without implementation of a Federal project. To define the potential impacts or benefits with various alternative plans, an understanding of the existing condition of the study area is required. Definition of this existing condition allows the comparison of the value of various alternatives to one another.

2.1 Existing Conditions

This section describes the existing conditions, projects, and important resources in the project area at the time of this study. Conditions, projects, and resources that are relevant to the plan formulation strategy and process are described here. A more detailed description of the important resources can be found in the accompanying Environmental Impact Statement (EIS).

2.1.1 Physical Setting

The Truckee River originates in the Sierra Nevada and flows east from the Lake Tahoe area into Nevada. Nearly all of the Lake Tahoe basin's storage and precipitation is in California. The river continues east down the Truckee Canyon, through Reno and Sparks, east to Wadsworth, where it turns north, and eventually terminates in Pyramid Lake. The Truckee River flows freely through the canyon; however, areas of dense urban development in Reno and Sparks limit channel capacity and impede flow through these areas. There are several reaches of Truckee River within the project area. These are described below and shown in Figure1-2.

Verdi Reach

The Verdi Reach, shown in Figure 2-1, is located within unincorporated areas of Washoe County, which includes the Verdi community, as well as the limits of the city of Reno. Land uses in the Verdi Reach generally consist of rural residential, open space, and undeveloped areas. The Truckee River emerges from steep canyons into the eastern foothills of the Sierra Nevada in this reach.

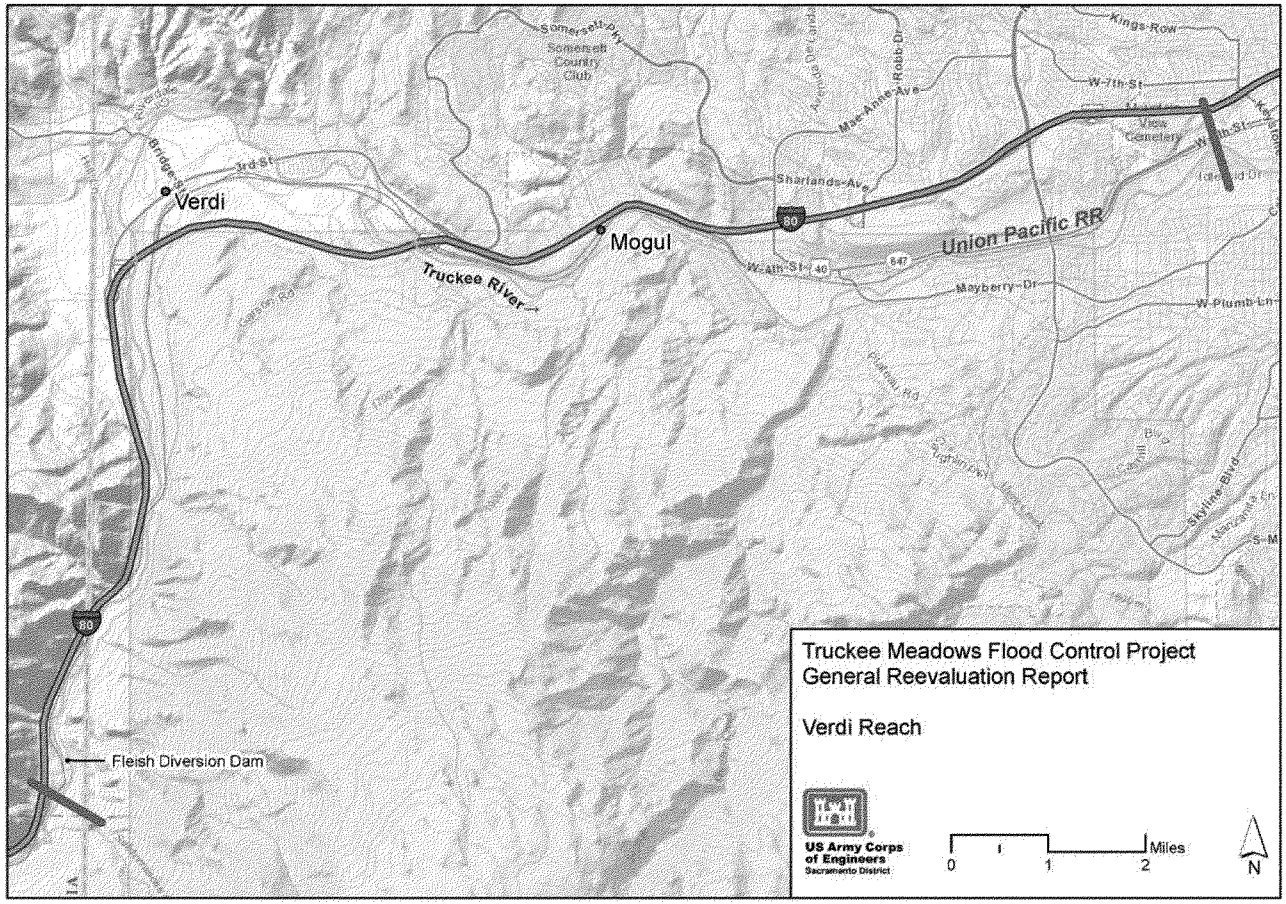

Figure 2-1. Verdi Reach

Downtown Reno Reach

Downtown Reno, shown in Figure 2-2, considered the central business district, consists of dense urban development with residential, commercial, and public structures, including casinos and hotels. The general topography of this portion of Reno is a moderately incised channel that slopes upward away from the river after several hundred feet. This generally confines flood flows to the first two blocks on either side of the river. Part of the reach on the south bank near Booth Street is steeply banked and susceptible to erosion (Figure 2-3). A low berm is located along the north bank downstream of Booth Street. Considerable development exists along the river with little setback. Existing floodwalls can be found along the river through much of the Downtown Reno Reach until roughly Lake Street (Figure 2-4). A river walk has been constructed along portions of the north and south banks of the Truckee River through downtown Reno, portions of which are below grade. Four bridges across the Truckee River within downtown Reno at Virginia, Sierra, Center, and Lake Streets are impediments to high flows, causing flooding of adjacent streets and businesses. The Center, Booth, and Arlington Street bridges have been replaced since the Truckee Meadows project was authorized, but the Center Street Bridge is still an impediment to high flows.

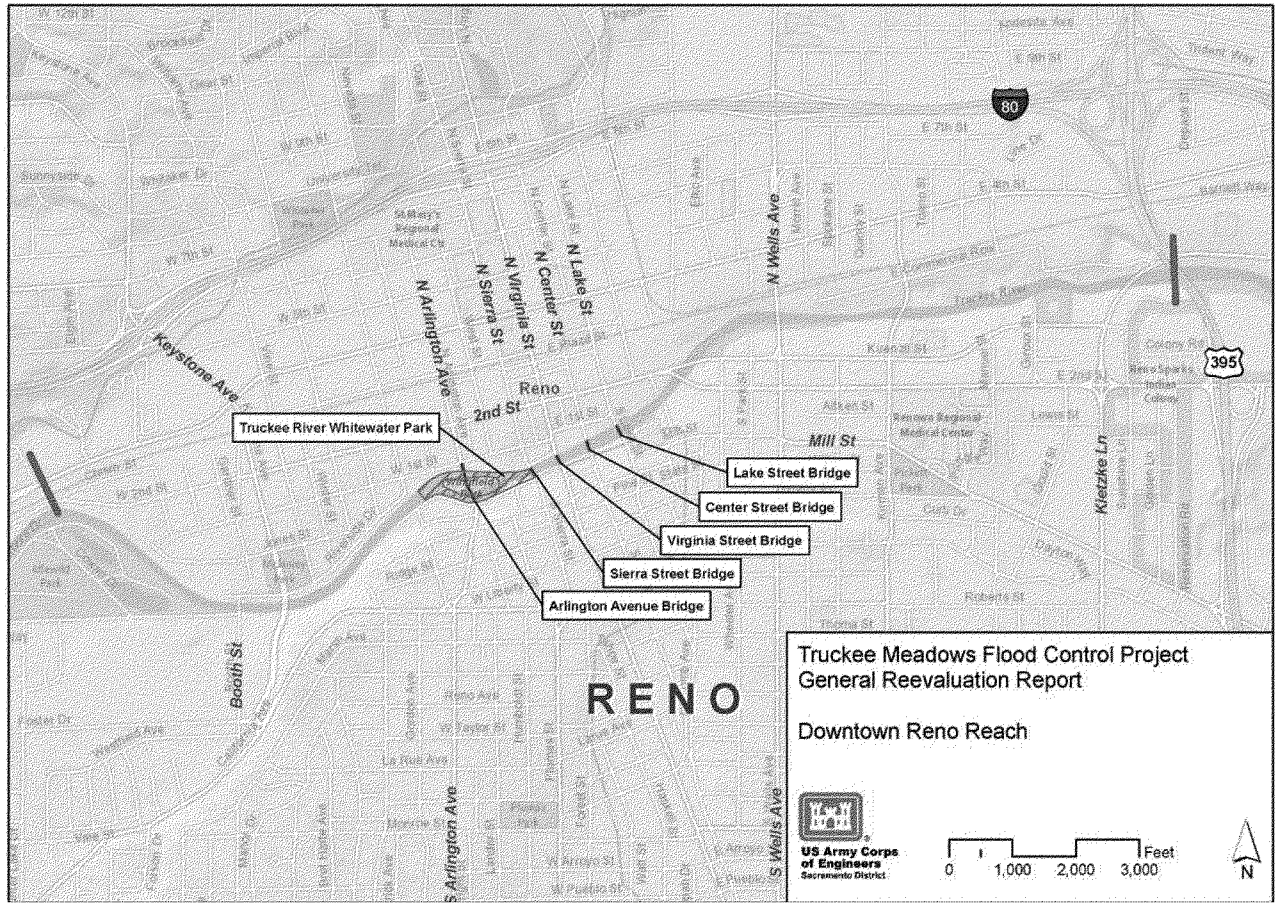

Figure 2-2. Downtown Reno Reach

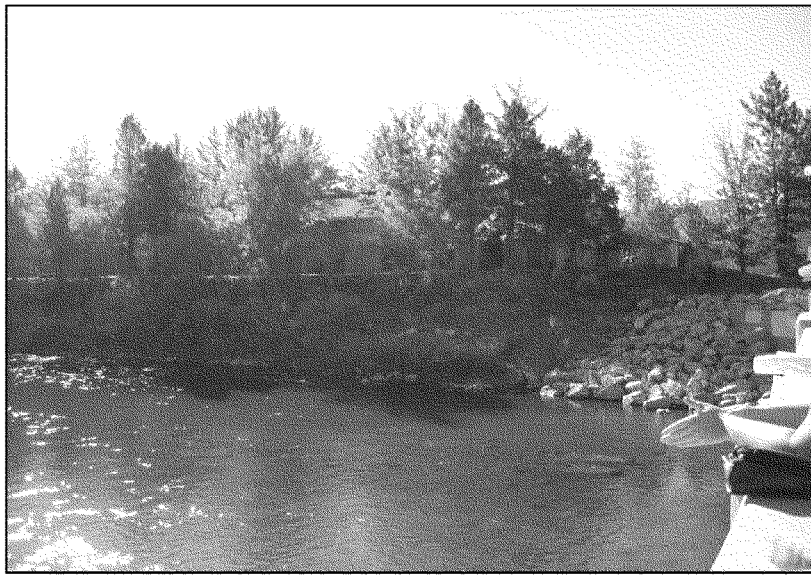

Figure 2-3. Truckee River Looking South from Booth Street

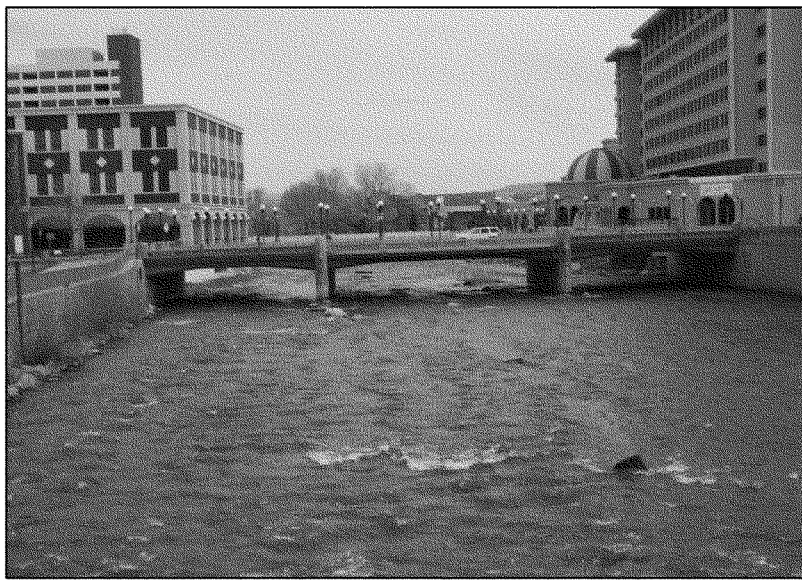

Figure 2-4. Downtown Reno Looking Downstream at Center Street Bridge

Truckee Meadows Reach

The Truckee Meadows Reach is shown in Figure 2-6. Just east of U.S. Highway 395, the river emerges from the more channelized Downtown Reno Reach onto a broader expanse of the plain historically known as the Truckee Meadows. Land uses in the area include commercial and industrial purposes (e.g., in the City of Sparks) as well as the Reno-Tahoe International Airport. Three major tributaries, Steamboat Creek, Boynton Slough, and the North Truckee Drain, flow into the river along this reach.

The Truckee Meadows encompasses the urban Reno-Sparks metropolitan area, UNR Farms and areas south of the Truckee River (Figure 2-5). It is located in a bowl-shaped area bounded by the Sierra Nevada Mountains on the west and the Virginia and Pah Rah ranges to the east. The project reach begins at U.S. Hwy 395 and follows the Truckee River downstream to the Vista Reefs. The Vista Reefs constrict outflows from the Truckee River, backing up flood flows throughout the Meadows (Figure 2-7). Although a previous USACE project lowered the Vista Reefs, a hydraulic constriction remains.

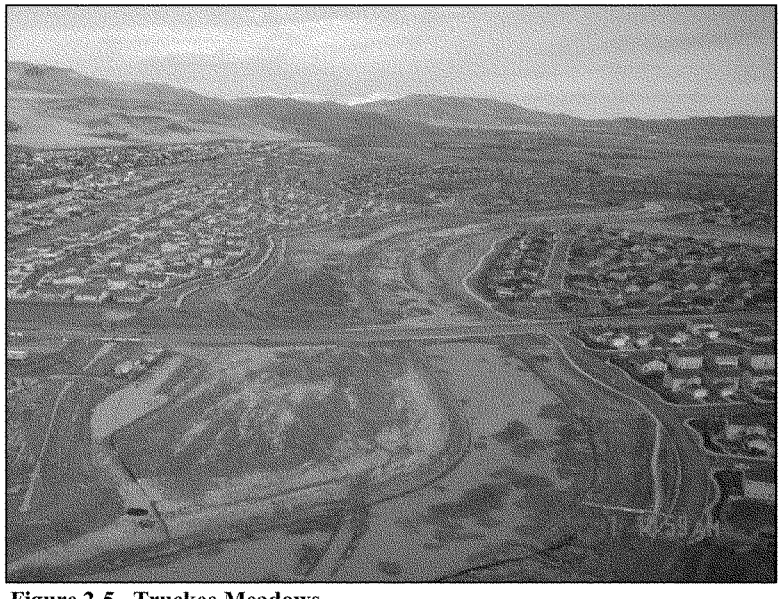

Figure 2-5. Truckee Meadows

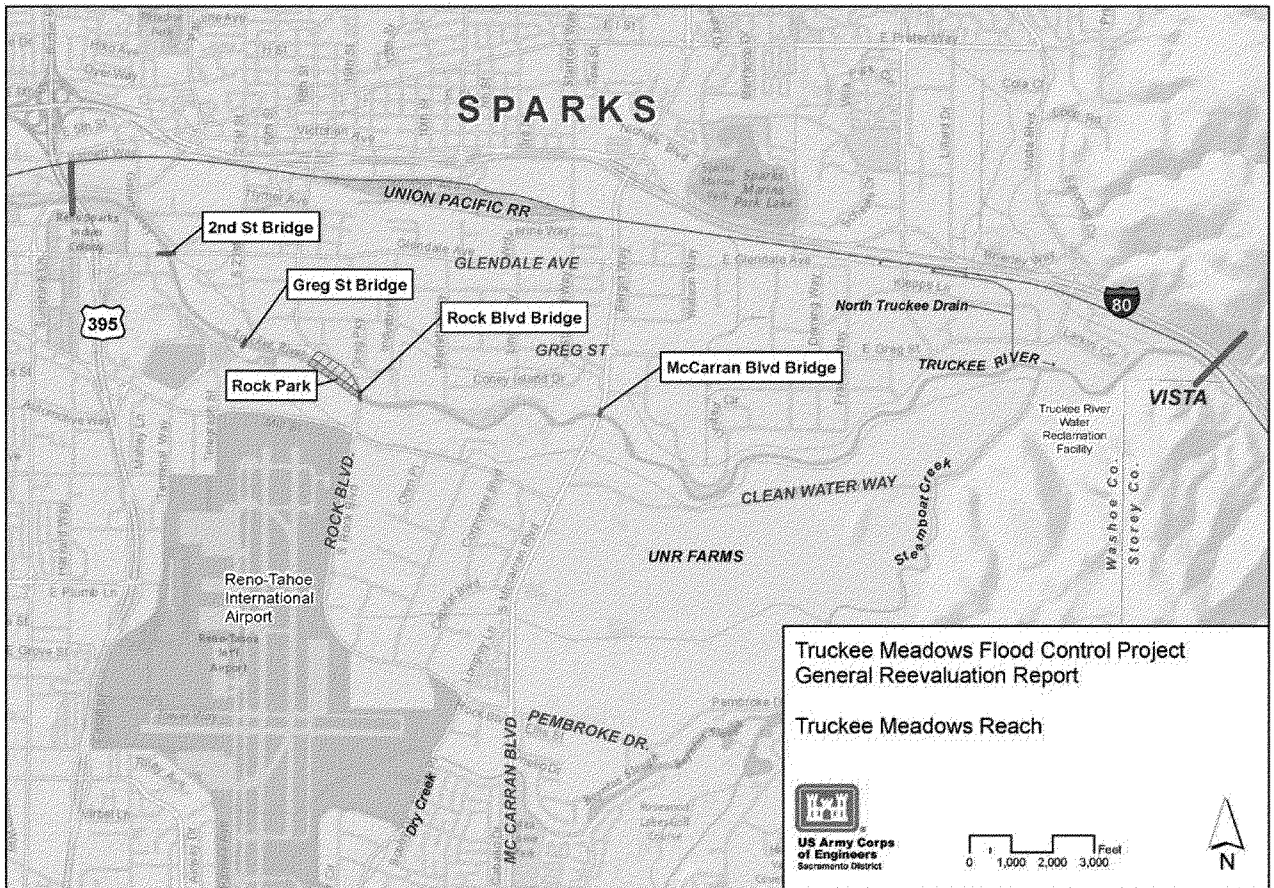

Figure 2-6. Truckee Meadows Reach

Lower Truckee River Reach

The Lower Truckee River Reach is shown in Figure 2-8. Near Vista, the Truckee River enters a narrow canyon on its way to its terminus in Pyramid Lake (Figure 2-7). The Truckee River downstream of Vista passes the small communities of Rainbow Bend, Painted Rock, Patrick, and Wadsworth and is generally confined to fairly narrow canyons and small overflow areas that are now used for ranching or agriculture (Figure 2-9). Derby Dam, which is located above Painted Rock, diverts portions of the Truckee River into the Newlands Reclamation Project in the adjacent Carson River watershed (Figure 2-10). At Wadsworth, the Truckee River turns north and enters the Pyramid Paiute Reservation. This reach of the river is in very narrow canyons and is sparsely populated. Numana Dam (Figure 2-11) and Marble Bluff Dam (Figure 2-12) are both located on the river in this reach. The Truckee River then terminates at Pyramid Lake (Figure 2-13). This reach presents excellent opportunities for ecosystem restoration in certain reaches where access to the historical floodplain exists. There are also numerous diversion structures that are obstructions to fish passage.

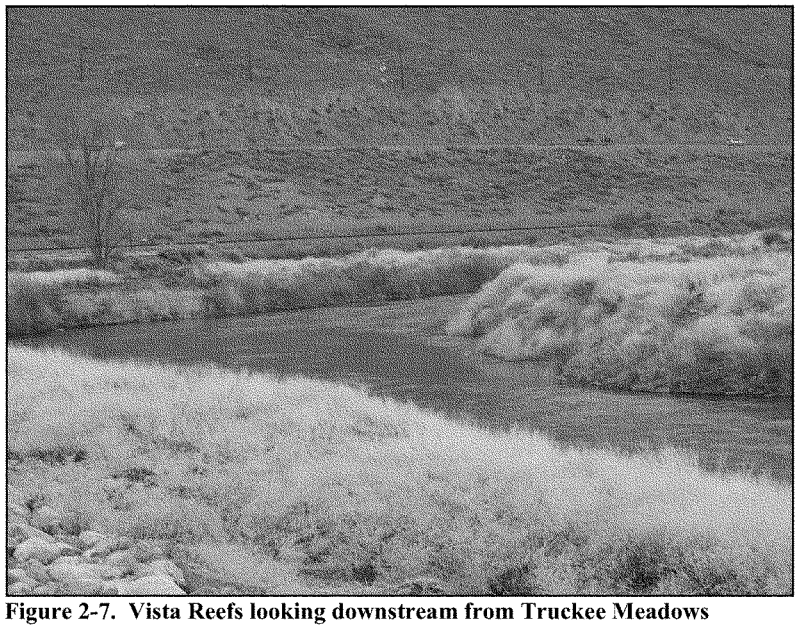

Figure 2-7. Vista Reefs looking downstream from Truckee Meadows

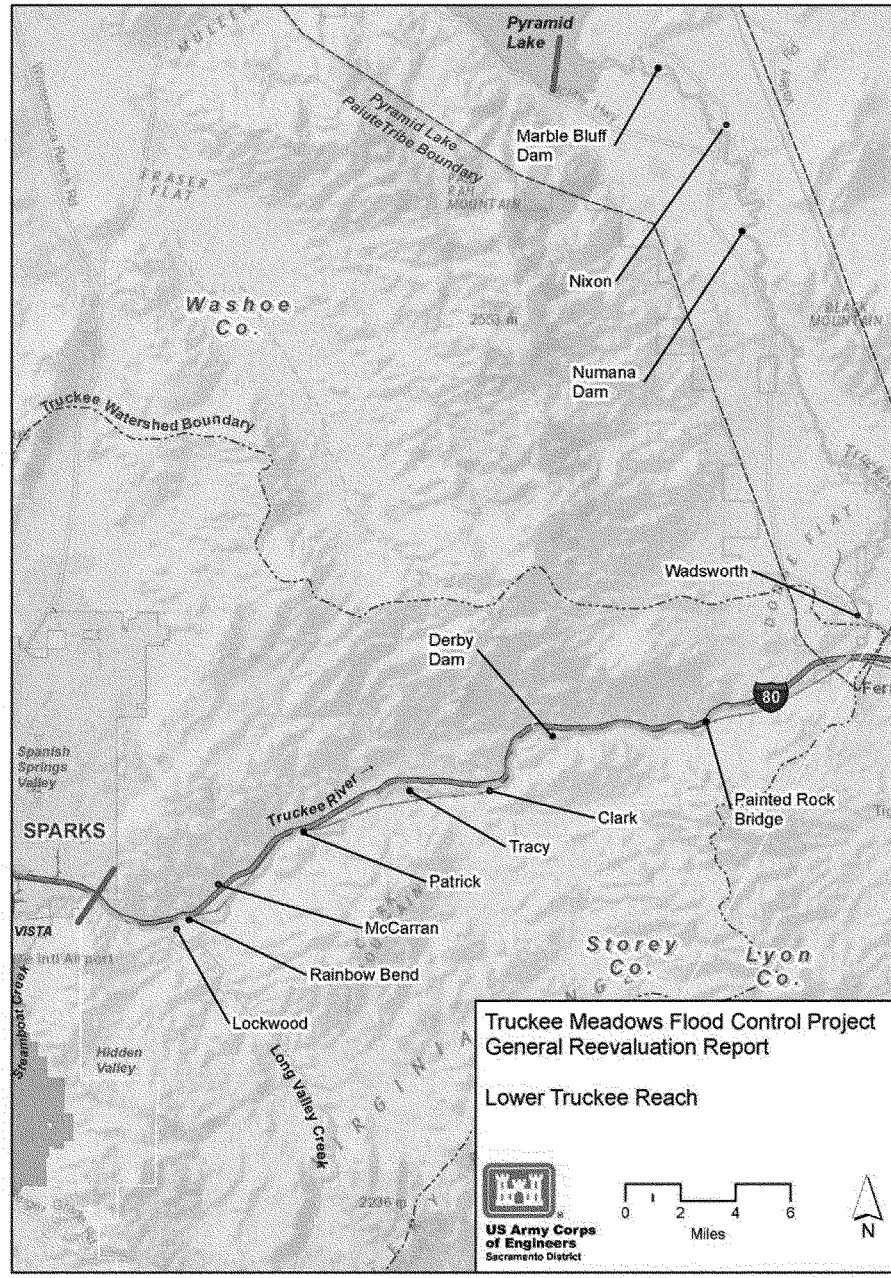

Figure 2-8. Lower Truckee Meadows River Reach

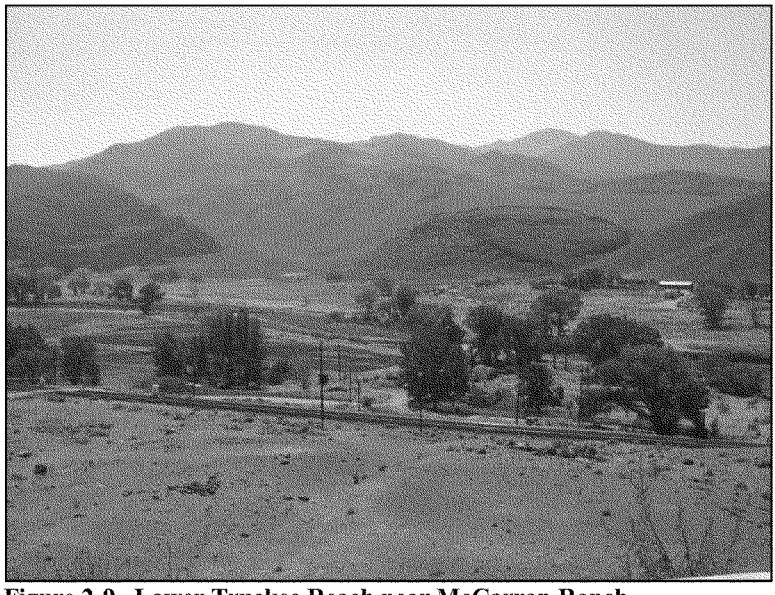

Figure 2-9. Lower Truckee Reach near McCarran Ranch

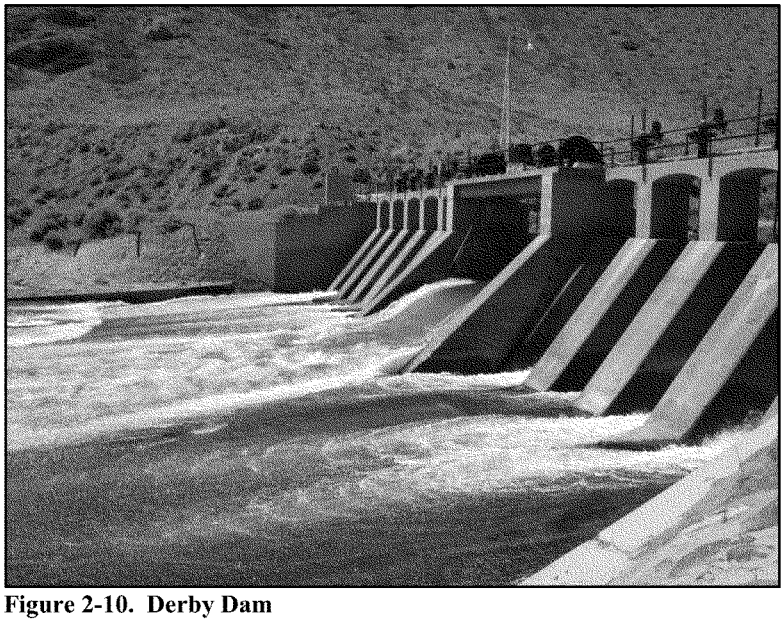

Figure 2-10. Derby Dam

Figure 2-11. Downstream of Numana Dam near Nixon

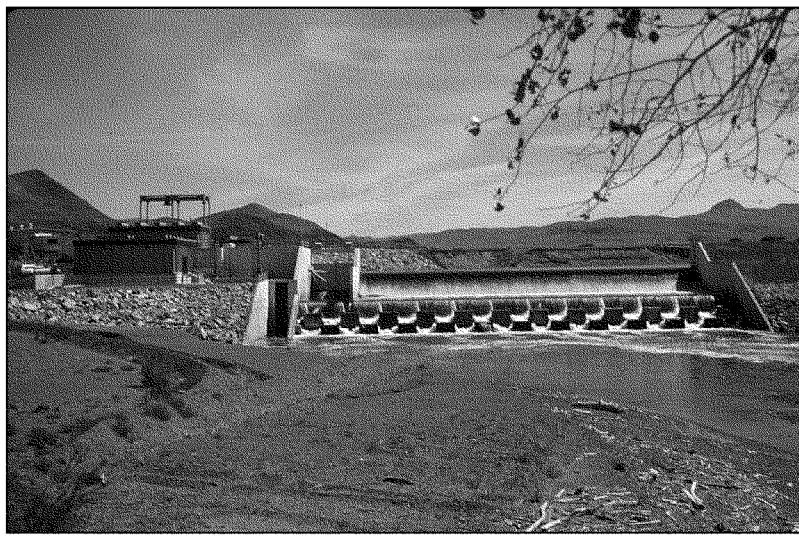

Figure 2-12. Marble Bluff Dam

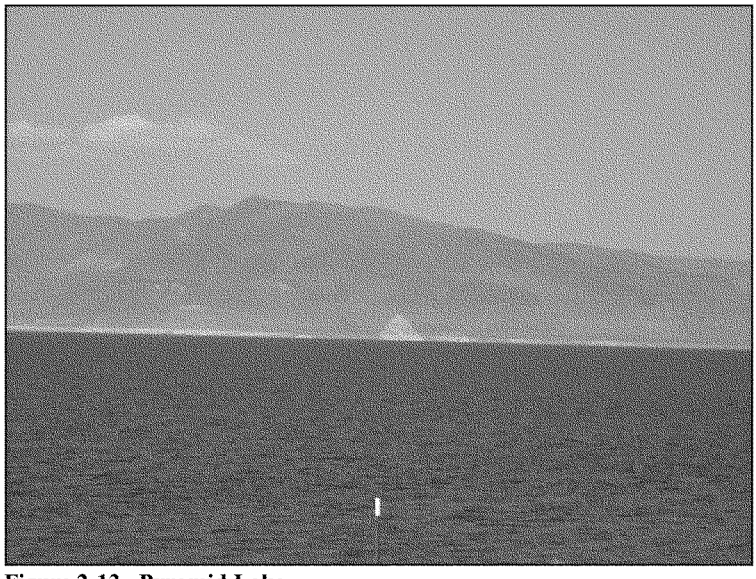

Figure 2-13. Pyramid Lake

2.1.2 Related Water Resources Projects

Several water resources projects have been constructed on the Truckee River over the last century. These projects addressed different issues within the watershed, but had a common desired outcome of minimizing damages caused by flooding.

Truckee River and Tributaries Project

Flood control work by USACE on the Truckee River began with the Truckee River and Tributaries project, which was authorized under the FCA 1954, § 203, and the FCA 1962, § 203,. Construction of channel improvements through the Truckee Meadows as part of the Truckee River and Tributaries project was completed in 1960. The Truckee River channel through Truckee Meadows was widened and straightened to increase the minimum channel capacity from about 3,000 cfs to 6,000 cfs. Additional channel improvements between Truckee Meadows and Pyramid Lake and in the vicinity of Sparks were completed in 1964 and 1968, respectively. Other project features included enlarging the Truckee River channel for approximately 3,200 feet downstream from the existing structure at Lake Tahoe; increasing the capacity of the outlet at Lake Tahoe to 2,500 cfs at lake level 6,228 feet, and to 3,300 cfs at lake level 6,229 feet; providing downstream channel improvements from Lake Tahoe to Truckee; and snagging and clearing at intermittent locations from Vista to Pyramid Lake to compensate for increased flows through Truckee Meadows. The states of California and Nevada and the Pyramid Lake Paiute Tribal Council are responsible for operation and maintenance of portions of the project. The portion of the project in Downtown Reno is discussed under Martis Creek Lake.

The segment of the project between Glendale Avenue in Sparks and Wadsworth maintained by the State of Nevada was last inspected by USACE in 2010. At that time, the overall rating of the segment was Minimally Acceptable due to sedimentation and vegetation in the channel, encroachments, and erosion of both banks. An engineering determination concluded that the unacceptable items would not prevent the project from performing as intended during the next flood event.

Reno Flood Warning Project

USACE conducted a Section 205 small flood control study for the Reno Flood Warning System, Nevada, with Washoe County and the cities of Reno and Sparks in 1998. The study resulted in a selected plan that includes expanding the network of gages used for forecasting stages in the mainstem of the Truckee River, adding gages in the tributary catchments and providing flood watch for forecasting tributary stages, providing the storm watch data filing and display tool for local jurisdictions, and developing the preparedness plan for the Reno-Sparks area. This plan increased the flood warning time from 8 to 14 hours on the Truckee River and from zero to 2 hours for the North Truckee Drain and Steamboat Creek basins. The plan allowed the River Forecast Center to improve the accuracy of its flood forecasts for the mainstem Truckee River, provide local jurisdictions with storm watch data for monitoring tributary stream levels, and improve flood response planning and implementation. The project was constructed in 2000 and is considered in-place and part of the without-project condition.

Clearing and Snagging on Truckee River

During the 1950s, in cooperation with Washoe County and the City of Reno, USACE completed four clearing and snagging projects on the Truckee River as authorized in the FCA 1954, § 208 (amending the Flood Control Act of 1937, Pub. L. 75-406, § 8, 50 Stat. 876 (1937).. These projects included removing sediment, vegetation, and debris from the river and channel straightening for flood control. Together, the four clearing and snagging projects extended from the California/Nevada border to Vista. The City and County provided the required assurances that the completed work would be maintained. Similar work in the City and County was performed by USACE in the mid-1950s and 1963 under a disaster relief authority.

Other Projects

There are numerous lakes and reservoirs in the upper Truckee River watershed. Several that significantly influence flood flows along the river in Reno are Lake Tahoe and Stampede, Boca, Prosser Creek, and Martis Creek Reservoirs. Martis Creek Dam and Lake is owned by USACE. The U.S. Bureau of Reclamation (USBR) owns Prosser Creek Dam and Reservoir, and Stampede and Boca Dams and Reservoirs. USACE and the USBR mutually agree to the flood control operating principles for the Truckee River Basin reservoirs. However, USACE is responsible for providing the flood control regulations. The physical features for each are shown in Table 2-1, and descriptions of each are summarized below.

Lake Tahoe. Lake Tahoe is the first point at which flow of the Truckee River can be controlled. Lake Tahoe covers 192 square miles, averages 990 feet in depth, and is the tenth deepest lake in the world. The lake drains an area of 506 square miles and occupies an unusually large portion of its drainage area. This means that much of the precipitation falling in the drainage basin falls directly on the lake's surface, with tributary inflow contributing a small portion of inflow. Lake Tahoe is both a natural lake of great beauty and a storage reservoir for the Truckee River. The lake could provide all the carryover storage that the area would need for the long term, but most of the water has been dedicated to in-place, non-consumptive use. Although Tahoe is a natural lake, it is controlled by a small dam constructed 400 feet downstream from the natural outlet rim at the northwestern edge of the lake, which lies at an elevation of 6,223 feet. Lake Tahoe has a capacity of about 122,160,000 acre-feet, but the dam, constructed in 1913 by the Truckee River General Electric Company, regulates the lake level to fluctuate a maximum of 6.1 feet, yielding a usable storage capacity of 744,600 acre-feet.

Stampede Project. Stampede, which was constructed by the USBR starting in 1966 and completed in 1970, is operated for water supply and flood control. At gross pool (elevation 5,948.7 feet), Stampede Reservoir is about 5 miles long, has a surface area of 3,440 acres, and a total capacity of 226,500 acre-feet. Stampede Dam is rolled earth and rockfill construction and has a height of 232 feet above streambed. It has a crest length of 1,511 feet, crest width of 40 feet, and crest elevation of 5,970 feet. The outlet works are located in the right abutment and consist of a trashracked vertical shaft intake structure with sill elevation at 5,765 feet. The tower directs flow into a 12-foot diameter circular tunnel upstream from the gate chamber. The capacity of the outlet works is 2,740 cfs when the water surface is at elevation 5,963.3 feet. The ungated spillway is located in the right abutment of the dam. The spillway crest is at elevation 5,948.7 feet and has a length of 15 feet. The spillway discharge capacity is 3,060 cfs when the water surface in the reservoir is at elevation 5,963 feet.

The USBR is currently evaluating Stampede Dam for dam safety and is considering raising the dam and constructing dikes on the south rim of the reservoir. The latest information from USBR indicates that the potential changes at Stampede Dam would have no effect on this project's hydrologic assumptions.

Boca Project. The Washoe County Water Conservation District operates Boca Dam and Reservoir. USBR also constructed Boca Dam starting in 1937 and completed it two years later. It was constructed for water supply, hydropower, and flood control. Boca Reservoir has a total capacity of 41,140 acre-feet and a surface area of 980 acres at gross pool elevation 5,605 feet. Boca Dam has a zoned, rolled earthfill embankment, and a rockfilled face. The structure rises about 100 feet above streambed.

The crest of the dam is at elevation 5,612 feet, has a total length of 1,629 feet, and a top width of 35 feet. The outlet works are located in the right abutment of the dam and commence with a trashracked structure having a sill elevation 5,521 feet. The capacity of the outlet works is 900 cfs when the water surface is at elevation 5,605 feet. The gated spillway structure is located in the left abutment of the dam. The spillway has a crest length of 38 feet and a crest elevation of 5,589 feet. Two radial gates, each 19 feet by 16 feet, control discharges into the 320-foot-long concrete-lined channel. The spillway design capacity is 8,000 cfs at elevation 5,605 feet.

Table 2-1. Principal Lakes and Reservoirs Providing Flood Protection in the Truckee River System

Lake/ Reservoir	Drainage Area (sq mi)	Surface Area[1] (sq mi)	Total Storage (ac-ft)	Storage capacity per foot[2] (ac-ft/ft)	Flood Control Volume[3] (acre-ft)	January 1997 Flood Control Release[4]
Lake Tahoe	506	190.7	122,160,000	122,000	744,600	2,500
Stampede	136	5.4	226,500	3,349	22,100	2,075[5]
Boca	172	1.5	41,140	930	8,000	0
Prosser	50	1.2	29,800	533	20,000	5
Martis	39	1.2	20,400	505	15,000	374

[1] Surface area at gross pool. Lake Tahoe surface area at maximum permissible elevation.
[2] Storage capacity per foot of depth. For flood control reservoirs, average value for flood control/joint use pool.
[3] Volume in flood control/joint use pool. Lake Tahoe value is volume between natural rim and maximum permissible elevation. Lake Tahoe is not drawn down to natural rim to provide flood control space.
[4] Outflow at time of peak flow at Farad.
[5] Inflow to Boca Reservoir.

Prosser Creek Project. The Prosser Creek project was also constructed by the USBR as part of the Washoe Project. The Prosser Creek project began in May 1960 and was completed in November 1962. Prosser Creek Reservoir has a surface area of 745 acres, and a capacity of 29,800 acre-feet at gross pool elevation 5,741.2 feet. The Prosser Creek Dam is a zoned earthfill structure rising 139 feet above streambed. The crest of the dam at elevation 5,761 feet has a length of 1,830 feet and a crest width of 30 feet. The outlet works, located in the left abutment of the dam, consist of an 8-foot-diameter circular conduit upstream from the gate and a 9-foot flat-bottom (arch roof) conduit downstream. Capacity of the outlet is 1,850 cfs when the water surface is at gross pool (elevation 5,741.2 feet) and about 750 cfs at elevation 5,650 feet. The spillway is an ungated concrete channel extending through the left abutment of the dam. It has a crest width of 15 feet (crest elevation 5,741.2 feet) and a discharge capacity of 2,750 cfs at elevation 5,754.5 feet.

Martis Creek Lake. Martis Creek Lake was authorized as part of the Truckee River and Tributaries Project by the Flood Control Act of 1962 (Pub. L. 89-874). Martis Creek Lake Project is located about 32 miles upstream from Reno. The project consists of a dam and lake for flood control, recreation, and future water supply, and about one mile of channel improvement work by local interests along the Truckee River in Reno. The intermittent channel improvement work in Reno from Booth Street to Center Street consisted mainly of modifying and extending existing floodwalls to provide a capacity of 14,000 cfs though the city. The segment of the project in Downtown Reno upstream of Glendale Avenue, maintained by the Carson-Truckee Water Conservancy District, was last inspected by USACE in 2010. At that time, the overall rating of the segment was Minimally Acceptable due to vegetation growing in and around the floodwalls, vegetation growing in the floodway, minor sedimentation within the channel, and an encroachment causing erosion. An engineering determination concluded that the

unacceptable items would not prevent the project from performing as intended during the next flood event.

The Martis Creek Dam has been identified as having a very high urgency of action to reduce the risk associated with dam failure. Interim risk reduction measures have been implemented which include leaving the gates open limiting the reservoir pool to approximately elevation 5,810 feet. Hydrologic modeling accounts for Martis Creek Dam operating with this interim risk reduction measure in place. A detailed Risk Analysis is being completed to justify whether this classification rating is still warranted. It is anticipated that the classification may be reduced to a lower risk rating. A selected course of action is expected to be identified in 2013. The future without-project assumption is that interim risk reduction measures would remain in place until a solution is identified, approved, and implemented.

Derby Dam and Truckee Canal. Located on the Truckee River about 20 miles below Reno, Derby Dam was constructed between 1903 and 1905 by the Bureau of Reclamation to divert water to the Newlands Project for agricultural purposes. The dam, a concrete gate structure with an embankment wing, is 31 feet high with a crest length of 1,331 feet. The dam diverts up to 1,500 cfs into the Truckee Canal. Constructed between 1903 and 1906, the canal has a bottom width of 20 feet, side slopes of 0.5:1, water depth of 13 feet, and length of 32.5 miles. The canal is believed to be capable of carrying somewhere between 800 to 1,000 cfs at full capacity. During a large flood event, the operating criteria for Derby Dam are to limit diversions into the Truckee Canal to prevent flooding in the vicinity of the Lahontan Reservoir; however, some diversions have occurred during past floods. Diversions tend to have little or no impact to flooding problems, especially in the Reno area.

Truckee River Storage Project. The USBR constructed the Truckee Storage Project to provide a supplemental supply of irrigation water to approximately 29,000 acres of land in the Truckee Meadows area. The actual irrigated area is being reduced by urban development. Supplemental irrigation water for the Project is stored in Boca Reservoir on the Little Truckee River, while release of water from Lake Tahoe (operated by the Truckee-Carson Irrigation District) and Donner Lake is made to provide better regulation of the Truckee River according to the Truckee River Agreement. Diversion and delivery of irrigation water is made by the 33 ditch companies which form the Washoe County Water Conservation District. Table 2-2 lists the major canals and capacities.

Washoe Project. The USBR constructed the Washoe Project to improve the regulation of runoff of the Truckee and Carson River systems and to provide supplemental irrigation water and drainage for presently irrigated lands, as well as water for municipal and industrial and fishery uses, flood protection, fish and wildlife benefits and recreation development. Major features of the project in addition to Prosser Creek and Stampede Dams include Marble Bluff Dam and Pyramid Lake Fishery, both in operation and within the study area.

NV Energy. NV Energy (formerly Sierra Pacific Power Company) owned and operated five hydroelectric power plants with a total installed capacity of 9,400 kW. Descriptive data for plants located along the Truckee River in the reach between Truckee and Reno are provided in Table 2-3.

Table 2-2. Major Canals and Capacities of the Truckee Storage Project

Canal	Capacity (cfs)
Coldron	20
Steamboat Ditch	110
Highland Ditch	104
Orr Ditch	60
Land Chance Ditch	47
Lake Ditch	50
Cochran Ditch	48
Glendale Ditch	40
Pioneer Ditch	35
North Truckee Ditch	43

Table 2-3. Hydroelectric Plants between Truckee and Reno

Plant	Total Head (feet)	Installed Capacity (kw)
Farad	83	2,800
Fleish	125	2,000
Verdi	96	2,400
Washoe	88	1,500
Reno	43	700

The power plants are all run-of-the-river type. Lake Tahoe and Boca River regulate stream flow for irrigation and power purposes, and further regulation is obtained from the Sierra Pacific Power Company's storage reservoir at Independence Lake on Independence Creek, a tributary of Little Truckee River. This reservoir completely regulates the runoff from an 8 square mile tributary area. The NV Energy has also acquired storage rights on Donner Lake, with a capacity of about 9,500 acre-feet on Donner Creek for joint use and Truckee River regulation. The Truckee River Water Authority has recently purchased these power plants.

2.1.3 Population

Washoe County's population was 421,407 in 2010; (US Census, 2010) the 2010 population for Reno was 225,986 and the population for Sparks was 90,264. Most of Storey County is rural or suburban, with only about 1,200 people living in Virginia City and Gold Hill. The U.S. Census recorded a population of 4,010 in 2010 for Storey County. In 2010, the population of the Pyramid Lake Paiute Reservation was 1,660 individuals. Fifty percent of the population resided in Wadsworth, and 15 percent resided in Sutcliffe.

2.1.4 Public Health and Safety

Washoe and Storey Counties, the Cities of Reno and Sparks, and the Pyramid Lake Paiute Tribe (PLPT) provide necessary public services to ensure the health and safety of their residents. These public services include police and fire protection, emergency medical services, and natural disaster plans and response. Public health and safety concerns for the study area include natural disasters, vector control, potential for bird-aircraft strike hazard, and risk of wildland fires.

Natural Disaster Plans and Response

The Washoe County Emergency Management and Homeland Security operates on a regional level and partners with several other local emergency response agencies to provide preparedness, response, mitigation, and recovery services for the County. The Regional Emergency Operations Center serves Washoe County, Reno, and Sparks as a single, permanently established, ready-to-operate location to perform individual and/or integrated emergency response services in support of jurisdictional emergencies or larger regional emergencies and disasters involving two or more jurisdictions. The Washoe County Emergency Management Program functions as a coordination agency during a disaster, providing such assistance as may be needed by the affected communities to safeguard life and property. The intent is to assess and address the effects of the event and use the Incident Command System as part of the National Incident Management System during the response phase.

Storey County Emergency Management provides planning and coordination for the response, recovery and mitigation of natural and man-made disasters occurring within Storey County. The Storey County Emergency Management Plan provides guidance and outlines a cooperative effort among several departments and divisions of county government, including the Fire Department, Sheriff, Public Works, Budget and Finance, Commissioners, District Attorney, Assessor, Recorder, and Clerk that work together to mitigate any actual or potential disaster or event.

The National Weather Service forecast office in Reno provides the watches, warnings, and advisories for the entire study area. Information during the response phase of an emergency is provided by the Emergency Alert System. The Emergency Alert System is the new system adopted by the Federal Communications Commission to replace the old Emergency Broadcast System and is a universal tool to route emergency messages to the public swiftly and efficiently. The Washoe County Emergency Alert System also includes a Flood Warning System, which is a web-based application enabling flood hazard information to be readily available during flood events as well as for general monitoring purposes. For the purposes of this GRR, the existing flood warning system is considered to be sufficient.

Aviation Safety

Reno International Airport is located within the Truckee Meadows Reach south of the Truckee River. Across the U.S., aircraft collisions with birds and other wildlife annually cause millions of dollars in damage and can jeopardize current and aircrews. Most public-use airports

incorporate large tracts of open, undeveloped land that provide added margins of safety for aircraft operations.

2.1.5 Environmental Resources

Water Resources

The Truckee Meadows area depends primarily on the Truckee River for its water needs. Groundwater provides approximately 15 percent of the water needs. Water rights in Nevada are based on the doctrine of prior appropriations; that is, the entity that first diverts water from a stream preempts a right to the quantity withdrawn, provided that the water is used beneficially. NV Energy sold its water power division, as a joint venture, to Washoe County and the Cities of Reno and Sparks, which provide service to a major portion of the Reno-Sparks metropolitan area as the Truckee Meadows Water Authority (TMWA).

According to the Washoe County Master Plan (2010), although the Truckee River is the major source of water for the region, the flow of the river is highly variable and requires reservoir storage for both municipal and industrial use. Seven reservoirs on the Truckee River and its tributaries provide storage to regulate the flow of the river. Lake Tahoe provides about 70 percent of the available storage on the river system. Most of the river's flow originates downstream from Lake Tahoe, where it can be regulated by only 30 percent of the available storage on the river system. Even with seven reservoirs, the storage is not sufficient to fully regulate the flow of the river.

Surface water ownership in the Truckee River Basin was established through the U.S. District Court's Orr Ditch Decree entered by the U.S. District Court for the District of Nevada. *United States v. Orr Water Ditch Co., et al,*, Equity Docket No. A3 (D. Nev. Sept. 8, 1944)). There are in excess of 300,000 acre-feet of water rights either adjudicated through the Orr Ditch Decree (Truckee River water) or permitted by the State Engineer (ground and surface water) in Washoe County (excluding the Lake Tahoe area). However, the actual extent of the water resource in a dry year is significantly less than indicated by the water rights. Most surface water use is for agriculture; however, the Truckee River also represents a potential source of domestic water supply.

Hazardous, Toxic, and Radiological Waste

USACE performed an Environmental Site Assessment during July 2003 and in 2011. The site assessment identified numerous sources of possible contamination due to hazardous, toxic, or radiological waste (HTRW) during a records search and field survey. The data search showed 686 sources of potential contamination within one mile of the study boundaries – but not within the boundaries. In addition to the data search, USACE performed a site visit to look for the following common environmental concerns: drums; landfill or solid waste disposal sites; pits, ponds, or lagoons; wastewater; PCB-containing transformers; and the presence or likely presence of any hazardous substance or petroleum products on the property under conditions that indicate an existing release, a past release, or a material threat of a release on the property or into the ground, groundwater, or surface water of the property. USACE neither saw any hazardous

materials nor encountered any storage containers during the site visit. There are several storage tanks (both AST's and UST's) that exist in the study area, but do not appear to interfere with any of the alternatives. USACE also observed transformers during the site visit that appeared to be recently replaced. HTRW is not expected to be an issue for formulation of alternative plans.

Vegetation

Vegetation in the urban areas of Reno, Sparks, and Truckee Meadows has been heavily modified by residential, commercial, and agricultural developments. Discontinuous, narrow strips of riparian vegetation are currently found along the river, confined to available substrates above and below existing riprap and to urban parks west of downtown Reno. The riparian vegetation is dominated by small stands of native black cottonwood, Fremont's cottonwood, white alder, buffaloberry, willow shrubs and trees, and nonnative ornamental elm trees. Herbaceous understory species include mugwort, horsetail, baltic rush, umbrella sedge, poison hemlock, weedy mustards, and lambsquarter.

Four habitat types are associated with the lower reach of the Truckee River: Great Basin cottonwood-willow riparian forest, Great Basin riparian scrub, upland sagebrush scrub steppe, and shadscale scrub communities. In addition to these native plant communities and species, there are several introduced species that are typically classified as noxious weeds that commonly occur along the lower reach of the Truckee River. These species include tamarisk, Russian olive, whitetop, wide-leaved peppergrass, cheatgrass, and foxtail chess. Tamarisk, whitetop, and wide-leaved peppergrass are of particular concern due to their high densities, extreme competitive behavior, high water use, and lack of usefulness for wildlife habitat and range forage.

Threatened and Endangered Species

Several Federally listed or proposed species have the potential to occur in the study area. These include the Lahontan cutthroat trout, cui-ui lake sucker, and Steamboat buckwheat. The Steamboat buckwheat is not known to occur in the project area.

The Lahontan cutthroat trout (LCT) and cui-ui lake sucker are known to inhabit the Truckee River. The LCT, listed as endangered in 1970, was reclassified as a threatened species in 1975. The U.S. Fish and Wildlife Service (FWS) is currently in the process of revising their 1995 Recovery Plan for the LCT.. In 2003, the Truckee River Recovery Implementation Team[1] developed a short-term action plan for LCT in the Truckee River basin which focuses on gathering information about habitat requirements and implementing demonstration projects and research (Interior & State, 2008). The action plan identifies tasks intended to eliminate or minimize threats that affect LCT in the Truckee River and through continued implementation of this process, ensure the long-term persistence of the species. Major issues include: (1) reduction and alteration of stream flow and discharge; (2) alteration of stream channels and morphology; (3) degradation of water quality; (4) reduction of Pyramid Lake elevation and concentration of chemical components; and (5) introductions of non-native fish species.

[1] Composed of representatives from USFWS, USGS Biological Resources Division, U.S. Forest Service, BIA, USBOR, CDFG, PLPT, Trout Unlimited, Otis Bay Consultants, and UNR.

The cui-ui is classified as endangered by the Federal government and the State of Nevada. The Federal listing occurred on 11 March 1967. Steps needed for the recovery and maintenance of the cui-ui are outlined in the FWS's Cui-ui Second Revision Recovery Plan, 1992. The cui-ui is publically recognized as significant as a sacred resource by the Pyramid Lake Paiute Tribe.

The LCT can be found throughout the entire Truckee River, including the four reaches under this study. The cui-ui are not able to access the river beyond Derby Dam, located downstream of Tracy. According to the Truckee River Operating Agreement (TROA) final EIS, Numana Dam is a complete impediment to cui-ui and impedes spawning success.

2.1.6 Related Ecosystem Restoration Projects

There have been many opportunities for ecosystem restoration along the Truckee River. Local interest in ecosystem restoration has resulted in multiple levels of local, regional, and federal agencies participation in designing projects that have provided an increase in ecosystem habitat within the watershed.

Lower McCarran Ranch

In June 2002, The Nature Conservancy (TNC) acquired the McCarran Ranch property in 2003 and developed a preliminary restoration plan to restore habitats for a diverse array of native species. The plan included reconstructing the river channel to elevate the existing incised riverbed and to reestablish the meandering pattern of the channel. The plan also included an eradication program to eliminate nonnative invasive plant species and revegetation specifications. This restoration plan combined with other measures and alternatives was studied as a USACE Section 1135 Continuing Authorities Program project. In 1986 Congress authorized USACE to modify existing projects to restore the environment (WRDA 1986, § 1135). However, funding constraints in that program caused TNC to proceed on its own.

TNC completed a 1-mile pilot project at the upstream portion of McCarran Ranch in late 2003. It included raising the river channel, and creating a series of pool and riffles in the existing channel and floodplain ponds for the western pond turtle. Restoration of the remaining 4 miles of the river at McCarran Ranch was completed in 2008 by TNC.

Lockwood

Washoe County acquired the Lockwood property on the downstream Truckee River floodplain for permanent open space and potential ecosystem restoration purposes. The County hired Otis Bay Riverine Consultants to prepare a Phase I conceptual level restoration and improvement alternatives study. This property is located about 2.5 miles downstream of Vista, extends 4,000 feet along the channel within Washoe County, and has a history of flooding and flood-related damage. The County purchased the property and removed all but one of the homes (one home is still in private ownership) to prevent future flood-related problems. The report, entitled *Truckee River – Lockwood Conceptual Restoration Project*, prepared by Otis Bay Riverine Consultants (January 2001), states that it is the County's intent to either use the

Lockwood property as land area where required mitigation could be implemented for adverse effects on water quality caused from operation of the Truckee River Municipal Wastewater Treatment Plant, or where increased flood storage or ecosystem restoration could occur as a part of this project. In 2009, the project proponents completed a restoration project on this property that included a trail system, boat launch facility, bank sloping, and plantings.

Steamboat Creek

In October 2001, USACE completed a Preliminary Restoration Plan for restoration of aquatic ecosystems in Steamboat Creek pursuant to WRDA 1996, § 206 (Section 206). The proposed project consists of excavation of a new channel through the alfalfa fields to the west of the current creek location, with an objective of creating a restored stream channel length from 1.1 miles to 2.2 miles upstream from the confluence with the Truckee River. The conceptual design for the new channel is a single threaded, low-gradient meandering channel. Placement of grade control structures and planting of appropriate native obligate wetland species in the channel and on floodplains are also features of the restoration plan. Funding constraints in Continuing Authorities Program forced the USACE to defer the Section 206 study indefinitely. The City of Reno has continued their planning effort for Steamboat Creek. For the purposes of this GRR, no specific restoration project is assumed under future without-project conditions because no specific restoration plan has been adopted or funded.

2.1.7 Recreational Projects and Facilities

Related Recreation Projects

Open Space Plan of 1972. The City of Reno has made efforts to recapture open space and create recreation features favored by residents. In the early 1970's, the city began to take steps to reverse the damage done to the river environment. An open space plan in 1972 identified objectives such as a system of lanes, paths, and trails developed for bicycles, linkages that could be used for equestrian trails, hiking and bicycling between the various existing open spaces, and various commitments to encourage cooperative development along the river to maintain open areas, provide public access to the river, preserve esthetic quality and the natural environment of the river. The city has undertaken several projects implementing aspects of the 1972 plan.

Whitewater Parks. Truckee River Park and Kayak Course at Wingfield Park was constructed in 2003 on the Truckee River above the Center Street Bridge. This whitewater park provides a hardened river-rafting course through the center of downtown Reno. The park is 1,400 feet long and contains five drop structures, current deflectors, benched banks, and boulders. The park also includes a pedestrian and bike path on Wingfield Island. A similar whitewater park has recently been completed for the reach of the Truckee River near Sparks. This park consists of many of the same features as the whitewater park at Wingfield Park.

Tahoe-Pyramid Bikeway. Plans are underway for the Tahoe-Pyramid Bikeway. This is a volunteer effort to create a 116-mile trail along the Truckee River from Lake Tahoe to Pyramid Lake. Several stretches of the bikeway have been completed. The Tahoe-Truckee Link connects Lake Tahoe with the town of Truckee. The Mogul-Verdi Link was opened in May 2005. It joins

the Verdi-Reno-Sparks section that is a continuous trail from Mogul to Vista. A 25-mile section on the Pyramid Paiute Reservation was completed in 2006. A day-use permit is required to use this portion of the bikeway on tribal lands.

Reservoirs. Upstream of the Reno-Sparks metropolitan area within the watershed of the Truckee River are Boca, Stampede, Prosser, and Martis Creek reservoirs. Along with providing flood control and water storage, the reservoirs provide recreational opportunities to residents in the region. Boca, Stampede, and Prosser reservoirs offer motorized and non-motorized boating, angling, swimming, sunbathing, picnicking, camping, hiking, hunting, off-road vehicle recreation, and sailing. Martis Creek Reservoir offers non-motorized boating, angling, hiking, river rafting, and hunting. Although not within the study area, these reservoirs provide recreation opportunities that were considered as part of the without-project condition for the regional recreation needs.

Recreation Facilities

Verdi Reach. The Verdi Reach provides limited opportunities for fishing and rafting. However, there are no developed facilities or public access points along this stretch of the Truckee River.

Downtown Reno Reach. The city of Reno has 17 parks and access sites to the Truckee River. Recreational opportunities exist along the Truckee River throughout the entire study area. The Truckee River Whitewater Park is a $1.5 million project in the downtown Reno district.

Truckee Meadows Reach. A recreation trail exists along portions of the Truckee River from Booth Street to Highway 395 and from Highway 395 through the city of Sparks. The city of Sparks has four parks and access sites and also maintains the Truckee River Greenway, which includes Fisherman's Park and a trail along the north bank of the river. This existing greenway follows the northern bank of the Truckee River and contains both developed park areas as well as natural open space. While facilities vary along the greenway depending on the location, the entire greenway has a paved pathway, which extends further west into downtown Reno. In total, this pathway is 6.8 miles long. A second whitewater park at Rock Park was constructed in 2009 as part of a total renovation of Rock Park. The whitewater park consists of 1,000 feet of constructed pools and riffles.

Along the Truckee River Greenway are picnic shelters, restrooms, sand volleyball courts, playgrounds, horseshoe pits, picnic areas, open play areas and turf, and parking areas. The City of Sparks has made a significant investment in the development and maintenance of the facilities and property along the greenway. Some of the parklands along the Sparks Truckee River Greenway were purchased with Land and Water Conservation Fund Act money. In total, the Sparks Truckee River Greenway occupies 75 acres.

Lower Truckee River Reach. This reach of the Truckee River has limited public access and few developed recreational areas. Most access is via private property. A portion of the Truckee River Greenbelt (a distant extension of the greenbelt in the Meadows reach) is located just downstream of Rainbow Bend. The greenbelt in the lower reach extends approximately 700

feet along the north bank of the channel. Recent restoration efforts at Lockwood and McCarran Ranch provide some passive recreation opportunities and other similar efforts are anticipated. A recent regional effort is the establishment of the Tahoe-Pyramid Bikeway. The objective of the bikeway is to establish a trail that would allow recreationists to follow the Truckee River by foot or by bicycle from its source at Lake Tahoe to its desert terminus, Pyramid Lake. Current open sections of the bikeway include a trail running through the Pyramid Lake Paiute Reservation from Wadsworth to Pyramid Lake.

Pyramid Lake, famous for its LCT fishery, is located about 35 miles north of Reno on the Pyramid Lake Paiute Indian Reservation. Pyramid Lake is the largest lake that is entirely located within the State of Nevada. Along with LCT, other species of fish within the lake are the Lahontan tui chub, the cui-ui, the Tahoe sucker, and the Sacramento perch.

2.1.8 Cultural Resources

A records and literature search of the study area was conducted at various sources in 2004 and 2010. A search of the National Register of Historic Places (NRHP) and the Nevada Historical Society for listed properties was conducted. According to the NRHP records, there are 37 listed historic properties, all of which are buildings, structures, and objects in the downtown Reno area. The term "historic property" refers exclusively to NRHP listed or eligible properties. The NRHP only includes sites that have been determined to meet specific criteria for historical significance; it does not include all known or potentially significant sites. A records search from the Nevada State Museum found that a total of 82 cultural resource surveys have been conducted in the study area. The search showed that 41 historic and historical period properties and 210 archeological sites had been recorded within the project's study area. Previous researchers with a long history of conducting archeology in the area were contacted to verify site locations and determined if they had any recommendations of any kind. Those dialogs were very useful in clarifying contradictory site location information, and testing results. The cultural resources inventory is a compilation of data gleaned from existing records, The National Parks Service, in-house pedestrian surveys, historic building survey contracts, and discussions with local property owners.

USACE met on separate occasions with Washoe Tribe of Nevada and California (Washoe Tribe) and the Pyramid Lake Paiute Tribe. On January 23, 2007 USACE personnel with two consulting ethnographers met with representatives from the Pyramid Lake Paiute Tribe, the Washoe Tribe of Nevada and California, and the Reno Sparks Indian Colony to discuss the upcoming Ethnohistory history report. The Tribal members were asked about known sites or areas of traditional Cultural interest, but offered no details regarding specific locations of interest. When asked specifically about the Truckee River they indicated the river held no spiritual importance to them.

The Painted Rock Bridge in the Lower Truckee River Reach and four other historical period properties have been recommended eligible for the NRHP by Nevada Department of Transportation and JRP Historical Consultants. Painted Rock Bridge and Virginia Street Bridge were dropped from consideration. The Virginia Street Bridge is being dealt with by local interests. The programmatic agreement has been amended as needed.

Cultural resources were given appropriate consideration during the formulation and evaluation of alternative plans.

2.1.9 Tribal Lands and Issues

The Washoe Tribe and Reno-Sparks Indian Colony have trust resources in the Truckee Meadows Reach that are subject to flooding. The Pyramid Lake Paiute Tribe is subject to flooding in the Lower Truckee Reach. Protection and restoration of fisheries, water supply, and water quality are important concerns of the Tribe.

2.1.10 Allocation of Water from the Truckee River

Truckee River water allocations for various uses are complex and are the result of a long history of Federal and interstate decrees, lawsuits, and laws. There are a total of 19 diversions from the Truckee River between the California-Nevada border and Pyramid Lake; 11 of the diversions are downstream of Vista. The Truckee River is the principle source of water for irrigation, municipal, industrial, and domestic uses in the cities of Reno and Sparks, and in the neighboring rural communities of Washoe and Storey counties.

The most significant water development project to affect the Truckee River resulted from the Reclamation Act of 1902 Pub. L. No. 57-161, 32 Stat. 388-390 (1902), which that authorized the Newlands Project and construction of Derby Dam and Truckee Canal, a trans-basin diversion for agricultural development in the Fernley and Fallon areas. This development has changed the hydrology of the Truckee River downstream of Vista to a highly variable regime of minimal low flows and periodic high flood flows when upstream storage is exceeded.

The diversion of over one-half of the annual flow of the Truckee River since 1905 is the major contributing cause of the lowering of the water surface elevation of Pyramid Lake. Pyramid Lake inflows have been significantly reduced during the last century as a result of these trans-basin diversions that caused the level of Pyramid Lake to drop about 80 feet between 1905 and 1967. Lake level fluctuations at the exposed delta at the river mouth have historically created channel instability and aquatic habitat degradation, including the blockage of endangered fish passage at the river's delta/lake interface to spawning grounds upstream.

2.1.11 Completed Local Projects

The following early implementation ("TRAction") projects have been completed by the sponsor:

Reno-Sparks Indian Colony Levee. The project consists of 2,241 linear feet of levee and floodwall construction on the border of the Reno-Sparks Indian Colony along the Truckee River. The project was designed to contain the flood event with an estimated 0.85 recurrence interval with risk and uncertainty included.

Lockwood Restoration. This project is located directly upstream of the Rainbow Bend planned community. It consists of 1,510 linear feet (4.5 acres) of in-stream riffle habitat, 750 linear feet (2.1 acres) of channel habitat; 1.8 acres of wetland habitat; 1.5 acres of grassland/ herbaceous habitat; 4.7 acres of native shrub habitat; and 22 acres of native woodland habitat.

Mustang Ranch Restoration. This project is located at Mustang Ranch along the Truckee River downstream of the Rainbow Bend community. It consists of 1,366 linear feet (3.7 acres) of in-stream riffle habitat; 2,563 linear feet (7.0 acres) of channel habitat; 10.7 acres of wetland habitat; 14.8 acres of grassland/herbaceous habitat; 90.7 acres of native shrub habitat; and 60.0 acres of native woodland habitat.

102 Ranch Restoration. This project is located at 102 Ranch along the Truckee River. The project consists of 875 linear feet (2.5 acres) of in-stream riffle habitat; 1615 linear feet (4.4 acres) of channel habitat; 4.9 acres of wetland habitat; 18.7 acres of grassland/herbaceous habitat; 23.4 acres of native shrub habitat; and 60 acres of native woodland habitat.

2.2 Future Without-Project Conditions

The assumed without-project condition is the benchmark against which alternative plans are evaluated. Under future without-project conditions, it is assumed for planning purposes that no Federal action will be taken to alleviate flood or ecosystem problems in the study area, other than the implementation of the Truckee River Operating Agreement approved in 2008 by the Bureau of Reclamation (BOR). Changes in future without-project conditions that are anticipated due to continuing trends or likely non-Federal actions are addressed in the following paragraphs. These forecasts are from the base year (year when a project is assumed to be operational) to the end of the period of analysis (50 years).

2.2.1 Physical Setting

Verdi Reach

No specific physical changes relevant to the evaluation of alternative plans are anticipated in the Verdi Reach.

Downtown Reno Reach

The existing floodwalls and levees will continue to serve as flood control features for the Downtown Reno Reach, if properly maintained. The Sierra, Virginia, Center and Lake Street bridges will continue to be a constraint on water passage on the Truckee River through downtown Reno.

Truckee Meadows Reach

Though the Reno Flood Warning System will continue to function and provide Reno and Sparks with advanced warning of flood events, the Reno-Sparks area will remain at risk from

flooding without a Federal project. Floodplain management, flood warning systems, and emergency preparedness are expected to continue in the region.

A regional water management plan will remain in place that addresses groundwater and surface water quality, water supply, flood and water drainage management, and other plan requirements.

Lower Truckee River Reach

The community of Rainbow Bend at Lockwood would likely remain the same size since developable land adjacent to the community is scarce. Rainbow Bend would remain at risk from flooding from Long Valley Creek, a tributary to the Truckee River.

2.2.2 Socioeconomic Conditions

Verdi Reach

There likely would be additional development in this reach in the future; however there are no specific plans. Developable areas lie outside the floodplain high on hills and terraces.

Downtown Reno Reach

Forecasts for future without-project conditions indicate that Reno and Sparks will continue to grow at a rate of about 1.4 percent per year. It is assumed that additional redevelopment of the downtown Reno area will continue and that development will include flood proofing from the 1% Annual Change of Exceedance (ACE) event (also referred to as 1:100, 1/100, or "100-year event"). By the year 2030, the city of Reno population is expected to increase to approximately 339,500.

Truckee Meadows Reach

Based on a projected population of 590,490 for Washoe County in the year 2030, the average annual growth rate is 1.32 percent. Pressure to develop the area closer to the Truckee River will continue to be managed by local ordinances that require that there be no net loss of flood storage in the Truckee Meadows area. Truckee Meadows is expected to develop in areas outside the floodplain.

Lower Truckee River Reach

The Nevada Small Business Development Center has estimated that the population of Storey County will increase to 6,023 by 2025. While some reduction in farming and ranching is expected due to economic conditions, it is not expected that development will increase substantially since opportunities closer to Reno and Sparks exist and would lure development before this highly rural area.

2.2.3 Environmental Resources

Previous studies along the Lower Reach of the Truckee River show a decrease in the number of bird species in the area and a decrease in the number of individuals of each species. The researchers concluded that the declining trend is probably due to the loss of suitable marsh and riparian habitats. Bird habitat has continually degraded since the last study in 1976. For example, cottonwoods that depend on a wet substrate for seed germination and development are now isolated from all but the more extreme flood flows. Eventually these isolated forests will die without regenerating new growth. As a result, bird diversity and abundance will continue to decline.

Reservoir storage requirements and in-stream flow requirements are assumed to remain the same under future without-project conditions. Current negotiations are addressing the need for additional water, but many complex issues and conflicting values among the participants result in uncertainty in predicting the future without-project conditions. River system operations are assumed to remain basically the same, since conflicting environmental, social, and economic factors will continue to make storage and in-stream flow changes to the system increasingly difficult with time. Because of the scarcity of water in Nevada and the institutional pressures created by that scarcity, it is assumed for planning purposes that no specific increases in flow for recovery of Federally listed fish species (LCT and cui-ui) will be implemented under the future without project conditions. However, it is assumed that Numana Dam on the lower Truckee River will be removed or modified for fish passage purposes by the PLPT in coordination with the Bureau of Indian Affairs per the Consolidated Appropriations Act of 2008 (Pub. L. No. 110-161, Truckee River Operating Agreement approved in 2008 which appropriated funding through tBOR's Terminal Lakes Project for that purpose. In addition, it is assumed that USBOR will install a fish screen on the Truckee Canal at Derby Dam under the future without-project condition, allowing the existing fishway at Derby Dam to be operated, as required by a USFWS Biological Opinion (File No. 1-5-01 -F-228) issued to BOR in 2001.

Future conditions of the ecosystem on the Truckee River will be heavily influenced by the availability of water for in-stream uses under any new water allocation arrangements. The latest effort to resolve long-standing disputes over water use and water rights on the Truckee River has been the enactment of the Tribes Water Rights Settlement Act, § 207). The Act requires to be effective, an operating agreement, known as the Truckee River Operating Agreement (TROA), must be implemented. The TROA would implement provisions of the Act, including interstate allocations between California and Nevada, greater flexibility in the operation of Truckee River reservoirs for efficient water use, changes to the exercise of water rights that will benefit listed species and storage of water in Federal reservoirs for the cities of Reno and Sparks during drought. TROA was signed in 2008, but is not yet fully implemented. Instead, flows in the river continue to fall under the Orr Ditch Decree of 1944 previously discussed in Section 2.1.5. However, it is assumed for planning purposes that TROA will be fully implemented in the future without-project condition.

It is assumed that no additional water will be available for restoration unless water rights are purchased. Under the TROA agreement, Washoe County is obligated to ensure that 6,700 acre-feet of yearly water flow will be dedicated to continued in-stream use, rather than

diverted for other uses. This study assumes that 6,700 acre-feet of existing annual flow will continue under future without-project conditions.

The McCarran Ranch ecosystem restoration project has been constructed and will provide restored habitat along a 4-mile stretch of the Truckee River below Vista. (Restoration projects have also been implemented at Lockwood, 102 Ranch, and a portion of Mustang Ranch. See Section 2.1.11 below for more information about these projects.) The Nature Conservancy will likely continue to implement restoration projects along the Truckee River. However, their efforts will be limited by the availability of funding. Because no specific restoration projects have been approved and identified as likely to be funded, no specific additional restoration projects are assumed to be constructed on the Lower Truckee River under future without-project conditions.

2.2.4 Recreational Projects and Facilities

The future without-project condition, from a recreation perspective, is a continued but growing deficit in all types of park amenities, but particularly for group picnic areas, open space for concerts, festivals, and sports and practice fields.

Recreation use without the project was estimated to be 1,800,000 recreation days, based on the surveys conducted earlier in the study process (2008). It is anticipated that the total recreation demand will increase over the period of analysis. From FWS estimates, fishing use without the project is estimated to be from 61,000 to 65,000 angler days in that part of the study area influencing angler use. As quality available land and water are limited, recreation opportunities will remain limited.

2.2.5. Regional Transportation Commission Project

Washoe County Regional Transportation Commission (RTC) plans to construct a 5.5 mile north to south roadway in the USACE study area. This roadway is referred to as the SouthEast Connector and spans the Truckee River and smaller creeks in the study area. Construction is planned in two phases:

- Phase 1 begins at the intersection of Greg Street and Sparks Boulevard in the city of Sparks and continues to just south of Clean Water Way, as shown in Figure 2-14. It includes bridges over the Truckee River and over Clean Water Way. Construction of Phase 1 has begun and is scheduled for completion in April 2014. Due to the design of the bridges, there would be no placement of dredged or fill material in waters of the United States and thus no Department of the Army (DA) permit from USACE under Section 404 of the Clean Water Act was required for Phase 1.

- Phase 2 includes a roadway from Clean Water Way to the intersection of South Meadows Parkway and Veterans Parkway. Phase 2 has opposition from citizen groups, including a notice of intent to sue. This roadway does impact jurisdictional waters of the United States, so the RTC must obtain a Section 404 permit. A permit application was recently submitted to USACE. Construction is tentatively scheduled by RTC for 2014 to 2016.

Although it is considered likely that a roadway project will be built, there is significant uncertainty about the final design and effects of the roadway. This uncertainty is due to changes that may be required in order to obtain a DA permit or to resolve the current public opposition. The SouthEast Connector is being designed to avoid any increase in water surface elevations for the 0.85% ACE flood event, but is not being designed to accommodate any future flood risk management project. Due to the high level of uncertainty, the hydraulic effects of the SouthEast Connector were not included in USACE's detailed hydraulic analysis for existing or future without project conditions. Instead, a sensitivity analysis was conducted for the NED Plan. The results of the sensitivity analysis are described in Chapter 6, Section 6.7.

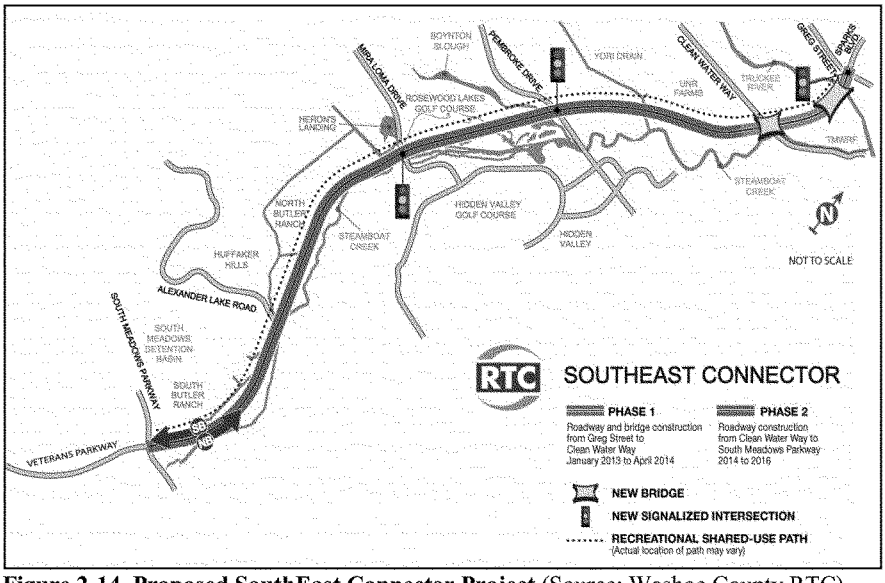

Figure 2-14. Proposed SouthEast Connector Project (Source: Washoe County RTC)

2.2.6 Cultural Resources

Under the future without-project condition, adverse effects to known cultural resources are more likely to occur from abandonment or disrepair rather than future flooding in the Truckee Meadows Reach. Hydraulic modeling indicates the parcels that include the Ferrari Farm historic buildings and structures and the creamery building and barn at Jones Ranch begin to experience flooding between the 1/20 ACE and 1/50 ACE. However, depths remain below 2 feet at the 1/100 ACE on the Ferrari Farms parcel, while flooding at the Jones Ranch creamery building and barn would experience flood depths of up to 6 feet for the 1/100 ACE. Prehistoric archeology sites have been inundated before and do not appear to have suffered any noticeable loss of integrity.

There is insufficient survey information available for the Lower Truckee River reaches to make a clear statement about effects under future without-project conditions. Past flood events generated debris loading on bridge piers, including the Painted Rock Bridge and this debris loading is expected to continue under future without-project conditions. The bridge deck for the Painted Rock Bridge currently overtops at approximately the 2% ACE (also referred to as 1:50, 1/50, or "50-year event"). Maintenance, repair, and potential replacement of the bridge would be expected to be continued by NDOT.

2.2.7 Tribal Lands and Issues

Within the Truckee Meadows Reach, the Reno-Sparks Indian Colony would continue to be affected by potential flooding and flood damages under future without-project conditions. Reno-Sparks Indian Colony trust resources in the Truckee Meadows Reach would continue to be at risk of flooding and flood damages.

Restoration on the Pyramid Lake Paiute Reservation, such as increased water quality and water level in Pyramid Lake, would be limited under without-project conditions. It is expected that the tribe will continue to work with Federal agencies to secure funds for restoration of water quality and the native fishery. Because there is no specific approved plan for restoration on tribal lands that is likely to be funded, it is assumed for planning purposes that no additional restoration will be implemented on tribal lands under without-project conditions.

2.2.8 Completed Local Work Eligible for Credit

The sponsor has constructed several potential project features that had previously received approval from the Assistant Secretary of the Army (Civil Works) for crediting eligibility. It is important to establish the without-project condition with regard to this completed work. The eligible flood risk management work consists of the Reno-Sparks Indian Colony (RSIC) levee/floodwall and the North Truckee Drain (NTD) modifications. Table 2-4 lists the completed ecosystem restoration work and funding sources (Federally-funded work is not eligible for credit). The RSIC levee/floodwall has been constructed, but the NTD modifications have not.

Because this local work was undertaken after approval of consideration for crediting, this work is assumed to not be in place under the without-project condition when formulating or evaluating plans for the same purpose. (For example, the Reno-Sparks Indian Colony Levee is assumed to not be in place when formulating or evaluating flood risk management measures, but would be assumed to be in place when formulating or evaluating ecosystem restoration measures, if it affected any potential restoration measures.) This assumption is necessary to determine whether the locally-constructed work should be included as cost-shared features in the USACE recommended plan. The hydraulic, economic, and environmental analyses for flood risk management include the completed local restoration work in the without-project condition, but exclude the Reno-Sparks Indian Colony Levee from the assumed without-project condition. The North Truckee Drain modifications have not been constructed and are not included in the without-project condition.

Table 2-4. Potentially Eligible Section 113 Restoration Work and Funding Sources

	LOCAL FUNDING SOURCES					FEDERAL FUNDING SOURCES						TOTAL
	TRFMA		WC	Reno/Sparks	SUBTOTAL	USBOR	USBLM	USFWS	FEMA	USACE	SUBTOTAL	
	1/8-cent Sales Tax	AB-5 Grant (State of NV)	SQ-1 Program	TMWRF Sewer Fees	Local Funding	DTL Program	SNPLMA Program				Federal Funding	All Funding Sources
LOCKWOOD (~28 acres) Ecosystem Restoration + Trailhead	$392,000	$0	$2,116,000	$0	$2,510,000	$1,725,000	$0			$0	$1,725,000	$4,236,000
102 RANCH (~ 128 acres) Ecosystem Restoration	$0	$3,100,000	$0	$306,000	$3,406,000	$2,500,000	$500,000	$30,000	$0	$0	$3,030,000	$6,436,000
LOWER MUSTANG RANCH (~ 280 Acres) Ecosystem Restoration	$0	$1,675,000	$1,302,000	$776,000	$3,753,000	$4,217,000	$0	$0	$0	$0	$4,217,000	$7,970,000
TOTAL CONTRIBUTION BY SOURCE:	$392,000	$4,775,000	$3,420,000	$1,082,000	$9,669,000	$8,445,000	$500,000	$30,000	$0	$0	$8,975,000	$18,644,000

Costs include land acquisition; planning, design, and permitting; construction; and short-term monitoring and maintenance
Estimates are approximate and intended only for planning purposes
See chapter 6 for further discussion of Section 113 crediting
Source: D. Henderson, TRFMA 2011

CHAPTER 3
PROBLEMS AND OPPORTUNITIES

This chapter identifies the problems and opportunities in the study area based on the existing and expected future without-project conditions. The main areas of concern include continued flooding in the Truckee Meadows and resulting flood damages, river channel instability, degradation of riparian habitat, restricted fish passage, and the lack of recreation opportunities on the Truckee River.

3.1 Flood Problems

Problem: Flooding poses a life and safety hazard to downtown Reno and Truckee Meadows.

The Truckee Meadows has a long history of flooding from the Truckee River. Five significant floods were recorded in the area in the nineteenth century and at least nine in the twentieth century. Early accounts indicate that flooding took place in the study area in 1861, 1862, 1867, 1886, and 1890. In the Twentieth Century, major floods occurred in 1907, 1909, 1928, 1937, 1950, 1955, 1963, 1986, and 1997. Implementation of flood control measures, beginning about 1960, reduced the magnitude and frequency of flood events. The 1950, 1955, and 1963 events were all similar in magnitude. They were also some of the most damaging of the historical events due to the development of Reno to the south and southwest of the downtown area.

The November 1950 flood was the greatest recorded up to that time, resulting from warm storms that produced more than 5 inches of rain in one day at some locations. A maximum flow of 19,900 cfs was recorded at Reno. Floodwaters extended from West Second Street on the north to Mill Street on the south. All bridges in downtown were closed; the Rock Street Bridge was destroyed; and damage was estimated at $2.5 million (unadjusted 1950 dollars). Flood depths in downtown reached 4 feet and approximately 3,800 acres of agricultural lands were damaged in Truckee Meadows.

A large flood event on the Truckee River occurred on December 23, 1955. A peak flow of 20,800 cfs was measured at Reno where floodwaters reached depths of 5 feet in some downtown locations. In Truckee Meadows, 6,000 acres of farmland sat beneath 6 feet of water for 6 to 10 days. Cannon International Airport (aka Reno/Tahoe International Airport) was flooded, and flights were canceled for several days.

The February 1986 flood event resulted from heavy precipitation upwards of 200% of normal in parts of northwest Nevada. Aided by aggressive flood fighting and the upstream reservoirs at Martis, Stampede, Prosser, and Boca, downtown Reno experienced only minor flooding compared to the 1950 and 1955 floods. The peak flow was 14,400 cfs. Downstream of Vista, overbank flooding damaged property in scattered locations until Pyramid Lake.

The January 1997 event was a significant rain flood event due to a combination of heavy, unseasonably warm rain and snowmelt runoff in the higher elevations. A subtropical storm system originating in the central Pacific Ocean near the Hawaiian Islands brought rains from December 30, 1996 through January 3, 1997. Snowstorms in December 1996 built up the snowpack in the higher elevations of the Sierra Nevada to more than 180 percent of normal. The warm rains falling below the 10,000 ft elevation depleted some of the higher elevation snowpack and melted almost all of the snowpack below 7,000 feet. The peak flow observed at Reno approximately equaled the previous record of December 1955. However, Martis Creek Lake Prosser Creek and Stampede Reservoirs served to reduce the peak considerably in comparison to the 1955 flood. During the peak flow periods, releases from these projects into the Truckee River were near zero. Lake Tahoe releases contributed approximately 2,500 cfs to the peak flows on the Truckee River. The official USGS records for the 1997 flood give a peak flow of 18,200 cfs and 18,400 cfs at the Reno and Vista gages respectively. Personnel at the Hydrologic Engineering Center in Davis, California, calibrated an unsteady state HEC-RAS model to high water marks and determined that the peak values were actually 23,000 cfs and 20,700 cfs, respectively. The USGS has not revised their values. This analysis uses the peak values developed by the Corps. Historic peak values are shown in Table 3-1.

See Appendix A for representative photographs of the major floods described in this section.

The threat to public safety from flooding includes exposure to floodwaters, accidents during evacuation, and accidents during flood fighting. Life safety concerns in the study area are limited due to increased warning times and limited residential areas within the floodplain. However, while limited, life safety remains a concern. Loss of life has occurred during the last several flood events, including the 1997 flood event when one life was lost.

Early in the plan formulation process (prior to 2012), USACE determined that the Downtown Reno reach and the Truckee Meadows/Lower Truckee combined reaches were "separable elements." They are physically separate and hydrologically independent based upon the floodplains developed for the study area, and have separable costs and benefits.

Table 3-1. Peak Flows of Selected Historic Floods since 1900

Date	Regulated			Unregulated		
	Peak Flow (cfs)	Max 1-Day Mean Flow (cfs)	Max 3-Day Volume (ac-ft)	Peak Flow (cfs)	Max 1-Day Mean Flow (cfs)	Max 3-Day Volume (ac-ft)
HISTORICAL RAINFLOODS - TRUCKEE RIVER AT RENO						
18 Mar 1907	18,500	14,600	68,400	18,500	14,600	68,400
16 Jan 1909	10,100	8,540	43,600	10,100	8,540	43,600
26 Mar 1928	18,800 (1)	-	66,900 (1)	-	-	-
11 Dec 1937	17,000 (1)	-	53,100 (1)	-	-	-
21 Nov 1950	19,900	14,100	55,300	20,500	15,660	62,837
04 Dec 1950	11,700	6,580	30,600	-	-	-
23 Dec 1955	20,800	16,200	67,400	27,800	25,670	86,937
02 Feb 1963	18,400	11,500	47,700	33,400	24,480	79,380
23 Dec 1964	11,300	9,400	44,600	24,300	14,560	76,999
17 Feb 1986	14,400	10,000	55,000	-	20,100	93,660
02 Jan 1997	23,000(2)	18,900(2)	-	47,600	37,600	-

(1) Estimated from records at other stations
(2) Estimated by Corps; calibrated HEC-RAS to high water marks (differs from USGS record). USGS record for regulated flow is peak=18,200 cfs and 1-day=17,870 cfs for 1997 flood.

Problem: Flooding incurs damages to structures and their contents in the Downtown Reno and Truckee Meadows reaches.

The 1997 flood is the event of record for the Truckee River and caused over $700 million in flood-related damages, $450 million of which was in the Truckee Meadows area. Much of the damage occurred in the industrial areas of the cities of Sparks and Reno, and at the Reno-Tahoe International Airport. Damages in Rainbow Bend and Wadsworth were relatively modest in comparison, but still exceeded several million dollars. The Verdi Reach did not sustain any substantial flood damages during the 1997 event. Flooding in downtown Reno in 1997 caused roughly $200 million in damages and inundated the Arlington Avenue Bridge, Sierra Street Bridge, Virginia Street Bridge, and Center Street Bridge.

3.1.1 Context of Flooding in the Study Area

The problems caused by flooding in the study area have existed for more than a century. This section provides information on the historic flooding in the study area and information on the floodplain, related flood control projects, the frequency of flooding, and the discharge

frequency of flooding. Potential damages caused by flooding have been documented and analyzed by reach and category in order to quantify the needs a project could meet.

3.1.2. Floodplains

Verdi Reach

Nature of the floodplain within this reach is such that there is no substantial flood risk to structures.

Downtown Reno Reach

The downtown section of Reno is partially in a steep-banked reach of the river. The reach through downtown Reno consists of dense urban development with residential, commercial, and public uses, including casinos and hotels. The City of Reno is currently in the process of redeveloping several blocks of riverfront property in the downtown Reno reach. This redevelopment takes into consideration the current flooding problem and would address it through garage first floors or flood proofing. During times of high flow, structures within the first two blocks of the river can be inundated up to 6 feet or more when the river flows through this part of the city. This flow pattern has been documented more than once in recent times. Since the flooding stems generally from the restrictions of the downtown bridges, flooding is slow with adequate warning time so that life safety is not large concern. Figure 3-1 shows the 5%, 2%, and 1% ACE floodplains for the Downtown Reno Reach.

Truckee Meadows Reach

East of Highway 395 the river emerges from the more channelized upstream reach onto a broader expansion of the plain historically known as the Truckee Meadows. It is this area that receives the greatest inundation of flood flows. The Truckee Meadows area effectively acts to attenuate large flood volumes for Truckee River flows. Flooding in this area is characterized as volume-generated, with ponding due to hydraulic backwater effects backing up Steamboat Creek at its confluence with the Truckee River. Three tributaries contribute to this flooding: Steamboat Creek, Boynton Slough, and the North Truckee Drain. In a 1% Annual Chance Exceedence (ACE) (also referred to as 1:100, 1/100, or "100-year event"), these tributaries contribute approximately one-fourth of the flow. The remaining three-fourths comes from the Truckee River. The reach ends at the Vista Reefs, which constricts outflows from the Truckee River, backing up flood flows throughout the Meadows. Thhe Truckee Meadows Reach has several distinct land uses including commercial, light industrial, and residential. Included in this reach is the Reno/Tahoe International Airport to the south. Flooding around the airport consists of sheet flow up to McCarran Boulevard. Also included in this reach are the industrial areas for the cities of Reno and Sparks. This is one of the most rapidly growing industrial areas that also include commercial and public uses. Flooding in the industrial area consists of both ponding and sheet flow. The existing Truckee River and Tributaries project constructed by USACE in the 1960s provides a minimum capacity of 6,000 cfs in this reach, which is approximately equal to the 20% ACE (also referred to as 1:5, 1/5, or "5-year event") under current hydrology.

Farther southeast, the land use is predominantly rural cropland and includes the land owned and operated by the University of Nevada, Reno, the majority of which is used as pasture. South of the University Farms land, the area has grown rapidly over the past few years to include residential subdivisions. There is additional pressure to further develop the remaining lands along the fringes of the floodplain, with the exception of the existing wetlands, into residential subdivisions and associated commercial areas. Residential subdivisions in this area include Hidden Valley, Rosewood Lakes, Donner Springs, and Double Diamond. Flood-related problems in this area are aggravated by flood flows from the tributary streams of Steamboat Creek, Boynton Slough, and Dry Creek.

Figure 3-2 shows the 5%, 2%, and 1% ACE floodplains for the Truckee Meadows Reach. Each of these floodplains are shown separately in Figures 3-3, 3-4, and 3-5.

Lower Truckee River Reach

Downstream of Vista, the topography confines the floodplains. Long Valley Creek is a major tributary that enters the Truckee River at the community of Rainbow Bend. This creek has a watershed of 107 square miles and has experienced flooding in 1955, 1969, and 1995, with the greatest recorded flow of 5,400 cfs in 1986.

The 1997 flood also affected areas downstream of Vista. The bridge at Painted Rock was overtopped preventing residents from leaving their homes for a short time and threatened the integrity of the bridge foundations. Several homes were flooded when the river went out of bank at Wadsworth.

Figure 3-6 shows the 1% ACE floodplain for Vista to Wadsworth and Figure 3-7 shows the 1% ACE floodplain for Wadsworth to Pyramid Lake.

3.2 Flood Damages

Concentrating on the areas with the greatest potential for economic damages due to flooding, the study focused the economic data collection on the Downtown Reno and Truckee Meadows reaches. For economic evaluation and project performance purposes, the two reaches were divided into 15 economic impact areas. These areas were established to address changes in hydrology, hydraulics, and economic conditions. The delineation also took into account potential flooding locations. Figure 3-8 depicts the Economic Impact Areas (EIAs.) For analysis purposes, these reaches were grouped into the two separable reaches: Downtown Reno (EIA 1) and The Meadows Area (EIAs 2-15) which lies east of I-395 along the Truckee River to Vista.

Damageable property in the Truckee Meadows floodplain consists of commercial, industrial, residential, and public buildings valued at about $5 billion (structures only). Additional effects on the day-to-day business of the Reno-Sparks Metropolitan area would be significant.

Figure 3-1. Existing Floodplains - Downtown Reno Reach (5%, 2%, and 1% ACE floodplains)

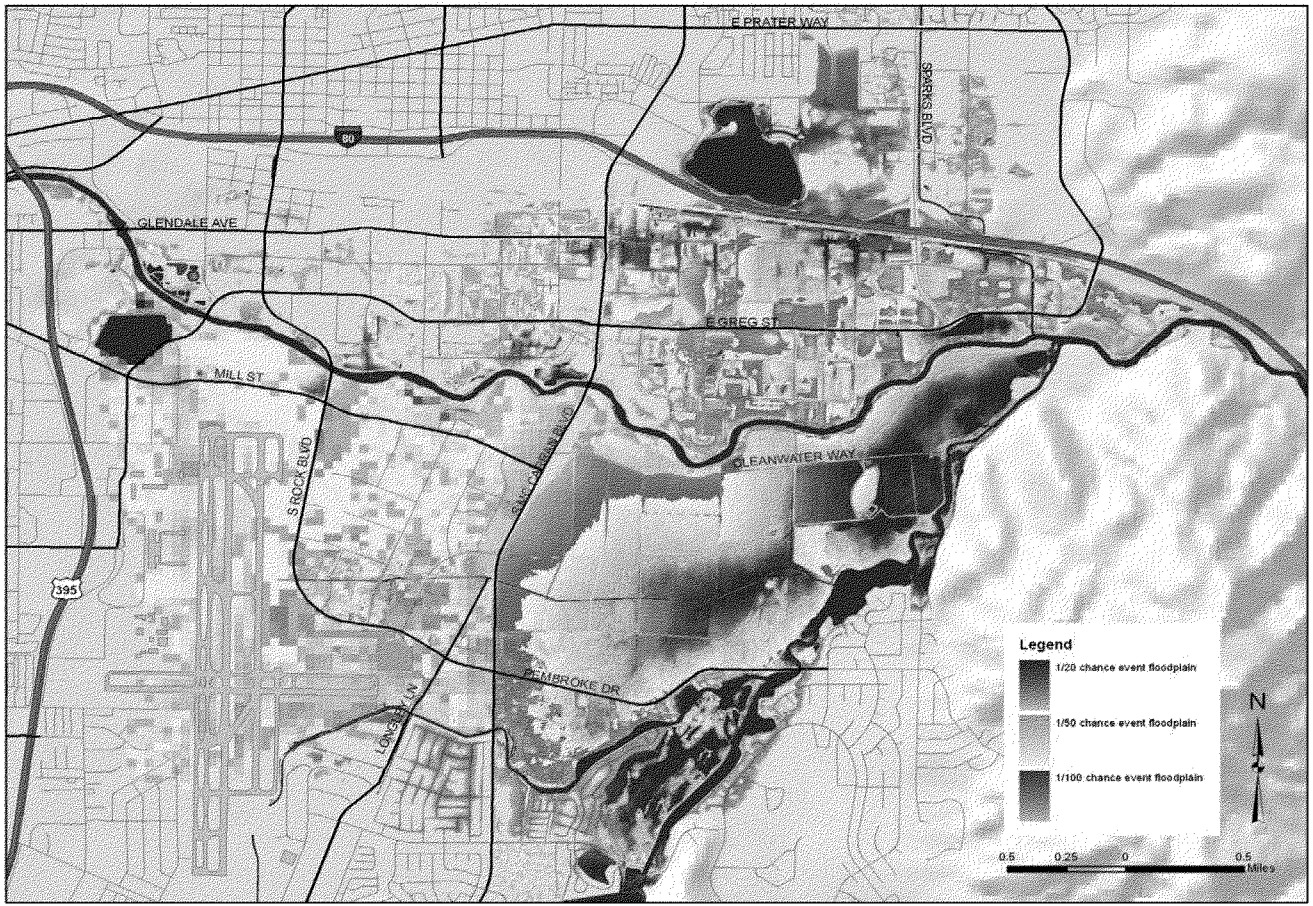

Figure 3-2. Existing Floodplain - Truckee Meadows Reach (5%, 2%, and 1% ACE floodplains)

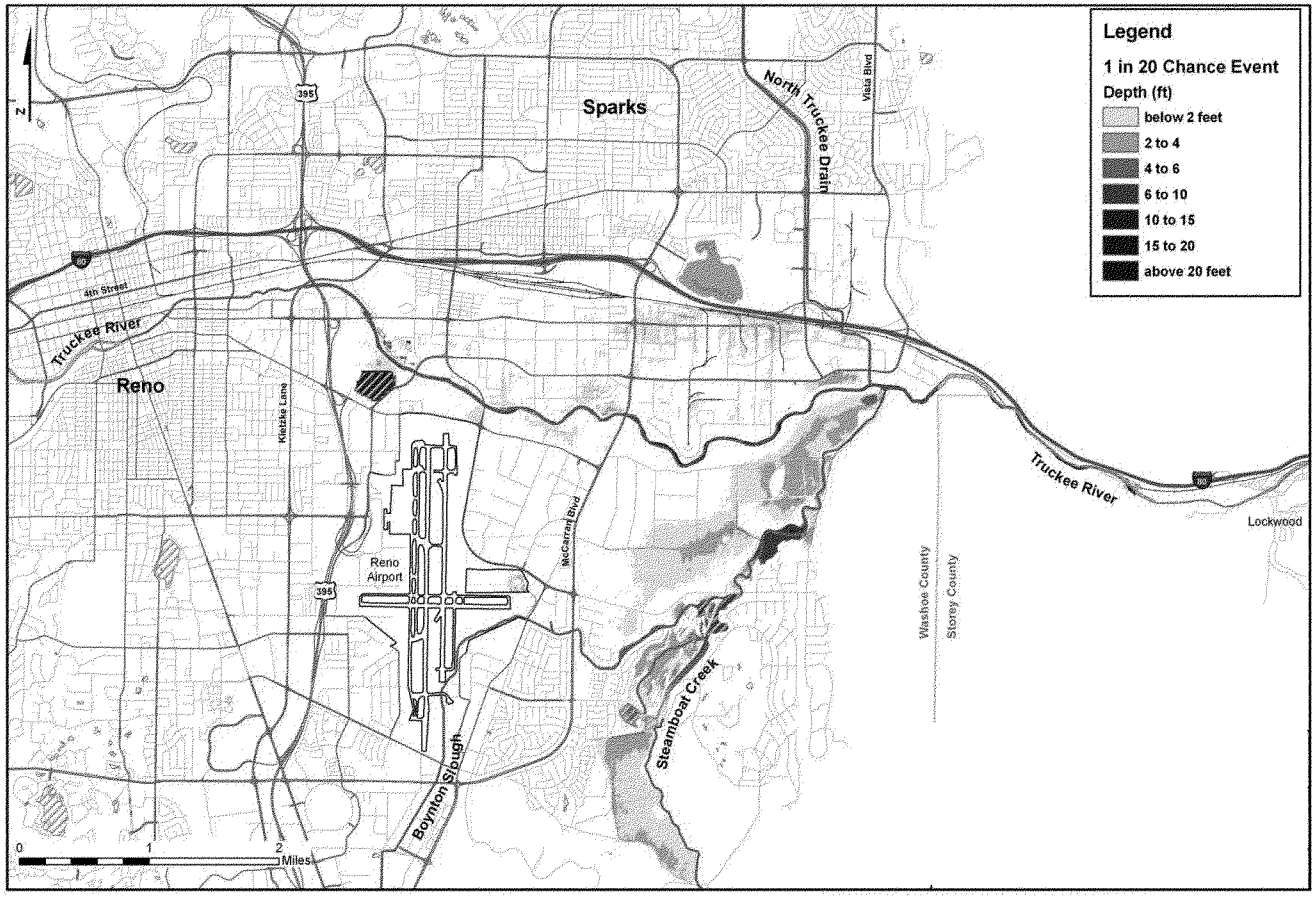

Figure 3-3. Existing Floodplain - Truckee Meadows Reach (5% ACE floodplain)

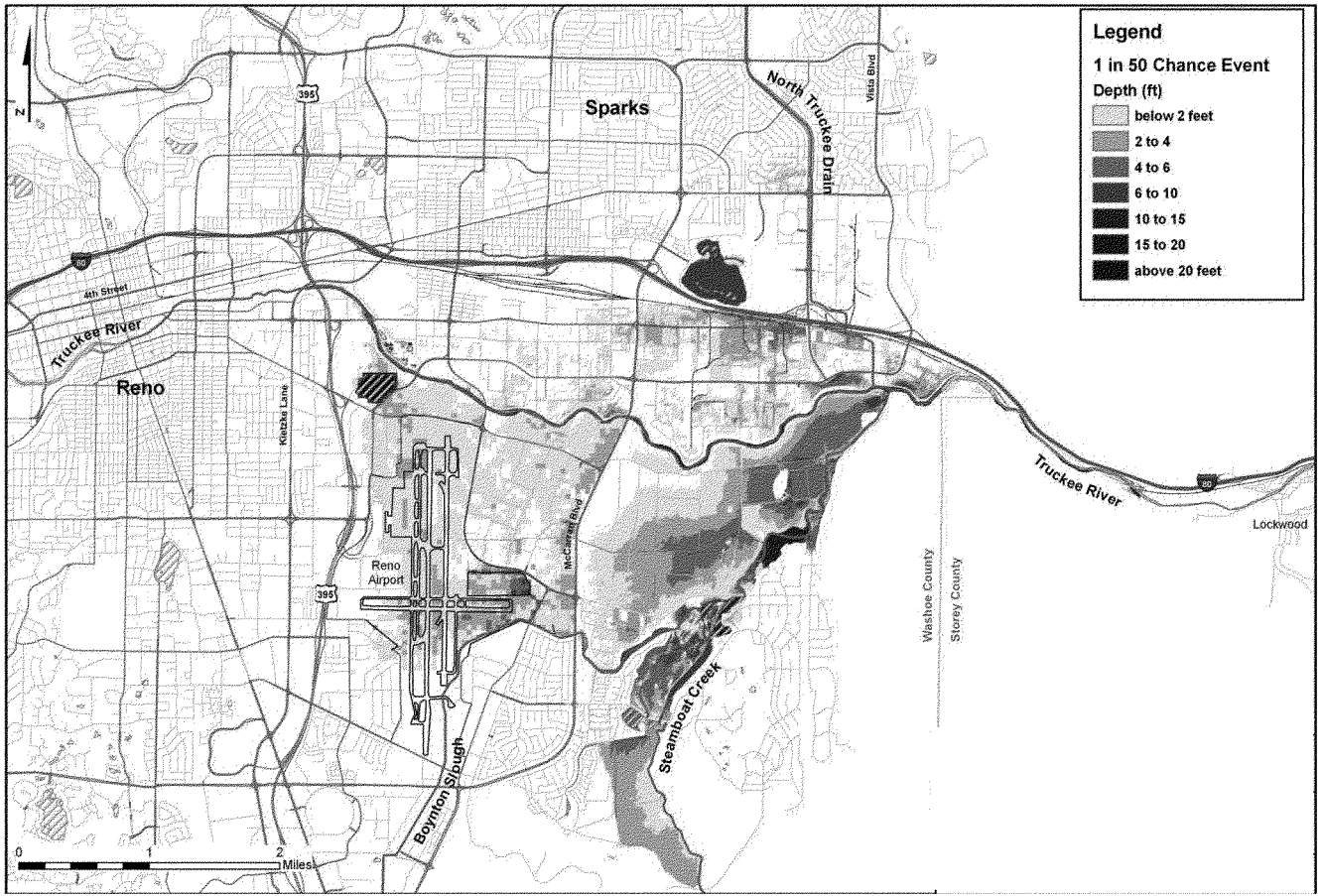

Figure 3-4. Existing Floodplain - Truckee Meadows Reach (2% ACE floodplain)

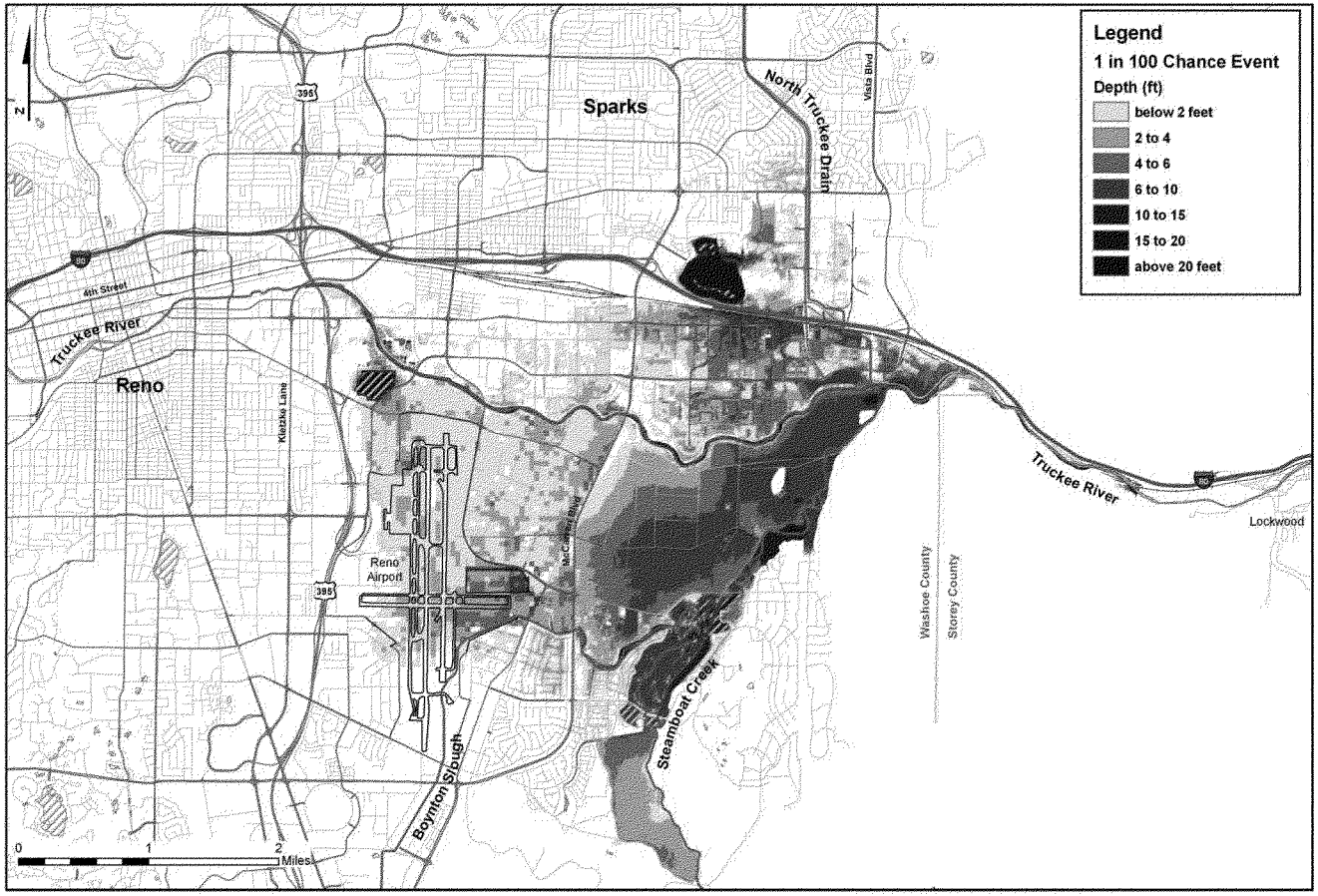

Figure 3-5. Existing Floodplain - Truckee Meadows Reach (1% ACE floodplain)

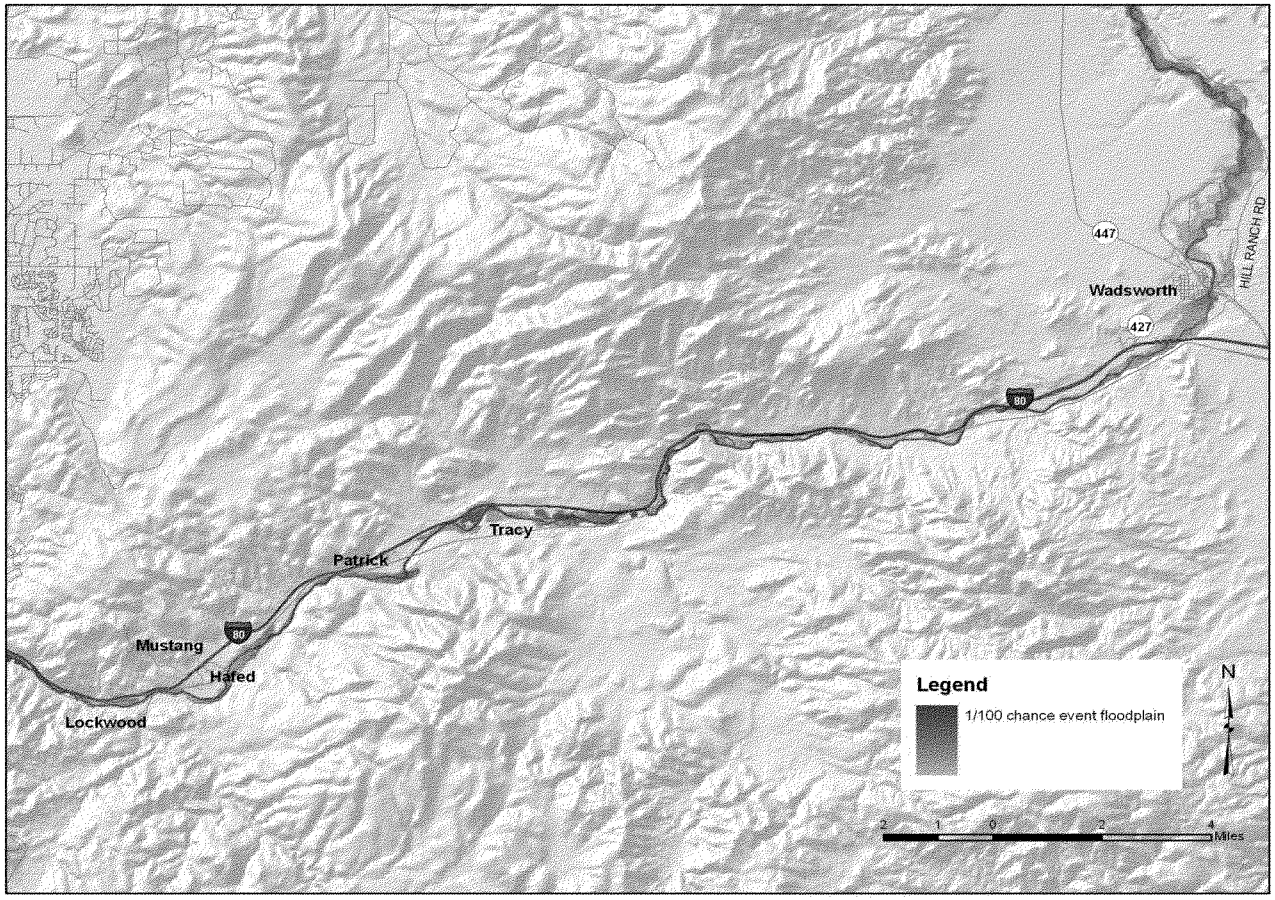

Figure 3-6. Existing Floodplains - Vista to Wadsworth (1% ACE floodplain)

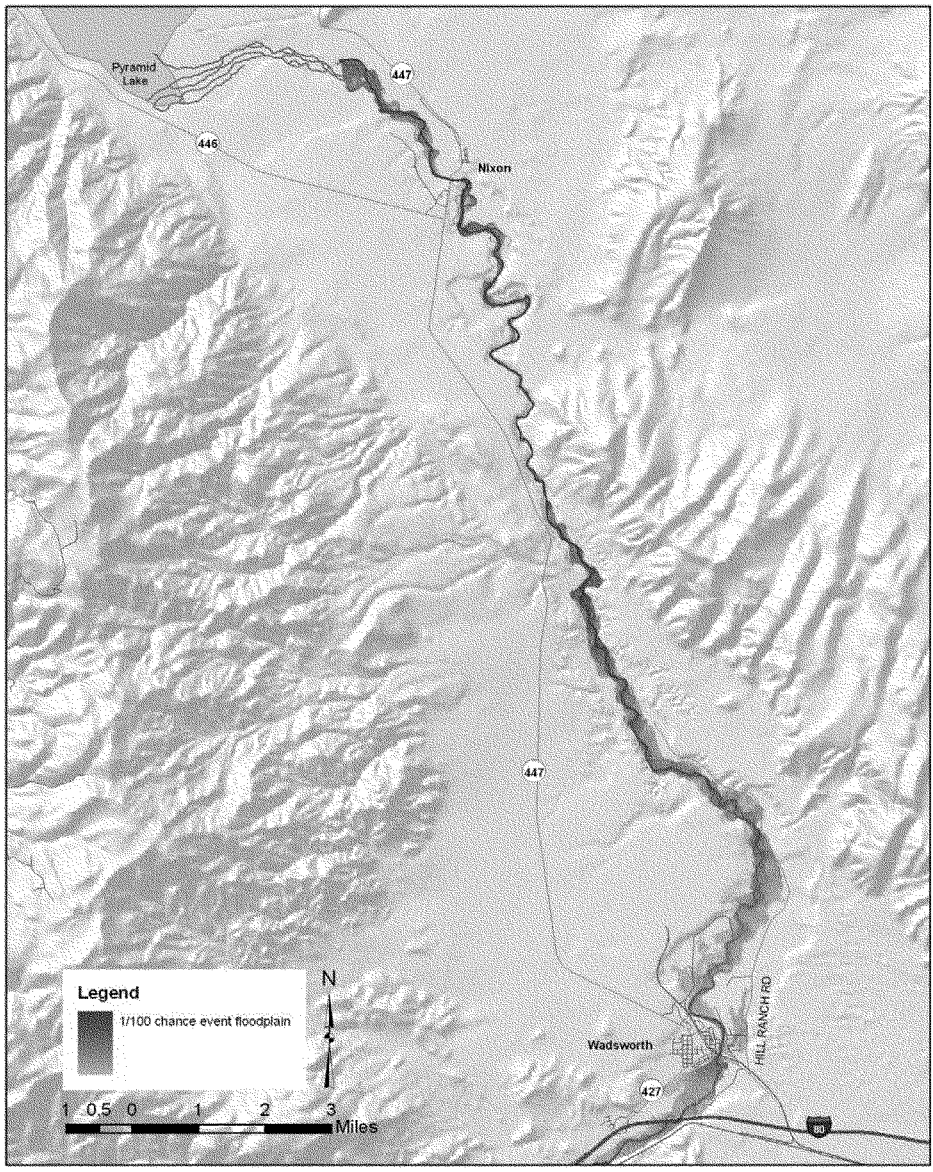

Figure 3-7. Existing Floodplains - Wadsworth to Pyramid Lake (1% ACE floodplain)

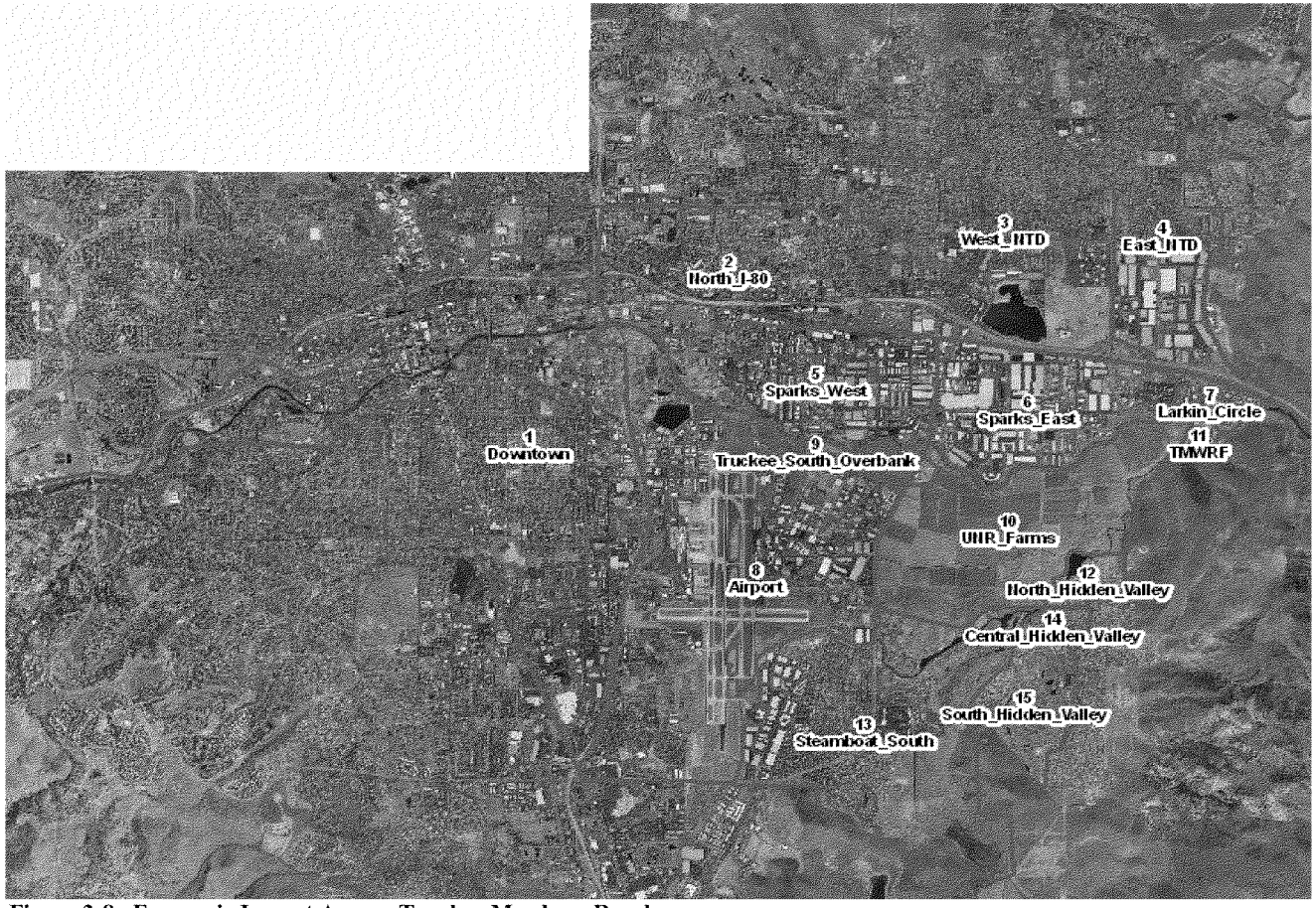

Figure 3-8. Economic Impact Areas - Truckee Meadows Reach

Physical damages caused by inundation losses or flood fighting preparation costs are the main types of flood damages within the floodplain. Physical damages include damages to, or loss of, buildings and their contents, raw materials, goods in process, and finished products awaiting distribution. Other physical damages include damages to lot improvements such as damages to roads, utilities and bridges, and cleanup costs. Additional costs are incurred during flood emergencies for evacuation and reoccupation, flood fighting, and disaster relief. Loss of life or impairment of health and living conditions are intangible damages that cannot be evaluated in monetary terms and have not been included in this analysis. Discussion of these potential effects can be found under Other Social Effects in Chapter 6.

3.2.1 Inventory

Land uses within the floodplains were determined based on parcel data characteristics, aerial photographs and visual inspections. GIS parcel data were provided by Washoe County which includes detailed information regarding land use, building type, square footage and other structural characteristics such as number of stories. Additional data on foundation heights and other structure qualities were noted in the inventory during field data collection. General land/building uses identified include: residential, commercial, casinos, public, and industrial.

- Residential. One- and two-story single family homes, duplexes, apartments, condominiums and mobile homes. Losses include structures and contents.

- Commercial. Shopping centers, offices, retail outlets, motels, hotels, and restaurants. Losses include structures, fixtures, and inventory.

- Casinos. Gaming facilities and casino hotels were separated from the standard commercial uses. Losses include structures, fixtures, and inventory.

- Public. Schools, hospitals, public organizations, offices, police and fire stations, utilities, and churches. Losses include structures and contents.

- Industrial. Warehouses, distribution centers, processing and packaging plants. Losses include structures and contents.

3.2.2 Value of Damageable Property - Structure Value

Depreciated structure values were calculated by obtaining improvement values from Washoe County assessor's data. With over 12,000 structures, valuation using direct depreciated cost valuation of each individual structure was not possible. These values were revised using Marshall and Swift valuation to represent current price levels in the inventory database used in the economic analysis. Table 3-2 depicts the number of structures, by damage category and flood event, within the study area.

Table 3-2. Total Number of Structures within the Study Area

Damage Category	Annual Chance Exceedance Flood Event						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
RES	0	3	21	318	1,237	5,938	10,086
COM	0	4	12	111	200	789	1,121
CASINOS	0	0	0	0	9	49	79
PUB	0	7	15	67	106	286	325
IND	0	9	55	269	436	682	825
TOTAL	**0**	**23**	**103**	**765**	**1,988**	**7,744**	**12,436**

Damage Category Definitions: RES – Residential, COM – Commercial, PUB – Public facilities, IND – Industrial buildings

3.2.3 Value of Damageable Property - Content Value

In addition to structures, building contents can also be at risk of flood damages. For this study, content values were estimated as a percentage of depreciated structure value based on land use. Content surveys were made to determine content percentages specific to the Sparks Industrial Area. For this reevaluation study, additional content surveys were completed to confirm or adjust values used in the original study.

Total value of damageable property includes the structural and content values described for the parcels within the 0.2% ACE (also referred to as 1/500, 1:500, or "500-year" event) floodplain. The breakdown of the value of structures and contents within the study area by event is located in Table 3-3. The breakdown of the damageable property by reaches is located in Appendix C – Economics.

3.2.4 Expected Annual Damages - Without Project Condition

Expected Annual Damages (EAD) were estimated using the risk-based Monte Carlo simulation program called HEC-FDA (version 1.2.4). The HEC-FDA program integrates hydrology, hydraulic, geotechnical, and economic relationships to determine damages, flooding risk, and project performance. Uncertainty is included for each relationship. The model samples form a distribution for each observation to estimate damage and flood risk and have the following relationships built in for each economic damage reach:

- Probability-Discharge - with uncertainty determined by the period of record
- Stage-Discharge - stage in the channel with estimated error in feet
- Interior-Exterior Stage - stage in the floodplain vs. stage in the channel
- Stage-Damage - for each damage category

In the HEC-FDA model, the stage-damage functions listed above were integrated with the discharge-exceedance probability functions and the stage-discharge functions utilizing a Monte Carlo simulation process. The derived probability-damage function was then integrated in the model to determine expected annual damages under without-project conditions. Detailed EAD by probability distribution can be found in Appendix B.

EAD under the without-project condition for the Downtown Reno and Truckee Meadows reaches was estimated for each damage category for all damage reaches. Table 3-4 summarizes the results. In total, there are $69.8 million in expected annual damages, with 12 percent of those damages occurring in the Downtown Reno Reach. Over 68% of all damages in the study area are from losses to industrial structures and contents.

The Lower Truckee River Reach was evaluated for flood risk, and it was determined that no substantive problem exists under the without-project condition. Since the reach is highly rural with limited population the flood risk to life and structures is very low.

Table 3-3. Value of Structures and Contents[1, 2] at Risk within Study Area by Event

Damage Category	Annual Chance Exceedance Flood Event						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
	Structure Value						
RES	0	104	1,731	61,760	255,353	796,015	1,284,139
COM	0	3,745	5,976	281,445	405,633	931,829	1,111,524
CASINOS	0	0	0	0	75,651	306,509	661,129
PUB	0	702	1,066	28,912	93,168	181,587	229,925
IND	0	14,095	100,118	522,933	891,191	1,267,637	1,546,199
TOTAL STRUCTURE	*$0*	*$18,646*	*$108,891*	*$895,050*	*$1,720,995*	*$3,483,577*	*$4,832,916*
	Content Value						
RES	0	52	865	30,880	127,677	398,008	642,070
COM	0	3,745	5,976	281,445	405,633	931,829	1,111,524
CASINOS	0	0	0	0	117,258	475,089	1,024,750
PUB	0	351	533	14,456	46,584	90,794	114,962
IND	0	70,347	495,356	2,339,589	4,010,424	5,598,708	6,739,329
TOTAL CONTENT	*$0*	*$74,495*	*$502,730*	*$2,666,370*	*$4,707,576*	*$7,494,427*	*$9,632,636*
TOTAL VALUE	**$0**	**$93,142**	**$611,621**	**$3,561,420**	**$6,428,571**	**$10,978,004**	**$14,465,552**

1. Damage Category Definitions: RES – Residential, COM – Commercial, PUB – Public facilities, IND – Industrial buildings
2. See Economic and Engineering Appendices regarding uncertainty.

The data in the damageable property tables above provide the basis for the following summary statistics:

- Total depreciated value of structures at risk of flooding (within the 0.2% ACE floodplain): $4.8 Billion.

- Total Value of Contents within at-risk structures: $9.6 Billion (Content-to-Structure value percentages used: Residential, 50%; Commercial, 100%; Casinos, 155%, Public, 50%, Industrial-light manufacturing, 160%, Industrial-Distribution Centers and Storage Warehouses, 558% (from fieldwork)).

- Total Value of Property at Risk (within the 0.2% ACE floodplain): $14.4 Billion.

Table 3-4. Expected Annual Damages Without Project[1] – by Category[2]

Economic Impact Area	AUTO	CAS	COM	IND	PUB	RES	PUB-INFR	TOTAL
Downtown Reno								
1-Downtown	401	3,657	1,864	298	1,116	1,058	0	**$8,394**
The Meadows Area (east of I 395 to Vista)								
2-North I-80	99	318	115	119	56	156	41	**$904**
3-West NTD	438	96	418	755	51	1,648	161	**$3,567**
4-East NTD	45	0	139	5,477	34	323	231	**$6,249**
5-Sparks West	2	11	183	2,933	7	9	43	**$3,188**
6-Sparks East	0	0	300	27,828	31	3	35	**$28,197**
7-Larkin Circle	0	0	37	1,078	1	0	2	**$1,118**
8-Airport	53	49	2,819	8,295	7	129	2,866	**$14,218**
9-Truckee South Overbank	0	0	1	296	6	1	0	**$304**
10-UNR Farms	1	0	5	0	1	3	0	**$10**
11-TMWRF	0	0	0	59	0	0	0	**$59**
12-North Hidden Valley	6	0	0	0	0	110	0	**$116**
13-Steamboat South	314	0	214	1,258	42	1,554	4	**$3,386**
14-Central Hidden Valley	7	0	0	0	1	47	0	**$55**
15-South Hidden Valley	7	0	0	0	0	103	0	**$110**
Sub-Total (2-15)	***$972***	***$474***	***$4,231***	***$48,098***	***$237***	***$4,086***	***$3,383***	***$61,481***
TOTAL	**$1,373**	**$4,131**	**$6,095**	**$48,396**	**$1,353**	**$5,144**	**$3,383**	**$69,875**

[1](October 2013 Prices, $1,000s);See Economic Appendix for economic uncertainty.
[2] Damage Category Definitions: AUTO – Automobile, CAS – Casino, COM – Commercial, IND – Industrial buildings, PUB – Public facilities, RES – Residential, PUB-INFR – Emergency/Public infrastructure.

3.2.5 Project Performance

In accordance with ER 1105-2-101, three statistical measures are provided to describe performance risk in probabilistic terms. These include annual exceedance probability (AEP), long-term risk, and assurance by events. AEP measures the chance

of having a damaging flood in any given year. Long-term risk provides the probability of having one or more damaging floods over a period of time (10, 30, or 50 years). Assurance indicates the chance of not having a damaging flood given a specific event. Existing condition performance statistics for each impact area are displayed in Table 3-5.

Table 3-5. Project Performance – Without-Project Condition[1]

EIA	AEP	LONG-TERM RISK			ASSURANCE BY ANNUAL CHANCE EVENT					
		10	30	50	10%	4%	2%	1%	0.40%	0.20%
1	2.7%	24%	50%	75%	99%	85%	32%	5%	0%	0%
2	0.9%	9%	20%	36%	99%	99%	96%	67%	16%	3%
3	3.0%	27%	54%	79%	99%	72%	30%	10%	0%	0%
4	3.3%	28%	57%	81%	98%	76%	40%	17%	1%	0%
5	5.3%	42%	74%	93%	96%	33%	4%	0%	0%	0%
6	3.9%	33%	63%	86%	99%	58%	21%	1%	0%	0%
7	2.1%	19%	42%	66%	99%	91%	60%	8%	0%	0%
8	10.1%	65%	93%	99%	54%	5%	0%	0%	0%	0%
9	4.1%	34%	64%	87%	97%	59%	17%	2%	0%	0%
10	19.4%	89%	99%	99%	26%	5%	1%	0%	0%	0%
11	1.1%	11%	25%	44%	99%	99%	96%	47%	2%	0%
12	6.1%	47%	79%	96%	85%	47%	18%	1%	0%	0%
13	2.6%	23%	49%	74%	99%	84%	56%	11%	0%	0%
14	3.9%	33%	63%	86%	95%	69%	37%	5%	0%	0%
15	2.8%	25%	51%	76%	98%	83%	55%	10%	0%	0%

1. See Engineering and Economic Appendices for information about project performance uncertainty.

Risk and Uncertainty

For this study, USACE risk assessment procedures, incorporating uncertainty analysis, were followed. These procedures incorporate the best-available hydrologic, hydraulic, geotechnical, and economic information to compute expected annual damage (EAD), accounting explicitly for uncertainty in the information.

Each aspect of the flood risk assessment must account for uncertainty. For hydrologic and hydraulic analysis, the principle variables are discharge and water surface elevation. Uncertainty in discharge exists because record lengths are often short or do not exist where needed, precipitation-runoff computation methods are inaccurate, and the effectiveness of flood flow regulation measures is not known precisely. Uncertainty factors that affect water surface elevation include conveyance roughness, cross-section geometry, debris accumulation, ice effects, sediment transport, flow regime, and bed form. For geotechnical and structural analyses, the principle source of uncertainty is the structural performance of an existing levee due to its physical characteristics and construction quality. Uncertainty also arises from a lack of information about the relationship between depth and inundation damage, lack of accuracy in estimating

structure and content values and locations, and the lack of ability to predict how the public will respond to a flood. These specific variables were explicitly accounted for in this risk assessment and via a sensitivity analysis. The uncertainty in the hydrology most influences the damage and engineering performance outputs and thus the alternative selection. However, variables not explicitly evaluated that could influence future performance include climate change, or unforeseen changes in the watershed conditions such as unplanned growth or dramatic changes in agricultural practices.

Details pertaining to how uncertainties were accounted for can be found in the report appendices. This applies to the existing and future without-project conditions, development and evaluation of alternative plans, and selection of a plan.

3.3 Ecosystem Problems and Opportunities

Problem: The quality and quantity of riparian and related floodplain habitats have diminished along the Truckee River.

The Truckee River was an integral part of a healthy riparian forest dominated by a cottonwood forest, willows, and alders. Historical accounts supported by geomorphic and photographic evidence indicate that the river channel was once well connected to its floodplain, its banks abundant with willow growth supporting a continuous, multi-canopied riparian forest.

Habitat supported by the Truckee River began to decline with the settlement of the area by European emigrants in the early 1850's. Degradation continued through the turn of the century with the completion of the Newlands Project that diverted flows of the Truckee River into the adjacent Carson River watershed for irrigation.

In 1954, USACE was authorized to construct the Truckee River and Tributaries Project to protect the cities of Reno and Sparks from frequent flooding by straightening, widening, and deepening large expanses and reaches of the river channel from Lake Tahoe to Pyramid Lake. This project caused excessive erosion and entrenchment of the river channel because of the altered hydrologic and geomorphologic conditions. This combined with other urban and agricultural encroachments into the floodplain caused substantial destruction and fragmentation of the riparian forest.

Associated floodplain habitats have also decreased significantly, especially wetlands habitat. These habitats were generally associated with riparian corridors and as those corridors diminished, so did the associated floodplain habitats.

Disturbed land areas that have a lack of vegetative cover allow for the introduction and dispersal of nonnative plant species. Among these species are tall whitetop, musk thistle, common ragweed, Canada thistle, bull thistle, poison hemlock,

prickly lettuce, whitetop, purple loosestrife, Russian thistle, Russian knapweed, yellow starthistle, cocklebur, and tamarisk. All of these invasive plant species have very low wildlife habitat value.

Whitetop, a nonnative invasive plant species, is prevalent in the upper reaches of the Truckee River below Vista. This plant species is most commonly associated with agricultural fields, river scoured areas, and other disturbed areas all characteristic of the Truckee River within the study area.

Tamarisk is another well-documented invasive plant species in the West and is found in the lower portion of the study area along the Truckee River between Wadsworth and Pyramid Lake. Tamarisk plants evapotranspire large amounts of water into the atmosphere. The amount of water consumed by tamarisk reduces the amount of water available for wildlife and for native riparian and wetland plant communities. Tamarisk tends to form dense, monotypic stands, outcompeting native vegetation.

Problem: The Truckee River is no longer a stable river system.

River damming, diminished flows, riparian forest destruction, and channel alterations all have contributed to channel instability throughout the study area. The banks in some areas have been stabilized with rock to protect the land from erosion. The Truckee River suffers in some reaches from considerable erosion that undercuts streamside habitat and results in barren streambanks with no habitat value.

Work done for the Truckee Meadows, Reno-Sparks Metropolitan Area, Nevada, Hydrology Report, 1980, documented that historic peak flows attenuated as they moved downstream. However, under regulated conditions, flows actually get larger as they move downstream. This hydrological occurrence can be related to the channelization work done in the lower river by USACE in the 1960's. This work likely induced geomorphic instability in the river.

Between Vista and Wadsworth, significant quantities of sediment have historically been delivered to the river by tributary alluvial fans. Due to the construction of Truckee Canal and Interstate 80 through the canyon, sediment delivery to this reach of the river has been significantly reduced. This lack of balance in the erosion/deposition characteristics normally seen in a healthy river system prevents the Truckee River from recovering on its own.

The channel in some locations has become incised, stranding cottonwood riparian forests on benches. Cottonwoods that depend on a wet substrate for seed germination and development are now isolated from all but the more extreme flood flows. Eventually these isolated forests will die without regenerating new growth.

Problem: The quality and quantity of aquatic habitat have diminished, causing adverse effects on the aquatic ecosystem, including special status fish species.

The Truckee River suffers from persistent water quality problems. Flows entering the study area have a high nutrient content largely from treated sewage effluent, agricultural runoff, and urban stormwater runoff. High nutrient levels accelerate algae growth and other indicators of water pollution, including physical and biological changes such as elevated aquatic temperatures and total dissolved solids, lowered dissolved oxygen levels, and modified existing biota towards pollution-tolerant species. Tertiary treated sewage enters the Truckee River from many treatment facilities throughout the system.

High instream temperatures are another significant water quality problem. Many factors influence instream temperature within the downstream reach of the Truckee River: loss of overstory shading through direct and indirect removal of riparian vegetation, lower than normal water flow levels due to diversions, naturally occurring thermal springs (upstream on Steamboat Creek), natural and human-induced surface runoff including agricultural flows, and decomposition of organic materials. High water temperatures result in less than optimum habitat conditions for cold water fish species including the Federally listed cui-ui lake sucker (*Chasmistes cujus*) and the Lahontan cutthroat trout (*Oncorhynchus clarki henshawi*) (LCT), and allow for the introduction of warm water species (native and nonnative) in their place.

The water quality of the Truckee River affects Pyramid Lake. Poor water quality has led to large blue-green algae "blooms" within Pyramid Lake that then further decrease water quality for the species present.

Problem: Passage of spawning fish species from Pyramid Lake is obstructed by various artificial barriers.

Construction of dams and water diversions has severely affected the movement of aquatic species throughout the Truckee River system. In particular, these structures act as complete or partial barriers to the upstream migration of the Federally listed LCT and cui-ui fish species to their historic spawning and rearing habitat. As a result, these native fish species are often forced to use sub-optimal habitats, reducing fish productivity and annual survivorship. Barriers are located starting at Marble Bluff Dam just upstream of Pyramid Lake up through the Verdi Reach into California. A list is included in Table 3-6.

Opportunity: Incorporate environmentally sustainable design into features and restore fish passage

There is an opportunity to incorporate environmentally sustainable design into flood risk reduction features and restore fish passage on the Truckee River.

Table 3-6. Primary Fish Passage Barriers on the Truckee River

Barrier Name	Function	Ownership
Marble Bluff	Grade Control	USBOR/FWS
Numana	Irrigation	USBIA/PLPT
Olinghouse #3	Irrigation	PLPT
S-S	Irrigation	UNR
Fellnagle	Irrigation	PLPT
Olinghouse #1	Irrigation	PLPT
Proctor	Irrigation	PLPT
Pierson	Irrigation	PLPT
Herman Ditch	Irrigation	PLPT
Gregory Ditch	Irrigation	Private
Washburn Ditch	Irrigation	Private
Derby	Irrigation	USBOR

3.4 Recreation Problem and Opportunity

Problem: Recreation opportunities have not kept pace with the increased demand stemming from increased population in the Reno/Sparks area.

The increase in population within the Reno-Sparks metropolitan area has caused an increase in demand for recreation. Existing facilities are unable to meet the current and projected future demand.

In particular, an insufficient number of outdoor recreation opportunities are located close to the population centers, where many lower-income and least formally educated citizens live. The 2010 Nevada Statewide Outdoor Recreation Plan indicates that lower income and lesser educated residents participate in outdoor recreation at lower rates than other groups. The America's Great Outdoors Initiative encourages recreation facilities to be located near populated areas to help serve these communities.

Opportunity: Incorporate recreation features associated with flood risk reduction and ecosystem restoration features.

There is an opportunity to incorporate outdoor recreation features, such as trails and kayak access, into flood risk management and ecosystem restoration features.

3.5 Summary of Problems and Opportunities

Reduction of flood damages, restoration of riparian areas and fish passage, and provision of recreation amenities were identified as opportunities addressing the problems and potentially having Federal interest.

Problems

- Flooding poses a threat to life and safety in downtown Reno and Truckee Meadows.
- Flooding incurs substantial damages to development in the Downtown Reno and Truckee Meadows.
- The quality and quantity of riparian and related floodplain habitats have diminished along the Truckee River.
- The Truckee River is no longer a stable river system.
- Passage of spawning fish species from Pyramid Lake is obstructed by various artificial barriers.
- Recreation opportunities have not kept pace with the increased demand stemming from increased population in the Reno/Sparks area.

Opportunities

- Incorporate environmentally sustainable design into flood risk reduction features and restore fish passage on the Truckee River downstream to Pyramid Lake.
- Incorporate recreation features associated with flood risk reduction and ecosystem restoration features.

CHAPTER 4
DEVELOPMENT OF ALTERNATIVE PLANS

This chapter discusses the development of alternative plans to help address the flood risk management, ecosystem restoration, and recreation problems in the study area. This formulation process focused on the primary purpose of flood risk management.

The development of alternative plans discussed in this chapter includes the evaluation of preliminary alternatives, including preliminary flood risk management alternatives for both the Downtown Reno and Truckee Meadows reaches. Alternatives that were carried forward for more detailed evaluation are discussed in Chapter 5.

4.1 Plan Formulation Process

Plan formulation is the multi-step process used to develop and evaluate alternative plans that meet national goals and planning objectives, and avoid planning constraints. After problems and opportunities are identified, the next step in this process is to identify the goals, objectives, and constraints that apply to this project. Once this is done, potential management measures can be proposed to achieve the project's objectives.

Next, the management measures are screened, and the most feasible ones are combined into preliminary alternative plans that focus on the project's potential purposes. After the screening of these preliminary alternative plans, the final array of alternative plans is selected for further evaluation based on planning criteria, including economic feasibility.

4.2 National Planning Goals

The Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G) require that Federal water and related land resources projects contribute to National Economic Development (NED) in a manner consistent with protecting the Nation's environment. Contributions to NED are achieved by increasing the net value of the Nation's output of goods and services, expressed in monetary units.

USACE projects for ecosystem restoration must contribute to National Ecosystem Restoration (NER) outputs by restoring degraded ecosystem structure, function, and dynamic processes to a less degraded, more natural condition. Contributions to NER are increases in ecosystem value and productivity, and are measured in non-monetary units such as average annual habitat units or acres.

4.3 Planning Objectives

Planning objectives are based on an analysis of existing and future conditions in the study area. Objectives are developed to address the problems and opportunities that were identified in this analysis and represent desired beneficial changes in future conditions.

The planning objectives for this study address three project purposes: flood risk management, ecosystem restoration, and recreation. The objectives for each of these project purposes are listed below. Each of these objectives applies to the 50-year period of analysis for this study. For each project purpose, the USACE objective is to maximize benefits relative to costs, consistent with the National planning goals. The sponsor also has a local objective of being able to accommodate flows from the 1% Annual Chance of Exceedance (ACE) (also referred to as 1:100, 1/100, or "100-year" event). This is consistent with National Flood Insurance Program (NFIP) criteria. USACE could not meet this local objective when selecting a plan because the economic analysis indicated that this was not economically justified.

Restoration of vegetation and aquatic habitat in and along the Truckee River was initially identified as an objective for this study. However, after preliminary alternatives were formulated and evaluated, it was determined that habitat restoration would not be considered further in this GRR.

4.3.1 Flood Risk Management

- Reduce flood damages in the Downtown Reno and Truckee Meadows reaches along the Truckee River and tributaries from overbank flows to the fullest extent consistent with Federal participation and community financial capabilities.

- Reduce the potential for loss of life from flooding from the Truckee River.

4.3.2 Ecosystem Restoration

- Improve fish passage at the dams and water diversion structures along the Truckee River between Lake Tahoe and Pyramid Lake.

4.3.4 Recreation

- Increase recreational opportunities along the Truckee River between Highway 395 and Vista.

4.4 Planning Constraints

A constraint is a restriction that limits the extent of the planning process. Constraints are designed to avoid undesirable changes in future conditions. A universal constraint for all project purposes is that the study will comply with all applicable Federal laws, regulations, and policies. The following constraints were identified to direct plan formulation efforts so that unacceptable adverse effects would be avoided.

4.4.1 Flood Risk Management

- Avoid adverse effects to threatened and endangered species, including the cui-ui and Lahontan cutthroat trout.

4.4.2 Ecosystem Restoration

- Avoid adversely affecting adjudicated water allocation in the Truckee River.

4.4.3 Recreation

- Limit recreation features within the runway clear zone or runway protection zone at the Reno/Tahoe International Airport.

4.5 Description and Screening of Management Measures

A management measure is a feature or an activity that can be implemented to address one or more of the planning objectives. After numerous collaborative meetings with the sponsor, other agencies, and the Community Coalition, a comprehensive list of flood risk management, ecosystem restoration, and recreation measures was compiled and then screened to determine which measures appeared to be feasible in the development of alternative plans.

This screening involved evaluating the potential effectiveness and efficiency of each measure. In this context, effectiveness was determined by how well a measure met the planning objectives. A simple scale of low, medium, or high was used. Measures that did not meet any planning objectives or scored low were dropped from further consideration. Efficiency was determined by the potential benefits and costs of the measure. Professional judgment and existing economic data were used to estimate the benefits and costs of each measure. Measures were determined to be efficient if benefits were at least equal to the estimated costs. Those measures for which the estimated costs far exceeded the benefits were dropped from further consideration.

A Value Engineering (VE) study was conducted in 2004 prior to the Alternative Review Conference (South Pacific Division Milestone F4) in accordance with SPD guidance. The purpose of the VE study was to ensure that the widest range of feasible and cost-efficient measures were considered and that alternatives formulated from those measures are not limited to those that first came to mind at the initiation of the GRR. Documentation of the VE study is available in the District's files.

This section describes the measures and discusses the reasons why the measures were either retained or dropped from further consideration. The results of the screening are summarized in Tables 4-1, 4-2, and 4-3.

4.5.1 Flood Risk Management: Nonstructural Measures

Nonstructural measures attempt to avoid flood damages by changing the use of the floodplains, accommodating existing land uses to the flood hazard, or excluding or removing damageable properties from flood-prone areas. These measures do not affect the frequency or level of flooding within the floodplain; rather, they affect floodplain activities.

The following flood risk management measures (both nonstructural and structural) were considered for the Downtown Reno and Truckee Meadows Reaches.

Flood Insurance

Under the authority of the National Flood Insurance Program42 U.S.C. § 4001, *et. seq.*, the Federal Emergency Management Agency (FEMA) has directed the Federal Insurance Administration to provide emergency assistance and Federally subsidized flood insurance for those residences and businesses projected to be affected by flooding. This measure has been implemented in the project area and is part of the future without- project condition. Therefore, this measure was dropped from consideration.

Early Flood Warning System

In previous investigations, this measure was considered as a potential solution for flood risk management. Subsequently, an early flood warning system was evaluated as part of the USACE Continuing Authorities Program and found to be justified. The Reno Early Flood Warning System is currently in place and is considered as a future without-project condition. Therefore, this measure was dropped from consideration.

Flood-proofing

Flood proofing of all structures within the floodplain would have a very high cost due to the large size of the floodplain; large numbers of residential, commercial, and industrial structures in the floodplain; and deep flood depths. However, as a selectively used measure, it could have high effectiveness. As a result, this measure was retained for further consideration.

Large Scale Floodplain Evacuation

Floodplain evacuation would include evacuating all buildings located within the floodplain and/or relocating structures to higher ground, raising materials above floodwaters, or removing materials to higher ground. Permanent evacuation of developed areas subject to inundation during high flows involves the acquisition of lands by purchase (through the local power of eminent domain, if necessary), removal of structural improvements, and relocation of the population. Lands acquired in this manner would be devoted to agriculture, parks, or permanent open space that would not impede flood flows.

To assess the potential accomplishments of this measure, two near stream areas were considered. These sites included the Sparks Auto Wrecking facility located on Larkin Circle and the East Sparks Industrial building located on Spice Island Drive. Both locations are considered representative of damageable property in the study area. The land acquisition costs to relocate these structures alone, without considering other associated relocation costs, are estimated to far exceed the benefits from the value of the new land use, reduction in emergency cost, or reduction in participation in NFIP. As a result, this measure was determined to be inefficient and was dropped from further consideration.

Small Scale Floodplain Evacuation

Although evacuation of structures from the floodplain on a large scale would likely not be feasible, evacuation of specific structures located within the floodway could be feasible if removal of the structure from the floodway would increase the channel carrying capacity. In addition, Washoe County and the cities of Reno and Sparks currently participate in the NFIP administered by the FEMA; therefore, any future development proposed within the jurisdictional boundaries of these local agencies is required to be constructed above FEMA's 100-year base flood elevation (1% ACE). This measure was retained.

Floodplain Management Plan

A comprehensive floodplain management plan would address issues with public outreach, preparedness, and emergency response for both pre- and post-disaster scenarios. A floodplain management plan would also address other issues within the floodplain, including controlling or limiting development, ordinances to ensure flood storage within the floodway, and other concerns. Any Federal project involving flood risk management requires a floodplain management plan. As a result, this measure was retained for further consideration.

Dedication of Floodplain to Storage

Dedication of Developed Floodplain to Natural Storage. Two developed floodplain areas were considered for reversion to natural floodplain for storage of flood flows. One location was the Sparks Auto Wrecking facility, located at Larkin Circle, and the second location was the East Sparks Industrial building, located on Spice Island Drive. Both locations are considered representative of damageable property within the floodplain of the study area. The costs to relocate existing structures including land acquisition costs and other costs associated with relocation would far exceed the benefits derived from the reduction in flood damages. Floodplain evacuation of structures to restore the river's connection to its floodplain would not be economically feasible for developed areas and was eliminated.

Dedication of Undeveloped Floodplain to Natural Storage. Dedication of specific property in the floodplain may be appropriate in undeveloped areas. Dedication of undeveloped areas to the natural floodplain such as UNR Farms is desired by the local community and provides opportunity for development of complementary ecosystem restoration and/or river parkway features. Thus, this measure has been retained for further consideration.

4.5.2 Flood Risk Management: Structural Measures

Structural measures are designed to control, divert, or exclude the flow of water from the flood prone areas to the extent necessary to reduce damages to property, any hazard to life or public safety, and general economic losses. The structural measures considered most appropriate in dealing with the character of the flood problems encountered typically include small detention basins, flood flow diversions, channel modification, and levees.

Storage/Detention

New Upstream Reservoirs. Several relatively large capacity upstream storage facilities along the Truckee River were considered, plus a combination of smaller sites and facilities. Most of the sites are located upstream of the City of Reno, within the state of California. These facilities would be on-stream reservoirs created by placing a dam on the river. By constructing an upstream storage dam and reservoir, excess peak flood flows could be temporarily stored so that downstream flood peaks would remain essentially unchanged from existing conditions. Preliminary cost-benefit analyses of each of the upstream storage facilities indicated that the total costs to construct the necessary infrastructure would significantly exceed the potential flood risk management benefits in the downstream urbanized area. For this reason, all upstream storage facilities that were evaluated were determined to be inefficient and were dropped from further consideration.

Upstream Detention with Weirs. Six potential sites for either on-stream or off-channel detention were considered. Potential storage capacity at any one of the six sites was up to 1,500 acre-feet. Target volume of over 4,000 acre-feet was determined necessary to provide sufficient flood protection for Reno and downstream areas. Due to the relatively small storage capacity of each facility, these options were determined to have low effectiveness and were dropped from further consideration.

On-stream Storage. The concept of using a series of several small on-stream storage areas from Lawton to the California-Nevada border was also considered. Permanent in-channel structures would visually affect the river channel and could interfere with recreational uses of the river. These structures could also pose a barrier to the movement of terrestrial wildlife. This measure was dropped from further consideration due to low expected efficiency.

Upstream, Off-Channel Detention. Four smaller sites for off-channel storage were evaluated: East Truckee, Union Bend, North Flat and Fleisch. At two of these sites (East Truckee and North Flat), variations were also considered, raising the total number of options considered to six. Potential water storage ranged from 900 acre-feet to nearly 12,000 acre-feet. Based primarily on the relatively high diversion structure costs, real estate costs, and/or only a slight reduction in the flood risk to Reno, this measure was determined to be inefficient and was dropped from further consideration.

Increasing Flood Control Storage at Upstream Reservoirs. Reoperating and raising the spillways of Stampede and Prosser Creek Dams, as well as increasing the allowable flood control storage in Martis Creek Reservoir, were evaluated and determined to only provide benefits during low probability events. No increase in flood benefits during higher probability events (e.g., 1% ACE) would be realized. This was evidenced during the January 1997 flood event in which no releases were being made into the Truckee River from Prosser, Boca, and Stampede Dams. During the 1997 event, additional flood control capacity at those reservoirs would not have reduced the magnitude of flooding in the Reno-Sparks-Truckee Meadows area.

Flood control space at Martis Creek Reservoir is limited to less than half of gross capacity due to geotechnical concerns regarding seepage and piping. Thus, there is uncertainty

regarding the technical feasibility of expanding available flood control storage at this reservoir.

Preliminary costs to enlarge the reservoirs at Stampede and Prosser Creeks with 5- and 10-foot spillway raises were reviewed. It was determined that the costs far exceeded the potential benefits. Therefore, this measure was determined to be inefficient and was eliminated from further consideration.

Tahoe Reoperation (precautionary release). The 1997 flood was the only recorded event where maximum releases from Lake Tahoe contributed to peak flood flows in the Truckee River during a large rain flood event in the Truckee River watershed. For all other significant rain flood events in the Tahoe Basin, there was sufficient space in the lake to accommodate inflows. In addition, 1997 was 1 of only 5 years of record since the completion of the existing Tahoe Dam in which discharge from Lake Tahoe into the Truckee River exceeded 2,000 cfs for 1 day or more.

Because in most flood situations one would not expect this circumstance to recur, this measure would be unlikely to consistently contribute to flood risk management. In addition, the rearrangement of operating rules for Lake Tahoe releases would probably be an institutionally complex and challenging task. There is a high degree of uncertainty regarding the feasibility and institutional acceptability of implementing this measure. This measure is consequently eliminated as it is expected to have low effectiveness.

Enclosed Detention Facility at University Farms. An enclosed detention facility at University Farms was included as part of the project that was authorized in 1988. The idea is to store some of the Truckee River flood flows in order to reduce the peak discharge of water carried downstream. This detention facility would result in a lower volume of backwater accumulating upstream of the Truckee's constriction at the Vista reefs, thereby reducing the floodwater surface elevations in the Truckee Meadows area and the downstream peak discharge during a flood. Therefore, this measure has been retained for further consideration and potential incorporation into a flood risk management plan alternative.

Mustang Ranch Detention Facility. The detention basin would be located off stream along the Truckee River on Mustang Ranch. The detention basin was included in the project to attenuate the impact of the increased downstream flood flows from the project improvements along the Truckee River. This measure was retained for further consideration.

Huffaker Hills Detention Facility. The detention basin would be located on stream along Steamboat Creek at Huffaker Hills (approximately 5 miles upstream of the main stem of the Truckee River). The detention basin was included in the project to attenuate the impact of the increased downstream flood flows from the project improvements along the Truckee River and Steamboat Creek. Preliminary indications were that this facility could reduce peak discharge from the Steamboat Creek watershed and was therefore retained for further consideration.

Bypass Tunnel to Huffaker Hills Reservoir. This measure consists of a small dam constructed on the Truckee River to divert flood flows south of Reno through a tunnel system extending to a reservoir constructed at Huffaker Hills on upper Steamboat Creek. Four earthquake faults are known to occur along the proposed alignment of the diversion tunnel. The

geologic investigations revealed that the tunnel would require a more substantial structural support system than normal because of the shallowness of the cover and unknown variables, such as weathering, fracturing, and other physical properties. The serious concerns regarding technical feasibility and extremely high cost vs. benefits derived give this measure low expected effectiveness and acceptability. Therefore, it was dropped from further consideration.

Increase Channel Flow Capacity

Channelization between Keystone and Arlington Avenues. Hydraulic modeling of this measure indicated that it was effective in reducing water surface elevations between Keystone and Arlington Avenues. Thus, this measure has localized hydraulic benefit that would not extend to the Reno redevelopment area or the Truckee Meadows area. This measure would therefore be expected to have limited (low) effectiveness. This measure is consequently eliminated from further consideration.

Channelization between Arlington Avenue and Virginia Street. This measure consists of temporarily removing the existing white water park located upstream of the Arlington Avenue Bridge, lowering the invert elevation by regrading the channel bottom to create a more uniform channel slope from Virginia Street upstream to a point approximately 1,500 feet above Arlington Avenue. The white water park would then be reconstructed. This measure would reduce velocity variances, prevent localized scour, reduce water surface elevations upstream of Arlington Avenue, and decrease the likelihood of additional sediment deposition between Virginia Street and Arlington Avenue. This measure is retained for further consideration.

Channel Widening from Sierra Street to Lake Street. This measure involves widening the river channel on the north bank from approximately Sierra Street to Lake Street in order to provide additional flow area. The widening would begin two vertical feet above the existing channel bottom and extend horizontally 12.5 feet into the riverfront lane. Channel widening would be implemented through the majority of this reach with the exception of the city block containing the AT&T building. Through this block the channel is widened by only 6 feet on the west and east sides of the AT&T building. There would be no widening along the front of the AT&T building. In conjunction with this measure, any replacement bridges at Sierra or Virginia Streets would need to be extended to span the wider channel. Similarly, a mini span at Center Street Bridge would be required. A culvert at Lake Street Bridge would also be necessary so that the additional flow area made possible by the widening could continue through the bridge location. This measure was retained for further consideration.

Culvert Around Replaced Lake Street Bridge. This measure provides for the installation of a culvert around Lake Street Bridge on the north side of the river. The culvert would direct excess flow around the bridge abutments, thereby increasing flow capacity. This measure would be implemented in conjunction with the widening measure (channel widening from Sierra to Lake Streets). A culvert would be required to accommodate the additional flow area created by channel widening because physical constraints (AT&T building) make lengthening of Lake Street Bridge infeasible. This measure was retained for further consideration.

Plazas. Plazas are a constructed open space using concrete with minimal appurtenances to ensure that flood flows would enter and leave the open space without constrictions. Plazas would be constructed on the north bank of the river and increase channel flow capacity. Plazas would begin at the north edge of the river, two feet above the bottom of the river channel, and extend perpendicularly from the river to First Street. One plaza would be placed between Sierra and Virginia Streets, using the entire block now occupied by the Masonic building, and the second plaza would be placed on the block formerly occupied by the Mapes casino and hotel. This measure would be consistent with downtown Reno redevelopment as an area of public access for river viewing. This measure was retained for further consideration.

Containment at First Street. This measure would set floodwalls north of the river back to First Street between Arlington Avenue and Center Street. This measure is intended to provide additional channel flow capacity beyond that of the river channel. The concept was based on an observation of the 1997 flood event during which a large amount of water broke overbank and flowed down First Street before reentering the channel further downstream. Further investigation determined that this measure would not provide protection to several structures. Therefore, this measure was determined to have low effectiveness and was not retained for further consideration.

Widening on the South Bank. Similar to the widening measure on the north bank of the river, this measure consists of widening the channel on the south bank. The south bank widening measure would begin just upstream of Sierra Street and end at Center Street. This measure was eliminated because of its significant cost relative to the benefits gained.

Downtown Buyout. This measure involves purchasing all buildings and parcels on the north bank from Sierra Street through Lake Street. The buildings would be removed and the vacant lots would become part of the channel. Starting from the existing bottom of the channel and extending to First Street, this measure would resemble the plaza concept, but would not be limited to the Mapes and mid-block sites. The intent of this measure was to create an increase in flow area without removing the historic bridges. The cost associated with land acquisition and excavation would be prohibitive. Therefore, the measure was dropped from consideration as inefficient.

Channelization at Glendale Park Area. This measure would reduce water surface elevations only in a localized area between Glendale Park and Rock Boulevard relative to a scenario with containment structures only. Since excavation in general is a costly undertaking, this measure would have low effectiveness for the Truckee Meadows area as a whole and would be inefficient in terms of the hydraulic benefit relative to the cost. In addition, local acceptability is questionable due to aesthetic concerns. This measure has consequently been eliminated.

Terracing Upstream of Steamboat Confluence. This measure would create an earthen terrace upstream of the confluence with Steamboat Creek. The purpose would be to reduce water surface elevation by 3 feet for a flow of 26,000 cfs. This measure has been retained for further consideration.

Terracing Downstream of Steamboat Confluence. Because this measure would result in a terrace above the existing low flow river channel, it does not pose the same environmental concerns as excavation down to or beyond the existing channel bottom. A terracing measure in the Vista area could reduce floodwater surface elevations at several points along the Truckee River relative to a scenario with containment structures only. The potential to provide hydraulic benefit makes this measure suitable for further consideration.

Extension of Airport Culvert on Boynton Slough. Due to backwater effects, containment of flows by levees and floodwalls in the Truckee Meadows area can increase water surface elevations, relative to existing conditions, in some reaches. Moderate increases in water surface elevations along Boynton Slough near the Reno International Airport cannot be contained by the existing natural topography of the area. Levees cannot be utilized near the Reno International Airport because levees must maintain a 10:1 side slope to meet airport regulations and space is limited in this area. An existing culvert conveys Boynton Slough flows beneath portions of the runways at the airport. In lieu of levees, extension of this culvert will be required under at least one of the alternatives. This measure would extend the existing triple-barrel box culvert approximately 1,795 feet. The internal dimension of each barrel is approximately 8 feet high by 12 feet wide. As the box culvert would be aligned along the existing channel alignment, minimal excavation would be required. This measure was retained.

Channel Widening (excavation to channel bottom). Excavation of the riverbanks down to the level of the channel bottom over an extended reach of the river would seriously affect the low-flow channel in that reach. This measure is considered inefficient due to significant environmental effects and associated high costs and has been eliminated from further consideration.

Channel Deepening at Vista Reefs. There have been efforts in the past to improve the flow past Vista by lowering the elevation of the rock outcropping. Recent studies have indicated that these actions in the past may have resulted in downcutting of the Truckee River up to 15 feet at McCarran Boulevard. This measure would also drastically affect the existing channel in the immediate area over which it is implemented. Channel deepening may increase the consequences to downstream locations since it allows more flow downstream as compared to the existing condition. Consequently, the measure is considered environmentally unacceptable and inefficient, and has been eliminated.

North Truckee Drain Realignment. The existing confluence of the North Truckee Drain with the Truckee River is located immediately upstream of the Steamboat Creek confluence. Relocating the confluence of the North Truckee Drain downstream from Steamboat Creek would reduce the extent of the backwater experienced along North Truckee Drain. The realignment would relocate the confluence approximately 4,500 feet downstream from its existing outlet and requires the construction of new conveyance facilities, including concrete lined channel and box culverts. This measure was retained for further consideration.

Reduce Flow Constrictions at Bridges in Downtown Reno

Bridge Rehabilitation. This measure would rehabilitate the historic bridges at Sierra, Virginia, and Lake Streets while maintaining their historic integrity. This rehabilitation would reinforce the bridges' structures, increasing their lifespan by approximately 25 years. In addition, it is assumed that the rehabilitation would be completed in a way that does not destroy the historic character of the bridges. The rehabilitation of Virginia Street Bridge would be conducted according to plans being developed by the Nevada Department of Transportation in consultation with the Nevada State Historic Preservation Office. No detailed plans have been developed for the Lake and Sierra Street Bridges. This measure has been retained for further consideration.

Bridge Preservation. This measure consists of preservation with only minor improvements to the historic bridges at Sierra, Virginia, and Lake Streets. Without major structural improvements, the Virginia Street Bridge would need to be closed to vehicular traffic within a few years, due to deterioration of structural conditions. The Nevada State Historic Preservation Office (SHPO) and Nevada Department of Transportation (NDOT) have indicated that major structural improvements can be made to Virginia Street Bridge without jeopardizing its historic character. Since this measure was not deemed effective, it was dropped from further consideration.

Replacement of Downtown Reno Bridges. Replacement of Sierra, Virginia, and Lake Street bridges has been retained as new structures could be designed to safely pass the mean 1% ACE flow thereby eliminating the flow constrictions caused by the structural characteristics of the existing bridges. There are two variations of this measure: replacement with Center Street type bridges and/or replacement with clear span bridges. This measure was retained.

Mini Spans at Center and Sierra Street Bridges. In conjunction with the channel widening measure is the addition of a partial or "mini" span to the existing Center and/or Sierra Street Bridges. Architecturally, each new "mini" span would resemble the current bridge spans. Where widening is implemented but a bridge is not replaced, the mini spans would be necessary to connect the existing bridges with the new channel bank. This span would provide an increase in the flow area at the bridge without requiring replacement of the entire bridge. This measure has been retained for further consideration.

New Span at Virginia Street Bridge. This measure would add a third span or archway to the north side of the Virginia Street Bridge. The new span would be implemented in conjunction with the plazas measure. Adding the new span would provide a direct hydraulic connection between the plazas and allow additional flow to pass through the bridge openings. The new span would be designed to have a similar appearance as the existing archway spans. Therefore, this measure was retained for further consideration.

Wells Avenue Lower Bridge Removal. This measure involves removing Wells Avenue's lower bridge to prevent backwater effects upstream of the bridge. Additional hydraulic modeling revealed that removal of the Wells Avenue lower bridge could reduce flood water elevations in the downtown reach. Therefore, this measure was retained for further consideration.

Arlington Avenue Bridge Replacement. This measure would replace the Arlington Avenue Bridge, which is actually composed of two separate bridges connecting Wingfield Park to the north and south banks of the river. A small section of roadway joins the two bridges. The bridge carries four lanes of through traffic, plus a turning lane. Due to the island located between the two portions of the bridge and the existing bridge's significant width, a large causeway would have to be constructed to create a bridge whose deck was elevated above flood flows, which would make it a costly measure. In addition, hydraulic modeling indicates that this measure would not significantly lower water surface elevations. The high cost relative to the hydraulic benefit caused the measure to be eliminated from further consideration due to low effectiveness and inefficiency.

Center Street Bridge Replacement. This measure would replace the Center Street Bridge with a bridge that was capable of passing the design event. This bridge was replaced in 1995 by the City of Reno based on pre-1997 hydrology. The current bridge does not have sufficient capacity to safely pass the mean 1% ACE on current hydrology. Due to the low effectiveness, this measure was dropped from further consideration.

Culverts around existing downtown Reno bridges. This measure combined with the cross-sectional flow areas of the existing bridges would not be effective. The culverts would also be costly and difficult to design at the existing bridges. Consequently, this measure is considered to have low effectiveness and efficiency and was not carried forward into an alternative plan.

Virginia Street Bridge Bypass. This measure consists of construction of two bypass channels along the north and south ends of the Virginia Street Bridge. This measure was not retained due to low effectiveness and uncertainty associated with hydraulic performance.

Culverts around new bridges (Sierra, Virginia, Lake, Center Streets). Modeling of this measure indicated that it could reduce water surface elevations relative to existing conditions. However, because debris accumulation could reduce the culverts' flow capacity, there is uncertainty regarding its reliability (an aspect of effectiveness), and it poses potential O&M burdens that are not desired by sponsoring agencies. Some uncertainty is also associated with the hydraulic design of these structures. Therefore, this measure was dropped from further consideration due to low effectiveness.

Bridge Lengthening at Rock and McCarran Boulevards. These lengthening measures are required as a consequence of any alternative that consists of the use of levees for flood flow containment. This measure has been retained for further consideration.

Bypass Channel at McCarran Boulevard. This measure consists of a bypass channel to split flows of the Truckee River around the historic property immediately west of McCarran Boulevard. This property is of historic interest and the sponsor had requested that a measure be evaluated to determine if the property could remain instead of being relocated. Therefore, this measure has been retained.

Build Floodwalls or Levees

Floodwalls. Floodwalls are physical barriers, typically reinforced concrete structures, designed to prevent waters from floods of a specified magnitude from inundating developed areas where residents, businesses, and/or high value property are located. These floodwalls could be in-channel floodwalls or on-bank floodwalls. This measure has been retained for further consideration.

Setback Floodwalls. Where undeveloped land immediately adjacent to the river's edge is available, setback of a floodwall would be feasible, provide hydraulic benefit, and not be cost prohibitive, then setback floodwalls would be used in preference to floodwalls that immediately border the river channel. This measure has been retained for further consideration.

Movable Barrier Floodwall System (MBFS). The MBFS is an automatic levee/floodwall system that theoretically operates solely by the buoyant forces of water. The system consists of a series of gasketed composite walls weighing approximately 20 pounds per cubic foot that are fitted inside a double-sided concrete channel trough. The moving walls are constructed of composite fiberglass and polyester materials. The MBFS is designed to keep at least 50 percent of its height inside the concrete channel when fully extended to provide support. There is a significant degree of uncertainty related to the technical feasibility of this measure because MBFS have never been installed and have no performance history. The measure is considered to have low efficiency and acceptability. As a result, this inefficient measure was dropped from further study due primarily to the estimated high cost and relatively short expected life.

Modular Floodwalls. Modular floodwalls consist of interlocking panels assembled on a ground surface level base system. The system typically consists of a concrete base with a guide and gasketed lock mechanism. Before flood events, lightweight wall panels are manually installed into the existing base system and locked into place. The wall panels are removed when the flood danger has passed. This measure was eliminated from further consideration due to the inefficiency of high labor requirements.

Tilt-up Floodwalls. Tilt-up floodwalls consist of concrete footings and/or base with hinged walls. The hinged walls, typically steel, lay flat against the ground surface when not in use. During flood events, these structures are raised to an angle near 90° with the ground surface, raising the effective height of the flood control structure. This measure determined to have low effectiveness and was eliminated from further consideration due to the physical limitations of erecting the floodwalls in time to handle flood events.

Levees/Berms. Levees are earthen flood control structures built high enough to prevent a specific flood event (e.g. the 1% ACE) from overtopping it, plus an additional height to allow a margin of safety. The allowable slope of the levee is determined by the strength of the soil comprising and underlying the levee, and the width of the levee at its base is determined in turn by both the required height and slopes. A layer of aggregate is often placed at the crest of the levee to provide firmer support for maintenance and inspection vehicles. For the flows for which they are designed to contain, levees can provide reliable flood protection if sited, designed, and constructed properly. This measure was retained for further consideration.

Setback Levees. Setback levees are simply levees which are set back a significant distance from the river's edge. Relative to levees that sit at the river's edge, setback levees increase somewhat the capacity of the high flow channel that is bounded by the levees. Where feasible and cost effective, setback levees would be used in preference to levees located immediately above stream banks. This measure was retained for further consideration.

Modify Other Infrastructure

Enlarge North Truckee Drain Capacity. This measure would place the existing North Truckee Drain into box culverts for a distance of approximately 3,200 lf, increasing its carrying capacity. This measure was retained.

Remove/Relocate Diversion Structures. This measure would address obstructions at specific diversion structures along the Truckee River. Consultation with local interests determined that the Glendale Ditch Diversion and the Pioneer Ditch Diversion were the two most problematic structures. However, both diversion structures are currently under study by other agencies for modification or removal. Therefore this measure was not carried forward for further evaluation.

Reduce Width of Riverside Drive. Marginally increasing the area allowed to flood by scaling back Riverside Drive would not be expected to significantly reduce flooding in the downtown Reno portion of the study area and would probably have no effect on flooding in the Truckee Meadows area. It is unclear how effective this measure would be, but it is expected that it would have high cost relative to benefit (i.e., low efficiency). Therefore this measure was eliminated from consideration.

Road Closure Bladders. Road closure bladders would be expected to have high effectiveness, as they tie off lines of physical defense from flood waters where floodwalls could not be erected and installation of levees would require redesign of a roadway. This measure was retained.

Replace culverts at Peckham Lane on Boynton Slough. This measure would extend the existing culvert on Boytnon Slough through the embankment at Peckham Lane and additional 1,800 lf. This measure was retained.

Screening results for FRM measures are summarized in Table 4-1.

4.5.3 Ecosystem Restoration (Fish Passage)

Eliminate Diversion Structure. This measure would include the removal of diversion structures within the project area to restore or improve fish passage in the Truckee River. This measure was retained.

Alter Diversion Structure. This measure would involve altering existing diversion structures to improve or restore fish passage. Structure alterations could include installing

secondary structures downstream of the main structure to reduce the hydraulic jump presented to fish migrating upstream, notching the existing structure, or lowering the structure's profile. This measure was retained for further study.

Combine Diversion Structures. This measure would involve combining diversion canals to reduce the number of diversion structures in the river. Preliminary investigations determined that this measure would not achieve project objectives and was dropped from further consideration.

Modify Existing Fish Ladders. This measure would involve modification to existing fish ladders at several diversion structures, as well as at Marble Bluff Dam, to improve their functional capacity for passage of a wider array of native fish species. This measure was retained.

Install a Bypass Channel. This measure would involve construction of a channel adjacent to the diversion structure at a gradient sufficient to accommodate upstream passage of targeted fish species from downstream of the diversion structure to upstream of the structure. Bypass channels provide fair to good upstream passage potential of targeted species and age classes, as well as the associated aquatic and riparian community, at a low to moderate cost. This measure was retained.

Install a Fish Ladder. Similar to the bypass channel, this measure would involve construction of a fish ladder either adjacent to or on the diversion structure that would accommodate upstream passage of targeted fish species from downstream of the diversion structure to upstream of the structure. Although fish ladders provide fair upstream passage potential of targeted species and age classes, passage of associated aquatic and riparian communities is generally poor, and costs are generally high. However, this measure was retained for further consideration.

Replace Diversion Structure with a Pump Diversion. This measure would involve replacement of the existing diversion structure with a screened pump intake. This would typically be associated with removal of the original structure and would provide good upstream passage potential. However, capital and operation and maintenance costs can be very high, depending on flow intake requirements, and physical constraints associated with the diversion site. This measure may be effective for those diversions in the system that have low diversion rates. This measure was retained for further consideration.

Install a Fish Screen. This measure would address downstream passage by reducing entrainment of fish in diversion canals. Installation of a screen at the inlet of a diversion canal or within the canal would either prevent fish from entering the canal or return fish to the river via a return canal. A variety of screen configurations exist, each with varying levels of fish exclusion capabilities, maintenance requirements, and cost. However, fish passage effectiveness is generally good. This measure was retained for further consideration.

Screening results for ecosystem restoration (fish passage) measures are summarized in Tables 4-2.

4.5.4 Recreation

Trail-Based Amenities

Create a Paved Maintenance Road/Bikeway. Construct a paved bikeway that could be used as a maintenance road. Consider possible linkage of all trails with the Tahoe-Pyramid Bikeway. This measure was retained.

Create Unpaved Trails. Develop unpaved nature trails and limited picnic or resting amenities in the ecosystem restoration areas. Create access to the river – nature trail system and gravel/sand beach terminal points. This measure was retained.

Provide Trailhead Access and Amenities. Develop new trailheads with parking and restrooms, small picnic area with a single shelter and 3-5 tables, waste receptacles, water fountains, kiosks, directional signage, nature trails and/or trail connection. Rural trailheads would need parking for 10 cars, as well, as other amenities described above. Trailheads shall be located along major exchanges of Interstate 80 and approximately 3-5 miles apart in rural reaches. This measure was retained.

Construct Pedestrian Bridges. Construct wooden pedestrian bridges to cross the Truckee River and provide linkage to existing and new trails. This measure was retained.

Provide (Americans with Disabilities Act) (ADA) compatible pathways. Provide ADA (universal accessibility) compatible pathways that, at a minimum, link parking and all permanent features. Preserve existing park amenities within the Project Lands and where possible assist with redevelopment plans. This measure was retained.

Truckee Meadows Recreation Features

Sports Courts. Design basketball courts in association with picnic areas and sport complex. This measure was dropped from consideration due to inconsistency with USACE policy regarding cost-shared recreation features.

Small and Large Open Fields. Practice fields would be the predominant use. Flat-fields would be designed such that they do not require fencing where practical, particularly on land neighboring the river, to reduce concerns that fencing could cause flood damages. Use design and landscaping with native "non-berry- and non-nut-producing" trees and shrubs to make area less attractive to geese and flocking birds and mammals near the airport. This measure was retained.

League-Size Soccer Complex. This measure consists of regulation-sized soccer fields with a central complex for scoring, refreshments, and restrooms. The scale of this measure would be dependent on available lands not in conflict with other project purposes. Fields would be turf and require permanent irrigation and lighting. This measure was dropped from further consideration due to inconsistency with USACE policy regarding cost-shared recreation features.

Diamond Sports Facility. A facility with sports diamonds would be designed to withstand or avoid the most common flood events. The electrical supply source would be kept out of the floodplain and would feed into buildings, sport complex lighting, amphitheatre lighting, concession and restrooms. This measure was dropped from consideration due to inconsistency with USACE policy regarding cost-shared recreation features.

Small and Medium Soccer Fields. Soccer fields with a permanent irrigation system for sport and practice fields and temporary irrigation to all other landscaped and ecosystem restoration areas to facilitate vegetation establishment would be constructed. Return/reuse water from the City of Reno will be used for irrigation. This measure was dropped from further consideration due to inconsistency with USACE policy regarding cost-shared recreation features.

Playground. A playground would be designed in association with picnic areas and sport complex. This measure was retained.

Picnic Sites and Shelters. Several sizes of picnic facilities would be provided to accommodate individuals and couples, small groups, and at least one large group facility. This would include a 500 person shelter near the current location of the Excel Building. This measure was retained.

Fishing Access. Trails or sites for fishing access would be provided. A flow-through pond site in the lower terrace of ecosystem restoration sites would be created for enhanced fishing opportunities. This could include pier and/or boardwalk or pedestrian bridges for trail linkage. This measure was retained.

Non-Motorized Water Craft—Kayak and Canoe Access. Access points on both sides of the river for put-in of recreational kayaks and canoes would be provided. This measure was retained.

Natural Amphitheatre. During excavation for floodplain terracing, a semi-circular area could be contoured and the slopes planted with native grasses so that the area could be used as an amphitheatre for public events. This measure was dropped from further consideration due to inconsistency with USACE policy regarding cost-shared recreation features.

Screening results for recreation measures are summarized in Tables 4-3.

Table 4-1. Summary of Flood Risk Management Measures Considered

Measures	Effectiveness[1]	Efficiency[2]	Dropped	Retained
Non-Structural Measures				
Flood Insurance		In place	✓	
Early Flood Warning System		In place	✓	
Flood-proofing	Medium			✓
Large Scale Floodplain Evacuation	Low	Inefficient	✓	
Small Scale Floodplain Evacuation	Medium			✓
Dedication of Developed Floodplain to Natural Storage	Low	Inefficient	✓	
Dedication of Undeveloped Floodplain to Natural Storage	High			✓
Floodplain Management Plan	Medium			✓
Structural Measures				
Storage/Detention				
New Upstream Reservoirs	Low	Inefficient	✓	
Upstream Detention with Weirs	Low	Inefficient	✓	
On-stream Storage	Low		✓	
Upstream, Off-Channel Detention		Inefficient	✓	
Increase Storage at Upstream Reservoirs	Low		✓	
Tahoe Reoperation (precautionary release)	Low		✓	
Enclosed Detention Facility at University Farms	Medium			✓
Mustang Ranch Detention facility	Medium			✓
Huffaker Hills Detention facility	Medium			✓
Bypass Tunnel to Huffaker Hills Reservoir		Inefficient	✓	
Increase Channel Flow Capacity				
Channelization Keystone Ave to Arlington Ave	Low		✓	
Channelization Arlington Ave to Virginia St	Medium			✓
Channel Widening Sierra St to Lake St	Medium			✓
Culvert Around Replaced Lake Street Bridge	Medium			✓
Plazas	Medium			✓
Containment at First Street	Low		✓	
Widening on the South Bank	Medium	Inefficient	✓	
Downtown Buyout	Medium	Inefficient	✓	
Channelization at Glendale Park Area	Low	Inefficient	✓	
Terracing Upstream of Steamboat Confluence	High			✓
Terracing Downstream of Steamboat Confl.	High			✓
Extension of Airport Culvert on Boynton Slough	Medium			✓
Channel Widening (to channel bottom)	Low	Inefficient	✓	
Channel Deepening at Vista Reefs	Low	Inefficient	✓	
North Truckee Drain Realignment	High			✓
Reduce Flow Constrictions at Bridges				
Bridge Rehabilitation	Medium			✓
Bridge Preservation	Low		✓	
Replacement of Downtown Reno Bridges	Medium			✓
Mini Spans at Center and Sierra Street Bridges	Medium			✓
New Span at Virginia Street Bridge	Medium			✓
Wells Avenue Lower Bridge Removal	Medium			✓
Arlington Avenue Bridge Replacement	Low	Inefficient	✓	
Center Street Bridge Replacement		Inefficient	✓	

Measures	Effectiveness[1]	Efficiency[2]	Dropped	Retained
Culverts Around Existing Downtown Bridges	Low	Inefficient	✓	
Virginia Street Bridge Bypass	Low	Inefficient	✓	
Culverts Around New Bridges (Sierra, Virginia, Lake, Center Streets)	Low		✓	
Bridge Lengthening at Rock and McCarran Boulevards	Medium			✓
Bypass Channel at McCarran Boulevard	Medium			✓
Floodwalls/Levees				
Floodwalls	High			✓
Setback Floodwalls	High			✓
Movable Barrier Floodwall System (MBFS)	Low		✓	
Modular Floodwalls	High	Inefficient	✓	
Tilt-up Floodwalls	Medium	Inefficient	✓	
Levees/Berms	High			✓
Setback Levees	High			✓
Modify Other Infrastructure				
Enlarge North Truckee Drain Capacity	Medium			✓
Remove/Relocate Diversion Structures	Low		✓	
Reduce Width of Riverside Drive	Low		✓	
Road Closure Bladders	Medium			✓
Extend culverts at Peckham Lane on Boynton Slough	Medium			✓

[1] Effectiveness is determined by how well a measure meets the planning objectives.
[2] Efficiency is determined by the potential benefits and costs of the measure.

Table 4-2. Summary of Ecosystem Restoration (Fish Passage) Measures Considered

Measures	Effectiveness[1]	Efficiency[2]	Dropped	Retained
Eliminate Irrigation Diversions	High			✓
Alter Irrigation Diversions	Medium			✓
Combine Diversion Structures	Low		✓	
Modify Existing Fish Ladders	Medium			✓
Install Bypass Channel	High			✓
Install Fish Ladder	Medium			✓
Replace Diversion Structure with Pump Diversion	Medium			✓
Install Fish Screen				✓

[1] Effectiveness is determined by how well a measure meets the planning objectives.
[2] Efficiency is determined by the potential benefits and costs of the measure.

Table 4-3. Summary of Recreation Measures Considered

Measures	Effectiveness[1]	Efficiency[2]	Dropped	Retained
Trail-Based Amenities				
Create a Paved Maintenance Road/Bikeway	High			✓
Create Unpaved Trails	High			✓
Provide Trailhead Access and Amenities	Medium			✓
Construct Pedestrian Bridges	Medium			✓
Provide ADA compatible pathways	Medium			✓
Truckee Meadows Features				
Sports Courts	Low	Not policy compliant	✓	
Small and Large Open Fields	Medium			✓
League-Size Soccer Complex	Low	Not policy compliant	✓	
Diamond Sports Facility	Low	Not policy compliant	✓	
Small and Medium Soccer Fields	Low	Not policy compliant	✓	
Playground	High			✓
Picnic Sites & Shelters	High			✓
Fishing Access	High			✓
Non-Motorized Water Craft--Kayak & Canoe Access	High			✓
Natural Amphitheatre	Low	Not policy compliant	✓	

[1] Effectiveness is determined by how well a measure meets the planning objectives.
[2] Efficiency is determined by the potential benefits and costs of the measure.

4.6 Formulation of Preliminary Alternative Plans

Preliminary alternative plans were formulated from the screened management measures previously discussed. These alternatives were developed to encompass a broad range of potential alternatives to address flood risk management and associated recreation opportunities in Downtown Reno and the Truckee Meadows, and fish passage restoration. Each of these preliminary alternative plans is configured to address the planning objectives defined by the study (see Section 4.3).

4.6.1 Formulation and Screening of Preliminary Alternatives for Flood Risk Management

Formulation Strategy

Preliminary flood risk management alternatives were formulated for the Downtown Reno reach and the Truckee Meadows reach, which have hydrologically separate floodplains. Flood risk management can be implemented in the Truckee Meadows Reach without affecting the Downtown Reno reach. However, improvements to conveyance in the Downtown Reno reach would increase flows in the Truckee Meadows Reach.

Each preliminary alternative consists of a combination of the retained flood risk management measures that are described in Section 4.6. Measures for the Truckee Meadows

Reach were scaled at the 1% ACE event and each alternative in the Truckee Meadows was scaled for the 1% ACE event to facilitate comparison of the alternatives. Most of these measures can be combined with other measures in the plan formulation process for either of the two reaches (Downtown Reno or Truckee Meadows) with some exceptions. Measures that are more general in application and not tied to a specific location can be considered in the plan formulation process for either or both reaches.

Once these alternatives were formulated, preliminary designs were developed for the purpose of developing cost estimates. These preliminary cost estimates were used to screen for cost effectiveness. Cost estimates for the purposes of screening alternatives were developed using historical bid histories and professional experience in recent construction market trends. Assumptions made during the development of these cost estimates included standard methods of construction, a five year construction period, and a 28.6 percent contingency.

Downtown Reno Reach

Substantial analysis was undertaken to address uncertainties about many measures and several of the more costly measures such as channelization, culverts around existing bridges, or channel widening were dropped prior to the formulation of alternatives.

Based on hydraulic modeling, the measures retained focused on addressing the insufficient passage at Virginia, Sierra, and Lake Street bridges and associated containment measures. Treatment of the bridges included rehabilitation, expansion, and replacement with designs matching the current Center Street Bridge design or incorporating the landmark design elements of the Virginia Street Bridge for all bridges.

Because this reach has an existing flow capacity estimated to safely convey the 1.6% AEP (also referred to as 1:60, 1/60, or "60-year event"), the formulation of alternatives focused on the 1% ACE event since an increment below that event would still incur the high costs of modifying the bridges without a substantial decrease in damages. Annual Exceedence Probability (AEP) is the chance of a flood of a given size (or larger) occurring in any one year. Table 4-4 displays the measures matrix for the preliminary alternatives formulated for Downtown Reno.

Truckee Meadows Reach

Alternatives formulated for the Truckee Meadows reach considered various ways to contain and control flooding from overbank flows and backwater floodwaters due to the narrows at Vista. Approaches to either retain floodwaters in the Truckee Meadows or to confine flows in the channel and move it more quickly downstream were considered. Table 4-5 displays the measures matrix for the preliminary alternatives formulated for the Truckee Meadows Reach.

Table 4-4. Management Measures Matrix - Preliminary Alternatives - Downtown Reno

Measure		DOWNTOWN RENO					
	Alt A Rehab	Alt B Matching	Alt C Landmark	Alt D Widening	Alt E New Span	Alt F Bridge Replacement	Alt G Non-structural
Increase Channel Flow Capacity							
Channelization between Arlington and Virginia St.	✓	✓	✓	✓	✓		
Channel widening from Sierra to Lake				✓	✓		
Culvert around Replaced Lake St. Bridge				✓	✓		
Plazas					✓		
Reduce Flow Constrictions At Bridges							
Replacement of Sierra St., Virginia St., Lake St. Bridges		✓	✓	✓		✓	
Rehabilitate Bridges at Sierra, Virginia, and Lake St.	✓				✓		
Mini spans at Center & Sierra St. Bridges				✓	✓		
Replace Bridges with Clear Span Bridges					✓		
New Span at Virginia Street Bridge					✓		
Wells Avenue Lower Bridge Removal	✓	✓	✓	✓			
Floodwalls, Levees							
Floodwalls	✓	✓	✓	✓	✓		
Levees/berms	✓	✓	✓	✓	✓		
Modify Other Infrastructure							
Road closure bladders	✓	✓	✓	✓	✓		
Non-structural Measures							
Non-structural Commercial & Residential Flood-proofing	✓	✓	✓	✓	✓	✓	✓
Small Scale Floodplain Evacuation							✓
Floodplain Management Plan	✓	✓	✓	✓	✓	✓	✓

Table 4-5. Management Measures Matrix - Preliminary Alternatives - Truckee Meadows

Measure	Alt 1	Alt 2	Alt 3
Storage/Detention			
Enclosed detention facility at University Farms		✓	
Dedication of undeveloped floodplain for natural storage	✓	✓	✓
Huffaker Hills detention facility		✓	✓[1]
Mustang Ranch detention facility		✓	✓[1]
Increase Channel Flow Capacity			
Terracing upstream of Steamboat confluence			✓
Terracing downstream of Steamboat confluence			✓
Extension of Airport Culvert on Boynton Slough	✓		
North Truckee Drain Realignment	✓	✓	
Reduce Constrictions At Bridges			
Bypass Channel at McCarran Blvd.	✓	✓	✓
Bridge lengthening at Rock and McCarrran Blvds.	✓	✓	✓
Extend culverts at Peckham Lane on Boynton Slough	✓		
Levees and Floodwalls			
Floodwalls	✓	✓	✓
Setback floodwalls	✓	✓	✓
Levees	✓	✓	✓
Setback levees			✓
Modify Other Infrastructure			
Enlarge North Truckee Drain Capacity			✓
Non-structural Measures			
Nonstructural Commercial and Residential Flood-proofing			✓
Floodplain Management Plan	✓	✓	✓

1. Detention was initially part of plans but subsequently dropped due to high costs and failing to meet the objectives.

4.6.2 Alternatives Descriptions, Downtown Reno Reach

Alternatives were formulated to address the project purpose of flood risk management for each reach. All alternatives would include development of a floodplain management plan to address residual risks.

Alternative A - Rehabilitation of Bridges with Floodwalls Alternative

Floodwalls. Left bank consists of a total of 3,615 feet, of which 1,095 feet are in-channel floodwalls, 1,970 feet are benched floodwalls and 550 feet are on-bank containment floodwalls (there are also 3,635 lineal feet of recreational facility floodwalls and 1,600 feet of on-bank containment floodwalls on the right bank). The walls vary in height from 4 to 21 feet. The floodwalls begin at Booth Street and end at Wells Avenue.

Channelization between Arlington and Virginia Streets. This measure consists of 40,500 cubic yards of excavation for 2,600 feet between Arlington and Virginia Streets.

Road Closures Bladders. There are several bridges where road crossings interrupt the continuity of proposed floodwall containment lines. With this measure, inflatable bladders would be installed at those bridges where a temporary barrier would be needed to provide a continuous barrier to adequately contain flood waters.

Nonstructural Commercial and Residential Flood Proofing. Four structures would require nonstructural flood proofing with this alternative. Three are located on the south bank, two are residential condominiums near Barbara Bennett Park and one is a single family residence. There is also a commercial building near Brick Park on the north bank.

Berm. Fill would be used to create a berm immediately downstream of Lake Street. The berm would measure 200 lineal feet by 2 feet high.

Rehabilitate Bridges at Sierra, Virginia and Lake Streets. Under this measure, the bridges at Sierra, Virginia, and Lake Streets would be rehabilitated while maintaining their historic integrity. This rehabilitation would reinforce the bridges' structures, increasing their lifespan by approximately 25 years. In addition, it is assumed that the rehabilitation would be completed in a way that does not destroy the historic character of any of the bridges. The rehabilitation of Virginia Street Bridge would be done according to plans being developed by NDOT in consultation with the Nevada State Historic Preservation Office (SHPO). Plans for the rehabilitation of Lake and Sierra Street Bridges would be done by USACE.

Wells Avenue Lower Bridge Removal. The Lower Wells Bridge, located beneath its replacement, is currently an obstruction to flows in the Truckee River. This measure would remove the bridge and its associated abutments.

Alternative B - Matching Bridges with Floodwalls Alternative

Floodwalls. The components of this feature are the same as Alternative A described above except for the wall heights, which vary from 3 to 19 feet.

Replace Bridges at Sierra, Virginia and Lake Streets. This plan component increases channel conveyance through the Downtown Reach principally by replacing the existing bridges at Sierra, Virginia, and Lake Streets with new bridges whose design and architecture would be similar to that of the Center Street Bridge. The Center Street Bridge was built in 1996, is capable of passing the design flow of 20,700 cfs, and blends architecturally with the post office and nearby floodwall railings on the river side of the building. Use of a design similar to the Center Street Bridge would provide a consistent and coherent architectural theme. This component is estimated to cost 8.7 million dollars.

Channelization, bridge closures, nonstructural commercial and residential flood proofing, and berm features are all the same as described for Alternative A above.

Alternative C- Landmark Bridges with Floodwalls Alternative

This alternative is identical to the Alternative B except that a bridge without any supporting structures located in the river (i.e., a clear span) would be constructed instead of a Center Street type bridge. The clear spans would provide even greater flow area and no bridge piers, further decreasing the potential for debris to accumulate at the bridges.

This alternative's relatively low floodwall heights would most enhance the visual experience along the river and be most consistent with the objectives and designated land uses of the redevelopment esplanade as stated in the River Corridor Action Plan.

The components of the floodwall feature are the same as Alternative A above except for the wall heights, which vary from 1 to 15 feet. Channelization, bridge closures, nonstructural commercial and residential flood proofing, and berm features are all the same as the Alternative A.

Alternative D - Widening of Bridges with Floodwalls Alternative

Floodwalls. The components of this feature are the same as Alternative A above except for the wall heights, which vary from 1 to 18 feet.

Replace Bridges at Sierra, Virginia, and Lake Streets. This component is identical to the Alternative B, but because of the channel widening associated with this alternative, more materials would be required to construct the replacement bridges. Therefore, the construction costs are greater than the other alternatives that do not include the channel widening.

Mini-Span at Center Street Bridge. In conjunction with the channel widening measure is the addition of a partial or mini span to the existing Center Street Bridge. Architecturally, the new mini-span would resemble the current bridge spans. Where widening is implemented but a bridge is not replaced, the mini-spans would be necessary to connect the existing bridges with the new channel bank. This would provide an increase in the flow area at the bridge without requiring replacement of the entire bridge. For the this alternative, a mini-span would be added only at the Center Street Bridge.

Channel Widening From Sierra to Lake Streets: This measure involves widening the river channel on the north bank from approximately Sierra Street to Lake Street to provide additional flow area. The widening would begin 2 vertical feet above the existing channel bottom and extend horizontally 12½ feet into the planned riverwalk. This flood risk management measure would be implemented through the majority of the Sierra-to-Lake-Street reach, with the exception of the city block that contains the AT&T building. Through this block, the channel would be widened by only 6 feet on the west and east sides of the AT&T building. There would be no widening along the front of the AT&T building.

Culvert at Lake Street. This measure provides for the installation of a culvert around Lake Street Bridge on the north side of the river. The culvert would direct excess flow around the bridge abutments, thereby increasing flow capacity. This measure would be implemented

only in conjunction with the widening measure. A culvert would be required to accommodate the additional flow made possible by widening, because physical constraints (AT&T building) make lengthening of Lake Street Bridge infeasible.

Channelization, bridge closures, nonstructural commercial and residential flood proofing, and berm features are all the same as Alternative A above.

Alternative E – Rehabilitation of Bridges with New Span and Floodwalls Alternative

Floodwalls. The components of this feature are the same as Alternative A above except for the wall heights, which vary from 3 to 18 feet.

Mini-Spans at Center and Sierra Street Bridges. Because of the channel widening associated with this alternative, a partial or mini-span would be constructed to lengthen the existing Center and Sierra Street bridges. Architecturally, each new mini-span would resemble the current bridge spans. Where widening is implemented but a bridge is not replaced, the mini-spans would be necessary to connect the existing bridges with the new channel bank. This would provide an increase in the flow area at the bridge without requiring replacement of the entire bridge.

Plazas. Plazas provide open areas on the north bank of the river to increase flow conveyance capacity. Plazas would begin at the north edge of the river, 2 feet above the bottom of the river channel, and extend perpendicularly from the river as far as the south side or closest public right-of-way line of First Street as measured from the river's edge. One plaza would be placed between Sierra and Virginia streets, using the entire block now occupied by the Masonic building, and the second plaza would be placed at the former Mapes block.

Channel widening and the culvert at Lake Street components of this alternative are the same as for Alternative D above. The Bridge Rehabilitation feature for this alternative is the same as Alternative A, above.

Channelization, bridge closures, nonstructural commercial and residential flood proofing, and berm features are all the same as Alternative A, above.

Alternative F - Bridges Replacement Only Alternative

This alternative consists of replacing Sierra, Virginia, and Lake Street bridges with bridges capable of passing 1% AEP event. No other confinement measures would be included. This alternative would provide only limited flood risk management beyond the current 2% AEP (also referred to as 1:50, 1/50, or "50-year event") non-damaging event. Both clear-span and double-span replacement bridges were considered with double-span bridges being selected due to lower costs.

Alternative G - Non-structural Alternative

A comprehensive non-structural solution for downtown Reno was determined to be infeasible due to high costs. During formulation, an average cost per structure to flood proof using recent project data was compared to preliminary property values. This comparison determined that it was not feasible to flood proof all structures. However, an alternative was formulated targeting the structures providing the greatest reduction in flood damages. A total of 10 structures were identified for flood proofing under this alternative.

4.6.3 Alternatives Screening, Downtown Reno Reach

The preliminary flood risk management alternatives were screened against the four P&G formulation criteria. Standards were established to determine if the alternative plans met each criterion. For a plan to be carried forward, minimum standards had to be met. The No-Action alternative was not included in this screening process because it must be carried forward in the process in order to serve as the baseline against which all retained alternatives are compared.

Standards established for the screening criteria are:

- Completeness. Completeness is a determination of whether or not the plan includes all elements necessary to achieve the objectives of the plan. It is an indication of the degree that the outputs of the plan are dependent upon the actions of others. Plans that depend upon the actions of others to achieve the desired output were dropped from consideration. Each alternative is considered complete.

- Effectiveness. Effectiveness is the extent to which a measure or alternative plan achieves the planning objectives. Measures or alternative plans that clearly make little or no contribution to the planning objectives were dropped from consideration. Since each alternative contributes to at least one planning objective, each is retained.

- Efficiency. Efficiency is a measure of the cost effectiveness of the plan expressed in net benefits. Benefits can be both monetary and non-monetary. Measures or alternative plans that provided little benefit relative to cost were dropped from consideration. Table 4-4 shows the results of the comparison of net benefits analysis.

- Acceptability. Acceptability is a measure of the ability to implement a measure or alternative plan. In other words, acceptability means a measure or plan is technically, environmentally, economically, and socially feasible. Unpopular plans are not necessarily infeasible, just unpopular. Measures or plans that were clearly not feasible were dropped from consideration. The measures developed for all of the alternative plans are generally considered satisfactory methods of addressing flooding problems and lack of habitat. While some measures are more preferable than others to the public, all were deemed acceptable. Therefore, all the alternatives were determined to be acceptable.

Benefits and costs computations were evaluated based on October 2012 prices. However, because of the length of analysis, price levels varied throughout the study phases. Nevertheless, values in previous price levels (2007 and 2011) that were critical to the evaluation and comparison of alternatives were brought to the current price level (October 2012). The remainder of the cost and benefits that were deemed un-influential remained at their respective levels.

Table 4-6. Economic Evaluation of Preliminary Flood Risk Management Alternatives in Downtown Reno at the 1% ACE.[1]

Preliminary Alternative	Total First Cost	Annualized First Costs	Annualized Benefits	Net Benefits	Economically Justified?
Alternative A	45,975	3,225	2508	-717	No
Alternative B	69,340	4,650	2508	-2142	No
Alternative C	56,560	3,925	2508	-1417	No
Alternative D	57,350	3,975	2508	-1467	No
Alternative E	63,290	4,385	2508	-1877	No
Alternative F	23,509	1,494	1,583	89	Yes
Alternative G	7,200	400	52	-348	No

[1] (October 2007 Prices, $1,000's, 4.125% Interest Rate)

As shown in Table 4-6, the only alternative with net benefits for the Downtown Reno reach was Alternative F - Bridge Replacement Only alternative. This alternative was retained for further NED analysis, including a detailed cost estimate. A comparison of the new cost estimate with updated economic benefits showed that removing and replacing the Sierra, Virginia, and Lake Street bridges was not cost-effective. Therefore, the project delivery team formulated a revised Bridge Replacement Only alternative in which the Sierra and Virginia Street bridges would be removed and replaced and the Lake Street Bridge would be removed, but not replaced. Benefits for this alternative are primarily from advanced bridge replacement cost savings. Each of the three bridges has some remaining life and currently serves transportation purposes. This plan extents the life of the bridges for the period of analysis. The replaced bridges would have extended life and would provide benefits beyond flood damage reduction. In Table 4-7, the advanced bridge replacement benefits for each bridge are shown.

Table 4-7. Advanced Bridge Replacement Benefits, Downtown Reno[1]

Bridge Crossing	First Cost of Bridge	Remaining Life in Years	Extension of Transportation Life	Average Annual Benefit
Sierra	12,047	25	25	$153
Virginia	14,587	1	49	$649
Total- Advanced Bridge Replacement Benefits				$802
Flood Damage Reduction Benefits				$772
Total Benefits – Bridge Replacement Only Alternative				$1,574

[1] (October 2011 Prices, $1,000's, 4% Interest Rate); See Economic Appendices regarding economic uncertainty.

As shown in Table 4-8, the revised Bridge Replacement Only alternative would not provide net benefits in excess of the costs. In addition, most of the benefits are for advanced bridge replacement and are incidental to the project purpose of flood risk management. Since a lower scale of project would provide fewer benefits but still require costly bridge modifications, no other scales were evaluated. Consequently, there is no Federal interest in the revised Bridge Replacement Only alternative. Despite iterative efforts, no measure or plan with a Federal interest has been identified for the Downtown Reno reach.

Table 4-8. Comparison of Alternative Plans in Downtown Reno[1]

Project Conditions	First Costs	Annual Benefits	Annual Costs	Net Benefit
Bridge Replacement Only (FRM & ABR)	$60,334	$1,574	$2,702	-$1,128
Bridge Replacement and Floodwalls (FRM & ABR)	$172,793	$3,353	$7,911	-$4,558

[1] 2011 Price Levels ($1000), 4% Interest Rate; See Economic Appendices regarding economic uncertainty.

4.6.4 Truckee Meadows Reach

Initial plan formulation efforts in the Truckee Meadows Reach focused on three preliminary alternatives for dealing with flood damage reduction. During public scoping meetings, it became clear that the induced flows of the first three preliminary alternatives were not acceptable to downstream interests. USACE conducted workshops and formulated 8 additional alternatives in an attempt to retain as much floodwaters in the Truckee Meadows as possible. These additional alternatives focused on increasing storage opportunities at Huffaker Hills and the UNR Farms locations.

Each of the preliminary alternatives was initially designed to address the 1% ACE event within the Truckee Meadows Reach to facilitate direct comparison of the alternatives. Optimization of the level of performance was deferred until after a cost effectiveness analysis could reduce the array of alternatives to a more manageable number. Since options for additional detention in the Meadows are limited, the team looked at expanding detention basins at UNR Farms, Huffaker Hills, and a new detention site at Upper Lockwood. Since downstream

hydraulic models were not completed at that time, the team used induced flows at Vista as a measure of the success of these 8 preliminary alternatives.

The evaluation showed that while induced flows could be reduced they could not be eliminated. In addition, the costs of including expanded detention were substantially higher th the three initial alternatives without any apparent increase in economic benefits. These costs were due to the high real estate costs in the Meadows that would be generated by increased detention sites and the larger levees required containing the additional flows.

Since additional detention measures did not increase the alternatives' ability to meet th planning objectives, the team determined that the five alternatives formulated with expanded detention facilities would not be carried further in the planning process. The evaluation also showed that a detention basin at Mustang Ranch was ineffective for mitigating downstream flows and this feature was dropped from the existing Alternatives 2 and 3.

Alternatives 1, 2, and 3 were retained for further evaluation as the final array of alternatives for flood risk management in the Truckee Meadows Reach. The following descriptions of the alternatives are based on designs that would address the 1% ACE flood eve

Downstream Induced Flows

Under each of the three alternatives, additional flows would be transferred from the Truckee Meadows Reach to the Lower Truckee River Reach under the with-project condition. An analysis was conducted to determine the potential for increased bank erosion and scour ove the without project condition to assist in the determination of whether mitigation would be needed.

Specifically, this effort consisted of the following: 1) identify locations where the proje would induce noticeable impacts on the velocity and shear on the channel, and 2) develop hydraulic-based designs which would provide protection. Channel shear stress and channel velocity were tabulated for both with- and without-project conditions design flow rates for eac cross section in the model. In addition, a corresponding shear category and velocity category were assigned to each value. The categories were numbered from 1 to 10 and range upward wi increasing hydraulic energy in the channel. Shear and velocity categories were delineated base on typical permissible shear and permissible velocity ranges for soil or sediment materials, vegetation, and rock sizes.

In comparing shear and velocity differences between without- and with-project conditions, if no increase or a decrease occurred under with-project conditions, or if the values increased but stayed within a single shear or velocity category, an impact number of 0 was assigned. If the shear or velocity increase caused a step up in one category level, an impact number of 1 or 2 was assigned, depending on whether one or both of the shear and velocity categories increased. Similarly, impact numbers of 3 and higher were assigned using the same logic.

The project delivery team subsequently identified locations where velocity and shear exceeded 0; the team assessed the potential for impacts to critical infrastructure, bridge piers, and proposed restoration sites. Based on that assessment, sites were identified and both structural and biotechnical bank protection measures were formulated and added to each alternative and costs for each were estimated.

Chapters 5 and 6 include additional information about induced flooding.

Description of Final Array of Flood Risk Management Alternatives

No Action Alternative

Under the No Action alternative, there would be no Federal action to reduce flood damages within the Truckee Meadows area. The population, structures and property within the floodplain would remain at risk from flooding during events greater than the 5% (also referred to as the 1:20, 1/20, or 20-year) ACE event.

Alternative 1 - Levees and Floodwalls Plan

This alternative accomplishes flood risk management in the Truckee Meadows Reach primarily by containing the flows with levees and floodwalls. Alternative 1 would not include any detention facilities or channel terracing. Because flows are contained, Alternative 1 has the highest design water surface elevations relative to the other alternatives, and downstream flows are increased in comparison to existing conditions. The major features of this alternative are listed in Table 4-9 and shown in Figure 4-1.

At the design flow event (1% ACE), Alternative 1 would induce an additional 2,400 cfs of flow above existing conditions in the Lower Truckee River Reach downstream of Vista. These additional flows could potentially increase flooding of residences in Lockwood/Rainbow Bend and Wadsworth, as well as increase inundation of agricultural lands in various locations in the Lower Truckee River Reach. Additional flows could also increase scour at the Painted Rock Bridge. Mitigation features proposed for these hydraulic effects include terracing at Rainbow Bend, constructing floodwalls at Wadsworth, and replacing the Painted Rock Bridge.

Bank Protection. A combination of bioengineered and rock bank protection is proposed to stabilize the streambank at locations where erosion could endanger critical infrastructure, such as the Union Pacific Railroad and I-80.

Table 4-9. Summary of Flood Risk Management Structures for Alternative 1

Water Course	Reach Description	Total Structure Length (feet)	Average Structure Height[1] (feet)	Structure Type(s)	Seepage Mitigation
Truckee River	North (left) Bank Glendale Avenue to Greg Street	1,000 2,000	8	Floodwall Levee	Drainage Blanket
	North (left) Bank Greg Street to 5,000 feet upstream of North Truckee Drain	7,800 (2,300 lf of in-channel floodwall) 8,700	7	Floodwall Levee	Relief Wells and Seepage Berms
	North (left) Bank 5,000 feet upstream of North Truckee Drain to North Truckee Drain	700 5,100	9	In-Channel Floodwall Levee	Relief Wells
	North (left) Bank North Truckee Drain to Vista	4,300	7	Levees	Relief Wells
	South (right) Bank Highway 395 to Greg Street	3,100 2,400	7	Floodwall Levee	Drainage Blanket
	South (right) Bank Greg Street to McCarran Boulevard	300 9,800	6	Floodwall Levee	Seepage Berm
	Levee east of McCarran Blvd	9,100	10	Levee	Seepage Berm
Steamboat Creek	West (left) Bank Upstream of Boynton Slough	5,700 1,500	8	Floodwall Levee	Cutoff Wall
	East (right) Bank	9,500	9	Floodwall	Cutoff Wall
Boynton Slough	North (left) Bank	1,900 6,500	6	Floodwall Levee	Cutoff Wall
	South (right) Bank	5,700 4,500	6	Floodwall Levee	Cutoff Wall
	Extend culvert on Boynton Slough near Reno-Tahoe International Airport	1,800		Culvert	
North Truckee Drain	West (right) Bank	9,400	8	Floodwalls	Relief Wells
	East (left)Bank	9,400	7	Floodwalls	Relief Wells
	Along both banks, all reaches	54,500 53,900 1,800		Floodwall Levee Culvert	

[1]Preliminary estimate of average levee and floodwall structure height are based on design water-surface elevation, 1% ACE, plus estimated 3 feet for risk and uncertainty on main stem of Truckee River and 2 feet for risk and uncertainty on Steamboat Creek, Boynton Slough, and North Truckee Drain.

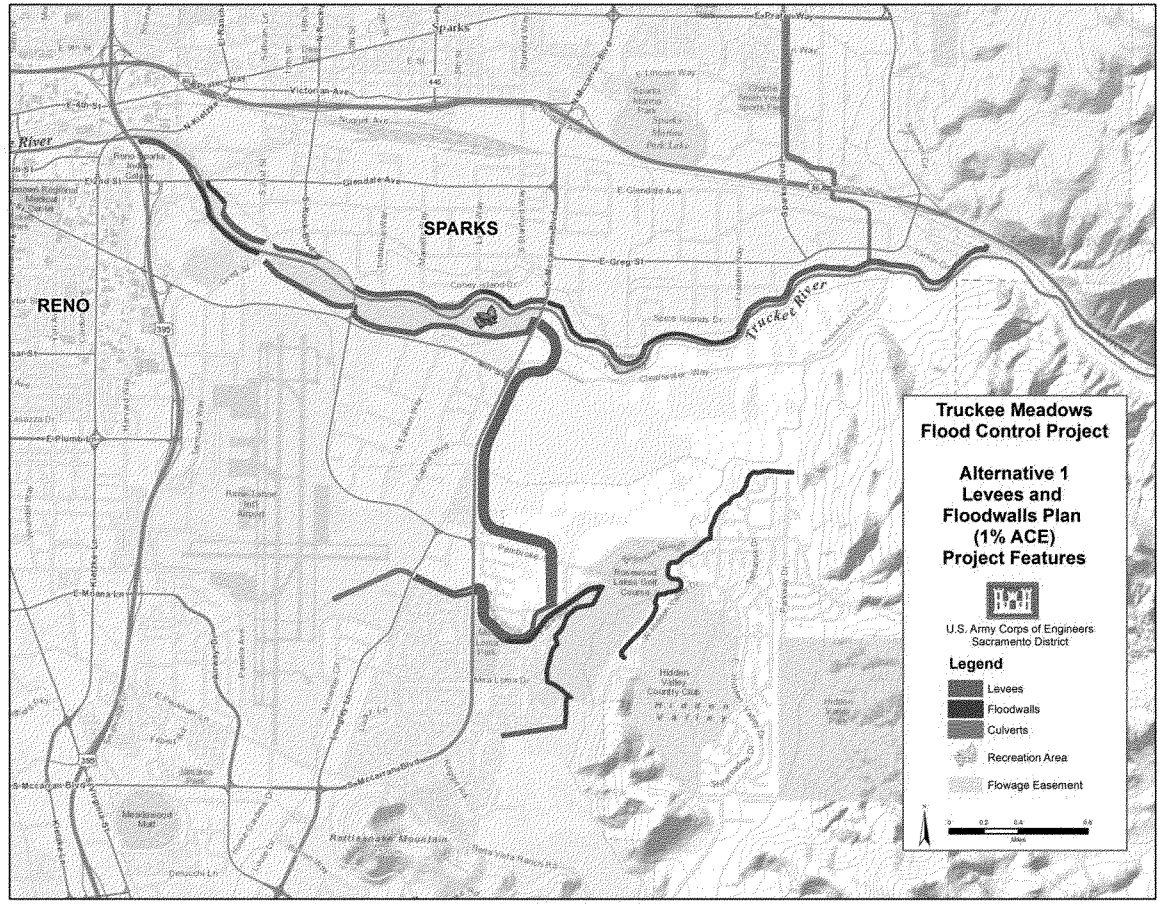

Figure 4-1. Alternative 1 - Levees and Floodwalls Plan

Lockwood/Rainbow Bend Terracing. Terracing of the banks at three locations downstream of the Lockwood Drive Bridge would lower water surface elevations from anticipated design flows such that water does not overtop the banks in the Rainbow Bend area. Excavation of terraces is proposed at two locations on the north bank and at one location on the south bank, approximately 500 feet downstream from the wastewater treatment facility. Depending on the underlying material, excavation could require some blasting of rock material to construct the channel terraces.

Replace Painted Rock Bridge. Painted Rock bridge would be replaced with a two-lane concrete girder bridge structure aligned immediately upstream of the existing bridge. The new bridge would be designed to handle anticipated debris loading from river flows and be constructed at an elevation sufficient to pass with-project design flows.

Construct a Floodwall at Wadsworth. Approximately 1,500 feet of floodwall is proposed along the east bank of the Truckee River to protect portions of a mobile home park.

Alternative 2 - Detention Plan

Alternative 2 accomplishes flood risk management in the Truckee Meadows area by capturing peak flows in detention facilities and by containing flows with levees and floodwalls. The detention basins were sited on stream along Steamboat Creek at Huffaker Hills (approximately 5 miles upstream of the main stem of the Truckee River), off stream at UNR Farms and off stream at Mustang Ranch. The detention basins were included in the project to attenuate the impact of the increased downstream flood flows from the project improvements along the Truckee River, Steamboat Creek and Boynton Slough. Due to construction of containment features along the Truckee River, peak flood flows downstream of Vista would be increased under project conditions. At the design flow event (1% ACE), Alternative 2 would induce an additional 1,800 cfs of flow above existing conditions in the Truckee River in the Lower Truckee River reach. Dimensions of the UNR detention basin are included in Table 4-10. The major features of this alternative are listed in Table 4-11 and shown in Figure 4-2. This alternative is similar to what was previously authorized.

Table 4-10. Summary of Levee Structures for UNR Farms Detention Facility

Reach Description	Total Structure Length (feet)	Average Structure Height (feet)	Structure Type(s)	Seepage Mitigation
West Levee	8,569	11.4	Levees	Seepage Berm
North Levee	6,667	12.2	Levees	Impervious Berm
East/South Levee	9,596	12.5	Levees	Cutoff Wall

Table 4-11. Summary of Flood Risk Management Structures for Alternative 2

Water Course	Reach Description	Total Structure Length	Average Structure Height[1] (feet)	Structure Type(s)	Seepage Mitigation
Truckee River	North (left) Bank Glendale Avenue to Greg Street	1,000 2,000	7.5	Floodwall Levees	Drainage Blanket
	North (left) Bank Greg Street to 5,000 feet upstream of North Truckee Drain	7,800 (2300 lf of in-channel floodwall) 8,700	6.5	Floodwalls Levees	Relief Well and Seepage Berm
	North (left) Bank 5,000 feet upstream of North Truckee Drain to North Truckee Drain	700 5,100	8.5	In-Channel Floodwall Levee	Relief Well
	North (left) Bank North Truckee Drain to Vista	4,300	6	Levee	Relief Well
	South (right) Bank Highway 395 to Greg Street	3,100 2,400	7	Floodwall Levee	Drainage Blanket
	South (right) Bank Greg Street to McCarran Boulevard	300 9,800	5.5	Floodwall Levees	Drainage Blanket and Seepage Berm
UNR Farms	UNR Detention Basin - West Levee	9,100	7.5	Levee	Seepage Berm
	UNR Detention Basin - North Levee	6,700	9.5	Levee	Seepage Berm
	UNR Detention Basin - East (South) Bank	9,600	10.5	Levee	Cutoff wall
Steamboat Creek	West (left) Bank Upstream of Boynton Slough	5,700 1,500	7.0	Floodwalls Levee	Cutoff Wall
	East (right) Bank	9,500	8	Floodwalls	Cutoff Wall
Boynton Slough	North (left) Bank	1,900 6,500	5.0	Floodwalls Levee	Cutoff Wall
	South (right) Bank	5,700 4,500	5.0	Floodwalls Levee	Cutoff Wall
North Truckee Drain	West (right) Bank	6,300		Floodwalls	Relief Wells
	East (left)Bank	6,300		Floodwalls	Relief Wells
	North Truckee Drain Box Culvert	5,300	10' by 20'	Concrete Box Culvert	NA
	North Truckee Drain Concrete Lined Channel	130		Concrete Lined Channel	NA
Total		48,300 70,200		Floodwall Levee	

[1]Average structure heights are based on design water-surface elevation, 1% ACE, plus 3 feet risk and uncertainty on main stem of Truckee River and 2-foot risk and uncertainty on Steamboat Creek, Boynton Slough, and North Truckee Drain.

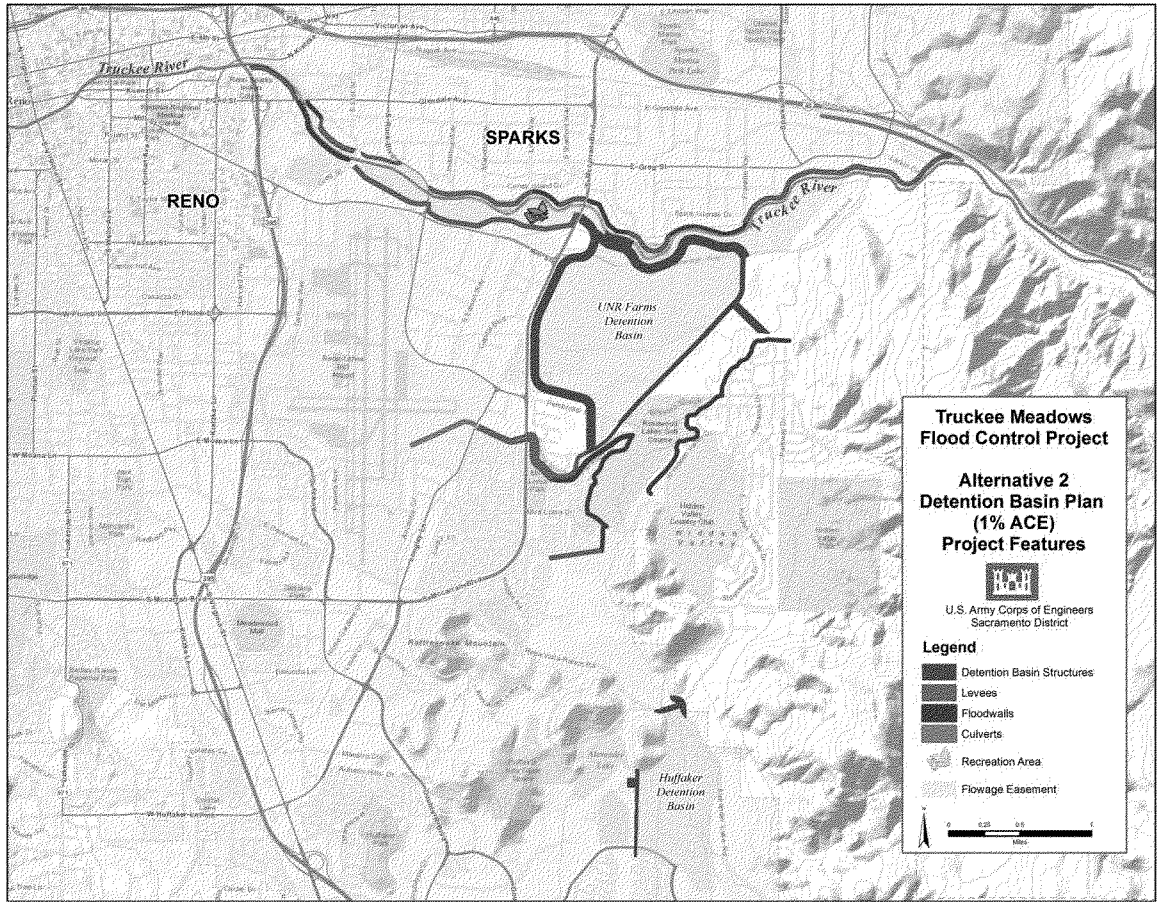

Figure 4-2. Alternative 2 - Detention Plan

At the design flow event (1% ACE), Alternative 2 would induce an additional 1,800 cfs of flow above existing conditions in the Truckee River in the Lower Truckee River reach. While less than the additional flows induced by Alternative 1, hydraulic mitigation would still be required at the same locations downstream. The hydraulic mitigation features for Alternative 2 would be the same as discussed for Alternative 1.

Alternative 3 – Floodplain Terrace Plan

Alternative 3 accomplishes flood risk management in the Truckee Meadows area by containing flood flows with levees and floodwalls, enlarging the flow area of the existing channel by terracing and by capturing peak flows in a designated overflow area. As a result of the channel terracing, Alternative 3 has the lowest water surface elevations in most areas relative to the other alternatives. Due to construction of containment features along the Truckee River, peak flood flows downstream of Vista would increase under project conditions. At the design flow event (1% ACE), Alternative 3 would induce an additional 3,100 cfs of flow above existing conditions in the Lower Truckee River reach. The major features of this alternative are displayed in Table 4-12 and shown in Figure 4-3. The hydraulic mitigation features for Alternative 3 would be the same as discussed for Alternative 1. Other features such as flood-proofing of existing structures and levees along Steamboat Creek and Boynton Slough were considered at this point in the planning process but were later dropped from consideration because they were found to not be incrementally justified.

Table 4-12. Summary of Flood Risk Management Structures for Alternative 3

Water Course	Reach Description	Total Structure Length (feet)	Average Structure Height[1] (feet)	Structure Type (s)	Seepage Mitigation
Truckee River	North (left) Bank Glendale Avenue to Greg Street	1,000 2,000	8	Floodwall Levee	Drainage Blanket
	North (left) Bank Greg Street to 5,000 feet upstream of North Truckee Drain	7,800 (2,300 lf of in-channel floodwall) 8,700	7.5	Floodwall Levee	Relief Wells and Seepage Berms
	North (left) Bank 5,000 feet upstream of North Truckee Drain to North Truckee Drain	700 5,100	8	In-Channel Floodwall Levee	Relief Wells
	North (left) Bank North Truckee Drain to Vista	4,300	5.5	Levee	Relief Wells
	South (right) Bank Highway 395 to Glendale	2,500	7	Levee	Drainage Blanket
	South (right) Bank Glendale to Greg Street	3.000	6	Floodwall	Drainage Blanket
	South (right) Bank Greg Street to McCarran Boulevard	300 9,800	4	Floodwall Levee	Drainage Blanket
	Terracing Downstream of Steamboat Confluence	4,300	-10	Floodplain Terrace	N/A
	Terracing Upstream of Steamboat Confluence	10,100	-10	Floodplain Terrace	N/A
	Ring Levee east of McCarran Blvd (UNR facilities)	2,600	5	Levee	Seepage Berm
Steamboat Creek	Steamboat Creek - East (right) Bank	2,800	6	Floodwall	Cutoff Wall
North Truckee Drain	North Truckee Drain - West (right) Bank (entrance to box culverts)	6,300	4	Floodwall	Relief Wells
	North Truckee Drain - East (left)Bank	6,300	4	Floodwall	Relief Wells
	North Truckee Drain Box Culvert	5,300	10' by 20'	Concrete Box Culvert	NA
	North Truckee Drain Concrete Lined Channel	130		Concrete Lined Channel	NA
	Total	28,200 25,200		Floodwall Levee	

[1]Average structure heights are based on design water-surface elevation, 1% ACE, plus 3 feet risk and uncertainty on main stem of Truckee River and 2-foot risk and uncertainty on Steamboat Creek, Boynton Slough, and North Truckee Drain.

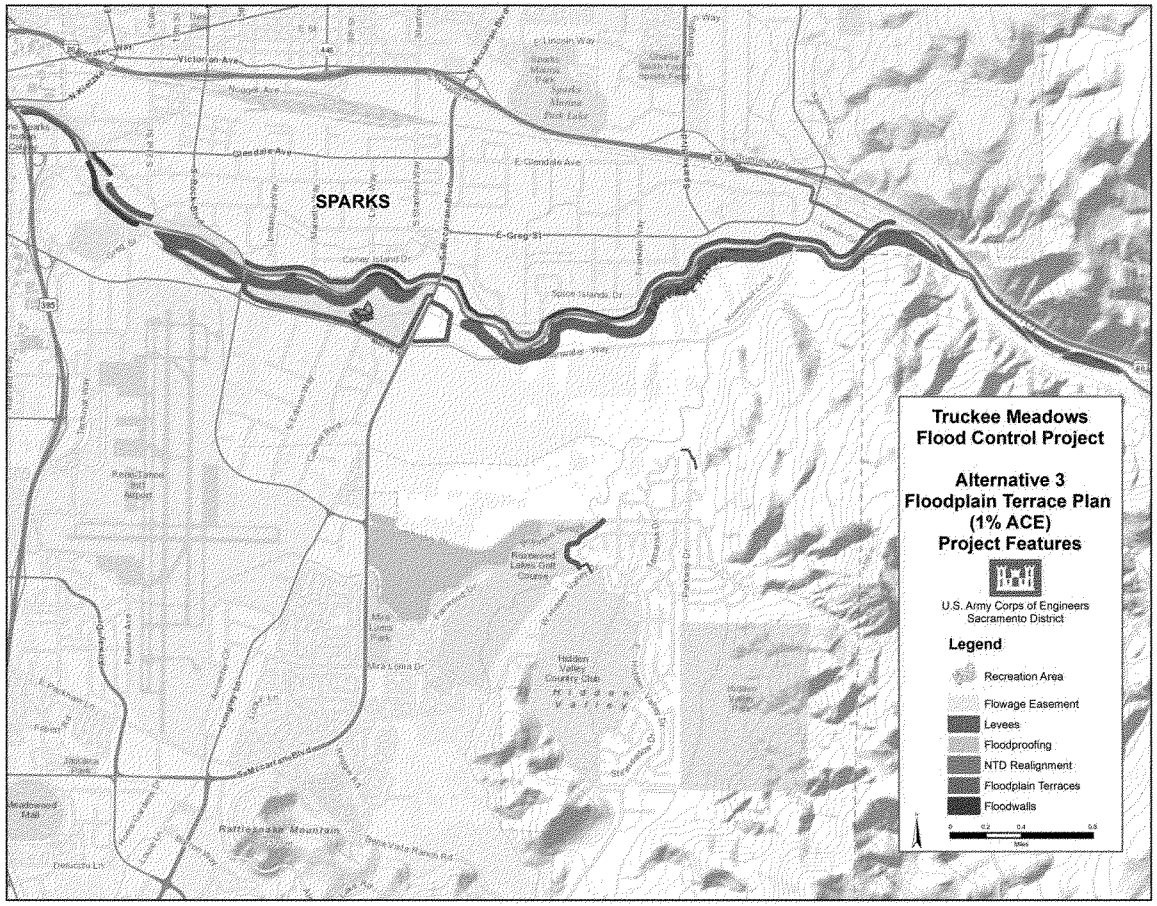

Figure 4-3. Alternative 3 - Floodplain Terrace Plan

4.7 Restoration of Fish Passage on the Truckee River

Restoration of fish passage on the Truckee River was evaluated in detail pursuant to the 1990 Tribes Water Rights Settlement Act, § 207. Measures and alternatives were developed by the USACE Engineer Research and Development Center (ERDC) to address fish passage problems at each barrier. The array of measures consisted of installing a bypass channel, installing a fish ladder, retrofitting existing fish ladders, diversion structure removal, replacing a diversion structure with a pump diversion, installation of a smaller secondary structure, installing a fish screen, and diversion structure modification.

Table 4-13 presents the measures considered for seventeen priority structures on the Truckee River. Many more exist in the system, but passage issues are being addressed at diversions that were deemed critical. Due to the prolific reproduction of cui-ui and some implementation issues, upstream passage received priority over downstream passage issues.

During the study, the United States Bureau of Reclamation (BOR) received funds for the removal of Numana Dam. That diversion was subsequently dropped from this analysis, reducing the number of priority structures to 16.

Table 4-13. Measures Considered at Diversions[1] on the Truckee River

Diversion	Measures Considered							
	Bypass Channel	Fish Ladder	Retrofit Fish Ladder	Diversion Removal	Pump Diversion	Secondary Structure	Fish Screens	Modify Structure
Marble Bluff	✓							
S-S				✓	✓		✓	✓
Fellnagle	✓			✓	✓	✓	✓	
Herman				✓	✓		✓	
Tracy PP					✓		✓	
Cochran							✓	
Idlewild Ponds							✓	
Chalk Bluff								
Orr				✓	✓		✓	
South Side				✓				
Lake							✓	
Last Chance							✓	
Washoe/High	✓		✓				✓	✓
Verdi	✓	✓					✓	
Steamboat	✓	✓				✓	✓	
Fleisch	✓		✓				✓	

1. Numana Dam diversion removal was originally identified but removed from analysis.

A diversion by diversion evaluation of measures and the likelihood of their success was undertaken, and a recommended action and secondary option were identified at each diversion. Also, further evaluation of the defunct South Side diversion indicated that its current condition did not represent a barrier to fish passage, and so it was not considered further in the study. Similarly, the Truckee Meadows Water Authority had recently modified the Chalk Bluff diversion and intake by installing a fish screen. Therefore, other than evaluating the performance of the fish screen's functionality, no further action was recommended by ERDC at Chalk Bluff. Tables 4-14 and 4-15 summarize the final array of upstream and downstream alternatives considered, respectively. Figure 4-4 shows the locations of each of the diversions evaluated.

There are two main components to successful fish passage around obstructions in the river. This includes improving or replacing existing facilities, or creating new facilities, to enable the efficient passage through or around the delta at the mouth of the Truckee River (herein referred to as downstream) and to upstream reaches above Derby Dam, to obtain access to upstream spawning habitat (herein referred to as upstream). Because upstream and downstream plans were developed independently of one another, a method was developed to assess combinations of these upstream and downstream plans into "system-wide" or "master" plans with all potential combinations of up- and downstream plans considered. This generated a total of 54 different master fish passage improvement alternatives to be assessed for environmental benefits and cost effectiveness.

The cost effectiveness and incremental cost analysis of the fish passage alternatives is displayed in Chapter 5.

Table 4-14. Summary of Upstream Alternatives Considered[1]

Structure-Alternative	Structure Alternative Measures
Marble Bluff-1	Bypass channel
Marble Bluff-2	Retrofit of existing fish ladder
Marble Bluff-3	New bypass channel + retrofit of existing fish ladder
S-S-1	Pump diversion
S-S-2	Modify existing diversion
Fellnagle-1	Partial dam removal + secondary structure
Herman-1	Construct new diversion upstream
Washoe/Highlands-1	Bypass channel
Verdi-1	Bypass channel
Steamboat-1	Constructed riffle-run (secondary structure)
Fleisch-2	Bypass channel

1. South Side diversion and Chalk Bluff diversions were considered but removed from analysis

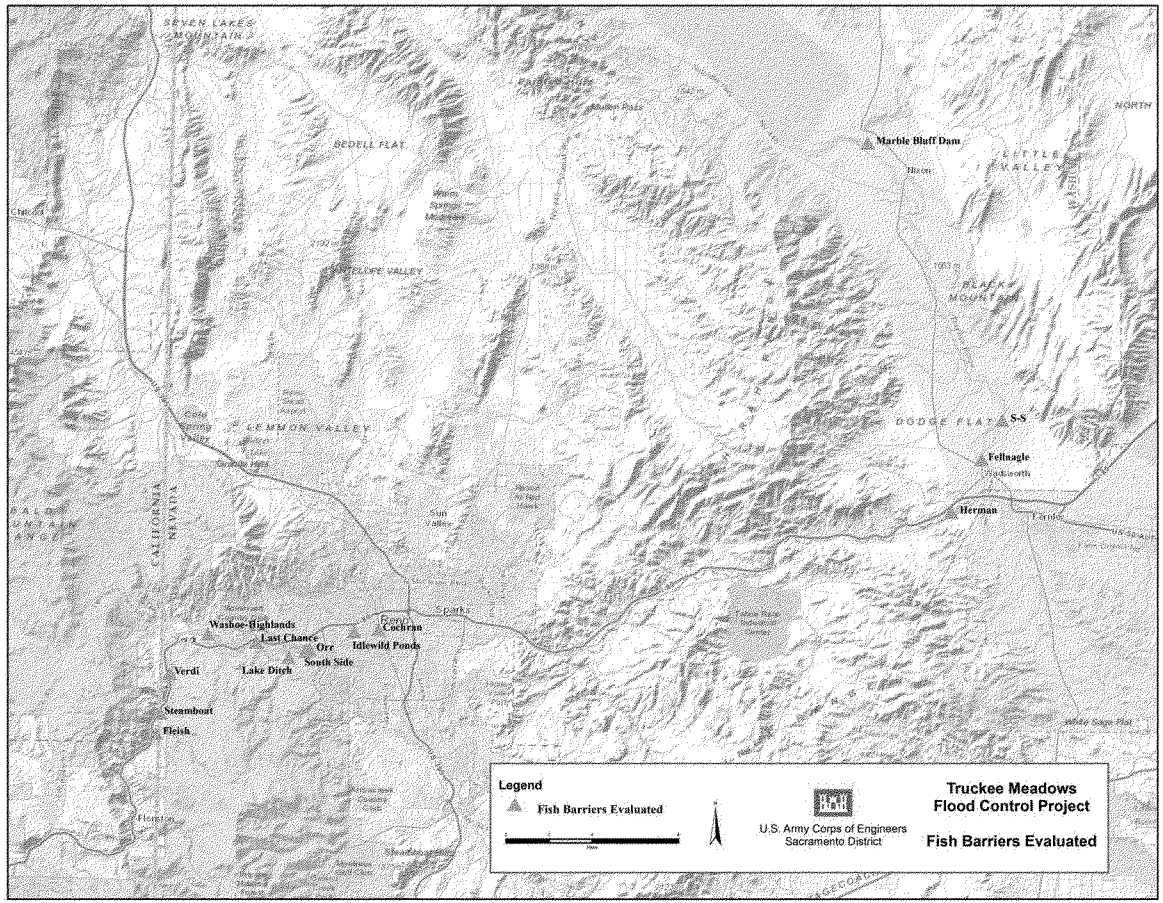

Figure 4-4. Fish Passage Improvement Locations

Table 4-15. Summary of Downstream Alternatives Considered[1]

Structure-Alternative	Structure Alternative Description
S-S-1	Fish screen on new diversion pump
S-S-2	Fish screen on modified diversion
Fellnagle-1	Fish screen
Herman-1	Fish screen
Tracy PP-1	Utilize diversion pump at off-stream pond for alternate cooling water source during critical river migration periods and install fish screen on existing river diversion pump
Cochran-1	Fish Screen
Idlewild Ponds-1	Fish Screen
Orr-1	Fish Screen
Lake-1	Fish Screen
Last Chance-1	Fish Screen
Washoe/Highlands-1	Fish Screen
Verdi-1	Fish Screen
Steamboat-1	Fish Screen
Fleisch-2	Fish Screen

1. South Side diversion was removed from analysis

4.8 Recreation Plan Formulation

An efficient means of formulating recreation plans was to wait until the array of alternatives was narrowed to a manageable level. For the following discussion, recreation features were formulated to be consistent with Alternative 3 in the Truckee Meadows. This section describes the formulation of preliminary recreation alternatives. Subsequent iterations were required to identify a plan that could be recommended. Descriptions of those iterations and subsequent evaluation and comparison can be found in Chapters 5 and 6.

4.8.1 Truckee Meadows Reach

USACE recreation specialists formulated and evaluated recreation plans. Meetings were held between local interests prior to the recreation planners and recreation economists planning activities. From these meetings, conceptual plans were developed by the project proponent's contractor, Stantec Consulting Inc. Stantec and the project proponents held charettes to capture local recreation demand and to provide concurrence with designs at the local level. This effort was not sufficient to meet the USACE criteria for identifying recreation demand due to lack of detail. However, it was determined the conceptual plans developed by Stantec could be used as a basis for plan formulation.

4.8.2 Recreation Demand and Benefit Methodology

To assess the community's recreational demand and willingness to pay, USACE hired Responsive Management of Harrisonburg, VA in 2008 to conduct a comprehensive recreation needs survey covering all planning regions throughout the eight-county area. The contractor used accepted statistical methods to determine the number of households needed in the sample and formulate an accurate, randomized survey.

A telephone survey of 1,218 residents over the eight-county area was completed. The results were weighted by city/county and gender so that the proportions of the male and female sample among the city and counties matched the distribution of the male and female population in the region as a whole. In other words, the results were weighted so that 5.4% of the sample was made up of males from Carson City, which matches its population proportion for the region as a whole, 5.4% of which are males from Carson City. Results of the survey were reported with a 95% level of confidence.

Survey responses showed that county residents, regardless of income or ethnic background, chose walking as the single most popular recreational activity;. of the top 18 recreation activities identified in the survey, based upon actual and desired participation, 50% involved walking, running or biking on roads, sidewalks and trails. Of the top 7 activities, three were walking on either roads/sidewalks, paved trails, and unpaved trails. The second most desired recreation activity was picnicking. The number 8 desired recreation activity was fishing. Respondents cited the Truckee Meadows area as particularly attractive for boating (kayaking) and wildlife viewing. This category also had the number 6 highest willingness to pay response from respondents. Sports court activities, field sports, and picnic/playground activities make up another 23% of expressed demand. The remaining 1% is for a BMX park. Since some of this demand is already being met, the alternatives analysis focused on the unfilled demand.

Existing recreation facilities were inventoried and assessed for usage using existing information provided by local recreation agencies. In addition, the 2008 survey asked if they did not participate in an activity because there were no places nearby to go or they did not know of any nearby places to go. For walking, running or biking on unpaved trails, 43% said there was no place to go and 36 % did not know of a nearly place. For paved trails the percentages were 50% and 29%. For the running/jogging and walking categories, no place to go nearby was the number one reason given by respondents for not participating in the activities.

As far as the specific features of the proposed trails that would make them especially attractive to recreation users, the survey asked all users of paved and unpaved trails what could be done to make them more inviting and interesting. Top responses include providing better signs/maps, extending/connecting the trails, better maintaining/improving the trails, providing educational signs/materials regarding vegetation and animals in the area, and adding plantings/vegetation to enhance them aesthetically.

For fishing, 21% of respondents cited the unavailability of facilities nearby as the reason they did not participate. For picnicking, 15% of respondents did not participate due to lack of nearby facilities.

The above statistics indicate that, especially for trails, there is a strong desire to participate in these activities, and many potential users are not engaging in these activities due to lack of available recreation resources.

Recreation benefits can be calculated in a number of ways. The unit day value (UDV) method, the travel cost method (TCM), and the contingent valuation methods (CVM) are all acceptable methods of calculating recreation benefits. In all cases, the number of visitors must be assumed or determined for each center of recreation such that it does NOT take benefits from another similar set of recreation opportunities. Double counting the same set of visitors would result in the over counting of demand and benefits.

The Unit Day Value (UDV) method was used to determine the benefits of recreation activities. Values for marginal increments were not quantified. The survey results identified the current recreation demand and the amount of unfilled demand for general recreation activities. The amount of expected participants was estimated based on survey results. A unit day value was developed for each recreation facility using the point system and dollar values from Economic Guidance Memorandum 13-03, Unit Day Values for Recreation for Fiscal Year 2013.

Facility use capacities were taken from the Texas Outdoor Recreation Planner, 1995 since no standard exists for Nevada. To account for seasonal use variations, final demand values were reduced by 20-25%. For each alternative, usage capacity for each facility was fixed and apportioned among all the possible types of activities within that facility. Usage figures were based on the number of stated visits per activity as a percent of the total possible visits for all activities.

4.8.3 Preliminary Recreation Alternatives

Two preliminary alternatives were formulated addressing those recreation activities with high demand. A USACE recreation alternative was formulated, using only those facilities eligible for federal cost-sharing, to be combined with the NED Plan for flood risk management. The second alternative, a locally-developed recreation plan, was provided by the project sponsor.

The USACE recreation plan included open fields, paved and unpaved nature trails, and picnic facilities, as well as river access points for fishing and non-motorized boating.

The locally-developed recreation plan included the same types of features as the USACE recreation plan. However, it decreased the amount of land available for environmental restoration use and increased open fields and water features. Table 4-16 provides a comparison of the two plans.

Table 4-16. Comparison of Preliminary Recreation Plans

Activity	Quantity		Units
	USACE Plan	Locally-Developed Plan	
Open fields (multi use reserved on large fields)	3	10	Acres
Open fields (multi use reserved on small fields)	3	10	Acres
Open fields (multi use reserved)	10	10	Acres
Unpaved Nature Trails (new)	10,032	10,032	LF
Playground	2	2	Site
Paved Trail (new)	9,389	9,389	LF
Picnic Site	32	30	Table
Small Picnic Shelter	4	4	Table
Medium Group Shelter	3	4	Table
Large Group Shelter	1	1	Site
Fishing Ramps and Pedestrian Bridges	6	6	Site
Non Motorized Water Craft Ramps	4	4	Site

CHAPTER 5
EVALUATION AND COMPARISON OF ALTERNATIVE PLANS

5.1 Evaluation Methodology

The alternatives formulated for the Truckee Meadows Flood Control Project were evaluated utilizing a plan evaluation framework with the following structure:

- NED analysis for flood risk management
- Cost Effectiveness and Incremental Cost Analysis for fish passage

The combined results of these analyses will result in a recommended plan with Federal interest. The evaluation of alternatives to the authorized project was conducted in accordance with Federal water resources planning procedures, regulations and laws, including the requirements of NEPA. Alternative modifications to the authorized project were considered to better meet the current project objectives for flood risk management, ecosystem restoration, and recreation while avoiding and mitigating adverse effects to the maximum extent practicable. These alternatives were developed and evaluated specifically to meet the planning objectives identified in Section 4.2.

5.2 Downtown Reno Reach

No alternative with Federal interest was identified for the Downtown Reno reach.

5.3 Truckee Meadows Reach

5.3.1 Preliminary Economic Analysis for the Truckee Meadows Reach

The three alternatives in the final array were evaluated at three levels of performance to economically optimize flood risk management. Preliminary benefits and costs for each level of performance were developed to identify the plan with the maximum net benefits. The cost estimates were preliminary in nature using conceptual designs, historic bid information, and professional judgment. These estimates were only used for screening. Ranking of the alternatives based on preliminary net benefits is shown in Table 5-1 (1 = highest rank). Only the relative ranking of alternatives is shown here, because significant inaccuracies were later found in the preliminary benefits (see explanation in next section).

Table 5-1. Comparison of Flood Risk Management Plans

Alternative (nominal level of performance[1])	First Costs[2] ($1000)	Rank Based on Preliminary Net Benefits
No-Action	0	8
Alternative 1a (50)	$ 321.3	4
Alternative 1b (100)	$ 513.3	7
Alternative 1c (117)	$ 555.0	6
Alternative 2a (50)	$ 315.9	5
Alternative 2b (100)	$ 598.1	10
Alternative 2c (117)	$ 614.1	9
Alternative 3a (50)	$ 325.4	2
Alternative 3c (100)	$ 482.8	3
Alternative 3d (117)	$ 488.3	1

[1] Nominal level of performance = 90% assurance of safely containing indicated event water surface elevation behind the lines of protection. For example, alternative 1a would safely contain the 2% (1/50) ACE water surface elevation 90% of the time.
[2] October 2007 prices

Based on the relative ranking of alternatives displayed above, Alternative 3 dominated Alternatives 1 and 2. The lowest net benefit produced by Alternative 3 at any level of performance exceeded the highest net benefit produced by either Alternative 1 or 2. Therefore, Alternative 3 was identified as the most cost effective plan, with Alternative 3d tentatively identified as the optimal plan for the Truckee Meadows Reach. Alternative 1 consistently outranked Alternative 2 at equivalent levels of performance and was therefore ranked second highest based on net NED benefits.

5.4 System of Accounts

The final array of alternatives was also evaluated and compared using the four accounts in the Principles and Guidelines, as displayed in Table 5-2. Evaluation of the Environmental Quality (EQ) account allowed consideration of the non-monetary effects the alternative plans may have on significant environmental resources. Also presented in the following table are the possible effects that the proposed plans may have on regional economic activity, specifically income and regional employment (compared under the Regional Economic Development (RED) account). Lastly, a comparison of the effects the alternatives may have on public facilities and services, recreational opportunities, transportation and traffic and man-made and natural resources (included under the Other Social Effects (OSE) account) are also presented.

Table 5-2. Comparison of System of Accounts

Criteria	No-Action	Alternative 1	Alternative 2	Alternative 3
National Economic Development Account				
Net NED Benefits (relative ranking)	n/a	Intermediate	Lowest	Highest
Environmental Quality Account				
Air Quality	Existing sources of air pollution would be expected to remain the same in the project area in the near-term future. Therefore, Hydrographic Area 87 would continue in the near-term future to be designated by the USEPA as being in serious non-attainment for PM.	The project construction emissions from this alternative would be less than the General Conformity de minimis thresholds and would have a less-than significant effect on air quality.	Same as Alternative 1.	Same as Alternative 1.
Water Resources and Quality	There would be a continued high risk of flooding and water quality could be adversely affected due to increases in total suspended solids and turbidity. Flooding in the study area would likely be considerable and could include bacterial and chemical (e.g., pesticides, petroleum products, heavy metals) contamination.	Increased flows could result in increased turbidity during peak flow events, but could also have positive effects such as reducing water temperatures and increasing dissolved oxygen levels. Loss of riparian vegetation shading the river could increase water temperature.	Increased flows in the Lower Truckee River would be less than modeled for Alternative 1, presenting a minor increase in turbidity during peak flow events. Loss of riparian vegetation shading would present similar increases to water temperature as Alternative 1.	Increased flows would be similar to Alternative 1. Revegetation of floodplain terraces in the Truckee Meadows would increase river shading, contributing to lower water temperatures.
Biological Resources		Vegetation and wildlife impacts include loss of riparian habitat in Truckee Meadows and Lower Truckee due to in-channel features such as floodwalls and hydraulic mitigation.	Vegetation and wildlife effects would be similar to Alternative 1 in the Truckee Meadows and slightly less than Alternative 1 in the Lower Truckee reach because of less hydraulic mitigation needed.	Vegetation and wildlife effects would be less than Alternative 1 and Alternative 2 in the Truckee Meadows because of setback levees and revegetation of floodplain terraces.
Special Status Species	A continued decline in special-status species' habitat value with associated decline in population numbers is likely.	Alternative expected to have adverse effects on special-status species. In-channel construction could directly affect fish species and changes in water quality (turbidity, temperature) could indirectly affect fish species.	Similar to Alternative 1 in the Truckee Meadows but slightly less than Alternative 1 in the Lower Truckee reach because of less hydraulic mitigation needs.	Similar to Alternative 1, but with a reduced affect to water temperature as a result of revegetation of floodplain terraces in the Truckee Meadows.
Cultural Resources	Existing sites would remain at risk from human activities.	Potential effects to historic and prehistoric sites located within levee footprint.	Same as Alternative 1.	Same as Alternative 1.

Criteria	No-Action	Alternative 1	Alternative 2	Alternative 3
Noise		Increased noise levels during construction. Noise generated by construction equipment, haul trucks, and worker vehicles. Noise levels exceed local objectives.	Same as Alternative 1.	Same as Alternative 1.
Aesthetics		Visual character of Truckee River would change to include high levees and floodwalls near the Truckee River, along Steamboat Creek, and on Boynton Slough.	Visual character of Truckee River would change to a greater degree than Alternative 1 due to the detention basin on UNR Farms.	Visual character of Truckee River would change but to a much smaller degree than Alternative 1 due to the reduction in levee and floodwall heights as a result of setback levees and floodplain terraces. Also, revegetation of floodplain terraces would provide beneficial effect.
Regional Economic Development Account				
Employment		Temporary increase in construction-related employment. The increased construction-related employment would have a corresponding short-term beneficial effect on the local economy. Increase would tend to be focused in lower specialization sector.	Employment effects anticipated to be similar to Alternative 1.	Employment effects anticipated to be similar to Alternative 1.
Housing Supply and Business		Implementation of Alternative 1 would not require removal of residences or displacement of businesses.	Implementation of Alternative 2 would require relocation of less than 10 residences and relocation of 23 businesses.	Same as Alternative 2.
Growth Inducing Impacts		Limited potential growth due to local restrictions for building in designated floodway.	Same as Alternative 1.	Same as Alternative 1.
Other Social Effects Account				
Public Health and Safety		Reduced flood losses for existing properties within the floodplain.	Same as Alternative 1.	Same as Alternative 1.

Criteria	No-Action	Alternative 1	Alternative 2	Alternative 3
Recreation		Informal public access to the Truckee River disrupted during construction; proposed maintenance roads would facilitate local plans for trails.	Same as Alternative 1.	Same as Alternative 1.
Transportation		Temporary increase in traffic on local roadways due to haul trucks and worker vehicles. Delays or disruption in traffic flow due to partial/full closure of roads. Change in circulation	Same as Alternative 1.	Same as Alternative 1.

5.5 Adjustments to Hydraulic and Economic Models

After a relatively optimal plan had been tentatively identified, concerns with the hydraulic and economic models were discovered during Agency Technical Review. A data-transfer error was discovered for Alternative 3d which had caused an underestimation of residual damages for that plan. This invalidated the previous tentative identification of Alternative 3d as the optimal plan. After consultation with the vertical team and project proponents, it was decided to reconstruct the hydraulic model rather than attempt to fix the flawed model. This would ensure a greater level of confidence in the resulting floodplains. The hydraulic model was reconstructed and has been used for the evaluations that follow.

Adjustments to the hydraulic and economic models affected all alternatives in a relatively consistent manner so that the previous ranking of alternatives beginning with the 2nd ranked plan would not change (see Table 5-1); therefore, Alternative 3a became the optimal plan. Alternatives 1 and 2 were not re-evaluated as a result of the model adjustments.

5.6 Reformulation Strategy for Truckee Meadows Reach

After adjustments were made to the hydraulic and economic models, a revised economic analysis was completed. The results indicated that none of the scales of Alternative 3 were economically justified and that an NED plan had not yet been identified. A reformulation workshop was held with the project delivery team, sponsor and vertical team members in November 2011 with the express purpose of identifying a Federally-supportable flood risk management plan for the Truckee Meadows Reach. The workshop analysis was based on existing information and informed professional judgment with the understanding that, if a plan was identified that appeared to be economically justified, more detailed evaluations on that plan would be conducted. The costs used in this workshop analysis were extracted from the preliminary cost estimate submitted with the submittal package that had undergone Agency Technical Review when the model problems were identified.

At this point in the iterative plan formulation process, an additional constraint was identified that due to budgetary considerations, the habitat restoration component of the ecosystem restoration would not be pursued any further in the process.

An additional measure was considered during this reformulation that had not been previously identified. Capping outlets of the People's Drain at the North Truckee Drain appeared to offer the potential for addressing flooding and was added to the array of measures considered.

The team began the reformulation process at the workshop by identifying the economic damage areas in the Truckee Meadows reach that provided the greatest potential for benefits. The East Sparks area and the Airport area were identified as having the greatest potential benefits, and the reformulation efforts focused on those areas. Downtown Reno was not evaluated further due to the lack of sufficient economic benefits to justify flood risk management measures.

The team first assessed the various elements of Alternative 3 for increments that could be implemented that would have a beneficial effect on the two highest priority economic damage areas. Terracing downstream of Steamboat Creek confluence was identified as the feature that incurred the greatest additional cost for downstream hydraulic mitigation and was identified as the likely break point for a cost effective plan. Formulation would focus on increments that would not require this terracing.

Terracing upstream of Steamboat confluence appeared to be an effective increment compatible with all other measures and was identified as Increment 1. This increment was not particularly effective in addressing the overall flooding problem, so additional increments were considered.

The next increment identified (Increment 2) was levees and floodwalls along the north bank of the Truckee River from McCarran Blvd. to Vista to reduce damages to the East Sparks Industrial area. This increment was estimated to have net benefits, but could be flanked from just upstream of McCarran Blvd. without additional features.

Levees and floodwalls along the north bank of the Truckee River from Highway 395 to McCarran Blvd. were the next added increment (Increment 3) to provide flanking protection to the East Sparks area. This increment would also reduce damages in the West Sparks area. The levee/floodwall on the north bank would induce flood flows over the south bank, so levees and floodwalls were added to the south bank from Highway 395 to McCarran Blvd. to reduce damages in the Airport area.

Increments 1, 2, and 3 would reduce existing flood storage within the floodplain and move the flows south into the UNR Farms area and up Steamboat Creek and the North Truckee Drain (NTD). Two alternative increments were identified for the NTD that would result in net benefits: Capping outlets from People's Drain at NTD, and realignment of NTD. Since capping the outlets maximized the net benefits, that measure was retained as Increment 4. Table 5-3 displays the results of the incremental analysis completed during the reformulation workshop. A gross estimate of benefits and costs were used in this analysis.

Table 5-3. Incremental Analysis for Flood Risk Management, Truckee Meadows Reach

Increment	First Cost	Annual Cost[1]	Annual Benefits	Net Benefits
1) Benching from Greg St. to 1,000 feet east of McCarran	9,900	461	6,055	5,594
Subtotal:	**9,900**	**461**	**6,055**	**5,594**
2) Levees and Floodwalls along north bank from McCarran to Vista, improvements along existing NTD alignment	46,800	2,131	10,092	7,961
Subtotal:	**56,700**	**2,592**	**16,147**	**13,555**
3) Levees and Floodwalls on both banks from I-395 to McCarran	32,500	1,500	4,037	2,537
Subtotal:	**89,200**	**4,092**	**20,184**	**16,092**
4) People's Drain caps (at NTD)	7,000	326	5,000	4,674
Subtotal:	**96,200**	**4,418**	**25,184**	**20,766**
Other Costs[2]	155,003	7,215	--	--
Rounded Totals:	**251,200**	**11,600**	**25,200**	**13,500**
Optional Modification to Increment 2): NTD realignment	*45,000*	*2,095*	*1,372*	*-723*

[1] 4% discount rate, $1000s.

[2] Other costs include bridge scour protection, environmental mitigation, construction management, and real estate.

Preliminary hydraulic modeling estimated that an added increment of benching the Vista reefs would likely cause sufficiently greater induced flows to require substantial hydraulic mitigation and cost between 2% and 1.3% ACE. Because a 2% ACE would be a relatively limited improvement over the without-project condition, with substantial damages beginning at approximately 5% ACE, it is unlikely that a level of performance below 2% ACE would provide increased net benefits to offset the additional costs benching of the Vista Reefs and associated hydraulic mitigation. Therefore, a 2% ACE was selected as the reasonably optimized scale for the reformulated flood risk management plan.

The reformulated plan for the Truckee Meadows reach is hereafter identified as Alternative 3 - Floodplain Terrace Plan as shown in Figure 5-1. This alternative has been carried forward for detailed evaluation.

During refinement of the preliminary hydraulic design, adjustments to the design were made where the project performance could be substantially improved at minimum additional cost. This resulted in an AEP near 1% for the main economic impact areas of concern. The estimated project performance varies by Economic Impact Area (EIA) as shown in Table 5-5.

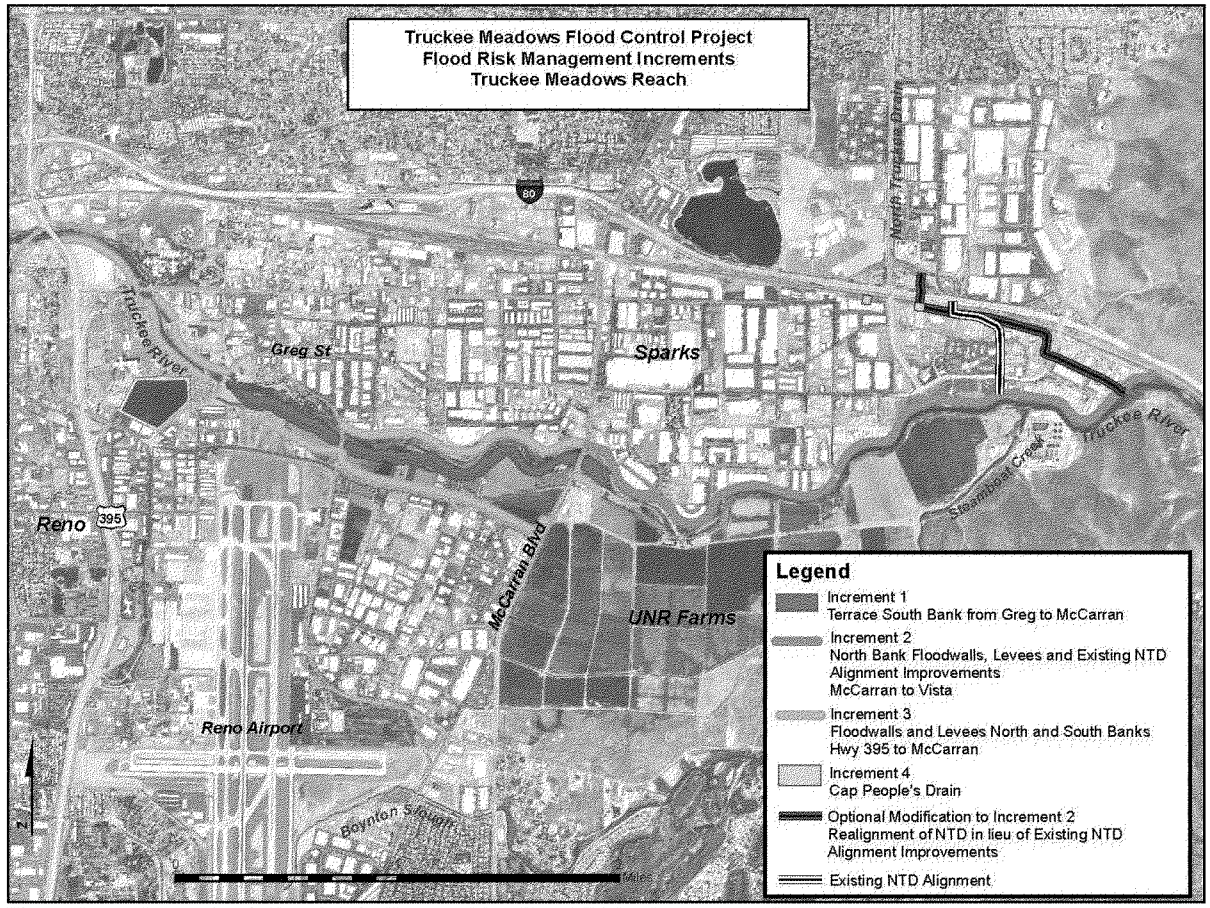

Figure 5-1. Alternative 3, Floodplain Terrace Plan Flood Risk Management Increments

5.7 Identification of NED Plan for Flood Risk Management, Truckee Meadows Reach

The preliminary flood risk management benefits, costs, net benefits, and benefit-to-cost ratio estimated for Alternative 3 - Floodplain Terrace Plan during the November 2011 workshop are summarized in Table 5-4 below. Because Alternative 3 - Floodplain Terrace was the highest ranked alternative in the final array and was formulated incrementally to provide a level of performance that reasonably maximizes net economic benefits, it has been identified as the NED Plan for FRM.

Table 5-4. Preliminary FRM Benefit-Cost Analysis for Truckee Meadows Reach ($1000) [1]

Alternative	First Cost	Annual Costs	Annual Benefits	Benefit-to-Cost Ratio	Net Benefits
Alternative 3 - Floodplain Terrace (1/50)	$251,200	$11,600	$25,200	2.1 to 1	$13,500

[1] October 2011 price levels; 50 years @ 4% interest; see Economic Appendix regarding economic uncertainty.

Feasibility-level designs and cost estimates were completed after the November 2011 workshop. Costs presented later in this report are based on those post-workshop products.

5.8 Residual Risk for NED Plan and Identification of Recommended Plan

5.8.1 Residual Risk

Not all Economic Impact Areas (EIAs) within the study area will have the same residual risk because some areas will get flooded by other tributaries/streams that are not part of the NED Plan (i.e., North Truckee Drain, Steamboat Slough, and Long Valley Creek) and/or are not directly behind the intended line of protection. While some of these areas may receive a slight benefit from the NED Plan, they will still have flooding from other sources at roughly the same frequency as they do under existing conditions. The EIAs that get flooded from other sources and/or are not directly behind an intended line of protection include EIAs 1, 2, 3, 4, 9, 10, 11, 12, 13, 14, and 15 (see Figure 5-2 and Table 5-5).

The project will increase the water surface elevations within the Truckee Meadows area as well as the downstream reaches of Steamboat Creek, Boynton Slough, and the North Truckee Drain. This increase in water surface elevation is due to the loss of storage in the floodplain. That is, construction of the proposed line of protection along the north side of the Truckee River results in the loss of storage in the commercial Sparks area which is removed from the Truckee River floodplain. This will result in an increase in water surface elevations of 4-8 inches for events between 2% and 1% ACE in EIAs 10-15. These increases were incorporated into the project performance and the impact to Annual Exceedance Probability and Assurance appear to be minimal as indicated in Table 5-5.

Figure 5-3 compares the residual floodplain for the NED Plan to the without-project floodplain for a 2% ACE event. The crosshatch area shows the without-project 2% ACE floodplain while the blue areas show the with-project 2% ACE floodplain.

Table 5-5. Project Performance[1] – With Project – Entire Study Area

EIA	Plan	AEP	LONG-TERM RISK			ASSURANCE BY ANNUAL CHANCE EVENT					
			10	30	50	10%	4%	2%	1%	0.40%	0.20%
1	*WO*	2.7%	24%	50%	75%	99%	85%	32%	5%	0%	0%
	Alt 3	2.7%	24%	50%	75%	99%	85%	32%	5%	0%	0%
2	*WO*	0.9%	9%	20%	36%	99%	99%	96%	67%	16%	3%
	Alt 3	0.8%	8%	18%	33%	99%	99%	97%	73%	21%	4%
3	*WO*	3.0%	27%	54%	79%	99%	72%	30%	10%	0%	0%
	Alt 3	2.6%	23%	49%	73%	99%	81%	41%	10%	1%	0%
4	*WO*	3.3%	28%	57%	81%	98%	76%	40%	17%	1%	0%
	Alt 3	2.6%	23%	48%	73%	99%	84%	50%	16%	3%	0%
5	*WO*	5.3%	42%	74%	93%	96%	33%	4%	0%	0%	0%
	Alt 3	0.7%	7%	16%	30%	99%	99%	98%	79%	29%	8%
6	*WO*	3.9%	33%	63%	86%	99%	58%	21%	1%	0%	0%
	Alt 3	0.9%	9%	20%	36%	99%	99%	99%	69%	3%	0%
7	*WO*	2.1%	19%	42%	66%	99%	91%	60%	8%	0%	0%
	Alt 3	1.0%	9%	21%	37%	99%	99%	98%	66%	3%	0%
8	*WO*	10.1%	65%	93%	99%	54%	5%	0%	0%	0%	0%
	Alt 3	0.9%	8%	20%	35%	99%	99%	95%	68%	19%	4%
9	*WO*	4.1%	34%	64%	87%	97%	59%	17%	2%	0%	0%
	Alt 3	--	--	--	--	--	--	--	--	--	--
10	*WO*	19.4%	89%	99%	99%	26%	5%	1%	0%	0%	0%
	Alt 3	20.4%	90%	99%	99%	24%	5%	1%	0%	0%	0%
11	*WO*	1.1%	11%	25%	44%	99%	99%	96%	47%	2%	0%
	Alt 3	1.2%	11%	25%	44%	99%	99%	95%	49%	2%	0%
12	*WO*	6.1%	47%	79%	96%	85%	47%	18%	1%	0%	0%
	Alt 3	6.4%	49%	81%	96%	83%	46%	16%	1%	0%	0%
13	*WO*	2.6%	23%	49%	74%	99%	84%	56%	11%	0%	0%
	Alt 3	2.7%	24%	50%	75%	98%	83%	54%	11%	0%	0%
14	*WO*	3.9%	33%	63%	86%	95%	69%	37%	5%	0%	0%
	Alt 3	4.0%	33%	64%	87%	94%	68%	35%	5%	0%	0%
15	*WO*	2.8%	25%	51%	76%	98%	83%	55%	10%	0%	0%
	Alt 3	2.8%	25%	51%	76%	98%	82%	52%	11%	0%	0%

1. See Engineering Appendix for uncertainty regarding project performance.

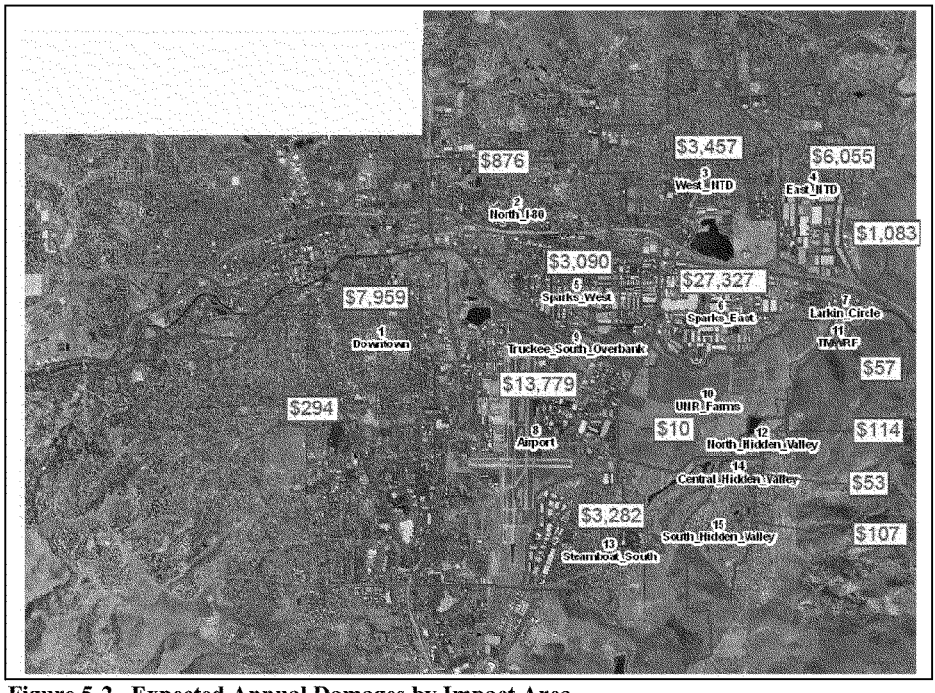

Figure 5-2. Expected Annual Damages by Impact Area
Oct 2011 Prices, $1,000's

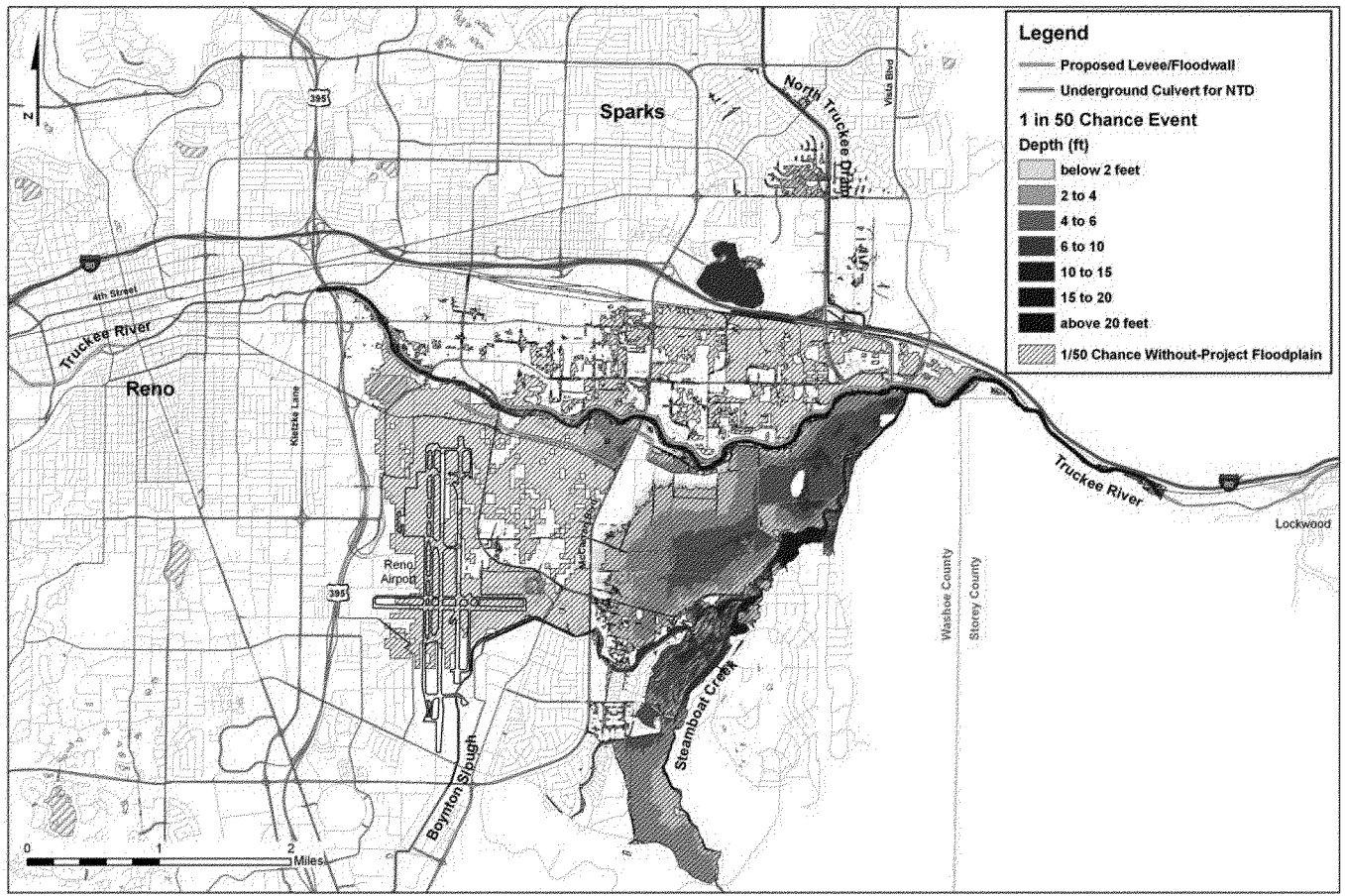

Figure 5-3. Without-project and residual floodplains for NED Plan for a 2% ACE

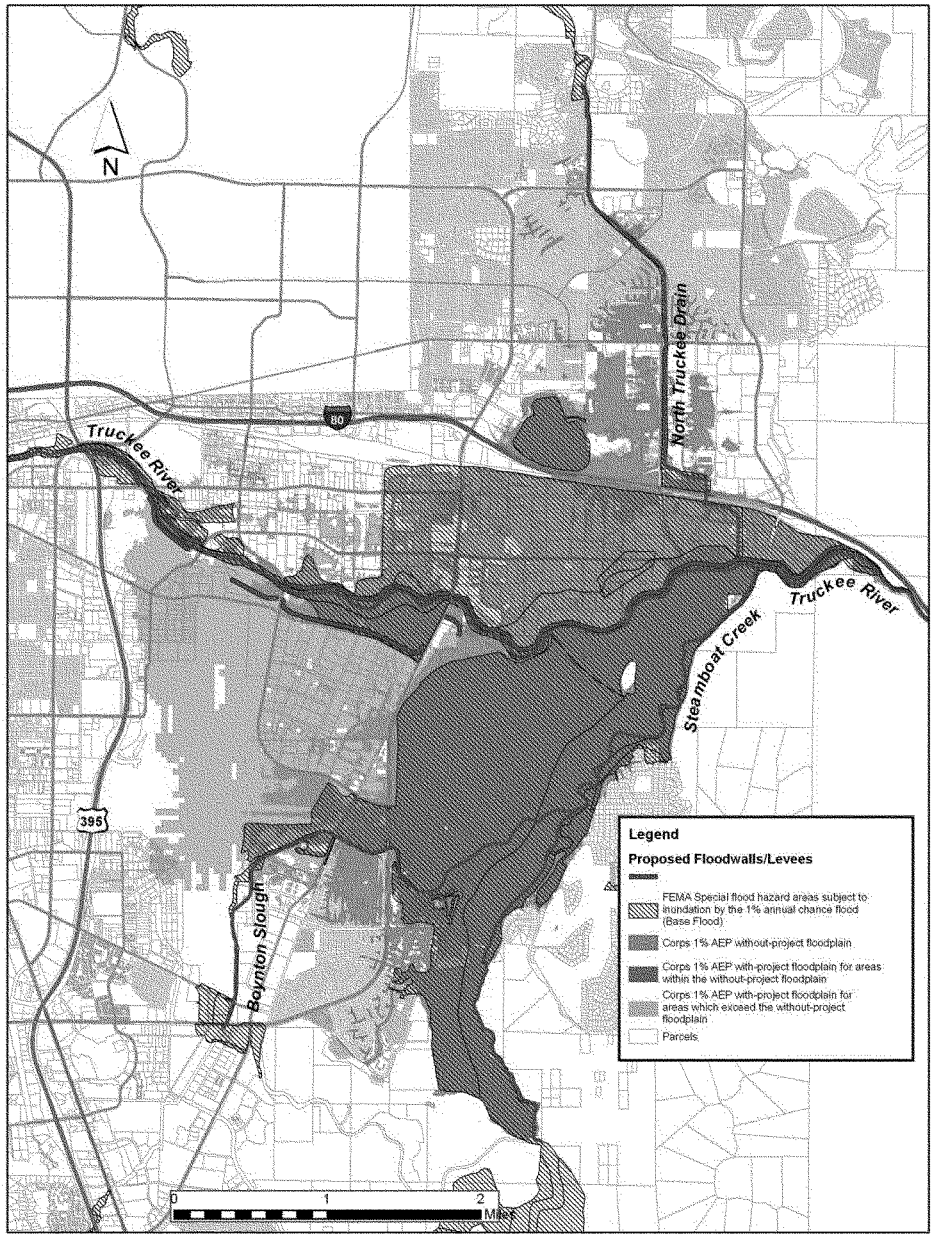

Figure 5-4. Without-project and residual floodplains for NED Plan for a 1% ACE

5.8.2 Induced Flooding Resulting From NED Plan in Two Areas

Hydraulic modeling of the NED Plan found that 1% ACE flood elevations would increase between 0.0 and 0.6 foot in several areas near the downstream end of the project compared to the without-project condition. (There is some level of uncertainty in any hydraulic model. In this case the actual without-and with-project water surface elevations could be 0.5 foot lower or higher than estimated.)

- UNR Farms and southern periphery (Steamboat South and Hidden Valley EIA's): The flood elevation increase in the UNR Farms area is up to 0.6 foot. USACE-estimated with-project 1% ACE flood elevations would exceed the first floor elevations of an estimated 900 existing structures (mostly single-family residences and multiplex apartment buildings) on the southern periphery of the UNR Farms area that are also within the USACE without-project 1% ACE floodplain. An estimated additional 175 residences that are outside of the USACE without-project 1% ACE floodplain would be within the limits of the with-project floodplain, but it is estimated that their first floors would still be above the with-project flood elevation. The estimated increase in the 2% ACE flood elevations would affect about 22 existing structures south of UNR Farms (Steamboat South and Hidden Valley EIA's), most of which would have an estimated increase of 0.2 to 0.4 foot.

- North Truckee Drain (NTD): The 1% ACE flood elevation on both sides of the North Truckee Drain (NTD) immediately north of I-80 would be increased by approximately 0.5 to 1 foot due to backwater effects in the NTD.

The average annual induced damages are estimated to be $90,000. Figure 5-4 shows the areas in the estimated without- and with-project 1% ACE floodplains based on USACE hydrology. The area shown in blue is the without-project 1% ACE floodplain and the area in green is the with-project 1% ACE floodplain. The areas shown in yellow are areas that are now in the 1% ACE (with-project) floodplain that were not in the without-project floodplain – these are areas that now are anticipated to flood from the 1% ACE event (see Figure 5-6 for additional view of these areas). The crosshatched area is the existing Federal Emergency Management Agency (FEMA) base flood area. The FEMA map is included here to illustrate the difference between the FEMA and USACE floodplains, as it is expected that FEMA will adopt USACE hydrology when the FEMA maps are updated.

Additional information regarding the increased flood elevation is included in the Economic Appendix and Attachment B to the Engineering Appendix.

5.8.3 Consideration of Mitigation for Induced Flooding From NED Plan

USACE policy allows mitigation for induced flooding to be recommended as a project feature when it is economically justified or there are overriding reasons of safety, economic or social concerns, or a determination of a real estate taking has been made (ER 1105-2-100, para.3-3.b.(5)). Potential mitigation measures for induced flooding were considered by the District, but none were found to be economically justified. The structural and non-structural measures considered for the south side of the Truckee River were: raising or wet floodproofing existing residential and commercial structures, levees and floodwalls to protect existing structures, a detention basin with perimeter levees in the UNR Farms area, excavation of the hydraulic constriction downstream of Truckee Meadows including downstream hydraulic and environmental mitigation, or purchase/ removal of the affected structures. The structural and non-structural measures considered for the north side of the Truckee River were a pump station, ring levees, or raising/wet flood-proofing existing residential and commercial structures. Raising/flood-proofing structures on the south side and a pump station on the north side were found to be the least costly options based on rough cost estimates for each measure by District civil and cost engineering staff using their professional experience. The average annual flood risk management benefits for those measures were found to be far less than required to justify their costs. Any increase in flooding will be an important concern for adversely affected property owners. However, because of the small increase in flood elevations and the low recurrence frequency of induced flooding, those concerns are not considered to be overriding safety, economic, or social concerns under USACE policy, and no real estate taking would occur specifically due to the increase in water surface elevations. Therefore, mitigation for induced flooding is not proposed as a project feature of the Federally-funded NED Plan.

5.8.4 National Flood Insurance Program Compliance

The increased 1% ACE flood elevations caused by the NED Plan (based on feasibility level hydraulic modeling) would trigger a National Flood Insurance Program (NFIP) regulatory requirement (44 CFR 60.3(d)) that communities must seek conditional approval from FEMA before allowing certain encroachments upon a floodplain. Applications for such conditional approvals must certify, among other things, that no structures are located in areas that would be impacted by increased base flood elevations (44 CFR 65.12(a)(5)). Under USACE policy (ER 1105-2-100, para.3-3.b.(5) and (10)), compliance with the NFIP is a non-Federal responsibility and compliance costs would be borne by non-Federal interests.

The cost for NFIP compliance is the estimated minimum cost for the non-Federal interests to comply with the NFIP if the NED plan is implemented. Participation in and compliance with applicable Federal floodplain management and flood insurance programs is a requirement of non-Federal sponsor participation in Federal flood control projects under Section 402 of WRDA 1986, as amended. The NFIP compliance costs are not based on specific features proposed by the sponsor. The estimated NFIP compliance costs are based on the least-cost

features that could be added to the NED Plan by local interests to achieve NFIP compliance, without modifying the NED Plan. NFIP compliance costs have been identified pursuant to the joint FEMA-USACE memorandum, subject: FEMA/USACE Joint Actions on Planning for Flood Risk Management Projects, signed in June 2012.

USACE considered several options for NFIP compliance and determined that non-structural methods including house raising would likely be the least-cost option on the south side of the Truckee River. Through coordination with regional FEMA staff, it was verified that raising the first floors of affected residences above the new base flood elevation would comply with the NFIP regulation. Approximately 764 homes and 128 multiplex apartment buildings would need to be raised in the area south of the river. Additionally, four commercial structures and three public buildings would also need to be raised or "wet flood-proofed" with closures and sealing. Figure 5-7 identifies the land parcels with structures that are estimated to require raising or flood-proofing. The preliminary cost estimate to raise and flood-proof structures for NFIP compliance on the south side of the Truckee River is $172 million. For the north side of the Truckee River, a 400-cfs capacity pump station on the North Truckee Drain with an outfall to the Truckee River would be the least-cost option. The estimated first cost for the pump station is $23 million. Therefore, the total estimated minimum non-Federal costs cost for NFIP compliance is $195 million.

Because compliance with the NFIP is a non-Federal responsibility, the affected NFIP communities could develop their own plan for compliance with the NFIP and would not be required to implement the specific assumed least-cost features. The estimated NFIP compliance costs are subject to change based on more detailed hydraulic analysis during final design of the project, including the results of NFIP hydraulic modeling assumptions and methods, and more detailed surveys of the elevations of existing structures.

5.8.5. Sensitivity Analysis of Potential Additional Effects of SouthEast Connector

Washoe County Regional Transportation Commission (RTC) plans to construct a 5.5 mile north to south roadway, SouthEast Connector, in the USACE study area (Figure 5-5). Although it is considered likely that a roadway project will be built, there is significant uncertainty about the final design and effects of the roadway. This uncertainty is due to changes that may be required in order to obtain a USACE permit and any changes resulting from the public opposition. However, a sensitivity analysis was conducted based on the current roadway design to determine whether it would significantly change the results of the economic analysis of the NED Plan or the recommendations in this GRR.

USACE reviewed the 50% design of the roadway and using professional hydraulic engineering judgment has estimated that the water surface elevation for the 1% ACE flood event under the NED Plan would increase up to an additional 1 foot (plus or minus 0.5 foot) primarily in the area on the west side of the roadway. An estimated 153 additional structures would have a 1% base flood elevation increased above their first floor. It is estimated that 152 of those

structures would need to be elevated for NFIP compliance and one commercial structure would be floodproofed. The 899 structures identified in Section 5.8.4 would also need to be raised (or floodproofed if appropriate) an additional foot. Based on preliminary estimates, the additional minimum non-Federal cost for NFIP compliance, if the SouthEast Connector is constructed as currently designed, would be $29 million, which is approximately $1.3 million in annual costs. A sensitivity analysis of the effect of that potential additional economic cost on the project justification is included in Section 6.7.

The hydraulic effects of the final design of the SouthEast Connector will be considered during PED for the Truckee Meadows Flood Control Project and adjustments will be made as appropriate.

5.9 Restoration of Fish Passage in the Truckee River

The Lahontan cutthroat trout (LCT) and cui-ui lake sucker occur only in the Truckee River and Pyramid Lake. The LCT is a Federally listed threatened species. The cui-ui is listed as endangered by both the Federal government and the State of Nevada. Both fish species are institutionally recognized as significant based on the criteria in ER 1105-2-100, Appendix E. The cui-ui is also publicly recognized as significant by the Pyramid Lake Paiute Tribe as a sacred resource. The LCT can be found throughout the entire Truckee River, although self-sustaining populations are only found in a few tributaries of the upper watershed. The cui-ui are not currently able to access the river above Derby Dam.

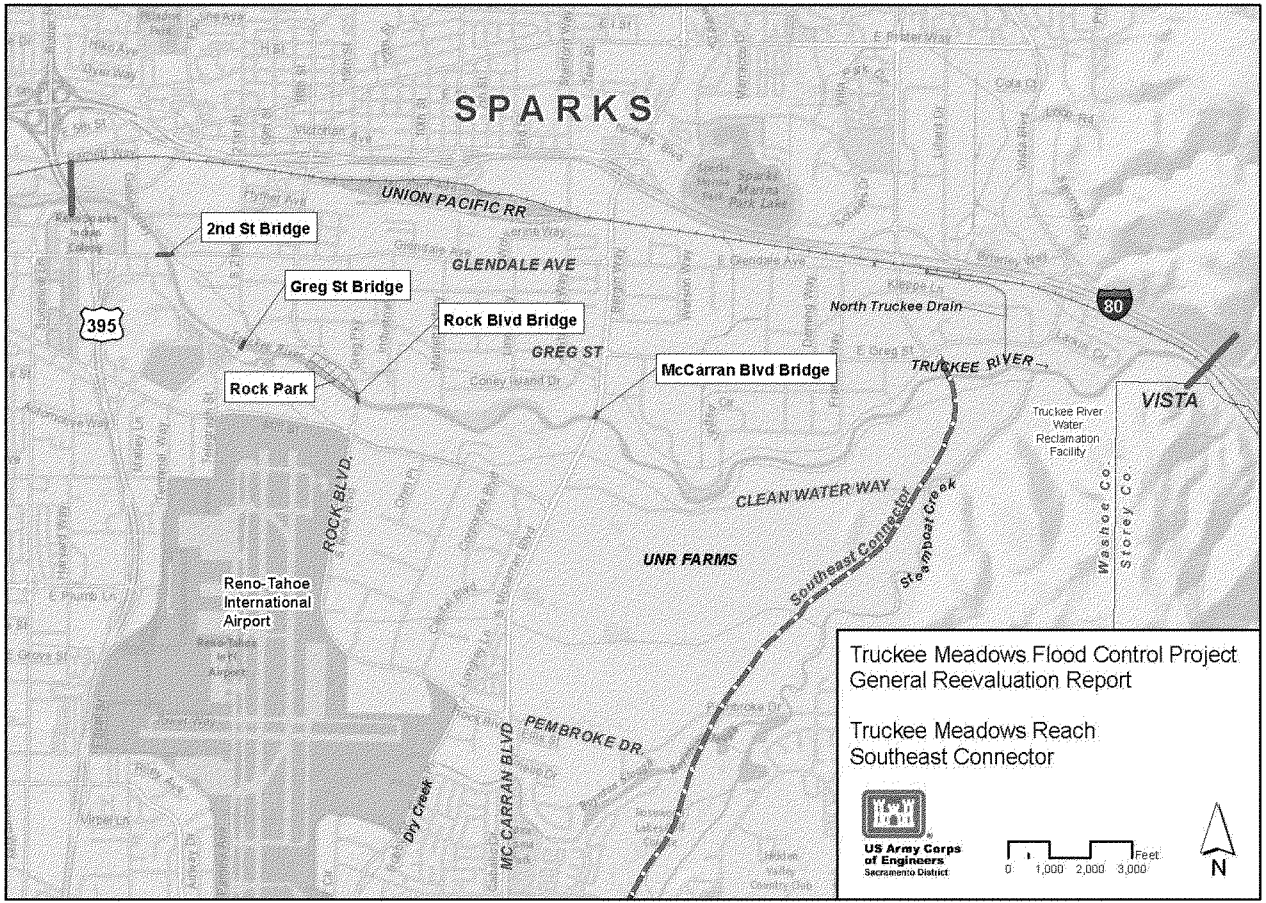

Figure 5-5. Proposed Location of SouthEast Connector

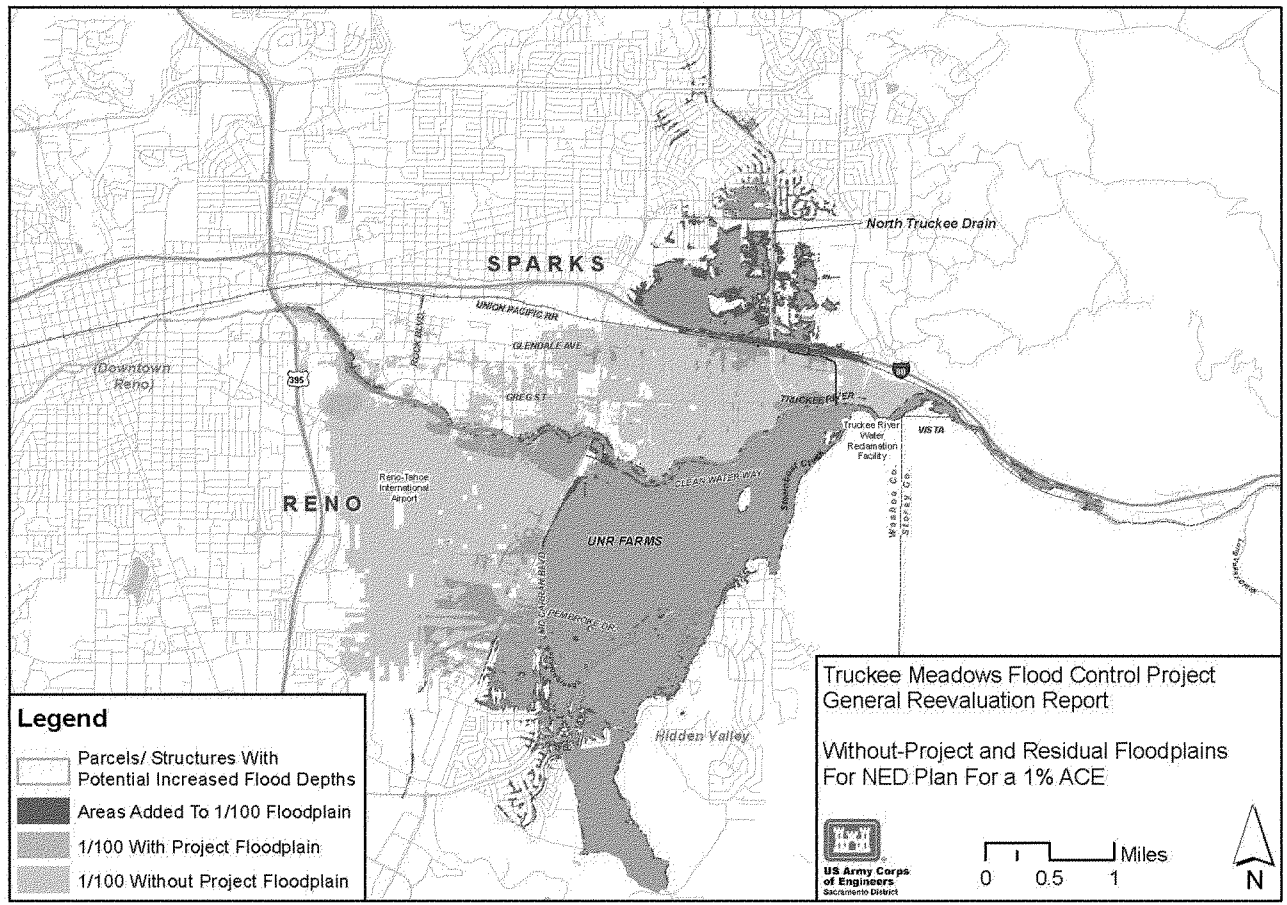

Figure 5-6. Areas added to 1/100 Floodplain and Parcels Potentially Requiring Raising/Flood-proofing for NFIP Compliance

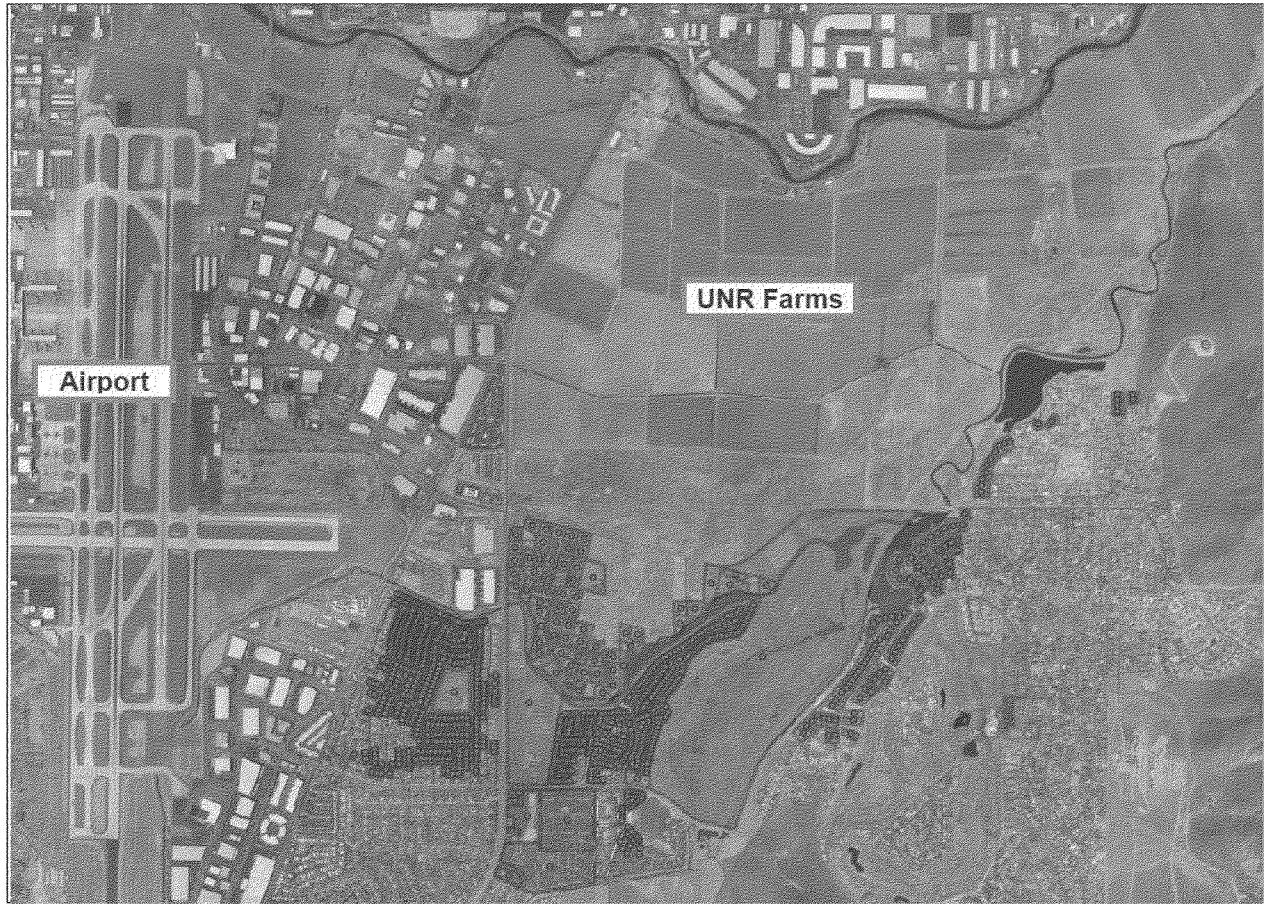

Figure 5-7. Parcels with Structures Potentially Requiring Raising/Flood-proofing for NFIP Compliance

5.9.1 Fish Passage Benefits

Crucial to the evaluation process for the fish passage alternatives is establishing the metric for the output or benefit of each alternative. Since there is no commonly accepted metric for fish passage, a specific method of quantifying benefits was established for the Truckee River. The development of benefits for the fish passage alternatives has been a cooperative venture between the USACE, Engineer Research and Development Center (ERDC), the Pyramid Paiute Tribe, and local resource agencies. The quantification of benefits for fish passage proved to be quite subjective, with the lack of basic species data forcing the team to make a number of assumptions that could potentially be challenged. It was determined that an expert elicitation would be the best route to determining the benefits of the various fish passage alternative plans.

Based on the number of assumptions and the species-specific knowledge, ERDC developed a simplified version of a recognized prioritization and benefits scoring system for northwestern anadromous salmonids for upstream benefits. The scoring system takes a number of variables to measure quality (such as population potential, habitat range, mobility potential) multiplied by river miles. Since the variables differ widely from species to species, there is not ideal score per mile. In general, the higher the output score, the better the alternative performs. A discussion of the benefit methodology, including formulas and algorithms used is in the Truckee River Fish Passage Report available in the Sacramento District's project files.

There are two main components to successful fish passage around obstructions in the river: upstream and downstream. The upstream and downstream components each required different solutions and, consequently, different benefit evaluations. As described in Chapter 4, a total of 54 different combinations of alternatives at all diversions were evaluated for fish passage.

5.9.2 Cost Effectiveness Analysis

The results of cost effectiveness analysis using the average output estimate are shown in Figure 5-8. There are 16 cost effective plans including No Action. The outputs are units of river miles; however, the equations scale river miles as a function of the ecosystem processes with significance to restoration. They are equivalent to the more conventional "habitat units," and can be scaled accordingly.

5.9.3 Incremental Cost Analysis

Incremental Cost Analysis was performed on all cost effective plans. The results of ICA using the average or expected value of environmental outputs are shown in Table 5-6 and Figure 5-8. ICA displays the increase in cost to obtain an increase in outputs for successively larger cost effective plans. The Best Buy plans are the most efficient in production of

successively larger (i.e., greater output) plans. The three Best Buy plans (in addition to No Action) are:

- Plan 37, which consists of Marble Bluff (bypass channel) + S-S (pump) (upstream only) + Fellnagle (upstream only) + Herman (upstream only)

- Plan 12, which consists of all upstream actions + Washoe downstream + Verdi downstream + Fleisch downstream

- Plan 11, which is the maximum plan consisting of all sites and all measures (upstream and downstream)

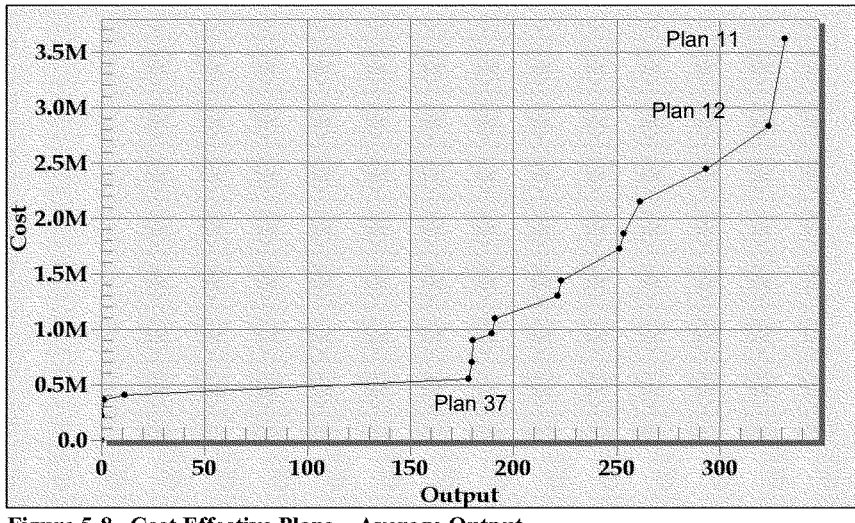

Figure 5-8. Cost Effective Plans – Average Output

Table 5-6. Incremental Cost Analysis: Best Buy Plans – Average Output

Alternative	Incremental Cost ($)	Incremental Output (miles)	Incremental Cost / Incremental Output
No Action Plan	0	0	0
Plan 37	553,373	178.0	3,109
Plan 12	2,280,725	145.6	15,659
Plan 11	783,342	7.9	99,567

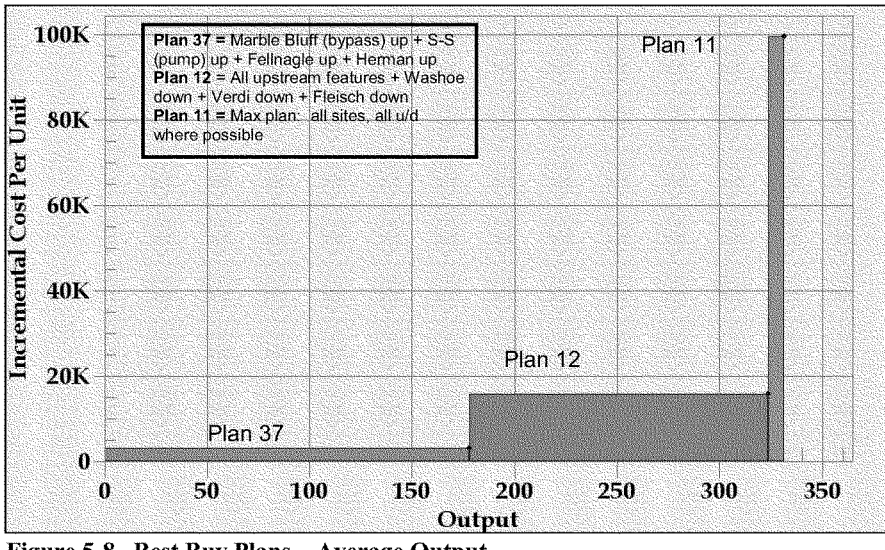

Figure 5-8. Best Buy Plans – Average Output

A sensitivity analysis was performed using minimum and maximum output forecasts. Plans 37, 12, and 11 were consistently identified as Best Buy plans. This gives the project delivery team confidence that, regardless of some residual uncertainties associated with estimation of subjective parameters in the benefits methodology, these plans are the most economically efficient.

5.9.4 Identification of Most Cost Effective Plan for Fish Passage

Table 5-7 provides a summary of the composition, benefit, and cost of each of the Best Buy Plans. Important considerations to note are:

- Plan 37 is an upstream passage plan that addresses only the lower river, which was not recommended by ERDC due to the importance of coldwater habitats in the upper system to Lahontan cutthroat trout and other species.
- Plans 11 and 12 include the most expensive and highest benefit upstream passage restoration plans.

Based on the results of the Cost Effectiveness/Incremental Cost Analyses, Plan 12 is the most cost effective plan for fish passage.

In summary, the features of Plan 12 are:

- Fleish Diversion: Construct new fish bypass channel and install a fish screen at ditch inlet.
- Steamboat Diversion: Modify existing rock weir/dam to improve fish passage.
- Verdi Diversion Dam: Construct new fish bypass channel and install a fish screen at ditch inlet.
- Washoe/Highlands Diversion: Construct new fish bypass channel and install a fish screen at ditch inlet.
- Herman Ditch Diversion: Reconstruct fish-friendly dam structure and ditch inlet.
- Fellnagle Diversion: Modify dam structure and ditch inlet.
- S-Bar-S Ranch: Install an irrigation pump with fish screen.
- Marble Bluff Dam: Construct new fish bypass and retrofit existing fishway for low lake level conditions.

The total first cost of Plan 12 is $47,224,000 (Oct 2012 price level). The plan restores upstream passage at all 9 diversions and downstream passage at 3 diversions. This restores fish access to approximately 90 miles of the Truckee River.

Through a series of meetings between 2008 and 2010, the Best Buy plans were presented to project partners, regulating agencies, and stakeholders to discuss the benefits and drawbacks of each plan and to solicit a preference for a specific plan. Based on feedback from the PLPT, USFWS, USBOR, NDOW, USGS, Washoe County, TMWA (TMWA was later replaced by TRFMA), and the University of Nevada, Reno, Plan 12 was also the stakeholders' preferred fish passage plan.

Table 5-7. Summary of Best Buy Plans for Fish Passage

Diversion	Plan 37	Plan 12	Plan 11
Marble Bluff	bypass channel	bypass and retrofit of fish ladder	bypass and retrofit of fish ladder
S-S	pump (with fish screen)	pump (with fish screen)	pump (with fish screen)
Fellnagle	modify existing dam and inlet structure	modify existing dam and inlet structure	modify existing dam and inlet structure with fish screen
Herman	modify existing dam and inlet structure	modify existing dam and inlet structure	modify existing dam and inlet structure with fish screen
Tracy PP			fish screen
Cochran			fish screen
Idlewild Ponds			fish screen
Orr			fish screen
Lake			fish screen
Last Chance			fish screen
Washoe/ Highlands		bypass channel and fish screen	bypass channel and fish screen
Verdi		bypass channel and fish screen	bypass channel and fish screen
Steamboat		modify existing rock weir	modify existing rock weir
Fleisch		bypass channel and fish screen	bypass channel and fish screen
Total Output (avg)	432.8	578.5	586.3
Net Output (miles)	178.0	323.6	331.5
Avg Annual Cost[1]	553,373	2,834,098	3,617,440
Total First Cost	8,662,860	44,425,460	56,824,100

[1]Average Annual Costs include OMRRR and IDC.

The Truckee Meadows project was authorized by Congress in 1988 for flood control and fish and wildlife enhancement. Since the 1990's, there has been a strong local interest in reestablishing a "living river" corridor to convey flood flows, reestablish native habitat and restore fish passage along the Truckee River. All of these project purposes were considered during USACE's general reevaluation of the project. Restoration of fish passage on the Truckee River was evaluated in detail pursuant to the 1990 Tribes Water Rights Settlement Act, § 207. In 2012, the USACE and the Administration, in coordination with the sponsor, decided to refocus plan selection on the primary project purpose of flood risk management to expedite completion of the study consistent with Administration and sponsor priorities (Reference: Commander, USACE South Pacific Division memorandum dated 6 July 2012, subject: Truckee Meadows Project General Reevaluation Report, NV). Federal interest in a plan for the restoration of fish passage has been established, but that plan is not being recommended for implementation by the USACE at this time.

5.10 Recreation Component

5.10.1 Recreation Plan Evaluation

Cost estimates for two preliminary recreation plans were completed in 2008. The sponsor's contractor, Stantec, prepared a preliminary cost estimate for the Locally-Developed Recreation Plan that totaled $74 million dollars. Because the costs exceeded the available recreation benefits, the sponsor and USACE downsized the plan. The revised preliminary estimate totaled $39.1 million, which still was not economically justified. The Locally-Developed Recreation Plan was therefore eliminated from further consideration.

The USACE recreation plan was formulated based on policy-compliant recreation features. The strategy used to formulate recreation alternatives was to start with a relatively few basic recreation measures and add more optional features (playground and group picnic shelters) as additional increments. The measures were evaluated against their ability to meet the planning objective and the four P&G screening criteria, particularly effectiveness. Three scales of recreation features were evaluated to complement the NED plan for flood risk management:

Alternative A includes:

- 50 Individual picnic areas
- 4 Kayak and canoe input areas
- 13 Fishing areas
- 9,700 lf paved trails
- 8,900 lf unpaved trails

Trailheads were included in the paved and unpaved trail features. Fishing access, non-motorized boat access and kayaking access costs were combined with the cost of trails leading to them because benefits cannot be derived from these activities unless access is provided by trails.

Alternative B adds the following measures to Plan A:

- 1 Playground
- Small group picnic shelter

Alternative C adds the following measure to Plan B:

- Medium group picnic shelter

Costs and benefits were developed for each of the three alternatives. Preliminary costs were used based on conceptual designs, previous bid results and professional judgment. Basic access, health, and safety features including parking and restrooms were included in all alternatives. The unit day benefit value was developed for each recreation alternative using professional judgment and the guidelines provided in Economic Guidance Memorandum 13-03, Unit Day Values for Recreation for Fiscal Year 2013. The unit day values are presented in Table 5-8. Point values were assigned based on an evaluation of existing recreation features within the project area using the point scale provided in EGM 12-03. Criteria measured included recreation experience, availability of opportunity, carrying capacity, accessibility, and environmental condition. Scoring was the result of informed opinion and professional judgment. Potential point values range from 0 to 100.

Table 5-8 Unit Day Value Worksheet for Alternative A

Alternative A - Recreation Unit Day Value Worksheet		
Evaluation Criteria	**Assigned Points**	**Notes on Judgment Factors**
Recreation Experience	without project: 11	Several general activities; one high quality value activity (rafting)
	with project: 13	Increase in general activities over w/o project
Availability of Opportunity	without project: 3	Recreation opportunities exist w/i both 1 hour and 30 min.
	with project: 6	Increases opportunities for some activities to w/i 30 min
Carrying Capacity	without project: 6	Basic + facilities (could be a 5)
	with project: 8	Provides adequate facilities at site.
Accessibility	without project: 10	Fair access to existing recreation
	with project: 13	Improved access to site
Environmental Condition	without project: 5	Average quality; viewshed limited or impaired
	with project: 13	New recreation would have high esthetic quality and improved viewshed
Total Assigned Points	without project: 35	
	with project: 53	

Table 5-9. Unit Day Value Worksheet for Alternative B

Recreation Unit Day Value Worksheet		
Evaluation Criteria	**Assigned Points**	**Notes on Judgment Factors**
Recreation Experience	without project: 11	Several general activities; one high quality value activity (rafting)
	with project: 15	Increase in general activities over w/o project and Alt A.
Availability of Opportunity	without project: 3	Recreation opportunities exist w/i both 1 hour and 30 min.
	with project: 6	Increases opportunities for some activities to w/i 30 min
Carrying Capacity	without project: 6	Basic + facilities (could be a 5)
	with project: 8	Provides adequate facilities at site.
Accessibility	without project: 10	Fair access to existing recreation
	with project: 13	Improved access to site
Environmental Condition	without project: 5	Average quality; viewshed limited or impaired
	with project: 13	New recreation would have high esthetic quality and improved viewshed
Total Assigned Points	without project: 35	
	with project: 55	

Table 5-10. Unit Day Value Worksheet for Alternative C

Recreation Unit Day Value Worksheet		
Evaluation Criteria	**Assigned Points**	**Notes on Judgment Factors**
Recreation Experience	without project: 11	Several general activities; one high quality value activity (rafting)
	with project: 16	Increase in general activities over w/o proj and Alts A & B
Availability of Opportunity	without project: 3	Recreation opportunities exist w/i both 1 hour and 30 min.
	with project: 6	Increases opportunities for some activities to w/i 30 min
Carrying Capacity	without project: 6	Basic + facilities (could be a 5)
	with project: 11	Provides optimum facilities at site.
Accessibility	without project: 10	Fair access to existing recreation
	with project: 14	Improved access to site and on site
Environmental Condition	without project: 5	Average quality; viewshed limited or impaired
	with project: 13	New recreation would have high esthetic quality and improved viewshed
Total Assigned Points	without project: 35	
	with project: 60	

Table 5-11. Unit Day Values and Recreation Value

Recreation Alternative	Assigned Point Value	Gen. Recreation Value
Project Without Project	35	$5.70
Alternative A	53	$8.07
Alternative B	55	$8.07
Alternative C	60	$8.78

Recreation demand was determined based on a 2008 recreation demand survey conducted by Responsive Management of Harrisonburg, VA. Table 5-12 displays the results by recreation feature. The methodology involves multiplying carrying capacity times turnover rate times weeks in the season divided by the percentage of day use. That total is then divided by the percentage of season use. Recreation demand for unpaved trails was calculated on the activities of running, walking, and jogging. The survey identified mountain biking as another activity that could make use of unpaved trails, however, for an urban setting this demand is considered to remain unmet by the project.

The general recreation value for each alternative was multiplied by the average annual users to determine a total annual recreation value for each alternative. The results are displayed in Table 5-13.

Each recreation alternative had a preliminary cost estimate developed. A preliminary estimate of the interest during construction and the routine OMRRR costs was developed to calculate the average annual cost for each alternative. The summary is displayed in Table 5-14.

Table 5-15 shows the preliminary recreation evaluation results. Alternative C has the greatest net recreation benefits at $333,006, as well as a benefit-to-cost ratio of 2.1:1 Therefore; Alternative C is identified as the NED recreation plan. A more detailed cost estimate for the recreation plan was subsequently prepared after a considerable length of time had elapsed. Consequently the final costs for recreation are considerably higher than those included in this benefit analysis. However, the increases in cost affected all the alternatives in a commensurate manner and Alternative C remains the NED recreation plan.

Table 5-12. Recreation Demand by Feature

Recreation Feature	Total Expected Participants[1]	Carrying Capacity	Turnover rate	Weeks in Season	Weekend Day Use[2]	Recreation Season Use	Annual Users per Feature (x number of features)
Medium Picnic Shelter - Large* 40' x 40' w/16 tables	363,853	64	1	30	35%	75%	7,314
Small - 20' x 20' w/4 tables	683,698	16	1	30	35%	75%	1,829
Picnic Areas	1,388,114	5	2	30	35%	75%	57,143
Kayaking	563,825	1	4	20	25%	65%	9,600[4]
Non Motorized Boats	812,744	0.5	4	20	20%	65%	NA
Fishing	998,330	0.2	4	20	20%	65%	1,600
Playgrounds	4,421,642	1	8	30	25%	65%	1,477
Trails							
Unpaved	9,950,885	12	4	30	30%	70%	24,080
Paved	5,015,074	12	4	30	30%	70%	12,597
Total							**115,640**

[1]Represents total demand for each recreation feature throughout survey area.
[2] Percentage of weekends facility is in use.
[3] Percentage of recreation season that facility is in use.
[4] Combined users for kayaking and non motorized boats.

Table 5-13. Total Annual Recreation Value

Recreation Alternative	Gen. Recreation Value	Avg. Annual Visitors	Total Annual Value	Net Annual Value
Without Project	$5.70	70,122	$399,695	0
Alternative A	$8.07	106,497	$859,433	$459,738
Alternative B	$8.07	108,326	$874,191	$474,495
Alternative C	$8.78	115,640	$1,015,320	$615,625

Table 5-14. Summary of Recreation Costs (Preliminary Costs, Oct 2011 Prices)

Recreation Alternative	First Costs	IDC	Total Investment Cost	Annualized Investment Cost	Annual O&M	Average Annual Costs
Alternative A	$3,959,230	$240,720	$4,199,950	$195,509	$54,890	$250,399
Alternative B	$4,148,760	$252,240	$4,401,000	$204,867	$57,400	$262,267
Alternative C	$4,476,250	$272,160	$4,748,410	$221,039	$61,580	$282,619

Based on October 2011 price levels, 4 percent rate of interest, and a 50-year period of analysis.

Table 5-15. Comparison of Alternative Recreation Plans (Prelim Costs, Oct 2011 Prices)

Recreation Alternative	Average Annual Benefits	Average Annual Costs	B/C Ratio	Net Benefits
Alternative A	$459,738	$250,399	1.84	$209,339
Alternative B	$474,495	$262,267	1.81	$212,228
Alternative C	$615,625	$282,619	2.18	$333,006

5.10.2 Recreation Plan Description and Detailed Benefit/Cost Evaluation

The NED recreation plan Alternative C consists of the following features in the Truckee Meadows Reach:

- 50 Individual picnic areas
- 4 Kayak and canoe input areas
- 13 Fishing areas
- 9,700 lf paved trails
- 8,900 lf unpaved trails
- 1 Playground
- Small group picnic shelter
- Medium group picnic shelter
- Access road, parking, restrooms, and signage

The table below provides the benefit/cost evaluation of the NED recreation plan (Alternative C) using more detailed cost estimates at October 2013 price levels and a 3.5% interest rate. Benefits were also updated to October 2013 prices.

Table 5-16. Revised BCR and Net Benefits for Alternative C (Oct 2013 Prices)

Recreation Alternative	Average Annual Benefits	Average Annual Costs	B/C Ratio	Net Benefits
Alternative C	$625,000	$612,000	1.0	$13,000

5.11 Identification of the Recommended Plan

The Recommended Plan for the Truckee Meadows GRR consists of:

- No action in the Downtown Reno Reach
- Flood risk management in the Truckee Meadows Reach, consisting of the NED Plan (FRM Alternative 3 - Floodplain Terrace Plan)
- NED Plan for recreation in the Truckee Meadows Reach (Recreation Alternative C)

CHAPTER 6
DETAILS OF THE RECOMMENDED PLAN

As identified in Chapter 5, the Recommended Plan consists of no action in the Downtown Reno Reach, flood risk management in the Truckee Meadows Reach (Alternative 3 - Floodplain Terrace Plan) and recreation in the Truckee Meadows Reach (Alternative C).

6.1 Features and Accomplishments

The principal features of the Recommended Plan are (1) construction of floodwalls, levees, and floodplain terracing in the Truckee Meadows Reach, and (2) basic recreation features in the Truckee Meadows Reach. A summary description follows and is also shown in Table 6-1.

6.1.1 Levees and Floodwalls

The Recommended Plan includes approximately 9,650 lineal feet of on-bank (6,500 feet) and in-channel (3,150 feet) floodwalls along the north bank and 31,000 lineal feet of levees along the north and south banks of the Truckee Meadows Reach (see Figure 6-2). A gravel maintenance road is included on the crown of the levee. The road will be 12 feet wide with 2-foot aggregate base shoulders.

6.1.2 Floodplain Terracing

This feature involves excavating a benched area along portions of the south (right) bank of the Truckee River between Greg Street to McCarran Boulevard. Vertically, the excavation would extend down to just above the two-year water surface elevation (WSE). Excavation would create a low bench above the low-flow channel bed, which would be inundated during higher winter and spring flow events. This low bench would extend approximately 150 to 250 feet to the landside of the south bank of the Truckee River from Greg Street to Vista. A second bench, approximately 2 feet higher in elevation, would be extended approximately 50-70 feet to the landside of most of the length of the low bench. Floodplain terracing would increase the flood flow channel capacity and thereby reduce water surface elevations in the Truckee Meadows area during a flood. Figure 6-1 shows a typical cross-section of the channel with terracing in place.

Erosion will be controlled on the excavated surfaces of the terraces through establishment of permanent vegetative cover. Native trees grasses and shrubs such as meadow barley, slender wheatgrass, cottonwoods, willows, golden currant, and buffaloberry will be utilized as they will provide a self sustaining cover of vegetation to serve both the purpose of stabilization and exclusion of noxious weeds. At the end of the Reno International Airport runways, between Greg Street and Rock Blvd., no cottonwood and red willow trees will be planted on the excavated terraces due to clearance zone restrictions. During the time that it takes to establish a permanent vegetative cover, erosion control best management practices will be utilized as needed. Hydraulic design of the Recommended Plan assumed that the terraces will be covered by mature vegetation, so the vegetation will not need to be managed to maintain the design hydraulic capacity of the terraces.

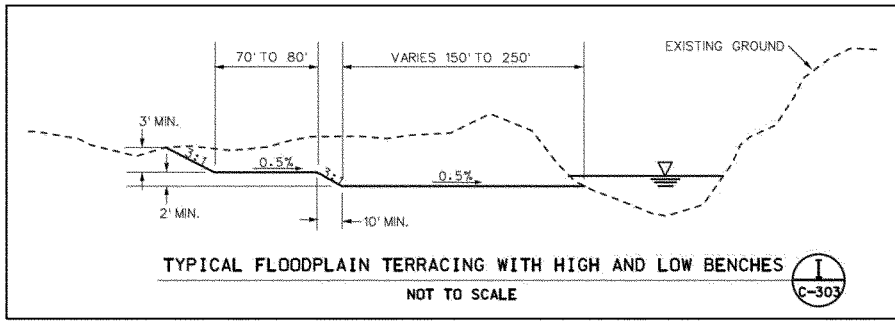

Figure 6-1. Typical cross-section of floodplain terrace

Table 6-1. Project Features – Truckee Meadows Reach

Features	Description
Levees	31,000 lf on north/south banks of Truckee River
Floodwalls (on-bank)	6,500 lf on north and south banks of Truckee River
Floodwalls (in-channel)	3,150 lf on north and south banks of Truckee River
Floodplain terrace	150 to 250 feet to the landside of the south bank of the Truckee River from Greg Street to just upstream of McCarran Boulevard. A higher bench, approximately 2 feet higher in elevation, would be extended approximately 50-70 feet to the landside of the low bench.
Box culverts on North Truckee Drain (NTD)	NTD placed in 2 box culverts for approximately 3,100 lf. The new drainage structure includes an approximately 200-lineal-foot extension to the existing People's Drain. Cap 2 junction structures of People's Drain.
Interior drainage	14 cfs pumping station just upstream of Glendale and new flap gates and vertical sluice gates for all existing storm drains.
Seepage prevention	Seepage berms, drainage blankets, impervious berms, and relief wells
Bridge pier/Scour protection	11,600 lf rock scour protection. Pier protection at 3 bridges between US Hwy 395 and Vista.

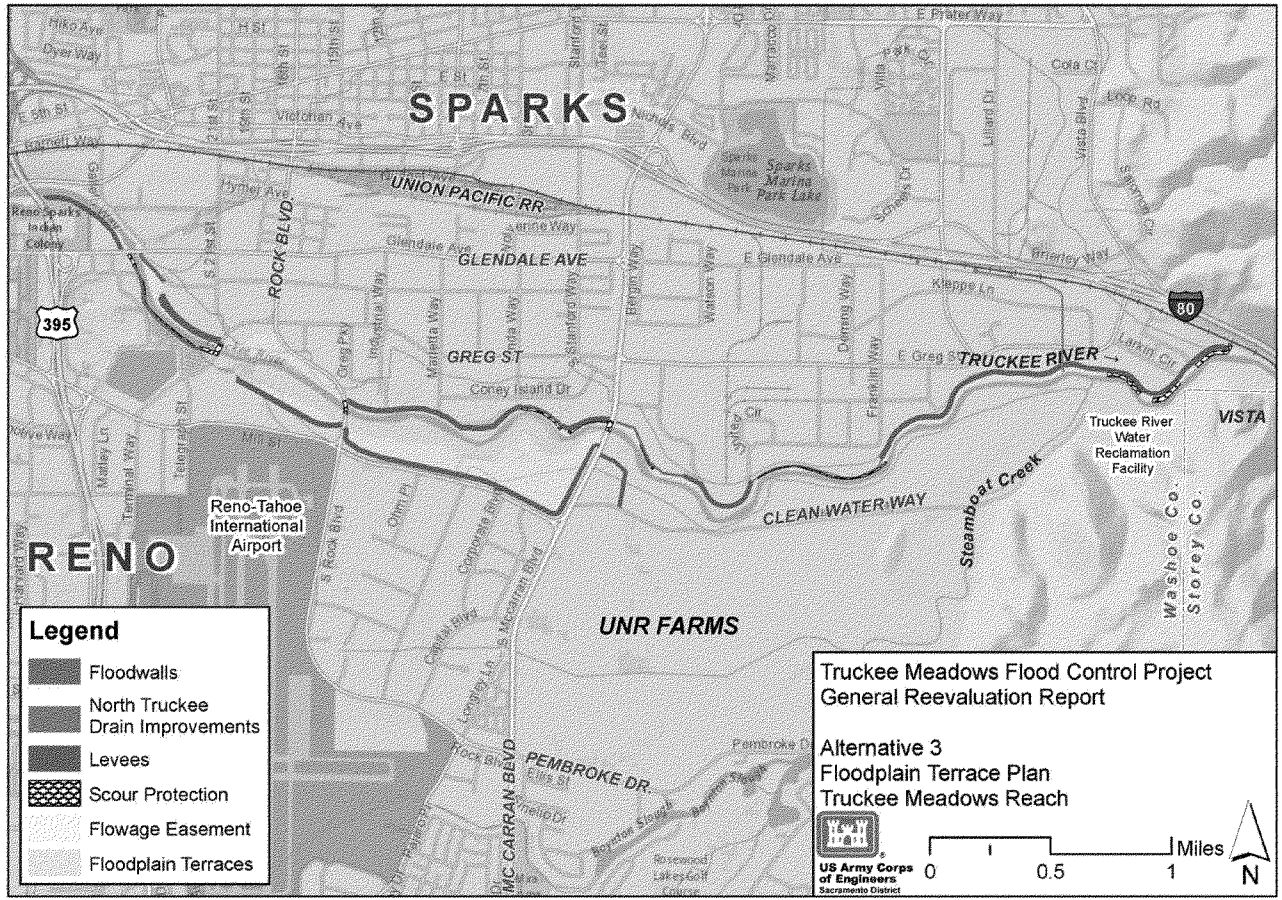

Figure 6-2. Alternative 3 - Floodplain Terrace Plan Truckee Meadows Reach

6.1.3 North Truckee Drain and People's Drain

To prevent overbank flooding upstream of the confluence with the Truckee River, the North Truckee Drain (NTD), downstream of I-80 and the UPRR, would be placed in two buried box culverts, about 11.5 feet wide by 10 feet high, for a length of approximately 3,100 lineal feet. The new drainage structure includes an approximately 200-lineal-foot extension to the existing People's Drain. At the transition at the existing NTD crossing under the railroad, a 20-foot-wide by 10-foot-high reinforced concrete box culvert would be installed. Two junction boxes along the existing People's Drain would be enclosed by sidewalls and precast lids to prevent overflows into the developed area south of I-80.

6.1.4 Bank and Bridge Pier/Abutment Scour Protection

Bank and pier scour protection is included in the Recommended Plan within the Truckee Meadows Reach. The bank protection is required to provide scour protection for the proposed levee and floodwall features consistent with standard design guidance. Bank protection is proposed for 13 sites and consists of two bio-engineered segments and 11 rip rapped segments having a total extent of approximately 11,600 linear feet or 2.5 miles. Additionally, scour countermeasures are proposed at 3 bridges to prevent increased erosion caused by increased in-channel flows which occur when the flows are limited to the channel by construction of the floodwalls and levees. Hydraulic analysis indicates that the flow concentration will significantly increase pier and/or abutment scour to the point where bridge failure may occur under the with-project condition. The cost of bridge repair or replacement is more costly than scour protection. A detailed scour analysis will be conducted in Pre-construction Engineering and Design (PED) to confirm the bank and bridge pier scour analysis.

6.1.5 Interior Drainage Facilities

Interior drainage facilities were designed in accordance with USACE guidance requiring minimum interior facilities to avoid induced interior flooding behind the line-of-protection for a levee/floodwall (EM 1110-2-1413). The potential for additional interior drainage facilities was considered, but no additional economically-justified facilities were identified. The formulation of interior drainage facilities, including residual floodplains, is discussed in detail in Hydraulics Attachment to the Engineering Appendix.

The proposed interior drainage facilities include a 14 cfs pumping station just upstream of Glendale Avenue and new flap gates and vertical sluice gates would be provided for all existing storm drains.

6.1.6 Seepage Remediation

Seepage remediation measures proposed include seepage berms, drainage blankets, impervious berms, and relief wells. Remediation measures were selected based on geotechnical seepage analysis. Relief wells were substituted in a limited area to minimize impact to adjacent

structures. A detailed list of locations and specific measures can be found in Appendix D, Engineering Appendix.

6.1.7 Relocations

No significant utility relocations are proposed for the Truckee Meadows Reach other than utilities that are through or under existing berms that will be replaced by levees/floodwalls. Compensable utilities that are disturbed will be replaced in kind. For feasibility-level design, utility relocations information provided by the sponsor and developed by an A/E firm was used as a basis for estimating required relocations.

6.1.8 Recreation Features

The Recommended Plan for recreation consists of one small group picnic shelter, one medium group picnic shelter, 50 individual picnic areas, one playground, an access road, parking and restrooms located north of Mill Street between Greg Street and McCarran Boulevard (Figure 6-3). In addition, 9,700 linear feet of paved trails and 8,900 linear feet of unpaved trails will be constructed linking the picnic areas with four kayak and canoe input areas and 13 fishing areas along the river (see Appendix E). All recreation features would be located on lands required for flood risk management purposes.

6.1.9 Habitat Mitigation

Impacts to fish and wildlife habitat in the Truckee Meadows Reach will be avoided and minimized by the environmentally sustainable design approach to flood risk management features in the Truckee Meadows Reach, particularly in regards to revegetation of floodplain terraces with native riparian vegetation and implementation of bioengineering techniques in the scour protection features, to the extent possible. No compensatory fish and wildlife habitat mitigation is proposed because there will be no net loss of significant habitat due to the flood risk management and recreation features of the Recommended Plan.

While construction activities, including in-channel construction, present the possibility of increased erosion and sedimentation in the river until disturbed areas are restored and stabilized, best management practices will be implemented to avoid or minimize erosion and sedimentation during construction and until revegetation efforts have been fully established. Best management practices and other requirements from NDEP's water quality certification will be included in a Storm Water Pollution Prevention Plan that will be developed and implemented during construction. Revegetation efforts will be implemented after each year of construction. Monitoring and adaptive management will take place for up to 3 years following completion of all construction activities to ensure successful plant establishment.

In-channel construction activities would occur the first 3 years of construction. In order to avoid or minimize effects to sediment load, in-channel construction will take place during the period of lowest river flows, July through September. In addition, the river will be temporarily

diverted around the area of in-channel construction. Water quality monitoring will be carried out on a daily basis both upstream and downstream of the construction area to ensure water quality thresholds are not exceeded.

Best management practices for this area will also be implemented for weed and pest control. This includes practices such as: revegetating banks at the end of each construction season, using certified weed-free hay/straw bales if needed for sediment control, updating and implementing the Comprehensive Wildlife Sensitive Weed Control Plan, minimizing use of herbicides within 30 feet of the river of any wetlands, and developing an integrated pest management plan. These and other best management practices to be implemented are further described in the EIS.

Costs for implementation of the best management practices have been accounted for in both the project and OMRR&R cost estimates. Additional information regarding these costs can be found in the Engineering Appendix.

As an indirect effect to flood risk management features in the Truckee Meadows Reach, during the modeled 1% annual chance event the Recommended Plan would induce an additional 1,520 cfs of flow in the Truckee River downstream of Vista relative to current conditions. In the long-term, shifts in sediment aggradation and degradation in the Lower Truckee River Reach would occur as an indirect result of this plan; however, sediment budget analyses carried out on larger plans that would induce flows in the Lower Truckee River Reach up to 3,300 cfs greater than the No Action condition in a 1% ACE event, indicated only minor changes to the average annual volume of sediment transport (or yield) along the Lower Truckee River (Corps, 2008b). These minor changes in transport volume translate to a less than significant change to sediment distribution in the river. For the Recommended Plan, induced flows are half of what was indicated for the larger plans and its changes to the average annual volume of sediment transport are expected to be substantially less.

It is important to note that estimates of the effective discharge were made during the sediment budget analysis. The effective discharge is defined as the mean of the discharge increment that transports the largest fraction of the annual sediment load over a period of years. The effective discharge is one estimator of the channel-forming discharge. The channel-forming discharge is a theoretical discharge that if maintained over a long period of time would produce a stable channel geometry in a fully alluvial stream. Other estimators commonly used are the bankfull discharge and the discharge for a specific recurrence interval. The advantage of the effective discharge is that it is a calculated value not subject to the problems associated with determining field indicators inherent in bankfull and recurrence interval methods.

In general, for both the No Action conditions and conditions for the larger plans evaluated in 2008, the effective discharge between Vista and Marble Bluff Dam was estimated at around 3,000 cfs which roughly translates to approximately a 33% ACE event (i.e., about a "3-year" event). Hydraulic modeling of the No Action and the Recommended Plan indicates no increases in flood discharges out of the Truckee Meadows for the 20% ACE event. Thus, significant long-term impacts in sedimentation due to the Recommended Plan are considered

unlikely since the effective discharge is not impacted by the project. With no changes to the effective discharge, vegetation and wildlife resources in the Lower Truckee River Reach would not experience substantial shifts in sediment dynamics and should not experience a significant shift in their ecological patterns. Therefore, no mitigation is proposed.

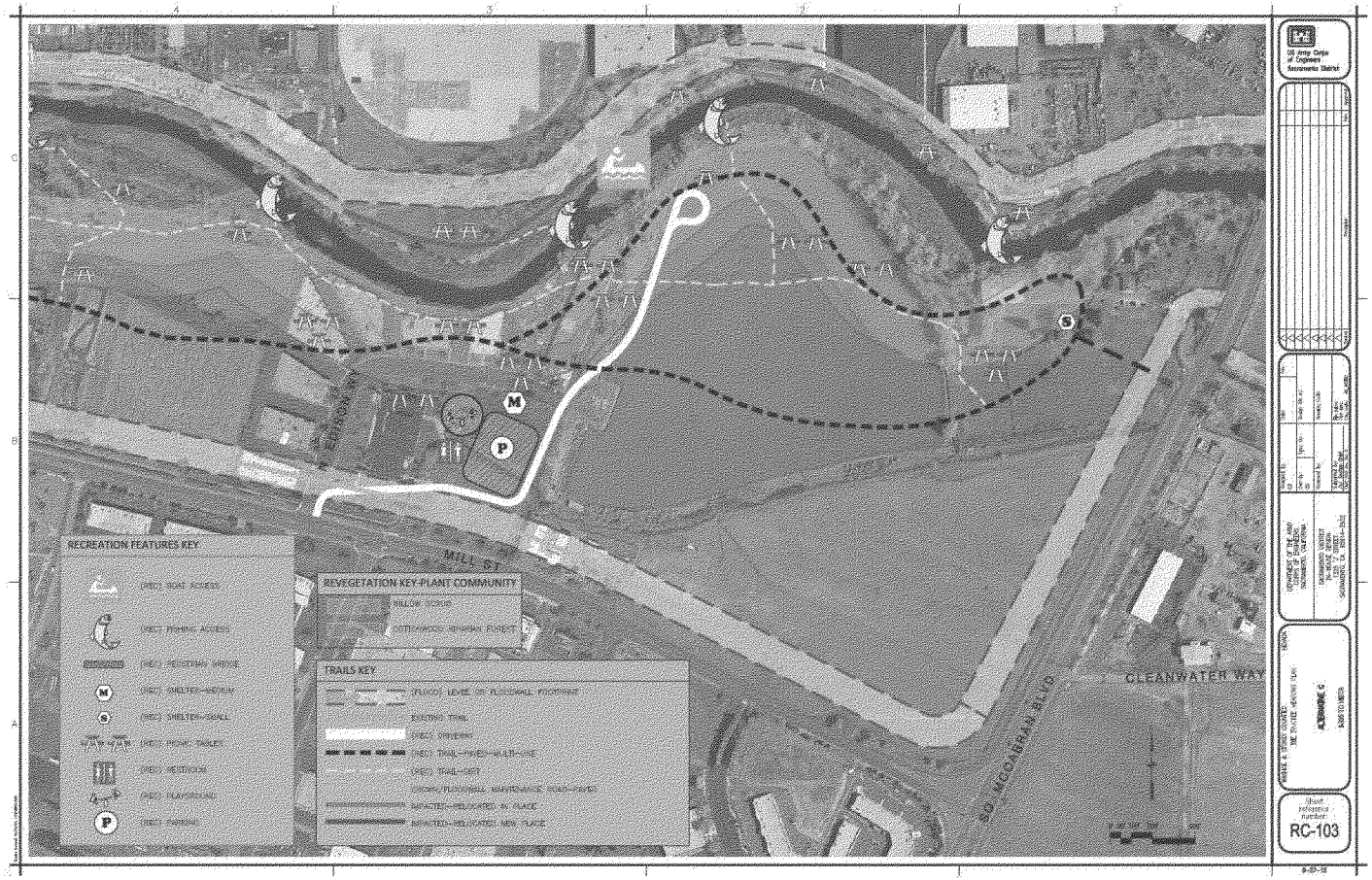

Figure 6-3. Conceptual Plan of Primary Recreation Access/Facilities in Truckee Meadows Reach

6.1.10 Operation, Maintenance, Repair, Replacement, and Rehabilitation

Once project construction is complete, the project would be transferred to the sponsor. The sponsor would then be responsible for the operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) of the project in accordance with the OMRR&R manual. Subsequent to the completion of the design of the project features and prior to construction, a draft OMRR&R manual would be prepared in coordination with the sponsor and affected agencies. A final OMRR&R manual would be prepared after the completion of construction.

Flood Risk Management Features

Structural Features

Operation and maintenance is required for floodwalls, levees, interior drainage, relief wells, seepage remediation, and scour/bank protection proposed in the Recommended Plan. The requirements include inspecting and maintaining all features regularly and keeping project features free from vegetation growth per USACE standards. During floods, the levees and floodwalls would be patrolled continuously to locate possible boils or unusual wetness that signals a problem in the structure.

At a minimum, annual inspection and monitoring reports will be provided by the sponsor to USACE. Reports will contain the inspection checklist and photographs from monitoring points. Additional monitoring at the discretion of the State, sponsor, and stakeholders will be encouraged.

The following practices currently used on California levees related to pesticide (rodenticide) were included for cost estimating purposes:

- Rodent control will include baiting and burrow repair.
- A combination of bait stations and broadcast spreading for rodents, mainly ground squirrels will be used
- Cost estimates were based on the use of anti-coagulant rodenticide applied to rolled oats.

All best management practices for both weeds and burrowing animals will be revisited during PED to ensure that the most up to date practices are used to minimize effects to non-target wildlife. An integrated pest management plan would be developed using a variety of control methods to provide safe and effective control.

Floodplain Terrace Revegetation

The vegetation on the floodplain terraces will require a 3 to 5 year establishment period consisting of weed control and irrigation. This maintenance would be required through contract award for three to five years following completion of construction. At the end of the three to five year term, the areas would be turned over to the local sponsor. The local

sponsor would need to perform periodic weed control to prevent noxious weeds from taking hold. The local sponsor would also need to remove garbage on a periodic basis for the purpose of maintaining public health and safety. Gates, locks and signs would need to be kept in functional order.

Control of noxious weeds will be a major focus of the maintenance of the floodplain terraces. Prior to turnover of the floodplain terraces to the Non-federal sponsor, during the installation and establishment period aggressive control of weeds will be performed through timed mowing, broad application of selective and nonselective herbicides, spot spraying and hand pulling of weeds. After the establishment period when native vegetation has become established and can significantly suppress noxious weeds the same weed control methods will be used but on a more infrequent basis. The vegetation targeted for the floodplain terraces should provide a cover of woody vegetation that shades out the main weed of concern, tall white top. Annual broadcast treatment of trouble spots, spot spraying and hand pulling of individual weeds would be required.

Recreation Features

Upon transfer at completion of construction, the operation and maintenance of the recreation features of the project becomes the responsibility of the sponsor. The picnic shelter, picnic sites, playground, new trails, trailheads, fishing access, kayak and boat launch sites will require maintenance. At a minimum, annual inspections will be performed and maintenance activities such as trash and litter removal, cleaning, weeding, painting, and replacement of broken parts would be performed on a regular basis.

OMRR&R Costs

For the Recommended Plan, the estimated average annual OMRR&R costs are $862,000. This includes $691,000 for flood risk management features and $171,000 for recreation features.

Modification of a Portion of the Truckee River and Tributaries Project

The Operation and Maintenance Manual for the existing Truckee River and Tributaries Project would be modified to be compatible with the new project. Because the Recommended Plan would completely replace the existing Truckee River and Tributaries Project between Glendale Avenue and Vista, the sponsor for the Truckee Meadows Flood Control Project would be responsible for OMRR&R of all project features in that reach. In Chapter 9, this GRR recommends modification of the Glendale Avenue to Vista Reach of Truckee River and Tributaries Project to ensure that the sponsor for the Truckee Meadows Flood Control Project has full and clear responsibility, as between USACE and the sponsor, for OMRR&R of all USACE flood risk management elements between Glendale Avenue and Vista. The State of Nevada would no longer be required by USACE to maintain that portion of the existing Truckee River and Tributaries Project. OMRR&R responsibilities for the parts of the Truckee River and

Tributaries Project upstream of Glendale Avenue or downstream of Vista would not be changed by the Recommended Plan.

Between U.S. Highway 395 and Glendale Avenue, the river channel is currently maintained by the Carson-Truckee Water Conservation District (CTWCD) under the Martis Creek Lake Operation and Maintenance Manual for Truckee River and would not be modified by the Recommended Plan. The only Recommended Plan feature in that approximately 2,700-foot segment is the Reno-Sparks Indian Colony floodwall/levee that has already been constructed and is proposed for Section 104 credit. The new floodwall/levee did not significantly modify the river channel or left (north) bank. Therefore, CTWCD will continue to maintain the river channel and banks riverward of the permanent levee easement for the Reno-Sparks Indian Colony floodwall/levee.

6.2 Real Estate Requirements

The real estate interests include the estates, number of ownerships, and estimated land values. The baseline cost estimates include a gross appraisal and the Federal and non-Federal costs associated with acquiring the lands for the project. The total gross appraisal estimate for real estate requirements for the Recommended Plan is shown in Table 6-5 and 6-6. More detailed information on the real estate interests is presented in the Real Estate Plan (Appendix B).

The sponsor will not receive credit for lands, easements, or rights-of-way that were provided for a previous Federal project, including the Truckee River and Tributaries (TRT) project. Within the Truckee Meadows Reach, the TRT project consists of approximately 29,500 feet of excavated channel, beginning at Glendale Avenue, with an 80-foot invert width. The as-built construction plans for TRT identify a permanent right-of-way of varying width.

Within the footprint of the current Recommended Plan, approximately 32 parcels, totaling 15 acres (outside of the State-owned riverbed) were previously required to be provided for the Truckee River and Tributaries project. The sponsor for the current project will not receive credit for those parcels.

Table 6-2. Real Estate Requirements-Recommended Plan, Total LERRDs

Recommended Plan	Acres	Costs	Incremental Real Estate Costs (Contingencies)	Total Costs Rounded
MCACES 01 ACCOUNT - LANDS AND DAMAGES (Non-Fed)				
Lands and Damages / Non Federal Admin (Gross Appraised Value)	320	$48,279,000	$16,096,000	$64,375,000
*Additional Section 113 FRM lands costs Expended		$1,912,000	N/A	$1,912,000
**Recreation		$115,000	$43,000	$158,000
			Sub Total:	$66,445,000
MCACES 01 ACCOUNT - LANDS AND DAMAGES (Fed)				
Federal Admin		$1,455,000	$73,000	$1,528,000
MCACES 01 ACCOUNT - LANDS AND DAMAGES: TOTALS (Fed & Non Fed)		**$71,849,000**	**$16,212,000**	**$67,973,000**
MCACES 02 ACCOUNT - RELOCATIONS (Non-Fed)				
Relocations (Construction)		$6,790,000	$1,835,000	$8,625,000
PED Relocations		$1,018,000	$283,000	$1,301,000
Construction Management		$679,000	$184,000	$863,000
TOTAL RELOCATIONS				**$10,789,000**
TOTAL LERRDS COSTS			**(Rounded)**	**$78,762,000**

[1] Financial cost for LER acquired in advance of the Project Partnership Agreement is $44,500,000. Corps estimated current fair market value for the same parcels is $42,588,000. Per Section 113, the sponsor must be credited based on expenditures. This is estimated to include an additional $1,912,000 above the current fair market value.

6.2.1 Section 113 Crediting

According to the provisions of Section 113 of the Energy and Water Development Appropriations Act (EWDAA) of 2006 (Pub. L. 109-103, § 113, 119 Stat. 2247, 2254) (Section 113), the crediting of the sponsor for lands, easements and rights-of-way (LER) is based on expenditures required for the Recommended Plan. Table 6-2 contains the accounting for future Section 113 crediting. To date, the sponsor has acquired some LER in the amount of $45,250,000 that is expected to be necessary for the Recommended Plan. There is no significant difference between these expenditures and the gross appraisal estimate of the Corps ($43,338,000 for nearly equivalent acquisition). The Recommended Plan estimate for the LER is based on a Corps' gross appraisal and the sponsor's additional expenditures for LER they have acquired. The gross appraisal is used for planning purposes and not for crediting of LERs. Crediting occurs after the PPA is executed, and absent the provisions of Section 113, normally involves the Corps review of a site specific acquisition appraisal that sets out the fair market value of the real property interests, plus certain incidental costs of acquiring those interests. Therefore the funds expended by the Sponsor under Section 113 could be more or less than what would normally be credited under the Corps regulations. The total result of implementing

Section 113 credit for LERs will not be known until the sponsor has completed all LER acquisitions and their expenditures are evaluated. Crediting of LER under Section 113 would have no effect on the economic analysis for the project because economic costs are determined by current fair market values, rather than expenditures. The effect of Section 113 on cost apportionment is discussed in Section 6.5.1.

Neither the preliminary project costs nor the preliminary cost allocation for the Recommended Plan include crediting for sponsor construction of water quality improvement features (including the provision of 6700 acre-feet of water rights) or ecosystem restoration features pursuant to Section 113 of Energy and Water Development Appropriations Act of 2006 (P.L. 109-103). A credit may only be given toward the non-Federal share of the project cost when a sponsor implements part of an authorized project. Because the Recommended Plan does not include water quality improvement features or ecosystem restoration features, the total project cost does not include costs for water quality improvement features or ecosystem restoration features and no credit for such costs can be given. The sponsor has not constructed or implemented any of the recreation features that are included in the Recommended Plan.

6.3 Cost Estimate

The first cost was estimated on the basis of October 2013 price levels and amounts to $280,820,000. Estimated average annual costs were based on a 3.5 percent interest rate, a period of analysis of 50 years, and construction ending in 2018. Table 6-3 shows the project first costs. Project first costs do not include associated economic costs. Project first costs include the sunk PED costs, which are estimated to be $42,200,000 at the time this GRR is completed. The sunk cost is included in first costs in Tables 6-3, 6-4, 6-5, and 6-6.

Table 6-3. Estimated First Costs of Recommended Plan[1]

Cost Account[2]	Description	Total First Costs ($1,000)
01	Lands and Damages[3]	$67,973
02	Relocations	$10,789
09	Channels	$46,765
11	Levees	$60,495
14	Recreation	$8,030
16	Bank Stabilization	$12,594
18	Cultural Resources	$1,817
30	Planning, Engineering, Design[4]	$61,487
31	Construction Management	$10,870
	Total Project First Cost	**$280,820**

[1] October 2013 price levels.
[2] Detailed cost estimates are presented in Appendix E.
[3] Lands and Damages include $1,912,000 additional non-Federal credit for expenditures to date in excess of current fair market value in accordance with Sec 113 of EWDAA 2006.
[4] PED includes $42,200,000 sunk costs.

6.4 Section 104 Credit for Reno-Sparks Indian Colony Levee

The Recommended Plan includes completed local work that is eligible for credit under Section 104 of WRDA 1986. Eligibility for Section 104 credit for levee and floodwall construction between U.S. 395 and Glendale Bridge was approved by the ASA(CW) on February 8, 2008. The completed work, locally identified as the Reno-Sparks Indian Colony (RSIC) project, consists of approximately 2,241 linear feet of floodwall/levee on the south bank of the Truckee River. The RSIC flood control work was designed to provide a 0.9% AEP (also referred to as 1:117 or "117-year") level of performance. The design of the work was reviewed by USACE prior to construction for consistency with USACE standards.

The Recommended Plan includes a levee that would provide an approximately 2% AEP (also referred to as 1:50 or "50-year") level of performance along the same alignment as the RSIC floodwall/levee. The amount credited under Section 104 will not exceed the amount that is a reasonable estimate of the reduction in Federal project expenditures resulting from substitution of the local work for authorized project elements. The maximum amount creditable will be the actual expenditures made by non-Federal entities. The estimated Section 104 credit for construction work, based on the current feasibility-level cost estimate for the Recommended Plan, is $2,406,000. This is substantially less than the approximately $3.6 million that was actually expended by non-Federal interests for construction of the RSIC floodwall/levee. Because the Section 104 work was constructed on the same alignment as the levee in the Recommended Plan, this GRR assumes that the credit for LERRD associated with the Section 104 work will be the same as the estimated LERRD cost for the corresponding Recommended Plan levee feature. Under that assumption, the sponsor would receive credit for providing the same LERRD with or without performing the Section 104 construction work, so the LERRD portion of the Section 104 credit has no effect on the preliminary cost apportionment in this GRR.

6.5 Preliminary Cost Allocation and Apportionment

The apportionment of costs between the Federal Government and the sponsor is presented in Tables 6-4 and 6-5. Table 6-4 shows the apportionment of costs prior to the consideration of credit under Section 104 for RSIC floodwall/levee completed by non-Federal interests. Table 6-5 shows the effect of the estimated Section 104 credit on cost apportionment. In both instances, the non-Federal cost is estimated at $99,168,000. Cost apportionment based on the fully funded cost estimate is presented in Table 6-6 using the current project schedule and projected future rates of price escalation.

6.5.1 Effect of Section 113 Crediting on Cost Apportionment

Crediting the sponsor for expenditures to date for lands, easements, and rights-of-way (LER) pursuant to Section 113, in lieu of crediting based on current fair market values, would increase the estimated sponsor credit and total project financial costs by approximately $1,912,000. The sponsor's estimated cost-share for FRM (based on a 35%

minimum cost-share) would increase by $669,200. The net increase in Federal costs would be $1,242,800 compared to costs without Section 113 crediting, based on current cost estimates.

Table 6-4. Preliminary Cost Allocation and Cost Apportionment for Recommended Plan Without Section 104 Credit

Without Sec 104 Credit	Federal ($1,000)	Non-Federal ($1,000)	Total ($1,000)
Flood Risk Management			
Construction	$119,854		$119,854
LERRD[1]	$1,496	$77,076	$78,572
PED (includes sunk costs)	$60,276		$60,276
Construction Management	$10,188		$10,188
Subtotal	$191,814	$77,076	$268,890
Minimum 5 percent cash contribution	($13,445)	$13,445	
Additional cash contribution[2]	($3,591)	$3,591	
Total FRM First Cost	$174,779	$94,112	$268,890
Percent of Total FRM	**65%**	**35%**	
Recreation			
Construction	$8,030		$8,030
LERRD[1]	$32	$158	$190
PED	$1,211		$1,211
Construction Management	$682		$682
Subtotal	$9,955	$158	$10,113
Cash contribution	($4,899)	$4,899	
Total Recreation First Cost	$5,057	$5,057	$10,113
Percent of Total Recreation	**50%**	**50%**	
Cultural Resources Data Recovery	$1,817		$1,817
TOTAL FIRST COSTS	**$181,652**	**$99,168**	**$280,820**

Oct 2013 price levels

[1] Federal costs on this line are administrative costs only. Non-Federal costs include Section 113 credit for expenditures to date.

[2] Cash contribution will include credit for $1.4M non-Federal cash contribution during PED pursuant to Memorandum of Agreement dated 22 Aug 2012.

Table 6-5. Preliminary Cost Allocation and Cost Apportionment for Recommended Plan With Section 104 Credit

With Section 104 Credit	Federal ($1,000)	Non-Federal ($1,000)	Total ($1,000)
Flood Risk Management			
Construction without Section 104	*$119,854*		
Section 104 Construction	*($1,948)*	*$1,948*	
Construction with Sec 104	$117,906	$1,948	$119,854
LERRD[1]	$1,496	$77,076	$78,572
PED without Section 104	*$60,276*		
Section 104 PED	*($292)*	*$292*	
PED with Sec 104 (incl sunk costs)	$59,984	$292	$60,276
Const Mngmt without Section 104	*$10,188*		
Section 104 Const Mngmt	*($166)*	*$166*	
Construction Mngmt with Sec 104	$10,022	$166	$10,188
Subtotal	$189,408	$79,482	$268,890
Minimum 5 percent cash contribution	($13,445)	$13,445	
Additional cash contribution[2]	($1,185)	$1,185	
Total FRM First Cost	$174,779	$94,112	$268,890
Percent of Total FRM	**65%**	**35%**	
Recreation			
Construction	$8,030		$8,030
LERRD[1]	$32	$158	$190
PED	$1,211		$1,211
Construction Management	$682		$682
Subtotal	$9,955	$158	$10,113
Cash contribution[2]	($4,899)	$4,899	
Total Recreation First Cost	$5,057	$5,057	$10,113
Percent of Total Recreation	**50%**	**50%**	
Cultural Resources Data Recovery	$1,817		$1,817
TOTAL FIRST COSTS	**$181,652**	**$99,168**	**$280,820**

Oct 2013 price levels

[1] Federal costs on this line are administrative costs only Non-Federal costs include Section 113 credit for expenditures to date.

[2] Cash contribution will include credit for $1.4M non-Federal cash contribution during PED pursuant to Memorandum of Agreement dated 22 Aug 2012.

Table 6-6. Summary of Cost Sharing for Recommended Plan (Fully Funded)[1]

Item	Federal ($1,000)	Non-Federal ($1,000)	Total ($1,000)
Flood Risk Management			
Construction[2,5]	$207,607	$2,758	$210,365
LERRD[3]	1,645	81,208	82,853
Minimum Cash Contribution (5%)	-14,661	14,661	
Additional Cash Contribution	3,999	3,999	
Sub-total Flood Risk Management	190,592	102,626	293,218
Recreation			
Construction[2]	11,696		11,696
LERRD[3,4]	35	166	201
Cash Contribution	-5,783	5,783	
Sub-total Recreation	5,949	5,949	11,897
Cultural Resources Data Recovery	1,985		1,985
Total	**$198,525**	**$108,575**	**$307,100**

[1] Total Project Cost (Fully Funded); Includes estimated Section 104 credit for RSIC levee at fully funded cost.
[2] Construction costs include PED and Construction Management costs.
[3] LERRD (Lands, Easements, Rights-of-Way, Relocations and Disposal areas) include Federal administrative costs ($1,680,000); and, per Sec 113, non-Federal credit for expenditures to date.
[4] Recreation LERRD limited to upgrade of FRM easements to fee title.
[5] Non-Federal Construction includes estimated creditable cost for completed Sec 104 work ($2,758,000).

6.6 Economic Costs and Benefits

Table 6-7 displays the economic costs and benefits of the Recommended Plan. The evaluation of economic benefits is described in detail in Appendix C, Economics. Benefit-cost ratios are shown for both the current water resources planning discount rate of 3.5% and the Office of Management and Budget (OMB) budgetary interest rate of 7%. The total economic costs, including the associated cost for NFIP compliance, were allocated to the purposes of flood risk management (FRM) and recreation. A separate benefit-cost analysis was completed for each purpose. Costs for cultural resource data recovery are excluded from the allocation of costs (up to 1% of the Federal project cost) in accordance with USACE guidance (ER 1105-2-100, Appendix E, paragraph E-63). Sunk costs expended prior to the completion of this GRR were also excluded from the economic analysis, although they are subject to cost-sharing during construction.

The estimated NFIP compliance costs included in the economic costs are based on the least-cost features that could be added to the NED Plan by local interests to achieve NFIP compliance, without modifying the NED Plan. Based on feasibility level hydraulic modeling, approximately 764 homes and 128 multiplex apartment buildings would need to be raised in the area south of the river. Additionally, four commercial structures and three public buildings would also need to be raised or "wet flood-proofed" with closures and sealing. The estimated cost to raise and flood-proof structures for NFIP compliance on the south side of the Truckee River is $172 million. For the north side of the Truckee River, a 400-cfs capacity pump station on the North Truckee Drain with an outfall to the Truckee River has been estimated to cost $23 million. These estimated economic costs are subject to change based on more detailed hydraulic analysis during final design of the project, including the results of NFIP hydraulic modeling assumptions and methods, and more detailed surveys of the elevations of existing structures.

The Recommended Plan provides $24.9 million of annual benefits from flood risk management, resulting in $13.7 million in annual net benefits and a benefit-to-cost ratio of 2.2 to 1 for flood risk management. The Recommended Plan also provides basic recreation features with an annual benefit of $625,000, resulting in $13,000 in net annual benefits and a benefit-to-cost ratio of 1.0 to 1 for recreation. The overall benefit-to-cost ratio for the Recommended Plan is 2.2 to 1.

In accordance with ER 1105-2-101, flood damages reduced were determined as mean values and by probability exceeded. Table 6-8 shows the benefits for the Recommended Plan for the 75%, 50%, and 25% probability that benefits exceed the indicated values. The damage reduced column represents the mean benefits for each increment and the 75%, 50%, and 25% represent the probability that the flood damage reduction benefits exceed the number in that column for that increment. The Recommended Plan has an average (mean) benefit of $24.9 million, but only a 50% chance that benefits will be greater than $24.1 million, 75% confidence that benefits will be greater than $15.4 million and a 25% confidence that benefits will exceed $35.1 million.

Table 6-7. Economic Costs and Benefits of Recommended Plan[1]

Item	Project Purpose	
	FRM ($1,000)	**Recreation ($1,000)**
Investment Cost		
NED First Cost[2]	$266,978	$10,113
Less Sunk PED costs	($42,200)	
Interest During Construction	$21,978	$227
Total Investment Cost	$246,756	$10,340
Annual Cost		
Interest and Amortization	$10,520	$441
OMRR&R[3]	$691	$171
Total Annual Costs	$11,211	$612
Annual Benefits (NED Plan)	$24,880	$625
Net Annual Benefits	$13,669	$13
Benefit-Cost Ratio **Water Resources Planning Rate: 3.5%**	**2.2**	**1.0**
Benefit-Cost Ratio OMB Circular No. A-94 Rate: 7%	1.2	0.7

[1] Based on October 2013 price levels, 3.5 percent rate of interest, and a 50-year period of analysis. See Economic Appendix regarding economic uncertainty.
[2] Cultural resources data recovery costs ($1,817,000) and Section 113 financial costs ($1,912,000) are not included in economic costs per USACE policy.
[3] Operation, Maintenance, Repair, Replacement, and Rehabilitation.

Table 6-8: Probability Distribution of Equivalent Annual Damages Reduced[1]

Expected Annual Damages			Probability Damage Reduced Indicated Values		
Without Project	**With Project**	**Damages Reduced**	**0.75**	**0.50**	**.025**
61,481	36,601	24,880	15,397	24,111	35,087

[1] $1,000, October 2013 Prices, 3.5% Interest Rate. See Economic Appendix for additional information.

6.7 Risk and Uncertainty

As noted in Chapter 3, each aspect of flood risk assessment must account for uncertainty. This includes hydrology, hydraulic, geotechnical, and economic analyses. USACE risk assessment procedures were followed in this study that account for uncertainty in the information to the extent practicable. However, there is some project performance uncertainty in all studies, even with the risk assessment procedures.

Chapter 2 identified a regional transit project that is planned in the project area, the SouthEast Connector. A sensitivity analysis, described in Section 5.8.5, showed that the NFIP compliance costs for the Recommended Plan could increase by $29 million ($1.2 million annual cost) if the SouthEast Connector is permitted and constructed as currently designed. This could reduce the benefit-to-cost ratio for the Recommended Plan. The Recommended Plan would still be economically justified and the recommendations of this GRR would not change. If the SouthEast Connector receives required permits, USACE will conduct a more detailed hydraulic analysis during final design of the Truckee Meadows Flood Control Project. USACE will continue to coordinate with the sponsor, Washoe County, and the Regional Transportation Commission regarding potential design of the SouthEast Connector. Local jurisdictions will need to continue to address NFIP requirements for any projects they plan or approve within the FEMA Special Flood Hazard Area.

CHAPTER 7
PUBLIC INVOLVEMENT

7.1 Overview

The public and concerned resource agencies have been invited to participate in all phases of the Truckee Meadows Flood Control Project since the initiation of the General Reevaluation Study in 1996. This has included opportunities to comment on the 1997 Reconnaissance Report (GRR), the Notice of Intent to prepare an Environmental Impact Statement (EIS), the Public Scoping Meeting conducted in 1999, and public workshops in 2000, 2003, and 2005. Additional efforts were made to solicit public input and feedback on the Truckee Meadows Flood Control Project planning efforts, including:

- Disseminating information through a project web site - www.truckeeflood.us.
- Creating and publishing a monthly newsletter on progress of the project.
- Creating opportunities for comment and discussion through public meetings and workshops at which USACE, local proponents, and other involved agencies have actively participated.
- The opportunity to review and provide comments on the draft GRR and EIS.

7.2 Scoping

A Public Scoping Meeting was held in 1999 to provide background information, discuss the purpose of the study, and discuss conceptual alternatives used in flood protection projects. Concerns identified during public scoping focused on four categories: flood protection, schedule, recreation, and environment.

Public concerns about flood protection included: the reduction of existing and potential flood damage to private and public properties and facilities, potential high maintenance costs for a flood control project, the length of time required to complete the project; noise impacts on adjacent landowners during construction, and removing properties from the "100-year" floodplain. All pertinent scoping concerns have been considered in the preparation of this document.

Environmental issues included public concerns about the biological effects of the project on vegetation, wildlife, and fish. Tribal concerns were raised concerning induced flood impacts, barriers to fish passage, and environmental impacts.

7.3 Public Meetings

USACE held several meetings with stakeholders of the Truckee River downstream of Vista. Informational meetings were held in 2002, 2004, 2005, 2007,

2010, and 2011 with representatives for the Pyramid Paiute Tribe, and residents of Rainbow Bend and Painted Rock.

In November 2003, a meeting was held in Rainbow Bend to update residents and other interested parties on project progress. Preliminary without project floodplains were presented, along with ecosystem restoration conceptual alternatives and a detailed description of the study process. In October 2004, after initial with-project floodplains were completed, another meeting was held at Rainbow Bend. That meeting was a workshop to solicit public input on potential solutions for both induced flooding impacts and effects of flooding from Long Valley Creek. A follow-up session was held in December 2004 to brief interested parties on the progress of the economic evaluation of potential damages at Rainbow Bend. Subsequent meetings between residents and the local sponsors resulted in a proposed solution for induced flooding impacts that was included in the alternatives array for evaluation.

Informational meetings were held with members of the Pyramid Lake Paiute Tribe throughout the study. USACE has also attended several tribal meetings to brief the tribal council on study progress. Tribal members were also included in an inter-agency resource group that helped to evaluate fish passage solutions on the Truckee River. Tribal concerns over water quality and induced flooding impacts were taken into consideration during the study.

A project website was established in coordination with the local proponents at www.truckeeflood.us. The website has grown steadily since its establishment and now serves as a prime portal for project information to the local community. USACE developed and distributed a project newsletter, which was later prepared and distributed by the local sponsor.

7.4 Local and Regional Interests

Throughout the General Reevaluation (GRR) study, USACE and local proponents have coordinated planning activities with other Federal, State, and local regulatory and planning agencies. USACE and local proponents have engaged these agencies throughout the development and refinement of a range of alternatives that would meet the flood risk reduction, recreational, and environmental objectives of the project. The primary conduit for technical feedback from other agencies and environmental groups included USACE interagency meetings and public outreach meetings, with members representing the following organizations:

- U.S. Army Corps of Engineers
- Truckee River Flood Project
- City of Reno
- City of Sparks
- Washoe County
- Storey County
- U.S. Fish and Wildlife Service

- U.S. Environmental Protection Agency
- Pyramid Lake Paiute Tribe
- Nevada Department of Transportation
- Federal Highways Administration
- Federal Aviation Administration

7.4.1 Community Coalition Process

A community-based planning process was initiated by the local project sponsors in response to the high level of expressed interest in public involvement in finding the most acceptable solution to the regional flooding problem. The Truckee Meadows Community Coalition was formed in 2000, and the local sponsors agreed to work with the Coalition in developing a preliminary alternative that would have broad community support and would be included in GRR. A facilitated community-based planning process began, and a diverse array of community members representing environmental, business, and neighborhood groups spent many hours establishing their goals and design objectives.

The Coalition pursued a preliminary alternative that would protect property from the 1% Annual Chance of Exceedance (ACE) (also referred to as 1:100, 1/100, and "100-year") event while minimizing or eliminating floodwalls in existing residential neighborhoods, and providing open floodplain area adjacent to the river for floodplain management, ecosystem restoration, and parkway purposes. Some of the Coalition members formed the Working Group and Hydrologic and Hydraulic (H&H) Modeling Group to assist in developing the Coalition preliminary alternative. The Truckee River hydrology was reevaluated and received concurrence from the H&H Modeling Group as well as USACE.

In March 2002, the Community Coalition provided their alternative for USACE to consider in the GRR. The alternative provided flood protection in downtown Reno with the Landmark Bridges alternative described in Chapter 3, flood protection combined with ecosystem restoration in the Truckee Meadows, and ecosystem restoration downstream.

A successor to the Community Coalition was the Truckee River Flood Project Working Group, consisting of members of the Community Coalition process who desired to remain involved in the process. They meet regularly with the local sponsors and provide input into the local planning efforts.

7.4.2 Flood Project Coordinating Committee

The Flood Project Coordinating Committee (FPCC) was formed in April 2005 consisting of representatives from Washoe County, City of Reno, City of Sparks, and University of Nevada, Reno. This group was formed under a cooperative agreement to establish a local voice in the implementation of the project. More than a dozen non-voting members from the public are also members of the FPCC. This committee met on

a monthly basis to conduct business related to the local efforts to support the project. USACE participated in these meetings, providing project briefings, and answering inquires from the committee.

The FPCC coordinated numerous public outreach meetings, seminars and public events during the study, as well as directed their technical staff regarding interaction with the project delivery team. The FPCC operated between 2005 and 2011.

7.4.3 Truckee River Flood Management Authority

In 2009 the Cities of Reno and Sparks and Washoe County determined that a cooperative agreement between the governing bodies would be necessary to meet the responsibilities of a non-Federal sponsor. The Nevada Legislature passed SB 175 authorizing cities and counties to collect fees for the purpose of a flood project. Truckee River Flood Management Authority (TRFMA) held its first meeting and formally approved the Interlocal Cooperative Agreement in 2011.

7.5 Views of the Local Project Proponent

Until 2012, this GRR was conducted at 100% Federal cost, so USACE did not have a cost-sharing agreement with a non-Federal sponsor. A Memorandum of Agreement was signed with TRFMA (sponsor) in 2012 that provided non-Federal funds for completion of the GRR. Additionally, TRFMA technical staff continues to interact with USACE on technical issues.

TRFMA is fully aware of its cost-sharing responsibilities, including the responsibility to furnish all project lands, easements, rights-of-way, and relocations. They are also aware of its responsibility to comply with the provisions of the NFIP. Washoe County voters approved a 1/8 cent sales tax to pay for their portions of the non-Federal cost-share prior to the initiation of the GRR. This funding is controlled by TRFMA. When it became clear that this would be insufficient to fund the non-Federal share of the project, a joint powers authority was created and additional funds will be raised through an assessment.

TRFMA has the objectives of achieving flood risk reduction for the 1% ACE event in downtown Reno and the Truckee Meadows areas and ecosystem restoration along the Truckee River downstream of Vista. Although the Recommended Plan does not meet these local objectives, TRFMA supports the GRR and has provided a letter of intent to serve as the non-Federal sponsor for the project as it proceeds into the Preconstruction Engineering and Design and Construction phases.

During the public review period TRFMA provided a letter in support of the Recommended Plan.

7.6 Views of Resource Agencies

The USFWS's primary concern is the loss of riparian and wetland habitat and the potential for induced flows to increase the risk of scour downstream of Vista along the river's bed and banks. Increased scouring could result in the loss of riverbank and aquatic habitats, which would adversely affect the Federally listed Lahontan cutthroat trout and cui-ui. The USFWS also participated in local working groups and assisted in the formulation of alternative plans for fish passage.

7.7 Views of Tribes

The Pyramid Lake Paiute Tribe's (PLPT) fundamental concerns are induced flows from a project in the Truckee Meadows and changes to water quality conditions that could affect native fisheries. Loss of riparian habitat and disturbance to the river channel during construction, as well as induced flows in the Lower Truckee River reach can increase sediment loading and degrade water quality, which can threaten aquatic habitat and native fisheries. The Tribe cultivates a successful Lahontan cutthroat trout fishery that provides income from sport fishing, so any negative effects from induced flows carry the potential to jeopardize an important part of the Tribe's livelihood. The Tribe is also concerned with the overall environmental effects of the project.

The PLPT is a proponent for fish passage improvements and has expressed concern that fish passage is not included in the Recommended Plan and concern that not enough coordination was conducted with the Tribe during the development of the Recommended Plan. The Corps has collaborated, coordinated and consulted with the Pyramid Lake Paiute Tribe on the Truckee Meadows Flood Control Project over the years. This communication was established prior to 2005. Government to Government consultation was initiated in 2005. Throughout the years, Corps staff identified, shared, and discussed potential effects and benefits for the array of alternatives under consideration and sought comments and views from the Pyramid Lake Paiute Tribe for consideration. After a brief pause on the project to review overall direction and scope/schedule, a tentatively selected plan (TSP) was established. As part of this pause, USACE, the Army, and TRFMA made a decision to remove the ecosystem restoration from the alternatives being considered. After the project pause, Corps staff re-engaged consultation with the Pyramid Lake Paiute Tribe. In April and May 2013, consultation opportunities included supplying information on the TSP, reviewing technical data and modeling, providing feedback for consideration and presenting information to the tribal governance. Additional information on Government to Government consultation is provided in the Final Environmental Impact Statement (EIS).

The PLPT is also concerned about adverse impacts to their lands. The hydraulic modeling of this study has shown that, although there would be a slight increase in the stage of the 1% ACE event along the river, it would not be great enough to affect existing structures in the Lower Truckee River reach, including on Tribal lands.

The PLPT's comments and USACE responses are included the Final EIS.

Another tribe in the study area is the Reno-Sparks Indian Colony (RSIC). The original RSIC land holding is adjacent to flood risk management features, and their stated concern was the flood risk reduction offered by the project. A Wal-Mart store was recently constructed on the RSIC land that included a floodwall along the proposed alignment of the flood project levee. This floodwall provides stand-alone flood risk reduction benefits for the RSIC property up to the 0.9% ACE flood event. TRFMA contributed funding for construction of the floodwall and has requested consideration of credit for this contribution towards their non-Federal cost-share obligations.

Additionally, the RSIC is concerned with the overall environmental effects of the project on traditional and cultural resources along the Truckee River.

CHAPTER 8
PLAN IMPLEMENTATION AND SCHEDULE

8.1 Public Review of Document

The GRR and EIS were circulated for agency and public review for 45 days. During the review period, two public meetings were held to obtain comments from the public, agencies, and other interested parties. After completion of the public review period, comments were considered and incorporated into the final GRR and EIS were appropriate. Responses to comments are included in the final EIS.

8.2 Report Review and Approval

The South Pacific Division Engineer will transmit copies of the final GRR and EIS to USACE Headquarters for review.

A Civil Works Review Board (CWRB) will be convened within 21 calendar days of receipt by USACE Headquarters of the Division Engineer's Transmittal Letter. During the CWRB briefing, the District Engineer and Division Engineer will provide briefings on the project and review process to date, including Independent External Peer Review. The Office of Water Project Review (OWPR) will also provide its assessment of the materials for policy and legal concerns that could delay the State and Agency (S&A) review.

Upon receipt of the CWRB decision to proceed with S&A review, USACE Headquarters will administer the S&A Review with assistance from the District. OWPR will provide transmittal letters, mailing list, and the proposed Report of the Chief of Engineers to the District for distribution. The final EIS will be circulated for a 30-day public review. The Division Engineer will issue responses to comments received from interested parties, as needed.

After S&A and NEPA reviews have been completed, the OWPR will complete its final policy compliance review of the package and issue the Documentation of Review Findings and certify policy compliance. Once these reviews have been completed, USACE Headquarters will prepare a recommendation package for the Chief of Engineers that includes documentation of the review to date, as well as the Chief of Engineers Report and Record of Decision for the FEIS for signature by the Chief of Engineers.

Once the Chief's Report has been signed, letters of notification are sent to Congress and a copy is sent to the Assistant Secretary of the Army (Civil Works) (ASA (CW)).

The ASA(CW) will review the documents to determine the level of Administration support for the Chief of Engineers recommendation. The ASA(CW) will submit a copy of the report to the Office of Management and Budget (OMB). OMB will review the documents to determine their relationship to the program of the President.

OMB will then provide a letter to ASA(CW) either clearing the release of the report to Congress or objecting to the release.

After receiving OMB views on the relation of the recommended project to the programs of the President, the ASA(CW) will sign the Record of Decision (ROD) and forward the Chief's Report, final GRR and EIS, state and agency review letters, and the ROD to Congress for authorization of the project.

8.3 Federal and Non-Federal Implementation Responsibilities

8.3.1 Federal Responsibilities

Following completion of the final GRR and EIS, USACE will enter into a Design Agreement with the sponsor and then prepare detailed designs, including plans and specifications. After Congressional authorization of the project, appropriation of construction funds, completion of a project partnership agreement, completion of the plans and specifications, and provision of LERRD by the sponsor, USACE will award and manage contracts to construct the project.

8.3.2 Non-Federal Responsibilities

Federal law requires non-Federal participation in the financing of projects. In accordance with the Water Resources Development Acts of 1986 and 1996 and other requirements, the non-Federal sponsor would, prior to implementation, agree to perform the responsibilities detailed in the Project Partnership Agreement, which briefly stated include the following:

a. Provide a minimum of 35 percent, but not to exceed 50 percent of total flood risk management costs as further specified below:

1. Provide 35 percent of design costs allocated by the Government to flood risk management in accordance with the terms of a design agreement entered into prior to commencement of design work for the flood risk management features;

2. Provide, during the first year of construction, a contribution equal to 35 percent of the costs related to performance of the reevaluation report for the project;

3. Provide, during construction, a contribution of funds equal to 5 percent of total flood risk management costs;

4. Provide all lands, easements, and rights-of-way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct all improvements required on lands, easements, and rights-of-way to enable the disposal of dredged or excavated material all as determined by the Government to be required or to be necessary for the construction, operation, and maintenance of the flood risk management features;

5. Provide, during construction, any additional funds necessary to make its total contribution for flood risk management equal to at least 35 percent of total flood risk management costs;

b. Provide 50 percent of total recreation costs as further specified below:

1. Provide 50 percent of design costs allocated by the Government to recreation in accordance with the terms of a design agreement entered into prior to commencement of design work for the recreation features;

2. Provide all lands, easements, and rights-of-way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct all improvements required on lands, easements, and rights-of-way to enable the disposal of dredged or excavated material all as determined by the Government to be required or to be necessary for the construction, operation, and maintenance of the recreation features;

3. Provide, during construction, any additional funds necessary to make its total contribution for recreation equal to at least 50 percent of total recreation costs;

c. Provide, during construction, 100 percent of the total recreation costs that exceed an amount equal to 10 percent of the Federal share of total flood risk management costs;

d. Shall not use funds from other Federal programs, including any non-Federal contribution required as a matching share therefore, to meet any of the non-Federal obligations for the project unless the Federal agency providing the Federal portion of such funds verifies in writing that expenditure of such funds for such purpose is authorized;

e. Not less than once each year, inform affected interests of the extent of protection afforded by the flood risk management features;

f. Agree to participate in and comply with applicable Federal floodplain management and flood insurance programs;

g. Comply with Section 402 of the Water Resources Development Act of 1986, as amended (33 U.S.C. 701b-12), which requires a non-Federal interest to prepare a floodplain management plan within one year after the date of signing a project cooperation agreement, and to implement such plan not later than one year after completion of construction of the flood risk management features;

h. Publicize floodplain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in adopting regulations, or taking other actions, to prevent unwise future development and to ensure compatibility with protection levels provided by the flood risk management features;

i. Prevent obstructions or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) such as any new developments on project lands, easements, and rights-of-way or the addition of facilities which might reduce the level of protection the flood risk management features afford, hinder operation and maintenance of the project, or interfere with the project's proper function;

j. Keep the recreation features, and access roads, parking areas, and other associated public use facilities, open and available to all on equal terms;

k. Comply with all applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended (42 U.S.C. 4601-4655), and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way required for construction, operation, and maintenance of the project, including those necessary for relocations, the borrowing of materials, or the disposal of dredged or excavated material; and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act;

l. For so long as the project remains authorized, operate, maintain, repair, rehabilitate, and replace the project, or functional portions of the project, including any mitigation features, at no cost to the Federal Government, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and State laws and regulations and any specific directions prescribed by the Federal Government;

m. Give the Federal Government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal sponsor owns or controls for access to the project for the purpose of completing, inspecting, operating, maintaining, repairing, rehabilitating, or replacing the project;

n. Hold and save the United States free from all damages arising from the construction, operation, maintenance, repair, rehabilitation, and replacement of the project and any betterments, except for damages due to the fault or negligence of the United States or its contractors;

o. Keep and maintain books, records, documents, or other evidence pertaining to costs and expenses incurred pursuant to the project, for a minimum of 3 years after completion of the accounting for which such books, records, documents, or other evidence are required, to the extent and in such detail as will properly reflect total project costs, and in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments at 32 Code of Federal Regulations (CFR) Section 33.20;

p. Comply with all applicable Federal and State laws and regulations, including, but not limited to: Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d) and Department of Defense Directive 5500.11 issued pursuant thereto; Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army"; and all applicable

Federal labor standards requirements including, but not limited to, 40 U.S.C. 3141- 3148 and 40 U.S.C. 3701 – 3708 (revising, codifying and enacting without substantial change the provisions of the Davis-Bacon Act (formerly 40 U.S.C. 276a *et seq.*), the Contract Work Hours and Safety Standards Act (formerly 40 U.S.C. 327 *et seq.*), and the Copeland Anti-Kickback Act (formerly 40 U.S.C. 276c *et seq.*);

q. Perform, or ensure performance of, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Public Law 96-510, as amended (42 U.S.C. 9601-9675), that may exist in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for construction, operation, and maintenance of the project. However, for lands that the Federal Government determines to be subject to the navigation servitude, only the Federal Government shall perform such investigations unless the Federal Government provides the non-Federal sponsor with prior specific written direction, in which case the non-Federal sponsor shall perform such investigations in accordance with such written direction;

r. Assume, as between the Federal Government and the non-Federal sponsor, complete financial responsibility for all necessary cleanup and response costs of any hazardous substances regulated under CERCLA that are located in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for construction, operation, and maintenance of the project;

s. Agree, as between the Federal Government and the non-Federal sponsor, that the non-Federal sponsor shall be considered the operator of the project for the purpose of CERCLA liability, and to the maximum extent practicable, operate, maintain, repair, rehabilitate, and replace the project in a manner that will not cause liability to arise under CERCLA; and

t. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended (42 U.S.C. 1962d-5b), and Section 103(j) of the Water Resources Development Act of 1986, Public Law 99-662, as amended (33 U.S.C. 2213(j)), which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until each non-Federal interest has entered into a written agreement to furnish its required cooperation for the project or separable element. (www.usace.army.mil/Portals/2/docs/civilworks/Project%20Planning/ppa/ioc/114986v7.pdf + HQ changes Feb13)

8.4 Project Partnership Agreement

Federal and non-Federal obligations for construction and OMRR&R will be defined in a PPA that will be signed after Congress authorizes the project and appropriates construction funds.

8.5 Project Schedule

Division Commander's Transmittal	August 2013
Chief of Engineers Report	April 2014
Potential Authorization	2014
Design Agreement	2014
Pre-construction Engineering and Design	2015-2016
Initiate Construction	2017
Complete Physical Construction	2020
Complete Plant Establishment Period	2023

8.6 Further Studies

During Pre-construction Engineering and Design (PED), some additional studies would be undertaken as part of developing detailed designs for the project. Upon initiation of PED, any new information that has been collected by others would be considered before undertaking these additional studies. These studies include:

- Interior drainage evaluation
- Topographic surveys
- Foundation explorations for levee design
- Soil borings
- Cultural resource surveys
- Detailed hydraulic modeling
- Detailed sedimentation study
- Site-specific appraisals and takings analysis
- Develop OMRR&R manual

CHAPTER 9
CONCLUSIONS AND RECOMMENDATION

9.1 Conclusions

Major conclusions of the study are:

- A plan to provide flood risk management (FRM) and recreation in the Truckee Meadows Reach of the Truckee River is physically, economically, and environmentally feasible.

- The primary features of the NED Plan include (1) floodwalls, levees, and floodplain terracing in the Truckee Meadows Reach (FRM Alternative 3 - Floodplain Terrace), and (2) paved and unpaved trails, picnic sites, fishing access points, kayak access sites, restrooms and a playground on lands acquired for flood risk management in the Truckee Meadows Reach (Recreation Alternative C).

- The Recommended Plan is the National Economic Development (NED) Plan.

- The estimated first cost for the Recommended Plan is $280,820,000 (October 2013 price level). An additional $195,000,000 is estimated as the minimum associated cost for non-Federal interests to comply with National Flood Insurance Program requirements by avoiding induced flooding of existing structures.

- The estimated fully funded project cost is $307,100,000.

- The FRM features of the Recommended Plan would be cost shared at a minimum of 35 percent non-Federal cost and the recreation features would be cost shared 50 percent non-Federal in accordance with WRDA 1986 as amended by WRDA 1996. The estimated cost-sharing for the Recommended Plan would be $176,596,000 Federal (including cultural resources data recovery) and $94,112,000 non-Federal for FRM, and $5,057,000 Federal and $5,057,000 non-Federal for recreation. The overall benefit-to-cost ratio is 2.2 to 1.

- Based on hydraulic and economic analyses, the Recommended Plan would provide improved flood risk management and increased recreation opportunities in the Truckee Meadows area.

- The Recommended Plan will not induce additional floodplain development.

- The environmental analysis indicates that the various project alternatives would result in potentially significant adverse effects on socioeconomics, traffic, public health, air quality, noise, and cultural resources. Most of these effects are temporary in nature and would be avoided by implementing appropriate best management practices.

- The Recommended Plan includes completed flood control work at the Reno-Sparks Indian Colony that is creditable under the provisions of Section 104 of WRDA 1986. The estimated credit for the completed work is $2,406,000 based on the current USACE cost estimate for the portion of the Recommended Plan that will not be constructed because of the completed work.

- The cost of the Recommended Plan would exceed the Section 902 limit for the Truckee Meadows Flood Control Project authorized by Congress in 1988 (preliminary estimate of the current Section 902 limit is $184,249,000), so additional project authorization will be required.

- USACE and the Administration, in coordination with the sponsor, have decided to give priority to flood risk reduction. Federal interest in a plan for the restoration of fish passage has been established, but that plan is not being recommended for implementation by USACE at this time.

9.2 Environmental Operating Principles

The Recommended Plan supports each of the seven USACE Environmental Operating Principles (EOPs). The EOPs are:

1. Foster sustainability as a way of life throughout the organization.

2. Proactively consider environmental consequences of all USACE activities and act accordingly.

3. Create mutually supporting economic and environmentally sustainable solutions.

4. Continue to meet our corporate responsibility and accountability under the law for activities undertaken by the USACE, which may impact human and natural environments.

5. Consider the environment in employing a risk management and systems approach throughout the life cycles of projects and programs.

6. Leverage scientific, economic, and social knowledge to understand the environmental context and effects of USACE actions in a collaborative manner.

7. Employ an open, transparent process that respects views of individuals and groups interested in USACE activities.

The EOPs are being addressed in the following ways:

Environmental balance and sustainability (EOPs 1, 2, 3, and 4)

- Recommended Plan avoids or minimizes environmental impacts while maximizing future safety and economic benefits to the community.

- Recommended Plan uses environmentally sustainable design of the flood risk management features, including revegetation of floodplain terraces with native species, to avoid or minimize significant adverse effects.

Planning with the environment (EOP 1, 2, 4, 5, and 7)

- Worked with local resource agencies during planning to minimize impacts to the environment.

- Potential for ecosystem restoration was evaluated and coordinated with local stakeholders and local resource agencies.

Leverage scientific, economic, and social knowledge base (EOP 6)

- Available scientific, economic, and social information was used whenever possible in the planning process.

- Environmental experts were consulted during the planning process, including the Engineer Research and Development Center, US Fish and Wildlife Service, Community Coalition, Desert Research Institute, Bureau of Reclamation, Nevada State Historic Preservation Officer, TRFMA, consultants, Pyramid Lake Paiute Tribe, and others.

Seeks public input and comment (win-win solutions) (EOP 7)

- Held stakeholder meetings and public workshops throughout the planning process.

- Worked with local Community Coalition to integrate project goals and public concerns during the planning process. Local public meetings were held during review of the draft GRR and EIS.

9.3 USACE Campaign Plan

The USACE Campaign Plan guides our policy decisions on how we organize, train, and equip our personnel; how we plan, prioritize, and allocate resources; and how we respond to emerging requirements and challenges. The Recommended Plan supports USACE Campaign Plan Goals 2a, 2b, 4a, and 4b as follows:

- **2a. Deliver integrated, sustainable, water resource solutions.** The project delivery team used a holistic approach to identify the Recommended Plan by considering a complete range of economic, social, and environmental goals and constraints within the Truckee River watershed during the planning process. The Recommended Plan incorporates a large natural overflow area to minimize adverse effects caused by increases in downstream flows. An environmentally sustainable design was developed for the Recommended Plan, including revegetation of excavated floodplain terraces with native species that will avoid and minimize impacts on significant resources so that compensatory mitigation is not required. The Recommended Plan also accounts for additional non-Federal associated costs that will be required to continue to comply with the National Flood Insurance Program as a result of the project.

- **2b. Implement collaborative approaches to effectively solve water resource problems.** During the study process, external agencies and stakeholders were engaged to identify and blend multiple approaches for planning and for management and delivery of the study. The sponsor and stakeholders engaged in a community coalition process to identify preferred solutions and provide the project delivery team with information regarding local problems, opportunities and constraints.

- **4a. Identify, develop, maintain, and strengthen technical competencies**. Project delivery team members have worked closely with appropriate communities of practice, such as the plan formulation and hydraulics sub-COPs, to address some of the complexities of the project. USACE team members presented papers at the Planning COP annual conference on the project to inform the broader community on insights and lessons learned.

- **4b. Communicate strategically and transparently.** USACE has an open, two-way communication strategy with the sponsor, stakeholders, the public, and within the project delivery team that is vertically synchronized.

9.4 Recommendation

After giving careful consideration to the environmental, social, and economic effects and engineering feasibility of the alternative plans, I recommend that the Recommended Plan for the Truckee Meadows Flood Control Project, with such modifications thereof as in the discretion of the Commander, HQUSACE, may be advisable, be authorized for implementation as a Federal project, subject to cost sharing, financing, and other requirements of the Water Resources Development Act of 1986, as amended.

Per Section 6.5, implementation of Section 113 of the Energy and Water Development Appropriations Act of 2006 (Pub. L. 109-103, § 113, 119 Stat. 2247, 2254) conflicts with standard USACE policies and practices for crediting non-Federal costs.

I further recommend that this report be approved as the basis for preparation of plans and specifications for construction of this project.

I also recommend that the part of the existing Truckee River and Tributaries Project between Glendale Avenue and Vista be modified in accordance with the Recommended Plan for the Truckee Meadows Flood Control Project within that same reach. Modification of that part of the Truckee River and Tributaries Project (which is currently maintained by the State of Nevada) will ensure that the non-Federal sponsor for the Truckee Meadows Flood Control Project has full and clear responsibility, as between the Department of the Army and the sponsor, for operation, maintenance, repair, replacement and rehabilitation (OMRR&R) of all Federal flood risk management elements between Glendale Avenue and Vista. OMRR&R responsibilities for the parts of the Truckee River and Tributaries Project upstream of Glendale Avenue or downstream of Vista would not be changed by the Recommended Plan.

I also recommend additional studies to investigate further reduction of the residual flood risk to the Reno-Sparks area and/or ecosystem restoration opportunities along the Truckee River, which may be undertaken as part of or coordinated with any future comprehensive investigation of the Truckee River watershed, or a portion thereof. The previously authorized purpose of fish and wildlife enhancement (i.e., ecosystem restoration) should be retained for the Truckee Meadows Flood Control Project for potential future implementation.

The recommendations contained herein reflect the information available at this time and current Departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national Civil Works construction program nor the perspective of higher review levels within the Executive Branch. Consequently, the recommendations may be modified before they are transmitted to the Congress as proposals for authorization and implementation funding. However, prior to transmittal to the Congress, the sponsor, the States, interested Federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

Michael J. Farrell
Colonel, U.S. Army
District Commander

APPENDIX A

HISTORIC PHOTOGRAPHS OF TRUCKEE RIVER FLOODING

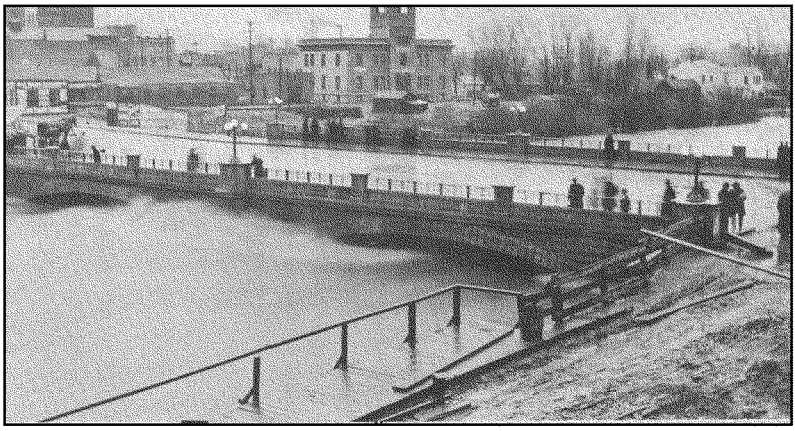

Photo 1. Downtown Reno flooding, 1907.

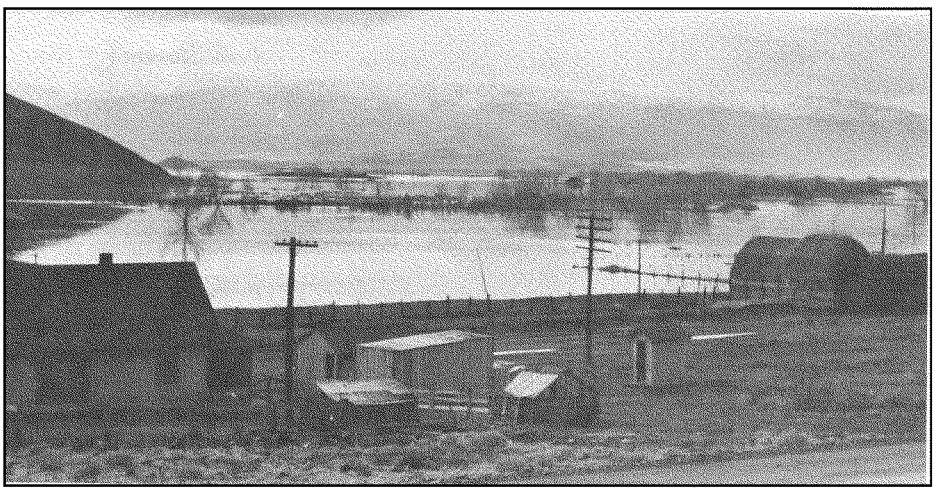

Photo 2. Flooding in Truckee Meadows near Vista, 1937.

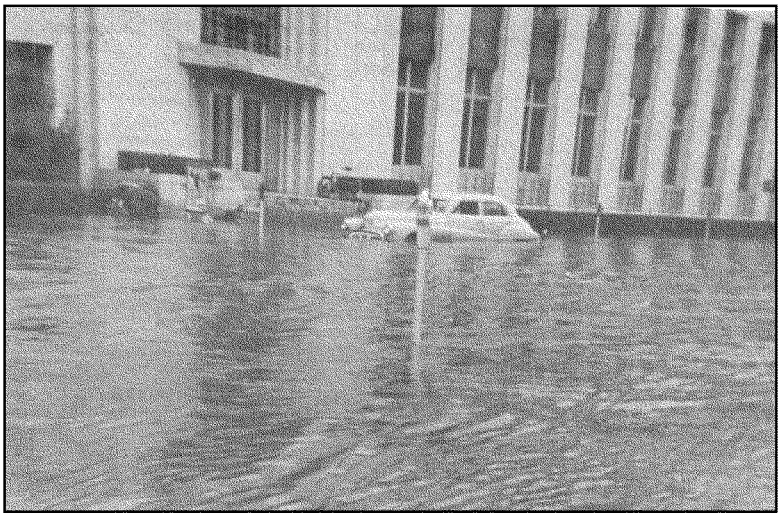

Photo 3. Downtown Reno, 1950 flood.

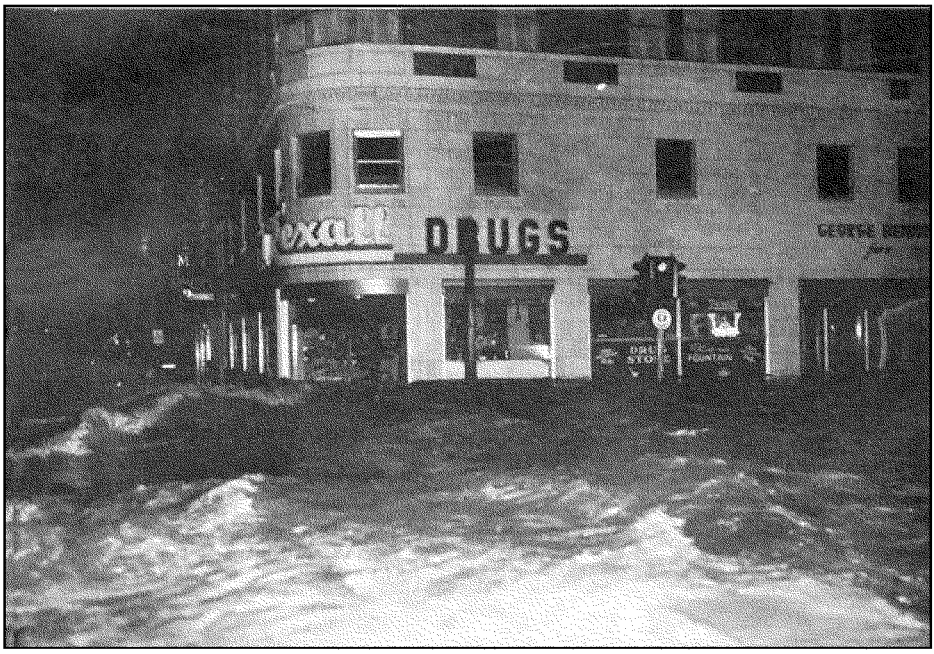

Photo 4. Downtown Reno, Mapes Hotel, 1950 flood.

Photo 5. Lake Street Bridge 1955 flood.

Photo 6. Clean-up after 1955 flood.

Photo 7. Downtown Reno, 1997.

Photo 8. Sparks Industrial Area, 1997.

Photo 9. 2005 flood fight efforts at Lake Street Bridge.

Photo10. Debris clearing from Virginia St. Bridge during 2005 flood.

APPENDIX B

REAL ESTATE PLAN
TRUCKEE MEADOWS FLOOD CONTROL PROJECT
December 2013

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REAL ESTATE PLAN
TRUCKEE MEADOWS FLOOD CONTROL PROJECT

1. Statement of Purpose

This Real Estate Plan is prepared in accordance with ER 405-1-12, Section 12-16, and in support of the General Reevaluation Report (GRR) for the **TRUCKEE MEADOWS FLOOD CONTROL PROJECT** located in Washoe County, Nevada. The purpose and scope of this Real Estate Plan is to describe the Recommended Plan and is to be used for planning purposes only. There may be modifications to the plans that occur during Preconstruction, Engineering and Design (PED) phase, thus changing the final acquisition area(s) and/or administrative land cost.

This Real Estate Plan is intended to support and present the real estate requirements for the Truckee Meadows Flood Control Project GRR located in Washoe County, Nevada.

The Truckee Meadows Flood Control Project was authorized under the Water Resources Development Act, Pub. L. No. 100-676, § 3(a)(10), 102 Stat. 4012 (1988), but was deferred during the Pre-construction Engineering and Design (PED) phase when changes in real estate costs made the project economically infeasible. In 1996, local communities requested that flooding problems in Truckee Meadows be reevaluated. As a result of consultations with local communities at that time, a decision was made to expand the study area beyond Truckee Meadows downstream to Pyramid Lake and to consider ecosystem restoration as a project purpose.

This Real Estate Plan is an appendix to the GRR which analyzes the flood and ecosystem problems in the study area, and develops alternatives to reduce flood risks, restore environmental resources, and increase recreational opportunities. The alternatives include the no-action plan and various combinations of structural and nonstructural measures. The selected plan is identified only after the engineering, economic, and environmental feasibility of the alternatives is evaluated.

The primary purpose of the re-scoped reevaluation study is to assess the feasibility of modifying the Federally-authorized project to reduce flood damages in the Truckee Meadows project area while avoiding or minimizing adverse effects.

In 2012, in coordination with the sponsor, the study was re-scoped to focus plan formulation on flood risk management with basic recreation features. The primary purpose of the General Reevaluation Study (GRR) was to re-scope and assess the feasibility of modifying the Federally-authorized project to reduce flood damages in the Truckee Meadows project area while avoiding or minimizing adverse effects.

Within the primary purpose, the specific goal of this study is to identify a complete plan that will yield an economically justified and environmentally sustainable project that accomplishes the following:

• Reduces flood damages to populated areas
• Provides access and recreation to the public, as feasible
• Avoids and minimizes effects to riparian and aquatic habitats
• Complies with pertinent planning and environmental laws, regulations, and policy
• Complements other Federal, state, and local plans and projects for the Truckee River and vicinity

2. Project Authority

The Truckee Meadows Flood Control Project was authorized by WRDA 1988, Construction of the authorized project was deferred during the Pre-construction Engineering and Design (PED) phase when changes in real estate costs made the project economically infeasible. The Truckee-Carson-Pyramid Lake Water Rights Settlement Act, P.L. 101-618 § 207, 104 Stat. 3294, 3312 (1990), provided direction regarding the conduct of a general reevaluation that had been undertaken by USACE. The Secretary of the Army also received guidance regarding USACE's conduct of the GRR pursuant to the House Report associated with the Energy and Water Development Appropriations Act (EWDAA) 1996.

Estimated real estate costs are based on a current gross appraisal consistent with standard USACE practices. The provisions of Section 113 of the Energy and Water Development Appropriations Act of 2006 (Pub. L. 109-103, § 113, 119 Stat. 2247, 2254) have not been applied to these estimated real estate costs used to calculate the BCR. The effect that application of Section 113 would have on real estate costs and cost apportionment is addressed Section 6.5 of the accompanying General Reevaluation Report.

3. Project Description

The primary purpose of the Truckee Meadows Flood Control Project is to investigate options for the reduction of flood damage currently experienced in the Truckee Meadows area of Nevada and to develop cost estimates for planning purposes. Historically, the Truckee River has been prone to flooding, a vulnerability that continues to pose a public health and safety threat.

Plan formulation began with 11 preliminary sets of alternatives for flood risk management on the Truckee River. These options were screened to three final alternative arrays: Alternative 1 - Levees and Floodwalls Plan, Alternative 2 - Detention Plan, and Alternative 3 – Setback Levees, Floodwalls, and Floodplain Terracing Plan.

Alternative 3 was ranked the highest, but required further refinement. Alternative 3 was the focus of a reformulation workshop with the sponsor and Corps vertical team members held in November 2011 to identify a Federally-supportable flood risk management plan. The reformulation workshop assessed the incremental costs and benefits of the various elements of Alternative 3 to ensure that each added element was incrementally justified. The workshop

focused on the 2% Annual Chance Exceedance (ACE) scale of Alternative 3 (also commonly called the 1:50, 1/50, or "50-year" event) as the previously-evaluated scale with the greatest net economic benefits. As a result of project reformulation, terracing downstream of Steamboat Creek was eliminated from Alternative 3, and capping of People's Drain outlets was added.

Federal policy requires the Corps to recommend the plan that reasonably maximizes net economic benefits consistent with protecting the Nation's environment (the National Economic Development or NED Plan), unless an exception is granted by the Assistant Secretary of the Army for Civil Works. The 2% ACE scale of the reformulated Alternative 3 was identified as the plan that reasonably maximizes net economic benefits consistent with protecting the environment, and therefore was determined to be the Recommended Plan.

The Recommended Plan encompasses an area along the Truckee River from Highway 395 on the west to Vista and the Virginia and Pah Rah Mountain Ranges on the east, south along Steamboat Creek to Huffaker Hills, and includes Sparks to the north. Land use within this reach includes residential, agricultural, commercial and industrial occupants. The University of Nevada and the Reno Airport are located in this reach as well. Sparks area includes many industrial and commercial use sites.

FRM Features of Recommended Plan	**Description**
Levees	31,000 lf on north/south banks of Truckee River
Floodwalls (on-bank)	6,500 lf on north and south banks of Truckee River
Floodwalls (in-channel)	3,150 lf on north and south banks of Truckee River
Floodplain terrace	150 to 250 feet to the landside of the south bank of the Truckee River from Greg Street to just upstream of McCarran Boulevard. A higher bench, approximately 2 feet higher in elevation, would be extended approximately 50-70 feet to the landside of the low bench.
Box culverts on North Truckee Drain (NTD)	NTD placed in 2 box culverts for approximately 3,100 lf. The new drainage structure includes an approximately 200-lineal-foot extension to the existing People's Drain. Cap 2 junction structures of People's Drain.
Interior drainage	14 cfs pumping station just upstream of Glendale and new flap gates and vertical sluice gates for all existing storm drains.
Seepage prevention	Seepage berms, drainage blankets, impervious berms, and relief wells
Bridge pier/Scour protection	11,600 lf rock scour protection. Pier protection at 3 bridges between US Hwy 395 and Vista.

Recreation Features of Recommended Plan:

- Picnic areas: 50 individual picnic areas, 1 small and 1 medium group picnic shelter, with parking, playground and restrooms.
- Water recreation access: 4 kayak/canoe input areas and 13 fishing areas.
- Trails: 18,800 lf of paved and unpaved trails.

Borrow

Borrow material for levee construction would be obtained primarily from usable soils (estimated at approximately 108,000 cubic yards) excavated to form the terracing features in the Truckee Meadows reach for all construction alternatives. All the existing borrow sites fall within the existing flowage easements and recreation fee areas. Any additional material needed for levee construction would be obtained from commercial sources within 15 miles of the project site. Excavation of 60 acres of floodplain terraces along 1.7 miles of the Truckee River would improve the conveyance capacity of the river in the meadows and provide an opportunity to reestablish new riparian habitat. This would include terracing along the south bank of the Truckee River from Greg Street downstream to McCarran Boulevard. The lower terrace would be excavated to a depth of approximately 5 feet to an elevation that would allow the 1 in 5 chance of occurrence event to overtop it. The upper terrace would be excavated to a depth of approximately 3 feet. Widths would vary from 150 feet to 250 feet for the lower terrace and 70 feet to 80 feet for the upper terrace. In addition to improving flood conveyance capacity, the terraces would also support trails for recreational uses and would be revegetated with native riparian habitat based on an environmentally sustainable design that also supports flood conveyance requirements.

Disposal

Disposal of excess or non-reusable material excavated from the Truckee Meadows reach would be a located at a potential disposal site known as the Granite Pit location near Tracy. It will be up to the Non Federal sponsors to acquire lands for a disposal site if potential sites become unavailable at the time of construction.

Land Use

The lands most affected by the proposed project are concentrated in the 100-year floodplain of the Truckee River and in the most urbanized sector of Washoe County—the incorporated cities of Reno and Sparks. The project area extends from the city limits of Reno and the city's central business district to Sparks and ends at Vista.

Land use within this metropolitan area varies and includes residential, commercial, industrial, and public uses structures and activities. The Reno-Tahoe International Airport is located within Reno City limits and protected by the proposed project.

Project construction will not occur near any cemeteries within the project area.

Washoe County's main unincorporated towns within the project boundaries include Wadsworth, Hafed, Tracey, and Thisby. Residential densities vary dramatically throughout unincorporated Washoe County. In general, densities decrease as development moves away from Truckee Meadows, transitioning to rural densities in the outlying basins. Historically, the growth pattern of unincorporated areas of Washoe County involved large-lot residential development (i.e. developments exceeding one acre). Conversely the area immediately surrounding Truckee Meadows is experiencing, and is expected to continue to experience, more concentrated residential development.

4. **Description of Lands, Easements, Right- of-Way, Relocations, Disposal (LERRD's)**

The real estate cost estimates set forth in Section 6, below, reflect acquisitions necessary for implementation of the Recommended Plan. These estimates are based on a Real Estate Cost Estimate for planning purposes prepared by the Appraisal Branch of the Sacramento District Real Estate Division with a date of value of September 7, 2012. The Recommended Plan includes a total of 159 parcels encompassing just over 320.28 acres of land. Estimated land acquisition costs, federal and non federal administrative costs, utility relocation costs, estimated moving assistance and replacement housing costs totals $78,762,000. A complete description of the easements and acquisitions required for this project is found in Section 6.

5. **LERRDs Owned by the Non-Federal Sponsor and Crediting**.

The non-Federal sponsor for the Truckee Meadows Flood Control Project is the Truckee River Flood Management Authority, located in Washoe County, Nevada. The Truckee River Flood Management Authority has acquired fee title of an estimated ten parcels on N. Edison, Mill Street and McCarran Blvd for FRM lands and those costs are shown in the cost table in Section 12. The sponsors have also executed a levee easement with the Reno-Sparks Indian Colony for one of their early implementation projects.

The Reno-Sparks Indian Colony Levee consists of 2,241 linear feet of levee and floodwall. This entire area will be incorporated into our current project. The project was designed to contain a flood event with an estimated 0.85 recurrence interval with risk and uncertainty included.

6. **Standard Federal Estates and Non Standard Estates**

Consistent with Corps policy the Non-Federal Sponsor is expected to acquire no more than the minimum interests in real estate needed to support construction and subsequent operation and maintenance of the project. For the Truckee Meadows Project these interests include parcels shown in the tract register found in Exhibit B.

1) Rights-of-way for construction, operation and maintenance of levee and floodwall sections to be built along the Truckee River's north bank, from Glendale Ave. to Vista. Levees and floodwalls along the north bank of the river would be generally set back approximately 25 feet from the stream bank. Rights-of way for construction, operation and maintenance of floodwalls to be built along the south bank of the

Truckee River, from Highway 395 to UNR Farms Main Experiment Station facilities.

2) Rights of way for construction, operation and maintenance of intermittent floodplain terraces to be built near the south bank of the Truckee River, from Greg Street to East McCarran Boulevard.

3) Rights of way for relocation of the North Truckee Drain, involving construction of twin 10.5-ft. x 11-ft. concrete box culverts south of I-80 and installation of a cap over the Peoples' Drain. These drain improvements will remediate under-seepage and help to manage interior drainage.

4) Acquisition of Pioneer Ditch by the Non-Federal Sponsor in order to accommodate new levee construction. The project will replace 22,000 ft. of paved trail with paved levee maintenance road/recreational trail. An additional 24,000 ft. of paved levee and floodwall maintenance roads and /recreation trails will be constructed.

Accordingly the following standard estates are identified as required for the project:

- **Fee**
  The fee simple title to [the lands described in Exhibit B], subject however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

- **Permanent Road Easement (PRE)**
  A perpetual and assignable easement and right-of-way in, on, over and across [parcel number] for the location, construction, operation, maintenance, alternation and replacement of (a) road(s) and appurtenances thereto; together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions and other vegetation, structures, or obstacles within the limits of the right-of-way; (reserving, however, to the owners, their heirs and assigns, the right to cross over or under the right-of-way as access to their adjoining land at the locations indicated in the tract register); subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

- **Flood Protection Levee Easement (FPLE)**
  A perpetual and assignable right and easement in the land [described in Exhibit B tract registers] to construct, maintain, repair, operate, patrol and replace a flood protection levee, including all appurtenances thereto; reserving, however, to the owners, their heirs and assigns, all such rights and privileges in the land as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

- **Channel Improvement Easement (CIE)**
  A perpetual and assignable right and easement to construct, operate, and maintain channel improvement works on, over and across the land [described in Exhibit B

tract registers], including the right to clear, cut, fell, remove and dispose of any and all timber, trees, underbrush, buildings, improvements and/or other obstructions therefrom; to excavate, dredge, cut away, and remove any or all of said land and to place thereon dredge or spoil material; and for such other purposes as may be required in connection with said work of improvement; reserving, however, to the owners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

- **Flowage Easement (Permanent Flooding).**
  The perpetual right, power, privilege and easement permanently to overflow, flood and submerge [described in Exhibit B tract registers] (and to maintain mosquito control) in connection with the operation maintenance of the project as authorized by the Act of Congress approved _____, and the continuing right to clear and remove and brush, debris and natural obstructions which, in the opinion of the representative of the United States in charge of the project, may be detrimental to the project, together with all right, title and interest in and to the timber, structures and improvements situate on the land [1] (excepting _____, (here identify those structures not designed for human habitation which the District Engineer determines may remain on the land)); provided that no structures for human habitation shall be constructed or maintained on the land, that no other structures shall be constructed or maintained on the land except as may be approved in writing by the representative of the United States in charge of the project, and that no excavation shall be conducted and no landfill placed on the land without such approval as to the location and method of excavation and/or placement of. landfill; [2] the above estate is taken subject to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used and enjoyed without interfering with the use of the project for the purposes authorized by Congress or abridging the rights and easement hereby acquired; provided further that any use of the land shall be subject to Federal and State laws with respect to pollution.

- **Flowage Easement (Occasional Flooding)**
  The perpetual right, power, privilege and easement occasionally to overflow, flood and submerge [the land described in Exhibit B] (and to maintain mosquito control) in connection with the operation and maintenance of the project as authorized by the Act of Congress approved, together with all right, title and interest in and to the structures and improvements now situated on the land, except fencing and [those structures not designed for human habitation which the

[1] Any structures existing in areas that will be allowed to remain must be evaluated using the same criteria that would be used to grant permission for a new structure to be placed in the easement, in coordination with the operational office.

[2] If sand and gravel or other quarriable material is in the easement area and the excavation thereof will not interfere with the operation of the project, the following clause will be added: "excepting that excavation for the purpose of quarrying (sand) (gravel) (etc.) shall be permitted, subject only to such approval as to the placement of overburden, if any, in connection with such excavation;"

District Engineer determines may remain on the land], provided that no structures for human habitation shall be constructed or maintained on the land, that no other structures shall be constructed or maintained on the land except as may be approved in writing by the representative of the United States in charge of the project, and that no excavation shall be conducted and no landfill placed on the land without such approval as to the location and method of excavation and/or placement of landfill; the above estate is taken subject to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used and enjoyed without interfering with the use of the project for the purposes authorized by Congress or abridging the rights and easement hereby acquired; provided further that any use of the land shall be subject to Federal and State laws with respect to pollution

- **Temporary Work Area Easement (TWAE)**
  A temporary easement and right-of-way in, on, over and across [the land described in Exhibit B] for a period not to exceed 2 years or time specified, beginning with date possession of the land is granted to TRFMA, for use by the United States, its representatives, agents, and contractors as a [borrow area or work area], including the right to borrow and/or deposit fill, spoil and waste material thereon (move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the Truckee Meadows Project, together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

- **Drainage Ditch Easement**
  A perpetual and assignable easement and right-of-way in, over and across [the land described in Exhibit B] to construct, maintain, repair, operate, patrol and replace a drainage ditch, reserving, however, to the owners, their heirs and assigns, all such rights and privileges in the land as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

- **Utility and or Pipeline Easement**
  A perpetual and assignable easement and right-of-way in, on, over and across [the land described in Exhibit A] for the location, construction, operation maintenance, alteration, repair and patrol of [(overhead) or (underground) utility or pipeline]; together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions and other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and

assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

- **Bank Protection Easement**
  A perpetual and assignable easement and right-of-way in, on, over and across the land hereinafter described for the location, construction, operation, maintenance, alteration, repair, rehabilitation and replacement of a bank protection works, and for the placement of stone, riprap and other materials for the protection of the bank against erosion; together with the continuing right to trim, cut, fell, remove and dispose therefrom all trees, underbrush, obstructions, and other vegetation; and to remove and dispose of structures or obstructions within the limits of the right-of-way; and to place thereon dredged, excavated or other fill material, to shape and grade said land to desired slopes and contour, and to prevent erosion by structural and vegetative methods and to do any other work necessary and incident to the project; together with the right of ingress and egress for such work; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however to existing easements for public roads and highways, public utilities, railroads and pipelines.

- **Non-Standard Estates**
  The current Recommended Plan is unlikely to require any non standard estates.

Coordination with Non-Federal Sponsor

Because a non-federal sponsor is responsible for acquiring lands, easements, and rights-of-way, full coordination and consultation with the non-Federal sponsor must occur prior to the Government's determination of the interests and estates required for a cost-shared project. If a sponsor indicates an intention to acquire real property interests in fulfillment of project-related LERRD obligations prior to execution of a project partnership agreement, the sponsor's costs may not be creditable by the Government against the sponsor's project costs. Accordingly the Government customarily sends risk letters advising sponsors of the financial risks associated with making early acquisitions.

The Truckee Meadows Flood Control Project's non-federal sponsor is the Truckee River Flood Management Authority (TRFMA), a joint local authority formed pursuant to an Interlocal Cooperative Agreement between the City of Reno, the City of Sparks and Washoe County, Nevada. Coordination with the Non-Federal Sponsor has been ongoing for the last several years. The sponsor has provided estimates of non federal administrative real estate costs for acquiring lands, provided utility relocation maps and inventories, preliminary legal opinions for utility relocations, and a draft relocation assistance plan. The Sponsor has also conducted numerous site visits and meetings with the Corps.

The Government has sent several risk letters to the NFS enumerating the Sponsor's financial risks associated with acquisition of real property interests prior to execution of the Project Partnership Agreement.

7. Description of any Existing Federal Project in or Partially in the Proposed Project

Truckee River and Tributaries Project

Initial flood control work on the Truckee River began with the Truckee River and Tributaries Project, which was authorized under the Flood Control Act of 1954. Construction of channel improvements as part of the Truckee River and Tributaries Project was completed in 1960 including widening and straightening of the Truckee River channel through Truckee Meadows to increase the channel capacity from 3,000 cfs to 6,000 cfs. This work took place on lands located within the footprint of the present project.

The sponsor cannot receive credit for lands, easements, or rights-of-way that were previously acquired for the Truckee River and Tributaries Project. Features of the Truckee River and Tributaries project that lie within the footprint of the proposed Truckee Meadows Project include approximately 29,500 feet of excavated channel, beginning at Glendale Avenue, with an approximately 80-foot invert width. The as-built construction plans identify a permanent right-of-way of varying width. Approximately 32 parcels (all but two publically owned) acquired in the 1960s for the Truckee River and Tributaries Project are located within the present project's footprint. . These parcels total approximately 15 acres and have an approximate market value of $1,118,000. The Recommended Plan would incorporate all 32 parcels.

Reno Flood Warning Project

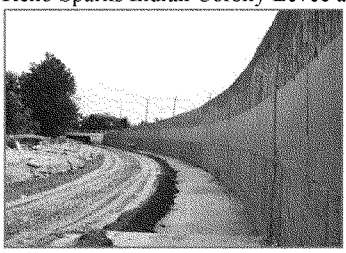
In 1998 the Corps conducted a study pursuant to Section 205 of the 1948 Flood Control Act for the Reno Flood Warning System, in coordination with Washoe County and the Cities of Reno and Sparks. The study resulted in a selected plan that included expanding the network of gages used for forecasting stages in the main stem of the Truckee River, adding gages in the tributary catchments and providing flood watch capabilities for forecasting tributary stages, providing a storm watch data filing and display tool for local jurisdictions, and developing a preparedness plan for the Reno-Sparks area. The project was constructed in 2000 but no significant real property interests were acquired for the Reno Flood Warning Project which could be used by the present project's non-federal sponsor in fulfillment of its LERRD requirements.

8. Description of any Federally Owned Land/Tribal Owned Land Needed for the Project

Federal lands identified within the boundaries of the project are under the stewardship of the Bureau of Land Management (BLM) and U.S. Bureau of Reclamation (USBR). In discussions with BLM and USBR, the agencies would consider issuing easements for their lands required for project use. Both agencies customarily grant only easement interests in lands they control.

Within the boundaries of the project, approximately 10 properties have been identified as tribal lands. The first parcel is owned by the Reno-Sparks Indian Colony and is discussed above in Section 5. The Reno-Sparks Indian Colony granted a levee easement to the Truckee River Flood Management Authority. The 2,241 foot levee/floodwall will be incorporated into the Recommended Plan. The project exists at Intersection of US 395 & Glendale St. as shown below.

Reno Sparks Indian Colony Levee and Floodwall



According to County Assessor's Records, ownership of the remaining properties is vested in the Pyramid Lake Paiute Tribe/United States of America TTEE. Real estate requirements for the project include portions of these ten parcels, to be acquired by the Non-Federal Sponsors in the following estates: Temporary Work Area Easements, Bank Protection Levee Easement, Road Easement or flowage easement. Since the Pyramid Lake Paiute Tribe is an independent sovereign nation, consultation and coordination with the Tribe's government would have to meet the requirements of Executive Order 13175 of November 6, 2000.

9. Application of Navigational Servitude to the LERRDs Requirement

The flood risk management features of the Truckee Meadows Flood Control Project may involve several lands located below the mean or ordinary high water mark of the Truckee River, where pier and scour protection under bridges must be provided and where an in-channel floodwall running along the north bank of the river will be constructed.

The Navigational Servitude is the dominant right of the Government under the Commerce Clause of the U.S. Constitution to use, control and regulate navigable waters of the United States and the submerged lands thereunder for commerce-related purposes, including navigation and flood control. In non-tidal areas, the servitude extends to all lands within the bed and banks of a navigable stream that lie below its ordinary high water mark.

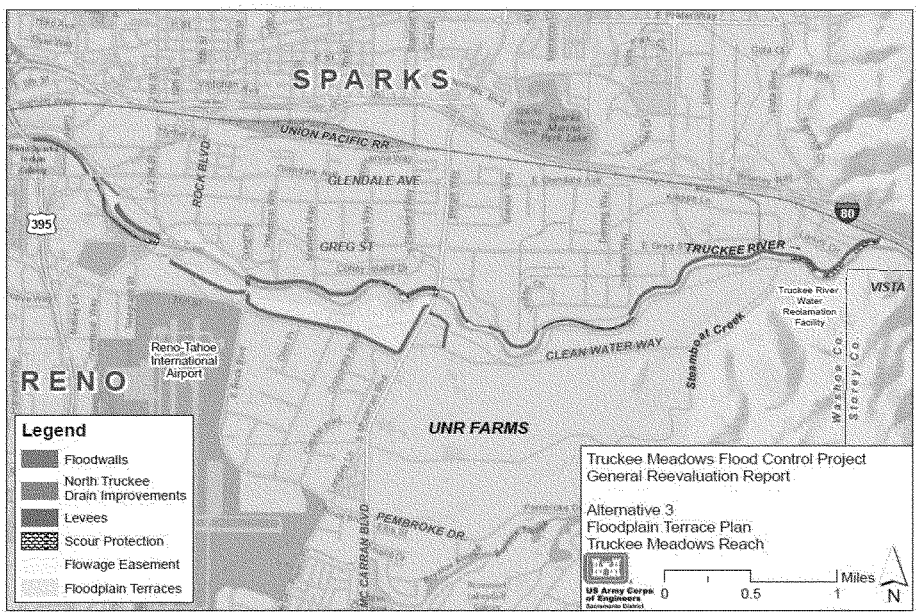
The determination of the availability of the Navigational Servitude is a two-step process. First, the Government must determine whether the project feature serves a purpose which is in the aid of commerce. Such purposes recognized by the courts include navigation, flood control and hydro-electric power. If it is so determined, then the second step is to determine whether the

lands at issue are located below the mean or ordinary high water mark of a navigable watercourse.

If the Navigational Servitude is found to be available through application of the process described above, then the Government will generally exercise its superior rights thereunder at no cost to the project. Generally, it is the policy of the U.S. Army Corps of Engineers (USACE) to utilize the Navigational Servitude in all situations where available. The Truckee River has been designated a "navigable water of the United States," which means that the State of Nevada owns the bed of the Truckee River up to the "present ordinary permanent high water mark," but subject to this superior pre-existing federal interest. Consequently those lands subject to the Servitude which are required for the project may be utilized without need by the Non-Federal Sponsor to obtain an easement from the State of Nevada.

Some of the bank and scour protection will take place in the Truckee River Channel. Navigational Servitude will be invoked.

10. <u>Project Map</u>



11. Anticipated Increased Flooding and Impacts

A takings analysis is appropriate when a flood control project is expected to alter surface water flows in a manner that may induce significant flooding and when that flooding may cause substantial damage or interference with rights of use of an affected property. Under the Fifth Amendment to the U.S. Constitution, private property cannot be taken by the Federal government for authorized public purposes without the payment of just compensation.

Because hydraulic modeling of storm water flows across the Truckee River flood plain surrounding the footprint of the Recommended Plan indicate a potential for incremental additional flooding during major storms caused by the project's structures, a detailed Physical Takings Analysis of potentially affected lands was undertaken, as required by ER 405-1-12, Chapter 12, Section 16(c)-9. Hydraulic modeling of the NED Plan found that 1% ACE flood elevations would increase between 0.0 and 0.6 foot in several areas in the Truckee Meadows reach compared to the without-project condition.

Neither Federal nor Nevada courts have defined a precise threshold at which intermittent flooding is sufficiently frequent and deleterious to constitute a taking. Nevertheless relevant case law generally holds that flooding occurring only several times a century (caused by 20-year, 50-year or 100-year storms) may be so infrequent as to fall below the legal standard of a taking.

As described below, estimated project-induced increases in flooding were examined for the project's Truckee Meadows Reach and for an area called the Lower Truckee Reach, which is no longer part of the Recommended Plan.

Truckee Meadows Reach

Preliminary analysis indicates that project infrastructure would cause no flood-related taking at any of the properties within or adjacent to the project's footprint.

Lower Truckee Reach

While the revised Truckee Recommended Plan no longer includes ecosystem restoration work in the Truckee River's lower reach, preliminary hydraulic modeling shows that the Recommended Plan may increase floodwaters in this section of the river. If further analysis indicates that project-induced flooding could lead to real property takings in this area, a more in-depth study will be undertaken during the PED phase.

Acquisition costs for any flowage easements that may prove necessary would be minimal because most of the property within this reach consists of grazing and scrub land.

12. Cost Estimate

Types of real property estates, the acreage required and projected costs of estates needed for the Recommended Plan are found in the tables below. Estimated values are based on a Real Estate Gross Appraisal used for planning purposes by the Corps. The Recommended Plan includes a total of 159 parcels encompassing just over 320.28 acres of land.

The Gross Appraisal for the Truckee Meadows Project conforms to Corps appraisal standards. The appraisal provides an estimate of costs associated with acquiring real property interests necessary to construct, operate, and maintain the Truckee Meadows Flood Control Project, from the City of Reno to Vista. The project is intended to provide flood damage reduction for a 50 year flood event. Estimates reflect the cost of acquiring fee title parcels where applicable, including the cost of any real property improvements, partial interests (easements), along with incremental costs of real estate totaling 37%. Incremental Costs include the following seven categories: Severance Damages, unknowns for Level of Study Definition, Unforeseen Aspects due to Inaccessibility, Cost/Value Increases from Time and development Pressure, Negotiation Latitude Above Estimated Market Value, Potential for Excessive Condemnation Cost/Awards, Potential for Unknown Natural Resources or Minerals.

For the present level of analysis precise engineered maps illustrating the proposed acquisitions were not available. Conceptual CAD project designs were provided by Engineering Division to the Real Estate Cadastral Section. The CAD designs were converted to GIS map layers over aerial photographs which displayed the estimated construction footprint and estimated acreages required for the proposed project footprint. The appropriate estate description was assigned to each parcel following existing guidance. Land use categories included agricultural and open space land, commercial land, industrial land, rural residential land, existing road and river public right of ways. The Sales Comparison Appraisal Approach analyzed recent sales of similar properties to derive an indication of value.

The following tables detail the estates needed to construct all project features, including the Recommended Plan:

Real Estate Requirements-Recommended Plan, Total LERRDs

Recommended Plan	Acres	Costs	Incremental Real Estate Costs (Contingencies)	Total Costs Rounded
MCACES 01 ACCOUNT - LANDS AND DAMAGES (Non-Fed)				
Lands and Damages / Non Federal Admin (Gross Appraised Value)	320	$48,279,000	$16,096,000	$64,375,000
*Additional Section 113 FRM lands costs Expended		$1,912,000	N/A	$1,912,000
**Recreation		$115,000	$43,000	$158,000
			Sub Total:	$66,445,000
MCACES 01 ACCOUNT - LANDS AND DAMAGES (Fed)				
Federal Admin		$1,455,000	$73,000	$1,528,000
MCACES 01 ACCOUNT - LANDS AND DAMAGES: TOTALS (Fed & Non Fed)		**$71,849,000**	**$16,212,000**	**$67,973,000**
MCACES 02 ACCOUNT - RELOCATIONS (Non-Fed)				
Relocations (Construction)		$6,790,000	$1,835,000	$8,625,000
PED Relocations		$1,018,000	$283,000	$1,301,000
Construction Management		$679,000	$184,000	$863,000
TOTAL RELOCATIONS				**$10,789,000**
TOTAL LERRDS COSTS			**(Rounded)**	**$78,762,000**

* Financial Cost for Real Estate acquired in advance of the PPA is $45,250,000. Corps estimated current fair market value for the same parcels at $43,338,000. Per Section 113, the Non-Federal Sponsor must be credited based on expenditures.

** A portion of the flowage easement area (26 acres) is also needed for recreation features. Recreation requires fee title which for this feature is estimated to cost an additional $158,000, which will be cost shared differently than FRM.

13. Relocation Assistance Benefits (as required by the Relocation Assistance and Real Property Acquisition Policies Act, PL91-646)

The Recommended Plan will require relocation of approximately (1) one residential owner and twenty-three (23) businesses. The majority of the businesses are located between the new setback levee and the Truckee River in the flowage easement area. No habitable structures may be located in a flowage easement area due to life safety issues. The non-Federal sponsor (TRFMA) must comply with the Uniform Relocation Assistance and Real Properties Acquisition

Policies Act of 1970, as amended, 42 U.S.C. 4601 et seq (P.L. 91-646-the Uniform Act) and provide relocation assistance to residences and businesses within the project area. The non-Federal Sponsor has prepared a draft relocation plan, which the Corps has reviewed.

Relocations required for Recommended Plan-

Sheet Number	APN	Description
2	011-121-06	2200 sf commercial
6	034-161-08	3,600 sf, commercial
5	034-430-01	7,500 sf, commercial, two story
4	021-010-05	4,000 sf, storage
4	021-010-05	2,500 sf, residential
4	021-010-05	2,000 sf, UNR Farms
4	034-362-09	70,000 sf, steel, warehouse
4	034-362-08	35,000 sf, steel, warehouse
4	034-362-06	45,000 sf, steel warehouse
4	012-272-12	44,000 sf, commercial
4	012-272-10	13,000 sf commercial
4	012-272-11	18,000 sf commercial
4	012-272-04	24,000 sf commercial
3	012-272-05	32,000 sf commercial
3	012-272-06	24,000 sf commercial
3	012-250-24	4,000 sf commercial
4	012-271-09	Washoe County
3	012-272-08	Washoe County 15,010 sf
4	012-272-07	Washoe County 18,512 sf
4	012-320-05	Washoe County 7,522 sf office
4	012-320-01	Washoe County
4	034-362-20	commercial
4	034-362-19	commercial
4	034-362-18	commercial

14. Mineral/Timber Activity

The real estate investigation did not identify any known mineral deposits, timber, or other value enhancing activities or assets within the project area that would affect the land cost estimate.

Gravel Mining

Several gravel mines presently operate along Steamboat Creek south of Bella Vista Ranch Road and Desert Way. None of the gravel mines occupy property within the construction footprint.

Gold and Silver Mining

There are no gold or silver mines, or mining claims, known to exist in the project area.

Timber Activities

There are no significant lumber operations in the project area.

15. Non-Federal Sponsor's Ability to Acquire

The Truckee River Flood Management Authority, non-Federal sponsor for the project, has the ability to acquire the necessary rights in real estate for the project, and has a professional staff sufficiently experienced to manage the real estate required by the project.

The sponsor has been advised of relocation assistance obligations imposed by the Uniform Relocation Assistance and Real Property Acquisition Policies Act (P.L. 91-646) and the requirements for documenting expenses for credit purposes.

16. Zoning Anticipated in Lieu of Acquisition N/A

17. Acquisition Schedule

REAL ESTATE ACQUISITION SCHEDULE				
Project Name: Truckee Meadows	**COE Start**	**COE Finish**	**NFS Start**	**NFS Finish**
Receipt of preliminary drawings from Engineering/PM	2011	2012		
Receipt of final drawings from Engineering/PM	2013	2014		
Execution of PPA/Finalize Chief's Report	Dec 2013 Depending on HQ and SPD Review times			
Formal transmittal of final drawings & instruction to acquire LERRDS	2014	2014		
Truckee Meadows Reach Contract 1D: North Truckee Drain Contract 2A: Vista to McCarran, Levee, Floodwall, Interior Drainage and Bank Protection Contract 3A: McCarran to Rock, Channel Benching, Levee, Floodwall, Interior Drainage, and Bank Protection Contract 4A: Rock to I-395, Channel Benching, Levee, Floodwall, Interior Drainage, and Bank Protection Contract R4A: Revegetation, McCarran to Rock Contract R5A: Revegetation; Rock to I-395 Contract REC4A: Recreation, 395 to Vista			 July 2015 Jan 2015 Jan 2016 Jan 2016 April 2017 April 2018 Jan 2018	 Dec 2017 Dec 2017 Dec 2018 Dec 2018 Dec 2022 Dec 2023 Dec 2018
Conduct landowner meetings			2014	2017
Prepare/review mapping & legal descriptions			2014	2017
Obtain/review title evidence			2014	2017
Obtain/review tract appraisals			2014	2017
Conduct negotiations			2014	2017
Prepare/review condemnations			2014	2017
Perform condemnations			2014	2017
Complete/review PL 91-646 benefit assistance			2014	2017
Certify all necessary LERRDS are available for construction			2014	2017
Prepare and submit credit requests			2014	2015
Review/approve or deny credit requests	2015	2023		
Establish value for creditable LERRDS in cost accounting system	2015	2023		

18. Description of Facility and Utility Relocations

The summary below presents an inventory of the utilities/facilities identified in the project area that would be impacted by the project and may require relocation. Consistent with Corps regulations, an Attorney's Preliminary Opinion of Compensability (hereinafter "Preliminary Opinion") has been prepared analyzing the compensability of such relocations. The Preliminary Opinion was based upon the locally preferred plan information and data submitted to the Sacramento District Office of Counsel for review as of February 14, 2011, including assumptions and qualifications made as of the date of the Preliminary Opinion. The utility inventory has been developed from the NED (Recommended Plan) and included in the tables listed below.

These utilities/facilities traverse the project boundaries and must be relocated to facilitate project construction. The utilities/facilities consist of electrical distribution and service facilities, telephone communication lines, street light utilities, sewer and storm drain utilities, irrigation facilities, bridges, and natural gas pipelines. The Recommended Plan estimates a total cost for potentially compensable utility/facility relocation unit costs and includes sponsor Construction Management and sponsor PED activities. Utility relocations are estimated to be $10,789,000.

Utility Relocations Summary Table Recommended Plan

Utility Relocation construction costs	$8,487,000
PED Activities for Relocation Construction Management	$1,301,000 $863,000 Total: $10,789,000

A summary of the attorney's compensability analysis, referencing the utility data set tables, is provided as follows:

(a) The following utilities /facilities appear, on a preliminary basis, to be compensable relocations under Nevada state law and—preliminarily—to have a demonstrated need for the provision of "substitute facilities:"

- **NV Energy Electric utilities:** NVE41A, NVE41B, NVE43A, NVE43B, NVE44A, NVE44B, NVE45A, NVE45B, NVE46A, NVE46B, NVE47, NVE48, NVE49B, NVE52, NVE56B, NVE57A, NVE57B, NVE58A, NVE58B, NVE58C, NVE58D, NVE58E, NVE71B, NVE74, NVE77, NVE79, NVE84, NVE116, and NVE118.

- **American Telephone and Telegraph utilities:** ATT15A, ATT20A, ATT20C, and ATT20D.

- **Washoe County Well Relocation**: WC1.

- **City of Reno sewer and storm drain utilities:** R78

- **City of Sparks storm drain and sewer utilities:** SP10, SP11, SP12, SP13, SP14, SP15, SP16,SP17, SP18, SP19, SP20, SP21, SP22, SP23, SP25, SP26, SP28, SP29

(b) The following utilities/facilities appear, on a preliminary basis, to be compensable relocations under Nevada state law, yet there appears to be no legal basis for the provision of "substitute facilities :"

- **Pioneer Ditch utility:** P1

(c) The following utilities/facilities appear, on a preliminary basis, to be compensable relocations under Nevada state law (assuming the existence of valid easement documentation), and—preliminarily—to have a demonstrated need for the provision of "substitute facilities:"

- **NV Energy electric utilities:** NVE41C, NVE42A, NVE42B, NVE82A, NVE82B, NVE82C, NVE98C.

- **American Telephone and Telegraph utilities:** ATT15B, ATT15C, and ATT17B.

- **Reno sewers and storm drain utilities:** R79, and R80.

- **Sparks storm drain and sewer utilities:** SP24.

(d) The following utilities/facilities are not compensable relocations as the proposed modifications to the utilities/facilities do not meet the definition of a "relocation expense" under applicable law and/or regulations:

- **NV Energy Electric utilities:** NVE49A, NVE49C, NVE59A, NVE59B, NVE59C, NVE59D, NVE60, NVE61, NVE62A, NVE62B, NVE62C, NVE62D, NVE63A, NVE63B, NVE63C, NVE64A, NVE64B, NVE64C, NVE65, NVE67A, NVE67B, NVE76C, NVE76D, NVE86B, and NVE104.

- **American Telephone and Telegraph utilities:** ATT21A, ATT21B, ATT21C, ATT21D, ATT21E, ATT21F, ATT21G, ATT23.

- **Reno sewer and storm drain utilities:** R81, R82, and R83.
- **Sparks storm drain and sewer utilities:** SP6 and SP7.

(e) The following utilities/facilities have no compensable property interest and, accordingly, are not compensable relocations and/or the utility owners are otherwise obligated to relocate the utilities/facilities at their own cost and expense:

- **Buckeye Gas line (to Reno Airport):** BUC1.
- **Charter Communications utilities:** CH29A.
- **Nevada Energy electric utilities:** NVE78D, NVE78E, and NVE138, NVE 139, NVE 140.
- **American Fiber System utilities:** AFS8A, AFS8B, AFS9A, AFS9B, AFS9C, AFS9D, AFS10A, AFS10B, AFS10C, AFS10D, and ATT20B.
- **Charter Communications utilities:** CH29B, CH29C, CH30, CH31, and CH32.
- **Federal Communications Commission Radio Tower:** FCC1.
- **Privately owned monitoring wells:** MW4 and MW8.

(f) The following utilities/facilities may have a compensable property interest under applicable law, however, the utility owner is obligated to relocate the utilities/facilities under the express terms of an applicable agreement:

Truckee Meadows Water Authority utilities: T11, T12, T13, T14, T16, T17, T18

There is insufficient information at this time to make a preliminary determination as to whether the following utilities/facilities are compensable relocations. The submission of additional data and further analysis is required:

Nevada Energy electric utilities: NVE71C, NVE72C, NVE83, NVE110, NVE111B, NVE139, NVE140

American Telephone and Telegraph utilities: ATT17C, ATT18, ATT24B, ATT24C, ATT105, ATT108, ATT109, ATT116, ATT 101

Sparks sewer and storm drain utilities: SP36

ANY CONCLUSION OR CATEGORIZATION CONTAINED IN THIS REPORT THAT AN ITEM IS A UTILITY OR FACILITY RELOCATION TO BE PERFORMED BY THE NON-FEDERAL SPONSOR AS PART OF ITS LERRD RESPONSIBILITIES IS FOR DISCUSSION PURPOSES FOR THE JANUARY 2011 ATR ONLY. THE GOVERNMENT WILL MAKE A FINAL DETERMINATION OF THE RELOCATIONS NECESSARY FOR THE CONSTRUCTION, OPERATION, OR MAINTENANCE OF THE PROJECT AFTER FURTHER ANALYSIS AND COMPLETION AND APPROVAL OF PRELIMINARY ATTORNEY'S OPINIONS OF COMPENSABILITY, AND THEREAFTER, FINAL ATTORNEY'S OPINIONS OF COMPENSABILITY FOR EACH OF THE IMPACTED UTILITIES AND FACILITIES.

19. Hazardous Toxic, Radiological Waste Impacts

While the Sacramento District's Environmental Engineering Branch has identified 26 possible HTRW locations within the footprint of construction of the recommended plan, these possible sources of contamination are not expected to pose hindrance or risk to the project. Ten of these locations are already remediated, or being remediated, and project features, as well as construction activities, will be planned to avoid any HTRW sites remaining at the time the project contractor starts construction.

For the majority of the identified HTRW locations, no field evidence or records were found to indicate that these potential sources have caused significant contamination. Data reviewed by the Engineering Branch involved registered USTs, hazardous waste generators, minor tank leaks, UST removal and remediation, or minor accidental releases.

All of the potential sources have been or are currently under investigation by other agencies, and project designers will actively coordinate final construction planning with all relevant state and federal authorities. All costs associated with HTRW clean up and removal are a local or Non Federal responsibility.

For more detailed information regarding HTRW please refer to GRR Engineering Appendix D and the EIS Section 5.2.2.

20. Attitude of Land Owners

The project has strong support of the citizens in Washoe County to resolve flood control problems along the Truckee River. The Pyramid Lake Paiute Tribe's (PLPT) fundamental concerns are induced flows from a project in the Truckee Meadows and changes to water quality conditions that could affect native fisheries. Loss of riparian habitat and disturbance to the river channel during construction, as well as induced flows in the Lower Truckee River reach can increase sediment loading and degrade water quality, which can threaten aquatic habitat and native fisheries. The Tribe cultivates a successful Lahontan cutthroat trout fishery that provides income from sport fishing, so any negative effects from induced flows carry the potential to jeopardize an important part of the Tribe's livelihood. The Tribe is also concerned with the overall environmental effects of the project.

The Pyramid Lake Paiute Tribe (PLPT) is a proponent for fish passage improvements and has expressed concern that fish passage is not included in the Recommended Plan and concern that not enough coordination was conducted with the Tribe during the development of the Recommended Plan. The Corps has collaborated, coordinated and consulted with the PLPT on the Truckee Meadows Flood Control Project over the years. This communication was established prior to 2005. Government to Government consultation was initiated in 2005. Throughout the years, Corps staff identified, shared, and discussed potential effects and benefits for the array of alternatives under consideration and sought comments and views from the PLPT for consideration. After a brief pause on the project to review overall direction and scope/schedule, a tentatively selected plan (TSP) was established. As part of this pause, the Corps, the Army, and

TRFMA made a decision to remove the ecosystem restoration from the alternatives being considered. After the project pause, Corps staff re-engaged consultation with the PLPT. In April and May 2013, consultation opportunities included supplying information on the TSP, reviewing technical data and modeling, providing feedback for consideration and presenting information to the tribal governance. Additional information on Government to Government consultation is provided in the Final Environmental Impact Statement (EIS).

The PLPT is also concerned about adverse impacts to their lands. The hydraulic modeling of this study has shown that, although there would be a slight increase in the stage of the 1% ACE event along the river, it would not be great enough to affect existing structures in the Lower Truckee River reach, including on Tribal lands.

The PLPT's comments and Corps responses are included the Final EIS.

Another tribe in the study area is the Reno-Sparks Indian Colony (RSIC). The original RSIC land holding is adjacent to flood risk management features, and their stated concern was the flood risk reduction offered by the project. A Wal-Mart store was recently constructed on the RSIC land that included a floodwall along the proposed alignment of the flood project levee. This floodwall provides stand-alone flood risk reduction benefits for the RSIC property up to the 0.9% ACE flood event. TRFMA contributed funding for construction of the floodwall and has requested consideration of credit for this contribution towards their non-Federal cost-share obligations.

Additionally, the RSIC is concerned with the overall environmental effects of the project on traditional and cultural resources along the Truckee River.

Prepared by:

Laurie Parker

Laurie Parker
Realty Specialist
Acquisition Branch

Date 10 Dec 2013

Reviewed and Approved by:

Sharon Caine

Sharon Caine
Chief, Real Estate Division
U.S. Army Engineer District, Sacramento

Date 10 Dec 2013

EXHIBIT A

ASSESSMENT OF NON-FEDERAL SPONSOR'S REAL ESTATE ACQUISITION/FINANCIAL CAPABILITY

TRUCKEE MEADOWS FLOOD CONTROL PROJECT

SPONSOR: Truckee River Flood Management Authority located in Washoe County, Nevada. Coordinated with acting Executive Director, Jay Aldean

I. **Legal Authority**:

a. Does the sponsor have legal authority to acquire and hold title to real property for project purposes? **Yes for Washoe County**

b. Does the sponsor have the power of eminent domain for this project? **Yes for Washoe County**

c. Does the sponsor have "quick-take" authority for this project? **Yes**

d. Are any of the lands/interests in land required for the project located outside the sponsor's political boundary? **Pauite Tribe Indian Reservation**

e. Are any of the lands/interests in land required for the project owned by an entity whose property the sponsor cannot condemn? **Tribal Lands**

II. **Human Resource Requirements**:

a. Will the sponsor's in-house staff require training to become familiar with the real estate requirements of Federal projects including P.L. 91-646, as amended? **Yes – The County hired a consultant**

b. If the answer to II.a. is "yes," has a reasonable plan been developed to provide such training? **Yes – The County has had a draft Relocation Plan report with P.L 91-646 guidance written and approved by the FPCC. The Corps will need to review the final Plan when it is completed and it may need to be modified.**

c. Does the sponsor's in-house staff have sufficient real estate acquisition experience to meet its responsibilities for the project? **Yes. The County has also hired a consultant.**

d. Is the sponsor's project in-house staffing level sufficient considering its other workload, if any, and the project schedule? **Yes**

e. Can the sponsor obtain contractor support, if required, in a timely fashion? **Yes**

f. Will the sponsor likely request USACE assistance in acquiring real estate? **No**

II. Other **Project Variables**:

a. Will the sponsor's staff be located within reasonable proximity to the project site? **Yes**

b. Has the sponsor approved the project real estate schedule/milestones? **Yes**

IV. Overall **Assessment**:

a. Has the sponsor performed satisfactorily on other USACE projects? **N/A**

b. With regard to this project, the sponsor is anticipated to be: **Truckee River Flood Management Authority**

V. **Coordination**:

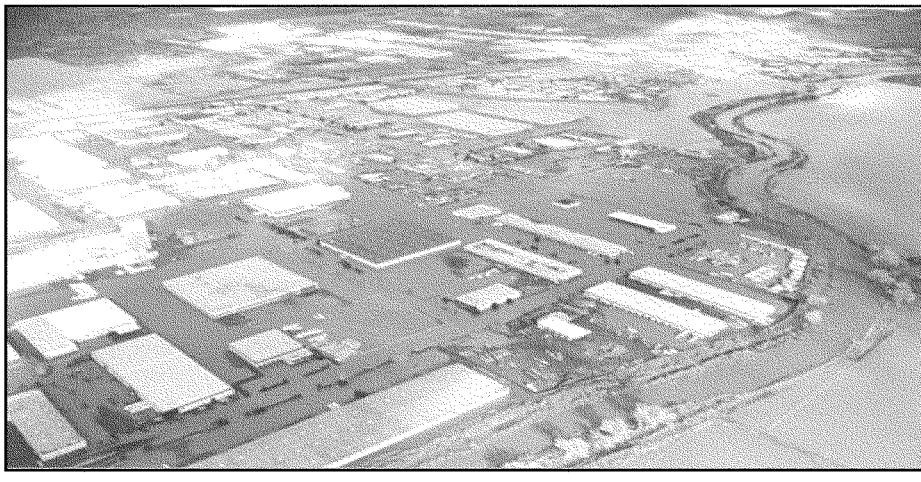
a. Has this assessment been coordinated with the sponsor? **Yes**

b. Does the sponsor concur with this assessment? **Yes**

EXHIBIT B
CADASTRAL MAPS AND TRACT REGISTER AVAILABLE ON DVD
UTILITY MAPS
RECREATIONAL TRAIL MAPS
TAKINGS ANALYSIS MAPS

Truckee Meadows General Re-Evaluation Report (GRR)
Final Report
Washoe County, Nevada

FLOOD RISK MANAGEMENT PROJECT



APPENDIX C
ECONOMICS

Planning Division
Sacramento District

December 2013

Truckee Meadows GRR
Washoe County, Nevada

FLOOD RISK MANAGEMENT PROJECT
APPENDIX C
ECONOMICS

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1 INTRODUCTION

1.1 PURPOSE

The purpose of this Economic Appendix is to: 1) document the evaluation of flooding and related problems in the Truckee Meadows and Reno, Nevada area resulting from the Lower Truckee River and tributaries watershed; 2) identify the expected Without Project (existing and future) economic damages; and 3) estimate National Economic Development (NED) and Regional Economic Development (RED) benefits of alternative solutions to the identified problems.

1.2 METHODOLOGY

The methodology employed for this economic analysis is in accordance with current Principles and Guidelines and standard economic practices. The primary source for economic guidance can be found in ER-1105-2-100, Planning Guidance Notebook. Guidance specific the risk-based analysis is from EM 1110-2-1619 and ER-1105-2-101, Risk-Based Analysis for Flood Damage Reduction Studies. Benefits and costs are computed at October 2013 price levels. This analysis uses the currently established Federal discount rate of 3.5 percent. The period of analysis is 50 years, with a project Base Year of 2020.

Benefits and costs computations were evaluated based on October 2013 prices. However, because of the length of analysis, price levels varied throughout the study phases. Price levels from previous analysis and alternative comparisons were not updated to current price levels for the purposes of reporting as long as the conclusions would not be impacted by such an adjustment.

1.3 STUDY AREA (DOWNTOWN TO VISTA)

1.3.1 Location & Characteristics

The cities of Reno and Sparks are located in the Truckee Meadows region of Northern Nevada along the Truckee River. Sparks' present population is 90,264 and Reno's present population is 225,986 (source data: 2010 US Census). The Reno/Sparks region is a major center for west coast tourism associated with the area's casinos and outdoor recreation opportunities. The area's industrial complex includes distribution, warehousing, and light manufacturing.

1.3.2 Historical Flood Problems

The Truckee Meadows area is subject to severe flooding from the Truckee River and its primary tributary, Steamboat Creek. Detailed information was documented of major floods that occurred in the 20th century. Floods in the magnitude of 20,000 cfs were recorded in 1950, 1955 and 1963. Estimated damages, based on prices and conditions at the time of the flood, were approximately $1.7 million for the event in 1963. The most recent flood events occurred in February 1986, January 1997 and December 2005 (with damages in the millions). The estimated peak flows of the 1986 and 1997 floods were 14,400 and 23,000 cubic feet per second. The 1986 event correlates to a 1.8% (1/55) annual chance exceedance (ACE) event for Reno and about a 1 in 65 for the Meadows area. The

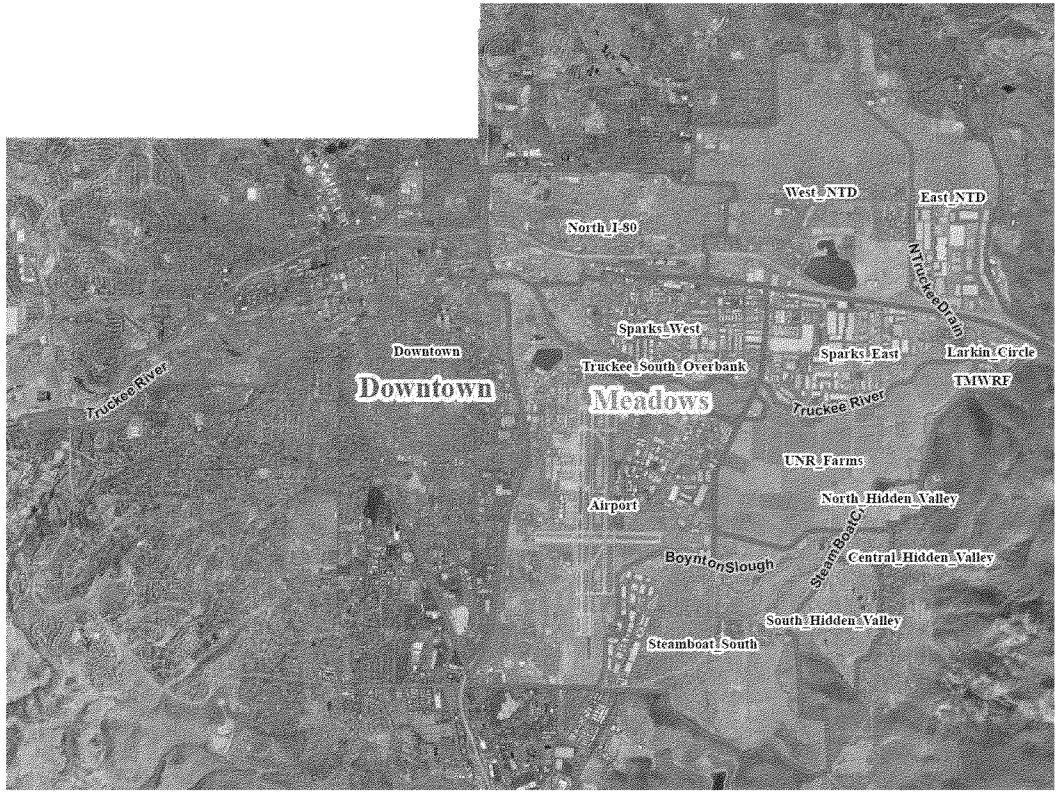
1997 event would have been around a 0.87% (1/115) ACE event for Reno and a 0.95% (1/105) ACE event for the Meadows area. The 1997 event is the event of record for the Truckee River, a flood that caused over $700 million (1997 prices) in reported flood-related damages in the Truckee Meadows. Most of these damages occurred in the industrial areas of the cities of Sparks and Reno and at the Reno-Tahoe International Airport. The 2005 flood event was slightly rarer than a 2% (1/50) ACE, as water barely came out of bank. In the Meadows area, water did overtop the levees at a frequency slightly less than a 2% ACE in terms of volume and slightly more than a 2% ACE based on peak flow. The significant increase in damages from 1963 to 1997 is primarily a result of development of damageable properties in the floodplain and conversion of agricultural lands to a highly developed industrial complex over the last forty years.

1.3.3 Economic Impact Area Delineation

See Figure 1 for identification of the study area and Economic Impact Areas (EIA's[1].) For analysis purposes, these reaches were grouped into two independent areas: Downtown Reno (EIA 1) and The Meadows Area (EIA's 2-15) which lies east of I-395 along the Truckee River to Vista. The location of the Truckee River and its primary tributaries (North Truckee Drain, Boynton Slough and Steamboat Creek) within the study area are also shown in this figure.

[1] In earlier Truckee studies, the study area was only divided into 6 EIA's (1 downtown and 5 Meadows). In 2010, the team re-delineated EIA's and divided the area into more impact areas based on Hydrology, Hydraulics, Economics and Geotech, which now total 15 (1 downtown and 14 Meadows).

Figure 1-1: Economic Impact Areas and Primary Rivers/Tributaries – Truckee Meadows



2 STUDY AREA DEVELOPMENT

2.1 FLOODPLAINS

New without project flood plains (developed by West Consultants, October 2010) were applied for delineating areas of inundation for both Downtown Reno (Economic Impact Area 1) and the Meadows Area (Economic Impact Areas 2-15). Water surface elevations (depths) were developed for events to include the 0.2% (1/500), 0.5% (1/200), 1% (1/100), 2% (1/50), 5% (1/20), 10% (1/10), and 20% (1/5) ACE events. Figure 2-1 shows the extent of the 100yr without project floodplain while Figure 2-2 shows the extent of the 0.2% ACE floodplain. With-project flood plains were also developed and utilized for estimating the with-project benefits and residual flooding damages associated with the alternatives considered. See the Engineering (H&H) appendix for additional information regarding the modeled floodplains and water surface elevations (depths).

Figure 2-1: Existing Condition 1% (1/100) Annual Chance Exceedance Floodplain

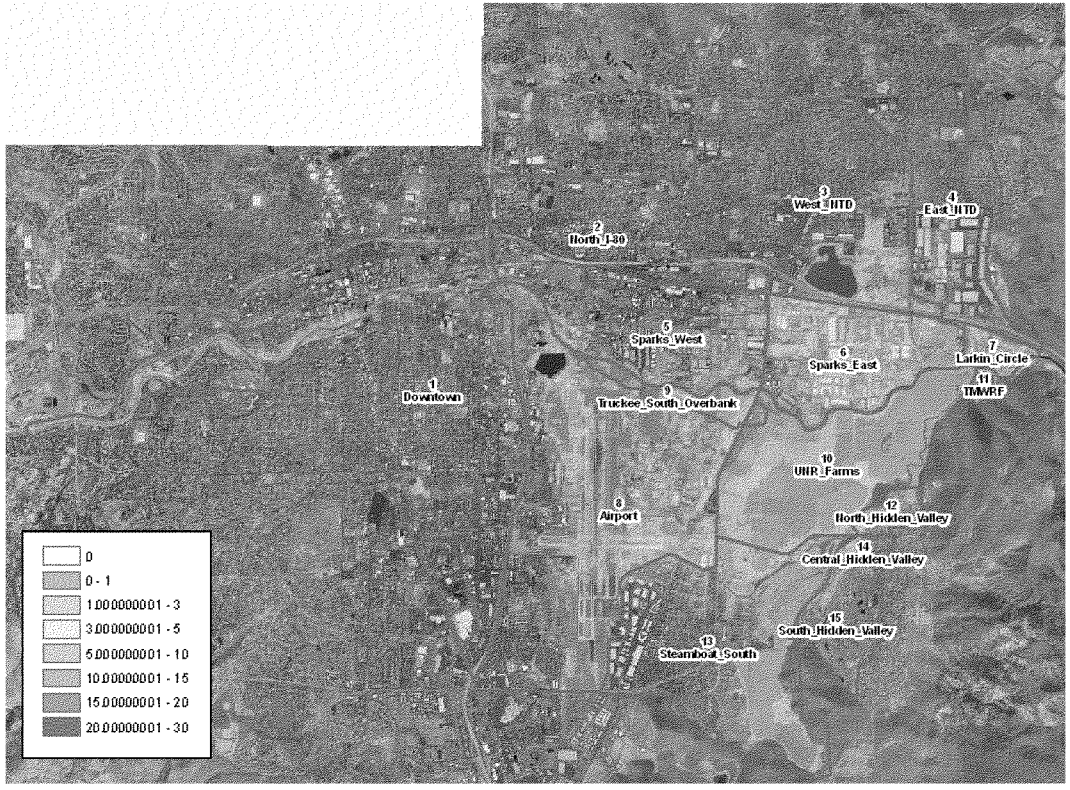
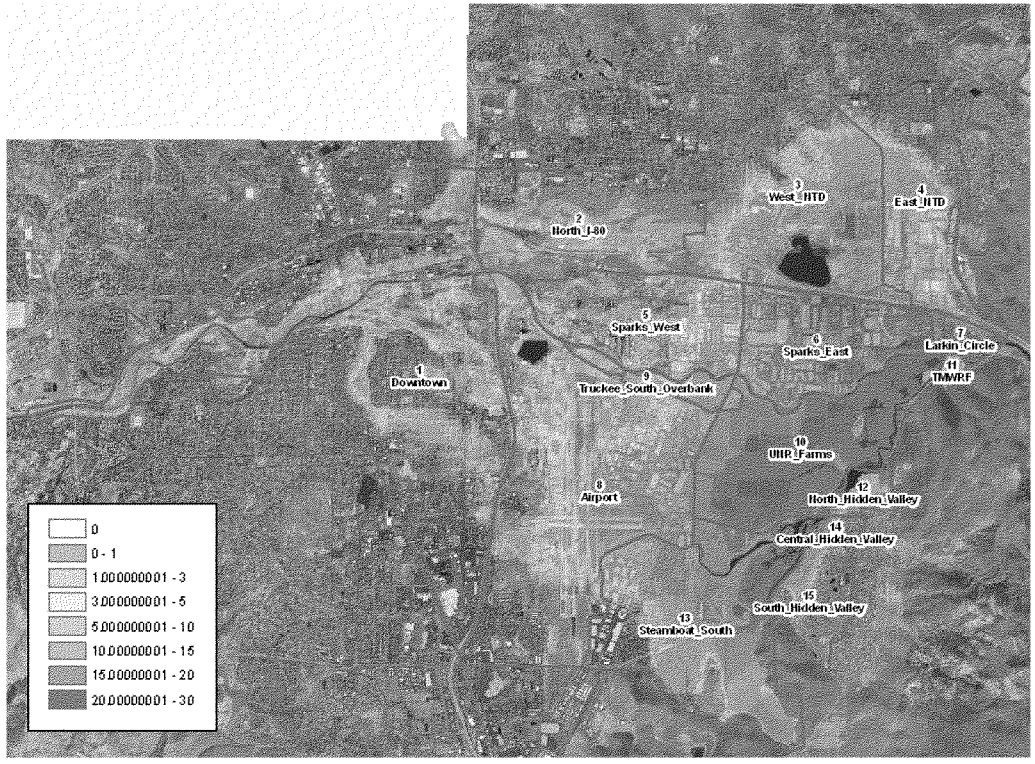


Figure 2-2: Existing Condition 0.02% (1/500) Annual Chance Exceedance Floodplain



2.2 STRUCTURAL INVENTORY

Land uses within the floodplains were determined based on parcel data characteristics, aerial photographs and visual inspections. GIS parcel data was provided by Washoe County which includes detailed information regarding land use building type, square footage and other structural characteristics such as number of stories. Additional data on foundation heights and other structure qualities were noted in the inventory during field data collection. General land/building uses identified include: commercial, casinos, industrial, residential, and public.

- Commercial (COM) - Shopping centers, offices, retail outlets, motels, hotels, and restaurants. Losses include structures, fixtures, and inventory.

- Casinos – Gaming facilities and casino hotels were separated from the standard commercial uses. Losses include structures, fixtures, and inventory.

- Industrial (IND) - Warehouses, distribution centers, processing and packaging plants. Losses include structures and contents.

- Residential (RES) - One and two story single family homes, duplexes, apartments, condominiums and mobile homes.

- Public (PUB) - Schools, hospitals, public organizations, offices, police and fire stations, utilities and churches, losses include structure and content.

2.2.1 Number of Structures

The number of structures within the study area floodplains was determined using GIS data, previous site surveys, county assessor's data and parcel maps. Floodplain shape files were overlaid on the parcel data files to determine how many structures were located within each floodplain by event. The number of structures, by structure type and floodplain, for all 15 EIA's are displayed in Tables 2-1 through 2-15. Note that while structures may be located within the two-dimensional boundary of a given floodplain, damages may be limited as damages are determined as a function of depth vs. first floor elevation.

The structural inventory, in terms of damageable property, is not expected to significantly change within the 1% (1/100) annual chance flood plain over the period of analysis. Almost all of the area within the 1% (1/100) ACE and even the 0.2% (1/500) ACEflood plain is built out and any new structures would have to be constructed with first floors one foot above the 1% ACE mean water surface elevation. Exclusion of any new structures is also consistent with WRDA 1990, Section 308 guidance which states "The Secretary shall not include in the benefit base for justifying Federal flood damage reduction projects any new or substantially improved structure built in the 1% (1/100) annual chance flood plain with a first floor elevation less than the 1% annual chance flood elevation built after July 1, 1991". Because any potential future development would not have a significant

impact on project benefits or plan formulation, the future without project condition was assumed to be the same as the existing condition in terms of structure inundation.

It should be noted that all structures within EIA 9 will be purchased as a cost of the project and removed from the floodplain, therefore without project damages will be counted and with-project damages become zero. Final Costs of the buyouts are still being finalized, but by removing these structures and using the land as terracing to increase capacity of the river, the benefits in damages reduced to EIA 9 as well as damages reduced downstream will far outweigh those costs. Other alternatives, such as on-channel levee systems were also considered, but were not as efficient.

Table 2-1: EIA 1 (Downtown Reno) – Structures within Floodplains

Damage Category	Annual Chance Exceedance Flood Event						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
RES	0	0	6	26	122	1,135	2,103
COM	0	0	0	12	47	381	651
CASINOS	0	0	0	0	9	38	66
PUB	0	0	1	10	21	48	63
IND	0	0	0	0	3	55	97
TOTAL	**0**	**0**	**7**	**48**	**202**	**1,657**	**2,980**

Table 2-2: EIA 2 (North I-80) Structures within Floodplains

Damage Category	Annual Chance Exceedance Flood Event						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
RES	0	3	3	4	4	1,136	1,168
COM	0	0	0	0	0	158	159
CASINOS	0	0	0	0	0	9	9
PUB	0	0	0	0	0	70	71
IND	0	0	0	0	0	25	25
TOTAL	**0**	**3**	**3**	**4**	**4**	**1,398**	**1,432**

Table 2-3: EIA 3 (West NTD) Structures within Floodplains

Damage Category	Annual Chance Exceedance Flood Event						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
RES	0	0	0	202	272	1,429	3,076
COM	0	0	0	4	9	50	81
CASINOS	0	0	0	0	0	1	2
PUB	0	0	0	1	2	12	18
IND	0	0	0	0	0	15	20
TOTAL	**0**	**0**	**0**	**207**	**283**	**1,507**	**3,197**

Table 2-4: EIA 4 (East NTD) Structures within Floodplains

Damage Category	Annual Chance Exceedance Flood Event						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
RES	0	0	12	18	32	352	814
COM	0	0	0	0	1	6	17
CASINOS	--	--	--	--	--	--	--
PUB	0	0	0	0	1	2	4
IND	0	0	0	0	3	15	25
TOTAL	**0**	**0**	**12**	**18**	**37**	**375**	**860**

Table 2-5: EIA 5 (Sparks West) Structures within Floodplains

Damage Category	Annual Chance Exceedance Flood Event						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
RES	0	0	0	1	7	32	34
COM	0	3	4	10	16	45	59
CASINOS	0	0	0	0	0	0	1
PUB	0	5	6	10	14	42	46
IND	0	4	21	69	120	218	277
TOTAL	**0**	**12**	**31**	**90**	**157**	**337**	**417**

Table 2-6: EIA 6 (Sparks East) Structures within Floodplains

Damage Category	Annual Chance Exceedance Flood Event						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
RES	0	0	0	0	1	1	1
COM	0	0	7	13	25	26	27
CASINOS	--	--	--	--	--	--	--
PUB	0	1	7	16	19	22	22
IND	0	5	32	82	137	157	157
TOTAL	**0**	**6**	**46**	**111**	**182**	**206**	**207**

Table 2-7: EIA 7 (Larkin Circle) Structures within Floodplains

Damage Category	Annual Chance Exceedance Flood Event						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
RES	--	--	--	--	--	--	--
COM	0	0	0	3	4	5	5
CASINOS	--	--	--	--	--	--	--
PUB	0	0	0	1	4	5	5
IND	0	0	0	9	15	16	16
TOTAL	**0**	**0**	**0**	**13**	**23**	**26**	**26**

Table 2-8: EIA 8 (Airport) Structures within Floodplains

Damage Category	Annual Chance Exceedance Flood Event						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
RES	0	0	0	25	29	85	99
COM	0	0	0	66	89	106	110
CASINOS	0	0	0	0	0	1	1
PUB	0	0	0	23	27	40	45
IND	0	0	0	101	143	159	161
TOTAL	**0**	**0**	**0**	**215**	**288**	**391**	**416**

Table 2-9: EIA 9 (Truckee South Overbank) Structures within Floodplains

Damage Category	Annual Chance Exceedance Flood Event						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
RES	0	0	0	1	1	1	1
COM	0	0	0	1	1	1	1
CASINOS	--	--	--	--	--	--	--
PUB	0	0	0	1	1	1	1
IND	0	0	2	8	8	8	8
TOTAL	**0**	**0**	**2**	**11**	**11**	**11**	**11**

Table 2-10: EIA 10 (UNR Farms) Structures within Floodplains

Damage Category	Annual Chance Exceedance Flood Event						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
RES	0	0	0	1	4	4	4
COM	0	0	0	0	1	1	1
CASINOS	--	--	--	--	--	--	--
PUB	0	0	0	1	1	1	1
IND	--	--	--	--	--	--	--
TOTAL	**0**	**0**	**0**	**2**	**6**	**6**	**6**

Table 2-11: EIA 11 (TMWRF) Structures within Floodplains

Damage Category	Annual Chance Exceedance Flood Event						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
RES	--	--	--	--	--	--	--
COM	--	--	--	--	--	--	--
CASINOS	--	--	--	--	--	--	--
PUB	--	--	--	--	--	--	--
IND	0	0	0	0	0	0	1
TOTAL	**0**	**0**	**0**	**0**	**0**	**0**	**1**

Table 2-12: EIA 12 (North Hidden Valley) Structures within Floodplains

Damage Category	Annual Chance Exceedance Flood Event						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
RES	0	0	0	3	8	56	99
COM	--	--	--	--	--	--	--
CASINOS	--	--	--	--	--	--	--
PUB	--	--	--	--	--	--	--
IND	--	--	--	--	--	--	--
TOTAL	**0**	**0**	**0**	**3**	**8**	**56**	**99**

Table 2-13: EIA 13 (Steamboat South) Structures within Floodplains

Damage Category	Annual Chance Exceedance Flood Event						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
RES	0	0	0	24	688	1,610	2,562
COM	0	1	1	2	7	10	10
CASINOS	--	--	--	--	--	--	--
PUB	0	1	1	4	15	42	48
IND	0	0	0	0	7	14	38
TOTAL	**0**	**2**	**2**	**30**	**717**	**1,676**	**2,658**

Table 2-14: EIA 14 (Central Hidden Valley) Structures within Floodplains

Damage Category	Annual Chance Exceedance Flood Event						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
RES	0	0	0	13	30	37	46
COM	--	--	--	--	--	--	--
CASINOS	--	--	--	--	--	--	--
PUB	0	0	0	0	1	1	1
IND	--	--	--	--	--	--	--
TOTAL	**0**	**0**	**0**	**13**	**31**	**38**	**47**

Table 2-15: EIA 15 (South Hidden Valley) Structures within Floodplains

Damage Category	Annual Chance Exceedance Flood Event						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
RES	0	0	0	0	39	60	79
COM	--	--	--	--	--	--	--
CASINOS	--	--	--	--	--	--	--
PUB	--	--	--	--	--	--	--
IND	--	--	--	--	--	--	--
TOTAL	**0**	**0**	**0**	**0**	**39**	**60**	**79**

Table 2-16: TOTAL Study Area - Structures within the Floodplains

Damage Category	Annual Chance Exceedance Flood Event						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
RES	0	3	21	318	1,237	5,938	10,086
COM	0	4	12	111	200	789	1,121
CASINOS	0	0	0	0	9	49	79
PUB	0	7	15	67	106	286	325
IND	0	9	55	269	436	682	825
TOTAL	**0**	**23**	**103**	**765**	**1,988**	**7,744**	**12,436**

2.2.2 Value of Structures & Contents

2.2.2.1 2007 Economic Update

Depreciated structure values were calculated by obtaining improvement values from Washoe County assessor's data. With over 12,000 structures, valuation using direct depreciated cost valuation of each individual structure was not possible. These values were revised using Marshall and Swift valuation to represent current price levels in the inventory database used in the economic analysis for the without project conditions (F3) report (Truckee Meadows GRR, Washoe County, Nevada).

During review of the study in 2007, the validity of the assessor data values was questioned. A sample of 500 structures covering each reach and structure type was provided to the Washoe County assessor's office to verify valuation. The main objective was to confirm that values used in the initial economic analysis were consistent with the County's valuation. The results from that sample analysis determined that the current values used in the economics fell between the replacement cost new and the total depreciated values. As a result, it appeared the current value was a reasonable approximation of the depreciated replacement value and no upward adjustments were made on the values based on the results of this sample.

During further review and discussions with local appraisers, it was determined that using the existing values without any upward adjustments would underestimate the depreciated replacement values of all structures. To estimate the error in valuation, regression analysis comparing the original values with new detailed valuation of a stratified sample of structures was proposed.

The goal of this analysis was to: 1) determine if the original values (when adjusted) would be a good predictor of the true structure value and 2) determine appropriate adjustment factors based on land use and location. An additional sample of 100 structures were provided to local appraisers[2] to compute depreciated replacement costs using cost valuation methods for each of the individual structures. The appraisers used the following methodology to determine the depreciated replacement value of each structure in the sample:

- Verification of physical data provided in the database
- Inspection of each of the properties identified
- Evaluation and classification of each of the buildings' construction methods, quality and condition
- Establishment of a new replacement cost estimate through reference to Marshall Valuation Service data
- Identification of the remaining economic life of each structure based on physical inspection for calculating depreciation
- Development of an estimate of the depreciated replacement value of each building in the sample using all information collected

[2] Structure valuation of the sample set was performed by Warren & Schiffmacher & Anthony J. Wren Associates, Reno Nevada.

Values from the appraiser's sample were compared with the corresponding individual values found in the existing economic inventory database. The sample included four categories (Downtown-Residential, Downtown-Non-Residential, the Meadows Area East of I-395-Residential, and the Meadows Area East of I-395-Non-Residential.) Simple linear regressions were performed with the original database value (independent variable) as the single predictor of 'true' depreciated replacement value (appraiser's sample values as the dependent variable with the intercept through the origin.) Results of the regression analysis can be found in Enclosure 1 of this appendix. The general findings are shown in Table 2-17 below including factors used to revise economic inventory. The factors represent values at October 2007 price levels. Note that there was a significant difference between residential factors in the Downtown and Meadows area reaches. The primary reason for this difference was due to the age of the homes in the two areas. The older homes in the downtown area had assessed values that did not accurately represent improvements over time as many of these homes have been modernized and rehabilitated so the assessed values tend to underestimate the true depreciated replacement value of these homes.

Table 2-17: Comparison between 2007 Original Economic Inventory and Appraiser Cost Valuations (2007 Prices)

Category	Sample Size	Average Value		Valuation Factor(Based on regression results not average value)
		Original Inventory	Appraised Depreciated Cost Structure	
Economic Impact Area 1 –Downtown Residential	25	$59,000	$118,000	1.9311
The Meadows Economic Impact Areas (2-15) –East of I-395 Residential	25	$94,000	$112,000	1.1191
Economic Impact Area 1 – Downtown Non-Residential	25	$943,000	$1,598,000	1.5320
The Meadows Economic Impact Areas (2-15) –East of I-395 Non-Residential	25	$1,049,000	$1,612,000	1.5320

2.2.2.2 2011 Economic Update

From 2007 to 2010, prices were updated Marshall and Swift construction factors and CPI indexes. But in June 2011, another more formal Economic Update was performed to ensure compliance with EC-11-2-199 (Budget Development Guidance). Also necessitating an update was the recession that the United States experienced starting in 2008, which included a nationwide decrease in real estate

values and possible land use changes (with Reno-Sparks being one of the hardest hit areas in the nation). Much like the previous update, regression analysis was performed comparing the indexed 2010 values with a new detailed valuation of a stratified sample of 220 structures. For the 2011 Economic Update, the sample was stratified into more groups than the 2007 update. Focus was given to the highest valued structures within each group as these were the structures that had a bigger impact on the results of the Economic Analysis. The non-residential structures were divided into the following 4 groups: Commercial, Industrial, Public, and Casinos. Residential structures were also divided into 4 groups: Multi-Family Residential (MFR), and Single Family Residential (SFR) low (below $100k), mid ($100k-$300k), and high (above $300k). Data collected in the field for each structure consisted of: construction class, construction quality, foundation height, number of stories, depreciation, and current building/land use. Square footages were obtained or verified using the latest Washoe County Assessor information. These structures were then valued using October 2011 Marshall and Swift construction values. For structures within the sample, the unique field observations and the resulting structure values and foundation heights were entered directly into the inventory import file. For those structures not in the sample, the results of a regression analysis were used as update factors by group, as shown in Table 2-18. For a more detailed description of the 2011 Economic Update, please see Enclosure 2.

Table 2-18: 2011 Economic Update Valuation Factors

Category	# of Structures Sampled	Update Factor
Commercial	40	0.7648
Industrial	40	1.1354
Public	40	0.9802
Casino	15	0.8644
MFR	10	1.1353
SFR_Low	25	1.1945
SFR_Mid	25	0.8810
SFR_High	25	0.9725

2.2.2.3 Content Values

Content values were set as a percentage of depreciated structure value by category. Public and residential contents were set equal to 50% of structure value. Commercial was set at 100% and general industrial at 160%. Two content percentages that were location specific to the Reno/Sparks area were casinos which were set at 155% and regional distribution warehouses which were equal to 558% of structure value. These values were taken from prior studies (including the 1985 Feasibility Study, 1997 Reconnaissance Report and 2001 field work from this current document) and were determined based on direct interviews.

Industrial Distribution Centers: Content values for the industrial warehouses have been found to be

higher for the Truckee Meadows area than on most studies due to the nature and type of distribution along I-80 in the Sparks area. This proximity to I-80 and the benefit of no inventory tax within the state of Nevada make this a very unique industrial sector nationally. Many of the warehouses are very large (up to 1.6 million square feet) and serve as regional distribution centers for the western United States. The contents range broadly from consumer items (such as the K-Mart Distribution Center) to casino machines (Bally, IGT) and much more. In the 1988 Feasibility Study, the distribution centers were estimated to have an average combined fixture and inventory value of 360% of structure value. The content percentages for casinos, public, general inventory, and commercial use in the current report came from the 1988 feasibility study. However, after the 1997 flood event, surveys were conducted with some individual tenants and with six large multi-parcel property owners in the industrial areas with over 200 tenants. Based on these actual 1997 flood losses, contents (product and equipment) exceeded structure loss by nearly 18 to 1. The 1997 flood indicated that industrial content losses were the greatest potential dollar risk and of great concern to the local community.

In 2001, additional surveys (10 representative owners) were completed and the average of 558% for distribution warehouses was determined and used in the economic analysis. In 2009, field work was conducted to verify that land use for industrial distribution had not changed substantially since the 1997 flood and subsequent 2001 survey. Tours were taken inside 4 large industrial centers and windshield surveys were conducted throughout industrial Sparks. This field work verified that land use had not changed and that the value of contents, if anything, had likely increased since 2001. This area was and still is a regional distribution hub for the western United States.

The current economic model used for this study shows a 9 to 1 ratio for industrial content-to-structure event damages for a similar 1% ACE event within industrial Sparks. Given the 18 to 1 ratio of actual 1997 flood content to structure industrial damages in the area it appears the economic model appears to be conservatively estimating industrial distribution CSVR's.

While industrial contents represent a very high percentage of project damages and benefits, it is appropriate for this unique study area and the most recent flood damages reported indicate that modeled damages and benefits most likely represent conservative results, with a low probability of being overestimated.

2.3 DAMAGEABLE PROPERTY

Table 2-19 summarizes the damageable property for the entire study area (Downtown to Vista) by damage category and event. Damageable property by EIA can be found in Enclosure 6. All values are in $1,000's and October 2013 price levels.

Table 2-19: TOTAL Study Area - Structure Values by Event

Damage Category	Annual Chance Exceedance Flood Event						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
	Structure Value						
RES	0	104	1,731	61,760	255,353	796,015	1,284,139
COM	0	3,745	5,976	281,445	405,633	931,829	1,111,524
CASINOS	0	0	0	0	75,651	306,509	661,129
PUB	0	702	1,066	28,912	93,168	181,587	229,925
IND	0	14,095	100,118	522,933	891,191	1,267,637	1,546,199
TOTAL STRUCTURE	*$0*	*$18,646*	*$108,891*	*$895,050*	*$1,720,995*	*$3,483,577*	*$4,832,916*
	Content Value						
RES	0	52	865	30,880	127,677	398,008	642,070
COM	0	3,745	5,976	281,445	405,633	931,829	1,111,524
CASINOS	0	0	0	0	117,258	475,089	1,024,750
PUB	0	351	533	14,456	46,584	90,794	114,962
IND	0	70,347	495,356	2,339,589	4,010,424	5,598,708	6,739,329
TOTAL CONTENT	*$0*	*$74,495*	*$502,730*	*$2,666,370*	*$4,707,576*	*$7,494,427*	*$9,632,636*
TOTAL VALUE	$0	$93,142	$611,621	$3,561,420	$6,428,571	$10,978,004	$14,465,552

The data in the damageable property tables above provide the basis for the following summary statistics:

- Total depreciated value of structures at risk of flooding (within the 0.2% (1/500) ACE flood plain): 4.8 Billion.

- Total Value of Contents within at-risk structures: $ 9.6 Billion (Contents percentages used: Residential, 50%; Commercial, 100%; Casinos, 155%, Public, 50%, Industrial-light manufacturing, 160%, Industrial-Distribution Centers and Storage Warehouses, 558% (from fieldwork).

- Total Value of Property at Risk (Within the 500-yr flood plain): $ 14.4 Billion.

3 WITHOUT PROJECT ANALYSIS

3.1 METHODOLOGY – HEC-FDA MODEL

For this study, expected annual damages (EAD) were estimated using the US Army Corps of Engineers FRM-PCX certified risk-based Monte Carlo simulation program HEC-FDA v1.2.4. Sensitivities were performed using HEC-FDA v1.2.5a when it became certified and there was no difference in the results. Because both versions of the model are certified, the analysis continued to use v1.2.4. Risk is a function of both probability and consequence, and the fact that risk inherently involves chance leads directly to a need to describe and plan for uncertainty. Corps policy has long been to acknowledge risk and uncertainty in anticipating floods and their impacts and to plan accordingly[3]. Historically, that planning relied on analysis of the expected long-term performance of flood-damage reduction measures, application of safety factors and freeboard, designing for worse case scenarios, and other indirect solutions (such as engineering judgment) to compensate for uncertainty. These indirect approaches were necessary because of the lack of technical knowledge of the complex interaction of uncertainties in estimating hydrologic, hydraulic, geotechnical, and economic factors due to the complexities of the mathematics required for doing otherwise. However, with advances in statistical hydrology and the availability of computerized analysis tools (such as HEC-FDA described below), it is now possible to improve the evaluation of uncertainties in the hydrologic, hydraulic, geotechnical, and economic functions. Through this risk analysis, and with careful communication of the results, the public can be better informed about what to expect from flood-damage reduction projects and thus can make more informed decisions. The determination of EAD for a flood reduction study must take into account complex and uncertain hydrologic, hydraulic, geotechnical, and economic information:

- **Hydrologic -** The discharge-frequency function describes the probability of floods equal to or greater than some discharge Q.
- **Hydraulics -** The stage-discharge function describes how high (stage) the flow of water in a river channel might be for a given volume of flow discharge (also known as a Rating Curve). Hydraulic functions can also be represented by frequency-stage relationship when backwater effects make flow non-monotonically increasing.
- **Geotechnical -** The geotechnical levee failure function describes the levee failure probabilities vs. stages in channel.
- **Economics -** The stage-damage function describes the amount of damage that might occur given certain in-channel stages.

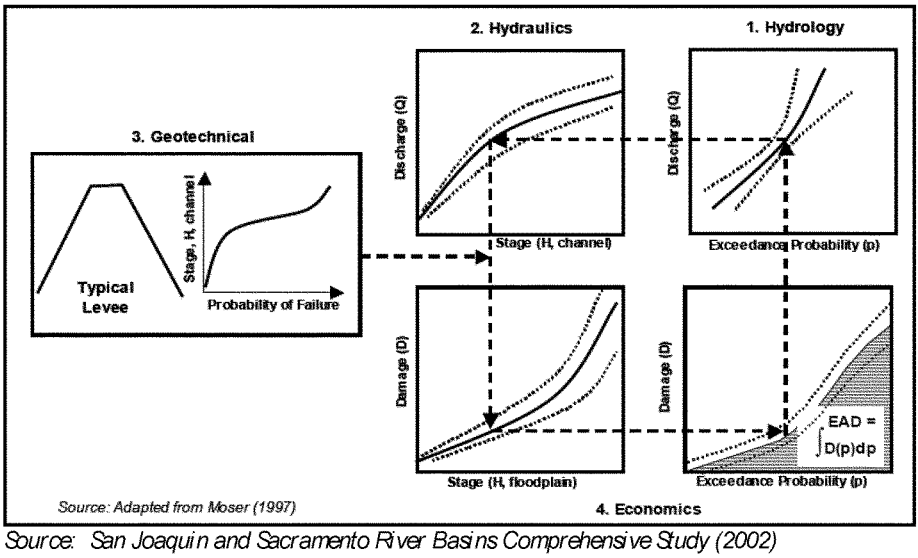
3.2 RISK AND UNCERTAINTY (R&U) VARIABLES

Figure 3-1 illustrates the conceptual risk approach for Corps' flood damage analyses. To find the damage for any given flood frequency, the discharge for that frequency is first located in the

3 In a flood risk management study, risk is defined as 1) the probability of failure during a flood event and 2) the consequence of flooding. Uncertainty is the measure of the imprecision of knowledge of variables in a project plan.

discharge-frequency panel (panel #1), then the river channel stage associated with that discharge value is determined in the stage-discharge panel (panel #2). Once the banks are overtopped and water enters the floodplain, the stages (water depths) in the floodplain inundate structures and cause damage (panel #4, left side). By plotting this damage and repeating for process many times, the damage-frequency curve is determined (panel #4, right side).[4] EAD is then computed by finding the area under the flood damage-frequency curve by integration for both without and with project conditions. Reductions in EAD attributable to projects are flood reduction benefits.

Figure 3-1: Uncertainty in Discharge, Stage and Damage In Determination of Expected Annual Damages



Source: San Joaquin and Sacramento River Basins Comprehensive Study (2002)

Uncertainties are present for each of the functions discussed above and these are carried forth from one panel to the next, ultimately accumulating in the EAD. These uncertainties are shown in Figure 3-1 as "error bands" located above and below the hydrologic, hydraulic and economics curves.[5] For the purposes of this study, the same Risk and Uncertainty factors were used under both without and with project conditions.

4 The HEC-FDA model uses Monte Carlo analysis to repeat this "sampling" process thousands of times. Mathematically, HEC-FDA computes EAD in a different manner than illustrated by this figure.

5 Uncertainty in the geotechnical levee probability of failure curves are multitude in character and the resultant curve used in the analysis reflects how well that levee can be expected to perform during random periods of high flows for a particular reach length. Typically, the greater the length of the levee reach, the less reliable that reach will perform during a flood event.

Some of the important uncertainties specific to Truckee include:

- **Hydrologic -** Uncertainty factors include hydrologic data record lengths that are often short or do not exist, precipitation-runoff computational methods that are not precisely known, and imprecise knowledge of the effectiveness of flow regulation.[6] The Equivalent Record Lengths for Truckee and other tributaries vary anywhere from 10 years to 78 years depending on the reach. Both analytical curves and graphical curves are utilized throughout the study area depending on the reach.
- **Hydraulics -** Uncertainty arising from the use of simplified models to describe complex hydraulic phenomena, including the lack of detailed geometric data, misalignments of hydraulic structures, debris load, infiltration rates, embankment failures, material variability, and from errors in estimating slope and roughness factors. For Truckee Meadows, the Hydraulic Design Section utilized both a one-dimensional RAS model and a two dimensional FLO-2D models for floodplain development depending on the type of flooding geographically. Both flow-stage and frequency-stage curves were used in the analysis depending on whether or not backwater effects were taking place or not in any given reach.
- **Geotechnical** – Under existing conditions there are several small (1-3ft) berms that have been constructed locally in a few areas which have historically provided some protection for the more frequent events. Under the direction of the Sacramento District Geotechnical Section, these existing berms were assumed to hold until the water made it halfway up (from toe elevation to crown elevation), at which point the levee would then fail 100% of the time for FDA modeling purposes. This assumption is based the Geotechnical Section's site surveys and general knowledge of soils in the particular area. Under with-project conditions all newly constructed levees/floodwalls are assumed to fail once overtopping begins at the index point.
- **Economics -** Uncertainty concerning land uses, depth/damage relationships, structure/content values, structure locations, first floor elevations, the amount of debris and mud, flood duration, and warning time and response of floodplain inhabitants (flood fighting).

The following economic uncertainties were applied (standard deviations of normal distributions) to the inventory during FDA's calculation of the Stage-Damage function:

- Structure Value: 15% Non-residential and 12% Residential.
- Content Value: 15% Non-residential and 12% Residential.
- First Floor Elevation (FFE): 0.5 feet.
- Depth Damage Functions: See Table 3-1 and Table 3-2 below.

6 The hydrologic data record lengths (period of record) are the number of years of a systematic record of peak discharges at a stream gage. This parameter directly influences the uncertainty associated with the frequency-discharge function shown in Figure 3-1 and consequently the project performance statistics. In general, a longer period of record implies less uncertainty associated with this function. The period of record used for Truckee was either 10 years, 55 years or 78 years depending on the reach of river/tributary involved.

The mean FFE for each structure was based upon existing inventory gathered in 2001 with direct values for specific buildings from the stratified samples and averages derived from that data and fieldwork for the rest of the structure population. Uncertainty assumptions for structure and content values were taken from averages of @Risk runs for uncertainties in similar Corps studies/inventory areas and best professional judgment based upon knowledge of the study area. An uncertainty of 15% for non-residential is based specifically on an average of recent @Risk runs done for other studies (Success DSAP, West Sacramento). An uncertainty of 12% for Residential is based upon past studies, such as the American River Economic Re-evaluation Report. Uncertainty in depth-damage functions for non-residential structures were taken from prior Sacramento District studies (Yuba River, South Sacramento Streams). Uncertainty in depth-damage functions for residential structures are based on the range of values found in EGM 01-03 Generic Depth Damage Curves.

3.3 DEPTH PERCENT DAMAGE FUNCTIONS

3.3.1 Determining Flood Depths

For structure and content damages, depth of flooding relative to the structure's first floor is the primary factor in determining the magnitude of damage. The GIS inventory database contains spatially referenced polygons for each parcel in the study area. Each parcel was then assigned a centroid in order to extract the floodplain depth for each structure at these points. First Floor Elevations were observed in the field and then estimated for sampled structures. These heights were then added to the assigned ground elevation (which were always zero because depth floodplains were provided by Hydraulic Design as opposed to water surface elevations) to establish first floor elevations. Depth floodplains were provided to Economics, in the form of raster grid files, for the 20%, 10%, 5%, 2%, 1%, 0.5%, 0.2% annual chance exceedance probability events. Using 3D analyst within ArcMap, this raster grid is converted into a 3-dimentional surface and a depth is assigned to each specific parcel centroid. Depths of flooding were assigned for each and every structure for all frequency events and these water surface profiles were then imported into the HEC-FDA models, for computation of stage damage functions.

3.3.2 Depth-Damage Relationships

Damages to structures and contents were determined based on depth of flooding relative to the structure's first floor elevation. To compute these damages, depth percent damage curves were used. These curves assign loss as a percentage of value for each structure. The deeper the relative depth, the greater the percentage of value damaged. The sources of the relationships were different depending on land use. For Residential structures, IWR depth damage curves were used in accordance with EGM 04-01. For Non-Residential structures, the damage curves were taken from the 1998 Adjusted FEMA Curves based on actual claims and losses between 1978 and 1997. Non-residential content curves are based on site-specific surveys done after historical flood events and interviews conducted within this specific region. Mobile home curves were taken from the May 1997 Final Report, Depth Damage Relationships in Support of Morganza to the Gulf, Louisiana Feasibility Study. A summary of depth damage functions (and their uncertainties) for residential

structures/contents is shown in Table 3-1 and non-residential structures/contents are shown in Table 3-2.

Table 3-1: Residential Depth Percent Damage Functions

DAMAGE CATEGORY	STRUCTURE / CONENTS	DEPTH OF FLOODING ABOVE 1ST FLOOR						
		-1	0	1	2	5	10	15
Single Family (1 story)	**Structure**	3	13	23	32	53	73	80
	Std. Dev	3	2	2	2	2	3	5
	Contents	2	8	13	18	29	38	40
	Std. Dev	2	2	1	1	2	2	4
Single Family (2 story)	**Structure**	3	9	15	21	36	56	68
	Std. Dev	4	3	3	3	3	4	5
	Contents	1	5	9	12	21	32	37
	Std. Dev	4	3	3	3	3	4	4
Single Family split level	**Structure**	6	7	9	13	29	63	84
	Std. Dev	3	2	2	2	2	5	8
	Contents	2	3	5	8	20	46	61
	Std. Dev	2	2	1	1	2	4	6
Multi Family (1 story)	**Structure**	3	13	23	32	53	73	80
	Std. Dev	3	2	2	2	2	3	5
	Contents	2	8	13	18	29	38	40
	Std. Dev	2	2	1	1	2	2	4
Multi Family (2 story)	**Structure**	3	9	15	21	36	56	68
	Std. Dev	4	3	3	3	3	4	5
	Contents	1	5	9	12	21	32	37
	Std. Dev	4	3	3	3	3	4	4
Apartments	**Structure**	3	9	15	21	36	56	68
	Std. Dev	4	3	3	3	3	4	5
	Contents	1	5	9	12	21	32	37
	Std. Dev	4	3	3	3	3	4	4
Mobile Home	Structure Low	6	9	43	43	92	92	92
	Structure-Mean	6	10	45	46	97	97	97
	Structure High	8	13	58	59	100	100	100
	Contents-Low	0	0	80	95	95	95	95
	Contents-Mean	0	0	85	95	99	99	99
	Contents-High	0	0	95	100	100	100	100

Note: For single and multi-family residential structures, the content percentages are based on a ratio of structure value.

Table 3-2: Non Residential Depth Percent Damage Functions

DAMAGE CATEGORY	STRUCTURE / CONENTS	DEPTH OF FLOODING ABOVE 1ST FLOOR						
		-1	0	1	2	5	10	15
Commercial-S (1 story)	Structure	0	7	15	25	31	46	50
	Std. Dev	0	5	5	5	5	5	5
	Contents	0	0	11	30	75	80	100
	Std. Dev	0	0	4	4	4	4	4
Commercial-S (2 story)	Structure	0	5	10	13	22	38	38
	Std. Dev	0	5	5	5	5	5	5
	Contents	0	0	7	20	56	67	92
	Std. Dev	0	0	4	4	4	4	4
Commercial-U (1 story)	Structure	0	7	16	25	31	46	50
	Std. Dev	0	5	5	5	5	5	5
	Contents	0	0	36	54	78	85	100
	Std. Dev	0	0	4	4	4	4	4
Commercial-U (2 story)	Structure	0	5	10	13	22	38	38
	Std. Dev	0	5	5	5	5	5	5
	Contents	0	0	20	38	71	84	92
	Std. Dev	0	0	4	4	4	4	4
Casino	Structure	0	7	16	25	31	46	50
	Std. Dev	0	5	5	5	5	5	5
	Contents	0	0	19	39	73	86	93
	Std. Dev	0	0	4	4	4	4	4
Industrial	Structure	0	7	16	25	31	46	50
	Std. Dev	0	5	5	5	5	5	5
	Contents	0	0	48	50	54	64	72
	Std. Dev	0	0	4	4	4	4	4
Industrial Distribution	Structure	0	7	16	25	31	46	50
	Std. Dev	0	5	5	5	5	5	5
	Contents	0	0	48	50	54	64	72
	Std. Dev	0	0	4	4	4	4	4
Public (1 story)	Structure	0	7	16	25	31	46	50
	Std. Dev	0	5	5	5	5	5	5
	Contents	0	11	18	24	40	60	60
	Std. Dev	0	10	4	4	4	4	4
Public (2 story)	Structure	0	5	10	13	22	38	38
	Std. Dev	0	5	5	5	5	5	5
	Contents	0	7	10	18	33	58	58
	Std. Dev	0	10	4	4	4	4	4

3.4 OTHER DAMAGE CATEGORIES

3.4.1 Emergency/Public Infrastructure

Actual losses to public infrastructure, flood fighting efforts, and clean-up from the 1997 event were taken from FEMA damage surveys and included as non-structure public damages. Losses from the 1997 damage surveys were categorized and reach locations were determined. Values were adjusted to October 2013 prices, assigned to the corresponding frequency event based on historical flow, and set proportionally for lower flows between the 1997 event and the non-damaging frequencies for each EIA. These damages were then added to the economic model, with the greatest losses occurring at the airport. These damages are shown in the "PUB-INFR" column in Table 3-20.

3.4.2 Automobile Impacts

Losses to automobiles were determined as a function of the number of vehicles per residence, average value per automobile, estimated percentage of autos removed from area prior to inundation, and depth of flooding above the ground elevation. Depth-damage relationships for autos were taken from EGM 09-04 and modified into a single curve based on weighted average of distributions of car types (SUV, truck, sedan, sports car, etc) in Nevada, according to the US Department of Transportation's record of current motor vehicle registrations. Damages for autos begin once flood depth has reached 0.5 feet, and this damage curve can be seen in Table 3-3. Vehicle counts were estimated using an assumption of 2 vehicles per residential structure. Evacuation (autos moved out of the flooded area) was assumed to be 50%, as used on American River and is consistent with EGM 09-04 for areas with less than 6 hours of warning time.. Depreciated replacement value of autos was based on weighted average used ($7,986) and new ($26,477) car prices according to the Bureau of Transportation Statistics. Uncertainty was incorporated using a normal distribution with a 2013 estimated mean of $13,538 and a standard deviation of 15%.

Table 3-3: Automobiles Depth Percent Damage Function

Depth Above Ground	Percent Damage	Standard Deviation
0	0.00%	0.00%
0.5	3.10%	9.29%
1	22.87%	7.66%
2	41.86%	6.04%
3	58.49%	4.56%
4	72.77%	3.42%
5	84.70%	4.37%
6	92.94%	6.72%
7	96.70%	7.05%
8	99.29%	7.36%
9	100.00%	7.67%
10	100.00%	7.67%

3.4.3 Categories Not Included In This Analysis

Due to the insignificant impact on the final result, the following other damage categories are not included in this analysis. If it were determined that these categories could impact plan selection or economic feasibility of a plan, they could be included in the analysis.

3.4.3.1 Road Damages

Damages to roads have been estimated in past iterations of the Truckee Meadows project based upon the number of miles affected by each event, the type of road (paved, two lane or four lane), the average depth of flooding, and the estimated damage per mile. GIS databases were used to determine miles of road in each flood plain in each reach. Uncertainties used in the Monte Carlo simulation were the number of road miles, water depth and percent damage by depth which were all given normal distributions. The results of the latest analysis showed that overall road damages were only 0.2% of the total study area damages. Since this analysis, new studies have indicated that depth in the floodplain is not a good indicator for road damages, and instead it should be depth relative to the crown of the road, meaning the actual road damage estimates would likely be less than 0.2% of the total.

3.4.3.2 Emergency/Clean Up Damages

While emergency and clean-up costs are accounted for in this analysis as described in Section 3.4.1, this was based upon only reported costs/damages from 1997 and could represent an underestimation of the actual total. Emergency and clean-up costs during a flood include: 1) efforts to monitor flood problems; 2) actions taken by relief agencies and to evacuate floodplain occupants; 3) flood fighting efforts—such as sandbagging; and 4) evacuation and reoccupation costs for floodplain residents.

These damages were estimated in 2007 for Truckee Meadows and were found to be less than 1% of the total study area damages. Because this analysis will not impact plan selection or the economic feasibility of the plans, an analysis of potential damages for the entire study area was not performed for the purposes of this report.

3.5 WITHOUT PROJECT DAMAGES

3.5.1 Stage-Damage Functions

Damages were estimated by each category, by impact area and by event based on varying depths within the flood plain relative to individual structures. These damages were then linked to a stage within the channel at a common index point for each impact area by exceedance probability. The stage-damage functions were calculated within HEC-FDA and they represent the economic relationships between the hydrology and hydraulics. Stage-Damages presented in this section is taken from the "StrucDetail.out" files within HEC-FDA and do not include economic uncertainty. Economic uncertainty is incorporated into the analysis during the EAD calculation within HEC-FDA. These functions can be found by event, damage category and impact area in Tables 3-4 through 3-18 below in October 2013 prices ($1,000's).

Table 3-4: EIA 1 (Downtown) Single Event Without Project Damages

Damage Category	Flood Event / Stage (ft.)						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
	4489.35	4490.42	4497.96	4500.62	4505.04	4508.2	4513.27
	Structure Damage						
RES	0	0	31	693	4,566	33,041	80,746
COM	0	0	0	115	5,048	37,745	80,338
CASINOS	0	0	0	0	7,071	53,253	130,930
PUB	0	0	2	5,103	10,290	31,248	50,326
IND	0	0	0	0	38	2,107	7,332
TOTAL STRUCTURE	*$0*	*$0*	*$33*	*$5,911*	*$27,013*	*$157,394*	*$349,673*
	Content Damage						
RES	0	0	20	383	2,584	19,087	46,263
COM	0	0	0	216	6,328	54,570	145,081
CASINOS	0	0	0	0	7,520	152,924	337,264
PUB	0	0	1	2,577	6,737	19,093	30,867
IND	0	0	0	0	96	10,286	31,935
TOTAL CONTENT	*$0*	*$0*	*$21*	*$3,176*	*$23,265*	*$255,961*	*$591,409*
TOTAL DAMAGES	$0	$0	$54	$9,087	$50,278	$413,355	$941,082

Table 3-5: EIA 2 (North I-80) Single Event Without Project Damages

Damage Category	Flood Event / Stage (ft.)						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
	4486.51	4487.61	4488.63	4494.45	4498.46	4504.25	4507.44
	Structure Damage						
RES	0	2	2	2	2	5,759	12,746
COM	0	0	0	0	0	2,425	6,000
CASINOS	0	0	0	0	0	9,873	12,968
PUB	0	0	0	0	0	2,967	5,279
IND	0	0	0	0	0	617	1,632
TOTAL STRUCTURE	*$0*	*$2*	*$2*	*$2*	*$2*	*$21,641*	*$38,626*
	Content Damage						
RES	0	2	2	2	2	3,333	7,401
COM	0	0	0	0	0	500	4,020
CASINOS	0	0	0	0	0	20,566	35,335
PUB	0	0	0	0	0	1,689	2,904
IND	0	0	0	0	0	72	13,116
TOTAL CONTENT	*$0*	*$2*	*$2*	*$2*	*$2*	*$26,160*	*$62,776*
TOTAL DAMAGES	$0	$3	$3	$4	$4	$47,802	$101,401

Table 3-6: EIA 3 (West NTD) Single Event Without Project Damages

Damage Category	Flood Event / Stage (ft.)						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
	4388.49	4389.23	4391.84	4395.6	4397.66	4400.06	4408.53
	Structure Damage						
RES	0	0	0	2,091	10,513	41,718	155,266
COM	0	0	0	42	424	5,372	27,095
CASINOS	0	0	0	0	0	1,614	3,576
PUB	0	0	0	4	113	1,750	4,396
IND	0	0	0	0	0	5,626	17,487
TOTAL STRUCTURE	*$0*	*$0*	*$0*	*$2,137*	*$11,050*	*$56,081*	*$207,820*
	Content Damage						
RES	0	0	0	1,185	6,287	24,428	88,740
COM	0	0	0	26	989	6,555	53,235
CASINOS	0	0	0	0	0	5,234	10,366
PUB	0	0	0	3	57	956	2,657
IND	0	0	0	0	0	46,228	88,835
TOTAL CONTENT	*$0*	*$0*	*$0*	*$1,214*	*$7,332*	*$83,401*	*$243,832*
TOTAL DAMAGES	$0	$0	$0	$3,351	$18,382	$139,481	$451,652

Table 3-7: EIA 4 (East NTD) Single Event Without Project Damages

Damage Category	Flood Event / Stage (ft.)						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
	4388.49	4389.23	4291.84	4395.6	4397.66	4400.06	4408.53
	Structure Damage						
RES	0	0	32	56	107	3,749	34,641
COM	0	0	0	0	0	1,404	8,118
CASINOS	--	--	--	--	--	--	--
PUB	0	0	0	0	7	501	3,380
IND	0	0	0	0	1,988	17,246	101,612
TOTAL STRUCTURE	*$0*	*$0*	*$32*	*$56*	*$2,102*	*$22,900*	*$147,751*
	Content Damage						
RES	0	0	16	31	65	2,145	19,832
COM	0	0	0	0	0	1,186	14,772
CASINOS	--	--	--	--	--	--	--
PUB	0	0	0	0	5	349	2,630
IND	0	0	0	0	0	156,409	752,323
TOTAL CONTENT	*$0*	*$0*	*$16*	*$31*	*$70*	*$160,090*	*$789,557*
TOTAL DAMAGES	$0	$0	$49	$87	$2,172	$182,990	$937,308

Table 3-8: EIA 5 (Sparks West) Single Event Without Project Damages

Damage Category	Flood Event / Stage (ft.)						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
	4400.19	4401.51	4402.54	4404.75	4406.88	4409.42	4411.29
	Structure Damage						
RES	0	0	0	3	89	296	685
COM	0	16	75	369	883	2,292	9,066
CASINOS	0	0	0	0	0	0	335
PUB	0	9	14	29	61	177	508
IND	0	48	55	915	3,341	11,139	54,919
TOTAL STRUCTURE	*$0*	*$73*	*$145*	*$1,315*	*$4,375*	*$13,904*	*$65,512*
	Content Damage						
RES	0	0	0	2	59	174	376
COM	0	0	0	180	779	1,972	9,136
CASINOS	0	0	0	0	0	0	0
PUB	0	6	9	18	36	111	288
IND	0	0	0	2,050	15,612	63,647	396,945
TOTAL CONTENT	*$0*	*$6*	*$9*	*$2,251*	*$16,486*	*$65,903*	*$406,745*
TOTAL DAMAGES	$0	$79	$154	$3,566	$20,861	$79,807	$472,257

Table 3-9: EIA 6 (Sparks East) Single Event Without Project Damages

Damage Category	Flood Event / Stage (ft.)						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
	4387.17	4389.02	4390.85	4393.62	4397.4	4400.83	4408.3
	Structure Damage						
RES	0	0	0	0	73	162	247
COM	0	0	83	1,086	3,416	6,391	9,659
CASINOS	--	--	--	--	--	--	--
PUB	0	12	92	194	433	774	1,135
IND	0	474	4,978	34,020	96,365	161,402	216,658
TOTAL STRUCTURE	*$0*	*$486*	*$5,153*	*$35,300*	*$100,288*	*$168,729*	*$227,699*
	Content Damage						
RES	0	0	0	0	42	88	127
COM	0	0	0	756	5,326	13,140	19,783
CASINOS	--	--	--	--	--	--	--
PUB	0	9	50	111	256	467	709
IND	0	0	41,353	319,976	897,864	1,175,750	1,463,225
TOTAL CONTENT	*$0*	*$9*	*$41,403*	*$320,842*	*$903,487*	*$1,189,445*	*$1,483,844*
TOTAL DAMAGES	$0	$495	$46,556	$356,143	$1,003,775	$1,358,173	$1,711,543

Table 3-10: EIA 7 (Larkin Circle) Single Event Without Project Damages

Damage Category	Flood Event / Stage (ft.)						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
	4386.47	4388.22	4390	4393.16	4397.15	4400.51	4408.13
	Structure Damage						
RES	--	--	--	--	--	--	--
COM	0	0	0	140	534	894	1,250
CASINOS	--	--	--	--	--	--	--
PUB	0	0	0	1	10	54	90
IND	0	0	0	1,636	5,156	8,187	10,960
TOTAL STRUCTURE	*$0*	*$0*	*$0*	*$1,777*	*$5,700*	*$9,135*	*$12,300*
	Content Damage						
RES	--	--	--	--	--	--	--
COM	0	0	0	217	923	1,711	2,458
CASINOS	--	--	--	--	--	--	--
PUB	0	0	0	1	6	29	58
IND	0	0	0	17,974	48,105	61,197	75,210
TOTAL CONTENT	*$0*	*$0*	*$0*	*$18,192*	*$49,034*	*$62,937*	*$77,726*
TOTAL DAMAGES	$0	$0	$0	$19,969	$54,733	$72,073	$90,026

Table 3-11: EIA 8 (Airport) Single Event Without Project Damages

Damage Category	Flood Event / Stage (ft.)						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
	4428.54	4429.54	4430.37	4432.11	4434.04	4437.19	4439.06
	Structure Damage						
RES	0	0	0	170	1,469	5,119	11,528
COM	0	0	0	28,245	37,825	52,921	95,840
CASINOS	0	0	0	0	0	362	2,950
PUB	0	0	0	39	84	265	502
IND	0	0	0	11,253	30,895	53,393	90,358
TOTAL STRUCTURE	*$0*	*$0*	*$0*	*$39,706*	*$70,273*	*$112,060*	*$201,177*
	Content Damage						
RES	0	0	0	106	765	2,973	6,665
COM	0	0	0	16,171	28,416	66,830	207,054
CASINOS	0	0	0	0	0	0	6,883
PUB	0	0	0	24	49	146	289
IND	0	0	0	91,829	247,535	456,425	598,601
TOTAL CONTENT	*$0*	*$0*	*$0*	*$108,130*	*$276,766*	*$526,374*	*$819,492*
TOTAL DAMAGES	$0	$0	$0	$147,837	$347,039	$638,433	$1,020,668

Table 3-12: EIA 9 (Truckee South Overbank) Single Event Without Project Damages

Damage Category	Flood Event / Stage (ft.)						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
	4410.26	4411.03	4411.76	4413.41	4415.36	4417.76	4418.98
	Structure Damage						
RES	0	0	0	3	18	34	46
COM	0	0	0	0	6	32	53
CASINOS	--	--	--	--	--	--	--
PUB	0	0	0	0	56	198	431
IND	0	0	11	621	1,707	2,632	2,898
TOTAL STRUCTURE	*$0*	*$0*	*$11*	*$624*	*$1,787*	*$2,897*	*$3,428*
	Content Damage						
RES	0	0	0	3	11	20	26
COM	0	0	0	0	0	0	18
CASINOS	--	--	--	--	--	--	--
PUB	0	0	0	0	42	108	261
IND	0	0	0	1,034	11,830	16,735	17,075
TOTAL CONTENT	*$0*	*$0*	*$0*	*$1,037*	*$11,883*	*$16,862*	*$17,381*
TOTAL DAMAGES	$0	$0	$11	$1,661	$13,671	$19,759	$20,809

Table 3-13: EIA 10 (UNR Farms) Single Event Without Project Damages

Damage Category	Flood Event / Stage (ft.)						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
	4386.64	4388.32	4390.28	4393.4	4397.44	4400.88	4408.34
	Structure Damage						
RES	0	0	0	4	72	130	183
COM	0	0	0	0	90	137	167
CASINOS	--	--	--	--	--	--	--
PUB	0	0	0	12	27	38	44
IND	--	--	--	--	--	--	--
TOTAL STRUCTURE	*$0*	*$0*	*$0*	*$16*	*$189*	*$305*	*$395*
	Content Damage						
RES	0	0	0	2	40	70	93
COM	0	0	0	0	157	265	338
CASINOS	--	--	--	--	--	--	--
PUB	0	0	0	7	17	24	26
IND	--	--	--	--	--	--	--
TOTAL CONTENT	*$0*	*$0*	*$0*	*$9*	*$214*	*$360*	*$457*
TOTAL DAMAGES	$0	$0	$0	$25	$403	$665	$852

Table 3-14: EIA 11 (TMWRF) Single Event Without Project Damages

Damage Category	Flood Event / Stage (ft.)						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
	4386.25	4387.99	4389.77	4392.7	4396.42	4399.71	4408.01
	Structure Damage						
RES	--	--	--	--	--	--	--
COM	--	--	--	--	--	--	--
CASINOS	--	--	--	--	--	--	--
PUB	--	--	--	--	--	--	--
IND	0	0	0	0	0	0	4,737
TOTAL STRUCTURE	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$4,737*
	Content Damage						
RES	--	--	--	--	--	--	--
COM	--	--	--	--	--	--	--
CASINOS	--	--	--	--	--	--	--
PUB	--	--	--	--	--	--	--
IND	0	0	0	0	0	0	14,596
TOTAL CONTENT	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$14,596*
TOTAL DAMAGES	$0	$0	$0	$0	$0	$0	$19,333

Table 3-15: EIA 12 (North Hidden Valley) Single Event Without Project Damages

Damage Category	Flood Event / Stage (ft.)						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
	4386.84	4388.49	4390.41	4393.42	4397.47	4400.92	4408.38
	Structure Damage						
RES	0	0	0	44	247	3,052	14,671
COM	--	--	--	--	--	--	--
CASINOS	--	--	--	--	--	--	--
PUB	--	--	--	--	--	--	--
IND	--	--	--	--	--	--	--
TOTAL STRUCTURE	*$0*	*$0*	*$0*	*$44*	*$247*	*$3,052*	*$14,671*
	Content Damage						
RES	0	0	0	26	139	1,756	7,875
COM	--	--	--	--	--	--	--
CASINOS	--	--	--	--	--	--	--
PUB	--	--	--	--	--	--	--
IND	--	--	--	--	--	--	--
TOTAL CONTENT	*$0*	*$0*	*$0*	*$26*	*$139*	*$1,756*	*$7,875*
TOTAL DAMAGES	$0	$0	$0	$70	$386	$4,807	$22,546

Table 3-16: EIA 13 (Steamboat South) Single Event Without Project Damages

Damage Category	Flood Event / Stage (ft.)						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
	4387.53	4388.83	4390.78	4393.73	4397.5	4400.96	4408.42
	Structure Damage						
RES	0	0	0	1,330	11,506	51,042	167,461
COM	0	266	793	1,167	2,062	4,054	6,466
CASINOS	--	--	--	--	--	--	--
PUB	0	2	2	7	348	2,040	3,796
IND	0	0	0	0	2,085	6,896	29,399
TOTAL STRUCTURE	*$0*	*$267*	*$795*	*$2,504*	*$16,000*	*$64,031*	*$207,122*
	Content Damage						
RES	0	0	0	670	6,505	29,078	93,698
COM	0	4	974	2,753	3,031	6,907	11,995
CASINOS	--	--	--	--	--	--	--
PUB	0	1	1	4	258	1,124	2,433
IND	0	0	0	0	21,387	66,043	177,260
TOTAL CONTENT	*$0*	*$5*	*$975*	*$3,427*	*$31,182*	*$103,152*	*$285,386*
TOTAL DAMAGES	$0	$272	$1,770	$5,930	$47,182	$167,183	$492,508

Table 3-17: EIA 14 (Central Hidden Valley) Single Event Without Project Damages

Damage Category	Flood Event / Stage (ft.)						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
	4387.35	4388.79	4390.72	4393.67	4397.49	4400.95	4408.41
	Structure Damage						
RES	0	0	0	79	807	1,762	3,399
COM	--	--	--	--	--	--	--
CASINOS	--	--	--	--	--	--	--
PUB	0	0	0	0	16	28	44
IND	--	--	--	--	--	--	--
TOTAL STRUCTURE	*$0*	*$0*	*$0*	*$79*	*$823*	*$1,790*	*$3,442*
	Content Damage						
RES	0	0	0	53	454	974	1,844
COM	--	--	--	--	--	--	--
CASINOS	--	--	--	--	--	--	--
PUB	0	0	0	0	8	18	28
IND	--	--	--	--	--	--	--
TOTAL CONTENT	*$0*	*$0*	*$0*	*$53*	*$463*	*$992*	*$1,872*
TOTAL DAMAGES	$0	$0	$0	$132	$1,285	$2,782	$5,314

Table 3-18: EIA 15 (South Hidden Valley) Single Event Without Project Damages

Damage Category	Flood Event / Stage (ft.)						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
	4387.55	4388.89	4390.82	4393.7	4397.5	4400.95	4408.42
	Structure Damage						
RES	0	0	0	0	569	4,322	10,936
COM	--	--	--	--	--	--	--
CASINOS	--	--	--	--	--	--	--
PUB	--	--	--	--	--	--	--
IND	--	--	--	--	--	--	--
TOTAL STRUCTURE	*$0*	*$0*	*$0*	*$0*	*$569*	*$4,322*	*$10,936*
	Content Damage						
RES	0	0	0	0	327	2,436	6,119
COM	--	--	--	--	--	--	--
CASINOS	--	--	--	--	--	--	--
PUB	--	--	--	--	--	--	--
IND	--	--	--	--	--	--	--
TOTAL CONTENT	*$0*	*$0*	*$0*	*$0*	*$327*	*$2,436*	*$6,119*
TOTAL DAMAGES	$0	$0	$0	$0	$896	$6,758	$17,055

Table 3-19: TOTAL Study Area - Single Event Without Project Damages (Values in $1,000's, October 2013 Price Levels)

Damage Category	Flood Event						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
	Structure Damage						
RES	0	2	65	4,476	30,038	150,184	492,554
COM	0	281	951	31,163	50,289	113,667	244,052
CASINOS	0	0	0	0	7,071	65,102	150,759
PUB	0	23	110	5,389	11,445	40,041	69,930
IND	0	522	5,044	48,445	141,575	269,244	537,993
TOTAL STRUCTURE	***$0***	***$828***	***$6,171***	***$89,472***	***$240,418***	***$638,239***	***$1,495,289***
	Content Damage						
RES	0	2	38	2,464	17,279	86,562	279,059
COM	0	4	974	20,318	45,948	153,636	467,888
CASINOS	0	0	0	0	7,520	178,724	389,848
PUB	0	16	62	2,744	7,472	24,113	43,150
IND	0	0	41,353	432,863	1,242,430	2,052,793	3,629,120
TOTAL CONTENT	***$0***	***$22***	***$42,426***	***$458,390***	***$1,320,649***	***$2,495,828***	***$4,809,066***
TOTAL DAMAGES	**$0**	**$849**	**$48,597**	**$547,861**	**$1,561,067**	**$3,134,067**	**$6,304,355**

3.5.2 Expected Annual Damages (EAD) -Without Project

In the HEC-FDA model, the stage damage functions listed above were integrated with the discharge-exceedance probability functions and the stage-discharge functions (or probability-stage functions where backwater effects were taking place) utilizing a Monte Carlo simulation process. The derived probability-damage function was then integrated in the model to determine expected annual damages under without project conditions (see Figure 3-1). EAD (mean value) results from HEC-FDA are displayed in Table 3-20 by damage category. In total, there are $69.9 million in expected annual damages, with 12% of those damages occurring in the Downtown Reach. Also note that over 68% of all damages in the study area are from losses to industrial structures and contents.

Table 3-20: Without Project Expected Annual Damages by EIA
(Values in $1,000's, October 2013 Price Levels)

Economic Impact Area	AUTO	CAS	COM	IND	PUB	RES	PUB-INFR	TOTAL
Downtown Reno								
1-Downtown	401	3,657	1,864	298	1,116	1,058	0	**$8,394**
The Meadows Area (east of I 395 to Vista)								
2-North I-80	99	318	115	119	56	156	41	**$904**
3-West NTD	438	96	418	755	51	1,648	161	**$3,567**
4-East NTD	45	0	139	5,477	34	323	231	**$6,249**
5-Sparks West	2	11	183	2,933	7	9	43	**$3,188**
6-Sparks East	0	0	300	27,828	31	3	35	**$28,197**
7-Larkin Circle	0	0	37	1,078	1	0	2	**$1,118**
8-Airport	53	49	2,819	8,295	7	129	2,866	**$14,218**
9-Truckee South Overbank	0	0	1	296	6	1	0	**$304**
10-UNR Farms	1	0	5	0	1	3	0	**$10**
11-TMWRF	0	0	0	59	0	0	0	**$59**
12-North Hidden Valley	6	0	0	0	0	110	0	**$116**
13-Steamboat South	314	0	214	1,258	42	1,554	4	**$3,386**
14-Central Hidden Valley	7	0	0	0	1	47	0	**$55**
15-South Hidden Valley	7	0	0	0	0	103	0	**$110**
Sub-Total (2-15)	*$972*	*$474*	*$4,231*	*$48,098*	*$237*	*$4,086*	*$3,383*	*$61,481*
TOTAL	**$1,373**	**$4,131**	**$6,095**	**$48,396**	**$1,353**	**$5,144**	**$3,383**	**$69,875**

3.5.3 Project Performance- Without Project Conditions

In addition to damages estimates, HEC-FDA reports flood risk in terms of project performance. Three statistical measures are provided, in accordance with ER 1105-2-101, to describe performance risk in probabilistic terms. These include annual exceedance probability, long-term risk, and conditional non-exceedance probability by events.

- Annual exceedance probability (AEP) measures the chance of having a damaging flood in any given year.
- Long-term risk provides the probability of having one or more damaging floods over a period of time.
- Assurance (formerly Conditional Non-Exceedance Probability (CNP)) is the probability that a target stage will not be exceeded during the occurrence of a specified flood.

Existing condition performance statistics for each impact area are displayed in Table 3-21.

Table 3-21: Project Performance by EIA – Without Project Conditions

EIA	AEP	LONG-TERM RISK			ASSURANCE BY ANNUAL CHANCE EVENT					
		10	30	50	10%	4%	2%	1%	0.40%	0.20%
1	2.7%	24%	50%	75%	99%	85%	32%	5%	0%	0%
2	0.9%	9%	20%	36%	99%	99%	96%	67%	16%	3%
3	3.0%	27%	54%	79%	99%	72%	30%	10%	0%	0%
4	3.3%	28%	57%	81%	98%	76%	40%	17%	1%	0%
5	5.3%	42%	74%	93%	96%	33%	4%	0%	0%	0%
6	3.9%	33%	63%	86%	99%	58%	21%	1%	0%	0%
7	2.1%	19%	42%	66%	99%	91%	60%	8%	0%	0%
8	10.1%	65%	93%	99%	54%	5%	0%	0%	0%	0%
9	4.1%	34%	64%	87%	97%	59%	17%	2%	0%	0%
10	19.4%	89%	99%	99%	26%	5%	1%	0%	0%	0%
11	1.1%	11%	25%	44%	99%	99%	96%	47%	2%	0%
12	6.1%	47%	79%	96%	85%	47%	18%	1%	0%	0%
13	2.6%	23%	49%	74%	99%	84%	56%	11%	0%	0%
14	3.9%	33%	63%	86%	95%	69%	37%	5%	0%	0%
15	2.8%	25%	51%	76%	98%	83%	55%	10%	0%	0%

4 WITH PROJECT RESIDUAL DAMAGES AND PROJECT BENEFITS

Flood risk management benefits are measured by comparing the without-project expected annual damages (EAD) to the with-project residual damages (with-project EAD) for various alternatives. HEC-FDA was run under both with and without project conditions to estimate project benefits. The difference between without EAD and with project EAD determines flood damage reduction benefits.

4.1 BENEFITS – DOWNTOWN RENO (ECONOMIC IMPACT AREA 1)

Price levels for the Downtown analysis have not been updated to current price levels, as indexing these values would lead to the same conclusions about its economic feasibility.

4.1.1 Bridge Replacement – Economic Impact Area 1 (Downtown Reno)

Several bridge crossings in Economic Impact Area 1 increase the flooding problem by constricting flow. Raising or modifying these bridges will provide some limited reduction in damages for EIA 1 by reducing depths. One alternative proposes to replace the three bridge crossings along Sierra and Virginia streets. FDA was rerun using with project depths provided with the bridge improvements in place. Flood damage reduction benefits for this project increment are displayed in Table 4-1.

Table 4-1: Expected Annual Damages Without Project and With Bridge Replacements (Values in $1,000's, October 2011 Price Levels)

Economic Impact Area	EAD Without Project	EAD With Bridge Improvement	With Project Benefits
1 (Downtown Reno)	$8,135	$7,363	$772

Additional benefits for this Bridge Replacement project measure can be counted in the form of advance bridge replacement cost savings. Each of the two bridges has some remaining life and still serves transportation purposes. The replaced bridges will have extended transportation life and will provide benefits beyond flood damage reduction. Table 4-2 summarizes the advanced bridge replacement benefits for each bridge using a 4% discount rate and a 50-year transportation life. The table shows that the annual benefits of replacing all three bridges (with modifications allowing for flood flows to pass) would be around $1.6 million while annual costs equal $2.7 million, giving Downtown Bridge replacements a B/C ratio of approximately 0.58.

Table 4-2: Advanced Bridge Replacement Benefits - Downtown Reno (October 2011 Prices, $1,000's, 4% Interest Rate)

Bridge Crossing	First Cost of Bridge	Remaining Life in Years	Extension of Transportation Life	Average Annual Benefit
Sierra	12,047	25	25	$153
Virginia	14,587	1	49	$649
Total- Advanced Bridge Replacement Benefits				$802
Flood Damage Reduction Benefits				$772
Total Benefits – Bridge Replacement				$1,574

4.1.2 Floodwall Improvements – Economic Impact Area 1 (Downtown Reno)

During an economic analysis in 2007, benefits were estimated based on the construction of different size floodwalls to protect EIA 1. Floodwall heights were modified in the HEC-FDA model to simulate different floodwall sizes. Using this methodology, HEC-FDA truncates the damaging events below the top of the floodwall (with uncertainty in flood parameters of discharge and stage) reducing losses for these events to zero. When the floodwall is exceeded, damages for that event are equivalent to the without project condition for the given event. Benefits are equal to the without project minus the with-project residual damages. The incremental average annual benefits for each wall height were found to be exceeded by costs, resulting in negative net benefits, Benefit-to-Cost ratios (BCR's) under 0.50 and the removal of floodwalls from NED consideration in EIA 1. For more detail about the 2007 screening analysis and a summary of the results, see Enclosure 4. For a detailed description of all Alternatives considered in the Downtown reach, see Chapter 4 of the GRR.

Net benefits and BCR's for Bridge Replacement only and Bridge Replacement + Floodwalls (set at a height to reliably pass the 1% ACE event) alternatives are presented in the table below.

Table 4-3: FRM Net Benefits – Downtown – 4% Interest Rate (October 2011 Prices, $1,000's)

DOWNTOWN - NET BENEFITS ($1,000's)					
Project Condition	**First Costs**	**Annual Benefits**	**Annual Costs**	**Net Benefit**	**B/C Ratio**
Bridge Replacement Only (FRM & ABR)	$60,334	$1,574	$2,702	-$1,128	0.58
Bridge Replacement and Floodwalls (FRM & ABR)	$172,793	$3,353	$7,911	-$4,558	0.42

4.1.3 Non-Structural Improvements – Economic Impact Area 1 (Downtown Reno)

Under no action, the Reno Flood Warning System (RFWS) will continue to provide an estimated $75,000 in average annual flood reduction benefits for the downtown Reno area. Additional non-structural improvements were considered that might remove or protect structures from the 1% (1/100) ACE flood. Ten commercial structures were identified as having the greatest risk of damage and the benefits of flood proofing these structures was estimated.

This specific non-structural increment, while the most promising non-structural plan from a flood damage reduction effectiveness perspective, would not be very efficient as costs exceed benefits. Part of this is due to the fact that damages from the significant events less frequent than the 1% annual chance flood would remain unchanged. Flood proofing the ten structures most at risk would provide only $52,000 in average annual flood damage reduction benefits. FEMA lists that on average a commercial structure can be dry-flood proofed to 3 feet for around $16 per square foot. A Penn State study lists ranges from $17 to $47 but includes potential raises (not practical for existing commercial structures). An LSU study regarding panels for openings estimated $10-14 per sf. Based on an average estimate of $ per sq. ft. ($16 per sq. ft) and the 240,000 square feet of first floor building space, the average annual costs would be over $208,000 providing a B/C ratio of around 0.25. Further analysis of any non-structural improvements for Downtown, were dropped as not economically feasible.

4.2 2007 FINAL ARRAY OF ALTERNATIVES IN THE MEADOWS (ECONOMIC IMPACT AREAS 2-15, (I-395 TO VISTA))

In 2007, three different alternatives were evaluated; each at three different design sizes for Economic Impact Areas 2-15[7] to determine which alternative would move forward to more detailed optimization.[8] These reaches in the Meadows Area are considered independent of the Economic

7 In 2007, the Meadows area was only separated into 5 Impact Areas (II-VI).

8 When this analysis was originally performed in 2007, it was meant to be the actual optimization. However, due to ATR comments, it was decided to do a more detailed hydraulic/economic model using fewer simplifying assumptions for the actual optimization. The 2007 analysis turned into a screening to find the most efficient alternative to further optimize by design level.

Impact Area 1 (Downtown Reno) for modeling purposes. The three design sizes were set at 2% (1/50), 1% (1/100) and 0.855% (1/117) annual chance mean WSEL plus R&U to provide overall project performance of 90% assurance that the project could pass the design identified event. The largest design was selected at 0.855% because to provide protection for the next larger evaluated event would require significant additional construction measures that would not be incrementally feasible.

With-project residual flood plains, with depths, were provided for each event and alternative. The existing inventory was then used but assigned new depths using GIS for each flood event. Because this screening analysis took place in 2007, prior to USACE requirement for model certification, an @RISK model was used to calculate stage damage functions and standard deviations which were then input manually into the FDA program for calculation of Expected Annual Damages.

Benefits were derived from flood reduction in two ways:

1) Reduction in Extent of Floodplains: With-project flood plains with smaller extent of flooding than under without project conditions effectively remove structures from the more frequent events.
2) Reduction in Floodplain Depths: Damages are reduced by reducing depths for structures still in the floodplain for the larger less frequent events. Benefits were measured by subtracting the with-project residual average annual damages from the without project average annual damages.

The three basic alternatives (as evaluated in 2007) and their differences are described below:

- *Alternative 1 – Levees and Floodwalls Plan:* This alternative consists of a system of confined levees and floodwalls along the Truckee River and Steamboat Creek to address flooding problems in the Truckee Meadows. This alternative is similar to the authorized plan in features sized for flood events based on the revised hydrology stemming from the 1997 flood event. This alternative consists of approximately 55,000 feet of floodwalls and 54,000 feet of levees and the relocation of the North Truckee Drain.

- *Alternative 2 – Detention Plan:* This alternative consists of approximately 70,500 feet of levees and 50,000 feet of flood walls along the Truckee River and Steamboat Creek. The North Truckee Drain outlet would be realigned to move the confluence with the Truckee River approximately 4,500 feet downstream of the current confluence. Relocating the confluence of the North Truckee Drain downstream from Steamboat Creek would reduce the extent of the backwater experienced at the Steamboat Creek/ Truckee River confluence. This alternative also includes detention basins at UNR Farms, and Huffaker Hills.

- *Alternative 3 – Floodplain Terrace Plan:* This alternative consists of approximately 25,000 feet of setback levees and 30,000 feet of floodwalls along the Truckee River and Steamboat Creek. It includes the realignment of the North Truckee Drain described in Alternative B.

This alternative involves excavating a benched area along portions of the south (right) and north (left) banks of the Truckee River between Greg Street to downstream of Vista. Vertically, the excavation would extend down to a level corresponding to the maximum water surface elevation (WSE) associated with approximately between one and two year flow under existing conditions. A higher bench, approximately 2 feet higher in elevation, would be extended approximately 50-70 feet to the landside of the low bench. Detention basins at Mustang Ranch and Huffaker Hills as described in Alternative B are included in this alternative. This alternative includes lengthening of the bridge at McCarran Boulevard and a bypass channel around the Sagewinds property. Floodproofing of structures in the Rosewood Lakes area is also included in this alternative.

For a more detailed description of these alternatives and the plan formulation process, see Chapters 4 and 5 of the GRR.

4.2.1 Screening of Alternatives

Ranking of the alternatives based on preliminary net benefits is shown in Table 4-4 (1 = highest rank). Only the relative ranking of alternatives is shown here, because significant inaccuracies were later found in the preliminary benefits (see explanation in next sub-section).

Table 4-4: Comparison of Flood Risk Management Plans

Alternative (nominal level of performance[1])	**First Costs *($1,000's)***	***Annual Costs[1] ($1,000's)***	***Rank Based on Preliminary Net Benefits***
No-Action	0	0	8
Alternative 1a (50)	$ 321.3	21.1	4
Alternative 1b (100)	$ 513.3	33.1	7
Alternative 1c (117)	$ 555.0	35.7	6
Alternative 2a (50)	$ 315.9	20.7	5
Alternative 2b (100)	$ 598.1	38.4	10
Alternative 2c (117)	$ 614.1	39.4	9
Alternative 3a (50)	$ 325.4	21.3	2
Alternative 3c (100)	$ 482.8	31.2	3
Alternative 3d (117)	$ 488.3	31.5	1

[1] Nominal level of performance = 90% assurance of safely containing indicated event water surface elevation behind the lines of protection. For example, Alternative 1a would safely contain the 2% (1/50) ACE water surface elevation 90% of the time.

Based on the relative ranking of alternatives displayed above, Alternative 3 dominated Alternatives 1

and 2. The lowest net benefit produced by Alternative 3 at any level of performance exceeded the highest net benefit produced by either Alternative 1 or 2. Therefore, Alternative 3 was identified as the most cost effective plan, with Alternative 3d tentatively identified as the optimal plan for the Truckee Meadows Reach. Alternative 1 consistently outranked Alternative 2 at equivalent levels of performance and was therefore ranked second highest based on net NED benefits.

4.2.1.1 Adjustments to Hydraulic and Economic Models

After an optimal plan had been tentatively identified, concerns with the hydraulic and economic models were discovered during agency technical review. A data-transfer error was discovered for Alternative 3d which had caused an underestimation of residual damages for that plan. This invalidated the previous tentative identification of Alternative 3d as the optimal plan. After consultation with the vertical team and project proponents, it was decided to reconstruct the hydraulic model rather than attempt to fix the flawed model. This would ensure a greater level of confidence in the resulting floodplains. The hydraulic model was reconstructed and has been used for the evaluations that follow.

4.2.1.2 2011 UPDATED analysis results

Between 2008 and 2011 simplifying assumptions utilized during the screening process were removed from both the Economic and Hydraulic modeling efforts (such as the use of surrogate floodplains[9] and non-certified @Risk models) to provide a more thorough analysis of the differing level of performances for Alternative 3. More detailed costs were also developed during this effort. This analysis was consistent with current Corps policy, methodologies and the use of certified models as discussed in Chapter 3.

The result of this analysis showed that residual risk had previously been underestimated and none of the 4 levels of Alternative 3 (3a, 3d, 3c and 3d) demonstrated a positive net benefits as a single purpose FRM plan. The details from this benefit analysis can be found in Enclosure 7. The team was charged to re-visit formulation to see if a new plan which incrementally addressed features using existing information within Alternative 3 could be identified as being economically justified as a single purpose FRM plan.

For a more in-depth discussion of this screening process, please refer to Chapters 4 and 5 of the GRR.

4.2.2 Non-Structural Improvements – The Meadows

Non-structural improvements were considered for two specific residential areas in the southern portion of the study area, Eastside Developments and Hidden Valley. Specifically, raising homes

[9] The term "surrogate floodplain" refers to using one with-project floodplain for multiple plans. For example, the 1/100 floodplains was modeled for the "100yr" event and that floodplain was applied to the "50yr" project and the "117yr" project.

within these areas were analyzed for economic feasibility. This analysis was done in FY11, so an interest rate of 4.125% was used. Damaging flooding within these areas begins between the 2% (1/50) and 1% (1/100) ACE events. There are approximately 40 homes within Eastside and 32 within Hidden Valley that fall within the 1% (1/100) floodplain and were thus evaluated for possible home raises. Because flooding depths are fairly uniform across this area, homes were analyzed as a group instead of on a house-by-house basis. Benefits were calculated for the Eastside area by raising the first floor foundation heights for each structure within FDA to 1ft above the 100yr depth at each structure. The resulting cumulative decrease in annual damages of the home raises to these 40 structures was $5,750/yr, or $144/structure/year. In order for this to be economically feasible, the total cost to raise all 40 structures would have to be around $100,000, or $2,500 per structure, while the actual cost to raise all 40 structures is likely to be in the $1,600,000 to $2,400,000, or $40,000 to $60,000 per structure. Using this range of estimated costs, and annualizing them at 4.125% over 50 years, would result in total annual costs of $76,082 to $114,122 infeasible B/C ratio between 0.05 and 0.08.

The primary reason that home raises are inefficient in this area is because they do not get flooded very frequently and when they do get flooded from a 1% ACE event, those depths are only in the 1-2ft range. Depths do become more significant for the 0.5% (1/200) and 0.2% (1/500) events (3-10+ft), but because these happen so infrequently the damages do not amount to much on an annual basis. The same analysis was performed raising each structure to 1ft above the 0.5% ACE mean WSEL, but the resulting B/C ratio range was still only be 0.09 to 0.13.

Because the flooding patterns in Hidden Valley are very similar to those in the Eastside area, and the B/C ratios for the Eastside area were so low, Hidden Valley was also deemed economically infeasible for home-raises and will not be included in an NED plan.

4.3 REFORMULATION STRATEGY FOR TRUCKEE MEADOWS REACH

After adjustments were made to the hydraulic and economic models, a revised economic analysis was completed. The results indicated that none of the scales of Alternative 3 were economically justified and that an NED plan had not yet been identified. A reformulation workshop was held with the project delivery team, local sponsors and vertical team members in November 2011 with the express purpose of identifying a Federally-supportable flood risk management plan for the Truckee Meadows Reach. The workshop analysis was based on existing information and informed professional judgment with the understanding that if a plan was identified that appeared to be economically justified; more detailed evaluations on that plan would be conducted. All information presented in Section 4.3 represents a "snapshot in time" from the workshop. Price levels are displayed at the time of the analysis and have not been updated to current levels, as indexing these values would lead to the same conclusions.

At this point in the iterative plan formulation process, an additional constraint was identified that due to budgetary considerations, the habitat restoration component of the ecosystem restoration would

not be pursued any further in the process.

An additional measure was considered during this reformulation that had not been previously identified. Capping outlets of the People's Drain at the North Truckee Drain appeared to offer the potential for addressing flooding and was added to the array of measures considered.

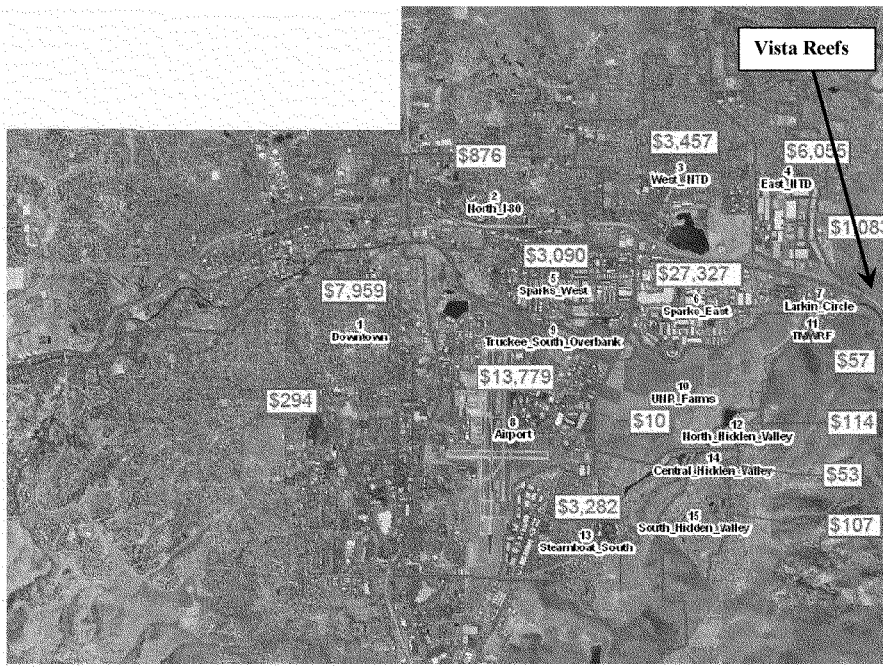
The team began the reformulation process at the workshop by identifying the economic damage areas in the Truckee Meadows reach that provided the greatest potential for benefits. The East Sparks area and the Airport area were identified as having the greatest potential benefits, and the reformulation efforts focused on those areas. Downtown Reno was not evaluated further due to the lack sufficient economic benefits to justify flood risk management measures.

The team first assessed the various elements of Alternative 3 for increments that could be implemented that would have a beneficial effect on the two highest priority economic damage areas. Terracing downstream of Steamboat Creek confluence was identified as the feature that incurred the greatest additional cost for downstream hydraulic mitigation and was identified as the likely break point for a cost effective plan. Formulation would focus on increments that would not require this terracing.

Terracing upstream of Steamboat confluence appeared to be an effective increment compatible with all other measures and was identified as Increment 1. This increment was not particularly effective in addressing the overall flooding problem, so additional increments were considered.

The next increment identified (Increment 2) was levees and floodwalls along the north bank of the Truckee River from McCarran Blvd. to Vista to reduce damages to the East Sparks EIA. This increment was estimated to have net benefits, but could be flanked from just upstream of McCarran Blvd. without additional features.

Figure 4-1: Expected Annual Damages by Impact Area
Oct 2011 Prices, $1,000's



Levees and floodwalls along the north bank of the Truckee River from Highway 395 to McCarran Blvd. were the next added increment (Increment 3) to provide flanking protection to the East Sparks area. This increment would also reduce damages in the West Sparks area. The levee/floodwall on the north bank would induce flood flows over the south bank, so levees and floodwalls were added to the south bank from Highway 395 to McCarran Blvd. to reduce damages in the Airport EIA.

Increments 1, 2 and 3 would reduce existing flood storage within the floodplain and move the flows south into the UNR Farms area and up Steamboat Creek and the North Truckee Drain (NTD). Two alternative increments were identified for the NTD that would result in net benefits: Capping outlets from People's Drain at NTD, and realignment of NTD. Since capping the outlets maximized the net benefits (mainly within the East Sparks EIA), that measure was retained as Increment 4. Table 4-5 displays the results of the incremental analysis completed during the reformulation workshop. A gross estimate of benefits and costs were used in this analysis.

Table 4-5: FRM Incremental Analysis Matrix, Alternative 3

Increment	First Cost	Annual Cost[1]	Annual Benefits	Net Benefits
1) Benching from Greg St. to 1,000 feet east of McCarran	9,900	461	6,055	5,594
Subtotal:	**9,900**	**461**	**6,055**	**5,594**
2) Levees and Floodwalls along north bank from McCarran to Vista, improvements along existing NTD alignment	46,800	2,131	10,092	7,961
Subtotal:	**56,700**	**2,592**	**16,147**	**13,555**
3) Levees and Floodwalls on both banks from I-395 to McCarran	32,500	1,500	4,037	2,537
Subtotal:	**89,200**	**4,092**	**20,184**	**16,092**
4) People's Drain caps (at NTD)	7,000	326	5,000	4,674
Subtotal:	**96,200**	**4,418**	**25,184**	**20,766**
Other Costs[2]	155,003	7,215	--	--
Rounded Totals:	**251,200**	**11,600**	**25,200**	**13,500**
Optional Modification to Increment 2): NTD realignment	*45,000*	*2,095*	*1,372*	*-723*

[1] 4% discount rate

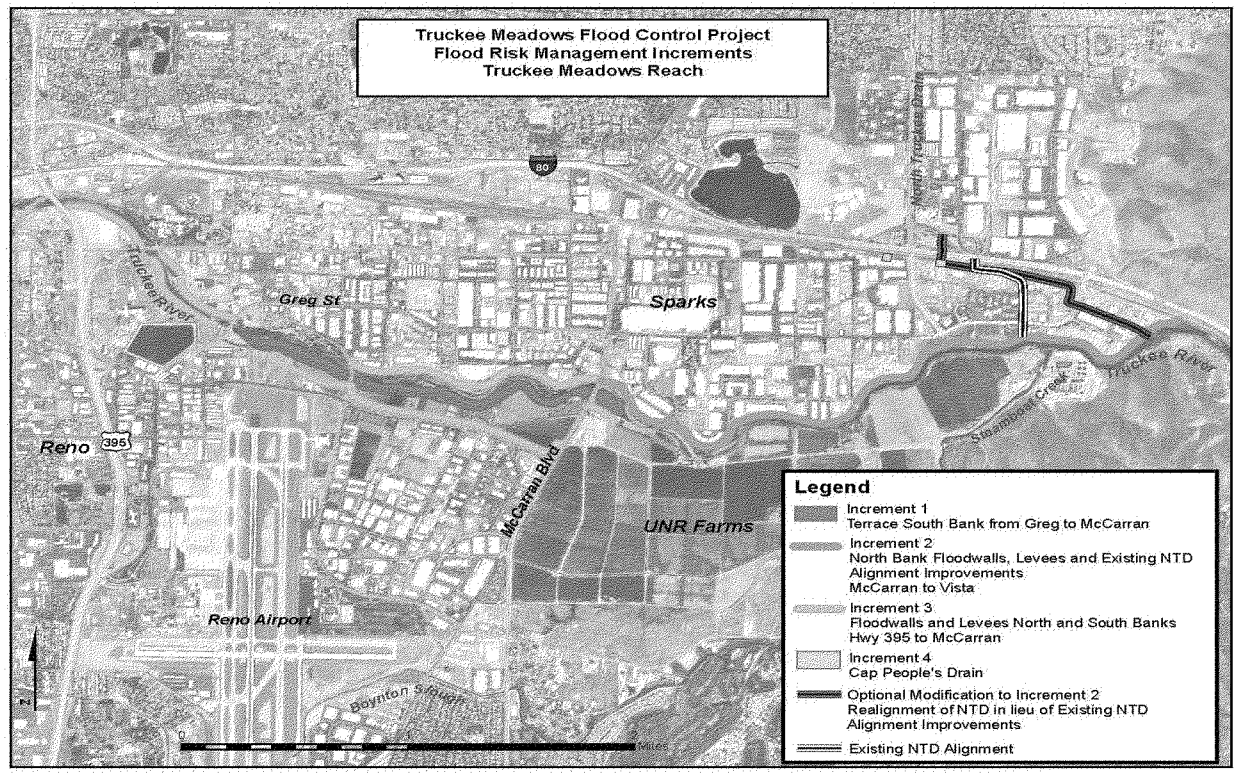
[2] Other costs include bridge scour protection, environmental mitigation, cultural resources cost recovery, construction management, and real estate.

Preliminary hydraulic modeling estimated that benching of the Vista reefs would likely cause sufficient induced flows to require substantial additional hydraulic mitigation between the approximate 2% (1/50) and 1.3% (1/75) ACE (with at least 90% assurance) plan scales (similar to levee heights of the old 3a and 3b plans respectively). Because an approximate 2% (1/50) ACE would be a relatively limited improvement over the without-project condition (with substantial damages beginning at approximately 1/20), it is unlikely that a level of performance below approximately 1/50 would provide increased net benefits. Therefore, an approximate 2% ACE scale (targeting 90% assurance for the 2% (1/50) ACE flood) was selected as reasonably optimized for the reformulated flood risk management plan. An important note is that the "approximate 1/50 plan" with at least 90% assurance would contain the mean 1% (1/100) ACE event.

The reformulated plan for the Truckee Meadows reach is hereafter identified as Alternative 3 - Floodplain Terrace, or "Alternative 3" for short. This alternative has been carried forward for detailed evaluation.

During refinement of the preliminary hydraulic design top of levee, adjustments to the design were made where the project performance could be substantially improved at minimum additional construction cost and no impact to downstream mitigation costs. This resulted in an AEP's of 1% or less for the primary benefit areas. The estimated project performance varies by Economic Impact Area (EIA) as shown in Table 4-11. Vertical agreement was made that Alternative 3 – Floodplain Terrace represented the reasonably optimized NED Plan and no further optimization was necessary.

Figure 4-2: Alternative 3 - Floodplain Terrace Flood Risk Management Increments.



4.4 AVERAGE ANNUAL EQUIVALENT DAMAGES AND BENEFITS – ALTERNATIVE 3

In order to validate the assumptions made during the November 2011 workshop, updated floodplain modeling for Alternative 3 (the reasonably optimized NED Plan) was completed and the residual floodplains were provided to economics in order to update project benefits. These updated damages/benefits are provided below.

All damages in the remaining tables of this report include Average Annual Equivalents, which because of our assumptions for Truckee Meadows; equal Expected Annual Damages. Equivalent Annual Damages for Alternative 3 are summarized by EIA in Table 4-6 below.

Table 4-6: Average Annual Equivalent Damages (October 2013 Prices, $1,000's, 3.5% Interest Rate)

Economic Impact Area	Alternative	
	Without	3
Downtown Reno		
1-Downtown	8,394	8,394
The Meadows Area (east of I 395 to Vista)		
2-North I-80	904	899
3-West NTD	3,567	3,517
4-East NTD	6,249	6,328
5-Sparks West	3,188	2,423
6-Sparks East	28,197	11,691
7-Larkin Circle	1,118	604
8-Airport	14,218	7,532
9-Truckee South Overbank	304	0
10-UNR Farms	10	12
11-TMWRF	59	58
12-North Hidden Valley	116	119
13-Steamboat South	3,386	3,244
14-Central Hidden Valley	55	59
15-South Hidden Valley	110	115
Sub-total (Meadows)	***$61,481***	***$36,601***
TOTAL	**$69,875**	**$44,995**

4.4.1 Average Annual Benefits

The Equivalent Annual Benefits for the Alternative 3 are summarized in Table 4-7 below.

Table 4-7: Average Annual Benefits
(October 2013 Prices, $1,000's, 3.5% Interest Rate)

Economic Impact Area	Alternative	
	Without	3
Downtown Reno		
1-Downtown	0	0
Advanced Bridge Replacement	0	0
Sub-total (Downtown)	***$0***	***$0***
The Meadows Area (east of I 395 to Vista)		
2-North I-80	0	5
3-West NTD	0	50
4-East NTD	0	-79
5-Sparks West	0	765
6-Sparks East	0	16,506
7-Larkin Circle	0	514
8-Airport	0	6,686
9-Truckee South Overbank	0	304
10-UNR Farms	0	-2
11-TMWRF	0	1
12-North Hidden Valley	0	-3
13-Steamboat South	0	142
14-Central Hidden Valley	0	-4
15-South Hidden Valley	0	-5
Sub-total (Meadows)	***$0***	***$24,880***
TOTAL	**$0**	**$24,880**

4.4.2 Probability Distribution of Damages Reduced

In accordance with ER 1105-2-101, flood damages reduced were determined as mean values and by probability exceeded. Table 4-8 shows the benefits for each Alternative for the 75%, 50% and 25%

probability that benefits exceed the indicated values. The damage reduced column represents the mean benefits for each increment and the 75%, 50% and 25% represent the probability that the flood damage reduction benefits exceed the number in that column for that increment. For example, Alternative 3, has an average (mean) benefit of $24.8m, but only a 50% chance that benefits will be greater than $24.1m, 75% confidence that benefits will be greater than $15.4m and a 25% confidence that benefits will exceed $35.1m. This range is the probability distribution of damages reduced which represents the uncertainty in the benefit estimates and incorporates all the uncertainties in hydrology, hydraulics, and economics in the HEC-FDA model. The wider this range, the more uncertain and less confident you are in the result. The uncertainty in damages reduced should be considered when selecting an optimal plan during the plan formulation process. Judgment should be used to determine if an alternative meets a reasonable level of confidence regarding positive net benefits and identifying if changes in net benefits from alternative to alternative are significant.

A detailed list of Probability Distribution of Damages Reduced by Impact Area can be found in Enclosure 6.

Table 4-8: Probability Distribution of Equivalent Annual Damages Reduced – The Meadows Only
(October 2013 Prices, $1,000's, 3.5% Interest Rate)

Plan	Expected Annual Damages			Probability Damage Reduced Exceeds Indicated Values		
	Without Project	With Project	Damages Reduced	0.75	0.50	0.25
Without	61,481	61,481	0	0	0	0
3	61,481	36,601	24,880	15,397	24,111	35,087

4.4.3 Induced Flooding Resulting from the NED Plan in Two Areas

Hydraulic modeling of the NED Plan found that 1% ACE flood elevations would increase between 0.0 and 0.6 foot in several areas near the downstream end of the project compared to the without-project condition. (There is some level of uncertainty in any hydraulic model. In this case the actual without-and with-project water surface elevations could be 0.5 foot lower or higher than estimated.)

- UNR Farms and southern periphery (Steamboat South and Hidden Valley EIA's): The flood elevation increase in the UNR Farms area is up to 0.6 foot. USACE-estimated with-project 1% ACE flood elevations would exceed the first floor elevations of an estimated 900 existing structures (mostly single-family residences and multiplex apartment buildings) on the southern periphery of the UNR Farms area that are also within the USACE without-project 1% ACE floodplain. An estimated additional 175 residences that are outside of the USACE without-project 1% ACE floodplain would be within the limits of the with-project floodplain, but it is estimated that their first floors would still be above the with-project flood elevation. The estimated increase in the 2% ACE flood elevations would affect about 22 existing structures south of UNR Farms (Steamboat South and Hidden Valley EIA's), most of which

would have an estimated increase of 0.2 to 0.4 foot.

- North Truckee Drain (NTD): The 1% ACE flood elevation on both sides of the North Truckee Drain (NTD) immediately north of I-80 would be increased by approximately 0.5 to 1 foot due to backwater effects in the NTD.

The average annual induced damages are estimated to be $90,000. Figure 4-3 shows the areas in the estimated without- and with-project 1% ACE floodplains based on USACE hydrology. The area shown in blue is the without-project 1% ACE floodplain and the area in green is the with-project 1% ACE floodplain. The areas shown in yellow are areas that are now in the 1% ACE (with-project) floodplain that were not in the without-project floodplain – these are areas that now are anticipated to flood from the 1% ACE event (see Figure 5-6 for additional view of these areas). The crosshatched area is the existing Federal Emergency Management Agency (FEMA) base flood area. The FEMA map is included here to illustrate the difference between the FEMA and USACE floodplains, as it is expected that FEMA will adopt USACE hydrology when the FEMA maps are updated.

Flooding depths actually decline for less frequent events, such as the mean 0.5% (1/200) ACE and 0.2% (1/500) ACE. With respect to project performance statistics in these induced areas (see Table 4-11), there is virtually no change to AEP (on tenth of one percent) and no more than a 3% decrease in Assurance for a given ACE event.

4.4.3.1 Consideration of Mitigation for Induced Flooding From the NED Plan

USACE policy allows mitigation for induced flooding to be recommended as a project feature when it is economically justified or there are overriding reasons of safety, economic or social concerns, or a determination of a real estate taking has been made (ER 1105-2-100, para.3-3.b.(5)). Potential mitigation measures for induced flooding were considered by the District, but none were found to be economically justified. The structural and non-structural measures considered for the south side of the Truckee River were: raising or wet floodproofing existing residential and commercial structures, levees and floodwalls to protect existing structures, a detention basin with perimeter levees in the UNR Farms area, excavation of the hydraulic constriction downstream of Truckee Meadows including downstream hydraulic and environmental mitigation, or purchase/ removal of the affected structures. The structural and non-structural measures considered for the north side of the Truckee River were a pump station, ring levees, or raising/wet flood-proofing existing residential and commercial structures. Raising/flood-proofing structures on the south side and a pump station on the north side were found to be the least costly options based on rough cost estimates for each measure by District civil and cost engineering staff using their professional experience. The average annual flood risk management benefits for those measures were found to be far less than required to justify their costs. Any increase in flooding will be an important concern for adversely affected property owners. However, because of the small increase in flood elevations and the low recurrence frequency of induced flooding, those concerns are not considered to be overriding safety, economic, or social concerns under USACE policy, and no real estate taking would occur specifically due to the increase in water surface elevations. Therefore, mitigation for induced flooding is not proposed as a project

feature of the Federally-funded NED Plan.

4.4.3.2 National Flood Insurance Program Compliance

The increased 1% ACE flood elevations caused by the NED Plan (based on feasibility level hydraulic modeling) would trigger an NFIP regulatory requirement (44 CFR 60.3(d)) that communities must seek conditional approval from FEMA before allowing certain encroachments upon a floodplain. Applications for such conditional approvals must certify, among other things, that no structures are located in areas that would be impacted by increased base flood elevations (44 CFR 65.12(a)(5)). Under Corps policy, compliance with the NFIP is a non-Federal responsibility and compliance costs would be borne by non-Federal interests. Estimated additional costs of NFIP compliance that would result from the Corps project are identified as associated costs of the project and are included in the economic costs of the project.

The associated economic cost for NFIP compliance is the estimated minimum cost for the non-Federal interests to comply with the NFIP if the NED plan is implemented. Participation in and compliance with applicable Federal floodplain management and flood insurance programs is a condition of non-Federal sponsor participation in Federal flood control projects as memorialized in the standard Project Partnership Agreements for FRM projects (FRM Model PPA Article II.I.). The NFIP compliance costs are not based on specific features proposed by the sponsor. The estimated NFIP compliance costs are based on the least-cost features that could be added to the NED Plan by local interests to achieve NFIP compliance, without modifying the NED Plan. NFIP compliance costs have been included in the associated economic costs pursuant to the joint FEMA-Corps memorandum, subject: FEMA/USACE Joint Actions on Planning for Flood Risk Management Projects, signed in June 2012. Incidental flood damage reduction benefits resulting from NFIP compliance have been included in the economic analysis of the NED Plan.

The District considered several options for NFIP compliance and determined that non-structural methods including house raising would likely be the least-cost option on the south side of the Truckee River. Through coordination with regional FEMA staff, it was verified that raising the first floors of affected residences above the new base flood elevation would comply with the NFIP regulation. Approximately 764 homes and 128 multiplex apartment buildings would need to be raised in the area south of the river. Additionally, four commercial structures and three public buildings would also need to be raised or "wet flood-proofed" with closures and sealing. Figure 4-4 identifies the land parcels with structures that are estimated to require raising or flood-proofing. The preliminary cost estimate to raise and flood-proof structures for NFIP compliance on the south side of the Truckee River is $172 million. For the north side of the Truckee River, a 400-cfs capacity pump station on the North Truckee Drain with an outfall to the Truckee River would be the least-cost option. The estimated first cost for the pump station is $23 million. Therefore, the total estimated minimum non-Federal costs cost for NFIP compliance is $195 million.

Because compliance with the NFIP is a non-Federal responsibility, the affected NFIP communities could develop their own plan for compliance with the NFIP and would not be required to implement

the specific assumed least-cost features. The estimated NFIP compliance costs are subject to change based on more detailed hydraulic analysis during final design of the project, including the results of NFIP hydraulic modeling assumptions and methods, and more detailed surveys of the elevations of existing structures.

There are incidental annual benefits to implementing these measures and these benefits are included in the cumulative benefits presented in Table 4-9.

Figure 4-3: Without Project and Residual NED Plan 1% (1/100) ACE Floodplains

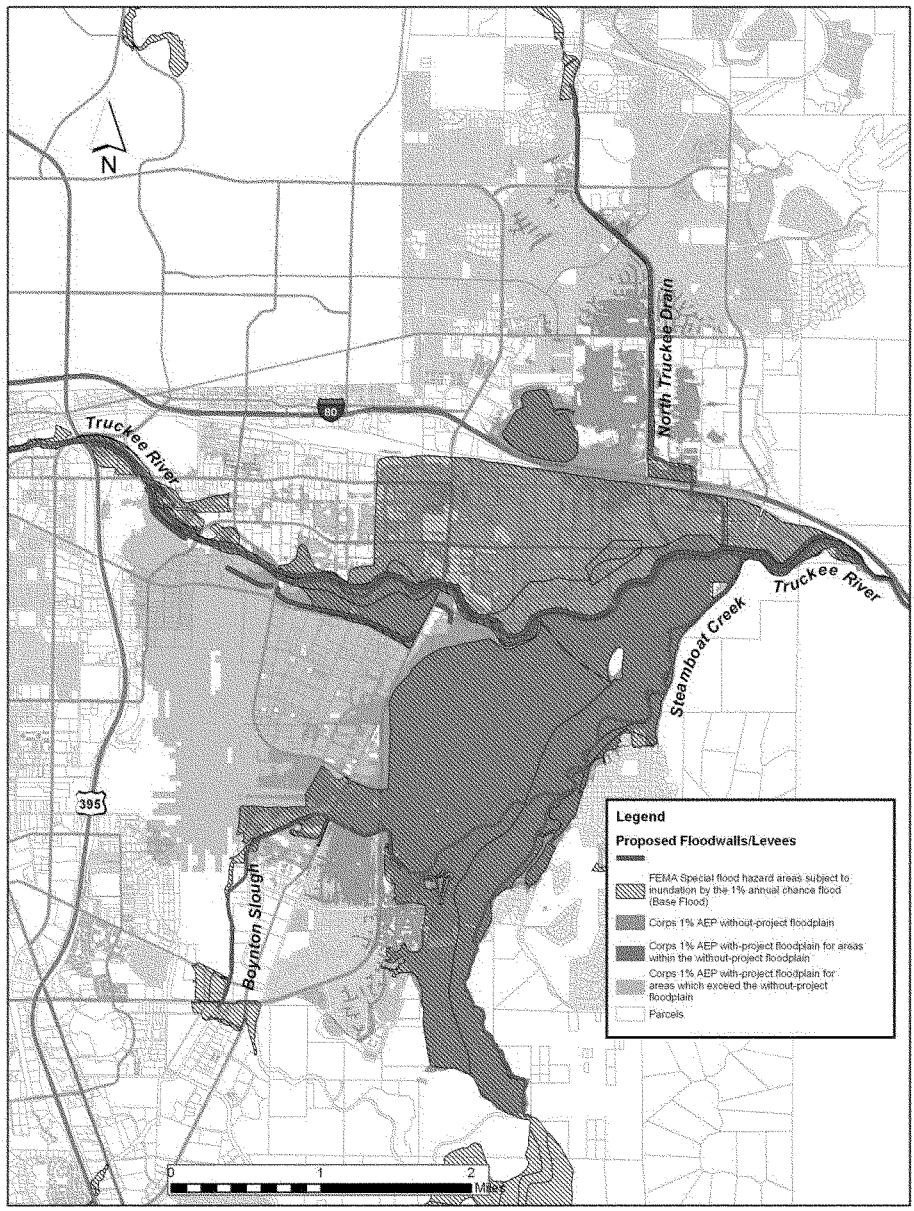


Figure 4-4: Parcels with Structures proposed for Raising/Flood-proofing for NFIP Compliance

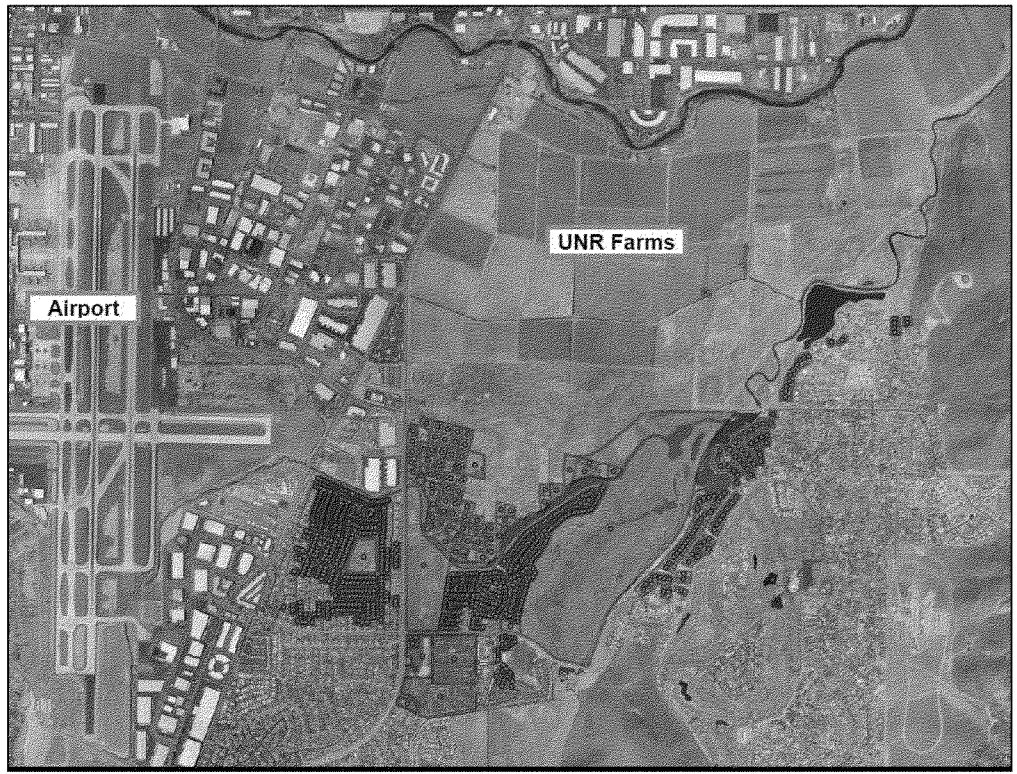


Table 4-9: Average Annual Benefits; Including NFIP Compliance Measures (October 2013 Prices, $1,000's, 3.5% Interest Rate)

Economic Impact Area	Alternative	
	Without	Alt 3
Downtown Reno		
1-Downtown	0	0
Advanced Bridge Replacement	0	0
Sub-total (Downtown)	***$0***	***$0***
The Meadows Area (east of I 395 to Vista)		
2-North I-80	0	5
3-West NTD	0	103
4-East NTD	0	403
5-Sparks West	0	765
6-Sparks East	0	16,506
7-Larkin Circle	0	514
8-Airport	0	6,686
9-Truckee South Overbank	0	304
10-UNR Farms	0	-2
11-TMWRF	0	1
12-North Hidden Valley	0	7
13-Steamboat South	0	570
14-Central Hidden Valley	0	22
15-South Hidden Valley	0	15
Sub-total (Meadows)	***$0***	***$25,899***
TOTAL	**$0**	**$25,899**

Table 4-10: Probability Distribution of Equivalent Annual Damages Reduced – Including NFIP Compliance Measures – The Meadows Only

Plan	Expected Annual Damages			Probability Damage Reduced Exceeds Indicated Values		
	Without Project	With Project	Damages Reduced	0.75	0.50	0.25
Without	61,481	61,481	0	0	0	0
3	61,481	35,582	25,899	16,416	25,130	36,106

4.5 PROJECT PERFORMANCE – WITH PROJECT CONDITIONS – RESIDUAL RISK

Figure 4-5 shows the residual floodplains of the 2% (1/50) ACE event with the NED in place compared to the without project conditions.

Table 4-11 shows the project performance under both existing and with-project conditions for each Economic Impact Area.

As mentioned in the without project section, the annual exceedance probability (AEP) measures the chance of having a damaging flood in any given year. As larger increments are analyzed, the AEP usually drops.

The long-term risk numbers measure the chance of having one or more damaging flood over a given period of time. This is usually useful, because it will tell residents the likelihood of them experiencing a damaging flood over the life of their mortgage.

Assurance measures the probability of not being damaged if a given event were to occur. As with the other measures, project conditions reduce the risk and larger projects have a greater reduction in risk than small projects. The Assurance for the 1% event is often targeted to determine if a project meets Corps/FEMA criteria for levee certification.

4.5.1 A Note about Project Performance Differences by EIA

As mentioned earlier, not all reaches within the study area will have the same residual risk because some areas are getting flooded by storm drainage or other tributaries/streams that aren't a part of the Truckee Meadows Flood Control Project (i.e North Truckee Drain, Steamboat Slough and Long Valley Creek.) and/or are simply not behind the intended line of protection. A map showing the location of flood risk management features (levees & floodwalls) for Alternative 3 is shown in Figure 4-2. The Impact Area's that get flooded from other sources and/or are not directly behind an intended line of protection include EIA's 1, 2, 3, 4, 9,10,11,12,13,14,and 15. Because Alternative 3 does not bench the Vista reefs, there could be an increase in WSEL of 4-8 inches for less frequent events between 2% and 1% annual chance probabilities in EIA's 10-15. These increases were incorporated into the project performance and the impact to AEP and Assurance appear to be minimal as indicated in Table 4-11 below.

Figure 4-5: NED Residual Risk: With and Without Project 2% (1/50) ACE Floodplains – NED Plan

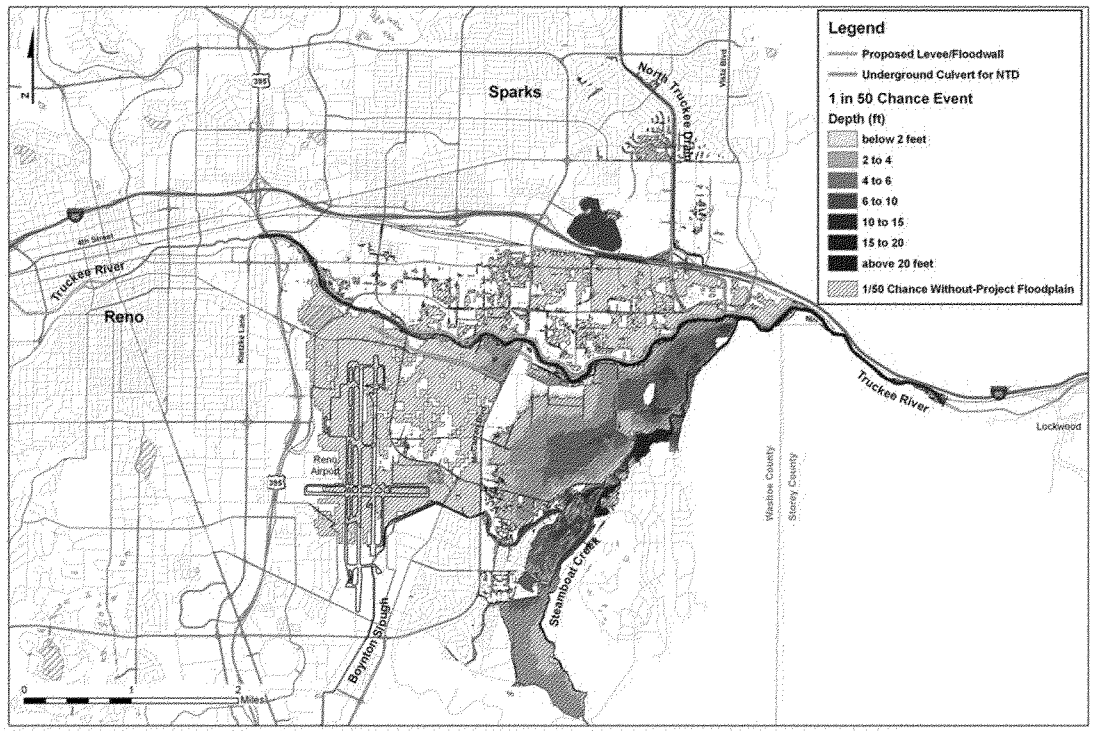


Table 4-11: Project Performance – With Project – Entire Study Area

EIA	Plan	AEP	LONG-TERM RISK			ASSURANCE BY ANNUAL CHANCE EVENT					
			10	30	50	10%	4%	2%	1%	0.40%	0.20%
1	*WO*	2.7%	24%	50%	75%	99%	85%	32%	5%	0%	0%
	Alt 3	2.7%	24%	50%	75%	99%	85%	32%	5%	0%	0%
2	*WO*	0.9%	9%	20%	36%	99%	99%	96%	67%	16%	3%
	Alt 3	0.8%	8%	18%	33%	99%	99%	97%	73%	21%	4%
3	*WO*	3.0%	27%	54%	79%	99%	72%	30%	10%	0%	0%
	Alt 3	2.6%	23%	49%	73%	99%	81%	41%	10%	1%	0%
4	*WO*	3.3%	28%	57%	81%	98%	76%	40%	17%	1%	0%
	Alt 3	2.6%	23%	48%	73%	99%	84%	50%	16%	3%	0%
5	*WO*	5.3%	42%	74%	93%	96%	33%	4%	0%	0%	0%
	Alt 3	0.7%	7%	16%	30%	99%	99%	98%	79%	29%	8%
6	*WO*	3.9%	33%	63%	86%	99%	58%	21%	1%	0%	0%
	Alt 3	0.9%	9%	20%	36%	99%	99%	99%	69%	3%	0%
7	*WO*	2.1%	19%	42%	66%	99%	91%	60%	8%	0%	0%
	Alt 3	1.0%	9%	21%	37%	99%	99%	98%	66%	3%	0%
8	*WO*	10.1%	65%	93%	99%	54%	5%	0%	0%	0%	0%
	Alt 3	0.9%	8%	20%	35%	99%	99%	95%	68%	19%	4%
9	*WO*	4.1%	34%	64%	87%	97%	59%	17%	2%	0%	0%
	Alt 3	--	--	--	--	--	--	--	--	--	--
10	*WO*	19.4%	89%	99%	99%	26%	5%	1%	0%	0%	0%
	Alt 3	20.4%	90%	99%	99%	24%	5%	1%	0%	0%	0%
11	*WO*	1.1%	11%	25%	44%	99%	99%	96%	47%	2%	0%
	Alt 3	1.2%	11%	25%	44%	99%	99%	95%	49%	2%	0%
12	*WO*	6.1%	47%	79%	96%	85%	47%	18%	1%	0%	0%
	Alt 3	6.4%	49%	81%	96%	83%	46%	16%	1%	0%	0%
13	*WO*	2.6%	23%	49%	74%	99%	84%	56%	11%	0%	0%
	Alt 3	2.7%	24%	50%	75%	98%	83%	54%	11%	0%	0%
14	*WO*	3.9%	33%	63%	86%	95%	69%	37%	5%	0%	0%
	Alt 3	4.0%	33%	64%	87%	94%	68%	35%	5%	0%	0%
15	*WO*	2.8%	25%	51%	76%	98%	83%	55%	10%	0%	0%
	Alt 3	2.8%	25%	51%	76%	98%	82%	52%	11%	0%	0%

4.5.2 Residual Population at Risk

As shown by the residual floodplain map above, the majority of the flooding reduction occurs in the principal deep flooded areas, which are primarily non-residential. Flooding in most residential areas is fairly shallow, infrequent and has relatively high warning times. Because of this, the population at risk (PAR) living within the floodplains does not change substantially from the without to the with project condition. The table below summarizes the residual PAR, which includes the home raises for NFIP compliance.

Table 4-12: Residual Population at Risk

ACE Event	Population living within residual floodplain boundary	
	Without	Alt 3
10%	0	0
5%	30	30
2%	2,200	2,000
1%	7,600	5,500
0.50%	27,500	26,700
0.20%	36,400	36,400

4.5.3 Other Benefit Categories

4.5.3.1 Income or Business Losses

Income losses are the loss of wages or net profits to business over and above physical flood damages that result from a disruption of normal activities. Prevention of income loss can only be considered a NED benefit only to the extent that such loss cannot be compensated for by the postponement of an activity or transfer of the activity to other establishments. The loss of income by firms is difficult to measure because of the complexity involved in determining whether the loss is recovered by a firm at another location or at a later time. Loss of income because of idle labor must be net of income to labor employed in cleanup and repair of damages. Unemployment compensation and other transfer payments to idle labor are not income from a NED perspective. For income losses to be considered NED benefits, the activity usually needs to be unique to the firm and be location and time dependent.

One possible source of income loss could be net profits to the hotel casinos in Reno and Sparks. The 1997 event occurred during the busy New Year's holiday. It is possible that some of these losses could not be recovered at a later time. But many of these losses could have been transferred as gains for the remaining majority of hotel casinos which lie outside the flood plain in the Reno/Sparks area. Note, that only four of the downtown casinos in the economic model are inundated from the 1% annual chance and only twelve from the 0.5% annual chance event. Only rare events would lead to national irreplaceable losses and the annual equivalents would be reduced further by very low probability that future events would fall on the busiest weekend. At this time, no specific cases of (NED) income losses from flooding have been identified for either the Downtown Reno or the Meadows Area reaches. All available data indicates that many of the short-term losses are either transferred to others as income gains or can be recovered at a later time. Income losses in terms of Regional Economic Development (RED) are discussed in a subsequent section of this report.

4.5.3.2 Location and Intensification Benefits

A location benefit can occur when the project condition allows for a change in land use that was not possible due to flood risk under the without project condition. Intensification occurs when the land use remains the same but the activity is more intense, leading to higher production of the same use. Intensification is usually limited to agriculture but is theoretically applicable to urban land uses.

Both location and intensification benefits face strict requirements under Corps guidance (see ER 1105-2-100 Appendix E) and are often difficult to quantify. Benefits cannot exceed the increased potential damages with the changed or intensified land use or the cost of fill/flood proofing, whichever is less. Location benefit is measured as the increase in aggregate net income (increases less decreases) due to efficiencies of a flood plain location compared to the best non floodplain location. Estimated change in floodplain land price under with project conditions can be used to determine benefit as long as decreases in prices at other locations are accounted for in the estimate. These benefits are still limited to the increase potential damages or cost of flood proofing.

Some vacant downtown parcels may provide an opportunity to consider possible location benefits. Given the Corps restrictions and indications that some development within the downtown floodplain is already occurring under without project conditions, the best way to estimate to potential benefit for the Truckee Meadows area would be identify vacant parcels where savings in flood proofing costs may be possible under future with project conditions. At this time, specific vacant parcels that are projected to be developed in the downtown area have not been identified and characterized as to when development will occur, how large the new buildings will be, or what the new land use will be under future conditions. With very few vacant parcels in Central Downtown Reno within the 100-year floodplain (about 4 acres total) it is doubtful that there is significant benefit to savings in flood proofing or increased land values. No location or intensification benefits are included in this analysis.

4.5.3.3 Recreation

Cost estimates for two preliminary recreation plans were completed in 2008. The local sponsor's contractor, Stantec, prepared a preliminary cost estimate for the Locally-Developed Recreation Plan that totaled $74 million dollars. Because the costs exceeded the available recreation benefits, the sponsor and the Corps downsized the plan. The revised preliminary estimate totaled $39.1 million, which still was not economically justified. The Locally-Developed Recreation Plan was therefore eliminated from further consideration.

The Corps recreation plan was formulated based on policy-compliant recreation features. The strategy used to formulate recreation alternatives was to start with a relatively few basic recreation measures and add more optional features (playground and group picnic shelters) as additional increments. The measures were evaluated against their ability to meet the planning objective and the four P&G screening criteria, particularly effectiveness. Three scales of recreation features were evaluated to complement the NED plan for flood risk management:

Alternative A includes:

- 50 Individual picnic areas
- 4 Kayak and canoe input areas
- 13 Fishing areas
- 9,700 LF Paved trails
- 8,900 LF Unpaved trails

Trailheads were included in the paved and unpaved trail features. Fishing access, non-motorized boat access and kayaking access costs were combined with the cost of trails leading to them because benefits cannot be derived from these activities unless access is provided by trails.

Alternative B adds the following measures to Plan A:

- 1 Playground
- Small group picnic shelter

Alternative C adds the following measure to Plan B:

- Medium group picnic shelter

Costs and benefits were developed for each of the three alternatives. Preliminary costs were used based on conceptual designs, previous bid results and professional judgment. Basic access, health, and safety features including parking and restrooms were included in all alternatives. The unit day benefit value was developed for each recreation alternative using professional judgment and the guidelines provided in Economic Guidance Memorandum 13-03, Unit Day Values for Recreation for Fiscal Year 2013. The unit day values are presented in the four tables below. Point values were assigned based on an evaluation of existing recreation features within the project area using the point scale provided in EGM 12-03. Criteria measured included recreation experience, availability of opportunity, carrying capacity, accessibility, and environmental condition. Scoring was the result of informed opinion and professional judgment. Potential point values range from 0 to 100.

Table 4-13: Unit Day Value Worksheet for Alternative A

Alternative A - Recreation Unit Day Value Worksheet		
Evaluation Criteria	**Assigned Points**	**Notes on Judgment Factors**
Recreation Experience	without project: 11	Several general activities; one high quality value activity (rafting)
	with project: 13	Increase in general activities over w/o project
Availability of Opportunity	without project: 3	Recreation opportunities exist w/i both 1 hour and 30 min.
	with project: 6	Increases opportunities for some activities to w/i 30 min
Carrying Capacity	without project: 6	Basic + facilities (could be a 5)
	with project: 8	Provides adequate facilities at site.
Accessibility	without project: 10	Fair access to existing recreation
	with project: 13	Improved access to site
Environmental Condition	without project: 5	Average quality; viewshed limited or impaired
	with project: 13	New recreation would have high esthetic quality and improved viewshed
Total Assigned Points	without project: 35	
	with project: 53	

Table 4-14: Unit Day Value Worksheet for Alternative B

Recreation Unit Day Value Worksheet		
Evaluation Criteria	**Assigned Points**	**Notes on Judgment Factors**
Recreation Experience	without project: 11	Several general activities; one high quality value activity (rafting)
	with project: 15	Increase in general activities over w/o project and Alt A.
Availability of Opportunity	without project: 3	Recreation opportunities exist w/i both 1 hour and 30 min.
	with project: 6	Increases opportunities for some activities to w/i 30 min
Carrying Capacity	without project: 6	Basic + facilities (could be a 5)
	with project: 8	Provides adequate facilities at site.
Accessibility	without project: 10	Fair access to existing recreation
	with project: 13	Improved access to site
Environmental Condition	without project: 5	Average quality; viewshed limited or impaired
	with project: 13	New recreation would have high esthetic quality and improved viewshed
Total Assigned Points	without project: 35	
	with project: 55	

Table 4-15: Unit Day Value Worksheet for Alternative C

Recreation Unit Day Value Worksheet		
Evaluation Criteria	**Assigned Points**	**Notes on Judgment Factors**
Recreation Experience	without project: 11	Several general activities; one high quality value activity (rafting)
	with project: 16	Increase in general activities over w/o proj and Alts A & B
Availability of Opportunity	without project: 3	Recreation opportunities exist w/i both 1 hour and 30 min.
	with project: 6	Increases opportunities for some activities to w/i 30 min
Carrying Capacity	without project: 6	Basic + facilities (could be a 5)
	with project: 11	Provides optimum facilities at site.
Accessibility	without project: 10	Fair access to existing recreation
	with project: 14	Improved access to site and on site
Environmental Condition	without project: 5	Average quality; viewshed limited or impaired
	with project: 13	New recreation would have high esthetic quality and improved viewshed
Total Assigned Points	without project: 35	
	with project: 60	

Table 4-16: Unit Day Values and Recreation Value

Recreation Alternative	Assigned Point Value	Gen. Recreation Value
Project Without Project	35	$5.70
Alternative A	53	$8.07
Alternative B	55	$8.07
Alternative C	60	$8.78

Recreation demand was determined based on a 2008 recreation demand survey conducted by Responsive Management of Harrisonburg, VA. Table 4-17 displays the results by recreation feature. The methodology involves multiplying carrying capacity times turnover rate times weeks in the season divided by the percentage of day use. That total is then divided by the percentage of season use. Recreation demand for unpaved trails was calculated on the activities of running, walking, and jogging. The survey identified mountain biking as another activity that could make use of unpaved trails, however, for an urban setting this demand is considered to remain unmet by the project.

The general recreation value for each alternative was multiplied by the average annual users to determine a total annual recreation value for each alternative. The results are displayed in Table 4-18.

Each recreation alternative had a preliminary cost estimate developed. A preliminary estimate of the interest during construction and the routine OMRRR costs was developed to calculate the average annual cost for each alternative. The summary is displayed in Table 4-19.

Table 4-20 shows the preliminary recreation evaluation results. Alternative C has the greatest net

recreation benefits at $333,006, as well as a benefit-to-cost ratio of 2.1:1 Therefore; Alternative C is identified as the NED recreation plan. A more detailed cost estimate for the recreation plan was subsequently prepared after a considerable length of time had elapsed. Consequently the final costs for recreation are considerably higher than those included in this benefit analysis. However, the increases in cost affected all the alternatives in a commensurate manner and Alternative C remains the NED recreation plan.

Table 4-17: Recreation Demand by Feature

Recreation Feature	Total Expected Participants[1]	Carrying Capacity	Turnover rate	Weeks in Season	Weekend Day Use[2]	Recreation Season Use	Annual Users per Feature (x number of features)
Medium Picnic Shelter - Large* 40' x 40' w/16 tables	363,853	64	1	30	35%	75%	7,314
Small - 20' x 20' w/4 tables	683,698	16	1	30	35%	75%	1,829
Picnic Areas	1,388,114	5	2	30	35%	75%	57,143
Kayaking	563,825	1	4	20	25%	65%	9,600[4]
Non Motorized Boats	812,744	0.5	4	20	20%	65%	NA
Fishing	998,330	0.2	4	20	20%	65%	1,600
Playgrounds	4,421,642	1	8	30	25%	65%	1,477
Trails							
Unpaved	9,950,885	12	4	30	30%	70%	24,080
Paved	5,015,074	12	4	30	30%	70%	12,597
Total							**115,640**

[1]Represents total demand for each recreation feature throughout survey area.
[2]Percentage of Weekends facility is in use.
[3]Percentage of recreation season that facility is in use.
[4]Combined users for kayaking and non motorized boats.

Table 4-18: Total Annual Recreation Value

Recreation Alternative	Gen. Recreation Value	Avg. Annual Visitors	Total Annual Value	Net Annual Value
Without Project	$5.70	70,122	$399,695	0
Alternative A	$8.07	106,497	$859,433	$459,738
Alternative B	$8.07	108,326	$874,191	$474,495
Alternative C	$8.78	115,640	$1,015,320	$615,625

Table 4-19: Summary of Recreation Costs
(Based on Preliminary Costs, Oct 2011 Prices)

Recreation Alternative	First Costs	IDC	Total Investment Cost	Annualized Investment Cost	Annual O&M	Average Annual Costs
Alternative A	$3,959,230	$240,720	$4,199,950	$195,509	$54,890	$250,399
Alternative B	$4,148,760	$252,240	$4,401,000	$204,867	$57,400	$262,267
Alternative C	$4,476,250	$272,160	$4,748,410	$221,039	$61,580	$282,619

Based on October 2011 price levels, 4 percent rate of interest, and a 50-year period of analysis.

Table 4-20: Comparison of Alternative Recreation Plans
(Based on Preliminary Costs, Oct 2011 Prices)

Recreation Alternative	Average Annual Benefits	Average Annual Costs	B/C Ratio	Net Benefits
Alternative A	$459,738	$250,399	1.84	$209,339
Alternative B	$474,495	$262,267	1.81	$212,228
Alternative C	$615,625	$282,619	2.18	$333,006

Recreation Plan Description and Revised BCR

The NED recreation plan Alternative C consists of the following features in the Truckee Meadows Reach:

- 50 Individual picnic areas
- 4 Kayak and canoe input areas
- 13 Fishing areas
- 9,700 LF Paved trails
- 8,900 LF Unpaved trails
- 1 Playground
- Small group picnic shelter
- Medium group picnic shelter
- Access road, parking, restrooms and signage

The table below describes the Benefit/Cost evaluation of the recommended recreation plan (Alternative C) using more detailed cost estimates at Oct 2013 price levels and a 3.5% interest rate. Benefits were also updated from October 2011 to October 2013 prices using CPI data.

Table 4-21: Revised BCR and Net Benefits for Alternative C

Recreation Alternative	Average Annual Benefits	Average Annual Costs	B/C Ratio	Net Benefits
Alternative C	$625,000	$612,000	1.0	$13,000

4.5.3.4 Other Social Effects (OSE)

The Other Social Effects (OSE) account includes urban and community impacts to income, population and employment distribution, fiscal conditions and displacement of people, businesses and farms. A flood event may have social effects through loss of life, reduced property values, contaminated drinking water, and greater exposure to biological toxins. Those regional impacts that are difficult to quantify in the RED analysis are included in the OSE account. In general, OSE effects are displayed in a qualitative manner, as opposed to the quantitative analysis available for RED. A detailed writeup of OSE can be found in Chapter 6 of the Main GRR Report.

4.6 IDENTIFICATION OF THE RECOMMENDED PLAN

The Recommended Plan for the Truckee Meadows GRR consists of:

• No action in the Downtown Reno Reach

- Flood risk management in the Truckee Meadows Reach, consisting of the NED Plan (FRM Alternative 3 - Floodplain Terrace)
- NED Plan for recreation in the Truckee Meadows Reach (Recreation Alternative C)

4.7 WITH PROJECT FLOODING DOWNSTREAM OF THE STUDY PROJECT AREA

The economic study area for determining flood risk management benefits was initially limited to the reaches from Downtown Reno to Vista. Under without project conditions, flooding can occur downstream of Vista (to Pyramid Lake) although these damages are significantly lower than in the Economic Impact Areas 2-15, primarily due to the fact that there are few structures downstream. An Economic Analysis was performed for this downstream reach in 2007 and the potential benefits of reducing flooding from the Truckee River for these areas were found to not justify the potential costs. Alternative 3 – Floodplain Terrace does not open up the Vista reefs, so the downstream impacts of induced flows and flooding are minimal. A detailed description of this analysis can be found in Enclosure 5.

5 NET BENEFIT AND BENEFIT-TO-COST ANALYSIS

Alternative 3 provides significant annual benefits ($24-25 million) in the Truckee Meadows reach. These results, while different from past studies in total benefits due to changes in inventory, structure valuation, flooding depth and frequencies, are consistent with the findings of prior studies where the majority of the benefits and flood risk were found to lie in the Meadows Area downstream of I-395 to Vista.

Annual benefits from the tables above were compared to annual costs for Alternative 3. Please see Chapter 6 of the GRR for a further description of the cost allocation and the methodology for plan optimization.

5.1 NET BENEFITS

Detailed estimates of project first costs, annualized costs and IDC calculations, using 3.5% and 7% interest rates, can be found in Enclosure 9. The construction schedule is assumed to be 4 years. IDC for NFIP Compliance assumes that it is built during the final year of construction and IDC is calculated at the mid-point of the year.

Alternative 3 demonstrates federal interest and represents the reasonably optimized NED plan. Net Benefits and BCR's will be presented in the tables below at 3.5% and 7% for the following 2 conditions: 1) before NFIP compliance measures and 2) after NFIP compliance measures (costs and benefits). Costs for cultural resource data recovery ($1.817 million) are excluded from the economic costs (up to 1% of the Federal project cost) in accordance with USACE guidance (ER 1105-2-100, Appendix E, paragraph E-63). Section 113 (Energy and Water Development Appropriations Act of 2006) related financial costs ($1.912 million) are also not included in the economic costs (see GRR for more detail).

While adding $195 million to the investment costs for NFIP compliance decreases the BCR substantially, Alternative 3 with NFIP compliance is still economically justified at the current interest rate.

The Recreation Plan is marginally economically justified at the current interest rate.

Table 5-1: Net Benefits and BCR – Before NFIP Compliance
(October 2013 Prices, $1,000's, 3.5% interest rate)

ITEM	Alternative 3		
	FRM	Recreation	TOTAL
Investment Costs:			
Project First Costs[1]	266,978	10,113	**277,091**
Less Sunk PED costs[2]	(42,200)	--	**(42,200)**
Interest During Construction	21,978	227	**22,205**
Total	***246,756***	***10,340***	**257,096**
Annual Cost:			
Interest and Amortization	10,520	441	**10,961**
OMRR&R	691	171	**862**
Subtotal	***11,211***	***612***	**11,823**
Annual Benefits:	***24,880***	***625***	**25,505**
Net Annual Benefits	***13,669***	***13***	***13,682***
Benefit-Cost Ratio	***2.2***	***1.0***	***2.2***

[1] Cultural resources data recovery costs ($1.82M) and Section 113 financial costs ($1.91M) are not included in economic costs per USACE policy
[2] Sunk PED Costs are for general reevaluation study, since authorization

Table 5-2: Net Benefits and BCR – Before NFIP Compliance
(October 2013 Prices, $1,000's, 7% interest rate)

ITEM	Alternative 3		
	FRM	Recreation	TOTAL
Investment Costs:			
Project First Costs[1]	266,978	10,113	**277,091**
Less Sunk PED costs[2]	(42,200)	--	**(42,200)**
Interest During Construction	46,090	456	**46,546**
Total	***270,868***	***10,569***	**281,437**
Annual Cost:			
Interest and Amortization	19,627	766	**20,393**
OMRR&R	691	171	**862**
Subtotal	***20,318***	***937***	**21,255**
Annual Benefits:	***24,880***	***625***	**25,505**
Net Annual Benefits	***4,562***	***(312)***	***4,250***
Benefit-Cost Ratio	***1.2***	***0.7***	***1.2***

[1] Cultural resources data recovery costs ($1.82M) and Section 113 financial costs ($1.91M) are not included in economic costs per USACE policy
[2] Sunk PED Costs are for general reevaluation study, since authorization

Table 5-3: Net Benefits and BCR – After NFIP Compliance
(October 2013 Prices, $1,000's, 3.5% interest rate)

ITEM	Alternative 3		
	FRM	Recreation	TOTAL
Investment Costs:			
Project First Costs[1]	266,978	10,113	**277,091**
NFIP Compliance Costs	195,000	--	**195,000**
Less Sunk PED costs[2]	(42,200)	--	**(42,200)**
Interest During Construction	25,601	227	**25,828**
Total	***445,379***	***10,340***	**455,719**
Annual Cost:			
Interest and Amortization	18,987	441	**19,428**
OMRR&R	691	171	**862**
Subtotal	***19,678***	***612***	**20,290**
Annual Benefits:	***25,899***	***625***	**26,524**
Net Annual Benefits	***6,221***	***13***	***6,234***
Benefit-Cost Ratio	***1.3***	***1.0***	***1.3***

[1] Cultural resources data recovery costs ($1.82M) and Section 113 financial costs ($1.91M) are not included in economic costs per USACE policy
[2] Sunk PED Costs are for general reevaluation study, since authorization

Table 5-4: Net Benefits and BCR – After NFIP Compliance
(October 2013 Prices, $1,000's, 7% interest rate)

ITEM	Alternative 3		
	FRM	Recreation	TOTAL
Investment Costs:			
Project First Costs[1]	266,978	10,113	**277,091**
NFIP Compliance Costs	195,000	--	**195,000**
Less Sunk PED costs[2]	(42,200)	--	**(42,200)**
Interest During Construction	52,800	456	**53,256**
Total	***472,578***	***10,569***	**483,147**
Annual Cost:			
Interest and Amortization	34,242	766	**35,008**
OMRR&R	691	171	**862**
Subtotal	***34,933***	***937***	**35,870**
Annual Benefits:	***25,899***	***625***	**26,524**
Net Annual Benefits	***(9,034)***	***(312)***	***(9,346)***
Benefit-Cost Ratio	***0.7***	***0.7***	***0.7***

[1] Cultural resources data recovery costs ($1.82M) and Section 113 financial costs ($1.91M) are not included in economic costs per USACE policy
[2] Sunk PED Costs are for general reevaluation study, since authorization

5.1.1 Probabilistic Net Benefits and BCR

The tables below summarize the net benefit analysis of Alternative 3 using varying confidence intervals in terms of benefits and costs (25%, 50% and 75%). Net Benefit and BCR mean values and ranges were calculated in a simple Monte-Carlo simulation using a triangular distribution in the annual benefits and the annual costs. While the varying confidence intervals presented here do not show the full range of possible Net Benefits and BCR's, it does show the most likely range and meets the intent of ER-1105-2-101. The expected values represent the best estimates using standard USACE policy while the confidence intervals represent our confidence that net benefits and BCR's will exceed the indicated values. This range of net benefits and BCR's represents the uncertainty in the benefit estimates associated with hydrology, hydraulics, and economics evaluated within the Hydrologic Engineering Center-Flood Damage Analysis (HEC-FDA) model along with the uncertainty in the cost estimates and contingencies used therein. The wider the range of benefits and costs, the more uncertain (and the less confidence associated with) the results.

Table 5-5: Probabilistic Net Benefits and BCR's – Before NFIP Compliance (FRM Only)
(October 2013 Prices, $1,000's, 3.5% interest rate)

Alternative	Probability Annual Cost exceeds indicated values (FRM only)			Probability Damage Reduced Exceeds Indicated Values			Annual Net Benefits			Benefit to Cost Ratio		
	75%	50%	25%	75%	50%	25%	75%	Expected	25%	75%	Expected	25%
No Action	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0
Alternative 3	10,035	10,549	10,949	15,397	24,111	35,087	4,702	13,669	24,827	1.5	2.2	3.4

Table 5-6 Probabilistic Net Benefits and BCR's – After NFIP Compliance (FRM Only)
(October 2013 Prices, $1,000's, 3.5% interest rate)

Alternative	Probability Annual Cost exceeds indicated values (FRM only)			Probability Damage Reduced Exceeds Indicated Values			Annual Net Benefits			Benefit to Cost Ratio		
	75%	50%	25%	75%	50%	25%	75%	Expected	25%	75%	Expected	25%
No Action	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0
Alternative 3	18,349	18,862	19,263	16,416	25,130	36,106	-2,306	6,221	17,419	0.9	1.3	1.9

5.2 CLIMATE CHANGE SENSITIVITY

While sea level rise over the 50 year period of analysis will not impact the Truckee Meadows study area due to its elevation above 4,000 feet and the fact that it does not drain into the ocean, climate change in general could have an effect. Current USACE policy is to consider the mitigation and adaptation investments and response to climate change.

Flood damages and net benefits are a significant factor in the selection of a preferred alternative. These factors are calculated using flood frequency estimates which are dependent on climate conditions. As a result, climate change could impact the selection of alternatives.

In order to evaluate the potential impact of climate change to damages and benefits within the Truckee Meadows, a sensitivity analysis was performed on one of the highest damage/benefit impact areas, EIA 8 (Airport), which contains the Reno International Airport and many surrounding commercial and industrial structures. The sensitivity analysis evaluated the potential increases and decreases in hydrologic flows associated with climate change over the 50 year period of analysis and the resulting changes in Equivalent Annual Damages and Benefits.

Key climate change assumptions as provided by the District hydrology section are as follows.

- Best estimate of climate change impacts over the next 50 years is equal to unregulated flow frequency curve.
- The "driest" estimate of climate change is a decrease in the "mean" of the unregulated flow frequency curve by 19%.
- The "wettest" estimate of climate change is an increase in the "mean" of the unregulated flow frequency curve by 40%.

The percentage decreases and increases in the mean were calculated by taking the antilog of the mean, increasing or decreasing by the given % change and then taking the log of this value, which was entered as the new mean in the Log Pearson III statistics. Numerical and graphical representation of this hydrology can be found in Enclosure 8.

Equivalent Annual Damages were re-run in HEC-FDA using the above criteria under the future conditions. The increased or decreased unregulated flows results in an increase or decrease in the probability-flow-stage-damage relationship, which then equates to an increase or decrease in future expected annual damages. These future damages are then discounted back to a present value using the current FY13 discount rate of 3.5% during the calculation of Equivalent Annual Damages. The table below summarizes the effects on Equivalent Annual Damages and benefits of each climate change scenario. The range of climate change impacts to annual benefits is from a 9% decrease to a 20% increase, with a most likely of no change. If the 9% decrease were to be extrapolated to the entire project benefits, the project BCR would drop from 2.2 to 2.1 without factoring in NFIP compliance. The BCR with NFIP compliance would drop from 1.3 to 1.2, which shows that even at the low (and unlikely) end, there would still be federal interest.

Table 5-7: EIA 8 Only - Climate Change
(October 2013 Prices, $1,000's, 3.5% interest rate)

Condition	Equivalent Annual Damages		Annual Benefits	% Change in Benefits due to Climate Change
	Without Project	NED		
Current NED (no climate change)	$14,218	$7,532	$6,686	–
Driest Climate Change NED	$12,889	$6,809	$6,080	-9%
Best Estimate Climate Change NED	$14,218	$7,532	$6,686	0%
Wettest Climate Change NED	$17,409	$9,375	$8,034	20%

6 REGIONAL ECONOMIC DEVELOPMENT BENEFITS

Results of this RED analysis are approximate based on previous detailed analysis of similar alternatives. While it has been updated to reflect some specific features/inputs of Alternative 3, those features/inputs not updated have insignificant differences and therefore the prior analysis provides a reasonable estimation of RED benefits.

Existing federal guidance, in particular the guidance from U.S. Army Corps of Engineers, does not go into great detail in describing either the definition or the procedures to determine Regional Economic Development (RED)[10]. Principles and Guidelines (P&G 1983) states that *the RED account registers changes in the distribution of regional economic activity that result from each alternative plan. Evaluations of regional effects are to be carried out using nationally consistent projections of income, employment, output and population.*

The Corps planning guidance notebook (ER 1105-2-100) states that while NED and Environmental Quality (EQ) accounts are required, display of RED is discretionary. The Corps 1991 NED Procedures Manual states there should be no doubt that RED benefits are real and legitimate benefits. The concern, from a federal perspective, is the fact that they are often offset by RED costs in other regions. But for the local community, these benefits are important and can help them in making their preferred planning decisions.

In this section, the evaluation of measurable monetary RED benefits (beyond the NED benefits described in prior sections) and the methodology and models used in determining RED will be described.

6.1 IMPLAN

For this study, the regional analysis model used is called IMPLAN. It was originally developed for the US Forest Service and is now administered and operated by the Minnesota IMPLAN Group Inc. It is an Input-Output model made up of both specific software and industry databases. Input-output accounting describes commodity flows from producers to intermediate and final consumers. Industries produce goods and services for final demand and purchase intermediate goods and services from other producers. A change in the output of final goods has the direct effect in terms of the final goods, an indirect effect regarding the intermediate goods, and an induced effect in terms of changes in household spending. What IMPLAN provides is the total final production by industry and commodity for specifically defined regions and mathematically derives the set of multipliers to determine not only the direct effects of production changes but also the indirect and induced effects. IMPLAN can estimate and report changes in employment, output, and value added (employee compensation, proprietors' income, property income and indirect business taxes) based on either a positive or negative impact.

10 The Institute of Water Resources released a draft White Paper titled *Review or Guidance and Procedures of Regional Economic Development and Other Social Effects, August 2006.* The analysis of RED for this study is consistent with this draft document.

6.2 WITHOUT PROJECT – FLOOD EVENT BASED INTERRUPTION OF LOCAL PRODUCTION

One the impacts not measured in the NED analysis was the potential income loss to the region if business operations were interrupted due to flooding in the area (see Section 4.5.3.1 of this Appendix). For this RED analysis, the study area was focused on the Truckee Meadows area. Total square footage of buildings by category was determined for each of the without project event frequency flood plains in the study. These categories were defined as:

- General Commercial
- Food Service
- Casino/Hotel
- Industrial
- Medical
- Offices
- Public Service
- General Retail

IMPLAN provided data at the Zip Code level of detail. Two IMPLAN data areas were developed based on collecting those zip codes where inundation of structures occurred for the 0.02% (500yr) event; one data set for each reach (does not include storm drainage). Total square footage within the IMPLAN areas for each of the eight categories described above was compared to the square footage of buildings within each flood plain event. Using this methodology, the percentage of production within the IMPLAN database by category that could be impacted by flooding based interruptions could be identified for each flood event. The percent of total production by flood plain for the area, by sector, is listed in Table 6-1 below.

Table 6-1: Production Percentages by Floodplain

Category	Percent of Production (based on total building sq ft) of IMPLAN Area Impacted by Flood Event					
	0.2% (500 Year)	0.5% (200 Year)	1% (100 Year)	2% (50 Year)	5% (20 Year)	10% (10 Year)
THE MEADOWS AREA						
General Commercial	74 %	57 %	30 %	6 %	1 %	1 %
Food Service	52 %	27 %	20 %	19 %	19 %	0
Casino/Hotel	100 %	8 %	1 %	0	0	0
Industrial	83 %	73 %	53 %	31 %	8 %	2 %
Medical	13 %	5 %	0	0	0	0
Offices	59 %	50 %	34 %	7 %	2 %	0
Public Service	29 %	15 %	9 %	3 %	0	0
General Retail	20 %	11 %	4 %	0	0	0

IMPLAN organizes production values into 500+ different sectors (not all of which have final products in our study area). Production output in IMPLAN represents total value for the entire year. Table 6-2 lists the potential loss in total value added for the entire year if all activities were interrupted within the given flood plain areas.

Table 6-2: Total Annual Production within each Flood Plain
(Values in $1,000's, October 2013 Prices)

EVENT	TOTAL ANNUAL VALUE ADDED WITHIN THE FLOOD PLAIN AREA			
	DIRECT	INDIRECT	INDUCED	TOTAL
THE MEADOWS AREA				
10% (10yr) Flood Plain Area	103,141	27,243	17,153	**$147,536**
5% (20yr) Flood Plain Area	170,631	46,077	29,821	**$246,529**
2% (50yr) Flood Plain Area	574,225	150,451	99,105	**$823,781**
1% (100yr) Flood Plain Area	1,356,750	356,060	241,708	**$1,954,519**
0.5% (200yr) Flood Plain Area	2,095,777	538,014	373,885	**$3,007,676**
0.2% (500yr) Flood Plain Area	2,315,848	556,736	404,716	**$3,277,300**

Actual losses are dependent on the total duration of the flood interruptions of business activities. These durations have a wide range of uncertainty and estimates by event are listed below. These durations were based on the number of structures impacted assuming a maximum of six months being the greatest interruption possible. Durations were then set proportional to estimated size of inventory impacted in the smaller flood plains.

Table 6-3: Business Interruption Duration Distribution

EVENT	MINIMUM ESTIMATED DURATION (IN DAYS)	MAXIMUM ESTIMATED DURATION (IN DAYS)	MOST LIKELY PERCENT OF ANNUAL TOTAL
THE MEADOWS AREA			
10% (10yr)	15	30	6 %
5% (20yr)	30	60	12 %
2% (50yr)	60	120	25 %
1% (100yr)	75	150	31 %
0.5% (200yr)	90	180	37 %
0.2% (500yr)	90	180	37 %

Monte Carlo simulations were run to estimate both mean and standard deviation for losses for single flood events based on the function of duration (triangular distribution) and value added for production within each flood plain. The values in Table 6-4 represent estimated losses in employee compensation, proprietors' income, property income and indirect business taxes (value added) from a single flood event.

Table 6-4: Business Losses by Event
(Values in $1,000's, October 2013 Prices)

EVENT	MEAN LOSSES	STANDARD DEVIATION OF LOSSES
THE MEADOWS AREA		
10% (10yr)	9,081	1,345
5% (20yr)	30,382	4,148
2% (50yr)	203,143	27,691
1% (100yr)	602,477	81,952
0.5% (200yr)	1,112,351	151,460
0.2% (500yr)	1,212,241	164,913

These frequency-damage relationships were then linked to their corresponding stages and entered into the HEC-FDA model to estimate RED benefits due to reduction in production losses due to flooding. Benefits were determined in the model based on frequency analysis. For each design level, damages were truncated for all lower frequencies to simulate project flood damage reduction accomplishments. RED benefits for the four design levels are shown in Table 6-5.

Table 6-5: Expected Annual RED Benefits- Reduction in Income Losses
(Values in $1,000's, October 2013 Prices)

ALTERNATIVE	EXPECTED ANNUAL DAMAGES - WITHOUT PROJECT	RESIDUAL ANNUAL DAMAGES - WITH PROJECT	ANNUAL RED-BENEFITS - REDUCED INCOME LOSSES
THE MEADOWS AREA			
3	21,589	10,993	**$10,595**

6.3 RED BENEFITS FROM CONSTRUCTION EXPENDITURES

In addition to RED benefits from reducing local production interruptions, under with project conditions benefits are injected in the region due to construction of the selected project. These benefits occur during construction as labor and the need for locally produced or distributed goods to complete the project contribute to the value added of the local economy.

For the alternatives, construction cost component values by category were identified and entered by sector in IMPLAN. IMPLAN uses Regional Purchase Coefficients (RPC's) to represent the proportion of the total supply of a good or service required to meet a particular industries intermediate demands and final demands that are produced locally. An example specific to this study is the RPG=0.668 for the Real Estate and engineering sector which translates to 67% of all the land acquisition and processing services required for the project can be met by local providers. These RPC's are used in the model to determine how much of the construction is met by local goods and services which in turn determines the percentage of RED benefits in the form of value added.

First costs, distributed by sector, were entered into the model and the corresponding RPC's were assigned. These are construction related costs for the entire project. For some categories, such as Real Estate (only the transaction/acquisition costs and not the land values were included in the model), the costs were limited to the local increment to eliminate internal local transfers. Construction elements were also assigned to three different IMPLAN reaches with their own regional coefficients and multipliers; the Meadows Area and Downstream (Vista to Wadsworth).

The value added from construction to the local area (including direct, indirect and induced benefits) was assumed to be equally distributed over a five year construction cycle and amortized based on a 50-year period of analysis and the FY13, 3.5% federal discount rate to provide average annual

equivalent construction based potential RED benefits as listed in Table 6-6. This analysis does not include construction costs associated with NFIP compliance.

Table 6-6: Average Annual RED Benefits from Construction (Values in $1,000's, October 2013 Prices)

ALTERNATIVE-COMPONENT	AREA INCREMENT FIRST COST	CONSTRUCTION VALUE ADDED			AVERAGE ANNUAL EQUIVALENT RED BENEFITS
		DIRECT	INDIRECT	INDUCED	
THE MEADOWS AREA					
3	181,135	68,853	24,287	18,484	4,976

These benefits are shown relative to overall study area project construction costs. On average, for every 100 dollars of construction cost, $65 is added to the local economy providing about $4 in average annual equivalent benefits.

6.4 EMPLOYMENT

As a result of construction of any of the Final Alternative Plans, 8.4 new jobs would be created in the Reno-Sparks region, with an additional 3.1 induced jobs created, per million dollars in construction within the study area[11]. Therefore, a one million dollar level of investment would support a total of 11.5 new jobs within the study area, resulting in the support over 2,000 jobs for complete construction of Alternative 3.

6.5 TOTAL RED BENEFITS

Combining the benefits for both reduction income losses due to flooding and construction shows the total monetary RED economic benefits to the local region for each alternative. These total annual RED benefits are shown in Table 6-7.

[11] Employment per million dollars expended figures were taken from the Local Sponsor's IMPLAN Analysis.

Table 6-7: Total Annual RED Benefits
(Values in $1,000's, October 2013 Prices, 50 Year Period of Analysis, 3.5% Federal Discount Rate)

ALTERNATIVE	ANNUAL RED BENEFITS		TOTAL ANNUAL RED BENEFITS
	FROM REDUCTION IN BUSINESS INTERRUPTION	FROM PROJECT CONSTRUCTION	
MEADOWS AREA			
3	$10,595	$4,976	$15,571

Enclosure 1: 2007 Valuation of Sample Structures and Regression Results

The structure values used in this analysis were based on improvement values listed in the Washoe County Tax Assessor database. During the Truckee Meadows F3 conference it was first noted that while the improvement values listed in the assessor data may be the most complete source available for structure valuation, they may tend to underestimate the 'true' depreciated replacement value. An initial check, prior to the F3 conference, was performed by the Washoe County assessor's office who found that the database values fell between the replacement cost new and the total depreciated values. At that time, it was determined that the values used were reasonable and no adjustment was made to the database.

As mentioned in the main appendix, further review and discussions with local appraisers led the team to believe that using the existing values without any adjustment would lead to an underestimation of the depreciated structure values. It was decided to re-evaluate a small sample of structures in detail and compare those values with the data from the flood plain database. A request was made to local appraisers in the Reno/Sparks area to propose to complete a depreciated replacement valuation of a supplied sample of parcels. The appraisers Robert E. Schiffmacher and Anthony J. Wren were selected to complete the valuation.

Sample Selection

The 12,000 plus structures in the flood plain inventory database were collected from each economic reach and then separated into four groups: Downtown Residential, I-395 to Vista Residential, Downtown Non-Residential, and I-395 to Vista Non-Residential. A random number generator sequence was created in the Excel Spreadsheet to select fifty parcels from each of the four groups (creating a sample of 200 parcels out of the original 9,000.) A few of these 200 had incomplete information (such as no site address) which would have made the field evaluation more difficult. A total of 45 parcels in each group (with the corresponding database information such as address, land use code, square footage) were provided to the selected appraisers. Their task was to determine the depreciated replacement values for 25 of the 45 from each group for a total of 100 individual sampled parcel values. The appraisers using field inspection evaluated and classified each building's construction methods, quality and condition. Several of the parcels had multiple buildings which were valued separately and then combined for comparison purposes. The next step, statistically evaluate the 100 new appraiser determined values with the initial 100 values in the sample.

Regression Analysis

Simple linear regressions were run on the entire sample and on various groupings using a basic statistic model. The goals were: 1) determine if the database values (when adjusted) are adequate for predicting the 'true' structure values, 2) determine what factors would be appropriate for adjusting the structures in each of the four groups. For the entire sample two regressions were run both with the y-intercept through the origin. One was a simple single variable regression the second included binary dummy variables for Downtown and Non-Residential.

Formulas

Y= Appraised Value
X= Econ Database Value
D1= Downtown (a value of 1 assigned for each parcel in Reach A and a value of 0 for all others)
D2= Non-Res (a value of 1 for all non-residential structures and a value of 0 for all residential

Simple Single Regression:
$Y= b_1X + U$ (U is the error term)

Regression with Dummy Variables:
$Y= b_1 (X) + b_2(D1) + b_3(D2) + U$ (U is the error term)

Results for the sample of 100 (with no intercept value)

$Y= b_1X + U$

b(1) = 1.53160 t-value = 49.858 (p-value 0.0) $R^2 = 0.9529$

$Y= b_1 (X) + b_2(D1) + b_3(D2) + U$

b(1) = 1.49621 t-value = 41.025 (p-value 0.0)
b(2) = 68354.9 t-value = 1.083 (p-value 0.28)
b(2) = 80713.2 t-value = 1.109 (p-value 0.27)
Adjusted $R^2 = 0.9539$

In both regressions, based on the R^2 it seems that the Econ Database Value can be a good fit for predicting the appraised value. The t-value indicates that b_1 (the factor we would use for adjusting the database values) is clearly significant. In the second equation, the t-values for the dummy variables appear that location (downtown vs. East I-395 reaches) and land use (non-residential vs. residential) may have an impact but have much lower confidence.

The next regressions were for the single variable equation but for 25 observations for each of the four groups.

Results for the sample of 25 (with no intercept value)

$Y= b_1X + U$

Downtown Non-Residential (25 observations)

b(1) = 1.54111 t-value = 24.248 (p-value 0.0) $R^2 = 0.9396$

I-395 to Vista Non-Residential (25 observations)

b(1) = 1.52433 t-value = 25.019 (p-value 0.0) $R^2 = 0.9468$

Downtown Residential (25 observations)

b(1) = 1.93106 t-value = 14.134 (p-value 0.0) $R^2 = 0.7444$

I-395 to Vista Residential (25 observations)

b(1) = 1.11909 t-value = 25.853 (p-value 0.0) $R^2 = 0.7941$

The fit of the residential functions is not quite as good as the non-residential but the limited observations still shows that econ database values can be used as a predictor of the true values. There is big difference (1.93 vs. 1.12) between the potential downtown and I395 to Vista factors for residential values. Based on the results above for non-residential structures, location does not seem to be the driving force. One additional regression was run for all 50 non-residential structures in the sample.

Results for the sample of 50 Non-Residential (with no intercept value)

$Y = b_1X + U$

b(1) = 1.53198 t-value = 35.214 (p-value 0.0) $R^2 = 0.9435$

Based on the summary of these regression results, the following factors were selected for adjusting the econ database structure values.

Downtown Residential = 1.931
I-395 to Vista Residential = 1.119
All Non-Residential= 1.532

The structure values and estimated damages found in this appendix were revised using these factors.

Enclosure 2: 2011 Valuation of Sample Structures and Regression Results

As mentioned in the main appendix, an Economic update was performed in June 2011 which compared the indexed 2007 to 2010 inventory values with a new detailed valuation of a stratified sample of 220 structures. This 2011 sample was stratified into more groups than the 2007 update. Focus was given to the highest valued structures within each group as these were the structures that had a bigger impact on the results of the Economic Analysis. The non-residential structures were divided into the following 4 groups: Commercial, Industrial, Public, and Casinos. Residential structures were also divided into 4 groups: Multi-Family Residential, and Single Family Residential low (below $100k), mid ($100k-$300k), and high (above $300k). Data collected in the field for each structure consisted of: construction class, construction quality, foundation height, number of stories, depreciation, and current building/land use. Square footages were obtained or verified using the latest Washoe County Assessor information and the ArcMap measuring tool in some cases. These structures were then valued using October 2010 Marshall and Swift construction values. For structures within the sample, the unique field observations and the resulting structure values and foundation heights were entered directly into the inventory import file. For those structures not in the sample, the results of a regression analysis were used as update factors by group,

Regression Analysis

Simple linear regressions were run on the entire sample and on various groupings using a basic statistic model. The goals were: 1) determine if the database values (when adjusted) are adequate for predicting the 'true' structure values, 2) determine what factors would be appropriate for adjusting the structures in each of the 8 groups. For purposes of the regression analysis any significant outliers and the highest overvalued and undervalued 1-3 observations were removed depending on the total group size.

Formulas

Y= 2011 Updated Value
X= Current 2010 Econ Database Value
U= Error Term

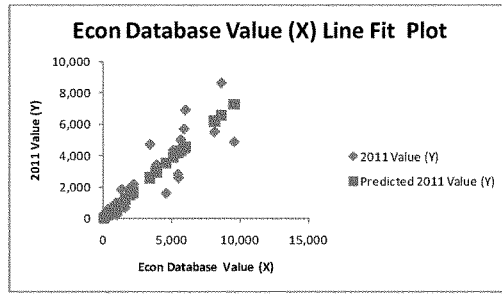
Simple Single Regression:

$$Y = b_1X + U$$

Results for each sample group (with no intercept value)

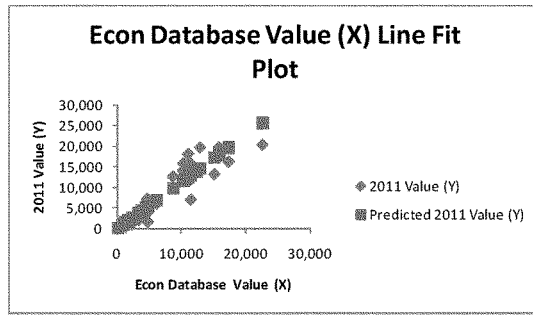
Commercial

Regression Observations = 34; b(1) = 0.76478; t-value = 17.495 (p-value 0.0); $R^2 = 0.90268$



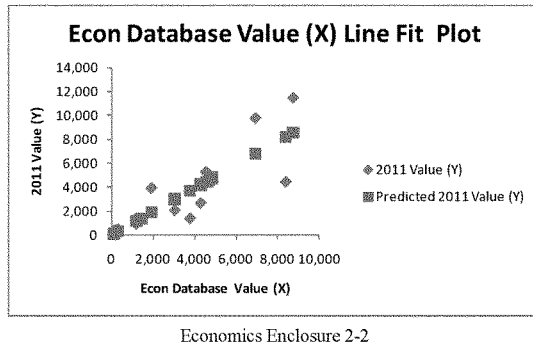
Industrial

Regression Observations = 38: b(1) = 1.13540; t-value = 24.659 (p-value 0.0); $R^2 = 0.94264$



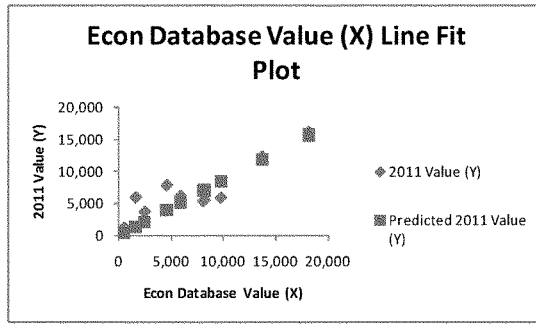
Public

Regression Observations = 17: b(1) = 0.98023; t-value = 9.88632 (p-value 0.0); $R^2 = 0.85933$



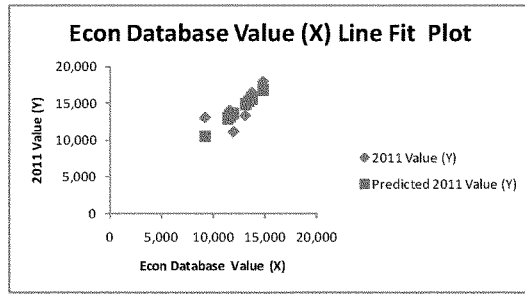
Casinos

Regression Observations = 10: b(1) = 0.86438; t-value = 10.268 (p-value 0.0); $R^2 = 0.92134$



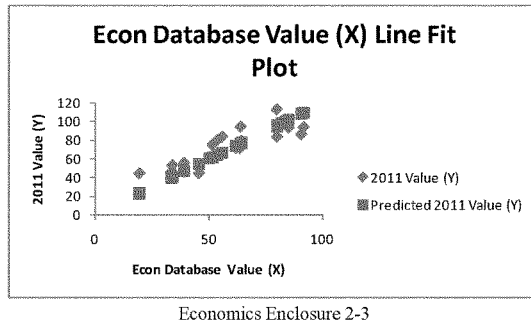
Multi-Family Residential

Regression Observations = 8: b(1) = 1.13536; t-value = 24.825 (p-value 0.0); $R^2 = 0.98877$

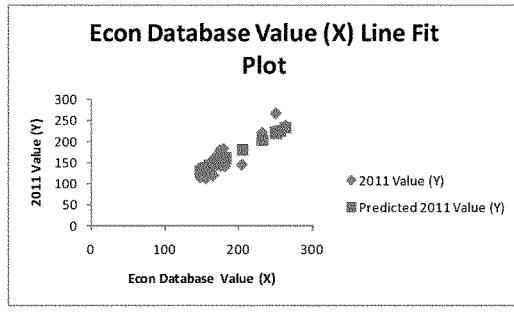


Single Family Residential Low (under $100k)

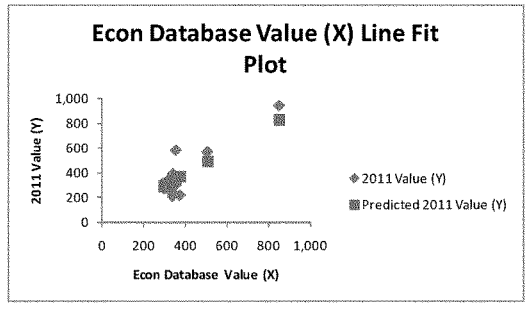
Regression Observations = 21; b(1) = 1.19448; t-value = 27.349 (p-value 0.0); $R^2 = 0.97396$



Single Family Residential Mid ($100k-$300k)
Regression Observations = 21: b(1) = 0.88096; t-value = 39.057 (p-value 0.0); $R^2 = 0.98706$



Single Family Residential High (over $300k)
Regression Observations = 21: b(1) = 0.97246; t-value = 20.507 (p-value 0.0); $R^2 = 0.95460$



For all 8 categories, based on the R^2, it seems that the indexed 2010 Economic Database Value can be a good fit for predicting the 2011 Updated values. The t-value indicates that b_1 (the factor we would use for adjusting the database values) is clearly significant for all categories.

A summary of the final 2011 Economic Updated Factors applied to the indexed 2010 inventory is shown below.

Summary of 2011 Inventory Update Factors

Category	# of Structures Sampled	Update Factor
Commercial	40	0.7648
Industrial	40	1.1354
Public	40	0.9802
Casino	15	0.8644
MFR	10	1.1353
SFR_Low	25	1.1945
SFR_Mid	25	0.8810
SFR_High	25	0.9725

Enclosure 3: Hydrology & Hydraulics Inputs

Along with the economic stage-damage functions, hydrologic and hydraulic functions are part of the flood damage analysis model. The probability-discharge/probability-stage relationship, stage-discharge relationship and non-damaging levee heights were provided and developed by the H&H members of the Truckee study team.

Exceedance Probability Curves and Period of Record

For EIA's 1, 2, 5, 8 and 9, analytical curves were used along with a regulated transform flow curve which states an outflow given a specific inflow. These curves were provided by the H&H section and are presented in the tables below. For all other impact areas, a probability-stage relationship was used due to backwater effects and those curves can be found in the Probability vs. Stage vs. Discharge section of this Enclosure.

Table E3-1: EIA's 1, 2, 5, 8, & 9 - Exceedance Probability Curves – With and Without Project

Exceedance Probability	Discharge (cfs)	Confidence Limit Curves Discharge (cfs) 95%	75%	25%	5%
0.9990	97	57	71	126	147
0.9900	179	114	138	225	258
0.9500	334	229	269	405	455
0.9000	478	342	394	570	633
0.8000	759	568	641	887	977
0.7000	1,080	831	925	1,249	1,369
0.5000	2,002	1,586	1,741	2,300	2,519
0.3000	3,883	3,074	3,366	4,513	5,008
0.2000	5,929	4,618	5,081	7,008	7,890
0.1000	10,968	8,215	9,160	13,411	15,516
0.0400	21,934	15,506	17,645	28,093	33,703
0.0200	35,039	23,703	27,403	46,442	57,211
0.0100	54,152	35,084	41,197	74,203	93,771
0.0040	92,870	56,912	68,188	132,777	173,327
0.0020	136,227	80,165	97,470	200,857	268,425
0.0001	619,087	308,743	398,701	1,034,160	1,519,505

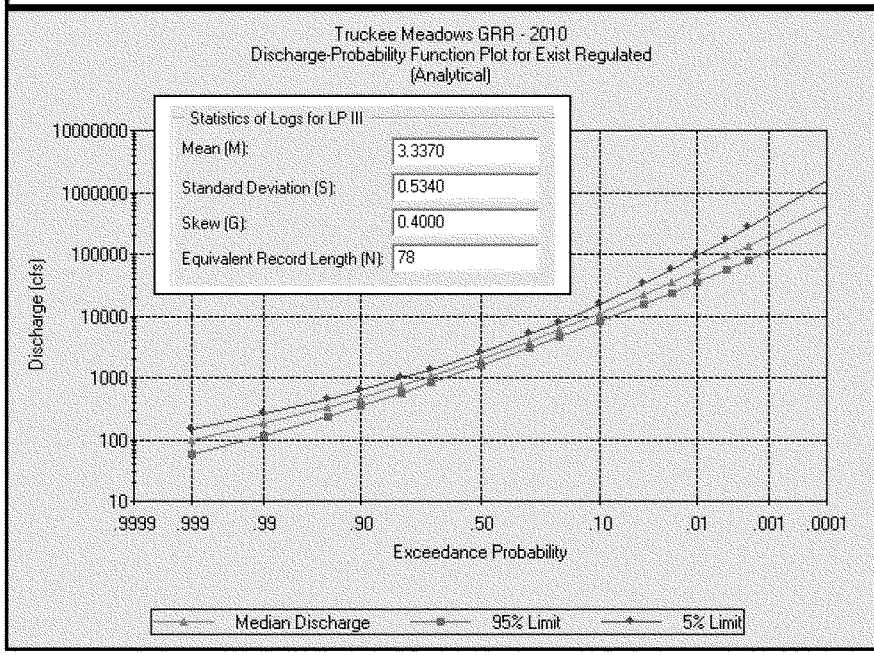


Table E3-2: Transform-Flow Curves EIA's 1, 2, 5, 8 & 9

EIA 1 & 2 – Transform-Flow Curve

Inflow (cfs)	Outflow (cfs)
478.0	631.0
2002.0	2300.0
3883.0	4000.0
5929.0	5922.0
10968.0	7509.0
21934.0	9877.0
35039.0	13679.0
54152.0	20674.0
92870.0	40237.0
136227.0	60840.0
197102.0	100500.0

EIA 5 – Transform Flow Curve

Inflow (cfs)	Outflow (cfs)
478.0	631.0
2002.0	2300.0
3883.0	4000.0
5929.0	5947.0
10968.0	7539.0
21934.0	9847.0
35039.0	13442.0
54152.0	19180.0
92870.0	27608.0
136227.0	29916.0
197102.0	39910.0

EIA 8 – Transform Flow Curve

Inflow (cfs)	Outflow (cfs)
478.0	631.0
2002.0	2300.0
3883.0	4000.0
5929.0	5948.0
10968.0	7540.0
21934.0	9899.0
35039.0	13717.0
54152.0	20769.0
92870.0	33541.0
136227.0	41706.0
197102.0	50662.0

EIA 9 – Transform Flow Curve

Inflow (cfs)	Outflow (cfs)
478.0	631.0
2002.0	2300.0
3883.0	4000.0
5929.0	5948.0
10968.0	7539.0
21934.0	9896.0
35039.0	13715.0
54152.0	20769.0
92870.0	31673.0
136227.0	36394.0
197102.0	46920.0

Probability vs. Stage vs. Discharge Curves

The tables below show the probability vs. stage vs. discharge relationships, used in the HEC-FDA model for with and without project conditions by EIA and stream group. The with project curves for EIA's 3-4 represent conditions prior to mitigation for induced NFIP flooding (pump station). For many impact areas, backwater effects limit the applicability of stage-discharge curves and thus probability-stage relationships were used within these reaches. Probability-Stage functions were used in EIA's 3, 4, 6, 7, 10, 11, 12, 13, 14 and 15 and stage-discharge was used for EIA's 1, 2, 5, 8 and 9. Stage represents elevation in channel and discharge is flow in channel. Curves were developed for each Economic Impact Area, for both without and with-project conditions.

Table E3-3: Truckee River - Without and With-Project Prob-Stage-Discharge Relationships

Truckee River Index Points						
EIA 5		Without-Project		With-Project		Project Impact
Frequency 1 in X Annual Chance	Exceedance Probability	Stage (ft-navd88)	Discharge (cfs)	Stage (ft-navd88)	Discharge (cfs)	Delta WSEL (ft)
5	0.2	4400.26	5947	4399.7	5947	-0.56
10	0.1	4401.46	7539	4400.63	7539	-0.83
20	0.05	4402.50	9128	4401.41	9094	-1.09
50	0.02	4404.73	13416	4403.43	13702	-1.30
100	0.01	4406.85	19135	4406.03	20738	-0.82
200	0.005	4409.45	27322	4409.94	32355	0.49
500	0.002	4411.36	29887	4413.86	40283	2.50
EIA 6		Without-Project		With-Project		
5	0.2	4387.17	5935	4387.23	5938	0.06
10	0.1	4388.99	7484	4389.14	7496	0.15
20	0.05	4390.85	8988	4390.82	9042	-0.03
50	0.02	4393.59	10944	4393.68	11044	0.09
100	0.01	4397.45	6427	4397.23	10732	-0.22
200	0.005	4400.90	7888	4401.36	14992	0.46
500	0.002	4408.31	11571	4408.96	25612	0.65
EIA 7		Without-Project		With-Project		
5	0.2	4386.47	6071	4386.54	6080	0.07
10	0.1	4388.17	7587	4388.34	7661	0.17
20	0.05	4390.00	9331	4389.96	9436	-0.04
50	0.02	4393.13	9434	4393.21	10432	0.08
100	0.01	4397.15	8493	4396.90	11445	-0.25
200	0.005	4400.58	8377	4401.02	15383	0.44
500	0.002	4408.13	18120	4408.65	25586	0.52
EIA 8		Without-Project		With-Project		
5	0.2	4428.54	5948	4428.50	5948	-0.04
10	0.1	4429.54	7539	4429.49	7539	-0.05
20	0.05	4430.37	9135	4430.31	9138	-0.06
50	0.02	4432.12	13716	4432.06	13718	-0.06
100	0.01	4433.73	20772	4434.06	20734	0.33
200	0.005	4436.78	31842	4437.10	32512	0.32
500	0.002	4439.23	41513	4440.01	43178	0.78
EIA 9		Without-Project		With-Project[12]		
5	0.2	4410.49	5948	---	---	---
10	0.1	4411.17	7539	---	---	---
20	0.05	4411.74	9133	---	---	---
50	0.02	4413.06	13715	---	---	---
100	0.01	4414.77	20771	---	---	---
200	0.005	4417.04	30973	---	---	---
500	0.002	4418.17	36444	---	---	---
EIA 11		Without-Project		With-Project		
5	0.2	4386.25	6584	4386.31	6630	0.06
10	0.1	4387.94	8077	4388.10	8236	0.16
20	0.05	4389.77	10298	4389.74	10121	-0.03

12 Index point number 9 was not used for the with-project condition since it was located in the exterior.

50	0.02	4392.67	15375	4392.80	15611	0.13
100	0.01	4396.42	22327	4396.30	22167	-0.12
200	0.005	4399.77	28181	4400.40	30253	0.63
500	0.002	4408.01	27275	4408.48	40205	0.47

Table E3-4: North Truckee Drain (NTD) - Without and With-Project Prob-Stage-Discharge Relationships

North Truckee Drain Index Points						
EIA 3 & 4		Without-Project		With-Project		Project Impact
Frequency 1 in X Annual Chance	Exceedance Probability	Stage (ft-navd88)	Discharge (cfs)	Stage (ft-navd88)	Discharge (cfs)	Delta WSEL (ft)
5	0.2	4387.39	110	4387.38	32	-0.01
10	0.1	4388.68	150	4388.72	72	0.04
20	0.05	4390.76	301	4390.99	183	0.23
50	0.02	4393.73	380	4394.82	306	1.09
100	0.01	4397.08	154	4397.62	150	0.54
200	0.005	4400.04	29	4399.77	-163	-0.27
500	0.002	4407.38	247	4407.41	-49	0.03

Table E3-5: Boynton Slough - Without and With-Project Prob-Stage-Discharge Relationships

Boynton Slough Index Point						
EIA 13		Without-Project		With-Project		Project Impact
Frequency 1 in X Annual Chance	Exceedance Probability	Stage (ft-navd88)	Discharge (cfs)	Stage (ft-navd88)	Discharge (cfs)	Delta WSEL (ft)
5	0.2	4387.53	112	4387.71	116	0.18
10	0.1	4388.74	122	4388.94	141	0.20
20	0.05	4390.76	289	4390.80	310	0.04
50	0.02	4393.71	553	4393.87	486	0.16
100	0.01	4397.59	366	4397.63	713	0.04
200	0.005	4401.08	803	4401.79	1477	0.71
500	0.002	4408.44	1797	4409.55	4450	1.11

Table E3-6: Steamboat Creek - Without and With-Project Prob-Stage-Discharge Relationships

Steamboat Creek Index Points						
EIA 10		Without-Project		With-Project		Project Impact
Frequency 1 in X Annual Chance	Exceedance Probability	Stage (ft-navd88)	Discharge (cfs)	Stage (ft-navd88)	Discharge (cfs)	Delta WSEL (ft)
5	0.2	4386.64	521	4386.74	553	0.10
10	0.1	4388.24	584	4388.44	667	0.20
20	0.05	4390.27	1176	4390.26	1220	-0.01
50	0.02	4393.39	1231	4393.63	1495	0.24
100	0.01	4397.52	3580	4397.43	4245	-0.09
200	0.005	4400.97	6496	4401.56	7351	0.59
500	0.002	4408.36	8776	4409.19	15127	0.83
EIA 12		Without-Project		With-Project		
5	0.2	4386.84	525	4386.95	556	0.11
10	0.1	4388.38	645	4388.59	672	0.21
20	0.05	4390.39	965	4390.41	1079	0.02
50	0.02	4393.41	1245	4393.67	1659	0.26
100	0.01	4397.55	2738	4397.51	3342	-0.04
200	0.005	4401.02	5001	4401.66	5804	0.64
500	0.002	4408.39	8054	4409.32	13042	0.93
EIA 14		Without-Project		With-Project		
5	0.2	4387.36	531	4387.49	570	0.13
10	0.1	4388.69	721	4388.85	695	0.16
20	0.05	4390.70	1553	4390.72	1501	0.02
50	0.02	4393.66	2393	4393.83	1982	0.17
100	0.01	4397.58	1354	4397.60	1957	0.02
200	0.005	4401.07	1914	4401.75	2921	0.68
500	0.002	4408.43	3537	4409.48	7023	1.05
EIA 15		Without-Project		With-Project		
5	0.2	4387.56	435	4387.52	176	-0.04
10	0.1	4388.8	599	4388.87	237	0.07
20	0.05	4390.80	1255	4390.78	702	-0.02
50	0.02	4393.69	1225	4393.86	1457	0.17
100	0.01	4397.59	1640	4397.62	1619	0.03
200	0.005	4401.07	2119	4401.76	1569	0.69
500	0.002	4408.43	3602	4409.49	3177	1.06

Enclosure 4: 2007 Screening of Measures and Alternatives

Downtown Reno Floodwall Analysis Results:

In 2007, benefits were estimated based on the construction of different size floodwalls to protect EIA 1. Floodwall heights were modified in the HEC-FDA model to simulate different floodwall sizes. Using this methodology, HEC-FDA truncates the damaging events below the top of the floodwall (with uncertainty in flood parameters of discharge and stage) reducing losses for these events to zero. When the floodwall is exceeded, damages for that event are equivalent to the without project condition for the given event. Benefits are equal to the without project minus the with-project residual damages.

Results are shown in Table E3-1 for floodwalls targeting three elevations: 1) floodwall height equal to the 2% probability exceedance (50-yr) design, 2) floodwall height providing minimum 1% ACE FEMA requirements (conditional non-exceedance probability for the 1% event = 90%), and 3) floodwall height equal to the 0.8547% probability exceedance (117yr) design. Table E3-2 shows benefits for alternatives with bridge replacement added to the floodwall increments. Based on preliminary costs, floodwall improvements would be significantly higher than bridge replacement. For formulation and the calculation of incremental benefits, floodwalls would be added as the next increment following the bridge replacement increment. The incremental average annual benefits for each wall height in would be: $126,000 for a 50-year flood wall design, $1,027,000 for 100-year floodwall design and $2,320,000 for a 117-year floodwall design (2007 prices). Costs for all of these floodwall heights were found to exceed the benefits, resulting in a negative net benefit, and removing floodwalls from NED consideration in EIA 1.

Table E4-1: Expected Annual Damages EIA 1 (Downtown Reno) Without Project and With Floodwall Improvements (October 2007 Prices, $1,000s)

Floodwall	EAD Without Project	EAD With Floodwall	With Project Benefits (Flood Damage Reduction)
1) 1/50 ACE Floodwall Design (Top of floodwall providing 90% CNP for the 2% event)	5,329	4,857	472
2) 1/100 ACE Floodwall Design (Top of floodwall providing 90% CNP for the 1% event)	5,329	3,813	1,511
3) 1/117 ACE Floodwall Design (Top of floodwall providing 90% CNP for the 0.8547% event)	5,329	2,313	3,016

Table E4-2: Expected Annual Damages Economic Impact Area 1 (Downtown Reno) Without Project and With Floodwall Improvements + Bridge Replacement (October 2007 Prices, $1,000s)

Floodwall	EAD Withou t Project	EAD With Project	With Project Benefits (Flood	With Project Benefits (Advance	With Project Benefits Total
1B) 1/50 ACE Floodwall Design + Bridge Replacement	5,329	4,175	1,154	738	1,892
2B) 1/100 ACE Floodwall Design + Bridge Replacement	5,329	3,274	2,055	738	2,793
3B) 1/117 ACE Floodwall Design + Bridge Replacement	5,329	1,981	3,348	738	4,086
Bridge Replacement for Sierra and Virginia Only (Lake removed but not replaced)					
1C) 1/50 ACE Floodwall Design + Bridge Replacement (Sierra &	5,329	4,175	1,154	647	1,801
2C) 1/100 ACE Floodwall Design + Bridge Replacement (Sierra &	5,329	3,274	2,055	647	2,702
3C) 1/117 ACE Floodwall Design + Bridge Replacement (Sierra &	5,329	1,981	3,348	647	3,995

Enclosure 5: Downstream Economic Analysis Rainbow Bend to Wadsworth

The economic study area for determining flood damage reduction benefits was initially limited to the reaches from Downtown Reno to Vista. Under without project conditions, flooding can occur downstream of Vista although these damages are significantly lower than in the Economic Impact Areas 2-15, primarily due to the fact that there are few structures downstream. In 2007, an Economic Analysis was performed to determine if any flood risk management features would be economically justified to include in the overall project. The result of the analysis below was that the potential benefits of reducing flooding from the Truckee River for these areas were found to not justify the potential costs, and downstream was to be considered for Hydraulic Mitigation and a Takings Analysis only. This analysis is presented in October 2007 price levels.

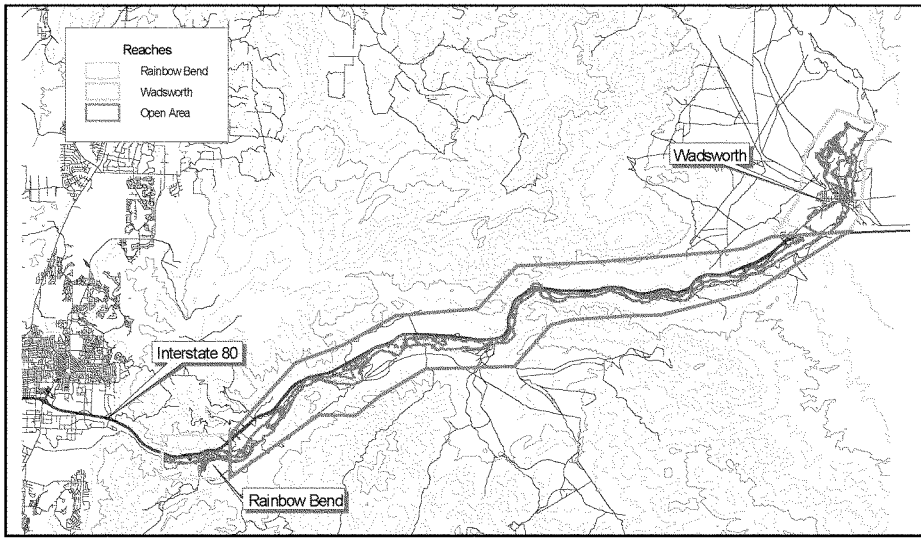
ADDITIONAL POTENTIAL STUDY AREA (RAINBOW BEND TO WADSWORTH)

Three reaches were added to the study downstream of Vista. Descriptions are provided in Table E4-1. A basic map of the area is shown in Figure E4-1.

Table E5-1: Truckee Meadows Downstream Of Vista Reach Delineation

Economic Impact Areas	Stream	Notes
DS I—Rainbow Bend	Lower Truckee River	Primarily residential community on right bank of the Truckee River, Storey County Nevada
DS II—Open Area	Lower Truckee River	Few structures scattered along the Truckee River, vast area is mostly vacant land running east along I-80 Parts in Storey and Washoe Counties
DS III—Wadsworth	Lower Truckee River	Small Community along the "Big Bend" of the Truckee River, includes part of the Pyramid Lake Paiute Tribe

Figure E5-1: Downstream Impact Areas



FLOODPLAINS

Without project flood plains were provided delineating areas of inundation for these three economic reaches. Depths were given for events to include the 20%, 10%, 2%, 1%, 0.5%, 0.2% annual chance events.

STRUCTURAL INVENTORY (DOWNSTREAM OF VISTA)

All structures in the flood plain were determined using GIS comparing aerial mapping and flood plain boundaries. Detailed parcel data for this area was not available. Each structure was identified and given coordinates to assign flood plain depths. Building first floor square footages were determined by measuring footprint areas on the aerial maps. Field visitation was performed to identify land use types, structure characteristics, foundation heights and overall condition. Depreciated replacement values for all structures were determined using Marshall Swift Valuation. The number of structures by value, land use and reach are shown in the tables below.

Table E5-2: Structural Inventory Within the Largest (1/500 ACE Alt-3) Flood plain Analyzed - Rainbow Bend
(Values in $ 1,000's, October 2007 Prices)

	NUMBER OF STRUCTURES	STRUCTURE VALUE	CONTENT VALUE	TOTAL VALUE
RESIDENTIAL	305	26,433	13,216	39,648
COMMERCIAL	1	3,042	3,042	6,084
OUT-BUILDINGS	7	45	30	75
PUBLIC	2	5	2	7
INDUSTRIAL	0	0	0	0
TOTAL	315	29,525	16,290	45,815

Table E5-3: Structural Inventory Within the Largest (1/500 ACE Alt-3) Flood plain Analyzed - Open Area
(Values in $ 1,000's, October 2007 Prices)

	NUMBER OF STRUCTURES	STRUCTURE VALUE	CONTENT VALUE	TOTAL VALUE
RESIDENTIAL	21	2,470	1,235	3,705
COMMERCIAL	2	2,374	2,374	47,48
OUT-BUILDINGS	39	99	67	166
PUBLIC	9	2,658	1,328	3,986
INDUSTRIAL	0	0	0	0
TOTAL	71	7,601	5,004	12,604

Table E5-4: Structural Inventory Within the Largest (1/500-ACE Alt-3) Flood plain Analyzed - Wadsworth
(Values in $ 1,000's, October 2007 Prices)

	NUMBER OF STRUCTURES	STRUCTURE VALUE	CONTENT VALUE	TOTAL VALUE
RESIDENTIAL	79	3,549	1,775	5,323
COMMERCIAL	0	0	0	0
OUT-BUILDINGS	42	199	133	332
PUBLIC	4	777	388	1,165
INDUSTRIAL	2	240	386	626
TOTAL	127	4,765	2,682	7,446

DAMAGES BY SINGLE EVENT

Modeled depth of flooding was assigned to each structure by event using GIS. Damages were then calculated using depth-damage functions by land/building use to calculate mean damages and standard deviation using the same HEC-FDA models used in the Meadows Area. The mean damages from the model were linked to channel stage and are displayed in the tables below. Alternative 3 results in the highest stages downstream and thus it was selected for defining the full range of damages. Note that the tables include damages under both without and with Alternative 3 stages. Alternative 3, without including any mitigation measures, produced higher stages than the W/O project events and these events were used for defining the full range of possible damages.

Table E5-5— Rainbow Bend Mean Damages—By Category By Event and Stage ($1,000s)

Frequency (Condition)	Stage	RES	COM	Out Building	PUB	AUTO	EMER	ROAD
1/10 (Alt-3)	4349.3	0	0	0	0	0	0	0
1/20 (W/O)	4350.2	15	0	0	0	0	1	6
1/50 (W/O)	4352.2	47	0	0	0	5	3	9
1/100 (W/O)	4354.2	81	0	1	0	8	7	18
1/100 (Alt-3)	4355.9	254	0	5	0	19	21	31
1/200 (W/O)	4356.8	1,005	0	12	1	100	78	39
1/200 (Alt-3)	4357.6	2,264	439	15	2	306	183	51
1/500 (W/O)	4359.4	8,742	2,622	24	2	1,170	633	73
1/500 (Alt-3)	4359.6	9,579	2,827	24	2	1,231	669	76

Table E5-6— Open Area: Mean Damages—By Category By Event and Stage ($1,000s)

Frequency (Condition)	Stage	RES	COM	Out Building	PUB	AUTO	EMER	ROAD
1/20 (Alt-3)	4196.9	0	0	0	0	0	0	0
1/50 (W/O)	4198.2	0	0	2	5	0	0	3
1/100 (W/O)	4199.8	15	133	7	7	1	2	46
1/100 (Alt-3)	4201.2	45	258	12	192	11	7	55
1/200 (W/O)	4202.4	109	632	16	236	20	12	57
1/200 (Alt-3)	4203.5	211	751	24	322	34	20	65
1/500 (W/O)	4206.4	1,004	2,112	46	780	80	55	79
1/500 (Alt-3)	4206.6	1,084	2,203	47	825	85	58	81

Table E5-7: Wadsworth Mean Damages—By Category By Event and Stage ($1,000s)

Frequency (Condition)	Stage	RES	IND	Out Building	PUB	AUTO	EMER	ROAD
1/10 (W/O)	4057.7	0	0	0	0	0	0	0
1/20 (W/O)	4058.8	0	0	1	0	0	0	1
1/50 (W/O)	4060.6	15	0	2	0	0	5	1
1/100 (W/O)	4062.0	53	0	7	1	9	14	7
1/100 (Alt-3)	4062.9	209	0	24	1	51	39	24
1/200 (W/O)	4063.7	668	69	43	6	199	105	34
1/200 (Alt-3)	4064.3	1,038	92	50	6	294	156	39
1/500 (W/O)	4065.6	2,319	219	103	95	383	215	56
1/500 (Alt-3)	4065.7	2,383	224	107	135	389	218	60

Expected Annual Damages (EAD) Downstream -Without Project

In the HEC-FDA model, the stage damage functions listed above were integrated with the discharge-exceedance probability functions and the stage-discharge functions utilizing Monte Carlo simulation. The derived probability-damage function was then integrated in the model to determine expected annual damages under without project conditions. Results from these runs are displayed in Table E4-8. In comparison to losses in downtown Reno or the Truckee Meadows area, these expected annual damages from Vista to Wadsworth under without project conditions are not significant and flood damage reduction benefits of any project would be minimal in comparison. Flooding from other sources than the Truckee River such as the Long Valley Creek near Rainbow Bend would have far greater impact and have a higher probability of flood risk. Based upon these minimal Annual damages, it was determined that there would be no reasonably cost effective measures to include the downstream reaches as part of the overall project benefits.

Table E5-8: Expected Annual Damages Without Project—By Category
(October 2007 Prices, $1,000s)

Economic Reach	RES	COM	Out-Building	PUB	IND	AUTO	EMER	ROAD	TOTAL
Downstream of Vista									
Rainbow Bend	55	15	0	0	0	7	4	1	83
Open Area	5	13	0	5	0	1	0	1	24
Wadsworth	16	0	1	0	1	3	2	1	24
Total	76	28	1	5	1	11	6	3	131

Expected Annual Damages (EAD) –With Upstream Projects – No Mitigation

To see if any of the upstream alternatives had negative economic impacts on the reaches downstream of Vista, the HEC-FDA model was run using with project frequency-stage relationships. The model was modified to include changes in flows and stage for all corresponding frequencies to represent conditions without any mitigation features added to a given alternative from Vista to Wadsworth. The results of these non-mitigated runs are displayed in the tables below. For any given alternative where benefits are shown to be negative, the indication is that mitigation measures may be required to restore flood risk to the prior without project conditions. The final alternatives will include any hydraulic mitigation components required and these will be included in the alternatives project costs.

Table E5-9: Expected Annual Damages Under With Project Conditions Rainbow Bend
(October 2007 Prices, $1,000s)

Project Conditions	EAD Without Project	EAD With Upstream Project	Benefits Change in Damages
Alt 3 -1/50 ACE	83	100	-17
Alt 3-1/100 ACE	83	103	-20
Alt 3-1/117 ACE	83	106	-23

Table E5-10: Expected Annual Damages Under With Project Conditions Open Area
(October 2007 Prices, $1,000s)

Project Conditions	EAD Without Project	EAD With Upstream Project	Benefits Change in Damages
Alt 3 -1/50 ACE	24	32	-8
Alt 3-1/100 ACE	24	33	-9
Alt 3-1/117 ACE	24	33	-9

Table E5-11: Expected Annual Damages Under With Project Conditions Wadsworth
(October 2007 Prices, $1,000s)

Project Conditions	EAD Without Project	EAD With Upstream Project	Benefits Change in Damages
Alt 3 -1/50 ACE	24	31	-7
Alt 3-1/100 ACE	24	32	-8
Alt 3-1/117 ACE	24	32	-8

Enclosure 6: Supporting Economic Data

Damageable Property by Economic Impact Area (Oct 2013 Price Levels)

Table E6-1: EIA 1 (Downtown) Structure Values by Event ($1,000's)

Damage Category	Annual Chance Exceedance Flood Event						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
	Structure Value						
RES	0	0	804	8,631	40,415	179,041	362,086
COM	0	0	0	1,403	52,987	334,682	459,547
CASINOS	0	0	0	0	75,651	234,921	579,744
PUB	0	0	117	25,461	82,364	116,071	151,614
IND	0	0	0	0	301	19,961	50,748
TOTAL STRUCTURE	*$0*	*$0*	*$922*	*$35,495*	*$251,717*	*$884,675*	*$1,603,740*
	Content Value						
RES	0	0	402	4,315	20,207	89,521	181,043
COM	0	0	0	1,403	52,987	334,682	459,547
CASINOS	0	0	0	0	117,258	364,127	898,604
PUB	0	0	59	12,730	41,182	58,035	75,807
IND	0	0	0	0	1,371	54,722	118,774
TOTAL CONTENT	*$0*	*$0*	*$461*	*$18,449*	*$233,006*	*$901,087*	*$1,733,775*
TOTAL VALUE	$0	$0	$1,382	$53,944	$484,723	$1,785,762	$3,337,515

Table E6-2: EIA 2 (North I-80) Structure Values by Event ($1,000's)

Damage Category	Annual Chance Exceedance Flood Event						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
	Structure Values						
RES	0	104	104	119	119	85,104	86,739
COM	0	0	0	0	0	64,483	64,728
CASINOS	0	0	0	0	0	53,016	53,016
PUB	0	0	0	0	0	29,717	30,221
IND	0	0	0	0	0	15,662	15,662
TOTAL STRUCTURE	*$0*	*$104*	*$104*	*$119*	*$119*	*$247,983*	*$250,367*
	Content Values						
RES	0	52	52	59	59	42,552	43,369
COM	0	0	0	0	0	64,483	64,728
CASINOS	0	0	0	0	0	82,175	82,175
PUB	0	0	0	0	0	14,859	15,111
IND	0	0	0	0	0	65,143	65,143
TOTAL CONTENT	*$0*	*$52*	*$52*	*$59*	*$59*	*$269,212*	*$270,526*
TOTAL VALUE	$0	$156	$156	$178	$178	$517,195	$520,893

Table E6-3: EIA 3 (West NTD) Structure Values by Event ($1,000's)

Damage Category	Annual Chance Exceedance Flood Event						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
	Structure Values						
RES	0	0	0	23,379	58,446	208,397	357,137
COM	0	0	0	339	8,373	52,476	77,212
CASINOS	0	0	0	0	0	5,659	9,239
PUB	0	0	0	54	542	10,593	16,362
IND	0	0	0	0	0	40,669	46,943
TOTAL STRUCTURE	***$0***	***$0***	***$0***	***$23,771***	***$67,361***	***$317,794***	***$506,894***
	Content Values						
RES	0	0	0	11,689	29,223	104,198	178,569
COM	0	0	0	339	8,373	52,476	77,212
CASINOS	0	0	0	0	0	8,772	14,320
PUB	0	0	0	27	271	5,296	8,181
IND	0	0	0	0	0	131,295	153,398
TOTAL CONTENT	***$0***	***$0***	***$0***	***$12,055***	***$37,867***	***$302,038***	***$431,680***
TOTAL VALUE	**$0**	**$0**	**$0**	**$35,827**	**$105,227**	**$619,831**	**$938,573**

Table E6-4: EIA 4 (East NTD) Structure Values by Event ($1,000's)

Damage Category	Annual Chance Exceedance Flood Event						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
	Structure Values						
RES	0	0	822	1,203	2,061	39,560	92,981
COM	0	0	0	0	4,040	9,636	30,753
CASINOS	--	--	--	--	--	--	--
PUB	0	0	0	0	212	9,322	14,152
IND	0	0	0	0	38,423	172,624	279,608
TOTAL STRUCTURE	***$0***	***$0***	***$822***	***$1,203***	***$44,735***	***$231,142***	***$417,493***
	Content Values						
RES	0	0	411	602	1,030	19,780	46,490
COM	0	0	0	0	4,040	9,636	30,753
CASINOS	--	--	--	--	--	--	--
PUB	0	0	0	0	106	4,661	7,076
IND	0	0	0	0	193,824	839,898	1,436,864
TOTAL CONTENT	***$0***	***$0***	***$411***	***$602***	***$199,000***	***$873,975***	***$1,521,184***
TOTAL VALUE	**$0**	**$0**	**$1,233**	**$1,805**	**$243,734**	**$1,105,118**	**$1,938,677**

Table E6-5: EIA 5 (Sparks West) Structure Values by Event ($1,000's)

Damage Category	Annual Chance Exceedance Flood Event						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
	Structure Values						
RES	0	0	0	146	1,222	2,746	2,858
COM	0	0	0	0	0	103,243	103,563
CASINOS	0	0	0	0	0	0	6,217
PUB	0	224	235	427	508	2,388	2,649
IND	0	4,428	16,761	68,769	126,836	223,531	298,834
TOTAL STRUCTURE	***$0***	***$4,652***	***$16,996***	***$69,343***	***$128,566***	***$331,907***	***$414,121***
	Content Values						
RES	0	0	0	73	611	1,373	1,429
COM	0	0	0	0	0	103,243	103,563
CASINOS	0	0	0	0	0	0	9,636
PUB	0	112	118	214	254	1,194	1,325
IND	0	19,348	75,495	277,410	495,703	878,144	1,211,083
TOTAL CONTENT	***$0***	***$19,460***	***$75,612***	***$277,697***	***$496,568***	***$983,954***	***$1,327,036***
TOTAL VALUE	**$0**	**$24,111**	**$92,608**	**$347,040**	**$625,134**	**$1,315,862**	**$1,741,157**

Table E6-6: EIA 6 (Sparks East) Structure Values by Event ($1,000's)

Damage Category	Annual Chance Exceedance Flood Event						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
	Structure Values						
RES	0	0	0	0	320	320	320
COM	0	0	2,231	10,558	18,698	20,201	20,661
CASINOS	--	--	--	--	--	--	--
PUB	0	469	704	1,002	2,125	2,409	2,409
IND	0	9,667	81,944	268,791	418,936	447,564	447,564
TOTAL STRUCTURE	***$0***	***$10,136***	***$84,878***	***$280,351***	***$440,080***	***$470,495***	***$470,955***
	Content Values						
RES	0	0	0	0	160	160	160
COM	0	0	2,231	10,558	18,698	20,201	20,661
CASINOS	--	--	--	--	--	--	--
PUB	0	234	352	501	1,063	1,204	1,204
IND	0	50,999	417,600	1,298,919	2,016,026	2,130,221	2,130,221
TOTAL CONTENT	***$0***	***$51,234***	***$420,183***	***$1,309,978***	***$2,035,947***	***$2,151,787***	***$2,152,247***
TOTAL VALUE	**$0**	**$61,369**	**$505,061**	**$1,590,329**	**$2,476,027**	**$2,622,281**	**$2,623,202**

Table E6-7: EIA 7 (Larkin Circle) Structure Values by Event ($1,000's)

Damage Category	Annual Chance Exceedance Flood Event						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
	Structure Values						
RES	--	--	--	--	--	--	--
COM	0	0	0	986	1,884	2,602	2,602
CASINOS	--	--	--	--	--	--	--
PUB	0	0	0	11	57	194	194
IND	0	0	0	10,527	21,923	22,626	22,626
TOTAL STRUCTURE	***$0***	***$0***	***$0***	***$11,525***	***$23,864***	***$25,422***	***$25,422***
	Content Values						
RES	--	--	--	--	--	--	--
COM	0	0	0	986	1,884	2,602	2,602
CASINOS	--	--	--	--	--	--	--
PUB	0	0	0	6	29	97	97
IND	0	0	0	47,487	105,227	109,148	109,148
TOTAL CONTENT	***$0***	***$0***	***$0***	***$48,479***	***$107,139***	***$111,847***	***$111,847***
TOTAL VALUE	**$0**	**$0**	**$0**	**$60,003**	**$131,003**	**$137,269**	**$137,269**

Table E6-8: EIA 8 (Airport) Structure Values by Event ($1,000's)

Damage Category	Annual Chance Exceedance Flood Event						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
	Structure Values						
RES	0	0	0	3,525	20,008	28,012	29,560
COM	0	0	0	263,526	306,145	329,671	337,623
CASINOS	0	0	0	0	0	12,913	12,913
PUB	0	0	0	557	776	1,634	2,159
IND	0	0	0	164,597	254,490	271,243	274,428
TOTAL STRUCTURE	***$0***	***$0***	***$0***	***$432,204***	***$581,420***	***$643,472***	***$656,682***
	Content Values						
RES	0	0	0	1,762	10,004	14,006	14,780
COM	0	0	0	263,526	306,145	329,671	337,623
CASINOS	0	0	0	0	0	20,015	20,015
PUB	0	0	0	278	388	817	1,080
IND	0	0	0	682,407	1,065,266	1,138,715	1,145,617
TOTAL CONTENT	***$0***	***$0***	***$0***	***$947,974***	***$1,381,803***	***$1,503,223***	***$1,519,114***
TOTAL VALUE	**$0**	**$0**	**$0**	**$1,380,178**	**$1,963,223**	**$2,146,695**	**$2,175,796**

Table E6-9: EIA 9 (Truckee South Overbank) Structure Values by Event ($1,000's)

Damage Category	Annual Chance Exceedance Flood Event						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
	Structure Values						
RES	0	0	0	163	163	163	163
COM	0	0	0	532	532	532	532
CASINOS	--	--	--	--	--	--	--
PUB	0	0	0	1,237	1,237	1,237	1,237
IND	0	0	1,413	10,249	10,249	10,249	10,249
TOTAL STRUCTURE	***$0***	***$0***	***$1,413***	***$12,181***	***$12,181***	***$12,181***	***$12,181***
	Content Values						
RES	0	0	0	81	81	81	81
COM	0	0	0	532	532	532	532
CASINOS	--	--	--	--	--	--	--
PUB	0	0	0	619	619	619	619
IND	0	0	2,261	33,364	33,364	33,364	33,364
TOTAL CONTENT	***$0***	***$0***	***$2,261***	***$34,597***	***$34,597***	***$34,597***	***$34,597***
TOTAL VALUE	$0	$0	$3,675	$46,777	$46,777	$46,777	$46,777

Table E6-10: EIA 10 (UNR Farms) Structure Values by Event ($1,000's)

Damage Category	Annual Chance Exceedance Flood Event						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
	Structure Values						
RES	0	0	0	36	234	234	234
COM	0	0	0	0	338	338	338
CASINOS	--	--	--	--	--	--	--
PUB	0	0	0	88	88	88	88
IND	--	--	--	--	--	--	--
TOTAL STRUCTURE	***$0***	***$0***	***$0***	***$125***	***$660***	***$660***	***$660***
	Content Values						
RES	0	0	0	18	117	117	117
COM	0	0	0	0	338	338	338
CASINOS	--	--	--	--	--	--	--
PUB	0	0	0	44	44	44	44
IND	--	--	--	--	--	--	--
TOTAL CONTENT	***$0***	***$0***	***$0***	***$62***	***$499***	***$499***	***$499***
TOTAL VALUE	$0	$0	$0	$187	$1,158	$1,158	$1,158

Table E6-11: EIA 11 (TMWRF) Structure Values by Event ($1,000's)

Damage Category	Annual Chance Exceedance Flood Event						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
	Structure Values						
RES	--	--	--	--	--	--	--
COM	--	--	--	--	--	--	--
CASINOS	--	--	--	--	--	--	--
PUB	--	--	--	--	--	--	--
IND	0	0	0	0	0	0	18,060
TOTAL STRUCTURE	***$0***	***$0***	***$0***	***$0***	***$0***	***$0***	***$18,060***
	Content Values						
RES	--	--	--	--	--	--	--
COM	--	--	--	--	--	--	--
CASINOS	--	--	--	--	--	--	--
PUB	--	--	--	--	--	--	--
IND	0	0	0	0	0	0	28,896
TOTAL CONTENT	***$0***	***$0***	***$0***	***$0***	***$0***	***$0***	***$28,896***
TOTAL VALUE	$0	$0	$0	$0	$0	$0	$46,956

Table E6-12: EIA 12 (North Hidden Valley) Structure Values by Event ($1,000's)

Damage Category	Annual Chance Exceedance Flood Event						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
	Structure Values						
RES	0	0	0	350	1,165	14,634	25,493
COM	--	--	--	--	--	--	--
CASINOS	--	--	--	--	--	--	--
PUB	--	--	--	--	--	--	--
IND	--	--	--	--	--	--	--
TOTAL STRUCTURE	***$0***	***$0***	***$0***	***$350***	***$1,165***	***$14,634***	***$25,493***
	Content Values						
RES	0	0	0	175	582	7,317	12,746
COM	--	--	--	--	--	--	--
CASINOS	--	--	--	--	--	--	--
PUB	--	--	--	--	--	--	--
IND	--	--	--	--	--	--	--
TOTAL CONTENT	***$0***	***$0***	***$0***	***$175***	***$582***	***$7,317***	***$12,746***
TOTAL VALUE	$0	$0	$0	$525	$1,747	$21,951	$38,239

Table E6-13: EIA 13 (Steamboat South) Structure Values by Event ($1,000's)

Damage Category	Annual Chance Exceedance Flood Event						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
	Structure Values						
RES	0	0	0	22,849	119,012	218,875	302,899
COM	0	3,745	3,745	4,101	12,637	13,966	13,966
CASINOS	--	--	--	--	--	--	--
PUB	0	10	10	74	5,165	7,842	8,746
IND	0	0	0	0	20,034	43,509	81,478
TOTAL STRUCTURE	***$0***	***$3,755***	***$3,755***	***$27,024***	***$156,848***	***$284,191***	***$407,089***
	Content Values						
RES	0	0	0	11,425	59,506	109,437	151,450
COM	0	3,745	3,745	4,101	12,637	13,966	13,966
CASINOS	--	--	--	--	--	--	--
PUB	0	5	5	37	2,583	3,921	4,373
IND	0	0	0	0	99,643	218,057	306,821
TOTAL CONTENT	***$0***	***$3,750***	***$3,750***	***$15,562***	***$174,369***	***$345,381***	***$476,609***
TOTAL VALUE	**$0**	**$7,505**	**$7,505**	**$42,587**	**$331,216**	**$629,572**	**$883,698**

Table E6-14: EIA 14 (Central Hidden Valley) Structure Values by Event ($1,000's)

Damage Category	Annual Chance Exceedance Flood Event						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
	Structure Values						
RES	0	0	0	1,360	3,445	4,236	5,292
COM	--	--	--	--	--	--	--
CASINOS	--	--	--	--	--	--	--
PUB	0	0	0	0	92	92	92
IND	--	--	--	--	--	--	--
TOTAL STRUCTURE	***$0***	***$0***	***$0***	***$1,360***	***$3,537***	***$4,328***	***$5,384***
	Content Values						
RES	0	0	0	680	1,722	2,118	2,646
COM	--	--	--	--	--	--	--
CASINOS	--	--	--	--	--	--	--
PUB	0	0	0	0	46	46	46
IND	--	--	--	--	--	--	--
TOTAL CONTENT	***$0***	***$0***	***$0***	***$680***	***$1,768***	***$2,164***	***$2,692***
TOTAL VALUE	**$0**	**$0**	**$0**	**$2,040**	**$5,305**	**$6,492**	**$8,076**

Table E6-15: EIA 15 (South Hidden Valley) Structure Values by Event ($1,000's)

Damage Category	Annual Chance Exceedance Flood Event						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
	Structure Values						
RES	0	0	0	0	8,744	14,693	18,378
COM	--	--	--	--	--	--	--
CASINOS	--	--	--	--	--	--	--
PUB	--	--	--	--	--	--	--
IND	--	--	--	--	--	--	--
TOTAL STRUCTURE	***$0***	***$0***	***$0***	***$0***	***$8,744***	***$14,693***	***$18,378***
	Content Values						
RES	0	0	0	0	4,372	7,347	9,189
COM	--	--	--	--	--	--	--
CASINOS	--	--	--	--	--	--	--
PUB	--	--	--	--	--	--	--
IND	--	--	--	--	--	--	--
TOTAL CONTENT	***$0***	***$0***	***$0***	***$0***	***$4,372***	***$7,347***	***$9,189***
TOTAL VALUE	**$0**	**$0**	**$0**	**$0**	**$13,116**	**$22,040**	**$27,567**

Probability Distribution of Damages Reduced by Economic Impact Area – Before NFIP Compliance (Oct 2013 Price Levels)

Table E6-16: Probability Distribution of Damages Reduced – EIA 1
(October 2011 Prices, $1,000s)

Plan	Expected Annual Damages			Probability Damage Reduced Exceeds Indicated Values		
	Without Project	With Project	Damages Reduced	0.75	0.50	0.25
Without	8,272	8,272	0	0	0	0
3	8,272	8,272	0	0	0	0

Table E6-17: Probability Distribution of Damages Reduced – EIA 2
(October 2011 Prices, $1,000s)

Plan	Expected Annual Damages			Probability Damage Reduced Exceeds Indicated Values		
	Without Project	With Project	Damages Reduced	0.75	0.50	0.25
Without	904	904	0	0	0	0
3	904	899	5	-1	4	10

Table E6-18: Probability Distribution of Damages Reduced – EIA 3
(October 2011 Prices, $1,000s)

Plan	Expected Annual Damages			Probability Damage Reduced Exceeds Indicated Values		
	Without Project	With Project	Damages Reduced	0.75	0.50	0.25
Without	3,567	3,567	0	0	0	0
3	3,567	3,517	50	0	28	65

Table E6-19: Probability Distribution of Damages Reduced – EIA 4
(October 2011 Prices, $1,000s)

Plan	Expected Annual Damages			Probability Damage Reduced Exceeds Indicated Values		
	Without Project	With Project	Damages Reduced	0.75	0.50	0.25
Without	6,249	6,249	0	0	0	0
3	6,249	6,328	-79	-141	-93	8

Table E6-20: Probability Distribution of Damages Reduced – EIA 5
(October 2011 Prices, $1,000s)

Plan	Expected Annual Damages			Probability Damage Reduced Exceeds Indicated Values		
	Without Project	With Project	Damages Reduced	0.75	0.50	0.25
Without	3,188	3,188	0	0	0	0
3	3,188	2,423	765	424	678	997

Table E6-21: Probability Distribution of Damages Reduced – EIA 6
(October 2011 Prices, $1,000s)

Plan	Expected Annual Damages			Probability Damage Reduced Exceeds Indicated Values		
	Without Project	With Project	Damages Reduced	0.75	0.50	0.25
Without	28,197	28,197	0	0	0	0
3	28,197	11,691	16,506	10,080	14,858	21,268

Table E6-22: Probability Distribution of Damages Reduced – EIA 7
(October 2011 Prices, $1,000s)

Plan	Expected Annual Damages			Probability Damage Reduced Exceeds Indicated Values		
	Without Project	With Project	Damages Reduced	0.75	0.50	0.25
Without	1,118	1,118	0	0	0	0
3	1,118	604	514	337	451	628

Table E6-23: Probability Distribution of Damages Reduced – EIA 8
(October 2011 Prices, $1,000s)

Plan	Expected Annual Damages			Probability Damage Reduced Exceeds Indicated Values		
	Without Project	With Project	Damages Reduced	0.75	0.50	0.25
Without	14,218	14,218	0	0	0	0
3	14,218	7,532	6,686	3,321	6,273	9,578

Table E6-24: Probability Distribution of Damages Reduced – EIA 9
(October 2011 Prices, $1,000s)

Plan	Expected Annual Damages			Probability Damage Reduced Exceeds Indicated Values		
	Without Project	With Project	Damages Reduced	0.75	0.50	0.25
Without	304	304	0	0	0	0
3	304	0	304	202	269	336

Table E6-25: Probability Distribution of Damages Reduced – EIA 10
(October 2011 Prices, $1,000s)

Plan	Expected Annual Damages			Probability Damage Reduced Exceeds Indicated Values		
	Without Project	With Project	Damages Reduced	0.75	0.50	0.25
Without	10	10	0	0	0	0
3	10	12	-2	-1	-1	1

Table E6-26: Probability Distribution of Damages Reduced – EIA 11
(October 2011 Prices, $1,000s)

Plan	Expected Annual Damages			Probability Damage Reduced Exceeds Indicated Values		
	Without Project	With Project	Damages Reduced	0.75	0.50	0.25
Without	59	59	0	0	0	0
3	59	58	1	0	0	1

Table E6-27: Probability Distribution of Damages Reduced – EIA 12
(October 2011 Prices, $1,000s)

Plan	Expected Annual Damages			Probability Damage Reduced Exceeds Indicated Values		
	Without Project	With Project	Damages Reduced	0.75	0.50	0.25
Without	116	116	0	0	0	0
3	116	119	-3	-5	0	3

Table E6-28: Probability Distribution of Damages Reduced – EIA 13
(October 2011 Prices, $1,000s)

Plan	Expected Annual Damages			Probability Damage Reduced Exceeds Indicated Values		
	Without Project	With Project	Damages Reduced	0.75	0.50	0.25
Without	3,386	3,386	0	0	0	0
3	3,386	3,244	142	78	121	184

Table E6-29: Probability Distribution of Damages Reduced – EIA 14
(October 2011 Prices, $1,000s)

Plan	Expected Annual Damages			Probability Damage Reduced Exceeds Indicated Values		
	Without Project	With Project	Damages Reduced	0.75	0.50	0.25
Without	55	55	0	0	0	0
3	55	59	-4	-6	-4	-1

Table E6-30: Probability Distribution of Damages Reduced – EIA 15
(October 2011 Prices, $1,000s)

Plan	Expected Annual Damages			Probability Damage Reduced Exceeds Indicated Values		
	Without Project	With Project	Damages Reduced	0.75	0.50	0.25
Without	110	110	0	0	0	0
3	110	115	-5	-6	-5	-3

Enclosure 7: 2008 to 2011 Economic Analysis and Results

Final Array of Plans Analyzed and Naming of the Alternative Plans

For NED Optimization of flood risk management, three design levels of Alternative 3 were analyzed with levees/floodwalls along the Truckee River set at the mean 1/50 ACE, 1/75 ACE, and 1/100 ACE WSEL's, plus R&U for each intended impact area. R&U was calculated as the additional height, over and above the mean WSEL for a given design event (i.e. 1/50 ACE), in order to obtain a 90% CNP for said event. Not all impact areas within the study area are behind the intended line of protection and can be flooded residually by other sources. From this point forward in this document, these three plans will be referred to by the following naming convention:

- **Alternative 3a**: Levees/floodwalls along the Truckee River set at the mean 2% (1/50) annual chance WSEL, plus R&U.
- **Alternative 3b**: Levees/floodwalls along the Truckee River set at the mean 1.3% (1/75) annual chance WSEL, plus R&U.
- **Alternative 3c**: Levees/floodwalls along the Truckee River set at the mean 1% (1/100) annual chance WSEL, plus R&U.

Plans that provide a lesser level of protection than Plan 3a (set at the mean 1 in 50yr WSEL plus R&U) were not considered because damaging flooding doesn't begin within most of the Meadows until between the 1/40 to 1/50 annual chance flood events, meaning that a smaller plan would not achieve significant benefits.

Features of Alternative 3 - Optimization in the Meadows

Between the screening and optimization, the Huffaker Hills Detention basin was analyzed further and removed as a project feature due to its economic inefficiency, as it did not incrementally lower the WSEL significantly enough to have any impact on the project benefits. Below is a detailed description of the Flood Risk Management features within Alternative 3 as analyzed for this optimization. For a complete description of all features and project purposes of Alternative 3 (Recreation, Ecosystem Restoration, etc) please see the Planning section of the main GRR report.

Floodwalls and setback levees would be constructed along the north and south banks of the Truckee River between Interstate 395 (I-395) to just downstream of the Reno-Sparks wastewater treatment plant to pass safely the design flood event, as follows:

- Between I-395 to Glendale Avenue a setback levee would be constructed on the south bank only
- From Glendale Avenue to Greg Street on bank floodwalls would be constructed on the south bank and on bank floodwalls and setback levee are to be constructed on the north bank

- Between Greg Street and Rock Boulevard a setback levee is to be constructed on the south bank only
- Between Rock Boulevard and McCarran Boulevard a setback levee is to be constructed on the south bank near Mill Street and a setback levee and on bank floodwall is to be constructed on the north bank
- From the McCarran Boulevard Bridge to approximately 2,000 feet downstream of the Reno-Sparks wastewater treatment plant a setback levee, on bank floodwall and in-channel floodwall is to be constructed

Just downstream of the McCarran Bridge, on the south bank, a ring levee is to be constructed to protect the University of Nevada Agricultural Experiment Station.

Channel benching is to be constructed along the south bank from approximately Greg Street to just upstream of Vista (a length of about 7 miles). The plan is to create two benches, a higher and a lower terrace within an approximately 350 foot-wide area. The purpose of the channel benching is to improve the conveyance capacity of the Truckee River and to provide an opportunity for riparian area re-establishment.

Seepage remediation measures proposed include seepage berms, drainage blankets, and relief wells. Mitigation measures would be included at specific sites based on effectiveness and available real estate.

Storm drainage features would be included to evacuate and/or accommodate any excess ponding behind protective works.

To prevent overbank flooding upstream, the North Truckee Drain, would be placed in one or more buried box culverts from just downstream of Interstate 80 and the UPRR railroad to the existing confluence with the Truckee River.

An existing irrigation ditch, Pioneer Ditch that is diverted from the Truckee River just upstream of the Greg Street Bridge, would be relocated outside the footprint of the south levee along Mill Street and the channel benching downstream of Greg Street. The relocated channel would reconnect with the existing Pioneer Ditch approximately 6,000 feet downstream of the McCarran Boulevard Bridge.

Clean Water Way, the primary vehicular access to the Reno-Sparks wastewater treatment plant, would be relocated outside of the project channel benching along the south bank of the Truckee River downstream of McCarran Boulevard.

To mitigate for increased flow due to containment features bed, bank and pier scour protection would be included in the project. Measures would include revetment and bioengineered protection. The project work would include approximately one hundred bank and overbank protection sites. Pier and abutment protection would be included for the elevated bridges at Virginia Street and Sierra Street, the new pedestrian bridge at Lake Street,

the elevated pedestrian bridge at Lower Wells Avenue and 22 bridges downstream from I-395 to Wadsworth, Nevada.

Due to increased flows under project flood stage conditions downstream of Vista, Painted Rock Bridge (located just upstream of Wadsworth) would be elevated. The existing bridge would be removed and replaced by a new bridge just upstream.

The Local Plan – Alternative 4

A Locally Developed Plan (Alternative 4) was also developed for this study and was analyzed for this report. The principal features of Alternative 4 would include all of the features of the Alternative 3 Plans plus features in the Downtown Reno and Truckee Meadows reaches to reduce damaging flood events to a 1 in 100 chance of occurrence in the Downtown Reno reach and a 1 in 117 chance of occurrence in the Truckee Meadows reach. The additional features are (1) replacement of Center and Lake Street in the Downtown Reno Reach, (2) floodwalls, levees, flood-proofing in the Downtown Reno Reach, and (3) lengthen bridges, bypass channel and detention basin in the Truckee Meadows Reach.

Non-Structural Improvements – The Meadows

Non-structural improvements were considered for two specific residential areas in the southern portion of the study area, Eastside Developments and Hidden Valley. Specifically, raising homes within these areas were analyzed for economic feasibility. This analysis was done in FY11, so an interest rate of 4.125% was used. Damaging flooding within these areas begins between the 2% (1/50) and 1% (1/100) ACE events. There are approximately 40 homes within Eastside and 32 within Hidden Valley that fall within the 1% (1/100) floodplain and were thus evaluated for possible home raises. Because flooding depths are fairly uniform across this area, homes were analyzed as a group instead of on a house-by-house basis. Benefits were calculated for the Eastside area by raising the first floor foundation heights for each structure within FDA to 1ft above the 100yr depth at each structure. The resulting cumulative decrease in annual damages of the home raises to these 40 structures was $5,750/yr, or $144/structure/year. In order for this to be economically feasible, the total cost to raise all 40 structures would have to be around $100,000, or $2,500 per structure, while the actual cost to raise all 40 structures is likely to be in the $1,600,000 to $2,400,000, or $40,000 to $60,000 per structure. Using this range of estimated costs, and annualizing them at 4.125% over 50 years, would result in total annual costs of $76,082 to $114,122 infeasible B/C ratio between 0.05 and 0.08.

The primary reason that home raises are inefficient in this area is because they do not get flooded very frequently and when they do get flooded from a 1% ACE event, those depths are only in the 1-2ft range. Depths do become more significant for the 0.5% (1/200) and 0.2% (1/500) events (3-10+ft), but because these happen so infrequently the damages do not amount to much on an annual basis. The same analysis was performed raising each structure to 1ft above the 0.5% ACE mean WSEL, but the resulting B/C ratio range was still only be

0.09 to 0.13.

Because the flooding patterns in Hidden Valley are very similar to those in the Eastside area, and the B/C ratios for the Eastside area were so low, Hidden Valley was also deemed economically infeasible for home-raises and will not be included in an NED plan.

Average Annual Equivalent Damages – The Meadows Area Only

All damages in the remaining tables of this report include Average Annual Equivalents, which because of our assumptions for Truckee Meadows; equal Expected Annual Damages. Equivalent annual damages for each with-project conditions are summarized by EIA in the table below.

There are some areas that aren't directly behind an intended line of protection (mostly south of the Truckee River, which may see constant or even increasing damages as our project gets larger (3a to 4). This is mostly due to the fact that more flow is contained in channel with-project and because it doesn't break out upstream, it instead makes it downstream to some of these areas.

Table E7-1: Average Annual Equivalent Damages – The Meadows
(October 2011 Prices, $1,000's, 4% Interest Rate)

Economic Impact Area	Alternative				
	Without	3a	3b	3c	4
The Meadows Area (east of I 395 to Vista)					
2-North I-80	876	853	847	838	465
3-West NTD	3,457	2,777	2,812	2,776	2,528
4-East NTD	6,055	3,876	3,929	3,927	3,464
5-Sparks West	3,090	2,276	1,987	1,848	1,275
6-Sparks East	27,327	17,403	15,311	15,861	10,654
7-Larkin Circle	1,083	606	529	493	584
8-Airport	13,779	6,823	5,571	4,702	4,682
9-Truckee South Overbank	294	0	0	0	0
10-UNR Farms	10	8	8	8	9
11-TMWRF	57	50	50	47	50
12-North Hidden Valley	114	88	89	86	95
13-Steamboat South	3,282	2,550	2,410	2,322	2,492
14-Central Hidden Valley	53	41	42	42	43
15-South Hidden Valley	107	81	83	81	84
Sub-total (2-15)	***$59,584***	***$37,432***	***$33,669***	***$33,031***	***$26,424***

Average Annual Benefits – The Meadows Area Only

The Average Annual Equivalent Benefits for all four alternatives in the Meadows are summarized in the table below. The results indicate almost zero incremental flood risk management benefit from building project 3c over 3b, meaning that either 3a or 3b will likely be the most efficient alternative when compared to project costs. Though Alternative 4 has noticeably higher benefits, the costs are also significantly higher.

Table E7-2: Average Annual Benefits – The Meadows
(October 2011 Prices, $1,000's, 4% Interest Rate)

Economic Impact Area	Alternative				
	Without	3a	3b	3c	4
The Meadows Area (east of I 395 to Vista)					
2-North I-80	0	23	29	38	411
3-West NTD	0	679	644	681	929
4-East NTD	0	2,180	2,126	2,129	2,592
5-Sparks West	0	814	1,103	1,242	1,815
6-Sparks East	0	9,924	12,017	11,466	16,674
7-Larkin Circle	0	478	555	590	499
8-Airport	0	6,956	8,208	9,077	9,097
9-Truckee South Overbank	0	294	294	294	294
10-UNR Farms	0	2	1	1	1
11-TMWRF	0	6	6	10	6
12-North Hidden Valley	0	26	25	27	19
13-Steamboat South	0	732	872	960	790
14-Central Hidden Valley	0	12	11	11	10
15-South Hidden Valley	0	26	24	26	23
Sub-total (2-15)	***$0***	***$22,152***	***$25,915***	***$26,553***	***$33,160***

Probability Distribution of Damages Reduced – The Meadows Area Only

In accordance with ER 1105-2-101, flood damages reduced were determined as mean values and by probability exceeded. Table E7-3 shows the benefits for each Alternative for the 75%, 50% and 25% probability that benefits exceed the indicated values. The damage reduced column represents the mean benefits for each increment and the 75%, 50% and 25% represent the probability that the flood damage reduction benefits exceed the number in that column for that increment. For example, Alternative 3b, has an average (mean) benefit of $24m, but only a 50% chance that benefits will be greater than $21m, 75% confidence that benefits will be greater than $14.2m and a 25% chance benefits will exceed $30.6m. This range is the probability distribution of damages reduced which represents the uncertainty in the benefit estimates and incorporates all the uncertainties in hydrology, hydraulics, and

economics in the HEC-FDA model. The wider this range, the more uncertain and less confident you are in the result. The uncertainty in damages reduced should be considered when selecting an optimal plan during the plan formulation process. Judgment should be used to determine if an alternative meets a reasonable level of confidence regarding positive net benefits and identifying if changes in net benefits from alternative to alternative are significant.

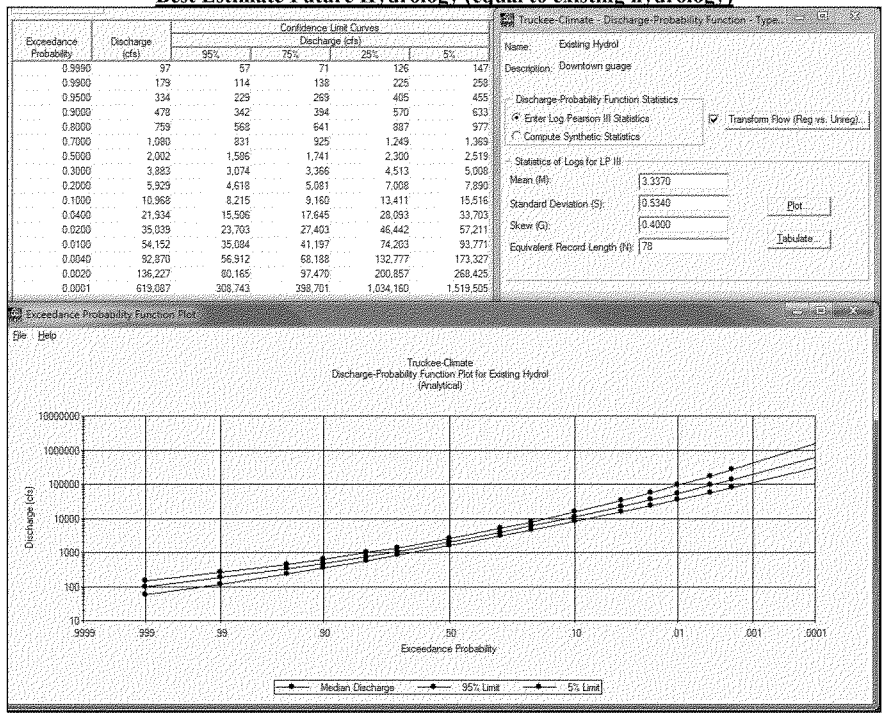
Table E7-3: Probability Distribution of Equivalent Annual Damages Reduced – Meadows Area Only (2-15) - All Alternatives
(October 2011 Prices, $1,000's, 4% Interest Rate)

Plan	Expected Annual Damages			Probability Damage Reduced Exceeds Indicated Values		
	Without Project	With Project	Damages Reduced	0.75	0.50	0.25
Without	59,584	59,584	0	0	0	0
3a	59,584	37,432	22,152	12,058	17,900	26,288
3b	59,584	33,669	25,915	14,228	21,042	30,577
3c	59,584	33,031	26,553	14,411	21,237	30,705
4	59,584	26,424	33,160	18,107	26,812	39,155

Enclosure 8: Climate Change Sensitivity - Hydrology Inputs

Best Estimate Future Hydrology (equal to existing hydrology)

Exceedance Probability	Discharge (cfs)	Confidence Limit Curves Discharge (cfs) 95%	75%	25%	5%
0.9990	97	57	71	126	147
0.9900	179	114	138	225	258
0.9500	334	229	269	405	455
0.9000	478	342	394	570	633
0.8000	759	568	641	887	977
0.7000	1,080	831	925	1,249	1,369
0.5000	2,002	1,586	1,741	2,300	2,519
0.3000	3,883	3,074	3,366	4,513	5,008
0.2000	5,929	4,618	5,081	7,008	7,890
0.1000	10,968	8,215	9,160	13,411	15,516
0.0400	21,934	15,506	17,645	28,093	33,703
0.0200	35,039	23,703	27,403	46,442	57,211
0.0100	54,152	35,084	41,197	74,203	93,771
0.0040	92,870	56,912	68,188	132,777	173,327
0.0020	136,227	80,165	97,470	200,857	268,425
0.0001	619,087	308,743	398,701	1,034,160	1,519,505



Driest Estimate Hydrology

Exceedance Probability	Discharge (cfs)	Confidence Limit Curves Discharge (cfs) 95%	75%	25%	5%
0.9990	78	46	58	102	119
0.9900	145	92	112	182	209
0.9500	270	186	218	328	368
0.9000	387	277	319	461	513
0.8000	615	460	519	719	792
0.7000	875	673	749	1,012	1,109
0.5000	1,622	1,285	1,410	1,863	2,041
0.3000	3,146	2,490	2,727	3,656	4,057
0.2000	4,802	3,741	4,116	5,677	6,391
0.1000	8,884	6,654	7,420	10,863	12,568
0.0400	17,767	12,560	14,293	22,756	27,300
0.0200	28,382	19,200	22,197	37,620	46,343
0.0100	43,865	28,419	33,371	60,106	75,957
0.0040	75,227	46,101	55,234	107,553	140,400
0.0020	110,348	64,936	78,954	162,700	217,432
0.0001	501,478	250,090	322,959	837,699	1,230,842

Truckee-Climate - Discharge-Probability Function - Type...

Name: Climate Low

Description: Downtown guage

Discharge-Probability Function Statistics

- (•) Enter Log Pearson III Statistics
- ( ) Compute Synthetic Statistics

☑ Transform Flow (Reg vs. Unreg)...

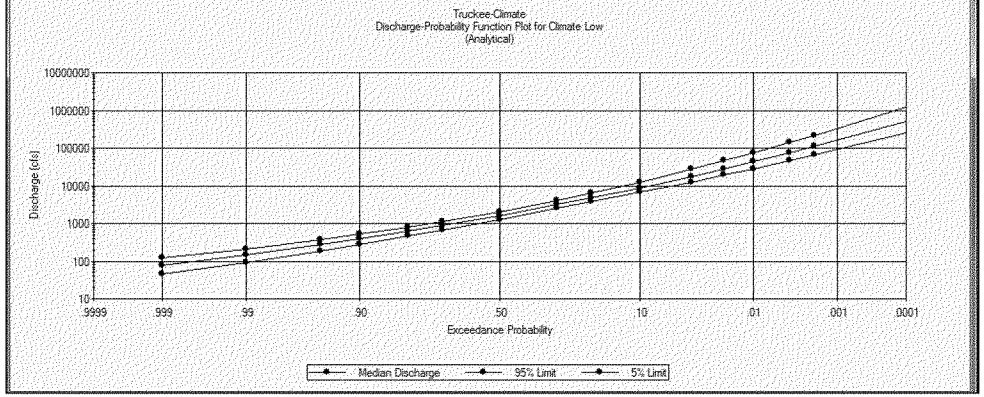
Statistics of Logs for LP III

Mean (M):	3.2455
Standard Deviation (S):	0.5340
Skew (G):	0.4000
Equivalent Record Length (N):	78

Plot... Tabulate...

Exceedance Probability Function Plot

File Help



Wettest Estimate Hydrology

Exceedance Probability	Discharge (cfs)	Confidence Limit Curves Discharge (cfs) 95%	75%	25%	5%
0.9990	135	79	99	176	206
0.9900	251	159	193	315	361
0.9500	467	321	376	567	636
0.9000	669	479	551	798	887
0.8000	1,063	795	897	1,242	1,368
0.7000	1,512	1,163	1,295	1,748	1,916
0.5000	2,803	2,221	2,438	3,219	3,527
0.3000	5,436	4,304	4,713	6,318	7,011
0.2000	8,299	6,465	7,113	9,810	11,045
0.1000	15,354	11,500	12,823	18,774	21,721
0.0400	30,706	21,707	24,702	39,328	47,181
0.0200	49,051	33,182	38,361	65,015	80,091
0.0100	75,808	49,115	57,672	103,877	131,271
0.0040	130,009	79,672	95,456	185,876	242,643
0.0020	190,705	112,223	136,450	281,181	375,771
0.0001	866,666	432,212	558,146	1,447,731	2,127,170

Truckee-Climate - Discharge-Probability Function - Type...

Name: Climate High

Description: Downtown guage

Discharge-Probability Function Statistics

- (•) Enter Log Pearson III Statistics
- ( ) Compute Synthetic Statistics

[✓] Transform Flow (Reg vs. Unreg)...

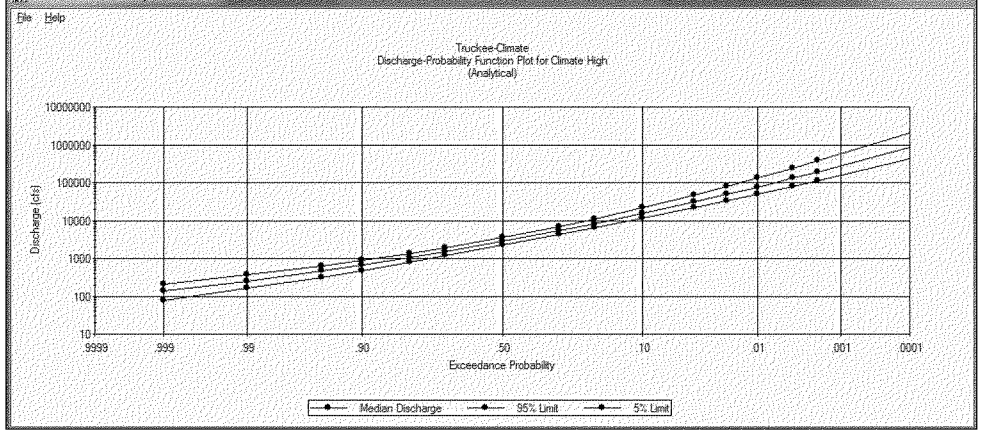
Statistics of Logs for LP III

Mean (M):	3.4831
Standard Deviation (S):	0.5340
Skew (G):	0.4000
Equivalent Record Length (N):	78

Plot... Tabulate...

Exceedance Probability Function Plot

File Help



Enclosure 9: Cost Estimates

See detailed Total Project Cost Summary (TPCS), Annual Operations, Maintenance, Repair, Replacement & Rehabilitation (OMRR&R) cost breakdown and Interest During Construction (IDC) calculations at 3.5% and 7% starting on the next page.

****TOTAL PROJECT COST SUMMARY****

12/10/2013

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE RECOMMENDED PLAN REPORT.
PROJECT: TRUCKEE RIVER FLOOD CONTROL
LOCATION: NEVADA

U. S. ARMY CORPS OF ENGINEER, SACRAMENTO DISTRICT
P.O.C.: JEREMIAH A. FROST, CHIEF, COST ENGINEERING SECTION

WORK BREAKDOWN STRUCTURE		ESTIMATED COST				PROJECT FIRST COST (CONSTANT DOLLAR BASIS)				TOTAL PROJECT COST (FULLY FUNDED)					
		Estimate Prepared: 23-Jul-2013 Effective Price Level: 1-Oct-2013				PROGRAM YEAR(BUDGET EC): FY2014 EFF. PRICE LEVEL DATE: 1-Oct-2013				SPENT THRU: 1-Oct-2013					
WBS NO.	Civil Works Feature\Sub-Feature Description	COST ($K)	RISK BASED CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC. (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	COST ($K)	INFLATED (%)	COST ($K)	CNTG ($K)		FULLY FUNDED ($K)
A	B	C	D	E	F	G	H	I	J	K	L	M	N		O
Index Codes: 0 - no esc. applied; A - Administration; C - Combined indexes; All other codes used coincides with the Code of Accounts.															
		Contingencies Applied To Remaining Cost Only													
	FEDERAL COSTS														
9	CHANNELS & CANALS	36,812	9,953	27	46,765	0.00	36,812	9,953	46,765	0	12.6	41,454	11,209		52,663
11	LEVEES & FLOODWALLS	47,622	12,873		60,495		47,622	12,873	60,495	0		52,062	14,073		66,135
	Construction 11	46,089	12,458	27	58,547	0.00	46,089	12,458	58,547	0	9.2	50,345	13,609		63,954
	Section 104 11	1,533	415	27	1,948	0.00	1,533	415	1,948	0	12.0	1,717	464		2,181
14	RECREATIONS	6,321	1,709	27	8,030	0.00	6,321	1,709	8,030	0	15.2	7,281	1,968		9,249
16	BANK STABILIZATION	9,914	2,680	27	12,594	0.00	9,914	2,680	12,594	0	9.5	10,853	2,932		13,785
18	CULT. RESRC. PRESERV. (1	1,477	340	23	1,817		1,477	340	1,817	0		1,614	371		1,985
	SUBTOTAL FEDERAL & NON-FEDERAL CONSTRUCTION COSTS	102,146	27,555		129,701		102,146	27,555	129,701	0		113,264	30,553		143,817
1	LANDS & DAMAGES, Admin (2	1,455	73		1,528		1,455	73	1,528	0		1,600	80		1,680
	Construction	1,425	71	5	1,496	0.00	1,425	71	1,496	0	10.0	1,567	78		1,645
	Recreation	30	2	7	32	0.00	30	2	32	0	9.4	33	2		35
30	PLAN/ENGINEERING/DESIGN	57,300	4,187		61,487		57,300	4,187	61,487	42,200		60,914	5,190		66,104
	Construction	56,352	3,924		60,276		56,352	3,924	60,276	42,200		59,696	4,852		64,548
	Construction A	56,122	3,862	28	59,984	0.00	56,122	3,862	59,984	42,200	23.6	59,412	4,775		64,187
	Section 104 A	230	62	27	292	0.00	230	62	292	0	23.6	284	77		361
	Recreation	948	263	28	1,211	0.00	948	263	1,211	0	28.5	1,218	338		1,556
31	CONSTRUCTION MANAGE'MT	8,557	2,313		10,870		8,557	2,313	10,870	0		11,121	3,004		14,125
	Construction	8,020	2,168		10,188		8,020	2,168	10,188	0		10,419	2,815		13,234
	Construction A	7,890	2,132	27	10,022	0.00	7,890	2,132	10,022	0	29.9	10,249	2,769		13,018
	Section 104 A	130	36	28	166	0.00	130	36	166	0	30.1	170	46		216
	Recreation	537	145	27	682	0.00	537	145	682	0	30.6	702	189		891
	SUBTOTAL FEDERAL & NON-FEDERAL CONTRIBUTION	169,458	34,128		203,586		169,458	34,128	203,586	42,200		186,899	38,827		225,726
	NON-FEDERAL CONTRIBUTION (-)	-21,771	-165		-21,936		-21,771	-165	-21,936	-13,527		-25,152	-2,074		-27,226
	TOTAL FEDERAL COSTS	**$147,687**	**$33,963**		**$181,650**		**$147,687**	**$33,963**	**$181,650**	**$28,673**		**$161,747**	**$36,753**		**$198,500**
	NON-FEDERAL COSTS														
1	LANDS AND DAMAGES	50,306	16,139		66,445		50,306	16,139	66,445	1,912		53,939	15,620		69,559
	Construction	50,191	16,096		66,287		50,191	16,096	66,287	1,912		53,818	15,575		69,393
	Gross Appraised Value C	48,279	16,096	33	64,375	0.00	48,279	16,096	64,375	0	4.8	51,906	15,575		67,481
	Section 113	1,912	0		1,912		1,912	0	1,912	1,912		1,912	0		1,912
	Recreation	115	43	37	158	0.00	115	43	158	0	5.1	121	45		166
2	RELOCATIONS	8,487	2,302		10,789		8,487	2,302	10,789	0		9,294	2,521		11,815
	Relocations Construction	6,790	1,835	27	8,625	0.00	6,790	1,835	8,625	0	9.9	7,460	2,017		9,477
	Plan/Engineering/Design	1,018	283	28	1,301	0.00	1,018	283	1,301	0	6.8	1,088	302		1,390
	Construction Management	679	184	27	863	0.00	679	184	863	0	9.8	746	202		948
	SUBTOTAL NON-FEDERAL	58,793	18,441		77,234		58,793	18,441	77,234	1,912		63,233	18,141		81,374
	NON-FEDERAL CONTRIBUTION (+)	21,771	165		21,936		21,771	165	21,936	13,527		25,152	2,074		27,226
	RECREATION - 50% of Recreation Cost	3,861	1,038		4,899		3,861	1,038	4,899	0		4,557	1,226		5,783
	CONSTR. - 35% of Remaining Cost Less 18 Acct.	17,910	-873		17,037		17,910	-873	17,037	13,527		20,595	848		21,443
	TOTAL NON-FEDERAL COSTS	**$80,564**	**$18,606**		**$99,170**		**$80,564**	**$18,606**	**$99,170**	**$15,439**		**$88,385**	**$20,215**		**$108,600**
	TOTAL FEDERAL & NON - FEDERAL COSTS	**$228,251**	**$52,569**		**$280,820**		**$228,251**	**$52,569**	**$280,820**	**$44,112**		**$250,132**	**$56,968**		**$307,100**

SESSIONS.CAMERON.LOUIS.1393765972 — CHIEF, COST ENGINEERING

REED.ANTHONY.GLEN.1075045839 — PROJECT MANAGER

CAINE.SHARON.K.1230386052 — CHIEF, REAL ESTATE

ESTIMATED FEDERAL COST: $198,500
ESTIMATED NON-FEDERAL COST: $108,600
ESTIMATED TOTAL PROJECT COST: $307,100

GENERAL NOTES

(1 Cultural Resources Preservation costs associated with mitigation and/or data recovery up to one percent of the total Federal cost are not subject to cost sharing.
(2 Federal administrative costs for non-Federal land acquisition.
(3 The Fully Funded cost estimate was prepared in compliance with indexes used from CWCCIS reflecting OMB future rates Mar. 31 ,2012.
(4 01 Account for Land and Demages cost ere from Real Estates.
(5 30 Account Planning, Engineering and Design and 31 Account Construction Management cost was provided by its respective organizations.

CONTINGENCY RATIONALE

(A CONTINGENCIES USED WAS DERIVED BY THE COST SCHEDULE RISK ANALYSIS PROCESS AND IS BASED ON A 80% CONFIDENCE LEVEL.

DETAILED ESTIMATE OF M & O COSTS & REPLACEMENT COSTS

ACCOUNT NUMBER	ITEM	ANNUAL COST ($)	FACTOR (%)	M&O COST ($)	PROJECT LIFE YRS	ITEM LIFE YRS	FACTOR (%)	REPLACEMENT COST ($)
			Effective Price Level (EPL): 1-Oct-2013					
09---	Channels							
	9 Continuous Flow	128066	1.5	192900				
	Channels			192900				0
11---	Levees							
	11 Levees/Flood Wall	311635	1.5	469400				
	Levees			469400				0
14---	Recreation Facil.							
	14 Recreation Facil.	113394	1.5	170800				
	Recreation Facil.			170800				0
16---	Bank Stabilization							
	16 Cobbles/Quarry Rock	19452	1.5	29300				
	Bank Stabilization			29300				0
	SUMMARY							
09---	Channels			192900				0
11---	Levees			469400				0
14---	Recreation Facil.			170800				0
16---	Bank Stabilization			29300				0
	TOTAL			**$862,400**				**$0**

DETAILED ESTIMATE OF INTEREST DURING CONSTRUCTION

PROJECT: TRUCKEE RIVER FLOOD CONTROL, Total
LOCATION: CALIFORNIA
INTEREST RATE: 3.500%

ACCOUNT NUMBER	DESCRIPTION	AMOUNT ($)	CONTRACT START DATE	CONTRACT END DATE	PLANT USAGE DATE	INTEREST DURING CONSTRUCTION
		Effective Price Level (EPL): 1-Oct-2013				
	FEDERAL COSTS					
1	LANDS AND DAMAGES, Administration	1,528,000				256,089
		1,496,000	Oct-15	Oct-16	Oct-20	250,726
		32,000	Oct-15	Oct-16	Oct-20	5,363
9	CHANNELS AND CANALS	46,765,000				2,286,115
		8,104,000	Oct-17	Oct-19	Oct-20	579,310
		5,162,000	Oct-18	Oct-20	Oct-20	181,715
		13,974,000	Apr-17	Oct-18	Oct-20	1,389,308
		12,409,000	Jan-19	Jun-24	Oct-20	122,972
		7,116,000	Jan-20	Jun-25	Oct-20	12,810
11	LEVEES AND FLOODWALLS	60,495,000				5,032,056
		12,058,000	Oct-16	Oct-18	Oct-20	1,314,158
		12,345,000	Oct-17	Oct-19	Oct-20	882,476
		5,816,000	Oct-18	Oct-20	Oct-20	204,738
		19,968,000	Oct-16	Oct-18	Oct-20	2,176,241
		2,524,000	Oct-17	Oct-19	Oct-20	180,427
		5,836,000	Oct-18	Oct-20	Oct-20	205,442
	Section 104	1,948,000	Oct-18	Oct-20	Oct-20	68,574
14	RECREATION FACILITIES	8,030,000				139,316
		8,030,000	Oct-20	Oct-21	Oct-21	139,316
16	BANK STABILIZATION	12,594,000				1,004,091
		6,554,000	Oct-16	Oct-18	Oct-20	714,297
		2,127,000	Oct-17	Oct-19	Oct-20	152,047
		3,913,000	Oct-18	Oct-20	Oct-20	137,747
18	CULTURAL RESOURCE PRES. (NO IDC)	1,817,000				
30	PLANNING, ENGR. & DESIGN	61,487,000				1,460,764
		180,000	Oct-87	Oct-88	Oct-20	0
		1,105,000	Oct-88	Oct-89	Oct-20	0
		1,601,000	Oct-89	Oct-90	Oct-20	0
		819,000	Oct-90	Oct-91	Oct-20	0
		68,000	Oct-91	Oct-92	Oct-20	0
		7,000	Oct-92	Oct-93	Oct-20	0
		7,000	Oct-93	Oct-94	Oct-20	0
		381,000	Oct-97	Oct-98	Oct-20	0
		1,260,000	Oct-98	Oct-99	Oct-20	0
		983,000	Oct-99	Oct-00	Oct-20	0
		910,000	Oct-00	Oct-01	Oct-20	0
		1,207,000	Oct-01	Oct-02	Oct-20	0
		1,748,000	Oct-02	Oct-03	Oct-20	0
		2,615,000	Oct-03	Oct-04	Oct-20	0
		2,472,000	Oct-04	Oct-05	Oct-20	0
		1,877,000	Oct-05	Oct-06	Oct-20	0
		2,571,000	Oct-06	Oct-07	Oct-20	0
		4,130,000	Oct-07	Oct-08	Oct-20	0
		3,153,000	Oct-08	Oct-09	Oct-20	0
		5,232,000	Oct-09	Oct-10	Oct-20	0
		6,664,000	Oct-10	Oct-11	Oct-20	0
		1,701,000	Oct-11	Oct-12	Oct-20	0
		1,509,000	Oct-12	Oct-13	Oct-20	0
		17,784,000	Oct-13	Jun-25	Oct-20	1,395,225
	Section 104	292,000	Oct-13	Jun-25	Oct-20	22,909
	Recreation	1,211,000	Oct-19	Oct-21	Oct-21	42,630
31	CONSTRUCTION MANAGEMENT	10,870,000				350,766
		10,022,000	Oct-16	Jun-25	Oct-20	333,412
	Section 104	166,000	Oct-16	Jun-25	Oct-20	5,522
	Recreation	682,000	Oct-20	Oct-21	Oct-21	11,832
	CASH CONTRIBUTION (-)	23,178,000	Oct-16		Oct-20	1,670,420
	TOTAL FEDERAL COST	**$180,408,000**				**$8,858,777**

DETAILED ESTIMATE OF INTEREST DURING CONSTRUCTION(CONT'ED)

ACCOUNT NUMBER	DESCRIPTION	AMOUNT ($)	CONTRACT START DATE	CONTRACT END DATE	PLANT USAGE DATE	INTEREST DURING CONSTRUCTION
	Effective Price Level (EPL): 1-Oct-2013					
	NON-FEDERAL COSTS					
1	LANDS AND DAMAGES	64,533,000				10,822,016
		64,375,000	Oct-15	Oct-16	Oct-20	10,789,079
	Recreation	158,000	Oct-15	Oct-16	Oct-21	32,937
2	RELOCATIONS	8,625,000				621,924
	Constr. Activities	8,625,000				621,924
3--	CEMETERIES, UTILITIES, & STRUCTURES					
		3,004,000	Oct-16	Oct-18	Oct-20	327,395
		2,664,000	Oct-17	Oct-19	Oct-20	190,435
		2,957,000	Oct-18	Oct-20	Oct-20	104,094
30	PLANNING, ENGR. & DESIGN	1,301,000				170,088
		1,301,000	Oct-13	Oct-20	Oct-20	170,088
31	CONSTRUCTION MANAGEMENT	863,000				62,196
		863,000	Oct-16	Oct-20	Oct-20	62,196
	CASH CONTRIBUTION (+)	23,178,000	Oct-16		Oct-20	1,670,420
	TOTAL NON-FEDERAL	**$98,500,000**				**$13,346,644**
	TOTAL	**$278,908,000**				**$22,205,421**

DETAILED ESTIMATE OF INTEREST DURING CONSTRUCTION

PROJECT: TRUCKEE RIVER FLOOD CONTROL, Total
LOCATION: CALIFORNIA
INTEREST RATE: 7.000%

ACCOUNT NUMBER	DESCRIPTION	AMOUNT ($)	CONTRACT START DATE	CONTRACT END DATE	PLANT USAGE DATE	INTEREST DURING CONSTRUCTION
	Effective Price Level (EPL): 1-Oct-2013					
	FEDERAL COSTS					
1	LANDS AND DAMAGES, Administration	1,528,000				544,391
		1,496,000	Oct-15	Oct-16	Oct-20	532,990
		32,000	Oct-15	Oct-16	Oct-20	11,401
9	CHANNELS AND CANALS	46,765,000				4,683,497
		8,104,000	Oct-17	Oct-19	Oct-20	1,181,300
		5,162,000	Oct-18	Oct-20	Oct-20	365,025
		13,974,000	Apr-17	Oct-18	Oct-20	2,865,556
		12,409,000	Jan-19	Jun-24	Oct-20	246,263
		7,116,000	Jan-20	Jun-25	Oct-20	25,353
11	LEVEES AND FLOODWALLS	60,495,000				10,366,082
		12,058,000	Oct-16	Oct-18	Oct-20	2,724,762
		12,345,000	Oct-17	Oct-19	Oct-20	1,799,501
		5,816,000	Oct-18	Oct-20	Oct-20	411,271
		19,968,000	Oct-16	Oct-18	Oct-20	4,512,195
		2,524,000	Oct-17	Oct-19	Oct-20	367,917
		5,836,000	Oct-18	Oct-20	Oct-20	412,686
	Section 104	1,948,000	Oct-18	Oct-20	Oct-20	137,750
14	RECREATION FACILITIES	8,030,000				276,297
		8,030,000	Oct-20	Oct-21	Oct-21	276,297
16	BANK STABILIZATION	12,594,000				2,067,767
		6,554,000	Oct-16	Oct-18	Oct-20	1,481,016
		2,127,000	Oct-17	Oct-19	Oct-20	310,048
		3,913,000	Oct-18	Oct-20	Oct-20	276,703
18	CULTURAL RESOURCE PRES. (NO IDC)	1,817,000				
30	PLANNING, ENGR. & DESIGN	61,487,000				3,112,928
		180,000	Oct-87	Oct-88	Oct-20	0
		1,105,000	Oct-88	Oct-89	Oct-20	0
		1,601,000	Oct-89	Oct-90	Oct-20	0
		819,000	Oct-90	Oct-91	Oct-20	0
		68,000	Oct-91	Oct-92	Oct-20	0
		7,000	Oct-92	Oct-93	Oct-20	0
		7,000	Oct-93	Oct-94	Oct-20	0
		361,000	Oct-97	Oct-98	Oct-20	0
		1,260,000	Oct-98	Oct-99	Oct-20	0
		983,000	Oct-99	Oct-00	Oct-20	0
		910,000	Oct-00	Oct-01	Oct-20	0
		1,207,000	Oct-01	Oct-02	Oct-20	0
		1,748,000	Oct-02	Oct-03	Oct-20	0
		2,615,000	Oct-03	Oct-04	Oct-20	0
		2,472,000	Oct-04	Oct-05	Oct-20	0
		1,877,000	Oct-05	Oct-06	Oct-20	0
		2,571,000	Oct-06	Oct-07	Oct-20	0
		4,130,000	Oct-07	Oct-08	Oct-20	0
		3,153,000	Oct-08	Oct-09	Oct-20	0
		5,232,000	Oct-09	Oct-10	Oct-20	0
		6,664,000	Oct-10	Oct-11	Oct-20	0
		1,701,000	Oct-11	Oct-12	Oct-20	0
		1,509,000	Oct-12	Oct-13	Oct-20	0
		17,784,000	Oct-13	Jun-25	Oct-20	2,978,391
	Section 104	292,000	Oct-13	Jun-25	Oct-20	48,903
	Recreation	1,211,000	Oct-19	Oct-21	Oct-21	85,634
31	CONSTRUCTION MANAGEMENT	10,870,000				720,856
		10,022,000	Oct-16	Jun-25	Oct-20	686,027
	Section 104	166,000	Oct-16	Jun-25	Oct-20	11,363
	Recreation	682,000	Oct-20	Oct-21	Oct-21	23,466
	CASH CONTRIBUTION (-)	23,178,000	Oct-16		Oct-20	3,437,052
	TOTAL FEDERAL COST	**$180,408,000**				**$18,334,766**

DETAILED ESTIMATE OF INTEREST DURING CONSTRUCTION(CONT'ED)

ACCOUNT NUMBER	DESCRIPTION	AMOUNT ($)	CONTRACT START DATE	CONTRACT END DATE	PLANT USAGE DATE	INTEREST DURING CONSTRUCTION
	Effective Price Level (EPL): 1-Oct-2013					
	NON-FEDERAL COSTS					
1	LANDS AND DAMAGES	64,533,000				23,006,589
		64,375,000	Oct-15	Oct-16	Oct-20	22,935,297
	Recreation	158,000	Oct-15	Oct-16	Oct-21	71,292
2	RELOCATIONS	8,625,000				1,276,244
	Constr. Activities	8,625,000				1,276,244
3--	CEMETERIES, UTILITIES, & STRUCTURES					
		3,004,000	Oct-16	Oct-18	Oct-20	678,818
		2,664,000	Oct-17	Oct-19	Oct-20	388,325
		2,957,000	Oct-18	Oct-20	Oct-20	209,101
30	PLANNING, ENGR. & DESIGN	1,301,000				363,087
		1,301,000	Oct-13	Oct-20	Oct-20	363,087
31	CONSTRUCTION MANAGEMENT	863,000				127,974
		863,000	Oct-16	Oct-20	Oct-20	127,974
	CASH CONTRIBUTION (+)	23,178,000	Oct-16		Oct-20	3,437,052
	TOTAL NON-FEDERAL	**$98,500,000**				**$28,210,946**
	TOTAL	**$278,908,000**				**$46,545,712**

US Army Corps
of Engineers ®
Sacramento District

Appendix D, Engineering Appendix

Final

Truckee Meadows Flood Control Project

Nevada

Prepared by

U.S. Army Corps of Engineers
Sacramento District

September 2013

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CHAPTER 1 - INTRODUCTION

1.1 Purpose and Scope

This appendix and its attachments summarize the engineering analysis the Project Delivery Team used to develop the feasibility design for the Alternative 3 Floodplain Terrace Plan (hereinafter, "Plan") for the Truckee Meadows Flood Control Project. The Plan has been identified as the Recommended Plan in the Truckee Meadows Flood Control Project General Reevaluation Report (GRR). This Engineering Appendix supports the design and cost estimates for the Plan only. The Plan is described graphically in the attached set of engineering plans.

1.2 Project Location

The study area includes approximately 60 miles of the Truckee River beginning just upstream of Reno, passing through Sparks and the Truckee Meadows, and ending at the river's terminus, Pyramid Lake, on the Pyramid Lake Paiute tribal lands (see Figure 1 below). Because of the size of the land area and the number of river miles involved, the study area is divided into four general reaches: Upper Truckee River, Downtown Reno, Truckee Meadows, and Lower Truckee River.

The Upper Truckee River Reach extends from Fleisch Dam (approximately 6 miles upstream of Reno) to just upstream of Booth Street. The Downtown Reno Reach extends from just above Booth Street downstream to Highway 395 (approximately 7 miles). The Truckee Meadows Reach encompasses an area bordered by Highway 395 to the west, Vista and the Virginia and Pah Rah Mountain ranges approximately 6 miles to the east, south along Steamboat Creek to Huffaker Hills, and north to Sparks. The Lower Truckee River Reach extends from Vista (second Union Pacific Railroad (UPRR) bridge) downstream to the river's terminus at Pyramid Lake (approximately 40 miles). Work for the Plan is located in the Truckee Meadows Reach.

1.3 Coordination

The Product Delivery Team, consisting of the Sacramento District Corps of Engineers, technical review representatives from Los Angeles and San Francisco Districts, Truckee River Flood Management Authority (TRFMA), City of Sparks, City of Reno, Washoe County and various architect-engineer firms, coordinated in the preparation of this Engineering Appendix. Close coordination was also maintained with the Washoe County Flood Project Coordinating Committee.

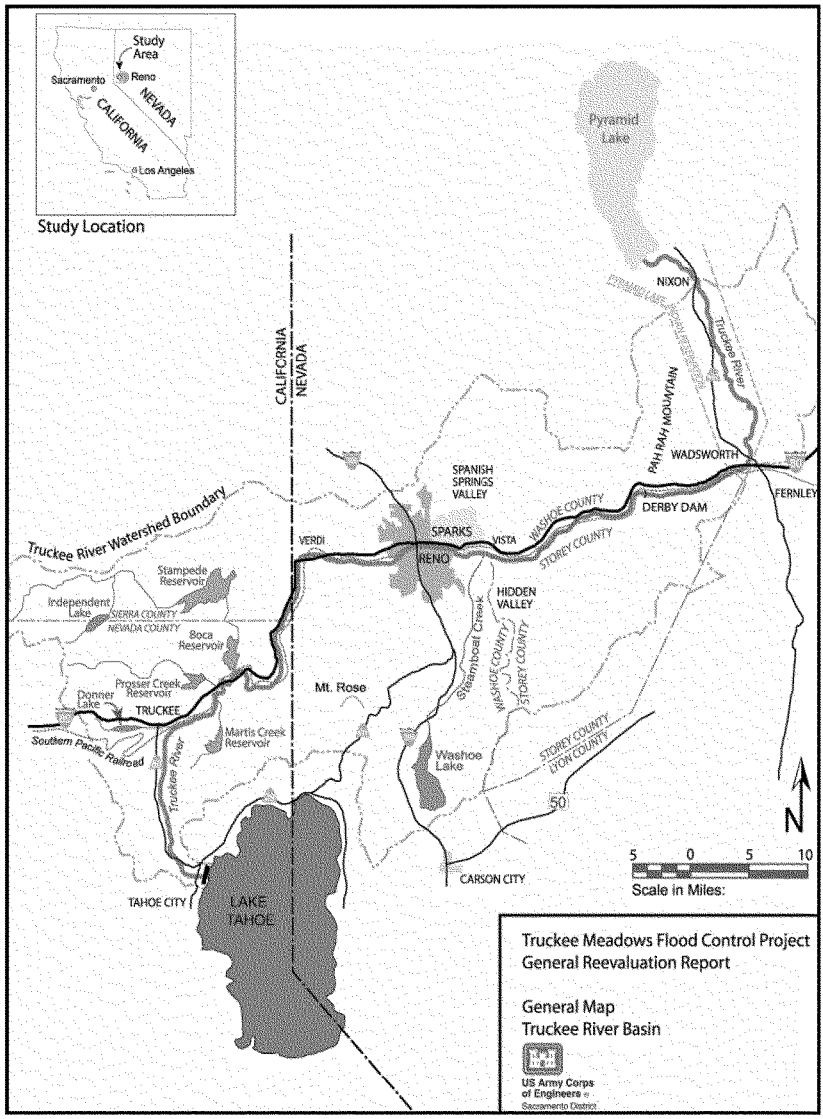


Figure 1 General Map, Truckee River Basin

CHAPTER 2 – GENERAL DESIGN CONSIDERATIONS

2.1 General

This chapter summarizes the project design considerations for development of the Plan. The considerations include the engineering guidance or methodology used and assumptions. Conclusions or features resulting from the analysis are provided in Chapter 3.

2.2 Hydrology

The hydrology report (existing conditions) for the main stem and concurrent tributary flows has been certified and is included as Attachment A.

The Truckee River has an overall flow pattern that is dominated by spring snowmelt peaks. These snowmelt peaks typically occur in May. Intense rain and rain-on-snow events also produce occasional high-magnitude, short-duration peaks that occur at various times throughout the year, but these events rarely occur between the months of July and September. The rising limb of these large peak flows is often much steeper than the declining limb.

Monthly mean discharges on the Truckee River are normally highest during the months of April, May, and June, with the notable exception of the Tahoe City gage at the outlet of Lake Tahoe, which experiences its highest monthly mean flow in August. The lowest monthly mean discharges occur during August, September, and October.

Although many storage facilities exist in the Truckee River's upper reaches, their impact on flood magnitude is low. However, the combined effects of channelization and the lowering of Vista Reef (with its subsequent down-cutting) by the Corps in the early 1960's, have significantly increased flood magnitude in the river's downstream reaches.

2.2.1 Existing Condition Peak Flows

The existing condition peak flows, in cubic feet per second (cfs), are shown below in Table 1 for each of the major gages on the Truckee River.

2.2.2 Estimated Non-damaging Channel Capacity

The estimated average non-damaging channel capacity through the downtown Reno reach is approximately 14,000 cfs. Overtopping of the existing floodwalls begins at approximately 15,000 cfs, or at about the 1-in-50 chance flood event.

The estimated average non-damaging channel capacity through the Truckee Meadows Reach is approximately 10,000 cfs. Minor flooding of parks and roadways adjacent to the river begins at between 6,000 to 9,000 cfs. Flooding that impacts adjacent warehouses and other structures begins between 10,000 to 12,000 cfs, or at about the 1-in-20 to 1-in-35 chance flood event.

Reach/Gage	Chance of Occurrence					
	1 in 10	1 in 20	1 in 50	1 in 100	1 in 200	1 in 500
Downtown						
At Reno	7,500	9,200	13,700	20,700	35,800	63,500
Truckee Meadows						
At Vista	8,200	10,000	14,500	20,200	29,300	52,000
Lower Truckee River						
Near Tracy	8,500	10,500	15,300	21,500	31,400	55,900
Below Derby Dam	8,200	9,800	14,200	19,900	28,900	51,300
Near Wadsworth	8,000	9,800	14,100	19,600	28,200	49,000
Near Nixon	7,800	9,700	14,300	20,100	29,400	52,700

Table 1 Existing Conditions, Truckee River Peak Flows

2.3 Hydraulic Design

The HEC-RAS modeling, flood plain analysis and associated hydraulic design studies completed for the project are discussed in Attachment B, Hydraulic Design.

2.3.1 Flood Event Design Flows

The peak flood event of record was in 1997, when the peak flow for the Truckee River was 20,690 cfs at Vista (second UPRR bridge). See Attachment A for further discussion of the flood event of 1997. The existing conditions 1-in-100 chance flood event peak flow at Vista used to develop the preliminary project alternatives was 20,200 cfs.

2.3.2 Flood Damage Reduction Feature Heights

Required structure heights for the bridges, floodwalls, levees, and temporary closure structures were determined by comparing the top of feature (levee/floodwall/bridge) profiles against the existing ground elevations of the floodwall or levee alignment. Attachment B describes in greater detail how the structure heights were determined.

2.3.3 Interior Drainage

Design guidance for interior drainage comes from EM 1110-2-1913, Design and Construction of Levees; EM 1110-2-3102, General Requirements of Pump Station Design and Layout; EM 1110-2-3104, Structural and Architectural Design of Pump Stations; and EM 1110-2-3105, Mechanical and Electrical Design of Pump Stations.

The area is essentially urban. By guidance, all gravity drains in urban areas are to be made of concrete reinforced pipe and all gravity outlets are to have sufficient invert elevation and slope to minimize siltation at outlets. Inverts must be low enough to allow pipes to flow full before the interior depth reaches damage elevation. Inlet designs include headwall and wing walls, and in areas where large debris may reach the inlet, trash racks are also included. Flap gates will be provided at the discharge end. Slide gates would be provided for positive closure.

2.4 Geotechnical

2.4.1 General

The regional and site geology, subsurface characterization, explorations, and design recommendations are included in Attachment D, Geotechnical Report. Design guidance and considerations used for the feasibility level civil designs are summarized below.

2.4.2 Design Guidance

Design guidance comes from EM 1110-2-1913, Design and Construction of Levees (Nov. 2000); EM 1110-2-1914, Design, Construction, and Maintenance of Relief Wells; ER 1110-2-1150, Engineering and Design for Civil Works Projects; and references found in these documents. Additional guidance was obtained from ETL 1110-2-556, Risk-Based Analysis in Geotechnical Engineering for Support of Planning Studies; Code of Federal Regulations, Title 44, Chapter 1, 65.10 Mapping of areas protected by levee systems; Code of Federal Regulations, Title 33, Volume 3, Navigation and Navigable Waters, Chapter II, Corps of Engineers, Department of the Army, Part 208 – Flood Control Regulations; ETL 1110-2-556 Design Guidance for Levees (1997); and SPK Geotechnical Levee Practice Manual.

2.4.3 Embankment Materials and Geometry

New levees should be constructed with soil meeting the requirements found in section 2.4.7 Borrow Materials. The embankments should be constructed with 1V:3H side slopes because the assumed borrow site contains medium to high plasticity clays and silts. Highly plastic material may have a propensity for shallow sloughing due to a loss of shear strength as soil moisture content increases. This is generally a result of a net increase in water content preceded by a period of shrinkage during dry weather. These failures require maintenance and could be eliminated or reduced in frequency by using less plastic soils near the surface of the slopes or by chemical stabilization of the surface soils. Furthermore, a 1V:3H slope not only assures stability, but is the steepest slope that can be conveniently traversed with conventional mowing equipment. The recommended crown width for the levee system is 20 feet, allowing for an access road that is 16 feet wide. The surfacing for the road should consist of 4 inches of compacted stabilized aggregate, which will permit vehicular traffic during wet weather without causing detrimental effects to the levee. The access road will provide access for inspections, maintenance, and flood fighting operations.

2.4.4 Foundation Preparation

The ground surface within the footprint of the levee should be cleared, stripped, and grubbed to remove low growing vegetation and organic topsoil. The minimum depth of stripping is 6 inches. Clearing, stripping and grubbing is also required under the footprint of seepage berms.

2.4.5 Inspection Trench

An inspection trench should be excavated underneath the alignment of the levee. The purpose of the inspection trench is to determine foundation conditions, to provide a cut-off to reduce seepage through near the surface deposits and to intercept undesirable features that may not be detected from a surface inspection (animal burrows, pipelines, buried logs, pockets of unsuitable material, etc.). The trench should be located between the centerline and waterside hinge point of the levee. The depth of the inspection should equal the height of the levee for levees less than or equal to 6 feet in height. For levees with a height greater than 6 feet, the depth of inspection trench is 6 feet. The inspection trench should have a base width of 12 feet and side slopes of 1V:1H. Backfilling of the trench should occur only after a careful inspection of the excavated trench to ensure that a seepage path or undesirable materials are not present. The inspection should be backfilled with fill meeting the same requirements of levee fill.

2.4.6 Foundation Seepage Control

For levees and floodwalls in which the calculated uplift/exit gradient exceeds the maximum allowable gradient of 0.5, seepage control is required. If excessive gradients are not controlled, the potential for adverse seepage conditions, including boils and piping, is high and could lead to unsatisfactory project performance and levee or floodwall failure. Seepage control measures were developed for the 13 reaches of the Meadows area for water surfaces which result in calculated gradients greater than 0.5.

The typical methods of foundation seepage control measures used by the Sacramento District are slurry cutoff walls, seepage berms / drain blankets, and relief wells. Given that the Meadows area is in a diverse area with roads, business, light industrial zoning to the North and open farm land to the south that are near the levee and floodwall alignments, an emphasis was placed on selecting seepage control measures that require a minimal amount of real estate acquisition. Floodwalls are recommended on much of the north bank and a mixture of new levee construction, benching , seepage berms , and relief wells were selected for the south bank.

Due to the difficulty of constructing slurry cutoff walls along the Truckee River, seepage berms, relief wells and toe drains are recommended to control seepage. Seepage berms, being the most easily constructed and cost effective measure, were recommended where sufficient open space is available next to the levee or floodwall. Relief well systems were recommended for areas where roads, buildings, or other structures are in close proximity to the levee or floodwall. It is recognized that it will be challenging to drill and install relief wells in material that contains cobbles and boulders.

2.4.6.1 Seepage Berms

Seepage berms are utilized where the foundation conditions consist of a relatively impervious top stratum (also referred to as the "blanket") that overlies a more pervious substratum. This type of foundation condition produces high uplift pressures under the top stratum during a flood event that will heave and rupture the top stratum resulting in sand boils and ultimately failure of the levee or floodwall due to piping. To reduce the threat of uplift and heave failures, a seepage berm is constructed along the landside toe. The berm improves seepage conditions by 1) adding weight to the top stratum to counteract the high uplift forces and 2) provides a filtered exit for seepage to safely pass without removal of foundations materials. The seepage berms recommended for the Truckee Meadows project consists of a gravel drainage layer that is encapsulated with either filter fabric or filter sand. Filter sand gradation is typically ASTM C33 fine aggregate while the drain rock material is typically ASTM C33 No. 7 or No. 67 coarse aggregate. The gravel drain should be at least 12 inches thick while the filter sand layer should be at least 6 inches thick. Random or impervious earth fill is placed over the filter and drain layers to add weight to counteract the uplift forces. The earth fill also serves to protect the filter and drainage layer from damage due to erosion or vandalism. The thickness of the earth fill cover depends on the necessary weight to counteract the seepage uplift forces, however at least 2 feet of earth fill cover should be provided. The earth fill cover should slope at least 2% away from the levee and floodwall to carry surface runoff away from the structure.

2.4.6.2 Relief Wells

As with seepage berms, relief wells are also utilized where foundation conditions consist of a relatively impervious top stratum that overlies a more pervious substratum. Relief wells reduce the uplift pressures which may cause sand boils and piping of foundation materials. Wells accomplish this by intercepting and providing a controlled outlet for seepage that would otherwise exit uncontrollably by heaving and rupturing the top stratum. Relief wells consists of a riser pipe and screen, filter pack, and a well head assembly. The riser pipe and screen are 8 inches in diameter and constructed of stainless steel to increase longevity from corrosion. The filter pack surrounds the screened portion of the riser pipe and is typically 4 inches thick which results in a 16 inch total diameter of the well. The well head assembly consists of a check valve, protective casing (typically a precast concrete manhole with steel cover), and a lateral steel pipe leading from the well head to a collector ditch. Flows from the relief wells are routed to the collector ditch where the flows are either pumped back into the river or are routed into the local stormwater drainage system. The spacing of relief wells is determined using a maximum allowable exit gradient of 0.5 at a point located midway between wells. Design calculations assumed a well depth of 40 feet into the pervious foundation zone.

2.4.6.3 Drainage Blankets

Drainage blankets are utilized where the foundation consists of pervious soils at the ground surface. Such foundation conditions exist along the Truckee River between Highway 395 and Greg Street. Since pervious soils exist at the ground surface, a heave type of seepage failure caused by excess hydrostatic pressures landward of the levee or floodwall is not the concern. Instead, the concern is high exit gradients localized near the toe that can leads to piping of foundation soils from

under the structure. The high exit gradients localized near the toe can be mitigated with a drainage blanket. Similarly to seepage berms, drainage blankets have a filter and drain layers that provide a filtered exit for seepage to safely pass without movement of foundation soils. The drainage blankets for the Truckee Meadows project consist of a gravel drain layer encapsulated with either filter fabric or filter sand. The gravel drain layer should be at least 12 inches thick and the filter sand layer at least 6 inches thick. A 4-inch thick layer of aggregate base course should be placed over the filter and drainage layers to provide protection from erosion and vandalism. The drainage layer material typically consists of ASTM C33 No. 7 or No. 67 coarse aggregate while the filter sand is typically ASTM C33 fine aggregate material.

2.4.7 Borrow Materials

The recommended embankment fill for construction of levees should consist of low to medium plasticity lean clay, sandy lean clay, clay, clayey sand, silt, sandy silt, or silty sands (CL, SC, ML, or SM) according to ASTM D2487 classification. These materials should meet the following requirements:

- Maximum particle size of 2 inches
- Minimum of 20% fines content (percent passing the No. 200 sieve)
- Liquid limit less than 45 and a plasticity index between 8 and 24
- No organic material or debris may be present

Three borrow sites have been evaluated during the history of this project. They include the eastern area of UNR Farms, the Channel Widening area along the south bank of the Truckee River between East McCarran Blvd and Steamboat Creek, and the south bank of the Truckee River between Rock Blvd and East McCarran Blvd. Of the three site investigated, the site with the most suitable material is from the Channel Widening site. The two other sites do contain suitable material, but the quantity is limited and suitable material is intermixed with unsatisfactory material so utilization of the sites will not be efficient or economical.

There appears to be sufficient quantity of suitable material at the Channel Widening site and the Rock Blvd to East McCarran Blvd site. However, the quality of the material is marginal given that the liquid limits are near the maximum of 45. Given the difficulty of finding material with a lower liquid limit in the Washoe County area within a short haul distance to the project, it will more economical to utilize the marginal embankment fill that is located a short haul distance away. The use of marginal borrow material will require that the levees have side slope no steeper than 1V:3H.

2.4.8 Seismic Performance/Liquefaction

A preliminary assessment of seismic induced liquefaction and consequences has been conducted for this project. Strong seismic shaking has the potential to induce liquefaction in some of the foundation soils within the footprint of the proposed project features. Liquefaction can cause deformation of foundation soils and possibly damage flood control structures founded on those soils. For most riverine flood control projects, including this project, it is unlikely that strong seismic shaking will occur concurrently with a high-water event. That is, it is unlikely that the flood control

structures will be loaded with high-water flows during a strong seismic event. If the flood control structures are not loaded by high-water flows when strong seismic shaking occurs, then even if liquefaction does occur and causes damage to the flood control structures, the damage would not cause inundation to occur at the time when the damage occurs.

Seismic performance criteria have been considered in this plan to correspond to high-water performance criteria. That is, seismic design is assumed to be based on ground motion exceedance probabilities that are equivalent to the high-water event exceedence probabilities that the project will be designed to withstand. The exceedance probability corresponding to the flood protection return period for this project results in a PGA on the order of 0.1g (or less) over the 50-year planning horizon for the project. Ground motions of this magnitude would not be expected to cause significant damage to flood control structures due to liquefaction. Due to this greater level of damage being relatively unlikely, the project would not be designed to withstand the greater loading.

Common practice is to develop and have in place an emergency response plan for rapidly repairing damage that might occur due to seismically induced liquefaction. Such a plan would be developed during the design phase of the project. At that time, the design team would develop best estimate characterizations and uncertainty ranges of potential liquefaction locations, extents, and magnitudes, as well as similar characterizations of potential resulting damage to the project flood control structures. It is anticipated that these characterizations would be used as a basis for identifying locations and quantities of potential emergency borrow site materials. In the event of liquefaction-induced damage to flood control structures, emergency borrow materials would be transported to the damage sites and placed as fill in configurations that comprise temporary flood protection measures. These temporary measures would be designed to provide flood protection for several seasons, while permanent repairs are being designed and constructed. It is anticipated that potential emergency borrow material sources can be identified throughout and nearby the project area. As such, it is not necessary to identify potential sources during feasibility-level studies. Potential emergency borrow sources and plans for placement of the materials will be developed during the design phase of the project.

2.5 Bed, Bank and Pier Scour Protection

2.5.1 General

A stability assessment was conducted by HDR and Associated California Engineers, LLC, in July 2008 under contract to the Sacramento District to determine if the project will have negative impacts, or if the stability of the proposed project condition will affect the flood control performance of the project from just upstream of Booth Street (Reno) to Pyramid Lake. Where necessary, measures to ensure channel stability (e.g., bank and/or grade protection) have been proposed. The original assessment was conducted using a larger magnitude flood event (117-year event). For alternative analysis and feasibility design of the Plan, District staff analyzed the scour protection requirements using the same methodology and revised quantities and cost estimates. The District analysis did not evaluate sizing of individual scour protection sites but analyzed whether they were necessary due to shear/velocity increases.

For the Truckee Meadows reach, sites were selected for this assessment on the basis of proximity to proposed project features and the likelihood of increased scour. Areas that are currently eroding or sloughing that would not be exacerbated by the project were not assessed. There are several locations where the proposed levees or floodwalls are set back from the river bank and positioned high enough that an overbank analysis was done to see if additional protection will be needed at the levee/floodwall. The analyses for these areas was conducted in the same manner as the typical bank protection above, except that the overbank flow parameters were used instead of the main river hydraulic parameters.

For the Vista to Pyramid Lake reach, sites were initially selected based on the river's proximity to critical infrastructure, such as Interstate 80 (I-80), the Union Pacific Railroad (UPRR), the Truckee Canal and Numana Dam. In addition, sites were selected near bridges and bridge abutments. The HDR analysis included 20 habitat restoration sites and the Plan includes only two sites. The reduction in habitat restoration sites was accounted for during analysis by District staff of alternatives and the Plan.

Downstream sites (from Vista to the Nixon area upstream of Marble Bluff) were analyzed if they had the potential to affect local water diversions and active, productive land.

The HDR results were modified to remove all bank protection in the Downtown Reno reach and there was no scour protection in the Upper Truckee reach. The current plan includes no features upstream of I-395 so these reaches have not been impacted.

The HDR results were further analyzed in January/February 2013 to consider additional criteria including economic justification and other criteria. The area reanalyzed was downstream of the last feature (about 1,000 feet downstream of Larkin Circle) to Pyramid Lake. The scour protection in the Meadows area is mainly protecting new project features and, therefore, the PDT considered the HDR analysis adequate for feasibility. Further analysis and design of scour protection will be conducted during the PED phase.

The re-analysis of sites downstream of the last feature followed the following steps:

- Identify bank erosion segments which potentially pose a problem for critical infrastructure (e.g., along the outside of bend and/or where channel is aimed at Interstate 80, the UPRR, or the Truckee Canal). [about 40 sites were initially identified]
- Of these, identify segments where there is a noticeable increase in channel velocity and/or shear for the 1% AEP event between the without- and with-project conditions (refer to HDR methodology on bank protection). [27 segments of the original 40 fit this criteria]
- Further eliminate segments where there is currently no erosion or existing bank protection is working to control/minimize bank erosion. The retained segments therefore potentially impact existing critical infrastructure and bank erosion is actively occurring [this reduced the inventory to 5 segments]. These segments are illustrated on Figures 1 through 5 in Attachment A.
- Review each segment to determine: 1) if there appears to be an economic justification for including bank protection, or 2) if the critical infrastructure is on the verge of falling into the river in the near future and thus represents a life safety issue.

- Although erosion is active at the five sites, none of the segments appear to meet the criteria in the above bullet. At three of the sites (i.e., RL-5, RL-26, and RL-51), there is sufficient distance between the infrastructure and the river such that there is sufficient time for O&M activities to be implemented, during the life of the project, to prevent erosion from failing the infrastructure. At the remaining two sites (i.e., RL-35 and -36), the bankline adjacent to the UPRR either has existing bank protection, in the form of large riprap, and/or the UPRR track is located on erosion resistant bedrock. There are currently no sites which appear to be on the verge of failing in the near future based on floods which may reasonably be expected to occur.
- Based on this analysis, there are no bank erosion sites which should be included in the Recommended Plan downstream of Vista.

Additional information related to the scour analysis is included in Attachment B – Hydraulic Design.

2.5.2 Design Considerations

The completed scour protection analysis includes field visits and documentation, analysis, design, and drawings with sufficient detail and dimensions to determine quantities and to support a cost estimate for feasibility level construction. The analysis identifies where the project improvements may have a negative impact on the riverbed, river banks and bridges, and where existing and proposed infrastructure may need protection from scour.

Bank Protection

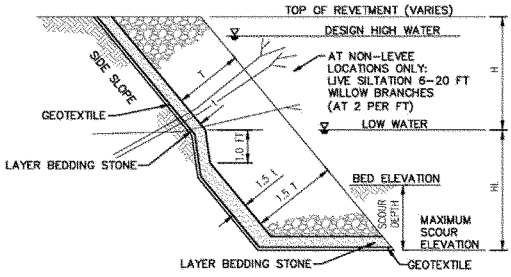
Modeling in the analysis is based on unsteady HEC-RAS hydraulic models (2008), channel stability assessments, and existing sediment gradation data; riprap design, based on velocity, is according to EM 1110-2-1601 and the CHANLPRO software; and bioengineering designs are based on design shear stress using materials with published values for shear stress capacity that exceeded the design condition values (WES, USACE, Fishchenich, 2001).

Briefly, velocity and shear stress categories were established within discrete ranges of velocity and shear stress values according to published capacities of native materials and engineered revetment. If an increase in velocity or shear stress in the proposed condition was sufficient to require the next higher class of bank protection material than under existing conditions, this was identified as a Category 1 impact. The average channel velocity and shear stress were used for this comparison. Further details on the method can be found in the Bank, Bed and Pier Scour Analysis (HDR, 2008).

If the average channel velocity was greater than 8 feet per second, riprap was designed; if less than 8 feet per second, bioengineering was considered. Willow pole planting is included in the standard riprap detail for environmental benefits. Bank protection horizontal limits were established according to conventional guidelines (from one channel width upstream of bends to two channel widths downstream, or as required by field conditions). Bank protection vertical limits extend from the top of the protection to the scour depth. Top of the protection is set at 2 feet above the with-

project water surface elevation (this was a simplifying assumption for consistent drawing depiction and quantity estimation). The bank protection slope is 3 horizontal to 1 vertical if placed on levees, and 2.5 horizontal to 1 vertical on all other banks, except for sites where 3:1 side slopes are required to design stable riprap revetment. Buried riprap for floodwall toe protection was assumed to be 1.5 horizontal to 1 vertical.

General figures of the typical bank protection designs (revetment and biotechnical) are shown below in Figures 2 and 3. For additional details, see the engineering plans.



	LEVEES	NON-LEVEES	OTHER
TOP OF REVETMENT	TO TOP OF LEVEE	2 FT ABOVE HIGH WATER	TO ELEV. OF FACILITY
SIDE SLOPE	3H:1V	2.5H:1V	2.5H:1V

	ABOVE LOW WATER	BELOW LOW WATER
RIPRAP THICKNESS	T	1.5 T
LAYER BEDDING STONE	t = 6 IN.	1.5 t = 9 IN.

Figure 2 Typical Bank Protection Design, Revetment

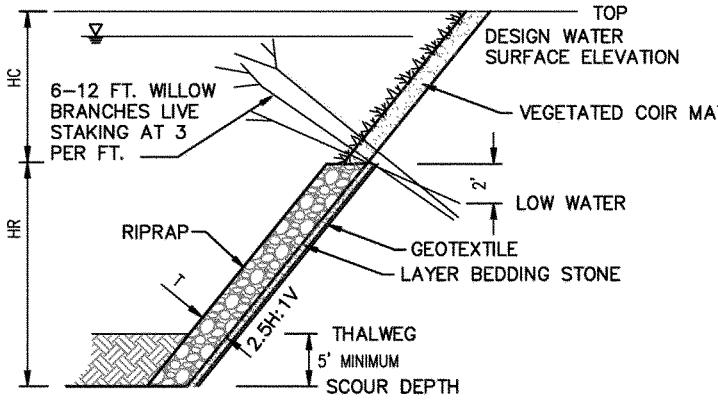


Figure 3 Typical Bank Protection Design, Bioengineering

Bridge Protection

Existing bridges were visited to observe current conditions, see whether there is evidence of existing scour, and if scour protection measures are in place. Bridge scour is calculated for proposed conditions using the methods described in FHWA HEC-18; bridge scour riprap countermeasures are designed according to FHWA HEC-23 guidelines for pier scour and abutment scour. Horizontal and vertical layouts for bridge scour countermeasures are also determined according to HEC-23 guidelines.

The hydraulic effects from the Project were estimated by comparing the Corps' unsteady HEC-RAS model results for existing and proposed conditions. An increase in discharge, depth, or velocity would generally indicate an increase in computed bridge contraction scour, pier scour or abutment scour.

Floodwall and Levee Protection

Protection for on-bank floodwalls generally consists of standard riprap bank protection. Bank protection placement slope follows the bank protection slope criteria described above. If it is judged that the channel bank will not migrate to the on-bank floodwall or if the on-bank floodwall is set back at such a large distance that erosion or migration of the existing channel bank could be monitored over time, no protection was designed.

Protection for in-channel floodwalls consists of standard riprap bank protection with a vertical placement extending from 2 feet above the top of footing to the computed total scour depth. Since the in-channel floodwall protection riprap would need to be placed primarily under the channel bottom, the riprap slope was assumed to be 1.5 horizontal to 1 vertical in order to minimize construction limits and riprap extent. Scour depth for in-channel floodwalls is computed according to HEC-23 procedures for scour at longitudinal structures.

Erosion protection for levees on or near the main channel bank was designed using the main channel hydraulic parameters. If the levee is set back a large distance from the channel bank, the hydraulic parameters from the overbank are used to evaluate protection requirements. If the overbank shear stress adjusted for curvature effects is less than 0.70 pounds per square foot(WES, USACE, Fishchenich, 2001), the standard erosion control seed mix with native grasses is assumed to be adequate erosion protection for the levee. For levee locations with adjusted shear stress values greater than 0.70 pounds per square foot, riprap was designed using the Corps of Engineers' method contained in the CHANLPRO software.

2.6 Civil Design

2.6.1 General

The civil design and site considerations required for construction of project features, access roads, contracting staging areas, real estate requirements, relocations, and quantities developed for the Plan analyzed for the GRR. Design consideration information includes floodwall and levee

construction guidance, EM 1110-2-1913 Design and Construction of Levees, floodway construction regulations (including design criteria near the Reno-Tahoe International Airport), seepage mitigation measures, and relocation requirements.

2.6.2 Topographic Data

Topography (above the waterline), developed using standard photogrammetric mapping techniques, is current as of 2006 for downtown Reno (Mayberry Drive Bridge to I-395) and the Truckee Meadows Reach (I-395 to Vista), and as of 2004 for lower Truckee.

2.6.3 Datum

The North American Datum of 1983 (NAD 83), Nevada West, was used for horizontal control. The North American Datum of 1988 (NAVD88) was used as vertical datum.

2.6.4 Bathymetric Data

Bathymetric data collected in a survey of the Truckee River completed in 2007 extends from downtown Reno to Pyramid Lake.

2.6.5 Real Estate

Engineering Division, Sacramento District, provided Real Estate Division footprints delineating project requirements for the Plan. The Real Estate Plan is prepared in accordance with ER 405-1-12, 12-18, Real Estate Plan. The general real estate requirements for the plan are the acquisition of temporary work area easements (TWAE), flood protection levee easements (FPLE), channel improvement easements (CIE), road and utility easements, flowage easements, and fee title.

The general TWAE width required is 15 feet and extends from the landside and/or waterside edge of the permanent FPLE, CIE or fee title acquisition to allow for the movement of construction equipment to and within the construction site. In some areas restricted by nearby structures or other improvements, a 15-foot TWAE would be used for the floodwall and/or levee construction. TWAE's will also be required for staging areas.

The FPLE is required for the construction and operation and maintenance of flood damage reduction project features. The easement varies in width depending on the type of feature and its overall height and width, and seepage remediation features, if applicable. A vegetation free zone (see section 2.6.7) will be included within the easement. The minimum width of the zone shall be the width of the levee or floodwall, including all critical appurtenant structures, plus 15 feet on the landside and waterside, measured from the outer edge of the outermost critical structure. Also, at a minimum, 15 feet will be provided for maintenance access within this zone on the landside of each floodwall, levee and/or seepage remediation feature.

The CIE is required for channel improvement features such as bank protection, channel benching, and widened channels at widened bridges. Roadway easements would be required for

bridge replacement or rehabilitation measures, as well as road relocations. Utility easements would be required for utility relocations due to construction of project features. Flowage easements are acquired for lands required to be flooded occasionally via the flood control feature, such as where setback levees will be constructed. Areas acquired in fee title include recreation and fish passage improvements.

2.6.6 Quantity Development

Quantities for construction of the included Plan features were developed by District Civil Design staff. The engineering design and quantity development was in accordance with ETL 1110-2-573 Construction Cost Estimating Guide for Civil Works and ER 1110-2-1302 Civil Works Cost Engineering. For Preliminary Cost Estimates, design focused on the cost drivers such as concrete quantities, levee excavation and backfill quantities, etc. For Feasibility Cost Estimates, design for the Plan was refined adding additional details and design clarification to support cost engineering.

2.6.7 Vegetation-Free Zone

The vegetation-free zone (ETL 1110-2-571, April 2009) is a three-dimensional corridor surrounding all levees, floodwalls, and critical appurtenant structures. The vegetation-free zone applies to all vegetation except grass. Grass species are permitted for the purpose of erosion control. The primary purpose of the vegetation-free zone is to provide a reliable corridor of access to, and along, levees, floodwalls, and appurtenant structures. This corridor must be free of obstructions to assure adequate access by personnel and equipment for surveillance, inspection, maintenance, monitoring, and flood-fighting.

The vegetation-free zone must be wide enough, and tall enough, to accommodate all likely access requirements. The vegetation free zone is generally within the FPLE. The general rule is as follows:

- The minimum height of the corridor shall be 8 feet, measured vertically from any point on the ground.
- The minimum width of the corridor shall be the width of the levee or floodwall including all critical appurtenant structures, plus 15 feet on each side, measured from the outer edge of the outermost critical structure. In the case of a planting berm, the 15 feet is measured from the point at which the top surface of the planting berm meets the levee section. Generally no vegetation, other than approved grasses, may penetrate the vegetation-free zone.

2.7 Structural Design

2.7.1 General

The Plan includes many structural features designed in earlier project studies including in-channel floodwalls, on-bank floodwalls, and box culverts. The design of these features has not been modified but District Structural Design Section staff reviewed these designs to confirm validity for feasibility design. These features will be further refined during Preconstuction, Engineering, and

Design (PED) but they have been designed to a level sufficient to establish costs for these features. Design criteria, design assumptions, and loading conditions are also discussed below and general structure layouts and typical details are shown in the Engineering Plans.

Flood walls are typically reinforced concrete structures built to contain a specific flood event (e.g., the 1 in 100 chance flood) with additional height added to allow a margin of safety. Required flood wall heights were determined by comparing the with-project design water surface elevation plus R&U for a given alternative against the existing ground surface elevation of the flood wall alignment.

For the Truckee Meadows area, structure heights were determined at intervals of approximately 100-feet along the identified flood wall alignments. Flood walls were utilized in areas where limited space was available for structure footprints, primarily in highly urbanized and residential areas. Maintenance and emergency operations access for flood walls is provided by a minimum 15-foot wide right-of-way on the landside of the flood wall. Two types of flood walls are used in the project alternatives: (1) on-bank floodwalls and (2) in-channel floodwalls.

2.7.2 On-Bank Floodwalls

On-bank floodwalls are used in the Truckee Meadows reach to avoid relocating or significant impacts to adjacent structures.

Concrete flood walls along the top of the bank would vary in height from 0 to 14 feet. The flood walls would be constructed of reinforced concrete with a patterned architectural finish. Excavation would be 4 to 4.5 feet below the existing grade and backfilled with compacted native soil. Footings would be founded 3 to 3.5 feet below the final grade. The toe of the footings would be located at least 4 feet from the top of channel bank. The R&U analysis for the flood walls would consider catastrophic consequences of failure.

Inverted T-type cantilever cross sections were used for all flood wall types in the Truckee Meadows reaches. The cross bar of the T serves as a base and the stem serves as the water barrier. Table 2 includes minimum required footing widths for given structure heights for on-bank flood wall structural designs.

Wall Height (ft)	Heel/Waterside Footprint (ft)	Wall Thickness (ft)	Toe Width/ Landside Footprint (ft)	Total Footprint Width (ft)
4	1.67	1	1.33	4
6	3.67	1	2.33	7
8	6.25	1.25	3.5	11
10	6.5	1.5	4	12
12	7.75	2	4.75	14.5
14	9.25	2	5.75	17

Flood wall height includes required structure height for containment of 100-year water surface elevation, an additional R&U factor and 2 feet for cover of footing.

Table 2 Floodwall Heights and Corresponding Max. Footing Widths for On-Bank Floodwalls

2.7.3 In-Channel Flood Walls

In-channel floodwalls were utilized where insufficient space was available for and on-bank floodwall. In-channel flood walls serve as a water barrier and retaining wall for adjacent banks. The wall height varies from 10 feet to 30 feet with a 2' guard rail at the top of the wall. Table 3 shows minimum required footing widths for given in-channel flood wall heights for structural design. For in-channel designs, the larger footing/heel is located on the landside of the flood wall.

Wall Height (ft)	Toe/Waterside Footprint (ft)	Wall Thickness (ft)	Heel Width/ Landside Footprint (ft)	Total Footprint Width (ft)
10	2	1	7	10
12	2.38	1.25	8.38	12
14	2.75	1.5	9.75	14
16	3.13	1.75	11.13	16
18	3.5	2	12.5	18
20	3.75	2.25	14	20
22	4.5	2.5	15	22
24	5.25	2.75	16	24
26	5.25	3	17.75	26
28	5.75	3.25	19	28
30	6.5	3.5	22	32
Flood wall height includes required structure height for containment of 100-year water surface elevation, an additional R&U factor, and 2 feet for cover of footing. In-channel flood wall structural designs also used for terraced flood walls.				

Table 3 Floodwall Heights and Corresponding Min. Footing Width for In-Channel Floodwalls

2.7.4 Design Criteria

The flood walls were designed in accordance with the latest criteria and procedures presented in the following design references:

EM 1110-2-2100, "Stability Analysis of Concrete Structures," 1 December 2005.

EM 1110-2-2104, "Strength Design for Reinforced Concrete Hydraulic Structures," 30 June 1992, Change1, 20 August 2003.

EM 1110-2-2502 and ETL 1110-2-322, "Retaining and Flood Walls," 29 September 1989 and 15 October 1990, respectively.

EM 1110-2-6050, "Response Spectra and Seismic Analysis for Concrete Hydraulic Structures," 30 June 1999.

EM 1110-2-6053, "Earthquake Design and Evaluation of Concrete Hydraulic Structures," 01 May 2007.
ER 1110-2-1806, "Earthquake Design and Evaluation for Civil Works Projects," 31 July 1995.
American Concrete Institute (ACI), "Building Code Requirements for Structural Concrete," ACI 318- 05.

2.7.5 Design Load Conditions

The load conditions to be considered for the design of flood walls and retaining walls are described in EM 1110-2-2100 and include: (a) infrequent flood, (b) maximum design flood, (c) coincident pool with maximum design earthquake (MDE) or operating basis earthquake (OBE), and (d) construction.

EM 1110-2-2100 and EM 1110-2502 present the criteria for sliding stability factors of safety, floatation, limits on resultant locations and bearing capacity factors of safety. EM 1110-2-2502 requires that at-rest earth pressures be used for driving side lateral force computations. Resisting side earth pressures shall not exceed one-half the passive earth pressures calculated using unfactored shear strengths. The seismic load case shall be analyzed for active earth pressures on the driving side. The effects of surcharge loads, ground water table and sloping backfill will be considered, as applicable, for all load cases. The Boussinesq method of analysis can be used to approximate the lateral earth pressures due to surcharge loads. The design construction load should take into consideration a vehicle equivalent to either a HS-20 truck or tandem, whichever one results in the larger loading condition, driving on the soil during construction.

During a seismic event, the structure is also subjected to dynamic soil pressures caused by the ground motion. Dynamic backfill pressures are influenced by the relative movement between the soil and the structure and the stiffness of the backfill. Methods for estimating the dynamic backfill pressures are outlined in EM 1110-2-2100. In addition to lateral earth forces, structure inertia forces due to earthquake accelerations are to be included in the earthquake design loading condition. For all wall types, use of the seismic coefficient method is dependent upon the foundation materials being non-susceptible to liquefaction. A liquefaction assessment should be conducted prior to final design of the wall systems.

2.7.6 Earthquake Design

2.7.6.1 Standard and Site-Specific Studies

Standard seismic studies use existing generic seismological studies, available site data and information, preliminary values of ground motions from published seismic zone maps, simplified assessment of liquefaction and deformation to determine if seismic loads control and to set the scope for a site-specific study if necessary. They are useful for preliminary analysis of all seismic zones and may be satisfactory for final design and evaluation in seismic zones 1 or 2A.

Site-specific studies are based on actual site and structural conditions determined from detailed field explorations and testing programs. They are divided into two approaches, deterministic seismic hazard analysis and probabilistic seismic hazard analysis. Site-specific studies should be done for projects in seismic zones 3 and 4 and for projects in zones 2A and 2B where earthquake loads control the design. The Truckee Meadows Flood Control Project is located in zone 3.

2.7.6.2 Design Earthquakes and Ground Motions

The Operating Basis Earthquake (OBE) is defined as an earthquake having a 50-percent probability of exceedance during the service life of the structure. The service life for hydraulic structures is normally taken as 100 years which results in a 144-year return period. The structure should function with little or no damage and without interruption of function. The purpose is to protect against economic losses from damage or loss of service, therefore the return period may be changed based on economic considerations. The OBE is determined by a probabilistic seismic hazard analysis. Seismic forces pertaining to the OBE are considered unusual loads.

The Maximum Design Earthquake (MDE) is the maximum level of ground motion for which a structure is designed. The structure should function without catastrophic failure, and severe damage or economic loss is tolerated. The MDE can be characterized as a deterministic or probabilistic seismic event. Seismic forces pertaining to the MDE are considered extreme loads.

The Maximum Credible Earthquake (MCE) is defined as the largest earthquake that can be reasonably expected to occur on a specific source on the basis of seismological and geological evidence. A site may have multiple MCE's due to the various earthquake faults, fault mechanisms, earthquake magnitudes, and distance from the site. The MCE is determined by a deterministic seismic hazard analysis.

Earthquake loads are to be combined with other loads that are expected to be present during routine operations. The retaining walls, flood walls, and other flood control structures that are to be built for the Truckee Meadows Flood Control Project are classified as critical structures. Critical structures are defined as structures that are part of a high hazard project and if failure occurs, it will result in loss of life. For critical structures, the MDE is the same as the MCE ground motion.

2.7.7 Seismic Coefficient Criteria

Preliminary estimates of minimum seismic horizontal acceleration coefficients are given in Appendix G of EM 1110-2-2100 and shown in Table 4. The seismic vertical acceleration coefficient is estimated as two-thirds of the horizontal acceleration coefficient. For further analysis, the estimated peak ground acceleration (EPGA) for the site is required and the horizontal acceleration coefficient is taken as being equal to two-thirds of the EPGA for yielding type retaining structures.

Zone	Seismic Horizontal Acceleration Coefficient
0	0.00
1	0.05
2A, 2B	0.10
3	0.15
4	0.20

Table 4 Minimum Seismic Horizontal Acceleration Coefficients

2.7.8 Reinforced Concrete Box Culverts

Box culverts will be constructed for the North Truckee Drain for the Plan. These culverts will consist of double 10-feet wide by 10-feet high reinforced concrete box culverts as well as other single sized culverts of varying sizes as shown on drawings. There are also shorter connector box culverts as shown on Plans.

2.8 Environmental Site Assessment

The Environmental Design Section of the Sacramento District performed an Environmental Site Assessment (ESA) for the entire area of the project, from downtown Reno to Pyramid Lake during May 2011. The site assessment described numerous sources of possible contamination due to hazardous, toxic, or radiological waste (HTRW) during a records search and field survey. The data search showed 686 sources of potential contamination within 1 mile of the study boundaries. The breakdown of these sources follows:

- 190 state-registered underground storage tanks (UST) and above-ground storage tanks (AST)
- 186 listed generators of hazardous waste regulated by the U.S. Environmental Protection Agency (USEPA)
- 207 facilities required to report their hazardous waste activities to the USEPA
- 13 leaking UST's since cleaned up or undergoing remediation
- 59 sudden or accidental releases of hazardous substances into the environment
- 14 non-UST active corrective action cases
- 15 pesticide-producing establishments and compliance activities
- 1 mine
- 1 coal/gas site
- 3 sites on the PCB database

Data research showed that of the potential sources described above, 26 of them were located within the construction zone of the project. The breakdown of these potential sources is as follows:

- 6 state registered UST's and AST's

- 10 sites that had leaking UST's but have since been cleaned up or are undergoing remediation.
- 1 hazardous chemical producing establishment and compliance activities
- 9 sites which transport, store, treat and/or dispose of hazardous waste as defined by RCRA.

There is no indication that these potential sources will affect activities within the construction zone of this project. For the majority of the sources, no field evidence or records were found to indicate that these potential sources have caused significant contamination. Most involve registered UST's, hazardous waste generators, minor tank leaks, UST removal and remediation, and minor accidental releases. An Environmental Site Assessment will be updated before construction activities begin, including coordination with appropriate environmental agencies. Based on information gathered during the database search and site visit, the feasibility level project design avoids the identified potential HTRW sources, including underground storage tanks.

2.9 Cost Engineering

The cost estimates for the preliminary alternatives and feasibility design of the Plan prepared by the Cost Engineering Section of the Sacramento District. Design guidance comes from ER 1110-2-1302, Civil Works Cost Engineering. Detailed preparation and the format of all estimates follow the guidance in Engineer Technical Letter (ETL) 1110-2-573. Summary of estimates for the feasibility estimate for the Plan are provided in Attachment C – Cost Estimate, Certification, & Project Cost and Schedule Risk Analysis Report.

2.10 Value Engineering

The Corps' Value Engineering Team completed a Value Engineering study on the project, 13 April to 15 April 2004. They identified, evaluated, and classified project features and functions; determined and assigned values to each function; developed a Function Analysis System Technique (FAST) diagram (based on the classification and evaluation of each function); proposed remedial alternatives for each function; evaluated the plausibility of each proposal and selected the most viable proposals for submittal; provided documentation for alternatives on original design, VE proposals, cost comparisons, and savings; and justifications for the selected proposals. Several proposals were incorporated into the design of the Plan; however, the PDT recommends an additional Value Engineering study be performed during PED as this report is over 9 years old.

2.11 Other Design Considerations

Project features near the Reno-Tahoe International Airport (RTIA)

Flood control structures near the RTIA must be planned and constructed in accordance with applicable Federal Aviation Administration regulations. The Runway Safety Area (RSA), the most restrictive of the airport safety zones (no project features allowed), extends 1,000 feet from the end of the runway and 250 feet either side of the centerline of the runway. No project features are within the RSA. In general, the safety guidance for all airports requires that no obstacles be present for as much area as possible from the end and corners of the runway to ensure maximum safety of precision instrument landings. The most critical issues are (1) precision landings controlled with the

50:1 slope criteria for airspace penetration from the end of the runway and (2) the RSA, with a clear zone with 0–3 percent slope down from the end of the runway (for planes aborting takeoff and running off the end of the runway). The RTIA obstacle clearance is already compromised by the existence of Mill Street immediately at the end of the runway. Restoration is proposed along the river at the end of the runways. To minimize hazards from airspace penetration, only shrubby plant material is being proposed.

An airspace evaluation using FAA form 7460-1 (notice of proposed construction or alteration) must be filed for the flood control project and submitted formally at least 60 days prior to notice for bid release for project features near the RTIA. An approval would not necessarily be automatic. If there were issues, these would have to be overcome prior to approval being granted. Construction can not start until the approval is obtained. The FAA recommends FAA Aviation Circulars 70/7460-1K and 150-5300-13 be referenced for guidance and criteria. Construction activities and periodic maintenance activities would also occur along the levee alignment. This maintenance would most likely include pickup trucks and/or other heavy equipment along the top of levee. The FAA noted that maintenance activities will need advance coordination with the RTIA. Flood monitoring activities would be handled as necessary.

For preliminary alternatives evaluated in the Truckee Meadows Reach that raised water surfaces high enough to require a containment structure on Boynton Slough immediately adjacent to the RTIA, the proposed measure would be to place the water course in a buried culvert through the reach.

Pursuant to Title 14, Code of Federal Regulations, Part 139.337(f), RTIA maintains a Wildlife Hazard Management Plan (WHMP) in cooperation with the U.S. Department of Agriculture's Wildlife Services program. The WHMP places emphasis on identification and abatement of wildlife hazards within the airfield environment; however, additional wildlife attractants (e.g., agricultural cropland, golf courses, public parks) within 5 miles of the airfield are also addressed, since they could potentially attract wildlife in a manner that could jeopardize safety of air traffic operating into and out of RTIA. The plan outlines steps for monitoring, documenting, and reporting potential wildlife hazards and strikes at RTIA. Project features must be planned and constructed to minimize wildlife hazards to the RTIA. Major recreation features planned for the project would be placed as far away as possible from the runways, at the corner of Mill Street and McCarran Boulevard.

Recreation features were assumed to be consistent with the Washoe County Department of Parks and Recreation "Green Book, Standard Details for Park and Open Space Construction" The details and standards were applied to the recreation plan as formulated in the GRR for the generation of quantities for cost estimating. A paved access drive and parking lot was provided as county development standards prohibit the use of unpaved parking lots. For the purposes of developing quantities for the cost estimate, playground equipment was assumed to be standard type of post and clamp equipment as supplied by major manufacturers of playground equipment.

2.12 Operation, Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R)

The non-Federal sponsor(s) will be responsible for the project operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) upon turnover of the project. The potential non-Federal sponsors for the project are the City of Reno, City of Sparks and the Counties of Washoe and Storey, Nevada. OMRR&R responsibilities include operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) of the completed project. OMRR&R payment responsibilities will be according to the Project Cooperation Agreement (PCA). The operation and maintenance costs represent the average cost to maintain the project improvements throughout the project life. The maintenance for flood control features (levees, channels, flood control structures and bank protection) and recreation and fish and wildlife improvements would be performed in accordance with provisions of Title 33, Flood Control Regulation, Maintenance and Operation of Flood Control Work, approved by Secretary of Army, 9 August 1944, published 17 August 1944, Federal Register. The general intent of the regulations is expressed as follows: "The structures and facilities constructed by the United States for local flood protection shall be continuously maintained in such a manner and operated at such times and for such periods as may be necessary to obtain the maximum benefits."

The Corp's Resident Engineer schedules and conducts joint acceptance inspections, monitors correction of deficiencies, schedules and monitors OMRR&R training, ensures that all as-built drawings are complete and accurate, and provides information/support for the Corps to prepare and distribute property transfer documentation.

Prior to final acceptance of the project or an increment of the project, pre-final inspections will be conducted on an area-by-area basis or may be conducted on a functional basis. The purpose of these inspections is to ensure turnover of a complete, functional and maintainable project (or increment), constructed fully in accordance with the contract specifications and drawings. Upon final acceptance of an area or the project, the Corps will prepare and transfer an OMRR&R manual for the project features and the non-Federal sponsor will assume OMRR&R.

CHAPTER 3 – ALTERNATIVE 3 FLOODPLAIN TERRACE

3.1 General

Flood damage reduction features begin in at Highway 395 and proceed downstream to the approximately 1,000 feet downstream of Larkin Circle. See the Engineering Plans for details and extents of the flood damage reduction features in the Plan. There are no improvements included for the Upper Truckee, Downtown Reno, and Lower Truckee reaches in the Plan. A list of the proposed features, construction contract location (for cost estimates), and general description is shown in Table 5.

The Plan includes the following features:

- Levees and Floodwalls (on-bank and in-channel)
- Floodplain terracing
- Improvements to the North Truckee Drain and People's Drain
- Interior drainage facilities
- Seepage remediation
- Bank and bridge pier/abutment and scour protection
- Relocation of utilities
- Recreation
- Revegetation

	Feature Description	Description
Contract 2A (McCarran to Vista)	East McCarran (North Bank) OBF	2,130 LF
	Franklin (North Bank) ICF	3,150 LF
	Spice Island, Arch Building (North Bank) Levee	2,100 LF
	Franklin Lumber Co (North Bank) Levee	9,150 LF
	Ring Levee at McCarran - South Bank	1,450 LF
	Seepage Berm	4,700 LF
	Relief Wells	57 Relief Wells Total Length = 2,800 LF
	Building Demolition	22,650 SF
	Asphalt Demolition	370,000 SF
	Scour Protection	6 Sites (2 bioengineered) Total Length = 6,100 feet; 1 Bridge
	Maintenance Road	18,000 LF
	McCarran-Rock West McCarran (North Bank) OBF	1000 LF
	Rock-McCarran (South Bank) Levee	7,030 LF
Contract 3A (Rock-McCarran)	Rock-McCarran East Rock (North Bank) Levee	4,200 LF
	McCarran-Rock West McCarran (North Bank) Levee	1,150 LF
	Seepage Berm	6,400 LF
	Relief Wells	61 Relief Wells Total Length = 3,000 LF
	Building Demolition	417,400 SF
	Asphalt Demolition	400,500 SF
	Scour Protection	2 Sites Total Length = 2,000 LF; 1 Bridge
	Interior Drainage	None
	Maintenance Road	13,500 LF
	Floodplain Terracing	28.8 Acres Total Excavated Volume = 481,000 CY
Contract 4A (I-395 to Rock)	Glendale-Greg (South Bank) OBF	2,600 LF
	Glendale-Greg (North Bank) OBF	800 LF
	Greg-Rock (South Bank) Levee	1,900 LF
	Glendale-Greg (North Bank) Levee	1,700 LF
	I-395 to Glendale (Walmart) (South Bank) Levee	2,300 LF
	Drain Blanket	3,300 LF
	Toe Drain	3,600 LF
	Asphalt Demolition	370,000 SF
	Scour Protection	5 Sites Total Length = 3,500 LF; 1 Bridge
	Interior Drainage	14 CFS Pump Station; 110 LF 42" RCP Gravity Drainage
	Maintenance Road	9,300 LF
	Floodplain Terracing	21.2 Acres Total Excavated Volume = 242,000 CY
	Revegetation, McCarran to Rock	
	Revegetation, Rock to I-395	
Contract 1D	North Truckee Drain Culvert	2-11 ft x 10 ft RCB Total Length = 3,100 LF
Contract REC4A	Recreation, I-395 to Vista	

Table 5 Proposed Project Features

3.2 Levees and Floodwalls

The Plan includes approximately 9,650 lineal feet of on-bank (6,500 feet) and in-channel (3,150 feet) floodwalls along the north bank and 31,000 lineal feet of levees along the north and south banks of the Truckee River. Reference the Engineering Plans, for plans, profiles, and details of the flood damage reduction features and measures in the Truckee Meadows Reach. A gravel maintenance road is included on the crown of the levee. The road will be 12 feet wide with 2-foot aggregate base shoulders.

In areas dominated by the invasive, non-native species tall-whitetop, all plant materials removed during construction would be left on-site in a location that would not allow plant material to enter waterways. To avoid spreading weeds, all machinery and vehicles that leave the site would be washed on site to remove attached seeds and roots.

3.3 Floodplain Terracing

This measure involves excavating a benched area along portions of the south (right) and north (left) banks of the Truckee River between Greg Street to just upstream of McCarran Boulevard. Vertically, the excavation would extend down to a level corresponding to the maximum water surface elevation (WSE) associated with approximately between one and two year flow under existing conditions. The two-year flow has a 50% probability of occurring in any given year. Since this level is above that which occurs throughout most of the year, excavation to just under the two-year WSE would create a low bench above the low-flow channel bed, which would be inundated during higher winter and spring flow events. This low bench would extend approximately 150 to 250 feet to the landside of the south bank of the Truckee River from Greg Street to just upstream of McCarran Boulevard. A higher bench, approximately 2 feet higher in elevation, would be extended approximately 50-70 feet to the landside of the low bench for a majority of the benching reach also. The measure is intended to increase the flood flow channel capacity and thereby reduce water surface elevations in the Truckee Meadows area during a flood.

Revegetation of the surfaces of the excavated areas and embankments will be carried out to stabilize the terraces in regards to erosion from both river flows and stormwater runoff. Due to their location at the end of the Reno International Airport runways, in the reach from the Greg Street Bridge to Rock Blvd. Bridge, Cottonwood and red willow trees will not be planted on the excavated terraces. The surfaces of the floodplain terraces will be revegetated to prevent the disturbed area from being colonized by noxious weeds, invasion by tall white-top being a primary concern. To these ends, native trees grasses and shrubs will be utilized as they will provide a self sustaining cover of vegetation to serve both the purpose of stabilization and exclusion of noxious weeds. In areas dominated by the invasive, non-native species tall-whitetop, all plant materials removed during construction would be left on-site in a location that would not allow plant material to enter waterways. To avoid spreading weeds, all machinery and vehicles that leave the site would be washed on site to remove attached seeds and roots. Prior to revegetation efforts, invasive perennials

such as whitetop species would be treated with herbicide prior to any revegetation efforts. For revegetation areas adjacent to the river and wetlands, perennial invasive species would be hand-pulled. Re-growth would be treated with weed herbicide using a wick applicator. Banks would be revegetated at the end of each construction season to limit spread of noxious weeds. The Comprehensive Wildlife Sensitive Weed Control Plan by Otis Bay Consulting (2006) would be updated and implemented. Manual removal would be used in sensitive areas near waterways and wetlands. If chemicals are used in these areas, a wick applicator and a water labeled formula 2,4-D would be used for infested areas located within 30 feet of the Truckee River and associated wetlands. Chemicals used in other areas would be applied according to the manufacturer's specifications by State-approved weed control experts. Measures for monitoring and associated adaptive management would be implemented to verify the performance of mitigation, construction BMPs, and other conservation features. Lessons learned from the earlier phases of construction would be applied to later phases.

The following tables show a preliminary list of the species that will be predominantly used, these are expected to be refined during the PED phase:

Cottonwood Riparian Forest Species (High Terrace)	
Scientific Name	*Common Name*
Trees and Shrubs	
Populus fremontii	Fremont Cottonwood
Populus deltoides monifera	Plains cottonwood
Ribes aureum	Golden currant
Rosa woodsii	Wood's rose
Salix exigua	Sandbar willow
Salix laevigata	Red willow
Salix lasiandra	Whiplash willow
Salix lutea	Yellow willow
Grasses	
Leymus triticoides	Creeping wildrye
Elymus trachycaulus	Slender wheatgrass
Hordeum brachyantherum	Meadow barley

Cottonwood Riparian Forest Species (Low Terrace and at end of airport runways)	
Scientific Name	*Common Name*
Trees and Shrubs	
Ribes aureum	Golden currant
Rosa woodsii	Wood's rose
Salix exigua	Sandbar willow
Shepherdia argentea	Buffaloberry
Grasses	
Leymus triticoides	Creeping wildrye

Cottonwood Riparian Forest Species (Low Terrace and at end of airport runways)	
Scientific Name	*Common Name*
Elymus trachycaulus	Slender wheatgrass
Hordeum brachyantherum	Meadow barley

Planting densities will be at 240-480 plants per acre for cottonwood riparian forest and will be at 550 to 870 plants per acre for shrub scrub habitat. Final density will consider row spacing for ease of plant establishment and rapid coverage of revegetated areas to crowd out noxious weeds.

Erosion will be controlled on the excavated surfaces of the terraces through establishment of permanent vegetative cover. During the time that it takes to establish a permanent vegetative cover, erosion control best management practices will be utilized as needed. The embankments leading down to the relatively level terraced areas will receive a lining of woven coir erosion control fabric in addition to vegetative plantings. If hay/straw bales are used for sediment control, they would be certified weed-free to reduce establishment/reestablishment of invasive weeds.

Revegetation plantings will be established by watering the plants for a period of 3-5 years depending on the severity of the ensuing growing seasons. Watering will be tapered off gradually in frequency to wean the plants from supplemental irrigation and to encourage deep rooting. Weed control will consist of timed mowing and herbicide applications for a period of 2-4 years depending on weed pressure. Revegetation plantings will be arranged in rows to facilitate mowing and weed control. The space between the plantings will be mowed. The rows of plants may be mowed or kept free of weeds by spraying a 3 to 4 foot wide strip along the rows where mowing is more difficult.

In areas dominated by the invasive, non-native species tall-whitetop, all plant materials removed during construction would be left on-site in a location that would not allow plant material to enter waterways. To avoid spreading weeds, all machinery and vehicles that leave the site would be washed on site to remove attached seeds and roots. The following are recommendations for weed control during establishment of the vegetation. These are generalized and would need to be adjusted for particular requirements of each area in which they would be applied. In areas within 30 feet of the river should herbicide be required, a water approved formula of 2,4,d would be wick applied.

Post construction, first season

1. In spring early germinating and perennial weeds will be sprayed with herbicide. (Escot,2,4,D have been effective)
2. In Mid spring the site will be mowed
3. In Mid –late spring herbicide will be re-applied to areas with new weed growth,
4. In late spring/early summer site will be mowed
5. Problem species of weeds, (especially pepperweed) will be spot sprayed on an ongoing basis during the growing season.
6. Manual weeding will be performed on a regular basis during the growing season.

Post construction, second season

1. In spring in problem areas, early germinating and perennial weeds will be sprayed with herbicide.
2. In Mid spring the site will be mowed
3. In Mid –late spring in problem areas, herbicide will be re-applied to new weed growth,
4. In late spring/early summer site will be mowed
5. Problem species of weeds, (especially pepperweed) will be spot sprayed on an ongoing basis during the growing season.
6. Manual weeding will be performed on a regular basis during the growing season.

Post construction, third and subsequent seasons

1. In Mid spring the site will be mowed
2. In late spring/early summer site will be mowed
3. Problem species of weeds, (especially pepperweed) will be spot sprayed on an ongoing basis during the growing season. Large outbreaks of weeds will be area sprayed.
4. Manual weeding will be performed on a regular basis during the growing season.

3.4 Improvements to North Truckee Drain and People's Drain

To prevent overbank flooding upstream of the confluence with the Truckee River, the North Truckee Drain (NTD), downstream of Interstate 80 and the railroad, would be placed in two buried box culverts, 10 feet wide by 10 feet high, for a length of approximately 3,200 lineal feet. The reinforced concrete box culverts will include maintenance access and be installed along the existing drainage channel alignment. The box culverts would be buried a minimum of 3 feet below the new grade line, with the invert approximately 2 feet below the invert of the existing channel, and include 1.5 feet of bedding material. The new drainage structure includes an approximately 200-lineal-foot extension to the existing Peoples Drain. At the transition at the existing NTD crossing under the railroad, a 20-foot-wide by 10-inch-high reinforced concrete box culvert would be installed.

The Plan includes enclosing two junction boxes along the existing People's Drain. The box enclosures include cast-in-place reinforced concrete box culverts that will extend from new headwalls located at the outlets of the existing culverts under the I-80 embankment to the existing junction with the People's Drain. The junction locations would include new cast-in-place sidewalls and precast lids to provide a watertight seal. Reference the Engineering Plans for plan, profile and details of improvements proposed for the North Truckee Drain and the People's Drain.

3.5 Interior drainage facilities

Interior drainage facilities include a 14 cfs pumping station coupled with gravity drainage just upstream of Glendale. Also, new flap gates and vertical sluice gates have been designed for all existing storm drains.

3.6 Seepage remediation

Seepage remediation measures proposed include seepage berms, drainage blankets, and relief wells. Appropriate seepage control measures were developed by the geotechnical engineers and are summarized in Table 6.

Reach	Location		Water Surface (H) where no seepage control measures are recommended.	Water Surface Height (H) and Corresponding Seepage Control Measures		
1	***Vista Reefs to North Truckee Drain***					
	left bank(N)	**Franklin Levee**	H ≤ 6'	6' < H ≤ 10' Relief wells spaced at 150'	10' < H ≤ 15' Relief wells spaced at 100'	15' < H ≤ 20' Relief wells spaced at 80'
	right bank(S)		----	----	----	----
2	***North Truckee Drain to 5,000' upstream of North Truckee Drain***					
	left bank(N)	**Franklin Levee**	H ≤ 10'	10' < H ≤ 20' Relief wells spaced at 200'	----	----
	right bank(S)		----	----	----	----
3	***5,000' upstream of North Truckee Drain to McCarran Blvd.***					
	left bank(N)	**1. Franklin In-Channel Floodwall** **2. Spice Island Levee** **3. McCarran On-Bank Floodwall**	H ≤ 4'	4' < H ≤ 7' 3' high by 40' wide seepage berm	7' < H ≤ 15' Relief wells spaced at 50'	----
	right bank(S)	**Ring Levee**	----	----	----	----
4	***McCarran to Rock - left bank(N)*** **1. West McCarran Levee** **2 On-Bank West Floodwall** **3. McCarran, East Rock Levee**		H ≤ 3'	3' < H ≤ 6' 3' high by 50' wide seepage berm	6' < H ≤ 15' Relief wells spaced at 50'	----
	McCarran to Greg) **1. McCarran-Rock Levee** **2. Rock-Greg Levee**		H ≤ 7'	7' < H ≤ 10' 5' high by 55' wide seepage berm	10' < H ≤ 15' 5' high by 80' wide seepage berm	15' < H ≤ 20' 5' high by 150' wide seepage berm
5	***Greg St. to Glendale Ave.***					
	left bank(N)	**1. Levee** **2. On-Bank Floodwall**	0	0' < H ≤ 5' Toe drain	5' < H ≤ 10' 10' wide drain blanket	10' < H ≤ 15' 20' wide drain blanket
	right bank(S)	**Greg-Glendale On-Bank Floodwall**	0	0' < H ≤ 5' Toe drain	5' < H ≤ 10' 10' wide drain blanket	10' < H ≤ 15' 20' wide drain blanket
6	***Glendale Ave. to Hwy 395 right bank(S)*** **Glendale-HWY 395 levee**		0	0' < H ≤ 5' Toe drain	5' < H ≤ 10' 10' wide drain blanket	10' < H ≤ 15' 20' wide drain blanket
7	***North Truckee Drain***		H ≤ 6'	6' < H ≤ 15' Relief wells spaced at 50'	----	----
8	***UNR Farms***		H ≤ 8'	8' < H ≤ 10' 5' high by 55' wide seepage berm	10' < H ≤ 15' 5' high by 75' wide seepage berm	15' < H ≤ 20' 5' high by 100' wide seepage berm

Table 6 Recommended Seepage Control Measures

See Engineering Plans for cross sections and approximate locations of seepage remediation measures.

3.7 Bank and Bridge Pier/Abutment Scour Protection

Due to the containment features such as levees and floodwalls, the in-channel flows are increased above existing conditions. To mitigate for increased flow, bed, bank and pier scour protection was analyzed and included as a project feature. The bank protection is required to provide scour protection for the proposed levee and floodwall features consistent with standard design guidance. Bank protection is proposed for 13 sites and consists of two bio-engineered segments and 11 rip rapped segments having a total extent of approximately 11,600 linear feet or 2.5 miles. Additionally, scour countermeasures are proposed at 3 bridges to prevent increased erosion caused by increased in-channel flows which occur when the flows are limited to the channel by construction of the floodwalls and levees. Hydraulic analysis indicates that the flow concentration will significantly increase pier and/or abutment scour to the point where bridge failure may occur under the with-project condition. A detailed scour analysis will be conducted in PED to confirm the bank and bridge pier scour analysis. See the Engineering Plans for plan view and profiles of sites and design details.

3.8 Relocation of Utilities, Relocation of Bridges, and Demolition

No significant utility relocations are proposed for the Truckee Meadows reach other than utilities that are through or under existing berms that will be replaced by levees/floodwalls. Utilities that are disturbed will be replaced in kind. For the lower Truckee River bank protection that is located immediately adjacent to the UPRR and I-80, relocations may be required for the Kinder-Morgan high pressure gas line. This will be coordinated closely with Kinder-Morgan during the design and construction of the project. For Feasibility Design, utility relocations information provided by TRFMA and developed by an A/E firm was used as a basis for developing relocations for the Plan. The TRFMA provided information was for a larger plan and Los Angeles District Civil Design staff determined impacted utilities using project features included in the Plan.

3.9 Recreation

The following list describes the features proposed under the recreation project purpose that would be eligible for cost sharing under Corps recreation planning policy. The following features would be provided in the recreation plan:

- 50 individual picnic tables
- 1 small picnic shelters each consisting of:
  - 20'x 20' steel shelter with standing seam metal roof
  - concrete paved area
  - Four 6' picnic tables with bench style seating, with provision for wheelchair accessible seating at one end of one of the tables for persons in wheelchairs.
  - Two trash receptacles
  - Drinking fountain with jug filler
- 1 medium group shelters each consisting of:
  - 40'x 40' steel shelter with standing seam metal roof
  - concrete paved area

  - Twenty 6' picnic tables with bench style seating, with provision for wheelchair accessible seating at one end of several of the tables for persons in wheelchairs.
  - Four trash receptacles
  - Drinking fountain with jug filler
- 13 fishing access sites
  - consists of connector trail to trail system, trail down river bank to allow access to river
- 4 canoe and kayak put-in sites
  - consists of connector trail to trail system, trail down river bank to allow access to river
- 8,900 feet of unpaved trails
- 9,700 feet of paved trails
- 2269 lf of 24 ft wide paved driveway
- 112 stall paved parking lot (50,000 s.f.)
- 1 Restrooms
- 10,000 s.f. playground with play equipment for various ages
- interpretive signage
- landscaping required to support and connect above features as appropriate

3.10 Staging Areas, Construction Access, Haul Routes, and Borrow/Disposal Areas

Staging Areas, Construction Site Access and Haul Routes

The project construction site access and haul routes would generally be on existing public roads in Truckee Meadows reaches. Staging areas for the Truckee Meadows work are generally within the flowage areas between the footprints for the north and south levees/floodwalls. Temporary access roads will be constructed for access to the levees, floodwalls, and scour protection sites with traffic control costs included in the project cost estimate.

The primary haul route to the disposal areas at Spanish Springs or Granite Pit from Truckee Meadows is as follows: Mill Street/Clean Water Way to South McCarran Boulevard to I-80 to Pyramid Highway north to Spanish Springs and Mill Street/Clean Water Way to South McCarran Boulevard to I-80 east to Granite Pit. Temporary access roads or existing maintenance roads from the scour protection and mitigation areas will be used as the haul routes from I-80 to Spanish Springs/Granite Pit.

Borrow and Disposal Sources

To date, the only area identified as a borrow site containing suitable embankment fill material is the investigation from McCarran Blvd. west toward Rock Blvd. The estimated available quantity of 130,000 CY of useable soil is inadequate relative to the required amount needed to complete the project. Further investigations will be necessary to identify additional suitable borrow material for levee fill, seepage blankets, and berms. See Attachment D – Geotechnical Summary Report for more information on borrow investigations and sites.

The current, tentative spoil areas for the project are located approximately 25 miles north and 12 miles east of the Truckee Meadows project area near the Spanish Springs community area and the Granite Pit site, just south of Interstate 80 at exit 32 (see Engineering Plans, sheet G-002). The

Granite Pit site encompasses approximately 71 acres of previously disturbed area. The area has been used as earth materials borrow area. It has a pit configuration with steeply graded banks and depth to original ground of approximately 5 to 30 feet. Effects to the grassland/herbaceous cover-type would be minimized by reseeding all areas with native grasses and forbs, including construction staging and disposal areas.

3.11 Operation and Maintenance, Repair, Replacement and Rehabilitation

Flood Damage Reduction Features

For the Truckee Meadows and Lower Truckee River reaches, operation and maintenance is required for floodwalls, levees, interior drainages, relief wells, seepage remediation, and scour protection. The requirements include inspecting and maintaining the floodwalls and interior drainage features regularly and inspecting and maintaining levees and keeping them free from vegetation growth that could reduce reliability. As noted above, inspections and maintenance activities near the RTIA must be coordinated in advance. The bank protection will be inspected annually prior to flood season and revetment replaced to maintain project performance.

The following practices currently used on California levees related to pesticide (rodenticide) were included for cost estimating purposes.

- Rodent control will include baiting and burrow repair.
- A combination of bait stations and broadcast spreading for rodents, mainly ground squirrels will be used
- Cost estimates were based on the use of anti-coagulant rodenticide applied to rolled oats.

All best management practices for both weeds and burrowing animals will be revisited during PED to ensure that the most up to date practices are used to minimize effects to non-target wildlife. An integrated pest management plan would be developed using a variety of control methods to provide safe and effective control.

During floods, the levees and floodwalls would be patrolled continuously to locate possible boils or unusual wetness that signals a problem in the structure. Pump stations will be operated and staffed and debris removed following the event.

Vegetation on Floodplain Terraces

The vegetation on the floodplain terraces will require a 3 to 5 year establishment period consisting of weed control and irrigation. This maintenance would be required through contract award for three to five years following completion of construction. At the end of the three to five year term, the areas would be turned over to the local sponsor. The local sponsor would need to perform periodic weed control to prevent noxious weeds from taking hold. The local sponsor would also need to remove garbage on a periodic basis for the purpose of maintaining public health and safety. Gates, locks and signs would need to be kept in functional order.

Control of noxious weeds will be a major focus of the maintenance of the floodplain terraces. Prior to turnover of the floodplain terraces to the Non-federal sponsor, during the installation and establishment period aggressive control of weeds will be performed through timed mowing, broad application of selective and nonselective herbicides, spot spraying and hand pulling of weeds. After the establishment period when native vegetation has become established and can significantly suppress noxious weeds the same weed control methods will be used but on a more infrequent basis. The vegetation targeted for the floodplain terraces should provide a cover of woody vegetation that shades out the main weed of concern, tall white top. Annual broadcast treatment of trouble spots, spot spraying and hand pulling of individual weeds would be required. Part of the weed control program would also include suppressing the growth of cottonwood and other large trees in the floodplain terrace areas between Gregg Street and Rock Boulevard located directly in front of the airport runways.

Another major concern during the maintenance period will be the removal of garbage, in particular in relation to illegal camping on the floodplain terraces which will likely be utilized by the local homeless population. The local sponsor would be required to prevent the buildup of large quantities of trash within the floodplain terraces and in general within the floodway.

Recreation Features

Upon transfer at completion of construction, the operation and maintenance of the recreation features of the project becomes the responsibility of the non-Federal sponsor(s). The new trails, trailheads, fishing access, kayak , boat launch sites and appurtenant landscaping, gates, signs, parking lots, driveways and restrooms will require maintenance to maximize project recreation benefits.

Contingency and Overhead

OMRR&R costs were developed with the intent of most of the work being performed using service contracts. To account for overhead and labor costs to administer contracts, TRFMA provided an estimate of $300,000, annually. The overhead costs were distributed proportionally between flood damage reduction (FDR) and recreation features based on OMRR&R costs. A contingency of 25% and 15% were added for FDR and recreation features, respectively. The contingency is added to cover the uncertainty of OMRR&R activities, storm frequency, and cost uncertainties.

Table 7 – OMRR&R Costs

Feature	Annual Cost
09 Channels and Canals	
North Truckee Drain/Peoples Drain	$ 7,900
Mitigation Features Truckee Meadows	$ 93,300
Contingency & Overhead	$ 91,700
Subtotal 09 Acct	$ 192,900
11 Levees and Floodwalls	
Levees	
Levees	$ 94,000
Emergency Monitoring	$ 1,400
Floodwalls	
Floodwalls	$ 34,400
Relief Wells/inspection and cleanout	$ 63,000
Pump Stations	$ 3,500
Event Driven Levee/Floodwall Repair	$ 50,000
Contingency & Overhead	$ 223,100
Subtotal 11 Acct	$ 469,400
16 Bank Stabilization	
Revetment	$ 15,400
Contingency & Overhead	$ 13,900
Subtotal 16 Acct	$ 29,300
Subtotal for FDR Features	**$ 691,600**

Feature	Extended Cost
14 Recreation	
Recreation Feature OMRR&R	$ 94,600
Contingency & Overhead	$ 76,200
Subtotal 14 Acct	$ 170,800
Subtotal for Recreation Features	**$ 170,800**

Total Annual OMRR&R Costs $ 862,400

CHAPTER 4 – COST ESTIMATE AND CONSTRUCTION SCHEDULE

4.1 Cost Estimates – Basis of Estimate

The project cost estimates were prepared by Cost Engineering Section, Sacramento District, and based on quantities and data furnished by the Civil Design Sections A and B and Real Estate Division. The preliminary estimates for alternatives were based on reconnaissance level information and data provided by field visits, discussions with and input from potential non-Federal sponsors, data developed under Architect-Engineer contracts, and data supplied by supporting districts.

The preliminary estimates for alternatives are not presented in this document. The estimates were developed prior to 2006 and underwent an ATR review at that time. At that time, alternative 3 was determined to be the tentatively selected plan but further optimization based on levels of protection were used to develop the Recommended Plan. The GRR still refers to the original alternative estimates but they have not been modified since 2006.

The feasibility estimates are based on 20-25% plans and quantities developed by the Civil Design Sections A and B. Quantities were developed with a focus on refinement of cost drivers from the preliminary estimates. Quantities for cost drivers were typically calculated using average end area methods but excavation and fill quantities were developed using In-Roads software.

Real estate estimates were based on footprint requirements for project construction, operation and maintenance provided by Civil Design Branch. Alternative level estimates on plans retained for the Plan were prepared based on refinements to the preliminary layouts, features, and measures as determined by screening analysis done by Planning Division, and input from the potential non-Federal sponsors. The cost estimates for the preliminary alternatives, were prepared by contract and/or the Cost Engineering Section of the Sacramento District. Design guidance came from ER 1110-2-1302, Civil Works Cost Engineering. Detailed preparation and the format of all estimates follow the guidance in Engineer Technical Letter (ETL) 1110-2-573. The fully funded cost estimate for the Plan (See Attachment C) was prepared in compliance with OMB INDEXES EC-11-2-199, published on 31 March 2010.

MOBILIZATION Current local mobilization rate of 5% has been found to reasonably represent the mobilization costs for this type of work, and as such has been used in the preparation of this estimate. In determining the mobilization costs, the following procedure was used: In each account, for each contract, the Mobilization was "omitted" at the contract level. The MII file was then recalculated and the "direct costs" were determined. This cost was then inserted in the task quantity box and a unit price of .05 inserted. Mobilization was then "un-omitted" and project recalculated.

CONSTRUCTION WINDOWS Estimate time is based on year round construction type productions. Schedule has been addressed to include typical weather delays November thru May. Project footprint will allow for multiple crews which equates to each reach being started and completed in year long contracts/projects.

OVERTIME This estimate assumes no overtime. At this level of estimate, 8 hr days where assumed. It appears that there is enough room for the contractor to use multiple crews and have

multiple headings on each contract. This does not imply that multiple shifts would be used. This is not an assumption made.

ACQUISITION PLAN The project plan of action will be accomplished by the bidding process, IFB, and will be awarded as a Firm Fixed-Price Construction Contract. It is assumed that the various contracts will not be small business set aside. It is conceivable that there could be small business quotas for the prime contractor.

CONTRACTING PLAN The Prime Contractor is a general engineering contractor. Subcontractors are used very little with the exception of those reaches that include floodwalls which will included rebar and concrete subcontractors.

PROJECT CONSTRUCTION SITE ACCESS Each contract has its challenges as far as access is concerned, but not insurmountable. Access may consist on only one entrance for some tasks, one way in and then another way out or two-way traffic. Project access is over improved roadways, a lot of it in an industrial area where a majority of the work is being performed. The project is located in and around Reno, NV and Sparks, NV. These towns have required equipment available and labor is available locally and within a 50-mile distance from the project. The prime contractor most likely will not be immediate area.

CONSTRUCTION METHODOLOGY The construction methodologies are standard and do not include much in the way of new and emerging techniques.

BORROW \ DISPOSAL AREAS Contract segments vary in the amount of borrow available. There are elements of work that are planned to be the borrow source for some of the work but not all. Other sources are available within 10 miles of the project. Time of the various contract may have an impact on available dump locations. There is a location identified that is large enough to handle all the excess soil requirements. There appears to be enough excavated material and borrow material between all the contracts to supply enough material for this project.

UNUSUAL CONDITIONS The only real unusual conditions on the project may the soils. The area is known to have large boulders on a sporadic basis, and is very inconsistent. It is assumed that 25% of the excavated soils will not be suitable for embankment fills.

EQUIPMENT, LABOR RATES, MATERIAL AND OTHER COSTS Equipment and labor is available locally or within a 60-mile radius that includes the Cities of Reno, Sparks, and Carson City, NV.

This estimate uses Davis Bacon labor rates for Washoe County, Nevada, General Decision Number: NV130030 03/22/2013 NV30.

Equipment rates used are from EP11R07 , Volume 7, Region 7, 2011. Fuel prices were adjusted to current rates. Material prices were obtained from quotes, supply catalogs, historical data, and the MCACES Unit Price Book.

ENVIRONMENTAL CONCERNS No environmental concerns beyond the environmental protection requirements have been assumed. It is noted that due to the location of this project, construction windows are severely impacted by weather from November to May. Complete shutdown will be required of contractor. Local sponsor does not believe there are any concerns with existing contamination on the project, so estimate is based on no concerns relating to this.

COST AND PRICING CONTINGENCIES - PROFIT - ESCALATION Contingency has not been included in the estimate. Contingency has been added as part of the Total Project Cost. Profit is included in this estimate, using the weighted guidelines method. Sales tax is 7.725% for the project location. For the Prime Contractor, Job Office Overhead is assumed to be 6.0%, Home Office Overhead is assumed to be 7.0%, and Bond is based on the bond tables supplied in MII. Escalation has not been accounted for in the MII estimate; however it has been in the Total Project Cost calculations.

30 & 31 ACCOUNT ASSUMPTIONS: 30 Account Planning, Engineering and Design and 31 Account Construction Management cost was provided by its respective organizations.

4.2 Cost and Schedule Risk Analysis

The Sacramento District performed the Cost and Schedule Risk Analysis (CSRA), relying on local Sacramento District staff and Truckee River Flood Management Agency to provide expertise and information gathering. The PDT conducted initial risk on November 6, 2012 supported with follow-on meetings. The initial risk identification meeting also included qualitative analysis to produce a risk register that served as the draft framework for the risk analysis.

Details regarding the analysis are contained in Attachment C - Cost Estimate, Certification, & Project Cost and Schedule Risk Analysis Report. As shown in the CSRA, the key or greater Cost Risk items of include:

☐ EXT-1: Funding Stream Impact - The construction schedule assumes an optimal funding stream. Potential reduction of funding, or intermittent funding through the remaining years, would increase cost, adding multiple contracts and contractor mobilizations, increased chances of project changes resulting from national, state or local requirements, competitive market changes, extreme construction inflationary events, etc.

Moderate risks, when combined, can also become a cost impact.

☐ TL-4: Borrow Source Variation - Floodplain terracing designs will be refined in PED and may increase/decrease. Floodplain terracing designs are based on preliminary hydraulic modeling and may change.

☐ TL-5: Floodwall Quantity Variation - Quantity increases for floodwalls. Floodwalls were not analyzed for sliding and may require a key to resist sliding. The floodwall dimensions may be likely be redesigned during PED. Redesign is expected to cause minor quantity and cost variations.

☐ 'TL-1: Re-vegetation Quantity Variation. - Re-vegetation quantities will be refined in PED and may increase. Terrace designs are preliminary and may change. Preliminary designs are based on widths developed using preliminary hydraulic modeling,

☐ TL-2: North Truckee Drain Quantity Variation- Cost increase for North Truckee Drain features. Minimal design effort for road crossings and limited design for box culvert details. There will probably be additional costs associated with road crossing areas not accounted for in current design. The cost impact will likely be marginal as these areas are limited (only two crossings).

Schedule Risks: The high value of schedule risk indicates a significant uncertainty of key risk items, time duration growth that can translate into added costs. Over time, risks increase on those out-year contracts where there is greater potential for change in new scope requirements, uncertain market conditions, and unexpected high inflation. The greatest risk is:

☐ EXT-1: Funding Stream Impact – Construction schedule assume an optimal funding stream. Potential reduction of funding stream than projected would likely Delay schedule.

Moderate risks, when combined, can also become a time and resulting cost impact.
☐ PPM-2S: Review Delays- Multiple reviews may delay approvals.
Discussion: With DQC, ATR, IEPR, and other vertical reviews, there's a chance for delayed approvals.

4.3 Proposed Construction Contract Schedule and Sequence of the Federal Plan

Construction is estimated to take a minimum of 5 years, assuming adequate funding is provided for construction, and adequate funding and resources are provided for final design. The mitigation plant establishment will continue for an additional 3 years. The revegetation work in the Truckee Meadows Reach will follow immediately after the flood damage construction for any reach. If the project is authorized for construction in FY 2014, it is assumed that FY 2015-2016 will be spent working on final designs for a construction start in FY 2017. Table 8 shows a description of the contracts, the proposed sequence of construction and the estimated duration of each one. This construction sequence has been provided for use in the final project cost estimate and also for use in determining the project's environmental impacts.

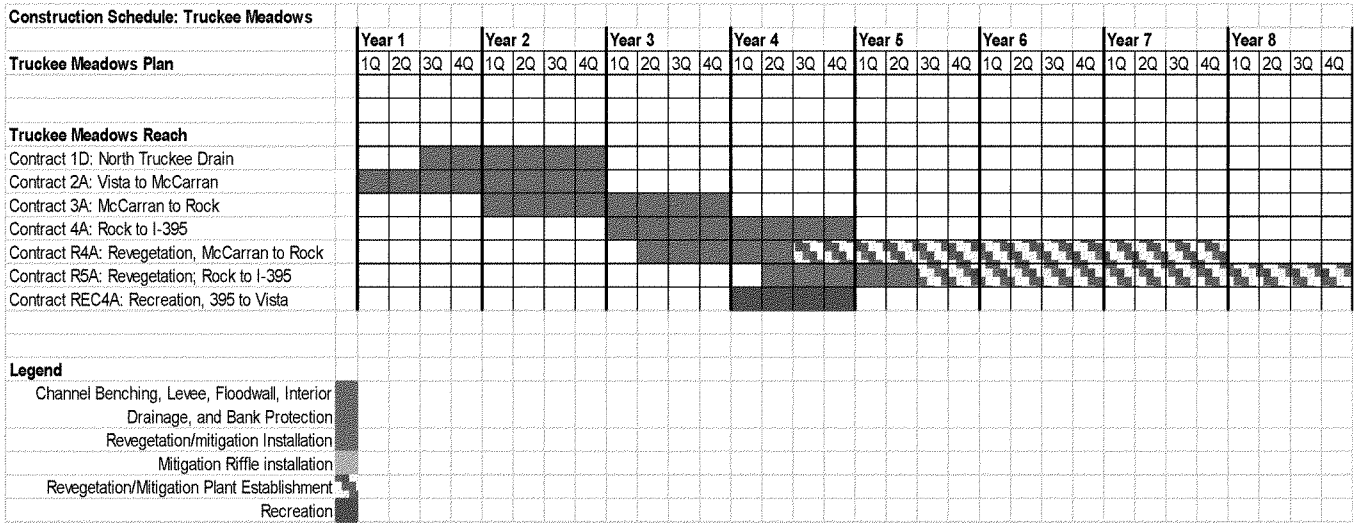


Table 8 Construction Schedule

CHAPTER 5 – ENVIRONMENTAL OBJECTIVES, REQUIREMENTS, AND SPECIAL STUDIES

5.1 Environmental Objectives and Requirements

The Environmental Impact Statement (EIS) for the Project analyzed the affected environment, environmental consequences, and mitigation for the alternatives and Plan. The EIS identifies the following significant issues:

Project Design

- Ensure that the community is involved in formulation of alternatives.
- Consider changing operation of existing upstream water storage facilities, as well as constructing new storage facilities, to increase flood protection downstream.
- Explore other alternatives to the 1988 authorized project's proposed use of University of Nevada, Reno (UNR), property as a stormwater detention facility.
- Consider non-structural measures and alternatives such as raising structures or removing structures from the floodplain.
- Avoid or minimize induced flooding downstream due to construction of flood protection features in the Truckee Meadows.
- Use bio-engineered methods for bank stabilization rather than riprap.

Hazardous, Toxic, and Radiological Waste

- Prevent hazardous materials spills during construction, particularly near waterways.

River Geomorphology

- Maintain the Truckee River's natural processes when developing alternatives.
- Minimize any increases in streambed or bank erosion.

Water Resources and Quality

- Maintain existing water rights and water supply.
- Avoid degrading surface water and groundwater quality.
- Minimize any increases in sediment levels in the river.

Vegetation and Wildlife

- Minimize effects to terrestrial and aquatic habitat, particularly wetland and riparian habitat.
- Avoid effects to native wildlife species, particularly those that are protected by Federal, State, or agency laws or regulations.
- Provide for the movement and needs of resident wildlife and avoid habitat fragmentation.
- Prevent the invasion and expansion of exotic weed species.

Fisheries

- Avoid effects to the Truckee River and Pyramid Lake fisheries.
- Improve fisheries populations and habitat by incorporating fish passage improvement measures at existing dams throughout the river system.

Land Use

- Consider the effects that existing land uses have had on the river's ecosystem.

Aesthetic Resources

- Avoid the use of high floodwalls and levees so that existing aesthetic values and view sheds are not significantly affected.

Air Quality

- Minimize effects to air quality from particulate or dust emissions.

Noise

- Minimize effects of construction noise on the public and wildlife.

Socioeconomics

- Avoid any disproportionate adverse effects to low-income or minority communities.
- Maintain safety and security at the airport.

Cultural Resources

- Consider existing agency agreements pertaining to the historic Virginia Street Bridge.
- Avoid effects to cultural resources, both historic and pre-historic, in order to maintain the historic integrity of the area.

Indian Trust Assets

- Consult with tribes that could be affected by the project as directed by Executive Order 13175 and the 1994 Presidential Memorandum on Government-to-Government Relations with Native American Tribal Governments.

Cumulative Effects

- Consider cumulative effects of other past, present, and potential future projects, including past Corps flood protection projects, when formulating alternatives and evaluating their effects.

Project Design

- Ensure that the community is involved in formulation of alternatives.
- Consider changing operation of existing upstream water storage facilities, as well as constructing new storage facilities, to increase flood protection downstream.
- Explore other alternatives to the 1988 authorized project's proposed use of University of Nevada, Reno (UNR), property as a stormwater detention facility.
- Consider non-structural measures and alternatives such as raising structures or removing structures from the floodplain.
- Avoid or minimize induced flooding downstream due to construction of flood protection features in the Truckee Meadows.
- Use bio-engineered methods for bank stabilization rather than riprap.

Hazardous, Toxic, and Radiological Waste

- Prevent hazardous materials spills during construction, particularly near waterways.

River Geomorphology

- Maintain the Truckee River's natural processes when developing alternatives.
- Minimize any increases in streambed or bank erosion.

Water Resources and Quality

- Maintain existing water rights and water supply.
- Avoid degrading surface water and groundwater quality.
- Minimize any increases in sediment levels in the river.

Vegetation and Wildlife

- Minimize effects to terrestrial and aquatic habitat, particularly wetland and riparian habitat.
- Avoid effects to native wildlife species, particularly those that are protected by Federal, State, or agency laws or regulations.
- Provide for the movement and needs of resident wildlife. and avoid habitat fragmentation.
- Prevent the invasion and expansion of exotic weed species.

Fisheries

- Avoid effects to the Truckee River and Pyramid Lake fisheries.
- Improve fisheries populations and habitat by incorporating fish passage improvement measures at existing dams throughout the river system.

Land Use

- Consider the effects that existing land uses have had on the river's ecosystem.

Aesthetic Resources

- Avoid the use of high floodwalls and levees so that existing aesthetic values and viewsheds are not significantly affected.

Air Quality

- Minimize effects to air quality from particulate or dust emissions.

Noise

- Minimize effects of construction noise on the public and wildlife.

Socioeconomics

- Avoid any disproportionate adverse effects to low-income or minority communities.
- Maintain safety and security at the airport.

Cultural Resources

- Consider existing agency agreements pertaining to the historic Virginia Street Bridge.
- Avoid effects to cultural resources, both historic and pre-historic, in order to maintain the historic integrity of the area.

Indian Trust Assets

- Consult with tribes that could be affected by the project as directed by Executive Order 13175 and the 1994 Presidential Memorandum on Government-to-Government Relations with Native American Tribal Governments.

Cumulative Effects

- Consider cumulative effects of other past, present, and potential future projects, including past Corps flood protection projects, when formulating alternatives and evaluating their effects.

Section 4.5 of the EIS has an extensive list of best management practices and mitigation measures related to this project. The EIS should be consulted prior to the PED phase for environmental requirements related to the design, construction, and operation of the project.

5.2 Special Studies

The following special studies are recommended during the PED Phase:

1. Value Engineering Study – A more recent Value Engineering (VE) Study will be conducted in PED. The alternatives VE study was conducted in 2004 and should be updated to capture design refinements that have occurred.
2. Borrow Source Study – further investigations are necessary to identify additional suitable borrow material for levee fill, seepage blankets, and berms.
3. Sediment Transport and Channel Stability Analysis – A more detailed HEC-6T type analysis will be conducted on the Plan to verify preliminary assessments.

RELATED STUDIES AND REPORTS

The following are earlier engineering and environmental documentation related to this project:

HDR, July 2011, Interior Drainage Preliminary Design Letter Report

HDR and Associated California Engineers LLC, September 2008, Initial Truckee River Flood Project Impact Analysis, Downtown Reno to Pyramid Lake

HDR and Associated California Engineers LLC, October 2008, Bank, Bed and Pier Scour Protection, Downtown Reno to Pyramid Lake

HDR, May 2009, Mitigation for Flood Damage Reduction Impacts at Rainbow Bend

URS, August 2006, Draft, Quantities for Downtown and Meadows Bridge Replacements

URS, September 2007, Feasibility Designs and Cost Estimates for Downtown and Meadows Bridge Replacements

Montgomery-Watson, May 2000, Design and Cost Estimates for Flood Damage Reduction, Downtown Reno Reach, Truckee Meadows, Nevada – Feasibility Report

Montgomery-Watson Harza, June 2002, Flood Damage Reduction Alternatives Report, Downtown Reno Bridges

Montgomery-Watson-Harza, September 2002, Flood Ecosystem Restoration Alternatives Design Paper, Truckee Meadows Flood Damage Reduction and Ecosystem Restoration Alternatives Project

Montgomery-Watson Harza, September 2002, Flood Damage Reduction Alternatives Design Paper, Truckee Meadows Flood Damage Reduction and Ecosystem Restoration Alternatives Project

Montgomery Watson and Harza, September 2003. Ecosystem Restoration Alternatives Design Paper for the Truckee Meadows Flood Damage Reduction and Ecosystem Restoration Project.

Montgomery-Watson-Harza, September 2003, Final Real Estate Requirements, Mustang Ranch Detention Facility

Montgomery-Watson-Harza, January 2004, Revised Draft Real Estate Requirements, Revised Draft Seepage Impacts Memo

Montgomery-Watson Harza, February 2004, Downtown Reno Bridges Summary Report, Truckee Meadows Flood Control Project

Montgomery-Watson Harza, March 2004, Revised Draft Real Estate Report, Downtown Reno Alternatives, Truckee Meadows

Montgomery-Watson Harza, April 2004, In-Progress Real Estate Report, Downtown Reno Alternatives, Truckee Meadows

Otis Bay Ecological Consultants, 2003. Lower Truckee River final Geomorphic Assessment and Final Preliminary Design, Vista to Pyramid Lake.

Ferrari Shields and Associates, July 2003, Historic Architectural Engineering Analysis for the Preservation of the Virginia Street Bridge, Reno, Nevada

U.S. Army Corps of Engineers, Sacramento District, February 1985, Feasibility Report and Environmental Impact Statement, Truckee Meadows (Reno-Sparks Metropolitan Area) Nevada

James C. Hanson, Consulting Civil Engineer, January 1990, Evaluation of Floodwalls and Bridge Foundations, Downtown Reno, Nevada

U.S. Army Corps of Engineers, Sacramento District, August 1997, Truckee Meadows, Nevada. Reconnaissance Reevaluation Report

U.S. Army Corps of Engineers, Sacramento District, October 1997, Basis of Design, Reconnaissance Report, Truckee Meadows Flood Control Project

U.S. Army Corps of Engineers, Sacramento District, May 1999, Draft Feasibility Report, Designs and Cost Estimates for Flood Damage Reduction, Downtown Reno Reach, Truckee Meadows, Washoe County, Nevada

U.S. Army Corps of Engineers, Sacramento District, April 2000, Truckee Meadows, Nevada, Information Paper

Attachment A – Hydrology

Provided under separate cover

Attachment B – Hydraulic Design

Provided under separate cover

Attachment C - Cost Estimate, Certification, & Project Cost and Schedule Risk Analysis

Attachment D - Geotechnical Report

Provided under separate cover

Attachment E - Engineering Plans

Provided under separate cover

TRUCKEE MEADOWS GRR
TRUCKEE RIVER, NEVADA

ATTACHMENT A

HYDROLOGY REPORT

US ARMY CORPS
OF ENGINEERS
Sacramento District

December 19, 2012

CERTIFICATION FOR
INDEPENDENT TECHNICAL REVIEW

PROJECT TITLE: Truckee Meadows General Re-Evaluation Report
PRODUCT: Addendum to Phase F3 Milestone Conference, Hydrology
LOCATION: Truckee Meadows, Nevada

GENERAL FINDINGS

Compliance with clearly established policy principles and procedures, utilizing clearly justified and valid assumptions, has been verified for the project indicated above. This includes assumptions; methods, procedures and materials used in analyses; alternatives evaluated; the appropriateness of data used and level of data obtained; and the reasonableness of the results, including whether the product meets the customer's needs consistent with law and existing Corps criteria and policy.

CERTIFICATION FOR INDEPENDENT TECHNICAL REVIEW

I certify that an independent technical review of the project indicated above has been completed and all technical issues have been identified and resolved. I recommend certification that the quality control process has been completed.

William Firth
William Firth
Hydraulic Engineer, San Francisco District

11 FEB 2003
Date

S.T. Su Chief of Water Resources Section San Francisco District

2-11-03
Date

CERTIFICATION FOR
INDEPENDENT TECHNICAL REVIEW

PROJECT TITLE: Truckee Meadows General Re-Evaluation Report
PRODUCT: Addendum to Phase F3 Milestone Conference, Hydrology
LOCATION: Truckee Meadows, Nevada

I certify that an independent technical review of the subject study has been completed. All comments have been addressed adequately and changes have been incorporated in the final report. All quality control activities defined in the "Programmatic Quality Control Plan" and the supplemental quality control plan specifically for Truckee Meadows, appropriate to the level of risk and complexity inherent in the product, have been completed and all the technical issues have been identified and resolved. I recommend certification that the quality control process is complete.

2/18/03
Date

Al Paniccia
ITRT Chairperson, San Francisco District

I certify that the quality control process has been completed and all technical issues have been identified and resolved for the subject study.

7/8/03
Date

~~Paul Pugner~~ Borden Johnson
Chief, Water Management Section, Sacramento District

7/9/03
Date

Ronald Muller
Chief, Civil Design Branch, Sacramento District

CERTIFICATION FOR INDEPENDENT TECHNICAL REVIEW

PROJECT TITLE: Truckee Meadows General Re-Evaluation Report
PRODUCT: Addendum to Phase F3 Milestone Conference, Hydrology for Lower Truckee River, Vista Gage to Marble Bluff Dam, June 2004
LOCATION: Truckee Meadows, Nevada

GENERAL FINDINGS

Compliance with clearly established policy principles and procedures, utilizing clearly justified and valid assumptions, has been verified for the project indicated above. This includes assumptions; methods, procedures and materials used in analyses; alternatives evaluated; the appropriateness of data used and level of data obtained; and the reasonableness of the results, including whether the product meets the customer's needs consistent with law and existing Corps criteria and policy.

CERTIFICATION FOR INDEPENDENT TECHNICAL REVIEW

I certify that an independent technical review of the project indicated above has been completed and all technical issues have been identified and resolved. I recommend certification that the quality control process has been completed.

William Firth
Hydraulic Engineer, San Francisco District

4 AUG 2004
Date

S.T. Su Chief of Water Resources Section San Francisco District

8-4-04
Date

CERTIFICATION FOR
INDEPENDENT TECHNICAL REVIEW

PROJECT TITLE: Truckee Meadows General Re-Evaluation Report, F3 Addendum, June 2004
PRODUCT: Hydrology for Lower Truckee River, Vista to Marble Bluff Dam
LOCATION: Truckee Meadows, Nevada

I certify that the quality control process has been completed and all technical issues have been identified and resolved for the subject study.

1/5/05
Date

Robert F. Collins
District Hydrologist, SPK

12-16-04
Date

Paul E. Pugner, P.E.
Chief, Water Management Section, SPK

1/25/05
Date

Ronald Muller
Chief, Design Branch, SPK

STATEMENT OF TECHNICAL REVIEW
COMPLETION OF AGENCY TECHNICAL REVIEW (ATR)

The District has completed the Hydrology Appendix, Part IV, Interior Drainage for Truckee Meadows GRR, Nevada. Notice is hereby given that (1) a Quality Assurance review has been conducted as defined in the Quality Assurance Plan and (2) an agency technical review that is appropriate to the level of risk and complexity inherent in the project, has been conducted. During the agency technical review, compliance with established policy principles and procedures, utilizing justified and valid assumptions, was verified. This included review of: assumptions, methods, and procedures used in analyses, the appropriateness of data used and level obtained, and reasonableness of the result, including whether the product meets the customer's needs consistent with law and existing Corps policy. The technical review was accomplished by a senior hydraulic engineer. All comments resulting from QA have been resolved.

This ATR covers Part IV of the Hydrology Appendix, Interior Drainage for Truckee Meadows, GRR, Nevada, dated 5 December 2012. Covered under this quality control certification includes the development of flow hydrographs for the 0.10% through 0.2% ACE percent chance flood events for Steamboat Creek, North Truckee Drain, Long Valley Creek, and for interior drainage areas within Washoe County including Reno and Sparks City.

William Firth
William Firth, P.E.
ATR Reviewer, San Francisco District

7 FEB 2013
Date

John High
John High
Hydrologist
Sacramento District

8 Feb 2013
Date

CERTIFICATION OF DISTRICT QUALITY ASSURANCE REVIEW

I certify that an independent technical review of the project indicated above has been completed and that all technical issues have been identified and resolved. I certify that the quality control process at the District level has been completed.

John M High
John M. High
Chief, Hydrology Section

8 Feb 2013
Date

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FOR TRUCKEE MEADOWS GRR

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PART II: RE-ANALYSIS OF DOWNTOWN AND TRUCKEE MEADOWS REACH

PART III: DOWNSTREAM OF VISTA REACH

PART IV: INTERIOR DRAINAGE HYDROLOGY

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PART I of Attachment A

UPPER WATERSHED AND DOWNTOWN REACH

PART I

1. Purpose and Scope. This Attachment (Hydrology) describes the development of the existing conditions hydrology for the mainstem Truckee River from downtown Reno to Marble Bluff Dam. The F3 Milestone Report dated July 1999 determined existing conditions hydrology for the Downtown and the Meadows Reaches. Nevertheless, the F3 Conference brought to light many unresolved concerns. The resolution of those concerns in the years after 1999 is described in Part II of this Attachment. The results of the re-analysis resulted in the following: 1) The Downtown Reach hydrology in the 1999 F3 Report was determined to be valid 2) The Meadows Reach hydrology was revised. Part III describes the analysis of the Truckee River between the Vista gage and Marble Bluff Dam that was completed in June 2004.

One of the major concerns in 1999 was the USGS estimated peak flows for the January 1997 flood event. The hydrology for the 1999 F3 was developed using a peak flow of 18,200 cfs and 18,400 cfs at the Truckee River at Reno and Vista gages for the 1997 flood as estimated by the USGS. After the F3 Conference, the Corps decided to adopt new peak values of 23,000 cfs and 20,700 cfs for the Reno and Vista gages, respectively. The new peak values were adopted after the Corps built and calibrated a new unsteady state HEC-RAS model to high water marks. This, among other reasons, caused the Corps to re-evaluate the hydrology for both reaches. A statistical analysis was performed for both reaches using the new values. The result of the re-analysis showed there was no justification for revising the 1999 F3 Report hydrology for the Downtown Reno Reach. This is due to the fact that there is 78 years of data for the Truckee River at Reno gage and revising the 1997 peak did not significantly change the statistics. In contrast, the Meadows Reach had special issues that needed resolution including the modification by the Corps of the Vista Reefs (natural, volcanic bedrock in the channel near Vista) in 1963, storage of flow volume in the overbanks, and the coincident timing of Steamboat Creek and North Truckee Drain flows in relation to the mainstem. A new approach was derived to analyze the Meadows Reach after the 1999 F3 Report and the existing condition flow frequency for this reach was ultimately revised in an addendum hydrology report dated January 2003.

To summarize, the re-analysis *reaffirmed* the Downtown Reach hydrology and *revised* the Truckee Meadows Reach hydrology. Part I of this Attachment describes the original hydrology developed for the upper watershed and the Downtown Reno Reach. Part II of this document describes the re-evaluation of the Downtown Reach and the establishment of new hydrology for the Meadows Reach. Part III describes the hydrologic analysis of the reach between the Vista gage and Marble Bluff Dam that was completed in June 2004.

2. References.

a. "Water Control Manual, Truckee River Reservoirs, Truckee River Basin, Nevada and California," Sacramento District, U.S. Army Corps of Engineers, July 1985.

b. "Truckee Meadows Investigation, Reno-Sparks Metropolitan Area, Nevada, Sacramento District, U.S. Army Corps of Engineers, July 1980.

c. "Hydrology Office Report, Truckee River, California and Nevada," Sacramento District, U. S. Army Corps of Engineers, February 1980.

d. "Flood Plain Information - Truckee River - Reno-Sparks-Truckee Meadows, Nevada," Sacramento District, U.S. Army Corps of Engineers, October 1970.

e. "Floods of November-December 1950, in western Nevada," U.S. Geological Survey, Water Supply Paper 1137-H, 1954.

f. "Report on December 1955 Floods, Sacramento-San Joaquin River Basins, California and Truckee, Carson and Walker Rivers, California and Nevada," Sacramento District, U.S. Army Corps of Engineers, May 1956.

g. "Report on the February 1986 Floods, Northern California and Northwestern Nevada," Sacramento District, U.S. Army Corps of Engineers, January 1987.

h. "Flood-Control Effects of Truckee River Basin Reservoirs December 31, 1996, Through January 4, 1997, California and Nevada," U.S. Geological Survey, Fact Sheet FS-037-97, March 1997.

i. "HEC-1, Flood Hydrograph Package, User's Manual," U.S. Army Corps of Engineers, Hydrologic Engineering Center, September 1990.

j. "HEC-5, Simulation of Flood Control and Conservation Systems, Exhibit 8 of User's Manual," U.S. Army Corps of Engineers, Hydrologic Engineering Center, January 1989.

k. "FFA, Flood Frequency Analysis, User's Manual," U.S. Army Corps of Engineers, Hydrologic Engineering Center, April 1991.

l. "Regional Frequency Computation," U.S. Army Corps of Engineers, Hydrologic Engineering Center, July 1972.

m. "Water and Related Land Resources, Central Lahontan Basin, Truckee River Subbasin, Nevada...California, Flood Chronology 1861-1976", U.S. Dept. of Agriculture, Forest Service, September 1977.

n. "Douglas County, Nevada, Hydrology Report Revision", U.S. Army Corps of Engineers, Sacramento District, March 1994.

o. "Guidelines for Determining Flood Flow Frequency, Bulletin #17B," Interagency Advisory Committee on Water Data, U.S. Geological Survey, revised September 1981.

3. Location. The procedure to develop the hydrology is given in Section 9 while Sections 3 through 8 provide a background to the watershed characteristics and history. The Truckee River basin lies on the eastern slope of the Sierra Nevada, see Chart 1, the crest of which forms the western boundary of the basin. The Sierra Nevada near the headwaters of the Truckee River is characterized by rugged rocky peaks, precipitous cliffs, steep canyons, and occasional small meadows and lakes. The lower portion of the basin consists of scattered valleys and dry lakebeds separated by mountain ranges. Elevations within the basin range from 3,790 at Pyramid Lake to over 10,000 feet in the Sierra Mountains. About half of the area tributary to the Truckee River between Lake Tahoe and Lawton is above 6,500 feet, but only 10% is above 8,000 feet. Chart 2 shows the Reno and Vista streamgages and some of the tributary streams in the area. The red stars indicate input locations for design hydrographs into the HEC-RAS model for the Meadows Reach.

The Truckee River basin consists of approximately 3,060 square miles of drainage area extending from Lake Tahoe, California to Pyramid Lake, Nevada. The mainstem of the Truckee River originates at the northwestern shore of the lake, where an outlet structure regulates flow into the river. From the lake, the river flows about 15 miles in a northerly direction then bends east through the city of Truckee, California. The river flows northeasterly about 40 miles to the city of Reno, Nevada. The main tributaries between Lake Tahoe and downtown Reno are the Little Truckee River, Prosser Creek, Donner Creek, Martis Creek, Hunter Creek, Alum Creek, and Dog Creek. Near Reno the river enters a vast meadow, the western and northern sections of which are occupied by the cities of Reno and Sparks. The eastern portion of the meadow, which is known as Truckee Meadows Reach, is low in elevation and poorly drained. During large runoff periods this area is flooded extensively. Most of the runoff that floods the Reno area originates above the city of Reno, Nevada. Flows originating above Reno are partially regulated by Stampede, Boca, Prosser Creek, and Martis Creek reservoirs and Lake Tahoe. The drainage area upstream of Reno is approximately 1,067 square miles, 506 square miles of which is controlled by Lake Tahoe. Below Reno, the Truckee River flows about 50 miles easterly and northerly to Pyramid Lake, a remnant of prehistoric Lake Lahontan. The stream basin has no outlet to the sea.

The main tributaries in the Truckee Meadows Reach are Steamboat Creek and North Truckee Drain. The biggest of these tributaries, Steamboat Creek, is a large watershed with elevations exceeding 9,000 feet and a significant snowpack. This stream, which originates at the outlet of Washoe Lake (a large flat depression that stores all flood runoff originating above it), drains the southern and eastern part of Truckee Meadows and enters the Truckee River near Vista. Evans and Dry Creek combine below Highway 395 to form Boynton Slough, a tributary to Steamboat Creek. Thomas, Whites and Galena Creeks are tributaries to Steamboat Creek which also originate on the northeastern slopes of Mt. Rose.

The North Truckee Drain joins the Truckee River near Vista. It consists of a natural channel, now largely improved and realigned to provide better drainage of Spanish Springs Valley and the northeasterly sector of Truckee Meadows. The area drained by North Truckee Drain consists of many small streams that drain the foothill areas surrounding the valley. With the exception of Steamboat Creek, all of the tributary streams in the vicinity of Reno are intermittent.

The Truckee River leaves the Truckee Meadows Reach after it passes the Vista gage. It is here that the river enters a more confined canyon. This is the beginning of the reach downstream of Vista. Between the Vista gage and Pyramid Lake, multiple tributaries enter the Truckee River; however, with the exception of Long Valley Creek (107 mi2 drainage area), these usually contribute little to the peak flow on the mainstem. This is partly due to the timing of the runoff from these areas and from the decreasing energy/precipitation as a storm moves eastward into the desert.

The study area includes both Washoe and Storey County. It is comprised of flood plains along the Truckee River extending from Lawton (east) to Vista (west) and from Sun Valley (north) to Huffaker Hills (south) and includes the Truckee River, Steamboat Creek and other tributaries influencing the Truckee Meadows basin. The study area was expanded to include the lower Truckee River downstream of the Vista gage to Pyramid Lake including contributing tributaries such as Long Valley Creek.

4. Project Descriptions. Martis Creek Dam on Martis Creek; Prosser Creek Dam on Prosser Creek; and, Stampede and Boca Dams on the Little Truckee River are the only storage projects in the study area with flood control as an authorized purpose. These four projects have a major impact on basin flows. Tahoe, Donner and Independence Lakes provide some incidental regulation because of the large surface areas of the lakes relative to their drainage areas. Generally, releases from these reservoirs during large floods are insignificant. Diversions have little or no impact to flooding problems.

4.1 Martis Creek Dam Project. Martis Creek Dam is a multipurpose project developed by the Corps of Engineers. The project provides storage for flood control and future water supply. The project controls 39 square miles of the 1,067 square miles of drainage area above Reno. Releases from Martis Creek Dam flow northerly down Martis Creek which is a tributary to the Truckee River about 3 miles below the town of Truckee, California. Martis Creek Dam and Lake was authorized by the Flood Control Act approved 25 October 1962 (Public Law 874, 87th Congress, 2nd Session), substantially in accordance with recommendations of the Chief of Engineers contained within the project document entitled, "The Truckee River and Tributaries Project, Nevada and California," and printed as House Document No. 535, 87th Congress, 2nd Session. Detailed information on Martis Creek Dam can be found in the "Truckee River Basin Reservoirs, Nevada and California, Water Control Manual," July 1985. Martis Creek Reservoir has a capacity of 20,400 acre-feet. Due to geotechnical concerns, the Martis Creek capacity for flood control is limited to less than half of its gross capacity. Until demand for municipal and industrial water develops, the principal objective for Martis Creek Dam is flood control only.

Construction of Martis Creek Dam and Lake began in August 1967. Construction of the embankment and appurtenance was started in May 1970 and was completed in August 1972. Impoundment of water commenced in March 1972. The project was completed in June 1974. In response to observed seepage and distress, minor and major seepage control modifications and measures were constructed from 1973 to the present.

Water stored in Martis Creek Lake is subject to the discretionary control of the Sacramento District, Corps of Engineers. The physical operation of Martis Creek Dam is accomplished by

Corps of Engineers personnel and the Boca Damtender (Washoe County Water Conservation District).

4.2 Prosser Creek Dam Project. Prosser Creek Dam is a multipurpose project developed by the USBR as the initial feature of the Washoe Project. Prosser Reservoir provides storage for flood control, fishery purposes and some incidental conservation benefits. It controls about 50 square miles of the 1,067 square miles of drainage area above Reno. Releases from Prosser Creek Dam flow easterly down Prosser Creek which is a tributary to the Truckee River about 4 miles northeast of the town of Truckee, California.

The Washoe Project Authorization Act, Public Law 858 (70 Stat. 777), Section 4, 84th Congress, 2nd Session, was enacted 1 August 1956. Public Laws 706 and 863, 85th Congress, provide for the construction and operation of Prosser Creek Reservoir by increasing the authorized appropriations for the Washoe Project. The increased funds permitted the construction of Prosser Creek Dam in lieu of the smaller Twin Valley reservoir on a tributary of Prosser Creek as authorized under the Washoe Project. Detailed information on Prosser Creek Dam can be found in the "Truckee River Basin Reservoirs, Nevada and California, Water Control Manual," July 1985. Prosser Creek Reservoir has a capacity of 29,800 acre-feet. Its principal objectives are flood control and water conservation.

Construction of Prosser Creek Dam began on 5 May 1960. The project was completed in November 1962.

4.3 Stampede Dam Project. Stampede Dam is a multipurpose project developed by the USBR under the Washoe Project. Stampede Dam provides for flood control, conservation, and hydroelectric power. It controls about 136 square miles of the 1,067 square miles of drainage area above Reno. Releases from Stampede Dam flow southerly down the Little Truckee River to the Boca Dam Project which is about 8 miles downstream.

Stampede Dam and Reservoir were authorized by the Washoe Project Authorization Act, Public Law 858 (70 Stat. 777) Section 4, 84th Congress 2nd Session, enacted 1 August 1956. House Document 181, Washoe Project, June 1955 proposed a 20 megawatt powerplant to be remotely located from the dam. Later studies deleted this hydropower installation but did recommend an installation smaller in size located at the dam. Stampede has a capacity of 225,100 acre-feet. Its principal objectives are flood control, water conservation, and hydropower.

Work on Stampede Dam and Reservoir began in early November 1966 and was completed in February 1970.

4.4 Boca Dam Project. Boca Dam is a multipurpose project developed by the USBR under the Truckee Storage Project. Boca Dam provides for flood control and conservation. Boca re-regulates the releases from Stampede Dam and Reservoir. Both projects combined control 172 square miles of the 1,067 square miles of drainage area above Reno. Releases from Boca Dam flow southerly down the Little Truckee River, a tributary to the Truckee River, located 6 miles northeast of Truckee, California.

Boca Dam and Reservoir on the Little Truckee River, a feature of the Truckee Storage Project, was approved by the President on 21 September 1935 under Section 4 of the Act of 25 June 1910 (36 Stat. 835) -- PL 61-289; and under subsection B of Section 4 of the Act of 5 December 1924 (43 Stat. 701) -- PL 68-292. Funds for construction were made available under the provisions of the National Industrial Recovery Act. Boca Reservoir has a capacity of 41,100 acre-feet. Its principal objectives are flood control and water conservation.

Construction of Boca Dam began 24 April 1937 and was completed before the irrigation season of 1939.

4.5 Related Control Facilities. Projects completed by the USBR in the Truckee River basin include:

1) Newlands Project. The USBR constructed the Newlands Project to provide the facilities for the distribution of irrigation water from the Truckee and Carson River Basins to the lower Carson Valley near Fallon in western Nevada. Completed in 1915, the Newlands Project consists of the Lake Tahoe Dam, the Lahontan Dam and Reservoir and Lahontan powerplant, the Derby Diversion Dam on the Truckee River, the Carson River Diversion Dam, and the Truckee Canal extending from Derby Dam to Lahontan Reservoir. Water is diverted from the Truckee River into the Truckee Canal for conveyance to Lahontan Reservoir for storage.

a) Lake Tahoe Project. Lake Tahoe effectively controls all rain floods originating above it. The lake is 22 miles long and 12 miles wide. It has a surface area of 192 square miles, an active storage capacity of about 745,000 acre-feet, and a total capacity of about 125 million acre-feet. Constructed between 1909 and 1913, Lake Tahoe Dam is an 18 foot high concrete slab and buttress structure 109 feet long, with a maximum width at the base of 19 feet and a top width of 11 feet. The level of Lake Tahoe is regulated by seventeen outlets with 5-by-4 feet vertical gates. The invert of these gates is at the lake's natural rim, which is approximately elevation 6,223.0 feet, MSL. The United States assumed control of the dam at the outlet of Lake Tahoe along with appurtenant land on 1 July 1915 pursuant to a decree by the U.S. District Court dated 4 June 1915. A Federal Court decree issued on 8 September 1944 fixes the high operational level of the lake, defines water rights, prescribes rates of flow at various points along the river, specifies diversion quantities, and provides that outlet gate operation begins when the lake level reaches 6,228 feet.

b) Derby Dam and Truckee Canal. Located on the Truckee River about 20 miles below Reno, Derby Dam was constructed between 1903 and 1905. The dam, a concrete gate structure with an embankment wing, is 31 feet high with a crest length of 1,331 feet. The dam diverts up to 1,500 cfs into the Truckee Canal. Constructed between 1903 and 1906, the canal has a bottom width of 20 feet; side slopes of 0.5:1; water depth of 13 feet; and length of 32.5 miles. The canal is believed to be capable of carrying somewhere between 800 to 1,000 cfs at full capacity. During a large flood event, the operating criteria for Derby Dam is to limit diversions into the Truckee Canal to prevent flooding in the vicinity of the Lahontan Reservoir; however, some diversions have occurred during past floods. Diversions tend to have little or no impact to flooding problems, especially in the Reno area.

c) Lahontan Dam and Reservoir. Completed in 1915, Lahontan Dam and Reservoir stores the natural flows of the Carson River along with water diverted from the Truckee River. The reservoir has a capacity of 295,000 acre-feet at spillway crest elevation. The use of flashboards on the spillway crest increases storage capacity to 317,300 acre-feet. The Lahontan Powerplant has facilities to utilize water from either Lahontan Reservoir or the Truckee Canal.

2) Truckee River Storage Project. The USBR constructed the Truckee Storage Project to provide a supplemental supply of irrigation water to approximately 29,000 acres of land in the Truckee Meadows area. The actual irrigated area is being reduced by urban development. Supplemental irrigation water for the Project is stored in Boca Reservoir on the Little Truckee River, while release of water from Lake Tahoe (operated by the Truckee-Carson Irrigation District) and Donner Lake is made to provide better regulation of the Truckee River according to the Truckee River Agreement. Diversion and delivery of irrigation water is made by the 33 ditch companies which form the Washoe County Water Conservation District. The following tabulation lists the major canals and capacities:

Canal	Capacity (cfs)
Coldron Ditch	20
Steamboat Ditch	110
Highland Ditch	104
Orr Ditch	60
Last Chance Ditch	47
Lake Ditch	50
Cochran Ditch	48
Glendale Ditch	40
Pioneer Ditch	35
North Truckee Ditch	43

3) Washoe Project. The USBR constructed the Washoe Project to improve the regulation of runoff of the Truckee and Carson River systems and to provide supplemental irrigation water and drainage for presently irrigated lands, as well as water for municipal and industrial and fishery uses, flood protection, fish and wildlife benefits and recreation development. Major features of the project in addition to Prosser Creek and Stampede Dams include Marble Bluff Dam and Pyramid Lake Fishery, both in operation.

4) The Sierra Pacific Power Company. The Sierra Pacific Power Company owns and operates five hydroelectric powerplants with a total installed capacity of 9,400 kW. Descriptive data for these plants which are located along the Truckee River in the reach between Truckee and Reno are as follows:

Plant	Total Head (feet)	Installed Capacity (kilowatts)
Farad	83	2,800
Fleish	125	2,000
Verdi	96	2,400
Washoe	88	1,500
Reno	43	700

The powerplants are all run-of-the-river type. Lake Tahoe and Boca Reservoir regulate stream flow for irrigation and power purposes, and further regulation is obtained from the Sierra pacific Power Company storage reservoir at Independence Lake. Independence Lake on Independence Creek, a tributary to Little Truckee River, completely regulates the runoff from the small tributary area (8 square miles). The Sierra Power Company and the Truckee-Carson Irrigation District have acquired storage rights on Donner Lake, with a capacity of about 9,500 acre-feet on Donner Creek for joint use and Truckee River regulation.

4.6 Channel Improvements. Developments by the Corps of Engineers and other interests include the following:

1) Channel improvement of the Truckee River for about 3,200 feet downstream from the outlet structure of Lake Tahoe was completed by the Corps of Engineers in 1960. It permits greater outflow from the lake and alleviates damage along the lakeshore during periods of high lake stage. Due to improved flow characteristics at the outlet, low levees and channel improvement work were required along the river at intermittent locations along the Truckee River downstream to Reno to prevent increases in the frequency and severity of damage to properties (mostly summer homes) subject to flooding. Although the Flood Control Act of 1954 authorized such improvements for Corps of Engineers construction, they were not completed and are indefinitely deferred.

2) Channel improvement of the Truckee River through the Truckee Meadows was completed in 1963 by the Corps of Engineers. The project consists mainly of widening and deepening the Truckee River channel for a distance of 7.5 miles extending from the downstream limits of Reno to a point near Vista.

3) Local interests have provided channel improvements along the Truckee River consisting of riprap and masonry retaining walls for stabilizing both banks through sections of

downtown Reno. The work was accomplished about 1930 to 1935 by the Works Program Administration in cooperation with local interests.

4) As part of the local interest requirements for the Corps of Engineers Martis Creek Lake Project, the city of Reno improved the channel to carry flows of 14,000 cfs through Reno. This work was completed in 1972.

5) The U.S. Natural Resources Conservation Service (formerly known as the U.S. Soil Conservation Service) constructed four flood control detention reservoirs in the Peavine, East and West Wash watershed north of Reno. Upper Peavine Reservoir with a capacity of 320 acre-feet, Lower Peavine with a capacity of 100 acre-feet, East Wash Reservoir with a capacity of 60 acre-feet and West Wash Reservoir with at capacity of 350 acre-feet contain a total of about 830 acre-feet of storage and provide flood protection to urban areas below the reservoirs.

5. Water Control Plan. The Truckee River Basin Reservoirs regulate flood flows in the lower Truckee River by controlling releases, insofar as possible, to obtain the maximum practicable reduction in flood damages. A coordinated reservoir plan for the entire Truckee River System is essential for the effective regulation of floods in the Reno-Sparks area. The overall operation for flood control is coordinated by the Federal Court appointed Watermaster in Reno, Nevada. The Federal Watermaster facilitates the coordinated flood control operation of all Truckee River Basin Reservoirs and Lake Tahoe outflow in accordance with the objectives prescribed in the "Truckee River Basin Reservoirs Water Control Manual." The specific objectives of the operation of the Truckee River Basin Reservoir Projects are as follows:

1) To protect the Reno-Sparks metropolitan area against all reasonably probable rain floods.

2) To protect the areas along the Truckee River in the Truckee Meadows area against damaging flows during all but very large floods, and to minimize and delay damaging flows during large floods.

3) To restrict flows downstream in the Truckee River to a controlling rate of 6,000 cfs at the Sparks stream gage, insofar as possible.

4) To provide the maximum conservation storage practicable, so that all downstream release requirements can be met without impairing the flood control function of the reservoir.

5) To provide the maximum amount of power practicable consistent with required flood control operations and the conservation functions of the reservoirs.

6) To provide releases to preserve and enhance the habitat for the Endangered Cui-ui and the Threatened Lahontan Trout in the Lower Truckee River.

6. Regulation for Flood Control. Flood control regulation begins when storage in any of the Truckee River Basin Reservoirs exceeds the flood control reservation required at any time, as indicated on the appropriate Water Control Diagram, Reference b. These diagrams are the result of analyses of flood frequency, seasonal flood potential, and downstream channel capacities

consistent with project objectives. If reservoir storage encroaches within the flood control reservation, then flood control releases are made as quickly as possible subject to the following limitations: 1) water shall be released as rapidly as possible without causing flows in Truckee River below Reno to exceed 6,000 cfs; 2) releases shall be coordinated with any simultaneous releases from other reservoirs in the Truckee River system in order to maintain, insofar as possible, an equitable distribution of empty space on the basis stated below, and shall be restricted to quantities (sometimes zero) which will not cause flows in the Truckee River below Reno to exceed 6,000 cfs. Remaining empty space shall be distributed as follows: A maximum of 65,000 acre-feet of joint use space in the four Truckee River Basin Reservoirs is used for flood control. Of this 65,000 acre-feet of flood control space, approximately 20 percent of it will be reserved at Martis Creek Lake, 30 percent at Prosser Creek Reservoir, and 50 percent at Stampede and Boca Reservoirs together. The flood control requirements for the projects according to the diagrams are as follows:

6.1 Martis Creek Lake: In 2007, due to geotechnical safety concerns at the dam, the Sacramento District officially enacted an Interim Risk Reduction Measure (IRRM) operation, which involves keeping all outlet gates open year round. With gates wide open, a total of 750 cfs can be released when the reservoir storage reaches gross pool (spillway invert). The Martis Creek Dam HEC-5 reservoir model used in this study (for existing conditions) operates somewhat similar to the historic dam operation during the January 1997 flood. The model releases are kept to less than 100 cfs until reservoir storage exceeds approximately 5000 ac-ft, at which time releases are increased to a constant 500 cfs outflow). The model rules were NOT modified after the IRRM was imposed in 2007, as both scenarios result in similar releases to the Truckee River on the peak day of an event (<200 cfs change). Sacramento District is currently conducting a separate study to evaluate alternatives to solve safety concerns at Martis Creek Dam. This is discussed briefly in the main body of the GRR report.

The initial operation plan at Martis Creek Dam after construction would have allowed the entire 20,400 ac-ft of capacity to be used for flood control. Insofar as possible, releases from the dam would have been kept to 100 cfs or less until the Truckee River flow recedes to less than 6,000 cfs downstream of downtown Reno. However, reservoir storage is currently kept to a minimum due to geotechnical concerns.

6.2 Prosser Creek Reservoir.

1) Flood control space increases uniformly from a minimum requirement of zero acre-feet on 1 October up to a maximum of 20,000 acre-feet by 1 November. The maximum reservation is maintained at 20,000 acre-feet through 10 April.

2) Flood control space required between 10 April through 5 July varies according to the forecasted snowmelt parameter. Unless additional reservation is indicated by the snowmelt parameter, the required space will decrease uniformly at a rate of 500 acre-feet per day to zero requirement as early as 20 May or else reach zero requirement as late as 5 July. The snowmelt parameter values are forecasts of the remaining natural runoff through 31 July, in thousands of acre-feet, of the Truckee River at Farad, excluding releases from Lake Tahoe. It is computed by

subtracting the daily natural flow at the Truckee River at Farad from the previous days computed remaining natural runoff. Space not required for flood control may be filled for conservation purposes.

6.3 Stampede-Boca Reservoirs. A maximum joint use space totaling 30,000 acre-feet will be reserved in Stampede and Boca Reservoirs. A minimum of 25 percent and a maximum of 8,000 acre-feet of the combined joint use space requirement for Stampede and Boca Reservoirs will be reserved in Boca Reservoir, insofar as practicable.

1) Flood control space increases uniformly from a minimum requirement of zero acre-feet on 1 October to a maximum of 30,000 acre-feet on 1 November. The maximum reservation is maintained at 30,000 acre-feet through 10 April.

2) Flood control space required between 10 April through 5 July varies according to the forecasted snowmelt parameter. Unless additional reservation is indicated by the snowmelt parameter, the required space will decrease uniformly at a rate of 750 acre-feet per day to zero requirement as early as 20 May or else reach zero requirement as late as 5 July. Space not required for flood control may be filled for conservation purposes.

7. Climate. The climate within the Truckee River Basin is temperate and varies from arid in the desert areas east of Reno to humid in the Sierra Nevada to the west. The climate of the study area is characterized by moderately cold winters and hot, dry summers. Both temperature and precipitation vary considerably throughout the basin due to the extreme range in elevations. Diurnal variations are usually large. The minimum and maximum temperatures of record at Reno are -16° F in the winter to about 104° F in the summer. The monthly distribution of mean temperatures for representative stations, in or near the study area, is presented in Table 1. Normal annual precipitation (NAP) over the drainage area between Lake Tahoe and Reno varies from 8 to 70 inches, with a basin mean of 26.5 inches. The mean monthly and annual distribution of precipitation at selected stations is given in Table 2.

In the upper part of the basin, approximately 85% of the annual precipitation falls during the winter months of November through April, but at Reno only about 70% of the annual precipitation falls during this period. In the study area, mean annual precipitation is approximately 7.3 inches, most of which occurs as rain or snow during the months of December, January, and February. Although numerous storms occur during the summer months, they do not contribute significantly to annual precipitation.

Precipitation usually falls as snow, above elevation 5,000 feet. However, snowfall may occur anywhere. In the upper basin some storms produce rain up to the highest elevations of the basin. Snowfall may also occur anywhere within the basin. Winter snowfall above 5,000 feet elevation normally accumulates until about the first of April, when increasing temperatures mark the beginning of the snowmelt season. Snow falling at lower elevations usually melts within a relatively short time. Basin snowpack data for a wet year (1952), a dry year (1963), a normal year (1953), and the average for 1 April at representative snow courses are given in Table 3. Historical monthly evaporation rates at Tahoe City and Boca are shown in Table 4. All data were obtained from a Class "A" pan.

The nearest station with wind records is Cannon International Airport Reno, Nevada. The records at Reno are considered representative of the Truckee River Basin Reservoirs. The fastest wind velocity recorded at Reno was 90 miles per hour from the southwest and occurred in January 1988. The maximum velocity for a 1-hour duration at Reno is estimated at 28 miles per hour.

TABLE 1.
MEAN MONTHLY AND ANNUAL TEMPERATURES

Month	Tahoe City Elev. 6230'	Truckee Ranger Sta. Elev. 5995'	Boca Elev. 5575'	Reno WB Airport Elev. 4404'
	Temperature (°F)			
Jan	28.2	26.0	24.0	32.4
Feb	29.6	28.7	27.3	37.6
Mar	32.0	32.0	34.5	41.5
Apr	38.1	38.9	39.7	47.6
May	45.4	46.4	47.0	55.3
Jun	52.6	53.5	53.5	62.8
Jul	60.7	61.3	60.2	70.1
Aug	59.6	59.7	58.1	68.0
Sep	54.0	55.0	52.9	60.9
Oct	45.2	45.8	44.8	50.9
Nov	35.9	35.3	35.6	40.1
Dec	30.5	27.8	27.6	33.1
Average Annual	42.7	42.5	42.1	50.0
Source	NOAA 1941-1970	NOAA 1941-1970	NOAA 1941-1970	NOAA 1941-1996

TABLE 2.
MEAN MONTHLY PRECIPITATION

Month	Tahoe City Elev. 6230' inches	%	Truckee Ranger Sta. Elev. 5995' inches	%	Boca Elev. 5575' inches	%	Reno AP Elev. 4404' inches	%
Jan	5.93	18.7	5.84	18.4	3.91	17.6	1.12	15.3
Feb	4.94	15.6	4.68	14.7	3.14	14.1	0.95	13.0
Mar	4.25	13.4	4.38	13.8	2.87	12.9	0.79	10.8
Apr	2.06	6.5	2.12	6.7	1.30	5.8	0.40	5.5
May	1.20	3.8	1.39	4.4	1.17	5.3	0.63	8.6
Jun	0.70	2.2	0.68	2.1	0.68	3.1	0.42	5.8
Jul	0.28	0.9	0.40	1.3	0.49	2.2	0.28	3.8
Aug	0.33	1.0	0.48	1.5	0.53	2.4	0.22	3.0
Sep	0.64	2.0	0.72	2.3	0.67	3.0	0.32	4.4
Oct	1.98	6.3	1.67	5.3	1.35	6.1	0.43	5.9
Nov	3.82	12.1	4.03	12.7	2.65	11.9	0.73	10.0
Dec	5.53	17.5	5.35	16.9	3.51	15.8	1.02	13.9
Annual	31.66	100.0	31.74	100.0	22.27	100.2	7.33	100.0
Nov-Apr	26.53	83.8	26.40	83.2	17.38	78.0	5.02	68.5
Source:	NOAA 1931-1995		NOAA 1948-1995		NOAA 1948-1995		NOAA 1937-1996	

TABLE 3.
1 APRIL SNOW SURVEY DATA
TRUCKEE RIVER BASIN, CALIFORNIA AND NEVADA

No.	Snow Course	Elev. (feet)	Snow Depth (inches)			Water Equivalent (inches)			% of Average			Average (inches) 1 April
			1952	1953	1963	1952	1953	1963	1952	1953	1963	
334	Mt. Rose	9,000	154	79	77	68.1	33.8	28.0	196	97	81	34.7
64	Webber Peak	7,800	184	106	61	86.8	43.5	20.5	193	97	46	44.9
69	Donner Summit	6,900	184	81	25	82.0	39.0	6.1	201	96	15	40.7
90	Sage Hen Cr.	6,500	113	53	24	45.3	21.0	5.0	244	113	26	18.6
92	Truckee #2	6,400	NR	41	21	NR	17.7	4.7	-	108	28	16.4
105	Tahoe City	6,250	89	30	16	38.6	14.6	2.9	345	130	21	11.2
95	Boca #2	5,900	61	7	T	25.0	3.8	T	500	76	0	5.0

Source: California Snow Update Survey Measurement Schedule, 1983
Average 1 April water content for the period 1931-1975

TABLE 4.
MEAN MONTHLY CLASS A
PAN EVAPORATION

Month	Tahoe City Elev. 6230'	Boca Elev. 4404'
	Evaporation (inches)	
Jan	1.33	-
Feb	1.02	-
Mar	2.48	-
Apr	3.03	-
May	4.06	6.77
Jun	4.96	8.34
Jul	6.02	10.00
Aug	5.79	9.04
Sep	3.86	6.47
Oct	2.13	3.97
Nov	2.36	-
Dec	1.46	-
Annual Total	38.5	44.59
Source:	State of California, DWR Bulletin 73-79, November 1979	NOAA 1948-1995

8. Storms and Floods. Significant runoff occurs when the ground approaches saturation, or when the ground is frozen and infiltration is minimal, or when warm rain on snow in the higher elevations adds to rainflood runoff. Floods in the Truckee River Basin can be divided into three distinct types: general rain floods, snowmelt floods, and cloudburst floods.

8.1 General Rain Floods. General rain floods, which occur during the period of November through April, result from general rain storms covering a large part of the basin. These floods are characterized by high peak flows and durations of 1 to 6 days. The total volume of runoff from such floods can be smaller than that from longer duration snowmelt floods. Precipitation in the headwater areas of the Truckee River Basin usually is associated with general storms. These storms originate over the Pacific Ocean and must cross the continuous barrier of the Sierra Nevada, which averages 8,000 feet in elevation, to reach these areas. The Truckee River headwater area is directly opposite the Donner Pass gap in the barrier, and occasionally air

masses carry considerable precipitable moisture over the pass and cause heavy rainfall on the eastern slopes and on the Mt. Rose ridge east and north of Lake Tahoe. Storm periods last from 1 to 4 days. These storms usually produce general snowfall over the headwater areas, but some storms produce rain up to the maximum elevation of the basin. A number of major general rain floods have been experienced in the Truckee River Basin.

8.2 Snowmelt floods. Snowmelt floods result from the melting of the snow-pack during the late spring and early summer (April through July). These floods have relatively large volumes and long durations. The distribution of runoff during the flood period is dependent on the ripeness of the snow and the variation in air temperatures. Generally, the highest rates of flow occur in May and June. Through the use of snow surveys, it is possible to predict with a fair degree of accuracy both the total volume and the probable maximum rate of flow some months in advance. This higher degree of predictability with snowmelt floods permits the evacuation of storage space in reservoirs and the taking of other flood-preventative measures. Snowmelt floods are essentially non-damaging in the Truckee Meadows area due to upstream reservoir regulation.

8.3 Cloudburst floods. Cloudburst floods are characterized by very high peak flows of short duration and low volume. These floods occur during the summertime. Cloudburst floods can carry large amounts of debris and sediment, and can cause considerable damage on the smaller tributaries. Local cloudbursts occur frequently during the summer. They usually occur in July and August when warm, moist air is more likely to reach this area of Nevada from the Gulf of California. These storms are characterized by high intensities over small areas and can produce large flood flows on the smaller tributary streams but do not have a major impact on flow in the Truckee River. These storms typically last no more than three hours.

8.4 Flood History. The study area has a long history of floods. Most of the runoff from the Truckee River Basin occurs from November through July. Rainfloods have caused major flood problems in the study area. The major rainfloods which have occurred since the turn of the century include those of March 1907, January 1909, March 1928, December 1937, November 1950, December 1955, February 1963, February 1986, and January 1997. Snowmelt floods occurred in 1906, 1907, 1938, and 1952. Cloudburst flooding occurs in the study area, but is of shorter duration and is less in areal extent than rain or snowmelt floods. Table 5 provides data on recorded peak flows since the turn of the century on some of the larger floods at Reno.

TABLE 5.
HISTORICAL RAINFLOODS - TRUCKEE RIVER AT RENO

Date	Regulated			Unregulated		
	Peak Flow (cfs)	Max 1-Day Mean Flow (cfs)	Max 3-Day Volume (ac-ft)	Peak Flow (cfs)	Max 1-Day Mean Flow (cfs)	Max 3-Day Volume (ac-ft)
18 Mar 1907	18,500	14,600	68,400	18,500	14,600	68,400
16 Jan 1909	10,100	8,540	43,600	10,100	8,540	43,600
26 Mar 1928	18,800 (1)	-	66,900 (1)	-	-	-
11 Dec 1937	17,000 (1)	-	53,100 (1)	-	-	-
21 Nov 1950	19,900	14,100	55,300	20,500	15,660	62,837
04 Dec 1950	11,700	6,580	30,600	-	-	-
23 Dec 1955	20,800	16,200	67,400	27,800	25,670	86,937
02 Feb 1963	18,400	11,500	47,700	33,400	24,480	79,380
23 Dec 1964	11,300	9,400	44,600	24,300	14,560	76,999
17 Feb 1986	14,400	10,000	55,000	-	20,100	93,660
02 Jan 1997	23,000(2)	18,900(2)	-	47,600	37,600	-

(1) Estimated from records at other stations
(2) Estimated by Corps; calibrated HEC-RAS to high water marks (differs from USGS record). USGS record for regulated flow is peak=18,200 cfs and 1-day=17,870 cfs for 1997 flood.

In the city of Reno and vicinity, the topography of the city of Reno, immediately on the north bank of the Truckee River, makes the area particularly vulnerable to flooding. Street and bridge elevations are approximately the same as the river bank elevations, and widespread flooding results when flood waters run overbank. Generally, the Truckee River and its tributaries, with the exception of the Truckee Meadows area, are mountainous streams where flows are confined to narrow canyon channels. Channel storage during large floods is small and does not significantly attenuate peak flows. Channel and overbank capacities through Reno are limited. When these capacities are exceeded, water leaves the overbank areas and flows in a southeasterly direction, eventually combining with other runoff in the Truckee Meadows area.

Wide areas are flooded by Evans and Dry Creek south of Reno Airport before their flood plains merge with that of the Truckee River near East Peckham Lane. The flood plain of the Truckee River downstream of Reno consists primarily of agricultural lands that lie generally contiguous to the river channel except in Truckee Meadows where a widespread area of about 7,000 acres is subject to inundation from large floods. The Meadows area begins near the eastern city limits of Reno and extends to the steep narrow canyon reach at Vista. Although the Truckee Meadows area is primarily agricultural, urban-industrial development is expanding into the Meadows area.

The flood plains of Steamboat Creek and the North Truckee Drain are inundated essentially by backwater from the Truckee River.

Floods in November 1950, December 1955, January-February 1963, and January 1997 were similar in magnitude. However, flood control works such as reservoirs and channel modifications have reduced the magnitude and frequency of flooding in the area since about 1960. Without the flood control works, the January 1997 event would have greatly exceeded all others since at least 1869.

The November 1950 flood resulted from a rapid succession of warm rainstorms that melted most of the early snow cover. The snowmelt augmented flood-runoff volumes to an undetermined extent. This storm produced more than 5 inches of precipitation in one day at some stations in the Truckee River Basin. Antecedent precipitation had been high, leaving soil moisture above normal. Precipitation in the area during September and October had been about 300 percent of normal. Also, temperatures were unseasonably high during much of the runoff period. A maximum flow of 19,900 cfs was recorded at Reno with a river stage of 13.83 feet. At Farad, the estimated peak flow was about 17,500 cfs with a stage of 14.50 feet. At Vista, the peak flow was estimated to be about 10,000 cfs. Lake Tahoe stored 233,000 acre-feet of runoff with negligible outflow during the period of November 13 to December 6. Boca Reservoir on the Little Truckee River, filled requiring spillway releases on 19 November while the first rise on the Truckee River was in progress. Spill continued during the second and larger rise so that this reservoir was not effective in reducing the peak flood on the Truckee River. Most of the flooded area was agricultural property; however, Reno sustained by far the largest damage of any city affected by the flood, either in California or Nevada. The Truckee River inundated a considerable portion of the business district of the city of Reno. Many commercial and industrial establishments as well as residences were flooded. Floodwater in the central district was more than 4 feet deep. In Truckee Meadows, the flood inundated about 3,800 acres of agricultural lands. Livestock drowned. The flood destroyed or damaged crops, farm and ranch buildings; irrigation facilities were washed out. Power and other utility lines were extensively damaged. The natural detention in the Truckee Meadows area greatly reduced the peak on the Truckee River. The peak reached Nixon on the Pyramid Lake Indian Reservation about 36 hours after the crest at Reno.

The December 1955 flood was one of the largest experienced in the study area. This flood was due to a combination of 15 inches of melted snow and more than 13 inches of rain within a 3-day period. A maximum flow of 20,800 cfs was recorded at Reno with a stage of 13.63 feet. At Farad, the estimated peak flow was approximately 14,400 cfs. At Vista, near the lower end of Truckee Meadows, additional local inflow into Truckee Meadows caused a peak flow of possibly 15,000 cfs. Lake Tahoe stored all inflow with its closed outlets and served to reduce flows in the Truckee River by 700 cfs. Initially at 27,500 acre-feet at the beginning of the flood event, Boca Reservoir filled to 41,400 acre-feet and spilled with 6 inches over the top of the gates due to an inability to open the gates during the latter part of the event. It is estimated that Boca contributed about 850 cfs to the peak flow at Reno. The flood inundated about 9,900 acres of land in the Truckee River Basin and caused severe damages in the city of Reno and the Truckee Meadows area. Advance preparations, a well-coordinated flood fighting program, and better channel conditions limited flood damages to less than half that occurring in 1950. In Reno, floodwater 4 to 5 feet deep covered a strip one to two blocks wide on each side of the river. In the Truckee Meadows-Steamboat Creek area, about 6,400 acres of agricultural land were flooded 1 to 6 feet deep for 6 to 10 days. Extensive flooding occurred in the Steamboat Creek area where

destruction of irrigation headgates let floodwater into the canals and onto the adjoining lands. Reno Municipal Airport was inundated and air traffic completely curtailed for several days, and the University Nevada Experimental Farm was damaged. Throughout the flooded areas, streambanks were eroded, fences destroyed, baled hay and haystacks ruined, and deep deposits of sand, silt, and debris were left on the land.

The storms of February 1986 severely affected northern California and northwestern Nevada. Heavy precipitation reached record levels in many locations. The heaviest precipitation occurred 200 miles north to 100 miles south of a line from San Francisco to Sacramento to Lake Tahoe. Over much of this area the precipitation ranged between 100 to 200 percent of normal February precipitation. In Nevada, the storms caused severe flooding, erosion and mudslides that damaged many public and private structures. The storm caused high flows and damages to areas and municipalities along the Truckee River. On the Truckee River, downtown Reno experienced only minor flooding, because 500,000 sandbags helped to abate the full impact of flooding. Martis Creek Lake and the Prosser Creek, Stampede and Boca Reservoirs collectively stored 58,000 acre-feet of water from 13 February - 23 February. Releases from these reservoirs are regulated when possible to limit flows to 6,000 cfs at the Truckee River at Reno site. Unfortunately, the storm centered below the reservoirs and over the city of Reno. On 17 February, the Truckee River at Reno flow was 14,400 cfs compared to the 23 December 1955 record of 20,800 cfs; The natural peak would have exceeded 18,000 cfs. On 18 February, the peak flow of the Truckee River at Vista was 15,200 cfs which was less than the 1 February 1963 record of 18,900 cfs.

The January 1997 event was another significant rainflood event occurring within this century. This flood was due to a combination of heavy, unseasonably warm rain and snowmelt runoff in the higher elevations. A subtropical storm system originating in the central Pacific Ocean near the Hawaiian Islands brought rains from December 30, 1996 through January 3, 1997. Snowstorms in December 1996 built up the snowpack in the higher elevations of the Sierra Nevada to more than 180 percent of normal. The warm rains falling below the 10,000 ft elevation depleted some of the higher elevation snowpack and melted almost all of the snowpack below 7,000 feet. The peak flow observed at Reno approximately equaled the previous record of December 1955; however, Martis Creek Lake, and Prosser Creek and Stampede Reservoirs which were constructed after 1955 served to reduce the peak considerably. The four flood control projects reduced flows at Reno from an estimated unregulated peak flow of over 47,000 cfs to about 23,000 cfs. At Farad, the estimated existing condition peak flow was approximately 14,800 cfs with a stage of 13.17 feet. During the peak flow periods, releases from the above-mentioned projects into the Truckee River were near zero. Lake Tahoe contributed significantly to Truckee River flows during the event. The Lake Tahoe outlets were open and making releases which exceeded 2,000 cfs for an extended length of time from late December into early March. Lake Tahoe releases contributed approximately 2,500 cfs to the peak flows on the Truckee River. Flooding was extensive in downtown Reno, at the Reno/Tahoe International Airport, and in the industrial area of Sparks. The official USGS records for the 1997 flood give a peak flow of 18,200 cfs and 18,400 cfs at the Reno and Vista gages respectively. Personnel at the Hydrologic Engineering Center in Davis, CA calibrated an unsteady state HEC-RAS model to high water marks and determined that the peak values were actually 23,000 cfs and 20,700 cfs respectively. The USGS has not revised their values.

9.0 Flow Frequency Analyses. A summary of the major steps utilized to perform the hydrologic analysis for downtown Reno is given below. Sections 9.1 through 9.5 provide a more detailed description of the analysis. Only **existing conditions** hydrology was analyzed. Future conditions hydrology was not analyzed for these reasons: 1) Approximately 70 to 80% of the volume of water flooding the Reno area normally comes from the Sierra Mountain watershed upstream of downtown Reno. Future development in this area is not expected to be significant. 2) development in the Meadows Reach has been on-going, but the local sponsors have imposed regulations in Washoe County which require developers to perform mitigation measures to maintain pre-project hydrologic conditions. A short summary of steps follows:

1) **Unregulated Frequency Curves**: Unregulated frequency curves were developed for the Farad and Reno streamgages that included the removal of storage effects of Stampede, Boca, Prosser, and Martis Creek Dams from the gage record. Incremental change in storage was added to the recorded flow at the gage.

2) **Develop Hydrographs for Area Above Farad:** An unregulated hydrograph was derived from the family of unregulated frequency curves for the Farad gage using the 1997 flood event as a pattern. A regression analysis on historical floods was used to determine the percent contribution from each of the four flood control reservoirs to the unregulated hydrograph at Farad. Hydrographs representing the inflow to each reservoir were developed and routed to Farad in an unregulated model. The combined hydrograph was subtracted from the Farad unregulated hydrograph to determine the hydrograph representing local flow between the projects and the Farad gage.

3) **Local Flow Hydrograph Between Farad and Reno:** An unregulated hydrograph for the Reno gage was derived from the family of unregulated frequency curves for Reno using the 1997 event as a pattern. The unregulated flow hydrograph for Farad (step 2 above) was routed to the Reno gage and subtracted from the Reno unregulated hydrograph to create a hydrograph representing local flow that is contributed between Farad and Reno for each frequency event.

4) **Regulate the Watershed:** To get back to the existing regulated conditions, an HEC-5 model of the watershed that included the four flood control reservoirs was built. Hydrographs input into the model include: 1) a constant 200 cfs from Lake Tahoe 2) inflow hydrographs to the four flood control reservoirs 2) a local flow hydrograph representing the uncontrolled area below Lake Tahoe and the flood control reservoirs down to the Farad gage and 3) a local flow hydrograph representing runoff from contributing areas between the Farad and Reno gages. The resulting simulation produced a regulated, existing condition hydrograph for downtown Reno for each frequency event modeled in HEC-5. The model output for downtown Reno was used as the design hydrograph for input into the existing conditions HEC-RAS model to map existing conditions floodplains in this reach.

9.1 Unregulated Flows. The following sections provide a more detailed description of the methodology used to develop the existing conditions hydrology for the Downtown Reno Reach. Unregulated flows are required to evaluate the existing flood control system and any project alternatives considered. Period-of-record unregulated flows were computed for the Farad, Reno, and Vista index locations. The Farad gage has the longest period-of-record

(1902 - present). Observed and computed unregulated flows were used to perform flow frequency analyses for flow durations of 1, 3, 7, 15, and 30 days. The period of October through March was selected for analysis of rainfloods. As previously stated, winter general rainstorms produce the damaging floods on the mainstem of the Truckee River. Streamflow records during this period were examined for snowmelt floods. The snowmelt floods were removed from the records, as much as practicable. However, gaged flows at all three index locations have been impaired since Boca, Prosser, Stampede and Martis Creek Reservoirs were completed in 1938, 1963, 1969, and 1972, respectively. Accordingly, adjustments to the recorded flows were made to obtain a uniform unregulated flow record. Adjustments to account for the operation of the various reservoirs were accomplished by routing the daily change s in storage at the reservoirs to the downstream gages. The routed daily changes were then added to the recorded daily flows. The volume-durations were further analyzed to determine the annual maximum volume for each duration. When selecting the annual maximum volume, rainfall records, flows, and dates of flows were scrutinized to determine the impacts of baseflow and releases from Lake Tahoe. Baseflow was identified by looking up to thirty days backward in time for flow unaffected by rain or snowmelt. The goal was to insure that the annual maximum volume selected was a result of a rainfall event. Very few estimates of unregulated condition peak flows are available. Except for 1997, unregulated peak flow estimates are based on rainfall-runoff studies. The 1997 unregulated peak flow was estimated by routing the hourly changes in storage at the reservoirs to the downstream gages and adding routed changes to the recorded hourly flows at Reno and Farad.

9.2 Unregulated Flow-Frequency for the Truckee River at Farad and Reno. A statistical analysis of the unregulated flows was performed using the HEC Flood Flow Frequency Analysis (FFA) program. The FFA program complies with the methods described in the Water Resources Council (WRC) report, Bulletin #17B - "Determining Flood Flow Frequency." The statistics were based on the Log-Pearson Type I11 distribution and were computed for 1-, 3-, 7-, 15-, and 30-day flow durations. The peak flow curve statistics were developed by regression with the 1-day flows. Data points were plotted using Weibull plotting positions. Flow frequency curves were drawn using the statistics computed from the analytical frequency analyses. By reviewing historical records, the 1997 event was found to be the largest event since at least 1869; therefore, statistics were developed based on this historic period. The unregulated volume frequency curves for the Truckee River at Farad and Reno are shown on Charts 3 and 4, respectively.

Four relatively large events (1982, 1986, 1995, and 1997) have occurred since the 1980 study of the Truckee River. The 1997 event is the largest of record. The 1986 event is the second largest, based on the 3-day unregulated volume. Primarily, because of these events, the frequency curves developed from current data are significantly higher than those presented in the 1980 report.

The flow data on the Truckee River does not plot along a smooth curve on a Log-Pearson Type III probability graph; however, the curves are acceptable by Bulletin #17B guideline standards. Natural storage in the basin, such as in meadows, or a mixed population (non-homogeneous) data set, can impact the fit of the data. An example of a mixed population

would be data combining general rain and snowmelt floods. These and other factors may be of varying significance, depending on the magnitude of an event. For example, natural storage may be less significant during major flood events when the basin is saturated. Although alternative methods of developing flow-frequency curves were explored, no compelling reasons could be found for use of an alternative method. Given the relatively long systematic record of 96 years, and a historic period of 129 years, there was no definitive reason for abandoning Bulletin # 17B guidelines. 2013 update to 1-day freq, curve show no change.

9.3 Truckee River Balanced Flood Hydrographs. Balanced flood hydrographs for the 5, 2, 1, 0.5, and 0.2 percent chance exceedence flood events were developed using the unregulated flow frequency statistics and the January 1997 flood hydrographs as a pattern. To improve the performance of the HEC-1 model used to balance hydrographs, the shape of the 1997 event was smoothed into a hypothetical pattern. The smoothing principally involved centering the peak in time and ordering observed hourly flows around the peak. The pattern hydrographs extends to 30 days, however, a 7-day series captures the major flood waves and hydrograph volume critical to the Truckee River flood control system. The HEC-1 model was used to balance I-, 3-, 7-, 15-, and 30-day flow volumes around the peak, using the pattern hydrograph and volume-duration relationships from the statistics. Balanced flood hydrographs are used where the time distribution of flow affects project performance. In balanced hydrographs, the peak flow, and I-, 3-, 7-, 15-, 20-, 25-, and 30-day volumes, all have the same exceedence probability. Maintaining the same exceedence probability for each flow duration of the hydrograph (balancing) allows for a statistically derived benefit-cost analysis.

9.3.1 Local Flow Hydrographs above Reno. Hypothetical inflow hydrographs at the existing flood control projects (Martis, Prosser, Stampede and Boca Reservoirs), and local flow at Farad, were required in order to simulate operation of the existing flood control system or any proposed alternatives. The flow distribution was determined from percentages of the total flow at Farad during observed events. Regression analyses based on the distribution of large historical events were performed to determine the percent of the total flow at Farad contributed by the drainages above each project. Flow from uncontrolled tributaries below Lake Tahoe was lumped into a single local flow hydrograph at Farad. Minor adjustments were made based on drainage area relationships.
Local flow between Stampede and Boca Reservoirs, between project reservoirs and Farad, and between Farad and Reno were computed from volume differences between the hydrographs at each location, after taking into account routing effects. This insured that the routed hypothetical hydrographs at Farad and Reno matched the volume-frequency relationships. Hypothetical unregulated flows developed from the flow frequency analyses were routed from the existing flood control projects to each index point, where local flow was added to compute the total flow. The location of the local flow hydrographs are shown in Table 6.

TABLE 6.
LOCAL FLOW HYDROGRAPHS FOR THE BASIN ABOVE RENO

Location	Description
Martis Creek at Martis Creek Dam	Martis Creek Lake Inflow
Prosser Creek Dam at Prosser Dam	Prosser Creek Reservoir Inflow
Little Truckee River at Stampede Dam	Stampede Reservoir Inflow
Little Truckee River at Boca Dam	Local Flow between Stampede and Boca Dam
Truckee River at Farad	Uncontrolled Local Flow above Farad (1)
Truckee River at Reno	Local Flow Between Farad and Reno

(1) Includes contributing area downstream of Tahoe, Martis, Prosser, and Boca Dams. Donner Lake is also included in this area since it has little effect during major rainflood events.

9.4 Flood Routing. Rainfall-runoff models developed in previous studies, used to derive the SPF and Probable Maximum Flood (PMF) hydrographs, were not re-evaluated in the current study. The 1980 Truckee River Hydrology office report gives a detailed description of these models. An HEC- 1 model with routing parameters developed during the earlier studies was used to balance and route the hypothetical hydrographs in the upper Truckee River to Reno. Routing parameters in the new model are essentially the same as those presented in the Truckee River Water Control Manual.

The Truckee River and its tributaries, with the exception of the Truckee Meadows area, are predominantly mountainous streams where flows are confined to narrow canyon channels. Channel storage during large floods is small and does not significantly attenuate peak flows. Accordingly, flood routings for the Truckee River basin were accomplished using Muskingum coefficients for most routing reaches to Reno.

9.5 Existing Conditions. Frequency curves which reflect existing conditions were developed from records of historical events and hypothetical flood routings. For existing conditions, the historical record and hypothetical routings reflect reservoir flood operation in accordance with the current water control plan. Balanced hydrographs of various magnitudes developed from the computed statistics of the unregulated flows, as described in previous paragraphs, were computed at the desired nodes. The distribution of flows into each flood control project was based on an analysis of historical flood flows, as described in paragraph 9.3.1. An HEC-5 reservoir simulation model was developed to route the hypothetical hydrographs. Routing parameters defined on the Truckee River System Routing Diagram were incorporated into the model. The balanced hydrographs were routed through the dams to define the regulated conditions at desired locations downstream. The routings account for the significant regulating effects of Boca, Stampede, Prosser Creek, and Martis Creek

Reservoirs. The regulated peak flow frequency curves for the Truckee River at Farad and Reno are shown on Charts 5 and 6, respectively. The resulting existing condition peak flow frequency for the Reno Gage is shown in Table 7 below.

Table 7
TRUCKEE RIVER AT RENO EXISTING CONDITION PEAK FLOW FREQUENCY

Frequency (Chance)	1 in 5	1 in 10	1 in 20	1 in 50	1 in 100	1 in 200	1 in 500
	5950	7500	9150	13700	20700	35800	63500

10. Lake Tahoe Storage and Releases During Large Flood Events. Although the outflow from Lake Tahoe was 10-15% of the total peak flow at Farad and Reno in 1997, Lake Tahoe outflow is typically a very small percentage of the total flow in the Lower Truckee River during a rainflood, regardless of flood magnitude. On very rare occasions, however, Lake Tahoe could effectively be operated for flood control with seemingly no significant adverse impact on Lake Tahoe development. Based on an analysis of historical coincident flows, Lake Tahoe outflow is only a minor consideration in determining the 100-year floodplain at Reno.

The capacity of Lake Tahoe, between the "natural rim" and the maximum permissible legal level, dwarfs the combined flood control capacity of the flood control reservoirs in the Truckee River system. A single large rainflood at Lake Tahoe produces only a small rise in the lake's water surface elevation. If the January 1997 rainflood event had been stored at Lake Tahoe for 5 days (0 cfs release), the lake stage would have increased approximately 2.5 inches over what actually occurred. The actual outflow during the 1997 event was approximately 2,500 cfs. Between elevation 6,223.0 feet (the natural rim of the lake) and elevation 6,229.1 feet (the maximum permissible elevation allowed by Federal Court decree), the storage capacity per foot of rise of Lake Tahoe is approximately 122,000 acre-feet, or 744,600 acre-feet of total volume.

The large storage capacity of Lake Tahoe effectively absorbs most rainfloods. During the maximum 3 day period of high flows at Reno, coincident high releases from Lake Tahoe are rare - only happening once since construction of the dam began in 1909. The levee design capacity at Reno could be exceeded for up to approximately 3 days in a large event. Only when the lake is at or very near the maximum permissible level, as in 1997, will a rainflood produce significant releases from Lake Tahoe. Significant releases normally occur well after the peak has occurred at Farad or Reno. Table 8 lists the Lake Tahoe outflow for the 13 of the 14 largest rainfloods of record (WY 1901-1997). Outflow records are not readily available for the 1907 event. The dam at Lake Tahoe was constructed between 1909 and 1913.

As previously stated, the outflow from Lake Tahoe was 10-15% of the total peak flow at Farad and Reno in 1997. Typically, however, Tahoe outflow makes up only a very small percentage of the total flow in the Lower Truckee River during a rainflood. Lake Tahoe stages are primarily dependent upon long term antecedent conditions, and are little influenced by single large rainflood events. The lowest lake stages during any year typically occur during the rainflood period. The highest lake stages, and outflow, normally occur during or after the snowmelt season. During the rainflood season, releases from Lake Tahoe exceed 200 cfs less than half of

the time. Releases of 1,000 cfs or greater occur only about 5 percent of the time. A coincident frequency analysis is required to determine the combined frequency of high lake stages and large rainflood events. However, based on the historical record, flood control operation of Lake Tahoe cannot reliably provide additional flood protection for Reno during major flood events. Table 9 lists pertinent data on the principal lakes and reservoirs providing flood control in the Truckee River system. Table 10 lists Truckee River reach lengths and flood wave travel times. Table 11 is a summary of period-of-record Lake Tahoe maximum and minimum daily stages for each month. Record stages for the month were set in December 1996, and January and February of 1997. The Lake Tahoe pool elevation exceeded the maximum permissible elevation during the 1997 flood.

TABLE 8.
LAKE TAHOE OUTFLOW DURING LARGE RAINFLOODS

Flood Event	Average Outflow (cfs)	Maximum Mean Daily Flow at Reno (cfs)
Mar 1907	na [1]	14,600
Jan 1909	15	8,500
Mar 1928	0	14,700 [2]
Dec 1937	40	13,300 [2]
Nov 1950	30	14,100
Dec 1950	15	6,580
Dec 1955	0	16,200
Jan-Feb 1963	50	11,500
Dec 1964	80	9,400
Jan 1970	525	5,500
Jan 1980	100	6,500
Dec 1981	60	8,600
Feb 1986	150	11,700
Jan 1997	2,500	17,900 [3]

[1] Lake Tahoe outflow records for 1907 are not readily available. The dam at Lake Tahoe was constructed between 1909 and 1913.
[2] Estimated from records at other stations.
[3] Provisional.

TABLE 9.
PRINCIPAL LAKES AND RESERVOIRS PROVIDING FLOOD CONTROL IN TRUCKEE RIVER SYSTEM

Lake / Reservoir	Drainage Area (sq. mi.)	Surface Area [1] (sq. mi.)	Storage capacity per foot [2] (ac-ft/ft)	Flood Control Volume [3] (acre-ft)	1997 Release [4]	Approximate Channel Capacity [5] (cfs)
Lake	506	190.7	122,000	744,600	2,500	2,500
Stampede	136	5.4	3,349	22,100	2,075[6]	3,000
Boca	172	1.5	930	8,000	0	3,000
Prosser	50	1.2	533	20,000	5	2,000
Martis	39	1.2	505	15,000	374	500

[1] Surface area at gross pool. Lake Tahoe surface area at maximum permissible elevation.
[2] Storage Capacity per foot of depth. For flood control reservoirs, average value for Flood Control / Joint Use Pool.
[3] Volume in Flood Control / Joint Use Pool. Lake Tahoe value is volume between natural rim and maximum permissible elevation. Lake Tahoe is not drawn down to natural rim to provide flood control space.
[4] Outflow at time of peak flow at Farad.
[5] Channel reach below lake / reservoir.
[6] Inflow to Boca Reservoir.

TABLE 10.
TRUCKEE RIVER REACH LENGTHS AND FLOOD WAVE TRAVEL TIMES

Locations	Length (miles)	Approximate Travel Times (hours)
Lake Tahoe to Truckee	17.5	4
Truckee to Farad	14.0	4
Farad to Reno	22.0	3
Stampede Dam to Boca Dam	3.4	1
Boca Dam to Farad	9.0	1
Prosser Creek Dam to Farad	11.0	2
Martis Creek Dam to Farad	13.0	3

TABLE 11.
SUMMARY OF LAKE TAHOE MAXIMUM AND MINIMUM DAILY STAGES BY MONTH

	Oct's	Nov's	Dec's	Jan's	Feb's	Mar's	Apr's	May's	Jun's	Jul's	Aug's	Sep's	Total
Avg Stage	5.59	5.41	5.37	5.49	5.70	5.86	6.01	6.27	6.64	6.60	6.20	5.82	5.87
Maximum	8.32	8.39	8.50	9.39	9.12	8.47	8.32	8.50	8.95	8.97	8.96	8.57	8.04
Max Yr	1983	1984	1996	1997	1997	1986	1986	1968	1986	1958	1958	1965	1970
Minimum	0.63	0.41	0.50	0.99	1.39	1.63	1.74	1.85	1.79	1.62	1.36	0.98	1.59
Min Yr	1993	1993	1993	1993	1993	1992	1992	1992	1992	1992	1992	1992	1992

Notes:
1. Lake levels regulated by a 17-gate concrete dam at outlet of lake. Dam was constructed between 1909 and 1913. There are minor diversions for domestic purposes, irrigation, and power.
2. Period of Record April 1900 to Present. Month end elevations only for Oct 1943 to Sep 1957. *Maximum permissible lake elevation is 6,229.1 ft by Federal Court decree.*
3. Datum of gage is 6,218.86 ft above National Geodetic Vertical Datum (NGVD) of 1929. Gage datum is 6,220.0 ft above US Bureau of Reclamation (USBR) datum. USBR datum used for gage height records.
4. Instantaneous values at 2400 hrs.

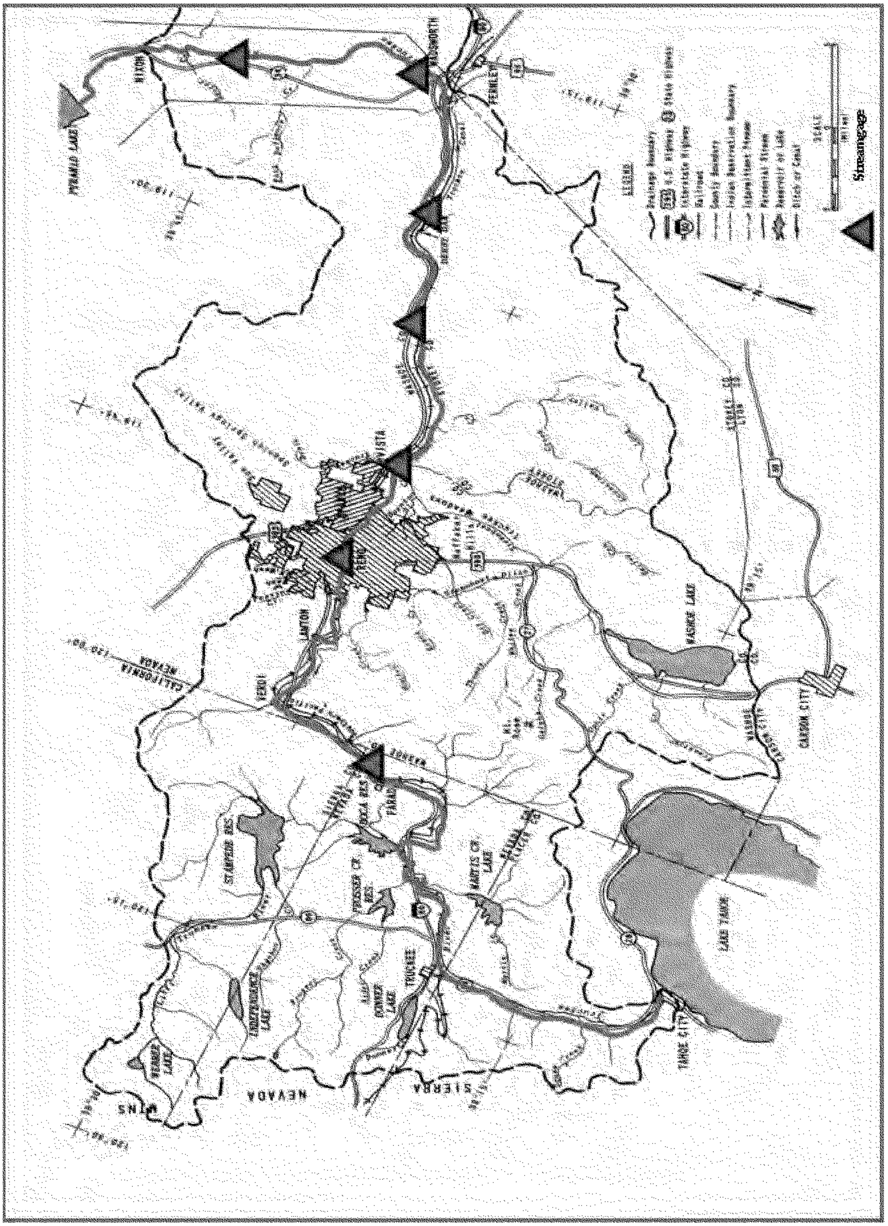

PYRAMID LAKE
NIXON
WADSWORTH
FERNLEY
RENO
VERDI
CALIFORNIA
NEVADA
STAMPEDE RES.
INDEPENDENCE LAKE
PROSSER CR. RES.
DONNER LAKE
TRUCKEE
MARTIS CR. LAKE
LAKE TAHOE
TAHOE CITY
WASHOE LAKE
CARSON CITY
SIERRA
NEVADA
LEGEND
SCALE

Chart 1

I-27

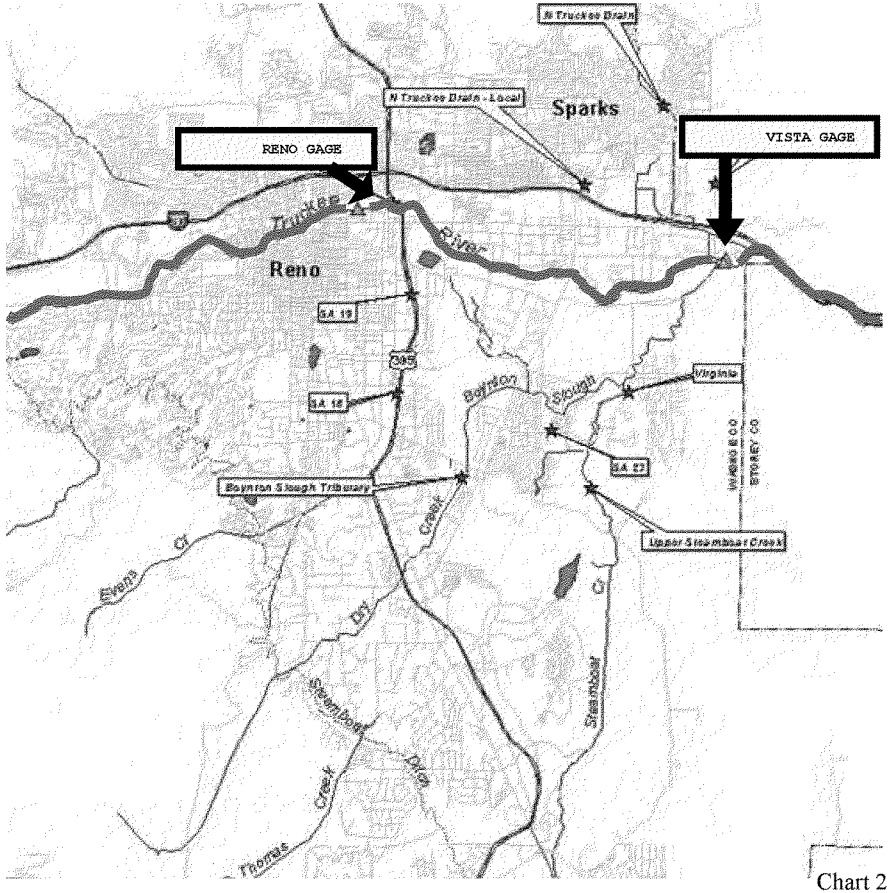
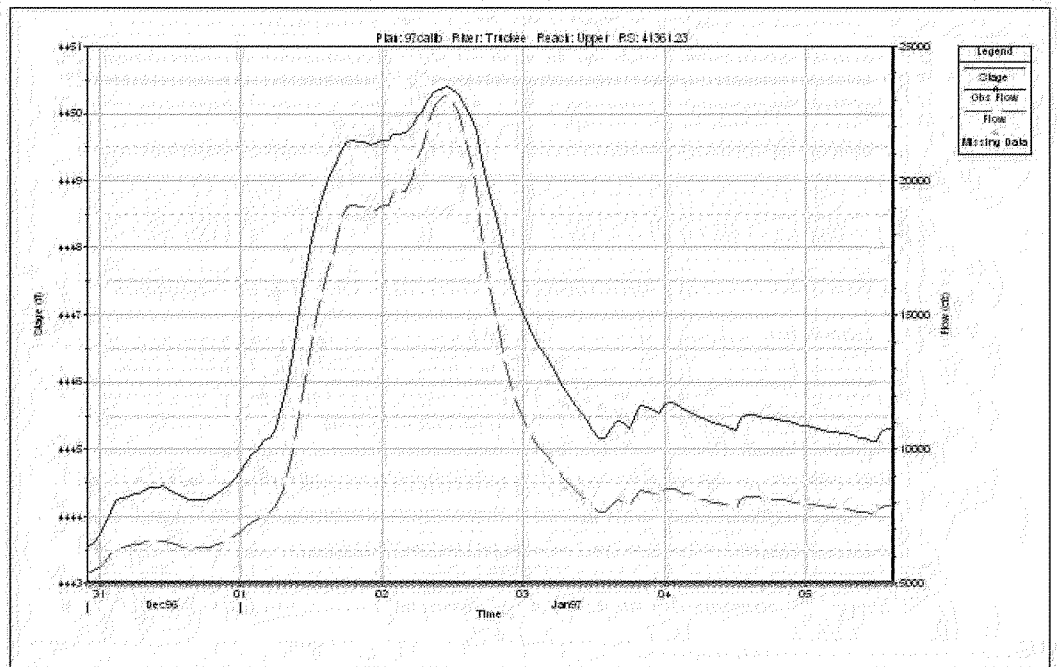

N Truckee Drain
N Truckee Drain - Local
Sparks
RENO GAGE
VISTA GAGE
Truckee
River
Reno
SA 19
395
SA 16
Bayron Slough
Virginia
SA 23
Bayron Slough Tributary
Upper Steamboat Creek
Evans
Ct
Creek
Steamboat
Ct
Steamboat
Creek
Thomas

Chart 2

500

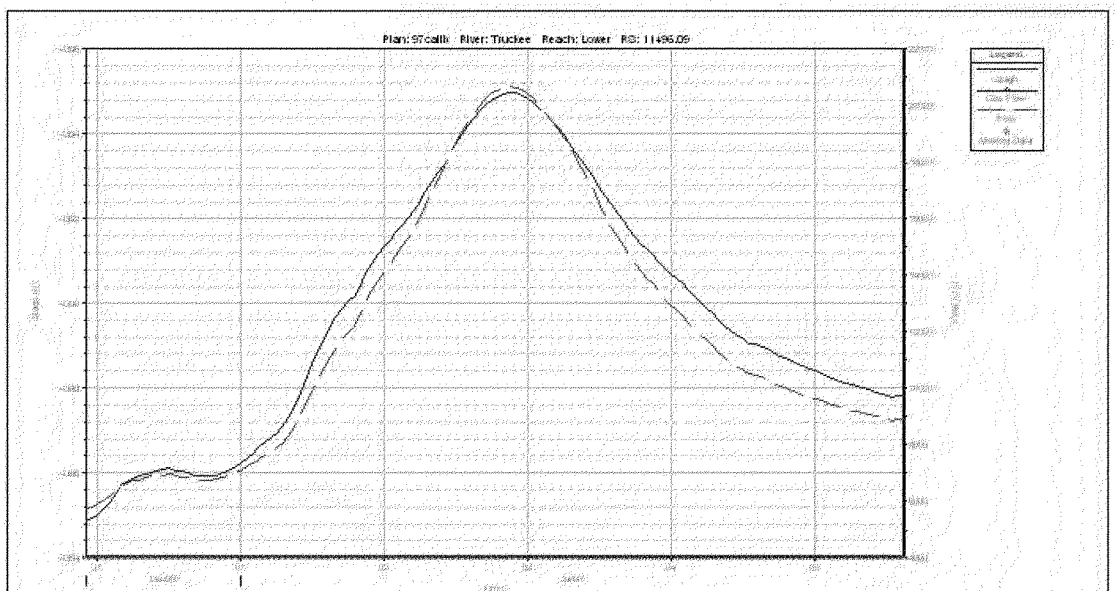
1997 Event at Reno Gage (US 395)
HEC-RAS Cross Section 41361.23



Stage and Flow Hydrograph at Reno Gage for 1997 Event

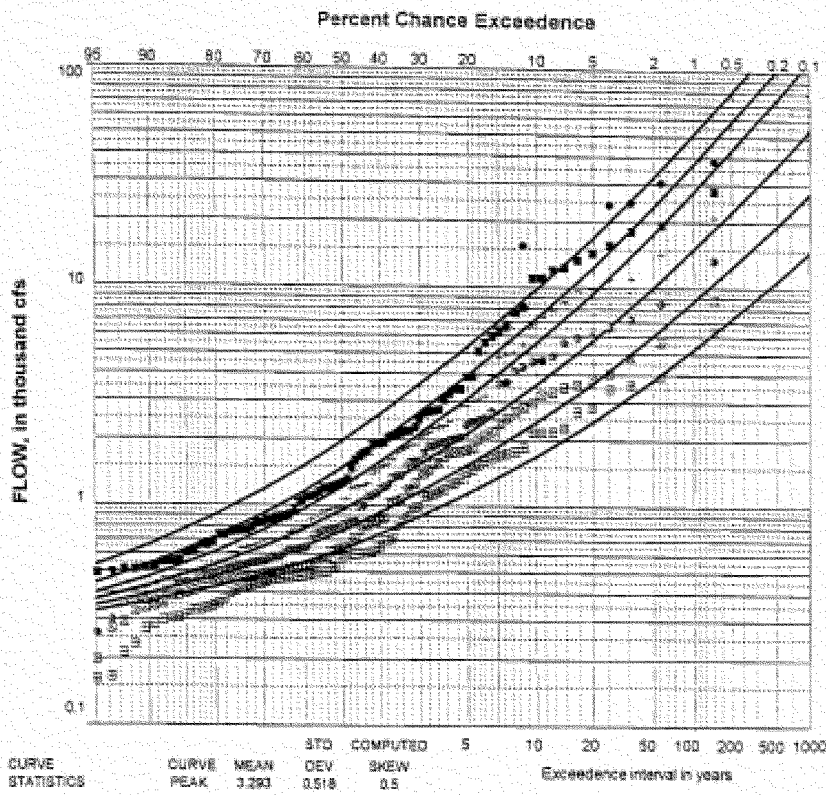
Chart 3

1997 Event at Vista Gage
HEC-RAS Cross Section 11496.09



Vista Gage Stage and Flow Hydrograph for 1997 Event

Chart 4



CURVE STATISTICS	CURVE	MEAN	STD DEV	COMPUTED SKEW
	PEAK	3.293	0.518	0.5
	1-DAY	3.157	0.518	0.5
	3-DAY	3.053	0.508	0.5
	7-DAY	2.919	0.460	0.5
	15-DAY	2.791	0.417	0.5
	30-DAY	2.669	0.379	0.5

Note: Only computed probability curves were used in study analysis

NOTES:
1. Unregulated conditions were computed by removing regulation of Martis, Prosser, Stampede, and Boca Dams.
2. Weibull plotting positions.
3. Curves reflect expected probability.
4. Contributing Drainage area below Lake Tahoe: 426 sq. mi.
5. Total Drainage Area: 932 sq. mi.
6. Historic Period 129 years.

Prepared by MVS

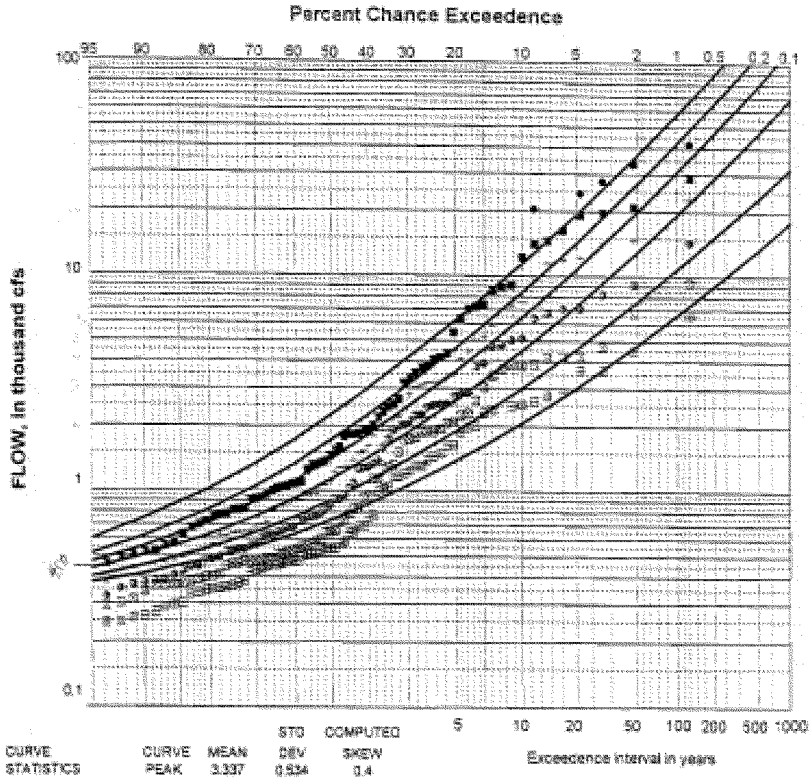
TRUCKEE MEADOWS, NEVADA
FEASIBILITY STUDY

RAIN FLOOD FREQUENCY CURVES
(UNREGULATED CONDITION)
TRUCKEE RIVER AT FARAD

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Jun 99

Chart 5



CURVE STATISTICS	CURVE	MEAN	STD DEV	COMPUTED SKEW
	PEAK	3.337	0.534	0.4
	1-DAY	3.200	0.534	0.4
	3-DAY	3.096	0.522	0.4
	7-DAY	2.973	0.492	0.4
	15-DAY	2.830	0.461	0.3
	30-DAY	2.690	0.430	0.3

Note: Only computed probability curves were used in study analysis.

NOTES:
1. Unregulated conditions were computed by removing regulation of Marlis, Prosser, Stampede, and Boca Dams.
2. Weibull plotting positions.
3. Curves reflect expected probability.
4. Contributing Drainage area below Lake Tahoe: 561 sq. mi.
5. Total Drainage Area: 1067 sq. mi.
6. Historic Period 130 years.

Prepared by MVS

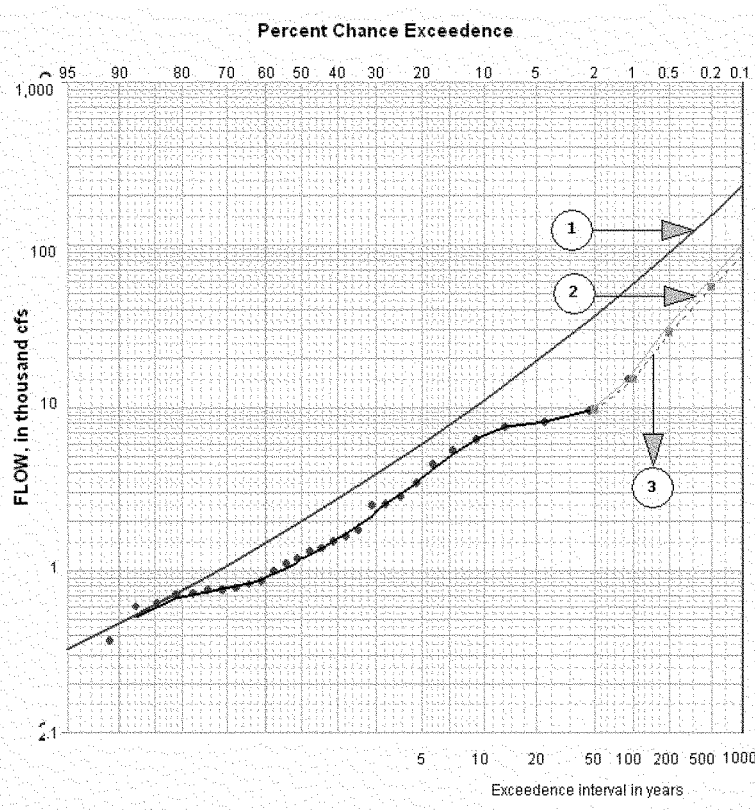
TRUCKEE RIVER, NEVADA
FEASIBILITY STUDY

RAIN FLOOD FREQUENCY CURVES
(UNREGULATED CONDITION)
TRUCKEE RIVER AT RENO

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Jun 99

Chart 6



Note: Only computed probability used in study analysis

CURVE: 1. Unregulated with expected probability.

2. Regulated - expected probability.

3. Regulated - computed probability.

NOTE: 1. Weibull plotting positions.

2. Systemic record length: 29 years

Historic record length: 91 years

3. Drainage Area: 932 sq. mi.

Prepared by MVB

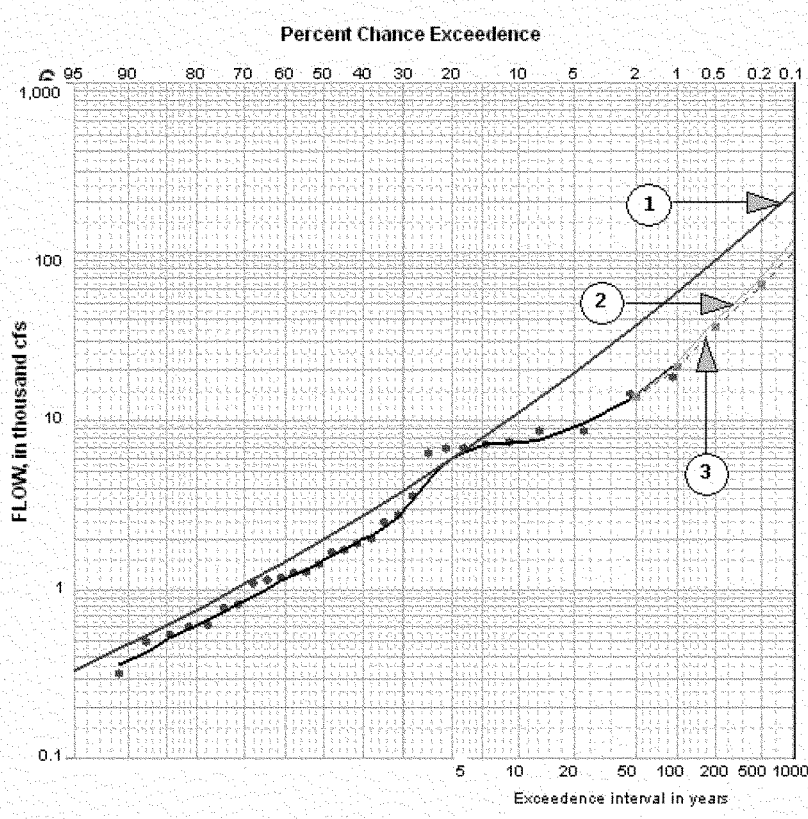
TRUCKEE MEADOWS, NEVADA
FEASIBILITY STUDY

PEAK RAIN FLOOD FREQUENCY CURVES
(EXISTING CONDITION)
TRUCKEE RIVER AT FARAD

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Jun 99

Chart 7



Note: Only computed probability curves used in study analysis

CURVE: 1. Unregulated with expected probability.

2. Regulated - expected probability.

3. Regulated - computed probability.

NOTE: 1. Weibull plotting positions.

2. Systemic record length: 29 years
Historic record length: 91 years

3. Drainage Area: 1,067 sq. mi.

Prepared by MVB

TRUCKEE MEADOWS, NEVADA
FEASIBILITY STUDY

PEAK RAIN FLOOD FREQUENCY CURVES
(EXISTING CONDITION)
TRUCKEE RIVER AT RENO

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Jun 99

Chart 8

PART II of Attachment A

RE-ANALYSIS OF DOWNTOWN AND TRUCKEE MEADOWS REACH

REFERENCES

1. Truckee Meadows, Nevada, General Re-Evaluation Report Phase, F3 Milestone Conference, July 1999, U.S. Army Corps of Engineers, Sacramento District.

2. Truckee River, California and Nevada, Hydrology, February 1980, U.S. Army Corps of Engineers, Sacramento District.

1. Introduction

This section describes the re-analysis of the Downtown and Meadows Reach hydrology to resolve concerns that remained after the 1999 F3 Conference. The hydrologic concerns that remained after the July 1999 F3 Conference included the following: 1) Uncertainty about the accuracy of the USGS published peak flows at the Reno and Vista gages for the January 1997 event 2) concern that the HEC-1 and HEC-5 models may have been calibrated (routing parameters) to an erroneous 1997 peak flow at Reno 3) the validity of adopting the standard deviation and skew of the 1-day frequency curve for use in the peak flow frequency curve 3) the validity of the existing conditions peak flow frequency curve at Vista due to the following: a) it's dependence upon the FLO-2D model to calculate the peak flow at Vista b) uncertainty about the tributary runoff and its coincident timing with the peak flow on the Truckee River c) concern that the 1963 channel modifications to the Vista Reefs were not properly accounted for in the Vista frequency analysis d) concern that the North Truckee Drain hydrology used in the F3 did not take into account flow attenuation by physical barriers such as highway and railroad culverts. e) concern about the effect of on-going urbanization in the Truckee Meadows area and its effect on the current hydrology. The above issues describe the concerns having to do with the hydrology. A hydraulic issue that was pushed by one of the sponsors was concern that the FLO-2D model that the Corps had built for the Meadows Reach might be computing incorrect stages. In response, the Corps enlisted the help of Gary Brunner of HEC to build a new unsteady state HEC-RAS model for this reach. The above hydrologic and hydraulic issues were analyzed and addressed in recent work by the study team. The re-analysis has resulted in the following: 1) the existing conditions hydrology for the downtown Reno reach remains **unaltered** since the July 1999 F3 Report. 2) the existing conditions hydrology for the Truckee Meadows area has been revised.

2. Overview of July 1999 F3 Hydrology:

For the benefit of the reader, the following paragraphs attempt to provide a general summary of the original 1999 F3 hydrologic analyses to gain perspective on additional work completed since that report. The 1999 F3 Report (reference 1) should be considered the ultimate reference for details on that analysis. Only existing conditions hydrology was analyzed due to: 1) much of the volume that floods the Reno area comes from the Sierra Mountain slopes upstream of Downtown Reno and relatively little development is expected in this area in the future 2) Washoe County is enforcing regulations which require developers to implement features which will keep the hydrology from changing due to urbanization.

2.1 Type of Event: A large-sized, frontal storm originating in the Pacific Ocean and consisting of rain or rain-on-snow is the type of event that causes flooding on the mainstem of the Lower Truckee River. A synthetic, general rainflood event was derived for the analysis. The January 1997 flood (flood of record) was a rain-on-snow event. A general map with streamgage locations is shown on Chart 1. Chart 2 lists pertinent information on the gages. Chart 3 shows the input locations in the HEC-RAS model

where mainstem and tributary hydrographs were needed to create the existing conditions floodplains.

2.2 Routing Flows with HEC-1: An HEC-1 model with flow routing parameters was calibrated to historic events. The model was **not** used for rainfall-runoff, only routing of hydrographs. Representative travel times for flows within the watershed are as follows:

Reach	Travel Time (Hours)
Lake Tahoe to Farad:	4
Martis Creek reservoir to Farad:	3
Farad to Reno:	3
Reno to Vista:	1

2.3 Unregulated Frequency Curves: A family of unregulated frequency curves was computed for the Truckee River at Farad (1907 – 1998), Truckee River at Reno (1907 - 1998), and Truckee River at Vista (1907-1998) streamgages. Recorded change-in-storage at the reservoirs on an hourly basis is limited to the 1997 event only. This presented a problem in the calculation of peak unregulated flow. Fortunately, several estimates of unregulated peak flow on the Truckee are available from previous rainfall-runoff studies. In order to compute unregulated peak instantaneous flow frequency curves for the gages, a regression equation was developed between the peak and 1-day unregulated flows that were available. This regression equation was used to create a synthetic record of annual maximum peak unregulated flows using corresponding annual maximum 1-day unregulated flows. The synthetic peak data was used to compute a new mean for the curve. The standard deviation and skew of the adopted 1-day frequency curve was adopted for use on the peak instantaneous curve. A whole family of curves for the peak through 30-day durations was created for each gage location.

2.4 Unregulated Hydrographs: Unregulated hydrographs for Farad and Reno were created using the 1997 flood as a pattern. A function in HEC-1 was utilized that balanced the pattern hydrographs to the unregulated frequency curve volumes. The shape of the 1997 event was smoothed to enhance HEC-1's performance.

2.5 Development of Reservoir Inflow and Local Flow to Farad: Lake Tahoe normally does not contribute significant flow to the Truckee River during floods (exception is 1997). Below Lake Tahoe, four reservoirs regulate approximately 25% of the area between Lake Tahoe and the Reno gage (Martis Creek, Prosser, Stampede and Boca Dam). A regression analysis of historic storms was made to determine the percentage contribution of each reservoir to the total unregulated flow at Farad. Pattern hydrographs representing inflow to each of the four reservoirs were attained from observed data recorded during the 1997 flood. The pattern hydrographs were manipulated until each attained its proper volume (in terms of percentage of the total flow at Farad). For each frequency event modeled, the reservoir inflow hydrographs were input into HEC-1 (without reservoir regulation) and routed to Farad. The combined hydrograph resulting

from routing of the reservoir inflows was then subtracted from the balanced hydrograph developed in paragraph 2.4 above to determine the local flow contribution (from areas below the reservoirs) to Farad.

2.6 Determination of Local Flow between Farad and Reno: For each frequency event modeled, the Farad hydrograph (balanced to the unregulated frequency curve) was routed in HEC-1 down to Reno. This hydrograph was then subtracted from the balanced hydrograph for Reno (as described in paragraph 2.4 above) to determine the local flow hydrograph representing contributions from the drainage area between the Farad and Reno gages. Using the methodology described in the above paragraphs, a complete set of hydrographs representing individual reservoir inflow, local flow to Farad, and local flow between Farad and Reno was created for each frequency event modeled.

2.7 Modeling Reservoir Regulation: For each frequency event modeled, a complete set of unregulated hydrographs were input into an HEC-5 model complete with reservoir regulation and flow routing parameters. The resulting regulated hydrograph at Reno was then designated as a "design hydrograph". The design hydrographs became input for the hydraulic model (FLO-2D for the 1999 F3 Report).

2.8 Contribution from Lake Tahoe: During the 1997 event, Lake Tahoe contributed a maximum flow of 2500 cfs during the peak flooding that occurred in Reno. This was the only major flood since 1909 that had a significant contribution from Lake Tahoe. Lake Tahoe has an immense storage capacity and usually absorbs the runoff upstream of the lake. The 1997 event was unusual in that the storm was extremely warm and melted much of the snow pack in the mountains below 7,000 feet. Many streams that are tributaries to Lake Tahoe recorded historic maximums during this event. In addition, the water surface of the lake prior to the storm was very high that year. It is believed that the 1997 event on the lower Truckee River represents an event more rare than a 1% chance event (about a 0.8% chance exceedence event at Reno due to the contribution from Lake Tahoe). The average contribution from Lake Tahoe for the 13 largest floods of record is only 275 cfs.

3. Re-Analysis of Existing Conditions Hydrology: The rest of this section describes the re-analysis of the existing conditions hydrology for the Downtown and Meadows Reaches.

3.1 Re-Analysis of January 1997 Flood: The largest flood of record occurred between December 30th, 1996 and January 3rd, 1997 when a warm, moist Pacific storm crossed over the Sierra Mountains and dumped rainfall on the Truckee River watershed. Much of the snow pack below elevation 7,000 feet was melted during this event. Areas within Reno City, the airport and the Truckee Meadows were severely flooded with damages running into the hundreds of millions of dollars. Peak flow at Reno is estimated by the Corps to have been 23,000 cfs (existing channel capacity in downtown Reno is 14,000 cfs). Farther downstream in the Truckee Meadows reach, channel capacity drops down to 6,000 – 9,000 cfs. Due to backwater effects on rating curve accuracy and malfunctioning equipment at the gages, there was some controversy over the true peak

flow at Reno and Vista. In addition, the AE Firm hired by the local sponsors felt that the FLO-2D model was not working properly. Due to this concern, the study team decided to build a new hydraulic model of the Truckee Meadows area using a new version of HEC-RAS that includes unsteady flow simulation. The new model was a joint effort between Gary Brunner of the Hydrologic Engineering Center (HEC) and a private AE Firm (WRC Nevada, Inc.). The model was calibrated to the 1997 flood using high-water marks observed at numerous locations. As a result of calibrating the model to match high water marks, it was determined that the peak flow at the Reno and Vista gages was 23,000 cfs and 20,700 cfs, respectively. Charts 4 and 5 display the Corps latest adopted hydrographs for the 1997 event for the Reno and Vista gages. USGS published values for these two locations are 18,200 and 18,400 cfs, respectively. Gary Brunner and WRC feel confident in their calibration. The calibration results were also reviewed by Montgomery Watson Harza (AE Firm hired by the Corps), which had built a steady flow model of downtown Reno. Gary Brunner, WRC, and Montgomery Watson supported the adoption of the new peak values. It should be noted that as of the writing of this report, the USGS has not changed their official peak value at Reno or Vista. The USGS maintains that the peak stage at the Reno gage was the result of downstream obstructions that caused backwater effects and a reduction in the velocity of the flow. The study team does not agree with the USGS published peak values for Reno or Vista. The calibration of the HEC-RAS model for the 1997 flood also resulted in the creation of a hydrograph for the Reno and Vista gages which is larger in **volume** than that found in USGS records (although not as significant as the change in peaks).

3.2 Re-Evaluation of the Truckee River at Reno Hydrology: After adopting the new peak flow and volume for the 1997 event that was determined in the calibration of the HEC-RAS model, a re-analysis of the design hydrology was needed. The hydrology for the Reno streamgage was re-evaluated using the new peak and volume for the January 1997 event as determined during the calibration of the HEC-RAS Model. In the 1999 F3 Study, the period of record of unregulated peak flow data at Reno was derived synthetically using a regression equation on five water years of peak and 1-day flows (including the 1997 event). Four of these came from rainfall-runoff reconstitutions of historical events and the fifth from recorded hourly data during the January 1997 flood. These were the only events for which peak unregulated flow data was available since hourly reservoir data (needed to compute unregulated peak flow) is not available for the period of record. The synthetically derived data set was used to determine the mean of the new frequency curve, while the standard deviation and skew was adopted from the 1-day curve. Although the original regression equation used in the 1999 F3 Hydrology could not be found, a sensitivity analysis determined that adopting the new 1997 peak flow and 1-day values did not result in a significant change to the frequency curves for those durations. In addition, the local sponsors asked the Corps to review the routing parameters used in the HEC-1 and HEC-5 models. Their concern was that the models might have been calibrated to the 1997 event using an incorrect peak flow at Reno. This scenario could have resulted in an incorrect Muskingum "x" coefficient (effects attenuation of the peak of the hydrograph as it moves downstream) being used in the HEC-1 and HEC-5 model. After further investigation, it was determined that the routing

parameters used in the models remained largely unchanged from those used in pre-1997 studies.

3.2.1 Analysis of the Standard Deviation and Skew of the Peak Curve: The local sponsors asked the Corps to verify the use of the standard deviation and skew of the 1-day, unregulated curve for use on the peak unregulated frequency curve. Adoption of 1-day statistics for the standard deviation and skew is sometimes done in hydrologic analyses since peak flow is the duration that is most susceptible to error or incorrect measurement. The skew is the parameter that is especially sensitive to being effected by a few incorrect values. As stated before, only a small sample of unregulated peak flows was available for the analysis. A synthetic period of record of peak values was derived by regression with the available 1-day values.

In order to analyze the relationship between the peak and 1-day unregulated statistics, regulated flow data was analyzed. About 25 pairs of observed (regulated) rainflood peaks and 1-day values exist at Reno. The rest of the water years consisted of snowmelt peaks. This data set was analyzed. The average percent increase between the **regulated** 1-day and peak flows was found to be 40%. This was compared with the percent increase between the 1% percent chance exceedence **unregulated** 1-day and peak flow (37% increase). This was a good match. In addition, statistics computed on the 25 pairs of regulated data showed that the standard deviation and skew for the 1-day and peak durations were similar. Therefore, the adoption of the 1-day statistics (standard deviation and skew) for the peak curve was deemed appropriate.

3.3 Results of Re-Analysis of Reno Hydrology: In conclusion, the design hydrology for the downtown Reno area was not changed from that used in the 1999 F3 Report. The study team requested that a 0.5% and 10% chance exceedence floodplain (not modeled in the 1999 Study) be computed. A Truckee River at Reno hydrograph for each event was derived for use in the HEC-RAS model. The new 0.5% and 10% chance event was designed to match the Existing Condition Peak Flow Frequency Curve published in the 1999 F3 Report.

4. Re-Evaluation of the Truckee River at Vista Hydrology (Truckee Meadows):
The hydrology for the Truckee Meadows reach (downstream of the Reno gage) was re-analyzed and modified from that used in the 1999 F3 Report. It should be noted that the newly adopted flows for the 1997 event at the Vista gage were used in the re-analysis for this reach.

4.1 Flow Dynamics in the Truckee Meadows: The Truckee Meadows is a low-lying area downstream of downtown Reno and the Highway 395 bridge. Channel capacity is only 6,000 – 8,000 cfs in this reach. For comparison, the channel capacity in downtown Reno is 14,000 cfs. Near the Vista gage, the channel becomes narrow and the flow becomes constricted. This area is sometimes called the Vista Reefs. During historic floods, backwater from this constricted reach causes a lake to form upstream of the Vista gage. Large volumes of water become stored in the overbank areas of the meadows. The tributaries flowing into the Truckee River in this area are mostly ungaged. The major

tributaries in this area include Boynton Slough, Steamboat Creek, and North Truckee Drain. The local sponsors had concerns about the timing and volume of the tributary flows used in the hydraulic model to determine the extent of floodplain. In the 1999 F3 Study, each frequency event modeled used a specific set of hydrographs representing the coincident runoff from the tributaries (with a set timing) and a hydrograph representing the Truckee River at Reno. The FLO-2D model routed the Truckee River hydrograph through the meadows and combined it with the tributary flows. The model computed the peak flow and stage at Vista. The model results determined the flow-frequency at Vista for existing conditions. After the 1999 F3, the local sponsors requested that target values of flow-frequency be developed at Vista **without** dependence upon a hydraulic model. It was also pointed out that modifications had been completed on the channel upstream of the Vista gage (area called the Vista Reefs) just prior to the February 1st, 1963 flood event. This meant that flow data at Vista was non-homogenous for the period of record. Therefore, it was decided that any new analysis on Vista peak flows would use only data recorded after the channel modifications. The 7-day and longer flow durations should not be significantly effected by the channel modifications since much of the water stored in the overbank drains back into the river and passes the Vista gage within a seven-day period.

4.2 New Flow-Frequency at Vista: Dr. Dave Goldman of the Hydrologic Engineering Center was consulted as to the appropriate methodologies to use for the Truckee Meadows area. A plan was developed to produce the new existing conditions flow-frequency at Vista. First, "target" peak flows for the 20% through 1% chance exceedence events would be determined - methodology is explained in Section 4.3. Next, the total 7-day volume of all tributary hydrographs would be determined by subtracting the unregulated 7-day curve value for Reno from the 7-day curve value at Vista (for each frequency). Representative tributary hydrographs would be multiplied by a ratio so that all hydrographs added together attained the calculated 7-day volume. An average timing (tributary runoff versus the Reno hydrograph) as determined from 3 historic floods in the Truckee Meadows area was used. The Truckee River at Reno hydrograph and the individual tributary hydrographs (with a set timing) were input into the new HEC-RAS model to determine the resulting peak flow at Vista. If the model did not match the target peak flow at Vista, the tributary hydrographs were increased or decreased (within a reasonable range), and then the hydraulic model was run again. The timing of the hydrographs was also adjusted for some frequencies. Adjustments were made until the HEC-RAS model achieved the target peak flow. Chart 6 displays the tributary hydrographs used to create 1% chance exceedence floodplain. Chart 7 displays all the major hydrographs for the 1% chance event including the Truckee River at Reno and Vista. Determining the peak flows for the 0.5% and 0.2% chance events was determined difficult to predict using historical data. Floods of this magnitude have not been recorded on the Lower Truckee River. The amount of overbank flow, which occurs in these events and its subsequent effect on the peak flow at Vista, cannot be determined without use of a model. Methods used to predict the target peak flow for the 20% through 1% chance exceedence events were performed only to find a range of values for these two frequencies. The peak flow for these events was determined by the original method used

in the 1999 Study, inputting design hydrographs into a hydraulic model (with a set timing) and letting the model determine the peak flow and stage at Vista.

4.3 Two Methodologies Used to Determine 20% - 1% Chance Exceedence Peak Flows: Dr. Goldman suggested two methods to determine target peak flows at Vista. The first method was to plot Reno versus Vista peak flow from large events occurring from 1963 to present (after the Vista Reef channel improvements). A best-fit curve or line was drawn through the points. Since the Reno peak flow frequency was determined in the 1999 Study, one could use the new curve to determine the corresponding Vista flow frequency.

Due to the uncertainties in the Truckee Meadows reach, more confidence is given to the flow frequency at Reno than at Vista. For method #2, Dr. Goldman suggested using the existing conditions Reno frequency curve (from the 1999 F3 Study) as a basis for constructing a Vista frequency curve. Observed peak flows at Reno for large events (1963 to present) were assigned a frequency based on the curve at Reno. The corresponding observed peak flow at Vista for each historic event was assigned the same frequency as that which occurred at Reno. The new flow-frequency points for the Vista gage were then plotted on frequency paper and a curve drawn through the points.

The two methodologies resulted in fairly similar estimates of peak flow. The results of both methods are plotted on Chart 8. Table 1 displays the tabular data for the two methods. Table 2 shows the adopted values for this latest analysis. The Vista flow-frequency values for the 1999 F3 Report are shown for comparison. It should be pointed out that the two methodologies described above were only used to determine the 20% through 1% chance exceedence values. The peak flow for the 0.5% and 0.2% chance exceedence events was determined by the original method used in the 1999 Study, inputting design hydrographs into HEC-RAS model with a set timing and letting the model determine the peak flow at Vista. Chart 9 shows the 1999 F3 Study curve and the newly revised curve. Chart 10 simply displays the revised curve by itself.

Table 1.
Target Peak Flow Estimates for Truckee River at Vista – Comparison of Methods

Frequency of Event in Percent Chance Exceedence	Range of Estimates Derived by 2 Methods Used to Determine Target Flow (cfs)
20% chance flow	6000 – 6600
10% chance flow	7900 – 8200
5% chance flow	9500 – 10900
2% chance flow	14,100 – 14,600
1% chance flow	20,000 –20,200

Table 2.
Revised Existing Conditions Peak Flow Frequency at Vista

Frequency of Event in Percent Chance Exceedence	Computed Probability Flow Frequency 1999 F3 Report (cfs)	Revised Computed Probability Flow Frequency (cfs)
20% chance flow	5950	6600*
10% chance flow	7500	8200*
5% chance flow	9150	10,000*
2% chance flow	15,000	14,500*
1% chance flow	19,000	20,200*
0.5% chance flow	26,500	29,300
0.2% chance flow	41,000	52,000

* These flow-frequency values determined by methods independent of hydraulic modeling. Values were determined by analysis of historical flow data and then verified through hydraulic model output.

4.4 Volume of the Tributary Hydrographs: To quantify the amount of coincident runoff from the Truckee Meadows tributaries during a specific frequency event on the Truckee River, the 7-day unregulated frequency curve at Reno was subtracted from the 7-day curve at Vista. Shorter durations like the 1- and 3-day curves could not be used since much of the water stored in the overbank does not drain back into the river until 6 days after the start of the event. The frequency curves computed in 1999 crossed one another at a frequency more rare than the 1% chance event. Subtracting the two curves resulted in a decreasing volume for the tributaries as the frequency became rarer. To rectify this, a new 7-day curve was computed for both Reno and Vista. Only overlapping water years for the two gages were analyzed. For each water year analyzed, the 7-day period that caused the highest flows at Reno, was then used to find the corresponding 7-day flow for the Vista gage. Two new 7-day curves were created from this specialized data set. See Chart 11. The new curves were used to determine a new 1%, 0.5% and 0.2% chance exceedence 7-day tributary volume, while less rare frequencies were determined from subtracting the two original curves derived in 1999. The 1999 Study used 5 tributary hydrographs as input to FLO-2D. In this latest analysis, the tributary contributions were split into 10 hydrographs for input into the HEC-RAS model. The 10 pattern hydrographs were multiplied by a ratio so that the sum of all equaled the desired 7-day volume. This calculation was made to determine tributary volume for the initial run of the hydraulic model. Adjustments were made after the first run (for the 50% through 1% chance exceedence events) to achieve the target peak flow at Vista. The final 7-day tributary volumes used in the hydraulic model are displayed in Table 3. The volumes used in the 1999 F3 Report are also shown for comparison.

Table 3.
Truckee Meadows Tributaries 7-Day Volume

Frequency of Event in Percent Chance Exceedence	1999 F3 Report 7-Day Volume (cfs-days)	Revised 7-Day Volumes For 2003 Report Addendum (cfs-days)
20% chance	Not modeled	225
10% chance	Not modeled	310
5% chance	Not available	650
2% chance	1400	1400
1% chance	1500	2310
0.5% chance	Not modeled	2540
0.2% chance	1500	3795

Note: Column 3 represents final tributary volume used in the hydraulic model to determine peak flow at Vista.

4.5 Timing of the Tributary Hydrographs: The Truckee Meadows tributaries are largely ungaged. The coincident timing between runoff on these tributaries and the peak flow on the Truckee River was not certain. Field observation of the Steamboat Creek runoff during the January 1997 flood gave one estimate of the timing. The timing observed in two other major floods was discovered in previous hydrology reports. The timing of the three events was averaged and used for the initial simulation of each frequency event in the HEC-RAS model. In some frequencies modeled, the timing of the tributary hydrographs was adjusted in order to achieve the target peak at Vista in HEC-RAS.

4.6 Effect of Urbanization: The existing conditions flow frequency for the Truckee Meadows area is uncertain due to complex backwater interactions and significant overbank storage. The tributaries in this area are largely ungaged except for a couple of scattered locations. The tributaries flowing into the Truckee River between the Reno and Vista gages constitute about 364 miles of drainage area, only 280 square miles of which contributes flow to the Truckee River (Washoe Lake, located in the headwaters of Steamboat Creek, absorbs runoff from 84 square miles). The tributaries receive smaller amounts of rainfall than the Sierras since general rainstorms crossing over the mountains tend to dry out as they move east and downward into the valley. In this study, the tributaries contribute approximately 20% of the maximum 7-day volume during the 1% chance event at the Vista gage. The bulk of the flooding in this area is driven by the runoff from the Sierra Mountains (mainly the uncontrolled area between Lake Tahoe and the Reno gage). While it is known that urbanization has been on going in the Truckee Meadows tributaries, it is believed that an analysis of the historic flow records is sufficient to quantify the flow-frequency at the Vista gage. Large portions of the tributary drainage areas remain undeveloped due to steep topography and other conditions. In addition, numerous detention ponds have been built on Steamboat Creek and North Truckee Drain watersheds to mitigate the increased runoff from these developments. While newly revised rainfall-runoff models of the Truckee Meadows

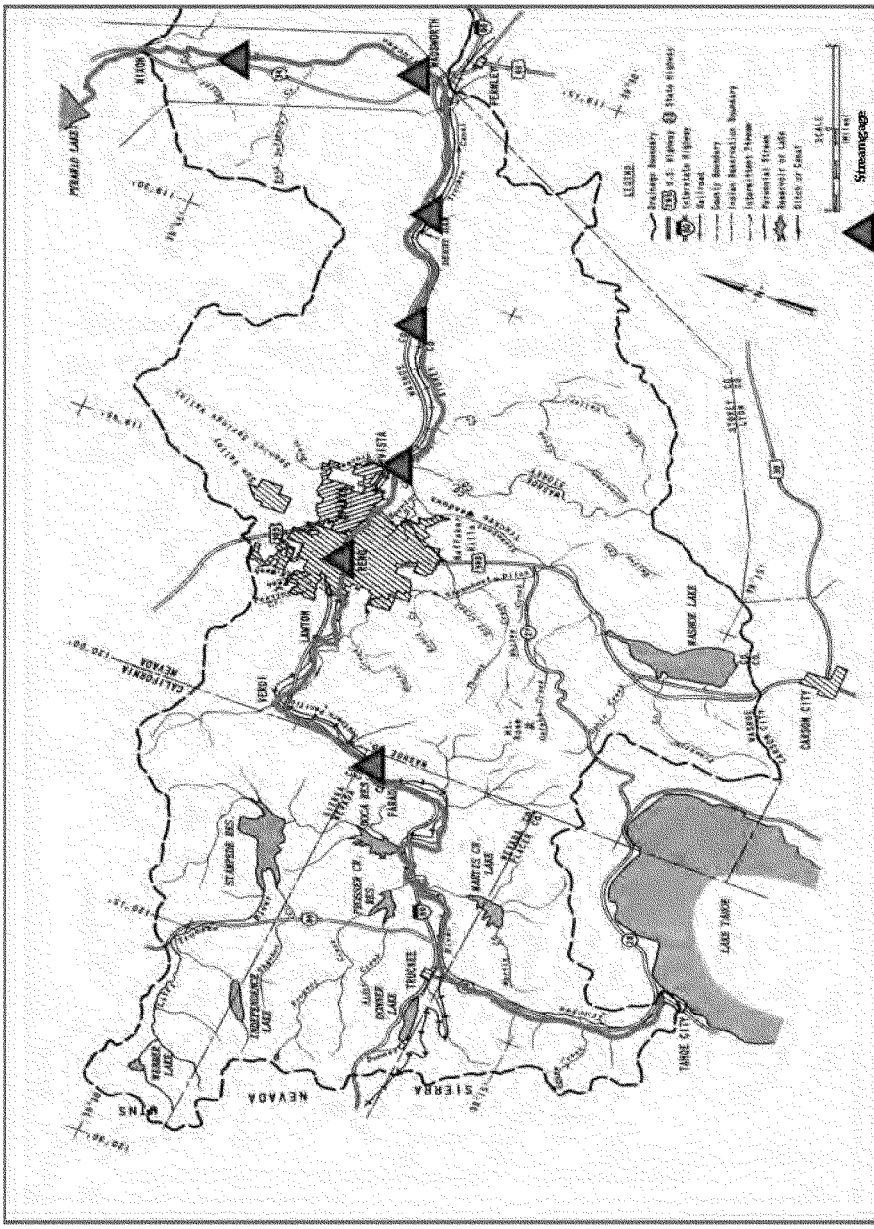
tributaries will give an updated estimate of flow frequency for storms centered on the tributary areas (such as the 1% peak flow), it will not provide a computation of coincident runoff from these areas during a general rainflood event over the entire Truckee River watershed. Due to the lack of streamgages on the tributaries, the results of a new rainfall-runoff analysis will be subject to considerable uncertainty since little historic flow data exists for calibration of model parameters. In conclusion, it is believed that a new rainfall-runoff analysis of the tributaries will not improve the existing conditions hydrology used to create the floodplains for the Truckee Meadows area.

5. Tributary Flow Contribution Between Vista and Wadsworth: Long Valley is the main tributary which contributes flow to the Truckee River between Vista and Wadsworth. Rainfall tends to decrease as large, general rainstorms move east into the desert valley. A regression analysis performed on Vista and Wadsworth streamgage data indicated decreasing peak flow rates (attenuation) from upstream to downstream. This analysis, based on historical data, indicates that the peak runoff from Long Valley tends to occur at a different time than the peak flow on the Truckee River. Calibration of the hydraulic model for the January 1997 event showed that no runoff was needed from Long Valley to match peaks at Derby and Wadsworth. In addition, a spike in the hydrographs at Derby and Wadsworth that did not occur at the Vista gage indicate that the Long Valley runoff occurred prior to the peak on the Truckee River. Due to the results of the regression analysis, a flow contribution from Long Valley was not included in the design hydrology.

6. Rainfall-Runoff Modeling of the Truckee Meadows Tributaries: New rainfall-runoff modeling of the Truckee Meadows tributaries is needed for this study for design of the project alternatives built on the tributaries. Levees or floodwalls need to be designed so that they are not outflanked by the peak flow coming down the tributary. This analysis is also needed to determine potential interior flooding problems that will be caused by the proposed structures. The local sponsors would also like to build a future conditions rainfall-runoff model to determine impacts due to future development in this area. The local sponsors have indicated that they would like to design project alternatives for existing conditions. They plan to pass laws that would force developers to mitigate the impact of new projects. The local sponsors would like to develop a future conditions model to quantify the hydrologic impacts should no mitigation occur. The Corps plans to contract out the development of new existing and future conditions rainfall-runoff modeling of the Truckee Meadows tributaries in the near future.

7. Conclusions: The existing conditions hydrology for the Lower Truckee River has been re-analyzed. The 1997 peak flows at Reno and Vista were revised as a result of the calibration of a new hydraulic model (HEC-RAS) for the Truckee Meadows area. The study team adopted these new peak flow values. It was determined that the new 1997 peak value at Reno did not require a revision of the existing conditions flow-frequency curve at Reno. A re-analysis of the flow-frequency at the Vista gage involved new methodologies not used in the 1999 F3 Report. To ensure only homogenous flow data was used, only post-1962 data was analyzed for flows exceeding the Truckee Meadows channel capacity. As a result, the existing conditions flow-frequency curve for the Vista

gage has been modified. It is believed that the revised hydrology presented in this addendum is acceptable for a feasibility level analysis of flood-protection alternatives.


PYRAMID LAKE
NIXON
WADSWORTH
PENALEN
LEGEND
Drainage Boundary
U.S. Highway
State Highway
Interstate Highway
Railroad
County Boundary
Indian Reservation Boundary
Intermittent Stream
Perennial Stream
Reservoir or Lake
Site of Gage
SCALE
Miles
Streamgage
RENO
VISTA
SPARKS
LAMOND
VERDI
CALIFORNIA
NEVADA
WASHOE LAKE
CARSON CITY
LAKE TAHOE
TAHOE CITY
TRUCKEE
STAMPEDE RES.
PROSSER CR. RES.
MARTIS CR. LAKE
BOCA RES.
FARMINGTON
BOWMAN LAKE
LAKE SPAULDING
WEBBER LAKE
NEVADA
SIERRA

STREAM GAGING STATIONS

USGS NO.	NAME OF STATION	DRAINAGE AREA (Sq. Mi.)	ELEVATION GAGE (Ft.)	PERIOD OF RECORD (Water Years) FROM	TO
3375	Truckee River at Tahoe City	506	6,216.75	1896, 1901	Present
3380	Truckee River near Truckee	552	5,860	1945	1961
3385	Donner Creek at Donner Lake near Truckee	14.6	5,930	1910	Present
33938	Martis Creek Lake near Truckee	40.0	5,780.88	1972	Present
3394	Martis Creek near Truckee	40.0	5,730	1959	Present
3397	Prosser Creek near Hobart Mills	27.4	5,840	1959	1963
3399	Alder Creek near Truckee	7.36	5,800	1959	1973
3403	Prosser Creek Reservoir near Truckee	50.5	--	1963	Present
3405	Prosser Creek near Truckee	53.2	5,602.31	1943	Present
3420	Little Truckee River near Hobart Mills	56.5	6,290	1947	1972
3430	Independence Creek near Truckee	7.63	6,940	1969	Present
3435	Sagehen Creek near Truckee	10.8	6,320	1954	Present
3443	Stampede Reservoir near Boca	136	--	1970	Present
3444	Little Truckee River above Boca Reservoir near Boca	146	5,618.67	1940	Present
3449	Boca Reservoir near Truckee	172	--	1939	Present
3445	Little Truckee River below Boca Dam near Truckee	172	5,500	1940	Present
3460	Truckee River at Farad	932	5,153.21	1900	Present
3473	Dog Creek near Verdi	16.2	5,660	1957	1961
3476	Hunter Creek near Reno	11.5	5,070	1962	1974
3478	Peavine Creek near Reno	2.34	4,990	1963	1974
3480	Truckee River at Reno	1,067	4,431.97	1907	Present
34846	Franktown Creek near Carson City	3.24	7,380	1975	Present
3487	Washoe Lake near Carson City	83.8	--	1963	Present
3488	Little Washoe Lake near Steamboat	83.8	--	1963	Present
3489	Galena Creek near Steamboat	8.5	5,592	1962	1994
3493	Steamboat Creek at Steamboat	123	4,600	1962	Present
3497	Whites Creek near Steamboat	8.02	5,955	1962	1966
3500	Truckee River near Vista	1,429	4,368.59	1900	Present
3504	Truckee River below Tracy	1,590	4,238.15	1973	Present
3516	Truckee River below Derby Dam	1,670	4,200	1909	Present
35165	Truckee River at Wadsworth	1,719	4,037.90	1966	Present
3517	Truckee River near Nixon	1,815	3,940	1958	Present
3513	Truckee Canal near Wadsworth	--	4,200	1967	Present

*Broken Record

Chart 2

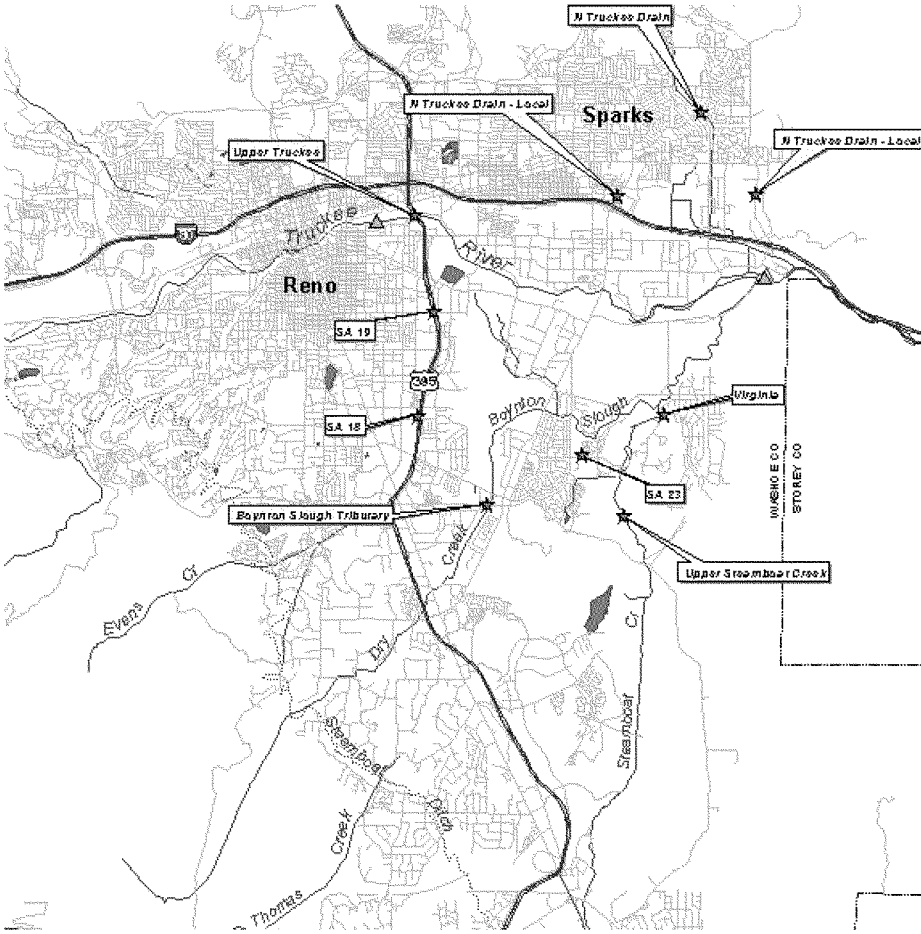
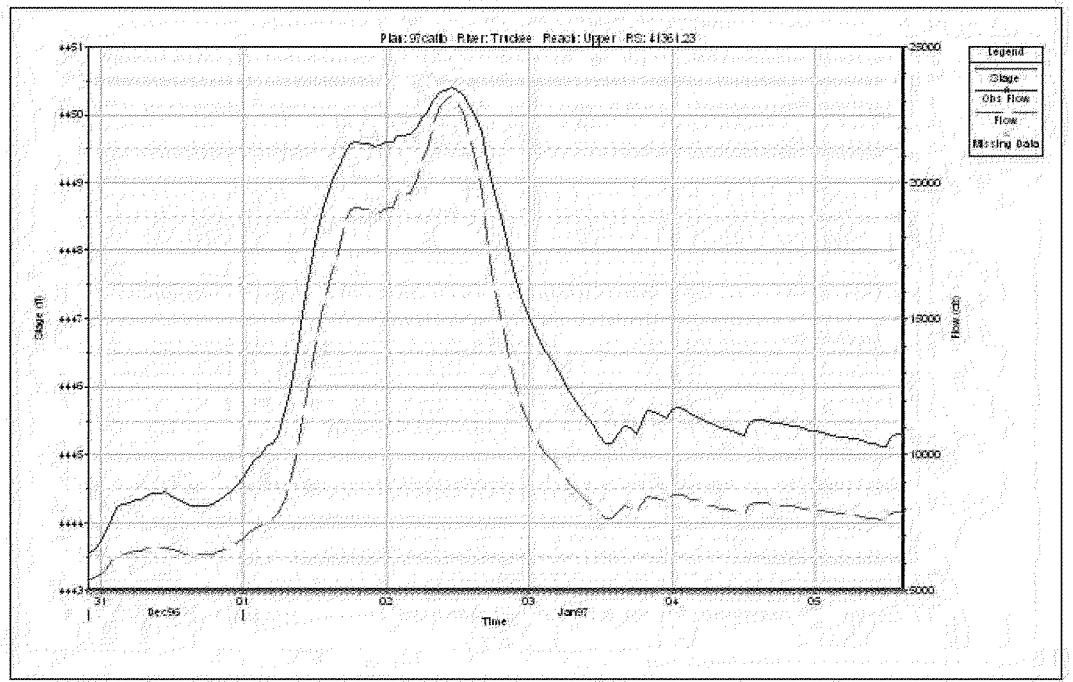

N Truckee Drain
N Truckee Drain - Local
Sparks
N Truckee Drain - Local
Upper Truckee
Truckee
River
Reno
SA 19
395
SA 18
Baynton
Slough
Virginia
SA 23
WASHOE CO
STOREY CO
Baynton Slough Tributary
Upper Steamboat Creek
Evans
Cr
Dry
Creek
Steamboat
Cr
Steamboat
Ditch
Creek
Thomas

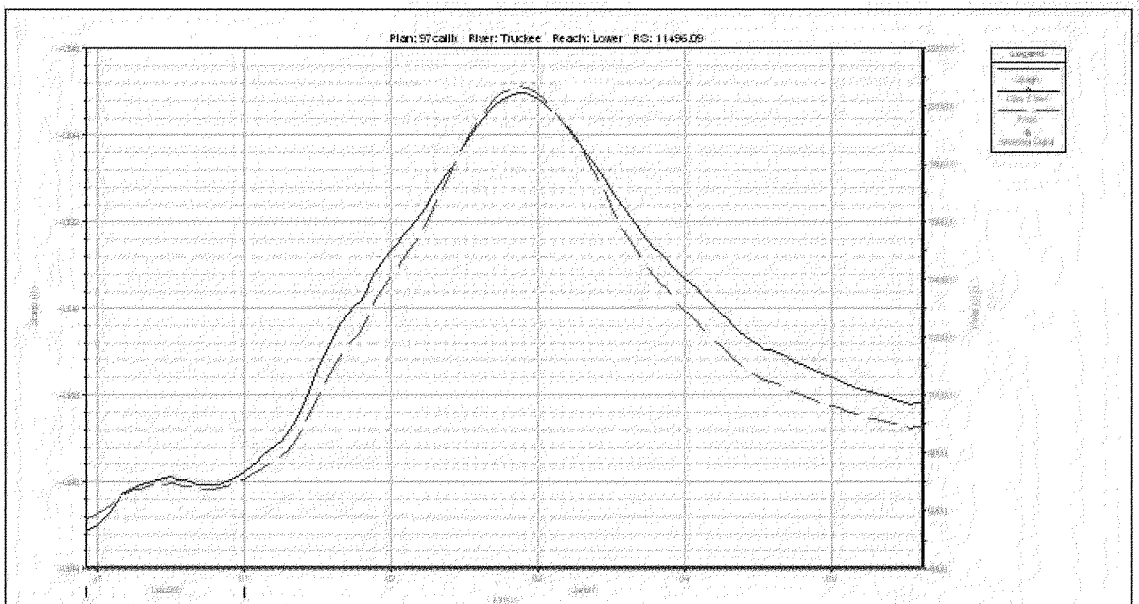
Chart 3

1997 Event at Reno Gage (US 395)
HEC-RAS Cross Section 41361.23



Stage and Flow Hydrograph at Reno Gage for 1997 Event

1997 Event at Vista Gage
HEC-RAS Cross Section 11496.09



Vista Gage Stage and Flow Hydrograph for 1997 Event

Chart 5

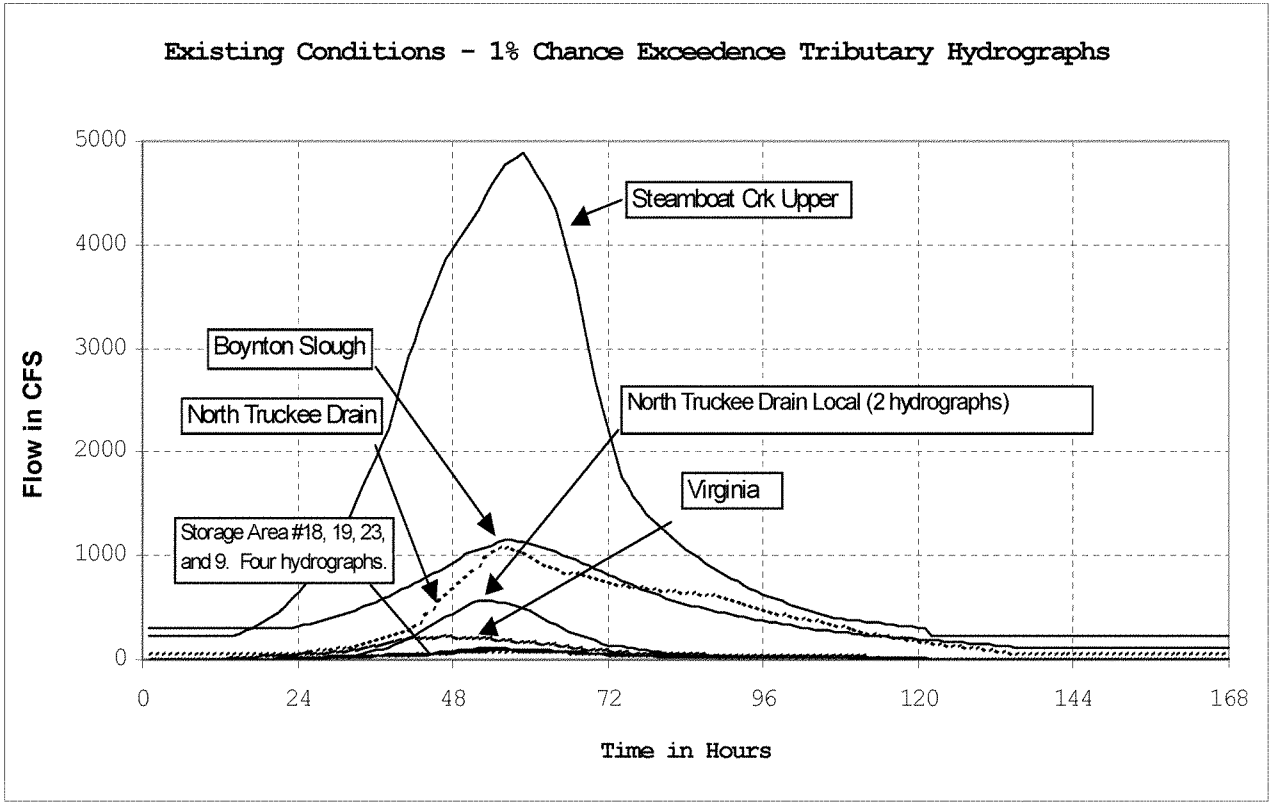

Existing Conditions - 1% Chance Exceedence Tributary Hydrographs
Flow in CFS
5000
4000
3000
2000
1000
0
0
24
48
72
96
120
144
168
Time in Hours
Steamboat Crk Upper
Boynton Slough
North Truckee Drain
North Truckee Drain Local (2 hydrographs)
Virginia
Storage Area #18, 19, 23, and 9. Four hydrographs.

Chart 6

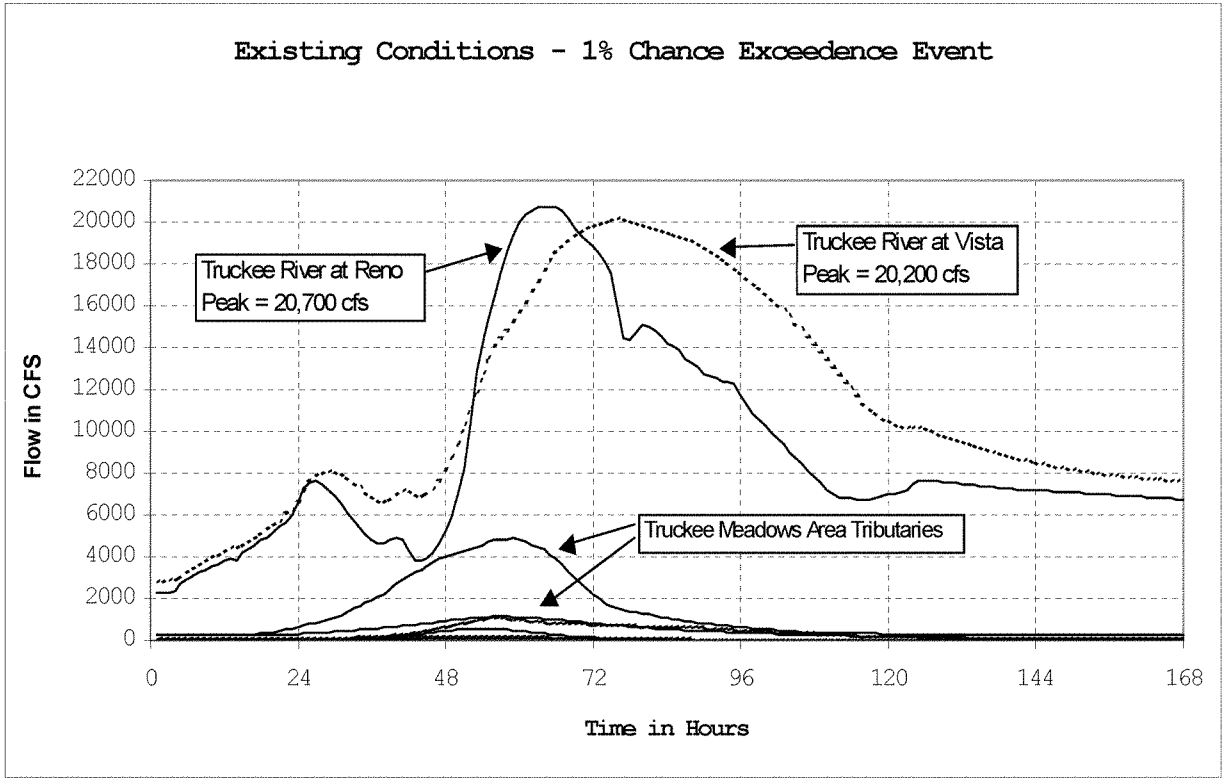
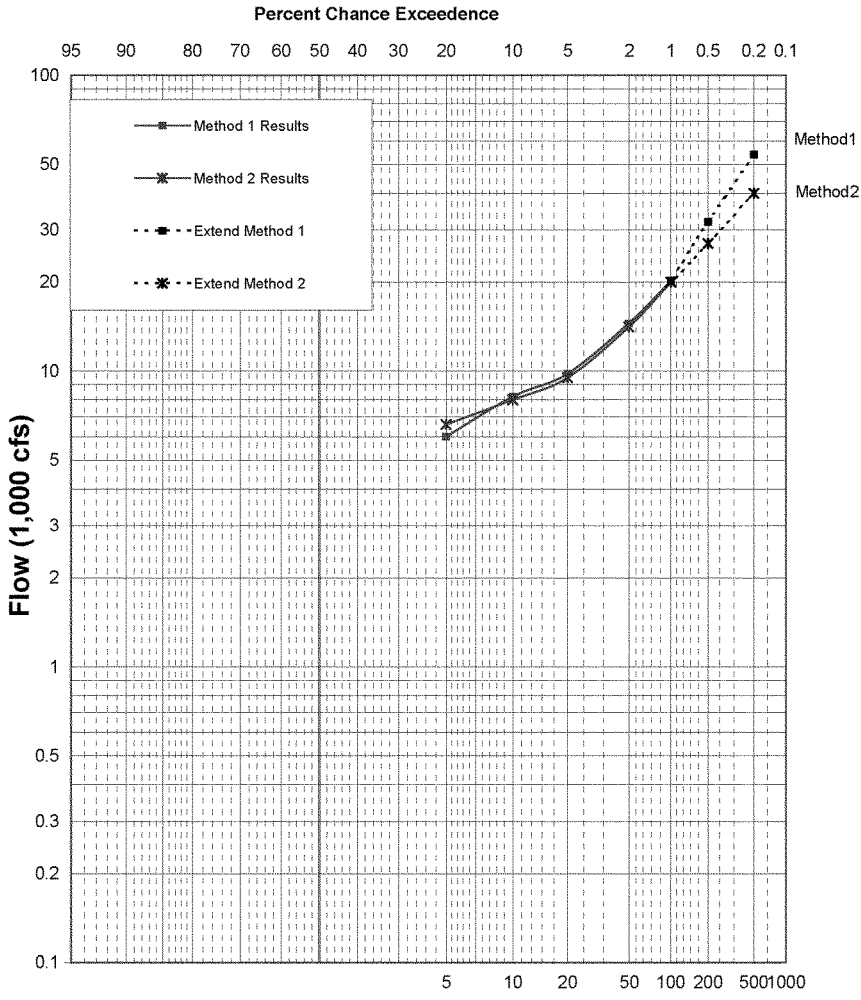

Existing Conditions - 1% Chance Exceedence Event
Flow in CFS
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
0
24
48
72
96
120
144
168
Time in Hours
Truckee River at Reno
Peak = 20,700 cfs
Truckee River at Vista
Peak = 20,200 cfs
Truckee Meadows Area Tributaries

Chart 7



Truckee Meadows GRR, 2003
Truckee River, Nevada

Notes:

1) Neither curve represents the final curve adopted for this study.
2) Neither methodology is appropriate for estimating frequencies that are more rare than 1% chance exceedence.
3) Period of record analyzed is 1963 to present (after the Vista Reef channel improvements).
4) D.A. = 1430 mi²

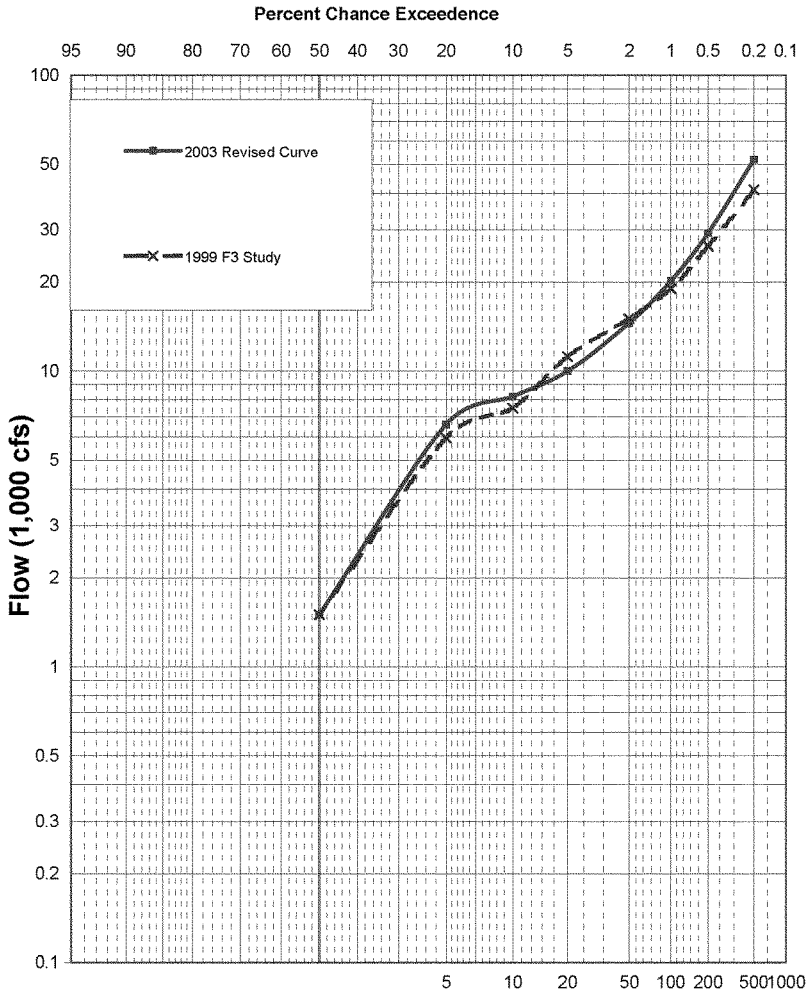
jmh

COMPARISON OF METHODS TO ANALYZE EXISTING CONDITIONS FLOW FREQUENCY FOR TRUCKEE RIVER AT VISTA

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Jan 03

Chart 8



Notes:

1) Computed Probability
2) D.A. = 1431 mi^2 including Lake Tahoe, 925 mi^2 without.
3) Period of record analyzed = 1963 to present (after Vista Reefs channel modifications)
4) For rare events, upstream overbank storage is quite large.
5) Analysis of both curves involved Hydraulic Models.

jmh

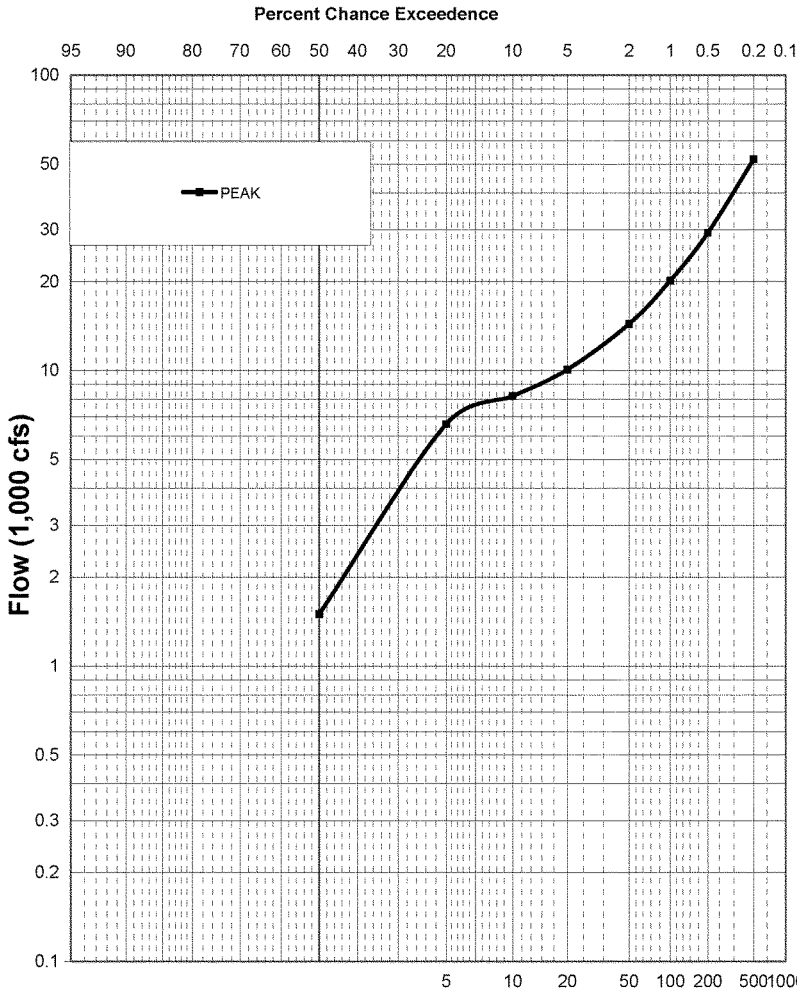
Truckee Meadows GRR, 2003
Truckee River, Nevada

PEAK RAINFLOOD FLOW FREQUENCY
TRUCKEE RIVER AT VISTA
EXISTING CONDITIONS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Jan 03

Chart 9



Notes:

1. HEC-RAS Unsteady Flow Model used to determine 0.5% and 0.2% chance exceedence values on curve.
2. Computed Probability Curve.
2. Period of record flows analyzed = 1963 to present (after 1963 channel improvements on Vista Reefs)
3. D.A. = 1431 sq. miles including Lake Tahoe
4. USGS Record = 10350000

jmh

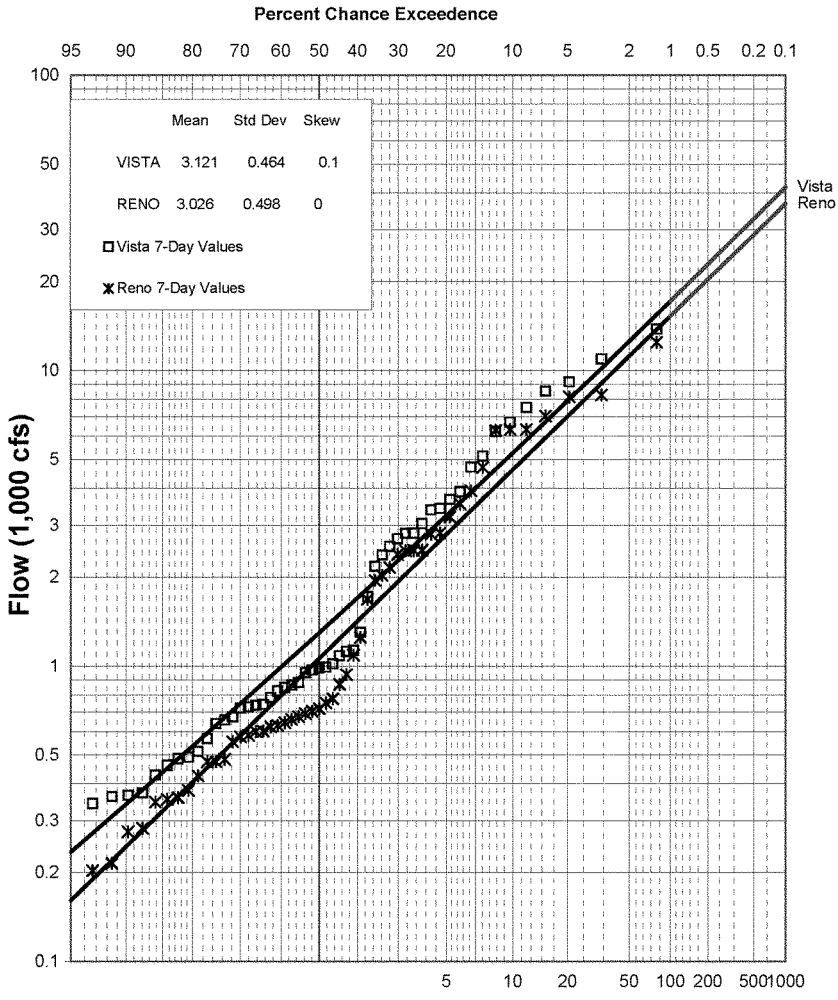
Truckee Meadows GRR, 2003
Truckee River, NV

PEAK RAINFLOOD FLOW FREQUENCY CURVE
TRUCKEE RIVER AT VISTA
EXISTING CONDITIONS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Jan 03

Chart 10



Truckee Meadows GRR, 2003
Truckee River, Nevada

TRUCKEE RIVER AT RENO AND VISTA
7-DAY UNREGULATED CURVES
USED FOR TRIBUTARY VOLUME CALCULATION

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Notes:

1. Computed Probability.
2. Median plotting positions
3. D.A.: Vista=1430 sq. mi., Reno=1067 sq. mi.
4. Used only overlapping events at gages (55 years record)!
5. Adopted skews are for upper end of curve

jmh

Jan-03

PART III of Attachment A

DOWNSTREAM OF VISTA REACH

1. Introduction

The purpose of this report is to describe the hydrologic analysis for existing conditions on the lower Truckee River between the Vista streamgage and Marble Bluff Dam. The original project boundary stopped at the Vista gage. Since the project boundary now extends to Marble Bluff Dam, existing conditions hydrology were analyzed for this new area. The hydrology for the Downtown Reno Reach (Verdi to the 395 Highway Bridge) and the Truckee Meadows Reach (395 Highway Bridge to the Vista streamgage) were described in the July 1999 F3 Report (Ref. 1). An addendum to the 1999 report was completed in January 2003 (Ref. 2) and contained **revisions** to the Truckee Meadows Reach hydrology. This latest analysis (June 2004) has two primary products 1) peak flow frequency curves at four locations 2) *concurrent* local tributary hydrographs that can be routed and combined in a hydraulic model with the mainstem Truckee River hydrograph as it moves downstream of Vista towards Marble Bluff Dam. This appendix only describes the development of the hydrology. The hydraulic modeling results will be described in a separate appendix.

2. Hydrologic Analysis

2.1 Description of Watershed

A general map showing the drainage area, topography, and streamgage sites for the lower Truckee River is displayed in Chart 1. The streamgaging stations used in this analysis are shown below.

Table 1. List of Streamgage Stations

Gage Name & I.D. Number	Drainage Area (mi^2)	Period of Record	Number of Years in Record
Truckee R. at Vista #10350000	1431	1899 – present	78
Truckee R. nr. Tracy #10350340	1580	1997 – present	6
Truckee R. below Tracy #10350400	1590	1972 – 1997	26
Truckee R. below Derby Dam near Wadsworth #10351600	1676	1918 – present	85
Truckee R. at Wadsworth #10351650	1728	1965 – present	32
Truckee R. nr. Nixon #10351700	1827	1957 - present	45
Truckee Canal nr. Wadsworth #10351300	Not Applicable	1944 - present	36

The Truckee River flows through Truckee Canyon, which is marked by a narrow floodplain of small fields, pastures, rural development, and stands of cottonwoods and willows hugging the riverbanks. The river runs approximately 65 miles between Vista and Pyramid Lake. Pyramid Lake is a sink with no outlet. Derby Dam, which is just upstream of the Derby streamgage, is a small diversion dam that can divert up to 1000 cfs into the Truckee Canal. The canal transports irrigation water to local farmers and to a lake in the Carson River watershed. The canal is very flat in terms of slope. Downstream of the Nixon gage, the river becomes increasingly entrenched. Marble Bluff Dam is a small run of the river dam that can divert water to a fish passage canal. At Marble Bluff Dam, the river channel forms steep vertical walls that are at least 30 to 40 feet in height. The erosion is due to increased diversions (irrigation and water supply) that have occurred over the last century, causing Pyramid Lake to drop. The drop in lake elevation has removed backwater effects and increased stream velocity and downcutting along this portion of the river. Due to the extremely entrenched channel and lack of damageable property, the floodplain will not be mapped downstream of Marble Bluff Dam. The floor of Truckee Canyon sits around 4000 feet elevation while a few of the tributary watersheds have ridges as high as 8000 or more feet. Approximately one quarter of the valley watershed lies above 5500 feet. Vegetation is more rich and abundant in the riparian zone close to the river but becomes scarce in the surrounding hills above the valley floor. Vegetation on the hills includes sagebrush and native grasses. The landscape is typical of high desert regions. Mean annual precipitation ranges from 4 inches in the lower basins to 30 inches on the mountain summits. Temperatures range from –10 to 110 degrees Fahrenheit. The geology of the canyon is formed from Tertiary Age volcanic rocks. Soils in the valley are composed of gravelly or sandy loams on the alluvial slopes and silty or clay loams on the bottomlands. The area is rural and relatively few small towns and communities can be found in the valley. These include Lockwood (at the outlet of Long Valley Creek), Wadsworth, and Nixon. The riverbed itself is sandy and gravelly in nature. The streamgage channel beds (invert) are subject to erosion and deposition before, during, and after high flows that can add a degree of uncertainty to the streamgage measurements on the Truckee River, especially during floods. Although this increases the uncertainty of measurements, it is felt that the streamgage records are of sufficient quality to derive results for this analysis. As is the case for the Truckee River above the Vista gage, it is large-sized, frontal storms originating in the Pacific Ocean and consisting of rain or rain-on-snow, that cause flooding on the mainstem of the Lower Truckee River.

2.2 Peak Flow Frequency

An attempt was made to perform a statistical analysis on regulated peak flows. The gages analyzed were the Truckee River at Vista, near Tracy, below Derby Dam, at Wadsworth, and near Nixon. Derby Dam is capable of diverting up to 1,000 cfs into the Truckee Canal. During large flood events, the dam is not supposed to divert water. To make the gage analysis homegenous, diverted flows (as recorded at the streamgage called Truckee Canal at Wadsworth) were added back to the downstream gages. Besides peak, the 1-, 3-, 7-, and 15-day regulated flow frequency curves were produced. The analysis was performed on 1) rain or rain-on-snow events only 2) water years 1973 and later

after the last upstream dam was built. Snowmelt events were removed. To make sure only rain induced events were included, the following procedure was followed: If the largest peak, 1-day, 3-day or longer duration value occurred in January or earlier, it was accepted as a rainflood event. All values occurring February or later were further scrutinized by graphing and visually inspecting the daily flow record. Snowmelt events often are identified by their shape (more gradual rate of change in the rising and falling limb). All flows occurring in a period identified as snowmelt were removed. An event that appeared to be induced by rain or rain-on-snow, that occurred in March or later, was further scrutinized to ensure that significant precipitation fell. The litmus test for "significant" is dependant on the size of the peak but in general would include at least 0.30 to 0.50 inches of rain per day.

Only one peak instantaneous value is given by the USGS per water year. The removal of snowmelt events caused there to be less peaks than other durations. To overcome this, the annual maximum data for all durations at all stations was input into a program called Regional Frequency (Regfreq). Attachment 1 displays the flow data used in Regfreq. This program computes raw statistics for each station and duration. In addition, it correlates the statistics of longer durations against shorter durations (like peak and 1-day). It also can correlate curves with those of other stations. The benefit of this approach is that the program will derive new statistics for a curve based on correlation with other curves that have more data. The resulting raw and adjusted statistics produced unreasonably high values for the more rare events like the 1% chance exceedence event. The output gave a 1% chance frequency event at Vista of 30,000 cfs that is considered unreasonable. The 1997 flood, which is believed to be the largest in a period of 130 years, was approximately 21,000 cfs at Vista. In addition, the 1% chance exceedence peak was determined to be 20,000 cfs in the 2003 F3 Report (Ref. 1). It may be that the effect of regulation from the upstream reservoirs (Martis Creek, Prosser, Boca, and Stampede Dams) may have too much effect on the lower end of the curve to properly perform a statistical analysis for rare events. An attempt to perform a statistical analysis on the upper end of the data values (50% chance exceedence or higher) in HEC-FFA did not improve the results significantly. A visual look at historic floods shows several things. See Table 2.

Table 2. Historic Peaks at Streamgages

Date of Flood	Truckee R. at Vista	Truckee R. nr. Tracy	Truckee R. blw Derby Dam	Truckee R. nr Wadsworth	Truckee R. nr Nixon
2–3 Jan 97	~21,000*	gage broke	19700	19100	21200
15 Nov 63	18900	no record	18400	no record	14400
18-19 Feb 86	16100	17500	16900	16800	16300
23-24 Dec 64	11700	no record	11400	no record	9950
14 Jan 80	9970	10200	8700	8820	8600
20 Dec 81	8550	8780	8270	8210	7420
13-14 Mar 83	8040	8150	8310	8000	7410

* Estimated value adopted by Corps. Value derived during calibration of hydraulic model to 1997 flood and by using older rating curve for highwater mark at old Vista gage site. USGS official value is 18,400 cfs.

Typically, the peak flow either attenuates or increases by a small percent as the flood wave moves downstream. The increase or decrease seems random from one event to the other. It should also be noticed that the largest floods of record for each gage come from the same storms. The conclusion is that the peak-inducing runoff originates from the Sierra Mountains and the tributaries upstream of Vista while the timing and volume of local flow seems to have a much less significant impact. The timing of the local runoff is apparently not coincident with the peak of the mainstem hydrograph as the historical record rarely shows a significant increase in peak from upstream to downstream. During the 1997 flood, an experienced hydraulic engineer from WRC Nevada, Inc. videotaped the flow coming out of Long Valley Creek at the same time the Truckee River peak was moving past the confluence of the two. The observer estimated that the flow in Long Valley Creek at the time was probably about 250 cfs, but no more than 500 cfs. The peak instantaneous flow recorded on Long Valley Creek that day by USGS was 1600 cfs. It is believed that the Long Valley peak reached the confluence prior to the mainstem peak. In the 1963 flood, Steamboat Creek (a tributary in the Truckee Meadows Reach above Vista) peaked about 12 hours prior to the Vista gage peak. Long Valley Creek is the only tributary below the Vista gage that has a gage record. There are only a limited number of years of record available. Table 3 displays the Long Valley Creek peak instantaneous flow record and, when available, Truckee River peaks that occurred on the same day.

Table 3. Long Valley Creek and Truckee River Peak Flow Records for Same Events

Date	Long Valley Crk Peak Instantaneous Flow (cfs)	Date	Truckee River at Vista Peak Instantaneous Flow (cfs)	Date	Truckee R. Nr. Tracy Peak Instantaneous Flow (cfs)
12/23/55	2500	-	Not available	-	No gage
03/16/67	1430		Not available	-	No gage
02/20/68	1	02/25/68	2180	-	No gage
01/25/69	2560	-	Not available	-	No gage
01/24/70	400	1/22/70	7630	-	No gage
06/26/71	20	06/27/71	3550		No gage
03/15/72	1	-	Not available		No gage
1973*	0	-	-	-	-
01/17/74	105	1/17/74	4000	1/17/74	3570
03/75*	180	-	-	-	-
08/01/76	17		Not available	-	Not available
1977*	2	-	-	-	-
03/78*	85	-	-	-	-
02/19/86	5400	2/18/86	16100	2/19/86	17500
03/10/95	2750	03/10/95	8800	03/10/95	8910
02/04/96	370	-	Not available	-	Not available
01/02/97	1600	1/02/97	20700	-	Gage broke
03/24/98	570	03/24/98	6090	03/24/98	6980
02/09/99	2	-	Not available	-	Not available
06/30/00	50		Not available	-	Not available

* Water years in which the USGS did not publish a specific day of occurrence for the recorded peak value on Long Valley Creek. The Long Valley gage is a crest stage recorder which means there is no continuous recording of flows.

An alternate method to determine peak flow frequency was adopted, based in part on the uncertainty of the statistical analysis and the timing of the local tributary runoff. The procedure was previously utilized in the analysis of the reach between the Truckee River at Reno and Vista gages (Ref. 2). A regression equation is derived between two gages. This involves plotting historical peaks from the same storm events for one gage on the x-axis the corresponding peak for the other gage on the y-axis. This method works well if the flow frequency at one of the gages has been determined. The peak flow frequency curve for Vista has already been in Ref. 2. The unknown values are the resulting peak flows at the other downstream gages when a hydrograph with an X percent chance exceedence occurs at the Vista gage. A regression equation based on historic trends can be used to predict the outcome. The beauty of analyzing recorded peak flows is that unknown factors like channel loss rates, snowpack melt, and the timing of local tributary

runoff are incorporated into the analysis automatically. The regression analyses were all performed using the Vista gage on the x-axis, to come up with a prediction equation for the corresponding peak at other gages. Adjustments for gages downstream of Derby Dam were made to account for diversions into the Truckee Canal. Only rainflood or rain-on-snow events were analyzed. Results are plotted on Charts 2 - 5. Included in the chart is the calculated regression equation. Flow frequency derived for each of the gages using the regression equations are shown in the table below. The flow data used in the regression equations is displayed in Attachment 2.

Table 4. Peak Flow Frequency for Streamgages below Vista Gage

Exceedence Frequency	Truckee R. at Vista*	Truckee R. nr. Tracy	Truckee R. blw Derby Dam	Truckee R. nr Wadsworth	Truckee R. nr Nixon
5%	10,000	10,500	9800	9800	9700
2%	14,500	15,300	14,200	14,100	14,300
1%	20,200	21,500	19,900	19,600	20,100
0.5%	29,300	31,400	28,900	28,200	29,400
0.2%	52,000	55,900	51,300	49,900	52,700

* Truckee River at Vista peak flow frequency curve was determined in 2003 F3 Report.

The correlation coefficient "R^2" for the regression equations exceeded 0.98 for all gages except Nixon (0.93). Two events, the December 1955 flood and the February 1963 flood, showed an unusually large drop in peak between the Vista and Nixon gages. The decreases were 20,800 to 14,000 cfs and 18,900 to 14,400 respectively. Dropping these two events out as low outliers brought the correlation to above 0.98. Since snowmelt events can effect the lower end of the frequency curve, a regression equation was not used for the **20%** and **10%** chance exceedence values. Instead, these values were derived by plotting annual recorded rainflood and snowmelt peak flows since 1974 (after the last reservoir was put in place) on probability paper. The derived values are shown in Table 5 below.

Table 5. Peak Flow Frequency for 20% and 10% Chance Exceedences

Exceedence Frequency	Truckee R. nr. Tracy	Truckee R. blw Derby Dam	Truckee R. nr Wadsworth	Truckee R. nr Nixon
20%	6800	6800	7000	6800
10%	8500	8200	8000	7800

Frequency curves for the Truckee River gages below Vista are displayed on Charts 6 through 9.

2.3 Local Tributary Hydrograph Development

A family of unregulated frequency curves was computed for the Truckee River at Vista, near Tracy, below Derby Dam, at Wadsworth, and near Nixon gages. These were derived so that they could be subtracted from each other to derive the coincident local flow runoff volume that occurs when two gages are experiencing an X% chance exceedence event. The unregulated curves were developed using rain and rain-on-snow events only, as this is the type of event that induces flooding on the lower Truckee River. Snowmelt events were removed from the data used to produce the curves. The results were inconclusive as the curves crossed each other. Smoothing of the skew and standard deviation was not enough to straighten the curves out so that there was increasing flow from upstream to downstream. A second attempt was made to compute curves from values that came from a data set limited to **all the same storms** for all gages. The resulting frequency curves are shown on Chart 10. The curves lay almost completely on top of each other and smoothing of statistics did not give meaningful results. It is believed that the comparatively small amount of local tributary runoff volume, gage measurement error, and channel losses all contribute to these findings.

An alternate method of deriving local flow tributary hydrographs is by using a rainfall runoff model (HEC-1). The watershed below Vista was split into numerous subasins as shown on Chart 11. Subasin delineation and subasin watershed parameters were derived using GEO-HMS software. Unit hydrographs were developed using the Los Angeles Unit Hydrograph Method. This methodology uses slope, length of the longest watercourse, length of centroidal flow path, and basin "n" to determine lag time for each subasin. Basin "n" is similar to an average Mannings channel N value for the entire watershed including overland sheet flow. The basin "n" value of 0.07 for all subasins was adopted from a rainfall runoff study of the lower Truckee performed in 1980 by the Corps of Engineers (Ref 3). A regional S-graph called the "Truckee Meadows Valley S-graph" derived in that study was used along with computed subasin lag to derive each individual unit-hydrograph. Long Valley is the largest tributary on the Truckee River below Vista. The Corps of Engineers conducted a rainfall runoff study in 1991 to evaluate the building of a dam in the watershed. Soil loss rates used in that study were 0.10 inches for the initial loss rate and 0.10 inches/hour for the constant loss rate. In that study, the 1% chance exceedence peak derived for a storm directly centered over that subasin was 10,000 cfs. For this study, the Corps adopted the constant loss rate from the 1991 study mentioned above; however, the initial loss rate of 0.10 inches was increased to 0.30 to reflect the fact that this study's goal is to model concurrent runoff, not a storm centered over a specific subasin. 0.30 inches of initial loss was used to model this area in 1980 (ref. 3). Chart 12 displays the HEC-1 routing diagram and Chart 13 shows normal annual precipitation for this area.

A 72-hour rainfall hyetograph pattern for the HEC-1 model was taken from the Reno Airport hourly raingage for the January-February 1963 flood event on the Truckee River. A minor amount of smoothing was made to the pattern. The rainfall pattern was balanced

to the 1% chance exceedence depths for the 6-, 12-, 18-, 24-, and 48-hour durations. The average point rainfall depths for the area between the Vista gage and Marble Bluff Dam for 6-, 24-, and 48-hour durations were computed from the latest revision of NOAA Atlas 14 (Precipitation Depth Duration Frequency for the Semi-Arid Southwest, National Weather Service, 2004). Average area precipitation was calculated from point precipitation using GIS software. The 12-hour depth was derived as a ratio of the 6-hour depth. The ratio was calculated from the average depth-duration change for the centroid locations of three subasins (Long Valley Creek, Gardella Canyon, and Little Valley). Since NOAA Atlas does not provide an 18-hour depth, it was calculated as the midpoint between the 12-hour and 24-hour depths.

The HEC-1 model only covers the area between the Vista gage and Marble Bluff Dam. The design precipitation for the model is the areally reduced rainfall that would occur on the **periphery** of a storm centered in the Truckee River watershed between Lake Tahoe and the Vista gage. The 1% chance exceedence hydrograph derived in the 2003 F3 Report will be input into the upper end of the HEC-1 model at Vista. Therefore, the goal was to derive the concurrent rainfall expected to happen in the 513 mi^2 area below Vista when a storm is centered in the 920 mi^2 above Vista.

The National Weather Service has not yet produced areal reduction factors for NOAA 14. Therefore, areal reduction factors were taken from Hydrometeorological Report No. 49, Probable Maximum Precipitation Estimates, Colorado River and Great Basin Drainages, National Weather Service and U.S. Army Corps of Engineers, 1977. More specifically, it is the areal reduction factors for a convergence type storm (minimal amount of orographic effects). The reasoning is that large general rainstorms in this area originate from the west. After passing over the Sierra Mountains, it drops down into the Great Basin. The storm compresses and warms as it moves downward. The warmer air can hold more water and precipitation decreases significantly as it moves east. The east side of the Sierra Mountains is a desert because of this effect.

Rainfall for the model was figured in the following manner: 1) The weighted average rainfall depth (per duration) for the entire watershed between Lake Tahoe and the Vista gage was reduced by an areal reduction factor for 921 mi^2. This is the average rainfall depth that would occur if a 1% chance exceedence storm were centered over this area. 2) Next, the average rainfall depth for the area between Lake Tahoe and Marble Bluff Dam was computed and reduced by a factor for 1433 mi^2. 3) The two depths from #1 and #2 were multiplied by their respective drainage areas to calculate two volumes. 4) The two volumes were subtracted from each other and then divided by 513 mi^2 (drainage area between Vista and Marble Bluff Dam). This final calculation yields the depth to apply to the rainfall pattern for a given duration. One design rainfall hyetograph was calculated for all subasins in the HEC-1 model. In other words, the rainfall applied to each subasin was the same.

Simple muskingum routing parameters were placed in the model to route flows to each major computation point. It should be noted that actual routings of individual tributary hydrographs, along with the mainstem Truckee River hydrograph, will be accomplished

in the hydraulic model (separate report). The HEC-1 model for the 1% chance exceedence concurrent event was run and tributary hydrographs computed. They are shown on Charts 14 and 15. Tabular values for the hydrographs are displayed on Charts 16 and 17.

2.4 Other Frequency Hydrographs

The HEC-1 model was initially developed using 1% chance exceedence event concurrent rainfall. To derive concurrent hydrographs for other frequency events, the rainfall hyetograph ordinates were multiplied by a ratio. Each ratio was calculated by dividing the 24-hour duration, 1% chance point rainfall divided by the 24-hour depth of another frequency for three sample locations (the centroids of Long Valley, Gardella Canyon, and Little Valley). An average was computed from the ratios of the three locations. The computed ratios are shown below.

Table 6. Ratio to Apply to Model Rainfall to Achieve Other Frequencies

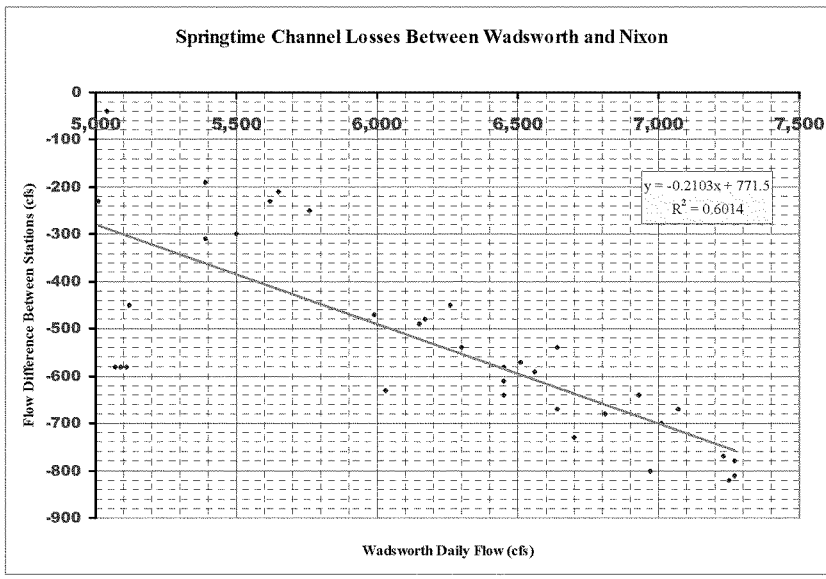
PERCENT CHANCE EXCEEDENCE EVENT	RATIO
20%	.54
10%	.64
5%	.74
2%	.89
1%	**1.0**
0.5%	1.12
0.2%	1.29

The initial and constant loss rates (0.30 and 0.10 inches respectively) were used for all model runs and frequencies since calibration data is not available to determine how they should be revised for frequencies other than the 1% chance event.

2.5 Channel Loss Rates

The flow frequency values listed in Table 4 show that the 1% peak flow does not steadily increase or decrease from upstream to downstream. This same fluctuation occurs during historic floods like the January 1997 flood event. It is believed that this fluctuation is partly due to soil losses in the channel bed material. An analysis of streamgage records during snowmelt events shows a trend toward a net loss of water (upstream to downstream) during the rising limb of an event and a net gain of water (upstream to downstream) during the falling limb of the event. This indicates that the soil in the banks is storing water as the stage increases (fills the channel) and releasing stored water as the stage drops. The HEC-RAS models for these reaches show very little attenuation of peak due to routing effects. Although a lengthy evaluation of channel loss rates is out of the scope of this study, an attempt was made to quantify them for four reaches between the gages. The reason for this effort is to justify the possible use of channel loss rates in the

HEC-RAS unsteady state model when analyzing hypothetical floods. The snowmelt period of April through June was analyzed for all available water years. This is considered the best period since it incurs relatively little rainfall yet has some significantly high flows. Only flows above 5,000 cfs were analyzed since values below this threshold were found to be equally divided between losses and gains (zero average loss). This may be partly due to the difficulty in measuring small flows in a wide channel accurately. The daily flow at the upstream gage was subtracted from the daily flow recorded at the downstream gage. The differences were plotted against the daily flow at the upstream gage. One such plot for the reach between Wadsworth and Nixon is shown below.



A regression equation was derived from these plots to predict channel loss rates. Since recorded snowmelt flows greater than 8,000 cfs are not available, loss rates above this threshold are not known. As a result, the regression equation was extrapolated out to 10,000 cfs and then held constant for any larger flows. It is believed that the sand and gravel alluvium layers found in the channel bed are highly permeable and easily transmit flow. As the water rises above normal baseflow, loss rates are high; however, as water leaves the channel into the overbank, a much less permeable layer of soil on the land surface will not support high infiltration. This was found to be the case at Mustang Ranch, located on the reach between the Vista and Tracy streamgages, where a Geotechnical analysis was performed by the Corps of Engineers. Estimated loss rates are shown below.

Table 7. Channel Loss Rates

REACH	Loss Rate (cfs) for Given Channel Flow (cfs)			
	5,000 cfs	10,000 cfs	25,000 cfs	50,000 cfs
Vista Gage to Tracy Gage	0	500	500	500
Tracy Gage to Blw Derby Dam Gage	0	500	500	500
Blw Derby Dam Gage to Wadsworth Gage	0	500	500	500
Wadsworth Gage to Nixon Gage	0	1300	1300	1300

3.0 Strategy for Hydraulic Modeling

If possible, channel loss rates will be incorporated into the hydraulic model. The mainstem Truckee River hydrograph, along with the tributary hydrographs computed in this study, will be input into the hydraulic model using an initial timing based on the 1963 flood event. The hydraulic model will then route the hydrographs downstream and compute peak flows at each streamgage location. If the computed peak does not match the **target peak** given in Table 3, adjustments will be made to the timing of the tributary runoff until the proper peak flow is achieved. In some cases, channel loss rates may have to be used to achieve the target peak flow. Peak flow at locations between or beyond the streamgages (such as Marble Bluff Dam) will be determined in the hydraulic model as it routes and combines hydrographs.

4.0 Conclusions

Historic streamgage records indicate the biggest factor driving peak flow on the Truckee River below Vista is the hydrograph that originates upstream of Vista. The impact of local runoff (due to its timing and relatively smaller volume) is less significant. The impact of local runoff also seems random from one storm to another. Sometimes the peak flow at a downstream gage will be higher than that recorded at Vista, and other times lower. An increase is usually not much more than two thousand cfs. At the confluence of Long Valley Creek and the Truckee River, the preliminary version of the unsteady HEC-RAS model indicates that an additional flow of 2,000 cfs above the 1% chance exceedence peak equates to about 4 – 6 inches of stage. This difference is within the range of accuracy of the hydraulic model to predict stage. Variables such as tributary snowpack conditions, the timing and amount of local rainfall, attenuation, and channel loss rate all effect the peak recorded at each gage. To account for the uncertainty of such factors, regression equations were developed from historical data to predict downstream gage peak flow when the Vista gage incurs an X percent chance exceedence flow. The resulting regression equations showed high correlation coefficients (above 0.98) in most cases. Perfect correlation has a coefficient of 1.0. These equations were used to derive

the 5% through 0.2% chance exceedence peak flows at each gage. The v-shape of the Truckee Canyon and its relatively small amount of overbank storage makes prediction of rare floods like the 0.2% chance exceedence peak using a regression equation feasible. The results of the regression analyses, shown in Table 4, will be used for future hydraulic analyses of floodplains. They represent the target peak flow to achieve in the hydraulic model. To meet the target, the timing of the local tributary hydrographs (and possibly channel loss rates) will be adjusted as needed.

To create local flow hydrographs for the unsteady state floodplain analysis, a rainfall-runoff model was created and model parameters borrowed from previous hydrology studies of the area. The design rainfall was derived as concurrent rainfall located on the periphery of a storm centered above the Vista gage. This significantly reduces the point rainfall that was derived from NOAA Atlas 14. The local runoff is significantly smaller in volume than the mainstem hydrograph that originates above Vista.

The hydrology presented in this appendix is for existing conditions on the lower Truckee River below Vista. It is suitable for a Feasibility Level analysis of existing conditions and for future analysis of proposed flood damage alternatives.

5.0 References

1. Truckee Meadows, Nevada, General Re-Evaluation Report Phase, F3 Milestone Conference, July 1999, U.S. Army Corps of Engineers, Sacramento District.

3. Truckee Meadows, Nevada, Addendum to General Re-Evaluation Report Phase, F3 Milestone Conference, Revised Hydrology, January 2003, U.S. Army Corps of Engineers, Sacramento District.

3. Truckee River, California and Nevada, Hydrology, February 1980, U.S. Army Corps of Engineers, Sacramento District.

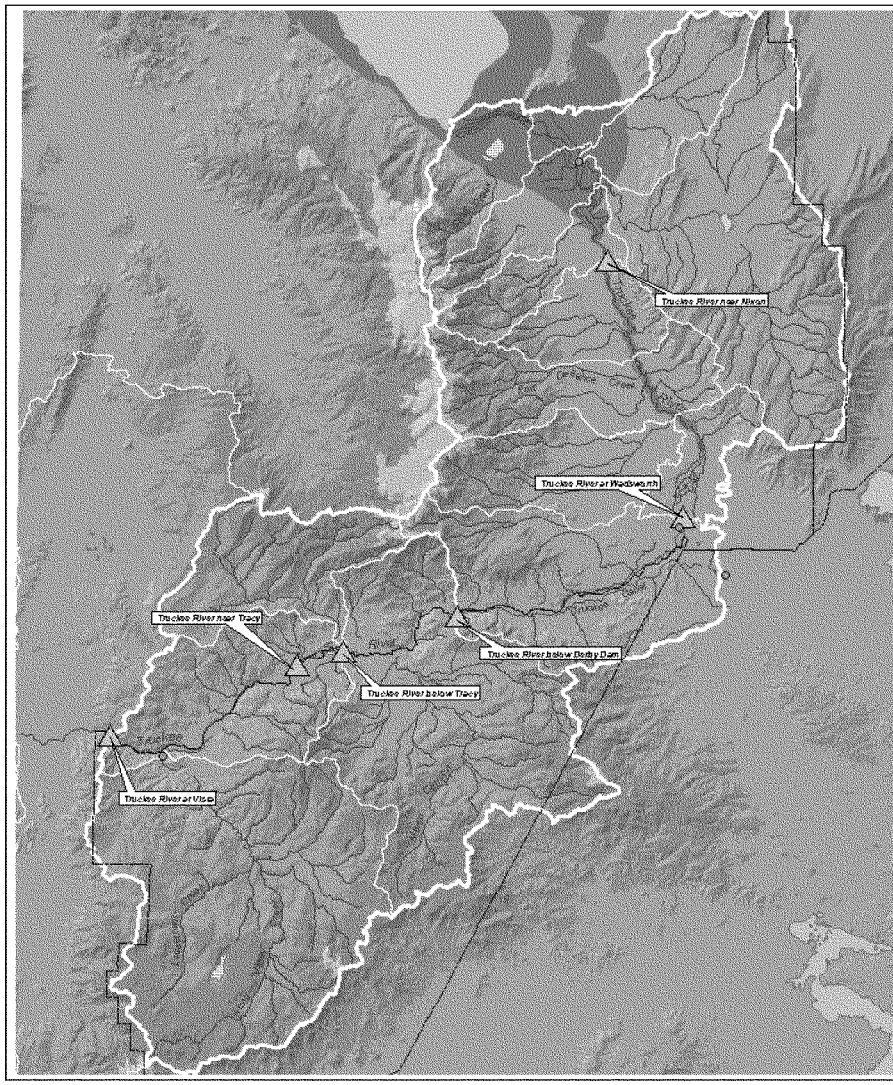

Truckee River near Alpine
Truckee River at Wadsworth
Truckee River near Tracy
Truckee River below Derby Dam
Truckee River below Tracy
Truckee River at Vista

Chart 1

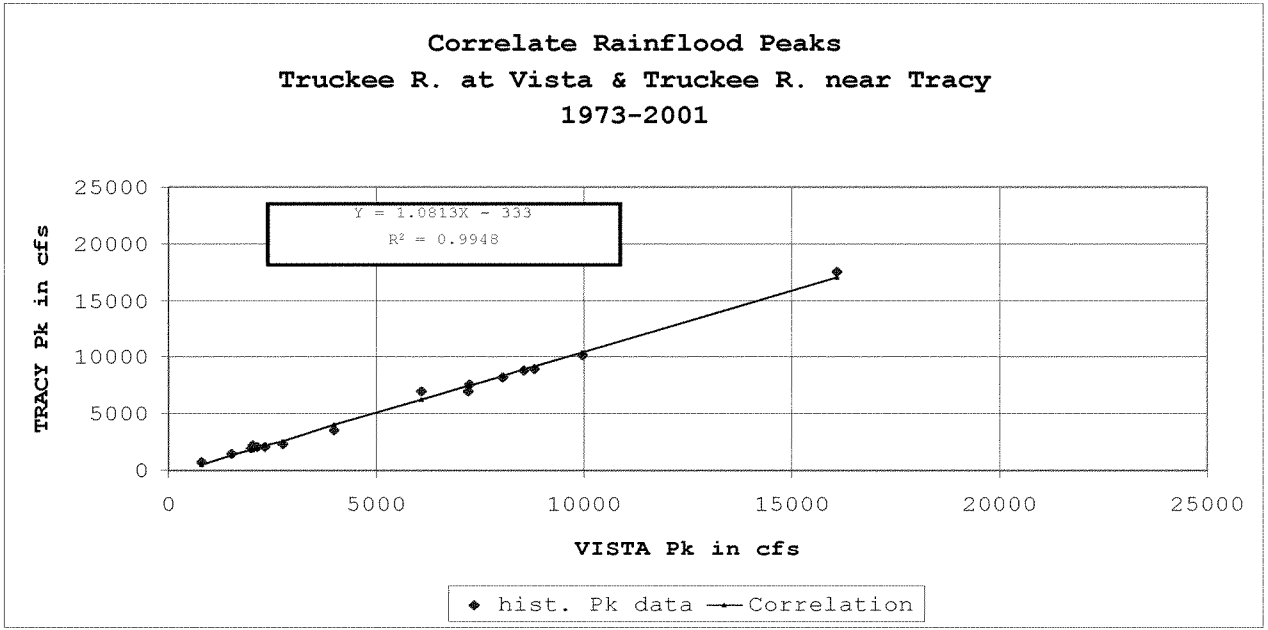

Correlate Rainflood Peaks
Truckee R. at Vista & Truckee R. near Tracy
1973-2001
Y = 1.0813X - 333
R² = 0.9948
TRACY Pk in cfs
25000
20000
15000
10000
5000
0
0
5000
10000
15000
20000
25000
VISTA Pk in cfs
hist. Pk data
Correlation

Chart 2

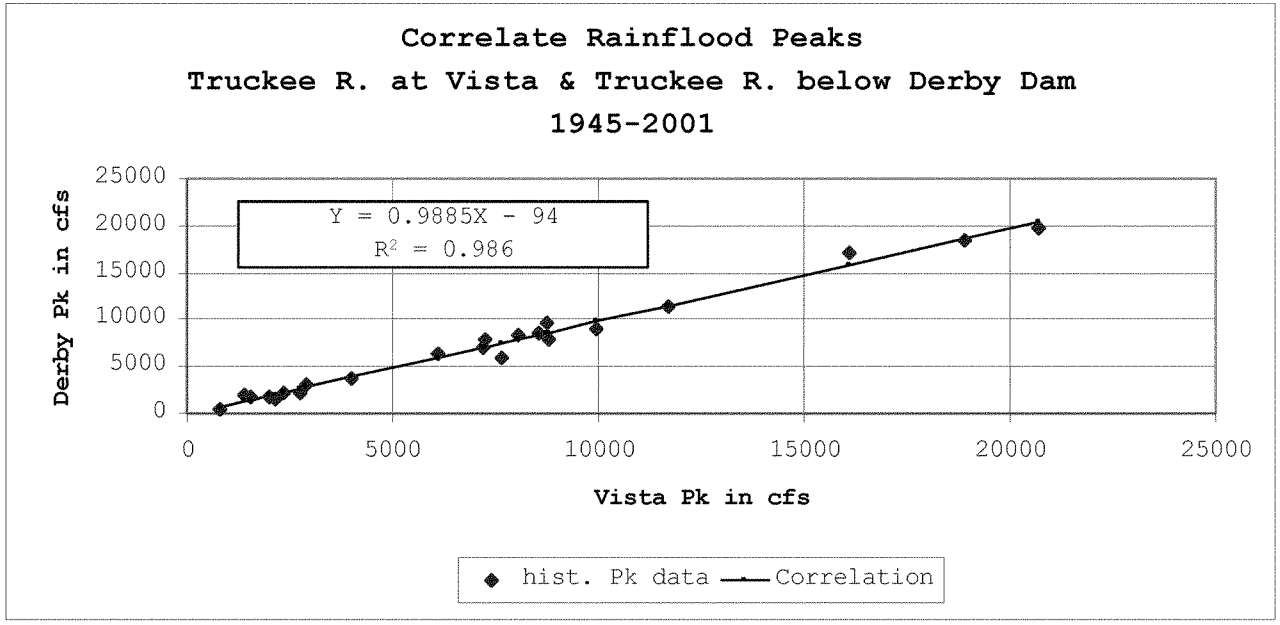

Correlate Rainflood Peaks
Truckee R. at Vista & Truckee R. below Derby Dam
1945-2001
Y = 0.9885X - 94
R2 = 0.986
Derby Pk in cfs
25000
20000
15000
10000
5000
0
0
5000
10000
15000
20000
25000
Vista Pk in cfs
hist. Pk data
Correlation

Chart 3

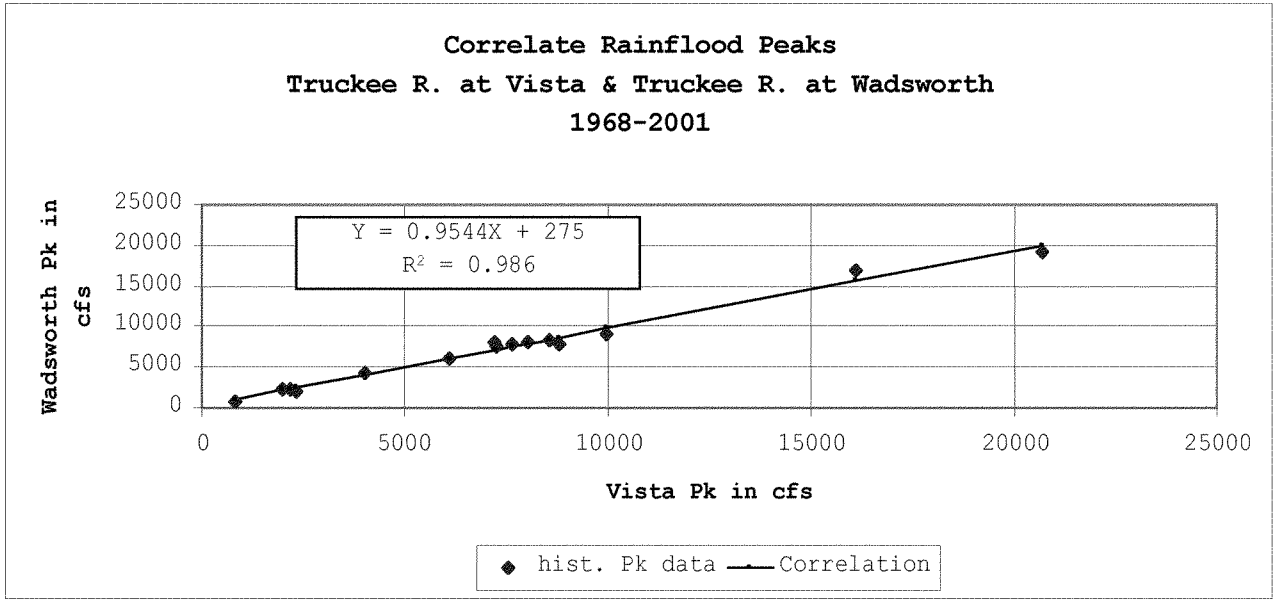

Correlate Rainflood Peaks
Truckee R. at Vista & Truckee R. at Wadsworth
1968-2001
Wadsworth Pk in cfs
25000
20000
15000
10000
5000
0
Y = 0.9544X + 275
R² = 0.986
0
5000
10000
15000
20000
25000
Vista Pk in cfs
hist. Pk data
Correlation

Chart 4

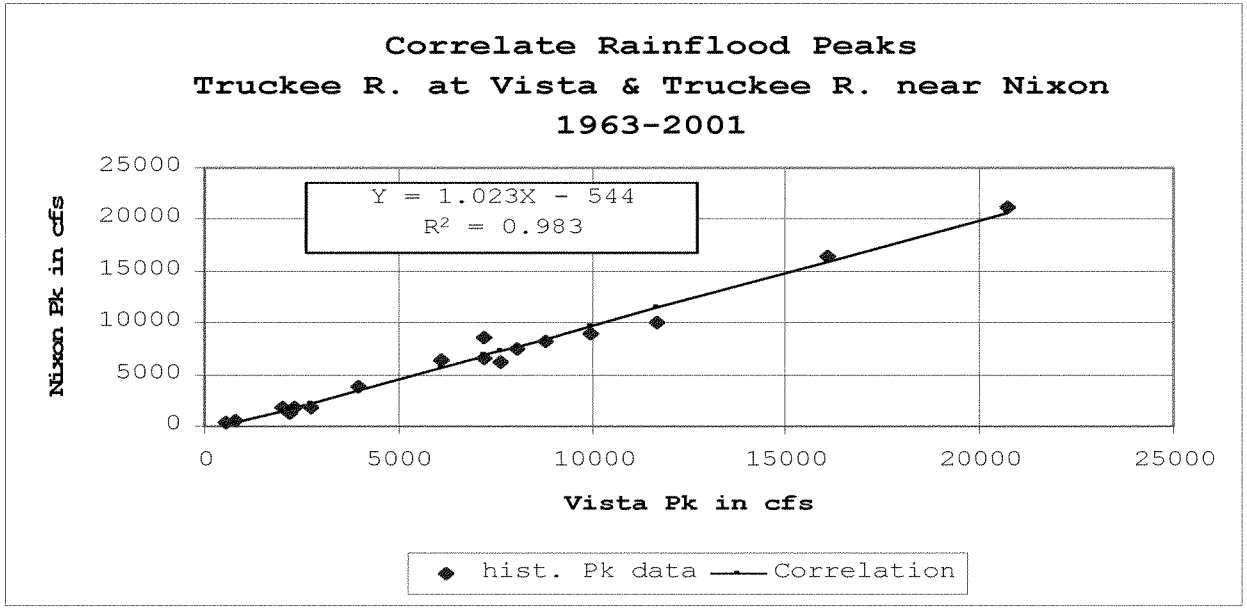
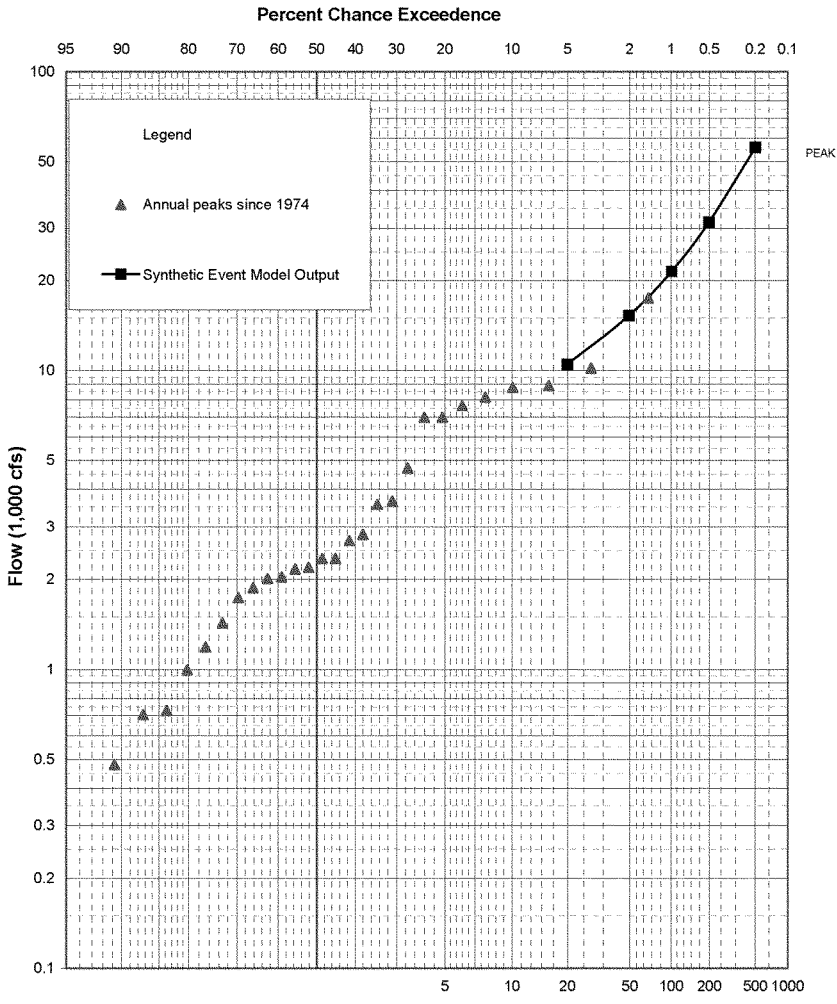

Correlate Rainflood Peaks
Truckee R. at Vista & Truckee R. near Nixon
1963-2001
Y = 1.023X - 544
R² = 0.983
Nixon Pk in cfs
25000
20000
15000
10000
5000
0
0
5000
10000
15000
20000
25000
Vista Pk in cfs
hist. Pk data
Correlation

Chart 5



Notes: Computed Probability

1. Drawn curve represents "rainflood frequency curve" derived by regression analysis.

2. Triangular points are annual peaks since 1974 (rainflood and snowmelt).

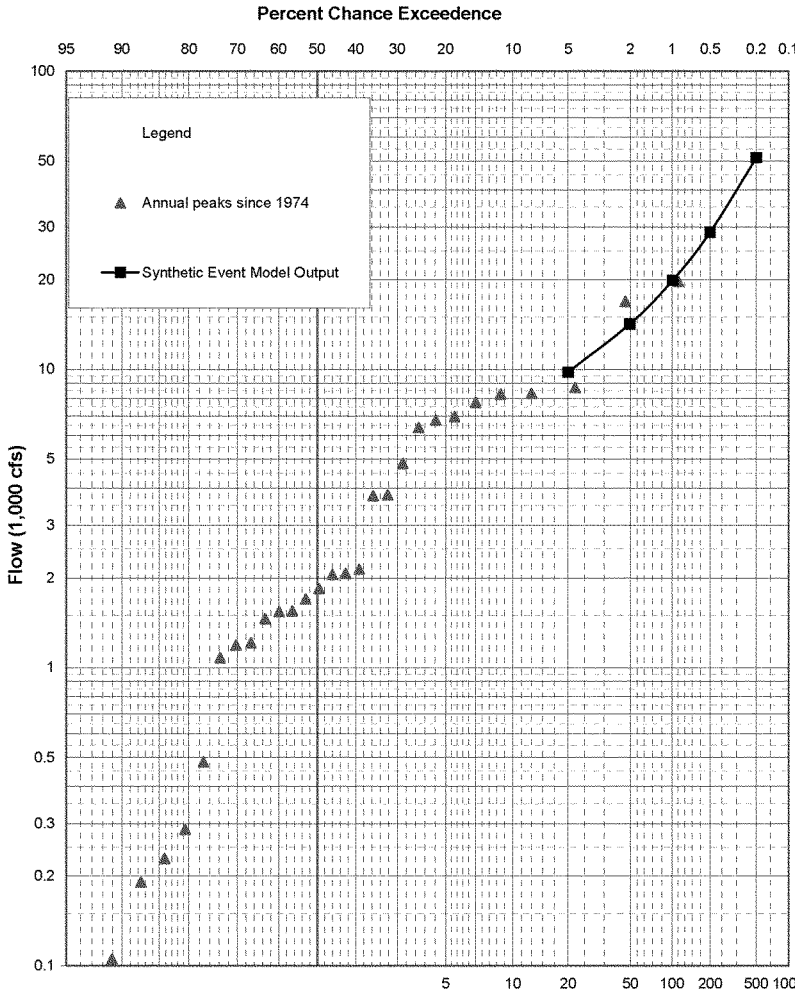
3. D.A. is 1580 square miles

TRUCKEE MEADOWS GRR STUDY
JUNE 2004

TRUCKEE RIVER AT TRACY
EXISTING CONDITIONS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Chart 6



Notes: Computed Probability

1. Drawn curve represents "rainflood frequency curve" derived by regression equations.

2. Triangular points are annual peaks (1974 to present) including rainflood and snowmelt events.

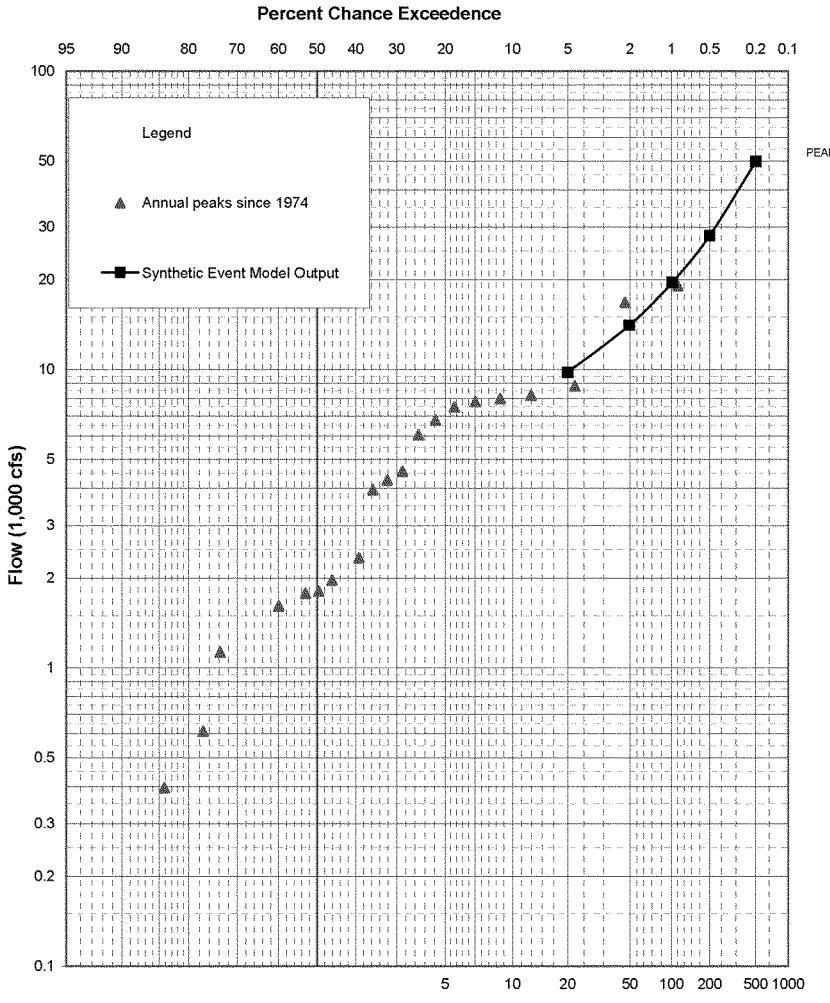
3. D.A. is 1676 square miles.

TRUCKEE MEADOWS GRR STUDY
JUNE 2004

TRUCKEE RIVER BELOW DERBY DAM
EXISTING CONDITIONS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Chart 7



Notes: Computed Probability

1. Drawn curve represents "rainflood frequency curve" derived by regression equations.

2. Triangular points are annual peaks 1974 to present (rainflood and snowmelt).

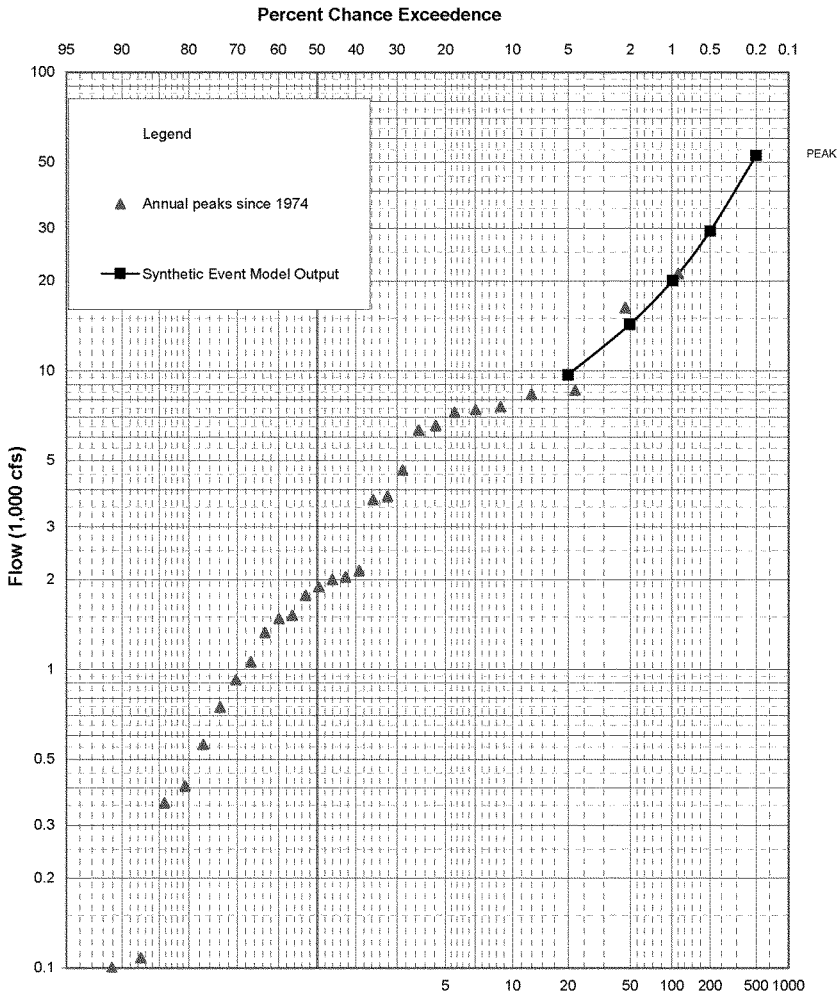
3. D.A. is 1728 mi2

TRUCKEE MEADOWS GRR STUDY
JUNE 2004

TRUCKEE RIVER AT WADSWORTH
EXISTING CONDITIONS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Chart 8



Notes: Computed Probability

1. Drawn curve represents "rainflood frequency curve" derived by regression equations.

2. Triangular points are annual peaks 1974 to present (rainflood and snowmelt events).

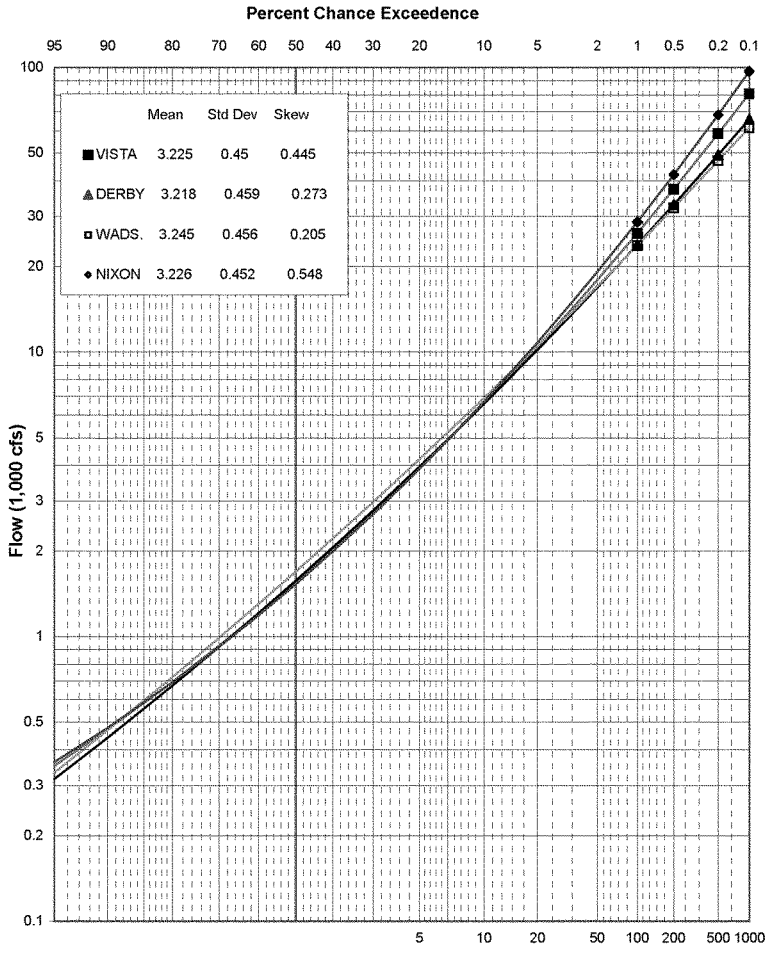
3. D.A. is 1827 mi2

TRUCKEE MEADOWS GRR STUDY
JUNE 2004

TRUCKEE RIVER AT NIXON
EXISTING CONDITIONS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Chart 9



Notes:

Computed Probability

At Vista Gage, D.A. = 1431 mi2

Below Tracy Gage, D.A. = 1580 mi2

Below Derby Dam Gage, D.A. = 1676 mi2

At Wadsworth Gage, D.A. = 1728 mi2

Near Nixon Gage, D.A. = 1827 mi2

Water Years 1968 - 1986, 1994 - 2002

TRUCKEE MEADOWS GRR STUDY
JUNE 2004

TRUCKEE RIVER BELOW VISTA GAGES
UNREGULATED RAINFLOOD FREQUENCY
5-DAY DURATION

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Chart 10

TRUCKEE MEADOWS GRR, 2004
TRUCKEE RIVER, NEVADA
SUBBASIN MAP
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT
CHART 11
Jun 2004
Prepared by J.&M.
MAP LEGEND
Study Watershed
Subbasin Boundary
Lake or Reservoir
Intermittent Lake
Dry Lake
River or Stream
County Boundary
City or Town
Stream Gage
CALIFORNIA
NEVADA
Truckee
Reno
Carson City
Sacramento
MAP SCALE
5 0 5 Miles
Lahontan Reservoir
N
Above Nixon City (T20)
Pyramid Lake
Big Mouth_Marble Bluff (T40)
Marble Bluff Dam
Davis Lake
Nixon
Lower Truckee Out (T50)
Big Mouth Canyon (T30)
Secret Canyon (T00)
Little Valley (T10)
WASHOE CO
CHURCHILL CO
Truckee River near Nixon
Truckee
Defiance_Nixon (S0)
Fort Defiance Creek
Defiance Canyon (B0)
River
Garbella Canyon (T0)
Truckee River at Wadsworth
Wadsworth
Wadsworth_Garbella (S0)
Fernley
Fernley Sink Lake
Pahrkah (S0)
Derby Dam_Wadsworth (S0)
Derby Dam
River
Truckee River near Tracy
Truckee River below Derby Dam
Truckee River below Tracy
Vista_Tracy (Z0)
Tracy_Derby Dam (A0)
Truckee
Clarkwood
Truckee River at Vista
Long Valley (T0)
Long Valley Creek
Little Valley Creek
Little Valley
Lagomarsino Canyon
Creek
Hunter Canyon
STOREY CO
WASHOE CO
STOREY CO
LYON CO

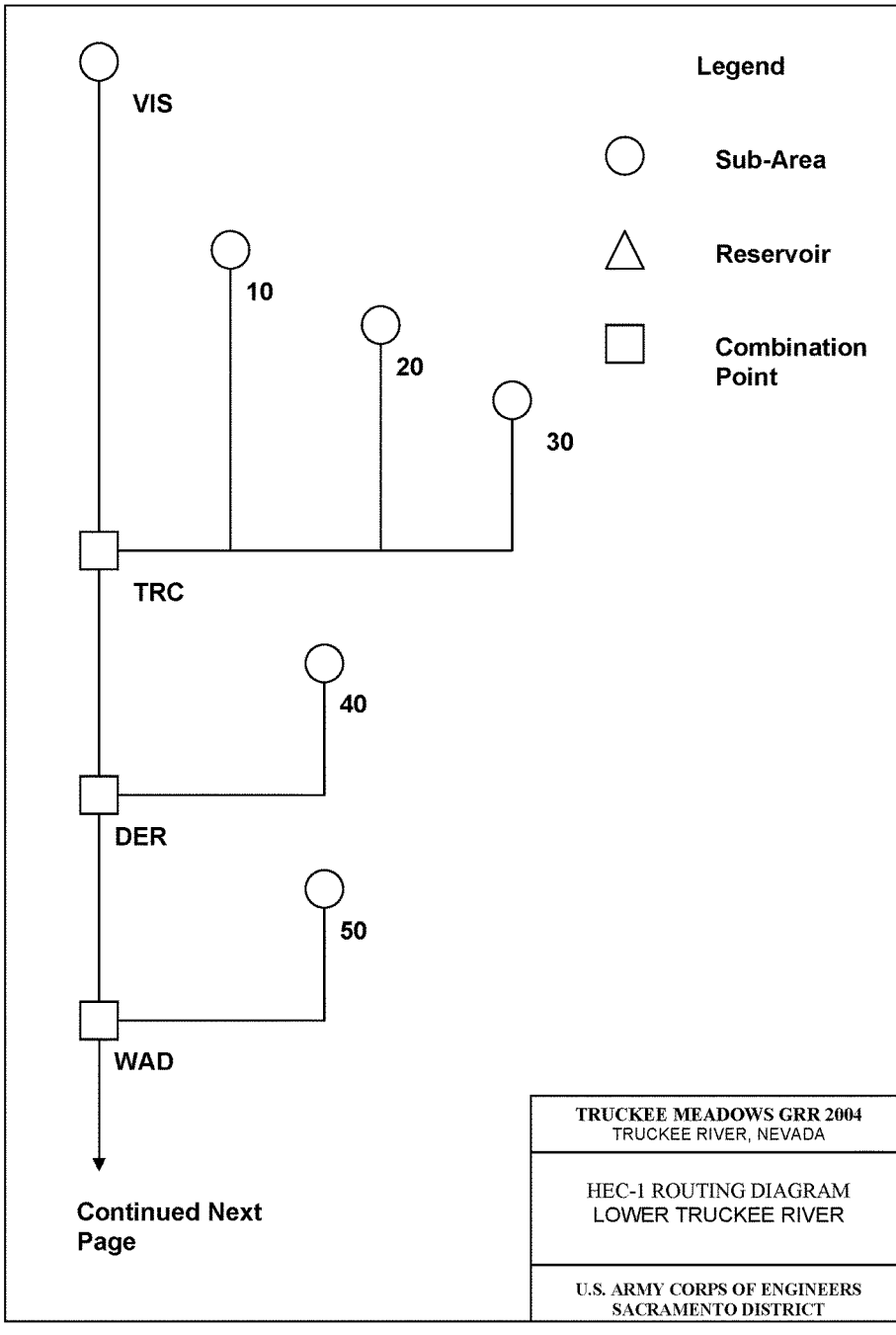

VIS
10
20
30
TRC
40
DER
50
WAD
Continued Next Page
Legend
Sub-Area
Reservoir
Combination Point
TRUCKEE MEADOWS GRR 2004
TRUCKEE RIVER, NEVADA
HEC-1 ROUTING DIAGRAM
LOWER TRUCKEE RIVER
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Chart 12A

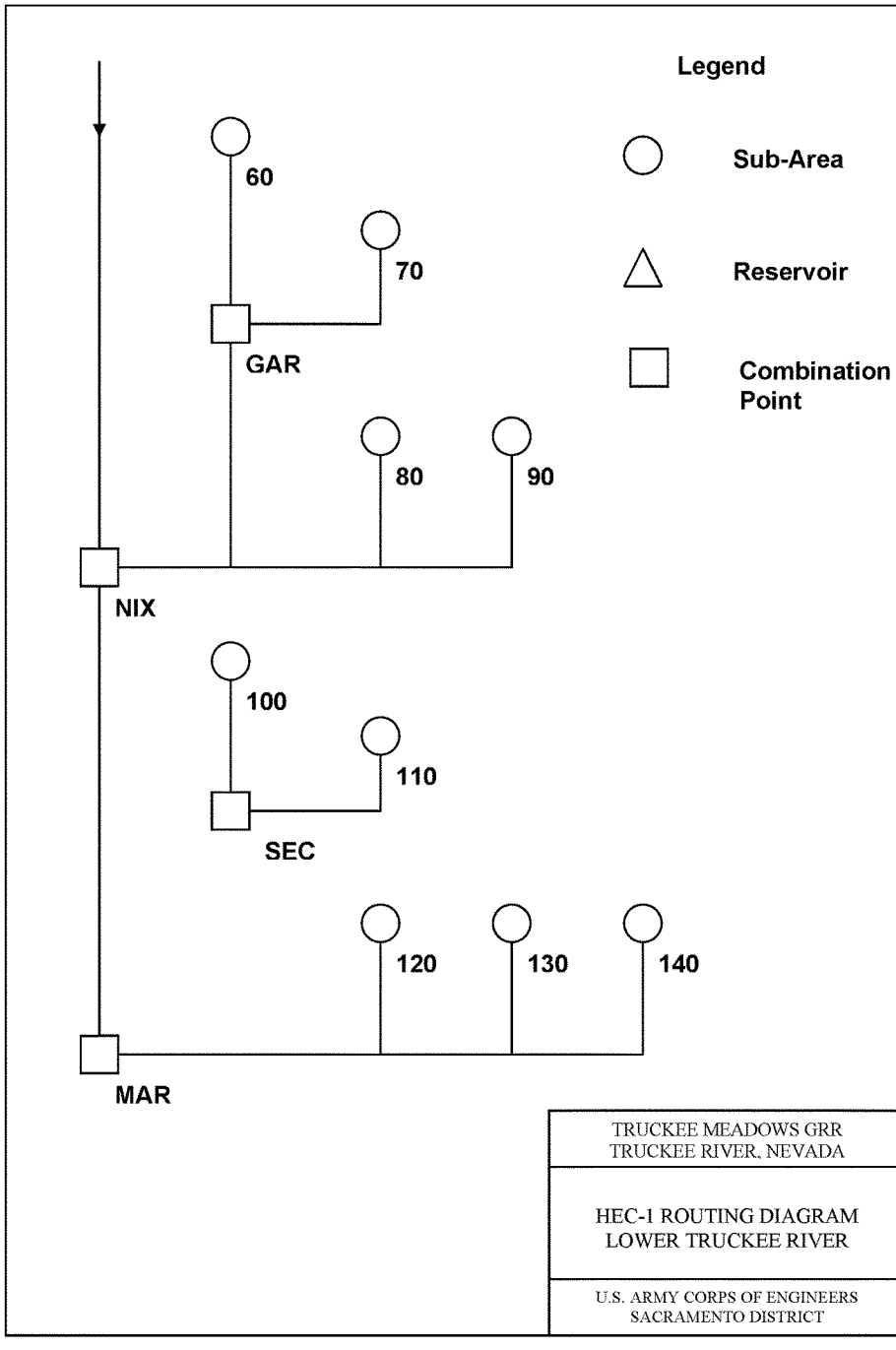
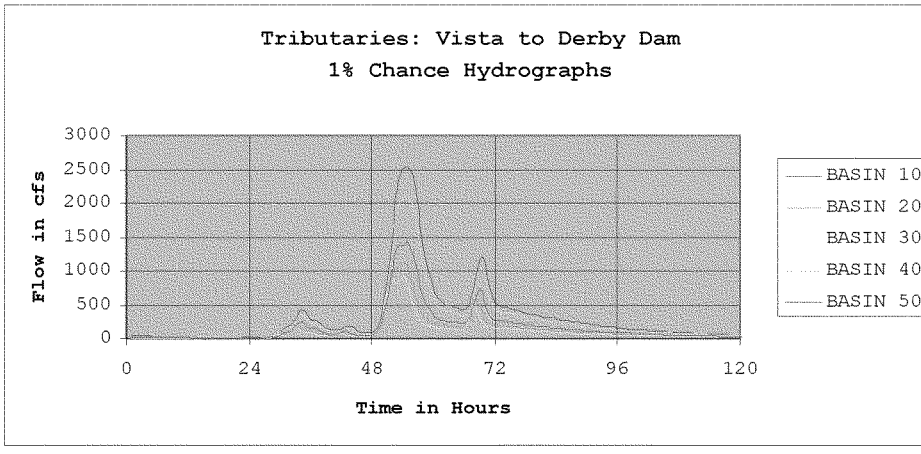
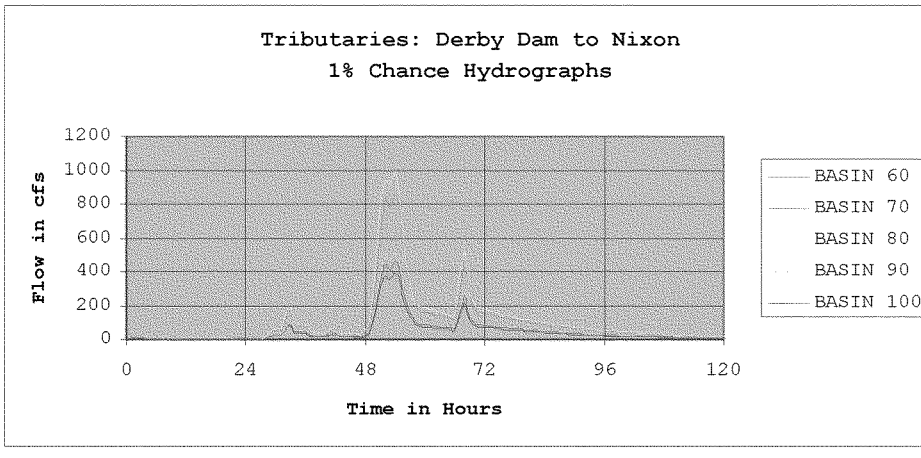

Legend
Sub-Area
Reservoir
Combination Point
60
70
GAR
80
90
NIX
100
110
SEC
120
130
140
MAR
TRUCKEE MEADOWS GRR
TRUCKEE RIVER, NEVADA
HEC-1 ROUTING DIAGRAM
LOWER TRUCKEE RIVER
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Chart 12B


Tributaries: Vista to Derby Dam
1% Chance Hydrographs
Flow in cfs
3000
2500
2000
1500
1000
500
0
0
24
48
72
96
120
Time in Hours
BASIN 10
BASIN 20
BASIN 30
BASIN 40
BASIN 50


Tributaries: Derby Dam to Nixon
1% Chance Hydrographs
Flow in cfs
1200
1000
800
600
400
200
0
0
24
48
72
96
120
Time in Hours
BASIN 60
BASIN 70
BASIN 80
BASIN 90
BASIN 100

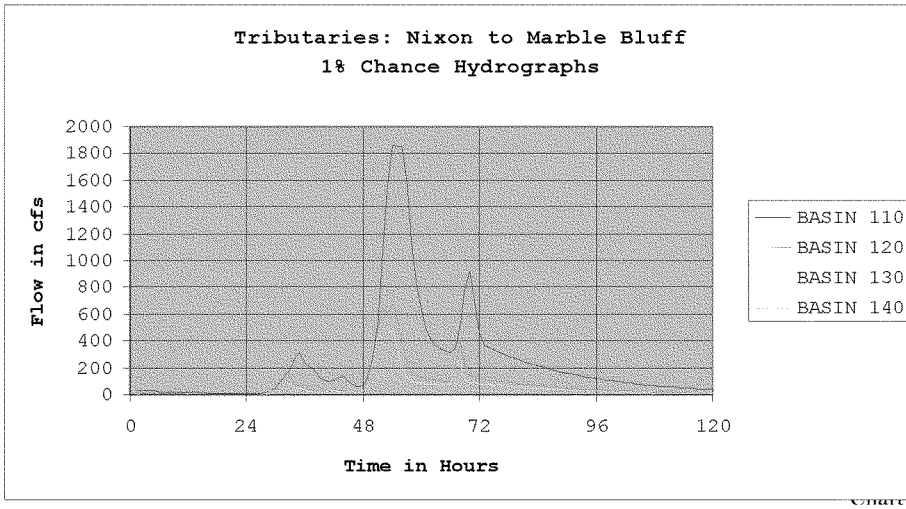


Chart 14

Chart 15

CHART 16
Coincident Flow Hydrographs from Tributaries (Derived in HEC-1)
When Truckee River Has a 1% Chance Exceedence Event
Subasins 10 through 80

	Subasin	Subasin	Subasin	Subasin	Subasin	Subasin	Subasin	Subasin
Time (hrs)	10	20	30	40	50	60	70	80
1	39	15	11	32	20	5	14	12
2	37	14	10	31	19	5	13	11
3	35	14	10	29	18	5	13	11
4	34	13	10	28	17	4	12	10
5	32	12	9	26	17	4	12	10
6	31	12	9	25	16	4	11	9
7	29	11	8	24	15	4	10	9
8	28	11	8	23	14	4	10	9
9	26	10	7	22	14	3	9	8
10	25	10	7	21	13	3	9	8
11	24	9	7	20	12	3	9	7
12	23	9	6	19	12	3	8	7
13	22	8	6	18	11	3	8	7
14	21	8	6	17	11	3	7	6
15	20	8	6	16	10	3	7	6
16	19	7	5	15	10	2	7	6
17	18	7	5	15	9	2	6	6
18	17	7	5	14	9	2	6	5
19	16	6	5	13	8	2	6	5
20	15	6	4	13	8	2	6	5
21	15	6	4	12	8	2	5	5
22	14	5	4	12	7	2	5	4
23	13	5	4	11	7	2	5	4
24	13	5	4	10	7	2	5	4
25	12	5	3	10	6	2	4	4
26	12	4	3	9	6	1	4	4
27	11	4	3	9	6	1	4	3
28	21	12	11	18	12	5	11	14
29	39	32	34	35	26	18	35	52
30	74	66	59	68	54	25	57	61
31	157	74	55	138	98	23	52	60
32	208	112	113	173	116	59	113	164
33	270	207	183	238	180	77	172	187
34	413	165	105	360	252	39	96	96
35	400	114	87	318	188	38	83	100

Chart 16A

CHART 16 Continued -								
	Subasin	Subasin	Subasin	Subasin	Subasin	Subasin	Subasin	Subasin
Time (hrs)	10	20	30	40	50	60	70	80
36	297	120	94	239	151	38	88	93
37	272	89	57	227	146	21	52	51
38	228	57	38	180	104	15	35	37
39	160	41	35	124	72	15	33	35
40	126	40	33	102	62	14	31	34
41	124	54	49	102	65	24	48	65
42	143	84	71	121	85	30	67	72
43	182	66	42	155	105	15	38	37
44	167	41	35	132	76	15	33	36
45	116	39	34	91	52	14	32	34
46	86	38	32	71	48	13	30	32
47	81	36	31	68	46	13	29	31
48	88	43	41	73	48	20	40	56
49	165	113	102	144	104	46	97	118
50	411	273	269	360	262	136	265	382
51	799	648	643	707	537	311	626	832
52	1497	1025	876	1335	1009	377	824	945
53	2262	1048	821	1944	1349	354	772	916
54	2501	1108	910	2076	1367	393	857	999
55	2532	1066	805	2121	1412	326	743	802
56	2436	796	541	2004	1265	206	491	496
57	1968	514	332	1566	926	125	300	300
58	1387	345	229	1089	626	86	207	209
59	979	256	180	778	452	76	169	192
60	751	217	172	595	346	73	161	183
61	595	207	164	472	281	69	153	174
62	502	197	156	416	268	66	146	166
63	479	188	148	396	255	63	139	158
64	456	179	141	377	243	60	132	150
65	434	170	135	359	232	57	126	143
66	413	162	128	342	221	54	120	136
67	481	289	294	406	281	151	291	423
68	755	579	512	669	506	217	480	528
69	1188	487	311	1032	724	113	279	267
70	1165	283	181	926	544	77	170	195
71	791	217	173	616	349	74	162	186
72	543	207	164	431	278	70	154	177

Chart 16B

CHART 17
Coincident Flow Hydrographs from Tributaries (Derived in HEC-1)
When Truckee River Has a 1% Chance Exceedence Event
Subasins 90 through 150

	Subasin	Subasin	Subasin	Subasin	Subasin	Subasin	Subasin
Time (hrs)	90	100	110	120	130	140	150
1	6	5	30	8	5	2	6
2	6	5	29	8	5	2	6
3	5	5	27	7	5	2	5
4	5	4	26	7	4	2	5
5	5	4	25	7	4	2	5
6	5	4	24	6	4	2	5
7	4	4	22	6	4	1	4
8	4	4	21	6	4	1	4
9	4	3	20	5	3	1	4
10	4	3	19	5	3	1	4
11	4	3	18	5	3	1	4
12	4	3	18	5	3	1	4
13	3	3	17	4	3	1	3
14	3	3	16	4	3	1	3
15	3	3	15	4	3	1	3
16	3	2	14	4	2	1	3
17	3	2	14	4	2	1	3
18	3	2	13	3	2	1	3
19	2	2	13	3	2	1	2
20	2	2	12	3	2	1	2
21	2	2	11	3	2	1	2
22	2	2	11	3	2	1	2
23	2	2	10	3	2	1	2
24	2	2	10	3	2	1	2
25	2	2	9	2	2	1	2
26	2	1	9	2	1	1	2
27	2	1	8	2	1	1	2
28	6	6	15	8	8	3	9
29	23	21	26	27	31	11	34
30	34	30	50	44	25	8	32
31	30	27	102	40	31	10	36
32	74	66	151	87	97	33	106
33	103	91	189	135	77	25	99
34	53	46	272	76	42	13	51
35	50	44	317	65	51	17	59

Chart 17A

CHART 17 Continued -								
	Subasin	Subasin	Subasin	Subasin	Subasin	Subasin	Subasin	
Time (hrs)	90	100	110	120	130	140	150	
36	51	45	235	69	39	12	49	
37	28	25	206	41	22	7	27	
38	20	18	184	27	19	6	21	
39	19	17	132	26	18	6	20	
40	19	16	104	25	17	6	19	
41	30	27	94	37	37	12	41	
42	40	35	106	53	29	9	38	
43	21	18	126	30	19	6	21	
44	20	17	134	26	18	6	20	
45	19	17	95	25	17	6	19	
46	18	16	72	24	16	6	18	
47	17	15	64	23	16	5	17	
48	26	23	66	31	32	11	36	
49	60	53	118	76	59	20	69	
50	172	155	272	206	227	78	247	
51	400	358	539	490	447	150	509	
52	497	442	982	651	434	141	528	
53	464	413	1545	610	459	152	535	
54	517	460	1860	677	476	155	569	
55	434	385	1858	590	353	113	437	
56	277	245	1850	392	207	65	262	
57	168	148	1569	240	126	40	159	
58	116	103	1154	165	94	31	114	
59	101	89	815	134	90	29	108	
60	96	85	617	127	86	28	103	
61	91	81	490	121	81	27	98	
62	87	77	399	115	78	25	93	
63	83	74	362	110	74	24	89	
64	79	70	345	105	70	23	85	
65	75	67	328	100	67	22	81	
66	72	64	313	95	64	21	77	
67	191	171	348	227	250	85	273	
68	288	256	528	379	225	72	284	
69	153	134	784	223	109	34	138	
70	102	91	921	135	92	30	110	
71	97	86	655	128	87	28	105	
72	93	82	461	122	83	27	100	

Chart 17B

Attachment 1

Note: Tables listed in Attachment 1 display regulated flow data input into the Regional Frequency Program (RegFreq) to obtain regulated flow frequency statistics on the lower Truckee River. An attempt was made to take out the impact of the diverted flow at Derby Dam into the Truckee Canal. The reason for this was two-fold: 1) During large floods, the operators of Derby Dam are not supposed to divert water into the Truckee Canal, although it sometimes happens by accident. Obtaining statistics that reflect this conservative condition is desirable for the rare frequencies 2) The diversion can have drastic impacts on downstream gages during low flow periods; therefore, it was hoped that removing the impact of the diversion would result in a more natural flow regime that would produce better statistics for the upper end of the curve. Removal of the impact of Derby Dam was accomplished by adding the daily Truckee Canal flows back to the gages downstream of the diversion. Where appropriate, the flow was lagged to compensate for travel time. To adjust peak instantaneous flows, a regression equation was used to estimate the "without diversion" peak. The results of the Regfreq analysis were not used in this study, although the data analyzed is provided for reference.

Table 1: Truckee R. at Vista Flow Input to Regfreq Program

Gage Name	Water Year	Peak	1-Day	3-Day	7-Day	15-Day
Truckee R. at Vista	1973	2330	1320	1223	1090	872
	1974	4000	3520	3207	2616	1923
	1975	missing	1550	1079	880	754
	1976	1530	1160	949	882	785
	1977	806	682	596	564	553
	1978	missing	844	735	581	533
	1979	missing	1200	1015	796	580
	1980	9970	6880	5787	4109	2448
	1981	missing	876	739	672	592
	1982	8550	7990	5280	3846	2825
	1983	8040	6280	5000	4669	4111
	1984	7230	5350	5123	4991	4514
	1985	missing	1370	1005	795	710
	1986	16100	15200	13030	9753	7837
	1987	missing	888	717	605	595
	1988	missing	474	442	428	423
	1989	2140	1630	1557	1257	944
	1990	missing	599	503	522	458
	1991	2740	1330	897	575	441
	1992	566	486	447	372	333
	1993	missing	1940	1763	1664	1495
	1994	missing	373	272	207	194
	1995	8800	5300	4547	3189	2423
	1996	7200	6810	6240	5637	4653
	1997	21300	16100	13363	10631	8990
	1998	6090	4950	3890	3340	2495
	1999	missing	3610	3353	2969	2827
	2000	1990	1470	1202	945	752
	2001	missing	506	495	473	462
	2002	missing	760	596	547	501

Table 2: Truckee River Near Tracy Flow Input to Regfreq Program

Gage Name	Water Year	Peak	1-Day	3-Day	7-Day	15-Day
Truckee R. Blw Tracy	1973	2100	1380	1173	1076	842
	1974	3570	3230	2937	2441	1810
	1975	missing	1530	1100	886	767
	1976	1430	1180	943	861	766
	1977	706	611	550	521	501
	1978	missing	889	781	645	524
	1979	missing	1210	952	761	562
	1980	10200	5830	5107	3996	2473
	1981	missing	738	642	589	536
	1982	8780	7790	5460	3853	2809
	1983	8150	6070	5213	4859	4263
	1984	7640	5410	5217	5083	4609
	1985	missing	1370	967	735	648
	1986	17500	16000	13167	9617	7343
	1987	missing	948	800	636	569
	1988	missing	558	500	479	466
	1989	2040	1580	1513	1290	1084
	1990	missing	591	498	459	443
	1991	2350	1440	830	558	438
	1992	missing	439	398	347	324
	1993	missing	2080	1897	1767	1559
	1994	missing	420	306	230	206
	1995	8910	5500	4733	3416	2607
	1996	6980	6580	6073	5481	4612
	1997	missing	15600	13217	10641	8995
	1998	6980	5220	4223	3467	2577
	1999	missing	3710	3453	3044	2893
	2000	2010	1330	1176	932	746
	2001	missing	142	135	129	114
	2002	missing	742	636	513	490

Table 3: Truckee R. Below Derby Dam Flow Input to Regfreq Program

Gage Name	Water Year	Peak	1-Day	3-Day	7-Day	15-Day
Truckee R. at Wadsworth	1973	2113	1573	1200	1095	862
	1974	4307	3726	3269	2773	2000
	1975	4538	1663	1301	1054	905
	1976	missing	1211	977	889	786
	1977	638	596	544	512	502
	1978	2361	1130	850	704	559
	1979	2337	1617	1104	807	637
	1980	9084	8086	5885	3978	2315
	1981	missing	863	714	645	560
	1982	8459	7063	5483	3720	2688
	1983	8020	5600	4855	4711	4197
	1984	7540	6432	5329	5242	4773
	1985	1861	1437	1112	847	710
	1986	16956	14771	12656	9231	7267
	1994	missing	251	222	213	198
	1995	7806	5815	4468	3235	2513
	1996	7878	6958	6394	5656	4583
	1997	19159	17520	14463	11410	9635
	1998	6084	4595	3997	3361	2498
	1999	4583	3657	3479	3096	2957
	2000	2280	1611	1210	971	765
	2001	missing	567	537	508	481
	2002	missing	820	610	548	502

Table 4: Truckee River at Nixon Flow Input to Regfreq Program

Gage Name	Water Year	Peak	1-Day	3-Day	7-Day	15-Day
Truckee R. at Nixon	1973	1793	1502	1252	1172	939
	1974	3747	3316	3146	2643	1951
	1975	missing	1383	1195	992	864
	1976	missing	1066	964	902	810
	1977	missing	645	572	538	529
	1978	missing	993	844	670	545
	1979	missing	1204	1010	778	599
	1980	8864	8433	5979	4006	2345
	1981	missing	755	666	648	557
	1982	7612	5702	4966	3719	2793
	1983	7440	5712	4774	4607	4121
	1984	6610	5838	5077	5015	4585
	1985	1571	1155	996	778	685
	1986	16456	14528	12485	9055	7083
	1987	missing	949	743	611	550
	1988	missing	470	464	450	446
	1989	1931	1708	1526	1306	1083
	1990	586	541	475	442	426
	1991	1777	1132	867	582	454
	1992	missing	465	432	360	321
	1993	missing	1838	1747	1663	1488
	1994	missing	278	249	224	207
	1995	8276	6499	4484	3260	2515
	1996	8435	7604	7177	6411	5034
	1997	21259	19312	14564	11556	9609
	1998	6381	4371	4019	3448	2505
	1999	missing	3725	3337	3017	2898
	2000	1911	1580	1181	923	746

Attachment 2

Table 1: Flow Data, Tracy Gage Regression Equation Derivation

Water Year	Peak Flow Data for Each Water Year			
	# USGS 10350000 Truckee R. at Vista		# USGS 10350400 Truckee R. Below Tracy	
	Date	Flow (cfs)	Date	Flow (cfs)
1986	18-Feb-86	16100	19-Feb-86	17500
1980	14-Jan-80	9970	14-Jan-80	10200
1995	10-Mar-95	8800	10-Mar-95	8910
1982	20-Dec-81	8550	20-Dec-81	8780
1983	13-Mar-83	8040	13-Mar-83	8150
1984	24-Nov-83	7230	24-Nov-83	7640
1996	18-May-96	7200	18-May-96	6980
1998	24-Mar-98	6090	24-Mar-98	6980
1974	17-Jan-74	4000	17-Jan-74	3570
1991	5-Mar-91	2740	5-Mar-91	2350
1973	16-Jan-73	2330	16-Jan-73	2100
1989	23-Nov-88	2140	24-Nov-88	2040
1987	17-May-87	2040	17-May-87	2170
2000	14-Feb-00	1990	14-Feb-00	2010
1976	27-Oct-75	1530	27-Oct-75	1430
1977	21-Feb-77	806	21-Feb-77	706

Table 2: Flow Data, Below Derby Dam Gage Regression Equation Derivation

Water Year	Peak Flow Data for Each Water Year			
	# USGS 10350000 Truckee R. at Vista		# USGS 10351600 Truckee R. Blw Derby Dam	
	Date	Flow (cfs	Date	Flow (cfs)
1997	2-Jan-97	20700	3-Jan-97	19759
1963	1-Feb-63	18900	1-Feb-63	18400
1986	18-Feb-86	16100	19-Feb-86	17056
1965	23-Dec-64	11700	23-Dec-64	11400
1980	14-Jan-80	9970	14-Jan-80	8964
1995	10-Mar-95	8800	11-Mar-95	7786
1951	21-Nov-50	8750	22-Nov-50	9746
1982	20-Dec-81	8550	20-Dec-81	8519
1983	13-Mar-83	8040	13-Mar-83	8333
1970	22-Jan-70	7630	24-Jan-70	5976
1984	24-Nov-83	7230	24-Nov-83	7826
1996	18-May-96	7200	18-May-96	7126
1998	24-Mar-98	6090	24-Mar-98	6431
1974	17-Jan-74	4000	17-Jan-74	3807
1945	2-Feb-45	2910	2-Feb-45	3115
1991	5-Mar-91	2740	5-Mar-91	2239
1973	16-Jan-73	2330	16-Jan-73	2099
1964	15-Nov-63	2170	15-Nov-63	1485
1989	23-Nov-88	2140	23-Nov-88	1492
2000	14-Feb-00	1990	14-Feb-00	1860
1976	27-Oct-75	1530	27-Oct-75	1711
1954	10-Mar-54	1400	9-Mar-54	2050
1977	21-Feb-77	806	21-Feb-77	471

Table 3: Flow Data, At Wadsworth Gage Regression Equation Derivation

Water Year	Peak Flow Data for Each Water Year			
	# USGS 10350000 Truckee R. at Vista		# USGS 10351650 Truckee at Wadsworth	
	Date	Flow (cfs)	Date	Flow (cfs)
1997	2-Jan-97	20700	3-Jan-97	19159
1986	18-Feb-86	16100	19-Feb-86	16956
1980	14-Jan-80	9970	14-Jan-80	9084
1995	10-Mar-95	8800	11-Mar-95	7806
1982	20-Dec-81	8550	20-Dec-81	8459
1983	13-Mar-83	8040	13-Mar-83	8023
1970	22-Jan-70	7630	24-Jan-70	7836
1984	24-Nov-83	7230	25-Nov-83	7540
1996	18-May-96	7200	18-May-96	7996
1998	24-Mar-98	6090	24-Mar-98	6091
1974	17-Jan-74	4000	19-Jan-74	4307
1973	16-Jan-73	2330	17-Jan-73	2113
1968	25-Feb-68	2180	25-Feb-68	2365
2000	14-Feb-00	1990	15-Feb-00	2280
1977	21-Feb-77	806	21-Feb-77	638

Table 4: Flow Data, At Nixon Regression Equation Derivation

Water Year	Peak Flow for Each Water Year			
	# USGS 10350000 Truckee R. at Vista		# USGS 10351700 TRUCKEE R. at Nixon	
	Date	Flow (cfs)	Date	Flow (cfs)
1997	2-Jan-97	20700	3-Jan-97	21259
1986	18-Feb-86	16100	19-Feb-86	16456
1965	23-Dec-64	11700	24-Dec-64	9950
1980	14-Jan-80	9970	14-Jan-80	8864
1995	10-Mar-95	8800	11-Mar-95	8276
1983	13-Mar-83	8040	14-Mar-83	7443
1970	22-Jan-70	7630	24-Jan-70	6276
1984	24-Nov-83	7230	25-Nov-83	6626
1996	18-May-96	7200	19-May-96	8516
1998	24-Mar-98	6090	24-Mar-98	6380
1974	17-Jan-74	4000	17-Jan-74	3747
1991	5-Mar-91	2740	5-Mar-91	1777
1973	16-Jan-73	2330	17-Jan-73	1793
1964	15-Nov-63	2170	15-Nov-63	1274
2000	14-Feb-00	1990	15-Feb-00	1910
1977	21-Feb-77	806	21-Feb-77	599
1992	22-Feb-92	566	30-Mar-92	367

PART IV of Attachment A

INTERIOR DRAINAGE HYDROLOGY

PART IV – INTERIOR DRAINAGE HYDROLOGY

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1. Introduction

1.1 Study Area. The Truckee Meadows Flood Damage Reduction and Ecosystem Restoration Project has analyzed many alternatives over the years for both downtown Reno, the Truckee Meadows Reach, and the Lower River Reach. Recently, some of these alternatives are no longer being considered. This section, Part IV of Attachment A, describes the analysis that was performed to determine existing condition interior drainage hydrology for various tributary watersheds in the study area using rainfall-runoff models. This interior drainage analysis has two major purposes: (1) provide various frequency hydrographs for mapping residual floodplains caused by storms centered over tributaries or urban areas (this is flooding that is NOT the direct result of mainstem Truckee River overbank flows) (2) provide hydrology to analyze impacts of proposed alternatives to interior drainage floodplains. Some alternatives such as Huffaker Dam on Steamboat Creek are no longer being considered, yet this interior drainage study report will include a description of the hydrologic analysis for these locations since one or more of these alternatives might considered again in the future. The main report, rather than this appendix, should be referenced for the latest information on alternatives.

Areas studied in this interior drainage report include North Truckee Drain, Steamboat Creek, Hidden Valley, south side of Truckee Meadows near the Airport, downtown Reno on south side of Truckee River, downtown Reno on north side of the Truckee River, and Long Valley Creek. This report also includes an estimated Probable Maximum Flood that was developed to size the spillway for the proposed Huffaker Dam.

As a reminder, the Truckee Meadows Flood Damage Reduction and Ecosystem Restoration Project is divided into three portions: (1) the reach of the Truckee River between Booth Street and U.S. Highway 395 (**Downtown Reno Reach**); (2) the reach of the Truckee River from Highway 395 to Vista, along with the tributaries of Boynton Slough, Steamboat Creek, and North Truckee Drain (**Truckee Meadows Reach**); and (3) the reach of the Truckee River between Vista and Pyramid Lake (**Lower River Reach**).

1.2 Methodology. All tributary watersheds to the Truckee River were analyzed with a rainfall-runoff model, either HEC-1 or HEC-HMS. On Steamboat Creek, which covers a couple of hundred square miles, the Corps utilized a 3-day general rain-on-snow event. A separate SNOW model was used to simulate the impact of rain melting the snow, precipitation falling as snow, or the snowpack absorbing and holding the rainfall. This is the only tributary high enough in elevation to require a snowpack analysis. A 3-day general rain was also used to model the 1% chance event on lower North Truckee Drain channel, a watershed of over 60 square miles that includes Spanish Springs Dam. For smaller areas like downtown Reno, both a general rain and a 3-hour cloudburst storm were modeled to see which dominated the flooding problem. Subsequent floodplain mapping performed by Hydraulic Design Section determined that general rain events determine the maximum amount of water that ponds against structures like levees because they have more volume than the cloudburst events. Cloudburst events have a flashy instantaneous peak but not much volume. For most locations the general rain storm was a 72-hour long event, except for downtown Reno and Long Valley Creek watershed, which used a 24-hour storm. Design storms were generally balanced to NOAA 14 Precipitation Frequency estimates published by the National Weather Service in 2003. For Steamboat Creek and North

Truckee Drain, soil loss rates were based on the Maricopa County, AZ Design Manual Green and Ampt Loss Rate Method (Ref. 22). For downtown Reno on the north side of the Truckee River, SCS curve numbers were used. For Long Valley Creek, initial/constant loss rates were utilized. The Corps initially used Curve Numbers for Steamboat Creek and North Truckee Drain; however, the method was later revised to Green and Ampt on the recommendation of an External Peer Review by David Ford Consulting Engineers, Inc. (Ref. 35). The External Peer Review was part of a new policy mandated by the Corps HQ in 2007, which required the team to consider certain technical portions of the study for outside review. The peer review for the North Truckee Drain hydrology was performed by Dr. Joe Devries of David Ford Consulting Engineers. Joe Devries is a former professor in the Civil Engineering Department at U.C. Davis. He also has many years experience in hydrology and hydraulics work, including a Probable Maximum Flood Analysis for Martis Creek Dam, which is in the Truckee River watershed. The result of the peer review indicated that the use of SCS Curve Numbers (CNs) should only be for storms with a duration of 24 hours. It was determined that is not appropriate to use CNs for durations longer or shorter than 24 hours. This conclusion was based in part on correspondence between Dr. Devries and Dr. Richard Hawkins of the University of Arizona (knowledgeable in the SCS methodology for drainage design). Since the Corps used a 72-hour storm for North Truckee Drain and Steamboat Creek watersheds, the use of CNs was deemed inappropriate for these watersheds. Instead, Dr. Devries recommended using the Green and Ampt loss rate method and the Corps followed this advice. SCS TR-60 does provide for adjustments to CNs for a 10-day storm. A linear interpolation for a 3-day event was tried but it did not prevent the loss rates from approaching zero inches on the 3rd day of the storm. As such, CNs were not used.

1.3 Concurrent Flows Between Truckee River and Tributaries. Whenever interior drainage is being modeled, there often needs to be an assumption of the concurrent tailwater condition in the mainstem of the river. The following rules were applied to hydraulic modeling of major tributaries or interior drainage areas next to the river.

1.3.1 Interior Drainage Areas Behind Levees or Floodwalls. For interior drainage areas behind levees or floodwalls in downtown Reno, the Meadows Reach, and Long Valley Creek, the concurrent event in the Truckee River was assumed to be approximately half the return period of the event occurring in the interior area. The timing assumption is that the interior area peaks at the same time the mainstem river peaks. The timing assumption is believed to be a little conservative.

% Chance Exceedence Interior Area	Concurrent % Chance Exceedence on Truckee River
10%	20%
2.0%	5.0%
1.0%	2.0%

1.3.2 North Truckee Drain Channel. The proposed North Truckee Drain channel design required the hydraulic modelers to look at two separate scenarios to see which was more critical. One scenario has a 1% event on the Truckee River with a concurrent event on the North Truckee Drain (i.e. 600 cfs on North Truckee Drain at the time of peak on the mainstem). The

second scenario is a 1% event on North Truckee Drain with a concurrent 2% chance event on the Truckee River mainstem (peak on peak). For the latter, the concurrent flow was based on the historic 1986 flood. In 1986, the North Truckee Drain incurred it highest recorded peak flow (estimated at 1850 cfs at Shadow Lane). The recorded peak flow at the Truckee River at Vista during that flood was a little rarer than a 2% chance event (1.54%).

Hydraulic Design has found that the 1% event on the Truckee River with a concurrent event on North Truckee Drain creates the highest stages on the lower end of the North Truckee Drain (all the way upstream to Prater Way). This is due to a high tailwater created by the Truckee River. This scenario is also critical for design of the proposed North Truckee Drain box culverts under the 80 freeway. The HEC-RAS model for this scenario includes both tributary and mainstem hydrographs with timing built into them so that the peak flow at the Vista gage equaled a 1% event. The concurrent flow on North Truckee Drain was approximately 600 cfs when the Truckee River reached its maximum stage.

1.3.3 Steamboat Creek Channel. Levees are proposed on Steamboat Creek to contain the backwater from the Truckee River. The Truckee River stages in the Meadows Reach will increase under with-project conditions. At one time, the locally preferred plan was to develop a project that contained the 117-year flood. This meant the levees on Steamboat Creek needed to be built all the way upstream to the Hidden Valley community. Because these levees could cause interior drainage problems for this community, an interior drainage analysis was performed on the Hidden Valley watershed. The analysis is described in Section 5.

The concurrent flow on the Truckee River when Steamboat Creek incurs an n-year flood was determined to be approximately half the return period of the event on Steamboat Creek. For example, during a 1% chance event (100-year) on Steamboat Creek, the concurrent event on the Truckee River is a 2% chance event (50-year). The timing is arranged in HEC-RAS such that Steamboat Creek and the Truckee River peak at the same time.

When simulating an n-year flood on the mainstem Truckee River, the concurrent Steamboat Creek and North Truckee Drain runoff, when added to the Truckee River flow creates a 1% chance peak flow at Vista under existing (without-project) conditions in the HEC-RAS model.

1.3.4 Town of Lockwood and Long Valley Creek Channel. The Corps must ensure that its with-project design does not induce flooding problems on the town of Lockwood near the mouth of Long Valley Creek. The Corps hydraulically modeled this area under two scenarios. The first scenario is a 1% chance event on the Truckee River with concurrent runoff in Long Valley Creek. The concurrent runoff had a built-in timing so that the peak flow downstream at the Tracy gage equaled a 1% peak. The concurrent runoff on Long Valley had a peak under 3,000 cfs for this scenario.

The other scenario that was modeled was a 1% chance event on Long Valley Creek with a 2% chance event on the Truckee River. The timing of the Long Valley hydrograph was adjusted in relation to the mainstem so that combined flows of the two did not exceed 21,500 cfs or the 1% chance peak flow at the Tracy gage on the Truckee River.

1.3.5 Justification for Assumptions. The January 1997 flood was slightly larger than a 1% chance event. Steamboat Creek, North Truckee Drain, and Long Valley Creek tributaries had smaller flows than the 1% chance event in their channels during this flood. The table below quantifies the percent chance event flows on tributaries and the Truckee River at Vista for three flood events.

Table 1. Comparison of Truckee River and Tributary Runoff for Historic Floods

	1997 Flood	1986 Flood	2005 Flood
Truckee R. at Vista (% chance event)	~ 0.95% (105-yr)	~ 1.54% (65-yr)	~ 2.2% (45-yr)
Steamboat Crk @ Steamboat gage (% chance event)	~ 4%	~ 2%	~ 2%
North Truckee Drain (% chance event)	< 10%	*Estimate > than 2%	< 10%
Long Valley Creek (% chance event)	< 10%	Between 5% and 2%	< 20%

* In 1986, Spanish Springs Dam and other smaller detention basins within the watershed did not exist, so comparison to existing conditions rainfall runoff modeling results is difficult.

The question that needed answering for the interior drainage analysis was which frequency event should be used on the mainstem Truckee River when a tributary or interior drainage area is incurring an n-year event. For Steamboat Creek, the data shows that the Truckee River and Steamboat Creek can both have approximately 2% chance events at the same time (1986 and 2005). Regression plots of the Steamboat Creek versus Truckee River at Vista flows show a wide scatter. The results are not conclusive. Some floods have bigger return periods on the tributaries than the mainstem and vice versa. The historic data does not appear to justify having a 1% chance event on the mainstem and on the tributaries of Steamboat Creek and North Truckee Drain, all at the same time. To simplify the modeling of 1% chance events on Steamboat Creek and North Truckee Drain, it was decided to use the next lowest return period available in the dataset, a 2% chance event on the mainstem. The 1986 flood on North Truckee Drain also validates this decision. A similar decision was made for Long Valley Creek and interior drainage areas. The decision was to use the next lowest return period in the data set for the mainstem (approximately n-year ÷ 2 when a tributary or interior drainage area incurs an n-year flood).

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2.0 North Truckee Drain

2.1 Study Area. The geographic area covered in this analysis is the north side of the Truckee River between the downtown Reno streamgage and the Vista streamgage. A map of this area is shown in Chart 2-1. The farthest north portions of this area include Sun Valley (northwest side) and Spanish Springs Valley (northeast side). Sun Valley subbasins include #500 through #520. Spanish Springs Valley is a natural, bowl-shaped watershed to the north of downtown Sparks. Subbasins 1 – 29B (upper subbasins with thin black and yellow boundaries on Chart 2-1) constitute the Spanish Springs HEC-1 model. The whole Spanish Springs watershed is approximately 77 square miles in area, but Boneyard Flat, an approximately 11 square mile sink, does not contribute runoff. The remainder of the Spanish Springs HEC-1 model covers 66 square miles. Spanish Springs Dam, near the outlet of Spanish Springs Valley, controls 60 square miles of the upper watershed. The dam was designed by the locals to contain a 1% chance event. The Corps adopted the Spanish Springs HEC-1 model from the City of Sparks and modified it for its own use.

The runoff from the Spanish Springs HEC-1 model becomes input to the Corps' North Truckee Drain model, which covers 28 square miles of the lower portion of the watershed that includes the downtown area of the City of Sparks. Runoff within the city generally flows south or southeast and collects behind east-west running transportation barriers like McCarren Blvd, Highway 80, and the Southern Pacific Railroad before being conveyed to the Truckee River via surface channels like the North Truckee Drain. North Truckee Drain is an improved channel that begins at about the latitude of Shadow Lane in the foothills below Spanish Springs Dam. The channel flows in a generally southerly direction through downtown Sparks City. It enters the Truckee River on the north side of the river via an open channel. The upper end of the channel has a natural, earthen bottom, whereas some lower reaches are lined with concrete. Contributing runoff on the eastern side of the watershed are the Pah Rah and D'Andrea watersheds (subbasins 700 and 710, respectively). The drainage from Sun Valley (subbasins 500, 505, and 510) flows into the Sun Valley Detention Basin at subbasin 511. Approximately 220 cfs of the outflow from the dam is diverted into an underground pipe that runs east along the route of McCarran Blvd until it reaches the North Truckee Drain in a six foot diameter drain. The remainder of the runoff from Sun Valley flows south into subbasin 511 as surface runoff. Significant portions of the runoff from 511, 520, 515, and 516 reach the Sparks Marina, which is a large sink with lots of storage capacity. During a flood which would fill the Marina, Highway 80 blocks the overflow from moving southward; therefore, the lake continues to fill, eventually flooding homes to the north. The northern boundary of subbasin 517 is Highway 80. This subbasin also contains People's Ditch, which parallels Highway 80 on the south side of the freeway, and flows east until it dumps into North Truckee Drain. During a flood event that fills the Marina, approximately 30 cfs is pumped from the Marina into People's Ditch. Runoff from subbasins 404, 405, 410, 415, and 420 flows eastward, parallel with the Truckee River; however, the runoff does not enter the North Truckee Drain. These subbasins, as well as 425, are interior drainage areas behind proposed levees where pumping stations might be required.

The climate of the Truckee Meadows area is generally arid, characterized by dry summers and long winters with somewhat little precipitation. Mean annual precipitation on the valley floor is only about 7.5 inches, with over half of that occurring between December and March.

Temperatures can vary from sub-zero on the eastern slopes of the Sierra Nevada Mountains to over 100° Fahrenheit in the valley. While snowfall may occur at any elevation in the basin, it typically falls above 5,000 feet. The winter snow pack begins to melt around April. Local engineers have said there is no discernable snowpack in the North Truckee Drain watershed including Spanish Springs Valley.

2.2 Historical Floods. The North Truckee Drain watershed, unlike Steamboat Creek, does not have high enough elevations to have a significant snowpack; therefore, snowmelt impacts do not need to be modeled in this watershed. The flood of record in this watershed was a general rain event that occurred in February 1986. Cloudburst storms can cause localized flooding; however, a general rain event is believed to be the dominant event which will cause a 1% chance exceedence peak on the lower North Truckee Drain. Two streamgages exist on North Truckee Drain. They include USGS gage #10348245 (N Truckee Drain at Spanish Springs Road nr Sparks) and #10348300 (N Truckee Drain at Kleppe Lane nr Sparks). The locations of the two gages are shown on Plate 1. The upper gage at Spanish Springs Road consists of only 10 years of broken record between 1986 and 2006. The lower gage consists of 12 years of broken record between 1993 and 2006. When the Truckee River incurs high stages, it causes a backwater effect on the Kleppe Lane gage, which makes its readings unreliable during large Truckee River floods. Below are the listed peak flows from the two USGS gages, #10348245 and #10348300.

Table 2-1. Peak Flows for USGS Gage #10348245, North Truckee Drain at Spanish Springs Rd. nr Sparks, NV, Drainage Area = 80.0 Square Miles

Date of Peak	Discharge in CFS
02/17/86	1850
07/14/93	34
09/28/94	31
03/11/95	27
01/02/97	15
08/01/02	43
06/20/03	20
06/26/04	23
06/24/05	115
12/31/05	286

Table 2-2. Peak Flows for USGS Gage #10348300, North Truckee Drain at Kleppe Ln nr Sparks, NV, Drainage Area Not Determined

Date of Peak	Discharge in CFS
01/20/93	106
05/19/94	153
05/02/95	455
05/18/96	670
08/07/99	120
08/03/00	228
04/20/01	92
08/01/02	282
12/16/02	120
02/25/04	220
06/24/05	312
02/28/06	561

During the flood of February 1986, there was a record amount of runoff from the tributaries in this area. Both North Truckee Drain and Steamboat Creek had their highest flows on record during this event. North Truckee Drain incurred an estimated peak of 1,850 cfs near Shadow Lane, while lower Steamboat Creek incurred an estimated peak of 5,600 cfs. The 1986 storm occurred prior to the existence of the North Spanish Springs Detention Basin and Spanish Springs Dam. The recorded flow at the Truckee River at Vista gage was 16,100 cfs. During the December 31st, 2005 storm event, North Truckee Drain flows were estimated to be about 300 cfs, while the Truckee River at Vista gage recorded a peak of 13,700 cfs.

2.3 HEC-1 Models. The City of Sparks has developed an HEC-1 model of Spanish Springs watershed over the years. The model covers the Spanish Springs Valley, which is a 66 square mile area. Residential developers have been mandated to mitigate for land-use change, which often takes the form of detention storage. Dozens of small detention facilities exist in the watershed. A number of A-E's firms have modified the model over the years as development occurs, so the area has been split into over one hundred subbasins. Near the end of the valley is Spanish Springs Dam, which was originally built by the local government to control a 1% chance event. The model follows some NRCS TR-55 guidelines including the use of SCS unit hydrographs for rainfall to runoff transform, SCS Curve Numbers for soil loss rates, and a 24-hour storm based on an unofficial, draft version of NOAA 14 Precipitation Frequency. Spanish Springs Dam is specified as having 1,503 acre-feet of flood control storage. It is a dry dam with no permanent storage. It has an ungated outlet and an uncontrolled spillway. Due to the complexity of modeling this urbanized valley, the Corps adopted the City of Sparks model and modified it for its own use. Modifications made by the Corps include: 1) creation of a 72-hour design storm using NOAA 14 Precipitation Frequency, 2) replacing SCS Curve Numbers with Green and Ampt loss rates, and 3) using a 5-minute computation interval. The Spanish Spring Model covers 66 square miles, which is the upper portion of the North Truckee Drain watershed.

A separate HEC-1 model for the lower North Truckee Drain watershed was created by the Corps. This model covers approximately 28 square miles of the lower watershed, some of which drains

directly to the Truckee River and does not enter North Truckee Drain. This model uses S-graphs developed in the 1980 Study (Ref. 5) for creating subbasin unit hydrographs, and Green and Ampt soil loss rates. Routing methods include Muskingum, Muskingum Cunge, and Modified Puls.

2.4 Flood Control Development. The largest flood control or detention storage structures include North Spanish Springs Detention Facility (sub #10B), Spanish Springs Dam (sub #26), Sun Valley Detention Basin (sub #510), Paradise Park (sub #605), the Sparks City Marina, and an in-line series of storage areas called the D'Andreas Dams (sub #710).

2.5 Runoff Model Development

As mentioned earlier, the Corps adopted the Spanish Springs model that was developed by the City of Sparks. This model covers about 66 square miles. The model includes the drainage above Spanish Springs Dam and about 6 square miles of local area below the dam. The model is based on methods defined in TR-55 including SCS Curve Numbers (CNs) for loss rates and a SCS Unit Hydrograph for rainfall to runoff transform. The Corps modified the precipitation used in the model to a three-day storm using NOAA Atlas 14 Precipitation Frequency. The remainder of the watershed model, including Sun Valley and lower North Truckee Drain, was developed by the Corps and its Contractor (MWH, Inc.). The North Truckee Drain model uses the Green & Ampt soil loss method. The Green & Ampt loss parameters for the Spanish Springs and NTD models were developed by HDR, Inc. using the Maricopa County, AZ Design Manual guidance.

2.5.1 Subbasin Delineation. Subbasin boundaries in the Spanish Springs Valley HEC-1 model were adopted from the existing model. In the Corps North Truckee Drain HEC-1 model, the watersheds were divided into numerous subbasins using topographic data and available information about existing drainage systems. Topographic data in digital format were collected for watersheds tributary to the Truckee River between Highway 395 and Vista. These data consisted of the following:

- List data from the USACE in the Truckee Meadows Project study area
- List data from Washoe County
- USGS 30-meter digital elevation models

The topographic layers were merged to form a continuous digital land surface. Subbasins were then automatically generated in a GIS environment using the digital land surface in combination with hydrographic line data. The subbasins were manually refined or adjusted, where necessary, to effectively represent the watersheds and account for drainage features not apparent on the digital land surface.

2.5.2 General Rainflood Storm Centered at Spanish Springs Dam. This storm was derived to determine the existing condition peak flows for various frequency events on lower North Truckee Drain. The hydrographs generated will be used to determine residual damages from interior floods and to design the North Truckee Drain Re-Alignment (a proposed project feature). Six flood frequencies were evaluated in this study: the 20%, 10%, 2%, 1%, 0.5%, and 0.2%

exceedence events. Precipitation data used in the HEC-1 model are based on partial duration NOAA Atlas 14 Depth Duration Precipitation Study which was completed in 2003. This study provides the most current annual, all-season precipitation frequencies for storm durations from 5 minutes to 60 days, and percent exceedences from 50% to 0.1%. Spatial data files (point-rainfall isohyetal maps) were downloaded from the National Weather Service's Precipitation Frequency Data Server as geographic shapefiles. The peak flow of record for North Truckee Drain is the 1986 flood, which was a general rain event.

a. 72-Hour General Rainflood. A historic storm pattern from 1986 for Reno Airport (AP) was used to develop 72-hour general rainflood precipitation for each subbasin. It was felt that inflow volume to the Spanish Springs Dam was an important factor in the analysis of the North Truckee Drain peak flows, and a historical look at past floods shows that more than 24-hours of precipitation can occur during one storm. Therefore, a longer duration than 24-hours was chosen for the design storm. The 1986 storm pattern and some other historic events are shown in the figures below.

FIGURE 2-1. FEBRUARY 1986 STORM PATTERN FOR RENO AIRPORT, ADOPTED FOR USE IN GENERAL RAINFLOOD EVENT MODELING

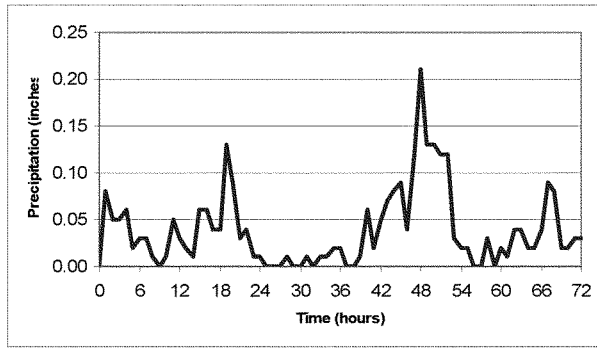


FIGURE 2-2. RENO AIRPORT PRECIPITATION DISTRIBUTION FOR 22 – 24 DECEMBER 1955 STORM

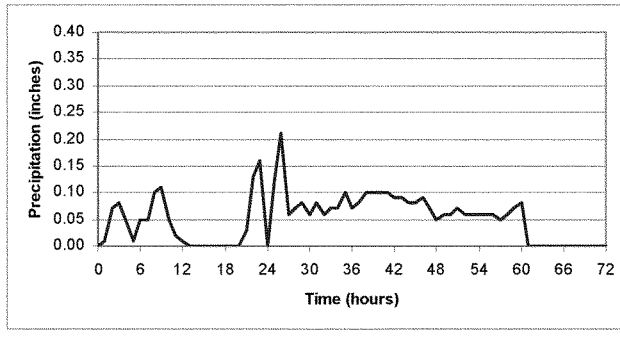


FIGURE 2-3. RENO AIRPORT PRECIPITATION DISTRIBUTION FOR 1 – 3 JANUARY 1997 STORM

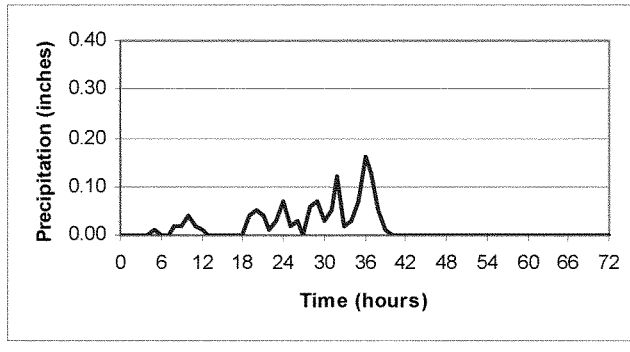


Table 2-3 shows the storm totals for various durations for the 1986 storm.

Table 2-3. 1986 Total Storm Depths Recorded at the Reno Airport Gage

	3-hr	6-hr	12-hr	24-hr	48-hr	72-hr
Total Depth	0.47	0.83	1.19	1.45	1.89	2.85
% of 24-hr depth	32%	57%	82%	100%	130%	197%

Table 2-4 shows the 1% chance exceedence NOAA 14 depths for the Subbasin named "SUNRIS" (tiny subbasin immediately downstream of Spanish Springs Dam; this is the bullseye of the general rain).

Table 2-4. NOAA 14 1% Chance Exceedence Storm Totals for Subbasin SUNRIS

	3-hr	6-hr	12-hr	24-hr	48-hr	72-hr
Total Depth	1.27	1.58	2.18	2.89	3.55	Not Available
% of 24-hr depth	44%	55%	75%	100%	123%	Not Available

Initially, the hourly ordinates of the 72-hour, 1986 storm pattern were multiplied by a ratio that would balance the maximum 24-hours to the 1% chance, 24-hour depth in NOAA 14. This caused the 12- and 48-hour durations to become more rare than the 1% event. Since this was not desired, the 12- and 48-hour depths were balanced to NOAA 14 as well. Since NOAA 14 does not provide a 72-hour depth, it was determined that the 72-hour depth should be a ratio of 1.07 of the 48-hour depth (based upon the ratio of the 1%, 3-day depth to the 1%, 2-day value at the Reno Airport for a Winter Season Frequency Curve). For subbasin SUNRIS, this depth was 131% of the 24-hour depth. As a result the following procedure was used to determine the design storm for each subbasin.

1. Determine the 24-hour Precipitation Frequency value in NOAA 14 for each subbasin using GIS.

2. Apply the following ratios to the 24-hour depth to obtain the other duration depths for each subbasin.

	3-hr	6-hr	12-hr	24-hr	48-hr	72-hr
% of 24-hr depth	32%	57%	75%	100%	122%	131%

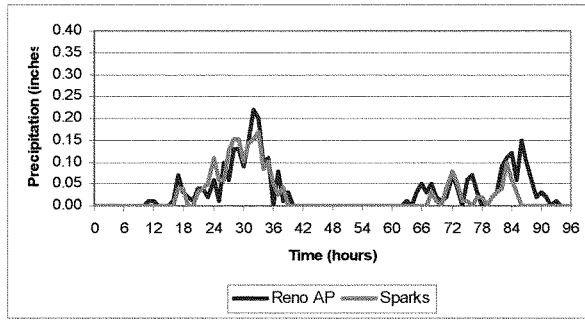
3. Balance the 1986 Storm Pattern ordinates to the depth-duration values obtained in Step 2 above.

4. Apply the proper areal reduction factor to each precipitation depth based upon the subbasin's proximity to the storm bullseye.

The Reno Airport gage storm pattern was considered appropriate for application to the North Truckee Drain watershed, based upon a comparison of two precipitation gages during the New Years Eve 2005 Flood Event, which was about a 2% chance flood in downtown Reno. The two gages were the Reno Airport gage and one near Spanish Springs Dam named KNVSPARK4. Figure 2-4 shows a comparison of the rainfall at the two gages during this event. Figure 2-5

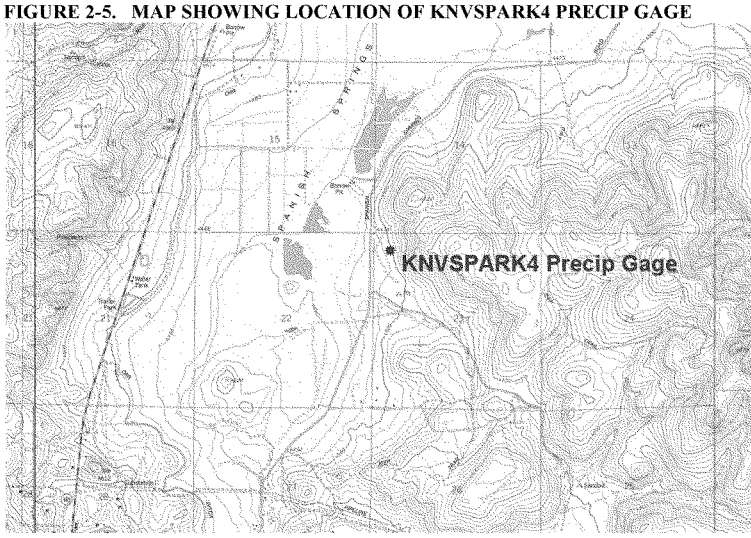
shows the location of the Sparks gage. The Sparks gage was not available during the 1986 storm event.

FIGURE 2-4. RENO AP AND SPARKS PRECIPITATION DISTRIBUTION FOR 30 DECEMBER 2005 – 2 JANUARY 2006 STORM



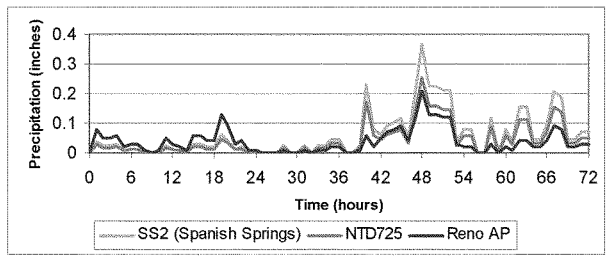
Reno Airport and KNVSPARK4 (Vistas Off Los Altos Way) Recorded Precipitation for the 30 December 2005 to 2 January 2006 Storm (51 Hours of Actual Precipitation over a 96-Hour Period at Reno).

FIGURE 2-5. MAP SHOWING LOCATION OF KNVSPARK4 PRECIP GAGE



The figure below shows the resulting design storm for two subbasins compared with the original 1986 storm at the Reno Airport.

FIGURE 2-6. 1% GENERAL RAINFLOOD PRECIPITATION DISTRIBUTION, BASED ON FEBRUARY 1986 STORM



Reno Airport Precipitation for 17 – 19 February 1986 and Design Storm Hyetographs for a Spanish Springs Subbasin and a North Truckee Drain Subbasin.

Table 2-5 displays the 1% point rainfall depths found in NOAA Atlas 14 for a general rain event compared with the 1% chance point precipitation used in the HEC-1 model for two subbasins (one in Spanish Springs and one in North Truckee Drain). In addition, the depth-area reduced rainfall used in the HEC-1 model is also shown as a percentage of the NOAA 14 point precipitation depths. The adjustment for Drainage Area Reduction Factors (DARF) is discussed later in this report.

TABLE 2-5
DISTRIBUTION OF PEAK PERIOD RAINFALL
FOR 1% GENERAL RAINFLOOD BASED ON 1986 EVENT
Peak Period for 3-, 6-, 12-, 24-, 48-, and 72-hour Durations

Peak Period	3-hour	6-hour	12-hour	24-hour	48-hour	72-hour
Time of Peak (hours)	48 to 50	47 to 52	42 to 53	40 to 63	25 to 72	1 to 72
Spanish Springs Subbasin #2 (GriffithCanyon) (Drainage Area 4.38 sq.mi.)						
NOAA 14 depths for subbasin (in.)	1.56	1.97	2.88	4.17	5.60	5.99
Actual point precipitation used in model (in.)	1.33	2.37	3.12	4.17	5.08	5.46
% of fully balanced storm (point precip) used in model	86%	121%	108%	100%	91%	91%
DARF-adjusted precipitation used in model (in.)	0.82	1.46	1.922	2.932	3.953	4.406
DARF-adjusted % of fully balanced storm (point precip) in model	53%	74%	67%	70%	71%	74%
North Truckee Drain Subbasin #725 near Prater Way (Drainage Area 1.09 sq.mi.)						
NOAA 14 fully balanced storm depths (in.)	1.28	1.61	2.26	3.07	3.85	4.12
Actual point precipitation used in model (in.)	0.98	1.75	2.30	3.07	3.75	4.03
% of fully balanced storm (point precip) used in model	77%	109%	102%	100%	97%	98%
DARF-adjusted precipitation used in model (in.)	0.57	1.01	1.33	2.07	2.83	3.17
DARF-adjusted % of fully balanced storm (point precip) in model	44%	63%	59%	67%	73%	77%

b. Depth-Area Reduction Factors. The precipitation data obtained from NOAA 14 is point precipitation, but, since it is being applied to each subbasin area, it is necessary to use depth area reduction factors (DARFs) to reduce the intensity of the precipitation based on storm duration and the area over which it is being applied. The storm shape chosen is a circular pattern. Those subbasins farthest from the bullseye were given the greatest amount of areal reduction. DARFs were taken from the Washoe County Flood Control Master Plan Meteorological Analysis, prepared by Hydmet, dated April 1994 (Reference 14). Hydmet is owned by Jack Humphrey, PhD, P.E. Hydmet analyzed precipitation gages in this region to determine precipitation frequency values and areal reduction factors for Washoe County. The equations are shown in Table 2-6, although not all were used. The equations are based upon precipitation studies in Utah and Arizona. Example reduction factors are given for 1, 5, 10, and 100 square miles and for durations from 5 minutes to 3 days. Note from the table that areal

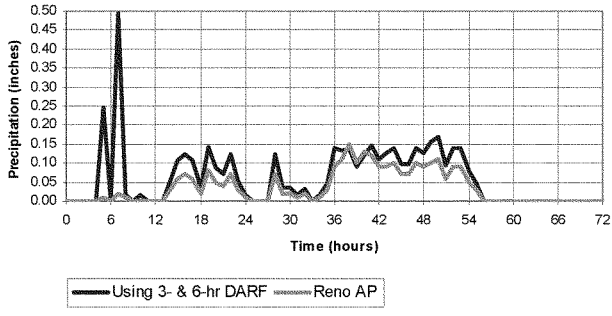
reductions for shorter durations are more severe than for longer durations. For example, for an area of 5 square miles, the 5-minute duration DARF is 0.61, while for the 3-day duration the DARF is 0.97, or over fifty-percent less reduction. **TABLE 2-6**
DEPTH AREA REDUCTION FACTORS

Rainfall Duration	DARF Equation	DARF 1 square mile	DARF 5 square miles	DARF 10 square miles	DARF 100 square miles
*5-min	.01*(100-18.5*Area^.46)	0.82	0.61	0.47	N/A
*10-min	.01*(100-14.2*Area^.46)	0.86	0.70	0.59	N/A
*15-min	.01*(100-12.0*Area^.46)	0.88	0.75	0.65	N/A
*30-min	.01*(100-9.2*Area^.46)	0.91	0.81	0.73	N/A
*1-hour	.01*(100-7.0*Area^.46)	0.93	0.85	0.80	N/A
*2-hour	.01*(100-5.3*Area^.46)	0.95	0.89	0.85	N/A
*3-hour	.01*(100-4.5*Area^.46)	0.96	0.91	0.87	0.63
*6-hour	.01*(100-3.5*Area^.46)	0.97	0.93	0.90	0.71
12-hour	.01*(100-2.6*Area^.46)	0.97	0.95	0.93	0.78
1-day	.01*(100-2.0*Area^.46)	0.98	0.96	0.94	0.83
2-day	.01*(100-1.5*Area^.46)	0.99	0.97	0.96	0.88
3-day	.01*(100-1.3*Area^.46)	0.99	0.97	0.96	0.89

*Note: Durations shaded were not considered applicable for general rain, only cloudburst.

Note that it was found that using the 3- and 6-hour DARF factors for the outlying subbasins (furthest from the storm center), resulted in the maximum 3- and 6-hour rainfall depths being reduced to unusually small amounts. The reduction was so drastic that the rainfall for these durations was smaller than for the longer durations. The original pattern was significantly altered. The figure below illustrates the problem.

FIGURE 2-7. 1963 STORM PATTERN COMPARED WITH SUBBASIN #405 BALANCED HYETOGRAPH AFTER APPLYING 3-, 6-, 12-, 24-, 48-, AND 72-HOUR DARF FACTORS



Notice that rainfall around hours 3 through 9 get pushed extraordinarily high compared to the original pattern. This is due to the short duration rainfall being pushed down too far by the areal reduction factors when compared to the longer durations. Further analysis determined that the 3- and 6-hour DARF factors, found in Reference 14 (Washoe County Flood Control Master Plan Meteorological Analysis), were more appropriate for use in a cloudburst storm, not a general rain distribution. To solve this, the areal reduction factors for the 3-hour and 6-hour durations were not used. Instead, only the 12-hour DARF factor was applied to the maximum 3-, 6-, and 12-hours of precipitation in the design storm.

c. Storm Centerings: Storms were based on a circular pattern with no maximum storm size. The storm was expanded outward until all subbasins in the HEC-1 model were covered. The centering or bullseye of the general rainstorm for the North Truckee Drain was in subbasin #1160, which is located in the Spanish Springs Valley, just below Spanish Springs Dam. The purpose of the centering was to create high peak flows on the North Truckee Drain channel. Chart 2-2 shows the bullseye as a red circle for the North Truckee Drain General Rainstorm.

d. Rain-on-Snow: As mentioned earlier, local experts say there is no discernable snowpack in the North Truckee Drain watershed. As a test, the Corps used a snowpack model and antecedent snowpack criteria developed for Steamboat Creek on the North Truckee Drain watershed. There are no subbasins above 5,500 feet elevation in the Spanish Springs Valley. Only six subbasins in North Truckee Drain model had elevations above 5,500 feet, with the potential of snowmelt contribution. The actual area above 5,500 feet was a very small percentage of each subbasin area. As a test, the SNOW program was used with these six subbasins to determine the net change in runoff due to snowmelt contribution. The result of running a rain-on-snow model simulation for the 1% chance event only changed the flow on

North Truckee Drain by 50 cfs. This basically verified the opinion of local experts. The final design storm for this watershed did not include snowpack modeling.

2.5.3 Soil Loss Parameters

a. Soil Type, Land Use, and Cover. The Spanish Springs HEC-1 model adopted from the City of Sparks uses SCS Curve Numbers for soil loss rates. A Corps' contractor also derived curve numbers for the North Truckee Drain model. Initially, this type of loss rate was used for several HEC-1 model runs using several different storm patterns. It became apparent that something might be wrong with using Curve Numbers for a 3-day storm event, as the Curve Numbers seemed to have unusually low loss rates as the storm progressed beyond the initial 24-hours. An External Peer Review was performed by Dr. Joe Devries of David Ford Consulting Engineers, Inc. His analysis confirmed that the curve number loss rates were approaching almost zero inches per hour on the third day of the storm event (Reference 35). Instead, the reviewer suggested using the Green and Ampt method as described in the Maricopa County, AZ Design Manual. Consequently, the Corps converted both the Spanish Springs and the North Truckee Drain manual to Green and Ampt soil loss rate method. A comparison of results from the two soil loss rate methods is shown in Table 2-10.

b. Green & Ampt Loss Parameters. The Green & Ampt loss method uses the following parameters in the HEC-1 model:

IA – initial loss in inches, primarily a function of land-use and surface cover (see Table 2-8). Zero rainfall excess is generated until the initial loss is satisfied.

DTHETA – volumetric measure of the soil moisture storage capacity available at the start of the storm (dry, normal, or saturated soil conditions).

PSIF – Wetting front suction in inches.

XKSAT – hydraulic conductivity at natural saturation in inches per hour.

RTIMP – percent impervious (see Table 3-4).

The parameters, DTHETA, PSIF, and XKSAT, are functions of soil characteristics, ground surface characteristics, and land management practices. The primary soil surface characteristics are vegetation canopy cover, ground cover, and soil crusting. Land management practices effect soil porosity. The parameters for bare ground are dependent on soil type, as tabulated in Table 2-7, below. The Corps used the DTHETA values for a normal antecedent soil moisture condition. Vegetation cover in each subbasin was accounted for in the process to derive the final loss rate.

TABLE 2-7
GREEN & AMPT LOSS RATE PARAMETER VALUES FOR BARE GROUND

Soil Classification	XKSAT (in/hr)	PSIF (in.)	DTHETA		
			Dry	Normal	Saturated
A1 loamy sand & sand	1.20	2.4	0.35	0.30	0.00
A2 sandy loam	0.40	4.3	0.35	0.25	0.00
B1 loam	0.25	3.5	0.35	0.25	0.00
B2 silty loam	0.15	6.6	0.40	0.25	0.00
B3 silt	0.10	7.5	0.35	0.15	0.00
C sandy clay loam	0.06	8.6	0.25	0.15	0.00
D1 clay loam	0.04	8.2	0.25	0.15	0.00
D2 silty clay loam	0.04	10.8	0.30	0.15	0.00
D3 sandy clay	0.02	9.4	0.20	0.10	0.00
D4 silty clay	0.02	11.5	0.20	0.10	0.00
D5 clay & rocky outcrop	0.01	12.4	0.15	0.05	0.00

The drainages in Washoe County are a mixture of several different soil types, so composite values for the Green & Ampt parameters need to be determined for each subbasin. The procedure to determine the subbasin composite value of XKSAT is to average the area-weighted logarithms of the XKSAT values of each soil type in that subbasin. The corresponding subbasin composite values for PSIF and DTHETA parameters are based on the subbasin XKSAT as determined from a graph (Figure 4.3 in the Maricopa County Design Manual). A final adjustment of the composite XKSAT is made based on subbasin percent vegetation cover.

Land use data, provided by Washoe County, were available for the study area. Land use information provided by Washoe County was rectified with the Maricopa County Design Manual land-uses. The consolidated land use categories with related percent impervious, basin n, and vegetation cover, are listed in **Table 2-8**. Basin n values are used in the calculation of lag (Los Angeles S-graph method) as described in the next section. Unit hydrographs derived from S-graphs were used in the North Truckee Drain model. These basin n values were adopted from the *Sacramento City/County Drainage Manual*, 1994. The A-E firm that derived the n values agreed that these values could be adopted for the Reno area. Acreage of each land use and soil type was extracted for each subbasin using ArcView. Composite values for initial loss, percent impervious, vegetation cover, and basin n value were determined for each subbasin using the ArcView land use data.

TABLE 2-8
LAND USE CATEGORIES AND CORRESPONDING DATA

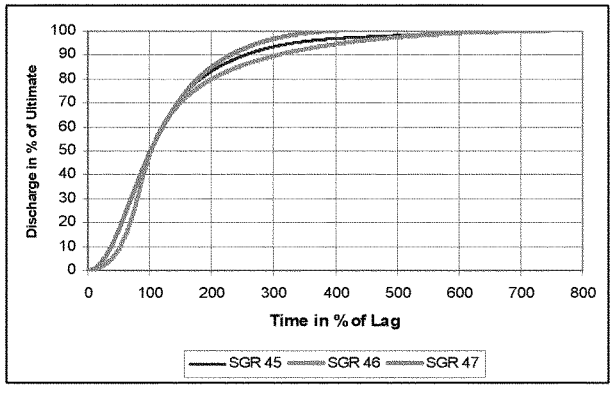
Description of Land Use	Percent Imper-vious	N value	Initial Loss (IA) (inches)	Vegetation Cover in %
Pasture - heavily grazed	5%	0.075	0.30	30%
Parks - fair grass cover	5%	0.070	0.30	60%
Parks - good grass cover	5%	0.070	0.30	80%
Major Highways	90%	0.030	0.10	0%
Commercial – Business	85%	0.031	0.10	75%
Industrial	72%	0.032	0.12	70%
Residential - 1/8 acre lots	65%	0.037	0.20	65%
Residentail - 1/4 acre lots	38%	0.042	0.25	50%
Residentail - 1/2 acre lots	25%	0.060	0.25	50%
Residential - 1 acre lots	20%	0.073	0.30	50%
Water Bodies	100%	-	0.00	0%

2.5.4 Hydrograph Development. The computer program SACPRE, a pre-processor to HEC-1, was used to develop unit hydrographs using the Corps S-graph method. An S-graph is not a unit hydrograph; it represents the hydrologic response of a basin to a rainfall event of infinite duration. The curve has a rising limb with a characteristic S-shape that eventually reaches a constant discharge rate equal to the constant excess rainfall rate multiplied by the area of the basin. An S-graph (shown in the figure below) is constructed from a series of unit hydrographs of length T by the process of successive lagging by T and summing the discharge values (ordinates). The beauty of the S-graph method is that one can derive unit hydrographs for events of any desired duration from them. The Corps Sacramento District developed three S-curves, a mountain general rain S-graph (SGR 45), a mountain cloudburst S-graph (SGR 47) and a valley general rain and cloudburst S-graph (SGR 46), specifically for use in the Truckee Meadows area. The S-graphs were developed for the 1980 Truckee River Study (Ref. 5). The S-curve procedure was not used in the Spanish Springs HEC-1 model. The Spanish Springs model adopted from Washoe County used the SCS unit hydrograph method.

TABLE 2-9. S-CURVES FOR THE TRUCKEE MEADOWS AREA

SACPRE Description	Curve No.
Truckee Meadows: Mountain General Rain	45
Truckee Meadows: Valley General Rain & Cloudburst	46
Truckee Meadows: Mountain Cloudburst	47

FIGURE 2-8. TRUCKEE MEADOWS AREA S-GRAPHS



The computer program SACPRE, originally developed by the Corps Los Angeles District as LAPRE-1, was used as a pre-processor to HEC-1 to produce unit hydrographs for each subbasin based on the drainage area, basin lag, and chosen S-graph.

2.5.5 Routing Parameters. Once rainfall has turned into runoff and flowed to the outlet point for a subbasin, it is necessary to combine this flow with upstream subbasin flows. The combined flow hydrograph is then routed through stream and drainage channels to the next subbasin outlet. There are a number of hydrologic routing techniques available in the HEC-1 program, such as Muskingum, Modified Puls, Muskingum-Cunge, and Kinematic Wave. While any of these techniques may be used, routing techniques were generally applied to this study as described below, based on a number of sources:

- 1983 Corps HEC-1 model (Muskingum and Modified Puls)
- Information from local government and their consultants (Muskingum and Muskingum-Cunge)
- Determination of travel time and attenuation developed for this study (Muskingum)
- Channel routing information from Corps HEC-RAS models of North Truckee Drain

2.5.6 Special Facilities and Model Features.

a. Diversions and Flow Splits. Diversions and flow splits were included in the model routing of subbasin flows where indicated from previous work by others. Diversion and flow split parameters were entered directly from existing models, where available.

b. Detention Basins. The major detention facilities include the North Spanish Springs Detention Facility (584 ac-ft, subbasin 1910), and Spanish Springs Dam (1500 ac-ft, subbasin

1500) within the Spanish Springs HEC-1 model. Detention facilities within the North Truckee Drain HEC-1 model include Sun Valley Detention Basin (subbasin 510), Paradise Park Detention Pond (subbasin 605), the Pah Rah Dams (subbasin 700), the D'Andreas Dams (subbasin 710) and the Sparks Marina next to Highway 80.

2.5.7 Model Verification. It is difficult to verify the computer models for Spanish Springs and North Truckee Drain. The upper gage has 10 years of broken record and the lower gage only has 12 years of record and is influenced by backwater from the Truckee River. Historic precipitation data are not available to calibrate a rainfall runoff model for this watershed. The 2005 flood event was too small on North Truckee Drain to be useful.

2.5.8 Model Runs As mentioned earlier, initial model runs were done using SCS Curve Numbers for loss rates. After completion of the External Peer Review on the North Truckee Drain HEC-1 model, the Corps changed to the Green and Ampt loss rate method. A comparison of the results between the two methods is shown below for the inflow and outflow for Spanish Springs Detention Basin for the 1% chance event.

TABLE 2-10. Model Run Comparison at Spanish Springs Dam

Loss Rate Method	Design Storm	Spanish Springs Det. Basin		
		Inflow (cfs)	Outflow (cfs)	Notes
SCS Curve Numbers	72 Hour Event, 1986 Pattern	2,950	1,910	Run #8: 86 Reno Airport pattern, 72-hr storm, model run based on 15-minute time computation steps
Green & Ampt	72 Hour Event, 1986 Pattern	1,040	530	Adopted model for this study, model run based on 5-minute time computation steps. Same storm as used above.

TABLE 2-11. Model Run Comparison on North Truckee Drain Near Prater Way

Loss Rate Method	Design Storm	North Truckee Drain at Prater Way	
		Peak Flow (cfs)	Notes
SCS Curve Numbers	72 Hour Event, 1986 Pattern	2,470 cfs	Run #8: 1986 Reno Airport pattern, 72-hr storm, model run based on 15-minute time computation steps
Green & Ampt	72 Hour Event, 1986 Pattern	1,910 cfs	Adopted model for this study, model run based on 5-minute time computation steps. Same storm as used above.

The North Truckee Drain at Spanish Springs Road streamgage record is shown below.

Table 2-12. USGS Gage #10348245 Peak Flows

Date of Peak	Discharge in CFS
02/17/86	1850
07/14/93	34
09/28/94	31
03/11/95	27
01/02/97	15
08/01/02	43
06/20/03	20
06/26/04	23
06/24/05	115
12/31/05	286

For purposes of comparison, the 1986 peak flow at Spanish Springs Road can be compared to the Spanish Springs inflow as modeled in HEC-1, although the gage site has an additional 6 square miles of drainage area. Of note is that the 1986 peak flow of 1,850 cfs exceeds the peak inflow for the 1% chance exceedence HEC-1 model run (1,040 cfs). A number of possible explanations exist: 1) The HEC-1 model has the North Spanish Springs Detention Facility (storage of over 500 acre-feet) which did not exist in 1986, 2) the HEC-1 model storm bullseye was located to maximize peak flow on the lower North Truckee Drain rather than to maximize inflow to Spanish Springs Dam, 3) the streamgage has an additional 6 square miles of drainage area as compared to Spanish Springs Dam 4), although significant development has occurred in the Spanish Springs watershed since 1986, developers have been mitigating for urbanization by installing numerous detention basins throughout the area, 5) the 1986 peak discharge was not measured directly but rather by an indirect estimate based on high water marks.

Unfortunately, precipitation within the North Truckee Drain watershed was not measured during the 1986 flood. Several precipitation gages in the region were checked for durations from 1 hour to 3 days to determine the % chance exceedence that occurred. See the table below.

TABLE 2-13
% CHANCE EXCEEDENCE FOR PRECIPITATION AMOUNTS FOR 5 STATIONS FOR VARIOUS DURATIONS FOR THE FEBRUARY 1986 STORM EVENT

Duration	Reno AP	Minden AP	Mt Rose Xmas Tree	Carson City	Virginia City
1-Hour	<20%	<20%	20%	N/A	N/A
2-Hour	<20%	<20%	20%	N/A	N/A
3-Hour	<20%	20%	10%	N/A	N/A
6-Hour	20%	20%	<10%	N/A	N/A
12-Hour	20%	<20%	<10%	N/A	N/A
24-Hour	<10%	20%	<4%	<20%	20%
2-Day	<10%	20%	<4%	20%	10%
3-Day	4%	<4%	10%	10%	10%

"<" means more frequent than…
N/A = not available

2.6 Summary of Results. Table 2-14 summarizes simulated peak flows (in cubic feet per second) for the general rain flood with a bullseye at the outlet of the Spanish Springs Detention Basin.

TABLE 2-14
SUMMARY OF SIMULATED PEAK FLOWS
FOR THE GENERAL RAIN FLOOD SERIES

Location	PEAK FLOWS (CFS) Exceedence Frequency					
		10%	2%	1%		
Spanish Springs Detention Basin						
Inflow		420	800	1,050		
Outflow		380	490	530		
NTD @ Prater Road		960	1,610	1910		

2.7 Hydrology for Areas Behind Levees. Planned project features include a levee on the north side of the Truckee River in the Truckee Meadows Reach. To evaluate interior flooding induced by the levee, two types of storms were evaluated: a 72-hour general rain event centered near the levees and a 3-hour cloudburst centered next to the levees. A 3 hour duration cloudburst was based on local observations of typical events. These cells tend to be isolated and cover at most about 5 square miles. Both cloudburst storms and general rainstorms need to be analyzed to see which will cause the most critical flood conditions for these interior areas. The subbasins of concern are 405, 410, 415, 420, 425, and 517. It was determined (Memorandum: Review FLO-2D Model, Jan 2012, Ford Consulting) using FLO-2D that runoff from subbasins north of Hwy 80 do not cross the highway but flow southeast to the Sparks Marina. At this time, the HEC-1 model was subsequently revised to reflect this routing. For interior drainage floodplain mapping on the south side of Hwy 80, the individual subbasin hydrographs were divided into smaller identical pieces and input into FLO-2D cells at the discretion of the hydraulic modeler. The HEC-1 model routing in this area was not used and should not be considered accurate since overland flow direction changes for different frequency events.

2.7.1 3-Hour Cloudburst for Subbasins 404, 405, 410, 420, 425 and 517.

Subbasin precipitation for the 3-hour cloudburst event was developed in 15-minute increments using a balanced hydrograph approach. The HEC-1 model is run in 5-minute time steps, which means each 15-minute precipitation depth provided in the dssfile is divided evenly into three additional increments by HEC-1. Consequently, if one 15 minute increment of rainfall is 0.15 inches, the model splits the precipitation into three five minute increments of 0.05 inches. As with the general rainflood, six cloudburst flood frequencies were modeled: the 20%, 10%, 2%, 1%, 0.5%, and 0.2% exceedence events. NOAA Atlas 14 provided the rainfall data for 15-, 30-, 60-, 12-, and 180-minute durations for each subbasin analyzed for interior drainage flooding. The 45-, 75-, 90-, 105-, 135-, 150-, and 165-minute precipitation totals were then estimated using

log-log interpolation. An example of the development of the 1% chance cloudburst event for a subbasin is shown in Figures 2-9 and 2-10.

FIGURE 2-9. INTERPOLATED CLOUDBURST RAINFALL TOTALS - SB130 (VALLEY)

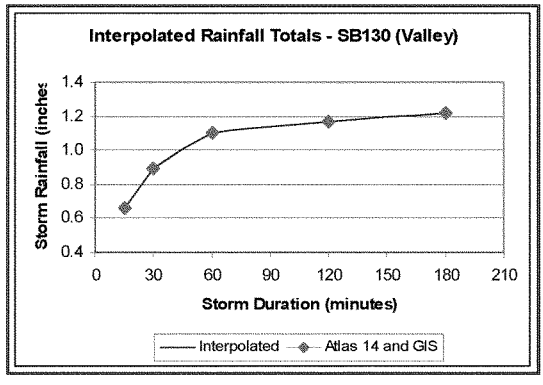
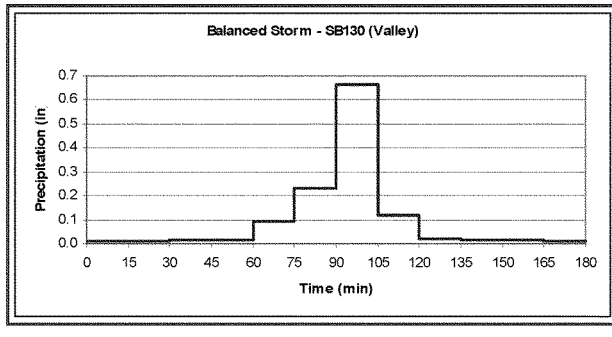


FIGURE 2-10. BALANCED CLOUDBURST STORM – SB130 (VALLEY)



2.7.2 General Rain

A 72-hour general rain storm based on the 1986 storm pattern was used for interior drainage for subbasins 405, 410, 415, 420, 425 and 517. The design storm was created in 1-hour increments of rainfall, although the HEC-1 model was run in a 5-minute timestep.

2.7.3 Depth Area Reduction for Both Cloudburst and General Rain Storms

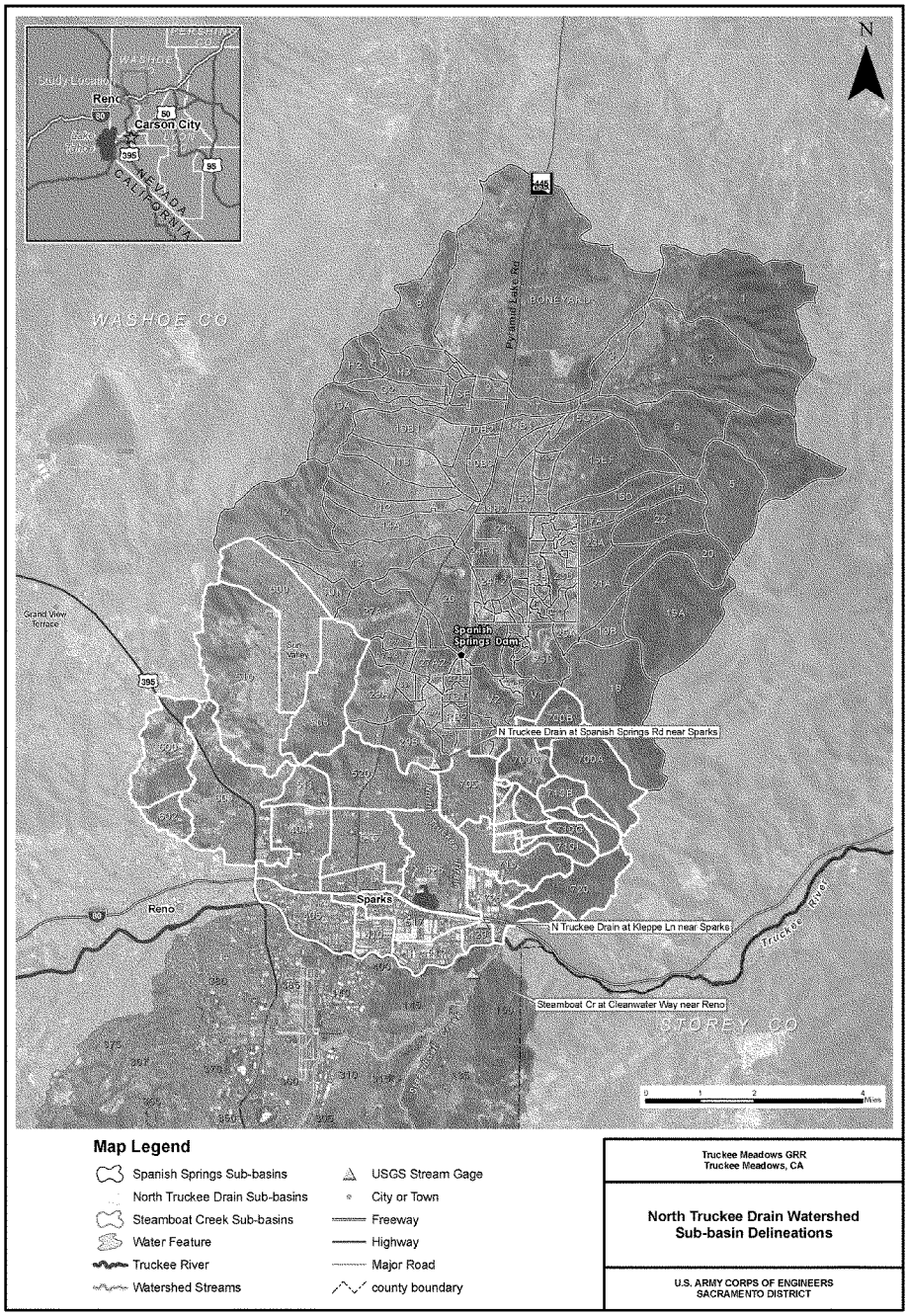
Point precipitation for subbasin 405 was adjusted with a depth area reduction factor for approximately 3 square miles (originally it was believed 404 flowed into subbasin 405). As this adjustment only decreases the point rainfall by 3%, the model was not re-run to use point precipitation. Point precipitation was used for subbasins 410, 415, 420 and 425. A minor ridge exists on the south side of subbasin 517 which confines the water to flow northwest towards People's Drain. HEC-1 model routings were not used on the south side of the Hwy 80. Hydraulic Design's FLO2D model covers this entire area. The hydrographs for subasins downstream of the freeway were split into smaller hydrographs and input into appropriate FLO2D cells for routing to model the floodplain. See the Hydraulic Appendix for results.

2.7.4 Results

Table 2-15 summarizes the peak flows and volumes for the five interior drainage subbasins for the cloudburst and general rainflood series. In all cases, the cloudburst flood peak flows are significantly larger than the general rainflood peak flows. Volumes for the general rainflood series are larger than the cloudburst volumes.

Table 2-15
Interior Drainage Results for Subbasins Next to Levees

Subbasin Abbrev.	405		410		415		420		425	
Drainage Area	2.93 sq.mi.		0.55 sq.mi.		0.69 sq.mi.		0.24 sq.mi.		0.21 sq.mi.	
Cloudburst Flood Series	Pk (cfs)	6-Hr Vol. (ac-ft)	Pk (cfs)	6-Hr Vol. (ac-ft)	Pk (cfs)	6-Hr Vol. (ac-ft)	Pk (cfs)	6-Hr Vol. (ac-ft)	Pk (cfs)	6-Hr Vol. (ac-ft)
20%	399	83	164	17	253	22	104	8	91	6
10%	488	96	205	19	313	25	129	9	115	7
2%	792	131	333	26	502	35	205	13	194	10
1%	966	151	405	31	611	41	251	15	240	12
0.50%	1,162	174	486	35	731	47	298	17	289	14
0.20%	1,494	220	624	44	935	59	381	22	373	18
Subbasin Abbrev.	405		410		415		420		425	
General Rainflood Series	Pk (cfs)	3-Day Vol. (ac-ft)	Pk (cfs)	3-Day Vol (ac-ft)	Pk (cfs)	3-Day Vol (ac-ft)	Pk (cfs)	3-Day Vol (ac-ft)	Pk (cfs)	3-Day Vol (ac-ft)
20%	127	92	51	30	68	42	27	18	24	18
10%	150	108	59	54	83	66	33	24	28	22
2%	206	149	82	72	120	96	47	36	39	30
1%	232	168	92	84	138	108	55	42	45	34
0.50%	260	188	103	90	154	120	60	48	49	37
0.20%	297	216	120	102	178	138	69	54	58	43



Map Legend

- Spanish Springs Sub-basins
- North Truckee Drain Sub-basins
- Steamboat Creek Sub-basins
- Water Feature
- Truckee River
- Watershed Streams
- USGS Stream Gage
- City or Town
- Freeway
- Highway
- Major Road
- county boundary

Truckee Meadows GRR
Truckee Meadows, CA

North Truckee Drain Watershed Sub-basin Delineations

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

JUN 2008 CHART 2-1

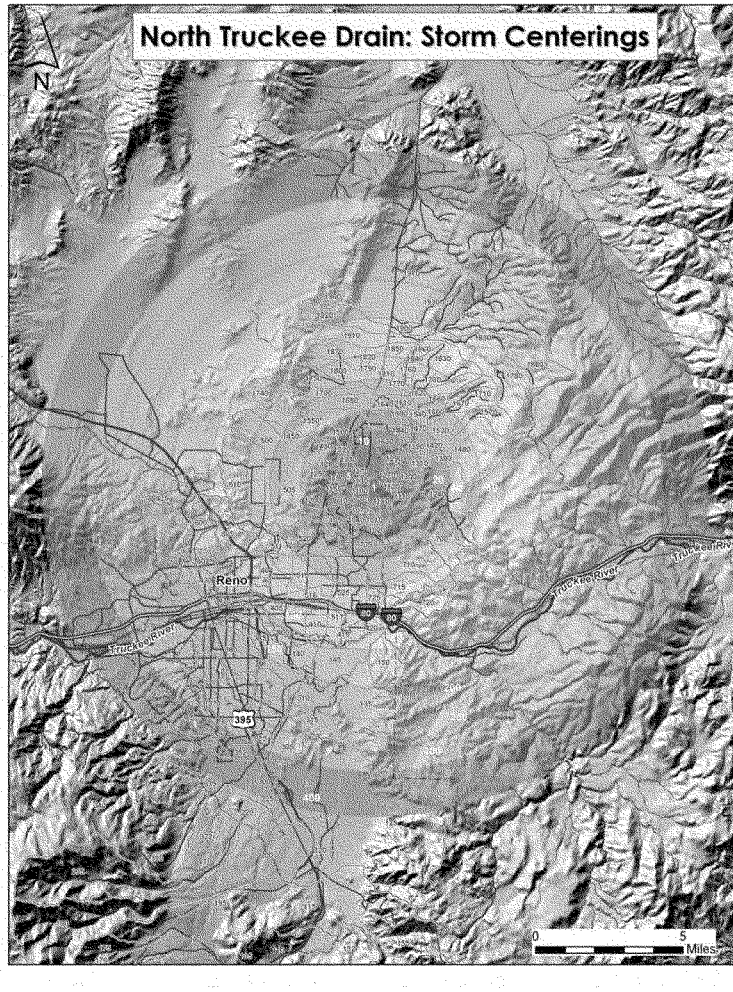

North Truckee Drain: Storm Centerings
N
Reno
Truckee River
Truckee River
395
0
5
Miles

Chart 2-2

3.0 Steamboat Creek

3.1 Study Area. This memorandum specifically addresses the runoff characteristics of the south side of the river in the Truckee Meadows Reach. The Steamboat Creek drainage is bounded by the Carson Range to the west and by the Virginia Range to the east. Steamboat Creek generally runs from south to north towards the Truckee River. Washoe Lake and Washoe Valley, an 85-square-mile watershed in the southernmost part of the watershed rarely contributes flow to Steamboat Creek. The large lake surface normally absorbs all the runoff during flood events and outflow is confined to a small weir-like structure with flashboards. The lake has to develop a significant head surface over the weir to be able to produce much outflow. The contribution from this part of the watershed during a 1% chance exceedence event on Steamboat is estimated to only be a couple hundred cfs. As in the 1980 Corps Study, this portion of the watershed was not modeled.

The southernmost tributaries on Steamboat Creek include Browns, Galena, and Bailey Canyon creeks. Flowing in from a more westerly direction are Whites and Thomas Creeks. Thomas Creek splits into two parts downstream of Last Chance Ditch. The majority of flow continues northeast and joins Steamboat Creek near the Huffaker Hills while the other split flows in a more northerly direction and connects with Boynton Slough. Dry and Evans Creeks are on the far northwest side of the watershed and once combined, form Boynton Slough. Boynton Slough passes through the airport area and connects with Steamboat Creek near the mouth of the entire watershed. The locally preferred plan includes a proposed dam at Huffaker Hills. Three streamgages exist in the watershed (Steamboat Creek at Steamboat, Steamboat Creek at Short Lane, and Steamboat Creek at Clean Water Way). A watershed map and the location of the proposed dam and existing gages are shown on Chart 3-1. The entire watershed extends up the slope of Mt Rose, which rises above 10,000 feet elevation and which has a significant winter snowpack. The summit of Mount Rose, elevation 10,776 feet, is the highest point in the watershed.

3.2 Historical Floods. The three largest floods of record on Steamboat Creek occurred in February 17th, 1986, January 1st, 1997, and December 31st, 2005. The flow records for these three events are shown below.

Peak Flows of Record on Steamboat Creek

Date of Peak	Steamboat Crk @ Steamboat (cfs)	Steamboat Crk @ Short Lane	Steamboat Crk@ Clean Water Way
02/17/86	3,600	5,600[1]	Not available
01/01/97	2,090	Not available	Not available
12/31/05	3,600	3,180	3,870

[1] This was an estimate based on slope-area measurements made by local officials

3.3 HEC-1 Models

The Steamboat Creek HEC-1 computer model was developed by MWH (Montgomery Watson Harza) for the U.S. Army Corps of Engineers. Subbasin unit hydrographs in the model were developed from S-curves derived from an analysis of the December 1955 and January-February 1963 flood events, presented in the Truckee River Hydrology Office Report dated February 1980 (Reference 5). The Steamboat Creek model does not include the Washoe Valley basin to the south, as Washoe Lake produces minimal outflow during large events. The original model also used SCS Curve Numbers for soil loss rates. The Corps attempted to calibrate the HEC-1 model to observed peak flows during the December 31st, 2005 flood event, but the resulting peaks were too high (at least by a factor of two). After the External Peer Review of the North Truckee Drain HEC-1 model, the Corps decided to change the model to the Green and Ampt Loss rate based on procedures found in the Maricopa County, AZ design manual. The model calibration worked better after this conversion.

3.4 Subbasin Delineation. The Steamboat Creek watershed was divided into numerous sub-watersheds or subbasins using topographic data and available information about existing drainage systems. Topographic data in digital format were collected for watersheds tributary to the Truckee River between Highway 395 and Vista. These data consisted of the following:

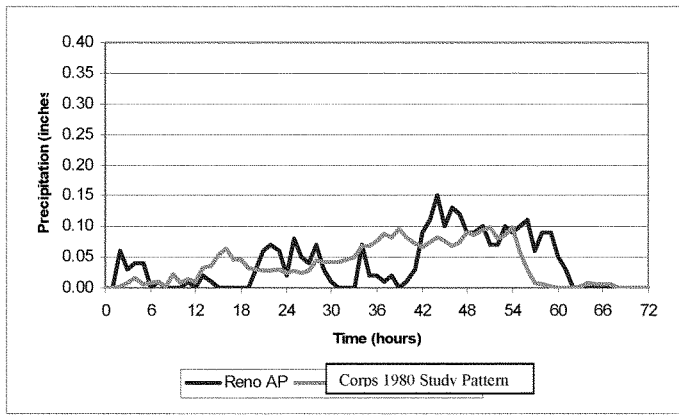
- List data from the USACE in the Truckee Meadows Project study area
- List data from Washoe County
- USGS 30-meter digital elevation models

The topographic layers were merged to form a continuous digital land surface. Subbasins were then automatically generated in a GIS environment using the digital land surface in combination with hydrographic line data. The subbasins were manually refined or adjusted, where necessary, to effectively represent the watersheds and account for drainage features not apparent on the digital land surface. Subbasin boundaries are shown in Chart 3-1.

3.5 General Rainflood. Six flood frequencies were evaluated in this study: the 20%, 10%, 2%, 1%, 0.5%, and 0.2% exceedence events. Precipitation data used in the HEC-1 model are based on partial duration NOAA Atlas 14 Depth Duration Precipitation Study which was completed in 2003. This study provides the most current annual, all-season precipitation frequency for this region. Spatial data files (point-rainfall isohyetal maps) were downloaded from the National Weather Service's Precipitation Frequency Data Server as geographic shapefiles. A major storm occurred in late January and early February 1963 on the upper Truckee River watershed. In the 1980 rainfall-runoff study of the Truckee Meadows tributaries (Reference 5), the Corps developed a design storm pattern for Steamboat Creek watershed based on the 1963 event. The Corps 1980 Study pattern could not be attributed to any specific gage, although it is believed to be a hybrid pattern based on a mix of mountain and valley precipitation gages. The 1980 Study precipitation pattern was adopted for this latest analysis. The pattern is illustrated in **Figure 3-1**, and the hourly rainfall distribution is tabulated in **Table 3-1**. The pattern storm was balanced to the 6-, 12-, 24-, and 48-hour depth duration frequencies in NOAA 14. The 3-hour depth found in NOAA 14 could not be used since cloudburst storms dominate this duration in the Reno area. Cloudburst storms have much higher intensities than winter general rains in this region.

Reference 14 was investigated for this reason. It was found that at higher elevations, cloudburst storms and winter storms depths did not differ as much as compared to lowland valleys; therefore, two separate ratios were derived. The analysis found that factors of 0.88 and 0.73 for mountain and valley, respectively, should be used to reduce the 3-hour cloudburst depths to an appropriate depth for general rainfloods. These ratios were derived by comparing "winter seasonal" against "annual" flow frequency depths found in Reference 14. The adjusted 3-hour depth from NOAA 14 was used to balance the design storm. Finally, a 72-hour depth was applied to the design storm pattern using a ratio of 1.04 times the 48-hour depth.

FIGURE 3-1 – JANUARY THRU FEBRUARY 1963 STORM PRECIPITATION DISTRIBUTION COMPARED WITH CORPS 1980 STUDY DESIGN STORM



Reno Airport Precipitation for the 29 January to 1 February 1963 Storm (46 Total Hours of Actual Precipitation).

Figure 3-1 above shows the Corps 1980 Study design storm, in violet color, compared with the observed rainfall recorded at the Reno Airport, in dark blue, for the 1963 storm event. Both patterns shown below have the same total rainfall, ~ 2.76 inches. Reno Airport had several periods of zero precipitation during the storm, while the design storm has more hours of continuous rainfall, appropriate for a watershed with higher elevation terrain and orographic effects.

3.6 Depth-Area Reduction Factors. The precipitation data obtained from NOAA is point precipitation, but since it is being applied to each subbasin area, it is necessary to use depth area reduction factors (DARFs) to reduce the intensity of the precipitation based on storm duration and the area over which it is being applied. The DARFs were applied to the general rainflood and cloudburst precipitation patterns for each subbasin prior to running the snowmelt and runoff models. Depth area reduction factors were taken from the Washoe County Flood Control Master Plan Meteorological Analysis (Hydmet, 1994). The DARF factors for durations 6-hour or

smaller in the Washoe County Report were found to be more applicable to cloudburst events; therefore, they were not used (see discussion on North Truckee Drain DARF). Therefore, only the 12-hour DARF was applied to the maximum 3-, 6-, and 12-hours of rainfall in the design storm.

TABLE 3-1
DEPTH AREA REDUCTION FACTORS

Rainfall Duration	DARF Equation	DARF 1 square mile	DARF 5 square miles	DARF 10 square miles	DARF 100 square miles
12-hour	.01*(100-2.6*Area^.46)	0.97	0.95	0.93	0.78
1-day	.01*(100-2.0*Area^.46)	0.98	0.96	0.94	0.83
2-day	.01*(100-1.5*Area^.46)	0.99	0.97	0.96	0.88
3-day	.01*(100-1.3*Area^.46)	0.99	0.97	0.96	0.89

3.7 Storm Centerings: Storms were based on a circular pattern with no maximum storm size. The storm was expanded outward until all subbasins in the HEC-1 model were covered. Two different storm centerings, or bullseyes, of the general rainstorm were developed for Steamboat Creek. One is the Huffaker Hills centering, with the bullseye in subbasin 200. The other centering, for Boynton – Steamboat, has its bullseye at the outlet of subbasin 345. The purpose of the Huffaker Hills centering is to create high peak flows for inflow to the potential Huffaker Hills flood detention facility. The purpose of the Boynton Slough centering is to create high peak flows on the Boynton Slough tributary to Steamboat Creek. Chart 3-2 graphically shows the storm bullseye for the Boynton Slough Centering. Chart 3-3 shows the location of the bullseye for the Huffaker Hill centering. The subbasins that were the bullseye for each centering are listed below.

STORM CENTERINGS

Storm Type	Centering Name	Abbrev-iation	Subbasin on which Storm is Centered	Corresponding Flow Output Node (HEC-1 Concentration Point)
	Boynton Slough	BOY	Intersection of 335, 345, 350, and 352	C360
	Huffaker Hills	HH	200	C130B

3.8 Snowmelt Analysis. Snowmelt on the eastern slopes of the Sierra Nevada Mountains can have a significant effect on runoff during winter and spring storm events. For this reason, precipitation for the general rainflood was processed prior to use in the HEC-1 model using a separate computer program to incorporate runoff from rain-on-snow events. The Corps Sacramento District developed the SNOW model for the purpose of calculating runoff for rain-on-snow conditions. The model performs a water-budget analysis to track water in an antecedent snowpack until it is released, using the concept of threshold density to estimate the shrinkage of

the snowpack as rainfall occurs. The SNOW model output for each subbasin is used as the precipitation input for the HEC-1 model. The SNOW model produces rainfall output at the computation timestep that is required for input to the HEC-1 model. As happens in nature, the SNOW model may determine a net loss from the initial precipitation falling on a subbasin due to retention by the snowpack. On the other hand, the computed net rainfall can significantly increase in some subbasins, with the addition of "melt" from a ripe snowpack.
Precipitation is computed for different elevation zones according to EM 1110-2-1406 using the following input:

- Basin exposure and canopy cover
- Mean basin precipitation
- Average air temperature and wind velocity per time interval
- Initial snow depth and density
- Threshold density.

Development of precipitation input for the SNOW model included the following steps:

1. 72-hour general rainflood precipitation events were constructed for each flood event and subbasin, as discussed previously in this chapter.
2. In a GIS environment, each subbasin was divided into1000-foot elevation band areas.
3. For each elevation band in each subbasin, 48-hour precipitation totals were calculated in GIS using the NOAA Atlas 14 spatial data.
4. 72-hour precipitation totals were estimated by multiplying the 48-hour precipitation total by a scaling factor of 1.04.
5. Wind from the Reno Airport gage for the 1963 storm was extrapolated by adding 2 mph in wind speed for each 1000-foot increase in elevation band, such that each elevation band in the watershed was accounted for.
6. The temperature lapse rate was set to -2.7 degrees F per 1000-foot elevation change. The program default is -3 degrees F. This lapse rate was derived by comparing the difference in daily minimum temperature (night-time low) recorded at Bald Mountain and the Reno Airport for the two heaviest days of precipitation during the 1963 storm.

DARFs were applied to the precipitation patterns prior to being input to the SNOW program. The revised general rainflood precipitation events calculated by SNOW for each subbasin were output to DSS, ready for direct input to the HEC-1 model.

The SNOW model requires specification of initial conditions for snow depth and snow water content by elevation zone. To develop this data, an investigation was performed to determine appropriate snowpack parameters for the 1% chance winter flood for watersheds in Washoe County. Historic data indicated that the largest winter floods resulting from high-elevation rain-on-snow occurred from late December through mid-February. All of these events were associated with strong southwest tropical moisture influx ("the pineapple express") with resulting warm temperatures and freezing levels above 10,000 ft. However, watershed response and storm

event snowpack data indicated that there were minimal runoff contributions above 7,000-7,500 feet elevation because existing snowpack melted slower and remained intact after the maximum precipitation period of the storms. Further, existing snowpacks significantly delayed and attenuated runoff due to transitory snowpack liquid water storage and because they impeded vertical and overland flow. The critical elevation zone for flood runoff was identified between 5,000 and 7,000 feet, where snowpacks melted nearly entirely during the flood events. The most critical initial snowpack condition for the design flood would likely occur during the earliest dates (i.e., January 1st), when the least snowpack would be expected. The NRCS database was accessed for all snow survey and snow sensor records in western Nevada and the Tahoe region. Two types of records were available:

(1) Monthly snow surveys for all sites on or near March 1st and April 1st, with more sporadic measurements for February 1st and January 1st, and

(2) Continuous measurements of snow water content for the entire winter and spring using telemetered snow pillows.

Table 3-2 lists long-term average snow survey data for sites in western Nevada and the Truckee River/ Carson River drainages.

The snowpack data were graphed with site elevation compared to snow water content. Relationships were estimated from the graphs for average snow depth and snow water content for January 1, February 1, March 1 and April 1. **Table 3-3** shows relationships for the Carson Range and relationships for the remainder of the study area. The February 1 relationships were used in the SNOW model as the most likely critical conditions for a winter rain-on-snow event. Modeled subbasins were assigned initial snow conditions for either the Carson Range or Washoe Valley depending upon their location in the watershed and maximum basin elevation.

In the South Area, model simulations indicated that the snowpack in the higher watershed elevations absorbed rainfall, decreasing rather than increasing runoff from these subbasins. As anticipated, the most significant contribution to runoff from rain-on-snow occurred in the 6,500 – 7,500 foot elevation range, where the snowpack was moderate and temperatures warm enough to allow snowmelt to occur. Overall, snowmelt contributed very little to runoff in the upper watersheds.

TABLE 3-2
LONG-TERM AVERAGE SNOW SURVEY DATA
(Note: SWE = Snow Water Equivalent, the amount of water contained within the snowpack)

Station Name	Elevation	Latitude Degrees	Longitude Degrees	January 1st		February 1st		March 1st		April 1st	
				Depth	SWE	Depth	SWE	Depth	SWE	Depth	SWE
Nevada Snow Data (Carson Range)											
Bald Mt.	6720	41.78	-119.62			10	2.8	11	3.3	8	2.7
Big Meadow Snowtel	8300	39.45	-119.95		7.4		12.1		18.2		21.2
Big Meadows	8300	39.45	-119.95	32	8.4	45	13.1	60	21.3	65	28.4
Clear Creek	7300	39.12	-119.90	10	1.8	27	7.4	34	10.9	29	10.9
Forty Nine Mtn.	6000	41.57	-119.82			13	3.4	13	3.6	8	2.7
Glenbrook #2	6900	39.08	-119.92	15	3.7	27	7.7	34	10.5	34	11.9
Hays Canyon	6400	41.30	-119.82			11	2.7	11	3.2	6	2
Little Bally Mt - Aerial	6000	41.57	-119.82			10	2.7	11	3.3	7	2.5
Little Valley	6300	39.25	-119.88		1.3	18	4.1	21	7.4	17	6.4
Marlette Lake	8000	39.15	-119.90	40	10.5	46	13.8	58	20.1	57	22.6
Mount Rose	9000	39.35	-119.88	37	11.7	51	17.7	75	28	79	33.6
Sheldon Snotel	5860	41.90	-119.45		0.5		0.7		0.9		0
Nevada Snow Data (117W-119W)											
Buckskin, Lower Snotel	6700	41.75	-117.53		4.1		6.3		8.3		8.2
Buckskin, Upper	7200	41.78	-117.53			18	6	27	9.2	27	10.5
Disaster Peak	6500	41.97	-118.20			25	8.6	37	13.7	28	11.2
Disaster Peak Snotel	6500	41.97	-118.20		4.7		7.3		10.8		8.3
Golconda #2	6560	40.90	-117.57	21	2.4	22	5.7	19	5.7	10	3.7
Granite Peak	7800	41.65	-117.40			38	11.4	38	12.6	44	15.3
Granite Peak Snotel	7800	41.65	-117.53		9.5		14.3		16.9		20.8
Martin Creek	6700	41.68	-117.53		6.1	26	7.1	28	8.8	25	9
Quinn Ridge AM	6300	41.00	-117.00		1.8	8	1.9	7	2.3	3	0.9
California Snow Data (Tahoe Region)											
Heavenly Valley	8800	38.92	-119.92	38	11.2	55	17.6	72	25.1	73	28.1
Freel Bench	7300	38.50	-119.95	20	5.2	29	8.9	33	11.5	27	10.7
Hegans meadow snotel	8000	38.85	-119.93		6.4		10.8		15.2		15.8
Boca # 2	5900	39.38	-120.09			19	5.2	20	6.8	11	4.5
Tahoe City Cross Snotel	6750	39.17	-120.15		6.1		10.3		13.4		10.4
Brockway Summit	7100	39.26	-120.07	22	6.5	39	12.1	45	15.6	43	16
Independence Creek	6500	39.49	-120.29	15	4.4	29	8.5	35	11.7	33	12.9
Fallen Leaf Snotel	6300	38.93	-120.05		3		5.1		6.4		2.9

TABLE 3-3
DESIGN FLOOD INITIAL SNOWPACK CONDITIONS
(Note: SWE = Snow Water Equivalent, the amount of water contained within the snowpack)

CARSON RANGE, WASHOE COUNTY, NEVADA								
	Average Snowpack Conditions (inches)							
Elev.	Jan 1st		Feb 1st		Mar 1st		Apr 1st	
(feet)	Depth	SWE	Depth	SWE	Depth	SWE	Depth	SWE
5500	2	0.4	5	1	5	1	2	0.5
6500	11	2.5	17	3.5	19	5	15	5
7500	21	5	33	8	37	11	32	12
8500	32	9	48	14	61	21	60	23
9500	46	14	69	22	90	35	97	42

WASHOE VALLEY EXCLUDING CARSON RANGE								
	Average Snowpack Conditions (inches)							
Elev.	Jan 1st		Feb 1st		Mar 1st		Apr 1st	
(feet)	Depth	SWE	Depth	SWE	Depth	SWE	Depth	SWE
5500	0	0	0	0	0	0	0	0
6500	2	0.4	2	0.4	2	0.4	2	0.4
7500	11	2.5	12	3	18	4	20	5
8500	23	5.5	27	6.5	35	8	32	9
9500	42	12	42	12	60	15	64	20

3.9 Soil Loss and Land Use Parameters.

3.9.1 **Soil Type, Land Use, and Cover**. Digital soil data were downloaded from an NRCS website. Land use data, provided by Washoe County, covered the entire study area. The land use data included numerous development categories, which were consolidated into eleven cover categories for the purpose of this study. Land uses were altered to reflect current development in the study area as indicated by aerial photography from 2000. The consolidated land use categories, with associated percent impervious, initial loss, and vegetation cover, are listed in **Table 3-4**. The derived XKSAT values (constant loss rate) for some subbasins were adjusted in later model calibration runs. A discussion of this calibration is discussed in Section 3.12, Model Verification.

Basin n values, used in the calculation of lag (Los Angeles S-graph method), are also shown in **Table 3-4.** These basin n values were adopted from the *Sacramento City/County Drainage Manual*, 1994 (Reference 31). Acreage of each land use was extracted for each subbasin using ArcView. Composite values for initial loss, percent impervious, vegetation cover, and basin n value were determined for each subbasin using the ArcView land use data.

TABLE 3-4
LAND USE CATEGORIES AND CORRESPONDING DATA

Description of Land Use	Percent Imper-Vious	N value	Initial Loss (IA)	Vegetation Cover
			(inches)	in %
Pasture - heavily grazed	5%	0.075	0.30	30%
Parks - fair grass cover	5%	0.070	0.30	60%
Parks – good grass cover	5%	0.070	0.30	80%
Major Highways	90%	0.030	0.10	0%
Commercial – Business	85%	0.031	0.10	75%
Industrial	72%	0.032	0.12	70%
Residential - 1/8 acre lots	65%	0.037	0.20	65%
Residential - 1/4 acre lots	38%	0.042	0.25	50%
Residential - 1/2 acre lots	25%	0.060	0.25	50%
Residential - 1 acre lots	20%	0.073	0.30	50%
Water Bodies	100%	-	0.00	0%

3.9.2 <u>Green & Ampt Loss Parameters</u>. The Green & Ampt loss method uses the following parameters in the HEC-1 model:

IA – initial loss in inches, primarily a function of land-use and surface cover (see Table 3-4). Zero rainfall excess is generated until the initial loss is satisfied.

DTHETA – volumetric measure of the soil moisture storage capacity available at the start of the storm (dry, normal, or saturated soil conditions).

PSIF – Wetting front suction in inches.

XKSAT – hydraulic conductivity at natural saturation in inches per hour.

RTIMP – percent impervious (see Table 3-4).

The parameters, DTHETA, PSIF, and XKSAT, are functions of soil characteristics, ground surface characteristics, and land management practices. The primary soil surface characteristics are vegetation canopy cover, ground cover, and soil crusting. Land management practices effect soil porosity. The parameters for bare ground are dependent on soil type, as tabulated in Table

3-5, below. The Corps used the DTHETA values for a normal antecedent soil moisture condition.

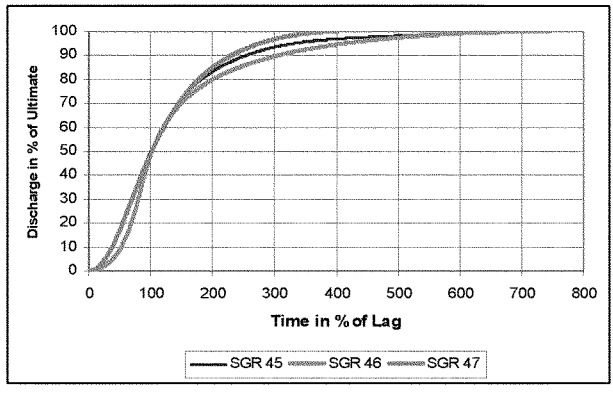
TABLE 3-5
GREEN & AMPT LOSS RATE PARAMETER VALUES FOR BARE GROUND

Soil Classification	XKSAT (in/hr)	PSIF (in.)	DTHETA		
			Dry	Normal	Saturated
A1 loamy sand & sand	1.20	2.4	0.35	0.30	0.00
A2 sandy loam	0.40	4.3	0.35	0.25	0.00
B1 loam	0.25	3.5	0.35	0.25	0.00
B2 silty loam	0.15	6.6	0.40	0.25	0.00
B3 silt	0.10	7.5	0.35	0.15	0.00
C sandy clay loam	0.06	8.6	0.25	0.15	0.00
D1 clay loam	0.04	8.2	0.25	0.15	0.00
D2 silty clay loam	0.04	10.8	0.30	0.15	0.00
D3 sandy clay	0.02	9.4	0.20	0.10	0.00
D4 silty clay	0.02	11.5	0.20	0.10	0.00
D5 clay & rocky outcrop	0.01	12.4	0.15	0.05	0.00

The drainages in Washoe County are a mixture of several different soil types, so composite values for the Green & Ampt parameters need to be determined for each subbasin. The procedure to determine the subbasin composite value of XKSAT is to average the area-weighted logarithms of the XKSAT values of each soil type in that subbasin. The corresponding subbasin composite values for PSIF and DTHETA parameters are based on the subbasin XKSAT as determined from a graph (Figure 4.3 in the Maricopa County Design Manual). A final adjustment of the composite XKSAT is made based on subbasin percent vegetation cover.

3.10 Hydrograph Development. The computer program SACPRE, a pre-processor to HEC-1, was used to develop unit hydrographs using the Corps S-graph method. An S-graph is not a unit hydrograph; it represents the hydrologic response of a basin to a rainfall event of infinite duration. The curve has a rising limb with a characteristic S-shape that eventually reaches a constant discharge rate equal to the constant excess rainfall rate multiplied by the area of the basin. An S-graph **(Figure 3-2)** is constructed from a series of unit hydrographs of length T by the process of successive lagging by T and summing the discharge values (ordinates). The beauty of the S-graph method is that one can derive unit hydrographs for events of any desired duration from them. The Corps Sacramento District developed three S-curves a mountain general rain S-graph (SGR 45), a mountain cloudburst S-graph (SGR 47) and a valley general rain and cloudburst S-graph (SGR 46), specifically for use in the Truckee Meadows area **(Table 3-6).** The S-graphs were developed for the 1980 Truckee River Study (Ref. 5).

FIGURE 3-2 – TRUCKEE MEADOWS AREA S-GRAPHS



The computer program SACPRE, originally developed by the Corps Los Angeles District as LAPRE-1, was used as a pre-processor to HEC-1 to produce unit hydrographs for each subbasin based on the drainage area, basin lag, and chosen S-graph.

TABLE 3-6
S-CURVES FOR THE TRUCKEE MEADOWS AREA

SACPRE Description	Curve No.
Truckee Meadows: Mountain General Rain	45
Truckee Meadows: Valley General Rain & Cloudburst	46
Truckee Meadows: Mountain Cloudburst	47

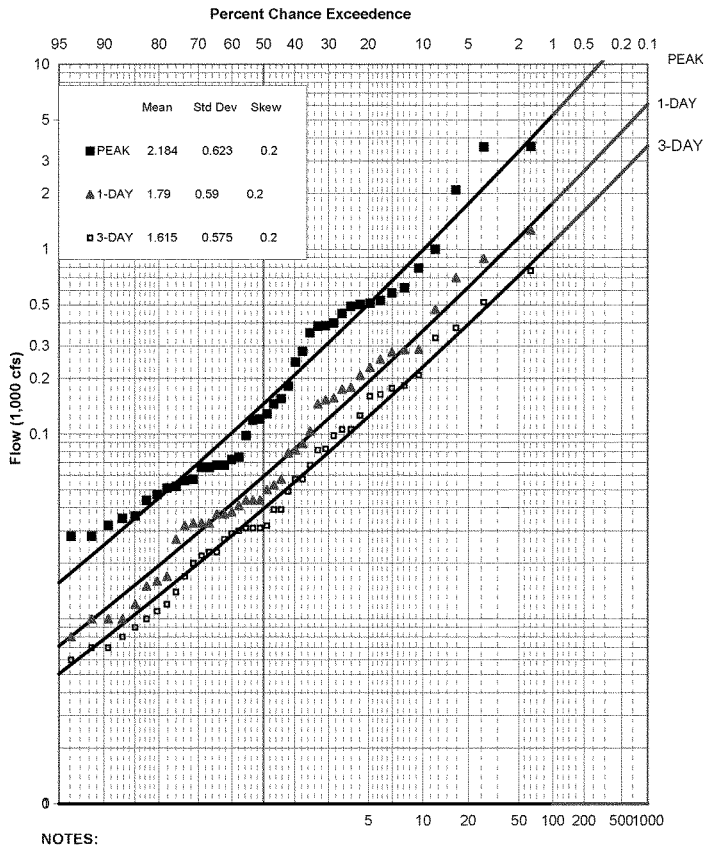
3.11 Routing Parameters. Once rainfall has turned into runoff and flowed to the outlet point for a subbasin, it is necessary to combine this flow with upstream subbasin flows. The combined flow hydrograph is then routed through stream and drainage channels to the next subbasin outlet. There are a number of hydrologic routing techniques available in the HEC-1 program, such as Muskingum, Modified Puls, Muskingum-Cunge, and Kinematic Wave. While any of these techniques may be used, routing techniques were generally applied to this study as described below, based on a number of sources:

- 1983 Corps HEC-1 model (Muskingum and Modified Puls)
- Information from local government and their consultants (Muskingum and Muskingum-

Cunge)
• Determination of travel time and attenuation developed for this study (Muskingum)
• Channel routing information from Corps HEC-RAS models of Steamboat Creek

3.12 Model Verification. An attempt was made to calibrate the HEC-1 model to the 2005 flood event, but the results were not conclusive due to the fact that the runoff at the Geiger Grade and Short Lane locations spread out laterally into the overbanks and away from the main channel profile, potentially causing the flow to run around the gage and making the flow measurements too low. It is also notable that the peak flow upstream at Steamboat was 3,600 cfs while the peak flows recorded farther downstream at Geiger Grade and Short Lane were around 3,000 cfs, despite a significant increase in drainage area. To calibrate the HEC-1 above the Steamboat Creek at Steamboat gaging station, a 1% chance design storm was centered above the gage. The XKSAT in the HEC-1 model was adjusted uniformly by a ratio until the resulting hydrographs had a good match with the 1% chance exceedence peak flow frequency curve. To achieve this fit, the original XKSAT parameters in each subbasin were reduced to 29% of their original values. Figure 3-3 shows the Steamboat at Steamboat Creek frequency curve. The gage record is 44 years in length. The statistics were derived by running the period of record data through the Regional Frequency Program (RegFreq).

During the 1986 flood event, the peak flow at Steamboat Creek at Steamboat was recorded as 3,600 cfs. The estimated peak flow at the Steamboat Creek at Short Lane (site of the proposed Huffaker Dam) was 5,600 cfs. This results in a downstream to upstream ratio of approximately 1.6 times the upper gage runoff. The 1986 storm event provides a good indication of the runoff potential from the lower part of the watershed. The XKSAT values for the subbasins between the Steamboat Creek at Steamboat gage and the Huffaker damsite were adjusted until the upstream to downstream peak flow attained a ratio of 1.62 for the 1% chance, storm centered above Huffaker Dam. This caused the XKSAT values to be adjusted to 36% of their original values that were based on soil characteristics. As no other information was available, the subbasins that contribute runoff downstream of the Huffaker Dam site were calibrated for the December 31st, 2005 event based on the additional flow runoff that occurred between the Steamboat Creek at Short Lane and Steamboat Creek at Clean Water Way gage. This resulted in using 90% of the original XKSAT values for the subbasins downstream of the Huffaker Dam site.



NOTES:

1. WY1962 -2005, 44 years = record length
2. Median plotting positions
3. Drainage area 123 sq. mi.
4. USGS Gage No. 10349300
5. Snowmelt & rainflood combined, stats similar to rainflood only analysis
6. FFA runs determined no low outliers
7. Adopted Stats from Regfreq output

FLOW FREQUENCY CURVES

STEAMBOAT CRK AT STEAMBOAT, NV
TRUCKEE RIVER

WATER YEARS 1962-2005

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

FIGURE 3-3

TABLE 3-7
COMPARISON OF STEAMBOAT AND SHORT LANE FLOWS FOR 1986 AND 2006 FLOODS AND THE 1% GENERAL RAINSTORM HUFFAKER HILLS CENTERING

Event	"At Steamboat" flows (cfs)			Flow Ratio:
1% General Rain Huffaker Hills Centering	Computed Flows (cfs)	Frequency Curve Flows (cfs)	Short Lane Computed Flows (cfs)	Short Lane to "at Steamboat"
1% peak flow	3,990	5,310	6,450	1.62
1% 1-day volume	1,710	1,780	3,500	2.05
1% 3-day volume	660	1,090	1,410	2.14
Feb 1986 flood	"At Steamboat"		Short Lane	
peak flow (obs. or est.)	3,600		5,600	1.56
Dec 2005 flood	"At Steamboat"		Short Lane	
peak flow (observed)	3,600		3,180	0.88
1-day volume (observed)	860		1,450	1.69
2-day volume (observed)	480		930	1.94

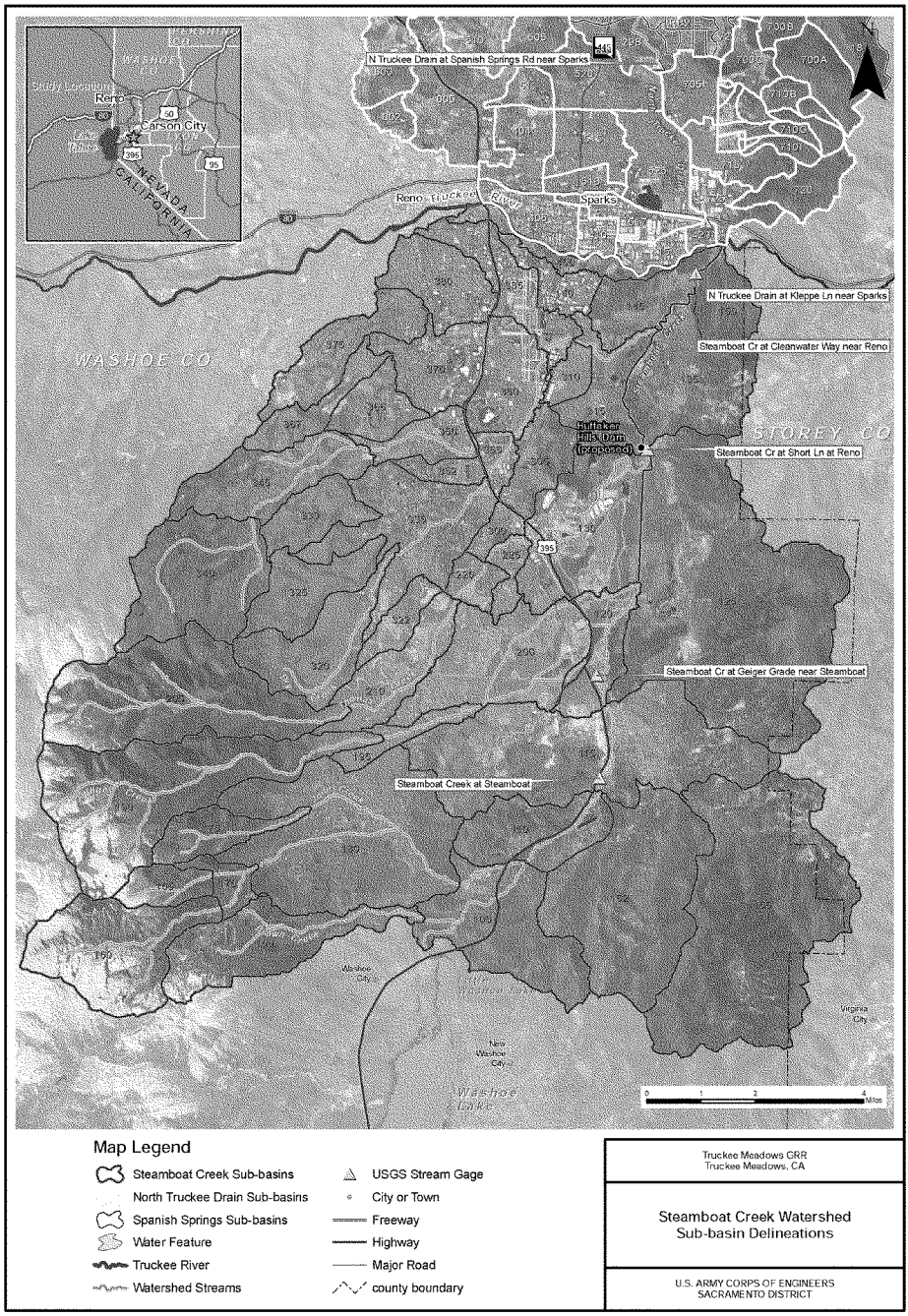
Note: Volumes are in day-cfs

3.13 Summary of Results. Table 3-8 summarizes simulated peak flows (in cubic feet per second) for the general rain flood series for the Boynton Slough and the Huffaker Hills centerings. The model assumes that the hydrographs on Steamboat Creek remain in-channel as they move downstream.

TABLE 3-8
SUMMARY OF SIMULATED PEAK FLOWS FOR THE GENERAL RAIN FLOOD SERIES

Location	PEAK FLOWS (CFS) Exceedence Frequency					
	20%	10%	2%	1%	0.50%	0.20%
BOYNTON SLOUGH CENTERING						
Steamboat Creek:						
At Steamboat	300	700	2,100	2,690	3,710	5,160
At Short Lane	740	1,230	3,720	4,500	5,600	7,600
At Mouth	1,730	2,180	5,170	6,480	8,280	10,500
Boynton Sl. at mouth	1,170	1,370	2,180	2,660	3,580	4,770
HUFFAKER HILLS CENTERING						
Steamboat Creek:						
At Steamboat	510	1,080	3,260	3,990	5,230	7,020
At Short Lane	980	1,780	5,200	6,450	8,260	10,700
At Mouth	1,770	2,540	6,340	7,710	9,950	13,100
Boynton Sl. at mouth	1,010	1,190	1,890	2,300	3,120	4,200

Note: Steamboat Creek at Short Lane is the same location as Huffaker Hills Damsite



Map Legend

- Steamboat Creek Sub-basins
- North Truckee Drain Sub-basins
- Spanish Springs Sub-basins
- Water Feature
- Truckee River
- Watershed Streams
- USGS Stream Gage
- City or Town
- Freeway
- Highway
- Major Road
- county boundary

Truckee Meadows CRR
Truckee Meadows, CA

Steamboat Creek Watershed
Sub-basin Delineations

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

JUN 2008 CHART 3-1

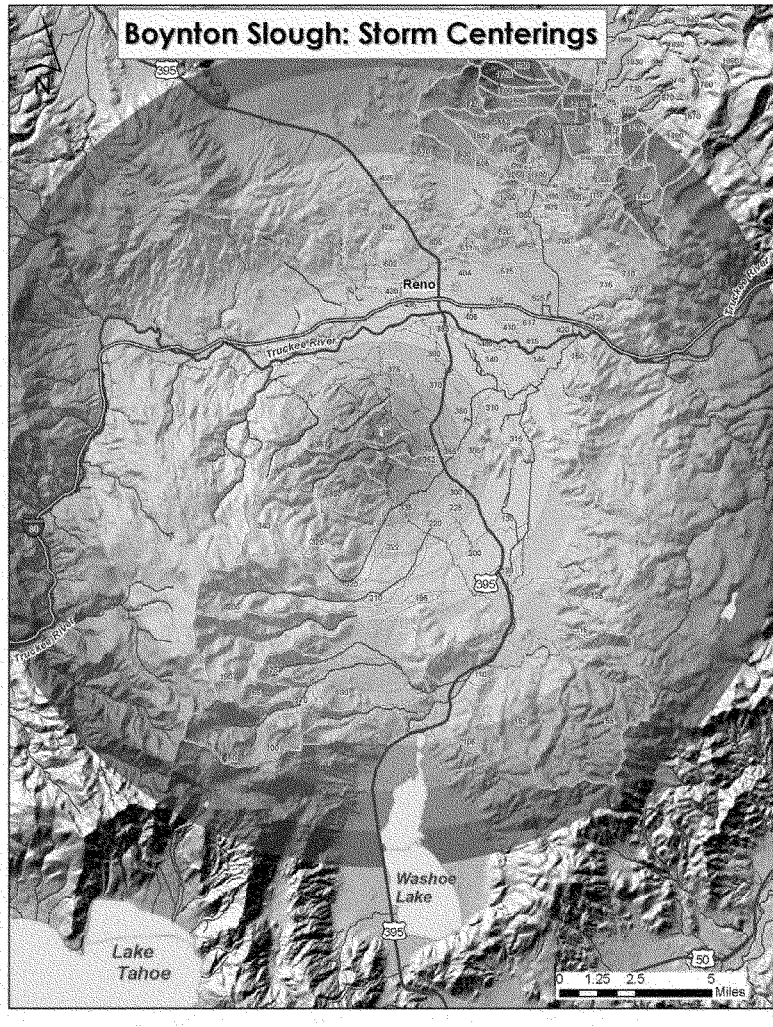

Boynton Slough: Storm Centerings
Reno
Truckee River
Truckee River
Truckee River
Washoe Lake
Lake Tahoe
395
395
395
50
0 1.25 2.5 5 Miles

Chart 3-2

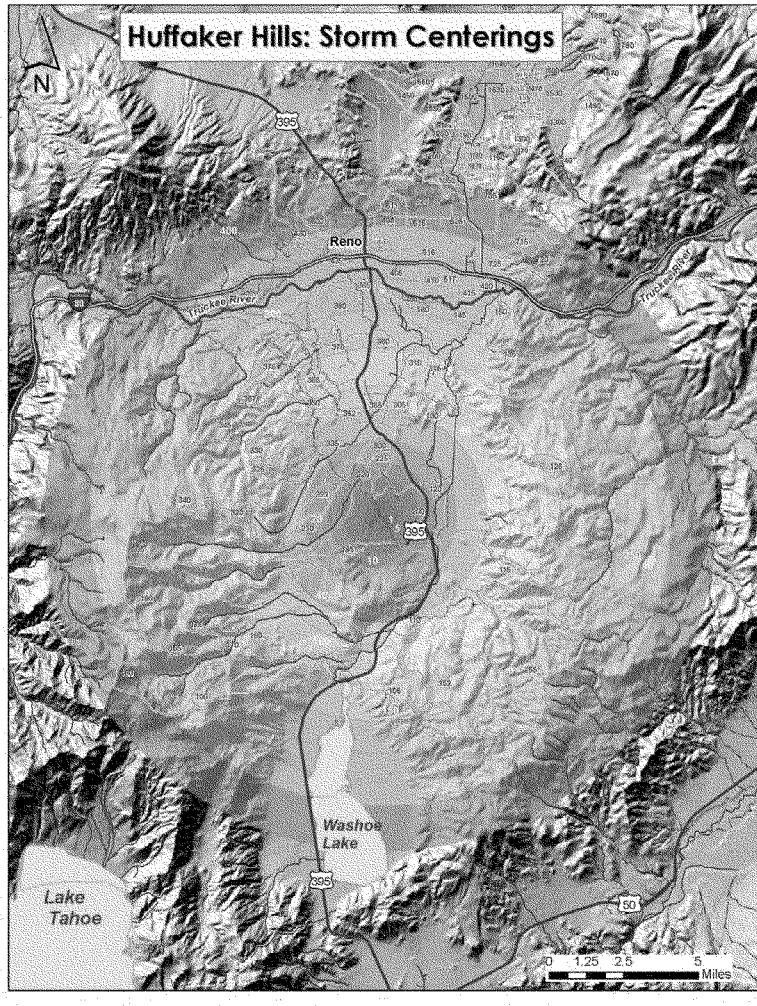

Huffaker Hills: Storm Centerings
N
395
Reno
Truckee River
Washoe Lake
Lake Tahoe
50
0 1.25 2.5 5
Miles

Chart 3-3

4.0 Probable Maximum Flood for Huffaker Dam

4.1 Introduction. The proposed Huffaker Dam was designed to decrease the flow downstream of Vista for rare events. Following Corps criteria, the dam needs a spillway that can safely pass a Probable Maximum Flood (PMF) without overtopping. Another goal is to minimize flooding behind the dam for rare floods approaching the PMF event. This section describes the development of the probable maximum flood for this dam. Due to time constraints, a few shortcuts were taken in following HMR 49 guidelines; however, it is believed that the product developed is sufficient for a Feasibility Level analysis of cost and performance. If this study should go into the P.E.D. phase with Huffaker Dam as part of the approved project, the PMF flood analysis should be refined to completely follow HMR 49 guidelines. The actual modeling and routing of the PMF through the proposed dam structure was accomplished by Hydraulic Design Section. Please see Attachment B-Hydraulics for details on the routing and resulting water surface elevations. The criteria for this region is covered in Hydrometeorological Report No. 49 (HMR 49) dated September 1997. It applies to the Colorado River and Great Basin drainages. The entire watershed above Huffaker Hills, including Washoe Lake is 194 square miles. The drainage area above the Washoe Lake outlet is 84 square miles. Washoe Lake itself covers approximately 25% of the watershed above the outlet of the dam. The outlet to Washoe Lake is a small weir with optional flashboards, which provides an enormous amount of surcharge space in the lake due to the minimal outflow capacity. Outflow capacity is directly related to the depth of the water (head) over the weir. Two separate HEC-1 models were used to model the watershed above and below Washoe Lake. Chart 3-1 shows a basin map, with the location for the proposed Huffaker Hills Dam.

4.2 Probable Maximum Precipitation (PMP). A general rain event was used for this watershed, since that is the type of event that will create the largest PMF hydrograph. Based on guidance in HMR 49, the general rain storm PMP is 72 hours long and has two components, orographic (precipitation affected by terrain) and convergence (precipitation from atmospheric processes not affected by terrain). The PMP was computed for each component for the month of interest, January. The storm has two components. Each component (orographic and convergence precipitation) was adjusted for drainage area and intermediate time durations (6-, 12-, 18-, 24-, 48-, and 72-hours). When completed, the separate components were added together to create a winter general-storm PMP. The resulting Washoe basin 72-hour storm total is 13.51 inches of precipitation, while the lower Steamboat watershed between the outlet of Washoe Lake and the Huffaker Dam site is 12.72 inches. The table below provides the values for various depth-durations. Figures 4-1 and 4-2 show the hyetograph used for the upper and lower portions of the watershed, based on HMR 49 guidelines.

Table 4-1. PMF Storm Precipitation in HEC-1 Models

HEC-1 Model	Incremental Increase in Precipitation Per Duration						
	6-hr	12-hr	18-hr	24-hr	48-hr	72-hr	Storm Total
Washoe Lake	3.25	2.11	1.50	1.22	3.51	1.91	13.51
Lower Steamboat Crk	3.07	1.99	1.41	1.14	3.29	1.81	12.72

The goal of this effort was to produce a conservatively large PMF that would not likely be exceeded. A full analysis of storm distribution patterns, including those for different seasons of the year, was not completed due to time constraints; however, it is believed that the January PMF will result in the highest flows.

Normally, precipitation is spatially distributed according to elevation and orographics. Instead, one hyetograph was developed for all subbasins in the Washoe Lake HEC-1 model, and another hyetograph was developed for all subbasins in the lower Steamboat Creek model. The storm depth of the PMP hyetograph used in this analysis was designed to be an approximate average for the whole watershed area being modeled.

Two hyetograph patterns were tested, although ultimately, only one was used. One test used the pattern for the all-season PMF (winter months) for French Meadows Dam on the middle fork of American River watershed. The watershed ranges from 5,200 to 9,000 feet elevation, whereas Steamboat Creek ranges from 4,400 to a little over 10,000 feet. The watershed is directly west of the Truckee River watershed, on the west slope of the Sierras. The resulting PMF had a smaller peak and volume than the final adopted one. The adopted pattern was based on Standard Project Flood found in the report Standard Project Rain-flood Criteria, Sacramento-San Joaquin Valley, California, 1972. The most intense 72-hours of this 96-hour storm were utilized for the pattern. The final hyetographs used for each HEC-1 model are shown in Figures 4-1 and 4-2. Since the largest historic floods on the Truckee River are the result of pacific storms moving east over the Sierra Mountains, the adoption of this pattern seemed reasonable.

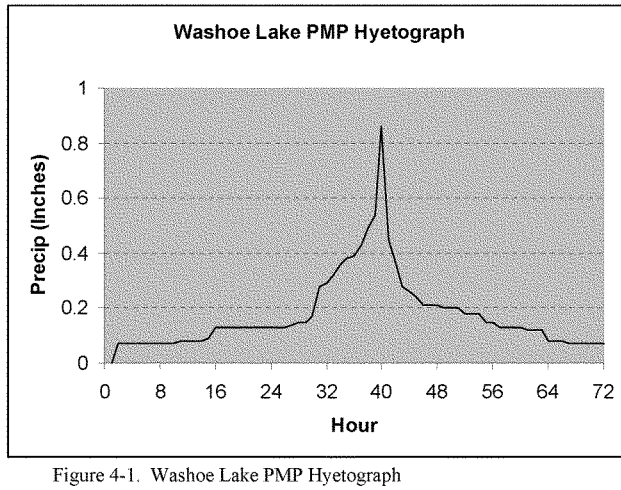


Figure 4-1. Washoe Lake PMP Hyetograph

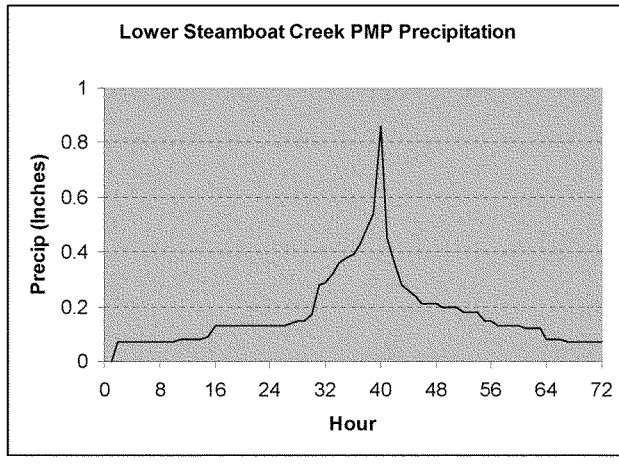


Figure 4-2. Lower Steamboat Creek PMP Hyetograph

4.3 Snowmelt Contribution. Snowmelt models had previously been developed for lower Steamboat Creek, below Washoe Lake, as discussed in Part IV, Section 3.8 of this report. The models include an initial snowpack, one for the higher elevation east-facing subbasins of the Carson Range and one for the west-facing subbasins of the Virginia Range. This snowmelt model, including initial snowpack conditions, was adopted to simulate snowpack melt during the PMF on lower Steamboat Creek. The initial snowpack conditions represent an average snowpack for the basin, based on an average of all 1st of February snowpacks for the period of record of the snow gages. To save time, the winds and temperatures used in the SNOW Model for the Steamboat Creek PMF were adopted from the PMF analysis for French Meadows Dam on the west slope of the Sierras. Both higher winds and higher temperatures increase the amount of snowmelt. The winds and temperatures used in this analysis are expected to be conservatively high for Steamboat Creek.

There is currently no snowmelt model for the watershed above Washoe Lake and time was not available to develop one. To account for potential snowmelt, the soil loss rates for the pervious areas in the Washoe Lake HEC-1 model were modified to 0.02 inches per hour constant loss, as compared to 0.05 inches per hour for lower Steamboat Creek. Washoe Lake itself was considered impervious (zero losses) since it is covered with water. A full 25% of the Washoe Lake watershed is covered by water. The computed PMF outflow from Washoe Lake for this analysis was found to be only 340 cfs, even though the inflow hydrograph had a peak of 29,000 cfs and a 3-day volume of over 54,000 ac-feet. The outflow from Washoe Lake is rather insensitive to the volume of inflow that occurs during a 72-hour period. This is due to the huge

storage capacity on Lake Washoe and its small outflow capacity. As such, not using a snowmelt model for this part of the watershed is not much of a concern.

4.4 Washoe Lake Basin HEC-1 Model. The 84-square-mile Washoe basin was treated as a single subbasin for the computer runoff model. Franktown Creek, the longest tributary to Washoe Lake, was used for the longest flow path into Washoe Lake. The average mountain Truckee Meadows general rain S-curve (SGR45.dat) was used to create the basin unit hydrograph. A topographic map of Washoe Lake is shown in Chart 4-1.

A storage-elevation relationship was presented in the USGS gaging station description for stage gage 10348700, Washoe Lake near Carson City, NV. Using GIS software and topographic maps, the stage-storage relationship was extrapolated to an elevation higher than the road surface of Highway 395, which runs along the west side of the lake. The outflow from Washoe Lake moves west through a culvert under Highway 395, before turning southeast down Steamboat Creek. The outflow from the lake is constrained by the culvert capacity until the lake overtops Highway 395. Once this happens, the highway itself becomes a weir, controlling outflow from the lake. A hydraulic stage-discharge rating for the Highway 395 embankment was created by Hydraulic Design Section and input into the HEC-1 model for Washoe Lake. The starting water surface elevation at Washoe Lake for the PMF simulation was chosen to be the highest water surface ever recorded during the period of record at the lake stage gage. It is 5032.62 feet, which occurred during the January 1997 flood. During the HEC-1 simulation of the PMF, the Highway embankment was barely overtopped, which is why the peak outflow only reached 340 cfs!

4.5 Huffaker Hills HEC-1 Model. The Washoe basin HEC-1 model outflow hydrograph with a peak of 340 cfs was input as a dssfile into subbasin 105 of the Lower Steamboat Creek HEC-1 model. As mentioned earlier, the SNOW program was used to model snowmelt contribution to Steamboat Creek from the east-facing subbasins of the Carson Range and west-facing subbasins of the Virginia Range. The resulting net precipitation from the SNOW model became the precipitation input into the Steamboat Creek HEC-1 model. The rainfall excess in the HEC-1 model plus the outflow from Washoe Lake were combined to make the PMF inflow hydrograph to the proposed Huffaker Dam site. Precipitation and runoff results are tabulated below.

Table 4-2. Huffaker Hills PMF Summary of Results

Watershed	drainage area (sq.mi.)	PMP (inches)	Peak Flow (cfs)	72-Hour Volume (ac-ft)
Washoe basin inflow (25% impervious)	83.8	13.44	29,300	54,700
Washoe basin outflow			340	2,000
Steamboat Cr. At Huffaker Hills Damsite including Washoe Lake Outflow	194.55 (including Washoe Lake)	12.72	28,000	57,600

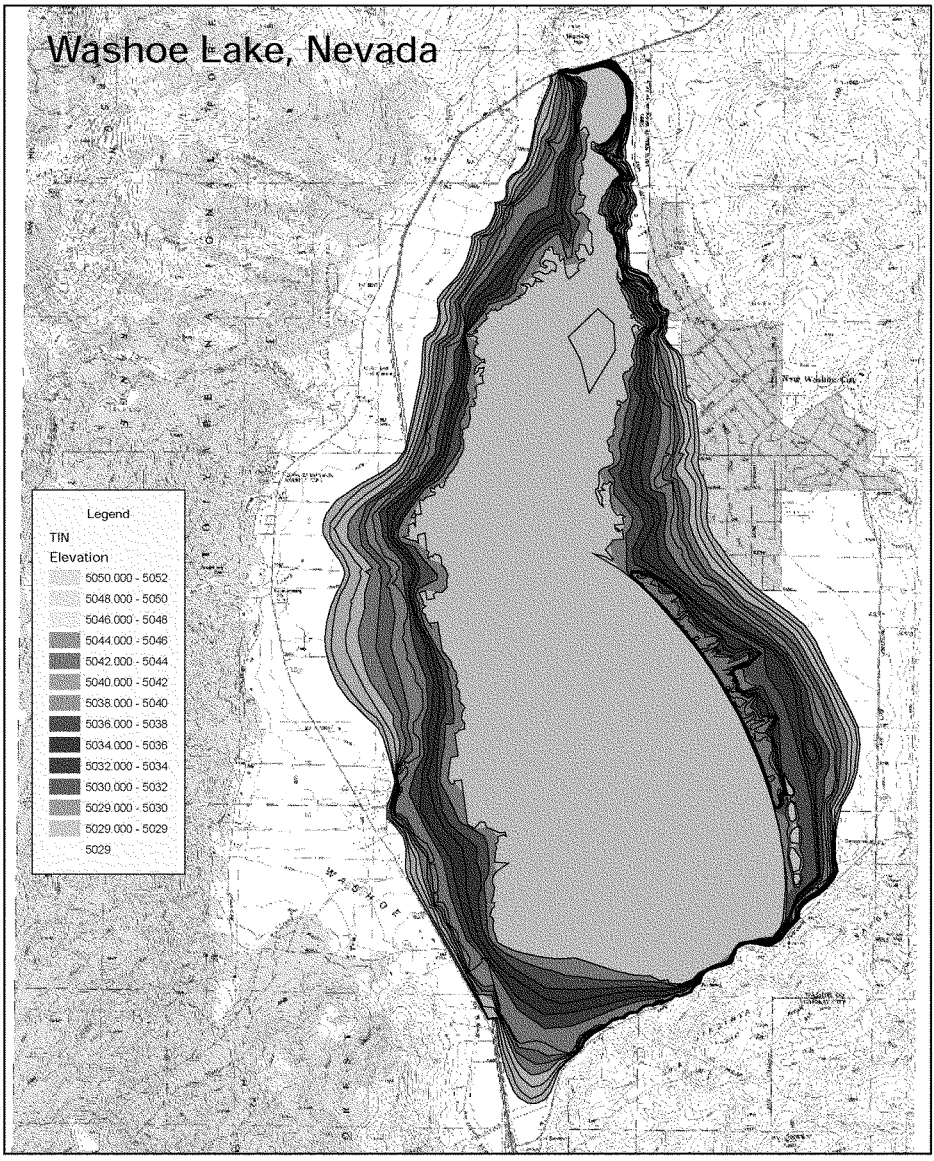

Washoe Lake, Nevada
Legend
TIN
Elevation
5050.000 - 5052
5048.000 - 5050
5046.000 - 5048
5044.000 - 5046
5042.000 - 5044
5040.000 - 5042
5038.000 - 5040
5036.000 - 5038
5034.000 - 5036
5032.000 - 5034
5030.000 - 5032
5029.000 - 5030
5029.000 - 5029
5029
WASHOE

Chart 4-1

5.0 Hidden Valley Interior Drainage

5.1 Introduction. Hidden Valley is a small community located on the eastern side of Steamboat Creek near its confluence with Boynton Slough. During the January 1997 flood event, some homes in this community were flooded by a combination of runoff from the Truckee River and Steamboat Creek. The Corps proposes to build a combination of floodwalls and levees along Steamboat Creek to protect this community from backwater inundation from the Truckee River. These structures could potentially cause an interior flooding problem by blocking the normal drainage path of runoff into Steamboat Creek; therefore, interior hydrology needs to be analyzed. A watershed map of Hidden Valley is shown on Chart 5-1. Both general rain and cloudburst events were analyzed. Frequencies evaluated were the 10%, 2%, 1%, 0.5%, and 0.2% chance events. The Corps obtained an HEC-HMS model that was built in late 2007 by the Reno office of the engineering firm HDR, Inc. The Corps obtained and modified the model for its own use as follows: 1) the soil loss rate method was changed from SCS Curve Numbers to Green & Ampt, 2) the design storm was modified to use NOAA 14 precipitation frequency, 3) Subbasin 9 of the original model was split into two subbasins (9a and 9b) to match existing conditions. Subbasin 9a flows into subbasin hv20. Subbasin hv9b flows into subbasin hv13.

5.2 General Rain Design Storm. A 72-hour General Rain event was developed. NOAA 14 precipitation frequency values for durations for the 3-, 6-, 12-, 24-, and 48-hour depths were extracted from the NOAA 14 website for the centroid of each subbasin. The 72-hour depth was estimated since NOAA 14 does not provide values for this duration. It was estimated as the 48-hour depth times 1.04, which is based on the ratio of the 72-hour depth to the 48-hour depth at the Reno Airport for the 1% chance event (Reference 14). In the Reno area, cloudburst storms that occur in the summer dominate the maximum, short duration rainfall depths recorded at precipitation gages. Since a general rain is being modeled, the 3-hour depth must be reduced to be realistic of a winter type storm. The 3-hour depth was multiplied by 0.73, derived by taking the 1% chance, 3-hour depth from the "winter only" frequency curve divided by the 3-hour depth for the annual frequency curve for the Reno Airport gage. NOAA 14 is an annual analysis and is therefore biased towards cloudburst events for short durations. A 1963 hourly storm pattern used in the 1980 Study of this area was balanced to the 3-, 6-, 24-, 48-, and 72-hour depths derived above. The rainfall runoff model was run on a 1-minute time step calculation.

Three areas were analyzed for interior drainage in this watershed. The first was the outlet for subbasins hv12a, b, and c. The Corps later decided to remove the proposed levee along this portion of Hidden Valley and, as such, the hydrograph for this area was not used in the interior flooding analysis. The second area was the outlet for hv13 and the third area was the outlets for subbasins hv19 and hv21. To maximize runoff into each of these areas, the entire Hidden Valley watershed was broken up into three zones and a storm developed for each one. Areal reduction factors found in Reference 14 were applied based on the area of each zone. In other words, a storm was centered over each zone to maximize runoff. The table below shows the subbasins found in each zone.

Table 5-1: Hidden Valley Watershed Storm Centering Zones

Zone	Subbasins
South zone	Hv6, hv7, hv10, hv11, hv12a, hv12b, hv12c
Central zone	Hv1, hv2, hv9b, hv13
North zone	Hv3, hv4, hv5, hv9a, hv14, hv15, hv16, hv17, hv18, hv19, hv20, hv21, hv22

5.3 HMS Model Components. The HMS model runs on a 1-minute time step increment. It uses SCS unit hydrographs for the rainfall to runoff transformation. The routings between basins were done using Muskingkum-Cunge. Green and Ampt loss rates were based on soil types found in each subbasin. The Green & Ampt parameters were based on the Maricopa County, AZ design manual (see ref. 22). The results of the model runs are shown below for the 1% chance event storm.

Table 5-2 . General Rain Model Results

Location	1% Chance Peak Flow in CFS
Outlet of HV12 (J12)	51
Outlet of HV13 (J13)	30
Outlet of HV19 (J19)	46
Outlet of HV21 (J21)	20

5.4 Cloudburst Design Storm. A cloudburst storm lasting 3 hours was created for the HMS model. NOAA 14 depth duration frequency values for the 15-, 20-, 60-, 120- and 180-minute durations were obtained for each subbasin in the model. The storm depths were applied to a triangular-shaped, balanced storm whereby the highest intensity value is placed in the center of the 3-hour period, the 2nd most intense to the right of the center, the third most intense to the left of center, and so on. The model was run on a 1-minute time step calculation. The only change in the HMS model from general rain to cloudburst was the design storm. The results of the modeling were as follows:

Table 5-3. Cloudburst Model Results

Location	1% Chance Peak Flow in CFS
Outlet of HV12 (J12)	300
Outlet of HV13 (J13)	200
Outlet of HV19 (J19)	280
Outlet of HV21 (J21)	160

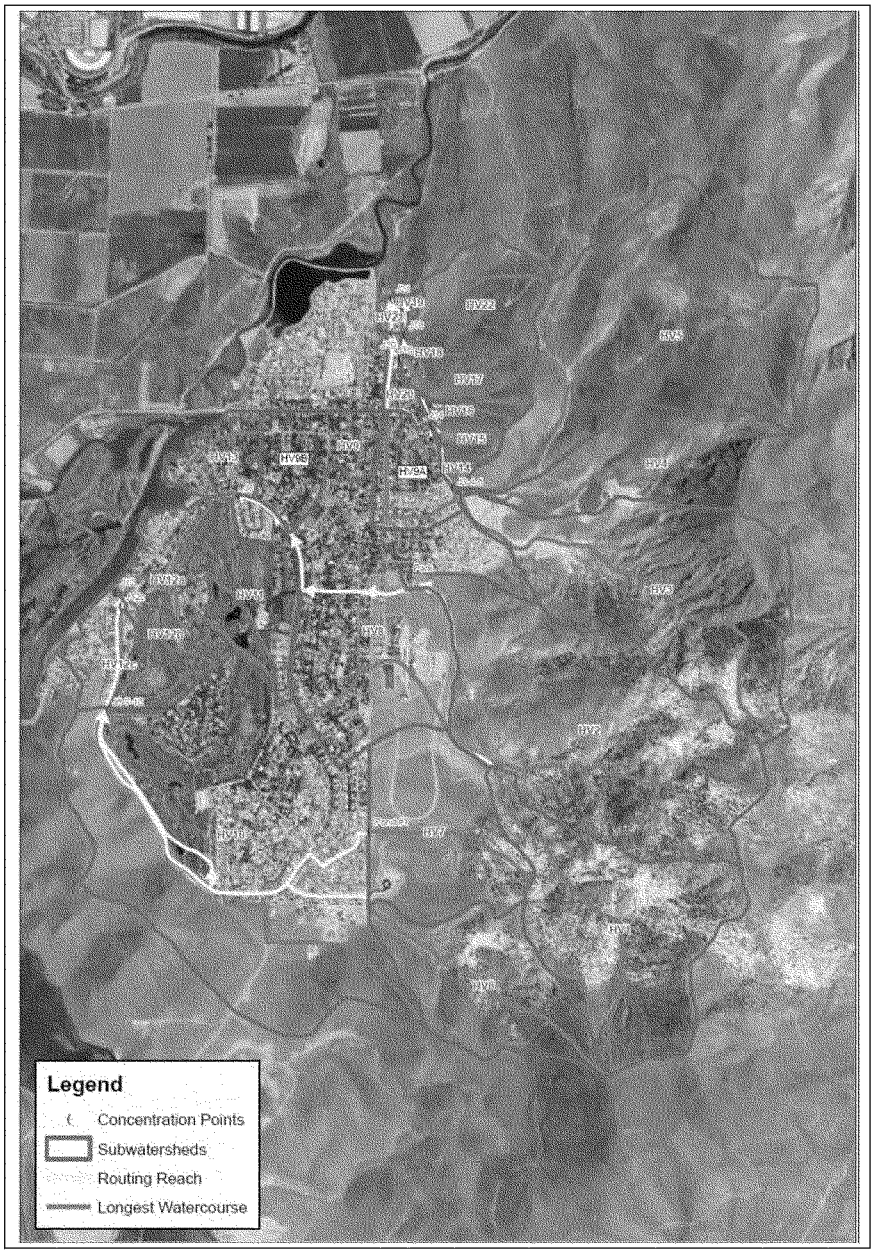

Legend
Concentration Points
Subwatersheds
Routing Reach
Longest Watercourse

Chart 5-1

6.0 South Side Meadows Reach near Airport Interior Drainage

6.1 Introduction. Levees will be placed on the south side of the Truckee River in the Truckee Meadows Reach near the Reno Airport. Since these structures could inhibit interior drainage, a hydrologic analysis was needed. Chart 6-1 shows the three areas that were modeled. The yellow lines are the footprint of the levees, while the gold and purple shaded areas show the contributing drainage for subbasins 400a and 400b, respectively. After the hydrology was completed, the levee related to subbasin 400b was moved to its present position in Chart 6-1. This made the contributing area smaller, which is why the purple shaded area extends to the river side of the levee. It was later determined in the HEC-RAS model that water flowed away (south) from the levee for subbasin 400B; therefore, the analysis was not re-done. Notice that McCarren Boulevard forms the west edge of the small interior area protected by the UNR Ring Levee. This area was modeled in HEC-1 as well. This section describes the hydrologic analysis for these three interior areas.

6.2 Cloudburst Design Storms. 3-hour duration cloudburst events for the 10%, 2%, 1%, 0.5%, and 0.2% chance events were modeled. Point rainfall with no areal reduction was applied to each subbasin because of their small size. The drainage areas of subbasin 400a, 400b, and the UNR Ring Levee are 0.26, 0.19, and 0.027 square miles, respectively. The cloudburst hyetograph was created in 15 minute increments, while the HEC-1 model runs in 5 minute time steps. The HEC-1 model automatically divides each 15-minute increment of rainfall into three even 5-minute parts. For example, a 15-minute value of 1.5 inches will be divided into three 5-minute increments of 0.5 inches. The 3-hour cloudburst event was balanced to the 15-, 30-, 60-, 120-, and 180-minute precipitation depths found in NOAA Atlas 14.

6.3 General Rain Design Storms. 72-hour duration general rain was modeled for the 10%, 2%, 1%, 0.5%, and 0.2% chance events. Point rainfall with no areal reduction was applied to each subbasin because of their small size. The general rain hyetograph was created in 1-hour increments, while the HEC-1 model runs in 15 minute time steps. A 1963 hourly storm hyetograph pattern was balanced to the 3-, 6- 12-, 24-, 48- and 72-hour depths. The 3-hour depth was taken from NOAA 14 and multiplied by a ratio of 0.73 to make it more characteristic of a general rain rather than a cloudburst event. The derivation of the ratios is described in more detail in Part IV, Section 3.5. The 6-, 12-, 24-, and 48-hour depths were taken from NOAA Atlas 14 without adjustment, while the 72-hour depth was estimated as 1.04 times the 48-hour value (based on an analysis of the Reno Airport gage).

6.4 HEC-1 Model. The HEC-1 model for these three subbasins uses unit hydrographs derived from the Truckee Meadows Valley S-graph. The soil loss rates are based on the Green and Ampt method as dictated in the Maricopa County, AZ Design Manual (see ref. 22). The original parameters were based on soil types, but the soil-based XKSAT value was multiplied by a ratio of 0.90 based on

calibration of the model to the December 31st, 2005 storm event on Boynton Slough and Steamboat Creek. A percent impervious value was estimated for each subbasin. The following table provides results of the model runs for the 1% chance event.

Table 6-1. Cloudburst Interior Drainage Modeling Results for Southside of Truckee Meadows

Exceedence Frequency	Subbasin 400A		Subbasin 400B		UNR Ring Levee	
	Peak (cfs)	5-hour Volume (ac-ft)	Peak (cfs)	5-Hour Volume (ac-ft)	Peak (cfs)	5-Hour Volume (ac-ft)
10%	111	8	12	1.3	13	2.4
2%	185	12	38	3.2	24	3.5
1%	228	14	54	4.4	30	4.2
0.5%	276	16	73	6	37	4.8
0.2%	357	20	105	8	49	6

Table 6-2. General Rain Interior Drainage Modeling Results for Southside of Truckee Meadows

Exceedence Frequency	Subbasin 400A		Subbasin 400B		UNR Ring Levee	
	Peak (cfs)	3-day Volume (ac-ft)	Peak (cfs)	3-day Volume (ac-ft)	Peak (cfs)	3-day Volume (ac-ft)
10%	27	24	3	3.2	2	1.8
2%	35	33	4.5	4.5	2.7	2.5
1%	40	37	5	5	3	2.8
0.5%	47	42	10	6	4	3.2
0.2%	62	47	20	10	5.4	3.8

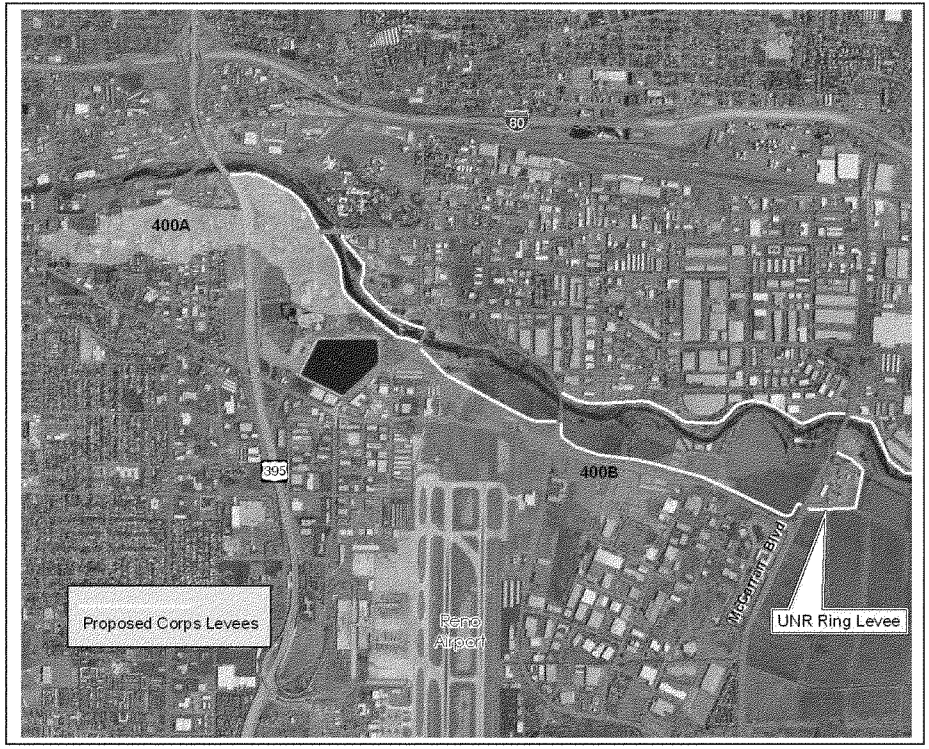

80
400A
395
400B
McCarran Blvd
Proposed Corps Levees
Reno
Airport
UNR Ring Levee

Chart 6-1

7.0 Interior Drainage Behind Huffaker Dam

7.1 Introduction. The proposed Huffaker Dam will create a large lake behind it which poses an inundation threat to some homes and buildings. Two floodwalls are proposed to protect these areas. The floodwalls create the potential for interior drainage problems since they will block normal drainage patterns. Chart 7-1 shows the proposed floodwall footprints as dark red lines. One floodwall protects four warehouses, while the other protects residential homes. Chart 7-2 displays the HEC-1 subbasin map for this area. Subbasin #1306 is the small drainage area within the floodwall protecting the four warehouses. Subbasins #1301 and 1302 contribute runoff to the channel that runs on the north side of the warehouse floodwall. The runoff from Thomas and Whites Creeks flows north through subbasin #1304 before passing between a neckwall that leads to the lake behind Huffaker Dam. The neckwall is designed to protect both the warehouses and the residential area from backwater from the lake that moves up the channel. Subbasin #1305 is the interior area behind the floodwall that protects the residential area. These areas were modeled in HEC-1 for both cloudburst and general rain events for the 10%, 2%, 1%, 0.5% and 0.2% chance exceedence frequency events. The following describes this analysis.

7.2 Cloudburst over Whites and Thomas Creeks. A circular-shaped, 10 square mile cloudburst with a bullseye on subbasin #1304 was created to maximize the peak flow that would pass through the neckwall at the outlet of this subbasin. Although these hydrographs were not used for the Feasibility Study, they may be used in P.E.D. to determine if the peak flow from a cloudburst would outflank or overtop the upstream end of the neckwall. Figure 7-3 shows the circular outline of the storm over the subbasins with a bullseye in subbasin #1304. The storm duration is 3-hours. Frequencies modeled include the 10%, 2%, 1%, 0.5%, and 0.2% chance events. Areal reduction was applied to each subbasin based on its proximity to the bullseye. The cloudburst hyetograph was created in 15 minute increments. The 3-hour cloudburst event was balanced to the 15-, 30-, 60-, 120-, and 180-minute precipitation depths found in NOAA Atlas 14. Loss rates were based on Green and Ampt. Unit hydrographs were created from the Truckee Meadows Valley S-graph. The drainage area for subbasin #1304 is 2.26 square miles. The contributing drainage area for cloudburst storms, including upstream subbasins #225 and #1303, is 4.32 square miles. The following table provides results of this analysis.

Table 7-1. Results for Thomas and Whites Creek 10 Square Mile Cloudburst Centered on Subbasin 1304

Exceedence Frequency	Peak Discharge (cfs) for Outlet Subbasin 1304 Contributing d.a. (4.32 sq.mi.)
10%	560
2%	1,200
1%	1,500
0.5%	2,000
0.2%	2,700

7.3 Cloudburst over Subbasins 1301, 1306, and 1305. A point rainfall cloudburst with no areal reduction was placed in each of these subbasins. The drainage areas for subbasins 1301, 1306, and 1305 are 0.84, 0.10, and 0.36 square miles, respectively. The storm shape matches the subbasin shape. The purpose of the storm over subbasin 1301 was to see if a cloudburst event that sends water down the channel that runs on the north side of the four warehouses would outflank or overtop the floodwall protecting it. Although this hydrograph was not used in the Feasibility Study, it can be used in P.E.D. for this purpose. The purpose of the cloudburst over subbasin 1306 was to see if flapgates or pumping stations are needed in the interior area behind the floodwall protecting the four warehouses. This was analyzed by Hydraulic Design Section and the results will be in the Hydraulics Attachment. The purpose of the cloudburst over subbasin 1305 was to determine if a cloudburst event in the Bella Vista area would cause interior drainage problems behind the floodwall. The storm duration is 3-hours. Frequencies modeled include the 10%, 2%, 1%, 0.5%, and 0.2% chance events. Point rainfall was placed in each subbasin with no areal reduction. The cloudburst hyetograph for subbasins 1301 and 1305 was created in 15 minute increments and the HEC-1 model was run in this time step as well. Due to the small size of subbasin 1306 (four warehouses), the HEC-1 model was run in a 5-minute time step. The 3-hour cloudburst event for each subbasin was balanced to the 15-, 30-, 60-, 120-, and 180-minute precipitation depths found in NOAA Atlas 14. Soil loss rates were based on Green and Ampt. Unit hydrographs were created from the Truckee Meadows Valley S-graph. The following table provides results of this analysis.

Table 7-2. Results for Cloudburst Over Subbasins 1301, 1306, and 1305

Exceedence Frequency	Subbasin 1301 d.a. (0.84 sq.mi.) Peak (cfs)	Subbasin 1306 d.a (0.10 sq.mi.) Peak (cfs)	Subbasin 1305 d.a. (0.36 sq.mi.) Peak (cfs)
10%	140	70	110
2%	310	110	220
1%	420	130	280
0.5%	540	160	350
0.2%	730	200	460

7.4 General Rain for Interior Drainage behind Huffaker Dam. The purpose of this analysis was to model potential interior drainage problems behind the two floodwalls during an event which filled the Huffaker Dam pool. The HEC-1 model described in Part IV, Section 3.0 was used for this simulation. The storm used is the Huffaker Hill Storm centering that was described in Section 3.7 and shown on Chart 3-3. The only modification to the HEC-1 model was to break down subbasin #130 into smaller pieces to correctly model interior drainage areas. The original subbasin #130 was broken down into subbasins #1301 through 1305, which are shown on Figure 7-2. The contributing drainage area to each of the subbasins #1301, #1306, and #1305 is the drainage area in each of those subbasins. Because this is the Huffaker Hills general rain centering, the contributing drainage area to subbasins #1304 includes the upstream drainage areas for Whites and Thomas creeks as well; the combined drainage area for #1304 is 29.23 square miles. The general rain flood hydrograph for #1304 does not include the upstream flow diverted from Whites Creek to Steamboat Creek or the upstream flow diverted from Thomas

Creek north to Boynton Slough. The concurrent interior runoff when Huffaker Dam incurs a 1% chance pool elevation is shown in the table below.

Table 7-3. Results for General Rain Interior Drainage

Exceedence Frequency	Sub #1301: Channel on West Side Warehouses d.a. (0.84 sq.mi.) Peak (cfs)	Sub #1306 Warehouses d.a (0.10 sq.mi.) Peak (cfs)	Sub #1304 White & Thomas Creeks d.a. (29.23 sq.mi.) Peak (cfs)	Sub #1305 Bella Vista d.a. (0.36 sq.mi.) Peak (cfs)
1%	90	17	1,100	45

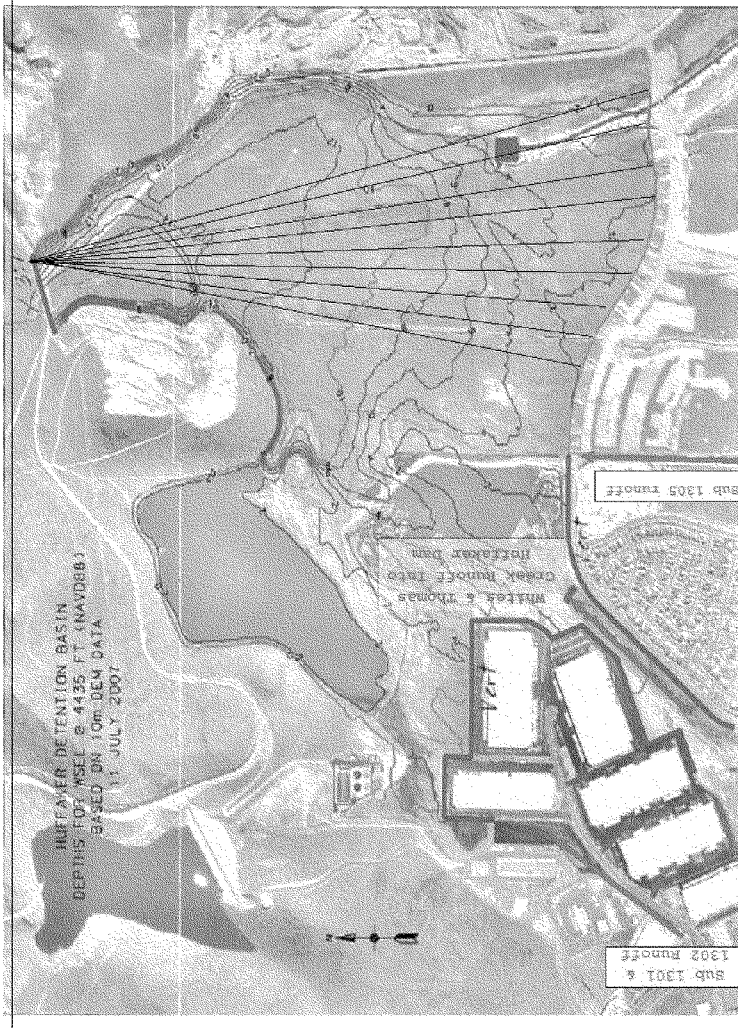

HUFFAKER DETENTION BASIN
DEPTHS FOR WSEL @ 4435 FT (NAVD88)
BASED ON 10m DEM DATA
17 JULY 2007
Sub 1301 &
1302 Runoff
Sub 1303 runoff
Willeke & Wagner
Creek Runoff Into
Huffaker Dam

Chart 7-1

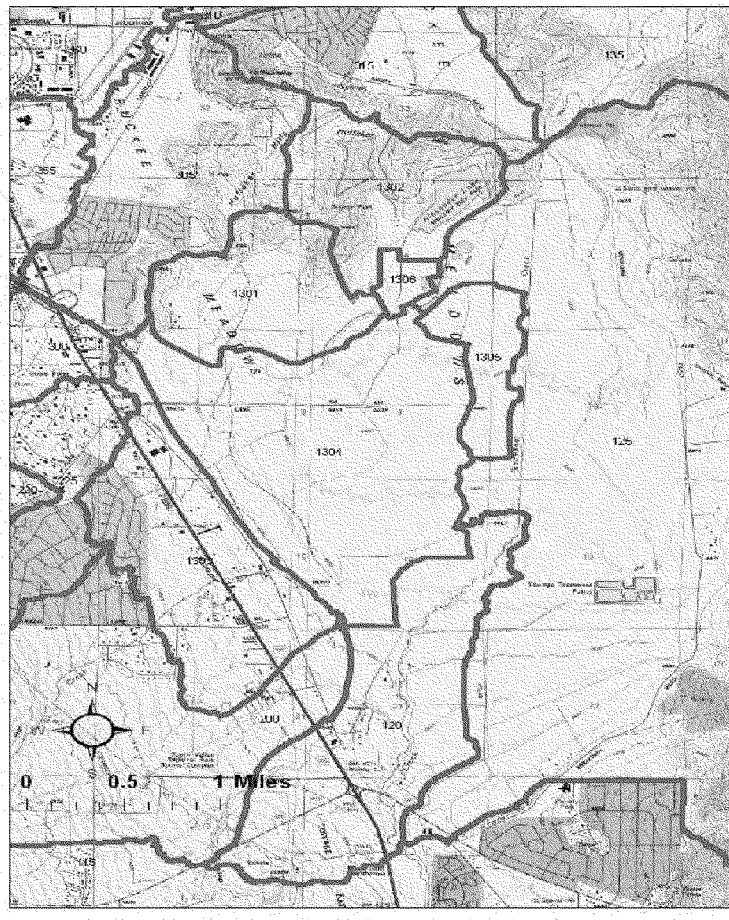
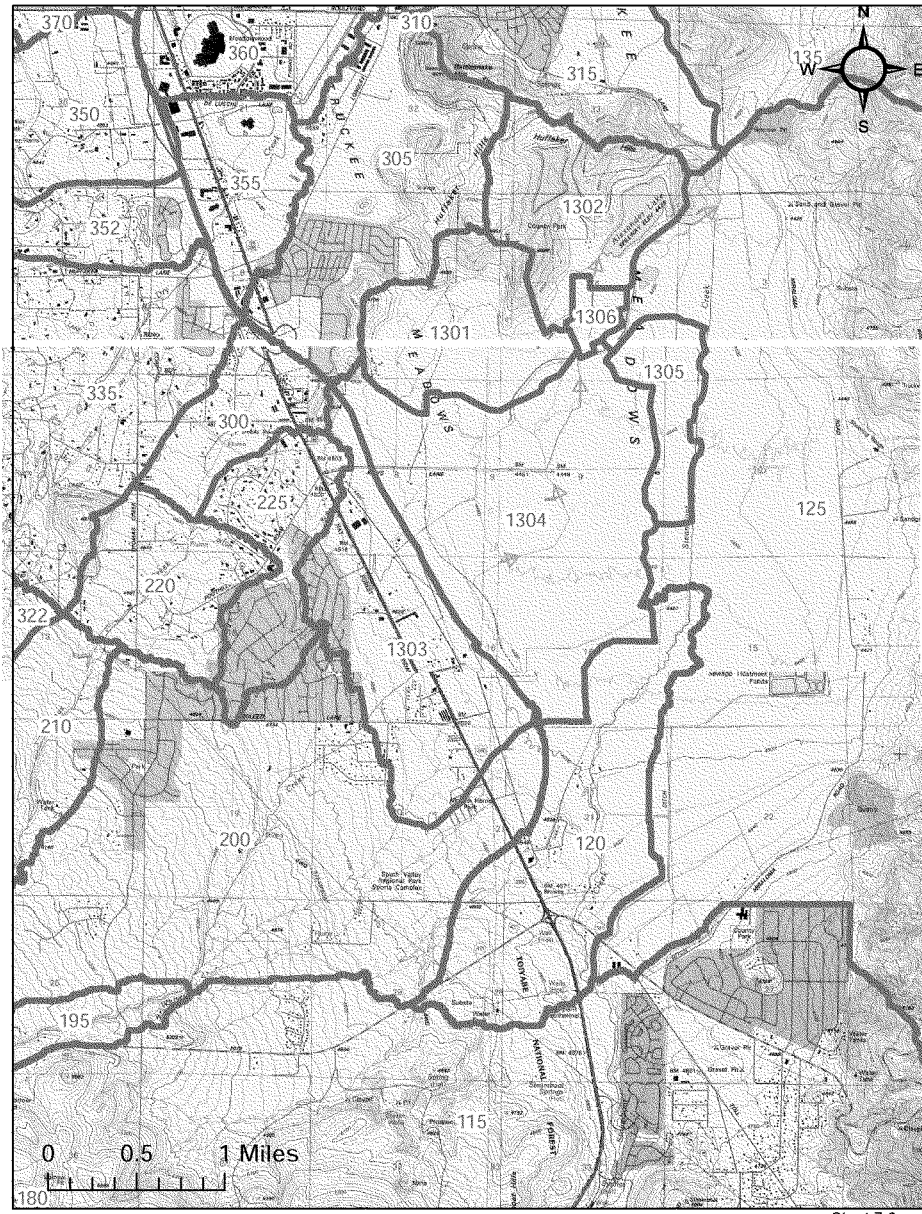


Chart 7-2


N
W
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370
360
310
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135
350
305
355
352
1302
1306
1301
1305
335
300
225
1304
125
220
322
1303
210
200
120
195
115
180
0 0.5 1 Miles

Chart 7-3

8.0 South Side of Downtown Reno.

8.1 Introduction. The Corps alternatives include floodwalls on the south side of the Truckee River in downtown Reno. The footprints for the floodwalls in the Downtown Reno Reach are shown in Chart 8-1 and 8-2. Chart 8-1 shows the 1.85 square mile drainage behind a short section of floodwall that connects to and runs a short distance upstream of Booth Street. Chart 8-2 shows the 1.5 acre empty lot that is flooded behind a short section of floodwall just upstream of the East 2nd Street Bridge. These structures may cause interior drainage problems. A 3-hour cloudburst and 72-hour general rain event were modeled in HEC-1 for the Booth Street Floodwall. Since cloudburst events have been found to dominate flooding in very small areas, only a cloudburst event was analyzed for the floodwall next to the East 2nd Street Bridge. Frequencies modeled include the 10%, 2%, 1%, 0.5%, and 0.2% chance events. The following text describes this analysis.

8.2 Floodwall Upstream of Booth Street. The 1.85 square mile area was modeled as one subbasin. A 3-hour cloudburst hyetograph was balanced to the 5-, 10- 15-, 30-, 60-, 120-, and 180-minute durations found in NOAA Atlas 14. The triangular-shaped rainfall hyetograph was built in 5-minute increments and the model was run on a 5-minute timestep. The Truckee Meadows Valley S-graph was used to create a 5-minute unit hydrograph for the rainfall to runoff transform. Soil loss rates are based on Green & Ampt. Areal reduction factors appropriate for a 2-square mile area were applied to point precipitation for this subbasin.

Table 8-1. Results for Cloudburst, Upstream of Booth Street

Exceedence Frequency	Peak (cfs)	Max. 6-hour volume (ac-ft)
10%	300	30
2%	580	45
1%	830	58
0.5%	1140	75
0.2%	1660	105

A 72-hour general rain event was also created for this location. A pattern based on the 1963 storm (Ref. 5) was balanced to the 3-, 6-, 12-, 24-, 48-hour depths found in NOAA Atlas 14. The 72-hour depth was estimated as a ratio (48-hour depth times 1.04). Normally, in this interior drainage analysis, the 3-hour precipitation from NOAA Atlas 14 is multiplied by a ratio of 0.73, when it is used for a general rain event (as explained in Section 3.5). By mistake, the 3-hour depth was not reduced for this simulation. This will result in higher runoff and a more conservative answer. It is recommended that if this study proceeds to the P.E.D. phase, that this oversight be fixed and the model be re-run. Areal reduction factors appropriate for a 2-square mile area were applied to point precipitation for this subbasin. The HEC-1 model was run on a 15-minute time step. The Truckee Meadows Valley S-graph was used to create a 15-minute unit hydrograph for the rainfall to runoff transform. Soil loss rates are based on Green & Ampt. The following table provides results for the general rain simulation.

Table 8-2. Results for General Rain, Upstream of Booth Street

Exceedence Frequency	Peak (cfs)	Max. 24-hour volume (ac-ft)
10%	123	68
2%	172	92
1%	198	100
0.5%	280	120
0.2%	450	160

8.3 East 2nd Street Interior Drainage Area. A floodwall is proposed on the south side of the Truckee River just upstream of the East 2nd Street Bridge. This location is shown in Chart 8-2. The area protected is only 1.5 acres and consists of an open lot with no structures. Due to the extremely small size of this area, only a cloudburst event was analyzed. The 3-hour storm has a triangular shape and was balanced to the 5-, 10-, 15-, 30-, 60-, 120- and 180-minute durations found in NOAA Atlas 14. Due to the small size of the area, no areal reduction factors were applied to the point rainfall, and the HEC-1 model was run in 2-minute computation intervals. A 2-minute unit hydrograph was derived from the Truckee Meadows Valley S-graph. The soil loss rates were based on Green & Ampt and a value of 30 percent impervious surface area was applied to the subbasin. The results of the modeling are shown below.

Table 8-3. Results for Cloudburst, East 2nd St. Drainage Area

Exceedence Frequency	Peak (cfs)	Max. 6-hour volume (ac-ft)
10%	1	<1
2%	2	<1
1%	2	<1
0.5%	3	<1
0.2%	5	<1

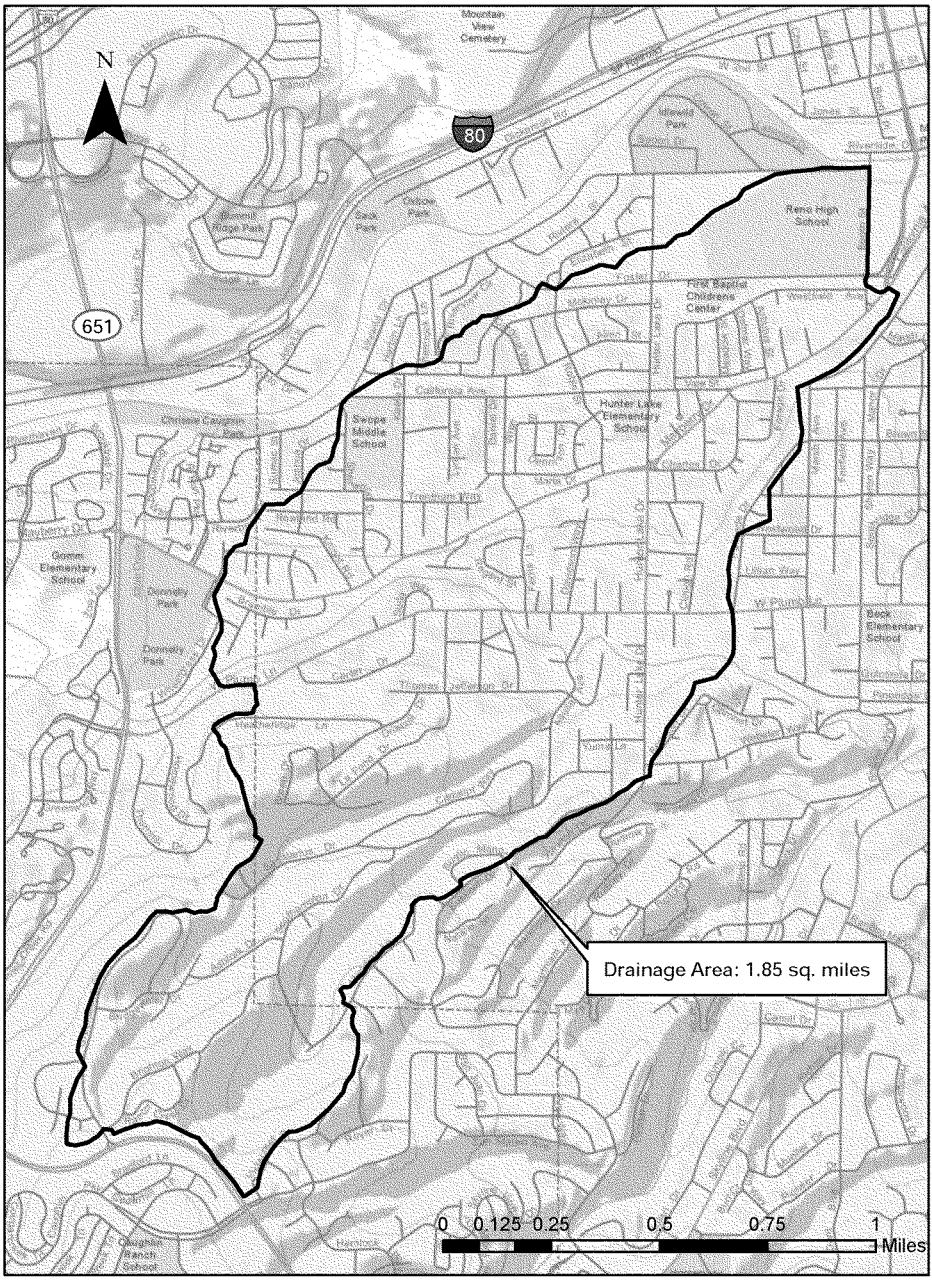


Chart 8-1

"Upstream of Booth St.
Interior Drainage Area"

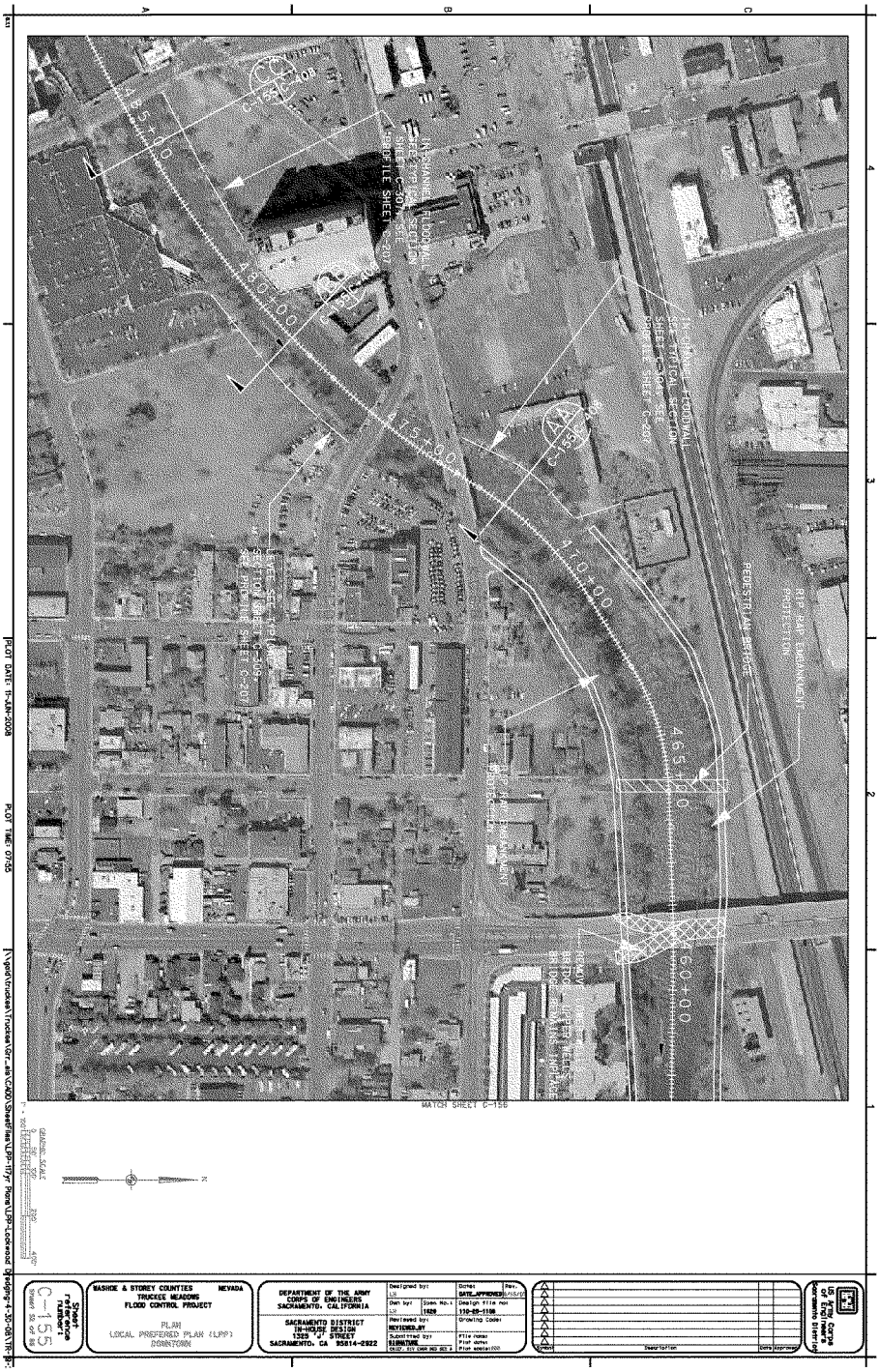

MATCH SHEET C-156
GRAPHIC SCALE
1" = 200'
N
NEVADA
TRUCKEE MEADOWS
FLOOD CONTROL PROJECT
PLAN
LOCAL PREFERRED PLAN (LPP)
DOWNTOWN
Sheet Number
C-155
Sheet 55 of 66
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 "J" STREET
SACRAMENTO, CA 95814-2922
US Army Corps of Engineers
Sacramento District
PLOT DATE: 15-JAN-2008
PLOT TIME: 07:55

Chart 8-2

9.0 North Side of Downtown Reno

9.1 Introduction. Floodwalls are proposed along portions of the north side of the Truckee River in downtown Reno. The floodwalls may block runoff from entering the Truckee River. The footprints of the floodwalls in the Downtown Reno Reach are shown on Chart 9-1. The downtown area is highly urbanized. The City of Reno recently completed the "Retrac Project", which involved dropping the existing Union Pacific railroad track that runs through downtown into a 30 foot deep, open trench. The railroad track runs east-west, parallel with 3rd Street. Bridges were used to connect roads on each side of the trench. A company named Stantec Consulting, Inc. built an HEC-1 model to model the 1% chance event runoff from the watershed above the railroad track. The model did not cover the area between the railroad track and the Truckee River. The Corps obtained the with-project HEC-1 model from Stantec and modified it for its own use. The Corps goal was to determine how much runoff would reach the land side of the downtown floodwalls for the purposes of interior flooding analyses.

9.2 HEC-1 Model Development. A detailed description of the original Stantec HEC-1 model adopted by the Corps exists in a report written in 2003 (Ref. 36). A subbasin map for the Stantec HEC-1 model is shown in Chart 9-2. The Stantec model was created by delineations of upper areas using 7.5 quad maps, analysis of previous studies including one for Evans Creek, delineations using 2-foot topographic data provided by the City of Reno for downtown areas, and on-site field investigations. The 2nd Street subbasin is a separate HEC-1 model and was not used by the Corps since it drains to an area west of the proposed floodwall. The rest of the watershed in the HEC-1 model covers 13.25 square miles. The Retrac Project placed a floodwall on the north side of the new railroad track to keep water out of the 30-foot deep trench. Runoff accumulates at this floodwall and flows east along 3rd Street and either crosses over the railroad trench at one of the bridges or continues east until it discharges into the Truckee River at Wells Avenue. Using the Manning Equation, the Corps determined that 3rd Street is able to convey 110 cfs at West Street, 30 cfs at Sierra Street, and 12 cfs at Virginia Street before flow is conveyed across the bridge at each location. The Retrac Project specifically designed the new bridges to convey runoff across them, up to the 1% chance pre-project condition. The goal of Retrac Project drainage plan was to keep flooding on the north side of the railroad trench equal or less than the without-project condition (no railroad trench and floodwall).

A subbasin flowchart is displayed on Chart 9-3 to show the connectivity of the modified HEC-1 model used by the Corps for this analysis. Several small dams exist in the watershed including Upper Peavine Dam, Lower Peavine Dam, West Wash Dam and East Wash Dam. All four dams were designed to detain the upstream 1% chance flows. Outflow from the dams and surface runoff from the subbasins named Elmcrest, Lower Peavine, Upper Peavine, Sprout, West Wash and East Wash all concentrate at the Vine Street Sump located on the north side of Highway 80. The sump connects to an underground pipe (84 inch RCP) which has a capacity of approximately 800 cfs. The pipe runs under the 80 freeway, and follows Vine Street until it reaches an inverted siphon at the intersection of Vine Street and the railroad trench. The inverted siphon allows head pressure to push the flow in the pipe under the railroad trench, where it continues south on Vine, then takes a left turn and heads east on 2nd Street, then takes a right turn and heads south on Arlington until it discharges into the Truckee River in a large, concrete box culvert under the Arlington Bridge.

Upstream, on the north side of Highway 80, at the Vine Street Sump, two 10' x 4' RCB's (west side of Vine Street) convey excess runoff (that runoff which exceeds capacity of the sump) south under the freeway where it continues on the surface down Vine Street towards the railroad. An inlet exists at the intersection of Vine Street, and the railroad to allow surface water to enter the 84" RCP when it is not flowing at capacity.

The Stantec model used a 24-hour design storm pattern balanced to NOAA Atlas 2. The model uses the SCS unit hydrograph to transform rainfall to runoff and SCS Curve Numbers for loss rates. The routing method is accomplished using Muskingum-Cunge.

The following describes the Corps modifications to the Stantec HEC-1 model. The Corps developed new design storms, including a 24-hour duration general rain and a 3-hour cloudburst based on NOAA Atlas 14 (the Stantec model used NOAA Atlas 2). Stantec simplified the modeling of runoff between Highway 80 and the railroad track by routing and combining all the runoff at a concentration point called CPE near Wells Ave on the eastern edge of the railroad project. Separate calculations for detailed street flow in this zone were accomplished by Stantec using another program. The Corps modifications to the Stantec HEC-1 model begin at Highway 80. The main goal of the Corps was to determine how much water could cross over the railroad trench and combine with the runoff from the urban area between the railroad and the Truckee River. This is the runoff that would potentially pond behind the Corps' new Downtown floodwalls. The Corps modified the HEC-1 model as follows: 1) modified the code to track the amount of water entering the 84" RCP at the Vine Street Sump at Highway 80 and the excess that would cross under the freeway through the 10' x 4' box culverts, 2) routed the outflow from the pair of 10' x 4' box culverts southward on the surface of Vine Street to its intersection with the railroad trench, 3) routed and tracked the amount of flow in the 84' Vine Street RCP, 4) determined if surface flow on Vine Street could enter the 84" RCP at the intersection of Vine and the railroad via an inlet, otherwise route the excess eastward along 3rd Street, 5) track total surface runoff flowing eastward on 3rd Street to determine how much, if any, could cross the bridges, 6) increased the size of the model by adding the drainage area between the railroad and the Truckee River (subbasins DT10 through DT70).

9.3 Development of HEC-1 Model Between Railroad and Truckee River. As mentioned earlier, the Stantec HEC-1 Model did not cover the area between the railroad track and the Truckee River. The Corps added this small area, which is only 0.34 square miles. This area was divided into 9 separate subbareas (subbasins DT10 through DT70), based on coordination with Hydraulic Design Section which performed the mapping of the interior flooding. These subbasins are shown on Chart 9-4. Two-foot topographic data were analyzed to determine the flow path of water at each street intersection. At some intersections, visual analysis alone could not determine the flow path, and InRoads software was used to determine the most likely flow path. When InRoads indicated an even likelihood of flow moving in either direction, judgment was used to determine the percent split flow down each street. These percentages are indicated on the flowchart in Figure 9-3. In the future, should the study go into P.E.D. phase, the Corps may want to use 1-foot contour data to provide better definition of flow paths. Like the rest of the model, the SCS unit hydrograph method was used for precipitation to runoff transform. For the general rain, soil loss rates utilized were SCS Curve Numbers. Since Reference 35 indicated

that SCS Curve Numbers are not appropriate for modeling storms less than or greater than a 24-hour duration, initial and constant loss rates were utilized for the 3-hour cloudburst model. The equivalent constant loss rate for each CN was determined by subtracting the total precipitation minus the total excess in the 0.2% chance general rain HEC-1 model output, after the initial abstract is satisfied. This gives an average loss rate during the simulation. The resulting constant loss rates ranged from 0.01 to 0.08 inches per hour. The flow routing was accomplished using Muskingum-Cunge. The only storm drain modeled for this area is the 800 cfs capacity pipe that runs south on Vine Street, east on 2nd Street, and then dumps into the Truckee River under the Arlington Ave. Bridge. The other known storm drains had a smaller outlet capacity to the Truckee River (approximately 5 cfs) and were deemed too small to be worth modeling. This decision will conservatively increase the total volume of surface runoff calculated.

9.4 General Rain Event. The general rain model uses a 24-hour storm balanced to the 15-minute, 1-hour, 2-hour, 3-hour, 6-hour, 12-hour, and 24-hour precipitation frequency depths for the watershed above the railroad trench. The depths were input on a PH card in the HEC-1 model, which distributes them in a triangular pattern with the most intense rainfall in the center of the storm. NOAA Atlas 14 depth duration frequency maps were overlaid on the subbasin map of the HEC-1 model in GIS in order to determine the averaged depths for each subbasin. The model runs on a 5-minute time step. The original Stantec HEC-1 model used point rainfall in each subbasin, with no areal reduction factors. For consistency, the Corps did not use areal reduction in their HEC-1 model for general rain either. As the whole watershed is only 13.25 square miles, this was not considered a significant issue.

The centroid of the 0.34 square mile area between the railroad trench and the Truckee River was used to find the NOAA 14 Atlas precipitation depths for all 9 subbasins. In other words, the same hyetograph was used for all 9 subbasins since it is so small. Since summer cloudburst events dominate the short-duration depths in NOAA Atlas 14, an adjustment was made to make the depths realistic for a general rain event. This adjustment was determined by studying 1% chance depths for the annual versus the winter precipitation frequency curves found in Reference 14 for the Reno Airport precipitation gage. The table below provides the ratios that were multiplied times the NOAA 14 precipitation to achieve depths representative of a general rain event.

Table 9-1. Ratios Applied to NOAA Atlas 14 Depths to Achieve General Rain Depths

Duration	Ratio Applied to Each Depth Duration
15-minute	0.36
30-minute	0.45
1-hr	0.54
2-hr	0.59
3-hr	0.72
6-hr	0.87
12-hr	1.0
24-hr	1.0

Note: If the 1-hour NOAA 14 depth is 1 inch, the new depth for general rain would be 0.54 x 1 = 0.54 inches.

The results of the general rain event modeling for the 10%, 2%, and 1% chance flood events are shown in the table below.

Table 9-2. Results for General Rain Modeling

	Peak Flow (cfs)							
% Flo-od	Subbasin DT10	Subbasin DT21 [1]CP CRD3	Subbasin DT30 [2]CP CRD4	Arlington Ave Box Culvert	Subbasin DT40 [3]CP CRD5	Subbasin DT51 [4]CP CRD6	Subbasin DT60 [5]CP CRD7	Subbasin DT70
10%	15	27	49	402	20	7	8	4
2%	28	48	120	732	28	10	14	7
1%	36	61	161	816	32	11	17	9

*1 – CP CRD3 refers to Concentration Point CRD3 which is the cumulative runoff from the outlet of subbasin DT20 and DT21.
See Flowchart on Chart 9-3.
*2 – CP CRD4 is a combination of runoff from subbasin DT30 and flow crossing over the West St and Sierra St. bridges.
*3 – CP CRD5 is a combination of runoff from subbasin DT40 and flow crossing over the Virginia St. Bridge.
*4 – CP CRD6 is a combination of runoff from subbasin DT50, DT51, and flow crossing over the Virginia St. Bridge.
*5 – CP CRD7 is a combination of runoff from subbasin DT50, DT60, and flow crossing over the Virginia St. Bridge.

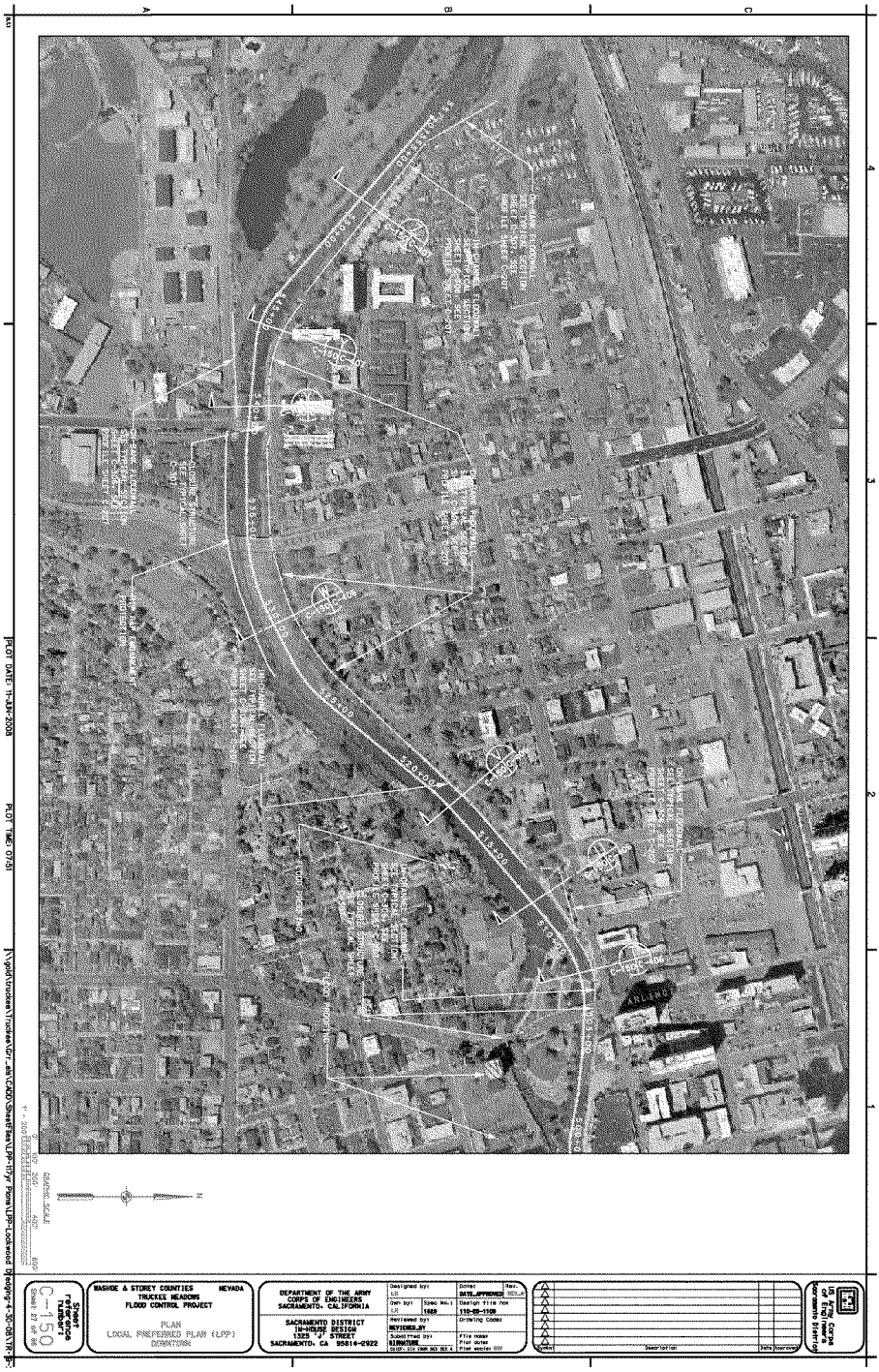
9.5 Cloudburst Event. The cloudburst HEC-1 model uses a 3-hour storm balanced to 15-minute, 30-minute, 1-hour, 2-hour, and 3-hour depths. The depths were input on a PH card in HEC-1 model, which distributes them in a triangular pattern with the most intense rainfall in the center of the storm. NOAA Atlas 14 depth duration frequency maps were overlaid on the subbasin map of the HEC-1 model in GIS in order to determine the averaged depths for each. The centroid of the 0.34 square mile area between the railroad trench and the Truckee River was used to determine the precipitation depths for all 9 subbasins. In other words, the same hyetograph was used for all 9 subbasins in this location. The model runs on a 5-minute time step. Since the intensity of cloudburst cell precipitation can change drastically in a small distance, a storm centering along with areal reduction factors was applied to the cloudburst HEC-1 model design storm. The bullseye of the cloudburst was positioned in the watershed just upstream of the railroad track. The storm centering is on the Vine subbasin. Areal reduction factors from Reference 14 were applied to the subbasins based on their relative position to the storm centering, with the largest areal reduction applied to those subbasins farthest from the bullseye. The cloudburst storm covered the entire 13 square miles of the HEC-1 model, slightly larger than the 10 square mile limit placed on cloudbursts in other watersheds in this interior drainage report.

The results of the cloudburst event modeling for the 10%, 2%, and 1% chance flood events are shown in the table below.

Table 9-3. Cloudburst Modeling Results

	Peak Flow (cfs)							
% Flo-Od	Subbasin DT10	Subbasin DT21 [1]CP CRD3	Subbasin DT30 [2]CP CRD4	Arlington Ave Box Culvert	Subbasin DT40 [3]CP CRD5	Subbasin DT51 [4]CP CRD6	Subbasin DT60 [5]CP CRD7	Subbasin DT70
10%	38	63	49	422	20	7	19	10
2%	62	103	111	734	27	12	31	17
1%	76	126	138	816	31	15	38	20

*1 – CP CRD3 refers to Concentration Point CRD3 which is the cumulative runoff from the outlet of subbasin DT20 and DT21.
See Flowchart on Chart 9-3.
*2 – CP CRD4 is a combination of runoff from subbasin DT30 and flow crossing over the West St and Sierra St. bridges.
*3 – CP CRD5 is a combination of runoff from subbasin DT40 and flow crossing over the Virginia St. Bridge.
*4 – CP CRD6 is a combination of runoff from subbasin DT50, DT51, and flow crossing over the Virginia St. Bridge.
*5 – CP CRD7 is a combination of runoff from subbasin DT50, DT60, and flow crossing over the Virginia St. Bridge.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PLOT TIME: 07:51
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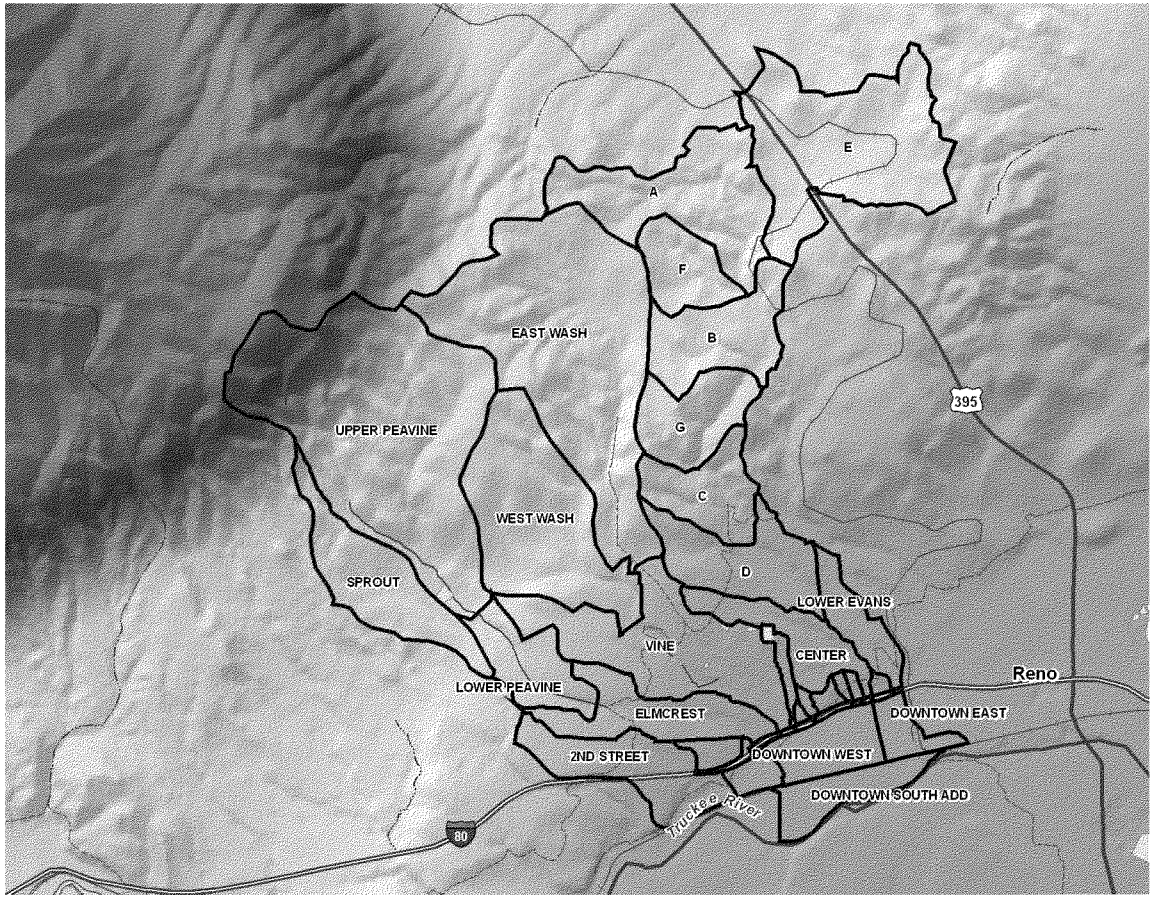
TRUCKEE MEADOWS
FLOOD CONTROL PROJECT
PLAN
LOCAL PREFERRED PLAN (LPP)
DOWNTOWN
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 "J" STREET
SACRAMENTO, CA 95814-2922
US Army Corps of Engineers
Sacramento District
Sheet Number
C-150
Sheet 27 of 98
GRAPHIC SCALE
1" = 200'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WEST WASH
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CENTER
Reno
LOWER PEAVINE
ELMCREST
DOWNTOWN EAST
2ND STREET
DOWNTOWN WEST
DOWNTOWN SOUTH ADD
Truckee River
80

Chart 9-2

NORTH SIDE OF DOWNTOWN RENO
HEC-1 MODEL SUBBASIN ROUTING FLOWCHART

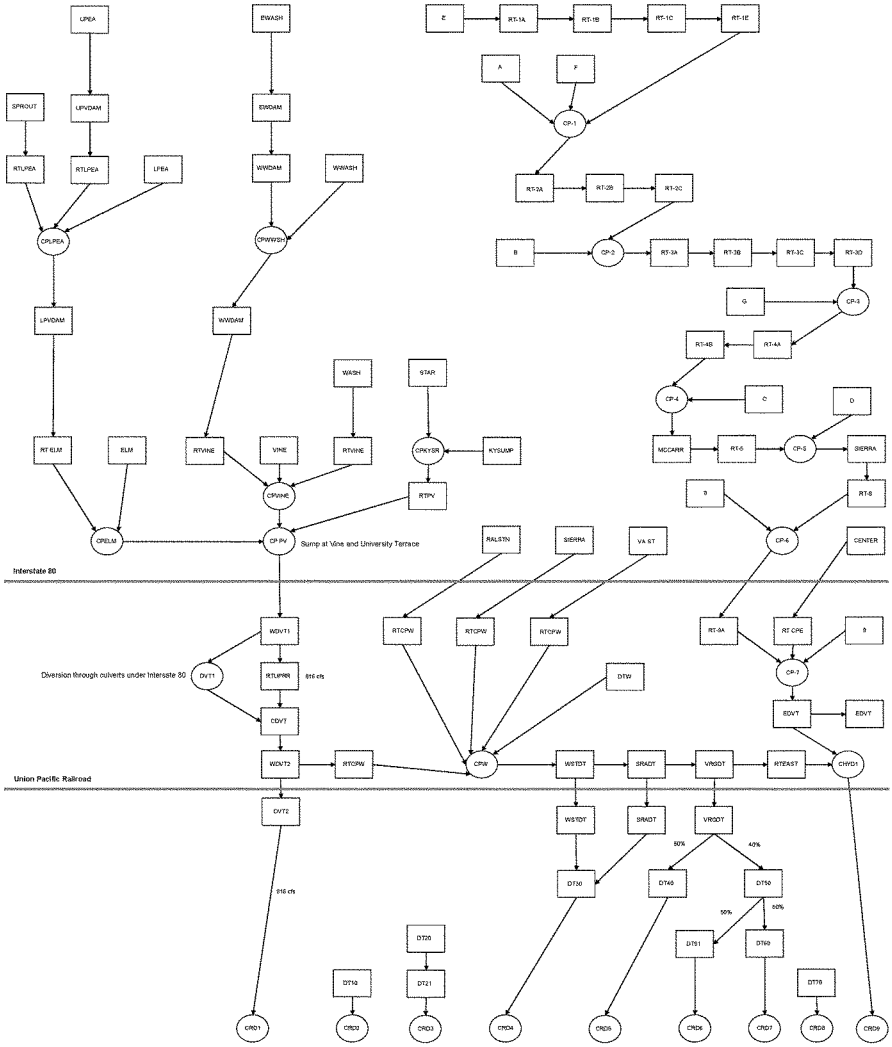
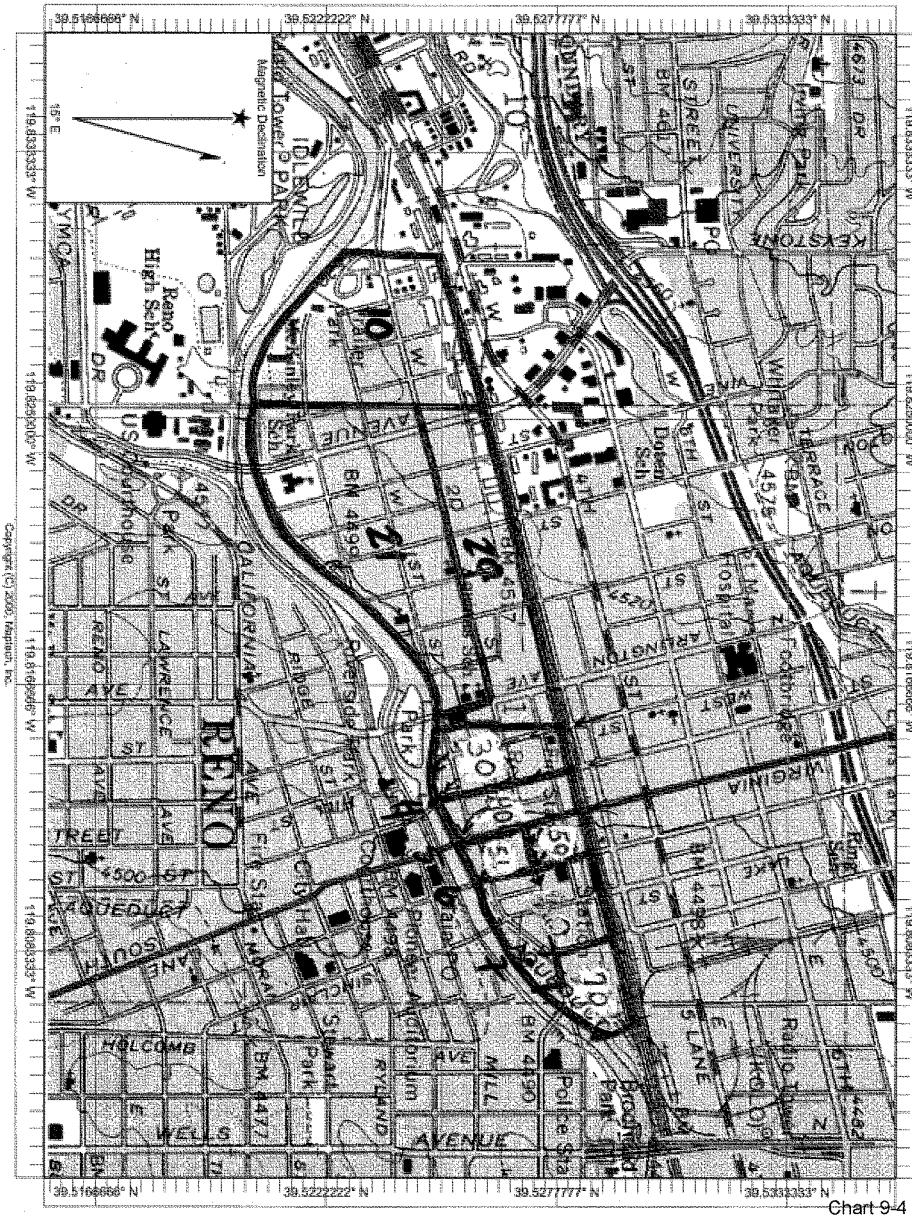


Chart 9-3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Magnetic Declination
15° E
Idlewild Park
Reno High Sch
YMCA
Hartman Park Sch
Northgate
Park
LAWRENCE
RENO
AVE
TREET
AQUEDUCT
HOLCOMB
CALIFORNIA
AVENUE
Riverside Park
Bridge
City Hall
Sierra Nevada
Pioneer Auditorium
Stewart Park
RYLAND
MILL
Police Sta
Broadway Park
Fire Sta
Rancho Sch
Hospital
Footbridge
Rancho Park
VIRGINIA
LAKE
G LANE
Wilmker Park
TERRACE
Doseen Sch
UNIVERSITY
STREET
KEYSTONE
Copyright (C) 2005, Maptech, Inc.

Chart 9-4

10.0 Long Valley Creek and Lockwood

10.1 Introduction. The Long Valley Creek watershed is approximately 100 square miles in area. It is the largest tributary on the Truckee River downstream of the Vista gage. A map of the watershed is shown in Chart 10-1 and a photograph of the community is shown in Chart 10-2. The watershed is arid and elevations range from 4,340 feet at its base to 7,420 feet at the top. There is no significant snowpack in the watershed and much of the year, including spring, the creek bed is dry. Near the mouth of the tributary sits the community of Lockwood, which has over 800 residents. The community sits within the 1% chance FEMA floodplain caused by Long Valley Creek. Long Valley Creek channel capacity is limited, partly due to bridge culverts on the creek that are partially filled in with sediment. A previous Corps hydrology study in the 1980's indicated the 1% chance peak flow for this watershed was 10,000 cfs. The 1980 hydrology was used to map the 1% chance FEMA floodplain. The community of Lockwood was flooded in February 1986, when the creek had an estimated peak discharge of 5,400 cfs.

Some of the proposed project alternatives in the Truckee Meadows Reach cause an increase in the peak flow and stage on the Truckee River at Lockwood for rare events like the 1% chance flood. The local sponsor plans to build a wall to protect the community from the increased stages on the Truckee River. Higher stages in the Truckee River can also increase the backwater effect on Long Valley Creek runoff. An analysis of Long Valley Creek flow frequency was needed to quantify the impacts of the with-project condition on the community of Lockwood. The concurrent flow in Long Valley Creek when the Truckee River is incurring an n-year event was determined in Part III of this Attachment. This hydrology was utilized by Hydraulic Design Section to analyze flood impacts on this community for the existing and with-project floods on the Truckee River mainstem (particularly the 1 in 100 and 1 in 117 chance events.).

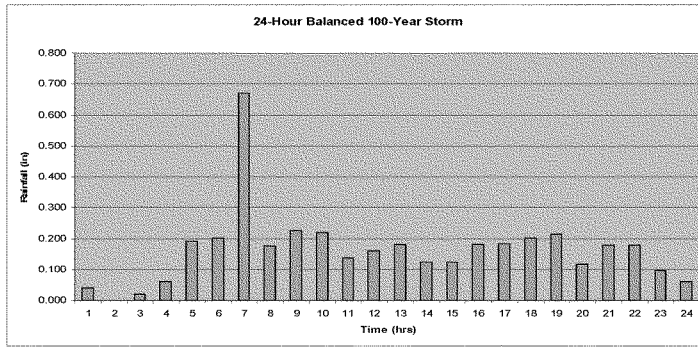
An additional analysis was needed to determine interior flooding problems when Long Valley Creek incurs an n-year event. With-project condition interior flooding problems can be worse than existing conditions due to either higher stages in the Truckee River or due to the wall that the local sponsors plan to build along the Truckee River to protect the Lockwood community. Several storm centerings were evaluated for both cloudburst and general rain events. This section describes the hydrologic analysis needed for this effort. A USGS peak instantaneous flow gage record exists on the Long Valley Creek.

10.2 General Rain on Long Valley Creek. An HEC-1 model was built for the entire watershed. The subbasin map for the model is shown in Chart 10-3. Approximately 2.7 square miles of subbasin 30 is a dry lakebed which will not contribute any runoff. The basin area card in HEC-1 (BA card) was reduced by this amount to account for this fact. 1-hour unit hydrographs were created from the Truckee Meadows Mountain General Rain S-curve. The model is run on a 1-hour time step. The soil loss rate method chosen was initial and constant. The constant loss rate for each frequency event was adjusted by calibration to the peak flow frequency curve adopted for this watershed.

A 24-hour duration general rain event was created for the model. 1-, 3-, 6-, 12-, and 24-hour precipitation frequency depths were gathered from NOAA Atlas 14 for each subbasin. The Jan-Feb 1963 storm pattern from Reference 5 was balanced to the depths mentioned above. The

storm was watershed-shaped as opposed to a circular or oval shape. A storm centering was created with the bullseye in subbasin 25. Chart 10-4 shows the areal reduction factors applied to each subbasin to achieve the storm centering. An example storm hyetograph for one of the subbasins is shown in the figure below.

Figure 10-1. Example General Rain Hyetograph for Long Valley Creek.



10.3 Long Valley Creek Peak Flow Frequency Curve. A staff gage called Long Valley Creek near Happy Valley (USGS # 10350100) lies in the lower portion of the watershed. The gage is in Lagomarsino Canyon, 3.3 miles upstream of the confluence with the Truckee River. The instrumentation at the site can only measure the instantaneous peak stage during a storm. There are no daily or hourly flow records. The peak of record occurred in February 1986 and was 5,400 cfs. Table 10-1 provides the period of record data for the gage.

Table 10-1.
List of Observed Annual Peak Flows at USGS #10350100
Long Valley Creek near Happy Valley Gage
Drainage area 82.6 sq.mi.

Year	Date	Peak (cfs)	Year	Date	Peak (cfs)
1956	23-Dec-55	2,500	1986	19-Feb-86	5,400
1967	16-Mar-67	1,430	1995	10-Mar-95	2,750
1968	20-Feb-68	1.0	1996	4-Feb-96	370
1969	25-Jan-69	2,560	1997	2-Jan-97	1,600
1970	24-Jan-70	400	1998	24-Mar-98	570
1971	26-Jun-71	20	1999	9-Feb-99	2
1972	16-Mar-72	1.0	2000	30-Jun-00	50
1973		0.1	2002	18-Mar-02	0.1
1974	17-Jan-74	105	2003	February	0.2
1975	March	180	2004	15-Aug-04	51
1976	1-Aug-76	17	2005	28-Mar-05	49
1977		1.5	2006	31-Dec-05	2,600
1978	March	85	2007	2-Jun-07	2

The gage record has missing water years (broken record) and only 26 years of data. The Steamboat Creek watershed, which is adjacent to Long Valley Creek, has higher elevations and a significant snowpack. The two watesheds have poor correlation. Correlation with the two-day rainfall recorded at the precipitation gage at Virginia City (which is just over the ridgeline) was used to estimate data for missing water years. Using a polynomial equation, enough correlation was found to estimate peak flows on Long Valley Creek. The correlation plot is shown in Figure 10-2. The correlation allowed for the estimation of an additional 16 water years of data. It is believed that the 1986 flood is the highest flow of record in 52 years based on discussion with Storey County. The 26 years of systematic record peak flows were plotted based on their ranking in the 42 years of combined systematic and estimated data. In addition, the plotting positions were adjusted for one historic flood (1986) that was the greatest in 52 years of record. Due to a sharp drop in flows at the lower tail of the frequency curve, statistics were derived for the upper end of the curve using a best fit regression line through the upper 10 recorded peak flow values. The final adopted frequency curve is shown in Figure 10-3.

Figure 10-2. Correlation of Long Valley Creek Peak Flows with Virginia City Precipitation

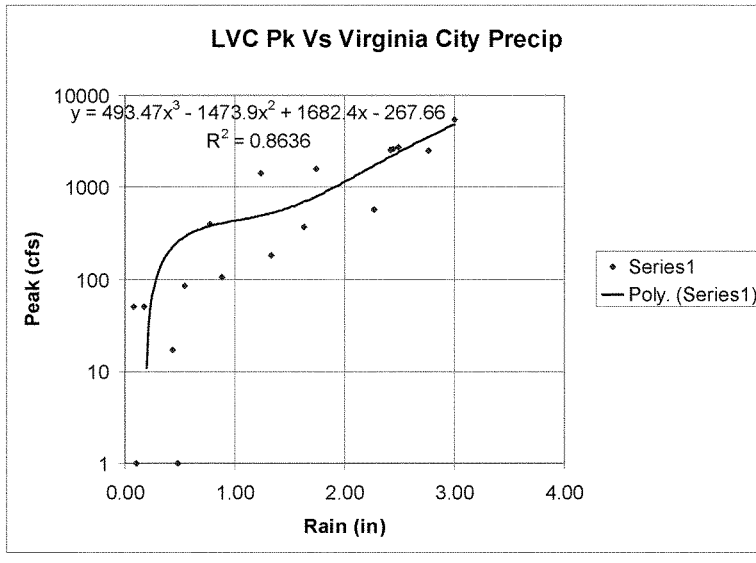
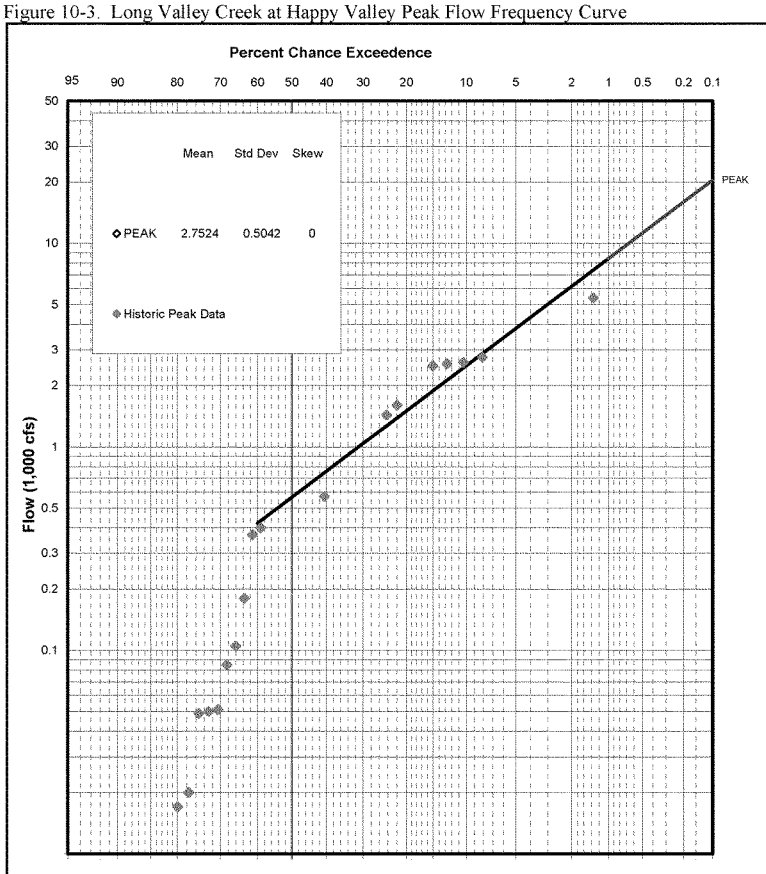


Figure 10-3. Long Valley Creek at Happy Valley Peak Flow Frequency Curve



NOTES:

1. Systematic record=26 years
2. Estimated values (not shown) estimated by correlation w/ Virginia City Precip.
3. Median plotting positions used to plot flows.
4. One historic flood with period of 52 yrs
4. Drainage area 82.6 sq.mi.
5. USGS Station 10350100

LONG VALLEY CREEK AT HAPPY VALLEY
PEAK FLOW FREQUENCY

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Table 10-2. Long Valley Creek at Happy Valley Peak Flow Frequency Curve

	Exceedence Frequency						
d.a. (82.6 sq.mi.)	20%	10%	5%	2%	1%	0.50%	0.20%
Peak Flow at Subbasin #C21, Gage Site (cfs)	1,500	2,500	3,800	6,100	8,400	11,200	16,000

The loss rates for the general rain HEC-1 model were adjusted so that the peak flow at subbasin C21 came close to the adopted peak flow frequency curve in Figure 10-2. The HEC-1 general rain model results are shown in the table below.

Table 10-3. General Rain HEC-1 Model Results.

	Exceedence Frequency						
	20%	10%	5%	2%	1%	0.50%	0.20%
Peak Flow at Subbasin #C21, Gage Site (cfs) d.a. (82.6 sq.mi.)	1,400	2,400	3,700	5,900	8,500	11,000	15,900
Peak Flow at Outlet of Watershed (cfs) d.a. (98.3 sq.mi.)	1,500	2,500	3,800	6,200	9,000	12,000	17,700
Loss Rates (in/hr)	0.17	0.16	0.17	0.13	0.10	0.08	0.04

10.4 Ten Square Mile Cloudburst Centered Upstream of Long Valley Creek Outlet. A 10 square mile cloudburst storm series was centered on Long Valley Creek upstream of the canyon mouth. The purpose of the centering was to create high flows on Long Valley Creek channel that might leave the channel and flood the community of Lockwood. The storm overlaid on Long Valley Creek is shown on Chart 10-5. A single subbasin was used to model the upper 9.43 square miles of the watershed, while an additional four subbasins were used to model the areas subject to interior flooding area behind a proposed floodwall. The four smaller subbasins are shown on Chart 10-6. A 10-minute unit hydrograph was derived from the Truckee Mountain Cloudburst S-graph. Soil loss rates with an initial loss of 0.10 inches and a constant loss rate of 0.05 inches were used in the model. A 3-hour duration, triangular-shaped cloudburst storm was balanced to the 5-, 10-, 15-, 30-, 60-, 120-, and 180-minute NOAA Atlas 14 rainfall. Frequencies modeled include the 10%, 4%, 2%, 1%, 0.5%, and 0.2% chance events. Areal reduction factors for 9.4 square miles were applied to the rainfall for the upper 9.4 square mile subbasin, while areal reduction factors for 10 square miles were applied to the four subbasins next to the river. The HEC-1 model was run on a 10-minute time step. The results of the model runs are shown below. Since the peak flow of 1,700 cfs for the 1% chance event stays completely in the Long Valley Creek channel, this storm centering was not used for interior drainage analysis by Hydraulic Design Section.

Table 10-4. Results for 10-Square Mile Cloudburst Centered Upstream of Long Valley Creek Outlet

	Exceedence Frequency						
	20%	10%	4%	2%	1%	0.50%	0.20%
Long Valley Creek Peak Flow in cfs d.a. (9.43 sq.mi.)	540	760	1,100	1,400	1,700	2,100	2,900
Concurrent Peak Flow, West Interior Drainage Area (cfs) d.a. (0.09 sq.mi.)	2	2	5	9	14	20	30
Concurrent Peak Flow, East Interior Drainage Area (cfs) d.a. (0.26 sq.mi.)	12	15	20	30	45	67	100

Note: This storm centering was not used for interior drainage analysis for Lockwood since the Long Valley Creek 1% peak flow stays completely within the channel.

10.5 Cloudburst Centered Over Lockwood Interior Drainage Areas. A 3-hour duration cloudburst storm centered directly over the small subbasins shown in Chart 10-6 was modeled in HEC-1. As cloudburst events are a summer phenomenon, no significant flow is expected in the Truckee River during this type of event. The purpose of this centering is to see if what measures might be needed to mitigate for flooding behind the proposed wall along the riverfront of Lockwood. The design storm was balanced to the 5-, 10-, 15-, 30-, 60-, 120-, and 180-minute duration point rainfall from NOAA Atlas 14. No areal reduction factors were applied to the precipitation for these subbasins. Precipitation was also placed in a 4 square mile area upstream of the outlet of Long Valley Creek to produce concurrent runoff in the channel; however, the concurrent runoff on Long Valley Creek stayed completely within the channel banks. The results of this modeling are shown in the table below.

Table 10-5. Results for Cloudburst Centered Over Lockwood Interior Drainage Area.

	Exceedence Frequency						
	20%	10%	4%	2%	1%	0.50%	0.20%
Long Valley Creek Peak Flow in cfs d.a. (4.00 sq.mi.)	400	580	870	1,140	1,400	1,800	2,500
Concurrent Peak Flow, West Interior Drainage Area (cfs) d.a. (0.09 sq.mi.)	24	33	47	60	76	96	130
Concurrent Peak Flow, East Interior Drainage Area (cfs) d.a. (0.26 sq.mi.)	80	110	160	200	250	310	410

Long Valley Creek Shown on Right Side of Photo

Chart 10-1

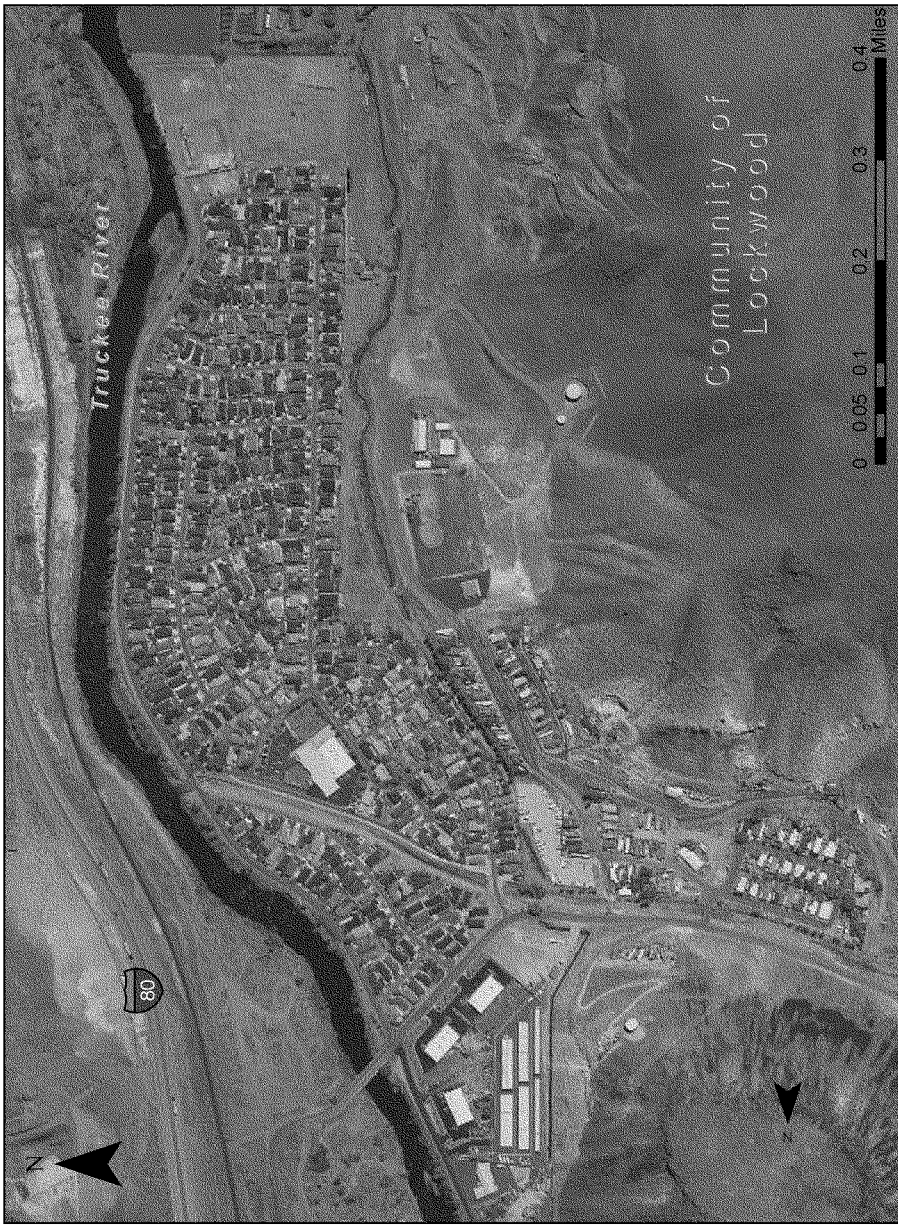
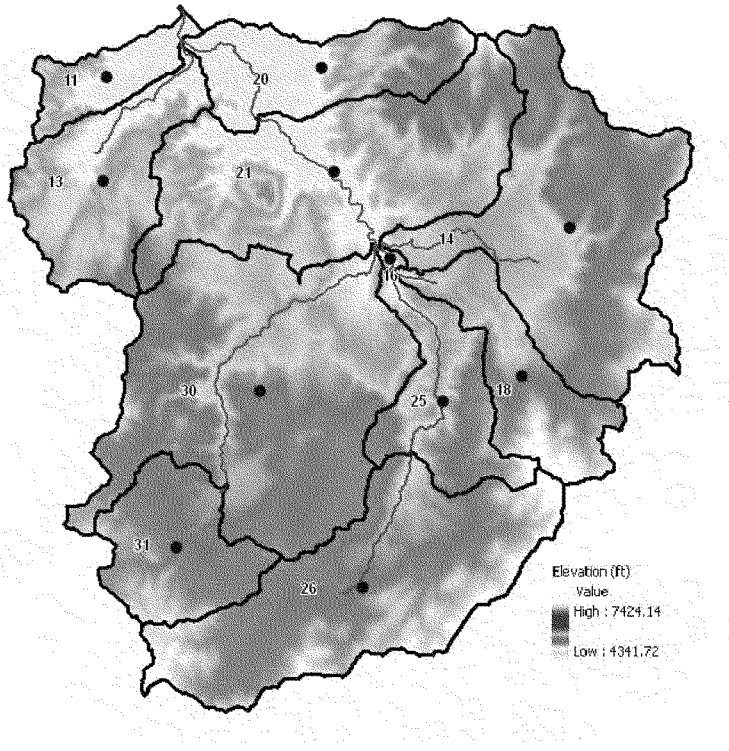
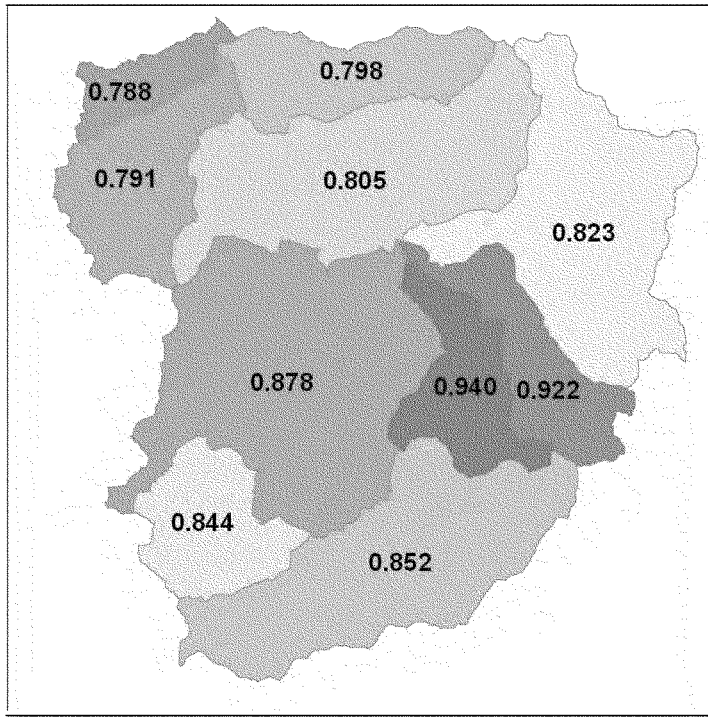

Community of
Lockwood
Truckee River
80
N
0 0.05 0.1 0.2 0.3 0.4
Miles

Chart 10-2



Long Valley Creek HEC-1 Model Subbasin Map

Chart 10-3



Depth Area Reduction Factors Used to Create Storm Centering Over Long Valley Creek Watershed for General Rain Storm

Chart 10-4

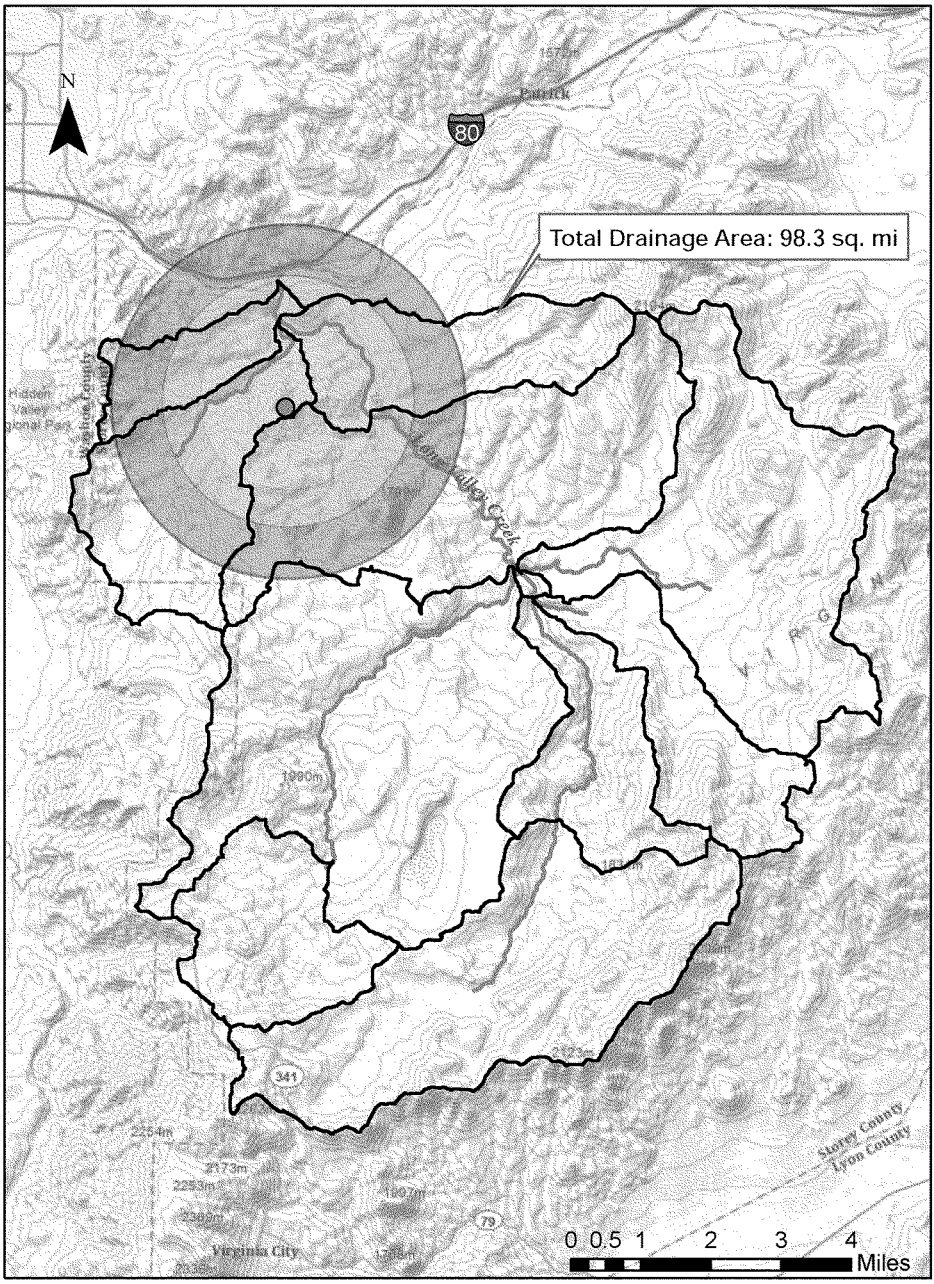


Chart 10-5

"Long Valley Creek Storm Centering"

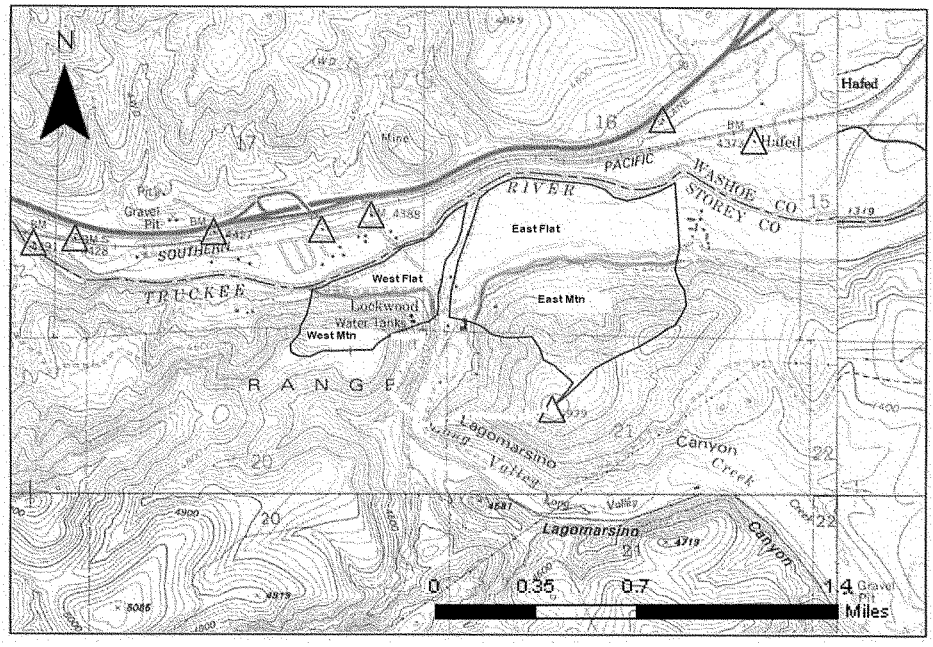

N
Hafed
Hafed
Mine
Gravel Pit
SOUTHERN
PACIFIC
RIVER
WASHOE CO
STOREY CO
East Flat
West Flat
East Mtn
Lockwood
Water Tanks
West Mtn
TRUCKEE
RANGE
Lagomarsino
Long Valley
Canyon
Creek
Lagomarsino
Long Valley
Canyon
Creek
0
0.35
0.7
1.4
Miles

Chart 10-6

PART V of Attachment A

RISK AND UNCERTAINTY INCLUDING CLIMATE CHANGE

Table of Contents

1.0 Purpose and Scope

2.0 Future Conditions

3.0 Climate Change

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5.0 Uncertainty of Timing of Tributary Runoff in the Meadows Reach

6.0 FDA Input: Frequency Curves and Confidence Limits

7.0 Updated 1-Day Unregulated Flow Frequency Curve for Truckee River at Reno

1.0 Purpose and Scope: Part V of the Hydrology Appendix was created to discuss the risk and uncertainty associated with the hydrologic analyses of the various study reaches. It includes 1) future conditions impacts from urbanization 2) future conditions impacts from climate change 3) sensitivity of the 1997 flood peak estimate to study results and 4) a discussion of risk and uncertainty parameters input into FDA and 5) an updated 1-day unregulated flow frequency curve for Truckee River at Reno. FDA uses the assigned period of record to draw confidence limits about the flow frequency curve. Computed probability flow frequency curves were provided to the economist for input into the FDA program. The FDA software utilizes these confidence limits to assess risk and uncertainty in the hydrologic analyses of each study reach including associated affects on stage frequency, economic damages, and the performance characteristics of various flood control alternatives.

2.0 Future Conditions Impacts from Urbanization: Historically, the largest floods that have affected the Reno/Sparks area are caused by winter general rain or rain-on-snow events lasting at least several days or more. Due to a process called orographics, the high elevation areas in surrounding foothills and mountains receive significantly more rain than the valley floor of Reno/Sparks during these types of events. Rainfall depths in the foothills and mountains can range from 4 to 15 inches or more over a 3-day period, whereas depths recorded at the Reno Airport are often less than 2 inches for the same flood event. In addition, a significant amount of snowpack below 7,000 feet may be melted in the mountains during these rain-on-snow events, increasing the total percentage of runoff from high elevation areas. Urbanization is mostly expected to occur in the lower elevations of the Truckee River watershed near the cities of Reno and Sparks.

Downtown Reach: Growth projections for the Downtown Reach are 1.4% per year until 2030. For this river reach, approximately 95% of the runoff that contributes to the peak flow in this reach comes from upstream of downtown Reno (mostly the east slope of the Sierra Mountains). Very little urban development is expected for the eastern slopes of the Sierra Mountains as much of it is federally owned land. Therefore, urbanization should have minimal impacts on this reach. In addition, the local sponsors have consistently indicated they will mitigate for future development so as to not impact the project design. Washoe County has local ordinances in place that requires developers to mitigate for urbanization up to the .01 ACE flood. In addition, Washoe County has developed a rainfall runoff model of the entire Truckee River watershed *specifically* for the purpose of analyzing urban development impacts on the proposed Truckee River project. The model will also be used to analyze mitigation measures. Therefore, future without project hydrology is assumed to be the same as existing condition hydrology.

Meadows Reach: Growth projections for urban areas in the Meadows Reach such as the City of Sparks are 1.3% per year. In this reach, approximately 70 - 80% of the runoff comes from the mainstem Truckee River upstream of Reno (east slope of Sierra Mountains). Much of the remaining 20 – 30% comes from approximately 290 square miles of contributing drainage

area between downtown and the Vista gage (excluding Washoe Lake since little to no contribution from this reservoir).

On the south side of the Meadows Reach, Steamboat Creek including Boynton Slough account for a little over 194 square miles of drainage area. This watershed ranges from 4,400 feet at the base to approximately 9,700 feet at the peak of Mt. Rose. Much of the Steamboat Creek watershed is undeveloped except for the lower meadows and hills near the river. The development incurred in the future will occur mostly downstream of the most highly orographic (high rainfall) areas of this mountainous watershed. Therefore, urbanization impacts on runoff may not be as significant as expected.

On the north side of the Truckee River, approximately 94 square miles of contributing area contribute runoff, mostly from the North Truckee Drain channel. The North Truckee Drain watershed includes Spanish Springs Dam (controls 60 square miles) which was designed to control the .01 ACE event based on county design standards.

The Corps .01ACE design flood on the mainstem of the Truckee River has a peak at the Truckee River at Vista of 20,200 cfs. The hydrographs on Steamboat Creek and North Truckee Drain input into HEC-RAS for this simulation are in the range of 5000 cfs and 1200 cfs respectively (peaks do not occur at same hour/time).

The local sponsor has stated they will mitigate for future urbanization. Washoe County has local ordinances in place that requires developers to mitigate for urbanization up to the .01 ACE flood. In addition, Washoe County has developed a rainfall runoff model of the entire Truckee River watershed *specifically* for the purpose of analyzing urban development impacts on the proposed Truckee River project. The model will also be used to analyze mitigation measures. Therefore, future without project hydrology will be assumed to be the same as existing condition hydrology for this reach.

3.0 Climate Change Impacts

The purpose of this section is to discuss potential climate change impacts to the hydrology of this watershed and potential impacts to the proposed project alternatives. A detailed scientific study of climate change is beyond the budget and schedule set for this study. There is no consensus among scientists on the impact of climate change on California or Nevada. In fact, a review of some Global Climatic Model (GCM) studies shows a wide range of impacts. Some show an increase in hydrologic runoff while others show a decrease. To date, no specific guidance has been provided to Districts on how to account for climate change impacts. Since there is large amount of uncertainty in this emerging science and no consensus from the GCMs upon whether flows will increase or decrease, the Truckee River Feasibility Study assumed future without project conditions would be the same as existing conditions. Nevertheless, climate change is expected to result in more uncertainty about the true size of floods for the future condition. This increases risk. If the project goes to the PED phase, climate change should be considered in the

project design. The future condition for the purposes of this study is 50 years into the future. A more detailed discussion of the topic is included below for the reviewer's knowledge and understanding.

The biggest impact areas of future climate change in California and Nevada in regards to the volume of flood runoff is expected to be in the mountains (rather than the lowlands). The big rivers in California and Nevada are driven largely by runoff from the high elevation watersheds that include foothill and mountain ranges. This is due to orographic impacts. The air mass cools as it passes over mountain ranges which induces condensation/precipitation in these areas. A mean annual precipitation map of California shows the valley floor typically receives 13 to 25 inches of precipitation, while the foothills and mountains range from 35 to 95 inches. Typically, the mountains receive 3 to 6 times more precipitation than the valley floor during large floods. Another reason that climate change will have a more significant impact on the mountains is that warmer air temperatures will elevate (raise) the snow line. The snow line is the demarcation between where precipitation falls as rain versus snow in a watershed. If the percentage of the watershed receiving rainfall increases, runoff volume will increase as well.

The National Oceanic and Atmospheric Agency (NOAA) recently completed an update to precipitation frequency for California. NOAA considered estimating climate change impacts to precipitation frequency but decided against it after their own research indicated there was not conclusive evidence that precipitation frequency would change in the future.

The California State Climatologist has provided the Corps with state funding to model climate change scenarios for rare floods on some pilot watersheds on the western slopes of the Sierra Mountains. The results have not yet been finalized. None of these scenarios involve an increase in precipitation, only an increase in temperature. The pilot studies look at two significant changes during rare floods. These are 1) changes to accumulation of the initial snowpack during the winter before a large storm 2) changes to the snow line elevation (rain/snow demarcation) during the actual storm event of interest. Nevertheless, it should be pointed out that there are GCM models that predict an increase in precipitation for the Sierra Mountains of California and Nevada. This illustrates the uncertainty in climate change science.

The Truckee River is a high elevation watershed that includes Lake Tahoe and hundreds of square miles of drainage area on the east slope of the Sierra Mountains. By the end of this century, it is expected that winter temperatures (January thru March) will increase between 1 to 4 degrees Celsius (1.8 to 5.4 degrees Fahrenheit) in California (ref 2). In the future, warmer winter temperatures will cause the snowpack to retreat to higher elevations (currently between 5,000 to 6,000 feet elevation). Within the Sierra Nevada, models project a decrease in mountain snowpack of at least 20 percent and up to 90 percent (Climate change and the Relevance of Historical Conditions, Safford and Meyer, 2012) over the next century. Since the 1970's, there is documented evidence of a decreasing snowpack on April 1st in the Sierras (ref. 1). This trend is expected to continue into the foreseeable future. Warmer temperatures will bring about an

earlier spring snowmelt. This early runoff may cause conflict with keeping the flood control space in Prosser, Stampede, and Boca Dams empty during February and March (when significantly large storms can still occur). Historically, snowmelt floods by themselves (even in wet years) have not caused significant problems on the Truckee River. The four flood control dams have plenty of storage to absorb the spring inflow, while channel capacity in the Reno area has been more than sufficient to handle uncontrolled snowmelt runoff occurring downstream of the reservoirs. Since projections for future conditions indicate the spring snowpacks will become even smaller in the future due to climate change, the spring runoff from snow will be smaller. Unfortunately, warmer spring temperatures will change the timing of the spring snowmelt so that it coincides more directly with the flood season that runs from approximately mid-november to the end of March. Since the Truckee River flood control dams need a specific amount of space to absorb and control large general rain or rain-on-snow floods, the earlier melting of the spring snowpack due to climate change is NOT desired. The true impact of this phenomenon is not known without more research and/or modeling studies. Aside from conducting such an investigation, a guess is that the impact will not be too substantial due to: 1) the relative ease at which snowmelt events have been controlled under existing conditions 2) projected smaller antecedent snowpacks in the future (20 to 90% smaller over the course of the century) and 3) the increase in downstream conveyance capacity (urban areas) under with-project conditions. Again, the size of the spring snowpack is projected to decrease by 20 – 90% over the course of the century. The earlier spring snowmelt will cause operating agencies to have more trouble controlling early to late spring rain-on-snow events at the reservoirs, but whether it will be more of a nuisance or more significant is not known. Climate change will cause more uncertainty in the future condition (more risk) and should at least be considered if the project goes into PED phase.

To venture into possible impacts for the Truckee River, a climate change sensitivity analysis performed by the Corps for the Feather River watershed in California (Ref 2: Sutter Basin Feasibility Study, 2012) was reviewed. The justification for this comparison is twofold: 1) The Feather River watershed (west slope) is adjacent to/at the same latitude as the Truckee River (east slope). Parts of each watershed share the same ridge line as a boundary. 2) A literature review found further justification. A study that averaged the results of 15 Global Climatic Models simulating climate change published a map showing a zone of similar magnitude of change in precipitation (winter months) due to climate change. The indicated zone of homogenous change included mountainous portions of both the Feather River and the Truckee River watershed. Historically, the same large scale storms that have caused record floods on the west slope of the Sierras (like 1986 and 1997) also caused record floods on the Truckee River as well. The two watersheds are meteorologically related.

Last year, the Sacramento District contacted Dr. Raff of USACE-IWR who recommended the Sutter Feasibility Study review the following paper: (Das T, MD Dettinger, DR Cayan, Hugo G Hidalgo (2010) Potential increase in floods in California's Sierra Nevada under future climate

projections. Springer Science+Business Media B.V. 2011). The Das, et al. study published an expected percent increase in the 3-day unregulated flood discharge for the northern and southern Sierra Nevada resulting from climate change as shown in Table 1 below.

The study evaluated three General Circulation Models (GCMs) including CNRM CM3, GFDL CM2.1, and NCAR PCM1. The study incorporated the results into a Variable Infiltration Capacity (VIC) hydrologic runoff model and simulated stream flows for 50% (1/2) to 2% (1/50) Annual Chance Exceedance (ACE) floods. Percent increases from the base condition (2001) were presented for future years 2049 and 2099 for the Northern and Southern Sierra Nevada Region. The table below summarizes the model outputs for 3-day volume for the future year 2049. Note that one or more of the GCM models indicate a change in precipitation under climate change, so the results below are a combination of both temperature and precipitation changes due to climate change. Also note that a rainfall runoff model was run continuously for 50 years with output from the Global Climatic Models. Consequently, the results in the table below will also capture the impact of a potentially smaller snowpack that starts at higher elevations than in the present.

Table 1. Percent increase in unregulated flow, 2001 to 2049, Northern Sierra Nevada

Annual Chance Exceedance %	Percent Increase in 3-day Flow by General Circulation Model Scenario, 2001 to 2049		
	CNRM CM3	GFDL CM2.1	NCAR PCM1
50	**12**	**22**	**6**
10	**21**	**27**	**-10**
5	**27**	**32**	**-14**
4	**28**	**33**	**-15**
2	**35**	**40**	**-19**
1	*35*	*40*	*-19*
0.5	*35*	*40*	*-19*
0.2	*35*	*40*	*-19*

Note: The DAS, et al study only analyzed impacts between the 50% and 2% ACE events (shown in bold). As the general trend is for increasingly negative or positive changes in runoff for more rare events, the impacts to the 1% ACE flood might be even greater than shown.

The above table describes impacts to unregulated 3-day runoff on the west slope of the Sierras. As these estimates are for the 3 day volume, an assumption could be made that similar impacts will occur with the 1-day volume and peak. In the Meadows Reach (major damage area for this study), peak instantaneous flow is driven by volume. The Vista Reefs perform like a weir structure that causes backwater and ponding in the Truckee Meadows. The depth of water (head) in the ponding area drives outflow over the reefs. Therefore, volume can be used as surrogate to infer impacts on the peak flow frequency curve at Vista in the Meadows Reach.

From table 1 above, one of the GCM models predicts a 40% increase in the 2% ACE event runoff, while another GCM indicates a 19% decrease. The current Truckee River NED plan as of the writing of this report is for a 2% ACE level of design. The peak flow in Reno, NV during a 2% ACE event is driven mainly by uncontrolled runoff downstream of both Lake Tahoe and the flood control dams in the Truckee River watershed. Three of the four flood control dams shut their gates to release only a couple hundred cfs while the uncontrolled runoff passes through Reno. Since uncontrolled runoff drives the flooding in Reno for events equal to or more frequent than the existing condition 1% ACE flood, the above estimates in Table 1 could reasonably be used to estimate changes in peak flow for the Meadows Reach for events equal to or more frequent than the 2% ACE. Unfortunately, a 40% increase in volume to the existing 1% chance event runoff on the Truckee River could result in greater than a 40% increase in the Meadows Reach because of induced spillway flow at the reservoirs. Currently, the four flood control dams maintain control up to 1% ACE event.

Similar results were shown for the Sutter Feasibility Study on the Feather River (ref. 2). For the sensitivity study on the Feather River, inflow volume to Oroville Dam was increased by 35% and 40% based on the CNRM and GFDL climatic models. Oroville Dam provides about a 1% chance level of protection on the Feather River. The increased inflow volume caused a corresponding 61% and 81% increase in outflow from Oroville Dam for the 1% event. Flood control alternatives on the Feather River for the Sutter Basin Feasibility Study mainly consist of levee improvements.

The Sutter Feasibility Study desired to determine whether climate change might impact the alternative selected or the design height of the levees. Two future condition flow frequency curves (for water year 2049) were input into the Flood Damage Analysis Program (FDA). One curve represented the wettest future climate change scenario (GFDL model) and one the driest scenario (NCAR model). The systematic record length of the existing condition unregulated flow frequency curve was used in FDA to compute confidence limits about the two future condition flow frequency curves. The unregulated to regulated transform used in FDA for existing conditions was used to translate future unregulated flow frequency to regulated flow frequency for the two scenarios. The FDA program was run by an economist for each alternative under the two climate change scenarios time. For each alternative and climate change scenario, new expected annual damages were computed, as well as net annual benefits. In the end, the ranking of the selected alternatives did not change for either of the two climate change scenarios compared to a future *without* climate change condition. In addition, it was found that increasing design levee heights on the Feather River to account for climate change was not economically justified due to 1) climate changes occur in small increments over the life of the project with full impacts not expected until 2049 2) the overall range of uncertainty increased since the NCAR

climatic model results actually lowered the flow frequency curve, while the GFDL model increased the frequency curve.

The hydrologist has provided two example future condition (with climate change) unregulated frequency curves to the economist (40% increase and 19% decrease in runoff for all frequency events. For this study, the existing condition unregulated frequency curve is assumed to be the best estimate due to the current state of climate change science. The economist will input those future climate change frequency curves into FDA for a representative damage point and provide results. See the Economic Appendix for a description of results. The sensitivity analysis may provide some insight into climate change impacts to the project.

In conclusion, climate change could possibly have significant impacts to peak flow frequency for the lower Truckee River watershed. Unfortunately, there is a wide range of impacts predicted by scientists and by the various GCM models in existence. Climate change could be considered in the final project design if constructed.

References:

1. Snowpack Trends in the Central Sierra Nevada Affecting Water Supply Forecasts on the East Slope Sierra Basins, Jolyne Lea, USDA NRCS National Water and Climate Center, 2nd Joint Federal Interagency Conference, June 27 – July 1, 2010.

2. Memorandum for File, Sensitivity of Flood Frequency Analysis to Climate Change Models, Sutter Feasibility Study, October 2012.

3. Das T, MD Dettinger, DR Cayan, Hugo G Hidalgo (2010) Potential increase in floods in California's Sierra Nevada under future climate projections. Springer Science+Business Media B.V. 2011.

4.0 Impact of January 1997 Flood on Flow Frequency Curve

The USGS estimated the peak flow at the Truckee River at Reno gage to be 18,200 cfs. This value was used to calculate the unregulated peak flow for the 1997 flood and to produce an unregulated peak flow frequency curve. The estimated unregulated peak flow for the 1997 flood is approximately 42,000 cfs. This value would increase by approximately 4800 cfs if the revised estimate by the Corps of 23,000 cfs is used. 42,000 cfs was used to calculate the unregulated peak flow frequency curve derived for the 199 F3 Report. A sensitivity analysis was conducted to estimate the impact of this event on results.

Near or around the time of the 1999 F3 Conference, Montgomery Watson Harza (MWH, Inc) calibrated an HEC-RAS model of downtown Reno to high water marks. They estimated the true regulated peak to be between 20,000 to 25,000 cfs.

Approximately 2 years later, a new HEC-RAS model was built for the Truckee Meadows Reach. The model was jointly developed by Gary Brunner of the Corps Hydrologic Engineering Center (HEC) and WRC, Inc of Reno. The model included a portion of the downtown reach. The model was calibrated to high water marks observed from the January 2nd, 1997 flood. The modelers concluded that the 1997 event peak flow in downtown Reno was 23,000 cfs and 20,700 cfs at the Vista gage. Note: Attenuation of the hydrograph occurs in the Meadows Reach due to induced overbank flow by the Vista Reefs. In addition, the calibration hydrograph showed a maximum 24-hour average flow at the Reno gage of 18,900 cfs. Gary Brunner (HEC staff) and WRC, Inc. expressed confidence in the calibration and Sacramento District ultimately adopted these values for the Truckee River Feasibility Study. The USGS was contacted about this issue but the agency did not revise their records. USGS stated they believe obstructions and slower velocity, not more water, caused the high water marks in the river.

For the 1999 F3 Study, only 25 unregulated peak flow values existed due to a lack of hourly reservoir inflow data for the period of record. Almost 80 years of 1-day unregulated flow values existed. Unregulated daily flow values were computed for the Reno gage based on daily "holdouts" at reservoirs (change in storage converted to average cfs/day) added to the daily flow value at the Reno gage. The regression equation was used to improve the estimated mean value of the peak curve. A 1-day to peak regression equation was computed to provide an additional 50 years of peak flow values. This provided a revised mean for the unregulated peak flow curve; however, the standard deviation and skew of the 1-day curve were adopted for the peak curve for the 1993 Study. It is recognized that the using a regression equation can reduce the uncertainty (i.e. standard deviation) of the curve; however, the standard deviation was adopted from the 1-day curve and was not impacted by the regression equation in this case. The District Hydrologist in SPK felt that adopting the 1-day curve's standard deviation and skew was more reliable than using the limited sample of unregulated peaks for estimating these moments.

In 2001, the local sponsors requested that the flow frequency analysis be re-visited based on the newly estimated 1997 peak and volume estimates derived from the calibrated HEC-RAS model. A sensitivity analysis was conducted. The analysis estimated the 1% ACE regulated peak flow for the Reno gage would change by less than < 4% while the 1-day volume would change by < 2%. Due to the results of the sensitivity analysis, the original unregulated and regulated flow frequency curves for downtown Reno, derived in the 1999 F3 Milestone Hydrology Appendix, were left unchanged. The regulated frequency curve for the Truckee River at Vista was modified in the 2003 F3 Report. The Truckee River at Vista regulated flow frequency curve utilized the new 1997 estimates as well as a new methodology to develop the curve.

5.0 Uncertainty of Timing of Tributary Runoff in Meadows Reach

In 2001, the local sponsors asked the Sacramento District to look into the uncertainty of the timing of Steamboat Creek and North Truckee Drain hydrographs during a mainstem Truckee River flood event. This analysis is described in Part II, Section 4 of the Hydrology Appendix. While some peak flow values exist for these tributaries, the exact timing of the peaks are unknown except for observations during a few events. The coincident timing between runoff on these tributaries and the peak flow on the Truckee River is uncertain. During a large flood, the Vista Reefs cause overbank flow and a lake covering approximately 5 square miles forms during a 1% ACE event. The backwater also makes the streamgage rating curves on lower Steamboat Creek and North Truckee Drain inaccurate. Field observation of the Steamboat Creek runoff during the January 1997 flood gave one estimate of the timing. The timing observed in two other major floods was discovered in previous hydrology reports. The timing of the three events was averaged and used for the initial simulation of each frequency event in the HEC-RAS model. It was determined that two additional steps would be taken. First, an unregulated 7-day flow frequency curve for the Reno gage and the Vista gage were constructed. Over a 7-day period, the lake that forms in the Meadows Reach will drain out and flow past the Vista gage. For a given frequency event, the two 7-day volumes from the frequency curves are subtracted. This determines the concurrent 7-day volume contributed by these tributaries during a flood. For simulation of specific frequency events in HEC-RAS, all tributary hydrographs for the Meadows Reach were initially scaled to match the target 7-day volume achieved by subtracting the two curves.

The Corps had confidence in the peak regulated flow frequency curve at Reno, but less confidence in the curve at Vista. Therefore, it was decided that a regression equation using historic floods could be used to estimate peak flow frequency estimates at the Vista gage (at least within the range of observed events). A relationship between historic peaks at the Reno gage and the Vista gage was produced. Only large events recorded after 1963 (year the Vista Reefs were modified by the Corps) were included in the equation. It was theorized that mingling/timing of the Meadows tributary flows with the mainstem Truckee River would be reflected in the historic response at the Vista gage. The regression equation was used to predict the 10% through 1% ACE flows at Vista with the known value (x) based on the regulated Reno peak flow frequency curve. The corresponding (y value) was the peak flow at Vista. These estimates were used to produce a "target peak flow" at the Vista gage location for each HEC-RAS simulation of a specific frequency flood. The modelers were told to adjust the timing of the tributary hydrographs (within a 12-hour range as seen in historic observations) until they matched the target peak flow at the Vista gage. As an additional step, if timing adjustments were not sufficient, the modelers were given the option of scaling the tributary hydrographs up or down to meet the target. The local sponsors and staff consulted at HEC were in agreement that this was a decent method to ensure the timing utilized in the HEC-RAS model was reasonable. The full degree to which adjusting the tributary timing might impact the peak flow is not entirely known unless a sensitivity analysis is conducted in HEC-RAS for both without and with-project conditions.

Discussions with the hydraulic engineer assigned to this study indicate that the peak flow at Vista is driven by volume (not peak) for existing and with-project conditions (although less so under with-project). The tributary hydrographs essentially enter into reservoir formed by the Vista Reefs. An educated guess by the hydrologist is that reasonable variation in the timing of the runoff might change the peak flow at Vista by less than a few thousand cfs for the 1% chance existing condition event at the Vista gage. This partly due to the fact that the design hydrograph for the mainstem Truckee River is very fat or robust in shape (not very peaked). The mainstem hydrograph has a peak that stays relatively high throughout the day. For example, during the 1997 flood, the peak instantaneous flow in downtown Reno was estimated at 23,000 cfs while the maximum average 24 hour flow was almost 19,000 cfs.

The hydrographs on Steamboat Creek and North Truckee Drain have a peak of about 5000 and 1200 cfs respectively for the HEC-RAS simulation of the 1% flood on the Truckee River. SPK analyzed a proposed flood control dam at Huffaker Hills on Steamboat Creek as a project alternative (the alternative also included levee improvements in the Meadows Reach). The modeled dam had approximately 3500 ac-ft of flood storage that was designed to strip the peak off the Steamboat Creek hydrograph. The gates were capable of releasing up to 4,000 cfs. A model simulation of a .0085% (117-yr) flood was done using HEC-RAS. The Steamboat Creek inflow hydrograph for that simulation had a peak of about 5400 cfs. The simulation of the .0085% event with Huffaker Dam in place showed only a 280 cfs change in peak at the Vista gage. Subsequently, this alternative was deemed to be ineffective. The hydraulic engineer feels this simulation indicates that volume, rather than tributary timing is driving the peak water surface elevation at Vista. The volume held back by Huffaker Dam probably allowed water from other sources to fill in the void in the flood storage pool in this reach. A sensitivity analyses in HEC-RAS would have to be done to completely quantify the uncertainty due to tributary timing, but the hydraulic engineer does not feel this effort would show much change in the water surface elevations in this reach.

6.0 FDA Input: Frequency Curves and Confidence Limits.

The frequency curves utilized in this study use computed probability. These curves were provided to the economist as input into the Corps' Flood Damage Analysis (FDA) software program. Appropriate confidence limits for the frequency curves are generated in the FDA program using "equivalent period of record" guidance as provided in EM 1110-2-1619, Table 4-5. Table 2 provides the period of record assigned to key locations in the study area. Table 3 provides period of record assignments for tributaries.

Table 2: Period of Record Assignments for Key Locations

Index Point	Damage Area No.	Function Utilized in FDA	Frequency Curve	Equivalent Period Record	Justification
5	5	Discharge Frequency	Truckee River at Reno Gage	78yrs	systematic record
6	6	Stage-Frequency	Truckee River at Vista Gage	55 yrs	Less than systematic record due to 1963 modifications to Vista Reefs
7	7	Stage Frequency		55 yrs	Less than systematic record due to 1963 modifications to Vista Reefs
8	8	Discharge Frequency		78 yrs	systematic record

Table 3: Period of Record Assignments for Tributary or Interior Drainage Watersheds

Location	**Function Utilized in FDA**	**Streamgage**	**Equivalent Period Record**	**Justification**
Lower Steamboat Creek	Discharge Frequency from Rainfall Runoff	Steamboat Creek at Short Lane	15yrs	Calibrated rainfall runoff model to poor quality short term gage data
Lower North Truckee Drain	Discharge Frequency from Rainfall Runoff	North Truckee Drain at Shadow Lane	15 yrs	No data for calibration of model
Downtown Reno	Discharge Frequency from Rainfall Runoff	None	15 yrs	No data for calibration of model

Downtown Reno and the Truckee Meadows Reach are two key reaches in the study area. Charts 1 and 2 below display the Truckee River at Reno and the Truckee River near Vista graphical, regulated frequency curves plotted with confidence limits as produced by the SSP software and using the period of records shown in Table 2. For this study, the input into FDA for the Downtown Reach is the unregulated peak flow frequency curve for Reno and an unregulated to regulated transform. For the Meadows Reach, some index locations directly use a stage-frequency curve as input to FDA. Consequently, the uncertainty about the regulated peak flow frequency curve shown in Charts 1 and 2 will not necessarily match the uncertainties found within the FDA program results.

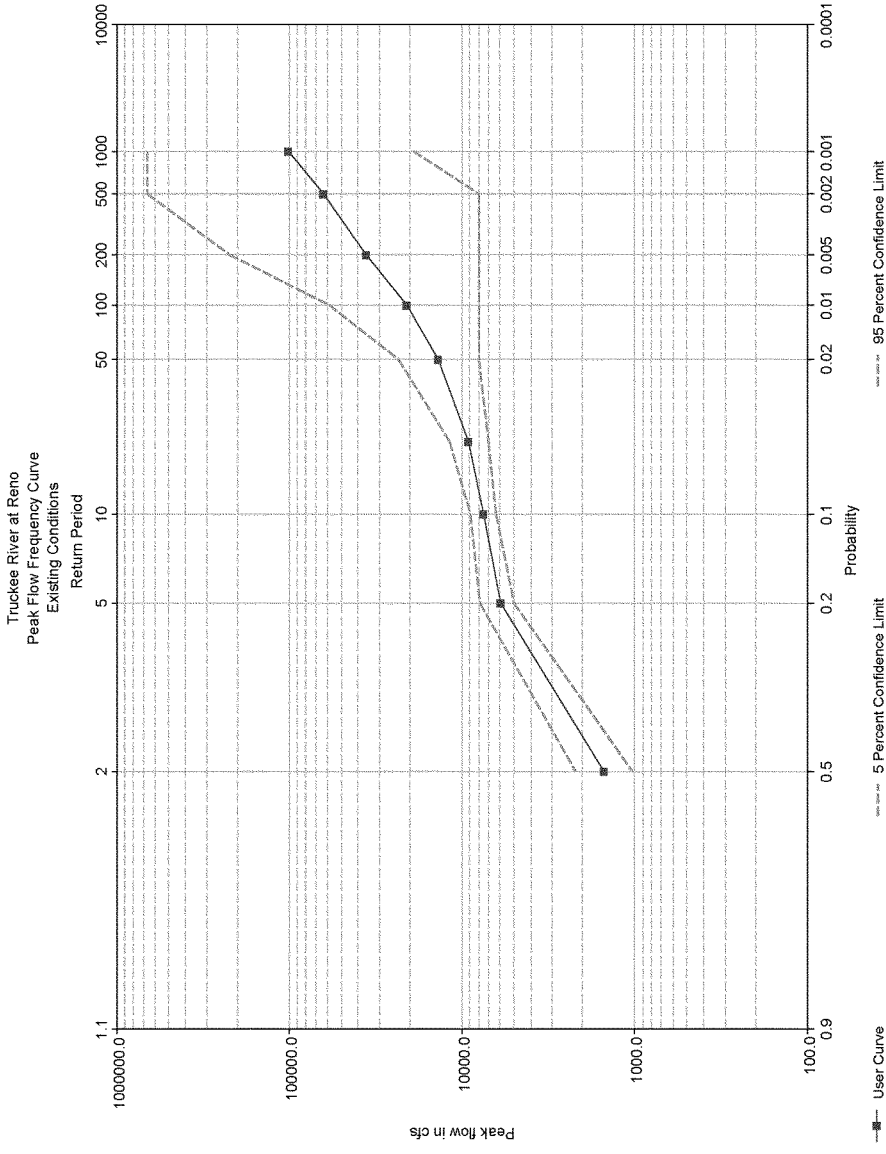


Chart 1 of Part V

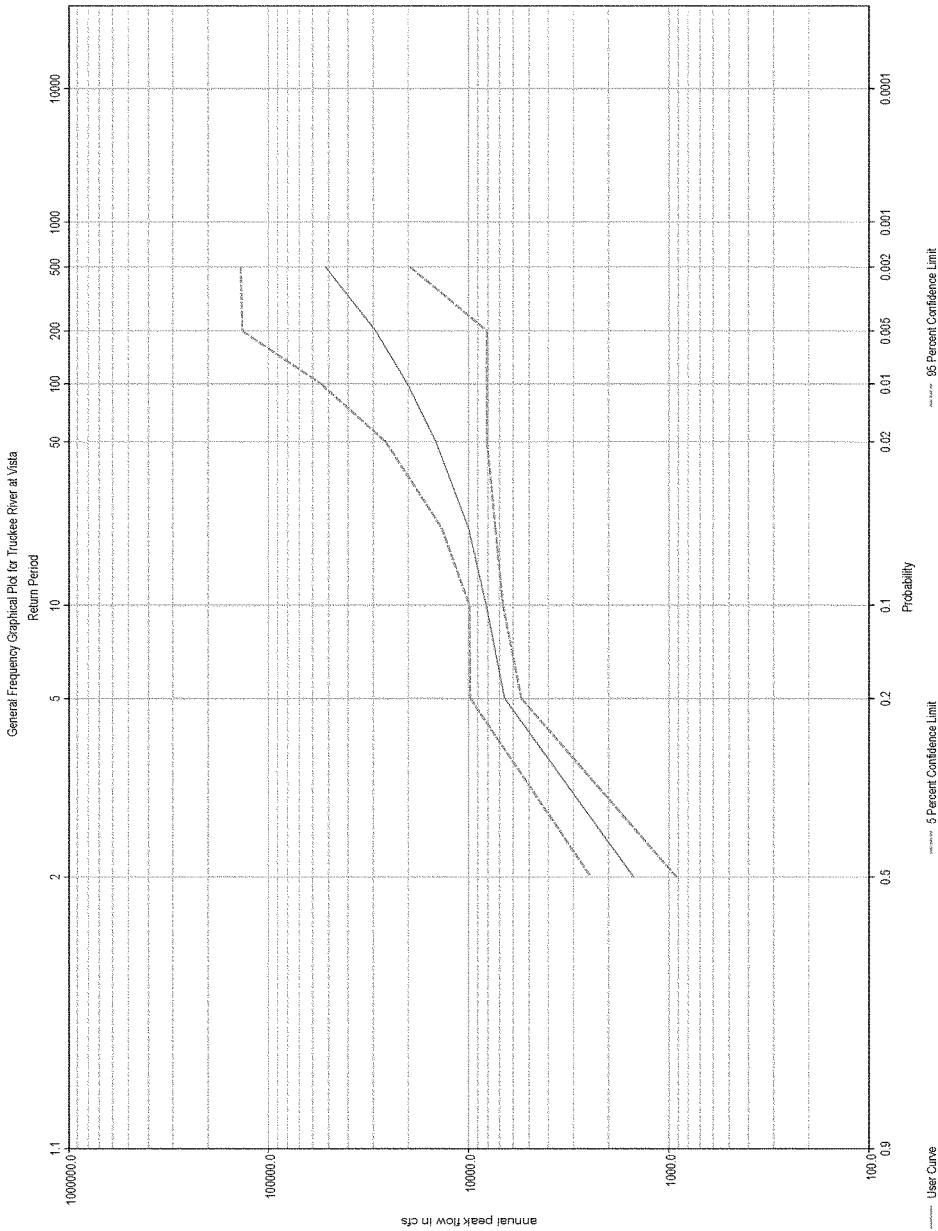


Chart 2 of Part V

7.0 Updated 1-Day Unregulated Flow Frequency Curve for Truckee River at Reno

The original family of Truckee River at Reno unregulated frequency curves (peak through 3-day duration) was produced in 1999. Since over a decade has passed since that time, there was a desire to see if adding additional water years of data would significantly change the statistics and quantiles of the curve. In addition, the 1999 unregulated frequency curve used a water year 1997 value based upon the USGS's published regulated peak flow value of 18,200 cfs. After 1999, the Corps adopted a regulated peak flow of 23,000 cfs for the 1997 flood based on calibration of an HEC-RAS model to high-water marks. The Corps adopted 1997 flood value will be used for computing a new unregulated flow value for this water year.

In FDA, the peak unregulated flow frequency curve is used for the Downtown Reno Reach along with an unregulated to regulated transform. Only a handful of estimated unregulated peak flow values exist, as hourly flow data is limited and not available for the entire period of record. For the original 1999 unregulated peak flow frequency curve, a synthetic record of peak unregulated values were derived using a regression equation (unregulated 1-day "x" to unregulated peak values "y"). The synthetic record was ONLY used to produce a mean for the 1999 peak curve. The standard deviation and skew of the 1999 unregulated 1-day curve were adopted for the statistics of the peak instantaneous flow frequency curve.

The Truckee River at Reno unregulated hydrograph is the foundation of the design hydrograph (regulated hydrograph) that is input into the HEC-RAS model in downtown Reno. It also represents 70 -80% of the volume that enters the Meadows Reach. The remaining volume comes from tributaries entering the Meadows Reach including Steamboat Creek and North Truckee Drain. For the following reasons, it was decided that the unregulated 1-day flow frequency curve was the most important curve to update for this sensitivity analysis: 1) the peak curve is dependent upon 1-day data and statistics as described above 2) the volume (not peak) in the design hydrographs drives the damages in the Meadows Reach (which is why a stage frequency curve is used in FDA for a couple of index points in the Meadows Reach).

The 1-day unregulated flow frequency curve for the Truckee River at Reno was updated as follows. Additional unregulated daily flow values for the Truckee River at Reno were computed for water years 2000 to 2013. Rainflood season maximum annual values were extracted from this data set. These maximum annual values were added to the annual maximums used in the original 1999 F3 Report curve except that the value for the January 1997 flood was revised (increased) based upon the Corps' reconstitution of this flood event using an HEC-RAS model calibrated to high water marks. The new dataset was input into a USGS program called PeakFQ. Per Bulletin 17B criteria, a regional skew value of (+0.10) was input into PeakFQ for weighting with the station skew. The regional skew was taken from the Bulletin 17B regional skew map for California/Nevada. New statistics were computed. Table 4 compares the original 1999 curve and 2013 revised curve quantiles.

Table 4: Comparison of 1-Day Unregulated Frequency Curves for Truckee River at Reno

	4% ACE	2% ACE	1% ACE	0.5% ACE	0.2% ACE
Original 1999	16,000	25,600	39,500	59,500	99,400
Revised 2103	**16,200**	**25,400**	**38,600**	**57,200**	**93,600**
% Difference	**1%**	**-1%**	**-1%**	**-4%**	**-6%**

To determine impacts to regulated peak flow frequency, the original 1993 1-day unregulated flow frequency curve along with regulated peak flows from HEC-RAS model runs were used to derive an *unregulated to regulated transform* for the Truckee River at Vista gage (Meadows Reach). New quantiles for the 2013 revised 1-day unregulated flow frequency curve were then applied to the transform to determine an estimated change in regulated peak instantaneous flow at Vista. Table 5 below provides the resulting estimated changes (in percentages) to the regulated peak flow frequency curve for the Truckee River at Vista. The differences below are considered relatively insignificant, especially for the 1% ACE and more common events which drive expected annual damages and benefits for this study.

Table 5: % Change in Regulated Peak Flow at Vista
(estimated from Unregulated 1-Day to Peak Regulated Transform Function)

	4% ACE	2% ACE	1% ACE	0.5% ACE	0.2% ACE
% Difference	**1%**	**0%**	**-2%**	**-5%**	**-6%**

PART VI of Attachment A

FUTURE WORK IN PED PHASE

Purpose:

The purpose of Part VI is to provide useful information to those who will participate in future work on this project, especially if this project proceeds to the PED phase. This is an issue that could not be addressed due to time and budget in the Feasibility Study Phase.

Unregulated flow frequency curves at Reno: A family of unregulated peak flow frequency curves were produced in the 1993 F3 Report. The Truckee River at Reno gage curves were adopted for the Downtown Reno Reach for this study. The family of curves have an unusually positive skew (0.40 for the peak instantaneous through 7-day curves). These curves were used to derive a synthetic, balanced, unregulated flow hydrograph for downtown Reno. The resulting hydrograph was then subdivided and distributed into parts to provide input hydrographs to an HEC-5 reservoir simulation model to obtain regulated, existing condition hydrographs for various frequency events. At least one local hydraulic engineer in the region has commented that the Corps regulated 0.2% ACE (500-year return period) event seems too large. The assigned hydrologist for this study now believes this concern is valid. Many years after the 1999 F3 conference, it was discovered that the HEC-5 simulation of the 0.2% ACE event showed two of the USBR flood control dams (including Stampede Dam) incur "dam overtopping" (not just spillway flow). The USBR dam spillways were designed to prevent overtopping by the Probable Maximum Flood. This indicates there is a serious problem with the size of the 0.2% ACE event used in this study. Recently, the USBR determined that Stampede Dam had an insufficient spillway and raised the dam based on this concern. Nevertheless, the assigned hydrologist still believes the Corps current 0.5% (and possibly 0.2% events are probably too large). Fortunately, the HEC-5 model handles the overtopping situation by extrapolating the spillway rating curve to produce higher outflow (not by converting the whole dam into a weir), so the resulting outflow hydrographs are not as extreme as might be expected. The underlying cause for these two dams to incur water surface elevations that exceed "top of dam" is probably the positive skew on the unregulated frequency curves.

In 2011, the hydrologist met with the PDT team and senior Planning and Project Management staff to discuss his concerns about the 0.5% and 0.2% ACE events being too large. The consensus among those present including the economist and the planner were 1) the potential revisions to the 0.5% and 0.2% ACE events would probably impact all the selected alternatives equally, so it should not impact final alternative selection 2) the 0.5% and 0.2% ACE events were so rare that it should not have a significant impact on the benefit

to cost ratio. Initial damages for this study occur for events more common than the 2% ACE event for the all important Truckee Meadows Reach.

The current NED plan provides protection for an event close to the 2% ACE event. The local sponsor desires to build a project that provides protection from the 1% ACE event. The assigned hydrologist believes that the 1% ACE and more common events adopted for this study are reasonable. This is based on several facts: 1) the January 1997 flood is believed to be the largest flood since 1869 (for unregulated conditions). This flood event is believed to have produced a 23,000 cfs peak in downtown Reno. The Corps 1% ACE design event has a peak flow of 20,700 cfs. 2) A sensitivity analysis on skew performed for the 1993 F3 Report hydrology did not indicate much impact to the 1% ACE flow quantiles.

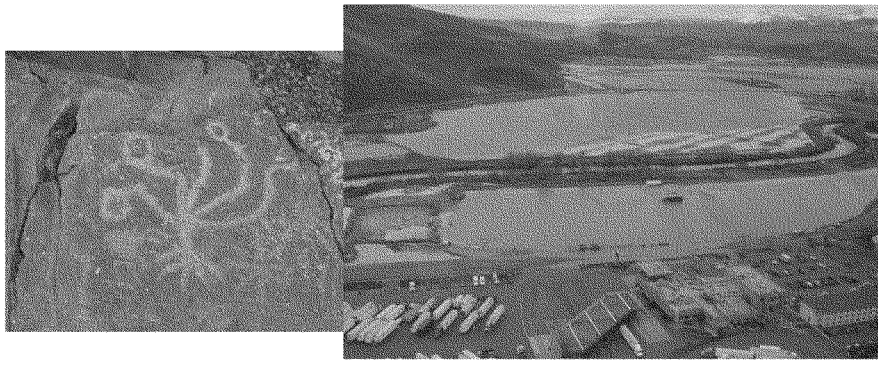
The purpose of bringing this issue to light is twofold. Most importantly, if the desired level of protection the project provides changes in the future to something significantly more rare than the 1% ACE event, then the 0.5% and 0.2% ACE events should be re-examined. Secondly, the user of this report should be warned that that the overly positive skew of the unregulated flow frequency curve for the Truckee River at Reno may not be reasonable for the upper end of the curve beyond the 1% ACE event. The upper end the curve could be re-examined using a rainfall runoff model of the Truckee River watershed. Rainfall runoff modeling is often a good method to validate the reasonableness of a flow frequency curve. In other words, can reasonable rainfall depths and loss rates be used to produce the 0.5% and 0.2% ACE runoff predicted by the unregulated flow frequency curves? If not, then the rainfall runoff model results should be adopted for these rare events. The flow frequency curve's positive skew (+0.4) is suspicious, especially given the overtopping of two USBR dams in the Truckee River HEC-5 model when simulating a 0.2% ACE event.

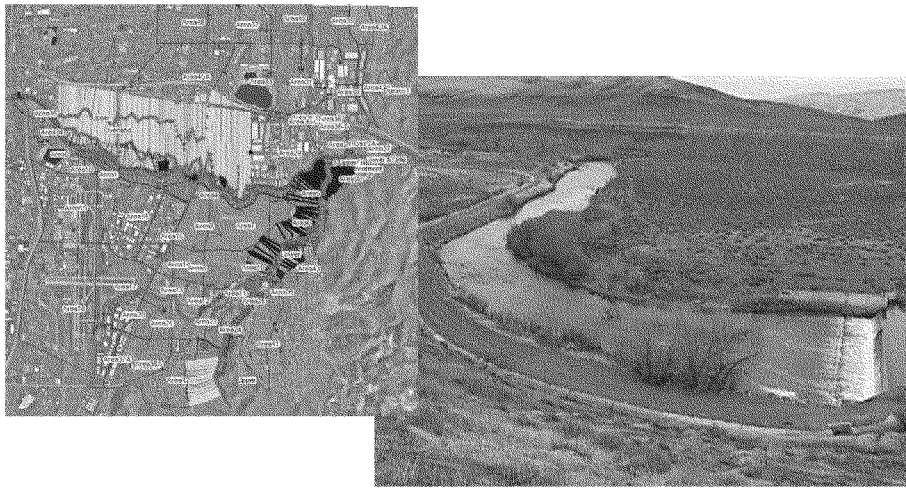
US Army Corps
of Engineers
Sacramento District

Truckee Meadows Flood Control Project
Reno, Nevada

Attachment B - Hydraulic Design

July 22, 2013





Attachment B
Hydraulic Design
Truckee Meadows Flood Control Project
Reno, Nevada

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Attachment B
Hydraulic Design
Truckee Meadows Flood Control Project
Reno, Nevada

1. PURPOSE OF DOCUMENTATION

1.1. This report documents the work conducted for the Truckee Meadows Flood Control Project to develop and modify hydraulic models and to establish existing hydraulic conditions and floodplains. Furthermore, this documentation focuses on details of the Recommended Plan as well as on the with-project floodplains, interior drainage, and sediment transport and channel stability assessments for the existing and with-project conditions. Given the geographic layout of the project, the format of the following discussion presents the relevant information on a study reach by study reach basis.

1.2. Although it is typical to have the without-project condition completely defined in the F3 phase of the study, various issues have arisen throughout the study process which have either necessitated redevelopment of the without-project floodplains and the corresponding economic analyses, or addition of new reaches to the study after the F3 conference which required identification of the without-project condition. The main product components of the various hydraulic analyses for each study reach include:

1.2.1. Update on the hydraulic modeling efforts and results since the F4 Conference;
1.2.2. Presentation of new without-project conditions where appropriate;
1.2.3. Limited discussion and presentation of hydraulic analyses of various alternatives, as applicable;
1.2.4. Discussion and presentation of hydraulic analyses for the Recommended Plan; and
1.2.5. Other issues, considerations, and observations considered significant and relevant to the overall project study.

1.3. A comprehensive collection of the hydraulic documentation and results for the previous National Economic Development (NED), Locally Preferred Plan (LPP), and Federal Interest Plan (FIP) projects is maintained with the Hydraulic Analysis Section's files[1].

[1] Most of the hydraulic analyses and documentation for this project were performed and the records maintained by the Sacramento District's Hydraulic Design Section. In August 2011, the Hydraulic Analysis Section was formed and all new hydraulic analyses and documentation and all of the existing records for the project were transferred to the new section. Throughout this report, references to existing data and records are made to the Hydraulic Analysis Section regardless of when the data was developed, for consistency. Documentation covering the history of the project uses the "Hydraulic Design Section" terminology, as appropriate, to ensure historical accuracy.

2. GENERAL

2.1. An F3 conference was held in July 1999 to discuss the Draft General Reevaluation Report (GRR) that the Corps of Engineers, Sacramento District developed for the Truckee Meadows Project. The Draft GRR described flooding problems in the Truckee Meadows and project alternatives to reduce the risk of flooding. However, the project sponsors, Washoe County and the Cities of Reno and Sparks, had concerns about the hydrologic and hydraulic analyses in the Draft GRR. The sponsors questioned the development of the existing condition hydrology, and the accuracy of the FLO-2D program, as applied in the Truckee Meadows reach. In the downtown reach, a steady state, non-georeferenced HEC-RAS model was used to compute the n-year profiles and the 20- through 100-year floodplains. A FLO-2D model was used for development of the 200- and 500-year floodplains. The use of the FLO-2D model in the downtown reach was not an issue to the local sponsors. Further details concerning the existing conditions modeling completed for the F3 conference are contained in the F3 Closeout Report and the WRC Report, dated December 8, 2003.

2.2. New HEC-RAS modeling was completed in 2000 in response to the sponsors' concern about the hydraulic analysis in preparation for the F3 conference to report on existing conditions. This modeling was done jointly by WRC and the Corps' Hydrologic Engineering Center (HEC). In preparation for the F4 Conference (held in January 2005), the Hydraulic Design Section, Sacramento District, defined the without-project conditions and floodplains for the 1/10, 1/20, 1/50, 1/100, 1/200, and 1/500 chance events and analyzed three alternatives for the Truckee Meadows area with the use of the HEC-RAS model to determine the economic benefit of the proposed individual alternatives. Additional analyses were also conducted, including hydraulic uncertainty analyses, to further refine the design.

2.3. A significant change in the project since the F3 Closeout Report consisted of inclusion of the downstream reaches in the overall project. Specifically, the reaches between Vista and Wadsworth and between Wadsworth and Pyramid Lake had been included in the study and were discussed in general terms in the F4 documentation. This document includes a more complete discussion of the analyses and results which have been completed since the F4 Conference.

2.4. In general, this documentation focuses on changes since the F4 Conference and only on the Recommended Plan. Previous sources of hydraulic documentation include the Hydraulic Design F4 Conference document and the documentation for the F3 phase of the study, titled "Truckee River Hydraulic Analysis of Existing Condition Flooding", and is maintained within the Hydraulic Analysis Section's files.

2.5. Following the F4 Conference, the Hydraulic Design Section, Sacramento District, continued to refine the HEC-RAS modeling in the Truckee Meadows study area and completed updating the without-project condition, as well as updating modeling of the

three alternatives which were sized to contain the 1/50, 1/100, and 1/125[2] chance events. This work was completed in early 2006 and follow-on economic analysis indicated that the NED plan coincided with Alternative 3, sized to contain the 1/117 chance event.

2.6. Unfortunately, the 2006 modeling and corresponding economic analysis were predicated on shortcuts and on potentially inappropriate use of surrogate results to meet deadlines which existed at that time. Thus, the project development team (PDT) reached consensus that a more homogenous set of results should be developed and used to confirm the selection of the NED plan.

2.7. In May 2009, Hydraulic Design Section, Sacramento District, completed detailed HEC-RAS and FLO-2D modeling of the Truckee Meadows study area for the without-project and with-NED project conditions. The with-project conditions included focusing on Alternative 3 (levees and floodwalls alternative in the Meadows) with- and without-detention at Mustang Ranch and was investigated for project sizing sufficient to contain the 1/50, 1/100, and 1/117 chance events. Unlike earlier attempts at modeling the Truckee Meadows area, this modeling provided homogeneous data as input to the corresponding economic analysis. The economic analysis indicated that the NED plan did not correspond to the 1/117 chance design, but was probably much closer the 1/50 chance level design.

2.8. In mid-2009, technical review of the economic analysis revealed some discrepancies in the economic as well as the hydraulic modeling results. Most of these discrepancies were due to inconsistencies in flood depths corresponding to the 1/200 and 1/500 chance events located in the City of Sparks along the North Truckee Drain corridor, upstream of Interstate 80, and between the UPRR and Truckee River. It is noted that the flooding for these large events is very complicated in these areas and that the modeling must include the correct connections both for flow over the Interstate 80 and UPRR embankments as well as for the various underground culverts which link the north and south floodplains.

2.9. The project local sponsors requested the Sacramento District to review the hydraulic and economic analyses and results. In June 2009, the District initiated an Agency Technical Review (ATR) of the 2009 hydraulic modeling which was conducted by the Corps' Albuquerque District. In general, their findings stated that "In the review of the project there were no errors discovered that would be expected to affect the outcome or conclusions regarding the selection of the NED plan." An additional External Technical Review (ETR) was initiated in September 2009 which was conducted by David Ford Consulting Engineers, Inc. to review both the 2006 and 2009 modeling. The general findings by David Ford indicated that "During the course of our review, we did not uncover a major modeling "bust" or "smoking gun" that would explain the

[2] Initially, the modeling focused on plans which could conceivably contain the 1/50, 1/100, and 1/125 chance events behind any proposed line of protection. After further review, it was revealed that the initial peak discharge corresponding to the 1/125 chance event was mislabeled. The correct label is the 1/117 chance event for this peak discharge.

floodplain differences. However, we did find numerous minor differences between the 2006 and 2009 hydraulic models and mapping procedures that cumulatively result in discrepancies between the floodplains."

2.10. In January 2010, the Corps' District management decided to conduct the hydraulic analysis of the Truckee Meadows via an external contractor. A lengthy process was used to develop a work plan which guided development of a scope of work for the modeling effort. In June 2010, WEST Consultants, Inc. began working on updating the modeling of the Truckee Meadows. The general plan was to use the latest topographic mapping available (1-foot contours based on 2007 and 2008 photogrammetric mapping) as well as Corps' 2006 bathymetric data. The updated model would use effectively the same general model construct (i.e., cross section locations, storage areas, etc.) as the previous model, maintaining nomenclature as best as possible. This new modeling effort included two significant changes from the prior modeling: 1) levee breaches would be included in the modeling, and 2) modeling of the NED plans would also include a configuration sized to contain the 1/75 chance event (i.e., in addition to the 1/50, 1/100, and 1/117 plans).

2.11. Throughout the summer of 2010, the updated model was constructed and calibrated to the 1997 flood event. By fall of 2010, WEST completed new draft conditional without-project modeling and floodplains. Due to a series of complications, the final with-project modeling, results, and floodplains were delayed until February 2011. The technical documentation for development of the updated HEC-RAS modeling for the Truckee Meadows is titled "Hydraulic Modeling Assumptions, Methods, and Results, Truckee Meadows Flood Control Project, Washoe and Storey Counties, Nevada" and is dated April 2011.

2.12. The initial work plan for the hydraulic portion of the overall study included completion of the economic floodplain analysis for potential NED-plans sized to contain the 1/50, 1/75, 1/100, and 1/117 chance events. As the study progressed, it became obvious that the NED plan sized to contain the 1/117 chance event was not cost effective and it was dropped from further study. It should be noted that, at that time, the 1/117 chance LPP project was not dropped from the study, but has since been dropped. As of this writing, there is no locally preferred plan since a cost effective plan has not been identified.

2.13. Throughout the period of November 2010 through about May 2011, the PDT was working towards refining the project documentation which supported the 1/75 chance sized plan as the selected NED plan. As the economic and cost analyses were finalized, it became obvious that none of the tentative n-year sized plans could be selected as a stand-alone flood damage reduction NED plan. As a result of coordination between the Sacramento District (SPK), the Corps' South Pacific Division (SPD), and the Corps' Headquarters Office (HQUSACE), a plan with federal interest was identified during a workshop held between 1 and 3 November 2011 at the Sacramento District office. This plan was conceptually similar to the old 1/50 chance NED plan, but does not include channel benching at Vista and the ecosystem channel

benching in the Truckee Meadows between McCarran Boulevard and Steamboat Creek. Also, the downtown Reno segment of the project was eliminated from the plan. It was thought that by eliminating the channel benching at Vista, the cost related to downstream hydraulic mitigation, in the form of bank and bridge scour protection, could be eliminated from the project. This Federal Interest Plan (FIP) would contain about the 1/50 chance annual exceedance event behind the proposed lines of protection in the Truckee Meadows and would have a benefit to cost ratio above unity.

2.14. Additional coordination between SPK, SPD, and HQUSACE following the November 2011 workshop resulted in a decision to eliminate all of the 11 ecosystem restoration segments located between Vista and Wadsworth from the Corps' project. In mid-January 2012, all work on the project was paused just prior to the Agency Technical Review (ATR) of the project documentation in early February 2012. The project was un-paused in July 2012 and the current plan is referred to herein as the Recommended Plan. This plan consists of the Federal Interest Plan discussed above, but without the ecosystem restoration segments as discussed earlier in this paragraph.

2.15. With respect to other noteworthy changes since the F4 report, it should be noted that in partial response to technical review comments in 2009, the economic damage areas were re-delineated to better match the flooding in the Reno and Truckee Meadows area. The new delineation is shown on **Plate 1** along with the corresponding index points. The damage area for downtown Reno remains effectively unchanged. Of special note is that the index point for damage area number 2 (North I-80) is located in downtown Reno since flooding in this area originates in downtown Reno during the 1/200 and 1/500 chance events. Flooding in this area does not occur for more frequent events.

2.16. The documentation contained herein was written with a focus on presenting only the Recommended Plan in the Truckee Meadows along with the corresponding downstream impacts between Vista and Pyramid Lake. A comprehensive collection of the hydraulic documentation and results for the previous National Economic Development, Locally Preferred Plan, and Federal Interest Plan projects is maintained with the Hydraulic Analysis Section's files.

2.17. One general note regarding the hydraulic analysis; the hydraulic analysis documented herein only analyzed the baseline conditions. Based on hydrologic and other study considerations, it is assumed that there is no difference between baseline and future conditions. That is, the baseline and future without-project conditions are the same. Also, the baseline and future with-project conditions are the same. The hydrology is assumed to remain unchanged for the foreseeable future and sea level change is not an issue for this study. The Corps' has not identified a recommended plan for the Martis Creek Dam (i.e. located upstream of the study area) and the hydrology used in this study assumes the current operating plan is in place. Refer to Section 2.2 in the main GRR for additional discussion on the baseline and future condition assumptions.

3. STUDY AREA

3.1. As discussed above, the overall project area has increased to include the reaches between Vista and Wadsworth and between Wadsworth and Pyramid Lake. These reaches are sometimes referred to as the "downstream reaches." This change was in response to the need to identify opportunities for hydraulic mitigation, possibly via ecosystem restoration, as well as to identify areas which may already be at risk to flooding whether or not a flood damage reduction project is located upstream of Vista.

3.2. The study area currently includes four distinct reaches as follows and as illustrated in **Figure 1**: 1) the downtown Reno reach, located between Mayberry Drive and Kietzke Lane (just upstream of Highway 395); 2) the Truckee Meadows reach, located between Kietzke Lane and Vista; 3) the Vista to Wadsworth reach; and 4) the Wadsworth to Pyramid Lake reach. In addition, major tributaries including Boynton Slough, Steamboat Creek, North Truckee Drain, and Long Valley Creek, have also been included in the analysis.

4. DOWNTOWN RENO REACH

4.1. General. At the time of the F4 Conference, a viable NED plan for downtown Reno did not exist. However, the study team planned to investigate an "Advanced Bridge Replacement" alternative wherein three bridges, at Sierra, Virginia, and Lake Streets, would be replaced with clear-span bridges to reduce, not eliminate, the 1/100 floodplain. In addition, the lower Wells Avenue Bridge, which is no longer used, would be removed to reduce water surface elevations and reduce overbank flooding. Removal of the lower Wells Avenue Bridge was part of both the NED and LPP plans.

4.2. Status of Recommended Plan in Downtown Reno. Based on economic and cost information, the Recommended Plan does not include any features in the downtown Reno reach. Further information regarding this situation can be found in the main GRR planning documentation. With respect to the documentation contained within this section, the without-project condition is presented since conditions in the downtown Reno reach affect the flow distribution into the Truckee Meadows. That is, for the 1/5 through 1/100 chance flood events, flood flows are contiguous to the main river channel; whereas, during the 1/200 and 1/500 chance events, flood flows in downtown Reno escape the immediate river corridor and flow into adjacent watersheds north and south of the Truckee River corridor. The without-project downtown Reno HEC-RAS model provides a means to quantify the distribution and location of overbank flows into the Truckee Meadows for these rare events.

4.3. Hydraulics for the With-Recommended Plan Conditions. Given that there are no features associated with the Recommended Plan, the n-year hydraulic conditions (e.g., the floodplains, water surface elevation profiles, and discharges) for the with-Recommended Plan in downtown Reno are the same as those for the without-project condition.

4.4. Study Reach and HEC-RAS Model. The specific extents of the downtown model reach are shown in **Figure 2** and have Mayberry Drive and Kietzke Lane as the upstream and downstream boundaries, respectively.

4.5. Model Changes since the F4 Conference. Changes to the model since the F4 Conference include adding floating debris to the bridge piers, and in some cases, to the bridge soffits (to match conditions observed in the prototype). Additionally, three pedestrian bridges which connect Wingfield Park (island) with the channel overbanks were added to the model. The most upstream pedestrian bridge, referred to as the Q1 Pedestrian Bridge, was constructed after the F4 Conference.

4.6. Existing Condition Floodplains. The without-project floodplains were originally presented in the hydraulic documentation for the F4 Conference. The updated version of the 1/5, 1/10, 1/20, 1/50, 1/100, 1/200, and 1/500 chance events are presented herein on **Plates 2** through **8**.

4.7. Discharges. The n-year peak discharges used in the analysis for downtown Reno are listed in **Table 1**. The discharges shown in this table were developed with the assumption that operation of Martis Creek Dam follows the current flood control operation, which is discussed in detail in Attachment A, Hydrology Report, Part I, Upper Watershed and Downtown Reno Reach, Section 6.1.

4.8. Modeling Approach. An unsteady HEC-RAS model was used for the hydraulic modeling of the downtown Reno reach. The without-project n-year floodplains were based on a 7-day simulation of the inflow flood hydrographs. The flood hydrograph 7-day volumes are also shown in **Table 1**.

4.9. Additional Background. For details regarding the historical aspects and background of the hydraulic analysis of the downtown reach up to the time of the F4 Conference, refer to the Hydraulic Design Appendix from the F4 Conference, dated January 18, 2005.

Table 1. N-Year peak discharges and hydrograph volumes for the Truckee River in the downtown Reno area

n-Year Flood Event	Peak Discharge (cfs)	7-day Volume (AF)
1/5 chance event	5949	43,484
1/10 chance event	7540	55,499
1/20 chance event	9150	64,133
1/50 chance event	13,721	78,221
1/100 chance event	20,734	124,901
1/200 chance event	35,826	211,646
1/500 chance event	63,485	369,767

4.10. Risk. Flooding in the downtown Reno area can cause property damage and poses a life and safety hazard. The flood risks for the downtown Reno study area are discussed in detail in Chapter 3 of the main GRR.

4.11. Uncertainty.

4.11.1. An uncertainty analysis was conducted to quantify the uncertainty in the stage-discharge rating curves for the without-project conditions. The uncertainty values were used in the economic analysis for the downtown Reno reach of the study and were developed for index point number 1 located at HEC-RAS station 52.1251 (see **Plate 1**).

4.11.2. A common approach to quantifying the hydraulic uncertainty is to perform the hydraulic model runs for both high and low conditions. The difference between these "extreme" water surfaces is then set equal to four standard deviations of the hydraulic uncertainty. In addition, it is assumed that the probability function is normal and symmetric about the best estimate water surface elevation. Furthermore,

although other distributions may be more applicable when describing the uncertainty in stage (e.g., gamma distribution), at the time this analysis was performed, the assumption of a normal distribution tended to produce the most reasonable results due to limitations with the HEC-FDA program.

4.11.3. Personal communication with the authors of Chapter 5 of EM 1110-2-1619 (Copeland and Deering) confirmed that either of the following two approaches are valid: 1) calculate the difference between the high and low sensitivity water surface elevations and divide by four, or 2) calculate the difference between the high sensitivity and mean water surface elevations and divide by two. Furthermore, these approaches may proceed without computation of the natural uncertainty portion which is assumed to be implicitly included in the resulting standard deviation value.

4.11.4. Unfortunately, experience shows that it can be very difficult to achieve stable unsteady HEC-RAS model runs for "low" conditions, especially in high-energy systems such as the downtown Reno reach of the Truckee River. Therefore, in the downtown Reno reach, the second approach discussed above was used to compute uncertainty values.

4.11.5. The "high" profile was based on running the downtown Reno HEC-RAS model with high values for the Manning's roughness value and a high debris loading on the bridges. Standard deviation values were computed for the all of the standard flood events (i.e., the 1/5, 1/10, 1/20, 1/50, 1/100, 1/200, and 1/500 chance events). In the case of the 1/100, 1/200, and 1/500 chance events, the standard deviation values were set equal to the 1/50 chance values for reasonableness. The standard deviations developed from this analysis are presented in **Table 2** for the without-project condition.

Table 2. Standard deviation values for downtown Reno for the without-project condition

Flood Event	Standard Deviation (ft)
	Without-Project
1/5 chance event	0.93
1/10 chance event	0.93
1/20 chance event	1.60
1/50 chance event	1.50
1/100 chance event	1.50
1/200 chance event	1.50
1/500 chance event	1.50

4.11.6. A review of the values listed in **Table 2** shows that, at the subject index point, the greatest uncertainty corresponds to the 1/20 chance event due to hydraulic conditions complicated by a series of bridges. The 1/10 chance event is conveyed as open channel flow by downstream bridges for both the high and mean conditions and has a relatively low standard deviation (i.e., 0.93 ft); whereas, pressure flow

occurs for the high condition and not for the mean condition during the 1/20 chance event producing a relatively large standard deviation of 1.60 ft. By the time the discharge gets up to the 1/50 chance event, pressure flow occurs at the downstream bridges for both the high and mean conditions and the standard deviation is about 1.50 ft which is less than that for the 1/20 chance event.

4.12. Without-Project Rating Data.

4.12.1. Table 3 lists the rating data developed for the without-project condition at index point number 1. These values were used in the economic analysis of the downtown Reno reach which constitutes economic damage area number 1.

Table 3. Rating data for index point number 1 in downtown Reno

Frequency 1 in X Chance	Exceedance Probability	Stage (ft-navd88)	Discharge (cfs)
5	0.2	4488.24	5,922
10	0.1	4489.35	7,509
20	0.05	4490.42	9,117
50	0.02	4497.96	13,679
100	0.01	4500.62	20,674
200	0.005	4505.04	36,116
500	0.002	4508.20	60,840

5. MEADOWS REACH

5.1. General. Following the F4 Conference the Truckee Meadows PDT met with downstream interests who were concerned about impacts of increased flows caused by the project on their respective reaches of the lower Truckee River. In response to these concerns, a number of alternatives, many of which were variations of the initial alternative numbers 1, 2, and 3, were included in the hydraulic modeling to determine, in a cursory manner, the general trends resulting from these alternatives for the 1/100 chance event. Specifically, the modeling was used to determine: 1) the peak flow at Vista which would be conveyed to downstream reaches, and 2) the peak water surface elevation in the Meadows. Alternatives which included storage at a Huffaker Dam and/or storage at a UNR Basin also had the peak water surface elevation of the stored water and the peak outflow from the dam/basin reported out for comparison.

5.2. In addition, a number of measures in the vicinity of Rainbow Bend (located downstream of Vista) were included in the modeling and tested to determine the impact on flooding at Rainbow Bend. The modeling focused on reducing the peak discharge and water surface elevation adjacent to the Rainbow Bend community. A complete chronology of the study process, interim results, and study directions can be found in the main GRR planning documentation.

5.3. Previously, the study proceeded with various potential NED plans and a locally preferred plan (LPP) for the Truckee Meadows study area. The tentative NED plans were sized to contain the 1/50, 1/75, 1/100, and 1/117 chance mainstem events along the proposed lines of protection; there may be areas which are not protected from the n-year mainstem events in the Truckee Meadows.[3] The LPP was sized to contain the 1/117 chance event along the proposed lines of protection; similar to the NED plans, there may be areas which are not protected from the 1/117 chance event in the Truckee Meadows. In general, both the NED and LPP projects had several features in common, including floodwalls and levees, floodplain terracing, and ecosystem restoration.

5.4. The following discussion presents the analyses performed to support the Recommended Plan. This plan was sized to contain the 1/50 chance event including uncertainty. At the time of this writing, there is no locally preferred plan. The documentation contained herein was written with a focus on presenting the current Recommended Plan in the Truckee Meadows, along with the corresponding downstream impacts between Vista and Pyramid Lake.

5.5. The specific features of the Recommended Plan which significantly affect the hydraulic modeling are shown in **Figure 3** and include floodwalls and levees, floodplain terracing, and an enclosed underground culvert for the lower end of the

[3] Areas which are not protected by the proposed line of protection may still be at risk of flooding from the design event. Examples of these areas include the overbanks of the North Truckee Drain upstream of Interstate 80, Hidden Valley, the Eastside Subdivision, Rosewood Lakes, and in general, the overbanks of Boynton Slough and Steamboat Creek since they are not located landward of any proposed flood protection features.

North Truckee Drain, located along the existing alignment of the drain between the downstream face of the Interstate 80 culvert and the confluence with the Truckee River. Scour and bank protection measures are also included in the project and are discussed in Attachment C (titled Bed, Bank and Pier Scour Protection) of the Basis of Design Report. The scour and erosion protection features do not significantly affect the hydraulic modeling and, therefore, are not shown in **Figure 3**.

5.6. Detailed modeling and results from the post F4 Conference analyses, discussed above, are not presented herein, but are maintained in the Hydraulic Analysis Section's files. This documentation focuses on the without- and with-project modeling for the Recommended Plan for the Meadows reach. The general study area of the Truckee Meadows and without-project HEC-RAS model is shown in **Figure 4**.

5.7. HEC-RAS Model Changes since the F4 Conference.

5.7.1. As expected, the HEC-RAS modeling was an ongoing effort with changes being made as new conditions of the prototype were learned, as the model was used to test new measures or alternatives, and as the HEC-RAS program was enhanced. The following are the modifications, or tweaks, to the Meadows model which are considered to be more than insignificant. These modifications were included in the Corps' 2009 modeling and have been carried forward into the new modeling of the Truckee Meadows by WEST (refer to the modeling document titled Hydraulic Modeling Assumptions, Methods, and Results, Truckee Meadows Flood Control Project, Washoe and Storey Counties, Nevada, dated April 2011, and maintained in the Hydraulic Analysis Section files). One of the most notable aspects of the original HEC-RAS model developed in 2000 was that it was constructed with a focus on the 1/100 chance event. When the Corps ran the model for the 1/200 and 1/500 chance events in support of standard economic analyses, it was observed that the basic model construct was not sufficient to appropriately contain these larger events. The need for several of the following modifications initially arose out of the effort to modify the model to contain all events up to the 1/500 chance event.

5.7.2. Two railroad bridges located between Vista and Lockwood were not included in the previous base condition or alternative modeling for the Truckee Meadows HEC-RAS model. The railroad bridges are located at HEC-RAS stations 66+50 and 6+50. Both bridges cross the channel at high skew angles and induce constriction effects on high flows due to the bridge abutments. The bridges have since been included explicitly into the model and result in a slightly increased pool elevation in the Truckee Meadows ponding area for both the base condition and alternatives due to the increased head loss through the bridges.

5.7.3. In a related item, the benching of the left bankline between the upstream railroad bridge discussed above and the abandoned rest stop upstream of Rainbow Bend has been modified to preclude channel benching on the left bank in the vicinity of the Court of Antiquities. The Court of Antiquities is a bedrock formation containing a number of petroglyphs and is considered a significant cultural resource. This rock

formation is located between stations 53+70 and 57+30 in the HEC-RAS modeling. Similar to inclusion of the railroad bridge, this modification to the with-project model causes a slight increase to the pool elevation in the Truckee Meadows ponding area for both the base condition and alternatives.

5.7.4. The configuration of the North Truckee Drain for the Recommended Plan has been re-designed to include a dual 11.5 x 10 ft (width x height) reinforced concrete box (RCB) located along the existing North Truckee Drain alignment between the downstream face of the Interstate 80 culverts and the Truckee River crossing. This change was made when the District was considering how to downsize the previously proposed re-aligned North Truckee Drain[4] for the 1/50 and 1/75 chance events compared to the previous size used for the 1/100 and 1/117 NED plans. It turns out that the new proposed configuration does not negatively impact flooding and that it is much more cost effective when compared to re-aligned the drain configuration.

5.7.5. A number of model storage areas located in the foothills on the east side of the North Truckee Drain as well as along the Truckee River have been modified to more closely match the hydrologic subareas. This modification results in both the hydrologic and hydraulic models identifying similar features which affect runoff patterns. There appears to be no net change in overall model results.

5.7.6. The model has been modified to reflect recent changes in the way water flows between the Sparks Marina Park Lake, the floodplain north of I-80 and the UPRR, and the Peoples Drain. These changes to the prototype have recently been put into place by the City of Sparks in an effort to preclude floodwaters from the Truckee River from getting north of the I-80 embankment during large flood events.

5.7.7. On the right overbank of the Truckee River between Highway 395 and Glendale Avenue, a Wal-Mart store has been constructed. The PDT worked closely with the developer's designer to ensure that the newly constructed levee and floodwall met Corps criteria. Given that this floodwall was constructed as part of a Section 104 Project (i.e., Advanced Construction of the Authorized Project), the Recommended Plan ignores the actual top of wall profile, but instead uses the top of wall profile as required and discussed later in paragraph 5.23.

5.7.8. In the Community Coalition Plan, the Rock and McCarran Boulevard bridges were lengthened (i.e. perpendicular to the flow) to obtain additional flow capacity and to provide a greater sense of connectivity for the "living river" concept. However, upon closer review, the existing bridges have sufficient capacity for the Recommended Plan without requiring any modification. Thus, these two bridges will not be modified as part of the Recommended Plan.

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[4] Previous modeling of the North Truckee Drain in support of the "old" NED plans included a re-aligned drain between the UPRR embankment and the Truckee River. The configuration included an underground RCB, using street right-of-ways, and entered the River at a point about 3300 feet downstream of the existing North Truckee Drain confluence.

5.7.9. As discussed in 2.10, the updated modeling includes levee breaches for both the with- and without-project conditions. The specific application of levee breaches in the modeling is discussed below in paragraph 5.9.

5.8. Economic Damage Areas. As discussed in paragraph 2.15, the economic damage areas were re-delineated in response to review comments coupled with experience gained by earlier hydraulic and economic analyses of the Truckee Meadows in 2006 and 2009. Specifically, given the complex nature of how damages are initiated in the Meadows during the rising limb of a flood, the previous damage areas did not correctly group areas by the type and source of flooding. Previously, there were a total of six damage areas while the new delineation uses fifteen damage areas (i.e., one in downtown Reno and fourteen for the Meadows), as shown on **Plate 1**.

5.9. Levee Breaches, Location of Initial Overtopping, & Index Points.

5.9.1. As the updated HEC-RAS model was being constructed by WEST, the Corps delineated the various existing levees and earthen berms located along the study reaches in the Truckee Meadows using the same terrain model which was used to extract the new model geometry[5]. Although many of the watercourse subreaches are entrenched in the without-project condition, there are several reaches where levees have either been constructed or where earthen berms, whether intentional or not, exist and may breach during large flood events.

5.9.2. For the without-project condition, levee breaches were limited to channel subreaches where levees or berms currently exist. Only one breach was allowed to occur into each damage area from a given watercourse. A damage area which is surrounded by multiple watercourses may have multiple breach locations. Levee breaches were not allowed to occur into a damage area if channel overtopping would occur and initiate damages before the levee breach would form. That is, given the limitations of the HEC-FDA program, only one source of damages could be simulated in the economic modeling.

5.9.3. During model construct of the without-project condition, the locations of levee/berm beaches were identified for damage area numbers 5, 6, 7, 8, and 9 (refer to **Plate 1**). In all of the remaining damage areas, channel overtopping was identified as the source of initial damage during the rising limb of large flood events. The locations of the breaches and initial overtopping were established as the index points for each damage area and are shown as the yellow dots on **Plate 1**. Throughout the with-project analysis, the location of the index points remained fixed. The with-project levee breaches were forced to occur at the same locations as the without-project breaches since levee breaches and index points are tied to each other throughout the entire hydraulic and economic analysis. It has been noted that in the with-project condition, if only the levee breach overtopping criterion

[5] The updated HEC-RAS model by WEST is based on 1-foot contour photogrammetric-based topographic data compiled by Washoe County which is dated 2007 and 2008.

discussed above was used to locate levee breaches, the location of levee breaches would tend to move. A complete listing of the key parameters for all of the index points for the without-project condition is presented in **Table 4**.

5.9.4. In the without-project condition, levee breaches were forced to occur for all events in which the computed maximum water surface elevation in the channel exceeded the elevation of the landward toe of the levee or berm.[6] This resulted in "conditional" floodplains for the without-project condition. The breach geometry was assumed to consist of a 200-foot opening with 1 to 1 sideslopes. The breach was assumed to fully form in one hour. In the with-project condition, the proposed levees and floodwalls were breached when the computed maximum water surface in the channel exceeded the top of the levee/floodwall by at least 0.1 feet.

5.9.5. Of special note are damage areas 6 and 7 (i.e., Sparks East and Larkin Circle) in which possible breach locations were identified from both the Truckee River and the North Truckee Drain (see **Plate 1**). In these two areas, both breaches (i.e. index points 6A & 6B and 7A & 7B) were allowed to occur for the without-project condition. Given that the subject reach of the North Truckee Drain would consist of an underground conduit for the Recommended Plan, only index points 6A and 7A were carried into the with-project analysis.[7]

5.9.6. Damage area 9 (i.e., Truckee South Overbank) is another special case in which the damage area is located in the interior for the without-project condition, but is completely located in the exterior for the with-project condition due to the location of the set-back levee along Mill Street. Thus, index point number 9 is included in the hydraulic analysis of the without-project condition (e.g., rating curve, uncertainty calculations, etc.), but is mostly ignored for the with-project condition.

[6] A series of trigger elevations were used to force a breach in the without-project condition with each breach location using the highest possible trigger elevation. The trigger elevations included: 1) the top of levee/berm plus 0.1 feet if the maximum water surface elevation exceeded this level; 2) the maximum water surface elevation minus one foot, but no lower than the landward toe elevation; and 3) the landward toe elevation.

[7] Index points 6A and 7A were carried forward in the nomenclature as index points 6 and 7 since points 6B and 7B were effectively dropped from the study.

Table 4. Hydraulic parameters for the Truckee Meadows index points without-project condition

Index Pt. Number	Damage Area Number	Damage Area Name	RAS Watercourse	RAS Reach	Side	RAS Station	RAS Lateral Weir	Type	Other IP's in DA	Minimum Top Elevation of Levee/Berm	Elevation of Levee/Berm Landward Toe
2	2	North I-80	Truckee River	Downtown	Left	52.021	NA	Overtopping	---	4500.50[1]	---
3	3	West NTD	NTD	Tributary	Left	4295.627	5160	Overtopping	---	4394.25	---
4	4	East NTD	NTD	Tributary	Right	4295.627	5269	Overtopping	---	4394.85	---
5	5	Sparks West	Truckee River	Upper	Left	27953.75	28078	Breach	---	4403.96	4401.3
6A	6	Sparks East	Truckee River	Upper	Left	16122.58	17594	Breach	6B	4392.11	4391.8
6B	6	Sparks East	NTD	Tributary	Right	2905.768	2961	Breach	6A	4388.74	4388.6
7A	7	Larkin Circle	Truckee River	Middle	Left	13261.42	13260	Breach	7B	4396.00	4391.4
7B	7	Larkin Circle	NTD	Tributary	Left	1465.880	1700	Breach	7A	4395.88	4395.05
8	8	Airport	Truckee River	Upper	Right	36974.9*	37158	Breach	---	4430.41	4428.8
9	9	Truckee South Overbank	Truckee River	Upper	Right	31795.06	32220	Breach	---	4412.47	4412.0
10	10	UNR Farms	Steamboat Creek	Lower	Right	6423.999	12200	Overtopping	---	4386.72	---
11	11	TMWRF	Truckee River	Lower	Right	12290.45	12670	Overtopping	---	4396.24	---
12	12	North Hidden Valley	Steamboat Creek	Lower	Right	10402.49	NA	Overtopping	---	4391.00	---
13	13	Steamboat South	Boynton Slough	Tributary	Left	4893.799	6246/4900	Overtopping	---	4394.14	---
14	14	Central Hidden Valley	Steamboat Creek	Lower	Right	15589.79	15865	Overtopping	---	4392.80	---
15	15	South Hidden Valley	Steamboat Creek	Upper	Right	18906.85	NA	Overtopping	---	4394.00	---

Note:

1 – The elevation of the top of the levee/berm in downtown Reno refers to the elevation of the Center Street bridge over the ReTRAC trench which controls flooding into the area north of the ReTRAC trench which ultimately drains into damage area number 2 (i.e., North I-80). Mainstem flooding to north of the ReTRAC trench only occurs for the 1/200 chance and greater events.

5.10. FLO-2D Modeling.

5.10.1. Although most of the Truckee Meadows study area is explicitly included in the HEC-RAS model, there are areas where sheet flow will occur in the overbanks. These overbank areas include most of the airport and surrounding vicinity and most of damage area 2 (refer to **Plate 1**) which is located north of Interstate 80 and east of Highway 395. The FLO-2D modeling was performed in this study using Version 2006.01.

5.10.2. HEC-RAS does a good job of tracking the flows in the airport area, but not so good when depicting floodplain depths. The reason for this is illustrated in **Figure 4** which shows that the model uses storage areas in the overbanks surrounding the airport to track the unsteady flows. Storage areas can depict floodplain depths in areas which pond and have a nearly flat water surface during floods, but storage areas do not accurately predict relatively shallow sheet flow depths, as is the case around the airport.

5.10.3. As discussed above, FLO-2D models were used in two areas within the Truckee Meadows study area as depicted in **Figure 5**. One model was used for the greater airport area (i.e., the airport model) and the other FLO-2D model was used to model sheet flows in Sparks (i.e., the I-80 model). The I-80 model was only used for the 1/200 and 1/500 chance events for overbank flows originating in the downtown Reno study reach, specifically overbank flows "trapped" on the north side of the ReTRAC trench.

5.10.4. A detailed discussion of the airport FLO-2D model is presented in section 7 of the document titled "Hydraulic Modeling Assumptions, Methods, and Results, Truckee Meadows Flood Control Project, Washoe and Storey Counties, Nevada" dated April 2011. The same model construct was used for the Recommended Plan with the exception that the overtopping and breaching flows as well as flows passing through the Highway 395 embankment were updated for the Recommended Plan conditions.

5.10.5. The I-80 FLO-2D model used a 100-foot grid and modeled outflows from the downtown Reno HEC-RAS model. The HEC-RAS outflows entered the I-80 model at three locations in the vicinity of the Interstate 80 and Highway 395 interchange. As briefly mentioned above, the I-80 model only modeled overbank flows for the 1/200 and 1/500 chance events since there are no overbank flows for more frequent events in the modeled area.

5.10.6. The Manning's roughness values used in the FLO-2D models ranged from 0.2 to 0.3. In general, roughness values in FLO-2D tend to run higher than those used in standard 1-D modeling since FLO-2D is a discretized system. This issue is further discussed in the training materials which accompany the FLO-2D software (please refer to FLO-2D N-Value Conceptualization).

5.10.7. Area Reduction Factors (ARFs) and Width Reduction Factors (WRFs) were not used in the I-80 model. Instead, the base n-values were adjusted to account for the effect of obstructions due to buildings using the below relationship. In the modeled areas, building obstructions mostly limited flow to the streets. In some cases, the obstructions may block up to 80-85% of the potential flow path which causes the base n-values to be increased by as much as 600%.

$$n = n_{streets}\left(\frac{W}{\Sigma W_{streets}}\right)$$

Where:

n = composite Manning's n-value

$n_{streets}$ = n-value for streets and right of way

W = total width of cross section

ΣWstreets = cumulative width of streets conveying flow.

5.10.8. Given that the FLO-2D models overlap the Meadows HEC-RAS model, the final floodplains represent a composite of the modeling results wherein the maximum depth computed from either the HEC-RAS or FLO-2D modeling was used as the n-year depth of flooding. This approach was used consistently for analyses of both the with- and without-project conditions and tended to produce slightly higher depths of flooding, specifically in areas where the HEC-RAS storage areas tend to pond water. Overall, the approach was marginally conservative and tended to give any project the benefit of doubt with regards to reduction of potential flood damages.

5.10.9. The areas of comparison where the HEC-RAS and FLO-2D results were compared for the with- and out-project conditions for both the airport and I-80 FLO-2D models are shown in **Figure 5**. As illustrated in this figure, the area of comparison for both the with- and without-project conditions for the I-80 model is the entire footprint of the I-80 FLO-2D model. The final floodplain depths used for the areas outside of the "areas of comparison" were those generated by the HEC-RAS modeling.

5.11. Discharges. The n-year peak discharges used in the analysis for the Truckee Meadows reach are listed in **Tables 5 – 8**. Specifically, peak discharges for the Truckee River are listed in **Table 5**. The contemporaneous peak n-year discharges for Steamboat Creek are listed in **Table 6**, for Boynton Slough are listed in **Table 7**, and for the North Truckee Drain are listed in **Table 8**. Given that the hydraulic modeling was conducted using an unsteady HEC-RAS model, flood hydrographs having a duration of 7 days were used to develop the n-year with- and without-project floodplains. The flood hydrograph volumes are also shown in **Tables 5 - 8**. Additional inflows to various overbank areas were used in the hydraulic modeling to account for local contemporaneous runoff. These flows represent a minor contribution to overall flood volume inflowing to the Meadows and are not included within this

documentation, but are included in the HEC-RAS modeling. Refer to Attachment A of the Basis of Design Report (Hydrology Report), Part II, Re-Analysis of Downtown and Truckee Meadows Reach, Section 4 for a complete discussion of development of inflows to the Truckee Meadows reach.

5.12. The peak discharges shown in **Tables 5 – 8** are for both the with- and without-project conditions of the Recommended Plan. It was observed during modeling activities for the previous NED and LPP projects, that for infrequent events (e.g., the 1/200 and 1/500 chance events), the NED and LPP projects impacted the overbank flow paths in the downtown Reno reach resulting in differing amounts of attenuation as the flow enters the Truckee Meadows. Therefore, if a project is considered in the future for the downtown Reno reach, this situation should be evaluated.

5.13. The discharges shown in **Table 5** were developed with the assumption that operation of Martis Creek Dam follows the current flood control operation, which is discussed in detail in Attachment A, Hydrology Report, Part I, Upper Watershed and Downtown Reno Reach, Section 6.1.

Table 5. Peak n-year discharges and hydrograph volumes for the Truckee River in the Truckee Meadows area

n-Year Flood Event	Peak Discharge (cfs)[8]	7-day Volume (AF)
1/5 chance event	5949	43,484
1/10 chance event	7540	55,499
1/20 chance event	9150	64,133
1/50 chance event	13,721	78,221
1/75 chance event	17,288	98,558
1/100 chance event	20,734	124,901
1/117 chance event	23,015	138,640
1/200 chance event	35,826	211,646
1/500 chance event	63,485	369,767

[8] The peak discharges shown for the 1/200 and 1/500 chance events reflect the total n-year peak discharges at the downstream end of the downtown Reno HEC-RAS study reach. This downstream boundary is located approximately along the Highway 395 embankment. These peak discharges include the flow in the channel as well as in the north and south overbanks. The without-project peak discharge in the channel for the 1/200 chance event is about 32,538 cfs and about 43,178 cfs for the 1/500 chance event.

Table 6. Contemporaneous peak n-year discharges and hydrograph volumes for Steamboat Creek in the Truckee Meadows area

n-Year Flood Event	Peak Discharge (cfs)	7-day Volume (AF)
1/5 chance event	484	3691
1/10 chance event	667	4102
1/20 chance event	1399	6039
1/50 chance event	3014	11,076
1/75 chance event	3798	13,955
1/100 chance event	4883	16,954
1/117 chance event	5420	18,819
1/200 chance event	5469	18,988
1/500 chance event	8182	28,408

Table 7. Contemporaneous peak n-year discharges and hydrograph volumes for Boynton Slough in the Truckee Meadows area

n-Year Flood Event	Peak Discharge (cfs)	7-day Volume (AF)
1/5 chance event	131	954
1/10 chance event	181	1087
1/20 chance event	380	1649
1/50 chance event	818	3802
1/75 chance event	1031	4790
1/100 chance event	1325	5034
1/117 chance event	1471	5588
1/200 chance event	1484	5638
1/500 chance event	2220	8435

Table 8. Contemporaneous peak n-year discharges and hydrograph volumes for the North Truckee Drain in the Truckee Meadows area

n-Year Flood Event	Peak Discharge (cfs)	7-day Volume (AF)
1/5 chance event	107	911
1/10 chance event	147	1025
1/20 chance event	309	1591
1/50 chance event	666	3229
1/75 chance event	839	4067
1/100 chance event	1078	4891
1/117 chance event	1197	5362
1/200 chance event	1208	5228
1/500 chance event	1807	7817

5.14. **Existing Condition Floodplains.** The existing condition floodplains were presented in the hydraulic documentation for the F4 Conference (i.e., Exhibit A). For details regarding the historic aspects and background of the hydraulic analysis of the Truckee Meadows reach up to time of the F4 Conference, refer to the hydraulic documentation for the F4 Conference.

5.15. Updated versions of the 1/5, 1/10, 1/20, 1/50, 1/100, 1/200, and 1/500 chance events are presented herein on **Plates 9 through 15**. As illustrated in these plates, the existing condition floodplains cover a large area and include the Reno airport, a significant portion of Sparks, the UNR farm lands, and the Truckee Meadows sink area. These floodplains are updated versions of those presented in the F3 and F4 documents and are presented herein for completeness.

5.16. **Interim Alternative Analysis Results.** As discussed above, a couple of performance indicators used to assess the project performance of the various interim alternatives were the peak 1/100 chance event outflow from the Meadows and the peak water surface elevation in the Meadows. In some cases, the maximum water surface elevations developed in the UNR detention basin and/or the Huffaker Dam pool were also used.

5.17. **Table 9** lists the values obtained from the alternative models. It is important to note that the results shown in **Table 9** are not homogeneous due to varying levels of detail of the models. All of the values shown in the table are from Corps' HEC-RAS modeling performed between 2005 and 2009.

Table 9. Interim alternative performance indicators for the 1/100 chance event

Alternative	Peak WSEL in Meadows (BS/SB)[9] (ft – NAVD88)	Peak Discharge at UPRR (cfs)	Peak WSEL at Huffaker (ft-NAVD88)	Peak WSEL at UNR Basin (SA 7) (ft-NAVD88)
Existing Condition	4396.5	20,140	---	---
1	4397.9	22,510	---	---
2	4397.1	21,960	4428.0	4399.6
3	4395.5	24,310	4428.0	---
4	4397.1	21,960	4428.0	4399.6
5	4395.5	24,310	4428.0	---
5 w/o Huffaker Dam	4396.0	24,080	---	---
6	4399.7	19,840	---	4399.7
7	4395.8	20,320	4445.4	4398.6
8	4394.5	22,520	4445.4	---
Existing Condition (117-yr)	4397.4	21,820	---	---
5 w/o Huffaker Dam (117-yr)	4397.1	26,280	---	---

[9] The water surface elevations in this column were obtained at the confluence of Boynton Slough and Steamboat Creek (i.e., BS/SB) which were usually located outside of the proposed UNR Farms Detention Basin.

5.18. A major part of determining the NED plan also included determining the appropriate level of protection (LOP) for the flood damage reduction plan. During the analysis, the net benefit versus cost curve for the selected plan had a very complicated shape wherein it was conceivable that the LOP of the NED plan could be somewhat higher than the 1/100 chance event. It was reasoned that the NED LOP would correspond to a LOP just shy of a major increase in the costs (e.g., a bridge raise) wherein there wasn't a significant increase in the LOP. In the 2006 timeframe, this approach lead to the identification of the Glendale Avenue /East 2nd Street bridge as a likely feature, where if raised, would cause project costs to increase significantly. Thus, the NED LOP was initially determined to correspond to the maximum discharge which could be safely passed through this bridge. Based on a trial and error approach, a discharge of about 23,000 cfs was estimated and corresponds to a 1/117 chance event.

5.19. **With-Recommended Plan Conditions.** As discussed in paragraph 2.14, it is currently assumed that the flood damage reduction plan consists of the Recommended Plan. In general, the Recommended Plan has a target level of protection of the 1/50 chance event (i.e., the 2-percent event or about the 50-year flood). The specific Recommended Plan features which significantly affect the hydraulic modeling are shown in **Figure 3** and include floodwalls and levees, floodplain terracing, and the NTD located in an enclosed underground culvert for the lower end of the drain between the downstream face of the Interstate 80 culvert and the confluence with the Truckee River.

5.20. Unlike the tentative NED and LPP plans, the Recommended Plan does not include channel benching at Vista specifically located between the downstream end of the Truckee Meadows Water Reclamation Facility (TMWRF) plant and the downstream UPRR bridge at Lockwood. The plan also does not include the ecosystem channel benching located along the south side of the River between McCarran Boulevard and Steamboat Creek. Additionally, the Recommended Plan includes capping of the open junctions of the People's Drain which helps reduce flooding in the commercial Sparks area from flood flows which pass through the Interstate 80 and UPRR embankments.

5.21. **Recommended Plan HEC-RAS Model.** The current with-project Truckee Meadows HEC-RAS model for the Recommended Plan is shown in **Figure 6**. The significant with-project features in the model (and shown in **Figure 3**) include:

- Levees/floodwalls along the Truckee River (one or both sides, as needed) between Highway 395 (RAS station 410+90) and a point about 3550 feet downstream of the existing Steamboat Creek confluence (RAS station 91+00) for a total of about 40,100 feet (7.6 miles) of river for the 1/50 chance Recommended Plan;
- Channel benching in the Meadows between Greg Street (RAS station 35+260) and McCarran Boulevard (RAS station 260+60);

- A dual 11.5 x 10-ft (width x height) RCB contains the North Truckee Drain between the downstream face of the Interstate 80 culvert and the Truckee River confluence; and
- Capping of the open junctions of the People's Drain to preclude outflows from the People's Drain into the commercial area of Sparks.

5.22. Analyses and Documentation of Recommended Plan Design. This section describes the approach used to define and/or design the with-project conditions for the Recommended Plan. This information includes establishing the top of floodwall and levee elevations/profiles, developing the residual floodplains, assessing interior drainage needs, and the analysis of bank and bridge pier scour protection.

5.23. Top of Floodwall and Levee Elevations. In general, the top of wall or levee elevations were established by setting the top of wall elevation sufficiently high enough to obtain a 90 percent assurance that the top of levee/floodwall would not be exceeded by the 1/50 chance flood event. Development of the uncertainty values was updated from the values used previously as presented in the F4 Conference document.[10] The following discussion documents the risk-based analysis and approach used to determine the total uncertainty values for each index point in the Truckee Meadows.

5.23.1. Uncertainty. EM 1110-2-1619 "Risk-Based Analysis for Flood Damage Reduction Studies" was used as guidance for this analysis. In general, the analysis consisted of identifying the various sources of uncertainty in the stage-discharge relationship which may affect design of top of wall/levee elevations. The next step included quantifying the significant sources of uncertainty, and in several cases, using minimum acceptable values presented in EM 1110-2-1619. Typical sources of uncertainty in the stage–discharge relationship, which are applicable to the subject study area, include natural uncertainty, computational uncertainty, topographic or geometric data, and long-term sedimentation trends. The uncertainty values are then combined into a single value for each study reach.

5.23.2. The uncertainty analysis was conducted for a series of index points and economic damage areas as shown on **Plate 1**. Selection of these index point locations and corresponding damage areas is discussed further in paragraph 5.9.3, above.

5.23.3. Most of the uncertainty analysis was originally performed for the 1/50 chance NED project. Given the similarity between in the 1/50 chance tentative NED plan and the Recommended Plan, a separate uncertainty analysis was not conducted

[10] Modeling conducted by the Corps in 2009 based the top of wall elevation on the greater of the uncertainty values or the wave run-up values which were computed for the Meadows area. This approach was only used where the proposed levees or floodwalls would be exposed to wave action. The current modeling and economic analysis does not include the impact of waves since that approach, given the limitations of the hydraulic models, can lead to a substantially more complicated analysis which, in the end, does not significantly affect the results. The impact of wave run-up will be included in the top of wall analysis in the Preconstruction Engineering and Design (PED) phase of the study.

exclusively for the Recommended Plan. The R&U values assumed for the Recommended Plan were adopted from the 1/50 chance NED project.

5.23.4. Natural Uncertainty. As shown in **Plate 1**, there are a number of stream gages located in the Reno and Truckee Meadows study areas. Specifically, gages are located on the Truckee River, the North Truckee Drain, and Steamboat Creek. The gages most important to this analysis included the "Reno" gage (located upstream of the Highway 395 crossing – No. 10348000), the "Near Sparks" gage (located upstream of the McCarran Boulevard bridge – No. 10348200), and the "Vista" gage (located just downstream of the TMWRF plant – No. 10350000). The historic records of flow versus stage were used to quantify the natural uncertainty. Specifically, discharge-stage measurements obtained from the USGS were plotted against the accepted mean rating curves corresponding to the time of the measurement. Differences between the measured stage (for a given discharge) and the mean rating curve were computed for all discharges which were at least in the bankfull range (i.e., at least 10,000 cfs for the Truckee River) or greater. Although there are a lot more measurements corresponding to smaller discharges (and lower stages), the data is relatively trivial when considering that the focus was on discharges for which the goal is to set top of wall elevations. For each of the three Truckee River gages, there were only two measurements which satisfied the bankfull criterion. The measured data are listed in **Table 10**.

Table 10. Measured gage data used to quantify natural uncertainty

Gage	Date	Measured Data		Rating Table Stage (ft)	Delta (ft)	Avg. Delta (ft)
		Stage (ft)	Discharge (cfs)			
Reno	1/2/1997	14.94	18,200	15.02	0.08	0.23
Reno	12/31/2005	12.70	15,100	12.92	0.22	
Nr Sparks	2/17/1986	14.28	12,720	14.10	0.18	0.18
Nr Sparks	1/1/1997	16.16	12,600	16.16	0.00	
Vista	1/2/1997	24.16	18,500	24.62	0.46	0.58
Vista	12/31/2005	20.26	14,100	20.62	0.36	

5.23.5. The average delta value (S) listed in the last column of Table 3 was computed using equation 5-3 from EM 1110-2-1619:

$$S = \sqrt{\frac{\sum_{i=1}^{N}(X_i - M)^2}{N-1}}$$

5.23.6. Computational Uncertainty. The computational uncertainty helps to identify the potential range of values in the computed water surface elevations, and can be determined by varying several variables in the HEC-RAS model. Variations can be made to achieve both a "high" error band and a "low" error band. The "high" error band represents the potential error *above* the mean water surface elevation along a

given study reach. The "low" error band represents the potential error *below* the mean water surface elevation. The uncertainty associated with the model geometry was accounted for by use of the appropriate value of the minimum standard of deviation of error in stage listed in Table 5-2 of EM 1110-2-1619. The variables that were adjusted to account for possible error were the Manning's roughness (n-value) and the assumed debris loading on the bridges. Furthermore, a review of the long-term sedimentation trends of the Truckee River and Steamboat Creek reveal that the thalweg profiles (see **Figure 7**) have been fairly constant since 1989 and do not show signs of aggradation or degradation, and thus, it was reasoned that there was no need to account for long-term sedimentation trends in the uncertainty of the hydraulic modeling. Given the O&M activities on the North Truckee Drain by the City of Sparks, that same conclusion can be made for that watercourse within the study area.

5.23.7. Specifically, the n-values in all of the channels were increased by 20-percent (consistent with SPK guidance) and the debris loading on the Truckee River bridges was doubled. This work was performed for both the without- and with-project modeling using the Corps' 2009 HEC-RAS models since the newer WEST models of the Truckee Meadows were not available at the time of the sensitivity analysis. The changes were only made to quantify the sensitivity of the roughness and debris loading on the stage while the computational uncertainty was being assessed. These changes were <u>not</u> used in the production runs of the n-year events for either the HEC-RAS or FLO-2D models.

5.23.8. As discussed for the downtown Reno reach, a common approach to quantifying the hydraulic uncertainty is to perform the hydraulic model runs for both high and low conditions. The difference between these "extreme" water surfaces is then set equal to four standard deviations of the hydraulic uncertainty. Consistent with guidance provided in paragraph 5-7 of EM 1110-2-1619, it is assumed that the probability function is normal and symmetric about the best estimate water surface elevation.

5.23.9. Similar to the approach used in the downtown Reno study reach, the uncertainty values in the Truckee Meadows were assumed to equal one-half of the difference between a reasonable "high" and the mean water surface profiles. It was assumed that the difference between these two profiles approximated two standard deviations of uncertainty.

5.23.10. The sensitivity analysis was run for the 1/100 chance event in models representing the high uncertainty band. The with-project modeling was only conducted for the 1/50- and 1/117-sized versions of the NED plan. It was reasoned that if the uncertainty values computed for both the 1/50- or 1/117-sized projects were less than the minimum values presented in Table 5-2 of EM 1110-2-1619, then there would be no value in computing computational uncertainty values for either the 1/75- or 1/100-sized NED plans. Typical values for uncertainty (i.e., one standard deviation in the computed water surface elevation) for the 1/100 chance

event ranged from about 0.20 to 0.46 feet for the without-project condition and from 0.31 to 0.68 feet for the with-project condition for the upper error band.

5.23.11. Based on guidance from EM 1110-2-1619, Table 5-2, the minimum computational uncertainty for the Truckee Meadows study reach should not be less than about 0.6 feet. This value is based on a combination of the quality of the topographic data coupled with the reliability in the selected Manning's roughness values. Specifically, the Manning's n-value reliability was assessed as being "good" given the results of the 2009 HEC-RAS model calibration wherein there was very good agreement between modeled and observed high water marks for the 1997 flood event. Furthermore, the specific selection of the 0.6 feet value (i.e., vs. a value of 0.3 feet listed in Table 5-2) was based on the 2-foot contour topographic data used for the model geometry of the Truckee Meadows.

5.23.12. As briefly discussed in paragraph 2.15, the index point for damage area 2 (i.e., "North I-80" located in the Truckee Meadows), is located in the downtown Reno reach of the hydraulic modeling. In this reach, it was reasoned that a value of 0.3 feet was appropriate for the minimum computational uncertainty as listed in Table 5-2 (EM 1110-2-1619) since most of the cross sectional geometry in the downtown Reno HEC-RAS model is based on field surveys. In addition, the downtown Reno model was calibrated to the 1997 flood event and there is good reliability in the model's roughness values.

5.23.13. **Combined Values of Total Uncertainty.** The computed and final values of the total uncertainty are presented in **Table 11** for the without-project condition and in **Table 12** for the with-1/50 chance project condition and **Table** 13 for the with-1/117 chance project condition.

5.23.14. The natural and computational uncertainties were combined using equation 5-6 from EM 1110-2-1619 as shown below:

$$S_{total} = \sqrt{S_{natural}^2 + S_{model}^2}$$

5.23.15. As can be seen from **Tables 11** and **12**, the same values for the total uncertainty were computed for both the 1/50 and 1/117 chance NED projects. Thus, it was reasoned that the same values would also apply to the 1/75 and 1/100 chance NED projects.

5.23.16. **Development of the Uncertainty Values.** The objective in the risk analysis is to set the levee and floodwall heights high enough so that they will contain the design event with a Conditional Non-Exceedance Probability (CNP) of 90 percent. The risk analysis was completed with the Flood Damage Reduction Analysis (HEC-FDA) program, version 1.2.4. The analysis was conducted only for the reaches where the with-project condition proposed a line of protection in the

form of a levee or floodwall. The analysis was conducted explicitly at index point numbers 5, 6, 7, and 8, as described below. The remainder of the index points were used solely in the economic analysis and did not correspond to any proposed line of protection.

5.23.17. The index points and corresponding reaches for which risk and uncertainty (R&U) values were computed are as follows:

- No. 5 – Truckee River between Greg Street and McCarran Boulevard;
- No. 6 – Truckee River between McCarran Boulevard and the North Truckee Drain;
- No. 7 – Truckee River between the North Truckee Drain and the downstream end of the proposed levee near HEC-RAS station 91+24; and
- No. 8 – Truckee River between Highway 395 and Greg Street.

Table 11. Standard deviation values for the without-project condition

			Initial Values	
Damage Area Number	Name	$S_{natural}$[11] (ft)	S_{model} (ft)[12]	S_{total} (ft)
2	North_I-80	0.23	0.46	0.52
5	Sparks West	0.30	0.21	0.36
8	Airport	0.30	0.29	0.41
9	Truckee South Overbank	0.30	0.20	0.36
			Final Values	
Damage Area Number	Name	$S_{natural}$ (ft)	S_{model} (ft)	S_{total} (ft)
2	North_I-80	0.23	0.46	0.52
5	Sparks West	0.30	0.60	0.67
8	Airport	0.30	0.60	0.67
9	Truckee South Overbank	0.30	0.60	0.67

[11] The natural uncertainty values shown in **Table 11** for damage area numbers 5, 8, and 9 were obtained by combining the delta values presented in **Table 10** for both the Reno and Nr Sparks gages, using equation 5-3 from EM 1110-2-1619, since the index points for these areas are located between these two gages.
[12] Values shown in red are considered too low compared to the minimum computational uncertainty values listed in EM 1110-2-1619 Table 5-2.

Table 12. Standard deviation values for the with-1/50 chance NED project condition

50-yr NED Project			Initial Values	
Damage Area Number	Name	$S_{natural}$ (ft)	S_{model} (ft) [12]	S_{total} (ft)
2	North_I-80	0.23	0.68	0.72
5	Sparks West	0.30	0.31	0.42
8	Airport	0.30	0.32	0.44
9	Truckee South Overbank	0.30	0.31	0.43
			Final Values	
Damage Area Number	Name	$S_{natural}$ (ft)	S_{model} (ft)	S_{total} (ft)
2	North_I-80	0.23	0.68	0.72
5	Sparks West	0.30	0.60	0.67
8	Airport	0.30	0.60	0.67
9	Truckee South Overbank	0.30	0.60	0.67

Table 13. Standard deviation values for the with-1/117 chance NED project condition

117-yr NED Project			Initial Values	
Damage Area Number	Name	$S_{natural}$ (ft)	S_{model} (ft) [12]	S_{total} (ft)
2	North_I-80	0.23	0.68	0.72
5	Sparks West	0.30	0.37	0.47
8	Airport	0.30	0.37	0.47
9	Truckee South Overbank	0.30	0.38	0.48
			Final Values	
Damage Area Number	Name	$S_{natural}$ (ft)	S_{model} (ft)	S_{total} (ft)
2	North_I-80	0.23	0.68	0.72
5	Sparks West	0.30	0.60	0.67
8	Airport	0.30	0.60	0.67
9	Truckee South Overbank	0.30	0.60	0.67

5.23.18. Levee and floodwall heights were adjusted in the risk analysis until the minimum height was met to produce a CNP of at least 90 percent for the n-year design event (e.g., the 1/50, 1/75, 1/100, and 1/117 chance events). A stage-discharge approach was used at index points 5 and 8 and a stage-frequency approach was used at index points 6 and 7. The FDA analysis used an equivalent period of record of 55 years[13] for the stage-frequency approach for index points 6 and 7. In general, in the economic analysis, the stage versus frequency approach was necessary for the vast majority of index points in the Truckee Meadows since the stage-discharge rating curves do not show increased stage with increased discharge due to the backwater effect caused by ponding of floodwater in the Meadows area upstream of the canyon entrance at Vista.

5.23.19. Given the hydraulics of the river system at index point numbers 6 and 7, located in a ponding area, it follows that there should be only minimal computational uncertainty at these points since the stage is primarily driven by volume (of the flood wave) and not by hydraulic roughness and debris loading. That is, downstream of the ponding area, the river enters a canyon reach wherein the entrance to the canyon acts as a local hydraulic control.

5.23.20. A sample of the initial stage-probability curve for index point number 6 is shown in **Figure 8**. Based on discussion with HEC staff, they noted that the flat portion of the rating curves (corresponding to the frequent events) tend to force the shape of the bounding standard deviation curves to spread apart unrealistically. HEC's suggestion was to replace the frequent event data of the rating curve with low stages to "force" a straight line linking the 0.02 and 0.05 AEP events to the most frequent events. As illustrated on **Figure 9**, the change in the rating curve with this modification results in more reasonable bounding standard deviation curves.

5.23.21. Furthermore, it was felt that the impacts of this adjustment (i.e., using artificially low data in the range between 0.9999 and 0.05) would not affect the results in the range of events which were of greatest interest (e.g., 0.02 to 0.0085). Additionally, the uncertainty values listed for the 1/75 and 1/117 chance NED plans were estimated using graphical interpolation versus using log-linear interpolation. This latter method appeared to yield more accurate values. The final uncertainty values selected for the four n-year sized NED plans are presented in **Table 14**.

[13] The equivalent period of record of 55 year corresponds to the gage at Vista. The Reno gage has an equivalent period of record of 78 years.

Table 14. Uncertainty values for the proposed levees and floodwalls which provide a 90% assurance against overtopping

Index Point	RAS XSEC	Damage Area No.	Damage Area	Uncertainty Values per the NED & Recommended Plans for a 90% Assurance				Remarks	Equivalent Period of Record
				1/50	1/75	1/100	1/117		
5	27953.75	5	Sparks West	1.7	2.6	2.9	3.1	Stage-Discharge	78yr
6	16122.58	6	Sparks East	*2.9*	*2.9*	2.9	2.9	Stage-Frequency	55yr
7	13261.42	7	Larkin Circle	2.9	*2.9*	2.9	2.9	Stage-Frequency	55yr
8	36974.9*	8	Airport	3.0	4.0	4.0	4.2	Stage-Discharge	78yr

5.24. **Wind and Wave Run-up.** Given the large fetch lengths in the Truckee Meadows ponding area associated with large flood events, a wind and wave run-up analysis was conducted for the 1/117 chance event to determine potential wave and wave run-up heights as part of the Corps' 2009 analysis. The analysis was based on guidance provided in ETL (Draft) 1110-2-570.

5.25. Although it would be desirable to include wave activity in the uncertainty analysis for the current Recommended Plan, previous experience on other projects and in-depth discussions with senior economics PDT members revealed that, from the perspective of estimating project benefits, inclusion of wave impacts into the subject analysis was not warranted. Based on engineering judgment, the costs associated with a potential raise of the levees/floodwalls is fairly insignificant when compared to the total project costs, such that the costs of the features should already be contained within the cost contingencies.

5.26. Therefore, given the limitations of the hydraulic models with regards to wave prediction and the likelihood of an overall increase in complexity in the hydraulic and economic analyses with no significant improvement in results, the current design analyses do not include the impact of wave action in setting the top of levee/floodwall profiles. The impact of wave run-up will be included in the top of wall analysis in the PED phase of the study.

5.27. **Initial Overtopping.** Application of initial overtopping criteria was included n the Recommended Plan design. Specifically, given that the UNR Farms is a natural overtopping and overbank ponding area within the Truckee Meadows, the south, or right side of the channel located between McCarran Boulevard and Steamboat Creek was identified as the designated overtopping reach.

5.28. The minimum top of levee and floodwall profile was set to ensure that the initial overtopping would occur in the designated overtopping reach. The final top of levee/floodwall profile was based on the greater of the 1/50 chance water surface elevation with the appropriate uncertainty or one foot above the 1/100 chance water

surface elevation. Using this design, events which initially exceed the 1/50 chance design event will not overtop the levees and floodwalls, but will flow into the UNR Farms overbank ponding area providing additional time for flood fighting activities and/or evacuations. As the flood intensity approaches and exceeds the 1/100 chance event, the levees and floodwalls may be overtopped and breached.

5.29. It is important to note that this design does not provide a 1/100 chance level of protection to the interior areas. Use of one foot above the computed 1/100 chance water surface elevation is well below the FEMA standard of three feet of freeboard and below the computed uncertainty values shown in **Table 14**. Simply put, this design does not provide a 90% non-exceedance probability for the 1/100 chance event.

5.30. It is expected that in the Preconstruction, Engineering and Design (PED) phase of the study, the final design may incorporate adjustments to levees heights and/or armoring of selected levee backsides to "force" initial overtopping at other least hazardous areas as well as to prevent catastrophic levee failure via levee overtopping/breaching when the design capacity of the flood reduction facilities are exceeded.

5.31. Hydraulic Analysis of Recommended Plan.

5.31.1. With-Project Levee Breach Parameters. Consistent with the with-project analysis for the previous NED and LPP projects, levee breaches for the Recommended Plan were triggered in the HEC-RAS modeling if the levee or floodwall was overtopped. Only one breach was allowed to occur into each damage area from a given watercourse. Levee breaches were not allowed to occur into a damage area if channel overtopping would occur and initiate damages before the levee breach would form. That is, given the limitations of the HEC-FDA program, only one source of damages could be simulated in the economic modeling for each damage area.

5.31.2. In the with-project models, the location of levee/berm breaches were identified for damage area numbers 5, 6, 7, and 8 (refer to **Plate 1**). In all of the remaining damage areas, channel overtopping was identified as the source of initial damage during the rising limb of large flood events. Index points 6B and 7B are not used in the with-project analysis since these two points are located where the NTD channel is proposed to consist of an underground conduit wherein overtopping and /or breaching are precluded. Index points 3 and 4, located upstream on the NTD, can be used to assess capacity issues associated with the proposed underground conduit. Index point 9 also becomes irrelevant since its corresponding damage area, Truckee South Overbank, is located in the exterior in the with-project condition.

5.31.3. Throughout the with-Recommended Plan analysis, the location of the index points remained fixed. The with-project levee breaches were forced to occur at the same locations as the without-project breaches since levee breaches and index points are tied to each other throughout the entire hydraulic and economic analysis. In all

cases, the levee breaches were initiated when the maximum water surface elevation exceeded the top of the proposed levee or floodwall by 0.1 feet. There was no criterion for duration of overtopping since the flood waves on the Truckee River system are so large that when a levee overtops, the duration is usually for at least several hours. The breach geometry was assumed to consist of a 200-foot opening with 1 to 1 sideslopes. The breach was assumed to fully form in one hour. A listing of the trigger elevations for all of the index points for the with-project condition is presented in **Table 15**.

Table 15. Hydraulic parameters for the Truckee Meadows index points with-project condition

Index Pt.	Damage Area			RAS Lat.		1/50 Chance Recommended Plan Trigger Elev	
Number	Number	Name	Station	Weir	Type	Breaching	Overtopping
2	2	North_I-80	52.021	NA	Overtopping	---	4500.50
3	3	West_ NTD	4295.627	5160	Overtopping	---	4394.25
4	4	East_NTD	4295.627	5269	Overtopping	---	4394.85
5	5	Sparks_West	27953.75	30210	Breach	4407.13	---
6A	6	Sparks_East	16122.58	16452	Breach	4398.33	---
7A	7	Larkin_Circle	13261.42	13259	Breach	4397.92	---
8	8	Airport	36974.9*	37157	Breach	4435.16	---
10	10	UNR_Farms	6423.999	12200	Overtopping	---	4386.72
11	11	TMWRF	12290.45	12670	Overtopping	---	4396.24
12	12	North_Hidden_Valley	10402.49	NA	Overtopping	---	4391.00
13	13	Steamboat_South	4893.799	6246/4900	Overtopping	---	4394.14
14	14	Central_Hidden_Valley	15589.79	15865	Overtopping	---	4392.80
15	15	South_Hidden_Valley	18906.85	NA	Overtopping	---	4394.00

Notes:
1 - Index points 6B and 7B are not applicable to the with-project condition since the NTD is located in an underground conduit at these points for the Recommended Plan.
2 - Index point 9 is not applicable to the with-project condition since Damage Area No. 9 (Truckee South Overbank) is located in the exterior for the Recommended Plan.
3 - "Breaching" refers to breaching of the proposed levees or floodwalls and corresponds to the initiation of damages for the subject damage areas.
4 - "Overtopping" refers to overtopping of the channel bankline. Overtopping of levees or floodwalls can also occur in these damage areas, but is not the initial source of damages.

5.31.4. 1/50 Chance Event Water Surface Profiles. Water surface profiles for the 1/50 chance (2 percent chance or ~50-year) flood event on the with-Recommended Plan are included in **Figures 10** through **14**. In addition to the with-project water surface profiles, the figures also show the corresponding without-project profile to illustrate the impact of the project on the water surface elevations throughout the Truckee Meadows area.

5.31.5. The figures show that the project will affect the 1/50 chance event water surface elevations compared to the without-project condition. Most notably, the project will increase the n-year pool elevations within the Truckee Meadows ponding area as well as the downstream reaches of Steamboat Creek, Boynton Slough and the North Truckee Drain. For the 1/50 chance event, the pool will be increased by about 0.5 feet, specifically in HEC-RAS Storage Area 7 (see **Figure 6**). This increase in water surface elevation is due to the loss of storage in the floodplain. That is, construction of the proposed line of protection along the north side of the Truckee River results in the loss of storage in the commercial Sparks area which is removed from the Truckee River 1/50 chance floodplain. This issue is also discussed in paragraph **5.33.1**.

5.31.6. As illustrated in **Figure 10**, along the Truckee River between Highway 395 and Greg Street, the with-project water surface elevations will be higher than the without-project surface due to the flow confinement caused by the levees and floodwalls. Between Greg Street and about 2000 feet upstream of McCarran Boulevard, the with-project water surface elevation will be less than the without-project due to benching and set-back levees along downstream reaches of the Truckee River.

5.31.7. Figures 10 and **11** show that the with-project water surface elevation in the Truckee River will be higher than the without-project profile at all locations downstream from a point located about 2000 feet upstream of McCarran Boulevard. The main reason for this trend is that the with-project peak discharge leaving the Meadows is 15,610 cfs and the without-project peak discharge is 14,625 cfs. This increase in the 1/50 chance discharge is a result of removal of part of the floodplain storage from the overall volume of the Truckee Meadows by construction of the floodwalls and levees. The 1/50 chance event discharge hydrographs are shown in **Figure 15** for the with-Recommended Plan and without-project conditions for the "upstream" UPRR bridge. The increase in discharge for the 1/50 chance event is about 985 cfs this location.

5.31.8. On Steamboat Creek, the impact of the project is a slight increase in the water surface compared to the without-project condition. This effect exists between the Truckee River confluence and a point just upstream of the Mira Loma crossing (see **Figure 12**). Upstream of this point, the with- and without-project profiles are the same. The cause of the increase in water surface elevation is the reduction in floodplain storage as discussed in paragraph **5.31.5**.

5.31.9. On Boynton Slough, the impact of the project is also a slight raise in the water surface compared to the without-project condition between the Steamboat Creek confluence and about station 6000 (see **Figure 13**). Between stations 6000 and 14000, the with-project water surface profile is noticeably lower than the without-project profile, similar to the previous analyses of the NED and LPP projects. The without-project profile is higher due to overbank flows entering Boynton Slough in

this sub-reach. These overbank flows originate as overtopping flows from the Truckee River downstream of the Glendale Avenue crossing and flow through the airport prior to being captured by Boynton Slough. The proposed Recommended Plan eliminates overtopping from the Truckee River for events up to the 1/50 chance event and results in a significantly lower water surface profile along Boynton Slough. Upstream of station 14000, the with- and without-project profiles are the same.

5.31.10. Between Interstate 80 and the Truckee River, the with-project North Truckee Drain will consist of two 11.5-feet wide by 10-feet high box culverts. The profile of the lower North Truckee Drain shown in **Figure 14** includes the with- and without-project water surface profiles for the 1/50 chance mainstem flood event between Springland Drive and the Truckee River confluence. This figure illustrates the impact of the Recommended Plan on the conditions in the NTD. That is, at the downstream face of the Interstate 80 culverts, the Recommended Plan with-project profile (and hydraulic grade line) is about 0.85 feet higher than the without-project condition. Upstream of the Interstate 80 culverts, the water surface is about 0.98 feet higher for the with-project conditions. The increased water surface extends upstream and eventually dovetails into the without-project profile about half way between Sparks Boulevard and Springland Drive. The 1/50 with-project water surface profile is contained within the NTD entrenched channel.

5.31.11. During the peak of the design event (i.e., corresponding to the maximum computed water surface elevations), the controlling condition is a peak flow of 9850 cfs in the Truckee River (upstream of the NTD confluence) and a contemporaneous flow of 560 cfs[14] in the North Truckee Drain. This flow loading results in a slight pressure condition in the culverts during the design event. The water surface and hydraulic grade line (HGL) profiles for the culverts are shown in **Figure 14**.

5.31.12. **1/100 Chance Event Water Surface Profiles.** The Recommended Plan will increase water surface elevations for the 1/100 chance event (1 percent chance or ~100-year). Plots of the water surface profiles for the 1/100 chance flood event on the with-Recommended Plan are included in **Figures 16** through **20**. In addition to the with-project water surface profiles, the figures also show the corresponding without-project profiles to illustrate the impact of the project on the water surface elevations throughout the Truckee Meadows area.

5.32. **Residual Floodplains.** Residual floodplains for the 1/5, 1/10, 1/20, 1/50, 1/100, 1/200, and 1/500 annual chance exceedance (ACE) events are shown on **Plates 16** through **22**. In the areas not located behind the proposed line of protection, these floodplains are primarily due to flooding from the Truckee River mainstem and main tributaries. In the areas located behind the proposed line of protection, the primary source of flooding may be due to a combination of flooding from interior runoff and

[14] The contemporaneous flow of 560 cfs is based on 410 cfs through the Interstate 80 culverts combined with about 150 cfs from the Peoples Drain.

from mainstem, and main tributary, flood events which exceed the capacity of the line of protection. Interior drainage floodplains are presented and discussed in the interior drainage section.

5.33. A discussion of the without- and with-project performance is presented in Section 4.5 of the Economics Appendix. Furthermore, a listing of the performance indicators is presented in Table 4-10 of the subject appendix for all of the index points.

5.33.1. As shown on **Plate 19**, flooding extents and depths are reduced for the 1/50 chance flood event behind the proposed lines of protection. Throughout the rest of the Truckee Meadows study area, flooding depths are slightly increased compared to without-project conditions. The slight increase in flood depths is illustrated in **Figure 21** and indicates that for most of the Truckee Meadows floodplain, the maximum increase in depth is about 0.4 to 0.8 feet. Between the levees/floodwalls, the increase may be as much as 3 feet.

5.33.2. Of note are the areas in which flooding will still occur with the project in place for the mainstem 1/50 chance event. This is due to two factors: 1) several areas within the Truckee Meadows study area are not located behind the proposed line of protection, as discussed in paragraph 5.3; and 2) even behind the line of protection flooding may continue to occur due to interior drainage runoff.

5.33.3. The areas which correspond to factor 1) include, but are not limited to, the UNR Farm area and the overbanks of the North Truckee Drain. The most pronounced of these areas is the UNR Farm area which serves as a natural detention basin and is bounded by the Truckee River, Steamboat Creek, Boynton Slough, and McCarran Boulevard. Flooding located in the overbanks of the North Truckee Drain is mostly due to the inability of local runoff to get into the drain. The benefit of any measure to improve local drainage into the drain (e.g., underground storm drains) would depend on whether or not the drain has sufficient capacity to contain all of the flows.

5.33.4. Similarly, the Steamboat Creek corridor between Boynton Slough and upstream of Mira Loma Drive will also continue to experience flooding during large flood events since the project does not provide any protection in this area.

5.33.5. The areas which correspond to factor 2) include the portion of Sparks located between Interstate 80 and the Truckee River and some limited flooding in the airport area. Residual flooding in Sparks is mostly due to interior runoff originating in the subject area. Overbank runoff from upstream watersheds has been determined to not significantly impact Sparks' commercial area as long as the open junctions of the People's Drain are capped. Limited flooding in the airport area is mostly due to interior runoff combined with backwater effects from the UNR Farms ponding area.

5.34. SouthEast Connector. It should be noted that the potential impact of the SouthEast Connector (SEC) highway, which would be located along the Steamboat Creek corridor, has not been incorporated into the detailed modeling or results discussed hitherto. However, given that one segment of the SEC project is currently under construction, a qualitative hydraulic assessment was performed to determine if cumulative impacts could occur due to the SEC when combined with the Recommended Plan. Additionally, an economic sensitivity analysis was performed to assess potential impacts of a fully-constructed SEC on the economic viability of the Recommended Plan.

5.34.1. As illustrated in the Figure 22, the SEC is a 6-lane roadway connecting the intersection of Greg Street and Sparks Boulevard (City of Sparks) with the intersection of South Meadows and Veteran's Parkways located south of the Huffaker Narrows. The proposed roadway will be about 5-1/2 miles in total length. The entire project should be completed approximately in April 2016.

5.34.2. The SEC will be constructed in two phases. Phase I extends between the intersection of Sparks Boulevard and Greg Street going south over the Truckee River, over Clean Water Way (without connector), and will terminate about 200 feet south of Clean Water Way. Phase I is currently under construction.

5.34.3. Phase II will extend between the southern limit of Phase I and run southward over the existing Yori Drain (bridge), an at-grade intersection with Pembroke Drive, over Boynton Slough (bridge), over a drainage channel in the golf course (bridge), and an at-grade intersection with Mira Loma Drive. The SEC will continue to run southward through the Huffaker Narrows and connect with Meadows Parkway on the southern end. Portions of the existing Steamboat Creek channel upstream of Mira Loma Drive may be impacted and/or relocated due to the SEC alignment.

5.34.4. The roadway (Phase I and II) will be designed to allow for at least one travel lane in each direction to remain above the pool elevation corresponding to the 0.85% (1/117) ACE event. In addition, the design was required to not impact the water surface in the Truckee Meadows. There are several culverts included under/through the SEC to ensure equalization of water surface elevations on both sides of the SEC. Furthermore, the design includes volume mitigation "borrow" holes/pits to ensure that the volume-stage relationship of the Truckee Meadows is not impacted by construction of the SEC. A no-rise certificate was issued for Phase I of the SEC project by the City of Sparks.

5.34.5. For both Phases, the without-project HEC-RAS model developed by WEST Consultants was used as the initial base model which focused on the 0.85% ACE event. Given the ill-defined situation wherein it is not clear which flood damage reduction (FDR) project will be constructed, the consulting firms have proceeded by simply comparing the with-SEC condition to the without-SEC condition. There is no FDR component to either of these conditions. To date, no modeling has been

performed to determine the cumulative impacts of the SEC in combination with the Corps' Recommended Plan (or in combination with a local interest plan).

5.34.6. As discussed above, it has been demonstrated that just the Phase I portion of the SEC project does not induce an increase in the water surface elevation for the 0.85% ACE event throughout the Truckee Meadows. This conclusion appears reasonable given that although most of the Phase I segment (i.e., with a total length of about 4400 feet) is to be constructed above grade, there is a wide opening under the proposed Truckee River bridge (i.e., the bridge spans about 1400 feet) and there is another opening over Clean Water Way. Additionally, there are two sets of equalization culverts located through the earthen road embankment which are designed to equalize the water surface elevation between the eastern and western sides of the roadway. There are two volumetric mitigation basins which provide volume to offset the volume of the roadway's earthen embankments. Furthermore, this segment is located in the deepest part of the Truckee Meadows floodplain where flood flows emanating from the Truckee River, Steamboat Creek, and Boynton Slough are fully comingled and the water surface elevations should approximate the elevations in the Truckee River, especially under the proposed are equal on either side of the SEC alignment. Nonetheless, it is unknown if there would be a cumulative impact on the water surface elevations if the Phase I portion was combined with the Corps TSP project.

5.34.7. Phase II of the SEC project is currently undergoing final hydraulic analysis and tweaking of the final design to ensure a no increase in water surface elevation condition. A review of the Phase II 50% Design Submittal plans indicates the following:

5.34.7.1. Most of the roadway will be located on top of an earthen embankment which is required to ensure that at least two lanes will be above the 0.85% ACE water surface elevation. This requires that the Mira Loma and Pembroke Drive intersections will be elevated compared to their current configuration.

5.34.7.2. A series of approximately five bridges are included which allow the SEC to cross the various watercourses in the Truckee Meadows.

5.34.7.3. Approximately six sets of equalization culverts are included through the roadway embankment.

5.34.7.4. A number of additional structures are included which will act as equalization culverts during a flood event (e.g., a golf cart underpass through the embankment, etc.)

5.34.7.5. Several large areas graded to provide volumetric mitigation to offset the volume of the roadway embankment are also included. These volumetric mitigation basins were not identified or completely illustrated on the plans that were provided.

5.34.8. Hydraulic modeling for either Phase I or Phase II was not available for this review and documentation of the hydraulic modeling for Phase II was also not available for this review.

5.34.9. Cumulative Impact Assessment. Given the alignment of the SEC (Phases I and II), it is obvious that the earthen embankment will act as a levee or a dam which will interrupt movement of overbank floodwaters in the Truckee Meadows from moving eastward to drain through Steamboat Creek to the Truckee River. As discussed above, there are a number of design features passing through the embankment to minimize the damming effect.

5.34.10. Hydraulic modeling performed to date for the SEC did not include any impacts from the Corps' Recommended Plan. This situation is of concern since the Recommended Plan will displace large volumes of flood waters from the Sparks commercial area and from the Reno airport area into the Truckee Meadows ponding area. As discussed above, the Recommended Plan results in increases in flood depths in the Truckee Meadows ponding area for the 1% ACE event and an increase in flow going downstream past Vista.

5.34.11. Given that the hydraulic modeling corresponding to the 50% submittal of the SEC Phase II segment is just mitigating the SEC project by itself, it is very likely that the two projects (i.e., the Corps' Recommended Plan and the SEC – Phases I and II) will have a noticeable cumulative impact on flood depths (or stages) in the Truckee Meadows for either the 1 or 2% ACE events. This conclusion is qualitative in nature (i.e., not based on analytical or modeling analysis) and is based on engineering judgment taking into consideration the hydraulic modeling results for the Phase II segment, the familiarity with the Truckee Meadows HEC-RAS model, and the impact of transference of large volumes of flood waters from the Sparks commercial and Reno airport areas to the Meadows' ponding area. A quantitative determination of the cumulative impact will require hydraulic modeling.

5.34.12. **Floodplain for Economic Sensitivity Analysis.** To facilitate the assessment of risks to the project, an economic sensitivity analysis was performed to assess potential impacts of a fully-constructed SEC on the economic viability of the Recommended Plan. Refer to the section 5.8.5 of the GRR for a discussion of the results of the sensitivity assessment.

5.34.13. In order to provide sufficient data for the economic sensitivity analysis, a qualitative estimate of the increase in stage for the 1% ACE floodplain was developed which assumed a maximum increase in stage of 12 inches due to the SEC. Specifically, as illustrated in Figure 23, the with-project stages were increased by 0, 3, 6, 9, or 12 inches for the HEC-RAS storage areas located in the Truckee Meadows ponding area. In general, the 12 inch increases were located immediately adjacent to the west side of the SEC embankment and lesser depths were used to simulate the tapering of the backwater effect towards the west. The new 1% ACE

depths, corresponding to the with-SEC and with-Recommended Plan features condition, were computed as the difference between the assumed water surface and the ground elevation. The stages at all other locations throughout the HEC-RAS model were assumed to be unchanged from the without-SEC condition.

5.34.14. As discussed above, quantitative cumulative impacts of the SEC will require hydraulic modeling. At the time of this writing, the PDT proposes that hydraulic modeling will occur shortly to validate the assumed impacts and the results will be incorporated into the study documentation.

5.34.15. Impacts to uncertainty values were not considered in the design of the top of levee/floodwall since the bulk of the uncertainties in the SEC impacts are located in the Truckee Meadows ponding area, away from the proposed lines of protection. Again, hydraulic modeling of the SEC will be required to quantify and validate the preceding assumptions.

5.35. With-Project Rating Data. **Table 16** lists the rating data developed for the with-project condition for the index points located on the Truckee River in the Truckee Meadows reach. **Table 17** lists the rating data for the index points located along the North Truckee Drain, **Table 18** lists the rating data for the index point located along Boynton Slough, and **Table 19** lists the rating data for the index points located along Steamboat Creek. These values were used in the economic analysis of the Truckee Meadows reach which constitute economic damage area numbers 3 through 15.

5.36. Interior Drainage. As illustrated in **Figure 3**, the Recommended Plan includes levees and floodwalls along the line of protection. In addition, the plan raises water surface elevations between Highway 395 and Greg Street (see **Figure 10**). Given the ability of the proposed levees and floodwalls to block interior sheet flow from entering the river channel, it can be concluded that the Recommended Plan has the potential to impact the interior drainage of the Truckee Meadows area. Two potential areas where the project may impact the interior drainage have been identified and are shown in **Figure 3**: 1) the north (left) overbank of the Truckee River just upstream of McCarran Boulevard, and 2) the west (right) overbank of the Truckee River just upstream of Glendale Avenue.

5.36.1. In general, the study approach developed for the interior drainage analysis of the Truckee Meadows area consists of the following steps:

5.36.1.1. Develop without-project mainstem floodplains for the areas of interest (i.e., already have these as discussed in paragraph 5.14);

5.36.1.2. Develop interior drainage floodplains for the without-project condition;

Table 16. With-project rating data for the index points located on the Truckee River in the Truckee Meadows

Truckee River Index Points						
Index Point 5		Without-Project		With-Project		Project Impact
Frequency 1 in X Annual Chance	Exceedance Probability	Stage (ft-navd88)	Discharge (cfs)	Stage (ft-navd88)	Discharge (cfs)	Delta WSEL (ft)
5	0.2	4400.26	5947	4399.7	5947	-0.56
10	0.1	4401.46	7539	4400.63	7539	-0.83
20	0.05	4402.50	9128	4401.41	9094	-1.09
50	0.02	4404.73	13416	4403.43	13702	-1.30
100	0.01	4406.85	19135	4406.03	20738	-0.82
200	0.005	4409.45	27322	4409.94	32355	0.49
500	0.002	4411.36	29887	4413.86	40283	2.50
Index Point 6A		Without-Project		With-Project		
5	0.2	4387.17	5935	4387.23	5938	0.06
10	0.1	4388.99	7484	4389.14	7496	0.15
20	0.05	4390.85	8988	4390.82	9042	-0.03
50	0.02	4393.59	10944	4393.68	11044	0.09
100	0.01	4397.45	6427	4397.23	10732	-0.22
200	0.005	4400.90	7888	4401.36	14992	0.46
500	0.002	4408.31	11571	4408.96	25612	0.65
Index Point 7A		Without-Project		With-Project		
5	0.2	4386.47	6071	4386.54	6080	0.07
10	0.1	4388.17	7587	4388.34	7661	0.17
20	0.05	4390.00	9331	4389.96	9436	-0.04
50	0.02	4393.13	9434	4393.21	10432	0.08
100	0.01	4397.15	8493	4396.90	11445	-0.25
200	0.005	4400.58	8377	4401.02	15383	0.44
500	0.002	4408.13	18120	4408.65	25586	0.52
Index Point 8		Without-Project		With-Project		
5	0.2	4428.54	5948	4428.50	5948	-0.04
10	0.1	4429.54	7539	4429.49	7539	-0.05
20	0.05	4430.37	9135	4430.31	9138	-0.06
50	0.02	4432.12	13716	4432.06	13718	-0.06
100	0.01	4433.73	20772	4434.06	20734	0.33
200	0.005	4436.78	31842	4437.10	32512	0.32
500	0.002	4439.23	41513	4440.01	43178	0.78
Index Point 9		Without-Project		With-Project[15]		
5	0.2	4410.49	5948	---	---	---
10	0.1	4411.17	7539	---	---	---
20	0.05	4411.74	9133	---	---	---
50	0.02	4413.06	13715	---	---	---
100	0.01	4414.77	20771	---	---	---
200	0.005	4417.04	30973	---	---	---
500	0.002	4418.17	36444	---	---	---
Index Point 11		Without-Project		With-Project		
5	0.2	4386.25	6584	4386.31	6630	0.06
10	0.1	4387.94	8077	4388.10	8236	0.16
20	0.05	4389.77	10298	4389.74	10121	-0.03
50	0.02	4392.67	15375	4392.80	15611	0.13
100	0.01	4396.42	22327	4396.30	22167	-0.12
200	0.005	4399.77	28181	4400.40	30253	0.63
500	0.002	4408.01	27275	4408.48	40205	0.47

[15] Index point number 9 was not used for the with-project condition since it was located in the exterior.

Table 17. With-project rating data for the index points located on the North Truckee Drain in the Truckee Meadows

North Truckee Drain Index Points						
Index Point 3 & 4		Without-Project		With-Project		Project Impact
Frequency 1 in X Annual Chance	Exceedance Probability	Stage (ft-navd88)	Discharge (cfs)	Stage (ft-navd88)	Discharge (cfs)	Delta WSEL (ft)
5	0.2	4388.49	110	4387.38	32	-1.11
10	0.1	4389.23	150	4388.72	72	-0.51
20	0.05	4391.79	301	4390.99	183	-0.80
50	0.02	4395.59	380	4394.82	306	-0.77
100	0.01	4397.69	154	4397.62	150	-0.07
200	0.005	4400.01	29	4398.67	-163	-1.34
500	0.002	4408.49	247	4404.26	-49	-4.23
Index Point 6B		Without-Project		With-Project[16]		
5	0.2	4386.60	142	---	---	---
10	0.1	4388.29	163	---	---	---
20	0.05	4390.26	353	---	---	---
50	0.02	4393.16	527	---	---	---
100	0.01	4397.24	209	---	---	---
200	0.005	4399.98	256	---	---	---
500	0.002	4408.43	1543	---	---	---
Index Point 7B		Without-Project		With-Project[16]		
5	0.2	4386.55	142	---	---	---
10	0.1	4388.26	174	---	---	---
20	0.05	4390.20	387	---	---	---
50	0.02	4393.15	-3	---	---	---
100	0.01	4397.24	217	---	---	---
200	0.005	4399.97	518	---	---	---
500	0.002	4408.31	4032	---	---	---

Table 18. With-project rating data for the index points located on Boynton Slough in the Truckee Meadows

Boynton Slough Index Point						
Index Point 13		Without-Project		With-Project		Project Impact
Frequency 1 in X Annual Chance	Exceedance Probability	Stage (ft-navd88)	Discharge (cfs)	Stage (ft-navd88)	Discharge (cfs)	Delta WSEL (ft)
5	0.2	4387.53	112	4387.71	116	0.18
10	0.1	4388.74	122	4388.94	141	0.20
20	0.05	4390.76	289	4390.80	310	0.04
50	0.02	4393.71	553	4393.87	486	0.16
100	0.01	4397.59	366	4397.63	713	0.04
200	0.005	4401.08	803	4401.79	1477	0.71
500	0.002	4408.44	1797	4409.55	4450	1.11

[16] Index point numbers 6B and 7B were not used in the with-project condition since these points are located where the with-project channel consists of an underground box culvert.

Table 19. With-project rating data for the index points located on Steamboat Creek in the Truckee Meadows

Steamboat Creek Index Points						
Index Point 10		Without-Project		With-Project		Project Impact
Frequency 1 in X Annual Chance	Exceedance Probability	Stage (ft-navd88)	Discharge (cfs)	Stage (ft-navd88)	Discharge (cfs)	Delta WSEL (ft)
5	0.2	4386.64	521	4386.74	553	0.10
10	0.1	4388.24	584	4388.44	667	0.20
20	0.05	4390.27	1176	4390.26	1220	-0.01
50	0.02	4393.39	1231	4393.63	1495	0.24
100	0.01	4397.52	3580	4397.43	4245	-0.09
200	0.005	4400.97	6496	4401.56	7351	0.59
500	0.002	4408.36	8776	4409.19	15127	0.83
Index Point 12		Without-Project		With-Project		
5	0.2	4386.84	525	4386.95	556	0.11
10	0.1	4388.38	645	4388.59	672	0.21
20	0.05	4390.39	965	4390.41	1079	0.02
50	0.02	4393.41	1245	4393.67	1659	0.26
100	0.01	4397.55	2738	4397.51	3342	-0.04
200	0.005	4401.02	5001	4401.66	5804	0.64
500	0.002	4408.39	8054	4409.32	13042	0.93
Index Point 14		Without-Project		With-Project		
5	0.2	4387.36	531	4387.49	570	0.13
10	0.1	4388.69	721	4388.85	695	0.16
20	0.05	4390.70	1553	4390.72	1501	0.02
50	0.02	4393.66	2393	4393.83	1982	0.17
100	0.01	4397.58	1354	4397.60	1957	0.02
200	0.005	4401.07	1914	4401.75	2921	0.68
500	0.002	4408.43	3537	4409.48	7023	1.05
Index Point 15		Without-Project		With-Project		
5	0.2	4387.56	435	4387.52	176	-0.04
10	0.1	4388.8	599	4388.87	237	0.07
20	0.05	4390.80	1255	4390.78	702	-0.02
50	0.02	4393.69	1225	4393.86	1457	0.17
100	0.01	4397.59	1640	4397.62	1619	0.03
200	0.005	4401.07	2119	4401.76	1569	0.69
500	0.002	4408.43	3602	4409.49	3177	1.06

5.36.1.3. Combine the without-project mainstem and interior floodplains to produce a composite floodplain comprised of the maximum depths from both sources of flooding;

5.36.1.4. Develop interior drainage floodplains for the with-project condition wherein the proposed line of protection is in place, as well as any minimum interior drainage facilities consistent with guidance presented in EM 1110-2-1413, Engineering and Design - Hydrologic Analysis of Interior Areas;

5.36.1.5. Subtract the without-project composite depths from the with-project interior drainage depths to identify locations, if any, where the with-project conditions have negatively impacted the n-year flood depths (i.e., regardless of the source of flooding);

5.36.1.6. Conduct an economic assessment to determine if there a problem which is cost effective to fix;

5.36.1.7. If a fix is required and is economically viable, use hydraulic modeling to develop and size a fix, potentially composed of gravity drains and/or pumps, which mitigates the increase in flood depth for the 1/100 chance interior drainage flood event. This solution is referred to as "FIX1";

5.36.1.8. Conduct the civil design activities of the drainage facility and develop M-CACES cost estimates.

5.36.2. Additional tasks may include identifying and mitigating environmental impacts. For the Truckee Meadows area, the with- and without-project floodplains have been developed for the two areas as well as the hydraulic analysis for the FIX1 solution. However, economic assessments of these areas have yet to be completed for any of the areas.

5.36.3. Storm Events. As discussed in the Hydrology Appendix, two types of precipitation events were used to develop runoff into the interior drainage areas. The precipitation events consisted of a general rain with a 72-hour duration and a cloudburst event with a 3-hour duration with a much smaller/focused drainage area. In general, one would expect the largest peak flowrates to be associated with the cloudburst events and the largest flood volumes to be associated with the general rain storm events.

5.36.4. Flood Events. The flood events used for the interior drainage analysis consisted of the 1/10, 1/50, and 1/100 chance events. Although runoff hydrographs were developed for all of the standard return frequencies, only these three were used for the following reasons: 1) the design level which would eventually pencil out for any "fix" would likely be included in the range studied (i.e., 1/10 to 1/100 chance events), 2) the study would progress much faster with fewer frequencies to analyze, combined with a high confidence that any results from this approach would be reasonable and would not lead the study in a flawed direction, and 3) the three events would produce at least three points sufficient for the economic analysis to develop annual damages and benefits. Although the original plan was to develop FIX1 solutions for the 1/10, 1/50, and 1/100 chance events, during the initiation of the Feasibility Reset Plan, the PDT decided to limit the FIX1 solution to just the 1/100 chance interior drainage flood event to save analysis time. During the PED phase of the study, other interior flood events may be analyzed so that an optimized solution may be developed.

5.36.5. Tailwater. For the general rain, the tailwater elevation in the adjacent mainstem channel was set to the peak n-year event of the next lower standard frequency event compared to that occurring on the tributary watershed. For example, during the 1/100 chance event on the tributary or interior drainage area, the 1/50 chance event

was simulated in the mainstem channel system. Similarly, during the 1/10 chance event on the tributary, the 1/5 chance event was simulated on the mainstem channel system. This approach was reviewed and was considered reasonable and appropriate by the PDT hydrologist based on his understanding of the contemporaneous flood conditions from different sources of flooding in the study area. The interior runoff hydrographs were adjusted forward or backwards in time so that the peaks of the mainstem and tributary area were coincidental and resulted in a peak to peak condition.

5.36.6. For the cloudburst precipitation event, it was assumed that there would be negligible tailwater in the receiving channels since the cloudburst events tend to occur during the summer and fall when the river system usually has low flows. Given the unsteady nature of the HEC-RAS model and the need to not let any reaches flow dry during the simulation, the modeling used the 1/5 chance event for the mainstem system to maintain a minimum flow throughout the model which also produced very low stages in the river.

5.36.7. Interior Drainage Study Areas

5.36.7.1. **North Side of Truckee River.** In the Sparks interior drainage area, the hydraulic analysis was conducted using the FLO-2D program to simulate the complex flow patterns in the overbank as well as to simulate the tailwater conditions of the Truckee River and the North Truckee Drain. A 150-foot grid was used and width reduction factors (WRF's) were used to block out conveyance through most of the large warehouse buildings. Hydraulic structures were used in the model to simulate several of the existing large storm drains which drain the overbank into the river. A series of hydraulic structures were also used to ensure that the correct stage-discharge relationship occurred in the river channel throughout the simulation.

5.36.7.2. The general layout of the Sparks interior drainage FLO-2D model is illustrated in **Figure 22**. Included in the figure is the computational domain (red boundary line), the hydrologic subareas (green lines), the hydraulic structures located in the Truckee River used to ensure the correct stage-time relationship (thick, bright red lines), and the inflow points for both direct rainfall as well as for point sources of inflow from upstream subareas (refer to the legend). The FLO-2D modeling and results are discussed below.

5.36.7.2.1. <u>1/10 Chance Event.</u> The without-project maximum composite floodplain for the Sparks interior drainage area is shown in **Figure 23a** for the 1/10 chance event. The red dashed line shows the location of the proposed line of protection for the Recommended Plan. The with-project maximum composite floodplain for the Sparks interior drainage area is shown in **Figure 23b** for the 1/10 chance event. A comparison of flood depths for the Sparks interior drainage area is shown in **Figure 23c** and illustrates that along the line of protection, there is no significant increase

in flood depths resulting from the proposed project. However, there are increased flood depths located along the North Truckee Drain, just downstream of the UPRR crossing.

5.36.7.2.2. These increased depths occur from interior runoff which would normally sheet flow into the open North Truckee Drain in the without-project condition. However, these sheet flows are blocked from entering the drain given that the with-project drain is covered. An obvious solution to this problem would be to increase the capacity of the local storm drain system (i.e., catch basins and drain lines) to mitigate the increase in flood depths. However, as discussed in paragraph 5.36.4, in the interest of analysis time, the FIX1 solutions were limited to only the 1/100 chance event. This refinement should be made in the PED phase of the study.

5.36.7.2.3. 1/50 Chance Event. The without-project maximum composite floodplain for the Sparks interior drainage area is shown in **Figure 24a** for the 1/50 chance event. The red dashed line shows the location of the proposed line of protection for the Recommended Plan. The with-project maximum composite floodplain for the Sparks interior drainage area is shown in **Figure 24b** for the 1/50 chance event. A comparison of flood depths for the Sparks interior drainage area is shown in **Figure 24c** and illustrates that along the line of protection, as well as all other locations in the Sparks interior drainage area, there is no significant increase in flood depths resulting from the proposed project.

5.36.7.2.4. 1/100 Chance Event. The without-project maximum composite floodplain for the Sparks interior drainage area is shown in **Figure 25a** for the 1/100 chance event. The red dashed line shows the location of the proposed line of protection for the Recommended Plan. The with-project maximum composite floodplain for the Sparks interior drainage area is shown in **Figure 25b** for the 1/100 chance event. A comparison of flood depths for the Sparks interior drainage area is shown in **Figure 25c** and illustrates that along the line of protection, as well as all other locations in the Sparks interior drainage area, there is no significant increase in flood depths resulting from the proposed project.

5.36.7.3. **South Side of Truckee River.** In the Meadows south side interior drainage area, the hydraulic analysis was conducted using the HEC-RAS program to simulate overbank areas with ponding behind the line of protection as well as to simulate the tailwater conditions of the Truckee River. The specific model was based on the Corps' HEC-RAS modeling from 2007 and 2008. The modeling focused on two areas: 1) the Wal-Mart site located in the west (right) overbank north of Glendale Avenue, and 2) within the proposed UNR Farms Station ring levee located on the south (right) overbank just east

of McCarran Boulevard. The UNR ring levee does not obstruct sheet flow for the 1/50 Recommended Plan.

5.36.7.4. The HEC-RAS model included the appropriate mainstem and interior runoff hydrographs as well as assumed minimal interior drainage facilities. The hydraulic analysis indicated that the general rain event controlled flooding when there is a tailwater in the Truckee River and that the cloudburst rain event produced the peak runoff flow rate. The results of the HEC-RAS modeling are discussed below.

Wal-Mart Site.

5.36.7.4.1. 1/10 Chance Event. The without-project maximum composite floodplain for the Wal-Mart site is shown in **Figure 26a** for the 1/10 chance event. The red dashed line shows the location of the proposed line of protection for the Recommended Plan. The with-project interior drainage floodplain for the Wal-Mart site is shown in **Figure 26b** for the 1/10 chance event. A comparison of flood depths for the Wal-Mart site is shown in **Figure 26c** and illustrates that along the line of protection, there is a significant increase in flood depths resulting from the proposed project.

5.36.7.4.2. 1/50 Chance Event. The without-project maximum composite floodplain for the Wal-Mart site is shown in **Figure 27a** for the 1/50 chance event. The red dashed line shows the location of the proposed line of protection for the Recommended Plan. The with-project interior drainage floodplain for the Wal-Mart site is shown in **Figure 27b** for the 1/50 chance event. A comparison of flood depths for the Wal-Mart site is shown in **Figure 27c** and illustrates that along the line of protection, similar to the 1/10 chance event, there is a significant increase in flood depths resulting from the proposed project.

5.36.7.4.3. 1/100 Chance Event. The without-project maximum composite floodplain for the Wal-Mart site is shown in **Figure 28a** for the 1/100 chance event. The red dashed line shows the location of the proposed line of protection for the Recommended Plan. The with-project interior drainage floodplain for the Wal-Mart site is shown in **Figure 28b** for the 1/100 chance event. A comparison of flood depths for the Wal-Mart site is shown in **Figure 28c** and illustrates that along the line of protection, similar to the 1/10 and 1/50 chance events, there is a significant increase in flood depths resulting from the proposed project.

5.36.7.4.4. By trial and error, the hydraulic modeling showed that a pump station with a capacity of 14 cfs was capable of reducing the with-project interior drainage depths to no greater than the without-project composite maximum depths for the 1/100 chance general rain event. In addition,

two 42 inch flapgated RCPs would be required to mitigate the with-project cloudburst interior drainage event. Thus, the FIX1 solution is a combination of a 14 cfs pump station and two 42 inch RCPs. The with-project interior floodplain with the FIX1 solution in place is shown in **Figure 29a** for the 1/100 chance event. **Figure 29b** shows the difference in depths between the FIX1 with-project condition and the without-project composite maximum depths.

6. LOWER TRUCKEE RIVER

6.1. General. As shown in **Figure 30**, the lower Truckee River reach is composed of two HEC-RAS model reaches consisting of: 1) Vista to Wadsworth, and 2) Wadsworth to Pyramid Lake. The upstream limit of the Vista to Wadsworth HEC-RAS model is located about halfway between the two UPRR bridges located upstream of Rainbow Bend and the downstream limit is located downstream of Wadsworth. The upstream limit of the Wadsworth to Pyramid Lake HEC-RAS model is located just upstream of the State Highway 427 bridge and the downstream limit is located just downstream of the Marble Bluff Dam.

6.2. The without-project modeling assumes that the conditions are as currently exists (2013) and that all of the recent ecosystem restoration features are present including the soon-to-be constructed restoration segment at Tracy. Since all of the ecosystem reaches constructed by The Nature Conservancy are not part of the proposed project, it was important to include these features in the without-project condition. Specifically, these restoration reaches include (from upstream to downstream) the Lockwood, Lower Mustang Ranch, McCarran Ranch, Tracy, and 102 Ranch segments. Previous without-project hydraulic modeling precluded inclusion of these restoration reaches (with the exception of the McCarran Ranch reach) since the restoration was originally part of the with-project condition. This is one of the most significant changes in modeling in the Vista to Wadsworth reach.

6.3. The with-project HEC-RAS model uses the future existing conditions (or without-project) model, with the exception that the inflows to the model (below Vista) are based on the 1/50 chance Recommended Plan in the Truckee Meadows. Additionally, all of the previously proposed channel stabilization and corresponding environmental mitigation features have been removed from the with-project modeling. Also, the access bridge at Painted Rock will remain "as is" for the Recommended Plan; whereas, previous plans included a new "raised" access bridge. In general, a review of the impacts of the Recommended Plan on the lower Truckee River indicated that although the increased peak discharges will slightly increase stages, the impact on bank erosion, bridge and pier scour, and traffic over the access bridge are sufficiently minor such that an economically viable fix to mitigate the impacts does not exist. The review of the bank erosion and bridge and pier scour is discussed in detail in paragraph 7.6.

6.4. Background. Originally, the downstream limit of the authorized Truckee Meadows study area was at Vista. However, the HEC-RAS evaluation of project alternatives conducted during the F3 and F4 phases of the study showed peak flow increases below Vista. Initially, it was envisioned that mitigating these peak flow increases presented an opportunity for ecosystem restoration along the Truckee River below Vista. However, additional hydraulic modeling of the reach between Vista and Wadsworth, conducted before the F4 Conference, showed that little, if any, flow attenuation would be realized by ecosystem restoration. Furthermore, additional hydraulic modeling of various alternatives to reduce peak flows to downstream reaches indicated that there was no cost effective means to reduce the flows.

6.5. Thus, following the F4 Conference, it was understood that the increased peak flood flows would have to be tracked all the way to Pyramid Lake so that a proper assessment of the impacts of the project on downstream conditions could be made. In 2004, the Corps developed updated mainstem hydrology and new interior hydrology for the reach between Wadsworth and Pyramid Lake. Additionally, a new HEC-RAS model for this reach was developed for the Corps by WEST Consultants, Inc.

6.6. Changes since the F4 Conference.

6.6.1. Vista to Wadsworth. Since the F4 Conference, the Vista to Wadsworth HEC-RAS model has undergone some adjustments to improve model prediction. The most notable change was the inclusion of tributary flows and losses to groundwater so that the model would reproduce the correct n-year peak flow versus frequency relationships as determined by the hydrologic analysis. The previous modeling tended to predict unreasonably high peak n-year flows at the Derby Dam and Wadsworth stream gage locations. The latest version of the without-project Vista to Wadsworth HEC-RAS model is shown in **Figure 31**.

6.6.2. Previous analyses of the Rainbow Bend reach included a "pre-existing" earthen berm and in some cases, modified channel geometry to allow passage of the peak flood event without inducing flooding in the Rainbow Bend community. The current Recommended Plan does not include any of these features since the with-project 1/50 and 1/100 peak flood events are contained within the existing channel.

6.6.3. Wadsworth to Pyramid Lake. At the time of the F4 Conference, a preliminary version of the HEC-RAS model for the Wadsworth to Pyramid Lake (alternatively - Marble Bluff Dam) reach had been constructed and calibrated. However, the without-project hydrology had not yet been finalized since the Vista to Wadsworth HEC-RAS model (i.e., the source of the hydrology for the subject reach) had not been finalized. As the Vista to Wadsworth modeling was completed, the Wadsworth to Pyramid Lake model was finalized with "final" inflow n-year, with- and without-project flood hydrographs.

6.6.4. This model was further refined by including tributary inflows so that the predicted n-year peak flows at the Nixon gage would match those from the hydrologic analysis. Additionally, a joint effort by the Bureau of Indian Affairs and the Pyramid Lake Paiute Tribe to remove the Numana Dam to improve fish passage is ongoing. Both the with- and without-project HEC-RAS modeling assumes that the Numana Dam has been removed. The Wadsworth to Pyramid Lake HEC-RAS model is shown in **Figure 32**.

6.7. Economic Damage Areas. Economic damage areas and index points were not delineated or analyzed for the reach between Vista and Pyramid Lake. In preparation for the F4 Conference, the District had determined that flooding between Vista and Wadsworth was not of sufficient magnitude as to support a stand-alone flood damage

reduction project. Instead, in discrete areas where the with-project condition negatively impacted flooding, the Corps would develop hydraulic mitigation measures. Refer to the main GRR documentation for a detailed discussion regarding this reach and the rationale for not computing inundation damages.

6.8. Levee Breaches. There are no levees or floodwalls in this reach for both the with- and without-project conditions. It is assumed that existing berms and other "levee-like" features may overtop, but do not breach.

6.9. Updated Without-Project Floodplains. Updated without-project floodplains are shown in **Plates 23 through 52** for the 1/5, 1/10, 1/20, 1/50, and 1/100 chance annual exceedance events along with the corresponding with-project floodplains. As illustrated in these plates, all of the floodplains are generally located contiguous to the main river corridor. The exception to this is that the 1/100 chance event breaks out of the channel in Wadsworth and flows down an independent flow path parallel to the main channel. The breakout flows then recombine at a point about 6000 feet downstream of the breakout. Smaller flood events, for example less than about 14,000 cfs, do not breakout of the main channel at Wadsworth. As may be gleaned from these floodplain plates, there aren't very many structures located in the without-project floodplains given the relative sparseness of the structural inventory.

6.10. Discharges. The without-project n-year peak discharges and 7-day hydrograph volumes used in the analysis for the Vista to Wadsworth and Wadsworth to Pyramid Lake reaches are listed in **Tables 20** through **22** and are a function of the n-year event. Specifically, peak discharges for handoff flows between the Truckee Meadows and Vista to Wadsworth HEC-RAS models are shown in **Table 20**, handoff flows between the Vista to Wadsworth and Wadsworth to Pyramid Lake HEC-RAS models are shown in **Table 21**, and the contemporaneous peak n-year discharges in Long Valley Creek are listed on **Table 22**.

6.11. The with-project discharges and 7-day hydrograph volumes for the Vista to Wadsworth HEC-RAS modeling reach are shown in **Table 23** for the 1/50 chance Recommended Plan. The with-project discharges for the Wadsworth to Pyramid Lake HEC-RAS modeling reach are shown in **Table 24**.

Table 20. Peak n-year discharges and hydrograph volumes for the Truckee River at the upstream end of the Vista to Wadsworth HEC-RAS model for the without-project condition

n-Year Flood Event	Peak Discharge (cfs)	7-day Volume (AF)
1/5 chance event	6630	49,103
1/10 chance event	8136	61,690
1/20 chance event	9915	73,638
1/50 chance event	14,625	97,116
1/100 chance event	20,641	152,067

Table 21. Peak n-year discharges and hydrograph volumes for the Truckee River at the upstream end of the Wadsworth to Pyramid Lake HEC-RAS model for the without-project condition

n-Year Flood Event	Peak Discharge (cfs)	7-day Volume (AF)
1/5 chance event	6704	49,186
1/10 chance event	7926	60,939
1/20 chance event	9568	72,099
1/50 chance event	13,769	92,737
1/100 chance event	19,751	141,842

Table 22. Contemporaneous peak n-year discharges in Long Valley Creek for the with- and without-project conditions

n-Year Flood Event	Peak Discharge (cfs)	7-day Volume (AF)
1/5 chance event	97	438
1/10 chance event	376	664
1/20 chance event	828	1345
1/50 chance event	1742	2358
1/100 chance event	2532	3481

Table 23. Peak n-year discharges and hydrograph volumes for the Truckee River at the upstream end of the Vista to Wadsworth HEC-RAS model for the with-project 1/50 chance Recommended Plan condition

n-Year Flood Event	Peak Discharge (cfs)	7-day Volume (AF)
1/5 chance event	6629	49,056
1/10 chance event	8234	61,825
1/20 chance event	11,024	73,986
1/50 chance event	15,610	97,548
1/100 chance event	22,162	152,237

Table 24. Peak n-year discharges and hydrograph volumes for the Truckee River at the upstream end of the Wadsworth to Pyramid Lake HEC-RAS model for the with-project 1/50 chance Recommended Plan condition

n-Year Flood Event	Peak Discharge (cfs)	7-day Volume (AF)
1/5 chance event	6701	48,628
1/10 chance event	7993	61,100
1/20 chance event	10,129	72,423
1/50 chance event	14,820	92,730
1/100 chance event	21,244	140,668

6.12. **Flow Losses.** As discussed above, the Vista to Wadsworth HEC-RAS model includes flow losses in order to better reproduce the peak n-year discharge-frequency relationships which are discussed in Part III (Tables 4 and 5) of the Hydrology Report. The flow losses are thought to be due to infiltration losses, but may also be in response to other factors. In addition, the inflow from Long Valley Creek was also included in the model since this tributary represents a relatively large sub-watershed in which flows may combine with mainstem flows to drive peak flows at the gage near Tracy.

6.13. The groundwater interflow option of HEC-RAS was not used to explicitly compute infiltration losses. Instead, channel losses were estimated between Vista and Wadsworth and were included in the HEC-RAS modeling as a series of diversions. The diversions were located along approximately every 5000 feet of channel and consisted of a rating curve relating the channel flow to the diverted flow. The loss rates from the Hydrology documentation (Part III – Table 7) were used as a starting point and the values were adjusted, by trial and error, to a point in which the n-year computed peak discharges at the downstream gauging stations approximately matched the target n-year peak discharges.

6.14. Additionally, the contemporaneous n-year hydrographs for Long Valley Creek were shifted forward and/or backwards through time until the peak n-year flow at the gage near Tracy approximated the values listed in Part III (Tables 4 and 5) of the Hydrology Report. The resulting peak n-year discharges at the gauging stations are listed in **Table 25**.

Table 25. Computed and target peak n-year discharges at gauging stations for the without-project condition

Exceedence Frequency	Truckee R. near Tracy		Difference	
	Hydrology (cfs)	HEC-RAS (cfs)	(cfs)	(%)
20%	6,800	6,700	-100	-1.5%
10%	8,500	8,266	-234	-2.8%
5%	10,500	10,302	-198	-1.9%
2%	15,300	14,992	-308	-2.0%
1%	21,500	21,325	-175	-0.8%
Exceedence Frequency	Truckee R. below Derby		Difference	
	Hydrology (cfs)	HEC-RAS (cfs)	(cfs)	(%)
20%	6,800	6,711	-89	-1.3%
10%	8,200	8,094	-106	-1.3%
5%	9,800	9,901	101	1.0%
2%	14,200	14,334	134	0.9%
1%	19,900	20,240	340	1.7%
Exceedence Frequency	Truckee R. near Wadsworth		Difference	
	Hydrology (cfs)	HEC-RAS (cfs)	(cfs)	(%)
20%	7,000	6,706	-294	-4.2%
10%	8,000	7,925	-75	-0.9%
5%	9,800	9,570	-230	-2.3%
2%	14,100	13,776	-324	-2.3%
1%	19,600	19,137	-463	-2.4%
Exceedence Frequency	Truckee R. near Nixon		Difference	
	Hydrology (cfs)	HEC-RAS (cfs)	(cfs)	(%)
20%	6800	6,671	-129	-1.9%
10%	7800	7,869	69	0.9%
5%	9,700	9,563	-137	-1.4%
2%	14,300	14,034	-266	-1.9%
1%	20,100	20,009	-91	-0.5%

6.15. With-Project Conditions. HEC-RAS modeling was conducted for the 1/50 Recommended Plan. The current versions of the with-project HEC-RAS models were modified to include the environmental mitigation segments and the removal of the Numana Dam (dam removal by others). The main focus of this modeling was to illustrate the impacts of the increase in peak flows (i.e., due to the Recommended Plan located in the Truckee Meadows) on this reach in terms of changes to the water surface profiles and the n-year floodplains.

6.16. Recommended Plan HEC-RAS Model. The latest versions of the with-project Vista to Wadsworth and Wadsworth to Pyramid Lake HEC-RAS models are shown in **Figure 31** and **Figure 32**, respectively. In general, these models were run using HEC-RAS version 4.1.0 for the Vista to Wadsworth modeling reach and version 3.1.3 for the Wadsworth to Pyramid Lake modeling reach. Version 3.1.3 was originally used to calibrate the Wadsworth to Pyramid Lake HEC-RAS model and it was determined that it was not worth migrating the model to the 4.1.0 platform considering that new calibration and verification efforts would be required. Documentation by WEST Consultants, Inc. for model construct and calibration efforts of the Wadsworth to Pyramid Lake model is maintained within the Hydraulic Analysis Section files.

6.17. Analysis and Documentation of the With-Project Condition. As discussed above, the focus of the HEC-RAS modeling in the Vista to Pyramid Lake reach was to illustrate the impacts of the with-project increase in peak flows on this reach as well as to show the impacts of the Meadows project on the water surface profiles and the n-year floodplains. Additionally, the results of the modeling were used as input to a physical takings analysis conducted by SPK's Office of Counsel.

6.17.1. Top of Floodwall and Levee Elevations. There are no proposed floodwalls or levees in the Vista to Pyramid reach for the 1/50 chance Recommended Plan.

6.18. Hydraulic Analysis of the Recommended Plan

6.18.1. With-Project Levee Breach Parameters. There are no floodwalls or levees in this reach for the 1/50 chance Recommended Plan.

6.18.2. Water Surface Profiles. The water surface profile for the 1/50 chance annual exceedance (i.e., 2 percent chance or ~50-year) flood event on the with-project is shown in **Figures 33** through **37** for the Truckee River and in **Figure 38** for Long Valley Creek. In addition to the with-project water surface profiles, the figures also show the corresponding 1/50 chance without-project profile to illustrate the impact of the project on the water surface elevations throughout the lower Truckee River study area.

6.18.3. The project will slightly raise water surface elevations compared to the without-project condition. Specifically, the range of increases in stage for the 1/50 chance annual exceedance event are shown in **Table 26** for various reaches along the lower

Truckee River. The maximum increase in stage is located in the Eagle Pitcher environmental mitigation segment partly due to inclusion of the riffles and is a desired impact.

Table 26. Computed increases to the 1/50 chance annual exceedance water surface elevation

River Reach	Maximum Difference (ft)	Minimum Difference (ft)	Average Difference (ft)
UPRR at Lockwood to Long Valley Crk	0.50	0.25	0.38
Long Valley Creek to Tracy Gage	0.80	0.16	0.40
Tracy Gage to Derby Dam	0.70	0.20	0.45
Derby Dam to Wadsworth Gage	0.70	0.13	0.41
Wadsworth Gage to Marble Bluff Dam	0.49	0.15	0.34

6.18.4. The Recommended Plan will increase water surface elevations for the 1/100 chance event (1 percent chance or ~100-year). Plots of the water surface profiles for the 1/100 chance flood event on the with-Recommended Plan are included in **Figures 39** through **44**. In addition to the with-project water surface profiles, the figures also show the corresponding without-project profiles to illustrate the impact of the project on the water surface elevations throughout the lower Truckee River between Vista and Marble Bluff Dam.

6.18.5. Similar to the 1/50 chance annual exceedance event, the project will slightly raise water surface elevations compared to the without-project condition for the 1/100 chance annual exceedance event. Specifically, the ranges of increases in stage for the 1/100 chance annual exceedance event are shown in **Table 27** for various reaches along the lower Truckee River.

Table 27. Computed increases to the 1/100 chance annual exceedance water surface elevation

River Reach	Maximum Difference (ft)	Minimum Difference (ft)	Average Difference (ft)
UPRR at Lockwood to Long Valley Crk	0.71	0.27	0.52
Long Valley Creek to Tracy Gage	0.82	0.15	0.53
Tracy Gage to Derby Dam	0.90	0.32	0.68
Derby Dam to Wadsworth Gage	0.88	0.32	0.51
Wadsworth Gage to Marble Bluff Dam	0.69	0.18	0.47

6.19. Residual Floodplains. Residual floodplains for the 1/5, 1/10, 1/20, 1/50, and 1/100 chance annual exceedance events are shown in **Plates 23** through **52** for the 1/50 chance Recommended Plan.

6.19.1. Overall, flooding is about the same for both the with- and without-project conditions, with a slightly larger flood extent for the with-project condition. The most notable areas with an increase in flooding are those areas that tend to be flat which allows small increases in the water surface elevation to extend over a greater area. Additionally, a slight increase in the water surface elevation over the proposed

riffles in the hydraulic mitigation reaches may increase the floodplain extents a minor amount.

6.19.2. Interior Drainage. As discussed in paragraph 6.17.1, the proposed Recommended Plan does not include any proposed floodwalls or levees and therefore does not impact interior drainage.

7. SEDIMENT TRANSPORT, CHANNEL STABILITY, AND BANK PROTECTION

7.1. Sediment Transport and Channel Stability Analysis. A feasibility-level sediment budget and channel stability assessment was conducted by the Vicksburg District for the Truckee River Flood Control Project. The purpose of this assessment was to identify project-induced impacts to the river system as compared to the without-project conditions and focused on the 1/117 chance NED and 1/117 chance LPP projects. In general, the assessment was based on a sediment budget approach relying heavily on the SAM and HEC-6T[17] programs. It is envisioned that a more detailed HEC-6T type of analysis will be conducted on the Recommended Plan to verify this assessment during the PED phase of the project. Results and documentation of this assessment are presented in draft documentation report titled "Sediment Transport and Channel Stability Assessment of the Truckee River" (July 2008).

7.2. In general, the analysis compares the with-project average annual volumes of sediment transported to the without-project volumes on a reach by reach basis. Given that this analysis was performed explicitly for the 1/117 chance NED and 1/117 chance LPP projects, the results need to be interpreted for the 1/50 chance Recommended Plan[18].

7.3. This channel stability assessment was conducted to determine the anticipated impact of sedimentation on project performance and maintenance. The level of effort corresponds to that recommended for a "Stage 1 - Sediment Impact Assessment" as described in EM 1110-2-4000. The channel stability assessment is only a partial requirement of the Sediment Impact Assessment as described in the Engineering Manual.

7.4. Sediment transport and yield calculations were made using the HEC-6T and SAMwin computer programs. Model studies were not conducted and there was no attempt to calibrate results. Consequently, the results are useful primarily for comparison purposes – i.e. to compare plan and existing conditions and/or upstream and downstream reaches. There is considerable uncertainty associated with the magnitude of the calculated sediment transport and yields.

7.5. The transport of sediment is dependent on both the hydraulic parameters and bed gradation at each cross section. The non-uniform nature of the Truckee River cross sections was accounted for in the calculation of hydraulic parameters by using the HEC-6T program. However, the equally non-uniform nature of the bed material gradation could only be represented by average armor and sub-surface bed gradations. Consequently, calculated sediment transport rates have considerable longitudinal variability that may or may not be representative of actual conditions in the river. This variability was reduced somewhat in the channel stability assessment by simulating a designated time of steady-state flow through HEC-6T, which allowed some adjustments in the bed gradation. The uncertainty associated with the bed gradations is

[17] In this analysis, the HEC-6T model was run with very short simulation durations sufficient to compute sediment transport capacities, but not to change the bed geometry significantly.
[18] Interpreting the results to the 1/50 chance-sized project is beyond the scope of work under the reset plan.

another reason that comparisons between calculated yields in the study sub-reaches can be made only in a general sense. Comparisons between existing and plan conditions can be made with greater confidence. Refer to "Sediment Transport and Channel Stability Assessment of the Truckee River" (July 2008) for detailed results of this analysis.

7.6. Analysis for Bank Protection and Local Scour. In 2008, a feasibility-level analysis was conducted by HDR under contract to the Corps to address bank and bridge pier protection features.[19] The geographic extent of this analysis was from downtown Reno to Marble Bluff Dam. Specifically, this effort consisted of the following: 1) quantify impacts of the project on the velocity and shear in the channel along pre-defined critical infrastructure segments as well as other segments which conceivably could be sediment sources, 2) develop hydraulic-based designs which would provide bank protection (i.e., both riprap as well as biotechnical designs), 3) perform an analysis to identify project induced bridge scour, 4) develop hydraulic-based countermeasures to mitigate for project induced bridge scour, 5) estimate the quantities and prepare the civil engineering details and plates, and 6) develop the M-CACES cost estimates. This analysis was performed for increased downstream flows associated with the 1 in 117 AEP NED and LPP projects. The increase in flow could exceed 4000 cfs for the 1% AEP event for both projects.

7.7. A precursor to the 2008 HDR analysis discussed above was a project impact analysis which provided an initial assessment of the potential bank erosion sites, resulting from project induced erosion, in the entire study area. This analysis was also conducted by HDR under contract to Washoe County and identified the segments for which noticeable impacts on velocity and/or shear could be identified.[20]

7.8. Similar to the NED and LPP projects, the Recommended Plan in the Truckee Meadows will also increase outflows into the Truckee River canyon. Specifically, during a 1% AEP event, the peak outflow from the Truckee Meadows will increase from about 20,640 to 22,160 cfs, or by about 1520 cfs for the Recommended Plan. The impact of the project on increases to downstream flows is illustrated **Figure 45** for a range of n-year events. Since the current plan has significantly reduced outflows from the Truckee Meadows, a re-analysis of the project-induced impacts on erosion has been performed to assess which mitigation measures, if any, are required.

7.9. The purpose of this analysis is to re-evaluate the estimated impacts of the Recommended Plan on critical infrastructure from induced bank erosion and bridge scour beyond the future without-project conditions. The following is an outline of the

[19] Refer to Truckee River Flood Control Project, Bank, Bed and Pier Scour Analysis, Final Letter Report, by HDR, October 2008. This reference includes GIS-based mapping of all of the bank erosion segments as well as field notes from the field investigations and detailed data sheets on all of the bridges in the study reaches.

[20] Refer to Letter Report – Truckee River Flood Project Impact Analysis, by HDR, May 2008. This reference includes GIS –based mapping of all of the sites where project induced impacts (velocity and/or shear) were identified throughout the study area. Additionally, the methodology for quantifying project induced impacts is presented in this report.

approach used to assess erosion impacts of the currently proposed project. The analysis is based on the impacts associated with the 1% AEP event. This event produces the greatest stress (or impact) on the river system compared to other n-year events reasonably expected during the project life and represents a reasonable worst case scenario. As illustrated in **Figure 45**, the impacts on the discharge are minimal below the 5% AEP event and above the 0.5% AEP event.

7.10. Fundamental assumptions in this assessment include: 1) conclusions drawn from this assessment are sufficient for feasibility-level planning activities and the conclusions will be verified in Preconstruction Engineering and Design (PED) and that monitoring and detailed site investigations of the various erosion segments and/or bridge sites may be conducted to develop a more detailed site by site assessment; and 2) if project induced bank erosion mitigation and/or bridge scour countermeasures are identified as being required in PED, it is unlikely that the associated cost increases would be significant compared to the total project cost or that plan selection would be affected.

7.11. **Bank Erosion.** The following steps were used to evaluate the need for bank erosion protection throughout the Truckee River canyon reach for the Recommended Plan.

- Identify bank erosion segments which potentially pose a problem for critical infrastructure (e.g., along the outside of bend and/or where channel is aimed at Interstate 80, local roads, the UPRR, or the Truckee Canal). [*about 40 sites were initially identified – refer to the HDR documentation discussed in footnote 19*]

- Of these, identify segments where there is a noticeable increase in channel velocity and/or shear for the 1% AEP event between the without- and with-project conditions (refer to HDR documentation discussed in footnote 20). [*27 segments of the original 40 fit this criteria*]

- Further eliminate segments where there is currently no erosion or existing bank protection is working to control/minimize bank erosion. This assessment was made by reviewing the field notes presented in the HDR documentation discussed in footnote 19. The retained segments therefore potentially impact existing critical infrastructure and bank erosion is actively occurring. [*this reduced the inventory to 5 segments*].

- Review each segment to determine: 1) if there appears to be an economic justification for including bank protection, or 2) if the critical infrastructure is on

the verge of falling into the river in the near future and thus represents a life safety issue.

- Although erosion is active at the five sites, none of the segments appear to meet the criteria in the above bullet. At three of the sites (i.e., RL-5, RL-26, and RL-51), there is sufficient distance between the infrastructure and the river such that there is sufficient time for O&M activities to be implemented, during the life of the project, to prevent erosion from failing the infrastructure. At the remaining two sites (i.e., RL-35 and -36), the bankline adjacent to the UPRR either has existing bank protection, in the form of large riprap, and/or the UPRR track is located on erosion resistant bedrock. There are currently no sites identified which appear to be on the verge of failing in the near future based on floods which may reasonably be expected to occur.

- Based on this analysis, there are no bank erosion sites which should be included in the Recommended Plan in the lower Truckee River between Vista and Pyramid Lake (i.e., downstream of the flood reduction features in the Truckee Meadows). This conclusion will be verified in PED and the with-project condition could include monitoring and detailed site investigations of the various erosion segments to assess the impact of the project on bank erosion.

7.12. Bridge Scour. The following steps were used to evaluate the need for scour protection at bridges within the Truckee River canyon reach. Basic assumptions used in this analysis include the general knowledge that most of the study area is underlain with bedrock and it is therefore assumed that all of the bridges and bridge abutments are point bearing structures. In the PED phase of the study, this assumption will require confirmation via review of as-built documentation and/or subsurface investigations.

- Identify all bridges located in the lower Truckee River between Vista and Pyramid Lake (i.e., downstream of the flood reduction features in the Truckee Meadows). Please refer to the HDR documentation discussed in footnote 19. [*total of 18 road, freeway, and railroad bridges*]

- Eliminate bridges from the inventory which already have scour countermeasures or countermeasures will be constructed in the near future based on schedules provided by NDOT.[21] Additional investigation and review of NDOT's scour

[21] A fundamental assumption in this analysis is that if an existing bridge already has scour protection, then it should be sufficient for the slightly increased with-project flows. Given time limitations, we didn't know what criteria (e.g., n-year discharge, debris conditions, etc.) were used to design the existing (or soon to be constructed) erosion protection at some of the bridges. Nonetheless, the analysis is sufficient for a feasibility "go or no go" determination

countermeasures will be conducted in PED to confirm this assumption. [*reduction of 5 bridges from the inventory*]

- Compute the contraction, pier, and abutment scour at each bridge using HEC-RAS for the 1% AEP event for both the without- and with-project conditions. Review the impacts of the project on induced scour at each bridge and determine if the impacts are significant enough to warrant inclusion of scour countermeasures, on a bridge by bridge basis, in the Recommended Plan between Vista and Pyramid Lake. Ignore long-term scour or aggradation as these values should more or less be the same under with- and without-project conditions.

- The potential impacts or increases in computed scour range from 0 to 4.1 feet at the thirteen bridges without existing or planned scour countermeasures. Project impacts for each type of scour are listed below in **Table 28**. The largest impacts are on the abutment scour values which range from 0 to 36.1 feet. In general, it appears that most of the non-zero abutment scour values appear to be unrealistically high given the relatively coarse gradation of the bed material[22]. Furthermore, some researchers have found that actual abutment scour depths are generally within about 25 to 30% of the best fit relationship. Thus, the increases in abutment scour computed for all but one bridge fall within this range of error, which indicates that the computed project-induced impacts (on abutment scour) are well within the noise of the scour computations.

Table 28. Computed impacts on bridge scour

Scour Type	Ranges of Computed Scour Values (ft)[23]			Project Impacts (ft)[24]	
	Minimum	Maximum	Average[25]	Minimum	Maximum
Contraction	0.0	7.0	2.6	0.0	0.9
Pier	4.1	16.7	9.0	0.1	0.3
Abutment	0.0	36.1	20.4	0.0	4.1

- As illustrated by the Project Impacts column in **Table 28**, the proposed project located in the Truckee Meadows induces very limited impacts on bridge scour at

on a bridge by bridge basis as to whether or not project-induced impacts on erosion/scour clearly justify project features on the basis on economics and/or life safety issues.

[22] It is understood that the bed material gradation is not a parameter in Froehlich's abutment scour equation. The only other approach available in HEC-RAS is the HIRE abutment scour equation which is was developed from Mississippi River data and is not likely applicable to the Truckee River.

[23] The computed scour values are based on both the with- and without-project conditions.

[24] The Project Impacts are equal to the with-project scour depth minus the without-project scour depth for each scour type.

[25] Zero values were not used to compute the average values.

the bridges located downstream of the project. Based on engineering judgment, these limited impacts do not warrant inclusion of scour countermeasures as part of the Recommended Plan at any of the existing bridges between Vista and Pyramid Lake. The need for scour countermeasures for the existing/without-project condition should be considered an O&M requirement.

- As stated above, this analysis is predicated on the assumption that all of the bridge piers and abutments are point bearing structures. This assumption will be verified in PED and the with-project condition could include monitoring of the various structures to assess the impact of the project on bridge scour.

7.13. Summary. A feasibility-level assessment was conducted to determine if bank erosion mitigation and bridge scour countermeasures due to project-induced impacts (i.e., increase in the 1% AEP peak discharge) were required. The findings of this assessment indicate that there are no bank erosion sites which should be included in the Recommended Plan in the lower Truckee River between Vista and Pyramid Lake (i.e., downstream of the flood reduction features in the Truckee Meadows). Additionally, the proposed project located in the Truckee Meadows induces very limited impacts on bridge scour at the bridges located downstream of the project. Based on engineering judgment, these limited impacts do not warrant inclusion of scour countermeasures as part of the Recommended Plan at any of the existing bridges between Vista and Pyramid Lake. The need for scour countermeasures for the existing/without-project condition should be considered an O&M requirement.

7.14. Limitations and Uncertainties of Erosion/Scour Analyses. A basic problem with the project–induced bank erosion assessment is that there is currently no deterministic method for computing the increase in erosion due to increased flow. For example, assuming that a bankline is currently eroding for the without-project condition, determination of the additional amount of project-induced bank erosion over the life of the project is problematic. And, if this impact could be reasonably estimated, how do we assign project costs for mitigating just the project induced increment of erosion? In the 2008 analysis, we proceeded by assuming that the project would cover the total cost of the erosion mitigation feature since it is usually not possible to construct just the last increment of a bank protection feature.

7.15. Some of the computational limitations in the assessment pertain to use of the various bridge scour equations which were originally developed for streams with bed material somewhat finer than that of the Truckee River. This leads to the inherent uncertainties in the scour computations. There is less uncertainty when the equations

are used to compare order of magnitude results between the with- and without-project conditions, but the actual values should be viewed for reasonableness.

7.16. There is overall uncertainty regarding the geology of the banks, the material underlying the alluvial bed sediments as well as underlying any of the bridge abutments. Comprehensive subsurface investigations have not been conducted and it is unknown how prevalent bedrock controls exist to limit bank erosion/migration. Furthermore, our assumption regarding that most of the bridges and bridge abutments are point bearing structures requires confirmation.

7.17. Overall, the assessment was conducted to support a planning-level feasibility study wherein slight deviations between our assumptions and reality (i.e., as identified in PED), if they occur, should result in relatively insignificant increases in cost (i.e., compared to the total project cost) and these changes would not invalidate plan selection.

8. REFERENCES

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Hydraulic Design Appendix from F4 Conference, by Corps of Engineers, Sacramento District (January 2005)

Hydraulic Modeling Assumptions, Methods, and Results, Truckee Meadows Flood Control Project, Washoe and Storey Counties, Nevada, WEST (April 2011)

Hydrology Report, Attachment A to the Truckee Meadows GRR Basis of Design Report (2012)

Letter Report – Truckee River Flood Project Impact Analysis, by HDR (May 2008)

Sediment Stability Assessment, Truckee River Flood Control Project, by Copeland (July 2008)

Truckee River Flood Control Project, Bank, Bed and Pier Scour Analysis, Final Letter Report, by HDR (October 2008)

Attachment B
Hydraulic Design
Truckee Meadows Flood Control Project
Reno, Nevada

Figures

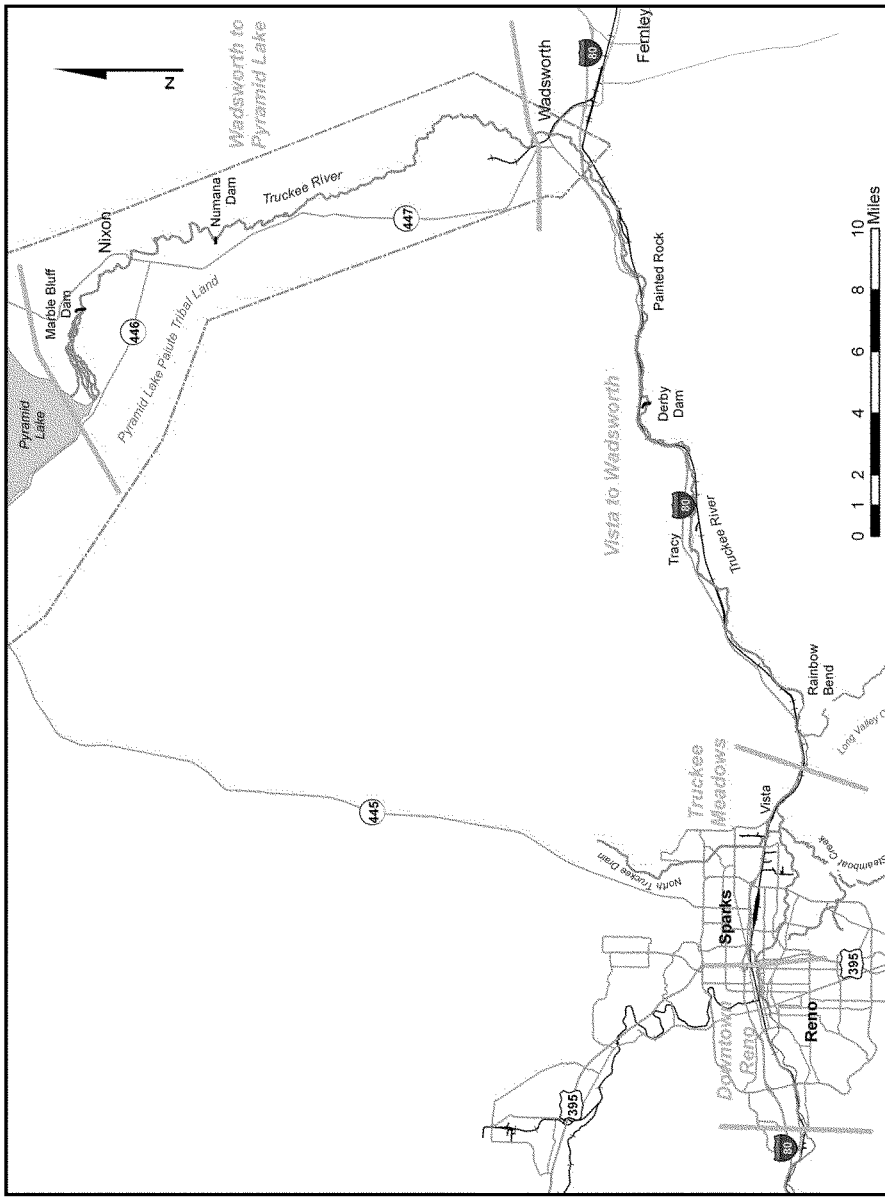


Figure 1. General study area and modeling reaches

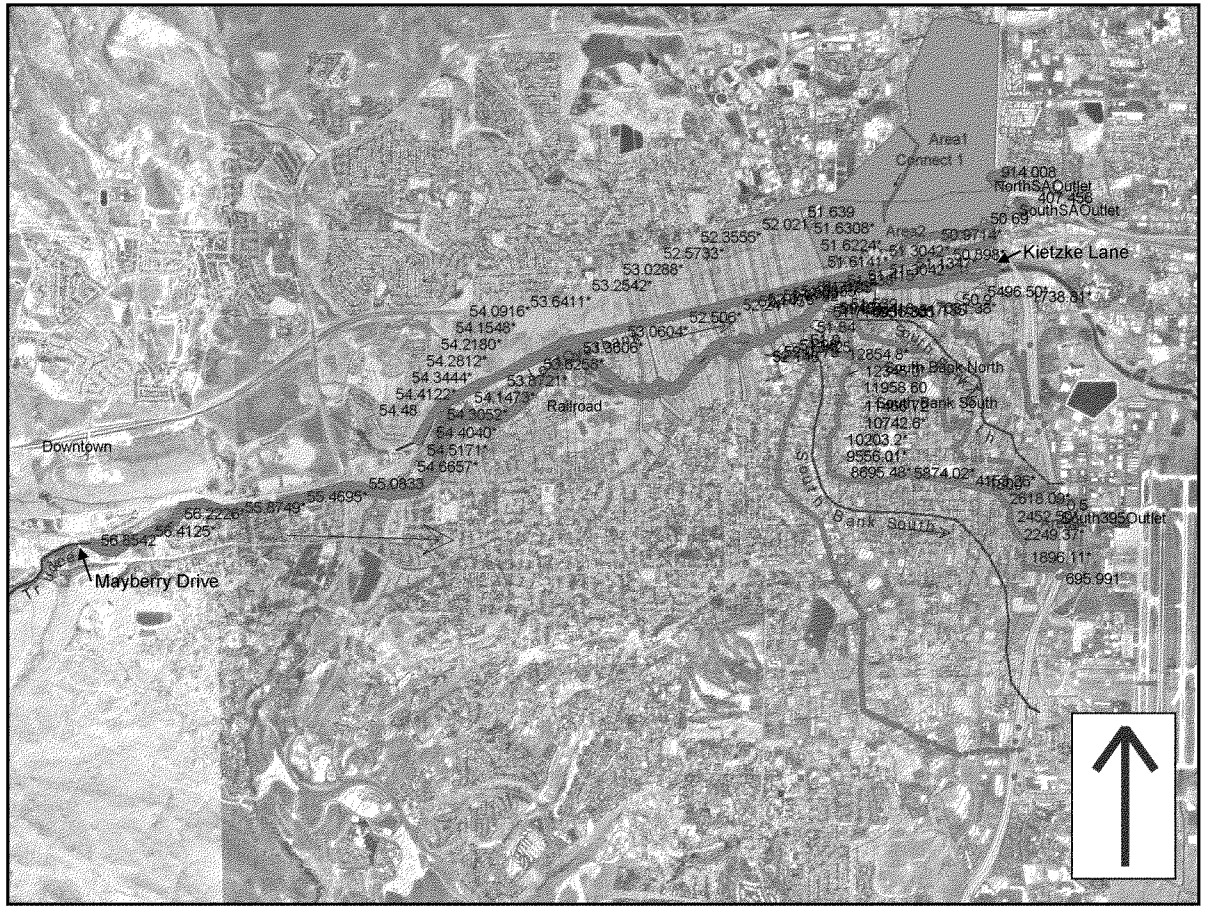


Figure 2. Downtown Reno HEC-RAS schematic and model extent

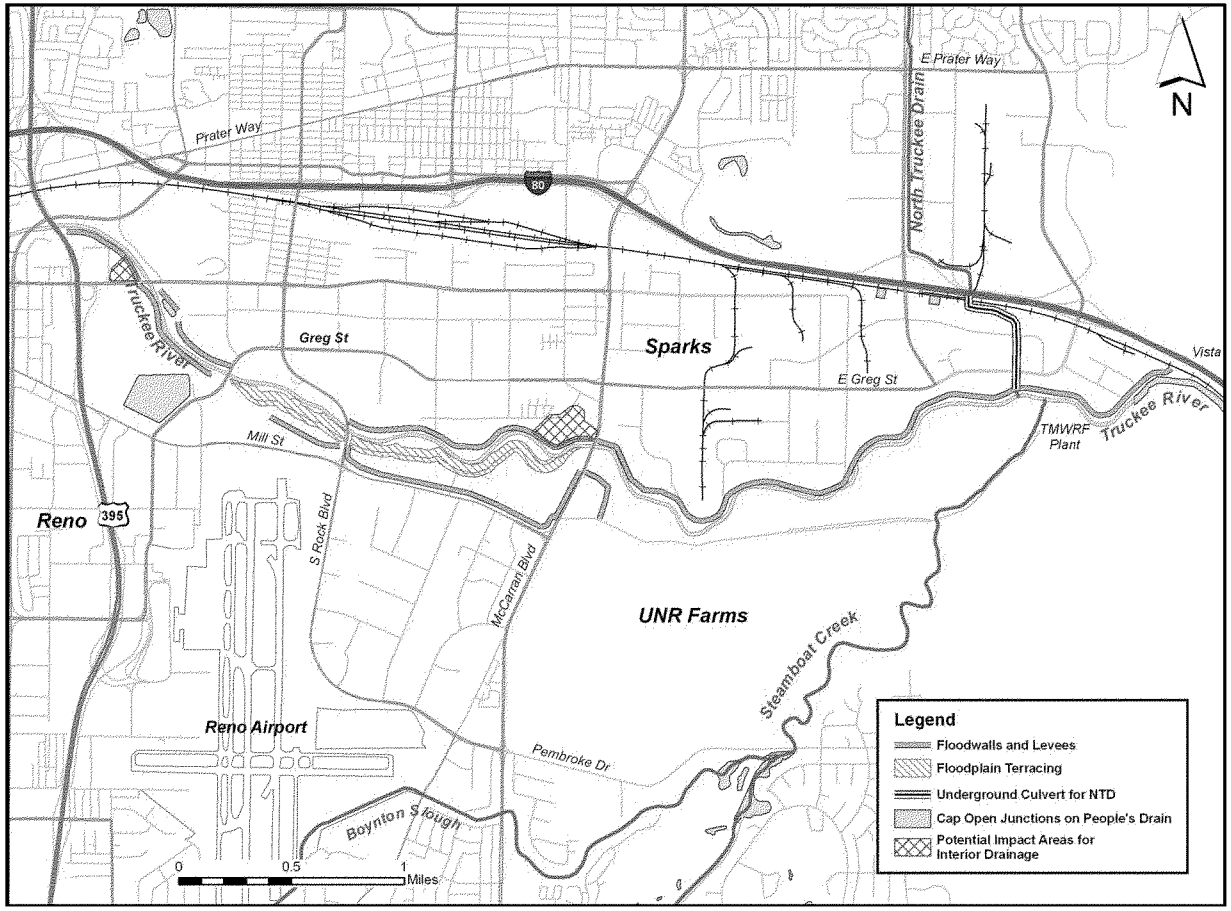


Figure 3. Overview of Recommended Plan with-project features in the Truckee Meadows study area

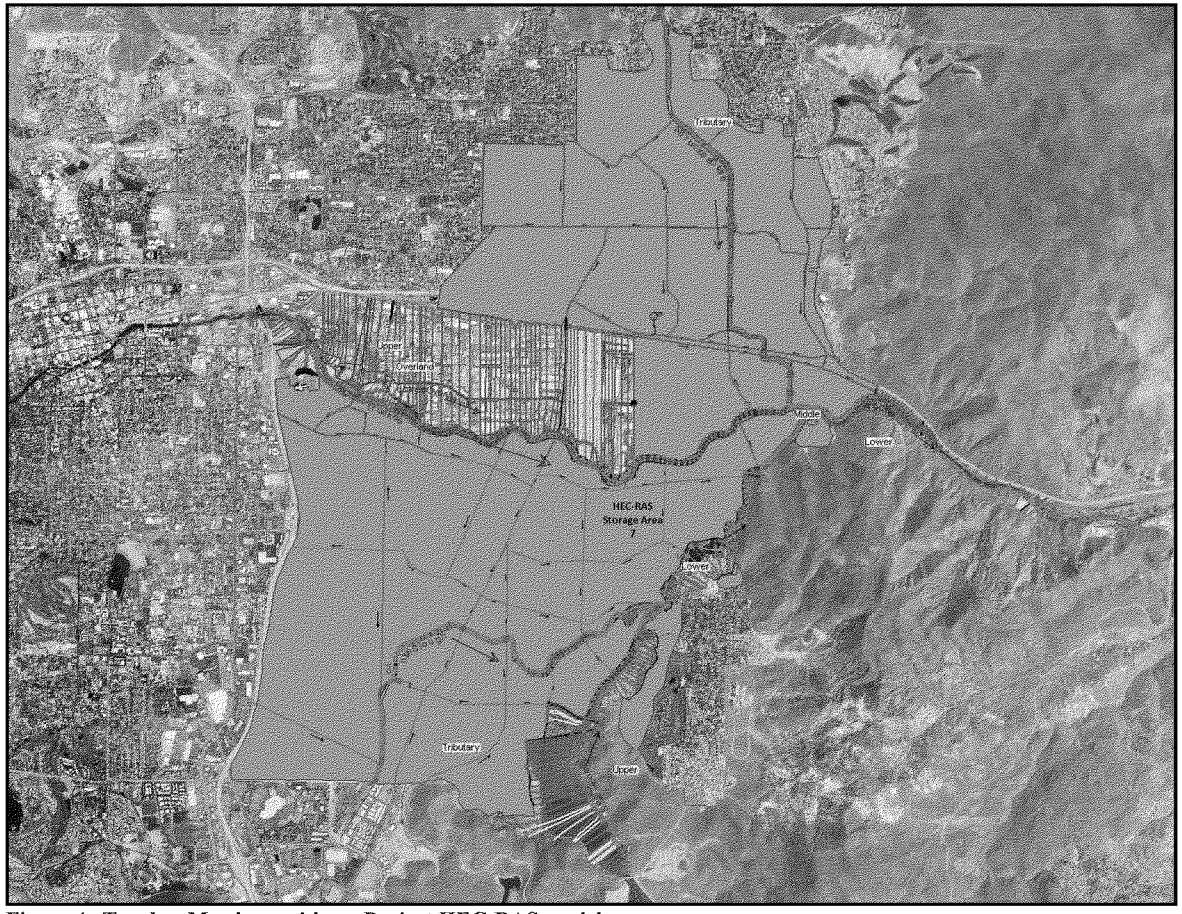


Figure 4. Truckee Meadows without-Project HEC-RAS model

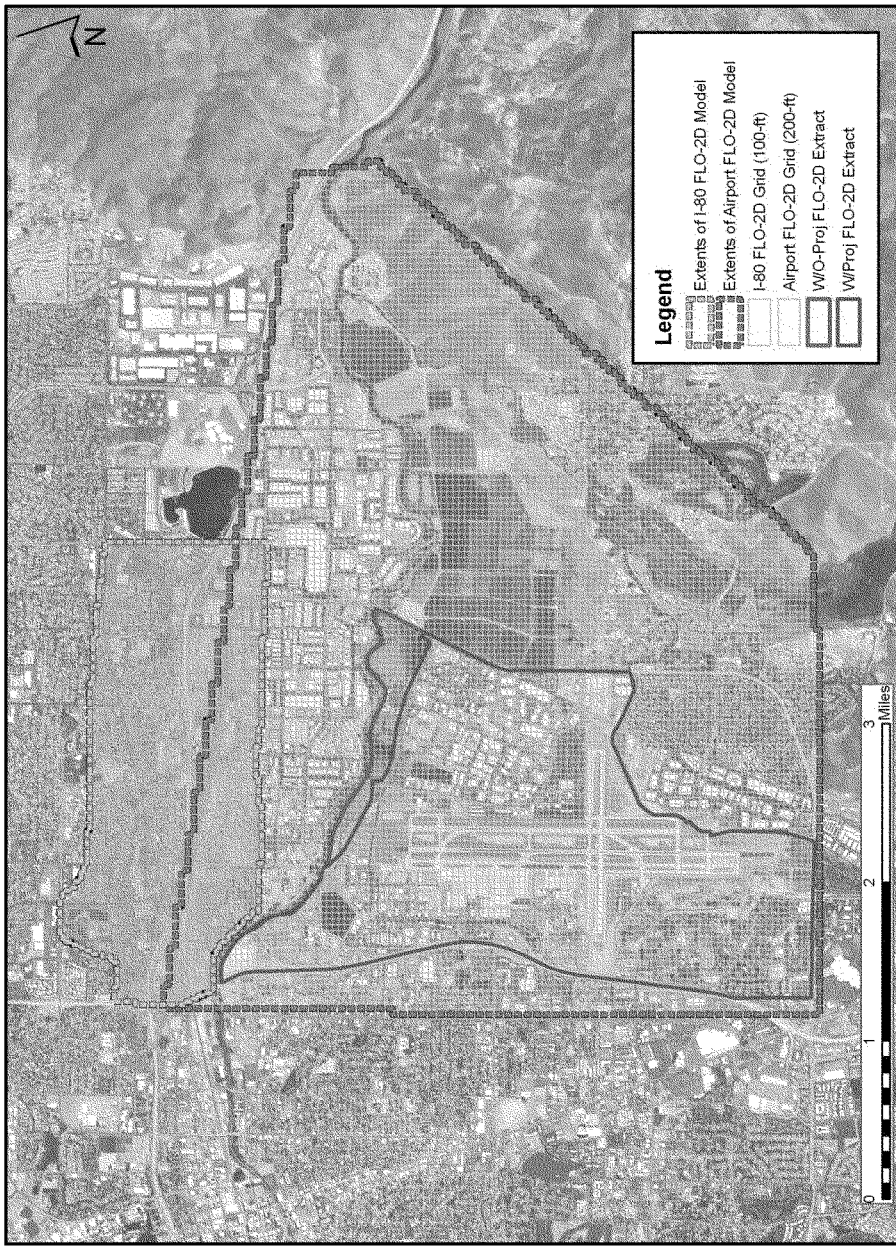


Figure 5. FLO-2D models in the Truckee Meadows

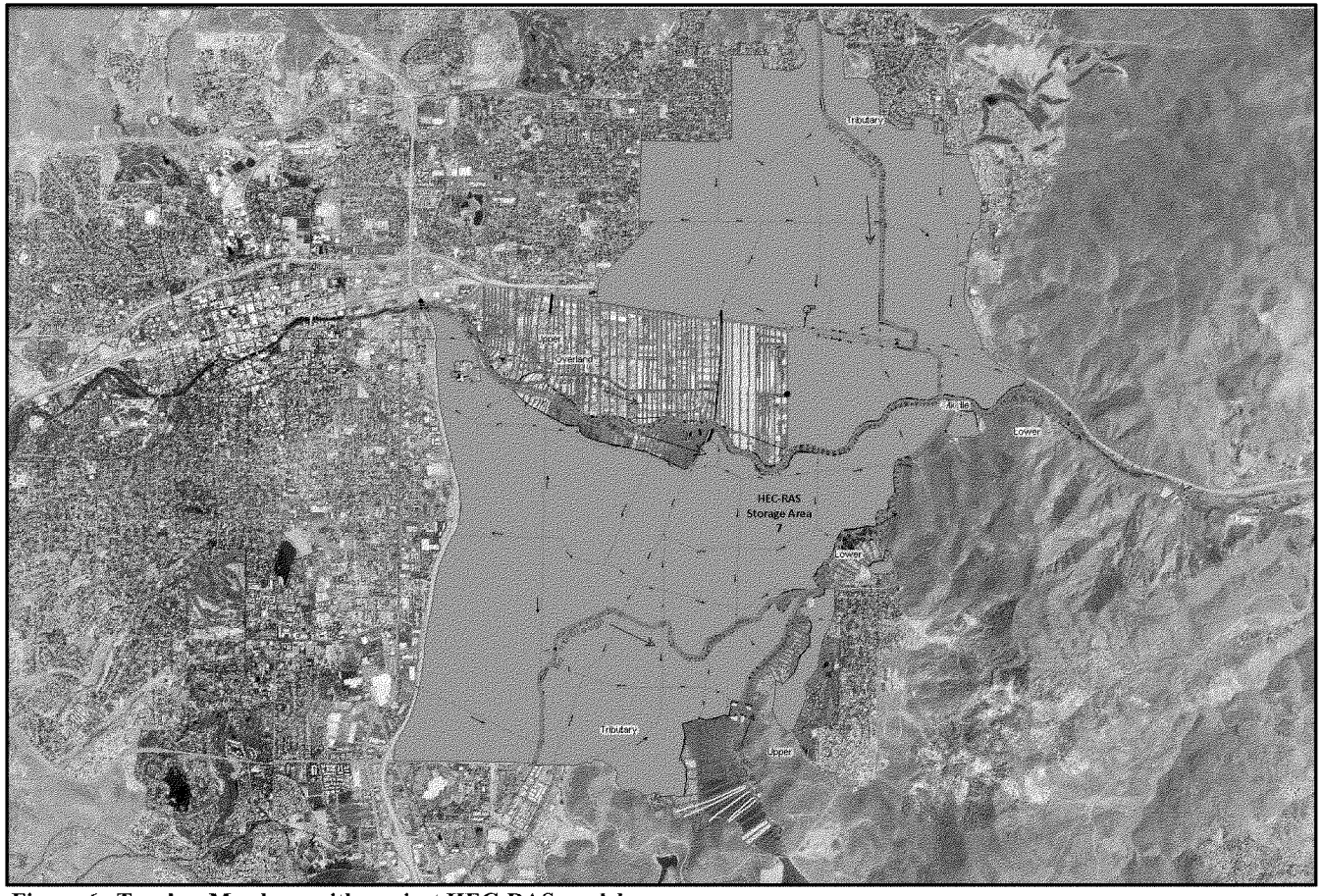
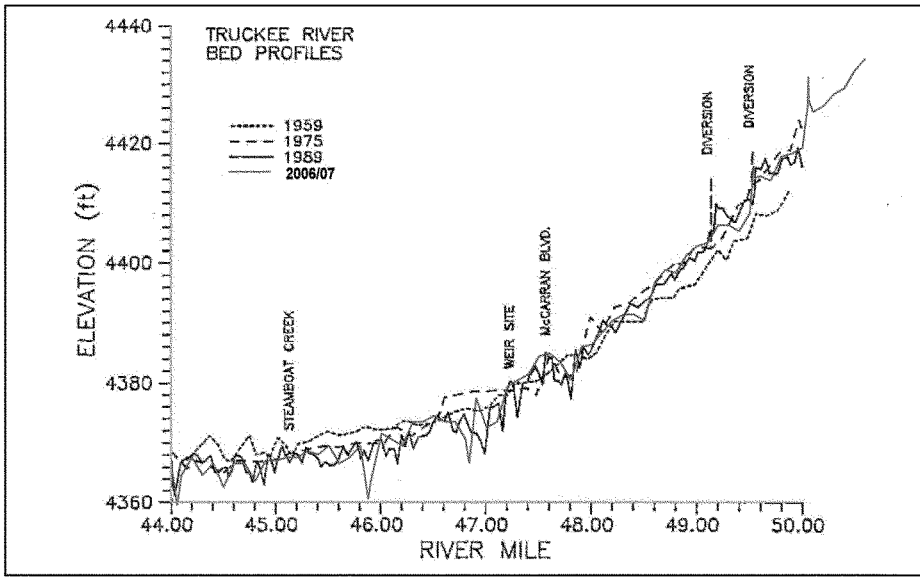


Figure 6. Truckee Meadows with-project HEC-RAS model



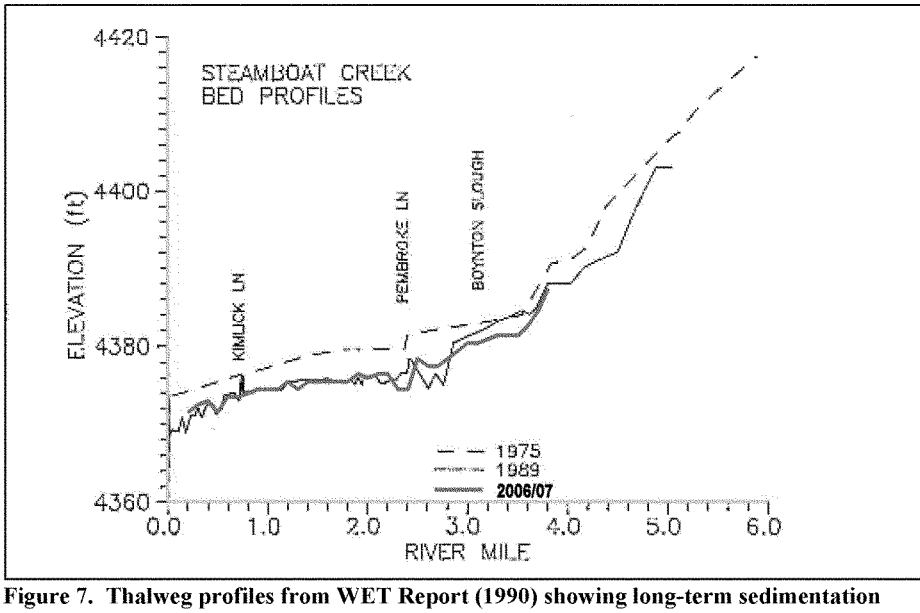


Figure 7. Thalweg profiles from WET Report (1990) showing long-term sedimentation trends

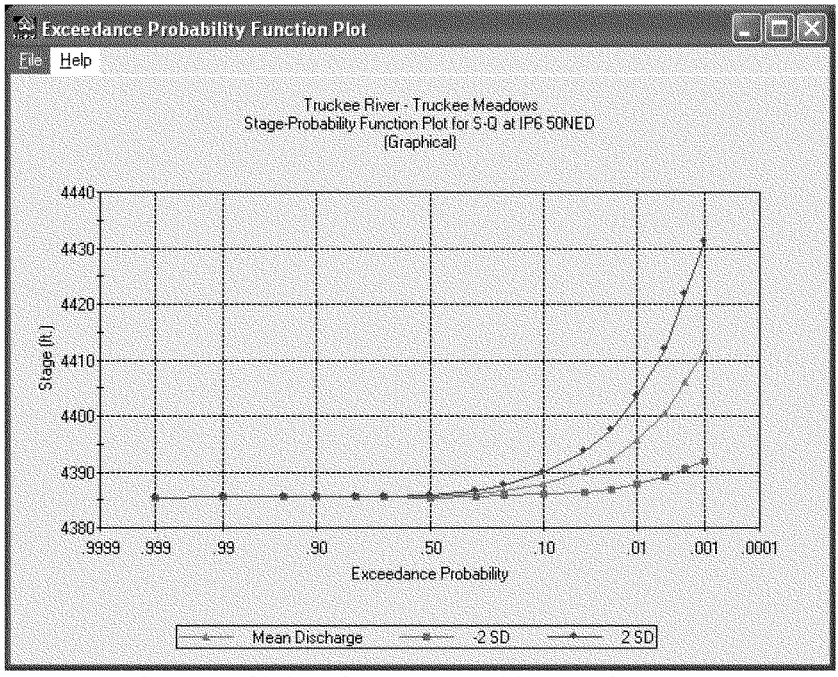


Figure 8. Sample of initial Stage-Probability plot for Index Point No. 6

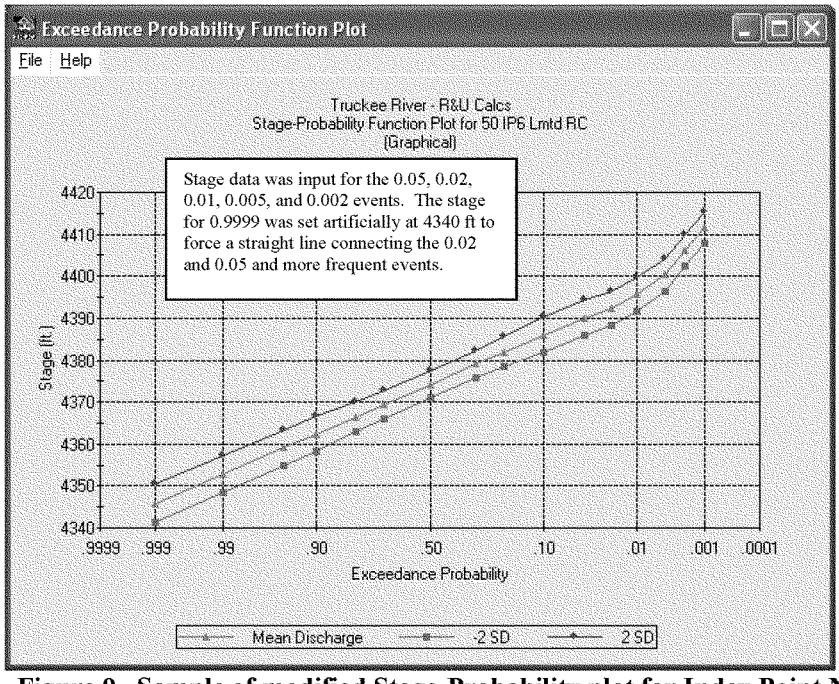


Figure 9. Sample of modified Stage-Probability plot for Index Point No. 6

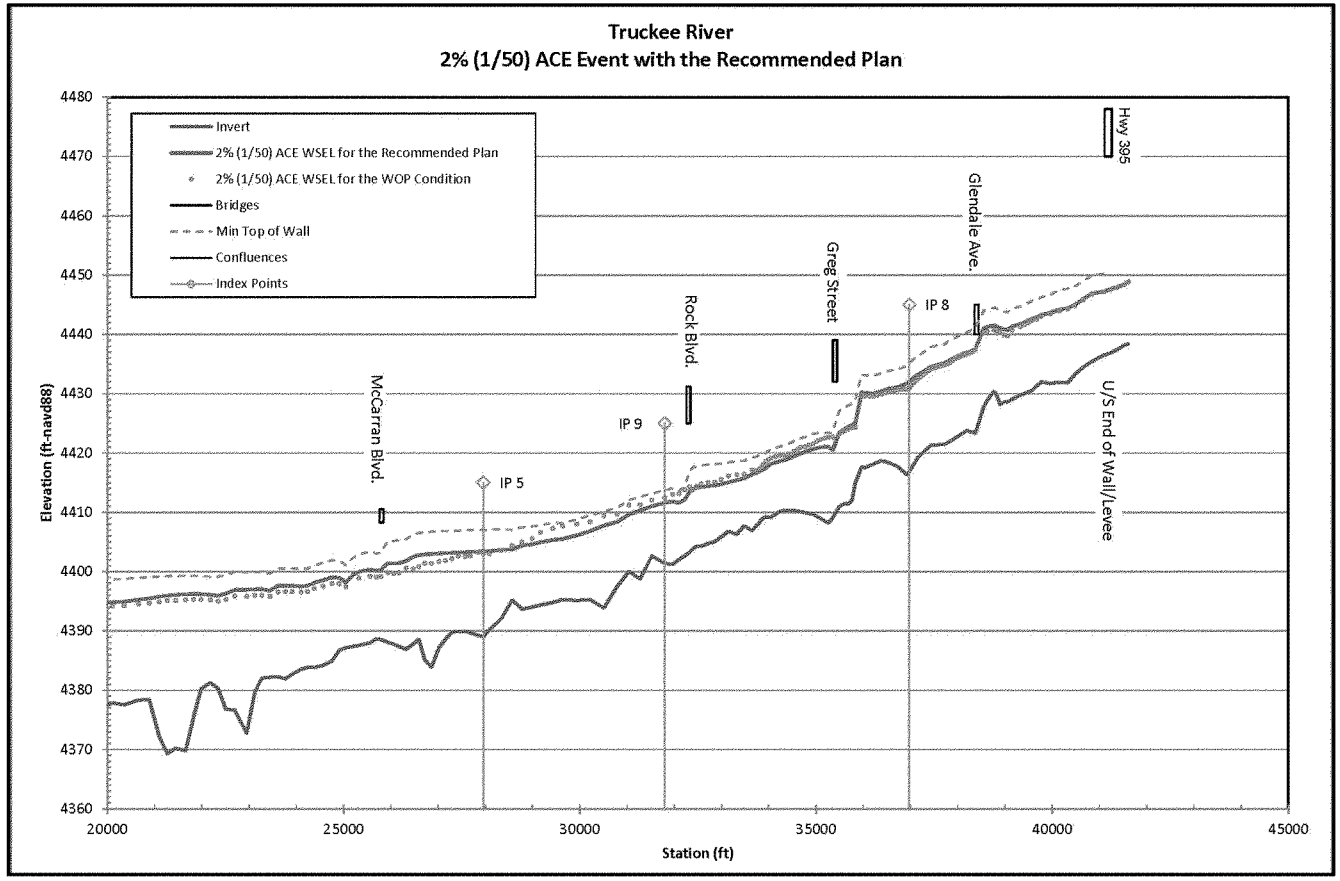


Figure 10. HEC-RAS water surface profiles for the Truckee River, between station 200+00 and Highway 395, for the 2% (1/50) ACE event in the Truckee Meadows reach with the Recommended Plan in place

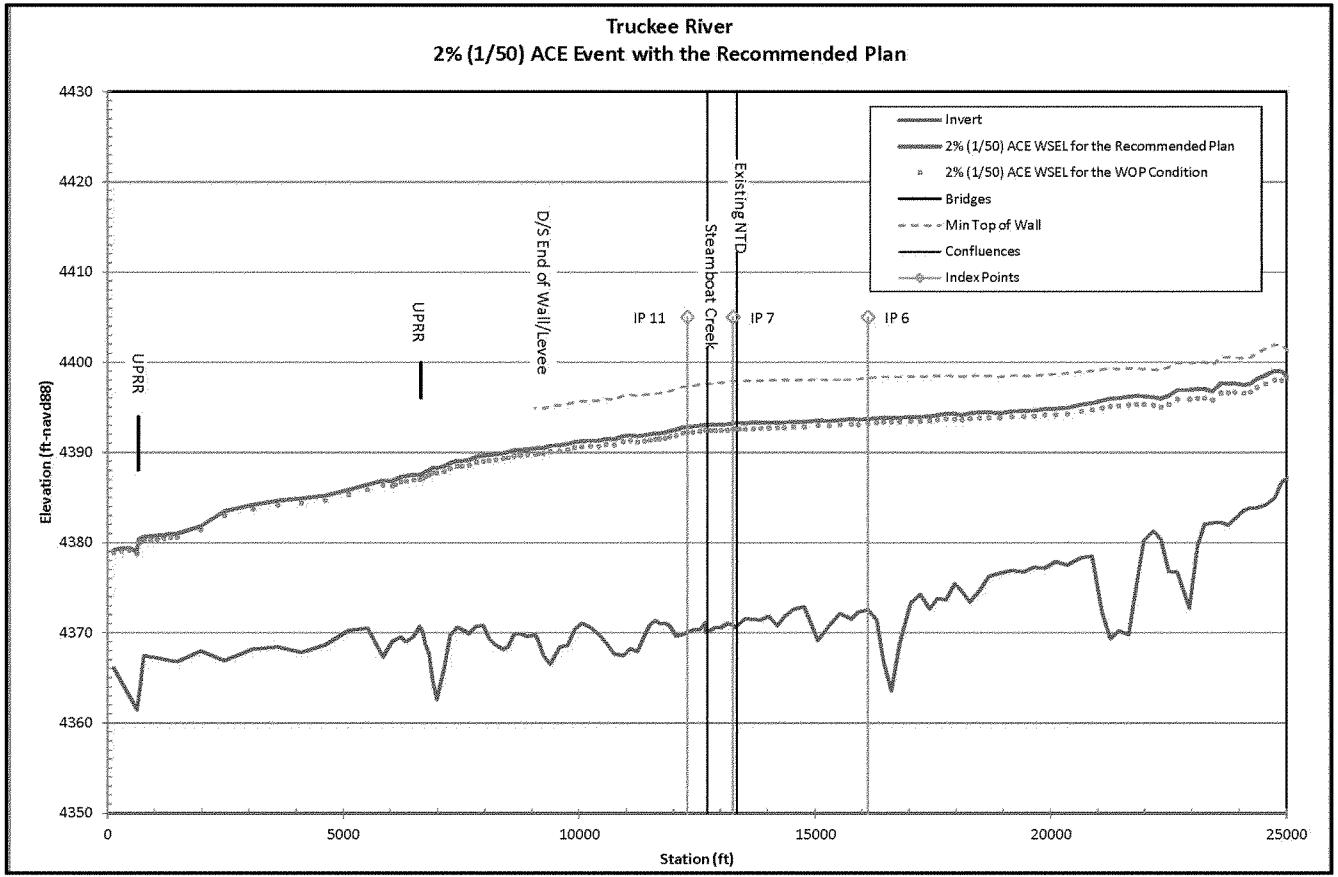


Figure 11. HEC-RAS water surface profiles for the Truckee River, between stations 0+00 and 250+00, for the 2% (1/50) ACE event in the Truckee Meadows reach with the Recommended Plan in place

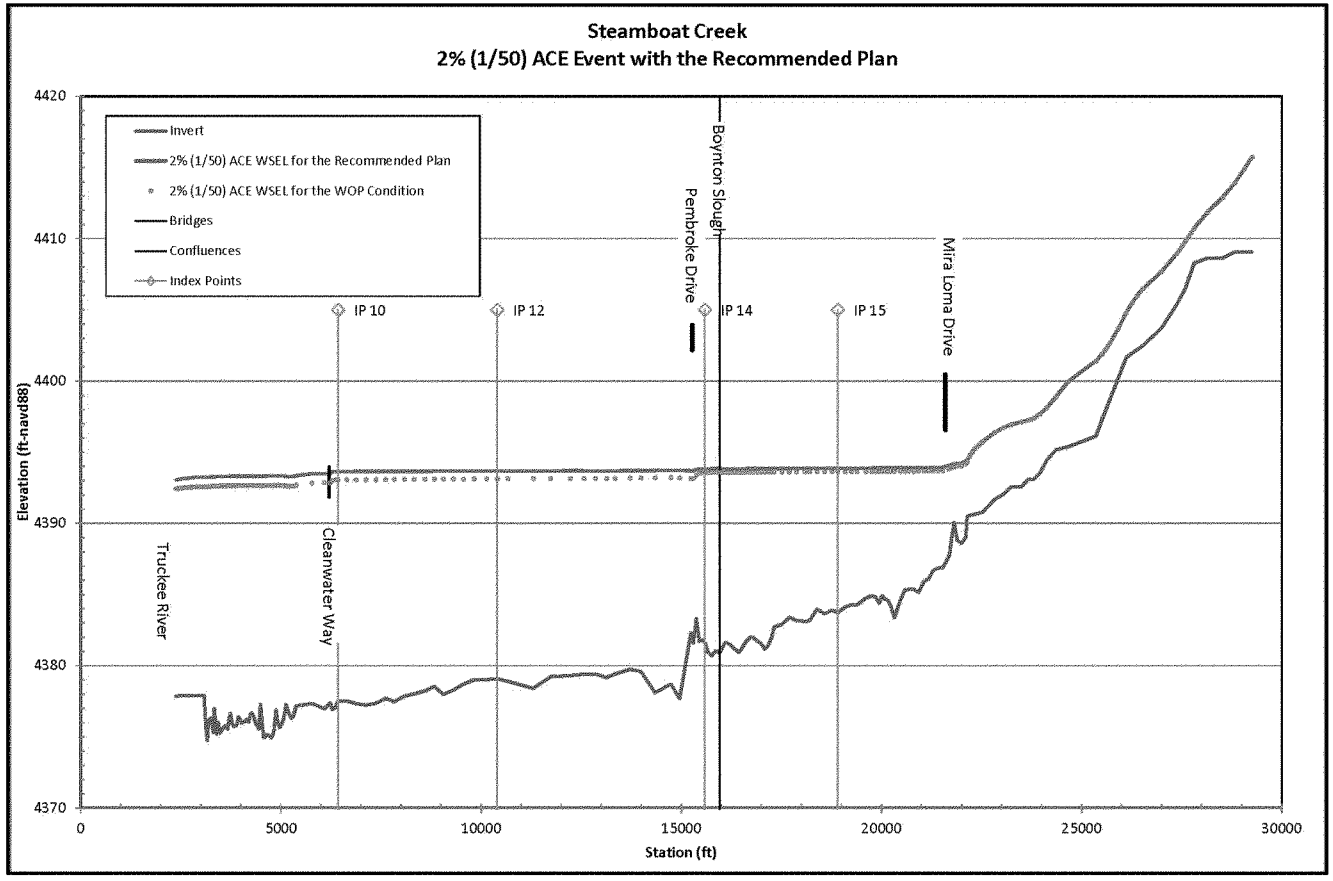


Figure 12. HEC-RAS water surface profiles for Steamboat Creek, between HEC-RAS station 0+00 and Huffaker Narrows, for the 2% (1/50) ACE event in the Truckee Meadows reach with the Recommended Plan in place

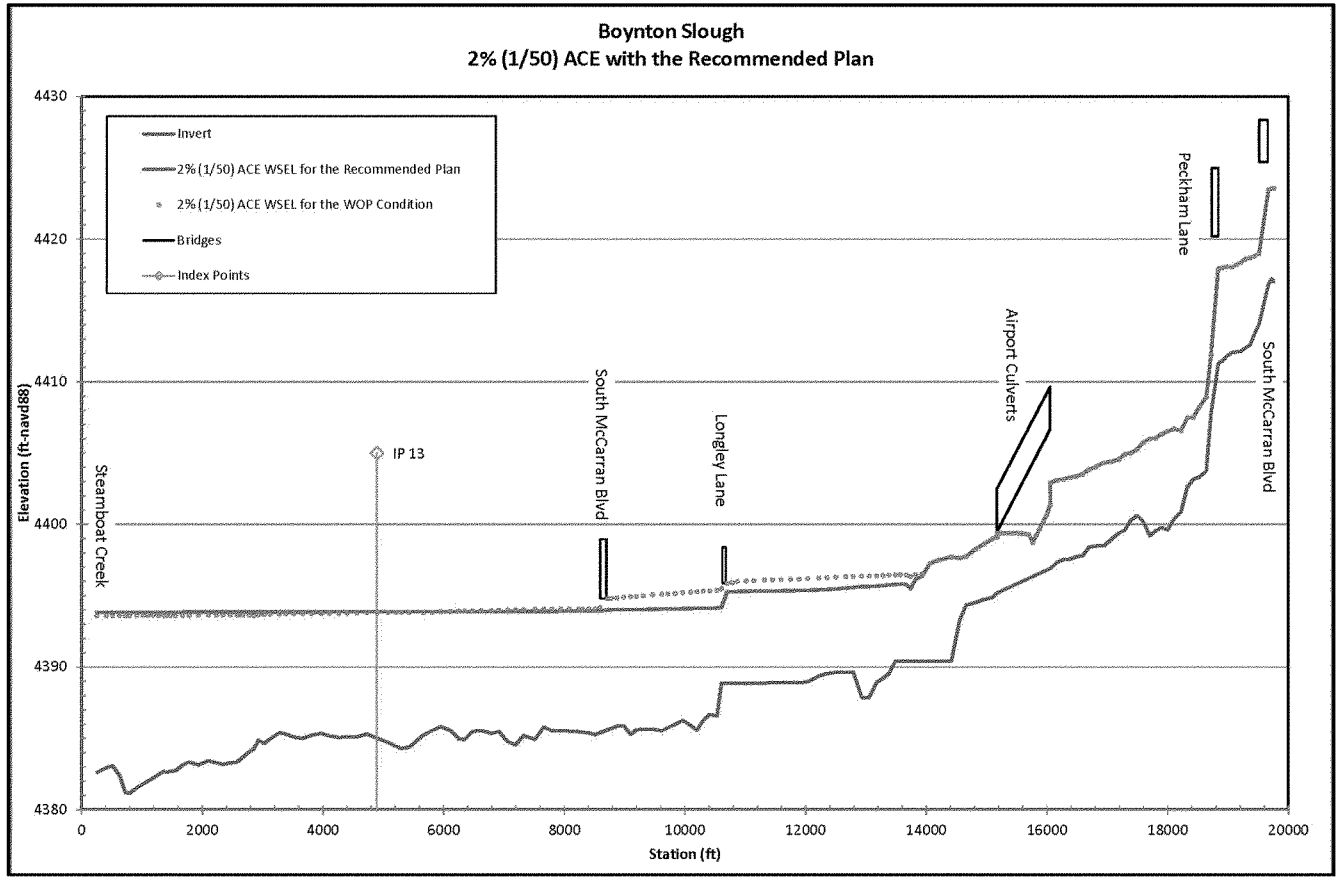


Figure 13. HEC-RAS water surface profiles for Boynton Slough, between HEC-RAS station 0+00 and South McCarran Boulevard, for the 2% (1/50) ACE event in the Truckee Meadows reach with the Recommended Plan in place

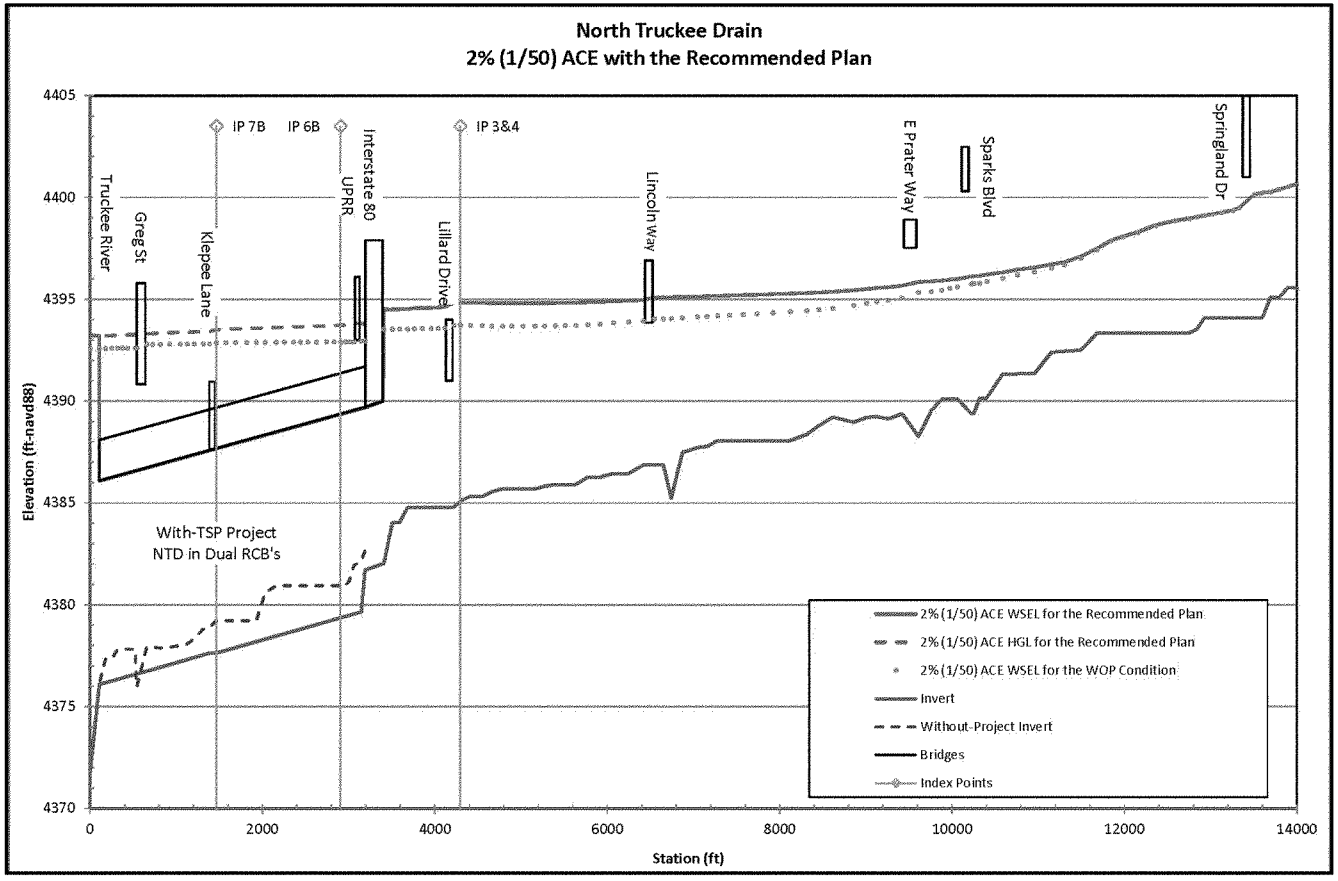


Figure 14. HEC-RAS water surface profiles for the North Truckee Drain, between the Truckee River and Springland Drive, for the 2% (1/50) ACE event in the Truckee Meadows reach with the Recommended Plan in place

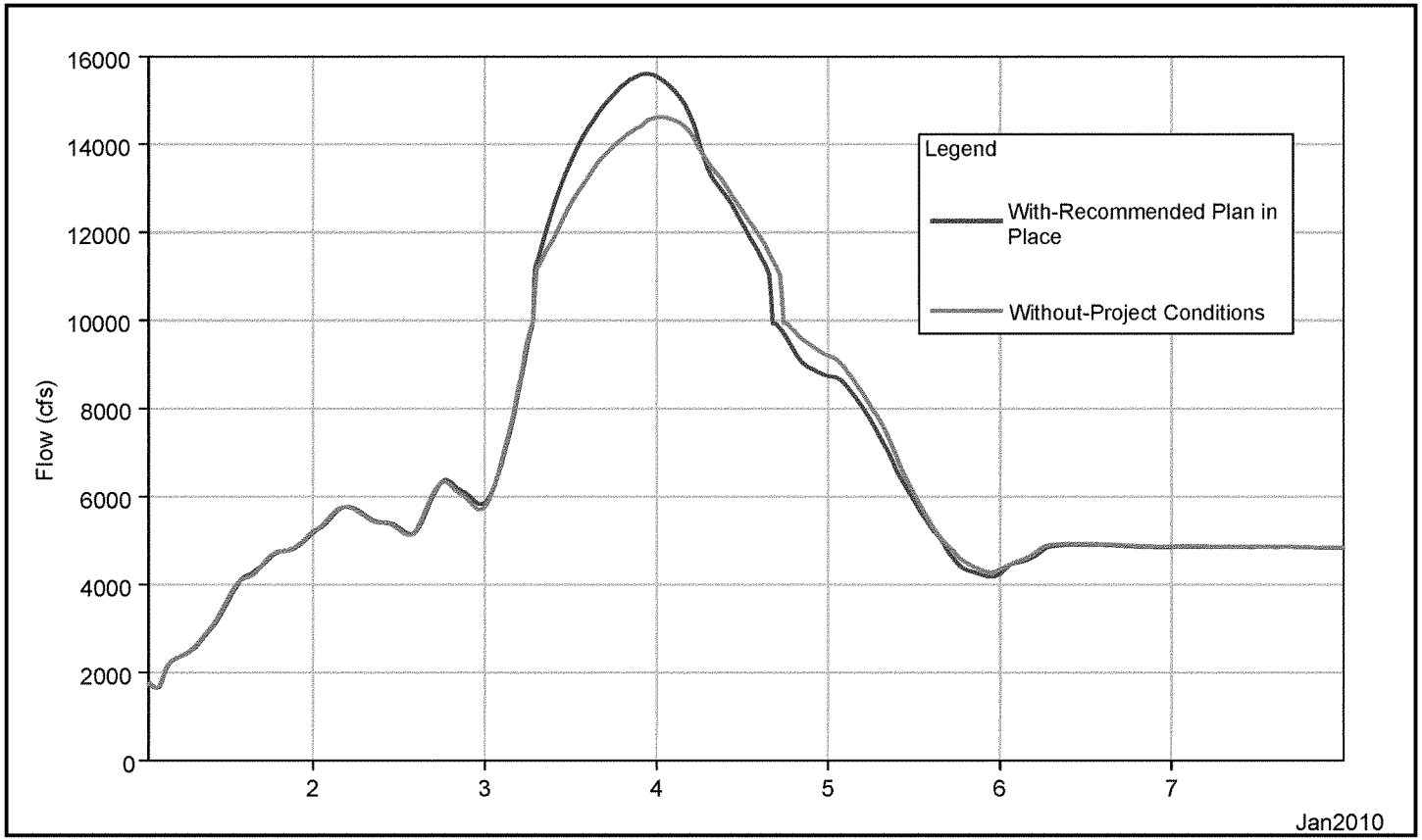


Figure 15. Comparison of with- and without-project discharge hydrographs for the 1/50 chance event at the UPRR bridge (RAS Sta 66+50) with the 1/50 chance Recommended Plan in place

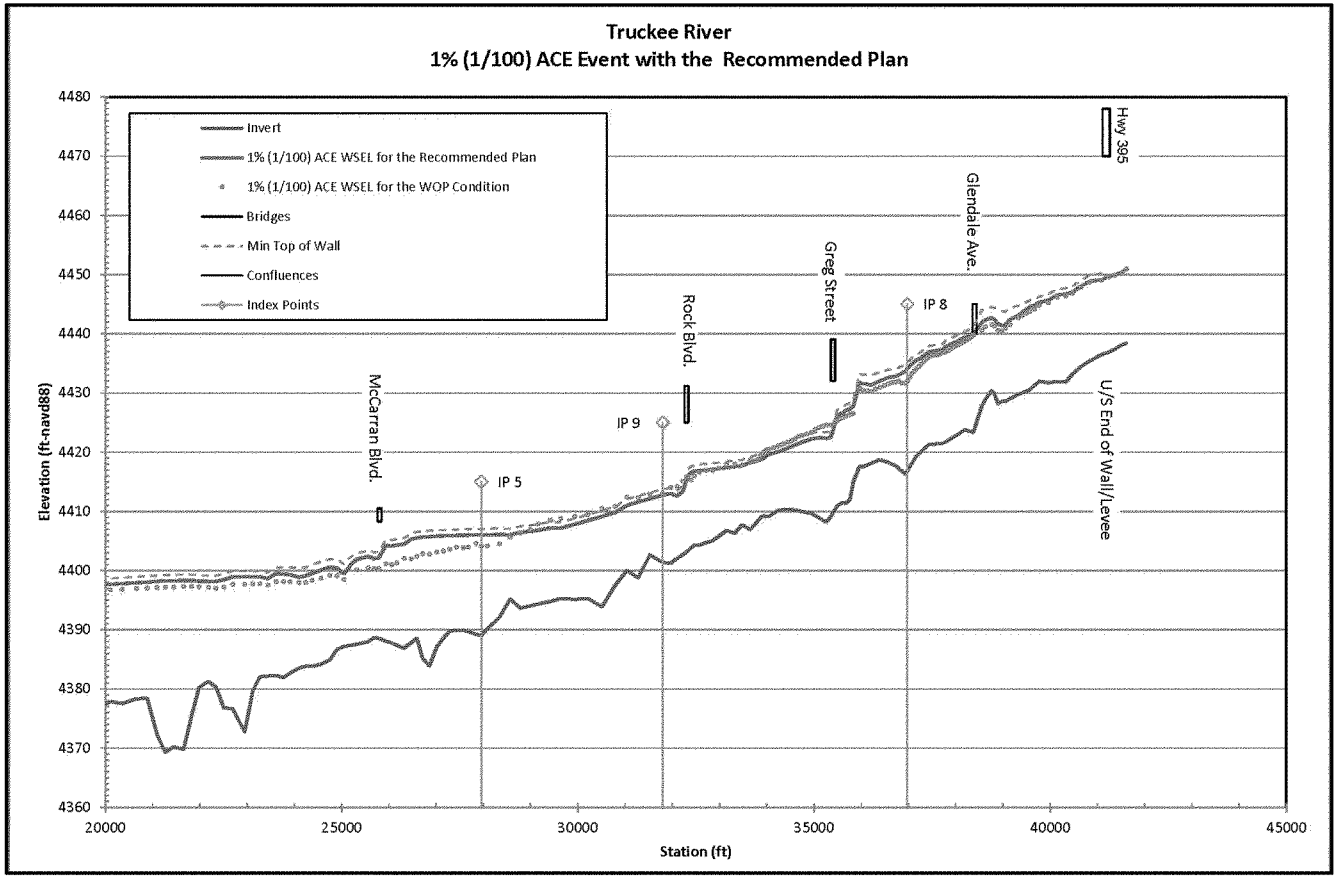


Figure 16. HEC-RAS water surface profiles for the Truckee River, between station 200+00 and Highway 395, for the 1% (1/100) ACE event in the Truckee Meadows reach with the Recommended Plan in place

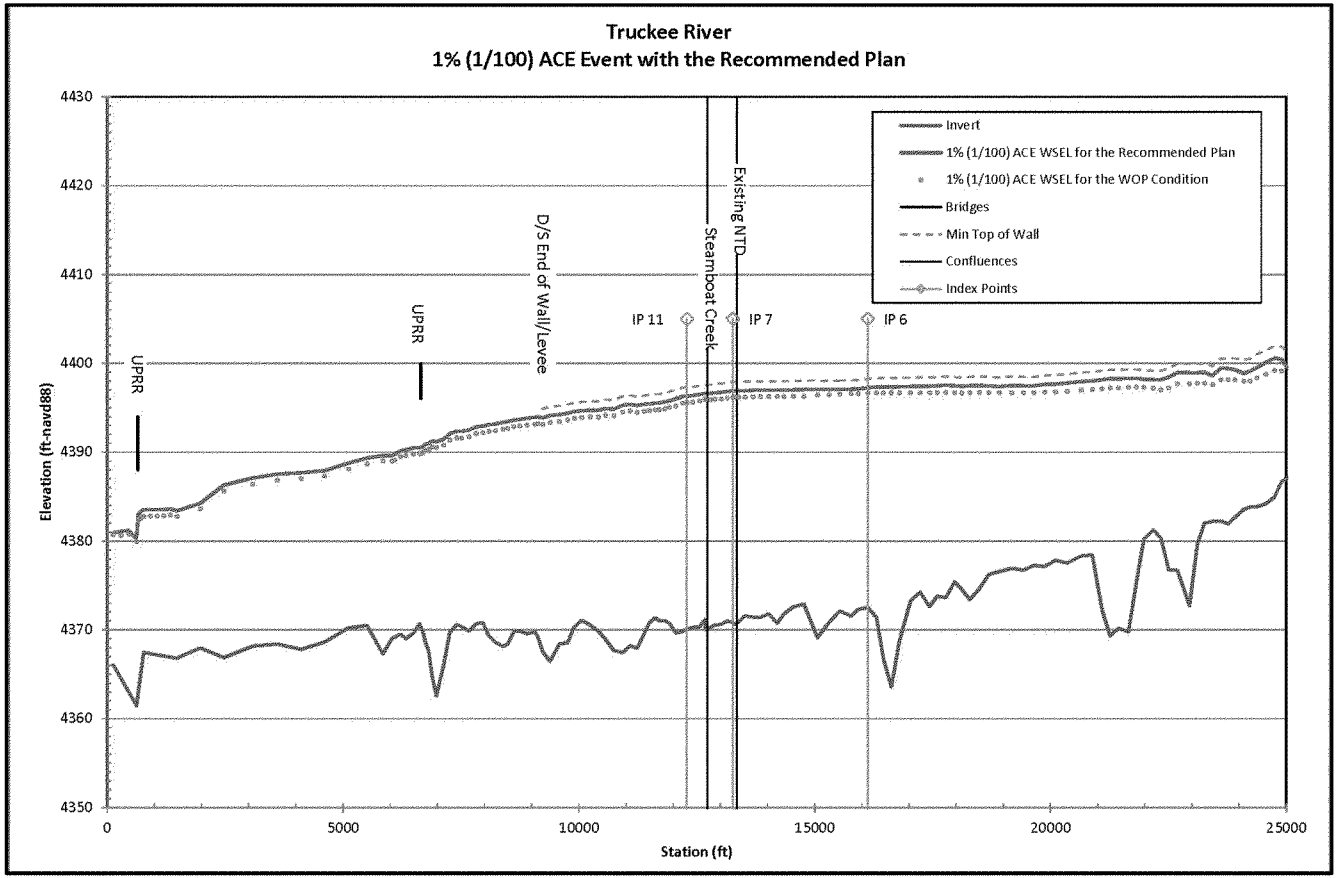
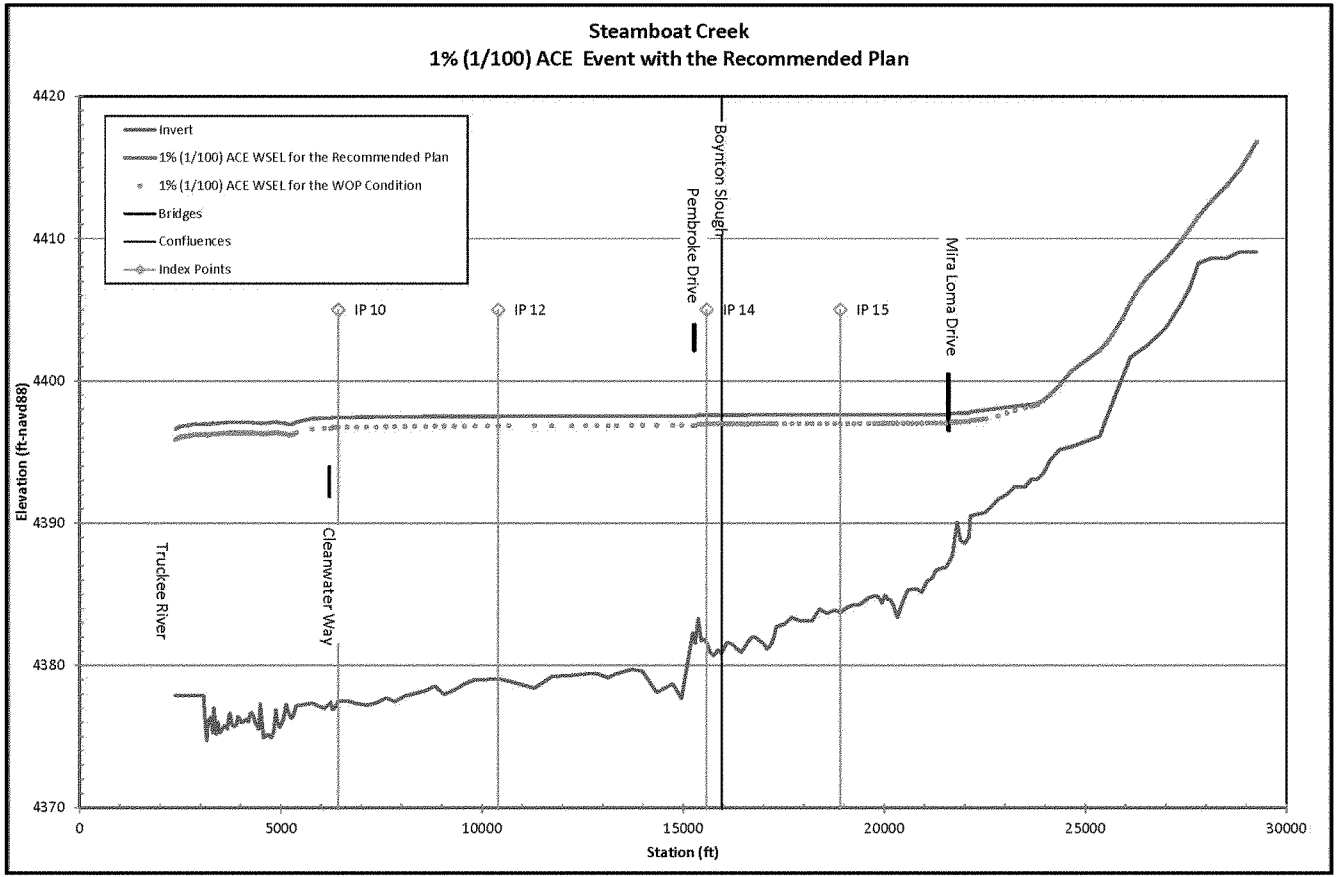


Figure 17. HEC-RAS water surface profiles for the Truckee River, between stations 0+00 and 250+00, for the 1% (1/100) ACE event in the Truckee Meadows reach with the Recommended Plan in place



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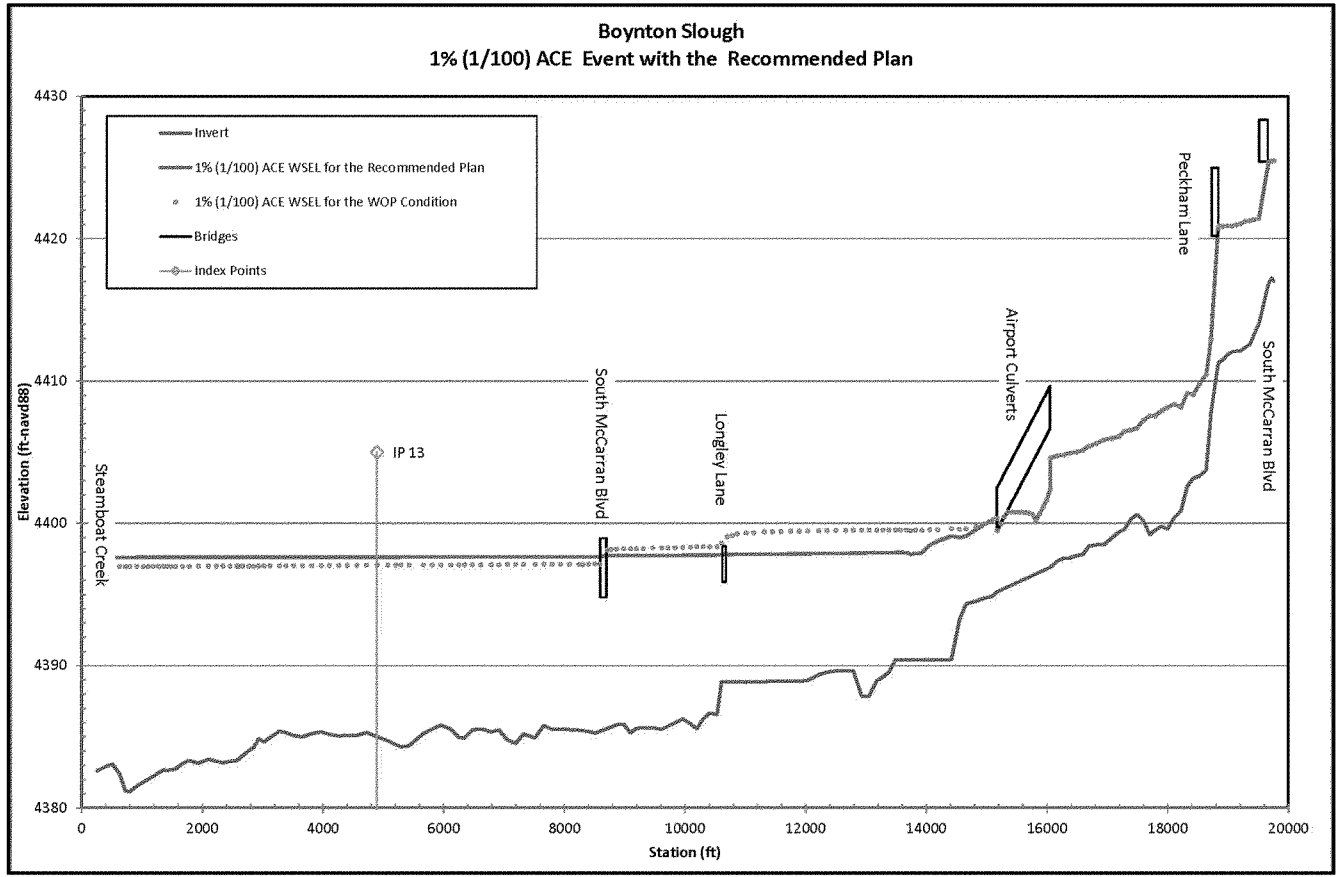

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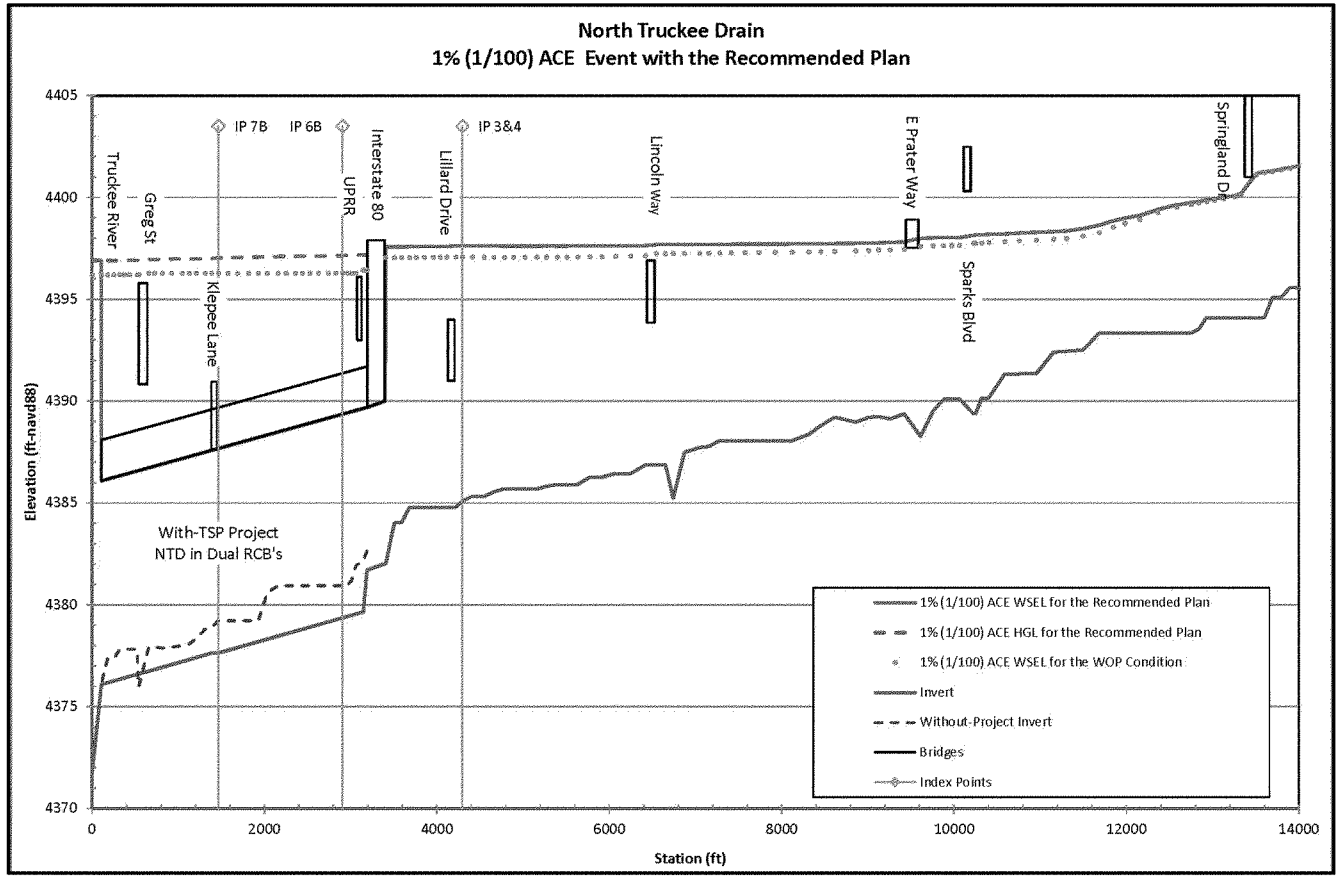


Figure 20. HEC-RAS water surface profiles for the North Truckee Drain, between the Truckee River and Springland Drive, for the 1% (1/100) ACE event in the Truckee Meadows reach with the Recommended Plan in place

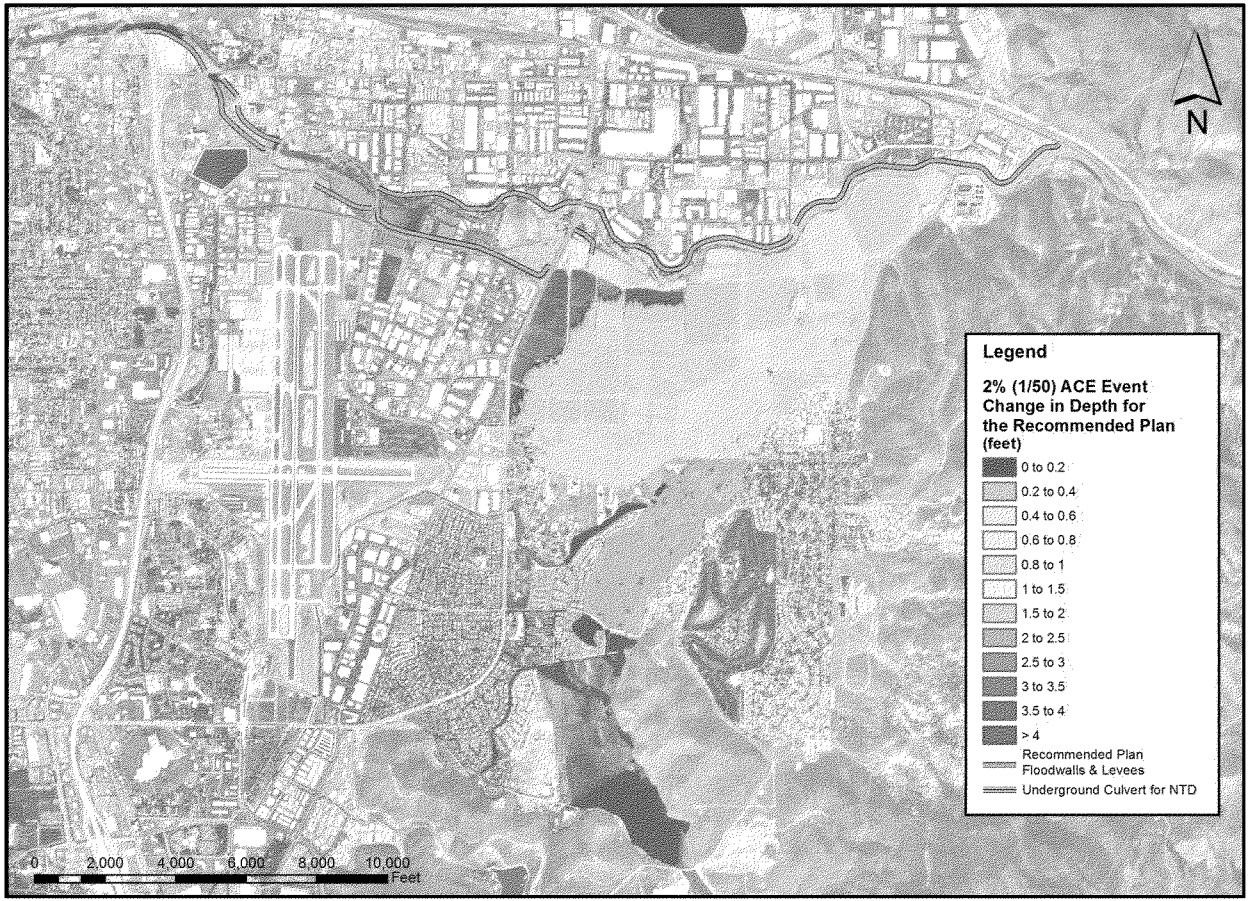


Figure 21. Comparison of 2% (1/50) ACE event depths for the Recommended Plan to the without-project condition

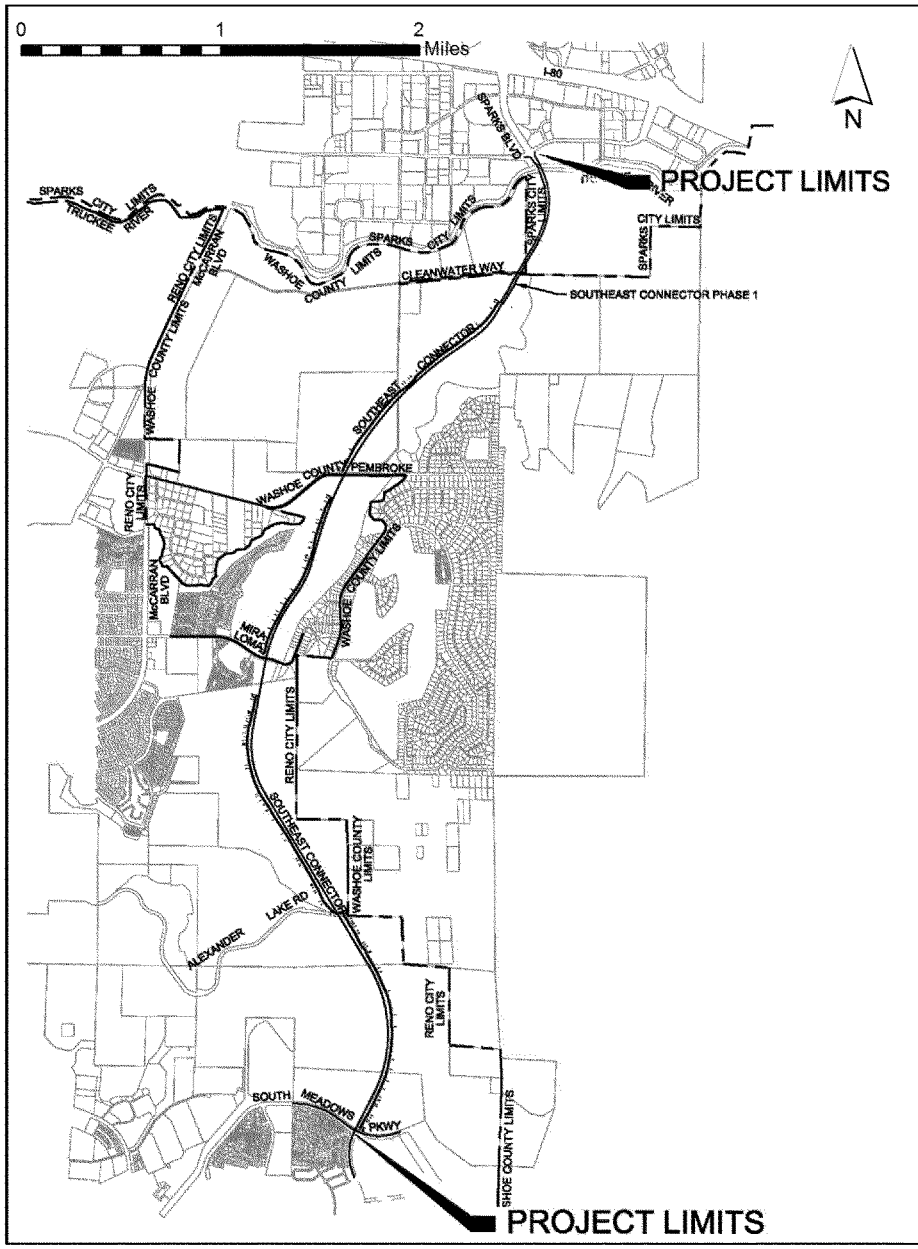


Figure 22. Location and extents of the proposed SouthEast Connector project

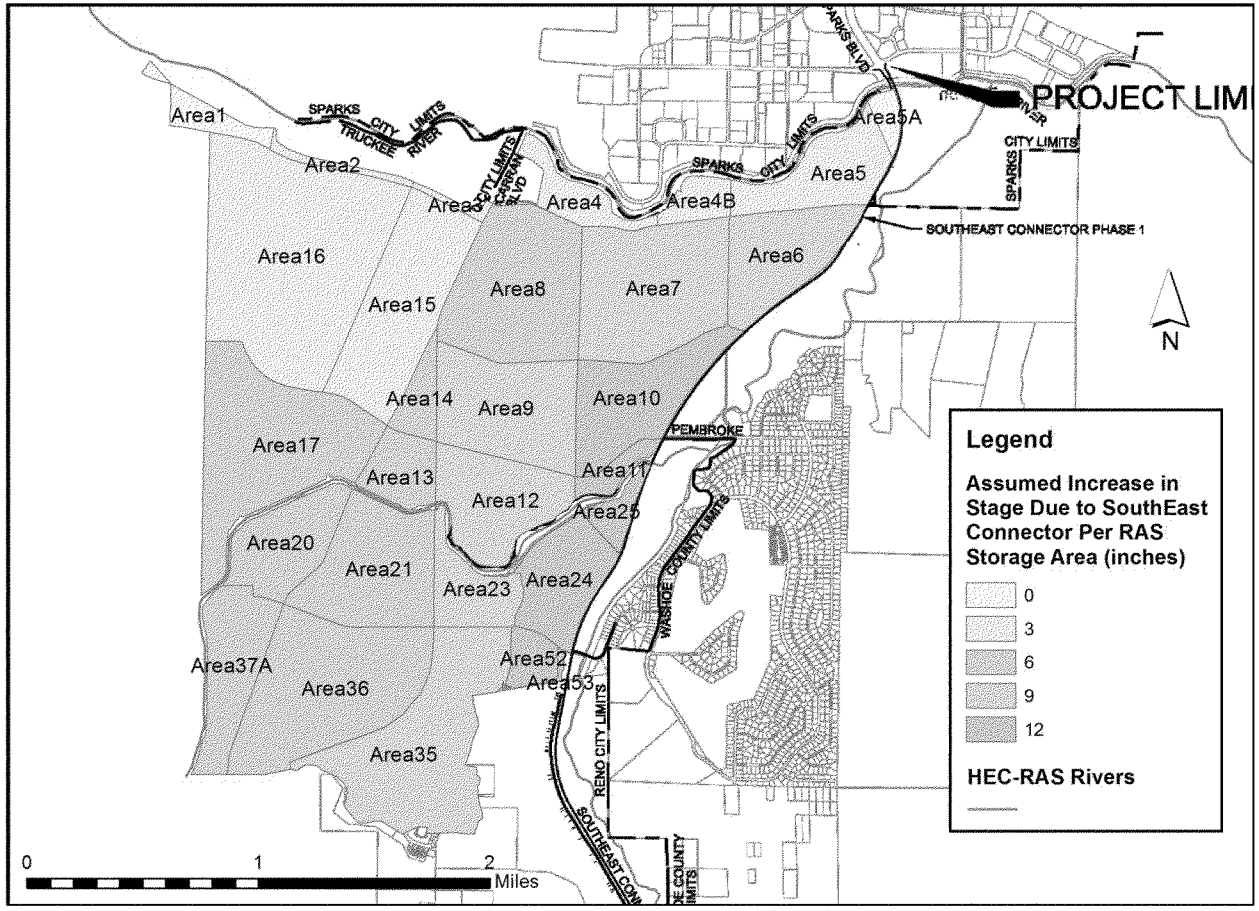


Figure 23. Assumed increase in stage due to the SouthEast connector per HEC-RAS storage area

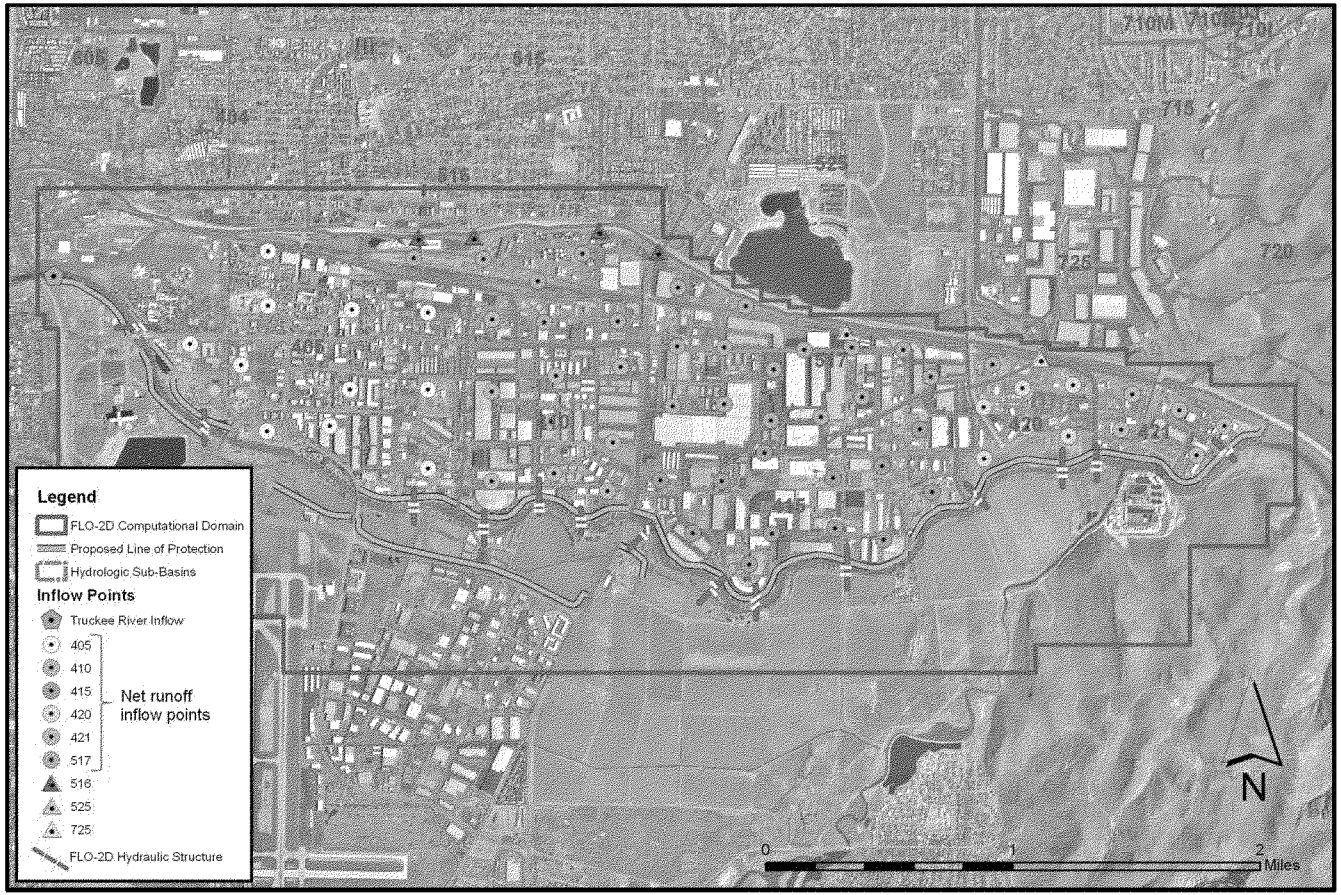
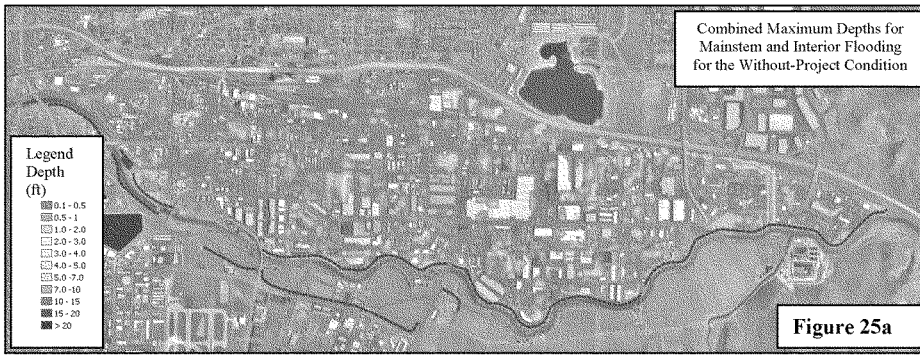
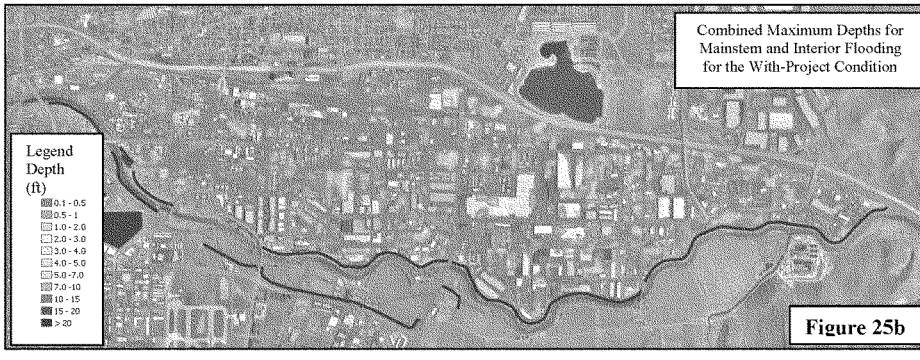


Figure 24. General layout of the Sparks interior drainage FLO-2D model





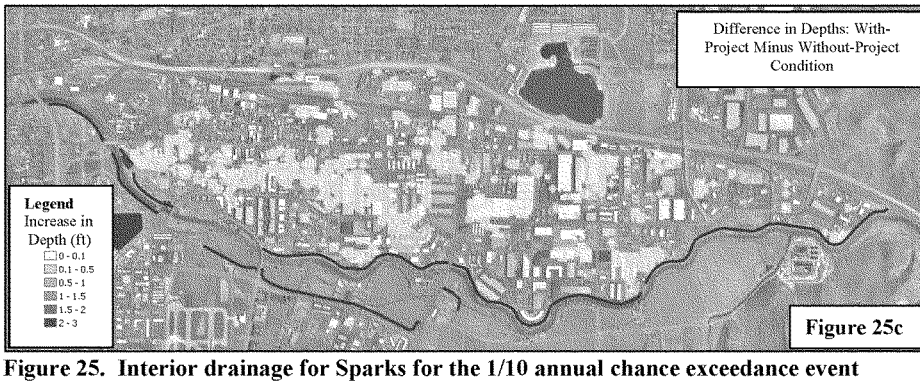
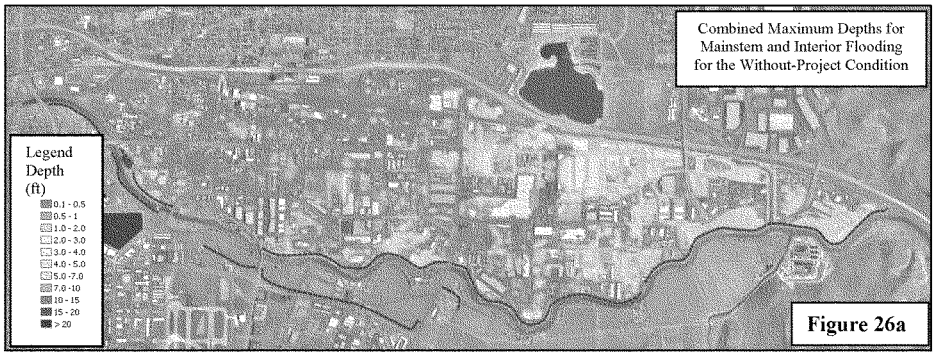
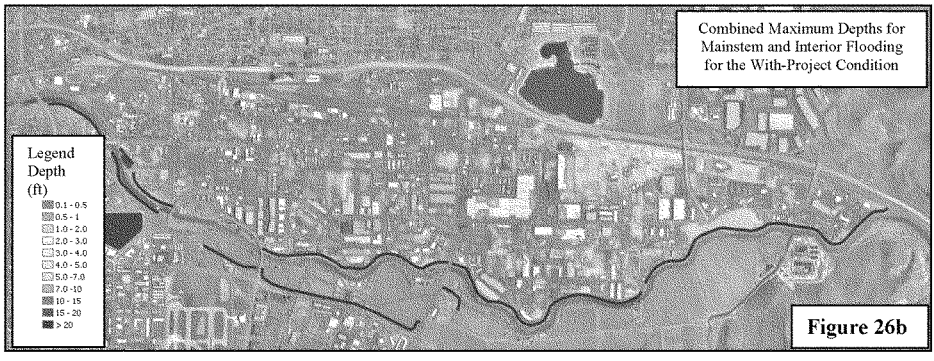


Figure 25. Interior drainage for Sparks for the 1/10 annual chance exceedance event





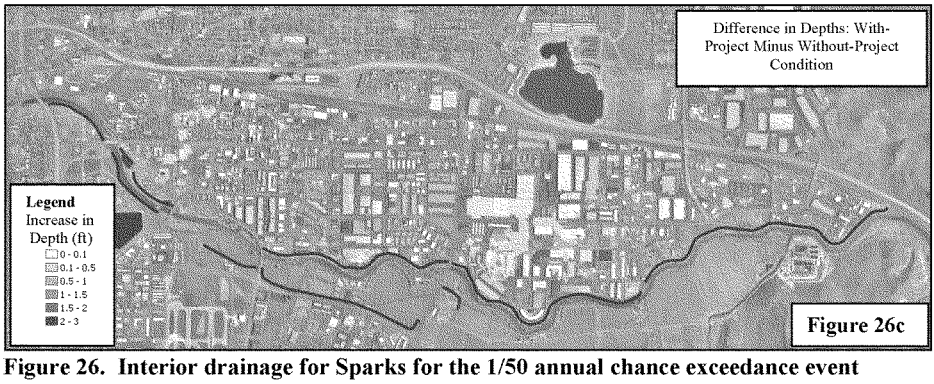
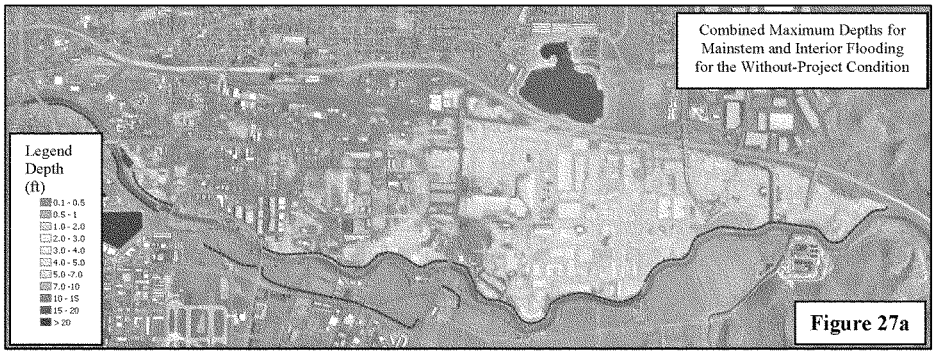
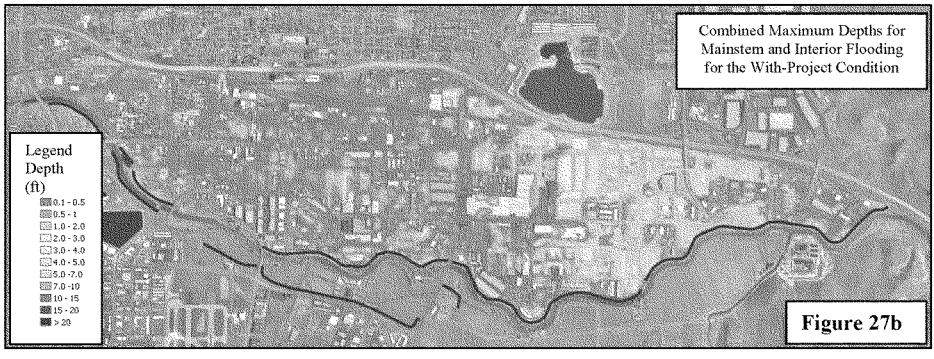


Figure 26. Interior drainage for Sparks for the 1/50 annual chance exceedance event





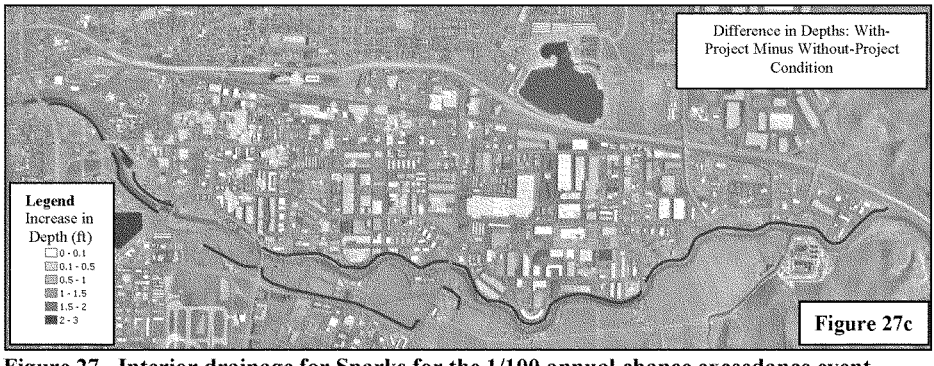


Figure 27. Interior drainage for Sparks for the 1/100 annual chance exceedance event

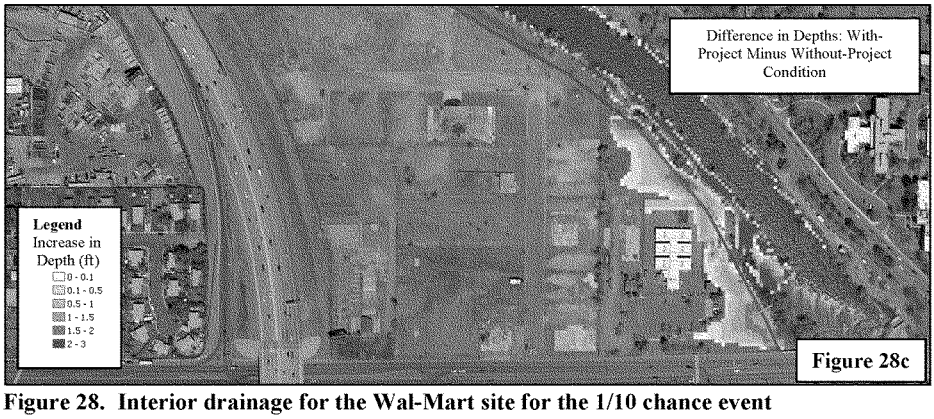


Figure 28. Interior drainage for the Wal-Mart site for the 1/10 chance event

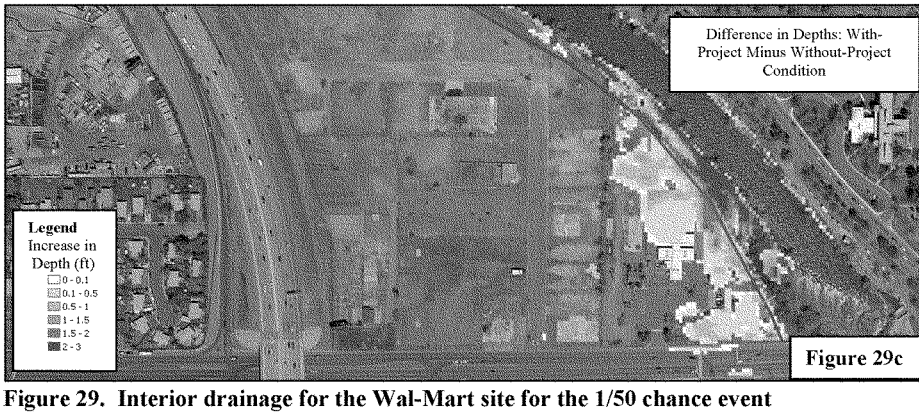


Figure 29. Interior drainage for the Wal-Mart site for the 1/50 chance event

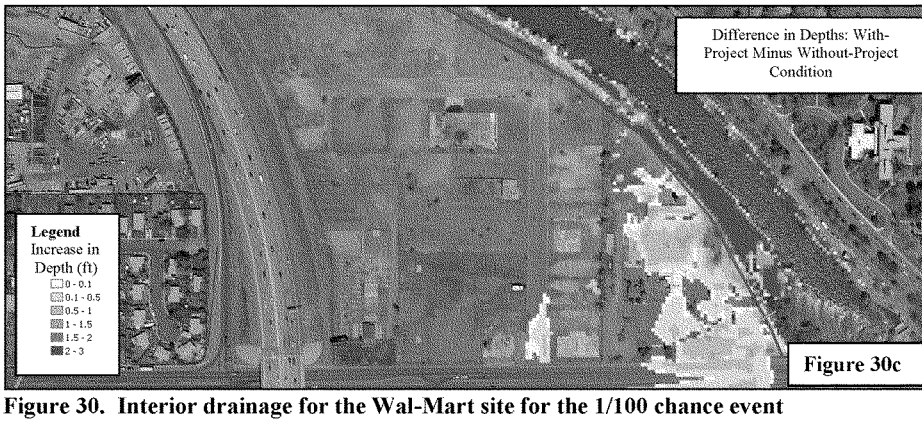
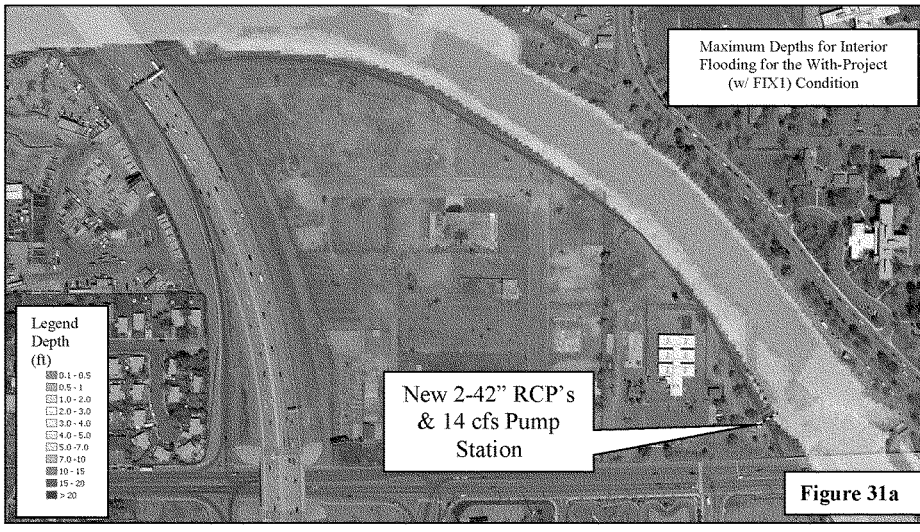


Figure 30. Interior drainage for the Wal-Mart site for the 1/100 chance event



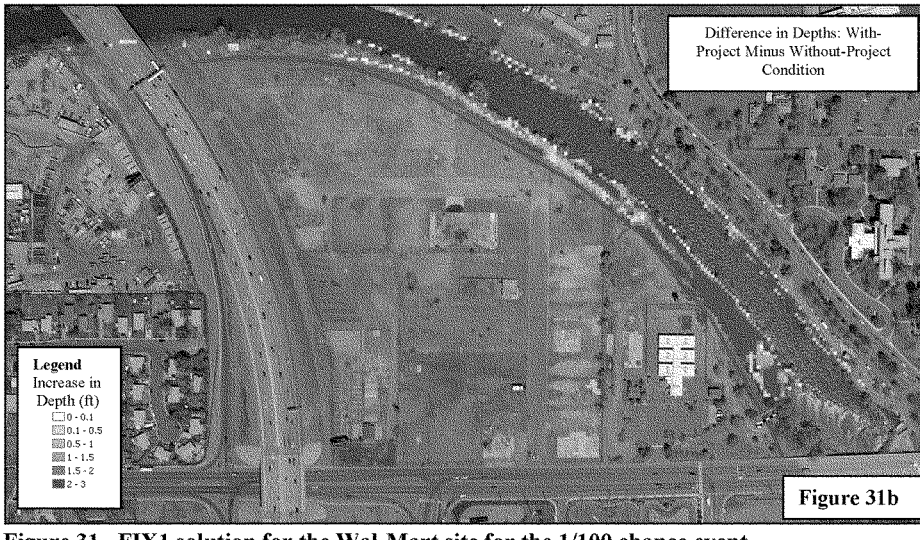


Figure 31. FIX1 solution for the Wal-Mart site for the 1/100 chance event

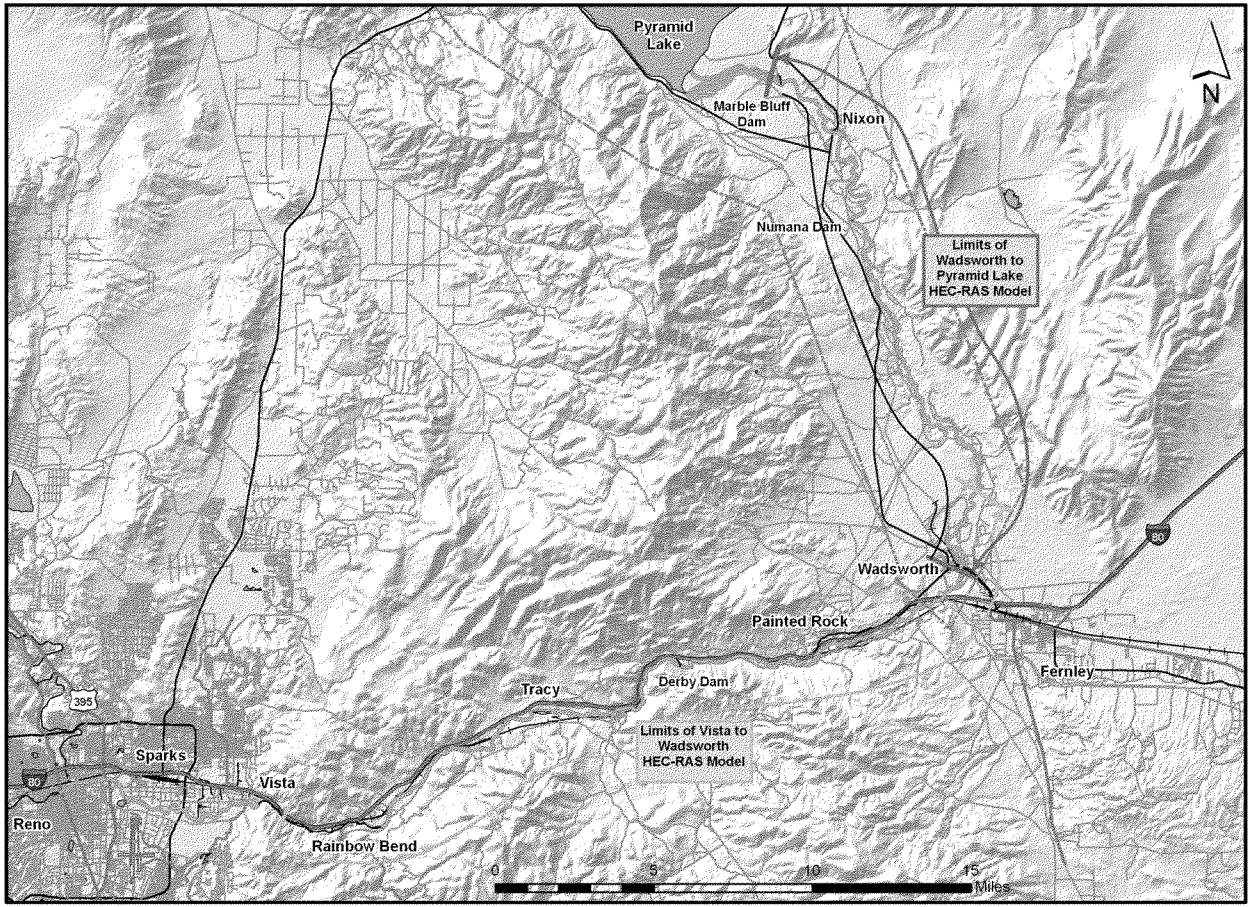


Figure 32. Vista to Pyramid Lake model reaches

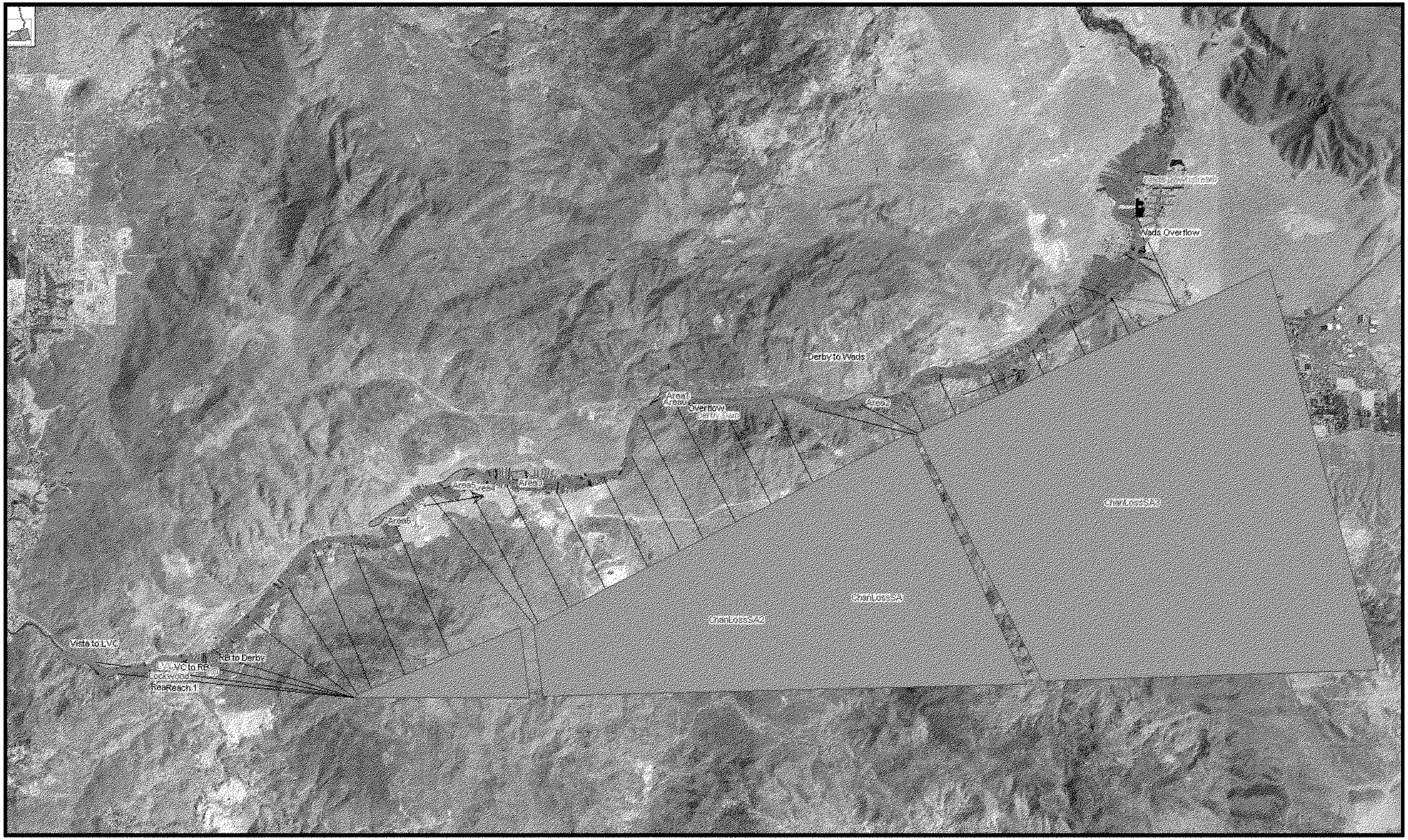


Figure 33. Vista to Wadsworth without- and with-project HEC-RAS model

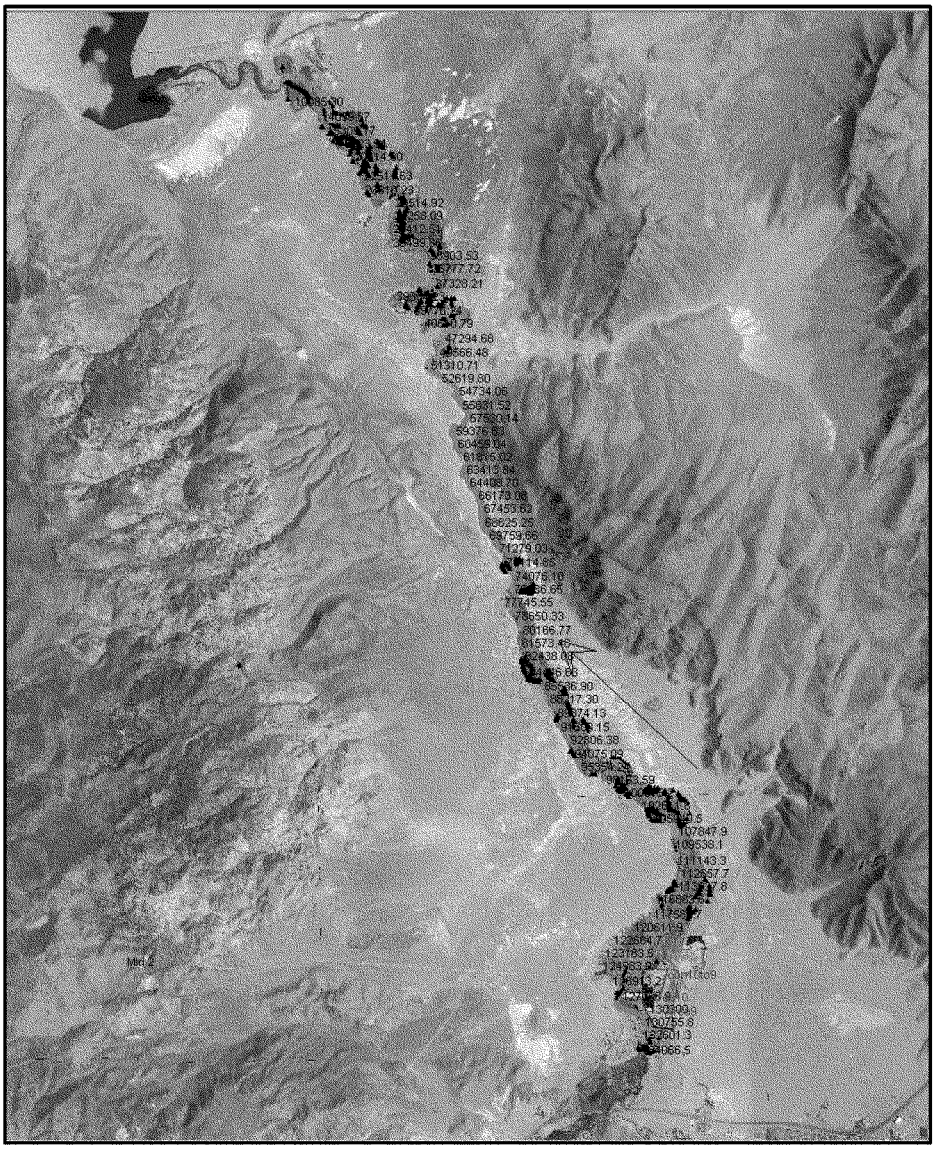


Figure 34. Wadsworth to Pyramid Lake HEC-RAS model

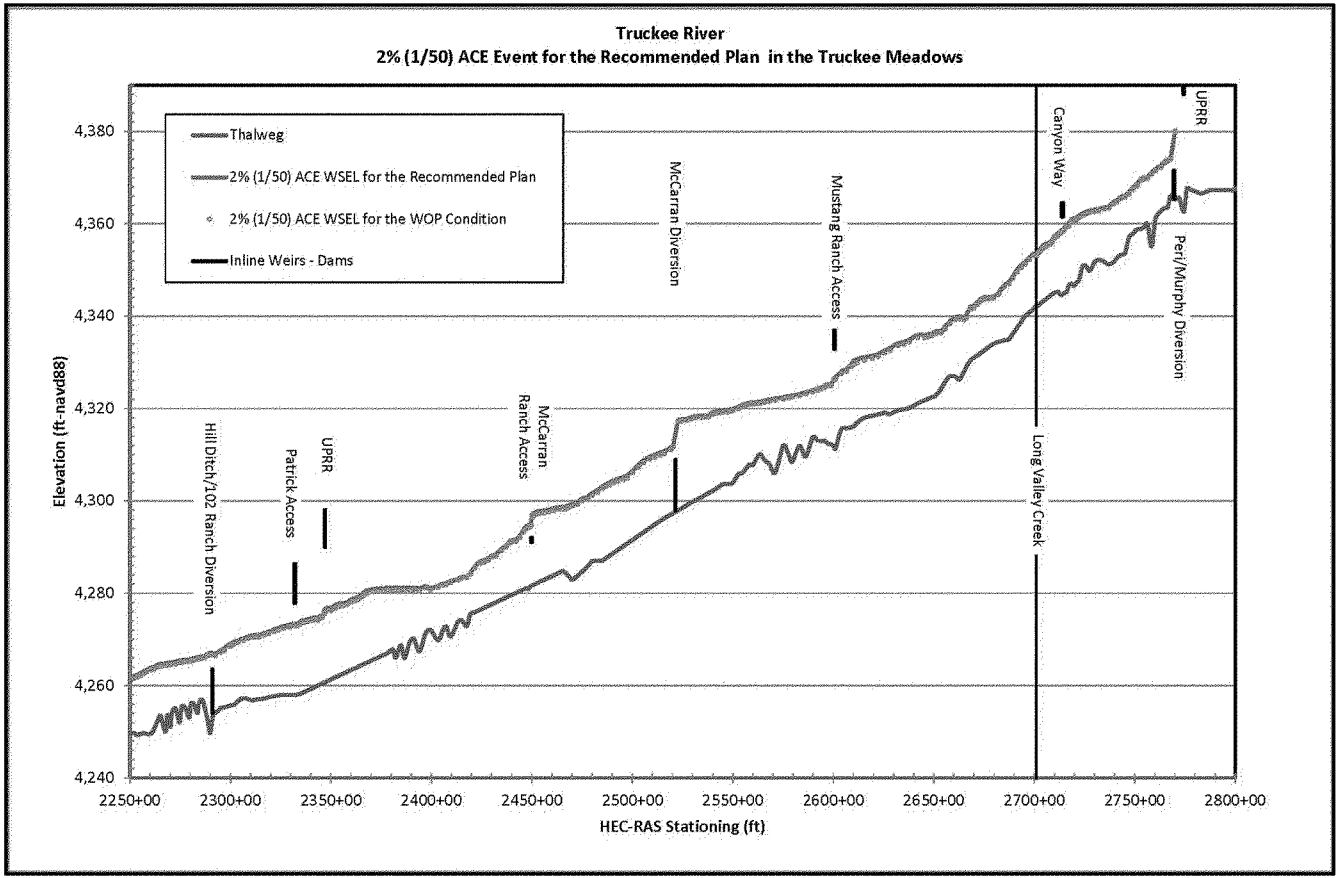


Figure 35. HEC-RAS water surface profiles for the Truckee River, between the UPRR bridge at Lockwood and station 2250+00, for the 2% (1/50) ACE event with the Recommended Plan in place

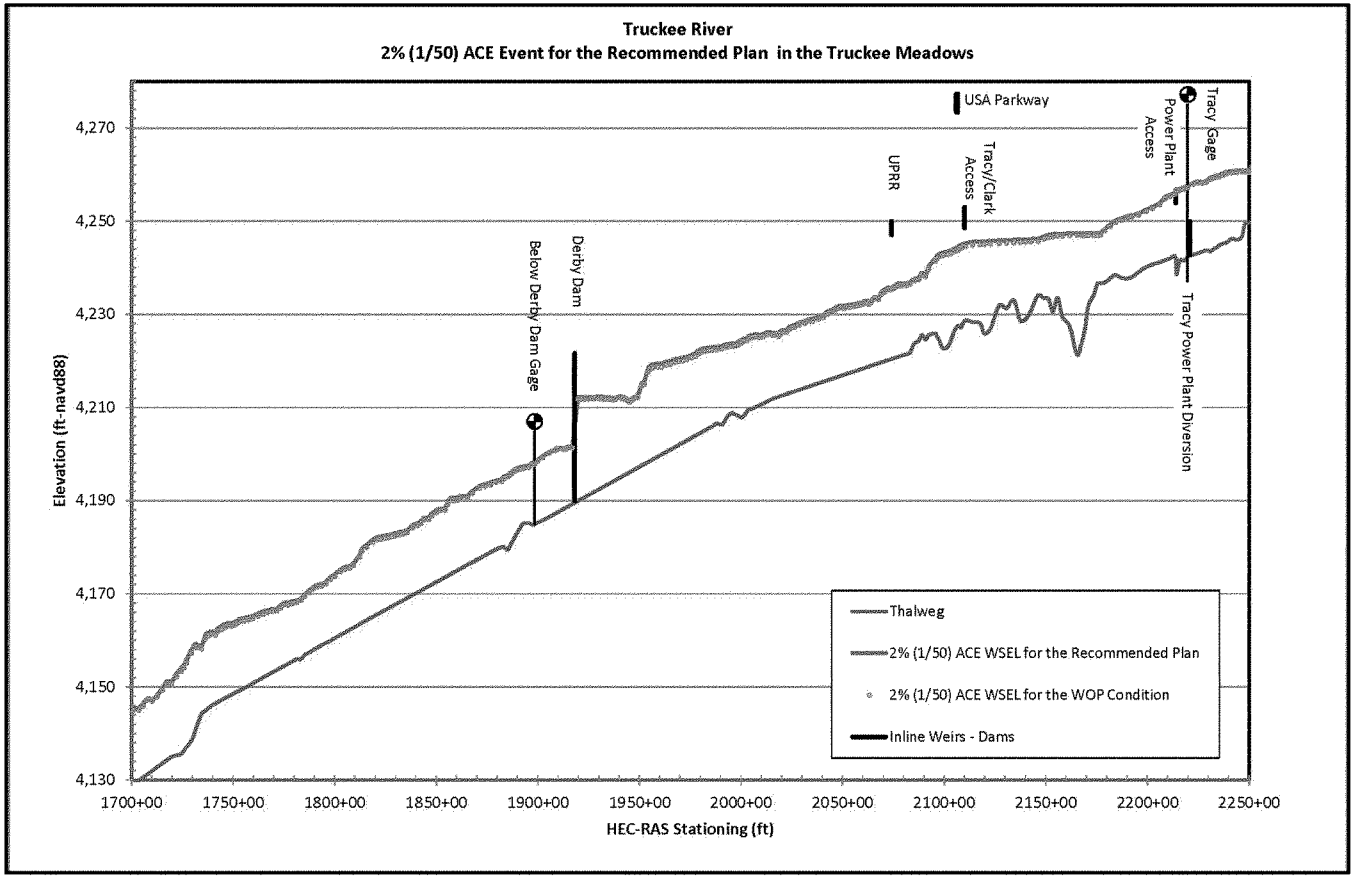


Figure 36. HEC-RAS water surface profiles for the Truckee River, between stations 2250+00 and 1700+00, for the 2% (1/50) ACE event with the Recommended Plan in place

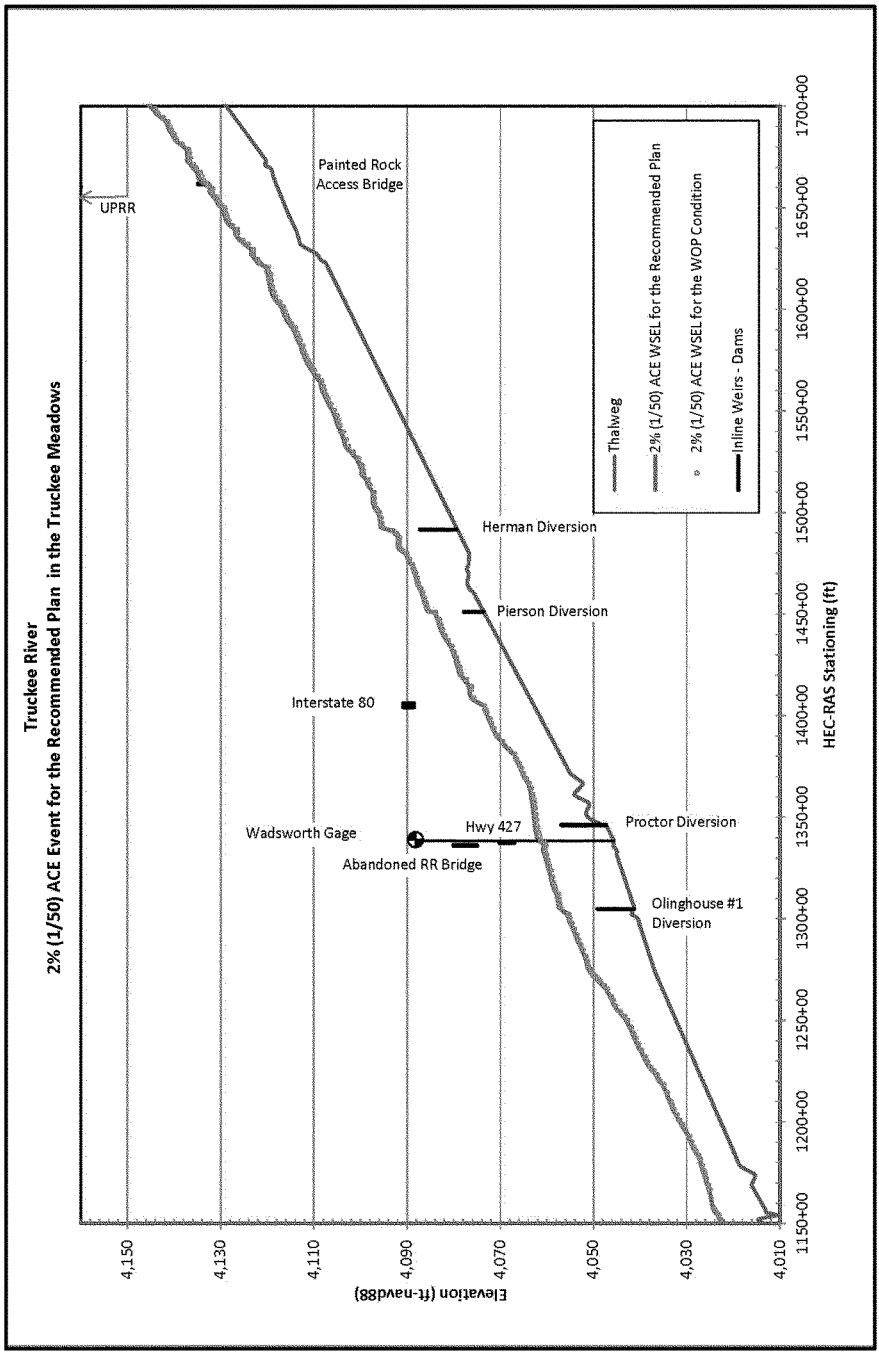


Figure 37. HEC-RAS water surface profiles for the Truckee River, between stations 1700+00 and 1150+00, for the 2% (1/50) ACE event with the Recommended Plan in place

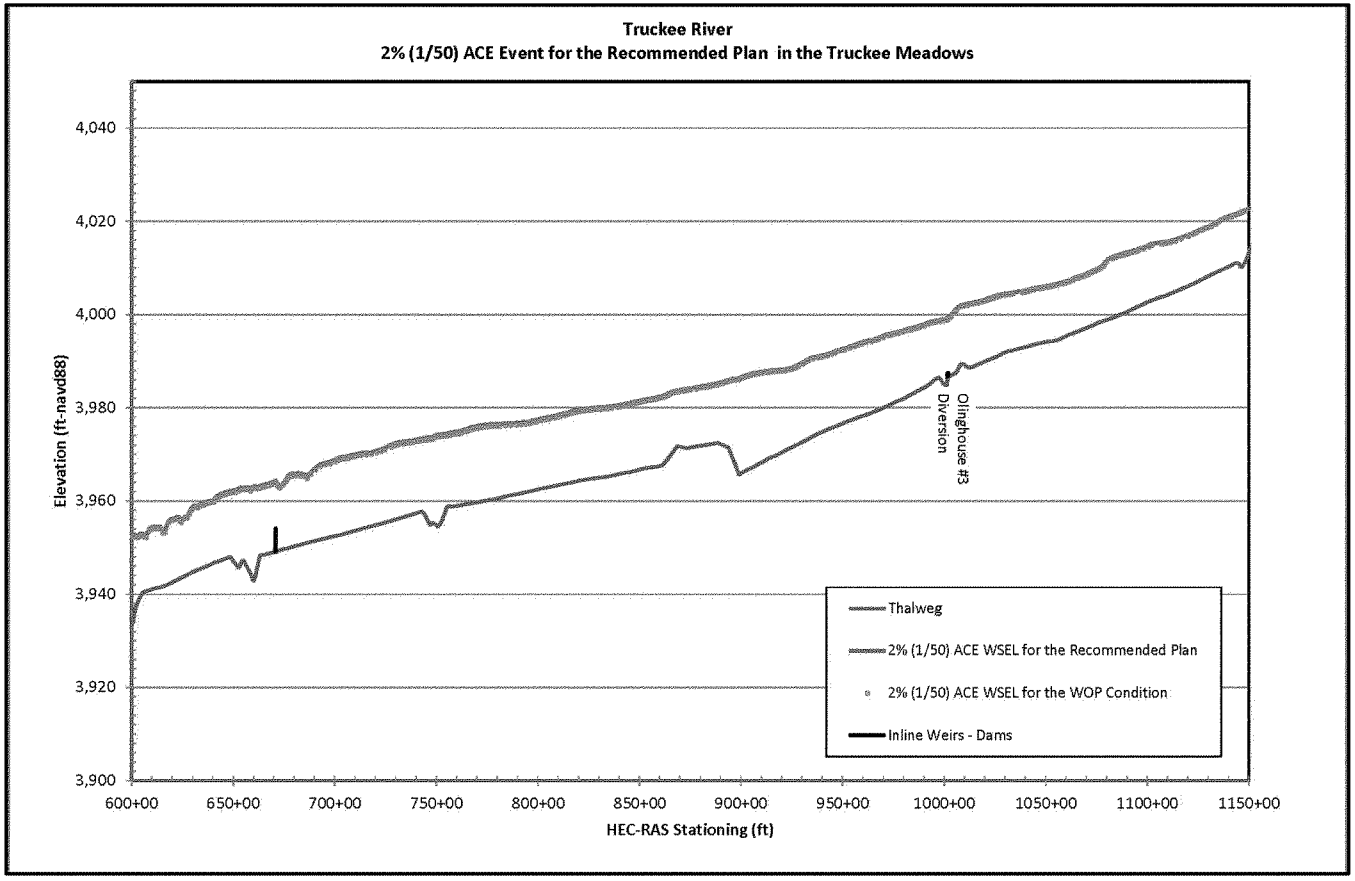


Figure 38. HEC-RAS water surface profiles for the Truckee River, between stations 1150+00 and 600+00, for the 2% (1/50) ACE event with the Recommended Plan in place

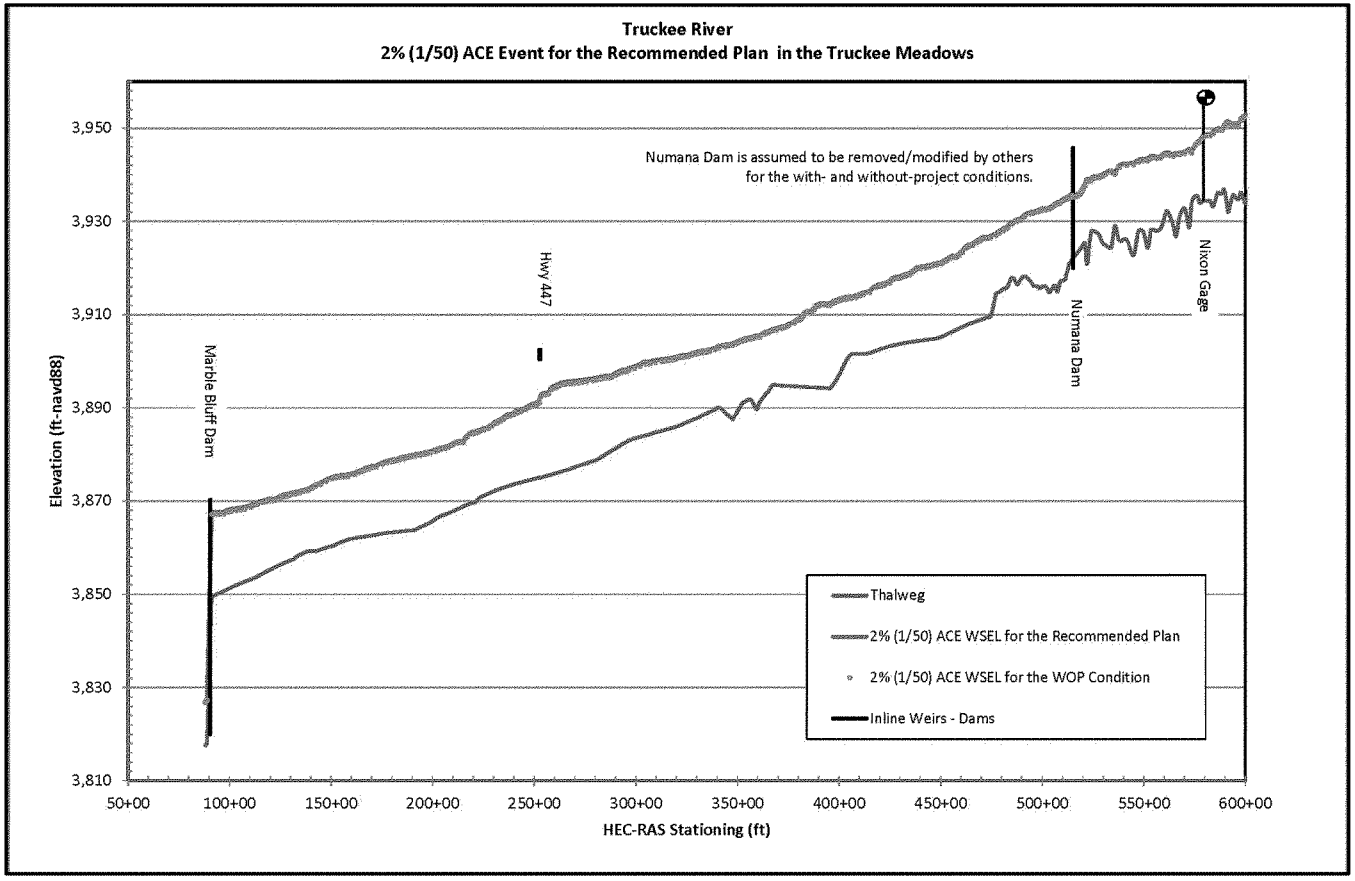


Figure 39. HEC-RAS water surface profiles for the Truckee River, between station 600+00 and Marble Bluff Dam, for the 2% (1/50) ACE event with the Recommended Plan in place

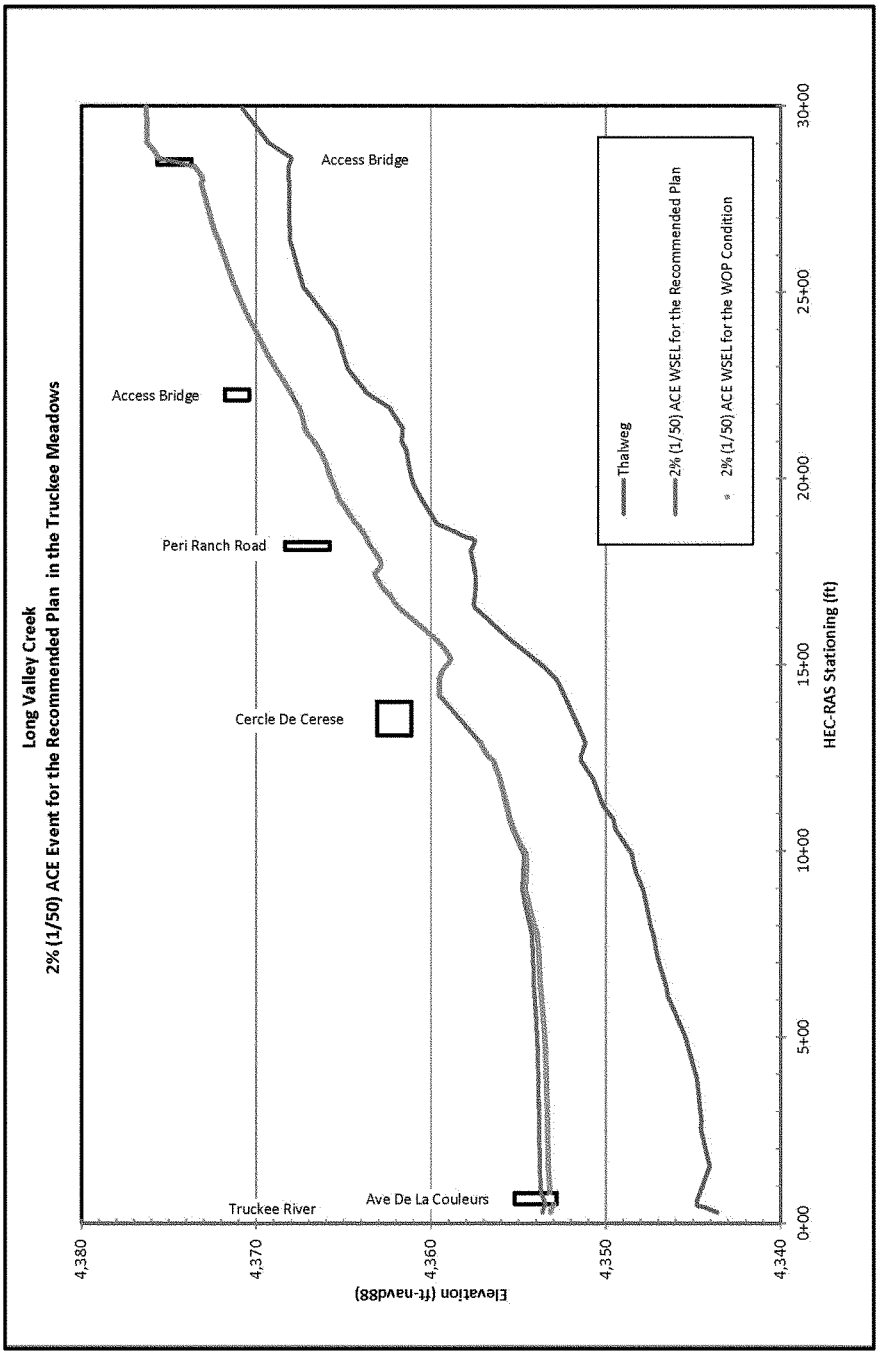


Figure 40. HEC-RAS water surface profiles for Long Valley Creek for the 2% (1/50) ACE event with the Recommended Plan in place

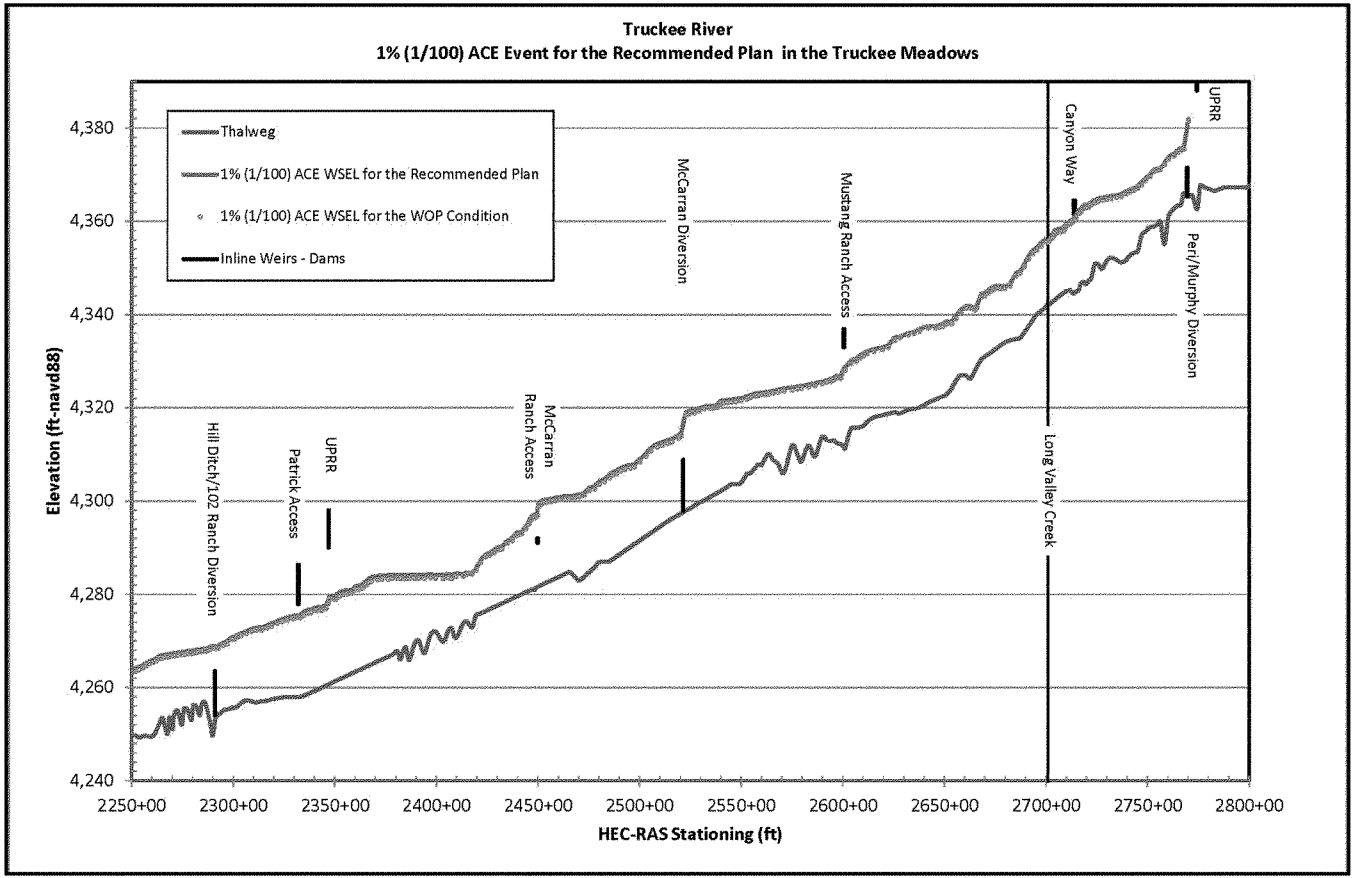


Figure 41. HEC-RAS water surface profiles for the Truckee River, between the UPRR bridge at Lockwood and station 2250+00, for the 1% (1/100) ACE event with the Recommended Plan in place

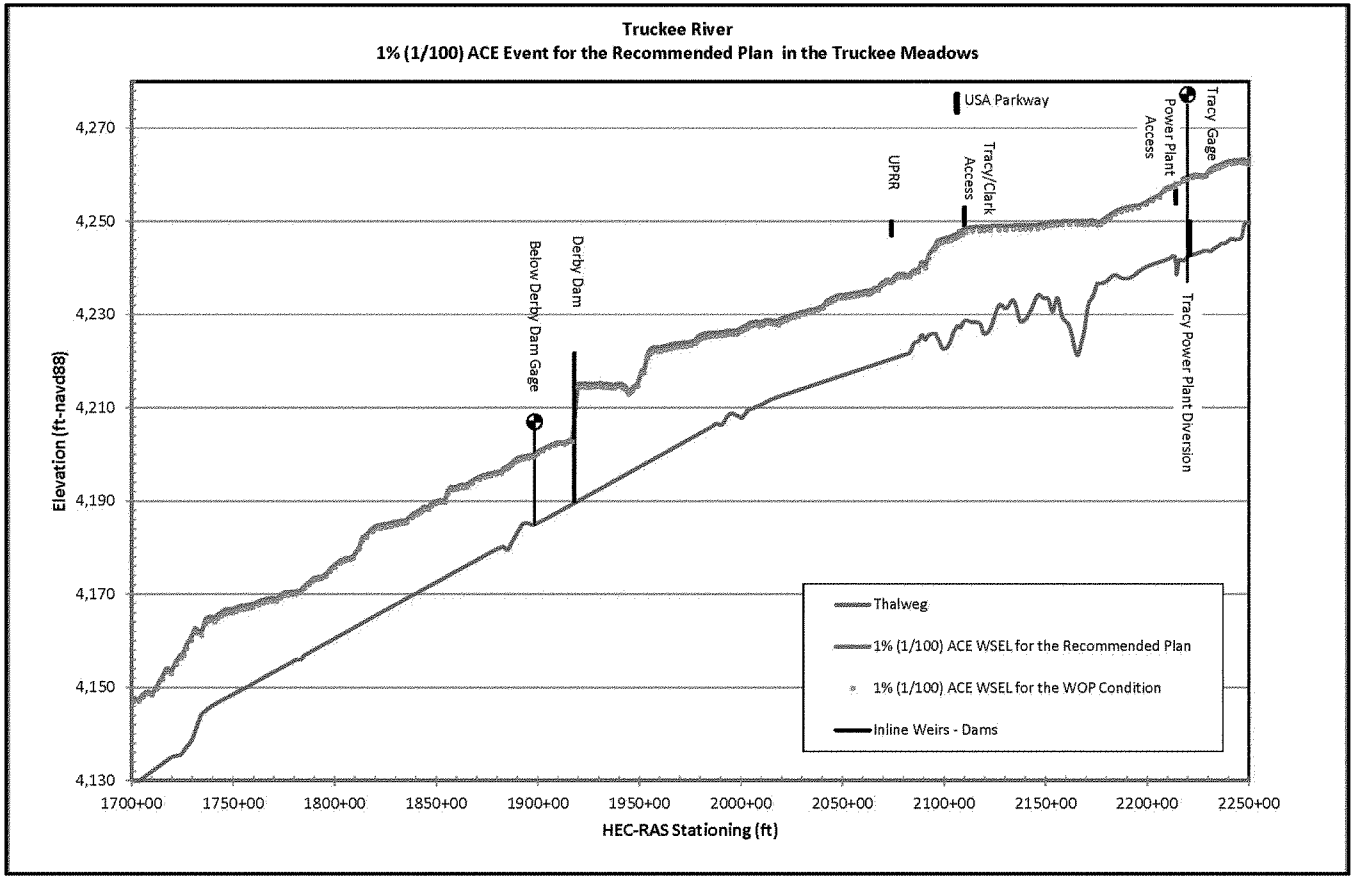


Figure 42. HEC-RAS water surface profiles for the Truckee River, between stations 2250+00 and 1700+00, for the 1% (1/100) ACE event with the Recommended Plan in place

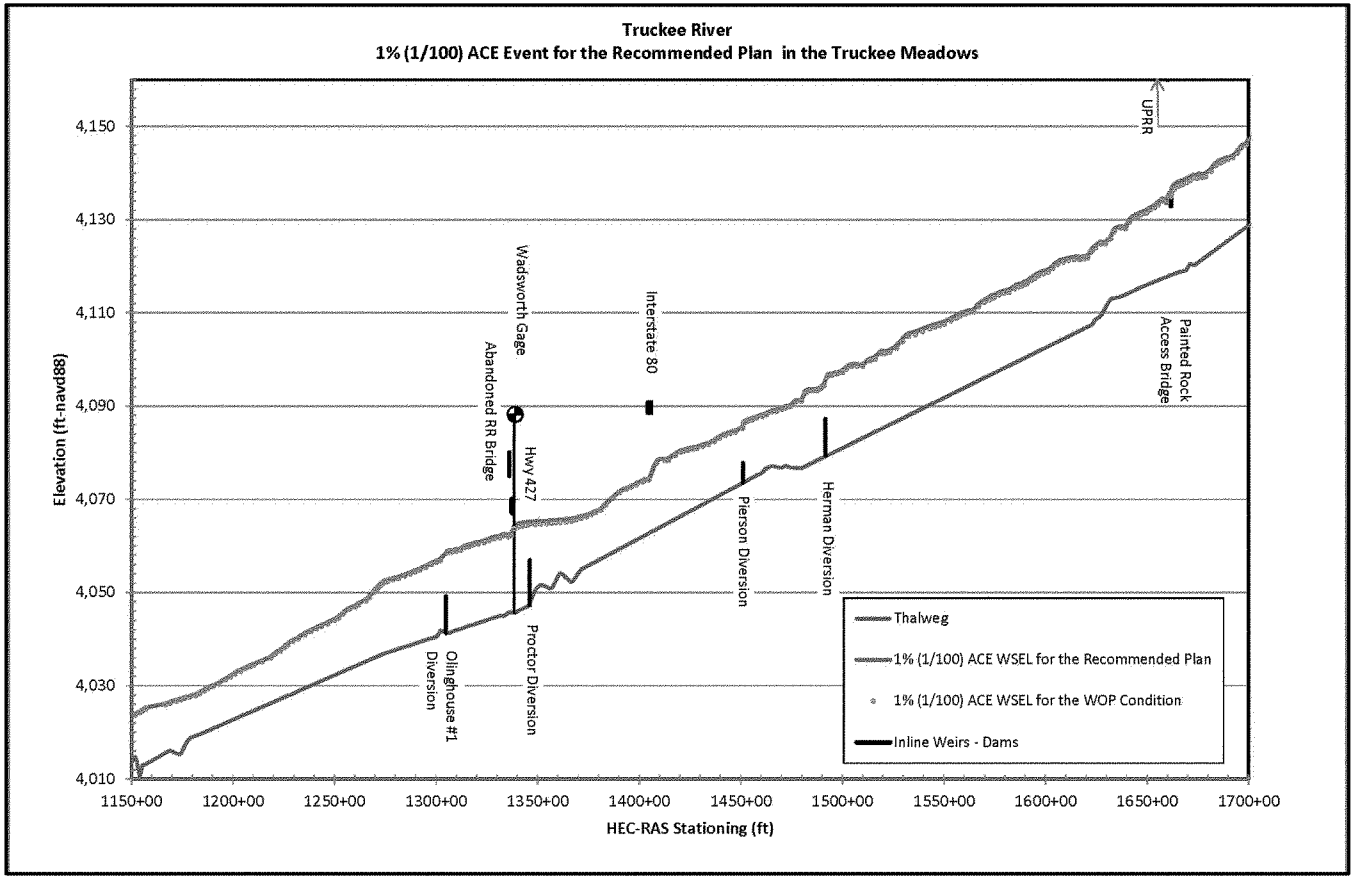


Figure 43. HEC-RAS water surface profiles for the Truckee River, between stations 1700+00 and 1150+00, for the 1% (1/100) ACE event with the Recommended Plan in place

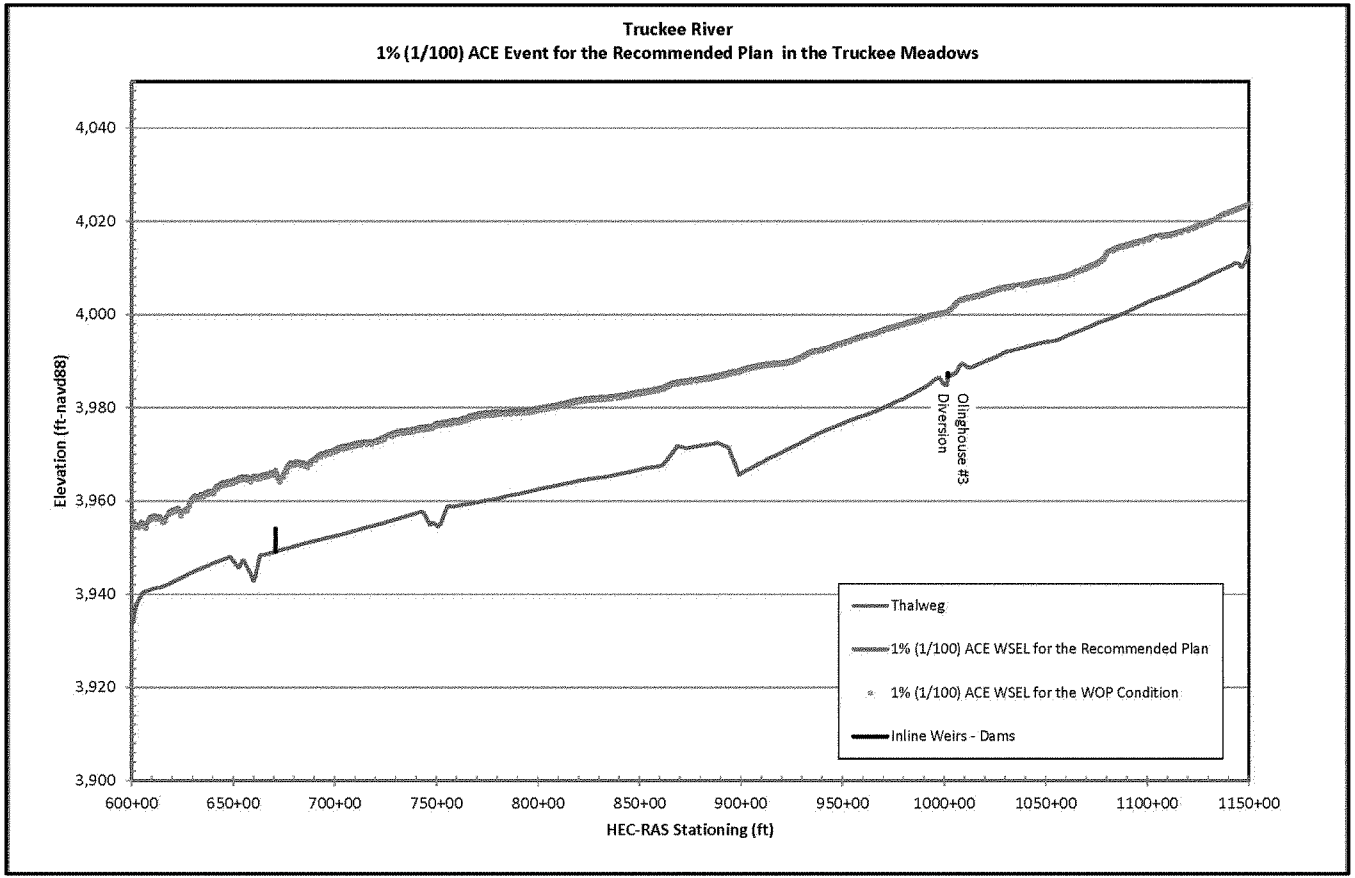


Figure 44. HEC-RAS water surface profiles for the Truckee River, between stations 1150+00 and 600+00, for the 1% (1/100) ACE event with the Recommended Plan in place

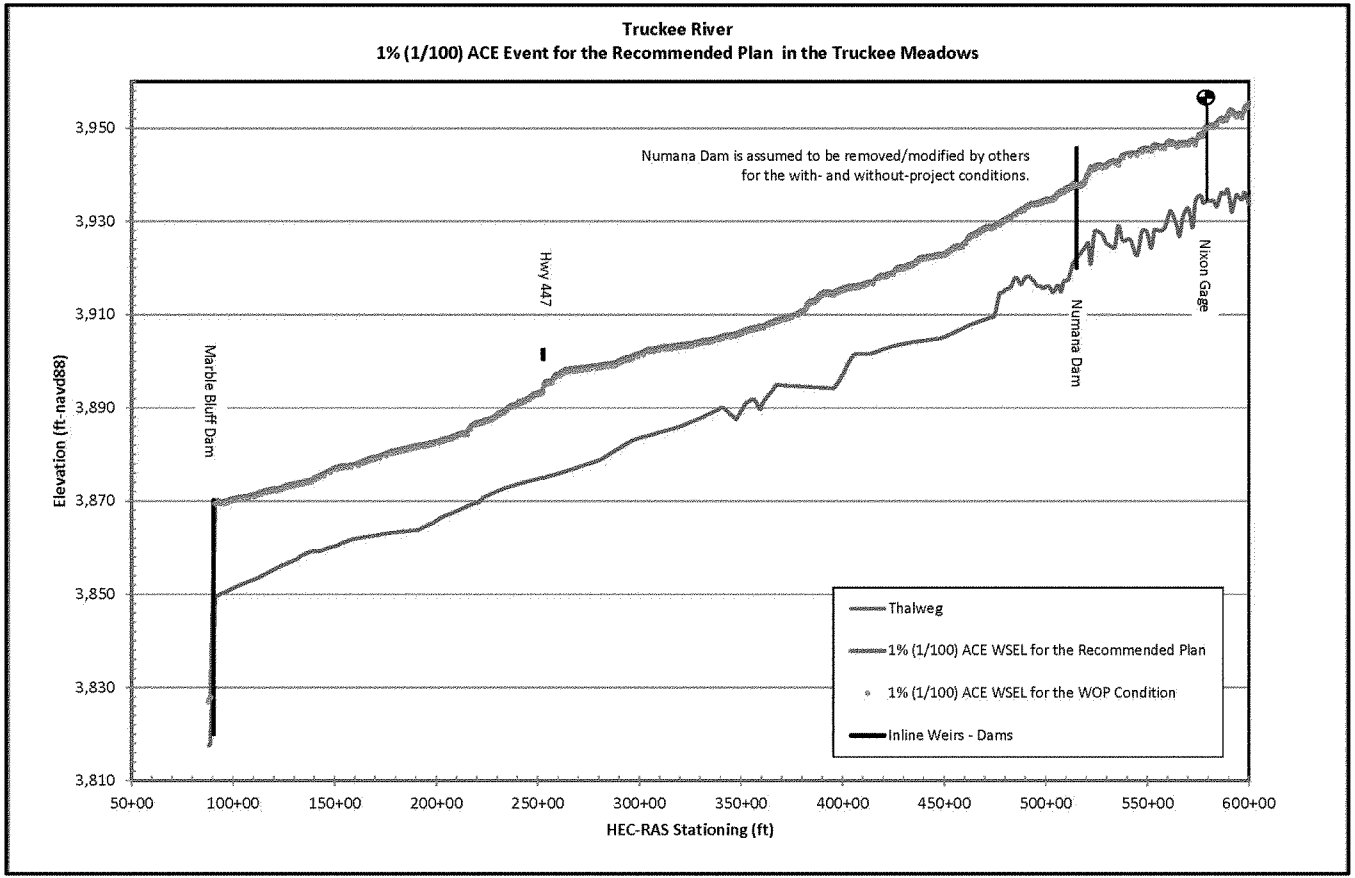


Figure 45. HEC-RAS water surface profiles for the Truckee River, between station 600+00 and Marble Bluff Dam, for the 1% (1/100) ACE event with the Recommended Plan in place

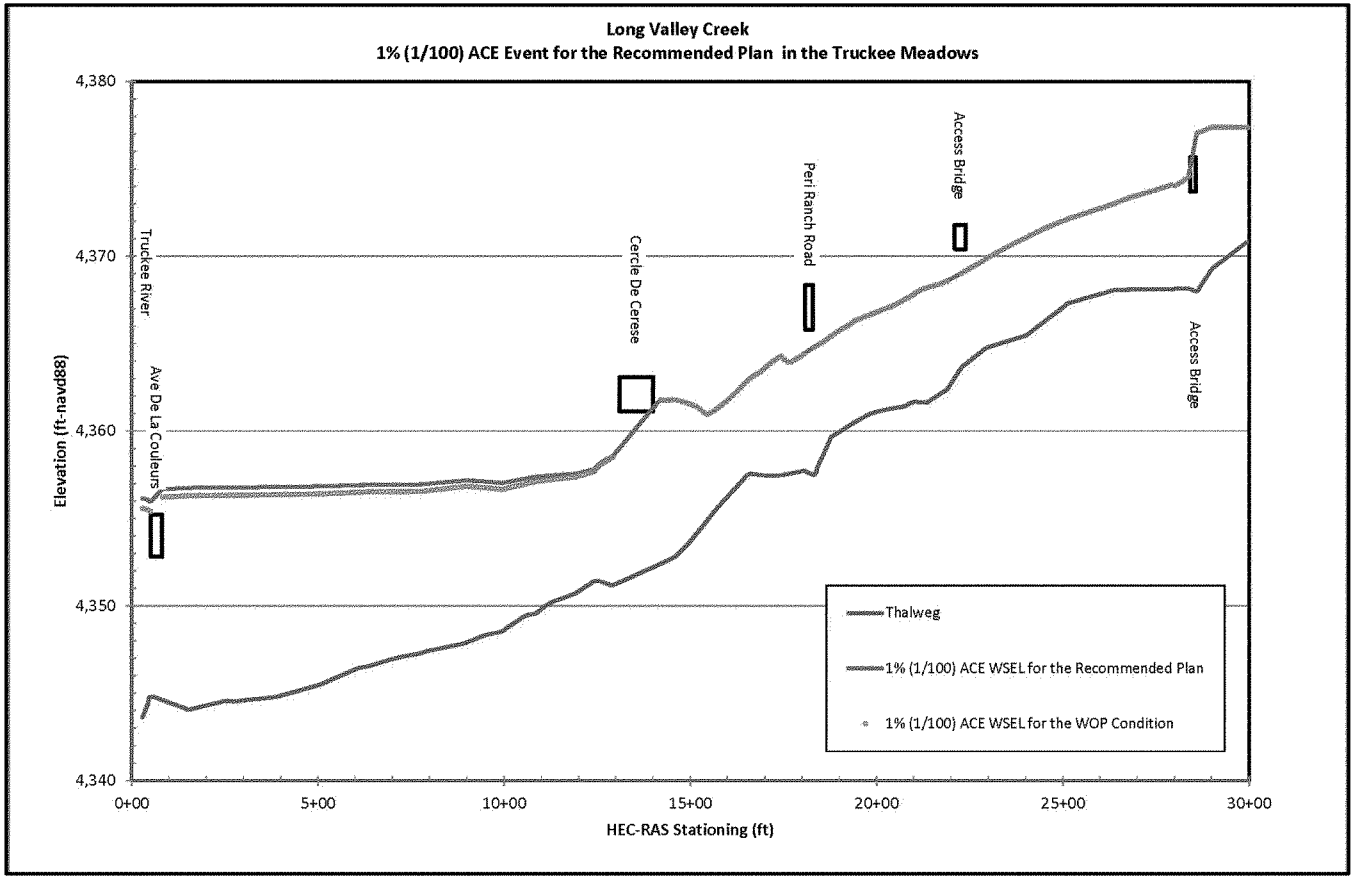


Figure 46. HEC-RAS water surface profiles for Long Valley Creek for the 1% (1/100) ACE event with the Recommended Plan in place

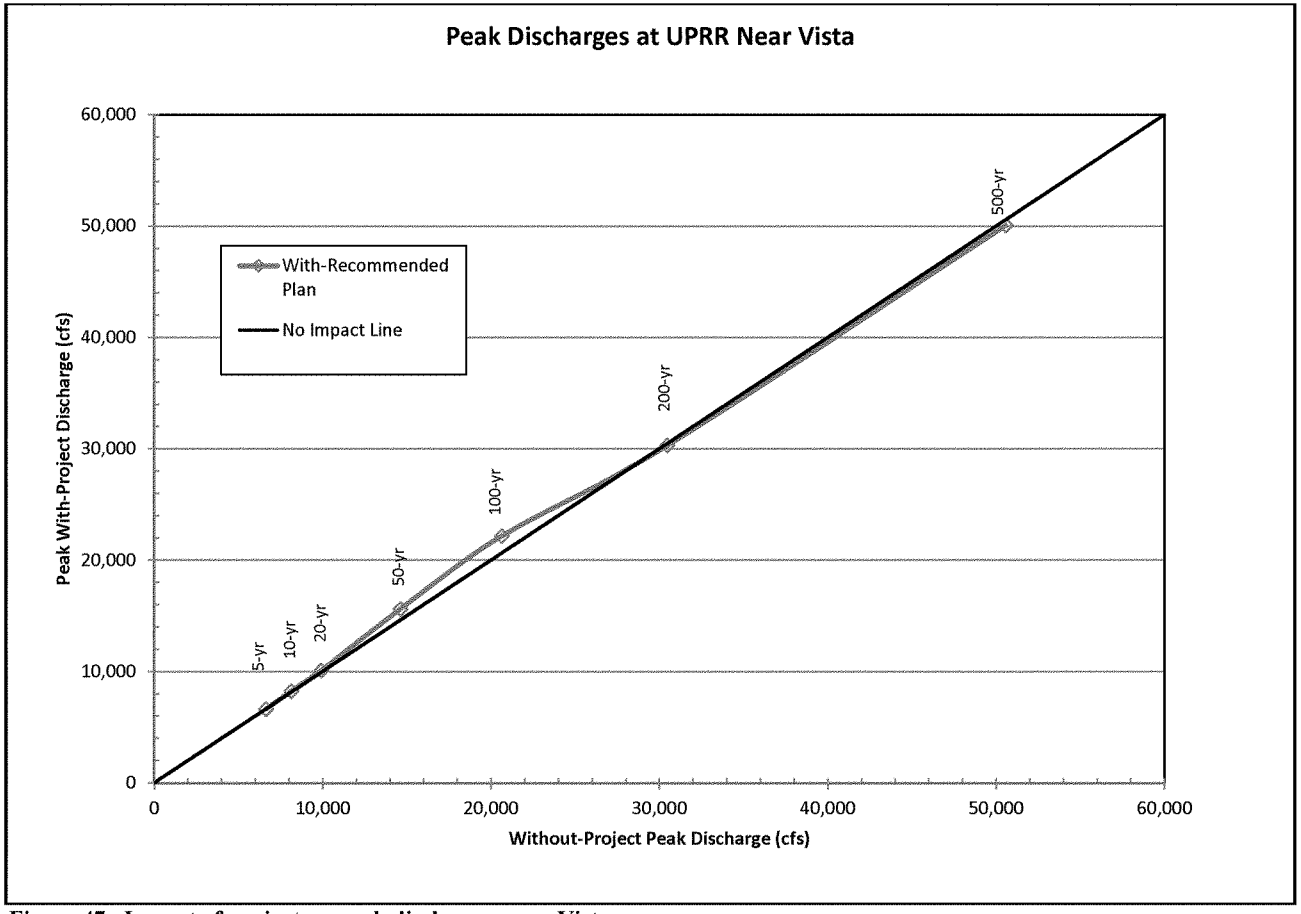
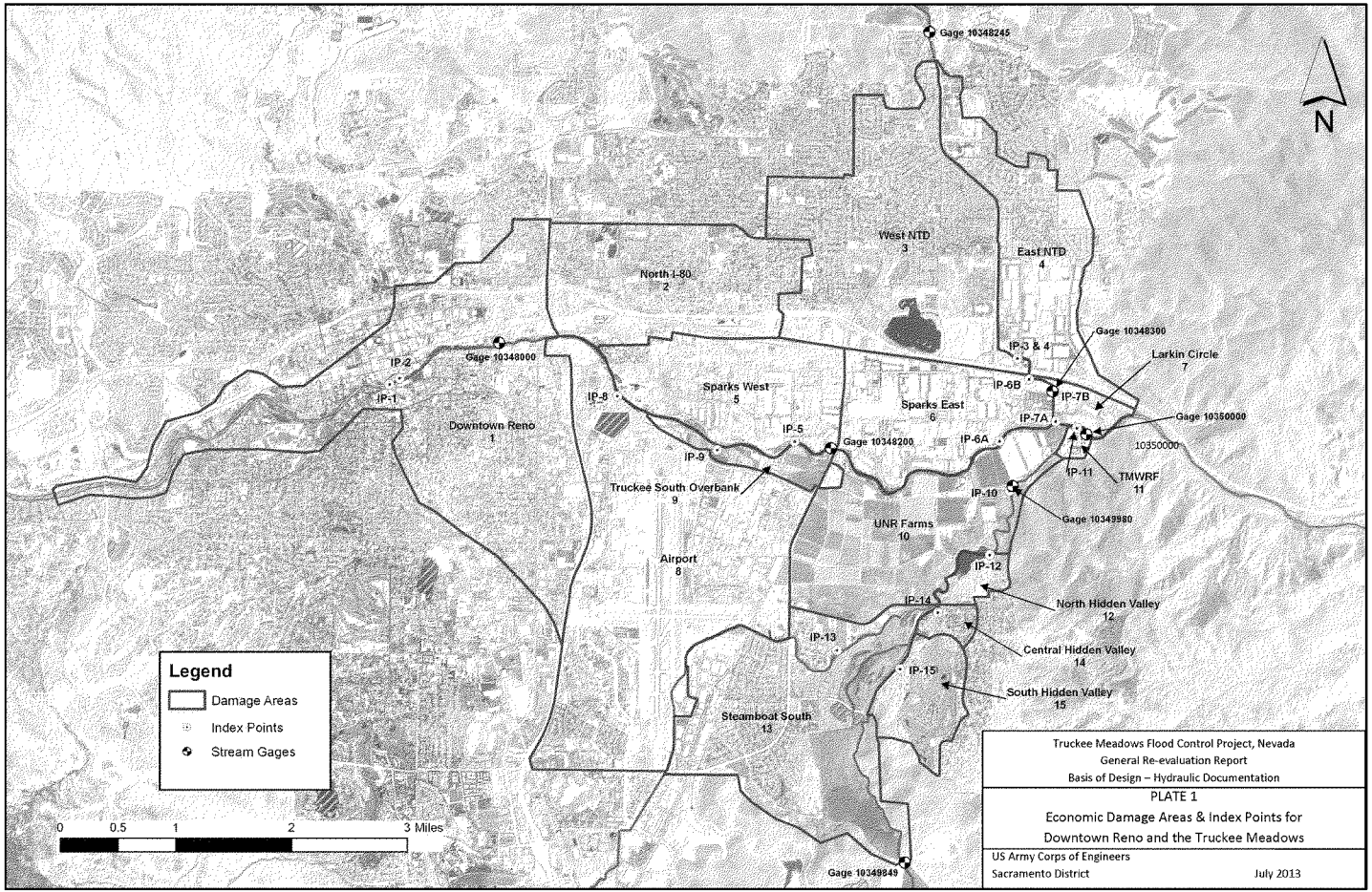


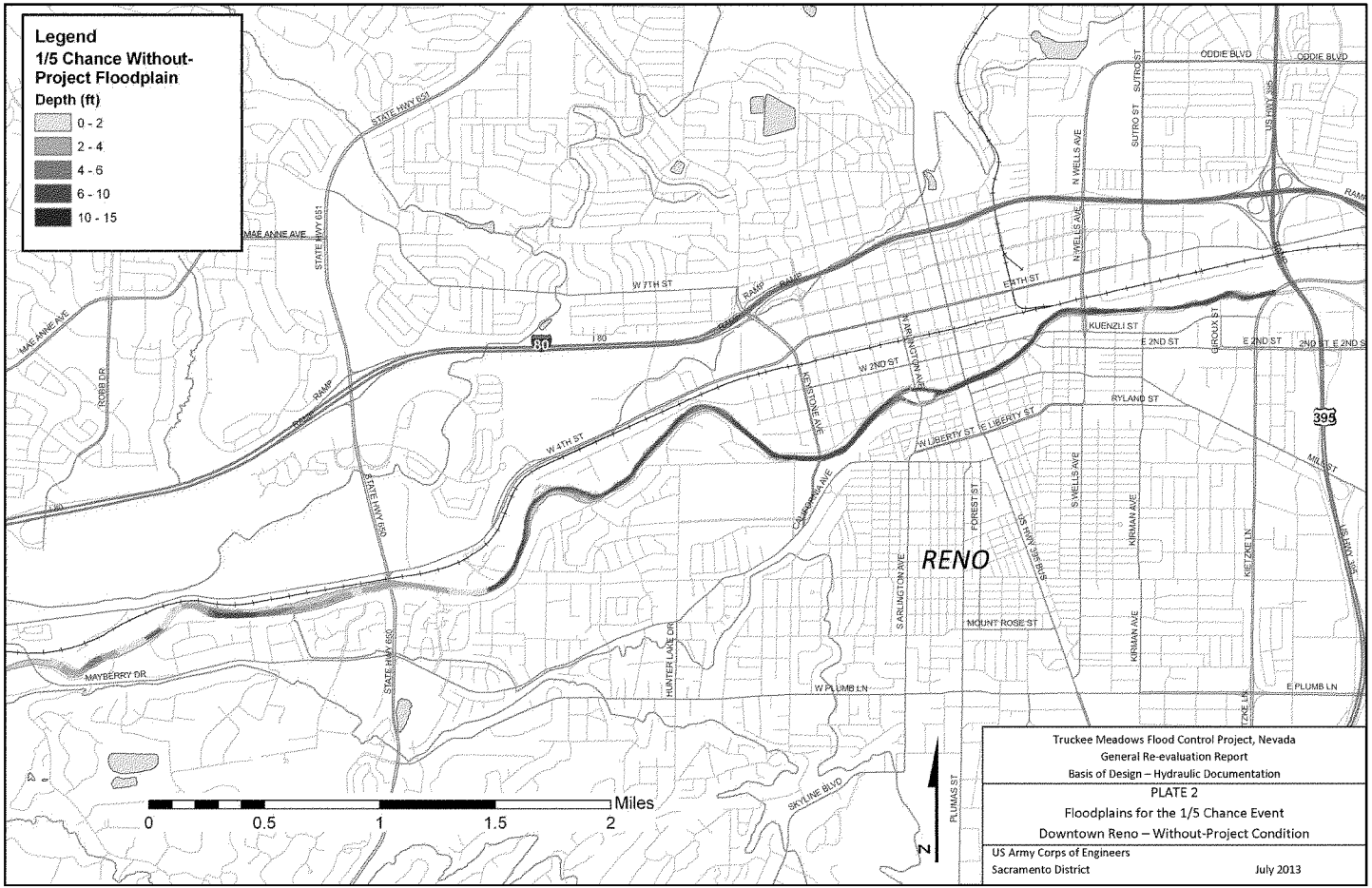
Figure 47. Impact of project on peak discharges near Vista

Attachment B
Hydraulic Design
Truckee Meadows Flood Control Project
Reno, Nevada

Plates (1 – 22)

Floodplains for Downtown Reno and the Truckee Meadows


Gage 10348245
N
West NTD
3
East NTD
4
North I-80
2
Gage 10348300
IP-3 & 4
Larkin Circle
7
IP-2
Gage 10348000
IP-1
IP-8
Sparks West
5
IP-6B
IP-7B
Sparks East
6
IP-7A
Gage 10350000
Downtown Reno
1
IP-5
Gage 10348200
IP-6A
10350000
IP-9
IP-11
TMWRF
11
Truckee South Overbank
9
IP-10
Gage 10349980
UNR Farms
10
Airport
8
IP-12
IP-14
North Hidden Valley
12
IP-13
Central Hidden Valley
14
IP-15
South Hidden Valley
15
Steamboat South
13
Gage 10349849
Legend
Damage Areas
Index Points
Stream Gages
0
0.5
1
2
3 Miles
Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation
PLATE 1
Economic Damage Areas & Index Points for
Downtown Reno and the Truckee Meadows
US Army Corps of Engineers
Sacramento District
July 2013



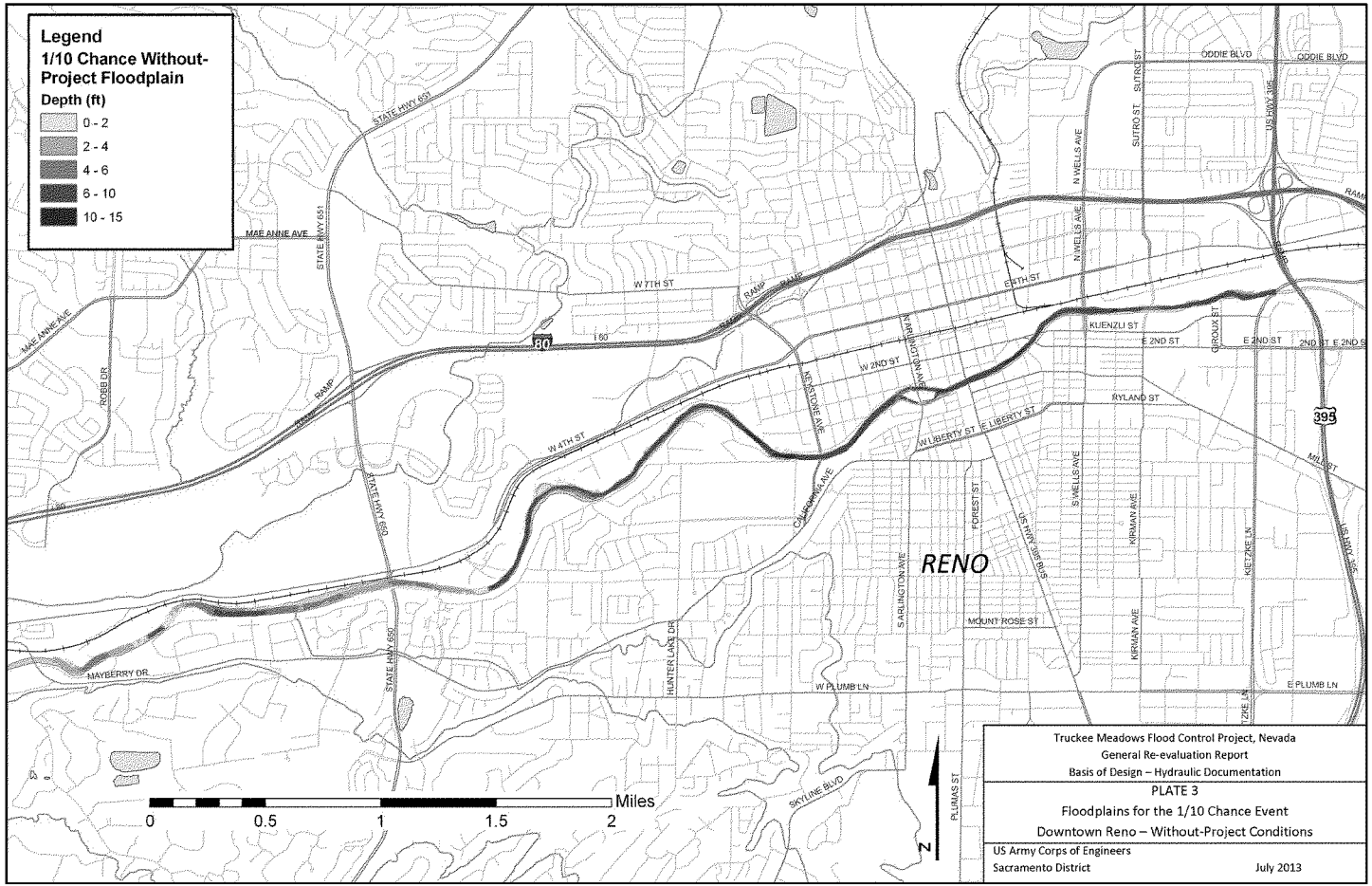
Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation

PLATE 2

Floodplains for the 1/5 Chance Event
Downtown Reno – Without-Project Condition

US Army Corps of Engineers
Sacramento District

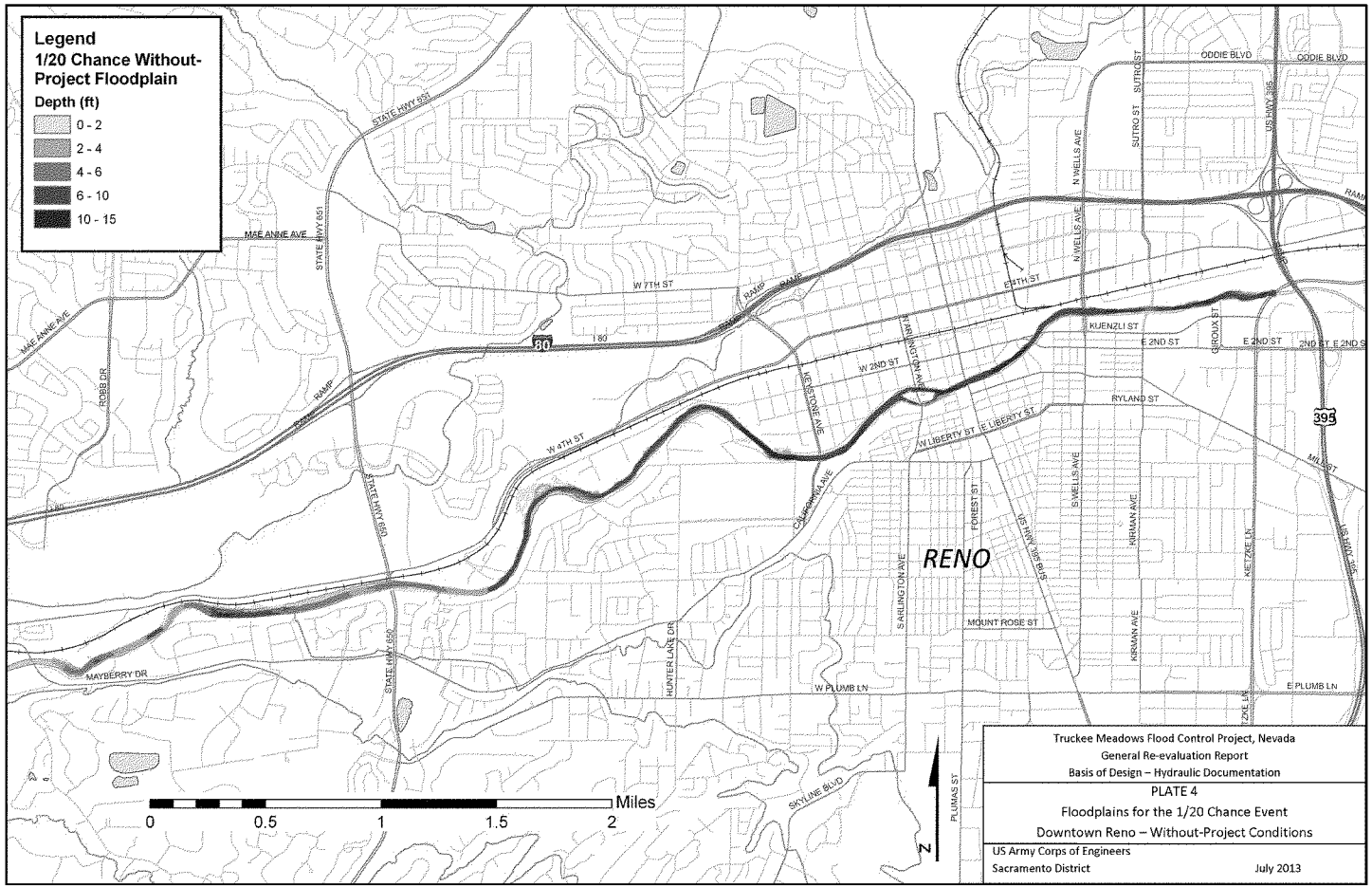
July 2013



Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation

PLATE 3
Floodplains for the 1/10 Chance Event
Downtown Reno – Without-Project Conditions

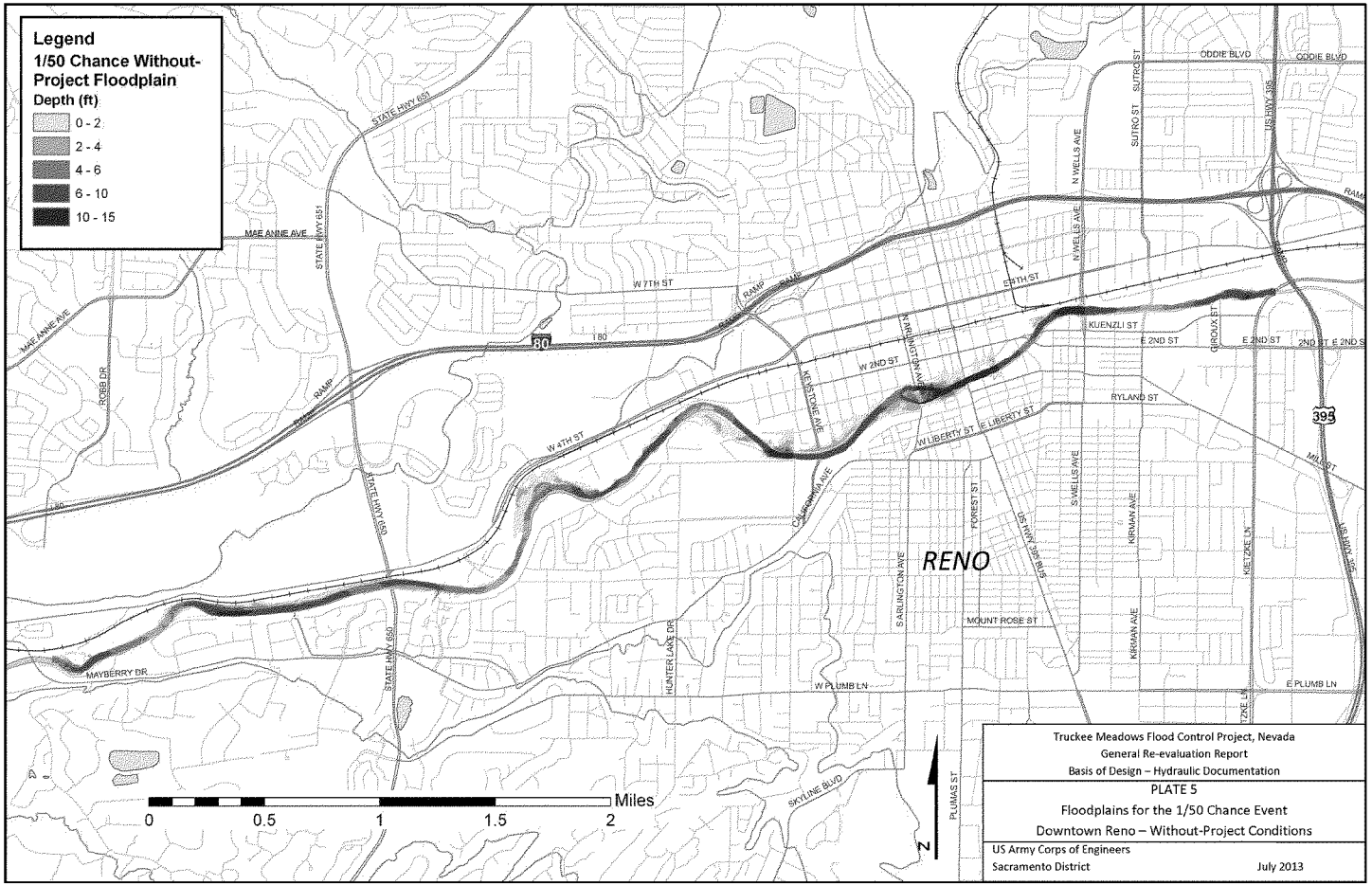
US Army Corps of Engineers
Sacramento District
July 2013



Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation

PLATE 4
Floodplains for the 1/20 Chance Event
Downtown Reno – Without-Project Conditions

US Army Corps of Engineers
Sacramento District
July 2013



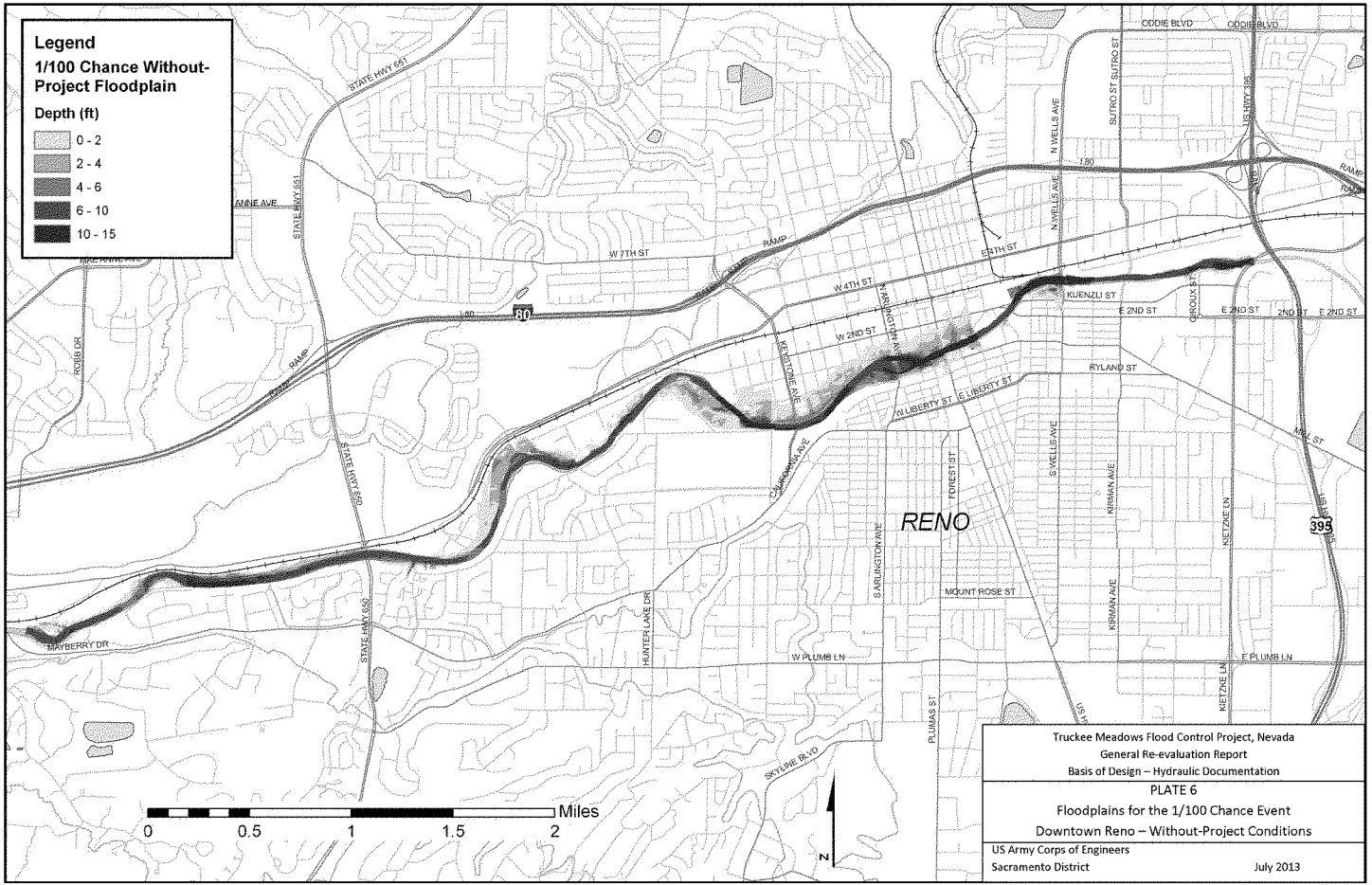
Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation

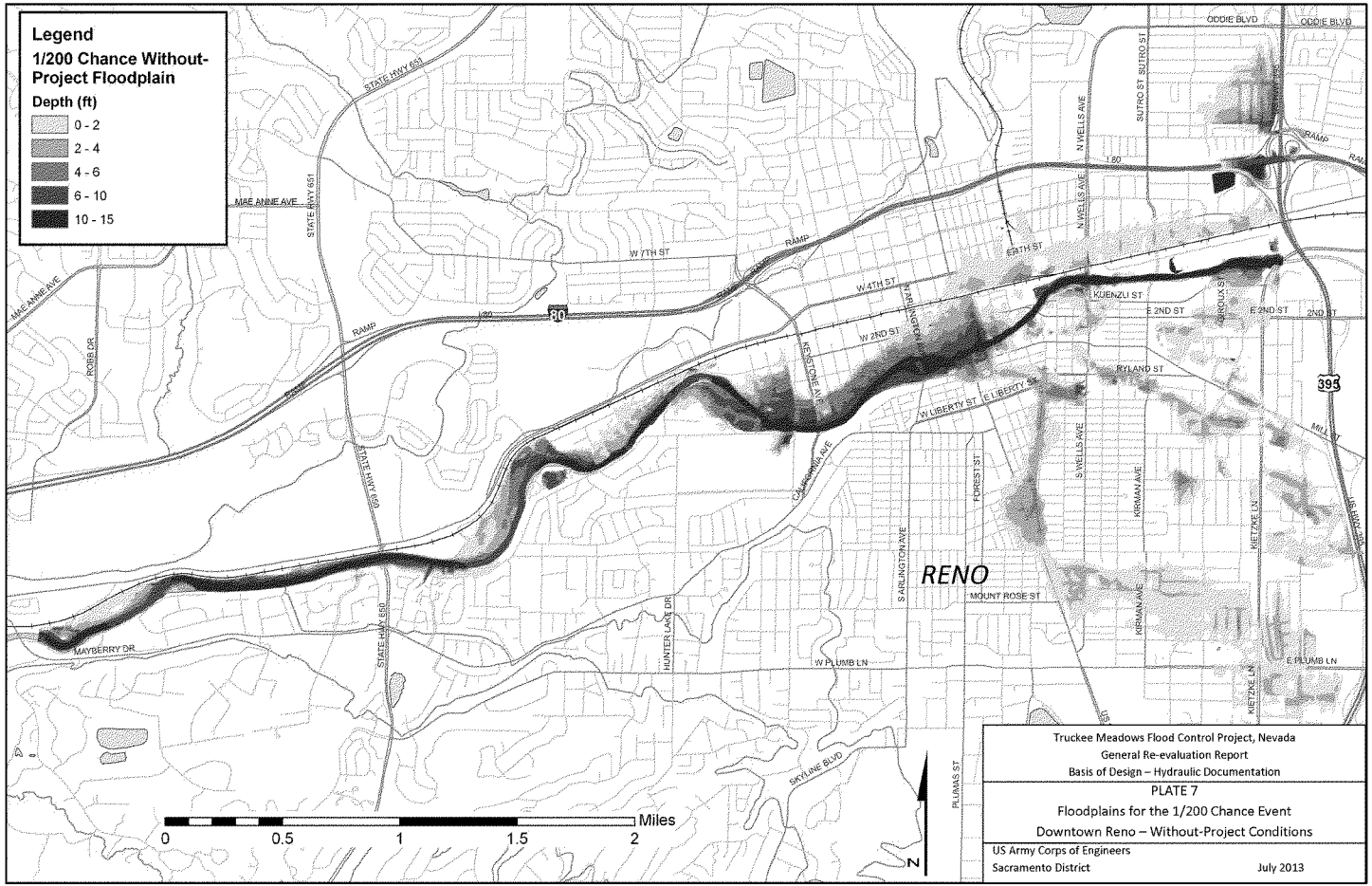
PLATE 5

Floodplains for the 1/50 Chance Event
Downtown Reno – Without-Project Conditions

US Army Corps of Engineers
Sacramento District

July 2013


Legend
1/100 Chance Without-Project Floodplain
Depth (ft)
0 - 2
2 - 4
4 - 6
6 - 10
10 - 15
RENO
ODDIE BLVD
SUTRO ST
N WELLS AVE
W 7TH ST
W 4TH ST
W 2ND ST
E 4TH ST
KUENZU ST
E 2ND ST
RYLAND ST
W LIBERTY ST
E LIBERTY ST
MILL ST
CARSON AVE
KEYSTONE AVE
N ARLINGTON AVE
S ARLINGTON AVE
FOREST ST
S WELLS AVE
KIRMAN AVE
KIETZKE LN
MOUNT ROSE ST
W PLUMB LN
E PLUMB LN
HUNTER LAKE DR
PLUMAS ST
SKYLINE BLVD
STATE HWY 651
STATE HWY 650
ANNE AVE
ROBB DR
MAYBERRY DR
RAMP
I-80
US 395
Miles
0
0.5
1
1.5
2
N
Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation
PLATE 6
Floodplains for the 1/100 Chance Event
Downtown Reno – Without-Project Conditions
US Army Corps of Engineers
Sacramento District
July 2013



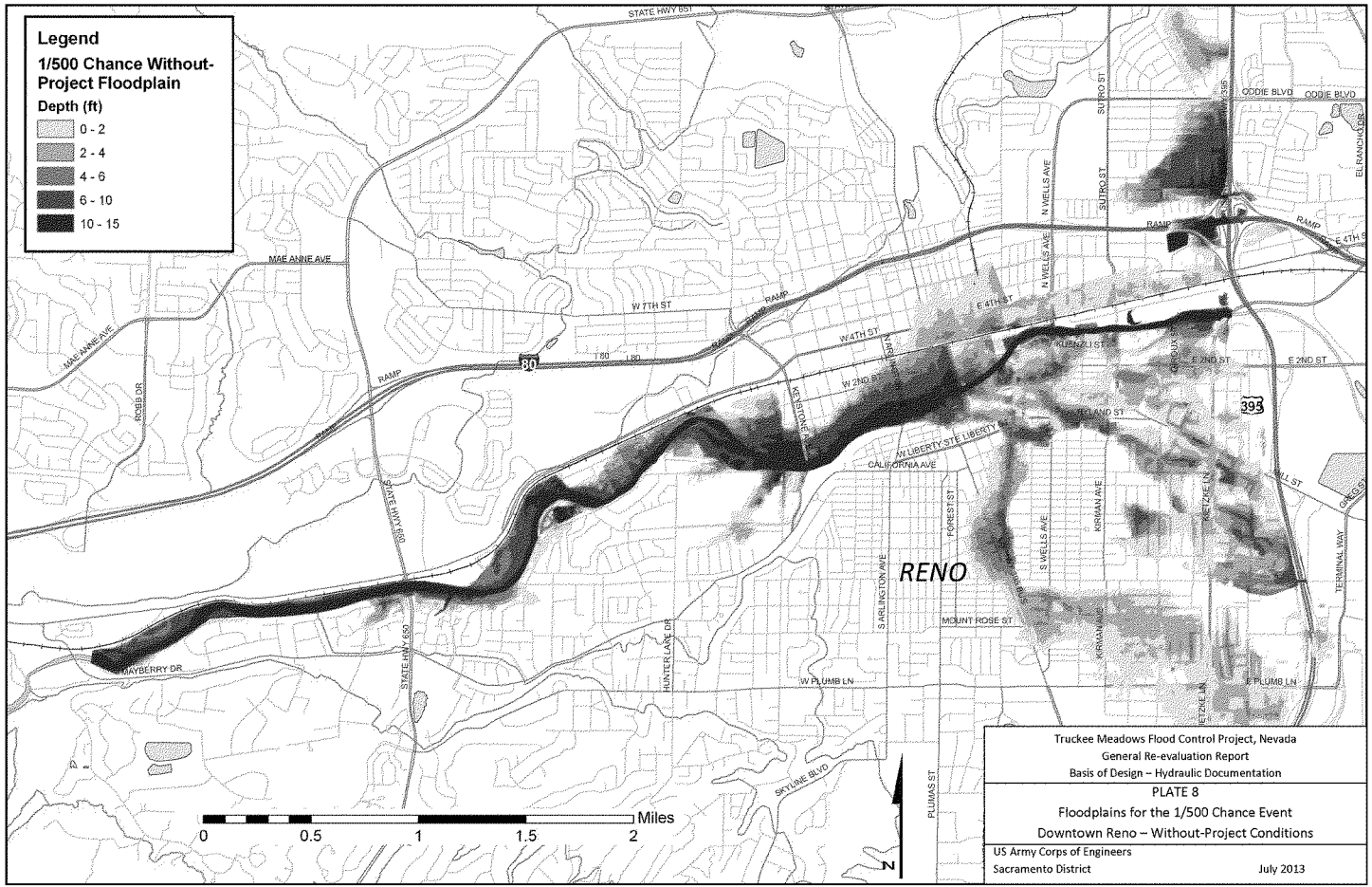
Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation

PLATE 7

Floodplains for the 1/200 Chance Event
Downtown Reno – Without-Project Conditions

US Army Corps of Engineers
Sacramento District

July 2013



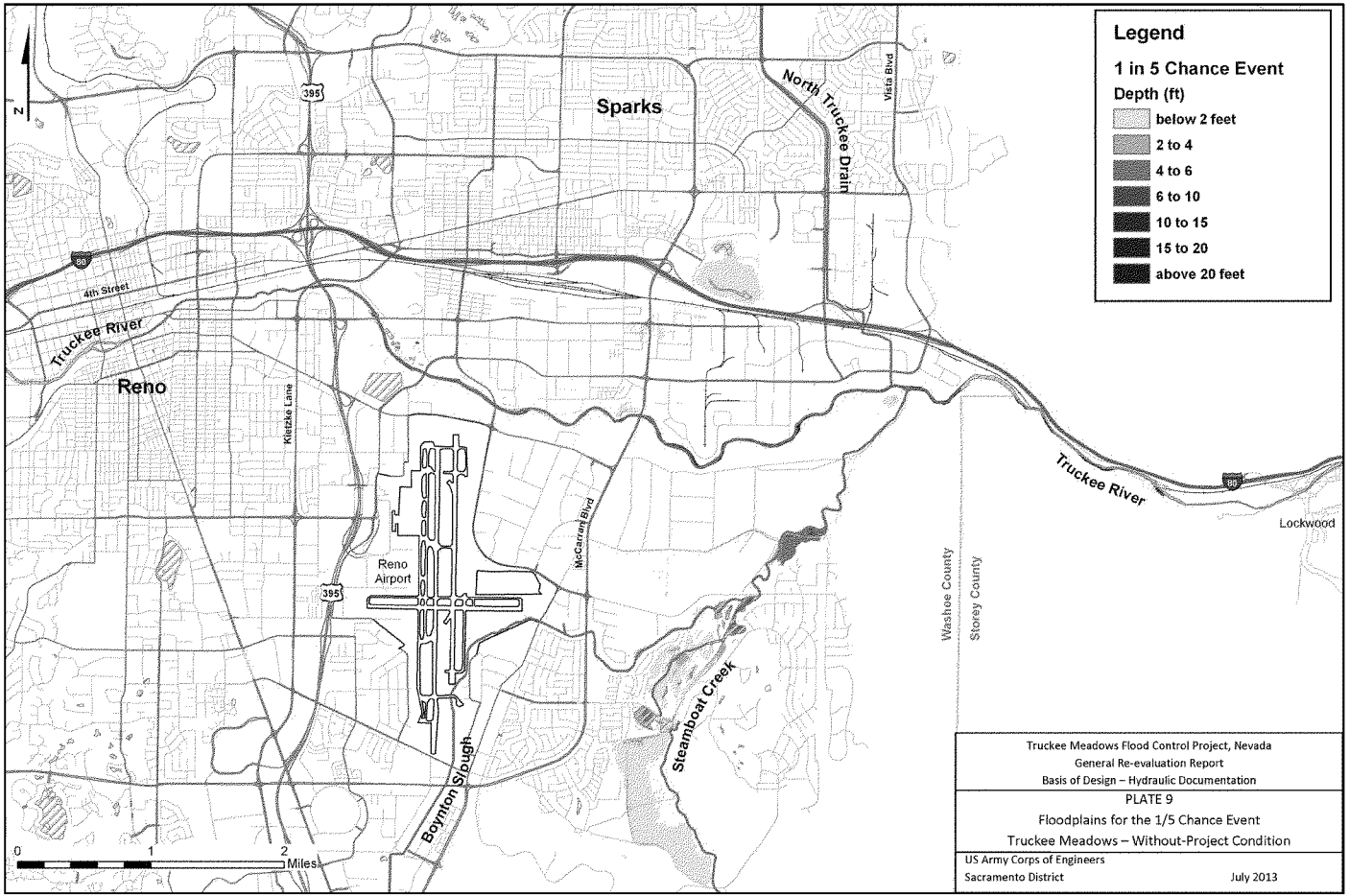
Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation

PLATE 8

Floodplains for the 1/500 Chance Event
Downtown Reno – Without-Project Conditions

US Army Corps of Engineers
Sacramento District

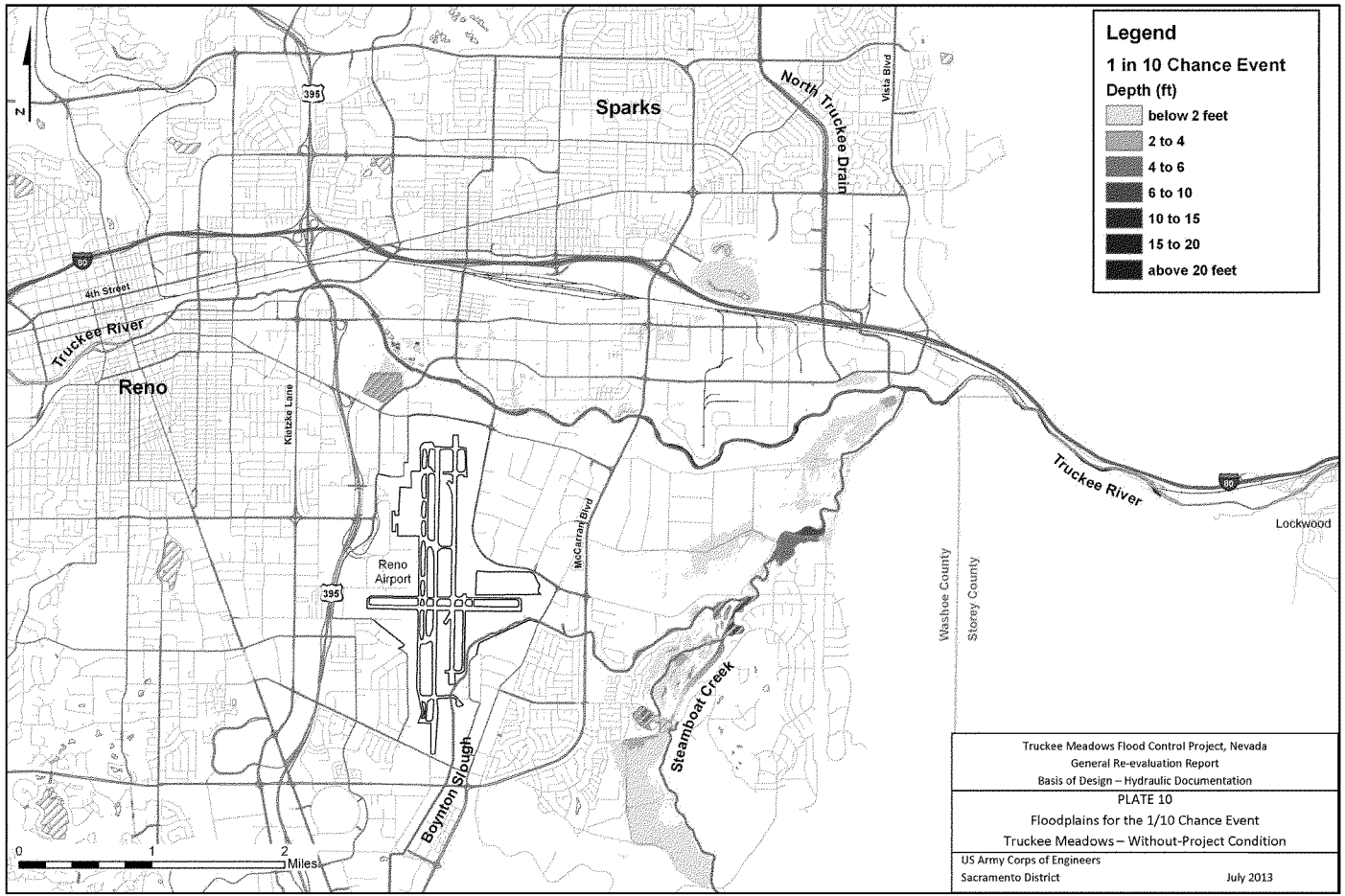
July 2013



Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation

PLATE 9
Floodplains for the 1/5 Chance Event
Truckee Meadows – Without-Project Condition

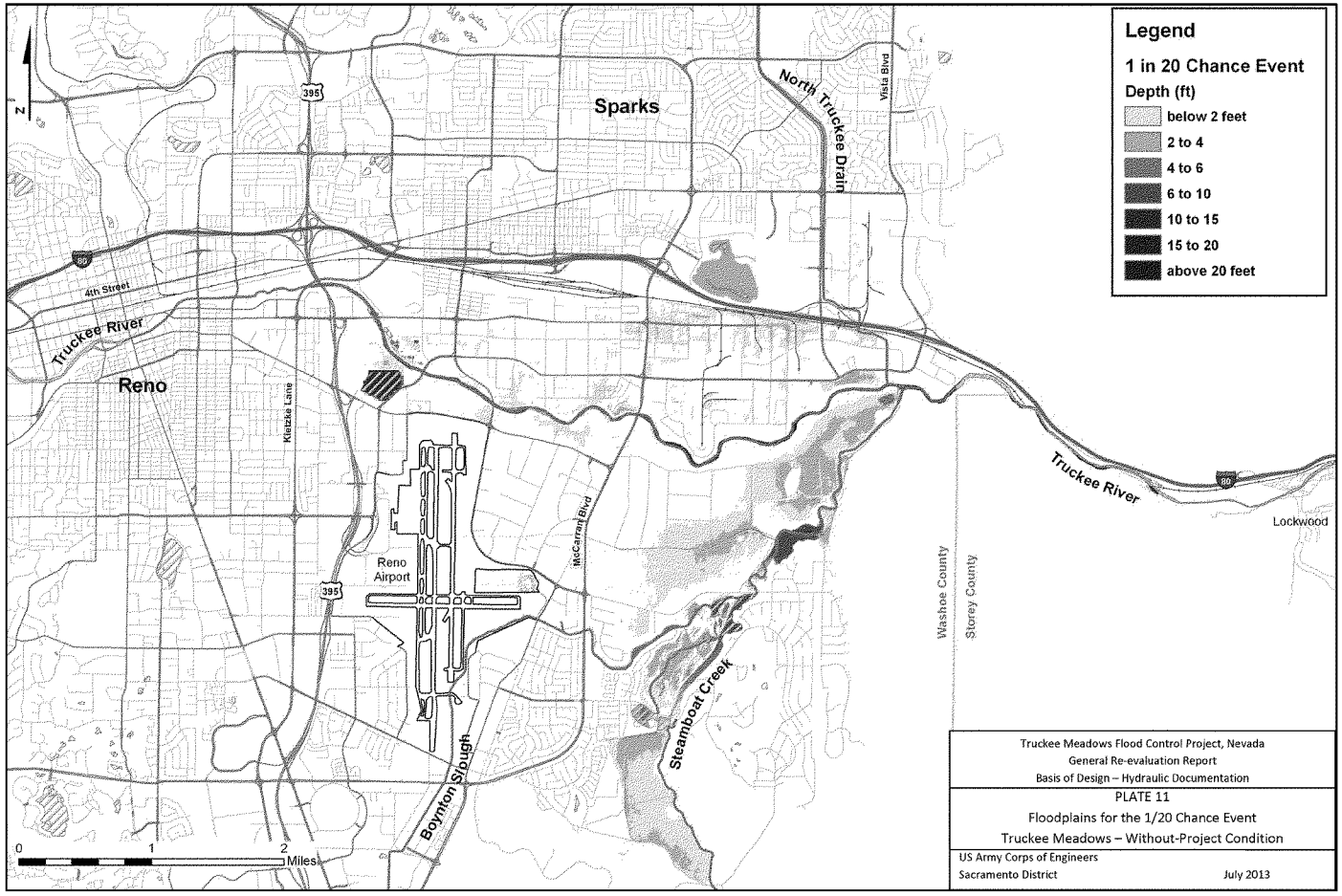
US Army Corps of Engineers
Sacramento District
July 2013



Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation

PLATE 10
Floodplains for the 1/10 Chance Event
Truckee Meadows – Without-Project Condition

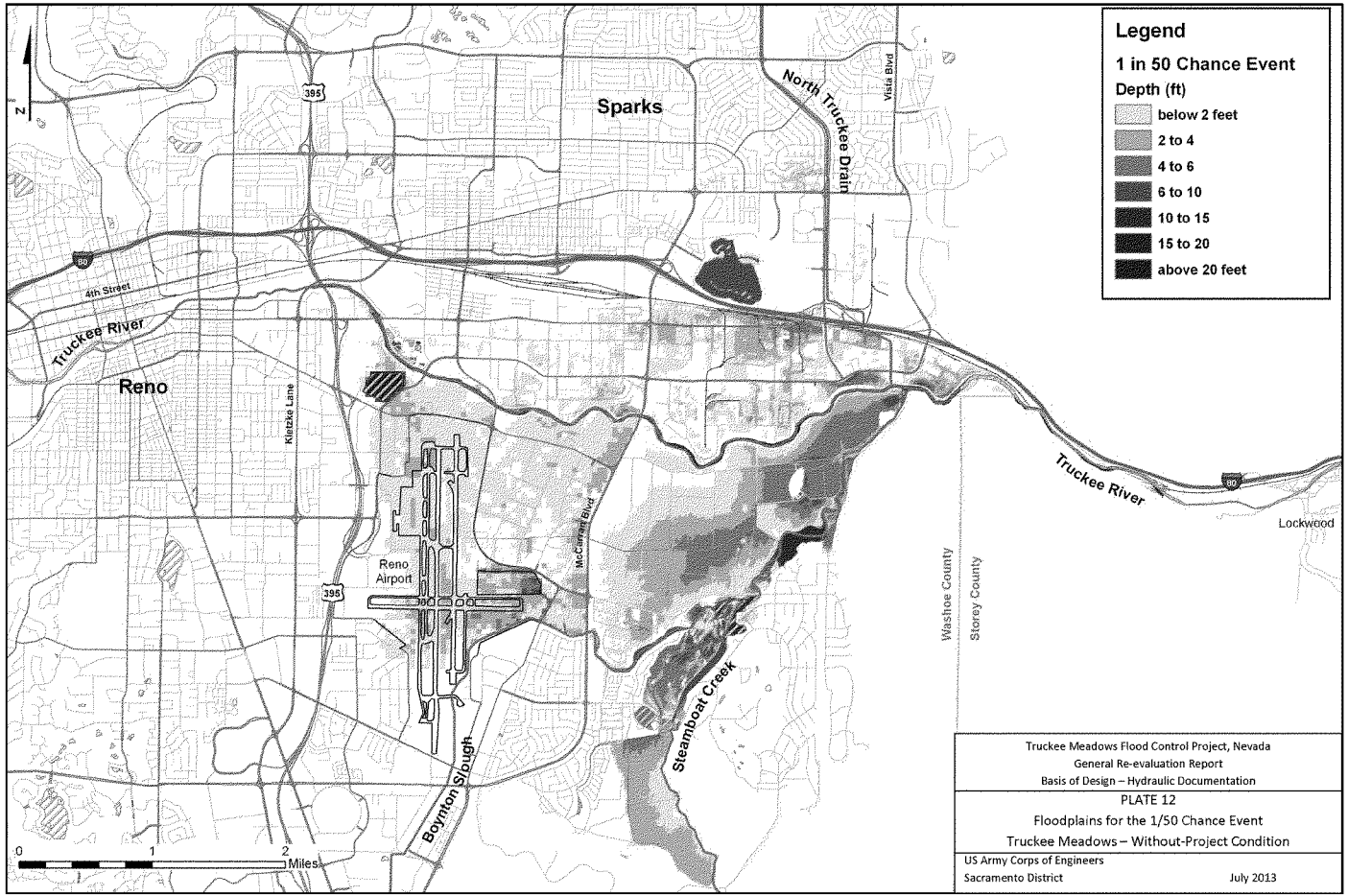
US Army Corps of Engineers
Sacramento District
July 2013



Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation

PLATE 11
Floodplains for the 1/20 Chance Event
Truckee Meadows – Without-Project Condition

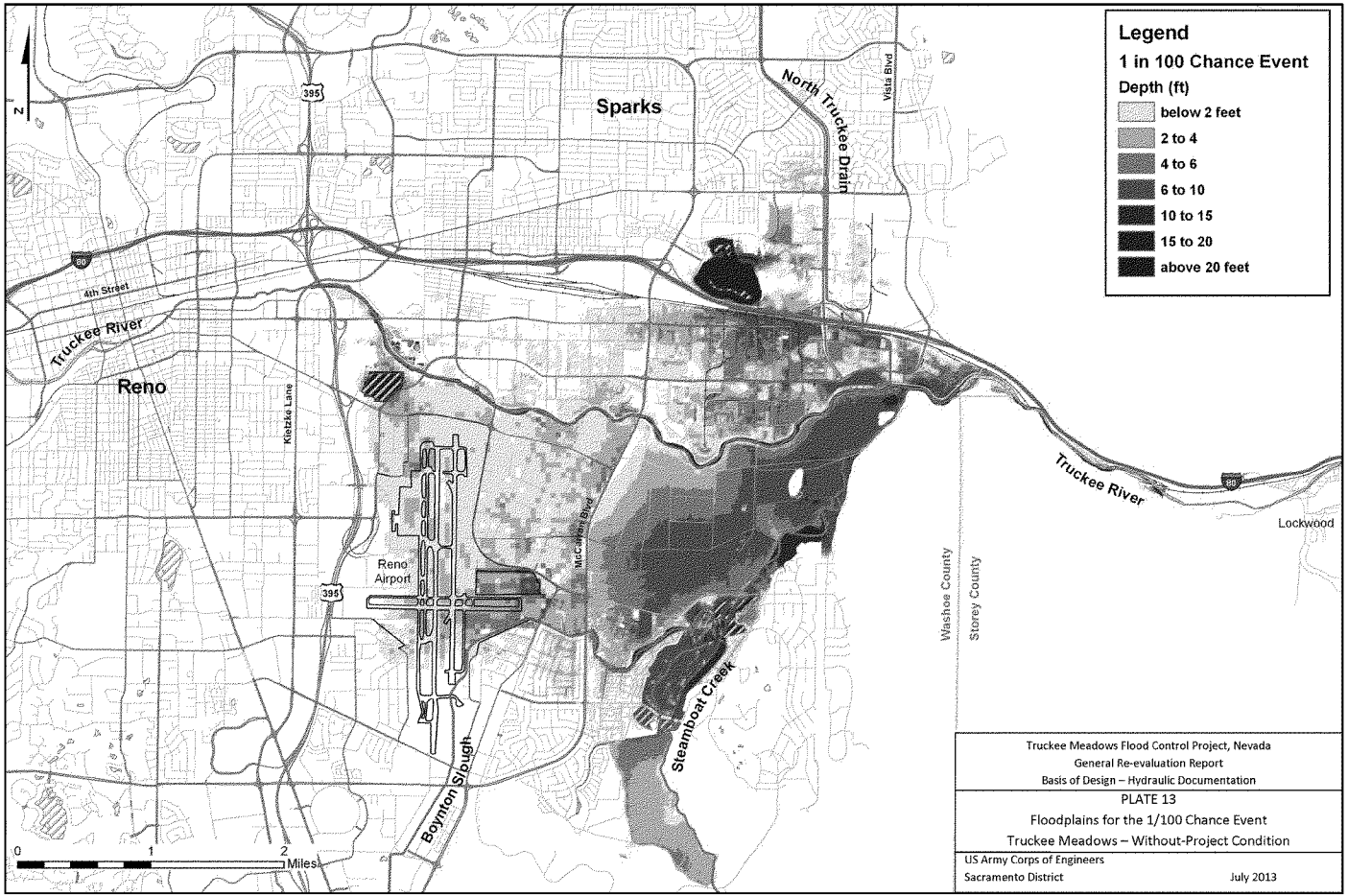
US Army Corps of Engineers
Sacramento District
July 2013



Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation

PLATE 12
Floodplains for the 1/50 Chance Event
Truckee Meadows – Without-Project Condition

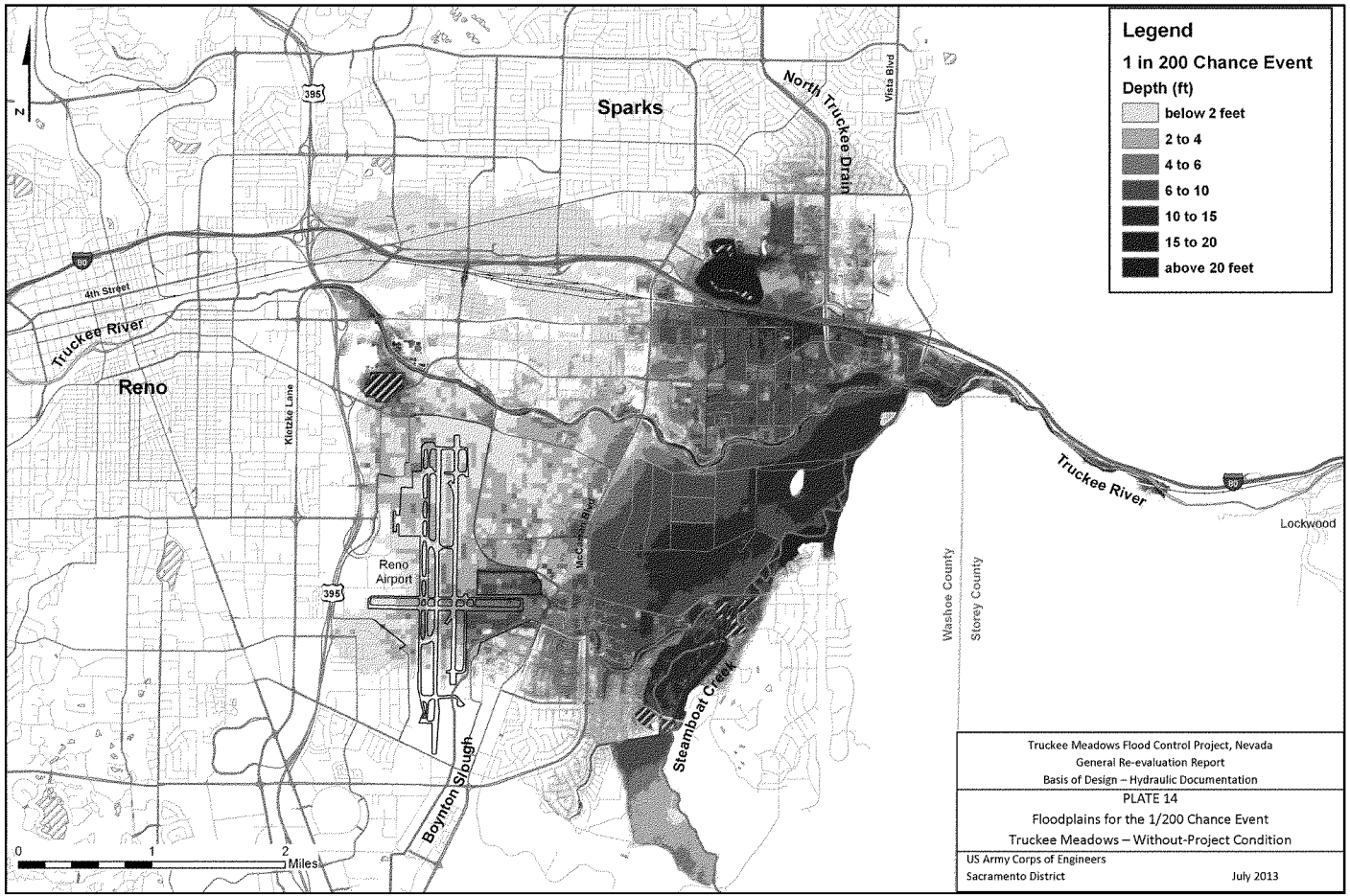
US Army Corps of Engineers
Sacramento District
July 2013



Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation

PLATE 13
Floodplains for the 1/100 Chance Event
Truckee Meadows – Without-Project Condition

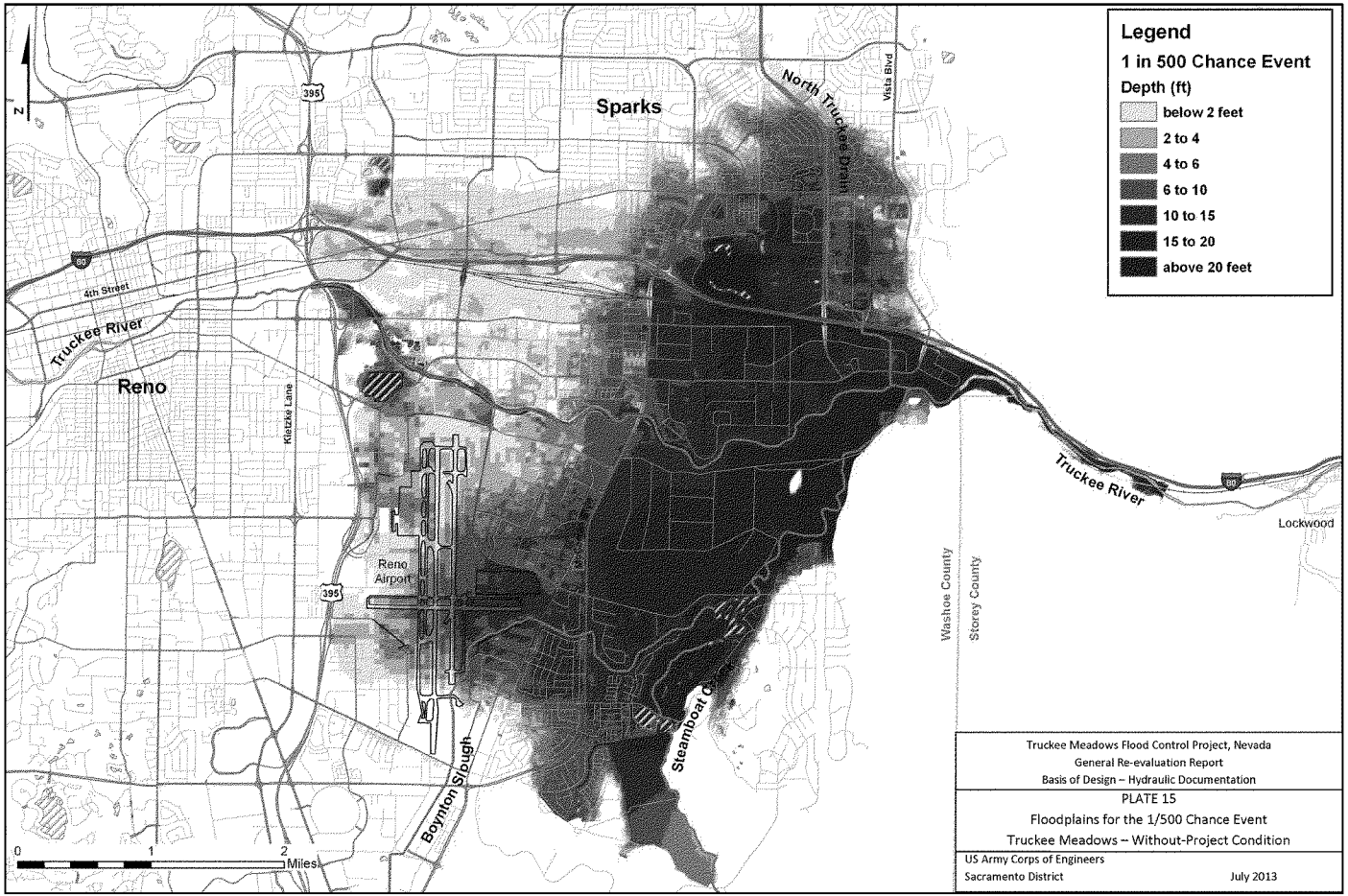
US Army Corps of Engineers
Sacramento District
July 2013



Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation

PLATE 14
Floodplains for the 1/200 Chance Event
Truckee Meadows – Without-Project Condition

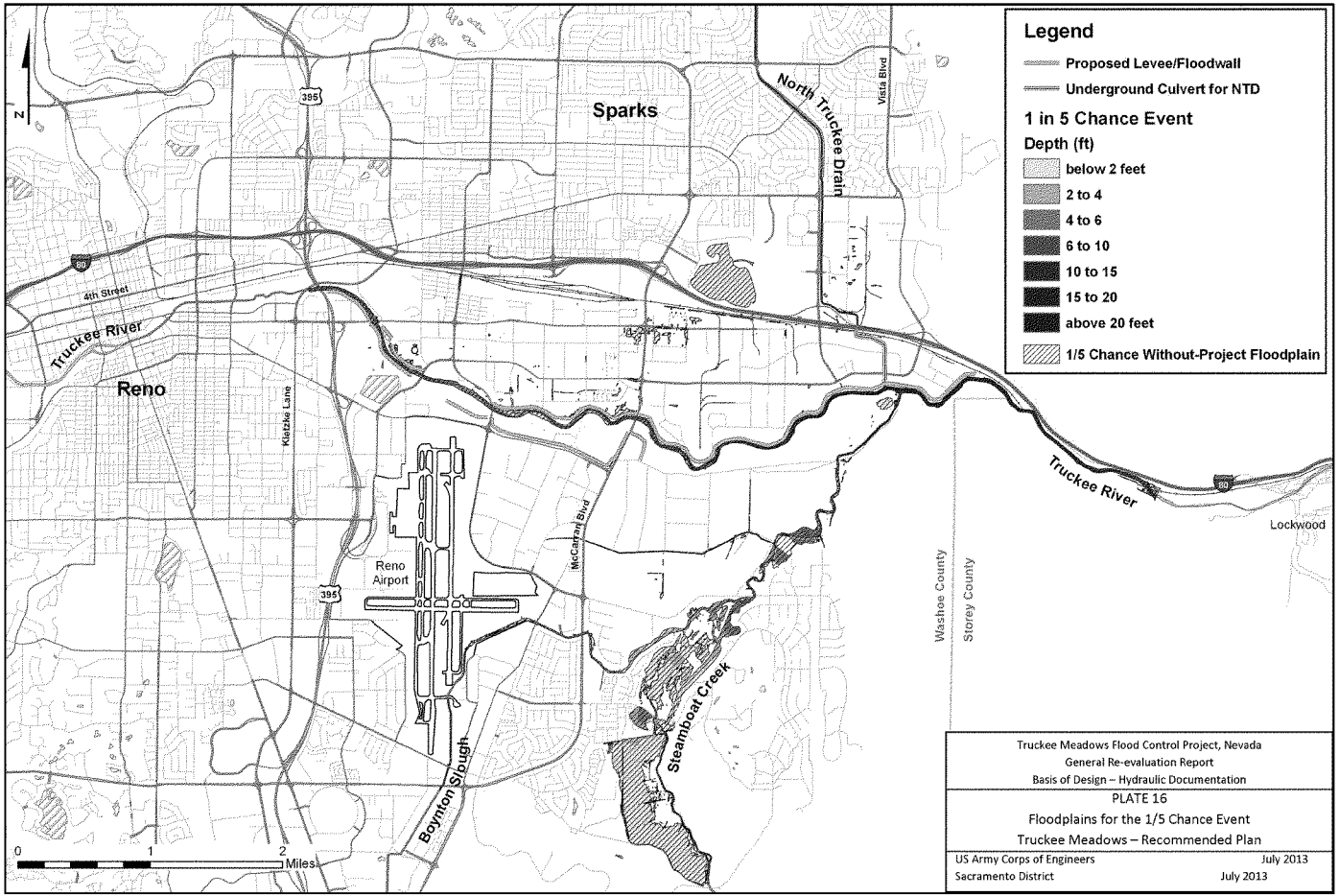
US Army Corps of Engineers
Sacramento District
July 2013



Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation

PLATE 15
Floodplains for the 1/500 Chance Event
Truckee Meadows – Without-Project Condition

US Army Corps of Engineers
Sacramento District
July 2013

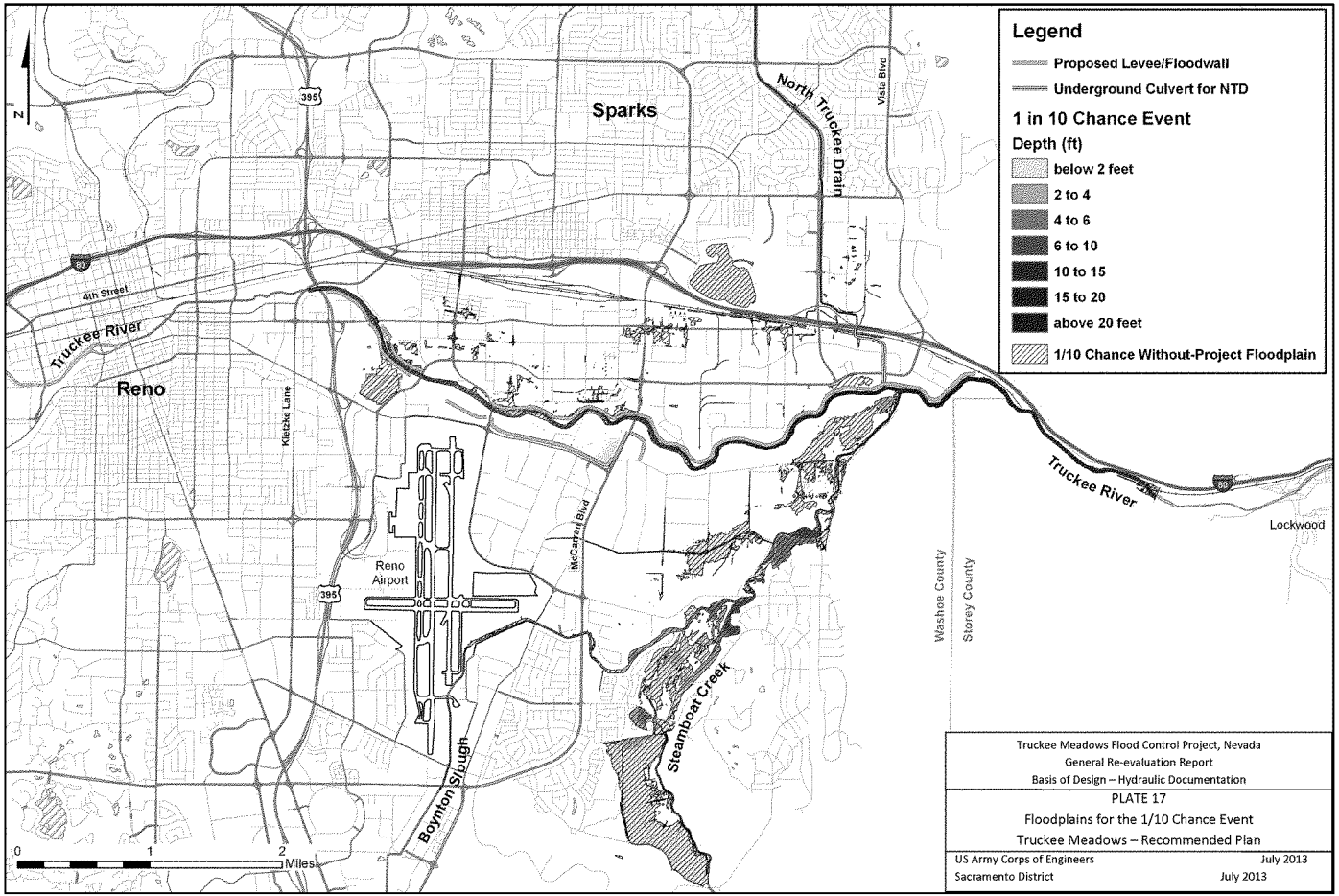


Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation

PLATE 16

Floodplains for the 1/5 Chance Event
Truckee Meadows – Recommended Plan

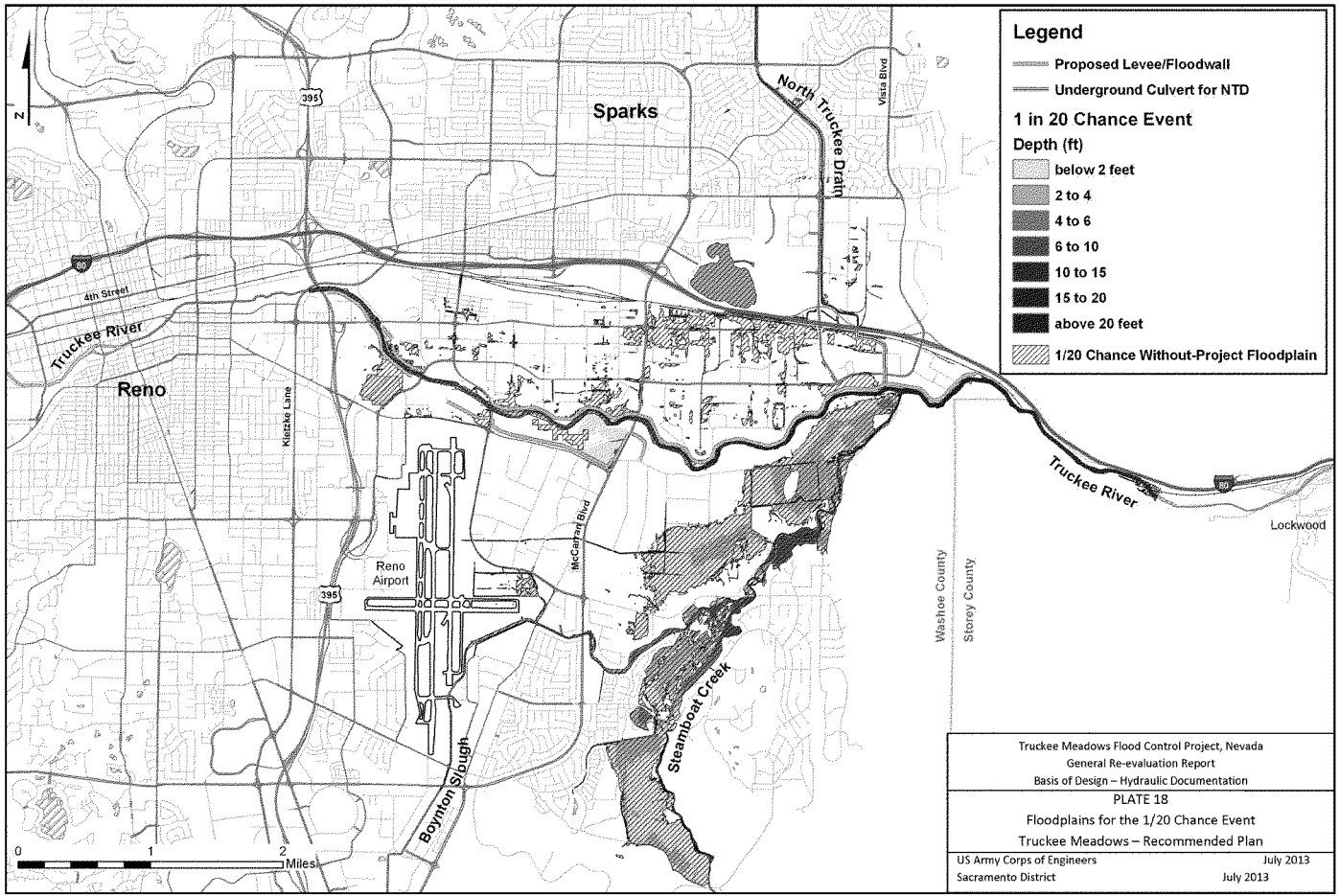
US Army Corps of Engineers July 2013
Sacramento District July 2013



Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation

PLATE 17
Floodplains for the 1/10 Chance Event
Truckee Meadows – Recommended Plan

US Army Corps of Engineers July 2013
Sacramento District July 2013

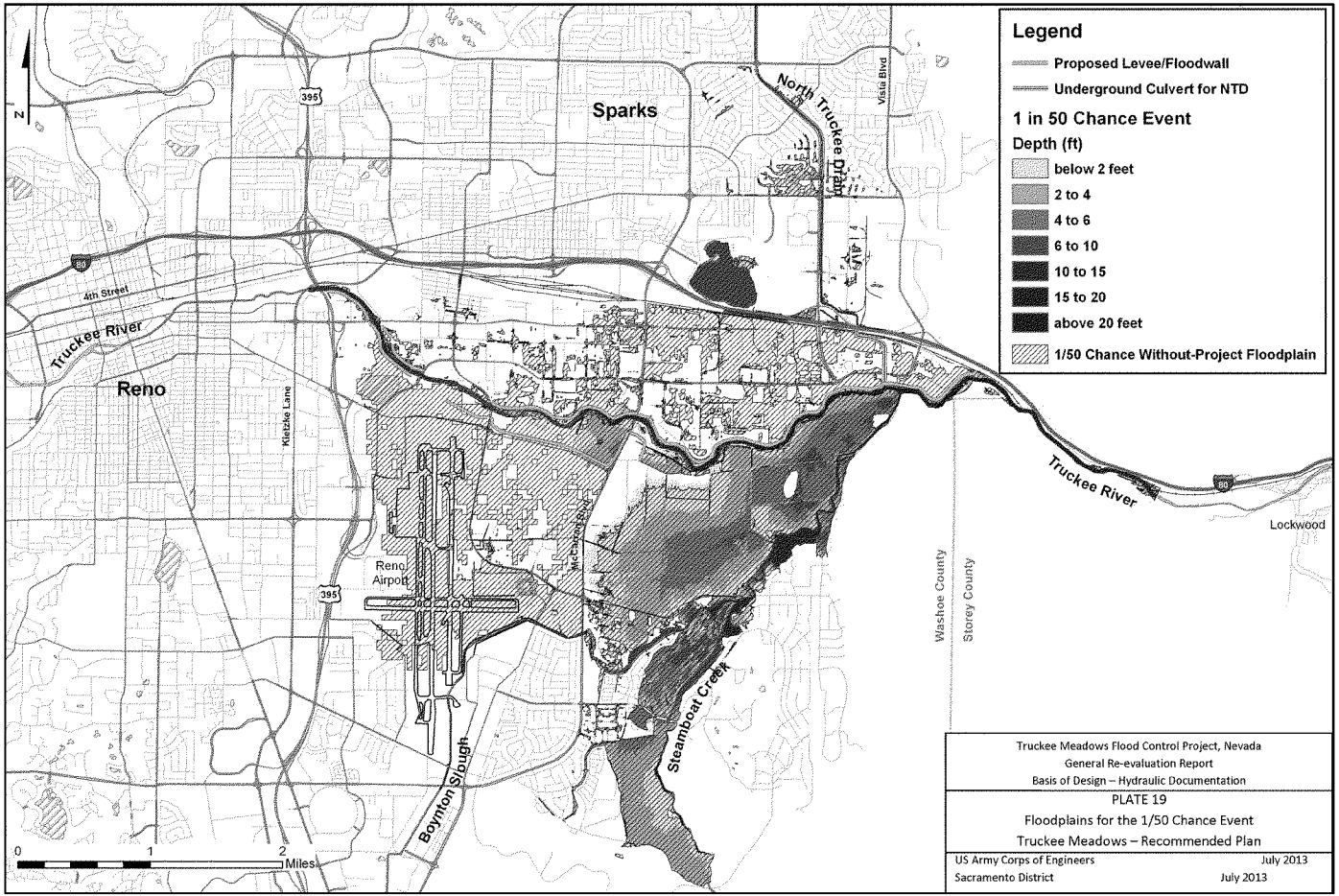


Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation

PLATE 18

Floodplains for the 1/20 Chance Event
Truckee Meadows – Recommended Plan

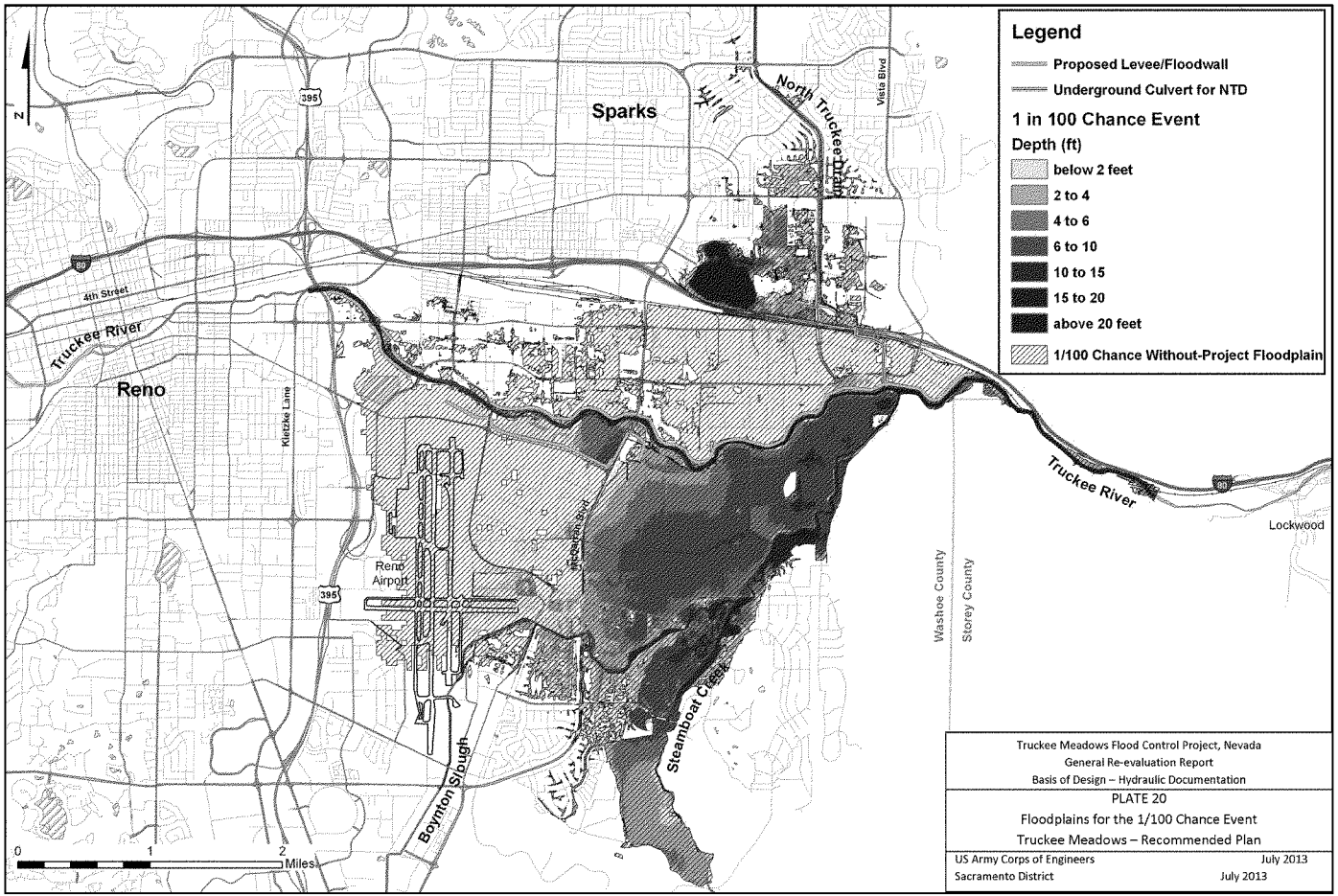
US Army Corps of Engineers July 2013
Sacramento District July 2013



Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation

PLATE 19
Floodplains for the 1/50 Chance Event
Truckee Meadows – Recommended Plan

US Army Corps of Engineers July 2013
Sacramento District July 2013

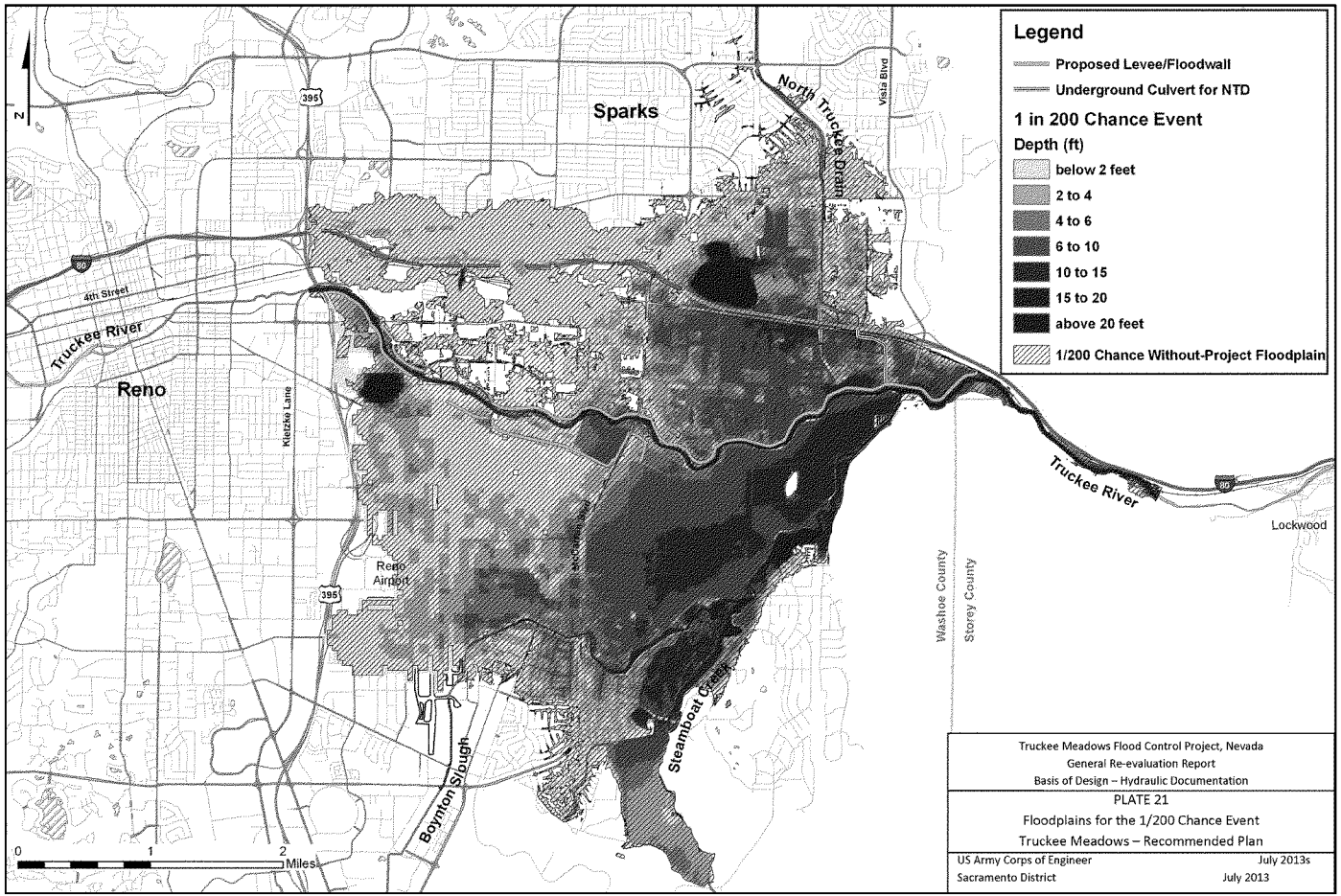


Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation

PLATE 20

Floodplains for the 1/100 Chance Event
Truckee Meadows – Recommended Plan

US Army Corps of Engineers July 2013
Sacramento District July 2013

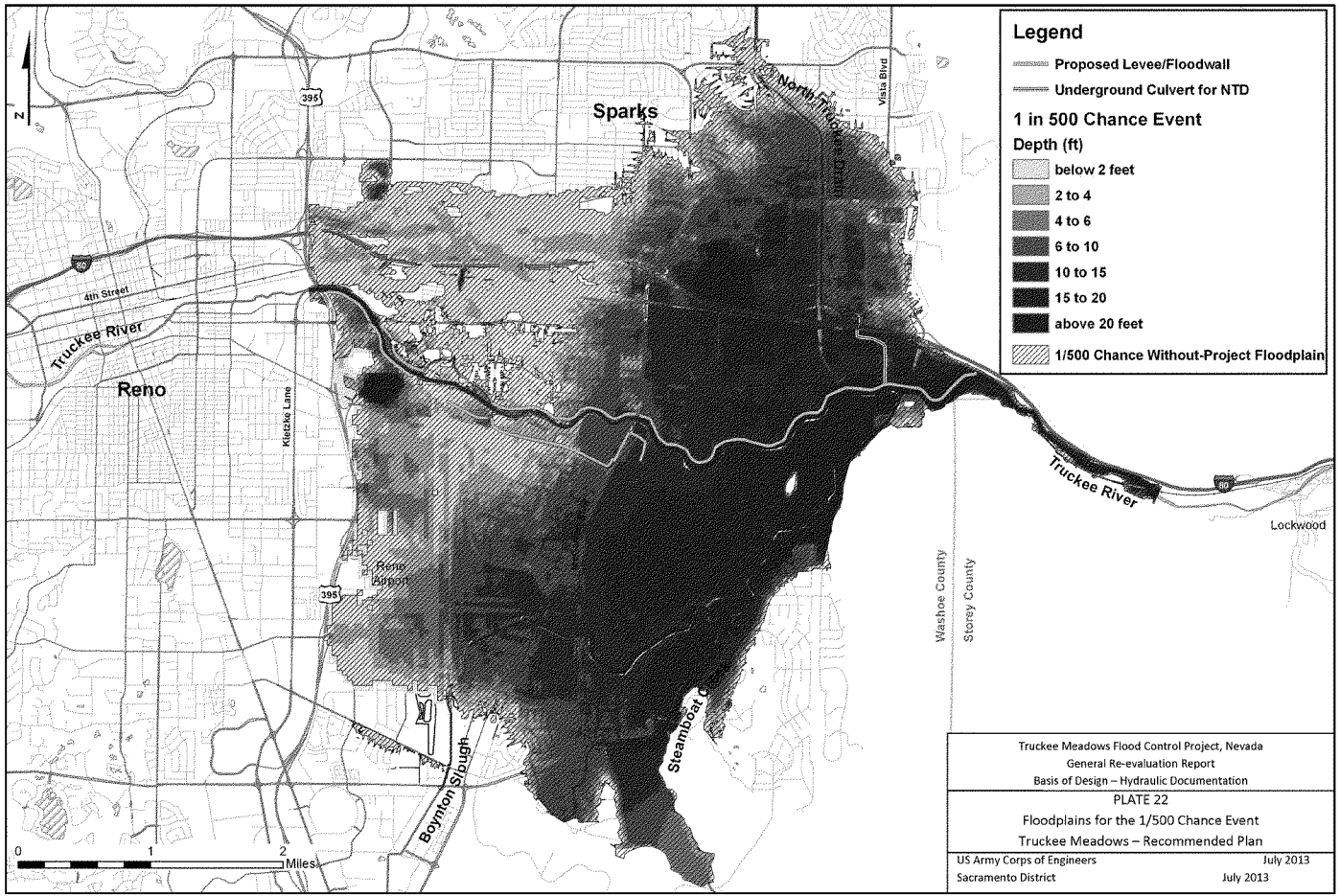


Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation

PLATE 21

Floodplains for the 1/200 Chance Event
Truckee Meadows – Recommended Plan

US Army Corps of Engineer July 2013s
Sacramento District July 2013



Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation

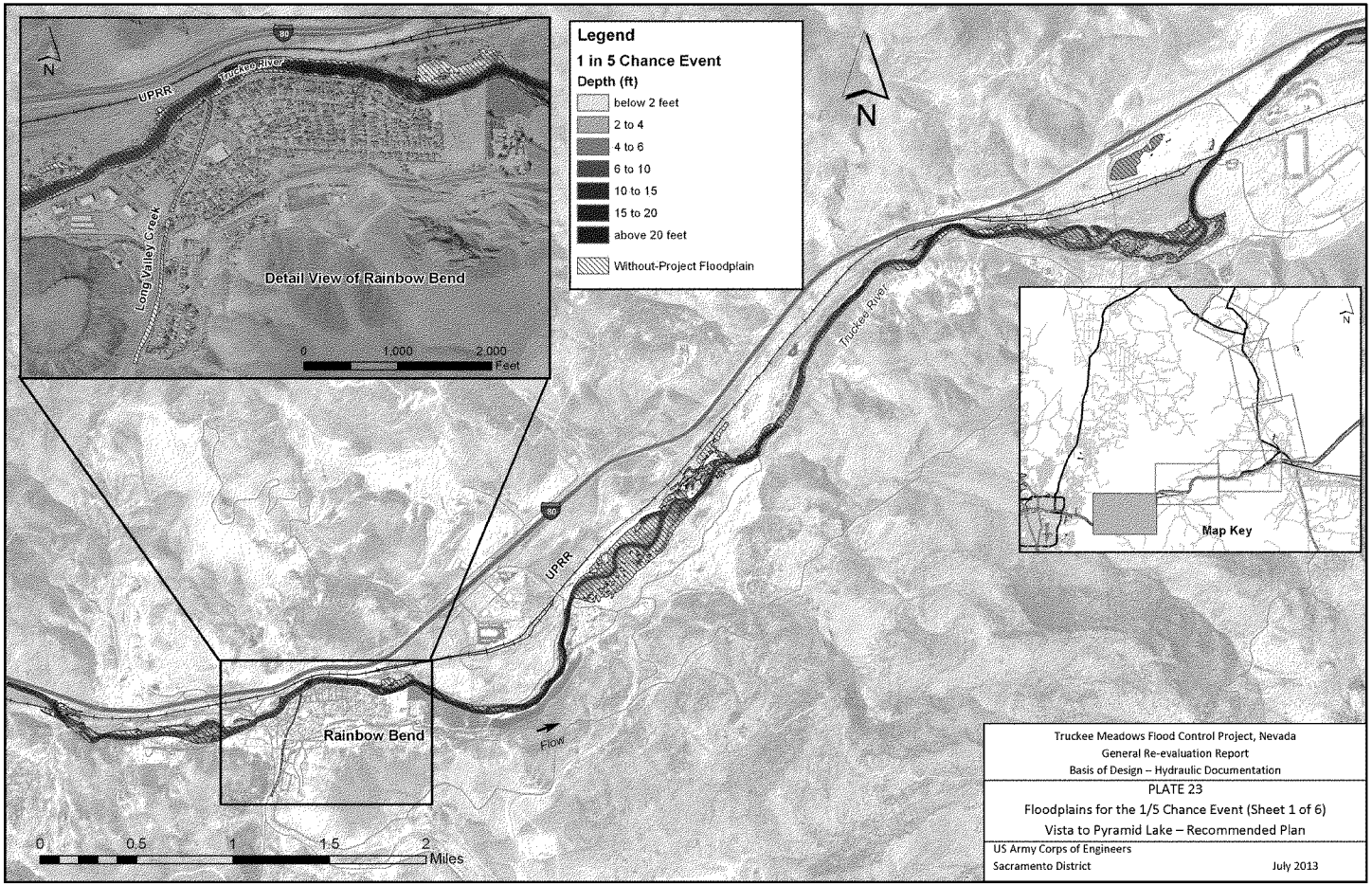
PLATE 22
Floodplains for the 1/500 Chance Event
Truckee Meadows – Recommended Plan

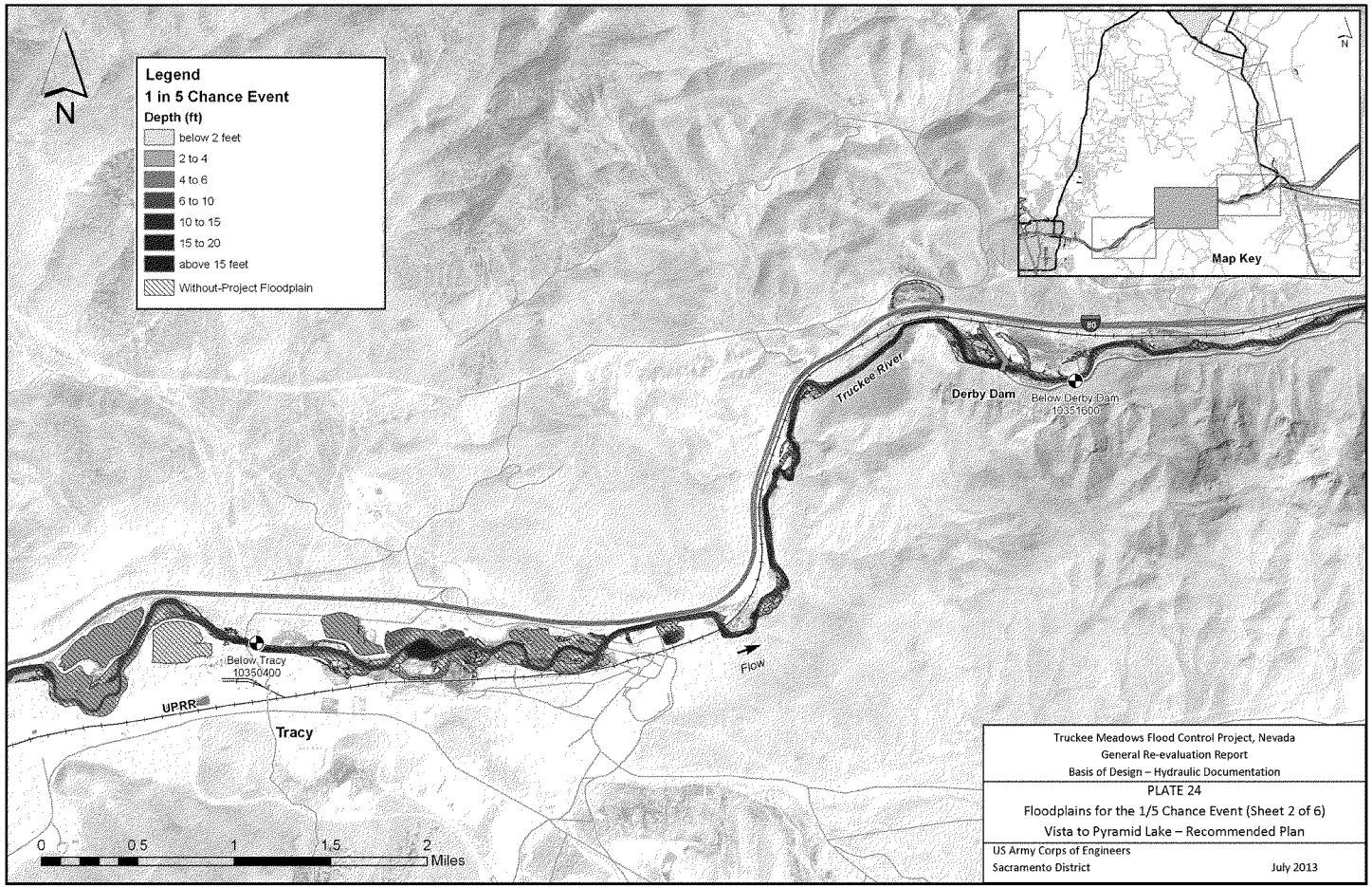
US Army Corps of Engineers July 2013
Sacramento District July 2013

Attachment B
Hydraulic Design
Truckee Meadows Flood Control Project
Reno, Nevada

Plates (23 – 52)

Floodplains for Vista to Pyramid Lake for the 1/50 Chance Annual Exceedance Recommended Plan in the Truckee Meadows

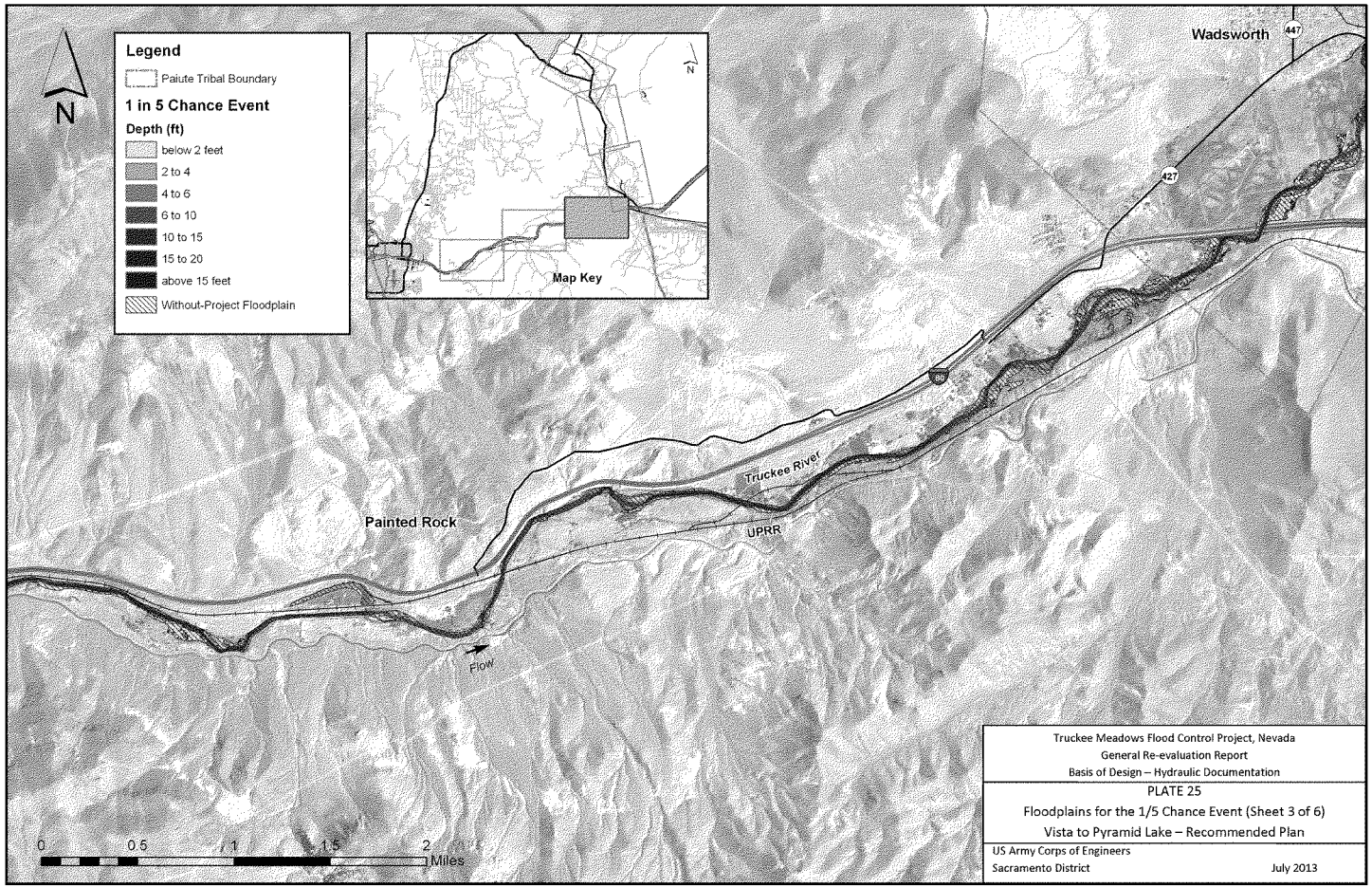

Legend
1 in 5 Chance Event
Depth (ft)
below 2 feet
2 to 4
4 to 6
6 to 10
10 to 15
15 to 20
above 20 feet
Without-Project Floodplain
N
Detail View of Rainbow Bend
UPRR
Truckee River
Long Valley Creek
0
1,000
2,000
Feet
Truckee River
UPRR
Rainbow Bend
Flow
0
0.5
1
1.5
2
Miles
Map Key
Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation
PLATE 23
Floodplains for the 1/5 Chance Event (Sheet 1 of 6)
Vista to Pyramid Lake – Recommended Plan
US Army Corps of Engineers
Sacramento District
July 2013



Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation

PLATE 24
Floodplains for the 1/5 Chance Event (Sheet 2 of 6)
Vista to Pyramid Lake – Recommended Plan

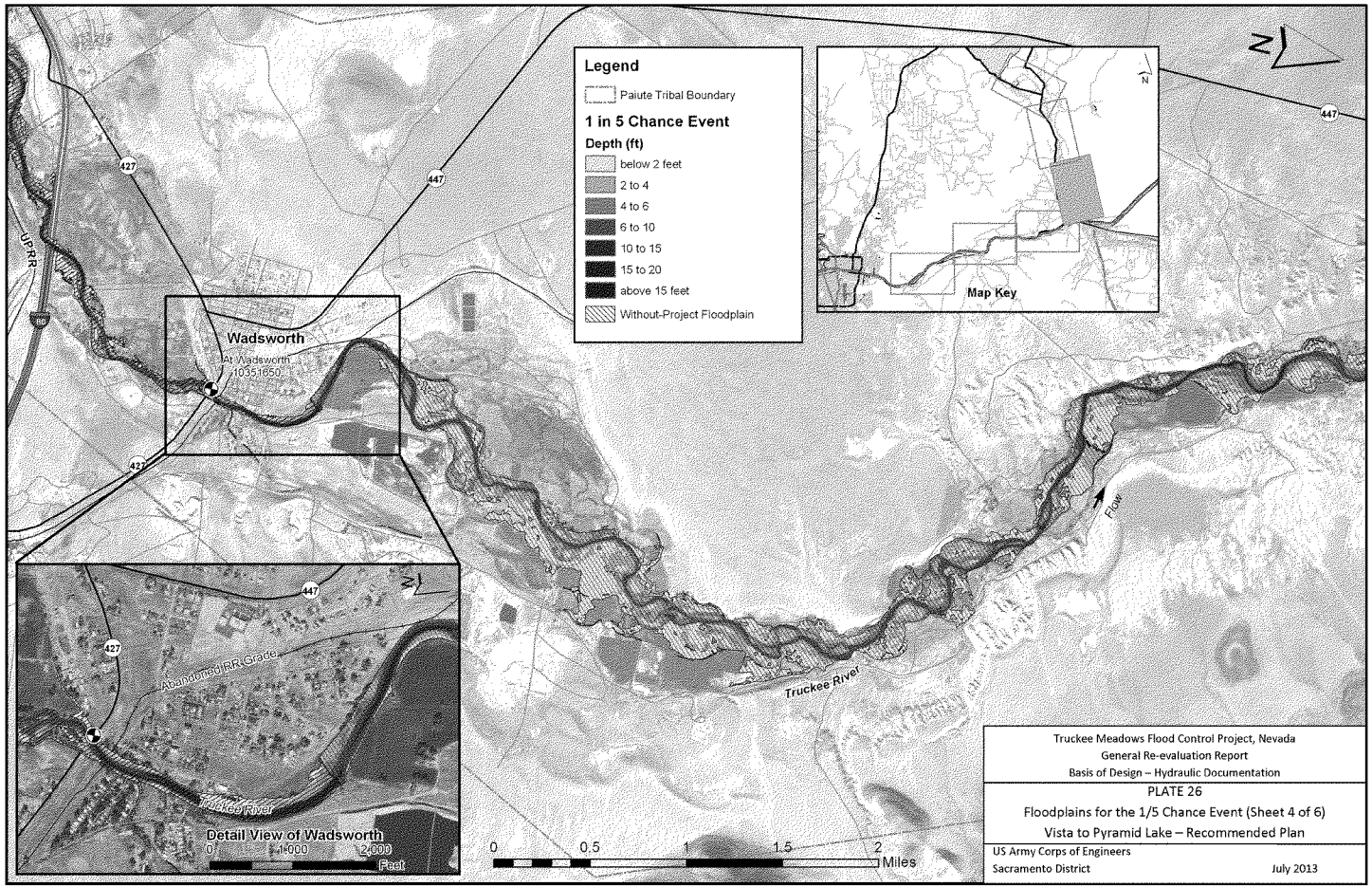
US Army Corps of Engineers
Sacramento District
July 2013



Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation

PLATE 25
Floodplains for the 1/5 Chance Event (Sheet 3 of 6)
Vista to Pyramid Lake – Recommended Plan

US Army Corps of Engineers
Sacramento District
July 2013



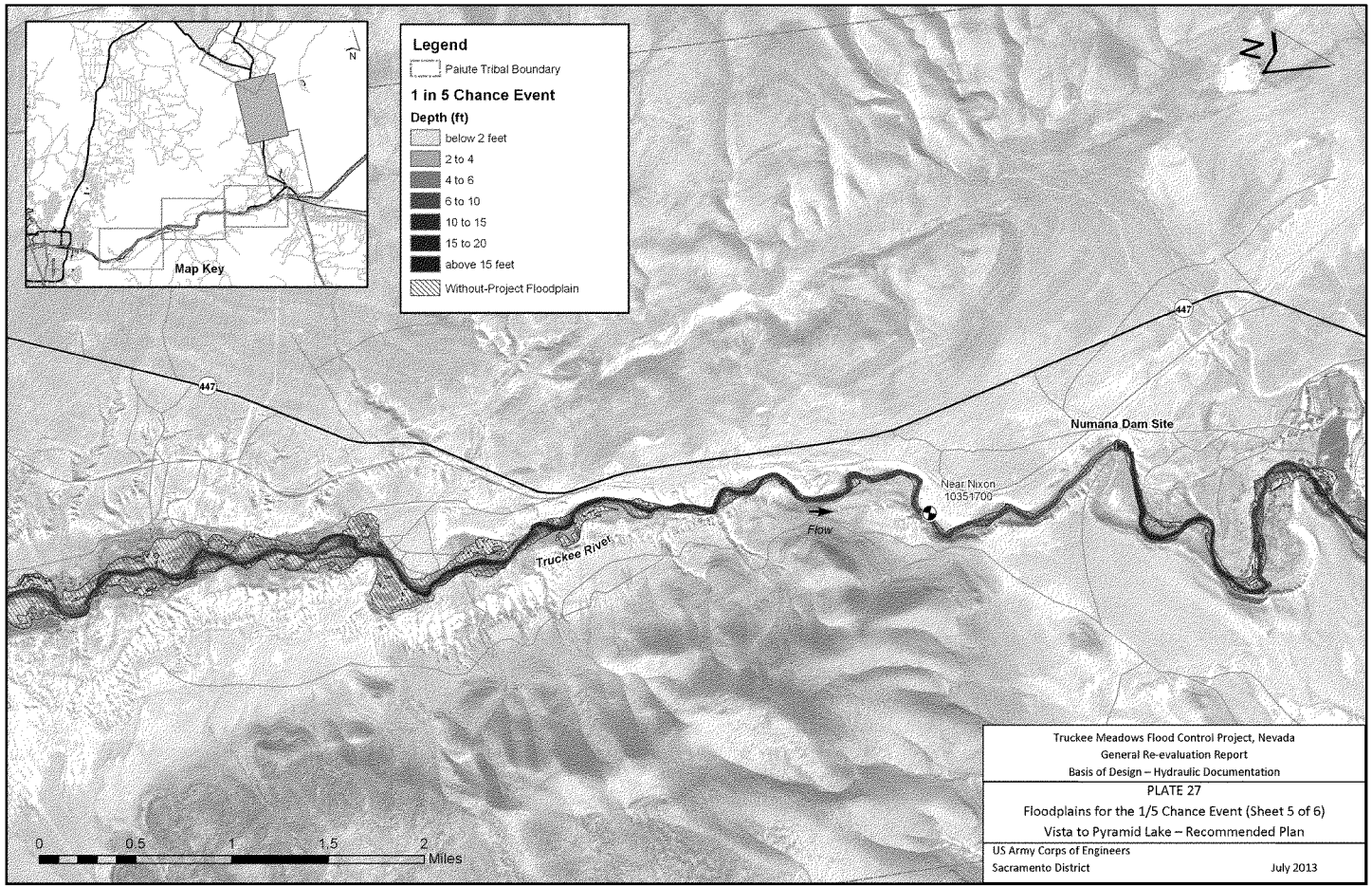
Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation

PLATE 26

Floodplains for the 1/5 Chance Event (Sheet 4 of 6)
Vista to Pyramid Lake – Recommended Plan

US Army Corps of Engineers
Sacramento District

July 2013

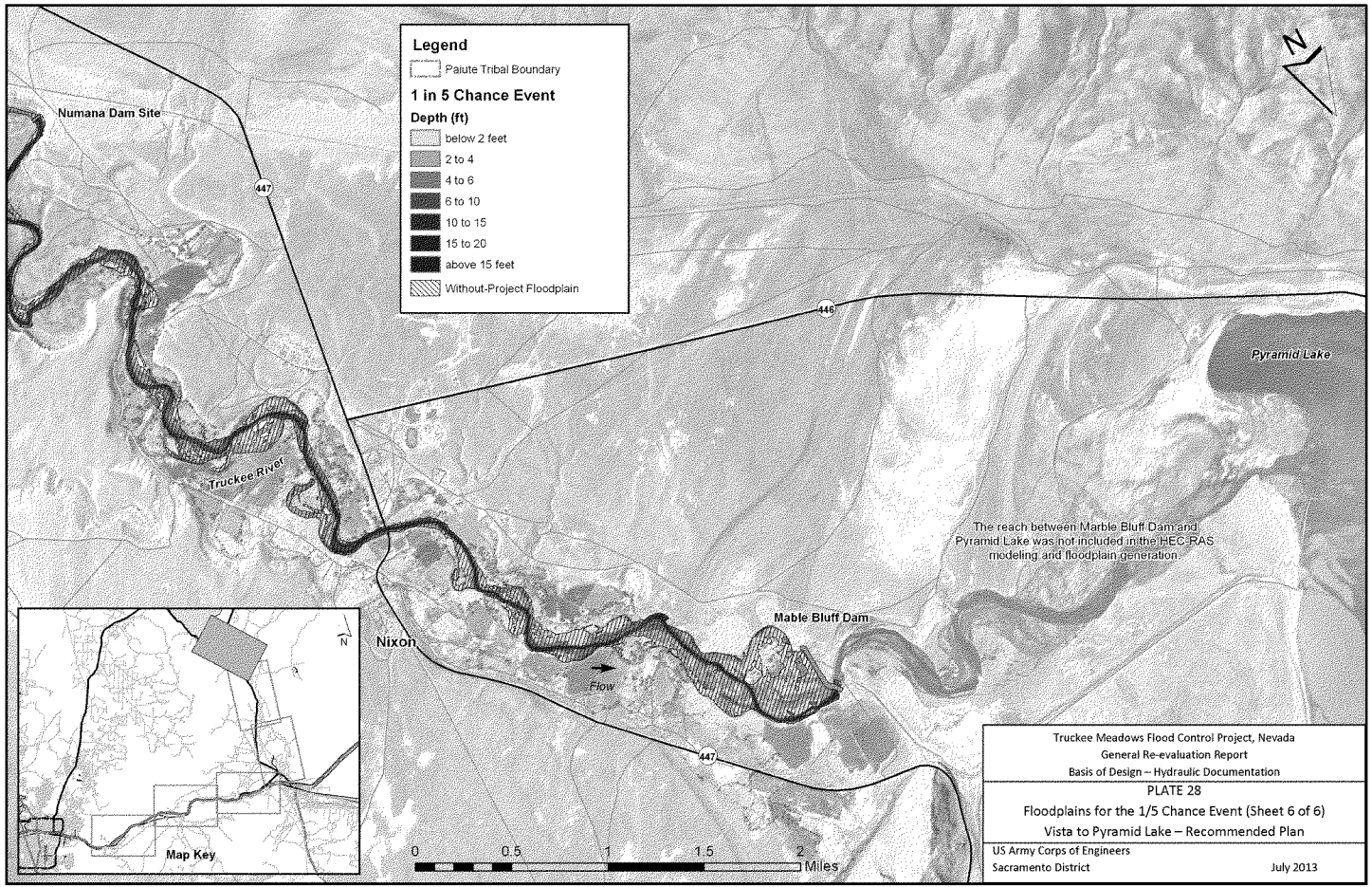


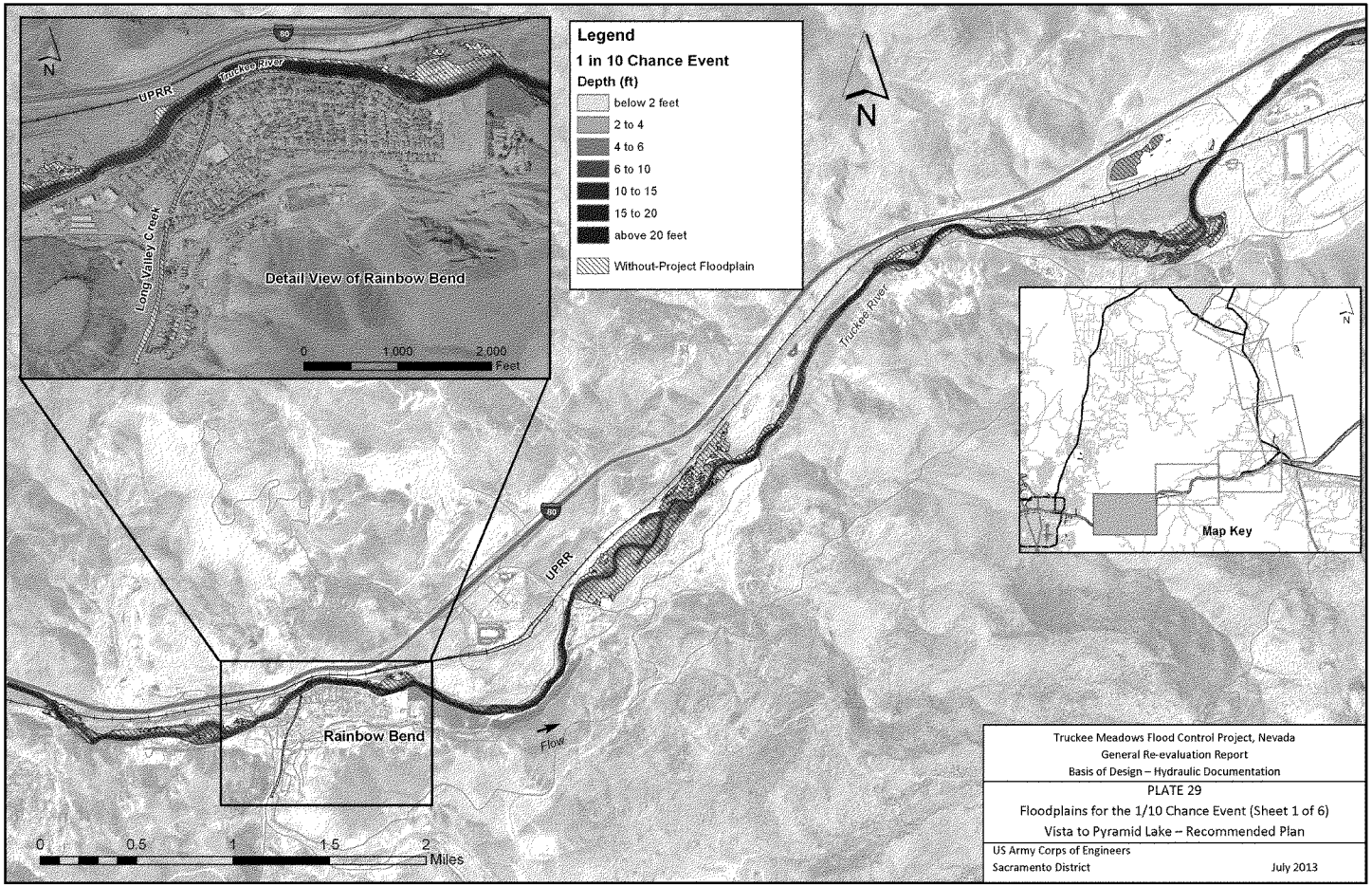
Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation

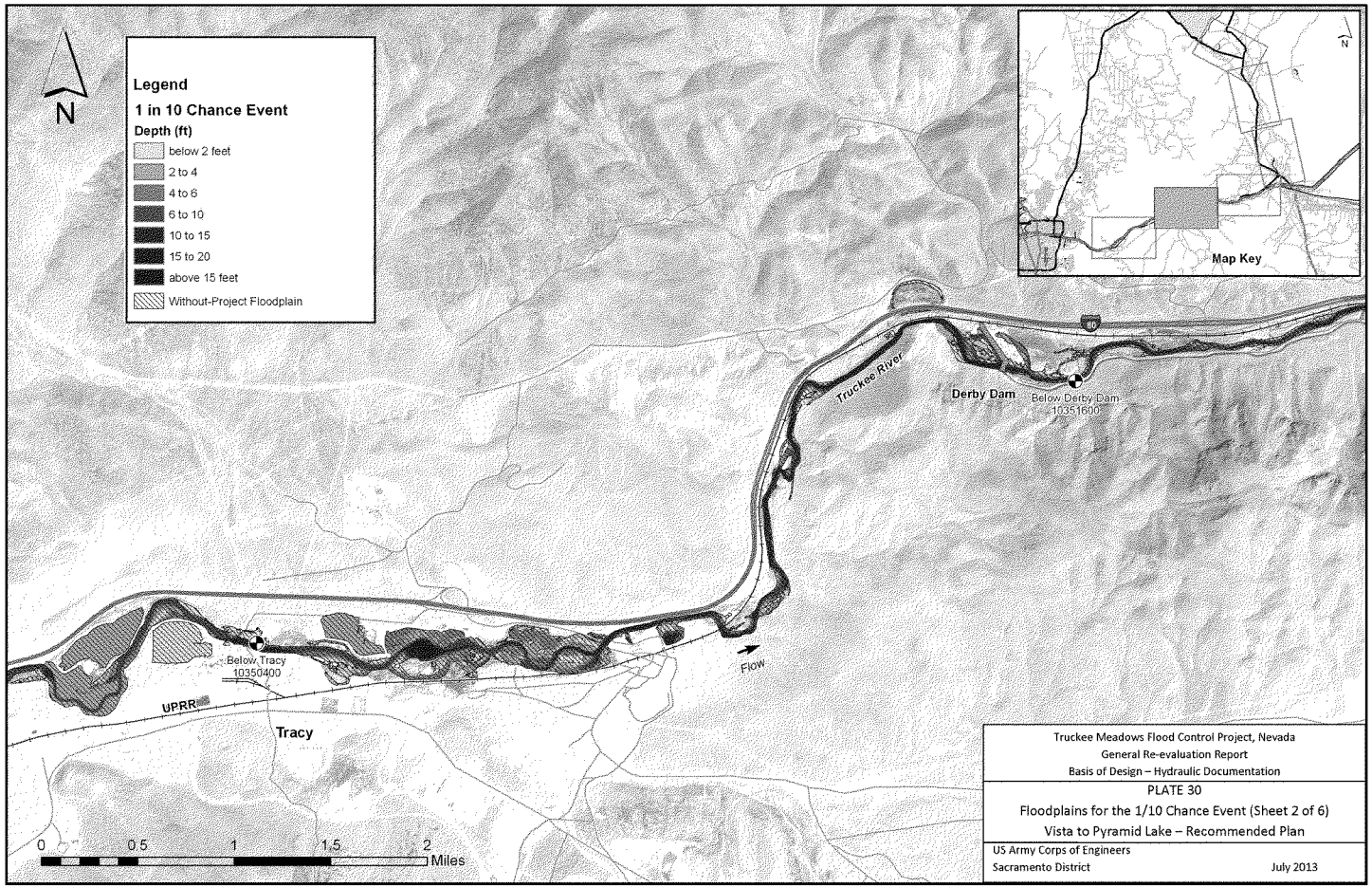
PLATE 27

Floodplains for the 1/5 Chance Event (Sheet 5 of 6)
Vista to Pyramid Lake – Recommended Plan

US Army Corps of Engineers
Sacramento District
July 2013


Legend
Paiute Tribal Boundary
1 in 5 Chance Event
Depth (ft)
below 2 feet
2 to 4
4 to 6
6 to 10
10 to 15
15 to 20
above 15 feet
Without-Project Floodplain
Numana Dam Site
447
446
Pyramid Lake
Truckee River
The reach between Marble Bluff Dam and Pyramid Lake was not included in the HEC-RAS modeling and floodplain generation.
Mable Bluff Dam
Nixon
Flow
447
N
Map Key
0
0.5
1
1.5
2
Miles
Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation
PLATE 28
Floodplains for the 1/5 Chance Event (Sheet 6 of 6)
Vista to Pyramid Lake – Recommended Plan
US Army Corps of Engineers
Sacramento District
July 2013


Legend
1 in 10 Chance Event
Depth (ft)
below 2 feet
2 to 4
4 to 6
6 to 10
10 to 15
15 to 20
above 20 feet
Without-Project Floodplain
Detail View of Rainbow Bend
UPRR
Truckee River
Long Valley Creek
0
1,000
2,000
Feet
N
Truckee River
UPRR
Rainbow Bend
Flow
0
0.5
1
1.5
2
Miles
Map Key
Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation
PLATE 29
Floodplains for the 1/10 Chance Event (Sheet 1 of 6)
Vista to Pyramid Lake – Recommended Plan
US Army Corps of Engineers
Sacramento District
July 2013

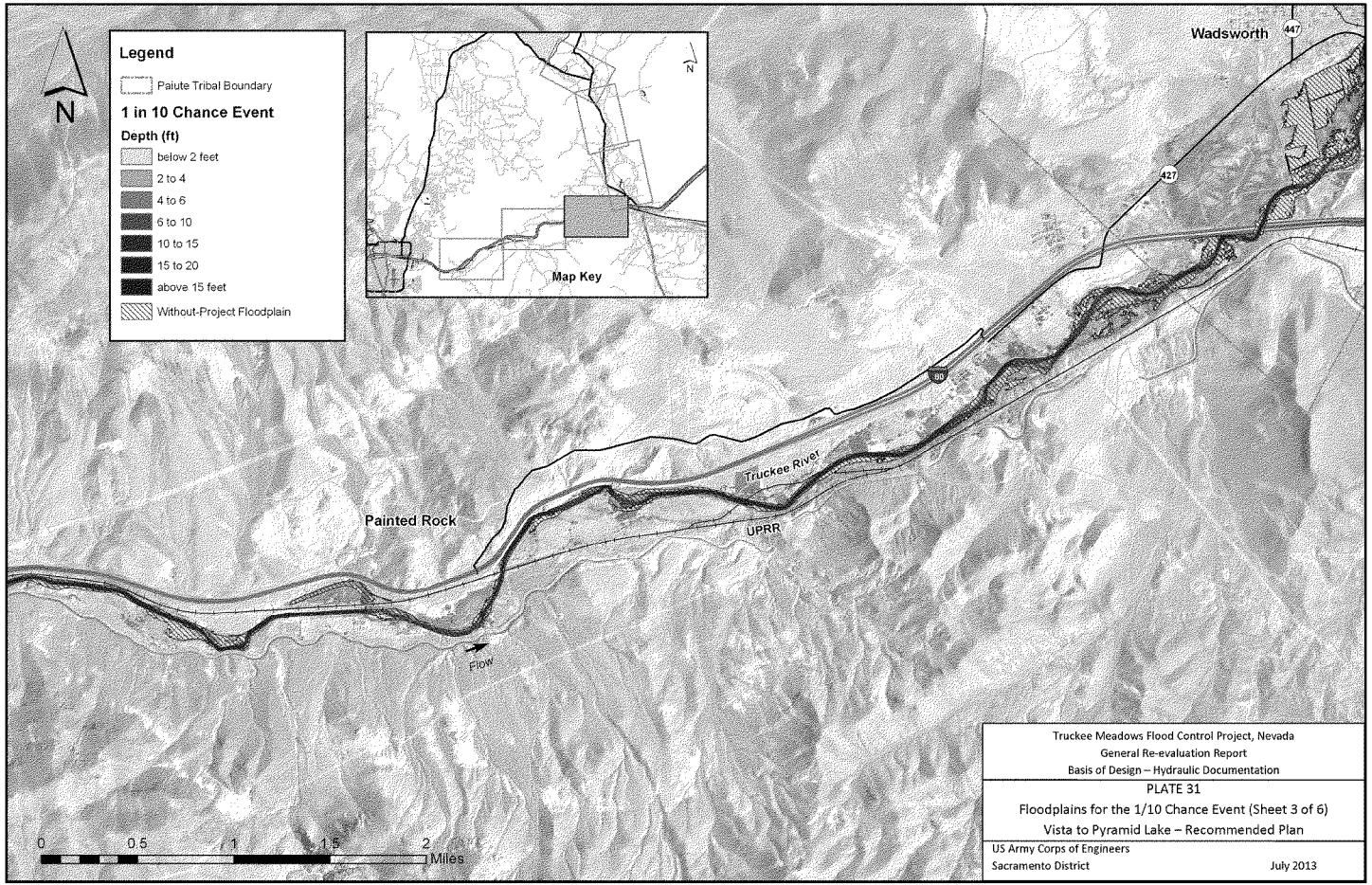


Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation

PLATE 30

Floodplains for the 1/10 Chance Event (Sheet 2 of 6)
Vista to Pyramid Lake – Recommended Plan

US Army Corps of Engineers
Sacramento District
July 2013

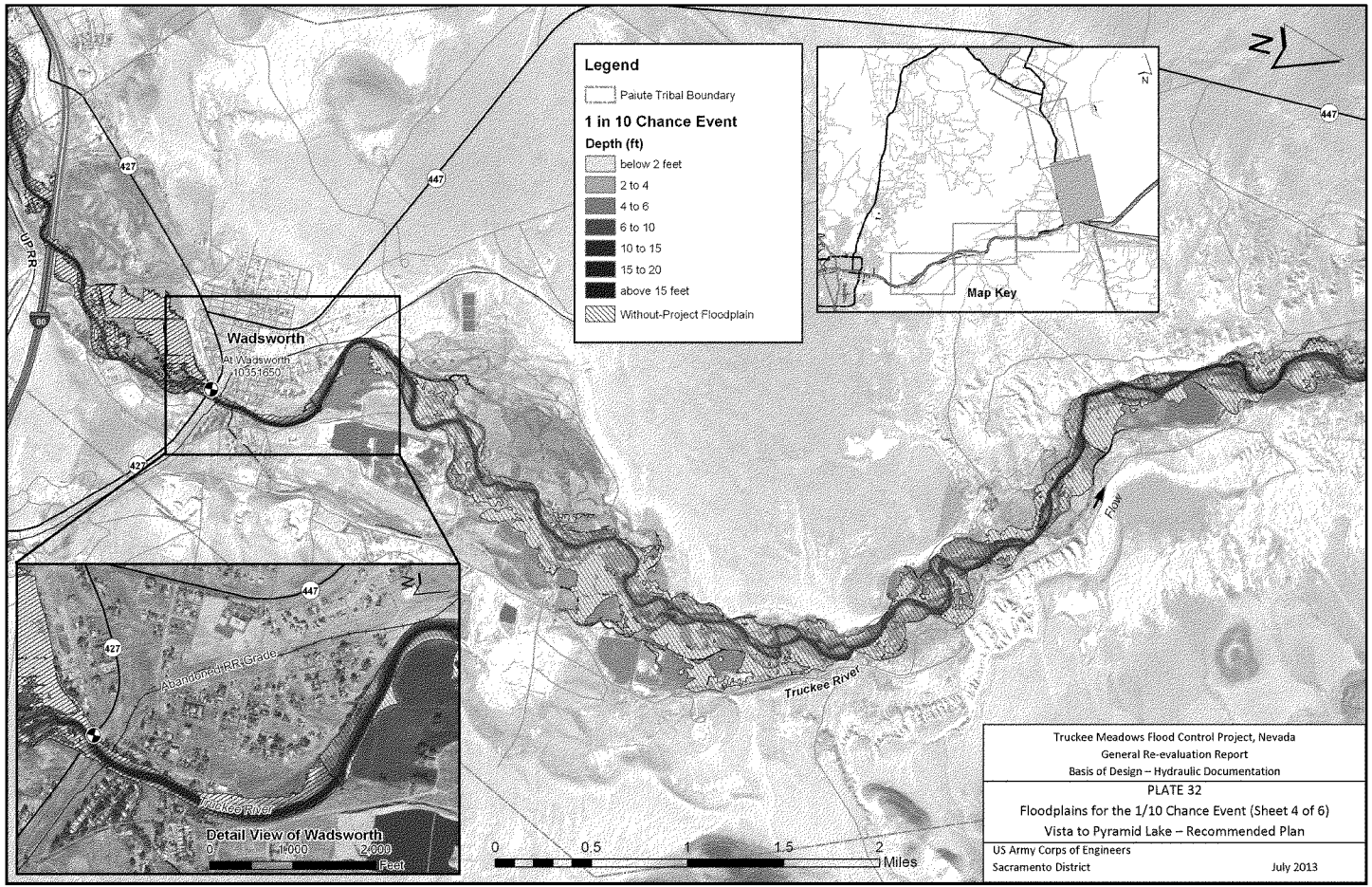


Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation

PLATE 31

Floodplains for the 1/10 Chance Event (Sheet 3 of 6)
Vista to Pyramid Lake – Recommended Plan

US Army Corps of Engineers
Sacramento District
July 2013



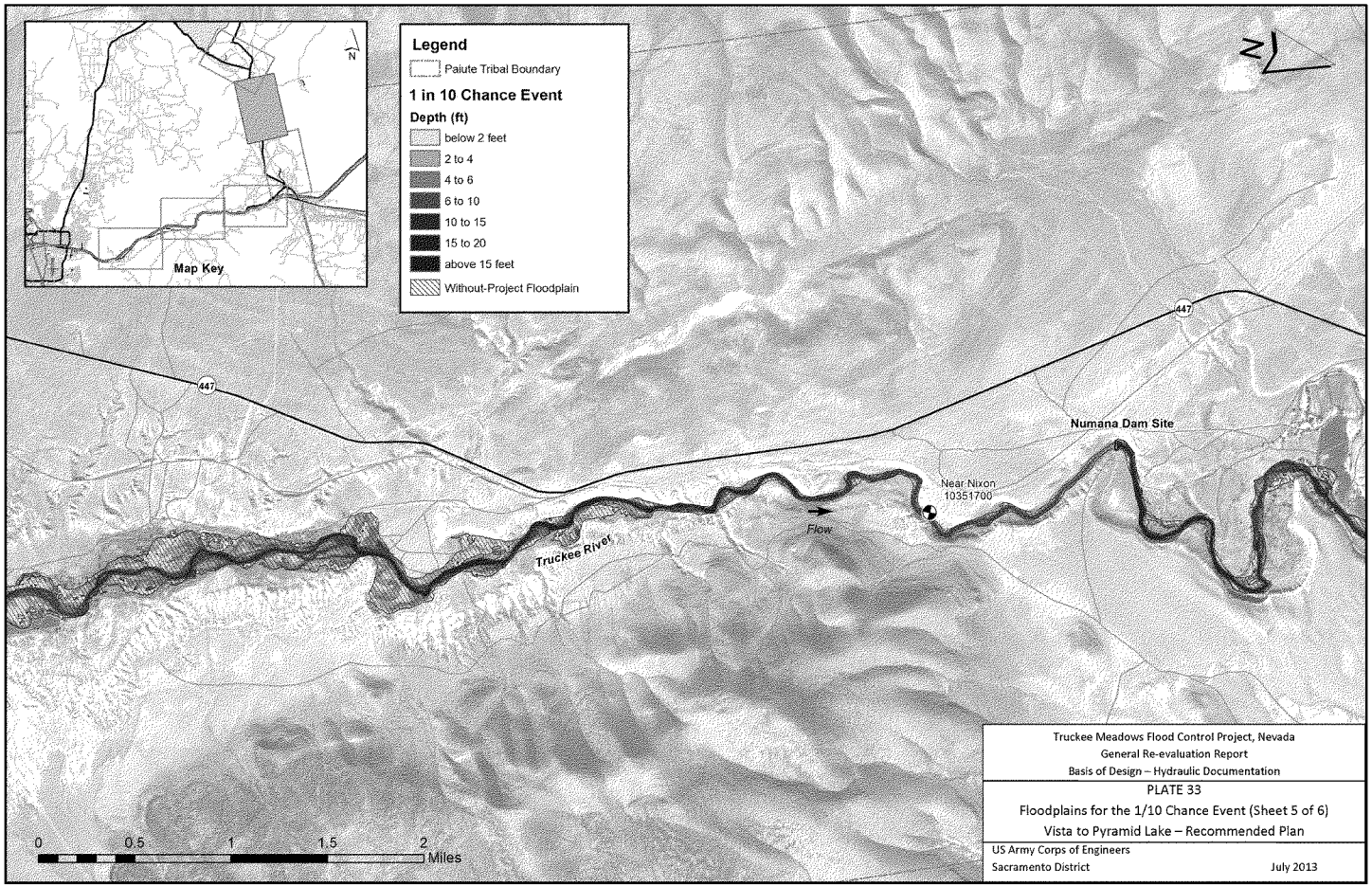
Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation

PLATE 32

Floodplains for the 1/10 Chance Event (Sheet 4 of 6)
Vista to Pyramid Lake – Recommended Plan

US Army Corps of Engineers
Sacramento District

July 2013

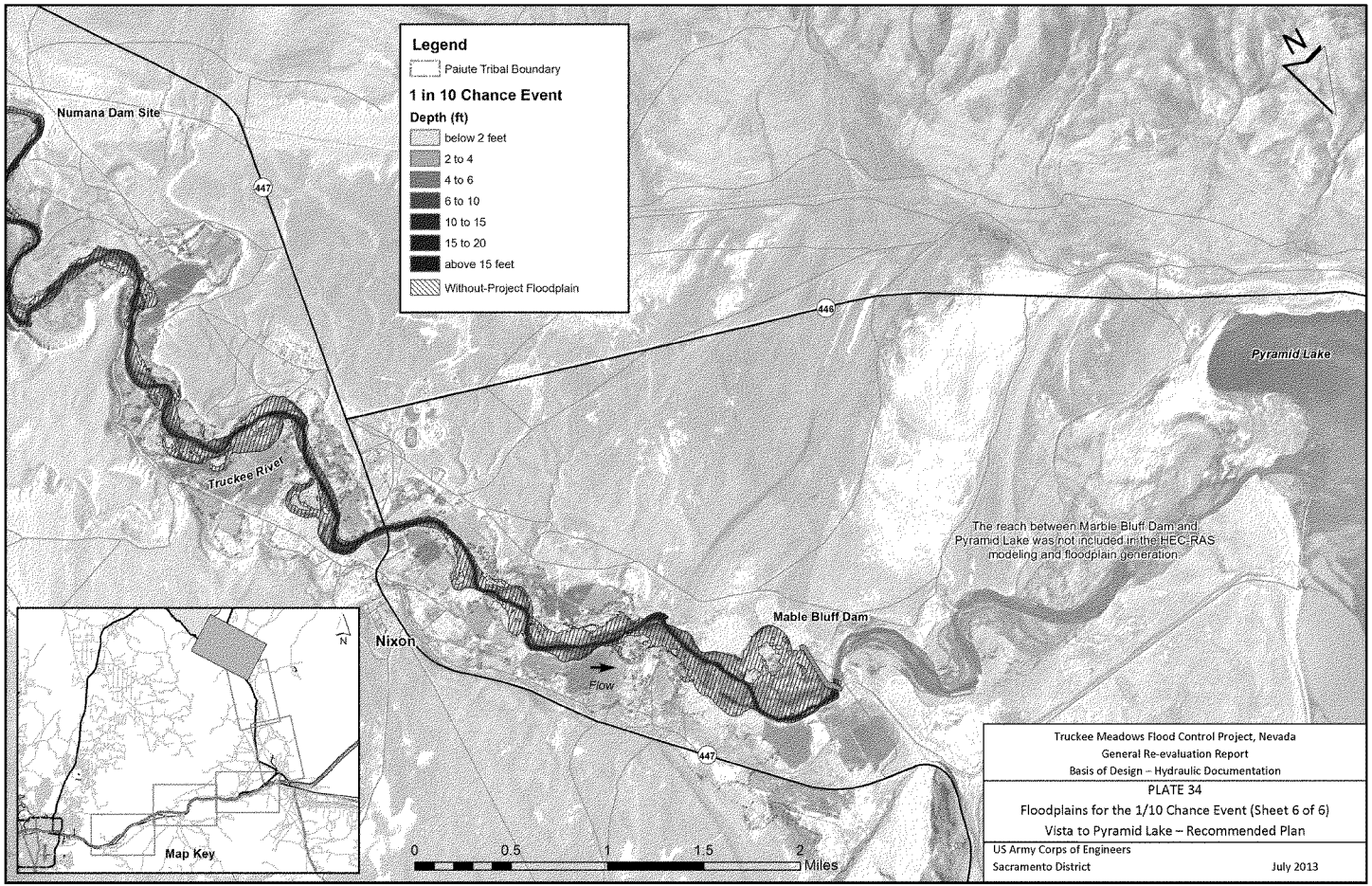


Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation

PLATE 33

Floodplains for the 1/10 Chance Event (Sheet 5 of 6)
Vista to Pyramid Lake – Recommended Plan

US Army Corps of Engineers
Sacramento District
July 2013

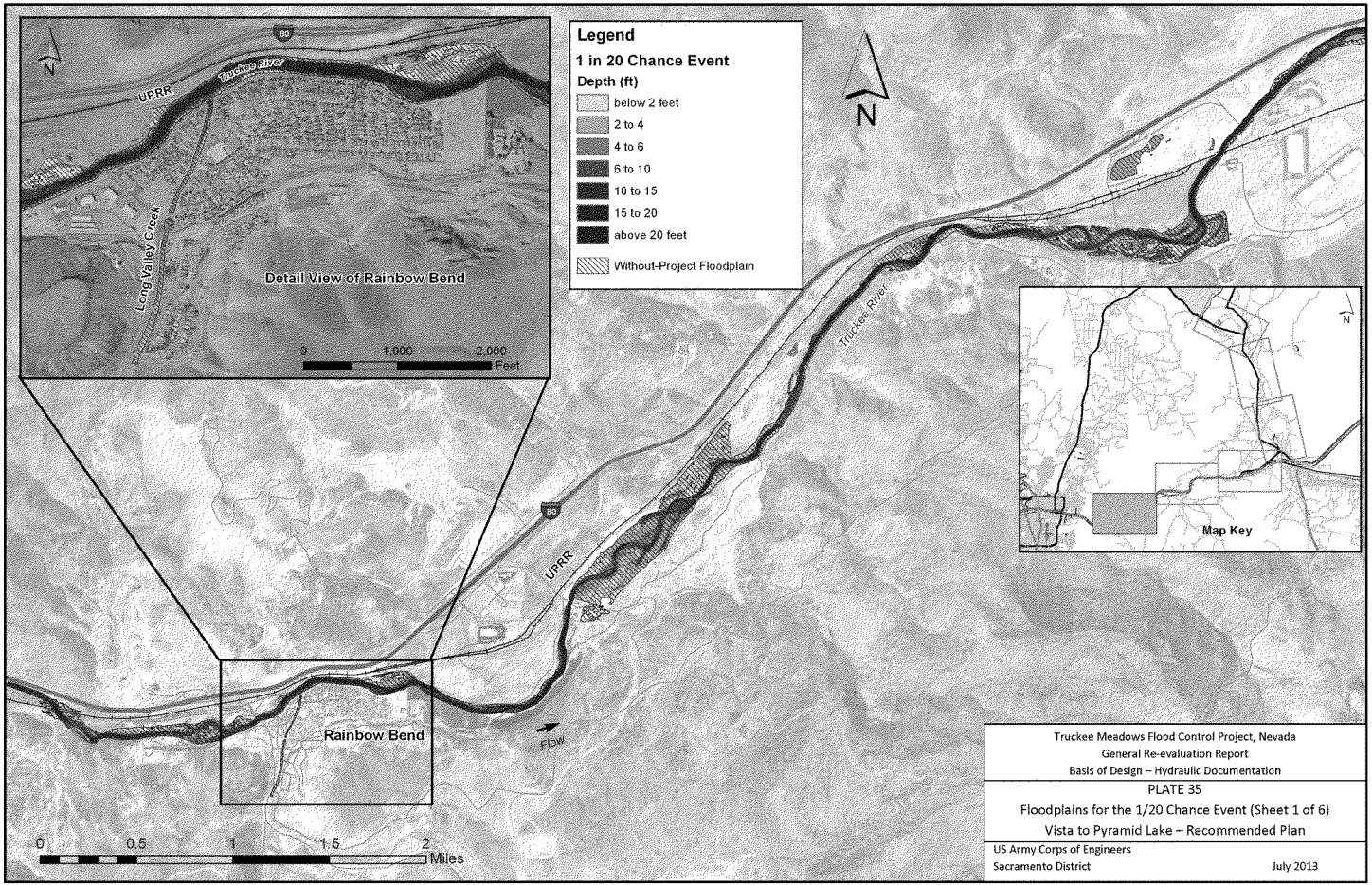


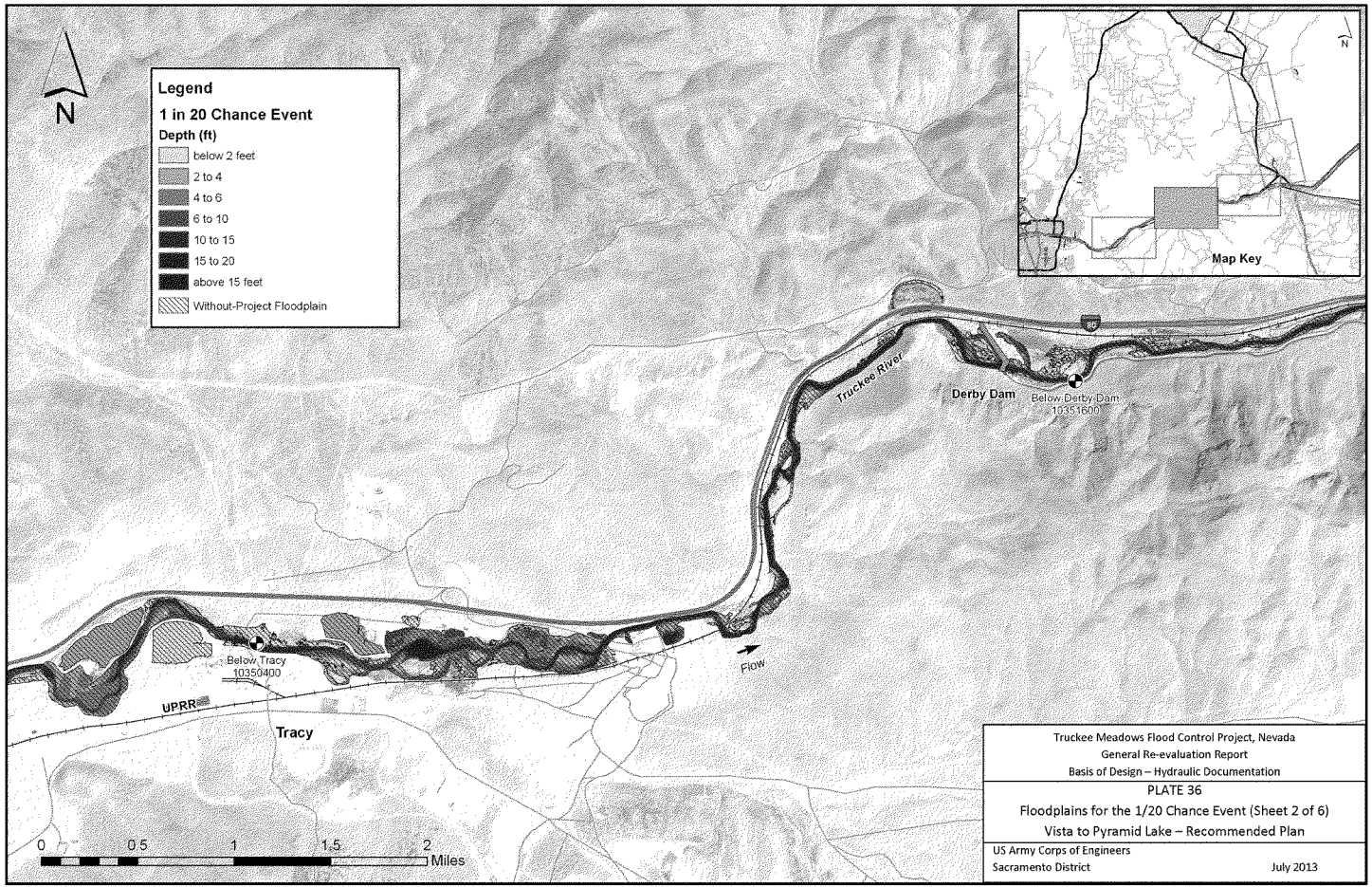
Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation

PLATE 34

Floodplains for the 1/10 Chance Event (Sheet 6 of 6)
Vista to Pyramid Lake – Recommended Plan

US Army Corps of Engineers
Sacramento District
July 2013


Legend
1 in 20 Chance Event
Depth (ft)
below 2 feet
2 to 4
4 to 6
6 to 10
10 to 15
15 to 20
above 20 feet
Without-Project Floodplain
N
Detail View of Rainbow Bend
UPRR
Truckee River
Long Valley Creek
0
1,000
2,000
Feet
Truckee River
UPRR
Rainbow Bend
Flow
0
0.5
1
1.5
2
Miles
Map Key
Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation
PLATE 35
Floodplains for the 1/20 Chance Event (Sheet 1 of 6)
Vista to Pyramid Lake – Recommended Plan
US Army Corps of Engineers
Sacramento District
July 2013

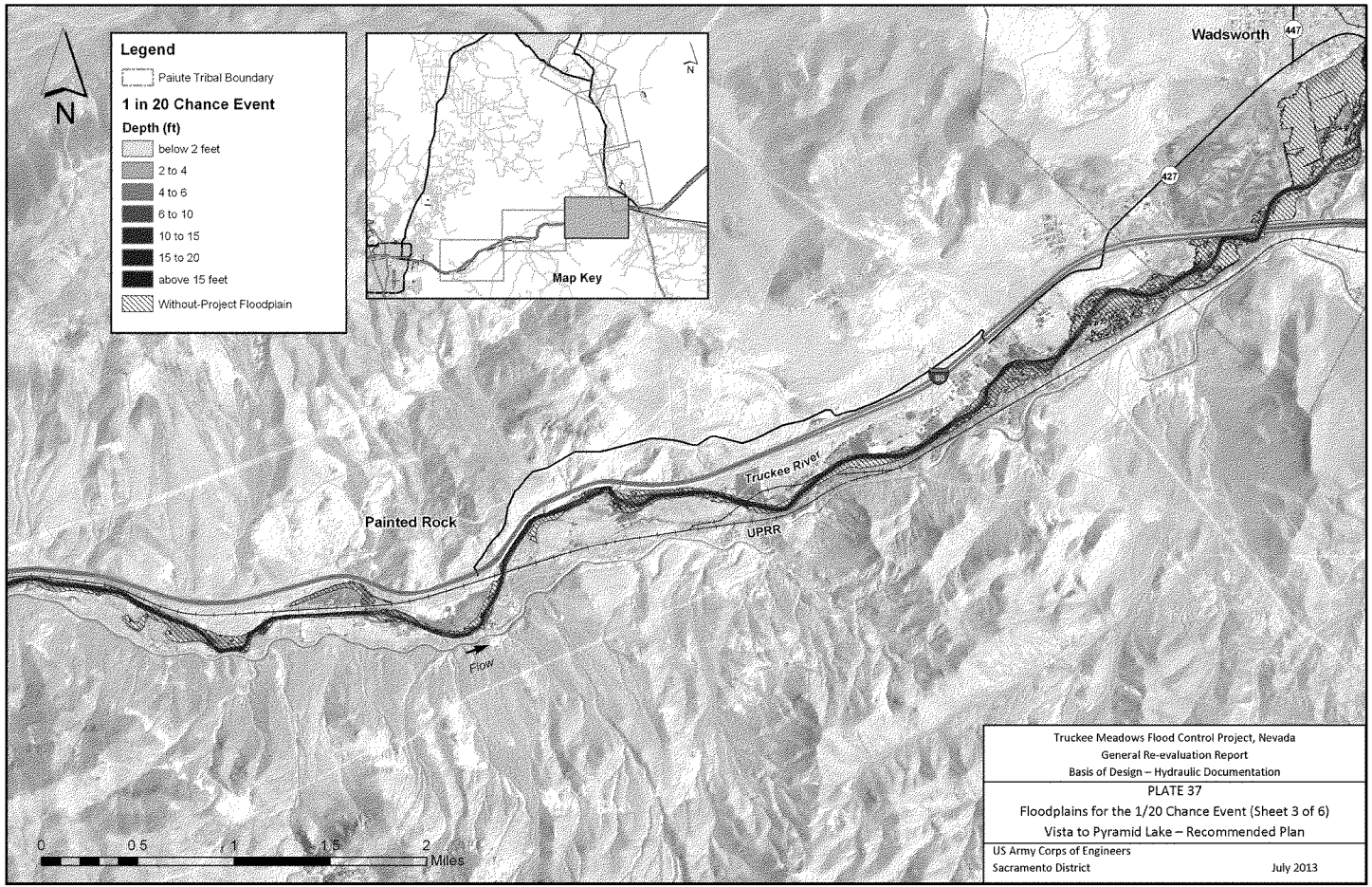


Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation

PLATE 36

Floodplains for the 1/20 Chance Event (Sheet 2 of 6)
Vista to Pyramid Lake – Recommended Plan

US Army Corps of Engineers
Sacramento District
July 2013

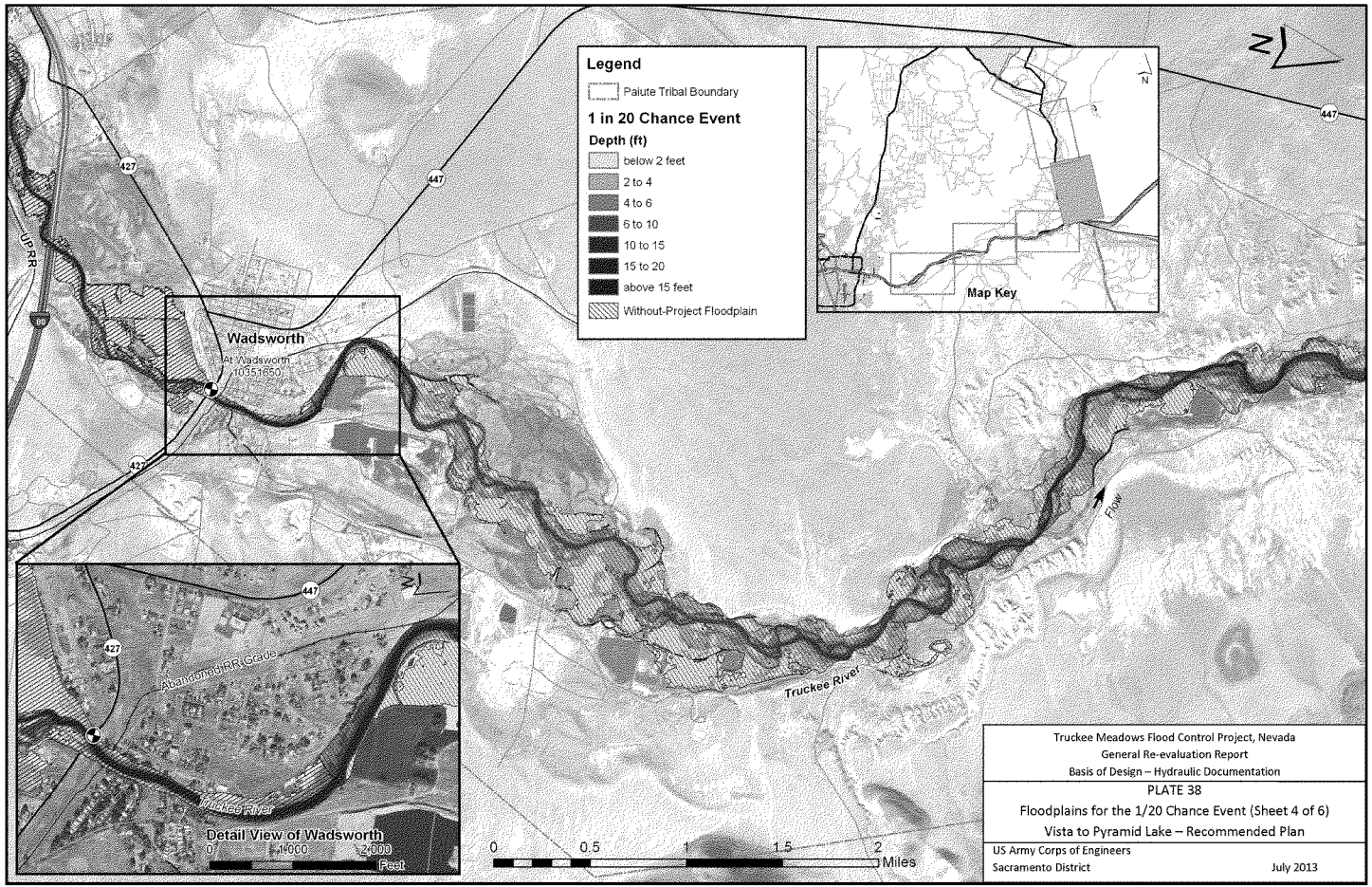


Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation

PLATE 37

Floodplains for the 1/20 Chance Event (Sheet 3 of 6)
Vista to Pyramid Lake – Recommended Plan

US Army Corps of Engineers
Sacramento District
July 2013



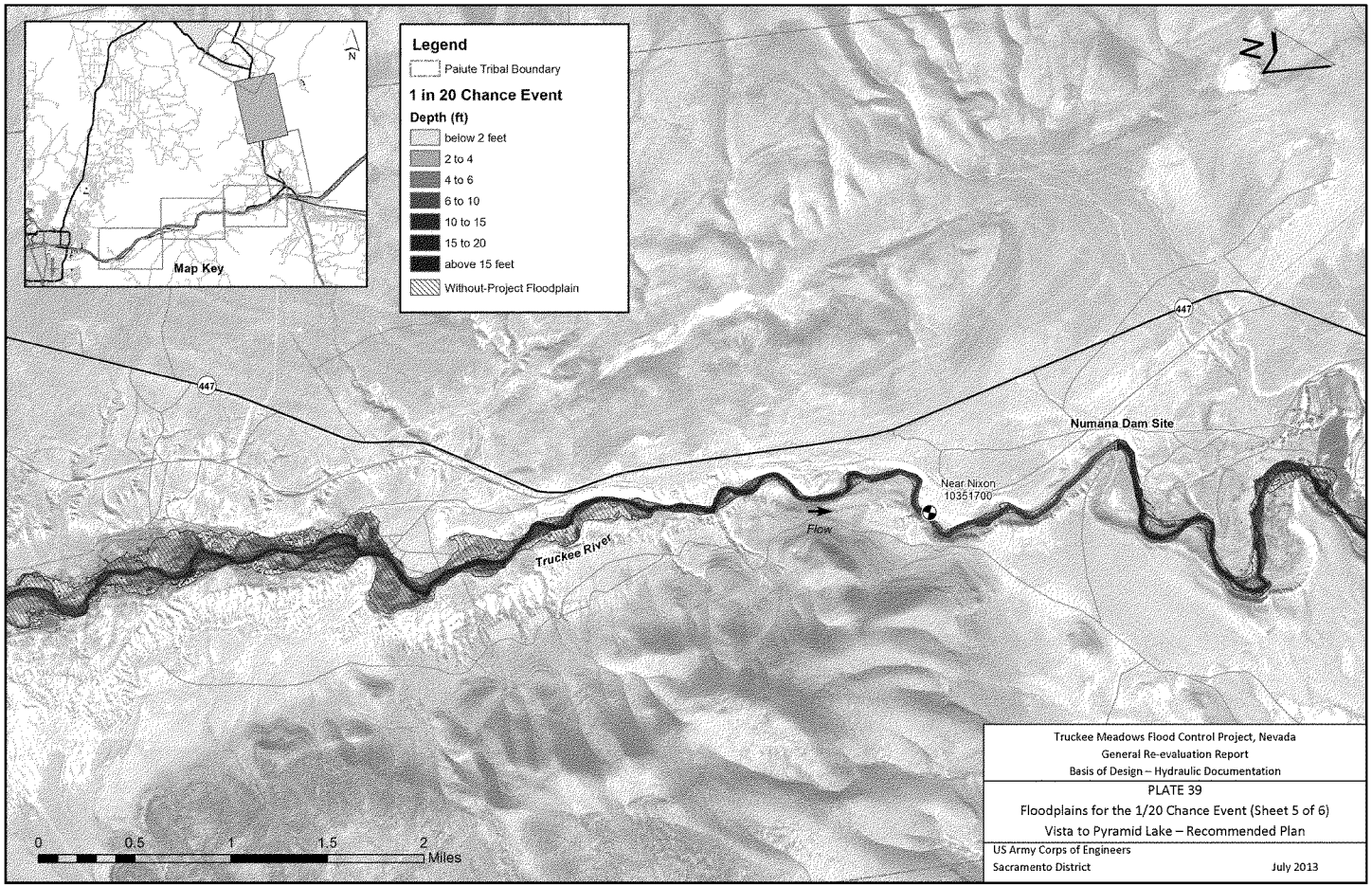
Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation

PLATE 38

Floodplains for the 1/20 Chance Event (Sheet 4 of 6)
Vista to Pyramid Lake – Recommended Plan

US Army Corps of Engineers
Sacramento District

July 2013

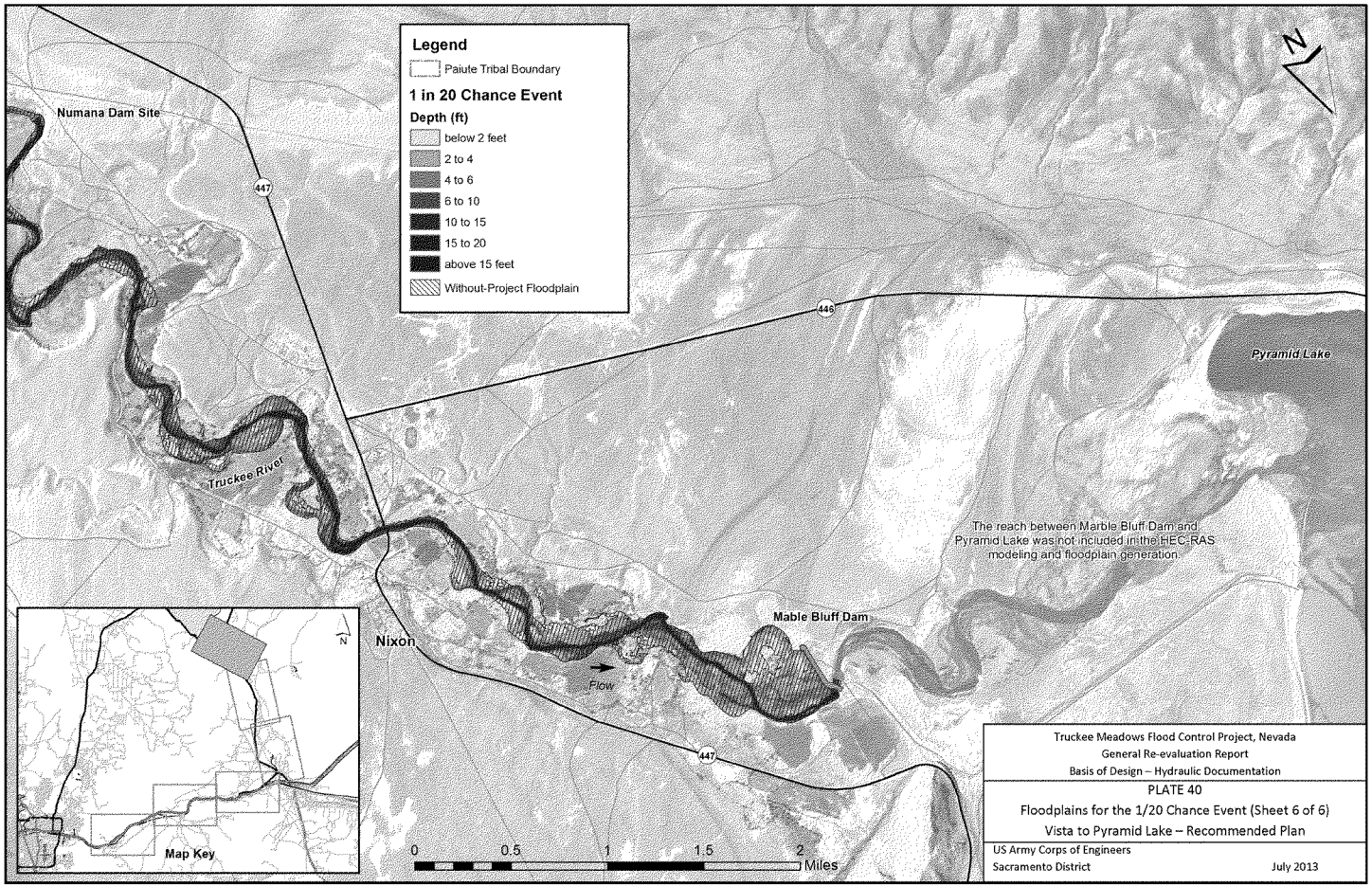


Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation

PLATE 39

Floodplains for the 1/20 Chance Event (Sheet 5 of 6)
Vista to Pyramid Lake – Recommended Plan

US Army Corps of Engineers
Sacramento District July 2013

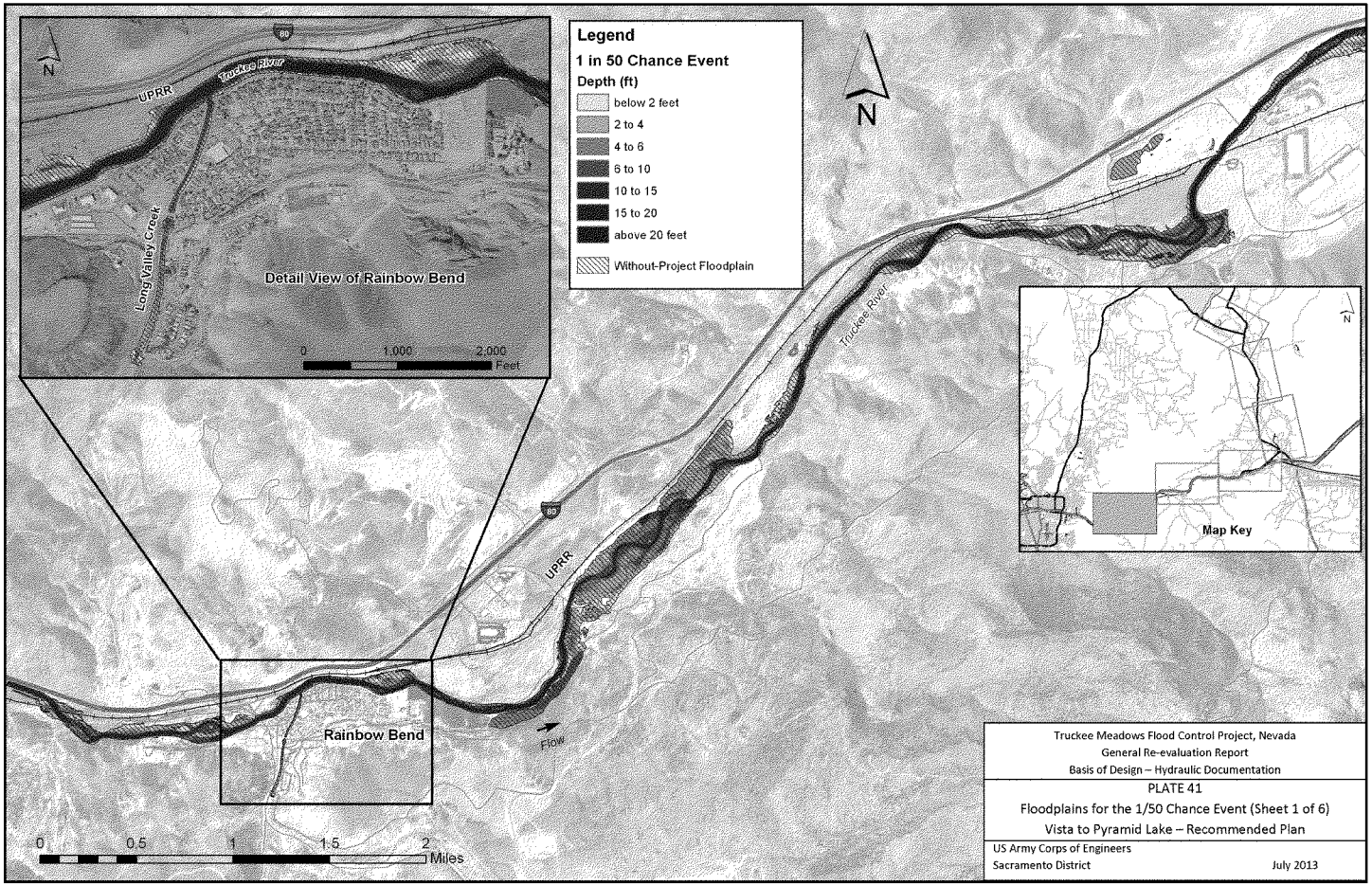


Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation

PLATE 40

Floodplains for the 1/20 Chance Event (Sheet 6 of 6)
Vista to Pyramid Lake – Recommended Plan

US Army Corps of Engineers
Sacramento District
July 2013



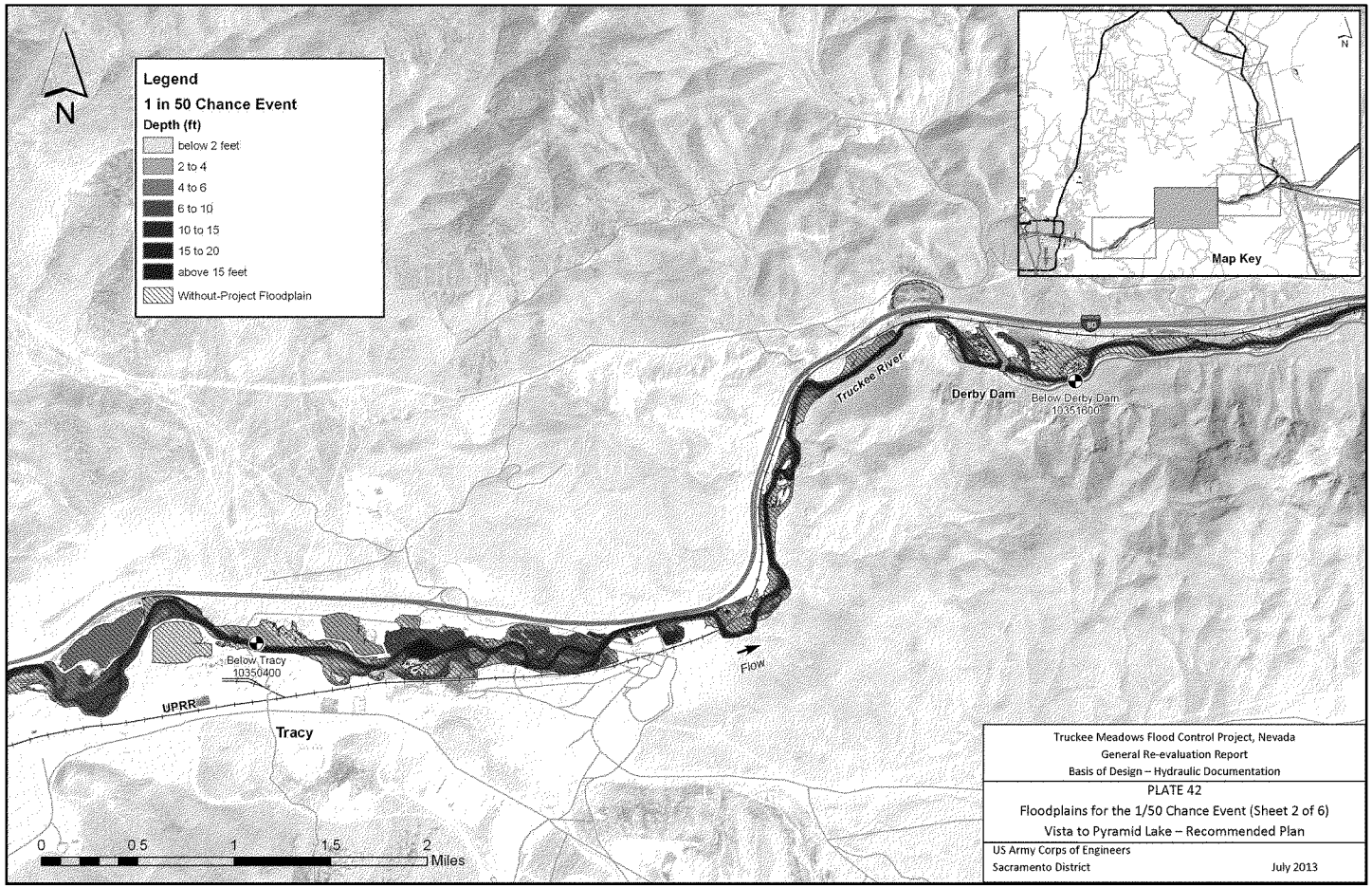
Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation

PLATE 41

Floodplains for the 1/50 Chance Event (Sheet 1 of 6)
Vista to Pyramid Lake – Recommended Plan

US Army Corps of Engineers
Sacramento District

July 2013

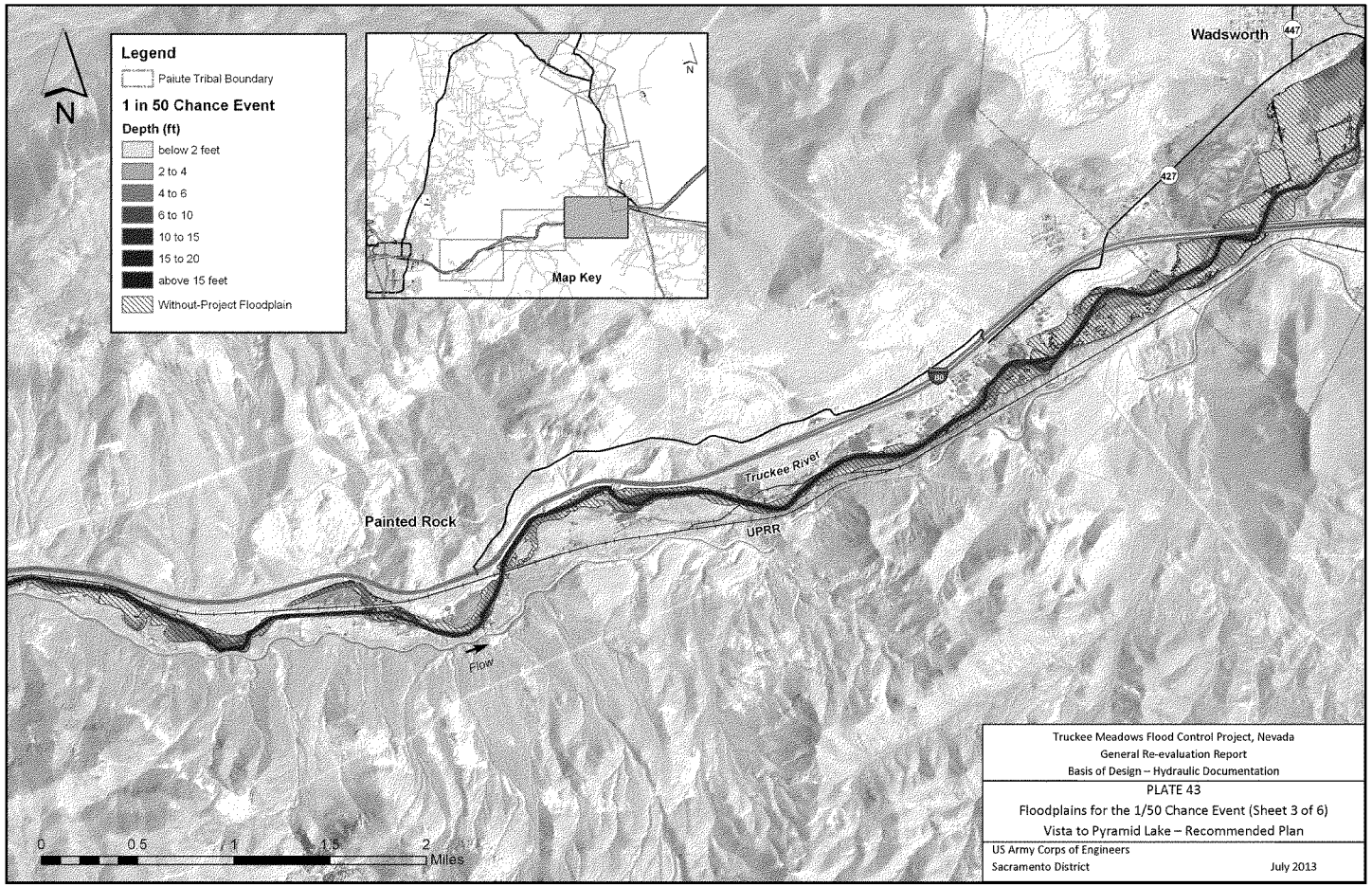


Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation

PLATE 42

Floodplains for the 1/50 Chance Event (Sheet 2 of 6)
Vista to Pyramid Lake – Recommended Plan

US Army Corps of Engineers
Sacramento District
July 2013

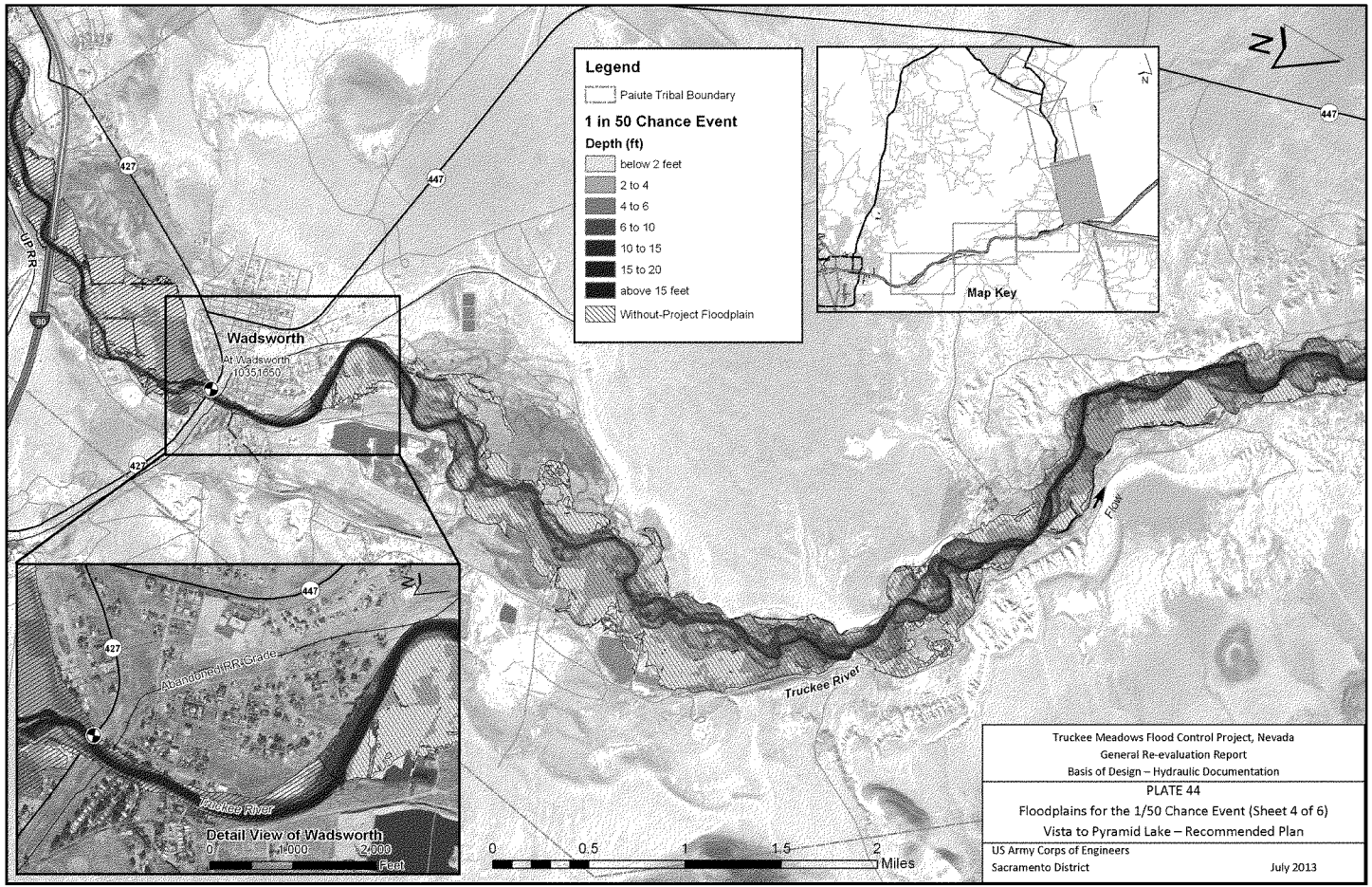


Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation

PLATE 43

Floodplains for the 1/50 Chance Event (Sheet 3 of 6)
Vista to Pyramid Lake – Recommended Plan

US Army Corps of Engineers
Sacramento District
July 2013



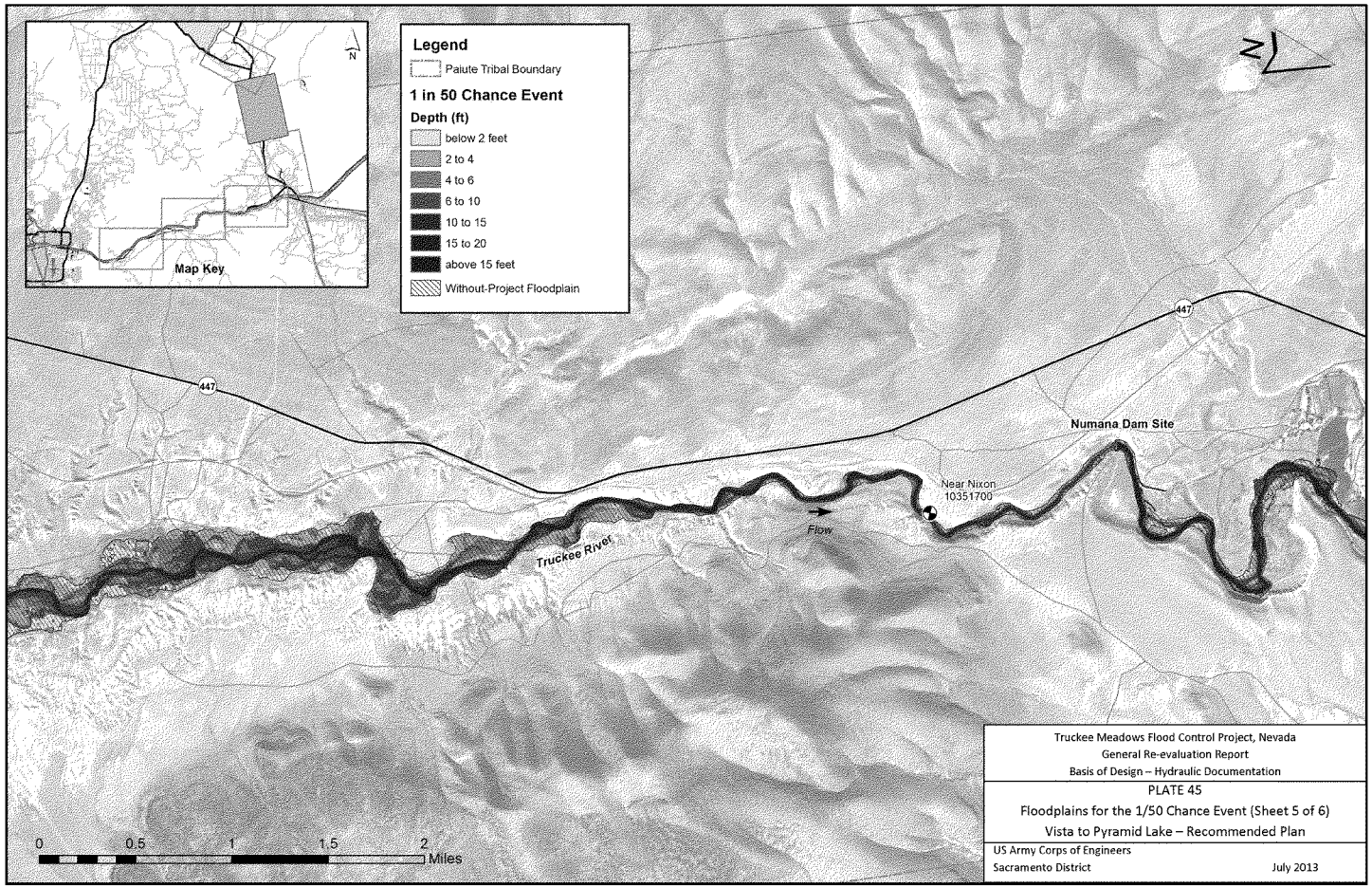
Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation

PLATE 44

Floodplains for the 1/50 Chance Event (Sheet 4 of 6)
Vista to Pyramid Lake – Recommended Plan

US Army Corps of Engineers
Sacramento District

July 2013

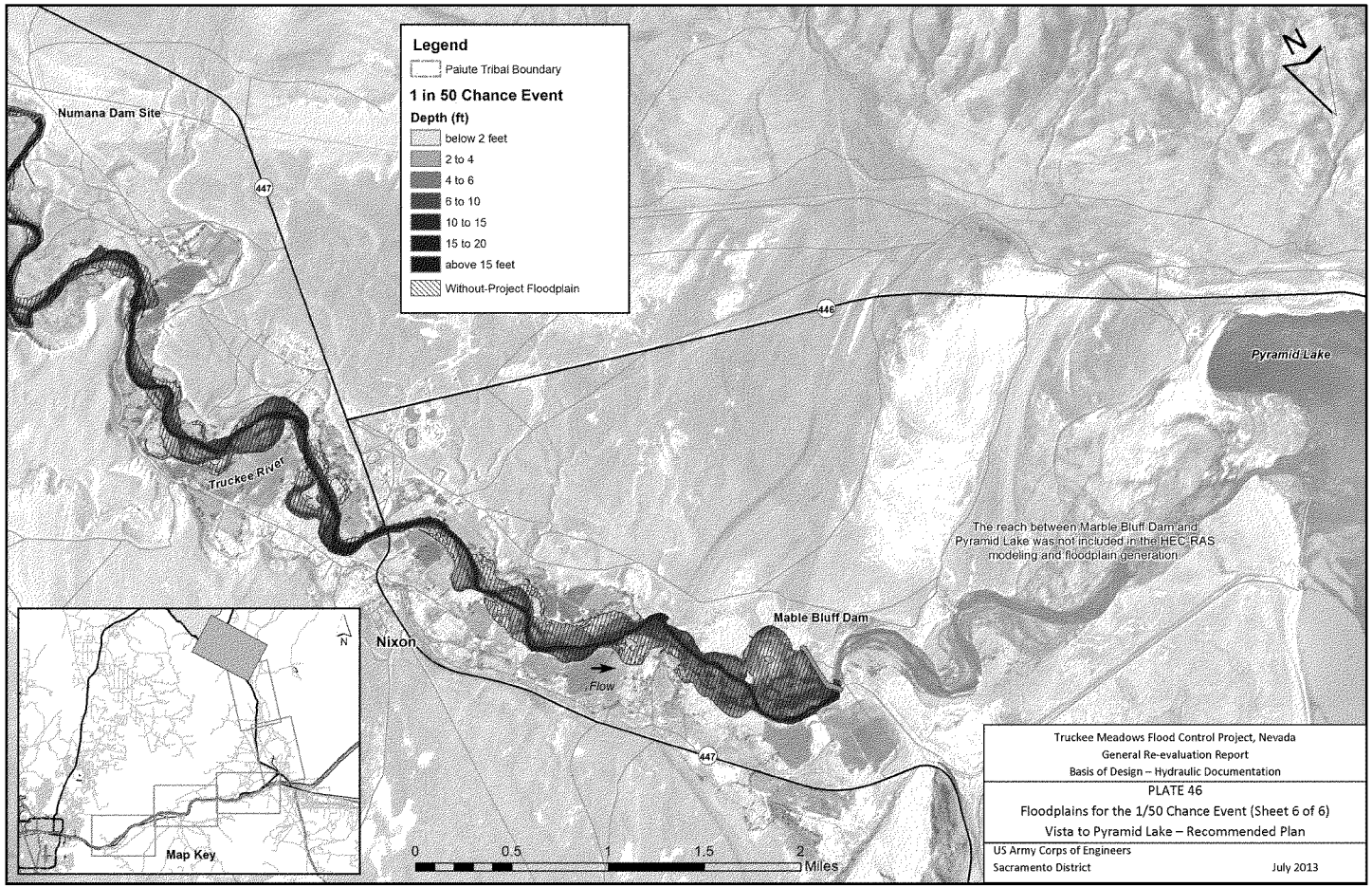


Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation

PLATE 45

Floodplains for the 1/50 Chance Event (Sheet 5 of 6)
Vista to Pyramid Lake – Recommended Plan

US Army Corps of Engineers
Sacramento District
July 2013

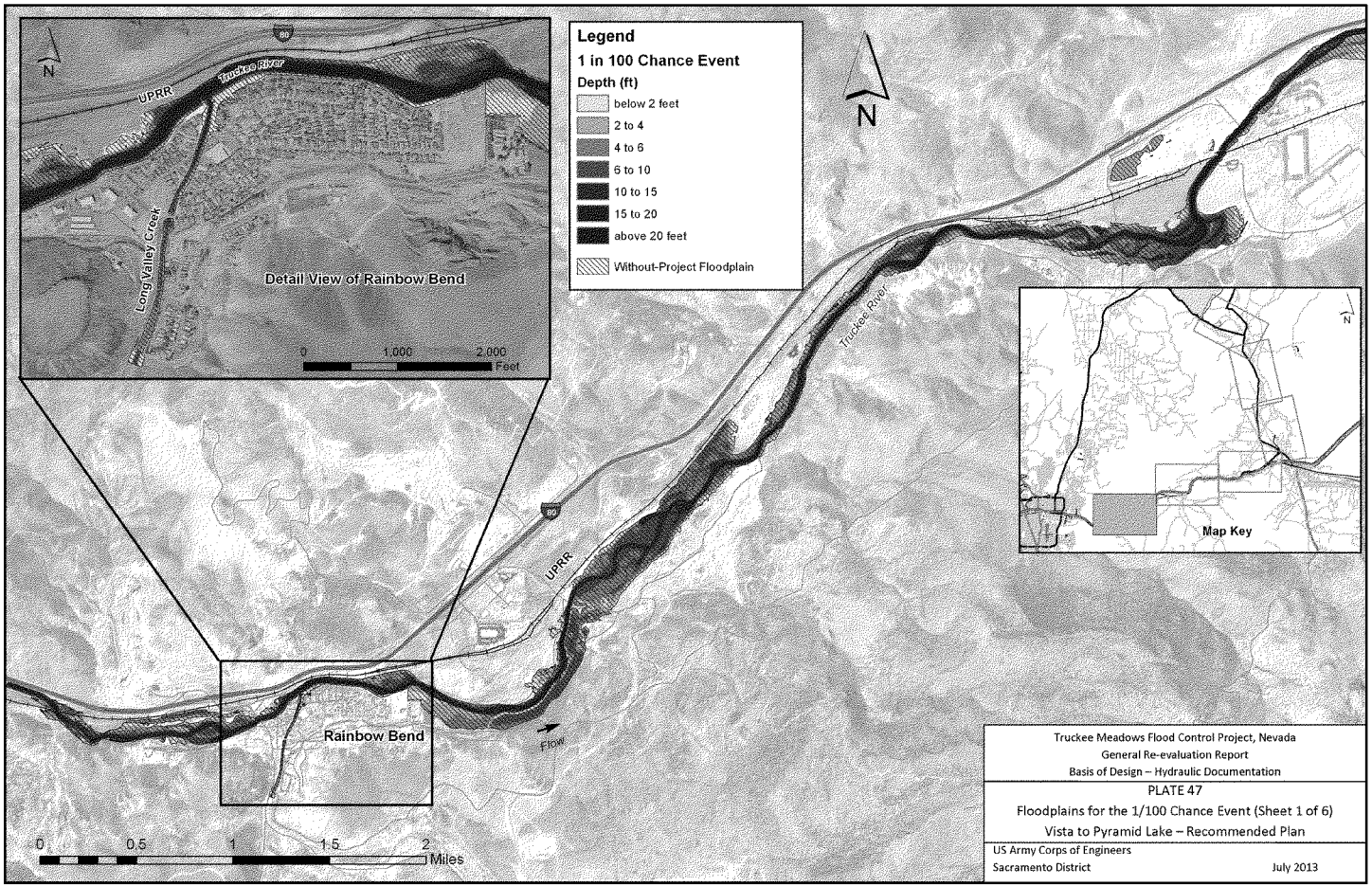


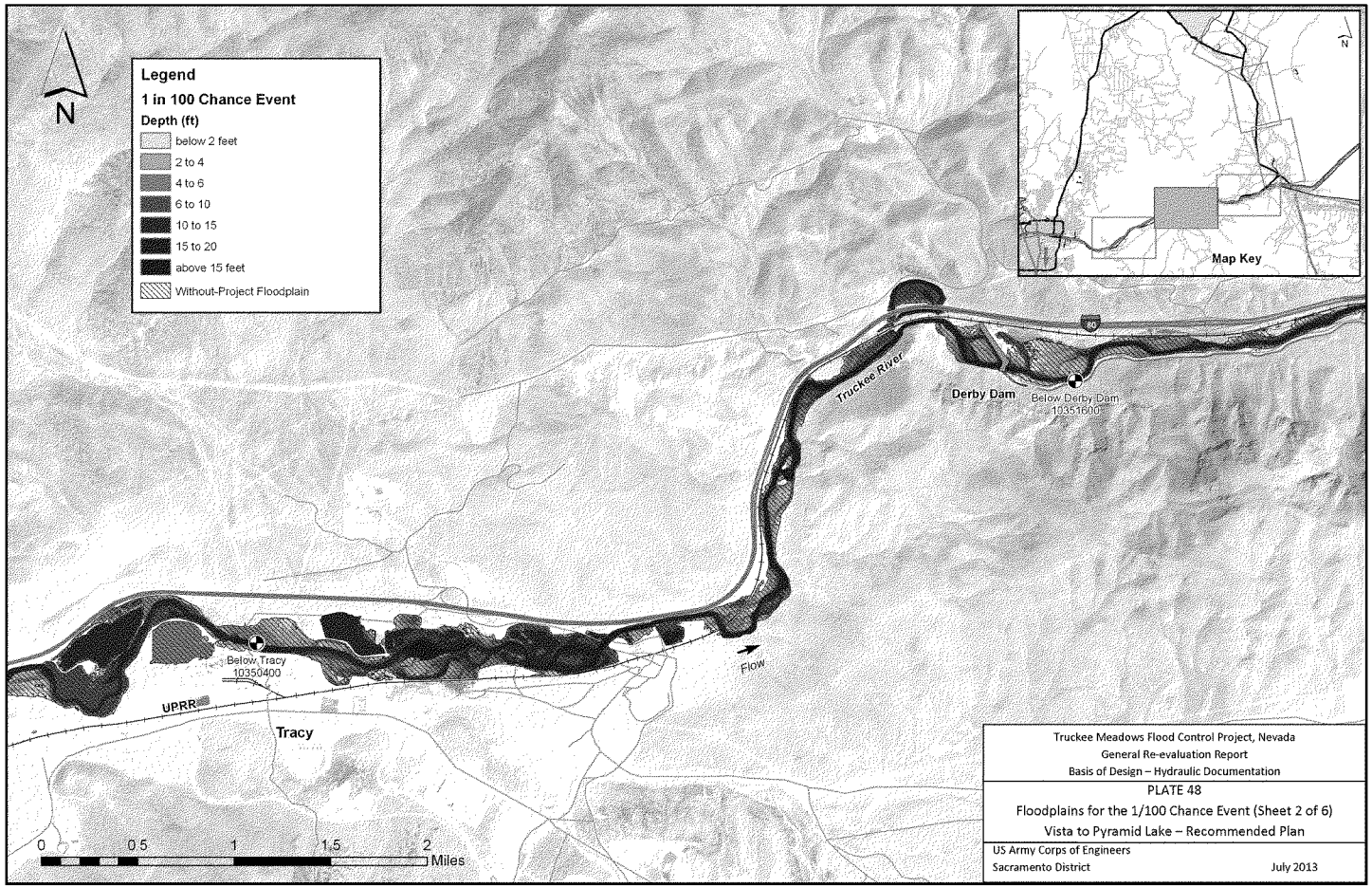
Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation

PLATE 46

Floodplains for the 1/50 Chance Event (Sheet 6 of 6)
Vista to Pyramid Lake – Recommended Plan

US Army Corps of Engineers
Sacramento District
July 2013


Legend
1 in 100 Chance Event
Depth (ft)
below 2 feet
2 to 4
4 to 6
6 to 10
10 to 15
15 to 20
above 20 feet
Without-Project Floodplain
N
Detail View of Rainbow Bend
UPRR
Truckee River
Long Valley Creek
0
1,000
2,000
Feet
Truckee River
UPRR
Rainbow Bend
Flow
0
0.5
1
1.5
2
Miles
Map Key
Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation
PLATE 47
Floodplains for the 1/100 Chance Event (Sheet 1 of 6)
Vista to Pyramid Lake – Recommended Plan
US Army Corps of Engineers
Sacramento District
July 2013

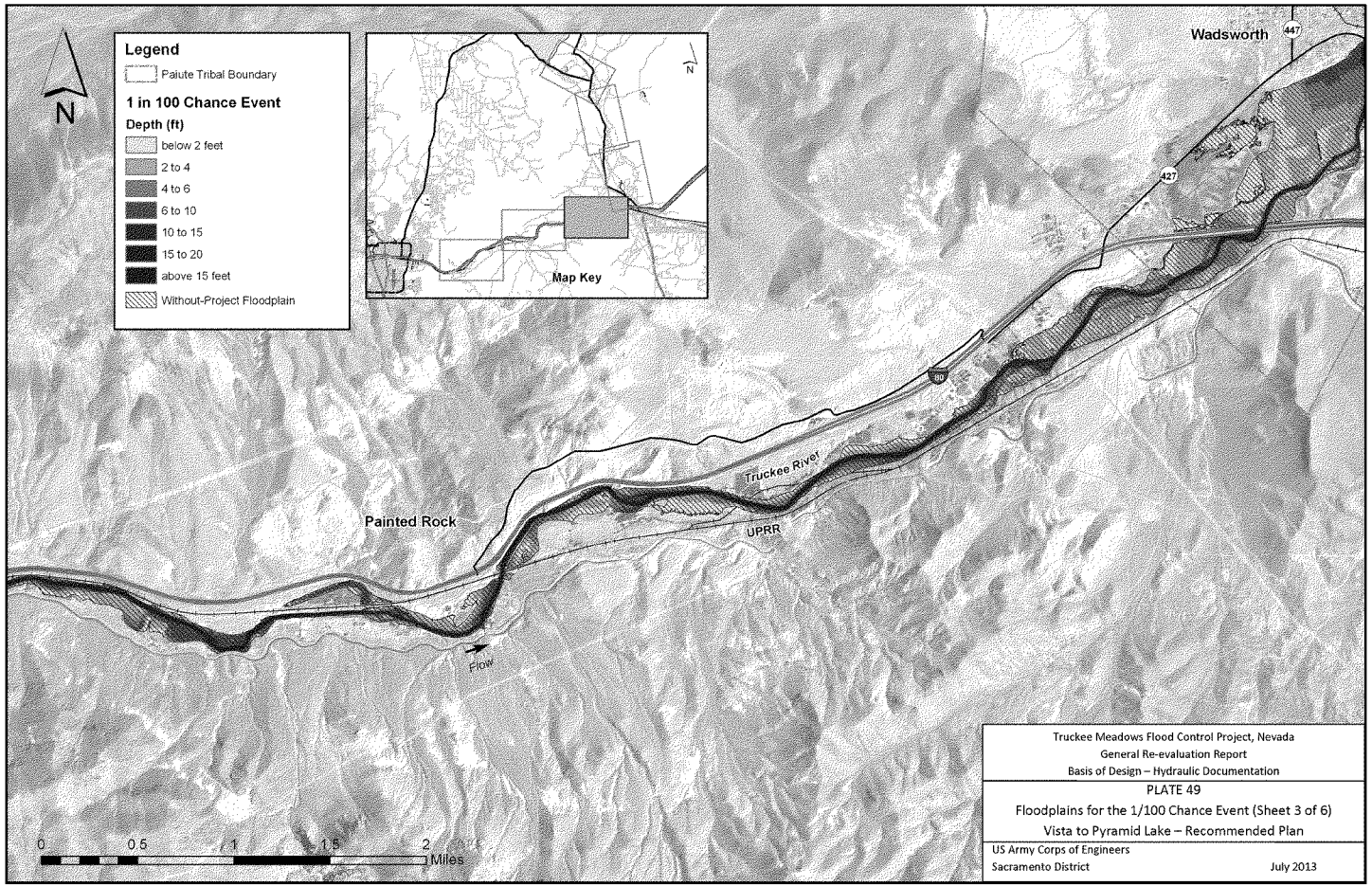


Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation

PLATE 48

Floodplains for the 1/100 Chance Event (Sheet 2 of 6)
Vista to Pyramid Lake – Recommended Plan

US Army Corps of Engineers
Sacramento District
July 2013



Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
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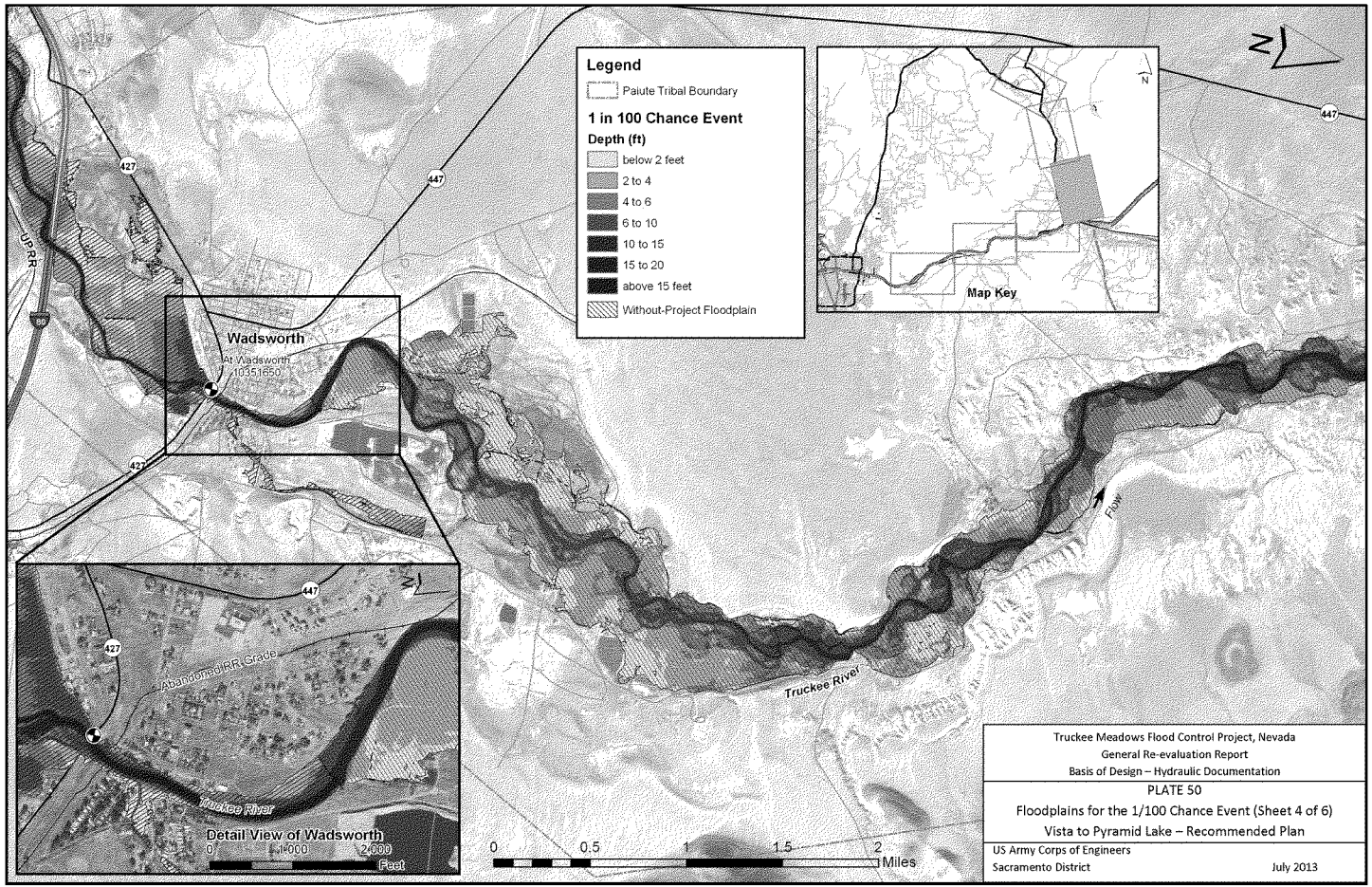
PLATE 49

Floodplains for the 1/100 Chance Event (Sheet 3 of 6)
Vista to Pyramid Lake – Recommended Plan

US Army Corps of Engineers
Sacramento District
July 2013



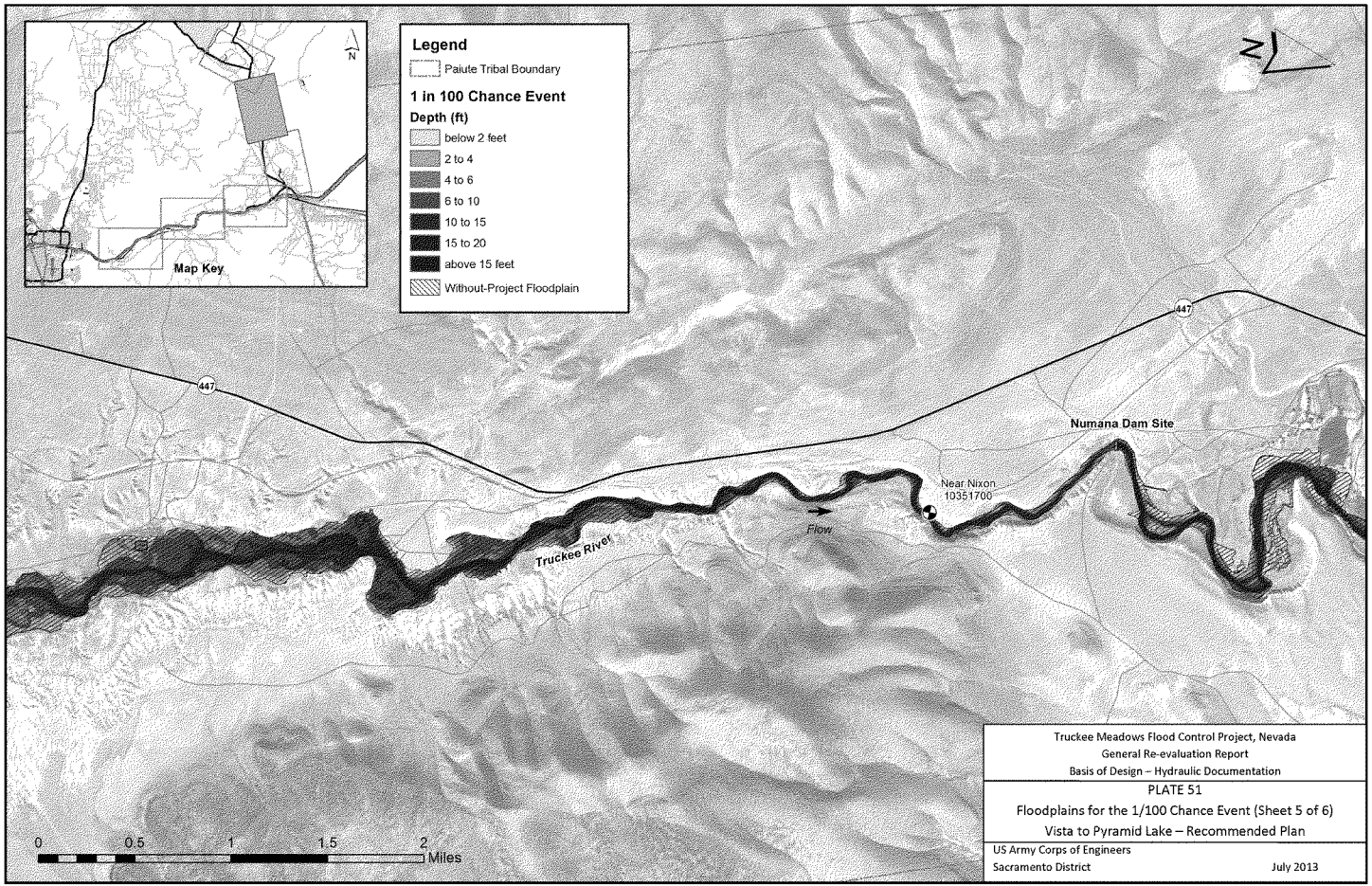
Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation

PLATE 50

Floodplains for the 1/100 Chance Event (Sheet 4 of 6)
Vista to Pyramid Lake – Recommended Plan

US Army Corps of Engineers
Sacramento District

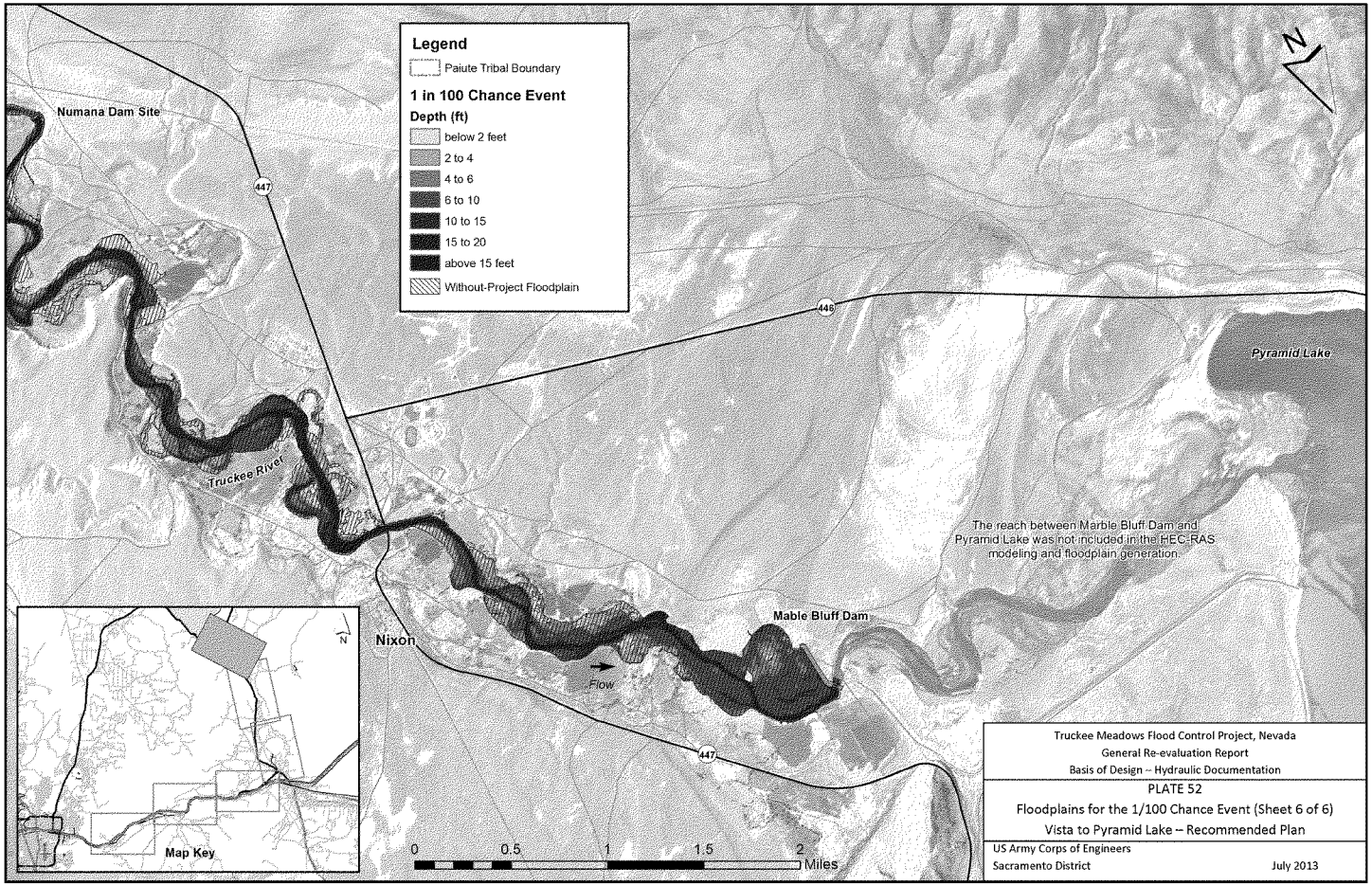
July 2013



Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design – Hydraulic Documentation

PLATE 51
Floodplains for the 1/100 Chance Event (Sheet 5 of 6)
Vista to Pyramid Lake – Recommended Plan

US Army Corps of Engineers
Sacramento District
July 2013



Truckee Meadows Flood Control Project, Nevada
General Re-evaluation Report
Basis of Design -- Hydraulic Documentation

PLATE 52

Floodplains for the 1/100 Chance Event (Sheet 6 of 6)
Vista to Pyramid Lake -- Recommended Plan

US Army Corps of Engineers
Sacramento District
July 2013

WALLA WALLA COST ENGINEERING MANDATORY CENTER OF EXPERTISE

COST AGENCY TECHNICAL REVIEW

CERTIFICATION STATEMENT

For Project No. P2 105630

SPK Truckee Meadows Flood Control

The Truckee Meadows Flood Control project, as presented by Sacramento District, has undergone a successful Cost Agency Technical Review (Cost ATR), performed by the Walla Walla District Cost Engineering Mandatory Center of Expertise (Cost MCX) team. The Cost ATR included study of the project scope, report, cost estimates, schedules, escalation, and risk-based contingencies. This certification signifies the products meet the quality standards as prescribed in ER 1110-2-1150 Engineering and Design for Civil Works Projects and ER 1110-2-1302 Civil Works Cost Engineering.

As of December 11, 2013, the Cost MCX certifies the estimated total project cost:

FY 2014 Project First Cost:	$280,820,000 incl $44.1M spent cost
Fully Funded Amount:	$307,100,000 includes spent costs

The spent costs were provided by the District and were not reviewed, which would require an internal audit. It remains the responsibility of the District to correctly reflect these cost values within the Final Report and to implement effective project management controls and implementation procedures including risk management throughout the life of the project.

JACOBS.MICHAEL.P.1160569537

Digitally signed by JACOBS.MICHAEL.P.1160569537
DN: c=US, o=U.S. Government, ou=DoD, ou=PKI, ou=USA, cn=JACOBS.MICHAEL.P.1160569537
Date: 2013.12.11 14:02:13 -08'00'

Michael P. Jacobs, PE, CCC
Chief, Cost Engineering MCX
Walla Walla District

****TOTAL PROJECT COST SUMMARY****

12/10/2013

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE RECOMMENDED PLAN REPORT.
PROJECT: TRUCKEE RIVER FLOOD CONTROL
LOCATION: NEVADA

U. S. ARMY CORPS OF ENGINEER, SACRAMENTO DISTRICT
P.O.C.: JEREMIAH A. FROST, CHIEF, COST ENGINEERING SECTION

WORK BREAKDOWN STRUCTURE		ESTIMATED COST				PROJECT FIRST COST (CONSTANT DOLLAR BASIS)				TOTAL PROJECT COST (FULLY FUNDED)					
		Estimate Prepared: 23-Jul-2013 Effective Price Level: 1-Oct-2013				PROGRAM YEAR(BUDGET EC): FY2014 EFF. PRICE LEVEL DATE: 1-Oct-2013				SPENT THRU: 1-Oct-2013					
WBS NO.	Civil Works Feature\Sub-Feature Description	COST ($K)	RISK BASED CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC. (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	COST ($K)	INFLATED (%)	COST ($K)	CNTG ($K)		FULLY FUNDED ($K)
A	B	C	D	E	F	G	H	I	J	K	L	M	N		O
Index Codes: 0 - no esc. applied; A - Administration; C - Combined indexes; All other codes used coincides with the Code of Accounts.															
		Contingencies Applied To Remaining Cost Only													
	FEDERAL COSTS														
9	CHANNELS & CANALS	36,812	9,953	27	46,765	0.00	36,812	9,953	46,765	0	12.6	41,454	11,209		52,663
11	LEVEES & FLOODWALLS	47,622	12,873		60,495		47,622	12,873	60,495	0		52,062	14,073		66,135
	Construction 11	46,089	12,458	27	58,547	0.00	46,089	12,458	58,547	0	9.2	50,345	13,609		63,954
	Section 104 11	1,533	415	27	1,948	0.00	1,533	415	1,948	0	12.0	1,717	464		2,181
14	RECREATIONS	6,321	1,709	27	8,030	0.00	6,321	1,709	8,030	0	15.2	7,281	1,968		9,249
16	BANK STABILIZATION	9,914	2,680	27	12,594	0.00	9,914	2,680	12,594	0	9.5	10,853	2,932		13,785
18	CULT. RESRC. PRESERV. (1	1,477	340	23	1,817		1,477	340	1,817	0		1,614	371		1,985
	SUBTOTAL FEDERAL & NON-FEDERAL CONSTRUCTION COSTS	102,146	27,555		129,701		102,146	27,555	129,701	0		113,264	30,553		143,817
1	LANDS & DAMAGES, Admin (2	1,455	73		1,528		1,455	73	1,528	0		1,600	80		1,680
	Construction	1,425	71	5	1,496	0.00	1,425	71	1,496	0	10.0	1,567	78		1,645
	Recreation	30	2	7	32	0.00	30	2	32	0	9.4	33	2		35
30	PLAN/ENGINEERING/DESIGN	57,300	4,187		61,487		57,300	4,187	61,487	42,200		60,914	5,190		66,104
	Construction	56,352	3,924		60,276		56,352	3,924	60,276	42,200		59,696	4,852		64,548
	Construction A	56,122	3,862	28	59,984	0.00	56,122	3,862	59,984	42,200	23.6	59,412	4,775		64,187
	Section 104 A	230	62	27	292	0.00	230	62	292	0	23.6	284	77		361
	Recreation	948	263	28	1,211	0.00	948	263	1,211	0	28.5	1,218	338		1,556
31	CONSTRUCTION MANAGE'MT	8,557	2,313		10,870		8,557	2,313	10,870	0		11,121	3,004		14,125
	Construction	8,020	2,168		10,188		8,020	2,168	10,188	0		10,419	2,815		13,234
	Construction A	7,890	2,132	27	10,022	0.00	7,890	2,132	10,022	0	29.9	10,249	2,769		13,018
	Section 104 A	130	36	28	166	0.00	130	36	166	0	30.1	170	46		216
	Recreation	537	145	27	682	0.00	537	145	682	0	30.6	702	189		891
	SUBTOTAL FEDERAL & NON-FEDERAL CONTRIBUTION	169,458	34,128		203,586		169,458	34,128	203,586	42,200		186,899	38,827		225,726
	NON-FEDERAL CONTRIBUTION (-)	-21,771	-165		-21,936		-21,771	-165	-21,936	-13,527		-25,152	-2,074		-27,226
	TOTAL FEDERAL COSTS	**$147,687**	**$33,963**		**$181,650**		**$147,687**	**$33,963**	**$181,650**	**$28,673**		**$161,747**	**$36,753**		**$198,500**
	NON-FEDERAL COSTS														
1	LANDS AND DAMAGES	50,306	16,139		66,445		50,306	16,139	66,445	1,912		53,939	15,620		69,559
	Construction	50,191	16,096		66,287		50,191	16,096	66,287	1,912		53,818	15,575		69,393
	Gross Appraised Value C	48,279	16,096	33	64,375	0.00	48,279	16,096	64,375	0	4.8	51,906	15,575		67,481
	Section 113	1,912	0		1,912		1,912	0	1,912	1,912		1,912	0		1,912
	Recreation	115	43	37	158	0.00	115	43	158	0	5.1	121	45		166
2	RELOCATIONS	8,487	2,302		10,789		8,487	2,302	10,789	0		9,294	2,521		11,815
	Relocations Construction	6,790	1,835	27	8,625	0.00	6,790	1,835	8,625	0	9.9	7,460	2,017		9,477
	Plan/Engineering/Design	1,018	283	28	1,301	0.00	1,018	283	1,301	0	6.8	1,088	302		1,390
	Construction Management	679	184	27	863	0.00	679	184	863	0	9.8	746	202		948
	SUBTOTAL NON-FEDERAL	58,793	18,441		77,234		58,793	18,441	77,234	1,912		63,233	18,141		81,374
	NON-FEDERAL CONTRIBUTION (+)	21,771	165		21,936		21,771	165	21,936	13,527		25,152	2,074		27,226
	RECREATION - 50% of Recreation Cost	3,861	1,038		4,899		3,861	1,038	4,899	0		4,557	1,226		5,783
	CONSTR. - 35% of Remaining Cost Less 18 Acct.	17,910	-873		17,037		17,910	-873	17,037	13,527		20,595	848		21,443
	TOTAL NON-FEDERAL COSTS	**$80,564**	**$18,606**		**$99,170**		**$80,564**	**$18,606**	**$99,170**	**$15,439**		**$88,385**	**$20,215**		**$108,600**
	TOTAL FEDERAL & NON - FEDERAL COSTS	**$228,251**	**$52,569**		**$280,820**		**$228,251**	**$52,569**	**$280,820**	**$44,112**		**$250,132**	**$56,968**		**$307,100**

SESSIONS.CAMERON.LOUIS.1393765972 — CHIEF, COST ENGINEERING

REED.ANTHONY.GLEN.1075045839 — PROJECT MANAGER

CAINE.SHARON.K.1230386052 — CHIEF, REAL ESTATE

ESTIMATED FEDERAL COST: $198,500
ESTIMATED NON-FEDERAL COST: $108,600
ESTIMATED TOTAL PROJECT COST: $307,100

GENERAL NOTES

(1 Cultural Resources Preservation costs associated with mitigation and/or data recovery up to one percent of the total Federal cost are not subject to cost sharing.
(2 Federal administrative costs for non-Federal land acquisition.
(3 The Fully Funded cost estimate was prepared in compliance with indexes used from CWCCIS reflecting OMB future rates Mar. 31 ,2012.
(4 01 Account for Land and Demages cost are from Real Estates.
(5 30 Account Planning, Engineering and Design and 31 Account Construction Management cost was provided by its respective organizations.

CONTINGENCY RATIONALE

(A CONTINGENCIES USED WAS DERIVED BY THE COST SCHEDULE RISK ANALYSIS PROCESS AND IS BASED ON A 80% CONFIDENCE LEVEL.

US Army Corps
of Engineers®

Truckee Meadows Flood Control, Nevada
General Re-Evaluation Report
Project Cost and Schedule Risk Analysis Report

Prepared by:

U.S. Army Corps of Engineers
Cost Engineering, Sacramento District

Dec 12, 2013

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EXECUTIVE SUMMARY

The US Army Corps of Engineers (USACE), Sacramento District, presents this cost and schedule risk analysis (CSRA) report regarding the risk findings and recommended contingencies for the Truckee Meadows Flood Control Project General Re-Evaluation Report (GRR). In compliance with Engineer Regulation (ER) 1110-2-1302 CIVIL WORKS COST ENGINEERING, dated September 15, 2008, a formal risk analysis, *Monte-Carlo* based-study was conducted by the Project Development Team (PDT) on remaining costs. The purpose of this risk analysis study is to present the cost and schedule risks considered, those determined and respective project contingencies at a recommend 80% confidence level of successful execution to project completion.

The study area includes approximately 60 miles of the Truckee River beginning just upstream of Reno, passing through Sparks and the Truckee Meadows, and ending at the river's terminus, Pyramid Lake, on the Pyramid Lake Paiute tribal. Due to the size of the land area and the number of river miles involved, the study area is divided into four general reaches for this study: Upper Truckee River, Downtown Reno, Truckee Meadows, and Lower Truckee River. The Recommended Plan has features in the Truckee Meadows reach of the project which encompasses an area bordered by Highway 395 to the west, Vista and the Virginia and Pah Rah Mountain ranges approximately 6 miles to the east, south along Steamboat Creek to Huffaker Hills, and north to Sparks.

The Recommended Plan is the NED plan for flood risk management (Alternative 3 – Floodplain Terrace Plan) and recreation (Alternative C). The principal features of the Recommended Plan are (1) construction of floodwalls, levees, and floodplain terracing in the Truckee Meadows reach, and (2) basic recreation features in the Truckee Meadows. Features are summarized below.

- Levees: 31,000 lineal feet (lf) on north/south banks of Truckee River.
- Floodwalls (on-bank): 6,500 lf on north and south banks of Truckee River.
- Floodwalls (in-channel): 3,150 lf on north and south banks of Truckee River.
- Floodplain terrace: 150-200 ft to the landside of the south bank of the Truckee River. A higher bench would be extended approximately 50-70 feet to the landside of the low bench.
- Box culverts: 2 box culverts on North Truckee Drain (NTD for approximately 3,100 lf. Includes a 200 lf extension to the existing People's Drain. Cap 2 junction structures of People's Drain.
- Interior drainage: 14 cfs pumping station and new flap gates and vertical sluice gates.
- Seepage prevention: Berms, drainage blankets, and relief wells.
- Bridge pier and scour protection: 11,600 lf rock scour protection. Pier protection at 3 bridges between US Hwy 395 and Vista.

- Picnic areas: 50 individual picnic areas, 1 small and 1 medium group picnic shelter, with parking, playground and restrooms.
- Water recreation access: 4 kayak/canoe input areas and 13 fishing areas.
- Trails: 18,800 lf of paved and unpaved trails.

Specific to the Truckee Meadows Flood Control Project, the current fully funded estimate approximates $307.1M which includes the project contingencies and escalation to midpoint of construction. Minor cost estimate changes can still occur during this General Reevaluation report phase that have little impact on risk outcome; therefore, contingencies can be expressed in dollars and/or percent values. The estimated project base cost for the remaining work approximates $184.1M (excluding spent costs, contingencies and escalation). This CSRA addresses the risks related to the remaining estimated efforts of $184.1M and is expressed in FY 2014 dollars. Based on the results of the analysis, Sacramento District recommends a contingency value of $52.6M or approximately 28.55% of base project cost. This contingency includes a separate $16.2M for Real Estate, another $29.4M for constructions costs, and $7M for design and construction management.

Sacramento District performed Cost Schedule Risk Analysis using the *Monte Carlo* technique for the estimated construction costs, supported by the district PDT input. The following table ES-1 portrays the development of the project contingencies (28.55%). The contingency is based on an 80% confidence level, as per USACE Civil Works guidance.

Table ES-1. Construction Contingency Results

Base Case Construction Cost Estimate	**$184,139,000**	
Confidence Level	**Construction Value**	**Contingency (%)**
5%	$192,493,000	4.54%
50%	$224,710,000	22.03%
80%	**$236,708,000**	**28.55%**
90%	$242,087,000	31.47%

The following table ES-2 portrays the full costs of the cost recommendations, combining all remaining costs. The costs are intended to address the congressional request of estimates to implement the project. The contingency is based on an 80% confidence level, as per accepted USACE Civil Works guidance.

Table ES-2. Cost Summary of Remaining Costs (FY2014 dollars)

TRUCKEE MEADOWS FEATURE ACCOUNTS		COST ($1,000)	CNTG ($1,000)	CNTG %	TOTAL ($1,000)
01	LANDS AND DAMAGES	49,849	16,212	31.3	66,061
02	RELOCATIONS	8,487	2,302	27.12	10,789
09	CHANNELS AND CANALS	36,812	9,953	27.0	46,765
11	LEVEES AND CHANNELS	47,622	12,873	27.0	60,495
14	RECREATION FACILITIES	6,321	1,709	27.0	8,030
16	BANK STABILIZATION	9,914	2,680	27.0	12,594
18	CULTRAL RESOURCR PRESERV.	1,477	340	23.0	1,817
30	PLANNING, ENGINEERING, AND DESIGN	15,100	4,187	27.0	19,287
31	CONSTRUCTION MANAGEMENT	8,557	2,313	27.0	10,870
FY 2014 REMAINING PROJECT COSTS		**186,139**	**52,569**	**28.55**	**236,708**
Schedule Completion with Contingency		**90 mo**	**38 mo**	**42.0**	**128 mo**

Notes:
1) Cost and Time contingencies presented w/ an 80% confidence level.
2) Costs exclude O&M and Life Cycle Cost estimates.

KEY FINDINGS/OBSERVATIONS RECOMMENDATIONS

The PDT worked through the risk register on two separate occasions: November 6, 2012 and again in February 27, 2013. That period of time allowed improved project scope definition, investigations, design and cost information, and resulted in reduced risks in certain project areas. The key risk drivers identified through sensitivity analysis suggest a cost contingency of $52.6M at an 80% confidence level.

Cost Risks: From the CSRA, the key or greater Cost Risk items of include:

- EXT-1: Funding Stream Impact – The construction schedule assumes an optimal funding stream. Potential reduction of funding, or intermittent funding through the remaining years, would increase cost, adding multiple contracts and contractor mobilizations, increased chances of project changes resulting from national,

state or local requirements, competitive market changes, extreme construction inflationary events, etc.

Moderate risks, when combined, can also become a cost impact.

- TL-4: Borrow Source Variation – Floodplain terracing designs will be refined in PED and may increase/decrease. Floodplain terracing designs are based on preliminary hydraulic modeling and may change.

- TL-5: Floodwall Quantity Variation – Quantity increases for floodwalls. Floodwalls were not analyzed for sliding and may require a key to resist sliding. The floodwall dimensions may be likely be redesigned during PED. Redesign is expected to cause minor quantity and cost variations.

- 'TL-1: Re-vegetation Quantity Variation. – Re-vegetation quantities will be refined in PED and may increase. Terrace designs are preliminary and may change. Preliminary designs are based on widths developed using preliminary hydraulic modeling,

- TL-2: North Truckee Drain Quantity Variation– Cost increase for North Truckee Drain features. Minimal design effort for road crossings and limited design for box culvert details. There will probably be additional costs associated with road crossing areas not accounted for in current design. The cost impact will likely be marginal as these areas are limited (only two crossings).

Schedule Risks: The high value of schedule risk indicates a significant uncertainty of key risk items, time duration growth that can translate into added costs. Over time, risks increase on those out-year contracts where there is greater potential for change in new scope requirements, uncertain market conditions, and unexpected high inflation. The greatest risk is:

- EXT-1: Funding Stream Impact – Construction schedule assume an optimal funding stream. Potential reduction of funding stream than projected would likely Delay schedule.

Moderate risks, when combined, can also become a time and resulting cost impact.

- PPM-2S: Review Delays- Multiple reviews may delay approvals. Discussion: With DQC, ATR, IEPR, and other vertical reviews, there's a chance for delayed approvals.

Recommendations: Timely coordination and risk resolution between the Sponsor and USACE is needed in areas funding requirements and updates as applicable. The PDT must include the recommended cost and schedule contingencies and incorporate risk monitoring and mitigation on those identified risks. Further iterative study and update of the risk analysis throughout the project life-cycle is important in support of the remaining project work within an approved budget and appropriation.

MAIN REPORT

1.0 PURPOSE

Under the auspices of the US Army Corps of Engineers (USACE), Sacramento District, this report presents a recommendation for the total project cost and schedule contingencies for the Truckee Meadows Flood Control Project.

2.0 BACKGROUND

The study area includes approximately 60 miles of the Truckee River beginning just upstream of Reno, passing through Sparks and the Truckee Meadows, and ending at the river's terminus, Pyramid Lake, on the Pyramid Lake Paiute tribal. Due to the size of the land area and the number of river miles involved, the study area is divided into four general reaches for this study: Upper Truckee River, Downtown Reno, Truckee Meadows, and Lower Truckee River. The Recommended Plan has features in the Truckee Meadows reach of the project which encompasses an area bordered by Highway 395 to the west, Vista and the Virginia and Pah Rah Mountain ranges approximately 6 miles to the east, south along Steamboat Creek to Huffaker Hills, and north to Sparks.

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- Interior drainage: 14 cfs pumping station and new flap gates and vertical sluice gates.
- Seepage prevention: Berms, drainage blankets, and relief wells.
- Bridge pier and scour protection: 11,600 lf rock scour protection. Pier protection at 3 bridges between US Hwy 395 and Vista.

- Picnic areas: 50 individual picnic areas, 1 small and 1 medium group picnic shelter, with parking, playground and restrooms.
- Water recreation access: 4 kayak/canoe input areas and 13 fishing areas.
- Trails: 18,800 lf of paved and unpaved trails.

As a part of this effort, Sacramento District requested that the USACE Cost Engineering Directory of Expertise for Civil Works (Cost Engineering MCX) provide an agency technical review (ATR) of the cost estimate and schedule for Recommended Project Plan.

3.0 REPORT SCOPE

The scope of the risk analysis report is to identify cost and schedule risks with a resulting recommendation for contingencies at the 80 percent confidence level using the risk analysis processes, as mandated by U.S. Army Corps of Engineers (USACE) Engineer Regulation (ER) 1110-2-1150, Engineering and Design for Civil Works, ER 1110-2-1302, Civil Works Cost Engineering, and Engineer Technical Letter 1110-2-573, Construction Cost Estimating Guide for Civil Works. The report presents the contingency results for cost risks for construction features. The CSRA excludes Real Estate costs and does not include consideration for life cycle costs.

3.1 Project Scope

The formal process included extensive involvement of the PDT for risk identification and the development of the risk register. The analysis process evaluated the Micro Computer Aided Cost Estimating System (MCACES) cost estimate, project schedule, and funding profiles using Crystal Ball software to conduct a *Monte Carlo* simulation and statistical sensitivity analysis, per the guidance in Engineer Technical Letter (ETL) CONSTRUCTION COST ESTIMATING GUIDE FOR CIVIL WORKS, dated September 30, 2008.

The project technical scope, estimates and schedules were developed and presented by the Los Angeles District. Consequently, these documents serve as the basis for the risk analysis.

The scope of this study addresses the identification of concerns, needs, opportunities and potential solutions that are viable from an economic, environmental, and engineering viewpoint.

3.2 USACE Risk Analysis Process

The risk analysis process for this study follows the USACE Headquarters requirements as well as the guidance provided by the Cost Engineering MCX. The risk analysis

process reflected within this report uses probabilistic cost and schedule risk analysis methods within the framework of the Crystal Ball software. Furthermore, the scope of the report includes the identification and communication of important steps, logic, key assumptions, limitations, and decisions to help ensure that risk analysis results can be appropriately interpreted.

Risk analysis results are also intended to provide project leadership with contingency information for scheduling, budgeting, and project control purposes, as well as to provide tools to support decision making and risk management as the project progresses through planning and implementation. To fully recognize its benefits, cost and schedule risk analysis should be considered as an ongoing process conducted concurrent to, and iteratively with, other important project processes such as scope and execution plan development, resource planning, procurement planning, cost estimating, budgeting and scheduling.

In addition to broadly defined risk analysis standards and recommended practices, this risk analysis was performed to meet the requirements and recommendations of the following documents and sources:

- Cost and Schedule Risk Analysis Process guidance prepared by the USACE Cost Engineering MCX.
- Engineer Regulation (ER) 1110-2-1302 CIVIL WORKS COST ENGINEERING, dated September 15, 2008.
- Engineer Technical Letter (ETL) CONSTRUCTION COST ESTIMATING GUIDE FOR CIVIL WORKS, dated September 30, 2008.

4.0 METHODOLOGY / PROCESS

The Sacramento District performed the Cost and Schedule Risk Analysis, relying on local Sacramento District staff and Truckee River Flood Management Agency to provide expertise and information gathering. The PDT conducted initial risk on November 6, 2012 supported with follow-on meetings. The initial risk identification meeting also included qualitative analysis to produce a risk register that served as the draft framework for the risk analysis.

Participants in the risk identification meeting included:

Name	Organization	Title
Tom Goebel	USACE - SPK	Engineering Division: Civil Design
James Lee	USACE - SPK	Engineering Division: Landscape
Joe Reynolds	USACE - SPK	Engineering Division: Cost Engineer
Jerry Frost	USACE - SPK	Engineering Division: Chief Cost Engineer
Darren Suen	USACE - SPK	PPMD Project Manger
Scott Stonestreet	USACE - SPK	Engineering Division: Hydraulic Engineer
Sherman Fong	USACE - SPK	Engineering Division: Cost Engineer
Laurie Parker	USACE - SPK	Real Estate Division: Real Estate
Jeff Nice	USACE - SPK	Planning: Administrator
Richard Perry	USACE - SPK	Engineering Division: Environmental
Jay Aldean	TRFMA	Civil Design
Paul Urban	TRFMA	Civil/Hydraulic
Eric Scheetz	TRFMA	Civil Design

*TRFMA = Truckee River Flood Management Agency

The risk analysis process for this study is intended to determine the probability of various cost outcomes and quantify the required contingency needed in the cost estimate to achieve the desired level of cost confidence. Per regulation and guidance, the P80 confidence level (80% confidence level) is the normal and accepted cost confidence level. District Management has the prerogative to select different confidence levels, pending approval from Headquarters, USACE.

In simple terms, contingency is an amount added to an estimate to allow for items, conditions or events for which the occurrence or impact is uncertain and that experience suggests will likely result in additional costs being incurred or additional time being required. The amount of contingency included in project control plans depends, at least in part, on the project leadership's willingness to accept risk of project overruns. The less risk that project leadership is willing to accept the more contingency should be applied in the project control plans. The risk of overrun is expressed, in a probabilistic context, using confidence levels.

The Cost MCX guidance for cost and schedule risk analysis generally focuses on the 80-percent level of confidence (P80) for cost contingency calculation. It should be noted that use of P80 as a decision criteria is a risk averse approach (whereas the use of P50 would be a risk neutral approach, and use of levels less than 50 percent would be risk seeking). Thus, a P80 confidence level results in greater contingency as compared to a P50 confidence level. The selection of contingency at a particular confidence level is ultimately the decision and responsibility of the project's District and/or Division management.

The risk analysis process uses *Monte Carlo* techniques to determine probabilities and contingency. The *Monte Carlo* techniques are facilitated computationally by a

commercially available risk analysis software package (Crystal Ball) that is an add-in to Microsoft Excel. Cost estimates are packaged into an Excel format and used directly for cost risk analysis purposes. The level of detail recreated in the Excel-format schedule is sufficient for risk analysis purposes that reflect the established risk register, but generally less than that of the native format.

The primary steps, in functional terms, of the risk analysis process are described in the following subsections. Risk analysis results are provided in Section 6.

4.1 Identify and Assess Risk Factors

Identifying the risk factors via the PDT is considered a qualitative process that results in establishing a risk register that serves as the document for the quantitative study using the Crystal Ball risk software. Risk factors are events and conditions that may influence or drive uncertainty in project performance. They may be inherent characteristics or conditions of the project or external influences, events, or conditions such as weather or economic conditions. Risk factors may have either favorable or unfavorable impacts on project cost and schedule.

A formal PDT meeting was held with the Sacramento District office for the purposes of identifying and assessing risk factors. The November 6, 2012 meeting included capable and qualified representatives from multiple project team disciplines and functions, including project management, cost engineering, design, environmental compliance, and real estate

The initial formal meetings focused primarily on risk factor identification using brainstorming techniques, but also included some facilitated discussions based on risk factors common to projects of similar scope and geographic location. Additionally, numerous conference calls and informal meetings were conducted throughout the risk analysis process on an as-needed basis to further facilitate risk factor identification, market analysis, and risk assessment. Another meeting was held Feb 27, 2013 for finalization of the risk register, resulting CSRA model, findings and results.

4.2 Quantify Risk Factor Impacts

The quantitative impacts of risk factors on project plans were analyzed using a combination of professional judgment, empirical data and analytical techniques. Risk factor impacts were quantified using probability distributions (density functions) because risk factors are entered into the Crystal Ball software in the form of probability density functions.

Similar to the identification and assessment process, risk factor quantification involved multiple project team disciplines and functions. However, the quantification process

relied more extensively on collaboration between cost engineering and risk analysis team members with lesser inputs from other functions and disciplines. This process used an iterative approach to estimate the following elements of each risk factor:

- Maximum possible value for the risk factor
- Minimum possible value for the risk factor
- Most likely value (the statistical mode), if applicable
- Nature of the probability density function used to approximate risk factor uncertainty
- Mathematical correlations between risk factors
- Affected cost estimate and schedule elements

The resulting product from the PDT discussions is captured within a risk register as presented in section 6 for both cost and schedule risk concerns. Note that the risk register records the PDT's risk concerns, discussions related to those concerns, and potential impacts to the current cost and schedule estimates. The concerns and discussions support the team's decisions related to event likelihood, impact, and the resulting risk levels for each risk event.

4.3 Analyze Cost Estimate and Schedule Contingency

Contingency is analyzed using the Crystal Ball software, an add-in to the Microsoft Excel format of the cost estimate and schedule. *Monte Carlo* simulations are performed by applying the risk factors (quantified as probability density functions) to the appropriate estimated cost and schedule elements identified by the PDT. Contingencies are calculated by applying only the moderate and high level risks identified for each option (i.e., low-level risks are typically not considered, but remain within the risk register to serve historical purposes as well as support follow-on risk studies as the project and risks evolve).

For the cost estimate, the contingency is calculated as the difference between the P80 cost forecast and the baseline cost estimate. Each option-specific contingency is then allocated on a civil works feature level based on the dollar-weighted relative risk of each feature as quantified by *Monte Carlo* simulation. Standard deviation is used as the feature-specific measure of risk for contingency allocation purposes. This approach results in a relatively larger portion of all the project feature cost contingency being allocated to features with relatively higher estimated cost uncertainty.

5.0 PROJECT ASSUMPTIONS

The following data sources and assumptions were used in quantifying the costs associated with the Truck Meadow Flood Control project.

a. The Sacramento District provided MII MCACES (Micro-Computer Aided Cost Estimating Software) files electronically. The MII and CWE files transmitted and downloaded on July 23, 2013 served as the basis for the final CSRA. Reference the Cost Appendix for further details.

b. The cost comparisons and risk analyses performed and reflected within this report are based on design scope and estimates that are at the preconstruction engineering and design (PED) level, most approximating a Feasibility stage.

c. Schedules are analyzed for impact to the project cost in terms of delayed funding, and languishing federal administration costs incurred throughout delay.

d. Per the CWCCIS Historical State Adjustment Factors in EM 1110-2-1304.

e. The Cost Engineering MCX guidance generally focuses on the eighty-percent level of confidence (P80) for cost contingency calculation. For this risk analysis, the eighty-percent level of confidence (P80) was used. It should be noted that the use of P80 as a decision criteria is a moderately risk averse approach, generally resulting in higher cost contingencies. However, the P80 level of confidence also assumes a small degree of risk that the recommended contingencies may be inadequate to capture actual project costs.

f. Only high and moderate risk level impacts, as identified in the risk register, were considered for the purposes of calculating cost contingency. Low level risk impacts should be maintained in project management documentation, and reviewed at each project milestone to determine if they should be placed on the risk "watch list".

6.0 RESULTS

The cost and schedule risk analysis results are provided in the following sections. In addition to contingency calculation results, sensitivity analyses are presented to provide decision makers with an understanding of variability and the key contributors to the cause of this variability.

6.1 Risk Register

A risk register is a tool commonly used in project planning and risk analysis. The actual risk register is provided in Appendix A. The complete risk register includes low level risks, as well as additional information regarding the nature and impacts of each risk.

It is important to note that a risk register can be an effective tool for managing identified risks throughout the project life cycle. As such, it is generally recommended that risk registers be updated as the designs, cost estimates, and schedule are further refined, especially on large projects with extended schedules. Recommended uses of the risk register going forward include:

- Documenting risk mitigation strategies being pursued in response to the identified risks and their assessment in terms of probability and impact.
- Providing project sponsors, stakeholders, and leadership/management with a documented framework from which risk status can be reported in the context of project controls.
- Communicating risk management issues.
- Providing a mechanism for eliciting feedback and project control input.
- Identifying risk transfer, elimination, or mitigation actions required for implementation of risk management plans.

6.2 Cost Contingency and Sensitivity Analysis

The result of risk or uncertainty analysis is quantification of the cumulative impact of all analyzed risks or uncertainties as compared to probability of occurrence. These results, as applied to the analysis herein, depict the overall project cost at intervals of confidence (probability).

Table 1 provides the construction cost contingencies calculated for the P80 confidence level and rounded to the nearest thousand. The construction cost contingencies for the P5, P50 and P90 confidence levels are also provided for illustrative purposes only.

Cost contingency for the Construction risks (including schedule impacts converted to dollars) was quantified as approximately $52.6 Million at the P80 confidence level (28.55% of the baseline construction cost estimate).

Table 1. Construction Cost Contingency Summary

Base Case Construction Cost Estimate	$184,139,000	
Confidence Level	**Construction Value**	**Confidence Level**
5%	$192,493,000	4.54%
50%	$224,710,000	22.03%
80%	**$236,708,000**	**28.55%**
90%	$242,087,000	31.47%

6.2.1 Sensitivity Analysis

Sensitivity analysis generally ranks the relative impact of each risk/opportunity as a percentage of total cost uncertainty. The Crystal Ball software uses a statistical measure (contribution to variance) that approximates the impact of each risk/opportunity contributing to variability of cost outcomes during *Monte Carlo* simulation.

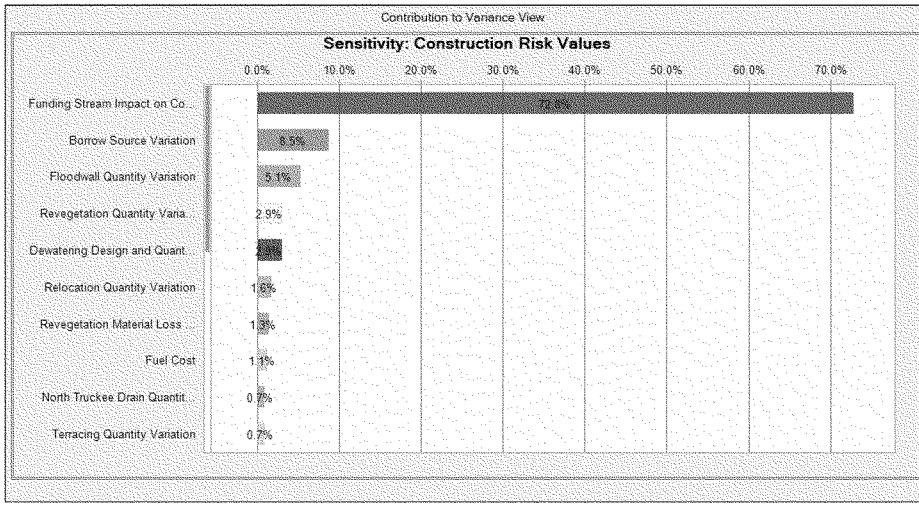
Key cost drivers identified in the sensitivity analysis can be used to support development of a risk management plan that will facilitate control of risk factors and their potential impacts throughout the project lifecycle. Together with the risk register, sensitivity analysis results can also be used to support development of strategies to eliminate, mitigate, accept or transfer key risks.

6.2.2 Sensitivity Analysis Results

The risks/opportunities considered as key or primary cost drivers and the respective value variance are ranked in order of importance in contribution to variance bar charts. Opportunities that have a potential to reduce project cost and are shown with a negative sign; risks are shown with a positive sign to reflect the potential to increase project cost. A longer bar in the sensitivity analysis chart represents a greater potential impact to project cost.

Figure 1 presents a sensitivity analysis for cost growth risk from the high level cost risks identified in the risk register. Likewise, Figure 2 presents a sensitivity analysis for schedule growth risk from the high level schedule risks identified in the risk register.

Figure 1. Cost Sensitivity Analysis



6.3 Schedule and Contingency Risk Analysis

The result of risk or uncertainty analysis is quantification of the cumulative impact of all analyzed risks or uncertainties as compared to probability of occurrence. These results, as applied to the analysis herein, depict the overall project duration at intervals of confidence (probability).

Table 2 provides the schedule duration contingencies calculated for the P80 confidence level. The schedule duration contingencies for the P50 and P100 confidence levels are also provided for illustrative purposes.

Schedule duration contingency was quantified as 38 months based on the P80 level of confidence. These contingencies were used to calculate the projected residual fixed cost impact of project delays that are included in the Table 1 presentation of total cost contingency. The schedule contingencies were calculated by applying the high level schedule risks identified in the risk register for each option to the durations of critical path and near critical path tasks.

The schedule was not resource loaded and contained open-ended tasks and non-zero lags (gaps in the logic between tasks) that limit the overall utility of the schedule risk analysis. These issues should be considered as limitations in the utility of the schedule

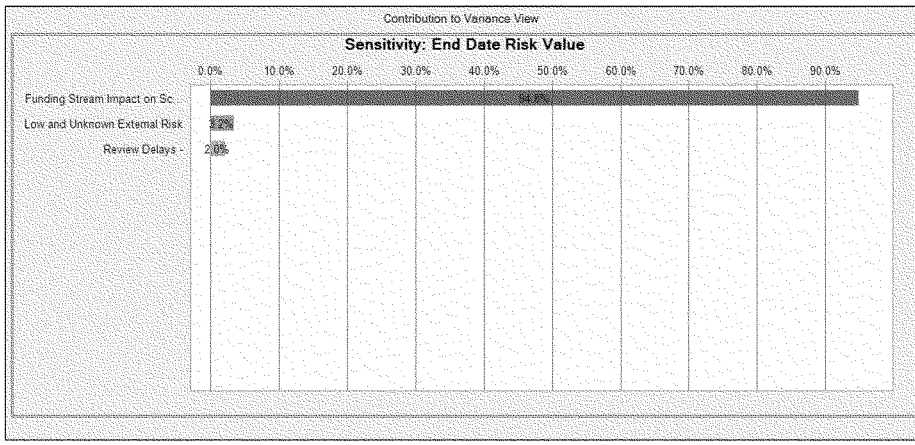
contingency data presented. Schedule contingency impacts presented in this analysis are based solely on projected residual fixed costs.

Table 2. Schedule Duration Contingency Summary

Risk Analysis Forecast	Schedule Duration (months)	Contingency[1] (months)
50% Confidence Level		
Project Duration	112	22
80% Confidence Level		
Project Duration	128	38
90% Confidence Level		
Project Duration	136	46

Notes:
1) The schedule was not resource loaded and contained open-ended tasks and non-zero lags (gaps in the logic between tasks) that limit the overall utility of the schedule risk analysis. These issues should be considered as limitations in the utility of the schedule contingency data presented in Table 2.
2) A P100 confidence level is an abstract concept for illustration only, as the nature of risk and uncertainty (specifically the presence of "unknown unknowns") makes 100% confidence a theoretical impossibility.

Figure 2. Schedule Sensitivity Analysis



7.0 MAJOR FINDINGS/OBSERVATIONS/RECOMMENDATIONS

This section provides a summary of significant risk analysis results that are identified in the preceding sections of the report. Risk analysis results are intended to provide project leadership with contingency information for scheduling, budgeting, and project control purposes, as well as to provide tools to support decision making and risk management as projects progress through planning and implementation. Because of the potential for use of risk analysis results for such diverse purposes, this section also reiterates and highlights important steps, logic, key assumptions, limitations, and decisions to help ensure that the risk analysis results are appropriately interpreted.

7.1 Major Findings/Observations

Project cost and schedule comparison summaries are provided in Table 3 and Table 4 respectively. Additional major findings and observations of the risk analysis are listed below.

The PDT worked through the risk register on two separate occasions: November 6, 2012 and again in February 27, 2013. That period of time allowed improved project scope definition, investigations, design and cost information, and resulted in reduced risks in certain project areas. The key risk drivers identified through sensitivity analysis suggest a cost contingency of $52.6M.

Cost Risks: From the CSRA, the key or greater Cost Risk items of include:

- EXT-1: Funding Stream Impact – The construction schedule assumes an optimal funding stream. Potential reduction of funding, or intermittent funding through the remaining years, would increase cost, adding multiple contracts and contractor mobilizations, increased chances of project changes resulting from national, state or local requirements, competitive market changes, extreme construction inflationary events, etc.

Moderate risks, when combined, can also become a cost impact.

- TL-4: Borrow Source Variation – Floodplain terracing designs will be refined in PED and may increase/decrease. Floodplain terracing designs are based on preliminary hydraulic modeling and may change.

- TL-5: Floodwall Quantity Variation – Quantity increases for floodwalls. Floodwalls were not analyzed for sliding and may require a key to resist sliding. The floodwall dimensions may be likely be redesigned during PED. Redesign is expected to cause minor quantity and cost variations.

- 'TL-1: Re-vegetation Quantity Variation. – Re-vegetation quantities will be refined in PED and may increase. Terrace designs are preliminary and may change. Preliminary designs are based on widths developed using preliminary hydraulic modeling,

- TL-2: North Truckee Drain Quantity Variation– Cost increase for North Truckee Drain features. Minimal design effort for road crossings and limited design for box culvert details. There will probably be additional costs associated with road crossing areas not accounted for in current design. The cost impact will likely be marginal as these areas are limited (only two crossings).

Schedule Risks: The high value of schedule risk indicates a significant uncertainty of key risk items, time duration growth that can translate into added costs. Over time, risks increase on those out-year contracts where there is greater potential for change in new scope requirements, uncertain market conditions, and unexpected high inflation. The greatest risk is:

- EXT-1: Funding Stream Impact – Construction schedule assume an optimal funding stream. Potential reduction of funding stream than projected would likely Delay schedule.

Moderate risks, when combined, can also become a time and resulting cost impact.

- PPM-2S: Review Delays- Multiple reviews may delay approvals.
  Discussion: With DQC, ATR, IEPR, and other vertical reviews, there's a chance for delayed approvals.

Table 3. Construction Cost Comparison Summary (Uncertainty Analysis)

Contingency Analysis				
Most Likely Cost Estimate	$228,251 K			
Confidence Level	Sunk Cost ($K)	Risk Value ($K)	Total Value ($K)	Contingency
0%	44,112	(1,509)	226,742	-0.82%
5%	44,112	8,354	236,605	4.54%
10%	44,112	18,218	246,469	9.89%
15%	44,112	21,443	249,694	11.65%
20%	44,112	24,669	252,920	13.40%
25%	44,112	27,728	255,979	15.06%
30%	44,112	30,786	259,037	16.72%
35%	44,112	33,419	261,670	18.15%
40%	44,112	36,051	264,302	19.58%
45%	44,112	38,311	266,562	20.81%
50%	44,112	40,571	268,822	22.03%
55%	44,112	42,473	270,724	23.07%
60%	44,112	44,376	272,627	24.10%
65%	44,112	46,303	274,554	25.15%
70%	44,112	48,229	276,480	26.19%
75%	44,112	50,399	278,650	27.37%
80%	44,112	52,569	280,820	28.55%
85%	44,112	55,259	283,510	30.01%
90%	44,112	57,948	286,199	31.47%
95%	44,112	73,306	301,557	39.81%
100%	44,112	88,663	316,914	48.15%

Table 4. Construction Schedule Comparison Summary (Uncertainty Analysis)

Contingency Analysis		
Most Likely Duration	90.1 Months	
Confidence Level	Value (Months)	Contingency
0%	90.07	**0.00%**
5%	91.02	1.06%
10%	91.97	**2.11%**
15%	92.92	3.17%
20%	93.88	**4.23%**
25%	94.96	5.43%
30%	96.05	**6.64%**
35%	100.03	11.06%
40%	104.01	**15.47%**
45%	107.87	19.76%
50%	111.73	**24.05%**
55%	114.42	27.03%
60%	117.10	**30.01%**
65%	119.60	32.79%
70%	122.10	**35.56%**
75%	125.01	38.79%
80%	**127.92**	**42.03%**
85%	131.78	46.31%
90%	135.63	**50.59%**
95%	146.30	62.43%
100%	156.97	**74.27%**

7.2 Recommendations

Risk Management is an all-encompassing, iterative, and life-cycle process of project management. The Project Management Institute's (PMI) *A Guide to the Project Management Body of Knowledge (PMBOK® Guide), 4th edition*, states that "project risk management includes the processes concerned with conducting risk management planning, identification, analysis, responses, and monitoring and control on a project." Risk identification and analysis are processes within the knowledge area of risk management. Its outputs pertinent to this effort include the risk register, risk quantification (risk analysis model), contingency report, and the sensitivity analysis.

The intended use of these outputs is implementation by the project leadership with respect to risk responses (such as mitigation) and risk monitoring and control. In short, the effectiveness of the project risk management effort requires that the proactive management of risks not conclude with the study completed in this report.

The Cost and Schedule Risk Analysis (CSRA) produced by the PDT identifies issues that require the development of subsequent risk response and mitigation plans. This section provides a list of recommendations for continued management of the risks identified and analyzed in this study. Note that this list is not all inclusive and should not substitute a formal risk management and response plan.

The CSRA study serves as a "road map" towards project improvements and reduced risks over time. Timely coordination and risk resolution between the Sponsor, Railroad, and USACE is needed in areas of ROW, mobile home relocations, site access and staging, and funding needs and updates as applicable. The PDT must include the recommended cost and schedule contingencies and incorporate risk monitoring and mitigation on those identified risks. Further iterative study and update of the risk analysis throughout the project life-cycle is important in support of remaining within an approved budget and appropriation.

Risk Management: Project leadership should use of the outputs created during the risk analysis effort as tools in future risk management processes. The risk register should be updated at each major project milestone. The results of the sensitivity analysis may also be used for response planning strategy and development. These tools should be used in conjunction with regular risk review meetings.

Risk Analysis Updates: Project leadership should review risk items identified in the original risk register and add others, as required, throughout the project life-cycle. Risks should be reviewed for status and reevaluation (using qualitative measure, at a minimum) and placed on risk management watch lists if any risk's likelihood or impact significantly increases. Project leadership should also be mindful of the potential for secondary (new risks created specifically by the response to an original risk) and residual risks (risks that remain and have unintended impact following response).

TRUCKEE RIVER FLOOD CONTROL , NED - RISK ANALYSIS CALCULATION Dec-12-2013

RISK NUMBER	RISK/OPPORTUNITY EVENT	DISCUSSION AND CONCERNS	PROJECT COST PROBABILITY (%)	PROJECT COST IMPACT*	PROJECT COST RISK LEVEL*	PROJECT SCHEDULE PROBABILITY (%)	PROJECT SCHEDULE IMPACT*	PROJECT SCHEDULE RISK LEVEL*	DECISION	MOST LIKELY ESTIMATED COST ($)	LOWER BOUND PERCENT LOWER (%)	LOWER BOUND COST ($)	UPPER BOUND PERCENT HIGHER (%)	UPPER BOUND COST ($)	CONFIDENCE LEVEL	50%	80%	90%	NOTES
01A	Federal Real Estate LERRD ADMIN.	Discussion: Real Estate has its own internal risk evaluation, Real Estate will not be part of the Risk Model								1,456,000					CONTINGENCY	+1.82%	6.02%	8.69%	RE Admin
															LERRD ADMIN - RISK VALUES	1,428,481	1,545,000	1,581,398	
01	Real Estate LERRD	Discussion: Real Estate has its own internal risk evaluation, Real Estate will not be part of the Risk Model								85,594,000					CONTINGENCY	28.59%	33.35%	36.38%	Real Estate
															Real Estate LERRD - RISK VALUES	61,261,893	64,533,000	65,959,481	
	Construction Features - Internal Risks (Internal Risk items are those that are generated, caused, or controlled within the PDT's sphere of influence.)																		
TL-1	Revegetation Quantity Variation	Concern: Vegetation quantities will be refined in PED and may increase. Discussion: Terrace designs and associated revegetations are preliminary and may change. Preliminary designs are based on limited developed using preliminary field data, mapping. Quantity variations can range from -10% to 30%	75%	2	Moderate				A	15,370,000	-10.0	13,833,000	30.0	20,749,500					Cost: affects entire construction cost; upper 95%, lower 10%, most likely 0%
TL-2	North Truckee Drain Quantity Variation	Concern: Cost increase for North Truckee Drain features. Description: Modified design prior for road crossings and limited design for bank repair details. There will probably be additional costs associated with road crossing areas not acquired for in current design. The cost impact will likely be marginal as these areas are limited (only two crossings). Quantity variation can reduce by 5% and increase by 30%	70%	2	Moderate				A	16,417,000	-5.0	10,296,150	30.0	14,068,100					Cost: affects entire construction cost; upper 90%, lower 5%, most likely 0%
TL-3	Terracing Quantity Variation	Concern: Floodplain terracing designs will be refined in PED and may decrease/increase. Discussion: Floodplain terracing designs are based on preliminary hydraulic modeling and may change. Quantity variation can reduce by 5% and increase by 25%	70%	2	Moderate				A	15,895,000	-5.0	10,074,750	25.0	13,256,250					Cost: affects entire construction cost; upper 95%, lower 5%, most likely 0%
TL-4	Borrow Source Variation	Concern: Borrow sources not fully determined. Discussion: Identified 20% of borrowed material available onsite, assumptions were made on other 75%. Key assumption is the use of quarries from UNR farms in close proximity of project. The option to importing fine grain materials which is likely longer haul cost. PDT believes UNR Farms is likely available for use as determined marginal impact. Potentially variation can increase by upto 50%	65%	2	Moderate				A	26,321,000	0.0	26,321,000	30.0	32,917,300					Cost: affects entire construction cost; upper 90%, lower 0%, most likely 0%
TL-5	Floodwall Quantity Variation	Concern: Quantity increases for floodwalls. Discussion: Floodwalls were not analyzed for sliding and may require a key to resist sliding. The floodwall dimensions may be slightly redesigned during PED. Impact is expected to be marginal as more variation in quantities anticipated. Potentially can increase by upto 30%	50%	2	Moderate				A	22,301,000	0.0	22,301,000	25.0	27,876,250					Cost: affects entire construction cost; upper 25%, lower 0%, most likely 0%
TL-6	Recreation Design and Quantity Variation	Concern: Changes in quantity & design. Discussion: Very little concern. Design and material variation. Any changes will be before PED. Would only recommend to keep costs from varying.	5%		Low				A	6,321,000	0.0	6,321,000	0.0	6,321,000					Cost: affects entire construction cost; upper 0%, lower 0%, most likely 0%
TL-7	Bank Protection Design and Quantity Variation	Concern: Potential increase in armor protection quantities for Truckee Meadows Reach. Discussion: With demonstration and design, quantities will likely increase. Potentially can increase by up to 25%	70%	2	Moderate				A	9,914,000	0.0	9,914,000	25.0	12,392,500					Cost: affects entire construction cost; upper 25%, lower 0%, most likely 0%
TL-8	Relocation Quantity Variation	Concern: Changes in quantity during design. Discussion: Variation of utilities items and greatly increase with better site investigations. Potentially can increase by up to 35%	75%	2	Moderate				A	6,790,000	0.0	6,790,000	35.0	9,166,500					Cost: affects entire construction cost; upper 35%, lower 0%, most likely 0%
ES-2	Dewatering Design and Quantity Variation	Concern: Dewatering during construction costs may increase. Discussion: Draw-down of the channel flows to will be refined in PED. Assumed simple dewatering mechanisms for estimate. Not direct account for particular high groundwater conditions, high water in river, weather, etc. May need more complicated dewatering so impact is significant. Potentially can increase by up to 10%	80%	2	Moderate				A	0	0.0	0	0.0	2,200,100					Cost: affects entire construction cost; upper 10%, lower 0%, most likely 0%
	General Account Variables									107,459,000	-2.4	104,849,900	28.3	138,097,500					
	External Risk (Items that are generated, caused, or controlled externally)																		
EXT-1	Funding Stream Impact on Cost	Concern: Construction schedule delayed, a result lately funding stream and cost instability. Discussion: Potential reduction of funding stream would likely increase cost. Political environment is the biggest driver for the risk/risk.	90%	3	High				A	18,118,992	-100.0	0	88.7	26,984,750					Cost: affects entire construction cost; upper 95%, lower 5%, most likely 15%

RISK ANALYSIS CALCULATION(Cont'd)

RISK NUMBER	RISK/OPPORTUNITY EVENT	DISCUSSION AND CONCERNS	PROJECT COST PROBABILITY (%)	PROJECT COST IMPACT*	PROJECT COST RISK LEVEL*	PROJECT SCHEDULE PROBABILITY (%)	PROJECT SCHEDULE IMPACT*	PROJECT SCHEDULE RISK LEVEL*	DECISION	MOST LIKELY EST/MATED COST ($)	LOWER BOUND PERCENT LOWER (%)	LOWER BOUND COST ($)	UPPER BOUND PERCENT HIGHER (%)	UPPER BOUND COST ($)	CONFIDENCE LEVEL	50%	80%	90%	NOTES
EXT-2	Revegetation Material Loss and Damage	Concerns: Vandalism and theft, inclement damage. Discussion: A need for additional mitigation costs. A need for replacement of irrigation equipment damaged by vandalism and theft.	40%	2	Moderate				A	0	0.0	0	0.0	3,074,036					Cost; affects entire construction cost; upper 20%, lower 0%, most likely 0%
Misc.	Fuel Cost	Concern: Fuel Cost increase. Discussion: More expected fuel cost indices has increased. It could likely increase to $5.00/gal.	100%	2	Moderate				A	0	0.0	0	0.0	2,734,476					Cost; affects entire construction cost; upper 0%, lower 0, most likely 0
EXT-3	Low and Unknown External Risk	Concern: There is always the potential for the unknown. Discussion: Consideration for Low and Unknown External Risk	100%	2	Moderate				A	0	0.0	0	0.0	6,372,950					Cost; affects entire construction cost; upper 5%, lower 5%, most likely 5%
	External Risk									16,118,850		0		38,048,212					
										123,577,850	-2.4	104,649,900	64.8	177,043,712	CONTINGENCY	20.34%	26.76%	29.84%	
															CONSTRUCTION - RISK VALUES	129,311,864	136,216,620	139,311,974	Construction only
	Schedule Risk - Used for applying Local Escalation Rates above CWCCIS National Average Rates														W/ ADD'L ESC	129,311,864	136,216,620	139,311,974	
	Start Month Delay (+/-)														W/ SCH DELAY	129,311,864	136,216,620	139,311,974	
PRM-25	Review Delays	Concerns: Multiple reviews may delay schedule. Discussion: With DOC, ATR, IEPR, and other critical reviews, there's a chance for delayed approvals.	50%	3	Low	A		0											Schedule; affects overall construction schedule; upper 6 Months, lower 0 Months, most likely 3 Months
															START MONTH - RISK VALUES	36	39	40	
	End Month Delay (+/-)																		
EXT-19	Funding Stream Impact on Schedule	Concerns: Construction schedule assume a optimal funding stream. Discussion: Potential reduction of funding stream than projected would likely increase cost.	50%	3	High	A		24											Schedule; affects overall construction schedule; upper 60 Months, lower 3 Months, most likely 24 Months
EXT-38	Low and Unknown External Risk	Concern: There is always the potential for the unknown. Discussion: Consideration for Low and Unknown External Risk	100%	3	Moderate	A		6											Schedule; affects overall construction schedule; upper 6 Months, lower 0 Months, most likely 6 Months
															END MONTH - RISK VALUES	112	128	136	
30	PED - Internal Risks (Internal Risk items are those that are generated, caused, or controlled within the PDT's sphere of influence.)																		
PRM-4	Coordination, Meeting, and Review Costs	Concerns: The cost of normal PDT function outside of design team as attending interagency working group meetings, reviewing work products, attending meetings, preparing IMPRS's, etc.) need to be included in the final cost. Discussion: There is likely an extensive record of the PDT time available to PM. This can be quantified by subtracting construction costs from overall project costs over a defined period and then adjusting that to PDT cost per year rate of consideration. This value can be used as the most likely cost of the future PDT tasks and to inform the upper and lower bound. This can be used to check any assumptions of this case (e.g. assume 12% of classifications costs in PDT-month) and future professional judgment of whether this assumed value is valid or needs to be revised.	75%	2	Moderate				A	16,118,000	-5.0	15,312,100	25.0	20,147,500					Cost; affects entire construction cost; upper 25%, lower 5%, most likely 0%
	General Account Variables									16,118,000	-5.0	15,312,100	25.0	20,147,500					
	External Risk (Risks that are generated, caused, or controlled externally)																		
EXT-1	Funding Stream Impact on Cost	Concerns: Construction schedule assume a most likely funding stream and constructability. Discussion: Potential reduction of funding stream would likely increase cost. Political announcements is the biggest driver for a variance.	50%	3	High	A		1,611,800	0.0	1,611,800	150.0	4,029,500							Cost; affects entire PED cost; upper 50%, lower 0%, most likely 0%
EXT-3	Low and Unknown External Risk	Concern: There is always the potential for the unknown. Discussion: Consideration for Low and Unknown External Risk	100%	2	Moderate	A		0	0.0	(805,900)	0.0	805,900							Cost; affects entire construction cost; upper 0%, lower 0%, most likely 0%
	External Risk									1,611,800		805,900		4,835,400					
															CONTINGENCY	13.66%	28.93%	31.36%	PED
										17,729,800	0.0	16,118,000	55.0	24,982,900	PED - RISK VALUES	19,125,869	20,468,432	21,173,240	
															CONTINGENCY	16.79%	23.62%	25.82%	*R Account

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RISK ANALYSIS CALCULATION(Cont'd)

RISK NUMBER	RISK/OPPORTUNITY EVENT	DISCUSSION AND CONCERNS	PROJECT COST			PROJECT SCHEDULE			DECISION	MOST LIKELY ESTIMATED COST ($)	LOWER BOUND		UPPER BOUND		CONFIDENCE LEVEL				NOTES
			PROBABILITY (%)	IMPACT*	RISK LEVEL*	PROBABILITY (%)	IMPACT*	RISK LEVEL*			PERCENT LOWER (%)	COST ($)	PERCENT HIGHER (%)	COST ($)		50%	80%	90%	
16	Cultural Resource	Discussion: Cultural Resource is based on 1% of Parent Obligation. Cultural Resource will not be part of the risk model.								1,477,000					Cultural Resource - RISK VALUES	1,724,938	1,317,000	1,858,290	
31	Supervision and Administration	Discussion: Supervision and Administration Contingency is assumed to have similar contingency as construction contingency. Supervision and Administration will not be part of the risk model.								9,330,000					CONTINGENCY	20.60%	27.04%	29.92%	31 Account
															S&A - RISK VALUES	11,138,267	11,723,000	11,989,927	
															CONTINGENCY	22.03%	28.55%	31.47%	TOTAL PROJECT
															TOTAL PROJECT - RISK VALUES	224,799,531	236,708,000	242,087,073	
															W/ ADD'L ESC	224,799,531	236,708,000	242,087,073	
	Total Project Cost									184,139,000					W/ SCH DELAY	224,799,531	236,708,000	242,087,073	

TRUCKEE MEADOWS FLOOD DAMAGE REDUCTION PROJECT, RENO, NEVADA

GEOTECHNICAL SUMMARY REPORT

US Army Corps
of Engineers
Sacramento District

PREPARED BY
SOIL DESIGN SECTION

GEOTECHNICAL BRANCH

October 21, 2013

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SECTION 1 PROJECT DESCRIPTION

1.1 PROJECT DESCRIPTION

The purpose of this report is to present the findings of geotechnical studies from 1977 to 2011 for flood control and containment measures for the Truckee Meadows Flood Damage Reduction Project. The project is located in Truckee Meadows area of Washoe County, Nevada from Highway 395 to Vista. A Vicinity Map and Project Location Map are provided in Figures 1 and 2.

This report specifically addresses the measures that pertain to the Meadows area (i.e., the north and south bank of the Truckee River between Highway 395 and Vista) and the ring levee around UNR Farms. Previous geotechnical reports included flood damage reduction measures for Downtown Reno, Huffaker Hills Dam, Mustang Ranch Detention Basin, Boynton Slough, Steamboat Creek, Lockwood, and Wadsworth. All of these areas have been removed from this report, as they are no longer part of the project.

1.1.1 TRUCKEE MEADOWS

Since this report is a compilation of past explorations, there are instances where both West Meadows and East Meadows are referred to as "the Meadows area". The Truckee Meadows area includes the north and south banks of the Truckee River from U.S. Highway 395 to Vista (Figure 2). West Meadows includes the north and south banks of the Truckee River from Highway 395 to East McCarran Blvd. East Meadows includes the north and south banks of the Truckee River from East McCarran Blvd to Vista. UNR Farms is an area within the boundaries of both East and West Meadows; however, it is independent for descriptive purposes of this report. The flood control features in these regions include a combination of levees, floodwalls, benching, seepage berms, relief wells, drainage blankets, and new levee construction.

1.1.2 UNR FARMS RING LEVEE

Previous iterations of the Truckee Meadows project included a detention basin at the University of Nevada Reno (UNR) Farms complex. The purpose of the detention basin was to attenuate floodwater flows of the Truckee River downstream of the project limits. The detention basin is no longer part of the current flood control plan. Instead a ring levee is proposed to surround and protect the buildings and structures located in the northwest corner of the UNR Farms complex. The ring levee is located immediately downstream of East McCarran Blvd on the south bank of the Truckee River. This new levee would encircle existing structures that, for economic purposes, are too large to elevate. This measure allows diversion of flood waters to flood waterside UNR farmland while leaving the existing structures protected. The length of the proposed ring levee is approximately 1.15 miles.

1.2 REGIONAL AND SITE GEOLOGY

Reno is located on the western edge of the Great Basin in a transitional region between the Basin and Range province and the Sierra Nevada province. Truckee Meadows is a structural basin bounded on the west by the Carson Range, on the east by the Virginia Range, on the south by the Steamboat Hills, and on the north by the Peavine Mountain block.

The Mesozoic age metavolcanic and metasedimentary rocks on the Peavine sequence are overlain by a thick sequence of Tertiary volcanic and epiclastic rocks consisting of lava flows, breccias, and tuffs. Fluviatile and lacustrine sediments were the initial deposits and consist of conglomerate, siltstone, sandstone and diatomite. These are exposed along the margins of Truckee Meadows. The three major categories of Quaternary deposits in the Truckee Meadows region, representing a long established pattern of basin sedimentation, consist of glacial outwash deposits and Truckee River gravels, alluvial fan deposits around the perimeter of the basin, and fine-grained flood plain and lake deposits through the central and eastern part of the Truckee Meadows.

The geologic structure of the area was produced by faulting and warping. Quaternary faults that trend due north are common and widespread northward through Reno and in the Mount Rose fan complex northwest of Steamboat Hills. Nearly all the faults are normal faults with displacement varying from a few feet to about 50 feet. Higher scarps are present along the western edge of Virginia Lake southward to the northwest side of Steamboat Hills. Another prominent set of faults trending north to northeast is concentrated in a 2 mile wide zone immediately northwest of the Truckee River in western Reno.

The Truckee River follows a winding eastward course through the Truckee River Valley west of Reno and into the Truckee Meadows area. The entire area is underlain by late Pleistocene Donner Lake and Tahoe glacial outwash deposits. The Donner Lake outwash deposit overlays bedrock and ranges from 30 feet thick at the west end of the basin to over 330 feet thick under Reno. The Tahoe glacial outwash deposit lies above the Donner Lake outwash and ranges in thickness from about 300 feet under the western part of Reno to over 1,000 feet beneath Sparks. The Truckee River has reworked the top portion of the outwash and deposited the material along the modern floodplain of the river, overlying earlier glacial outwash. Both glacial outwash deposits contain boulders as large as 16 feet in diameter. Portions of the outwash are overlain by floodplain and lacustrine deposits. The floodplain materials are primarily clayey silt, silt, and silty sand with interstitial lenses of either peat or clay-rich sediments as shown on the Soil Conservation Map (Figure 3). Geologic stratigraphic profiles along the north and south banks of the Truckee River are provided in Figures 17 and 18.

1.3 REGIONAL SEISMICITY

Two major fault systems are responsible for most of the seismic activities in western Nevada. The Sierra Nevada Frontal System is an irregular zone of major and secondary faults extending from the Garlock Fault northward along the east side of the Sierra Nevada Range for more than 400 miles. A second major zone, possibly related to the Frontal System, is the 118-degree Meridian Zone that trends southwest of Winnemucca to at least Owens Valley. Reno lies between these two major fault zones. The Peak Ground Acceleration (PGA) for 0.2 and 1.0 second (Sec) spectral acceleration (SA) values are listed in Table 1 with their respective return periods:

Return Period (years)	PGA (g)	0.2 Sec SA (g)	1.0 Sec SA (g)
100	0.14	0.34	0.09
975	0.44	1.12	0.33
2475	0.61	1.36	0.49
5000	0.74	1.76	0.67
10000	0.71	1.99	0.84

Table 1: PGA for 0.2 and 1.0 second SA values with their respective Return Periods in years.

A prominent set of northeast-trending faults occurs in northwest and central Reno (see Figure 16). One northeast-trending fault crosses the Truckee River north of the Reno Cannon International Airport. The east margin of Truckee Meadows is bounded by a fault. An obscured fault, with indications of fairly recent activity, may lie due north of the sewage facility. Areas underlain by glacial outwash and mainstream deposits of the Truckee River are believed to be potentially unstable and subject to slumps or ground disturbances along steep cuts or embankments during a major seismic event. Areas underlain by flood plain and lake deposits are subject to liquefaction should severe ground motion occur, and surface dislocation. This is especially dangerous in areas of groundwater discharge or where the soils are saturated.

Historically, the most severe earthquakes in the area included those of magnitudes 6.0 and 6.4 just south of Reno in 1914. The first had an intensity of VII (Modified Mercalli Scale) in the Truckee Meadows area. It produced cracks in buildings and had two distinct shocks lasting 6 to 30 seconds. The second had an intensity of VIII in Reno. It lasted 10 seconds and toppled chimneys in the area. Two more earthquakes, both of magnitude 6.0 occurred near Virginia City in 1869 and near Verdi in 1948. There was another earthquake of magnitude 5.7 north of Truckee in 1966.

Research has found three to five separate movements on faults just north of Reno on the Mount Rose fan complex occurring within the last 11,000 years. A zone of recent micro-activity is centered about 9 miles south of the Truckee River in the vicinity; the faults cutting through the area are considered to be capable faults.

SECTION 2 EXPLORATIONS

2.1 TRUCKEE MEADOWS

Explorations have been performed in the Truckee Meadows area during five exploration programs, the first performed in 1982. Explorations have been drilled along the alignments of the proposed flood control features (levees and floodwalls) along the north and south bank of the Truckee River between Highway 395 and Vista, the UNR Farms Detention Basin, the UNR Farms Ring Levee, Steamboat Creek, Boynton Slough, and the North Truckee Drain. The current plan now only includes flood control features along the north and south bank of the Truckee River and the UNR Farms Ring Levee. The Boring Location Maps for the West Meadows, East Meadows, and UNR Farms Explorations are provided in Figures 4 through 9.

2.1.1 1982 EXPLORATION PROGRAM

The first exploration program was conducted in March 1982 by Leeds, Hill and Jewett, Inc. under contract with the USACE. The program consisted of sixteen borings drilled to a depth of 20 feet. The borings were drilled by P.C. Explorations, Inc. of Roseville, CA using a 6-inch outside diameter hollow-stem auger powered by a Mobile truck-mounted drill rig. Standard Penetration Tests (SPT's) were performed in accordance with ASTM D1586-67 and consisted of dropping a 140-pound hammer a distance of 30 inches to drive a 1-3/8-inch inner diameter split spoon sample. SPT's were performed approximately every 2-foot of borehole advance, except in intervals where undisturbed Shelby tube samples were taken or where gravel was encountered. Representative soil specimens were selected and laboratory tested. The borings are labeled B-1 through B-16. The logs of explorations are provided in Appendix A.

2.1.2 1988 EXPLORATION PROGRAM

The second exploration program was conducted by the Sacramento District in August 1988 and consisted of eight borings drilled to a depth of 20 feet. The borings are designated as 2F-88-1 through 2F-88-8. Drilling was performed by Western Strata Exploration using a Mobile B-53 drill rig with an 8-inch hollow stem auger. SPT data was obtained with an 18-inch long standard penetrometer and a 140-pound automatic trip hammer with a 30-inch drop. SPT's were continuous to 5 feet, then taken at every 5 feet to the bottom of the hole. Disturbed samples were obtained from the penetrometer and undisturbed samples were taken at predetermined depths in all borings using a 3-inch diameter by 36-inch long Shelby tube. Soil samples were tested at the South Pacific Division (SPD) laboratory. The logs of explorations and a summary of laboratory test data are provided in Appendix A.

In October 1988 the Sacramento District excavated three trenches along the south bank of the Truckee River using a Case 680-E Backhoe equipped with an 18-inch bucket. Sack samples were collected from each change of material in each trench and the samples were sent to the SPD Laboratory for testing. The three trenches were located in the West Meadows area and are

labeled 4F-88-1 through 4F-88-3 (Figure 4). Logs of the trenches and laboratory test data are provided in Appendix A.

2.1.3 1998 EXPLORATION PROGRAM

In September 1998, four cone penetrometer explorations (CPT-98-1 through CPT-98-4) were drilled by VBI In-Situ Testing of Oakland, CA, under contract with the USACE. Two of the explorations (CPT-98-3 & 4) were pushed to their target depth of 40 feet. The other two were only pushed to depths of 27 and 31 feet due to the tip encountering very hard material. The CPT's are located in the East Meadows, UNR Farms, and Boynton Slough area. The locations of CPT's are shown in Figures 5 and 6.

In November 1998, six borings were drilled by Western Strata Explorations under contract with the USACE. The borings are designated 2F-99-1 to 2F-99-6. The borings were drilled with a Mobile B-61 drill rig using a 6-inch diameter hollow-stem auger. Five of the six borings were drilled to depths of 40 to 43 feet. One boring, 2F-99-5 was only drilled to 25 feet because of auger refusal on cobble/boulder material. Disturbed soil samples were collected with an SPT sampler every 2 feet for the upper 20 feet of boring then taken every 5 feet from 20 feet deep to the bottom of boring. Undisturbed samples of fine-grained material were collected with a 3-inch diameter by 36-inch long Shelby tube. Soil samples were sent to a USACE certified laboratory for grain size distribution, Atterberg limits, moisture content, dry density, unconsolidated-undrained triaxial compression, consolidated-undrained triaxial compression with pore pressure measurements, and consolidation tests. The locations of the borings are shown on Figures 4 and 5 and the drill logs are provided in Appendix A.

2.1.4 2003 EXPLORATION PROGRAM

In September 2003, the Sacramento District conducted an exploration program in the Truckee Meadows area that included The Meadows Area, UNR Farms, North Truckee Drain, and Mustang Ranch. Drilling was performed by Taber Consultants using a Dietrich D-120 drill rig using an 8-inch diameter hollow stem auger and mud-rotary with a 3-1/2-inch drag bit. Drilling started out with the hollow stem auger and then switched to mud-rotary when the hollow-stem augers encountered either refusal, heaving sands, or groundwater. An automatic trip safety hammer for the collection of SPT samples. The penetrometer had an inside diameter of 1-3/8 inches and a length of 24 inches. SPT samples were collected every two feet. The samples were field classified and all soil descriptions were performed by a geologist from the Sacramento District. The program consisted of 15 borings designated as 2F-03-39 to 2F-03-53 (Figure 4, 5, and 6) drilled to depths of 39 to 41.5 feet. The logs of explorations are provided in Appendix A. Three of these borings (2F-03-46, 47, and 48) are located in the Mustang Ranch area and are outside the current project limits.

2.1.5 2009 EXPLORATION PROGRAM BY KLEINFELDER

In October 2009, Kleinfelder, under contract with the USACE, conducted an exploration and testing program in the Truckee Meadows area from Highway 395 eastward to Larkin Circle in Sparks. These explorations consisted of 102 sonic borings, 68 hollow-stem auger borings, 35 Cone Penetrometer Tests, and the installation of 18 piezometers. Locations of the explorations are provided in Figures 7, 8, and 9. Stick Logs for both the North Shore and South Shore can be found on Figures 10 through 15. The logs of the sonic, auger holes, and CPT's are provided in Appendix A.

A total of 102 sonic borings were drilled and are designated SF-09-001 to SF-09-102. The drilling depth ranged from 60 to 90-feet (Figures 7, 8, and 9). The sonic borings were drilled using a 4-inch core barrel on a truck-mounted Gus Pech RS-400 Super Sonic or a Brata Sonic 1455 drill rigs. Sonic cores were retrieved in 10-foot runs and placed in 5-foot long wood core boxes. Samples were selectively collected and bagged immediately from sonic cores to obtain more accurate moisture content for test results.

A total of 68 hollow-stem auger borings were drilled with an eight inch diameter auger to a target depth of 60 feet using a truck-mounted CME 85 or a CME 95 drill rig. The hollow-stem auger borings are designated 2F-09-01 to 2F-09-68. Representative soil samples were collected using a 1-3/8-inch inside diameter, 2-inch outside diameter, 24-inch long standard penetration split spoon sampler (SPT); the type that does not accept liners. SPT's were driven using a 140-pound hammer free falling a distance of 30-inches. SPT samples were collected at 2-foot intervals beginning at a depth of 0.5-feet extending to the bottom of drill hole. Shelby tube samples were collected at locations chosen by the engineer on site.

Eighteen piezometers were constructed to obtain ground water readings for before project conditions, also to determine the change in ground water over time as the river rises to measure horizontal and vertical hydraulic conductivity. The piezometers were constructed of 2-inch diameter, schedule 80, flush threaded, Type II Polyvinyl Chloride casing with 0.02-inch wide slot screen. Screen was placed in each boring from the bottom to five feet below ground surface. The filter-pack was placed slowly with RMC Pacific Materials Lapis Lustre No. 2.5mm sand from the bottom of the boring to two feet above the screened interval. A bentonite clay seal with a minimum thickness of 2-feet was placed above the filter pack using non-beneficiated bentonite pellets. Bentonite-cement grout was placed slowly from the top of the bentonite clay seal to the ground surface using a trimmie-pipe. All piezometers were read within 0.01 ft.

Thirty-five Cone Penetrometer Tests (CPT) were completed with a maximum target depth of 60 feet. All soundings encountered refusal with actual depths ranging from 5 to 35 feet. CPT soundings were performed with a 25-ton truck-mounted CPT rig. A Kleinfelder engineer was on site to observe all soundings and direct pore pressure dissipation testing.

In summary, Kleinfelder drilled 68 HSA borings with a target depth of 60 feet and was successful at meeting this depth at most locations; 102 sonic borings were successful at depths of 60 to 90 feet; thirty-five (35) cone penetrometer tests (CPT); eighteen (18) piezometers were installed. The 2009 HAS borings, sonic borings and CPT tests are shown on Kleinfelder Plates 4, 5, and 6; gINT logs with lab results and CPT data can be requested for review.

Both primary and secondary testing Laboratory testing was performed. Primary testing consisted of Sieve Analysis (ASTM D 422), Atterberg Limit tests (ASTM D 4318), and moisture content tests (ASTM D 2216). Primary testing was performed to determine soil characteristics and soil classification. Secondary testing consisted of Consolidation Tests (ASTM D 2435), Consolidated Undrained Triaxial Compression Tests (ASTM D 4767), and Unconsolidated Undrained Triaxial Compression Tests (ASTM D 2850). Secondary testing was performed to determine the strength parameters of the soil.

2.2 EXPLORATIONS FOR BORROW SITE EVALUATION

Three borrow sites have been investigated including the UNR Farms, the South Bank Truckee River at the Channel Widening site between South McCarran Blvd and Steamboat Creek, and the South Bank Truckee River between Rock Blvd. and East McCarran Blvd. Logs of explorations performed in the borrow sites area provided in Appendix B.

2.2.1 UNR FARMS

A borrow investigation program was performed on 23 September 1998 to investigate the eastern section of UNR Farms. The area is located along the west bank of Steamboat Creek between Pembroke Drive and Cleanwater Way. The borrow site was investigated with ten backhoe trenches (4B-98-01 through 4B-98-10). The depth of trenches was 10 to 12.5 feet. Laboratory testing included grain size distribution, Atterberg limits, and moisture content. Compaction and shear strength testing was initiated several months later, but due to budgetary restrictions, funds were rescinded during testing in August 1990, which resulted in less than 5 percent completion of the test program.

2.2.2 CHANNEL WIDENING SITE

A borrow investigation program was performed in 2001 along the south bank of the Truckee River starting at East McCarran Boulevard and extending a distance of 1.7 miles to the east to near the mouth of Steamboat Creek. It was proposed to widen the channel of the Truckee River along the south bank of the river so a borrow investigation program was performed to sample and test the suitability of the subsurface material within the excavation limits of the channel widening for suitability for levee fill material. A total of 31 backhoe trenches were

excavated to a planned depth of 15 feet using a JCB backhoe with a 2-foot wide bucket. All trenches were excavated within 300 feet of the south bank of the Truckee River. The trenches are designated as 4F-01-01 through 09 and 4F-01-12 through 33 (note that trenches 4F-01-10 & 11 were not excavated because rights-of-entry were not granted to the USACE). A map showing the locations of the trenches is provided on Figures 4, 5, and 6.

2.2.3 KLEINFELDER 2011 BORROW EXPLORATION

Kleinfelder completed a borrow investigation on 28, January 2011. This study for a local borrow source consisted of 18 trenches near the south bank Truckee River from Rock Boulevard heading east to East McCarran Boulevard. The trenches are designated 4F-10-01 to 4F-10-18. The 2009 Kleinfelder soil investigation for the setback levee in the same area showed that suitable soil for levee construction may exist in this area. Test data show approximately 30% of test pits contained soil that meets USACE Plasticity and Grain Size Distribution criteria for levee fill. The chart showing acceptable USACE Plasticity and Grain Size Distribution criteria for levee fill is located shown on Figure 20. A map showing locations of the trenches is provided in Figure 19.

SECTION 3 SUBSURFACE CHARACTERIZATION

3.1 GENERAL

Exploration logs used for subsurface characterizations referenced in this report have been included in Appendix A. The logs contain detailed information of conditions encountered during the drilling and sampling of the soil borings, as well as results of laboratory testing. The majority of the foundation and deep foundation soils are a mixture of sands and gravels with high hydraulic conductivity. Logs of trenches performed in the proposed borrow sites are provided in Appendix B.

3.2 TRUCKEE MEADOWS (EAST AND WEST MEADOWS)

The soil along the north bank of the Truckee River in the East Meadows region is predominantly silty sand for the first 8 to 12 feet. The loose to firm, sub-angular, sand is generally moist and dark-yellowish brown to pale brown in color. The fines content ranges from 33% to 49% and are low plasticity. The silty sand is underlain by a firm to stiff clay that is moist and grayish brown in color. The clay has 80% to 90% medium plastic fines and 10% to 20% fine sand. The clay material is underlain with a sand to gravel, pervious substratum. The groundwater table was encountered at depths ranging from 12 to 21 feet below the surface.

The subsurface conditions in the West Meadows region may be characterized as a silty sand top stratum that is 5 to 10 feet thick underlain by a gravel substratum. The silty sand has sand particles that are generally fine and angular, containing approximately 20% non-plastic fines. The silty sand is underlain with a sand and fine to coarse gravel substratum. The sand and gravel particles are sub-angular, dense, and contained a few cobbles and boulders. The average depth to the groundwater table was 10 feet.

3.3 UNR FARMS AREA

Subsurface conditions in the UNR Farms region are characterized as a clay top stratum overlaying a gravel substratum. The clay blanket ranges in thickness from 5 to 20 feet and is dark gray to grayish brown in color and loose to firm in consistency. Partially decayed broadleaf grasses at depths of 8 to 11 feet were found in some of the borings and are indicative of a wet marshy environment. The gravel is granitic, well graded, dense and usually contained more than 15% sand and non-plastic fines. The average depth to the water table near the Truckee River is 7 feet. The 2009 Kleinfelder investigation focused on northwest corner of UNR Farms, the area where the proposed ring levee is to be constructed. Soil encountered here is similar to that listed above.

3.4 BORROW SOURCES

3.4.1. UNR FARMS

A section of UNR Farms was investigated for a borrow source in 1998. The area is located on the eastern side of UNR Farms along the west bank of Steamboat Creek between Pembroke Drive and Cleanwater Way. The borrow site was investigated with ten backhoe trenches (4B-98-01 through 4B-98-10). The material encountered in the top five feet was field classified as lean and fat clay. The trenches encountered a significant amount of fat clay, elastic silts, and nonplastic silts and silty sands which are not acceptable for levee fill. Therefore, it was concluded that the borrow site was not acceptable due to the limited amounts of suitable fill and the intermixing of suitable fill with unsatisfactory fat clays, elastic silts, and nonplastic silty sands which would make obtaining suitable fill problematic.

3.4.2 CHANNEL WIDENING SITE

The channel widening area is located along the south bank of the Truckee River from East McCarran Blvd to the confluence with Steamboat Creek. The area was investigated as a potential borrow source in 2001 when 31 backhoe trenches were excavated.

Groundwater was encountered at depths ranging from 7 to 14 feet in nine trenches, all of which are located west of 4F-01-18. Furthermore, there appears to be a transition from coarse-grained material in the western trenches to fine-grained material in the eastern trenches. This transitional area occurs at or near the locations of trenches 4F-01-15 and 4F-01-18. All but two of the trenches on the east side of the transition area were excavated to their planned depth of 15 feet, whereas none of the trenches on the west side were excavated to their full depths due to caving and high groundwater. As would be expected in cohesionless soils, the final depth of the west side trenches were generally within one or two feet of groundwater occurrence.

The most common soil groups encountered in the 17 trenches east of 4F-01-15 were clay and silt or any combination thereof. Most samples were categorized as CL/ML in the exploration logs to indicate that they are a borderline classification between the two groups. This material was encountered 29 times in 18 different trenches for a total footage of 147 feet. The material has a liquid limit that ranges from 28 to 49 and a plasticity index that ranges from 4 to 20. The dry unit weight of a CL/ML sample was found to be 96 pcf. The second most common soil type was fat clay and elastic silt (CH/MH) or any combination thereof. Again, most of these were classified as CH/MH to indicate a borderline classification between the two groups. This material was found in all 17 trenches east of 4F-01-15 and has a liquid limit between 39 and 64 and a plasticity index that ranges from 12 to 34. The dry unit weight of a CH/MH sample was found to be 87 pcf. This soil is too plastic and most likely contains organic material thus eliminating is as suitable soil.

Twelve different soil groups were encountered in the 14 trenches west of 4F-01-18. Though seven of these classifications were coarse-grained soils, the foremost is a borderline CL/ML combination similar to that of the east side. The CL/ML soil was encountered 19 times in 12 different trenches for a total of 90.5 feet. The material has a liquid limit that ranges from 29 to 49 and a plasticity index that ranges from 1 to 19. The dry unit weight of a CL/ML sample was found to be 99 pcf. The coarse grained material most probably does not meet USACE Grain Distribution requirements.

The second most common soils encountered west of 4F-01-18 were silty and clayey sands. These materials occurred 15 times in 13 different trenches for a total footage of 36.5 feet. The fines content ranged from 15% to 49% and is mostly non-plastic to medium plasticity. Also encountered in the area, but to a lesser degree, were poorly graded sands and gravels with clay or silt. The dry unit weight of a poorly graded sand with silt found to be 99 pcf. This is most probably suitable soil for levee construction.

3.4.3 ROCK BLVD TO EAST McCARRAN BLVD.

A study for borrow sources was completed by Kleinfelder on 28, January 2011. This study consisted of 18 additional trenches along the south bank of the Truckee River from Rock Blvd in the west to McCarran Blvd on the east. Test data show approximately 30% of test pits meet USACE Plasticity and Grain Size Distribution criteria for levee fill. The trench locations and logs are located in Appendix B. The 2011 Kleinfelder report shows that only about 130,000 cubic yards of suitable borrow material may be excavated from this site.

3.4.4 CONCLUSION

Sacramento District's design guidance recommends that levees be constructed of clays, silts, clayey sands, and silty sands with at least 20 percent fines (material passing the #200 sieve) and a maximum particle size of 2 inches. The fines should have a plasticity index of at least 8 and less than 25, and a maximum liquid limit of 45. It is currently proposed to utilize material from the Channel Widening excavation and from the Rock Blvd to McCarran reach for borrow material for levee and embankment construction. Based on the limited exploration program conducted at the two sites, there appears to be a sufficient quantity of material available that meets Sacramento District's specifications. It is recommended, however, that additional explorations occur during subsequent design phases to define limits of acceptable borrow material. The uncertainty associated with actual borrow materials and quantities available at each site may have several impacts on the project. Such impacts may include differences in costs to obtain borrow or design modifications to accommodate the differing materials. These potential impacts are not expected to pose significant risks or changes in cost for the project.

SECTION 4 SEEPAGE ANALYSIS

4.1 GENERAL

Seepage analyses were performed to evaluate foundation underseepage conditions under the levees and floodwalls and also to determine the phreatic surface in the levees for slope stability evaluation. Seepage analyses were performed using computer generated flownets computed by the program SEEP2D using Groundwater Modeling System (GMS) version 3.1 graphical interface. For foundation conditions under levees and floodwalls in which a relatively impervious top stratum overlies a more pervious substratum, the USACE blanket theory analysis, as described in Appendix B of EM 1110-2-1913, was used.

Soil properties used in the seepage models are based on field classifications and available lab results from the explorations. Because permeability testing was not within the scope of these test programs, hydraulic conductivities were used from various published sources that correlate permeability coefficients with soil types, often based on soil index properties, to hydraulic conductivity. It is assumed that the borrow material for all embankments in this project will be comprised of a semi-impervious soil such as a sandy clay or clayey sand. Hydraulic conductivities used in the seepage models for the embankments (0.252 feet/day horizontal and 0.028 feet/day, vertical) are the same for all project areas.

Sacramento Districts' design criteria, requires that the exit gradient be not greater than 0.5 at the toe of a levee or floodwall and not greater than 0.8 at the toe of a seepage berm. It is recognized that at this level of study the design presented herein should be considered preliminary and is intended largely for preliminary costing purposes to assist with selection of a preferred flood damage reduction plan. With further subsurface investigations and laboratory testing or additional analysis where soil boring data exists, proposed seepage control measures can be better defined making cost refinements possible.

4.2 UNDERSEEPAGE ANALYSES IN THE TRUCKEE MEADOWS AREA

Seepage analysis was performed to evaluate foundation underseepage conditions under the levees and floodwalls proposed in the Meadows area. The Meadows region was divided into 13 reaches and seepage conditions were evaluated for each reach. The reaches were separated based on subsurface conditions, proposed flood control structure (i.e., levee or floodwall), and geographical location. The 13 reaches are designated as Reach 1, 2, 3a, 3b, and 4 through 12 and are listed in Table 2. Also listed in Table 2 are the generalized subsurface conditions for each reach.

When the underseepage analysis was conducted, the Truckee Meadows Project was a larger project that included flood damage reduction measures not only in the Meadows area but also along Steamboat Creek, Boynton Slough, and the North Truckee Drain. These features have been eliminated from the currently proposed plan, however the results of the underseepage analysis are still presented in this report. Furthermore, underseepage analysis was also

conducted for the UNR Detention Basin which was proposed in previous iterations of the project. The current project has eliminated the detention basin and instead has construction of a ring levee around structures in the northwest corner of the UNR Farms complex. The underseepage conditions of the ring levee are similar to Reach 7 (UNR Farms Detention Basin West & South Levee) and Reach 8 (UNR Farms Detention Basin North Levee).

Reach Number	Location	Proposed Flood Control Structure	Subsurface Conditions
1	Truckee River left (north) bank - Vista to North Truckee Drain	Levee	12' thick clay top stratum; sand & gravel substratum of unknown thickness
2	Truckee River left (north) bank - North Truckee Drain to 5,000' upstream of North Truckee Drain	Levee	20' thick clay top stratum; sand & gravel substratum of unknown thickness
3a	Truckee River left (north) bank - 5,000' upstream of North Truckee Drain to McCarran Blvd.	Levees and Floodwalls	8' thick silty sand top stratum; sand, gravel, & cobble substratum of unknown thickness
3b	Truckee River left (north) bank - McCarran Blvd. to Greg St.	Levees and Floodwalls	5' thick silty sand top stratum; sand, gravel, & cobble substratum of unknown thickness
4	Truckee River left (north) bank - Greg St. to Glendale Ave.	Levees and Floodwalls	Sand, gravel, & cobble from ground surface to unknown depth
5	Truckee River right (south) bank - McCarran Blvd. to Greg St.	Levee	9' thick sandy silt top stratum; sand, gravel, & cobble substratum of unknown thickness
6	Truckee River right (south) bank - Greg St. to Hwy 395	Floodwall	Sand, gravel, & cobble from ground surface to unknown depth
7	UNR Farms Detention Basin - West & South Levee	Levee	9' thick clay top stratum; sand & gravel substratum of unknown thickness
8	UNR Farms Detention Basin - North Levee	Levee	12' thick clay top stratum; sand & gravel substratum of unknown thickness
9	UNR Farms Detention Basin - East Levee	Levee	17' thick clay top stratum; 20' thick sand and gravel substratum
10	Boynton Slough (both banks)	Levees and Floodwalls	15' thick clay top stratum; 15' sand and gravel substratum
11	Steamboat Creek (both banks)	Levees and Floodwalls	7 to 15' thick clay top stratum; 10' thick sand substratum
12	North Truckee Drain	Floodwall	12' thick clay top stratum; sand & gravel substratum of unknown thickness

Table 2: Location of Reaches and Subsurface Conditions.

SECTION 4 SEEPAGE ANALYSIS

Seepage conditions were evaluated using the Corps' blanket theory analysis for subsurface conditions in which a less pervious top stratum is underlain with a more pervious substratum. The blanket theory analysis was done according to procedures outlined in the Corps EM 1110-2-1913 Appendix B. Blanket theory analysis calculates the substratum pressure at the base of the less pervious top stratum at a point under the toe of the levee or floodwall. The corresponding upward gradient through the top stratum is also calculated by dividing the substratum pressure by the thickness of the top stratum. For the reaches in which there is no top stratum, such as Reaches 4 and 6, flow nets were constructed to evaluate the seepage conditions. Flow nets were constructed using the finite element computer program SEEP2D and Groundwater Modeling System version 3.1. The localized exit gradient at the toe of the levee or floodwall was calculating using the flow net.

The upward gradients calculated by blanket theory and the localized exit gradients calculated by flow nets are compared to the maximum allowable gradient. If the upward/exit gradient is less than the maximum allowable gradient, then the potential for adverse seepage conditions (i.e., boils, piping, top stratum heave) is low. Conversely, if the calculated upward/exit gradients are greater than the maximum allowable gradient, then the potential for adverse seepage conditions is high and corrective action is required to control the excessive gradients so that the project will perform satisfactory during a flood event. A maximum allowable gradient of 0.5 is selected for this project in accordance to guidance found in the Sacramento District's, Geotechnical Branch SOP #3.

There are five basic soil types encountered in the subsurface of the Meadows area that were included in the seepage models. The soil types include a clay top stratum, sandy silt top stratum, silty sand top stratum, sand and gravel layer along Boynton Slough and Steamboat Creek, and gravel, cobble, and possibly boulders along the Truckee River, North Truckee Drain, and the western alignment of UNR Farms Detention Basin. The permeability values assigned to each soil type are shown in Table 3.

Material	Permeability (ft/day)	
	Horizontal	Vertical
Clay top stratum < 10' thick	1.13	0.28
Clay top stratum 10' to 15' thick	0.56	0.14
Clay top stratum > 15' thick	0.112	0.028
Sandy silt top stratum	1.13	0.28
Silty sand top stratum <5' thick	11.3	2.8
Silty sand top stratum 5' to 10' thick	5.7	1.4
Sand and gravel	28	7
Gravels, Cobbles, Boulders	112	28

Table 3: Permeability Values used in the Seepage Analysis of the Meadows Area.

Seepage analyses were conducted at each reach using various floodwater elevations to determine the highest water surface at which the uplift or exit gradient does not exceed the maximum allowable gradient of 0.5. If the gradient is 0.5 or less for a given water surface, foundation seepage control is not required. Results of the seepage analysis are shown in Table 4. Calculations are provided in Appendix C. The water surface heights provided in the third column of Table 4 is the vertical distance between the top of the water surface and landside ground of the levee or floodwall. For water surfaces less than or equal to the values presented in Table 4, foundation seepage is not required. If, however, the water surface for a given reach exceeds the values presented in Table 4, then foundation underseepage control is recommended. Underseepage control measures are described in Section 7.

The analysis methods and parameters used in the seepage analyses, most notably the permeability values, incorporate some degree of uncertainty into the analysis results. Subsequent phases of study and design will utilize more refined analysis methods and more refined site-specific parameters. These refinements will likely result in some differences between the analysis results reported herein and those developed in those subsequent study phases. In particular, the controlling water surface heights presented in Table 4 may change. Such changes would be expected to result in changes to the design elements, but mostly in terms of dimensions of those elements. It is considered unlikely that significant changes, such as wholesale changes to mitigation approach for numerous reaches, would occur.

Reach Number	Location	Water Surface Height (1) (feet)	Uplift or Exit Gradient
1	Truckee River left (north) bank - Vista to North Truckee Drain	6	0.44
2	Truckee River left (north) bank - North Truckee Drain to 5,000' upstream of North Truckee Drain	10	0.47
3a	Truckee River left (north) bank - 5,000' upstream of North Truckee Drain to McCarran Blvd.	4	0.45
3b	Truckee River left (north) bank - McCarran Blvd. to Greg St.	3	0.52
4	Truckee River left (north) bank - Greg St. to Glendale Ave.	5	0.43
5	Truckee River right (south) bank - McCarran Blvd. to Greg St.	7	0.47
6	Truckee River right (south) bank - Greg St. to Hwy 395	5	0.43
7	UNR Farms Detention Basin - West & South Levee	8	0.48
8	UNR Farms Detention Basin - North Levee	15	0.50
9	UNR Farms Detention Basin - East Levee	12	0.48
10	Boynton Slough (both banks)	7	0.45
11	Steamboat Creek (both banks)	8	0.50
12	North Truckee Drain	6	0.49

(1) Water Surface Height is the vertical distance between the top of water surface and the landside ground of the levee or floodwall.

Table 4: Results of Seepage Analysis

SECTION 5 SLOPE STABILITY ANALYSIS

5.1 GENERAL

Embankment stability against shear failure was analyzed using the UTexas4 software package. The principal method used was the Spencer Procedure with an assumed sliding surface having the shape of a circular arc within the embankment and/or foundation. The three loading conditions that were analyzed were End-of-Construction (EOC), Steady State Seepage and Rapid Drawdown. Results for these U-Texas4 evaluations see Appendix D.

The End-of-Construction analysis is considered a short-term evaluation and is based on expected conditions that will exist at the completion of construction. Because neither the embankment nor the foundation is expected to fully drain or consolidate during this period, total stress or unconsolidated-undrained shear strength parameters are used. Materials above and below the water table are assigned moist and saturated unit weights, respectively. Pore water pressures for cohesive material below the phreatic surface are accounted for in the shear strength properties using undrained based shear strenghts. The minimum required factor of safety for this loading condition is 1.3 based on Corps Criteria.

The long-term evaluation is considered a steady state seepage condition and is based on the assumption of a fully developed phreatic surface through the embankment during a flood event. Drained shear strengths are used and are characterized by the effective stress shear strength parameters. Saturated unit weights are used in the embankment and the pore water pressure is calculated by UTexas4. External water pressures from the reservoir are applied as a distributed load against the upstream slope. The minimum required factor of safety for this loading condition is 1.4 for the surcharge elevation and 1.5 for the gross pool elevation for detention structures. For levees, the minimum factor of safety is 1.4 from full flood stage based on Corps Criteria.

The rapid drawdown analysis is used to verify stability of the embankment under the condition of drawing down a reservoir pool faster than the pore water pressure can be dissipated. It is assumed that the drawdown is very fast and no drainage occurs in low permeability materials. The procedure is a two-stage analysis and requires two sets of stability calculations. The first stage of the analysis is representative of consolidated conditions just prior to drawdown and uses the same effective stress parameters used in the long-term analysis. The second stage of this procedure uses the normal and shear stresses developed during the first stage and estimates undrained shear strength parameters to compute the factor of safety during the undrained loading. This analysis was completed for both the gross pool and surcharge pool elevations. For levees, the minimum factors of safety range from 1.0 to 1.2. These minimum factors of safety are based on Corps Criteria.

5.2 EAST AND WEST MEADOWS

The slope stability evaluation for the East and West Meadows is based on two borings that represent the most critical subsurface conditions in the area. Two different models were created based on differing foundation conditions between 2F-99-01 and 2F-88-03. The primary difference between the two is that the blanket in 2F-99-01 is comprised of a fine grain material, whereas the blanket encountered in 2F-88-03 is comprised of a coarse grain, silty sand material.

The embankments with 1V:3H side slopes were modeled as homogeneous structures with heights of 18 and 23 feet. The standard crest widths and inspection trenches were included in the models. Soil parameters used in the evaluation are given in Tables 5 and 6. Both steady state and rapid drawdown conditions were evaluated at assumed pool elevations that were 3 feet below the crest. The selected geometry was found to be stable at all design water surfaces. Resulting factors of safety are given in Table 7.

The results of these analyses, although based on relatively limited geotechnical data, are based on relatively conservative parameters and yet provide good factors of safety. So, although there is some uncertainty in the parameters and the resulting values, differences in the parameters and corresponding different resultant values would be expected to provide the same overall result, and pose little risk to the project design, configuration, and cost.

Layer (Depth, ft)	Unit Weight		Cohesion		Friction Angle	
	Moist	Saturated	Undrained	Drained	Undrained	Drained
	lb/ft^3	lb/ft^3	lb/ft^2	lb/ft^2	Deg.	Deg.
Embankment, CL	112	120	1400	200	14	26
Blanket, CL (0 – 12)	112	116	1000	0	0	30
Substratum, SW (12 – 42)	-	125	0	0	0	32

Table 5: East Meadows (2F-99-01) Shear Strength Parameters

Layer (Depth, ft)	Unit Weight		Cohesion		Friction Angle	
	Moist	Saturated	Undrained	Drained	Undrained	Drained
	lb/ft^3	lb/ft^3	lb/ft^2	lb/ft^2	Deg.	Deg.
Embankment, CL	112	120	1400	200	14	26
Blanket, SM (0 – 20)	110	120	0	0	30	30
Substratum, SW (20 – 60)	-	125	0	0	35	35

Table 6: East Meadows (2F-88-03) Shear Strength Parameters

Loading Condition	Minimum Factor of Safety for Shown Borings	
	East Meadows (2F-99-01)	East Meadows (2F-88-03)
End of Construction	3.01	2.77
Steady State Seepage	1.46	1.55
Rapid Draw Down	1.32	1.46

Table 7: East Meadows Critical Slope Stability Minimum Factor of Safety

5.3 UNR FARMS RING LEVEE

Slope stability analysis for UNR Farms is based upon foundation conditions in boring 2F-99-03, which represents the most critical foundation conditions in the UNR Farms area. For modeling purposes, the subsurface was generalized as a fine grain material with alternating layers of soft and stiff clays and silts. Material properties used in the model are found in Table 8.

The embankment that was modeled had 1V:3H side slopes, a height of 18 feet and a 20-foot wide crest. The elevation of the water surface for the steady state seepage conditions was 15 feet above the existing ground surface. The minimum safety factors from this analysis are found in Table 9.

Layer (Depth, ft)	Unit Weight		Cohesion		Friction Angle	
	Moist	Saturated	Undrained	Drained	Undrained	Drained
	lb/ft^3	lb/ft^3	lb/ft^2	lb/ft^2	Deg.	Deg.
Embankment, CL	112	120	900	200	9	26
Blanket, CL (0 – 4)	112	115	900	100	9	30
Substratum, Soft CH (4 – 13)	112	115	400	100	0	26
Substratum, CL (13 - 20)	112	115	800	100	0	30
Substratum, Soft CL,ML (20 - 40)	112	115	360	100	0	33

Table 8: UNR Farms Shear Strength Parameters

Loading Condition	Minimum Factor of Safety
End of Construction	1.65
Steady State Seepage	1.74
Rapid Draw Down	1.35

Table 9: UNR Farms Critical Slope Stability Minimum Factors of Safety

SECTION 6 DESIGN RECOMMENDATIONS

6.1 EMBANKMENT DESIGN

The pertinent aspects of the proposed embankments for the Meadows and UNR Farms area are discussed in the following subsections.

6.1.1 EMBANKMENT MATERIALS AND GEOMETRY

New levees should be constructed with soil meeting the requirements found in section 6.4 BORROW MATERIALS. The embankments should be constructed with 1V:3H side slopes because the assumed borrow site contains medium to high plasticity clays and silts. Highly plastic material may have a propensity for shallow sloughing due to a loss of shear strength as soil moisture content increases. This is generally a result of a net increase in water content preceded by a period of shrinkage during dry weather. These failures require maintenance and could be eliminated or reduced in frequency by using less plastic soils near the surface of the slopes or by chemical stabilization of the surface soils. Furthermore, a 1V:3H slope not only assures stability, but is the steepest slope that can be conveniently traversed with conventional mowing equipment. The recommended crown width for the levee system is 20 feet, allowing for an access road that is 16 feet wide. The surfacing for the road should consist of 4 inches of compacted stabilized aggregate, which will permit vehicular traffic during wet weather without causing detrimental effects to the levee. The access road will provide access for inspections, maintenance, and flood fighting operations.

6.1.2 FOUNDATION PREPARATION

The ground surface within the footprint of the levee should be cleared, stripped, and grubbed to remove low growing vegetation and organic topsoil. The minimum depth of stripping is 6 inches. Clearing, stripping and grubbing is also required under the footprint of seepage berms.

6.1.3 INSPECTION TRENCH

An inspection should be excavated underneath the alignment of the levee. The purpose of the inspection trench is to determine foundation conditions, to provide a cut-off to reduce seepage through near the surface deposits and to intercept undesirable features that may not be detected from a surface inspection (animal burrows, pipelines, buried logs, pockets of unsuitable material, etc.). The trench should be located between the centerline and waterside hinge point of the levee. The depth of the inspection should equal the height of the levee for levees less than or equal to 6 feet in height. For levees with a height greater than 6 feet, the depth of inspection trench is 6 feet. The inspection trench should have a base width of 12 feet and side slopes of 1V:1H. Backfilling of the trench should occur only after a careful inspection of the excavated trench to ensure that a seepage path or undesirable materials are not present. The inspection should be backfilled with fill meeting the same requirements of levee fill.

6.2 FOUNDATION SEEPAGE CONTROL

For levees and floodwalls in which the calculated uplift/exit gradient exceeds the maximum allowable gradient of 0.5, seepage control is required. If excessive gradients are not controlled, the potential for adverse seepage conditions, including boils and piping, is high and could lead to unsatisfactory project performance and levee or floodwall failure. Seepage control measures were developed for the 13 reaches of the Meadows area for water surfaces which result in calculated gradients greater than 0.5. The recommended seepage control measures for flood walls are only presented in Table 10.

The typical methods of foundation seepage control measures used by the Sacramento District are slurry cutoff walls, seepage berms / drain blankets, and relief wells. Given that the Meadows area is in a diverse area with roads, business, light industrial zoning to the North and open farm land to the south that are near the levee and floodwall alignments, an emphasis was placed on selecting seepage control measures that require a minimal amount of real estate acquisition. Floodwalls are recommended on much of the north bank and a mixture of new levee construction, benching , seepage berms , and relief wells were selected for the south bank.

Due to the difficulty of constructing slurry cutoff walls along the Truckee River, seepage berms, relief wells and toe drains are recommended to control seepage. Seepage berms, being the most easily constructed and cost effective measure, were recommended where sufficient open space is available next to the levee or floodwall. Relief well systems were recommended for areas where roads, buildings, or other structures are in close proximity to the levee or floodwall. It is recognized that it will be challenging to drill and install relief wells in material that contains cobbles and boulders.

Reach Number	Location	Water Surface Height (H) for which **no** seepage control measures are recommended. (1)	Water Surface Height (H) and Corresponding Seepage Control Measures		
1	Truckee River left bank - Vista to North Truckee Drain	H ≤ 6′	6′ < H ≤ 10′ Relief wells spaced at 150′	10′ < H ≤ 15′ Relief wells spaced at 100′	15′ < H ≤ 20′ Relief wells spaced at 80′
2	Truckee River left bank - North Truckee Drain to 5,000′ upstream of North Truckee Drain	H ≤ 10′	10′ < H ≤ 20′ Relief wells spaced at 200′	----	----
3a	Truckee River left bank - 5,000′ upstream of North Truckee Drain to McCarran Blvd.	H ≤ 4′	4′ < H ≤ 7′ 3′ high by 40′ wide seepage berm	7′ < H ≤ 15′ Relief wells spaced at 50′	----
3b	Truckee River left bank - McCarran Blvd. to Greg St.	H ≤ 3′	3′ < H ≤ 6′ 3′ high by 50′ wide seepage berm	6′ < H ≤ 15′ Relief wells spaced at 50′	----
4	Truckee River left bank - Greg St. to Glendale Ave.	none	0′ < H ≤ 5′ Toe drain	5′ < H ≤ 10′ 10′ wide drain blanket	10′ < H ≤ 15′ 20′ wide drain blanket
5	Truckee River right bank - McCarran Blvd. to Greg St.	H ≤ 7′	7′ < H ≤ 10′ 5′ high by 55′ wide seepage berm	10′ < H ≤ 15′ 5′ high by 80′ wide seepage berm	15′ < H ≤ 20′ 5′ high by 150′ wide seepage berm
6	Truckee River right bank - Greg St. to Hwy 395	none	0′ < H ≤ 5′ Toe drain	5′ < H ≤ 10′ 10′ wide drain blanket	10′ < H ≤ 15′ 20′ wide drain blanket
7	UNR Farms Detention Basin - West & South Levee	H ≤ 8′	8′ < H ≤ 10′ 5′ high by 55′ wide seepage berm	10′ < H ≤ 15′ 5′ high by 75′ wide seepage berm	15′ < H ≤ 20′ 5′ high by 100′ wide seepage berm
8	UNR Farms Detention Basin - North Levee	H ≤ 15′	15′ < H ≤ 20′ 9′ high by 80′ wide impervious berm on the Truckee River side of levee	----	----
9	UNR Farms Detention Basin - East Levee	H ≤ 12′	12′ < H ≤ 20′ 40′ deep slurry cutoff wall	----	----
10	Boynton Slough both banks	H ≤ 7′	7′ < H ≤ 20′ 45′ deep slurry cutoff wall	----	----
11	Steamboat Creek both banks	H ≤ 8′	8′ < H ≤ 20′ 40′ deep slurry cutoff wall	----	----
12	North Truckee Drain	H ≤ 6′	6′ < H ≤ 15′ Relief wells spaced at 50′	----	----

(1) Gradients for these water surfaces are less than or equal to the maximum allowable gradient of 0.5

Table 10: Recommended Seepage Control Measures for Truckee Meadows

6.2.1 SEEPAGE BERMS

Seepage berms are utilized where the foundation conditions consist of a relatively impervious top stratum (also referred to as the "blanket") that overlies a more pervious substratum. This type of foundation condition produces high uplift pressures under the top stratum during a flood event that will heave and rupture the top stratum resulting in sand boils and ultimately failure of the levee or floodwall due to piping. To reduce the threat of uplift and heave failures, a seepage berm is constructed along the landside toe. The berm improves seepage conditions by 1) adding weight to the top stratum to counteract the high uplift forces and 2) provides a filtered exit for seepage to safely pass without removal of foundations materials. The seepage berms recommended for the Truckee Meadows project consists of a gravel drainage layer that is encapsulated with either filter fabric or filter sand. Filter sand gradation is typically ASTM C33 fine aggregate while the drain rock material is typically ASTM C33 No. 7 or No. 67 coarse aggregate. The gravel drain should be at least 12 inches thick while the filter sand layer should be at least 6 inches thick. Random or impervious earth fill is placed over the filter and drain layers to add weight to counteract the uplift forces. The earth fill also serves to protect the filter and drainage layer from damage due to erosion or vandalism. The thickness of the earth fill cover depends on the necessary weight to counteract the seepage uplift forces, however at least 2 feet of earth fill cover should be provided. The earth fill cover should slope at least 2% away from the levee and floodwall to carry surface runoff away from the structure.

6.2.2 RELIEF WELLS

As with seepage berms, relief wells are also utilized where foundation conditions consist of a relatively impervious top stratum that overlies a more pervious substratum. Relief wells reduce the uplift pressures which may cause sand boils and piping of foundation materials. Wells accomplish this by intercepting and providing a controlled outlet for seepage that would otherwise exit uncontrollably by heaving and rupturing the top stratum. Relief wells consists of a riser pipe and screen, filter pack, and a well head assembly. The riser pipe and screen are 8 inches in diameter and constructed of stainless steel to increase longevity from corrosion. The filter pack surrounds the screened portion of the riser pipe and is typically 4 inches thick which results in a 16 inch total diameter of the well. The well head assembly consists of a check valve, protective casing (typically a precast concrete manhole with steel cover), and a lateral steel pipe leading from the well head to a collector ditch. Flows from the relief wells are routed to the collector ditch where the flows are either pumped back into the river or are routed into the local stormwater drainage system. The spacing of relief wells is determined using a maximum allowable exit gradient of 0.5 at a point located midway between wells. Design calculations assumed a well depth of 40 feet into the pervious foundation zone.

6.2.3 DRAINAGE BLANKET

Drainage blankets are utilized where the foundation consists of pervious soils at the ground surface. Such foundation conditions exist along the Truckee River between Highway 395 and Greg Street. Since pervious soils exist at the ground surface, a heave type of seepage failure caused by excess hydrostatic pressures landward of the levee or floodwall is not the concern. Instead, the concern is high exit gradients localized near the toe that can leads to piping of foundation soils from under the structure. The high exit gradients localized near the toe can be mitigated with a drainage blanket. Similarly to seepage berms, drainage blankets have a filter and drain layers that provide a filtered exit for seepage to safely pass without movement of foundation soils. The drainage blankets for the Truckee Meadows project consist of a gravel drain layer encapsulated with either filter fabric or filter sand. The gravel drain layer should be at least 12 inches thick and the filter sand layer at least 6 inches thick. A 4-inch thick layer of aggregate base course should be placed over the filter and drainage layers to provide protection from erosion and vandalism. The drainage layer material typically consists of ASTM C33 No. 7 or No. 67 coarse aggregate while the filter sand is typically ASTM C33 fine aggregate material.

6.3 EASEMENTS

A minimum 20-foot wide maintenance easement should be provided along the landside toe of the levees and floodwall and along the landside toe of the foundation seepage control measures (i.e., seepage berms, drainage blankets, and relief wells). The 20-foot wide maintenance easements should be free of all vegetation, utilities, or any encroachments (i.e., power poles, fences, buildings) that would inhibit inspection, maintenance, and flood fighting of the levees and floodwalls.

6.4 BORROW MATERIALS

The recommended embankment fill for construction of levees should consist of low to medium plasticity lean clay, sandy lean clay, clay, clayey sand, silt, sandy silt, or silty sands (CL, SC, ML, or SM) according to ASTM D2487 classification. These materials should meet the following requirements:

- Maximum particle size of 2 inches
- Minimum of 20% fines content (percent passing the No. 200 sieve)
- Liquid limit less than 45 and a plasticity index between 8 and 24
- No organic material or debris may be present

Three borrow sites have been evaluated during the history of this project. They include the eastern area of UNR Farms, the Channel Widening area along the south bank of the Truckee

River between East McCarran Blvd and Steamboat Creek, and the south bank of the Truckee River between Rock Blvd and East McCarran Blvd. Of the three site investigated, the site with the most suitable material is from the Channel Widening site. The two other sites do contain suitable material, but the quantity is limited and suitable material is intermixed with unsatisfactory material so utilization of the sites will not be efficient or economical.

There appears to be sufficient quantity of suitable material at the Channel Widening site and the Rock Blvd to East McCarran Blvd site. However, the quality of the material is marginal given that the liquid limits are near the maximum of 45. Given the difficulty of finding material with a lower liquid limit in the Washoe County area within a short haul distance to the project, it will more economical to utilize the marginal embankment fill that is located a short haul distance away. The use of marginal borrow material will require that the levees have side slope no steeper than 1V:3H.

6.5 SEISMIC PERFORMANCE/LIQUEFACTION

Seismic performance of the proposed flood control structures has been considered, and a preliminary assessment of seismically induced liquefaction and consequences has been conducted for this project.

Seismic performance criteria have been considered in this plan to correspond to high-water performance criteria. That is, seismic design is assumed to be based on ground motion exceedance probabilities that are equivalent to the high-water event exceedence probabilities that the project will be designed to withstand. The exceedance probability corresponding to the flood protection return period for this project results in a peak ground acceleration on the order of 0.1g (or less) over the 50-year planning horizon for the project. Ground motions of this magnitude would not be expected to cause significant damage to flood control structures due to either seismic shaking or liquefaction. Due to this greater level of damage being relatively unlikely, the project would not be designed to withstand the greater loading.

This is an appropriate design criteria approach with respect to seismic performance. However, there is some potential for strong seismic shaking to occur during the planning horizon for the project. Strong seismic shaking has the potential to induce liquefaction in some of the foundation soils within the footprint of the proposed project features. Liquefaction can cause deformation of foundation soils and possibly damage flood control structures founded on those soils. For most riverine flood control projects, including this project, it is unlikely that strong seismic shaking will occur concurrently with a high-water event. That is, it is unlikely that the flood control structures will be loaded with high-water flows during a strong seismic event. If the flood control structures are not loaded by high-water flows when strong seismic shaking occurs, then even if liquefaction does occur and causes damage to the flood control structures, the damage would not cause inundation to occur at the time when the damage occurs.

SECTION 6 DESIGN RECOMMENDATIONS

Common practice for riverine flood control structures is to develop and have in place an emergency response plan for rapidly repairing damage that might occur due to seismically induced liquefaction. Such a plan would be developed during the design phase of the project. At that time, the design team would develop best estimate characterizations and uncertainty ranges of potential liquefaction locations, extents, and magnitudes, as well as similar characterizations of potential resulting damage to the project flood control structures. It is anticipated that these characterizations would be used as a basis for identifying locations and quantities of potential emergency borrow site materials. In the event of liquefaction-induced damage to flood control structures, emergency borrow materials would be transported to the damage sites and placed as fill in configurations that comprise temporary flood protection measures. These temporary measures would be designed to provide flood protection for several seasons, while permanent repairs are being designed and constructed. It is anticipated that potential emergency borrow material sources can be identified throughout and nearby the project area. As such, it is not necessary to identify potential sources during feasibility-level studies. Potential emergency borrow sources and plans for placement of the materials will be developed during the design phase of the project.

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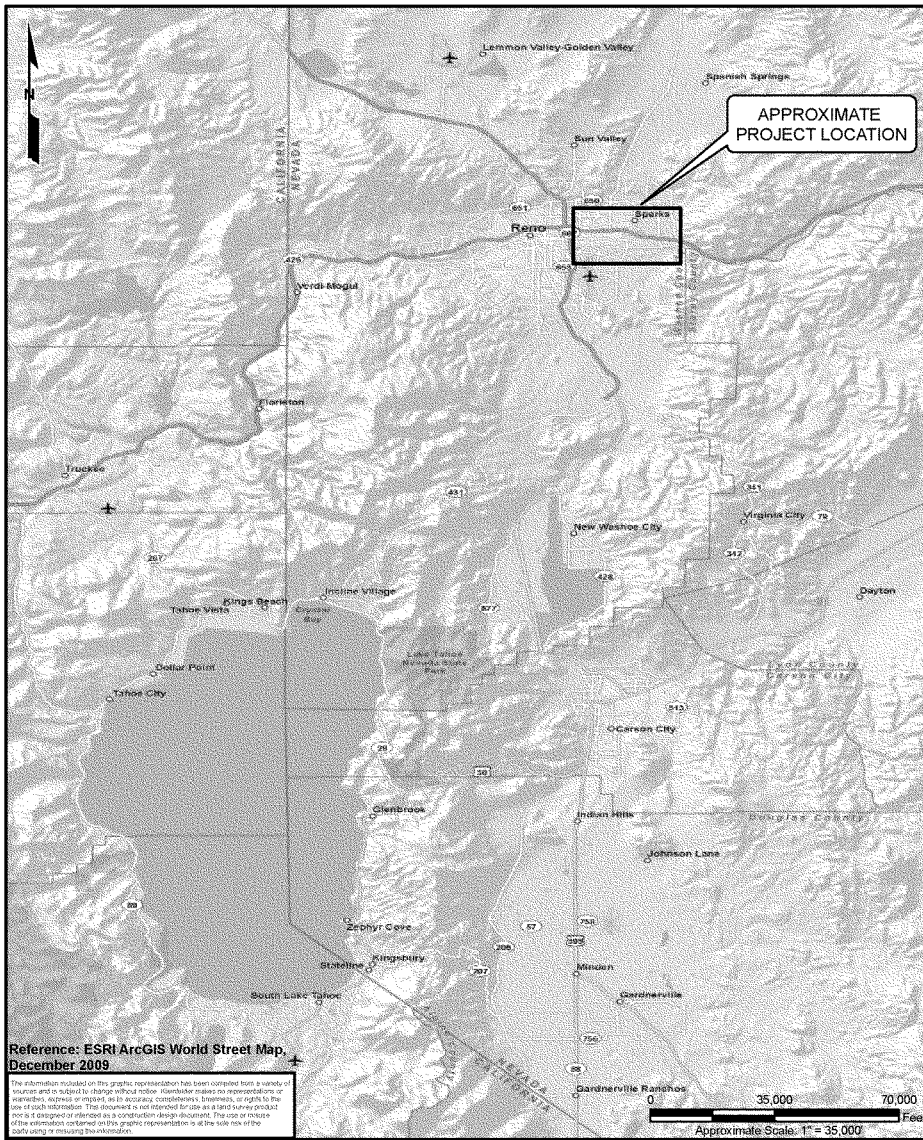
U.S. Army Corps of Engineers (USACE) 1986 EM 1110-2-1901- Seepage Analysis and Control for Dams (30 September 1986 (original), 30 April 1993 (change 1))

U.S. Army Corps of Engineers (USACE) The Engineering and Construction Bulletin (ECB) , that replaced ETL 1110-2-569, dated 1 May 2005, which expired in May 2010



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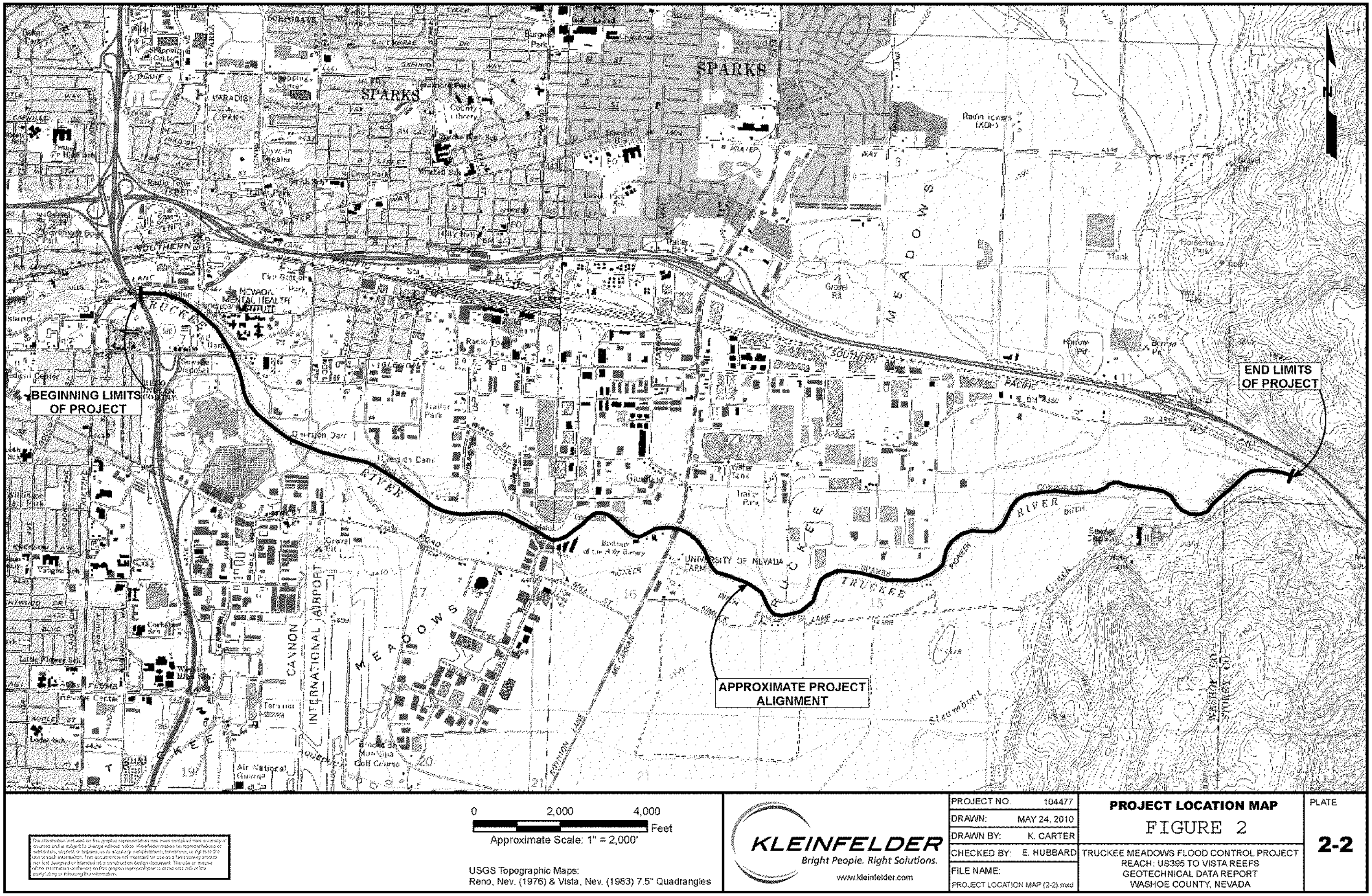
PROJECT NO.	104477	**VICINITY MAP** FIGURE 1	PLATE **2-1**
DRAWN:	MAY 24, 2010		
DRAWN BY:	K. CARTER		
CHECKED BY:	D. ADAMS	TRUCKEE MEADOWS FLOOD CONTROL PROJECT REACH: US 395 TO VISTA REEFS GEOTECHNICAL DATA REPORT WASHOE COUNTY, NEVADA	
FILE NAME:	VICINITY MAP (2-1).mxd		


BEGINNING LIMITS OF PROJECT
END LIMITS OF PROJECT
APPROXIMATE PROJECT ALIGNMENT
SPARKS
MEADOWS
TRUCKEE RIVER
SOUTHERN PACIFIC
UNIVERSITY OF NEVADA FARM
CANNON INTERNATIONAL AIRPORT
NEVADA MENTAL HEALTH INSTITUTE
0 2,000 4,000 Feet
Approximate Scale: 1" = 2,000'
USGS Topographic Maps:
Reno, Nev. (1976) & Vista, Nev. (1983) 7.5" Quadrangles
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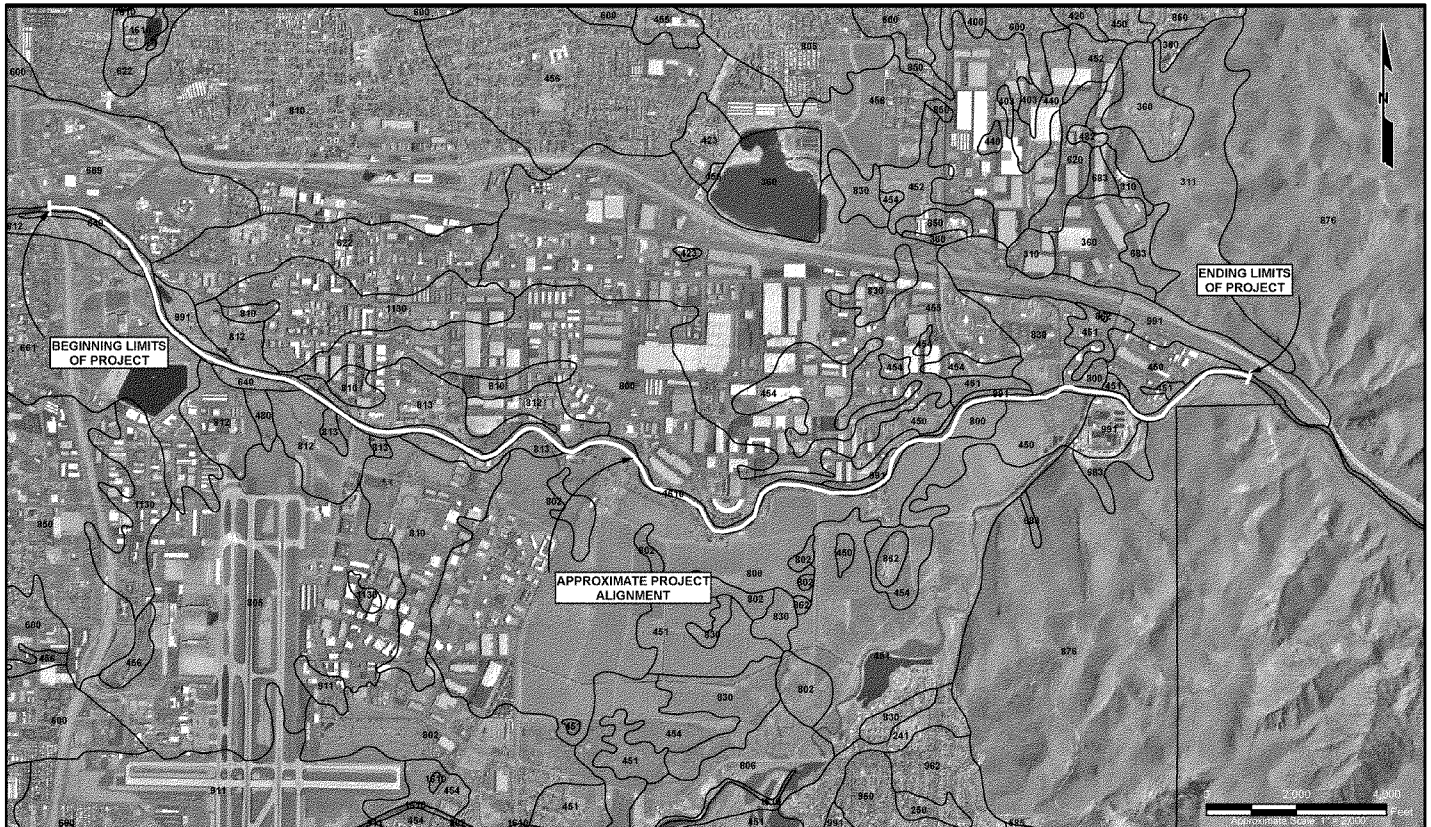
PROJECT NO. 104477
DRAWN: MAY 24, 2010
DRAWN BY: K. CARTER
CHECKED BY: E. HUBBARD
FILE NAME:
PROJECT LOCATION MAP (2-2).mxd
PROJECT LOCATION MAP
FIGURE 2
TRUCKEE MEADOWS FLOOD CONTROL PROJECT
REACH: US395 TO VISTA REEFS
GEOTECHNICAL DATA REPORT
WASHOE COUNTY, NEVADA
PLATE
2-2


BEGINNING LIMITS OF PROJECT
ENDING LIMITS OF PROJECT
APPROXIMATE PROJECT ALIGNMENT
N
0
2,000
4,000
Approximate Scale 1" = 2000'
LEGEND
110 Jove Variant sandy loam, 4-8 percent slope
241 Lupline loam, gravelly substratum
750 Cascus gravelly sand loam, 2-4 percent slope
910 Risley-Rock outcrop complex, 8-15 percent slope
911 Risley-Rock outcrop complex, 15-50 percent slope
580 Pits
460 Jubilee Variant loam, slightly saline
433 Gedeville loamy sand
423 Gedeville variant loamy sand
450 Vidalia loam
451 Vidalia loam, slightly saline
454 Vidalia silty clay, drained
456 Vidalia-Truckee complex, drained
458 Vidalia silty loam, gravelly substratum
480 Holbrook gravelly loamy sand, 2-8 percent slopes
595 Bernard-Trico association
606 Alverd clay loam, drained
622 Orr stony sandy loam, gravelly substratum, 2-4 percent slopes
640 Helka loamy fine sand
661 Qest boulders sandy loam, 2-8 percent slopes
668 Qest gravelly sandy loam, 0-2 percent slopes
683 Qest gravelly sandy loam, 0-2 percent slopes
820 Truckee silt loam
802 Truckee silt loam, strongly saline
806 Truckee sandy loam, gravelly substratum
808 Truckee sandy loam, sandy substratum, strongly saline
812 Rose Creek fine sandy loam, drained
817 Rose Creek loamy fine sand, drained
815 Rose Creek gravelly fine sandy loam, drained
930 Pettis silty clay loam
950 Wadsha gravelly sandy loam, 0-4 percent slopes
962 Reywat very loamy sandy loam, 8-15 percent slopes
878 Xerter-Cappa-Old Camp association
911 Vamp silt loam, strongly saline-alkali
962 Kaya stony sandy loam, 2-4 percent slopes
962 Kaya very stony sandy loam, 4-8 percent slopes
991 Xaac Tenorthents-Urban land complex
1130 Orthod sandy loam
1610 Water
Soil Delineation
Reference:
U.S. Department of Agriculture Soil Conservation Service,
Soil Survey of Washoe County, Nevada, 1980
Aerial imagery dated 2006, USDA, FSA/NAPP, DHM Data unknown
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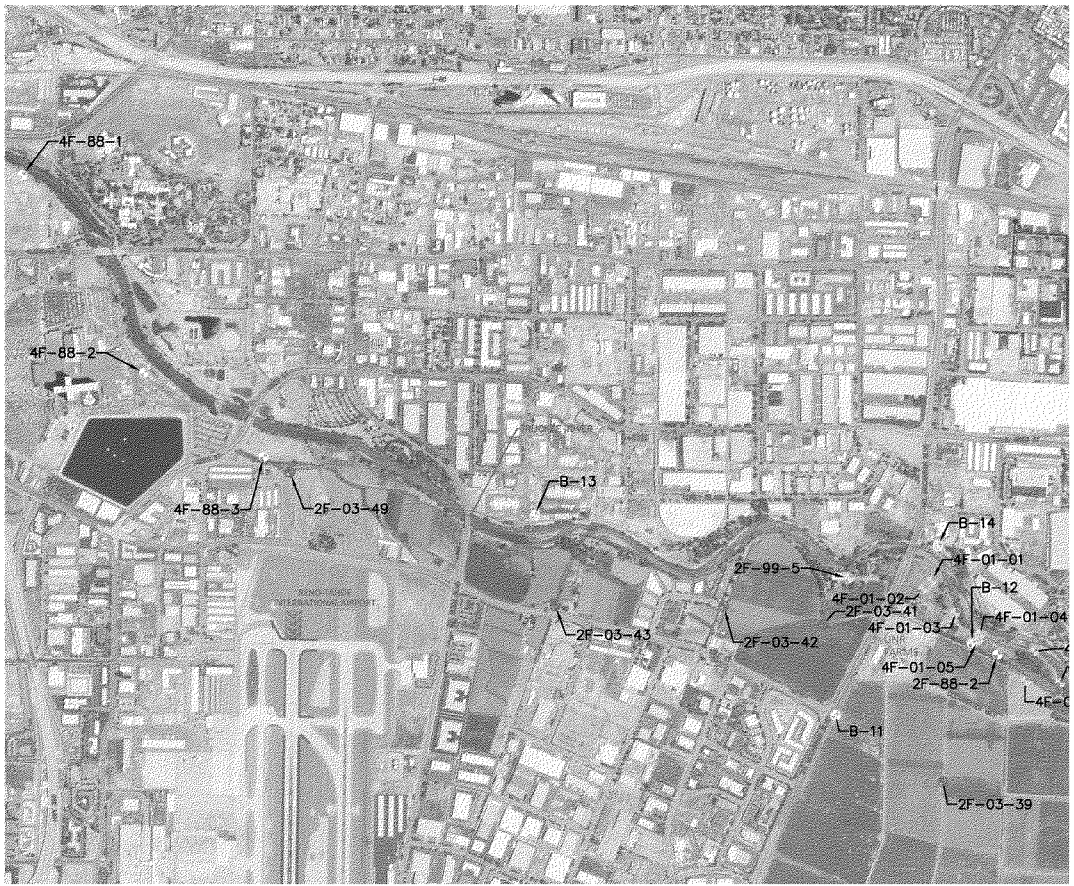
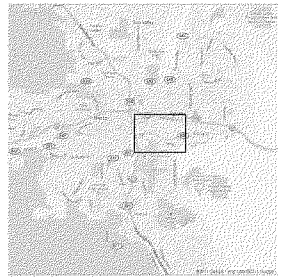
DRAWN BY: K. CARTER
CHECKED BY: D. ADAMS
FILE NAME: SOIL CONSERVATION MAP (4-7).mxd
SOIL CONSERVATION MAP
FIGURE 3
TRUCKEE MEADOWS FLOOD CONTROL PROJECT
REACH: US 395 TO VISTA REEFS
GEOTECHNICAL DATA REPORT
WASHOE COUNTY, NEVADA
PLATE
4-7



USACE 2003
USACE 2001
USACE 1999
USACE 1998
USACE 1990
PEZONELLA ASSOC. 1989
USACE 1988
EARTH SCIENCE CONSLT. 1983
USACE 1982
EARTH SCIENCE CONSLT. 1977



SCALE IN FEET

1200 600 0 1200 2400

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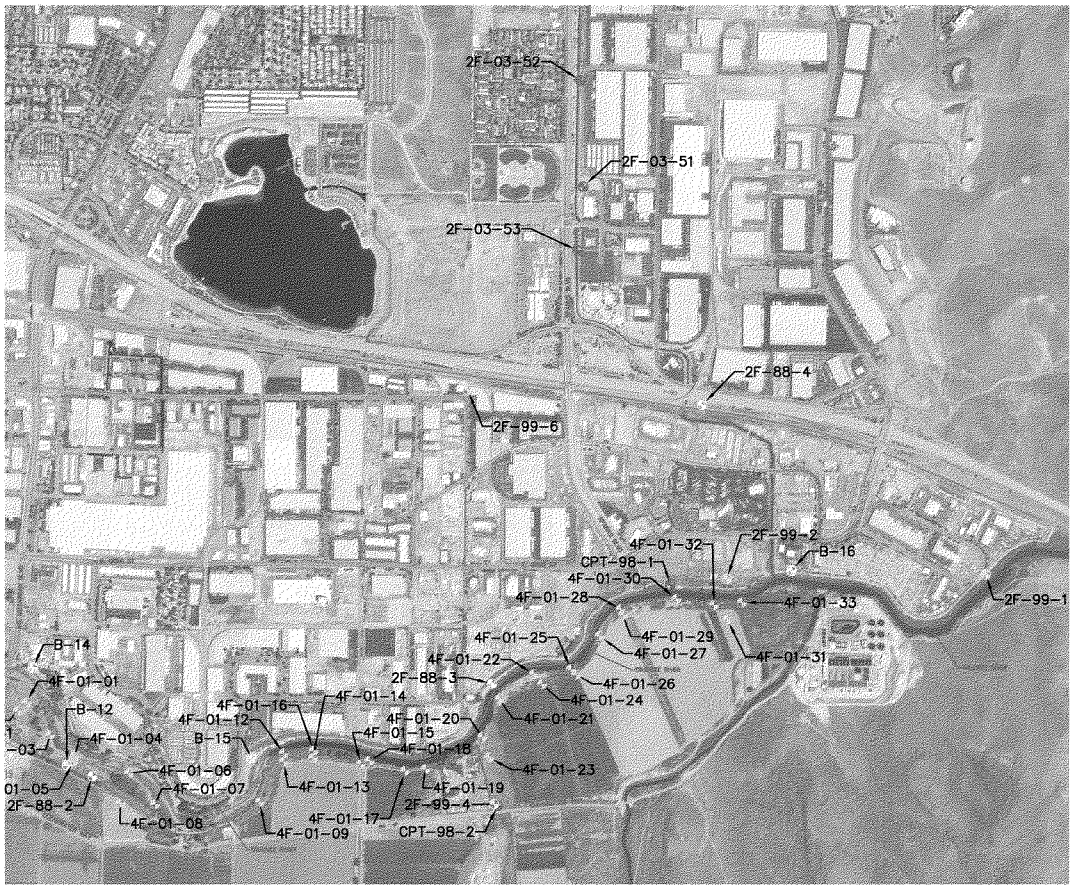
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

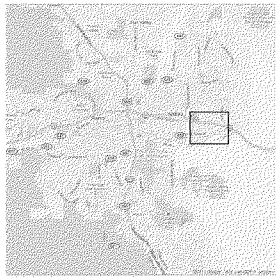
WASHOE/STOREY/LYON COUNTY NEVADA

TRUCKEE MEADOWS FLOOD DAMAGE REDUCTION PROJECT
GEOTECHNICAL REPORT
OVERVIEW MAP
LOCATION OF EXPLORATORY BORINGS
WEST MEADOW SOIL EXPLORATIONS

DATE	SCALE	
25 FEB 2011	1" = 1200'	FIGURE 4



USACE 2003
USACE 2001
USACE 1999
USACE 1998
USACE 1990
PEZONELLA ASSOC. 1989
USACE 1988
EARTH SCIENCE CONSLT. 1983
USACE 1982
EARTH SCIENCE CONSLT. 1977



SCALE IN FEET

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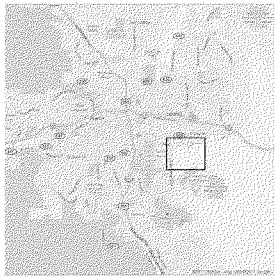
TRUCKEE MEADOWS FLOOD DAMAGE REDUCTION PROJECT
GEOTECHNICAL REPORT

OVERVIEW MAP
LOCATION OF EXPLORATORY BORINGS

EAST MEADOWS SOIL EXPLORATIONS

DATE:	SCALE:	
25 FEB 2011	1" = 1200'	FIGURE 5

USACE 2003
USACE 2001
USACE 1999
USACE 1998
USACE 1990
PEZONELLA ASSOC. 1989
USACE 1988
EARTH SCIENCE CONSLT. 1983
USACE 1982
EARTH SCIENCE CONSLT. 1977



SCALE IN FEET

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WASHOE, STOREY, LYON COUNTY — NEVADA

TRUCKEE MEADOWS FLOOD DAMAGE REDUCTION PROJECT
GEOTECHNICAL REPORT

OVERVIEW MAP
LOCATION OF EXPLORATORY BORINGS

UNIVERSITY NEVADA RENO FARMS SOIL EXPLORATIONS

DATE	SCALE	
25 FEB 2011	1" = 800'	FIGURE 6

0 300 600
Feet
Approximate Scale: 1" = 300'
Legend
Approximate Hollow Stem Auger Boring Location
Approximate Hollow Stem Auger Boring (Piezometer) Location
Approximate Sonic Boring Location
Approximate Sonic Boring (Piezometer) Location
Approximate CPT Location
Previous Exploration Location
Existing Ditch
Proposed Relocated Ditch
Truckee River Alignment and Stationing
Element Alignment and Stationing
Berm Alignment and Stationing
Reference: Aerial Imagery and alignment source, USACE Sacramento District, data unknown.
Note:
Base maps, flood element alignment and stationing data were provided by the USACE. The accuracy of these data could not be verified by the USACE. Kleinfelder is not responsible for the accuracy of the base map or flood element alignment represented on this drawing.
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DRAWN MAY 24, 2010
DRAWN BY K. CARTER
CHECKED BY D. ADAMS
FILE NAME
EXPLORATION LOCATION MAP CF-1.dwg
EXPLORATION LOCATION MAP
TRUCKEE RIVER STATION
410+00 TO 295+00
TRUCKEE MEADOWS FLOOD CONTROL PROJECT
REACH: US 395 TO VISTA REEFS
GEOTECHNICAL DATA REPORT
WASHOE COUNTY, NEVADA
PLATE
3-1

FIGURE 7

0 300 600 Feet
Approximate Scale: 1" = 300'

Legend

- Approximate Hollow Stem Auger Boring Location
- Approximate Hollow Stem Auger Boring (Piezometer) Location
- Approximate Sonic Boring Location
- Approximate Sonic Boring (Piezometer) Location
- Approximate CPT Location
- Previous Exploration Location
- Existing Ditch
- Proposed Relocated Ditch
- Truckee River Alignment and Stationing
- Element Alignment and Stationing
- Berm Alignment and Stationing

Reference: Aerial imagery and alignment source: USACE Sacramento District, date unknown.
Note:
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CHECKED BY:	D. ADAMS
FILE NAME:	EXPLORATION LOCATION MAP (5-2.dwg

EXPLORATION LOCATION MAP
TRUCKEE RIVER STATION
320+00 TO 205+00

TRUCKEE MEADOWS FLOOD CONTROL PROJECT
REACH: US 395 TO VISTA RIDGE
GEOTECHNICAL DATA REPORT
WASHOE COUNTY, NEVADA

PLATE
3-2

FIGURE 8

Legend
Approximate Hollow Stem Auger Boring Location
Approximate Hollow Stem Auger Boring (Piezometer) Location
Approximate Sonic Boring Location
Approximate Sonic Boring (Piezometer) Location
Approximate CPT Location
Previous Exploration Location
Existing Ditch
Proposed Relocated Ditch
Truckee River Alignment and Stationing
Element Alignment and Stationing
Berm Alignment and Stationing
0 300 600 Feet
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DRAWN: MAY 24, 2010
DRAWN BY: K. CARTER
CHECKED BY: D. ADAMS
EXPLORATION LOCATION MAP
TRUCKEE RIVER STATION
205+00 TO 91+00
TRUCKEE MEADOWS FLOOD CONTROL PROJECT
REACH: US 395 TO VISTA REEFS
GEOTECHNICAL DATA REPORT
WASHOE COUNTY, NEVADA
PLATE
3-3
CLEARWATER WAY
SPARKS BLVD
NORTH TRUCKEE DRAIN

FIGURE 9

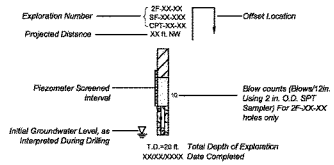
SOIL PROFILE LEGEND BASED ON UNIFIED SOIL CLASSIFICATION SYSTEM (ASTM D2487)

GW	WELL-GRADED GRAVEL OR WELL-GRADED GRAVEL WITH SAND	SW	WELL-GRADED SAND OR WELL-GRADED SAND WITH GRAVEL	ML	SILT, SILT WITH SAND, SILT WITH GRAVEL, SANDY SILT, SANDY SILT WITH GRAVEL, GRAVELLY SILT OR GRAVELLY SILT WITH SAND
GP	POORLY GRADED GRAVEL OR POORLY GRADED GRAVEL WITH SAND	SP	POORLY GRADED SAND OR POORLY GRADED SAND WITH GRAVEL	CL	LEAN CLAY, LEAN CLAY WITH SAND, LEAN CLAY WITH GRAVEL, SANDY LEAN CLAY, SANDY LEAN CLAY WITH GRAVEL, GRAVELLY LEAN CLAY, OR GRAVELLY LEAN CLAY WITH SAND
GW-GM	WELL-GRADED GRAVEL WITH SILT OR WELL-GRADED GRAVEL WITH SILT AND SAND	SW-SM	WELL-GRADED SAND WITH SILT OR WELL-GRADED SAND WITH SILT AND GRAVEL	CL-ML	SILTY CLAY, SILTY CLAY WITH SAND, SILTY CLAY WITH GRAVEL, SANDY SILTY CLAY, SANDY SILTY CLAY WITH GRAVEL, GRAVELLY SILTY CLAY, OR GRAVELLY SILTY CLAY WITH SAND
GW-GC	WELL-GRADED GRAVEL WITH CLAY OR WELL-GRADED GRAVEL WITH CLAY AND SAND	SW-SC	WELL-GRADED SAND WITH CLAY OR WELL-GRADED SAND WITH CLAY AND GRAVEL	OL	ORGANIC CLAY, ORGANIC CLAY WITH SAND, ORGANIC CLAY WITH GRAVEL, SANDY ORGANIC CLAY, SANDY ORGANIC CLAY WITH GRAVEL, GRAVELLY ORGANIC CLAY, GRAVELLY ORGANIC CLAY WITH SAND
GP-GM	POORLY GRADED GRAVEL WITH SILT OR POORLY GRADED GRAVEL WITH SILT AND SAND	SP-SM	POORLY GRADED SAND WITH SILT OR POORLY GRADED SAND WITH SILT AND GRAVEL	MH	ELASTIC SILT, ELASTIC SILT WITH SAND, ELASTIC SILT WITH GRAVEL, SANDY ELASTIC SILT, SANDY ELASTIC SILT WITH GRAVEL, GRAVELLY ELASTIC SILT, OR GRAVELLY ELASTIC SILT WITH SAND
GP-GC	POORLY GRADED GRAVEL WITH CLAY OR POORLY GRADED GRAVEL WITH CLAY AND SAND	SP-SC	POORLY GRADED SAND WITH CLAY OR POORLY GRADED SAND WITH CLAY AND GRAVEL	CH	FAT CLAY, FAT CLAY WITH SAND, FAT CLAY WITH GRAVEL, SANDY FAT CLAY, SANDY FAT CLAY WITH GRAVEL, GRAVELLY FAT CLAY OR GRAVELLY FAT CLAY WITH SAND
GM	SILTY GRAVEL OR SILTY GRAVEL WITH SAND	SM	SILTY SAND OR SILTY SAND WITH GRAVEL	OH	ORGANIC SILT, ORGANIC SILT WITH SAND, ORGANIC SILT WITH GRAVEL, SANDY ORGANIC SILT, SANDY ORGANIC SILT WITH GRAVEL, GRAVELLY ORGANIC SILT, OR GRAVELLY ORGANIC SILT WITH SAND
GC	CLAYEY GRAVEL OR CLAYEY GRAVEL WITH SAND	SC	CLAYEY SAND OR CLAYEY SAND WITH GRAVEL		
GC-GM	SILTY, CLAYEY GRAVEL OR SILTY, CLAYEY GRAVEL WITH SAND	SC-SM	SILTY, CLAYEY SAND OR SILTY, CLAYEY SAND WITH GRAVEL		

OTHER PROFILE LEGEND

	VOLCANIC ROCK
	ASPHALT CONCRETE
	FILL; COLOR BASED ON UNIFIED SOIL CLASSIFICATION SYSTEM (ASTM D2487 OR ASTM 2488)
	AGGREGATE BASE; MIXTURES OF SAND, GRAVEL AND FINES BENEATH ASPHALT CONCRETE ROADWAYS

LOG LEGEND



NOTE: 2F-XX-XX Denotes Hollow-Stem Auger Exploration Holes
SF-XX-XXX Denotes Sonic Exploration Holes
CPT-XX-XX Denotes Cone Penetrometer Test Holes

Notes:

1. Base map, flood element alignment and stationing data were provided by the USACE. The accuracy of these data could not be verified by the USACE. Kleinfelder is not responsible for the accuracy of the base map or flood element alignment represented on this drawing.
2. Boring and CPT elevations were surveyed for this report and are presented in NAD 83 (horizontal) and NAVD 88 (vertical datum).
3. Only colored borings apply to this study.

Reference: Aerial imagery and alignment source; USACE Sacramento District, date unknown.

FIGURE 10

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DRAWN BY:	K. CARTER
CHECKED BY:	D. HERZOG
FILE NAME:	Plan and Profile.dwg

PLAN AND PROFILE LEGEND AND NOTES

TRUCKEE MEADOWS FLOOD CONTROL PROJECT
REACH: US 395 TO VISTA REEFS
GEOTECHNICAL DATA REPORT
WASHOE COUNTY, NEVADA

PLATE **4-1**

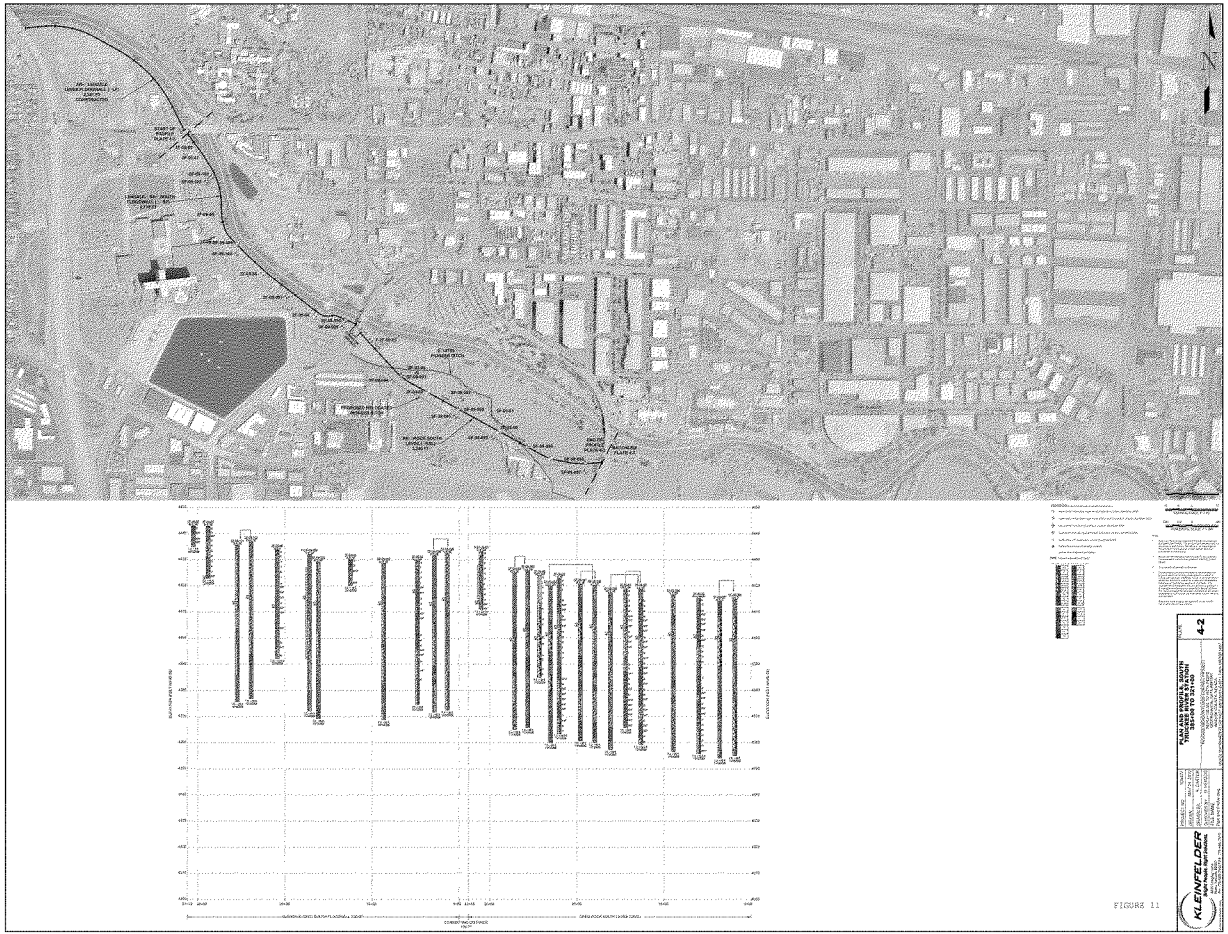

FIGURE 11

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WALLACE BOULEVARD SEWER
PRIORITY PIPE REPAIR
PROJECT NO. 96-0-0
DATE: MAY 1, 2002
DRAWN BY: K. LEWIS
CHECKED BY: K. LEWIS
FILE NAME:
4-3

FIGURE 12

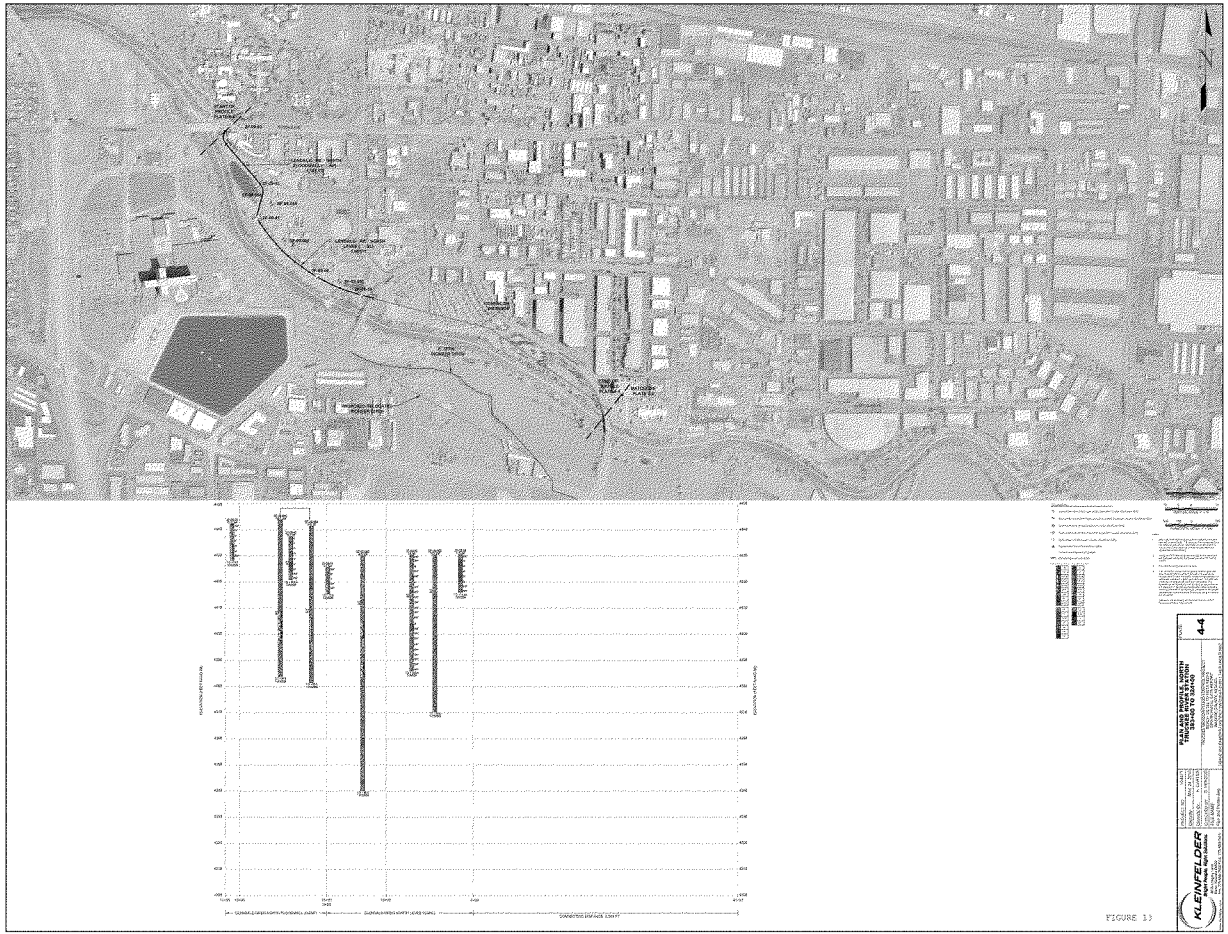
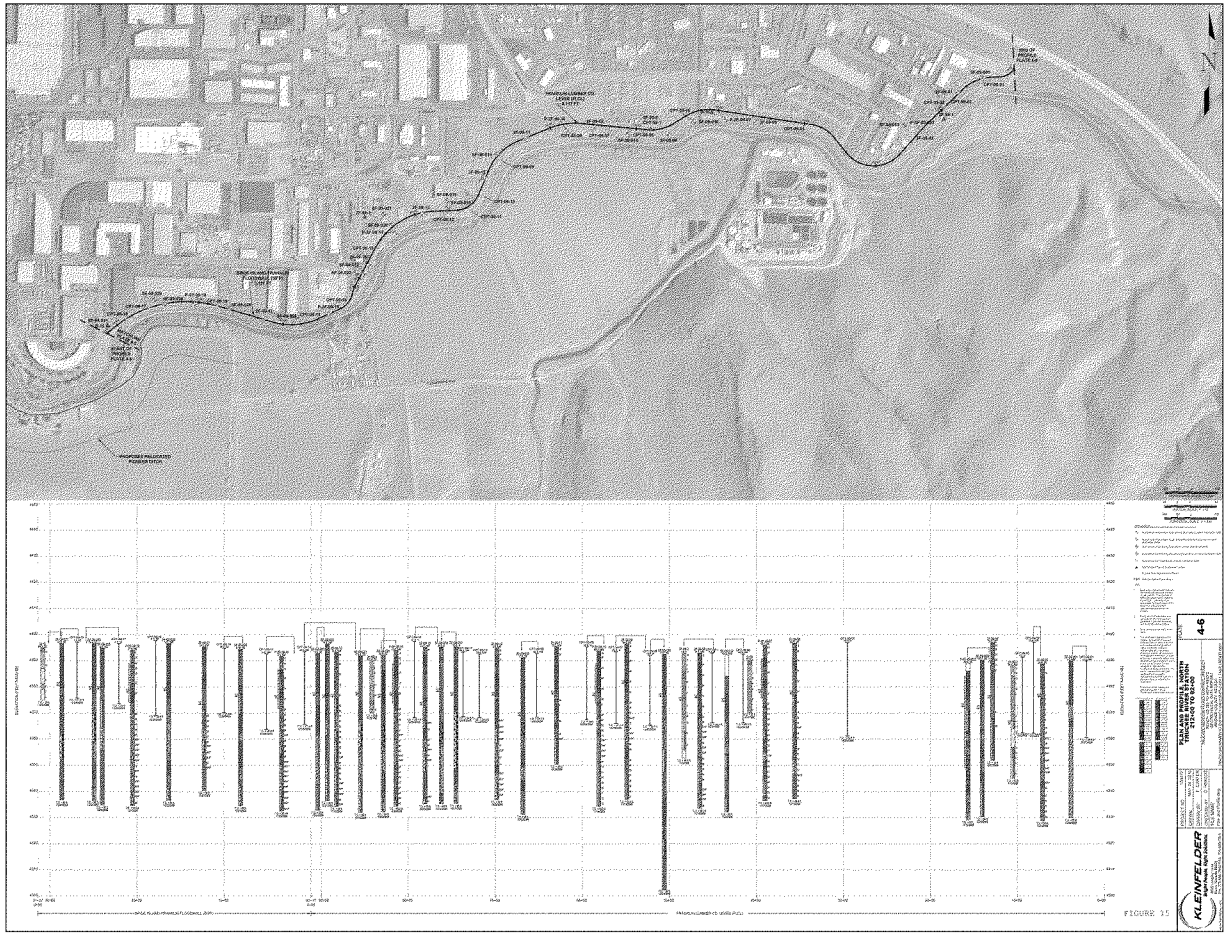
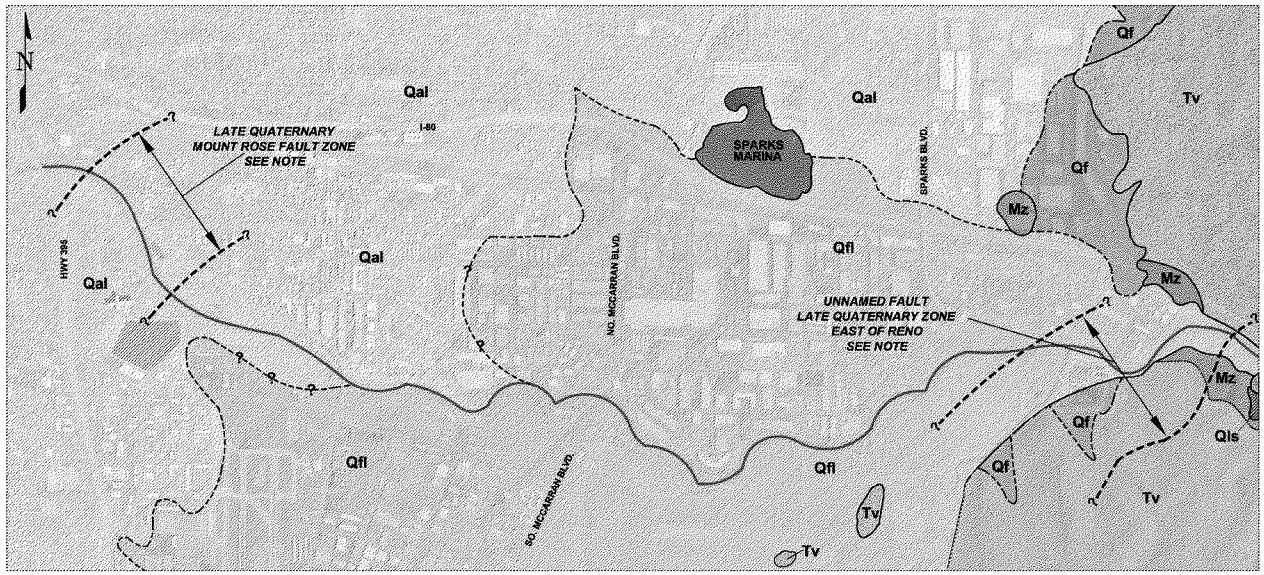


FIGURE 13

KLEINFELDER
PLAN AND PROFILE, NORTH
TRUCKEE RIVER STATION
326+00 TO 312+00
4-5
FIGURE 14


N
KLEINFELDER
4-6
FIGURE 15



Qfl Quaternary Floodplain deposits

Qal Quaternary Alluvium

Qf Quaternary alluvial fan deposits

Qls Quaternary landslide deposits

Tv Tertiary volcanics

Mz Mesozoic volcanic and sedimentary rocks

— — —? Geologic contact, dashed where approximate, queried where uncertain

— — —? Fault, dashed where approximate, queried where uncertain

Reference: Aerial imagery and alignment source; USACE Sacramento District, date unknown.

Notes:

1. Base map, flood element alignment and stationing data were provided by the USACE. The accuracy of these data could not be verified by the USACE. Kleinfelder is not responsible for the accuracy of the base map or flood element alignment represented on this drawing.

2. Location of geologic contacts shown are approximate. The contacts were primarily developed from available published data and modified based on borings performed for this report. Contact locations will likely change as additional subsurface data becomes available.

3. Fault locations are based on dePolo, C.M., et. al., 2008. Locations are shown as approximate 3000-foot wide zones to account for uncertainties in location, concealed features, base map errors, scale of original data, and that minor fault traces are likely present parallel to the main fault trace.

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2,000 1,000 0 2,000

APPROXIMATE SCALE: 1" = 2,000'

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DRAWN:	MAY 24, 2010
DRAWN BY:	K. CARTER
CHECKED BY:	E. HUBBARD
FILE NAME:	GEOLOGIC MAP (4-8).dwg

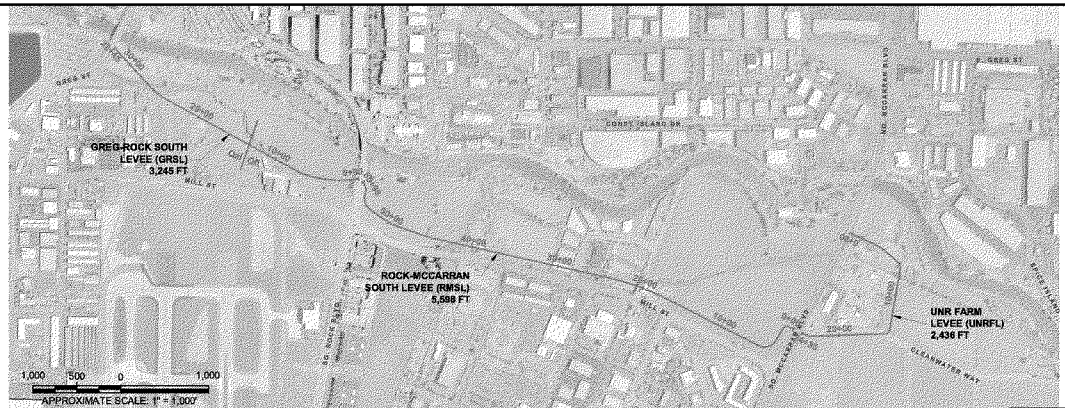
GEOLOGIC MAP

FIGURE 16

TRUCKEE MEADOWS FLOOD CONTROL PROJECT
REACH: US 395 TO VISTA REEFS
GEOTECHNICAL DATA REPORT
WASHOE COUNTY, NEVADA

PLATE

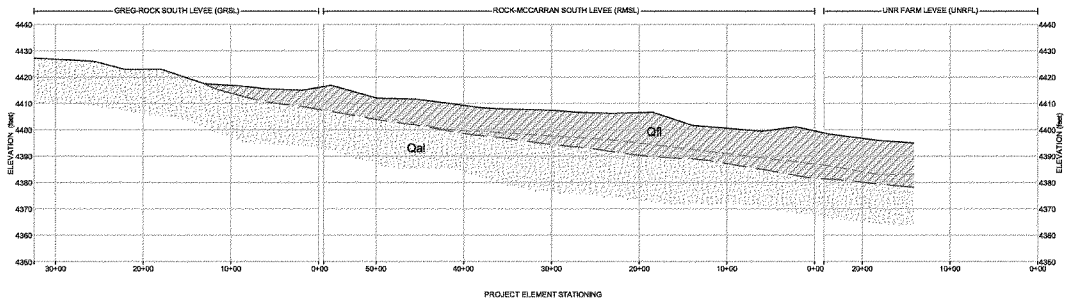
4-8



Notes:

1. Fault locations are based on dePolo, C.M., et. al., 2008. Locations are shown as approximate 3000-foot wide zones to account for uncertainties in location, concealed features, base map errors, and that minor fault traces are likely present parallel to the main fault trace.
2. Ground surface profile is estimated by connecting selected surveyed top of boring elevations and is not exact between borings.
3. Base map, flood element alignment and stationing data were provided by the USACE. The accuracy of these data could not be verified by the USACE. Kleinfelder is not responsible for the accuracy of the base map or flood element alignment represented on this drawing.

Reference: Aerial imagery and alignment source: USECE Sacramento District, date unknown.



30 15 0 30
VERTICAL SCALE: 1" = 30'

1,000 500 0 1,000
APPROX. HORIZONTAL SCALE: 1" = 1,000'

Qfl	Quaternary floodplain deposits (Some locations shown as Qfl contain fill of varying thickness up to a maximum of 13 feet)
Qal	Quaternary alluvium
Tv	Tertiary Volcanics
——— ———	Interpreted geologic contact, dashed where approximate, queried where uncertain
— — —?	Fault, dashed where approximate, queried where uncertain
---- ---- ----	Depth of CPT refusal
. . . . .	Depth of significant increase in sampler blow counts

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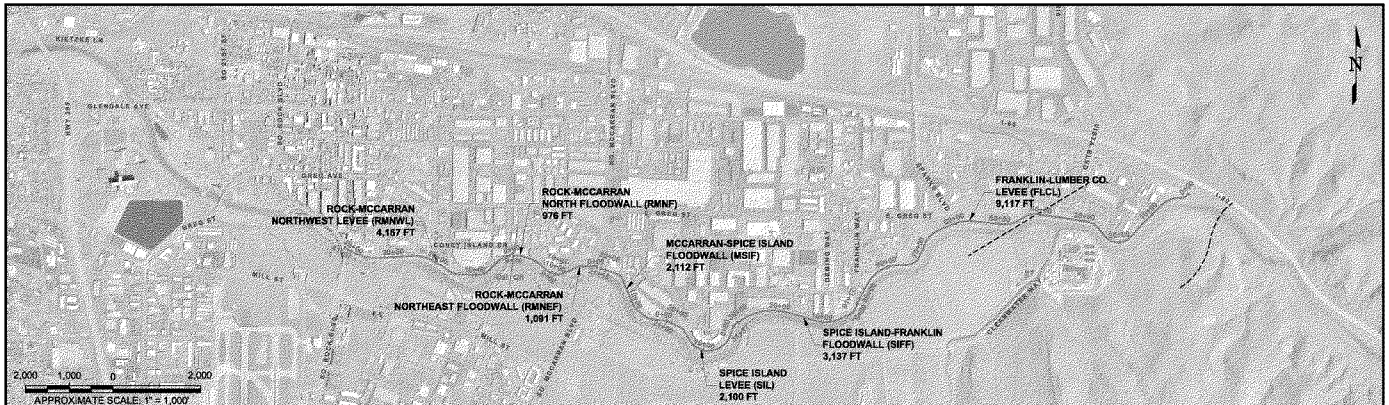
DRAWN:	MAY 24, 2010
DRAWN BY:	JS/KC
CHECKED BY:	E. HUBBARD
FILE NAME:	Stratigraphic Profile.dwg

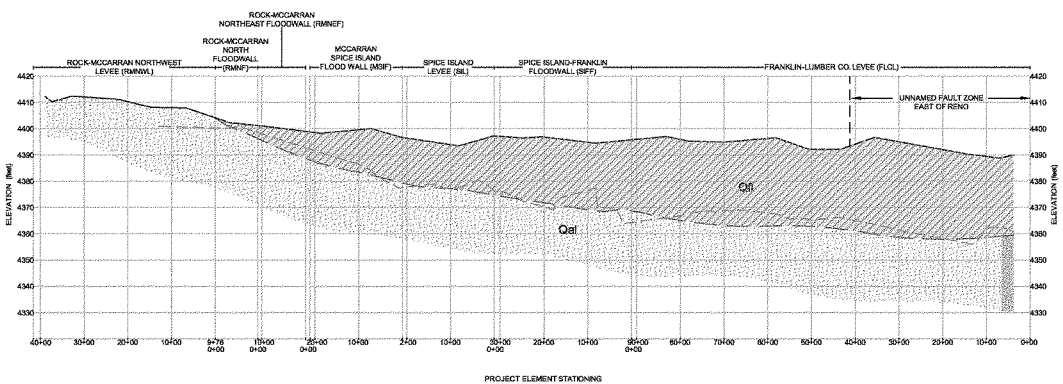
SOUTH STRATIGRAPHIC PROFILE

TRUCKEE MEADOW FLOOD CONTROL PROJECT
REACH: US 395 TO VISTA REEFS
GEOTECHNICAL DATA REPORT
WASHOE COUNTY, NEVADA

PLATE **7-1**

FIGURE 17





Notes:

1. Fault locations are based on dePolo, C.M., et. al., 2008. Locations are shown as approximate 3000-foot wide zones to account for uncertainties in location, concealed features, base map errors, and that minor fault traces are likely present parallel to the main fault trace.
2. Ground surface profile is estimated by connecting selected surveyed top of boring elevations and is not exact between borings.
3. Base map, flood element alignment and stationing data were provided by the USACE. The accuracy of these data could not be verified by the USACE. Kleinfelder is not responsible for the accuracy of the base map or flood element alignment represented on this drawing.

Reference: Aerial imagery and alignment source: USECE Sacramento District, date unknown.

30 15 0 30
VERTICAL SCALE: 1" = 30'

2,000 1,000 0 2,000
APPROX. HORIZONTAL SCALE: 1" = 2,000'

Qfl	Quaternary floodplain deposits (Some locations shown as Qfl contain fill of varying thickness up to a maximum of 13 feet)
Qal	Quaternary alluvium
TV	Tertiary Volcanics

Interpreted geologic contact, dashed where approximate, queried where uncertain

Fault, dashed where approximate, queried where uncertain

Depth of CPT refusal

Depth of significant increase in sampler blow counts

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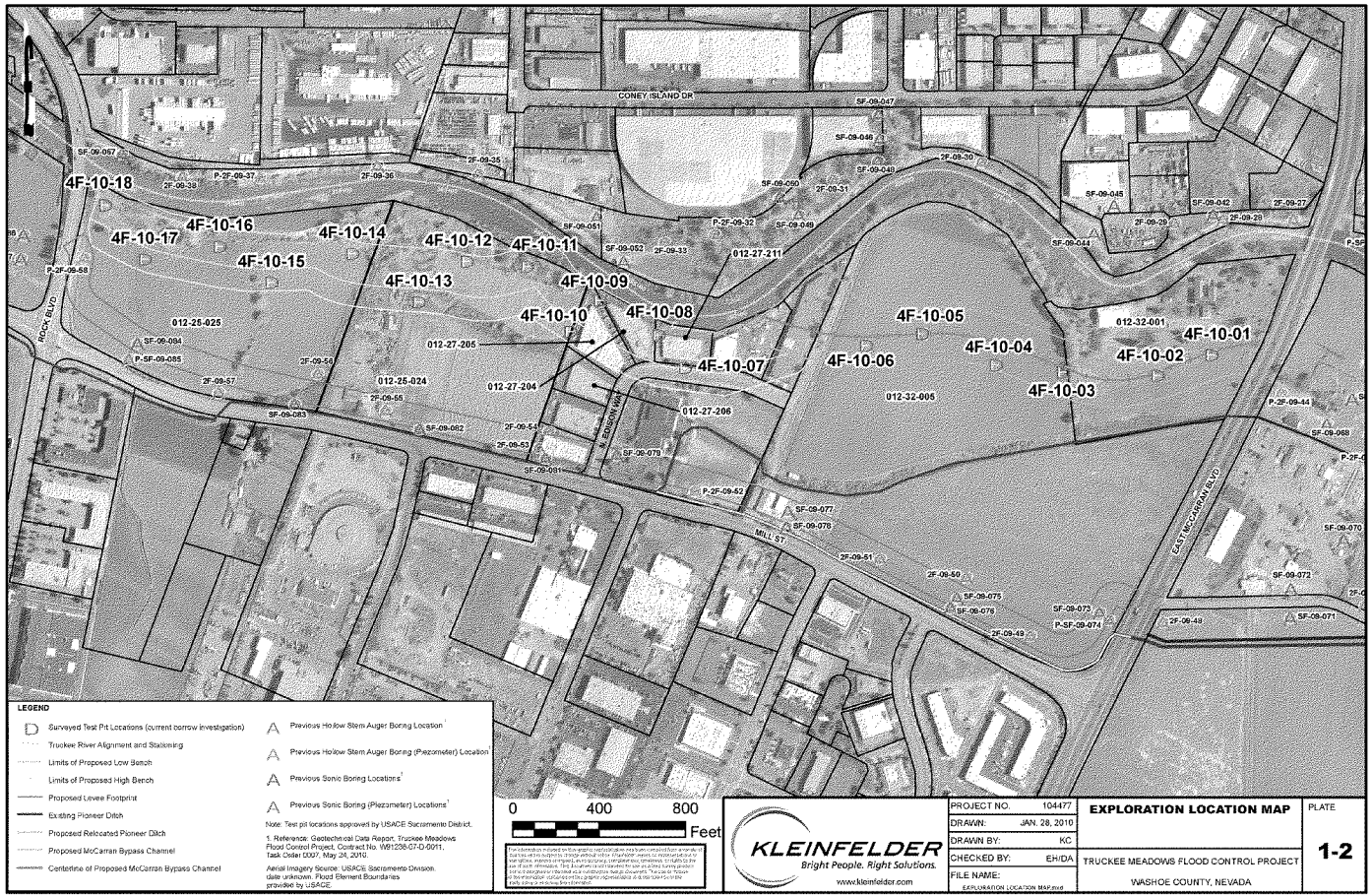
PROJECT NO.	104477
DRAWN:	MAY 24, 2010
DRAWN BY:	JS/KC
CHECKED BY:	E. HUBBARD
FILE NAME:	Stratigraphic Profile.dwg

NORTH STRATIGRAPHIC PROFILE

TRUCKEE MEADOW FLOOD CONTROL PROJECT
REACH: US 395 TO VISTA REEFS
GEOTECHNICAL DATA REPORT
WASHOE COUNTY, NEVADA

PLATE **7-2**

FIGURE 18


CONEY ISLAND DR
BECK BLVD
A. BERRON WAY
MILL ST
EAST McCARRAN BLVD
4F-10-18
4F-10-17
4F-10-16
4F-10-15
4F-10-14
4F-10-13
4F-10-12
4F-10-11
4F-10-10
4F-10-09
4F-10-08
4F-10-07
4F-10-06
4F-10-05
4F-10-04
4F-10-03
4F-10-02
4F-10-01
012-25-025
012-25-024
012-27-205
012-27-204
012-27-206
012-27-211
012-32-005
012-32-001
LEGEND
Surveyed Test Pit Locations (current borrow investigation)
Truckee River Alignment and Stationing
Limits of Proposed Low Bench
Limits of Proposed High Bench
Proposed Levee Footprint
Existing Pioneer Ditch
Proposed Relocated Pioneer Ditch
Proposed McCarran Bypass Channel
Centerline of Proposed McCarran Bypass Channel
Previous Hollow Stem Auger Boring Location[1]
Previous Hollow Stem Auger Boring (Piezometer) Location
Previous Sonic Boring Locations[1]
Previous Sonic Boring (Piezometer) Locations[1]
Note: Test pit locations approved by USACE Sacramento District.
1. Reference: Geotechnical Data Report, Truckee Meadows Flood Control Project, Contract No. W912J8-07-D-0011, Task Order 0007, May 24, 2010.
Aerial Imagery Source: USACE Sacramento Division, date unknown. Flood Element Boundaries provided by USACE.
0 400 800
Feet
KLEINFELDER
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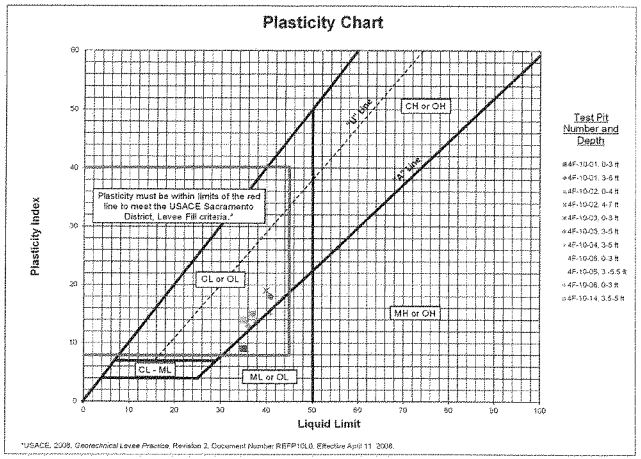
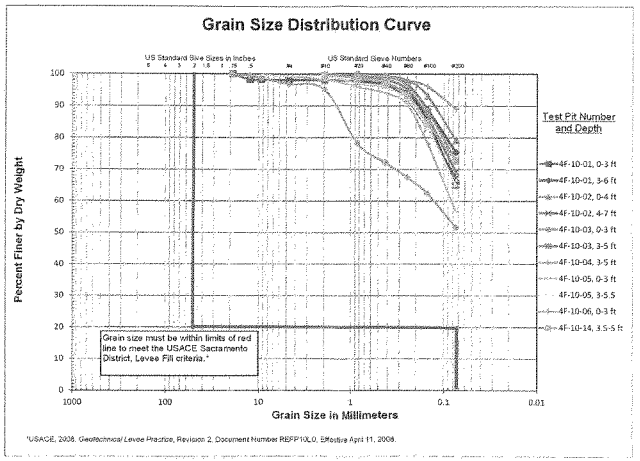
www.kleinfelder.com
PROJECT NO. 104477
DRAWN: JAN. 28, 2010
DRAWN BY: KC
CHECKED BY: EHIDA
FILE NAME: EXPLORATION LOCATION MAP.dwg
EXPLORATION LOCATION MAP
TRUCKEE MEADOWS FLOOD CONTROL PROJECT
WASHOE COUNTY, NEVADA
PLATE
1-2

FIGURE 19



*USACE, 2008, Geotechnical Levee Practice, Revision 2, Document Number: REFP10L0, Effective April 11, 2008.



*USACE, 2008, Geotechnical Levee Practice, Revision 2, Document Number REFP10L0, Effective April 11, 2008.

FIGURE 20

KLEINFELDER Bright People. Right Solutions. www.kleinfelder.com	PROJECT NO. 104477 DRAWN: JAN. 28, 2011 DRAWN BY: KC CHECKED BY: DA FILE NAME: GRAPHS (3-1 & 3-2).dwg	MATERIAL MEETING THE USACE SACRAMENTO DISTRICT LEVEE FILL CRITERIA TRUCKEE MEADOWS FLOOD CONTROL PROJECT WASHOE COUNTY, NEVADA	PLATE 3-1

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ATTACHED IMA/
ATTACHED XRE
RENO, NV

CAD FILE: L:\2010\Project\104477\Drafting\Borrow Study Drai... LAYOUT: 3-1 PLOTTED: 25 Jan 2011, 4:36pm, kcarb...

TRUCKEE MEADOWS
FLOOD CONTROL PROJECT
ENGINEERING PLANS
ALTERNATIVE 3 FLOODPLAIN TERRACE PLAN

SHEET INDEX

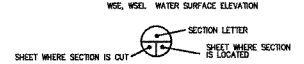
SHEET NUMBER	REFERENCE NUMBER	DRAWING TITLE
1	G-001	TITLE SHEET AND INDEX
2	G-002	GENERAL SHEET AND VICINITY MAP
3	G-003	GENERAL SHEET AND VICINITY MAP
4	G-004	CIVIL PLAN SHEET LAYOUT – TRUCKEE MEADOWS
5	G-005	REVEGETATION AND MITIGATION SHEET LAYOUT
6	G-006	RECREATION SHEET LAYOUT
7	C-101	PLAN – TRUCKEE MEADOWS
8	C-102	PLAN – TRUCKEE MEADOWS
9	C-103	PLAN – TRUCKEE MEADOWS
10	C-104	INTENTIONALLY BLANK
11	C-105	PLAN – TRUCKEE MEADOWS
12	C-106	PLAN – TRUCKEE MEADOWS
13	C-107	PLAN – TRUCKEE MEADOWS
14	C-108	PLAN – TRUCKEE MEADOWS
15	C-109	PLAN – TRUCKEE MEADOWS
16	C-110	PLAN – TRUCKEE MEADOWS
17	C-111	PLAN – TRUCKEE MEADOWS
18	C-112	PLAN – TRUCKEE MEADOWS
19	C-113	PLAN – TRUCKEE MEADOWS
20	C-114	PLAN – TRUCKEE MEADOWS
21	C-115	PLAN – TRUCKEE MEADOWS
22	C-116	PLAN – TRUCKEE MEADOWS
23	C-117	PLAN – TRUCKEE MEADOWS
24	C-200	TRUCKEE MEADOWS – PROFILES
25	C-201	TRUCKEE MEADOWS – PROFILES
26	C-202	TRUCKEE MEADOWS – PROFILES
27	C-203	TRUCKEE MEADOWS – PROFILES
28	C-204	TRUCKEE MEADOWS – PROFILES
29	C-205	NORTH TRUCKEE DRAIN – PROFILES
30	C-301	MISCELLANEOUS – TYPICAL SECTIONS
31	C-302	FLOODWALL – TYPICAL SECTIONS
32	C-303	LEVEE – TYPICAL SECTIONS
33	C-304	SCOUR PROTECTION DETAILS-1
34	C-305	SCOUR PROTECTION DETIALS-2
35	C-400	CROSS SECTIONS – TRUCKEE MEADOWS
36	C-401	CROSS SECTIONS – TRUCKEE MEADOWS
37	C-402	CROSS SECTIONS – TRUCKEE MEADOWS
38	L-101	REVEGETATION PLAN – TRUCKEE MEADOWS OVERVIEW
39	L-111	REVEGETATION PLAN – CHANNEL TERRACING REVEGETATION
40	L-112	REVEGETATION PLAN – CHANNEL TERRACING REVEGETATION
41	L-113	REVEGETATION PLAN – CHANNEL TERRACING REVEGETATION
42	RC-101	RECREATION PLAN ALTERNATIVE C – TRUCKEE MEADOWS
43	RC-102	RECREATION PLAN ALTERNATIVE C – TRUCKEE MEADOWS
44	RC-103	RECREATION PLAN ALTERNATIVE C – TRUCKEE MEADOWS
45	RC-104	RECREATION PLAN ALTERNATIVE C – TRUCKEE MEADOWS
46	RC-105	RECREATION PLAN ALTERNATIVE C – TRUCKEE MEADOWS
47	RC-106	RECREATION PLAN ALTERNATIVE C – TRUCKEE MEADOWS

NOTES:

1. ELEVATIONS ARE BASED ON NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88). HORIZONTAL CONTROL IS BASED ON THE NORTH AMERICAN DATUM OF 1983 (NAD83), NEVADA WEST.
2. BUILDINGS AND STRUCTURES WITHIN FPLE ARE SUBJECT TO DEMOLITION AND REMOVE OR RELOCATION.

ABBREVIATIONS

AB	AGGREGATE BASE	MIN	MINIMUM
ABUT	ABUTMENT	NTS	NOT TO SCALE
AC	ASPHALT CONCRETE	OG	ORIGINAL GRADE
CL	CENTERLINE	PVC	POLY VINYL CHLORIDE PIPE
DWS, DWSE	DESIGN WATER SURFACE ELEVATION	PVI	POINT OF VERTICAL INTERSECTION
EG	EXISTING GRADE	RCB	REINFORCED CONCRETE BOX CULVERT
EGL	ENERGY GRADE LINE	RCP	REINFORCED CONCRETE PIPE
EL, ELEV	ELEVATION	RAU	RISK AND UNCERTAINTY
EXIST, EX	EXISTING	SDMH	STORM DRAIN MANHOLE
FG	FINISH GRADE	SHLD	SHOULDER
FPLE	FLOOD PROTECTION LEVEE EASEMENT	STA	STATION
FT	FEET	T	THICKNESS
HGL	HYDRAULIC GRADE LINE	TCID	TRUCKEE CARSON IRRIGATION DISTRICT
HWY 395	HIGHWAY 395	TWAE	TEMPORARY WORK AREA EASEMENT
I-80	INTERSTATE 80	TYP	TYPICAL
		UPRR	UNION PACIFIC RAILROAD
		WSE, WSEL	WATER SURFACE ELEVATION



US Army Corps of Engineers
Sacramento District

Symbol	Description	Date

DEPARTMENT OF THE ARMY
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SACRAMENTO, CALIFORNIA

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Drawn by: TJ
Checked by: TJ
Reviewed by: TJM, DWS
Approved by: TJM, DWS
Scale: NONE
Date: 13-MAY-13
File name: G-001.dgn
Plot date: 13-MAY-13
Plot scale: 1:1
Plot time: 08:32

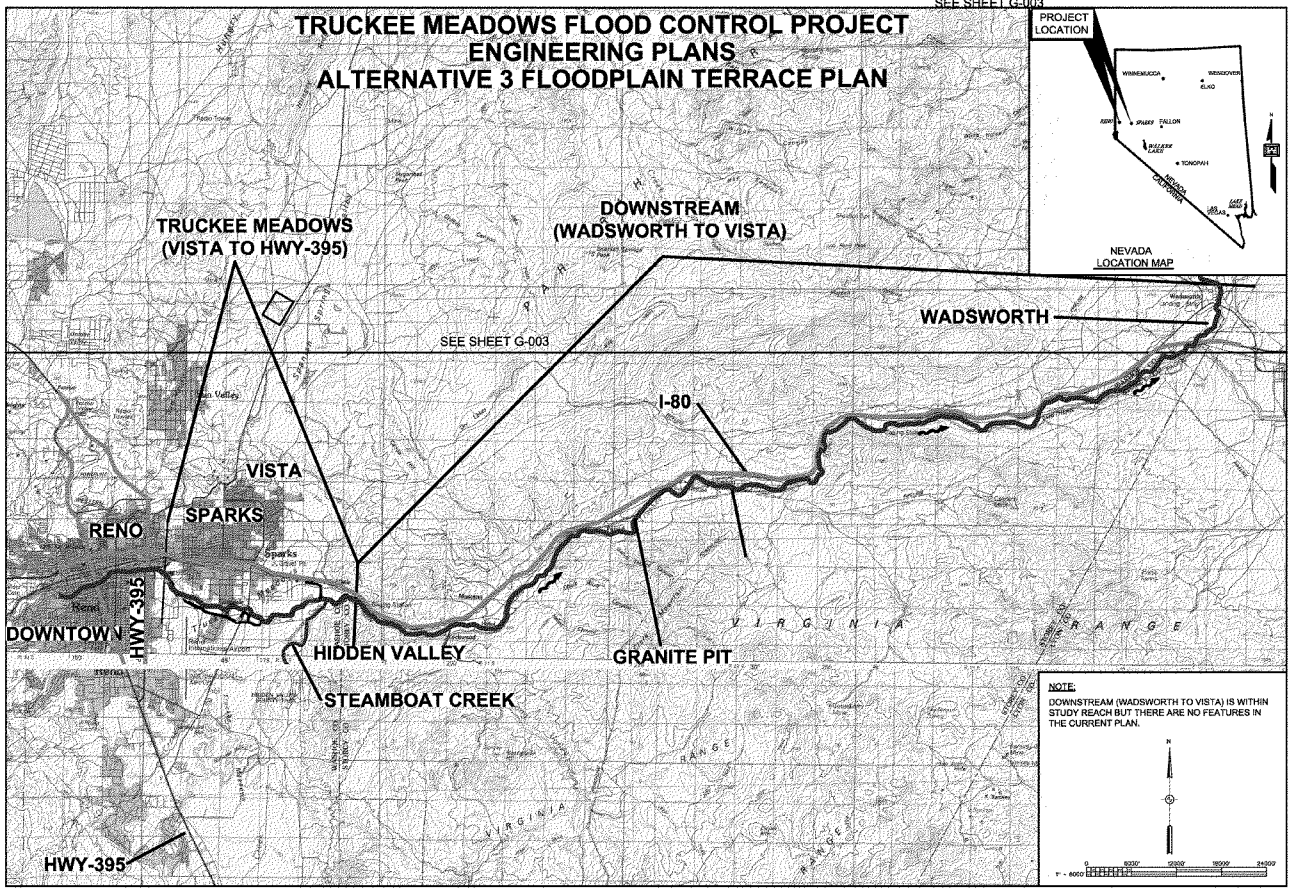
SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CA 95814-2922

WASHOE & STOREY COUNTIES NEVADA
TRUCKEE MEADOWS
FLOOD CONTROL PROJECT
ALTERNATIVE 3 FLOODPLAIN TERRACE PLAN

TITLE SHEET AND INDEX

Sheet reference number:
G-001
Sheet 1 of 47

TRUCKEE MEADOWS FLOOD CONTROL PROJECT
ENGINEERING PLANS
ALTERNATIVE 3 FLOODPLAIN TERRACE PLAN



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Checked by: JCM
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Plot time: 06:32
File name: G-002.dgn
Project number: 14000

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TRUCKEE MEADOWS
FLOOD CONTROL PROJECT
ALTERNATIVE 3 FLOODPLAIN TERRACE PLAN

GENERAL SHEET AND VINCINITY MAP

Sheet reference number:
G-002
Sheet 2 of 47

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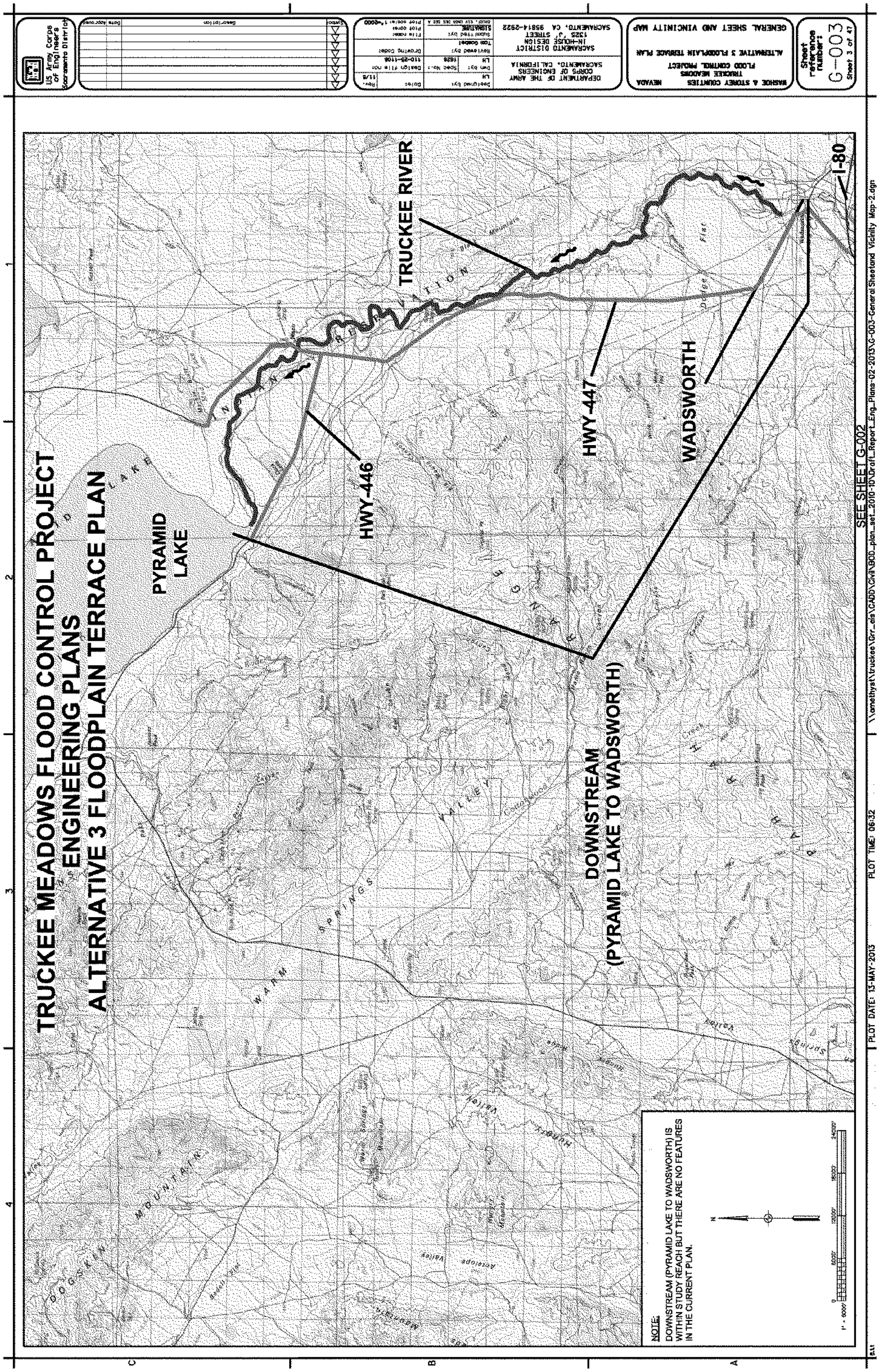
TRUCKEE MEADOWS FLOOD CONTROL PROJECT
ENGINEERING PLANS
ALTERNATIVE 3 FLOODPLAIN TERRACE PLAN
PYRAMID LAKE
TRUCKEE RIVER
HWY-446
HWY-447
WADSWORTH
I-80
DOWNSTREAM
(PYRAMID LAKE TO WADSWORTH)
SEE SHEET G-002
NOTE:
DOWNSTREAM (PYRAMID LAKE TO WADSWORTH) IS WITHIN STUDY REACH BUT THERE ARE NO FEATURES IN THE CURRENT PLAN.
PLOT DATE: 13-MAY-2013
PLOT TIME: 06:32
US Army Corps of Engineers Sacramento District
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SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
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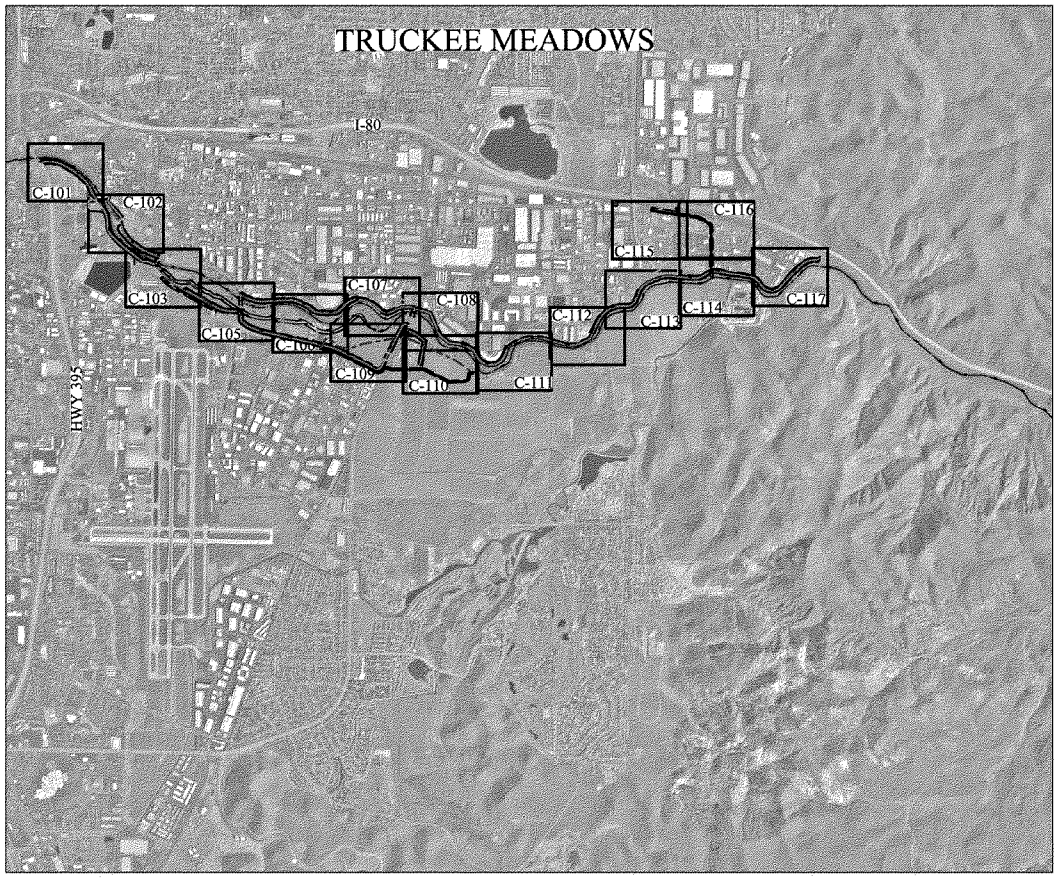
TRUCKEE MEADOWS
FLOOD CONTROL PROJECT
ALTERNATIVE 3 FLOODPLAIN TERRACE PLAN
GENERAL SHEET AND VINCINITY MAP
Sheet reference number:
G-003
Sheet 3 of 47



N

0 1500' 3000' 4500' 6000'
1" = 1500'

US Army Corps of Engineers
Sacramento District

Date	Description

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SACRAMENTO, CA 95814-2922

Designed by: LB
Drawn by: LB
Scale: NONE
Date: 11-4-13
Reviewed by:
Date Reviewed:
Approved by:
Date Approved:
SIGNATURE
Date: Mon 03 Jun 2013

WASHOE & STOREY COUNTIES NEVADA
TRUCKEE MEADOWS
FLOOD CONTROL PROJECT
ALTERNATIVE 3 FLOODPLAIN TERRACE PLAN

CIVIL PLAN SHEET LAYOUT
TRUCKEE MEADOWS

Sheet reference number:
G-004
Sheet 4 of 33

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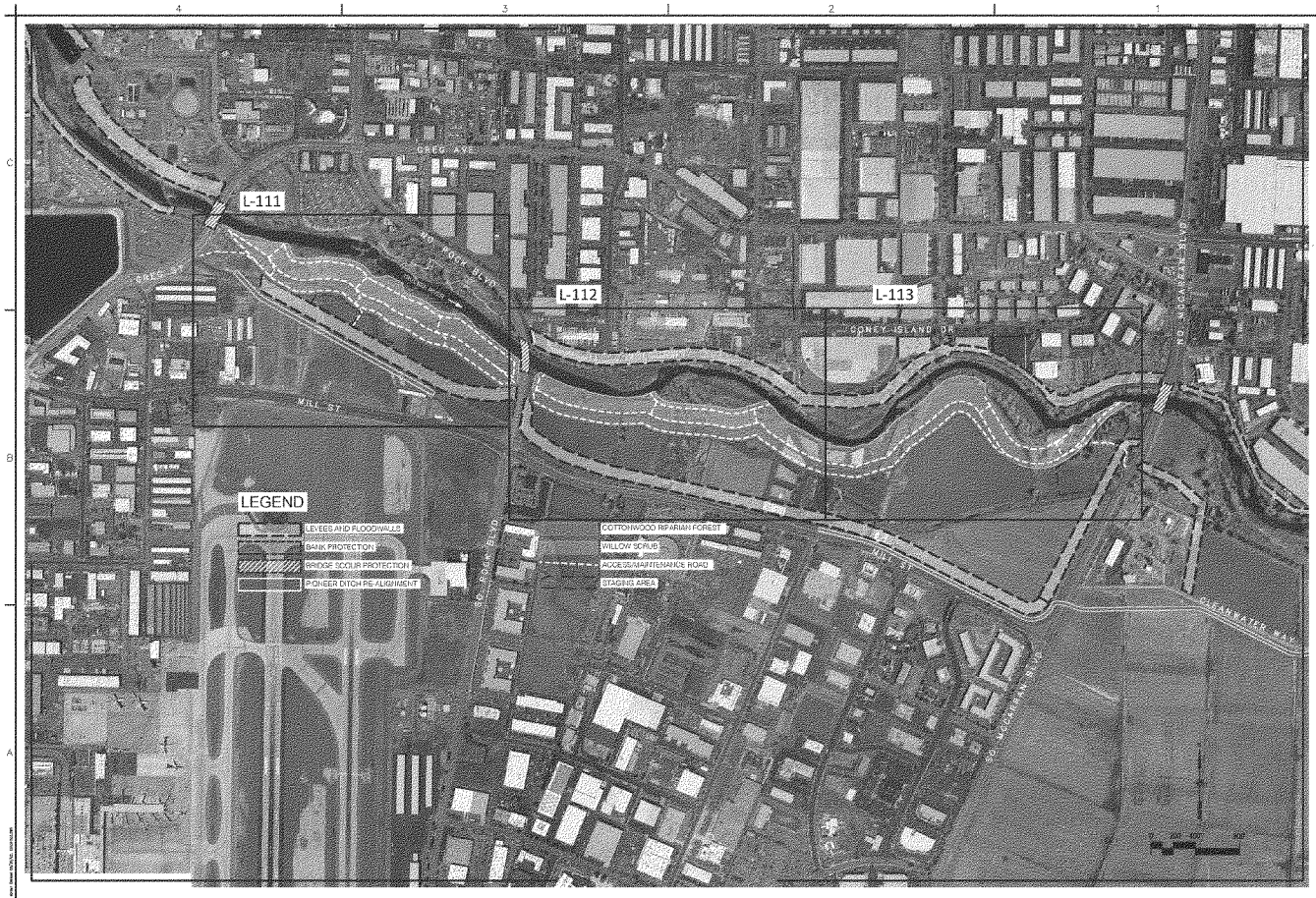

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Reviewed by
Date
Scale
Design file no.
Drawing file no.
Contract no.
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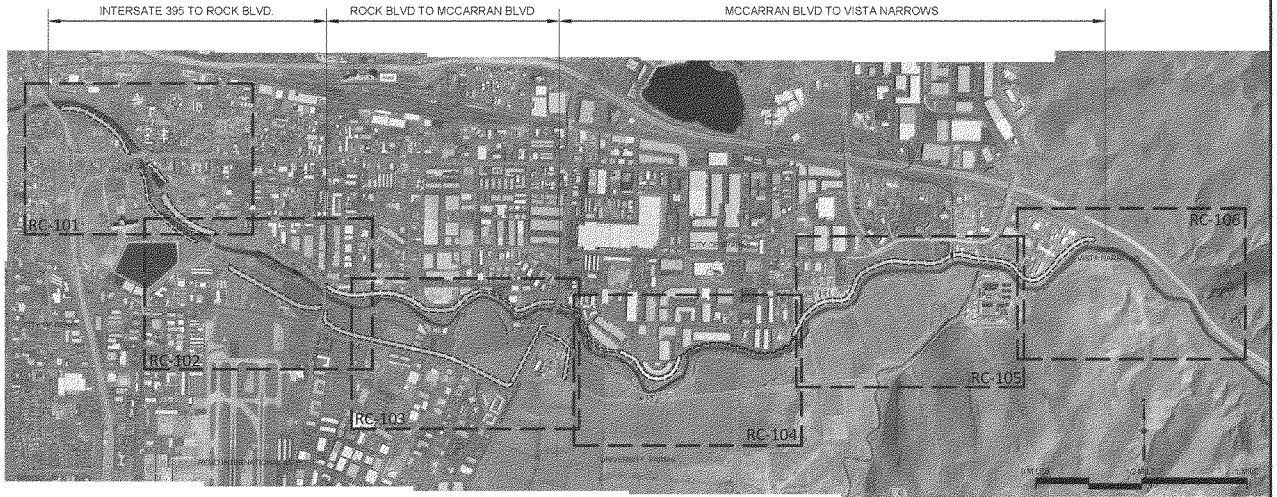
NOMAD
RIVERS & STREET CLEARED
TRUCKEE MEADOWS
FLOOD CONTROL PROJECT
ALTERNATIVE 1 FLOODPLAIN REVISE PLAN
REVEGETATION PLAN
TRUCKEE MEADOWS OVERVIEW

Sheet reference number
G-005
Sheet 3 of 47

06-11-2013



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Mark	Description	Date	Approved

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SACRAMENTO, CA 95814-2922

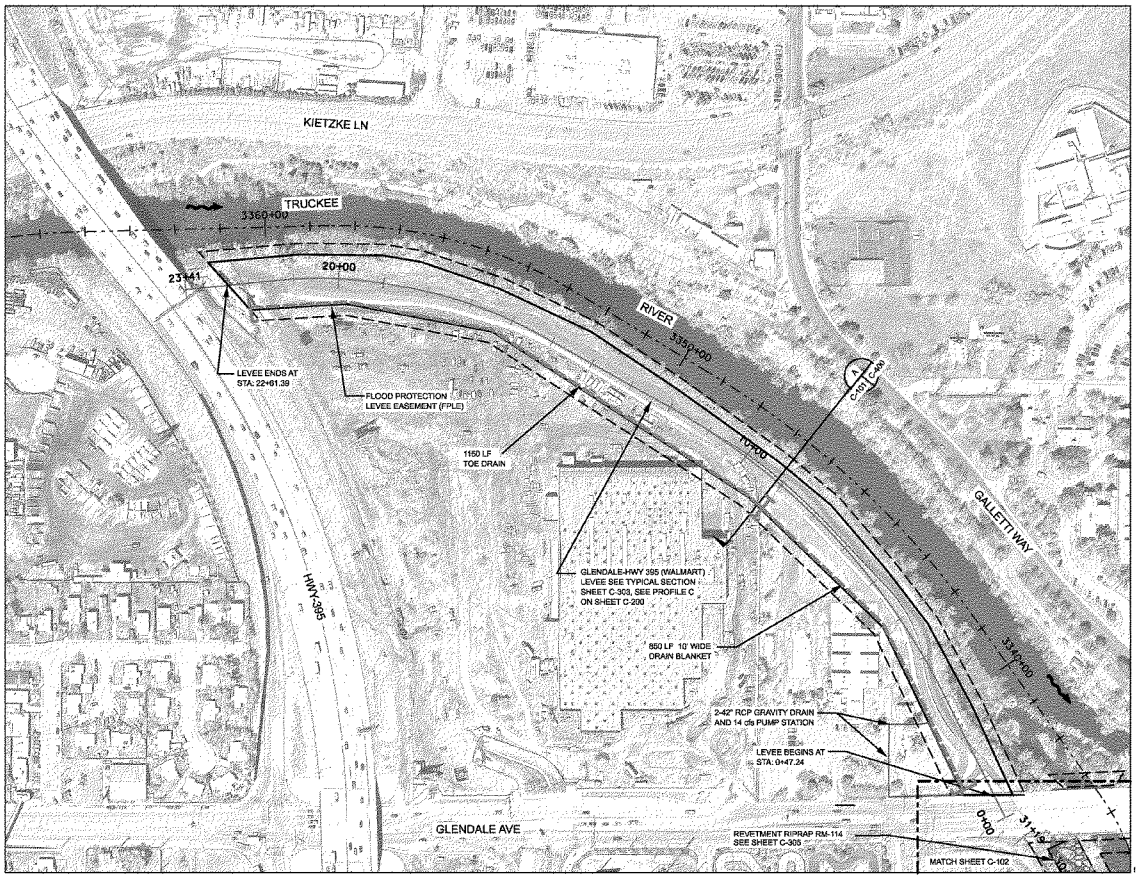
Designed by CB
Drawn by CB
Reviewed by CB
Date 05-11-2010
Scale 1" = 1000'
Checked by TJW
Date 05-11-2010
File name
Sheet size 36 x 48
Project No. 26-06

WASHOE & STOREY COUNTIES
TRUCKEE RIVER
CITY OF SPARKS, NEVADA
ALTERNATIVE 3 FLOOD RELIEF PLAN

RECREATION
SHEET LAYOUT

Sheet reference number:
G-006
Sheet 6 of 47

05-11-2010



LEGEND

- ACCESS ROAD
- TEMPORARY WORK EASEMENT
- ON-BANK FLOODWALL
- IN-CHANNEL FLOODWALL
- LEVEE
- FLOOD PROTECTION LEVEE EASEMENT (FPLE)
- RE-ALIGN PIONEER DITCH
- FLOODPLAIN TERRACING
- EXISTING PIONEER DITCH
- SEEPAGE FEATURE
- REVETMENT RIPRAP
- BRIDGE SCOUR PROTECTION

US Army Corps of Engineers
Sacramento District

Date	Description

Designed by: LM
Drawn by: LM
Checked by: DA
Scale: N/A
Date: 1/1/13
Revised by:
Submitted by:
Approved by:
Drawing Code: DRAFTING CODE
File name: Plot date: Plot scale:
ESTIMATOR
Date: Version 03.03.01

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SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
1325 J STREET
1325-J-SIDE SECTION
SACRAMENTO, CA 95814-2922

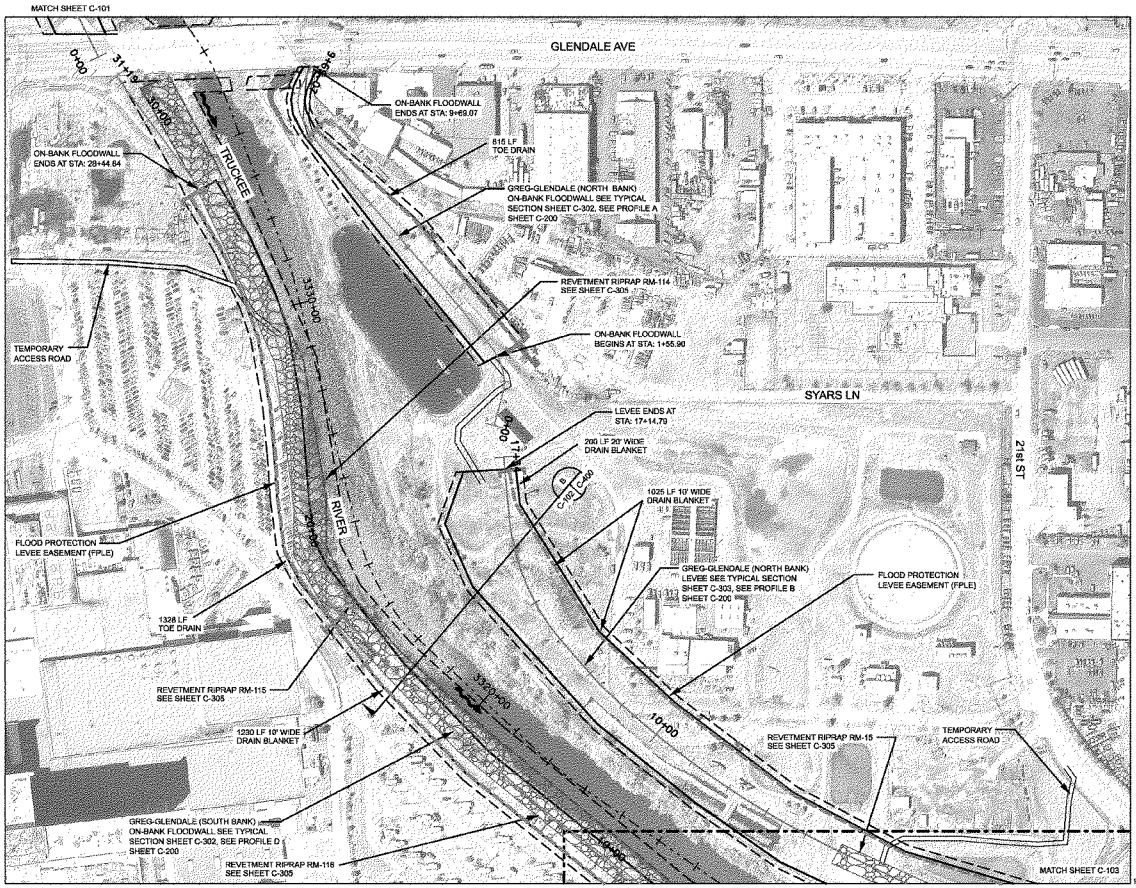
NEVADA

WASHOE & STOREY COUNTIES
TRUCKEE MEADOWS
FLOOD CONTROL PROJECT
ALTERNATIVE 3 FLOODPLAIN TERRACE PLAN

PLAN
TRUCKEE MEADOWS

Sheet reference number:
C-101
Sheet 7 of 47

PLOT DATE: 02-JUL-2013 PLOT TIME: 10:35 \\amethyst\truckee\Drr_eis\CADD\Civil\B00_plan_set_2010-10\Draft_Report_Eng_Plans-02-2013\C-101-Civil Plan.dgn



LEGEND

- ACCESS ROAD
- TEMPORARY WORK EASEMENT
- ON-BANK FLOODWALL
- IN-CHANNEL FLOODWALL
- LEVEE
- FLOOD PROTECTION LEVEE EASEMENT (FPLE)
- RE-ALIGN PIONEER DITCH
- FLOODPLAIN TERRACING
- EXISTING PIONEER DITCH
- SEEPAGE FEATURE
- REVETMENT RIPRAP
- BRIDGE SCOUR PROTECTION

US Army Corps of Engineers
Sacramento District

Symb	Description
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Drawn by: LM
Checked by: DL
Sheet No.: 1 of 18
Date: 11/08/2012
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Reviewed by: Chief Civil
Approved by: Chief Civil
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Plot date: 20-JUN-2013
Plot time: 12:38

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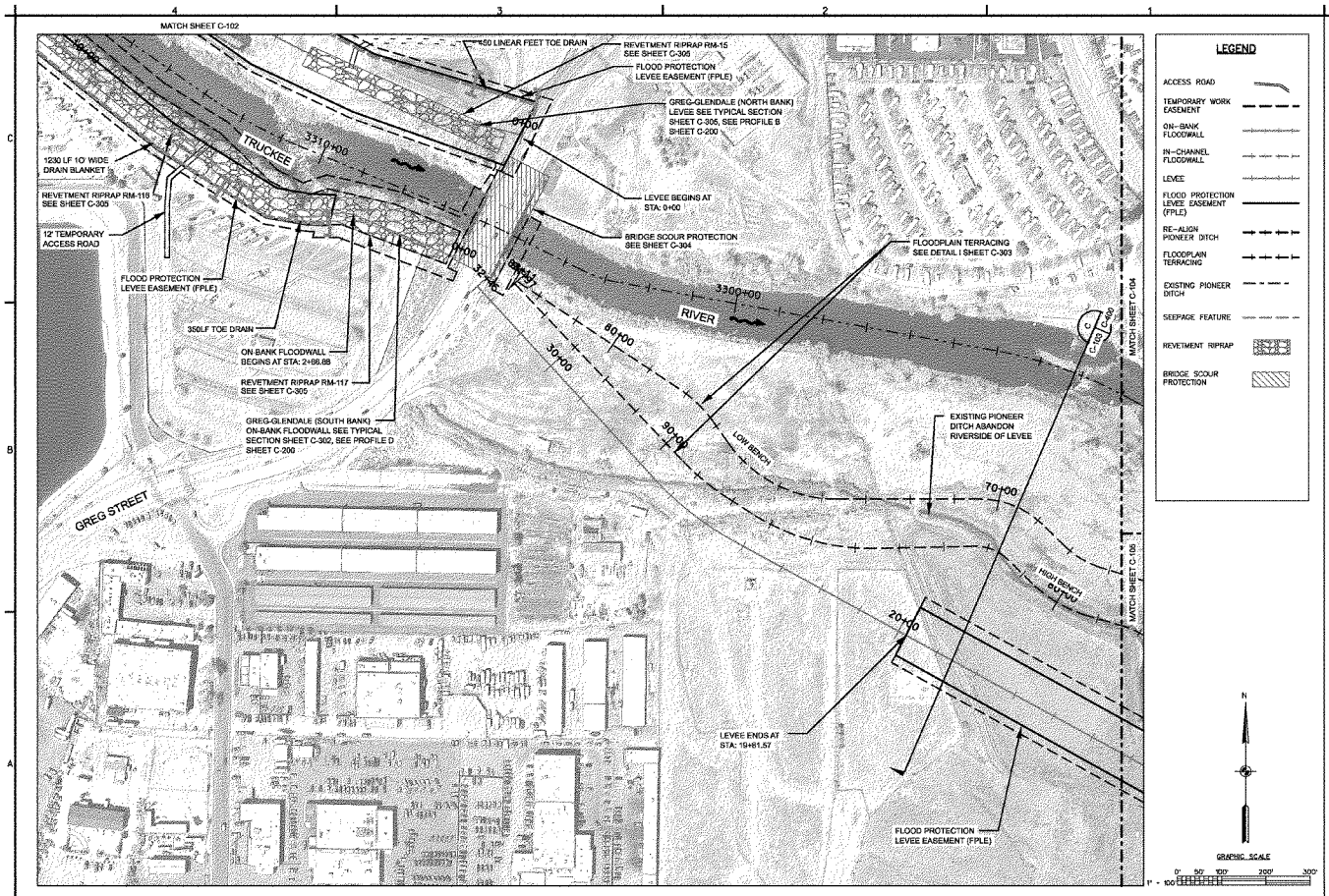
SACRAMENTO DISTRICT
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
1325 J STREET
THIRD FLOOR, ROOM 1350
SACRAMENTO, CA 95814-2922

NEVADA
PLACER & STOREY COUNTIES
SACRAMENTO, CALIFORNIA
FLOOD CONTROL PROJECT
ALTERNATIVE 3 FLOODPLAIN TERRACE PLAN
PLAN
TRUCKEE MEADOWS

Sheet reference number:
C-102
Sheet 6 of 47



US Army Corps of Engineers
Sacramento District

Symbol	Description	Date	Approved
A			

Scale: 1"=100'
Date: Sept 2013
Design Agency: USACE
Design Agency Symbol: SPK-PD-EG
Drawing Number: C-103
Revision Number: 0

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SACRAMENTO, CALIFORNIA

Designed by: LJV
Drawn by: DM
Checked by: DM
Reviewed by: JAN
Approved by: JAN

SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CA 95814-2922

WASHOE & STOREY COUNTIES NEVADA
TRUCKEE MEADOWS
FLOOD CONTROL PROJECT
ALTERNATIVE 3 FLOODPLAIN TERRACE PLAN
PLAN
TRUCKEE MEADOWS

Sheet reference number:
C-103
Sheet 5 of 47

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Sheet reference number: C-104
Sheet 10 of 47

WASHOE & STOREY COUNTIES NEVADA
TRUCKEE MEADOWS
FLOOD CONTROL PROJECT
ALTERNATIVE 3 FLOODPLAIN TERRACE PLAN
PLAN
TRUCKEE MEADOWS

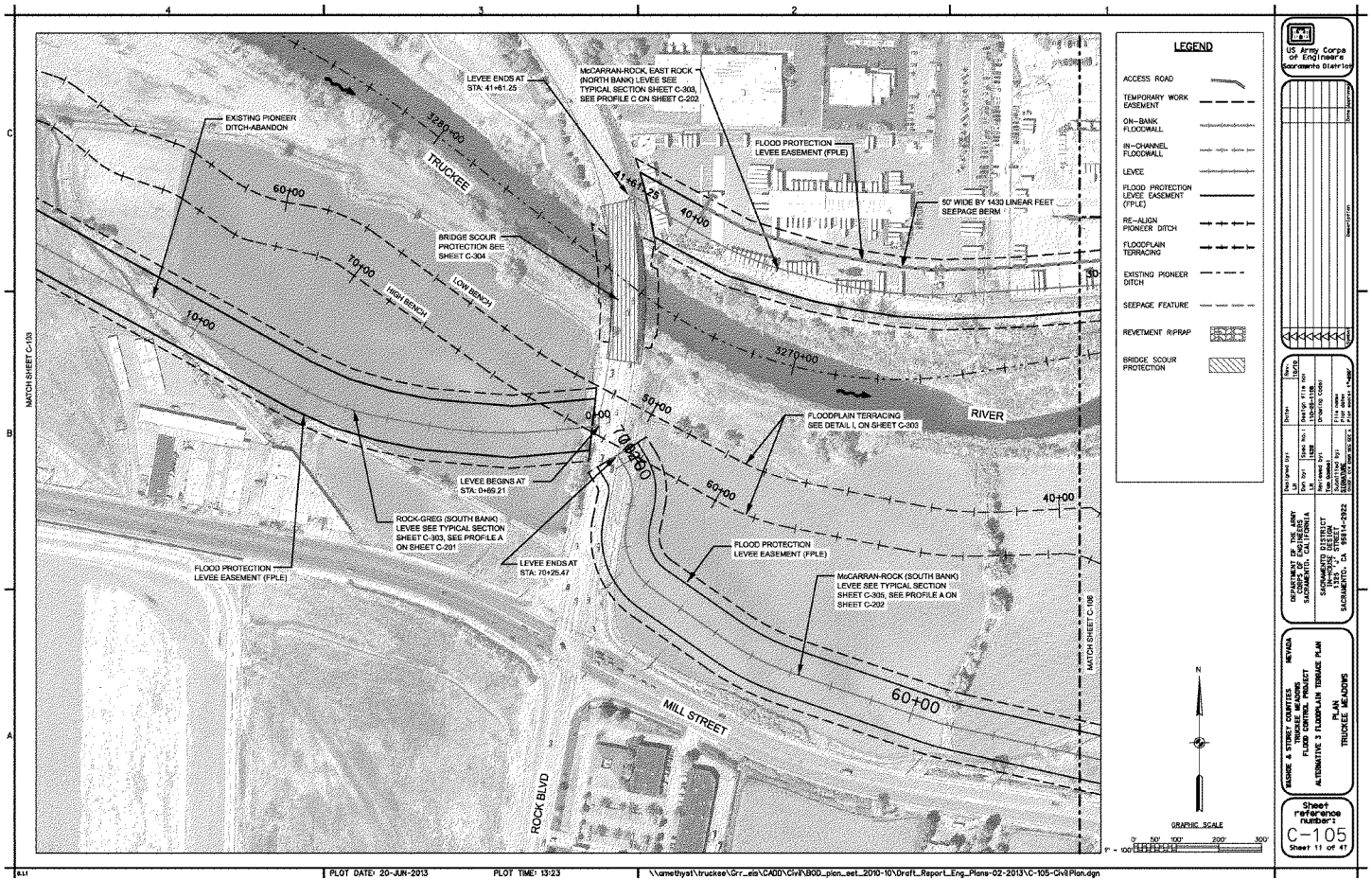
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 'J' STREET
SACRAMENTO, CA 95814-2922

Designed by: LH
Date:
Rev. 11/3
Dwn by: LH
Spec No.: 1628
Design file no: 110-25-1108
Reviewed by: Tom Goebel
Drawing Code:
Submitted by: SIGNATURE
File name:
Plot date:
Plot scale: 1"=800'

Symbol | Description | Date | Approved

US Army Corps of Engineers Sacramento District



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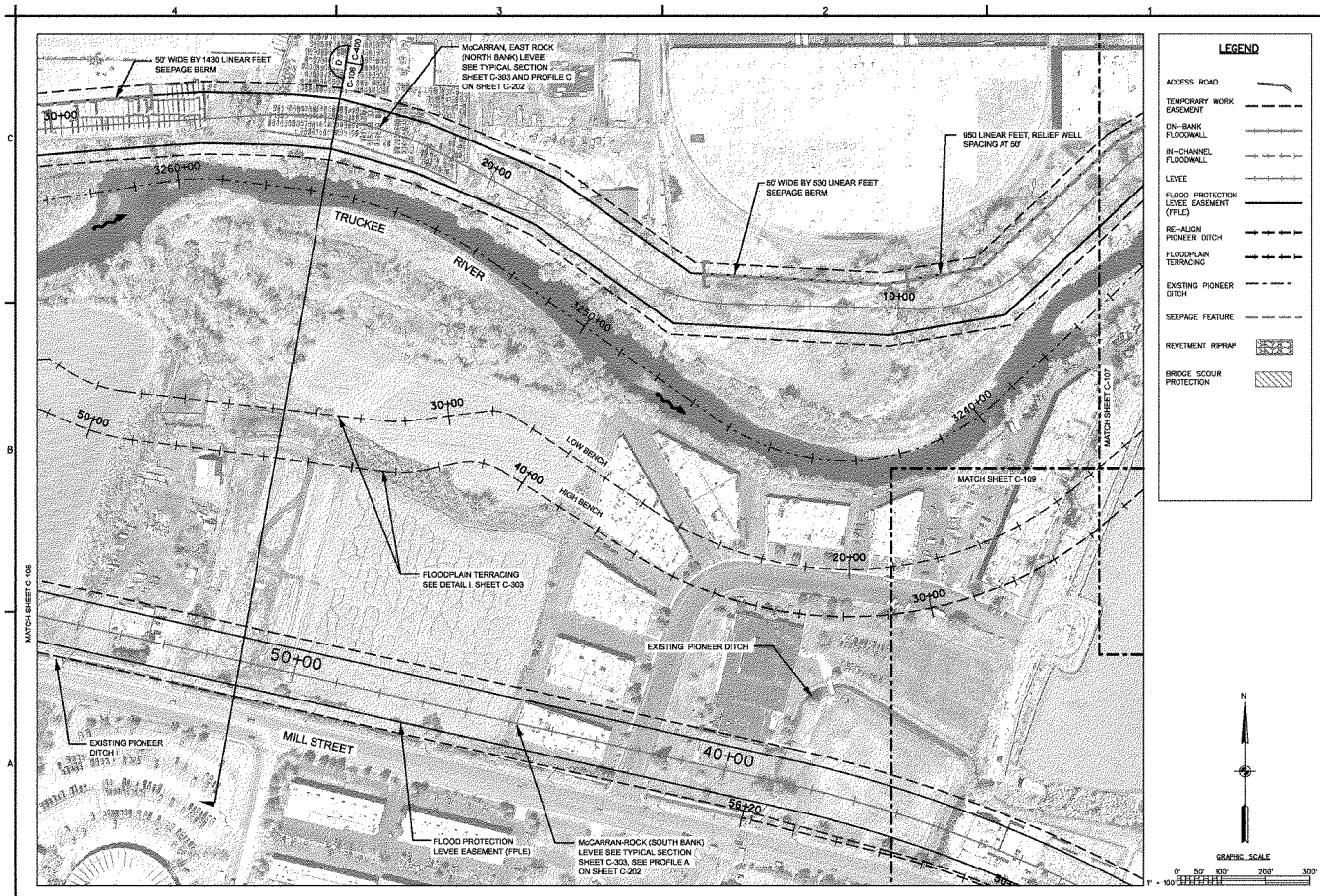
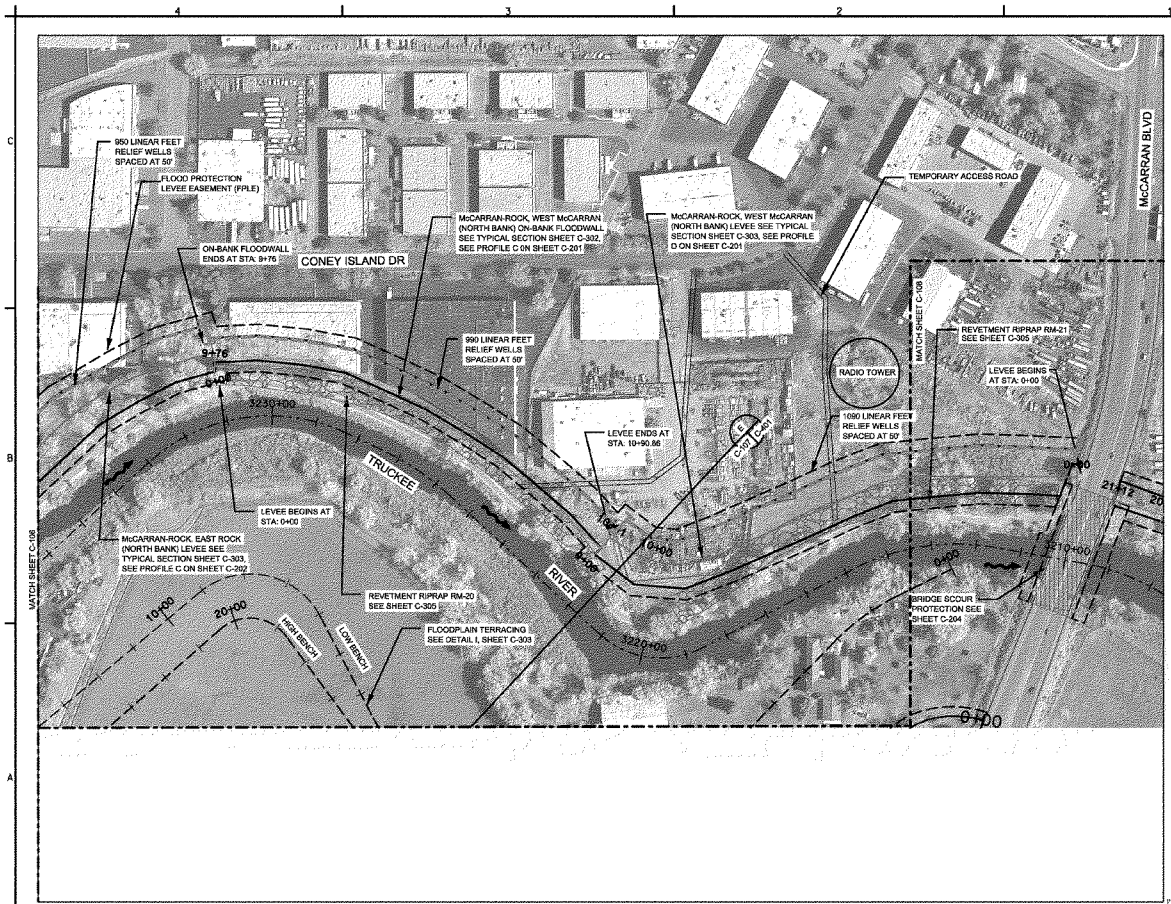


PLOT DATE: 20-JUN-2013 PLOT TIME: 13:47 \\amethyst\truckee\Grr_eis\CADD\Civil\800_plan_set_2010-10\Draft_Report_Eng_Plans-02-2013\C-106-Civil Plan.dgn



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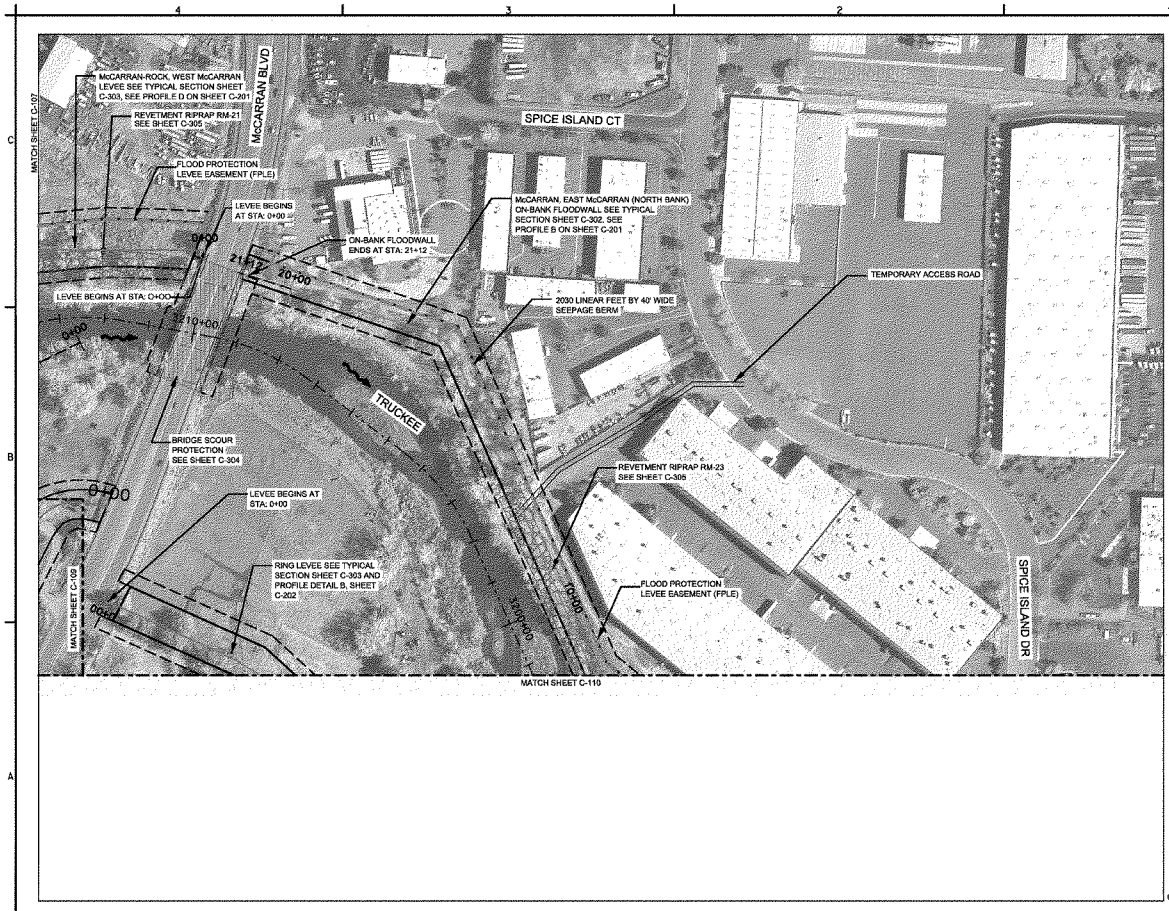


US Army Corps of Engineers
Sacramento District

Date	Description

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
SACRAMENTO, CALIFORNIA

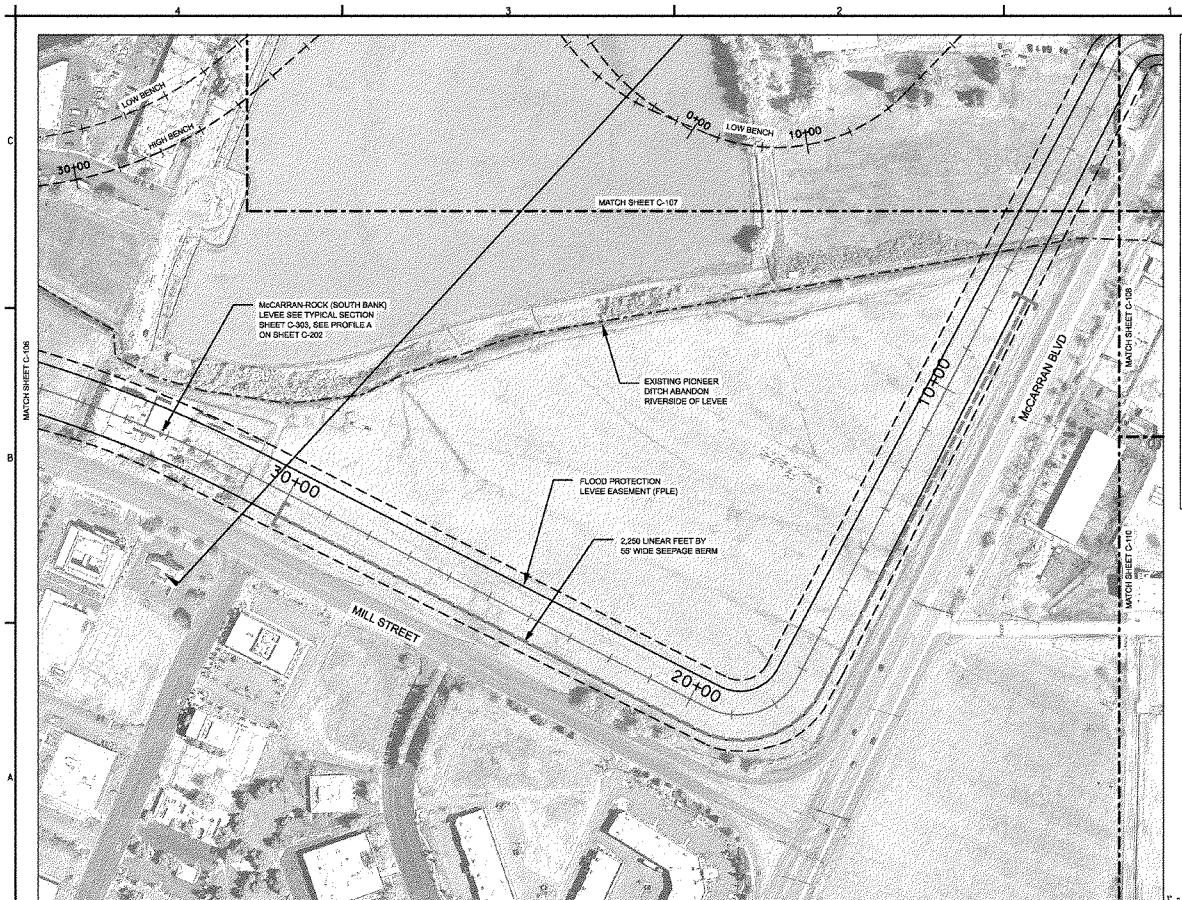
Designed by: LM
Drawn by: LM
Checked by: LM
Approved by: LM
Date: Nov 1976
Scale: 1"=100'
Design file no: 1
Drawing code: 1
File name: 01-01-01
Date plotted: 13-MAY-2013
Time plotted: 08:40
SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CA 95814-2922

WASHOE & STOREY COUNTIES NEVADA
TRUCKEE MEADOWS
FLOOD CONTROL PROJECT
ALTERNATIVE 3 FLOODPLAIN TERRACE PLAN

PLAN
TRUCKEE MEADOWS

Sheet reference number:
C-108
Sheet 14 of 47

A.11 | PLOT DATE: 13-MAY-2013 | PLOT TIME: 08:40 | \\amethyst\truckee\Drr_els\CADD\CIVIL\BOD_plan_set_2010-10\Draft_Report_Eng_Plans-02-2013\C-108-Civil Plan.dgn


LOW BENCH
HIGH BENCH
30+00
0+00
LOW BENCH
10+00
MATCH SHEET C-107
McCARRAN-ROCK (SOUTH BANK) LEVEE SEE TYPICAL SECTION SHEET C-303, SEE PROFILE A ON SHEET C-202
EXISTING PIONEER DITCH ABANDON RIVERSIDE OF LEVEE
FLOOD PROTECTION LEVEE EASEMENT (FPLE)
2,250 LINEAR FEET BY 55' WIDE SEEPAGE BERM
30+00
10+00
McCARRAN BLVD
MILL STREET
20+00
MATCH SHEET C-108
MATCH SHEET C-109
MATCH SHEET C-110
LEGEND
ACCESS ROAD
TEMPORARY WORK EASEMENT
ON-BANK FLOODWALL
IN-CHANNEL FLOODWALL
LEVEE
FLOOD PROTECTION LEVEE EASEMENT (FPLE)
RE-ALIGN PIONEER DITCH
FLOODPLAIN TERRACING
EXISTING PIONEER DITCH
SEEPAGE FEATURE
REVETMENT RIPRAP
BRIDGE SCOUR PROTECTION
N
GRAPHIC SCALE
0' 50' 100' 200' 300'
1" = 100'
US Army Corps of Engineers
Sacramento District
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CA 95814-2922
NEVADA
PLAN
TRUCKEE MEADOWS
Sheet reference number:
C-109
Sheet 15 of 47
PLOT DATE: 20-JUN-2013
PLOT TIME: 13:38
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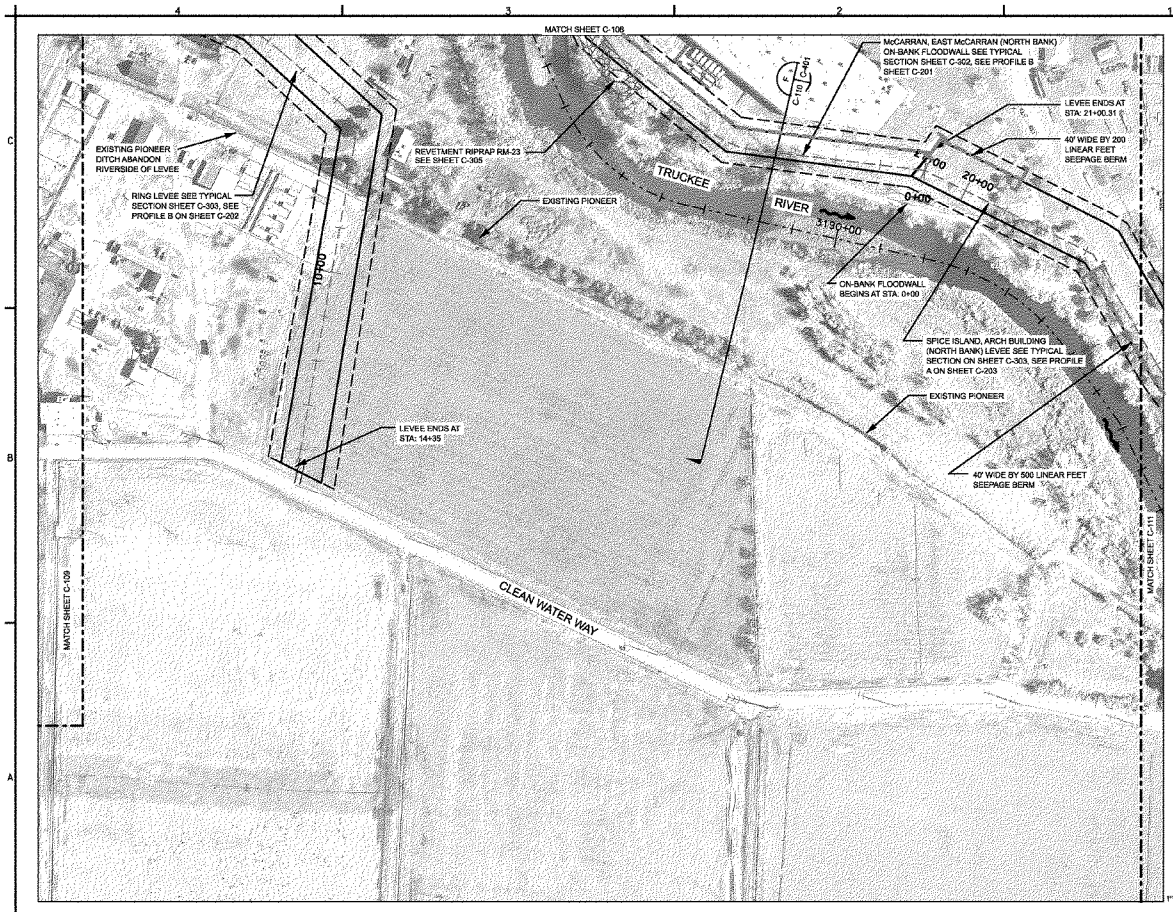
MATCH SHEET C-108
McCARRAN, EAST McCARRAN (NORTH BANK) ON-BANK FLOODWALL SEE TYPICAL SECTION SHEET C-302, SEE PROFILE B SHEET C-201
C-110 (C-401)
LEVEE ENDS AT STA: 21+00.31
40' WIDE BY 200 LINEAR FEET SEEPAGE BERM
EXISTING PIONEER DITCH ABANDON RIVERSIDE OF LEVEE
REVETMENT RIPRAP RM-23 SEE SHEET C-305
RING LEVEE SEE TYPICAL SECTION SHEET C-303, SEE PROFILE B ON SHEET C-202
EXISTING PIONEER
TRUCKEE
RIVER
10+00
20+00
0+00
31+00
ON-BANK FLOODWALL BEGINS AT STA: 0+00
SPICE ISLAND, ARCH BUILDING (NORTH BANK) LEVEE SEE TYPICAL SECTION ON SHEET C-303, SEE PROFILE A ON SHEET C-203
EXISTING PIONEER
LEVEE ENDS AT STA: 14+35
40' WIDE BY 500 LINEAR FEET SEEPAGE BERM
CLEAN WATER WAY
MATCH SHEET C-109
MATCH SHEET C-111
LEGEND
ACCESS ROAD
TEMPORARY WORK EASEMENT
ON-BANK FLOODWALL
IN-CHANNEL FLOODWALL
LEVEE
FLOOD PROTECTION LEVEE EASEMENT (FPLE)
RE-ALIGN PIONEER DITCH
FLOODPLAIN TERRACING
EXISTING PIONEER DITCH
SEEPAGE FEATURE
REVETMENT RIPRAP
BRIDGE SCOUR PROTECTION
N
GRAPHIC SCALE
0' 50' 100' 200' 300'
1" = 100'
US Army Corps of Engineers
Sacramento District
Date Approved
Description
Date
Sheet No.
Drawing No.
Designed by
Drawn by
Checked by
Approved by
Submitted by
File name
Plot date
Plot scale
Plot time
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT
1325 J STREET
ROOM 1350
SACRAMENTO, CA 95814-2922
WASHOE & STOREY COUNTIES
TRUCKEE MEADOWS
NEVADA
FLOOD CONTROL PROJECT
ALTERNATIVE 3 FLOODPLAIN TERRACE PLAN
PLAN
TRUCKEE MEADOWS
Sheet reference number:
C-110
Sheet 16 of 47
PLOT DATE: 20-JUN-2013
PLOT TIME: 13:44
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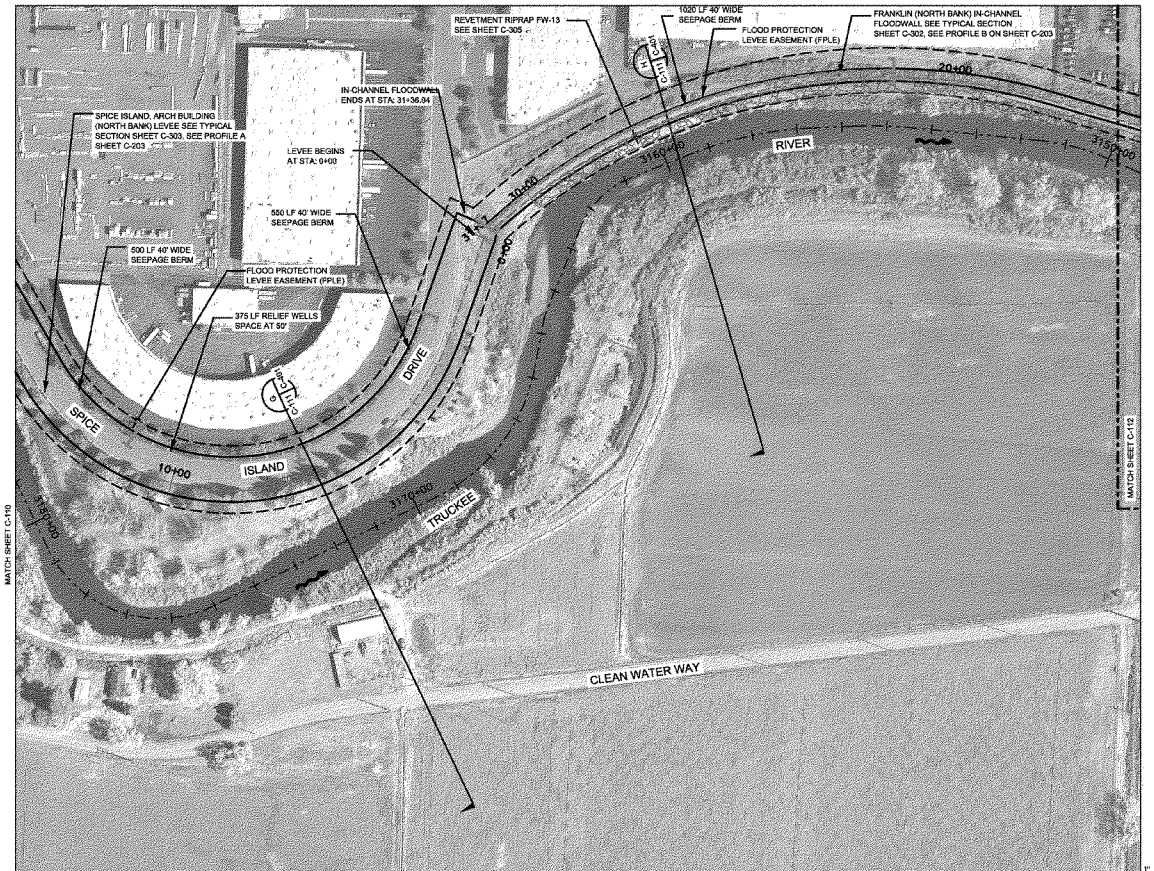
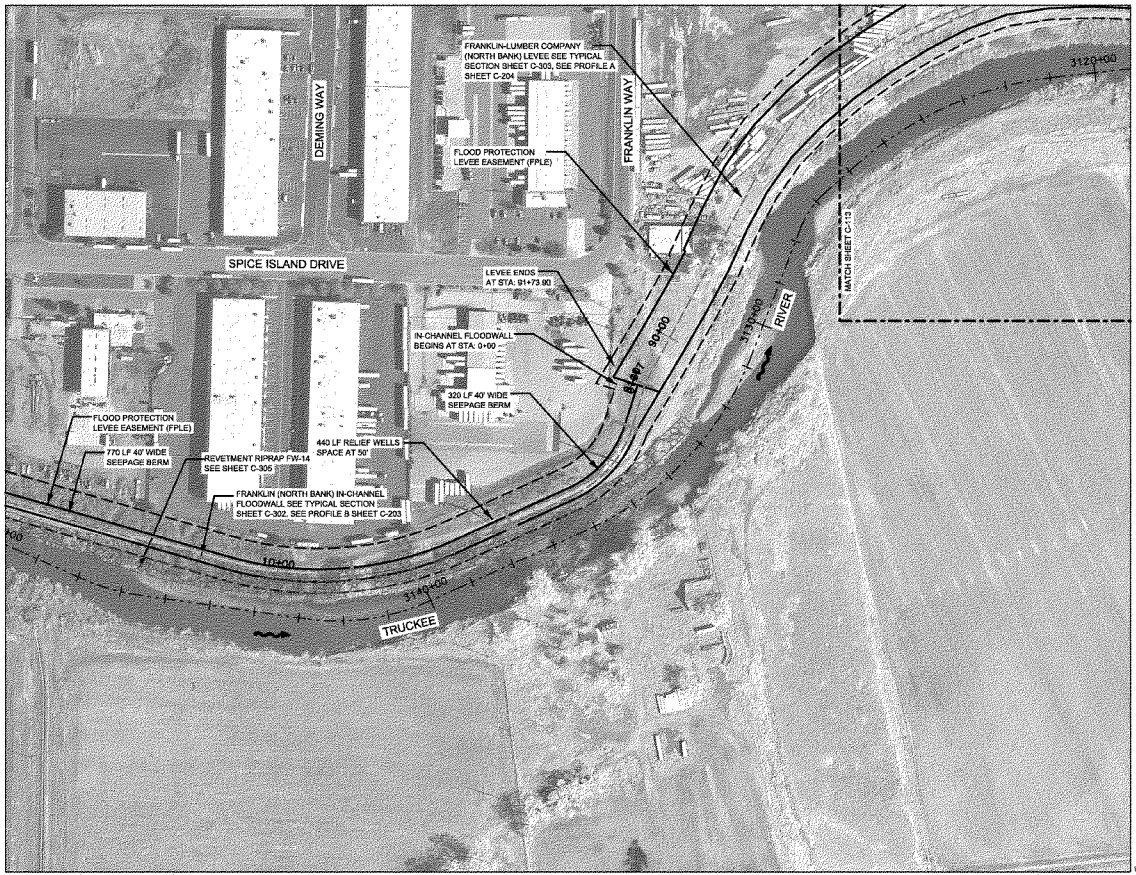

REVETMENT RIPRAP FW-13
SEE SHEET C-305
1020 LF 40' WIDE
SEEPAGE BERM
FLOOD PROTECTION
LEVEE EASEMENT (FPLE)
FRANKLIN (NORTH BANK) IN-CHANNEL
FLOODWALL SEE TYPICAL SECTION
SHEET C-302, SEE PROFILE B ON SHEET C-203
IN-CHANNEL FLOODWALL
ENDS AT STA: 31+36.04
SPICE ISLAND, ARCH BUILDING
(NORTH BANK) LEVEE SEE TYPICAL
SECTION SHEET C-303, SEE PROFILE A
SHEET C-203
LEVEE BEGINS
AT STA: 9+03
550 LF 40' WIDE
SEEPAGE BERM
500 LF 40' WIDE
SEEPAGE BERM
FLOOD PROTECTION
LEVEE EASEMENT (FPLE)
375 LF RELIEF WELLS
SPACE AT 50'
SPICE
ISLAND
DRIVE
TRUCKEE
RIVER
CLEAN WATER WAY
MATCH SHEET C-110
MATCH SHEET C-112
LEGEND
ACCESS ROAD
TEMPORARY WORK EASEMENT
ON-BANK FLOODWALL
IN-CHANNEL FLOODWALL
LEVEE
FLOOD PROTECTION LEVEE EASEMENT (FPLE)
RE-ALIGN PIONEER DITCH
FLOODPLAIN TERRACING
EXISTING PIONEER DITCH
SEEPAGE FEATURE
REVETMENT RIPRAP
BRIDGE SCOUR PROTECTION
GRAPHIC SCALE
US Army Corps of Engineers
Sacramento District
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CA 95814-2922
PLAN
TRUCKEE MEADOWS
Sheet reference number:
C-111
Sheet 17 of 47
PLOT DATE: 13-MAY-2013
PLOT TIME: 08:42


FRANKLIN-LUMBER COMPANY (NORTH BANK) LEVEE SEE TYPICAL SECTION SHEET C-303, SEE PROFILE A SHEET C-204
FLOOD PROTECTION LEVEE EASEMENT (FPLE)
DEMING WAY
FRANKLIN WAY
SPICE ISLAND DRIVE
LEVEE ENDS AT STA: 91+73.90
IN-CHANNEL FLOODWALL BEGINS AT STA: 0+00
320 LF 40' WIDE SEEPAGE BERM
440 LF RELIEF WELLS SPACE AT 50'
FLOOD PROTECTION LEVEE EASEMENT (FPLE)
770 LF 40' WIDE SEEPAGE BERM
REVETMENT RIPRAP FW-14 SEE SHEET C-305
FRANKLIN (NORTH BANK) IN-CHANNEL FLOODWALL SEE TYPICAL SECTION SHEET C-302, SEE PROFILE B SHEET C-203
TRUCKEE
RIVER
MATCH SHEET C-111
MATCH SHEET C-113
3120+00
3130+00
3140+00
10+00
80+00
LEGEND
ACCESS ROAD
TEMPORARY WORK EASEMENT
ON-BANK FLOODWALL
IN-CHANNEL FLOODWALL
LEVEE
FLOOD PROTECTION LEVEE EASEMENT (FPLE)
RE-ALIGN PIONEER DITCH
FLOODPLAIN TERRACING
EXISTING PIONEER DITCH
SEEPAGE FEATURE
REVETMENT RIPRAP
BRIDGE SCOUR PROTECTION
N
GRAPHIC SCALE
0' 50' 100' 200' 300'
1" = 100'
US Army Corps of Engineers Sacramento District
DEPARTMENT OF THE ARMY CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT 1325 J STREET SACRAMENTO, CA 95814-2922
NEVADA
PLACER & STOREY COUNTIES TRUCKEE MEADOWS FLOOD CONTROL PROJECT
ALTERNATIVE 3 FLOODPLAIN TERRACE PLAN
PLAN
TRUCKEE MEADOWS
Sheet reference number:
C-112
Sheet 18 of 47
MATCH SHEET C-111
PLOT DATE: 13-MAY-2013
PLOT TIME: 08:43
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US Army Corps of Engineers
Sacramento District

Symbol	Date	Description

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Drawn by: CM
Checked by: LR
Scale: 1" = 100'
Date: 11/13
Date: Feb-Apr 2013 as noted
Drawing code: 2
Approved by: Tom Gunkel
Date: 11/13
File name: Plan sheet
Project name: Truckee Meadows
Signature: Tom Gunkel
Date: 11/13

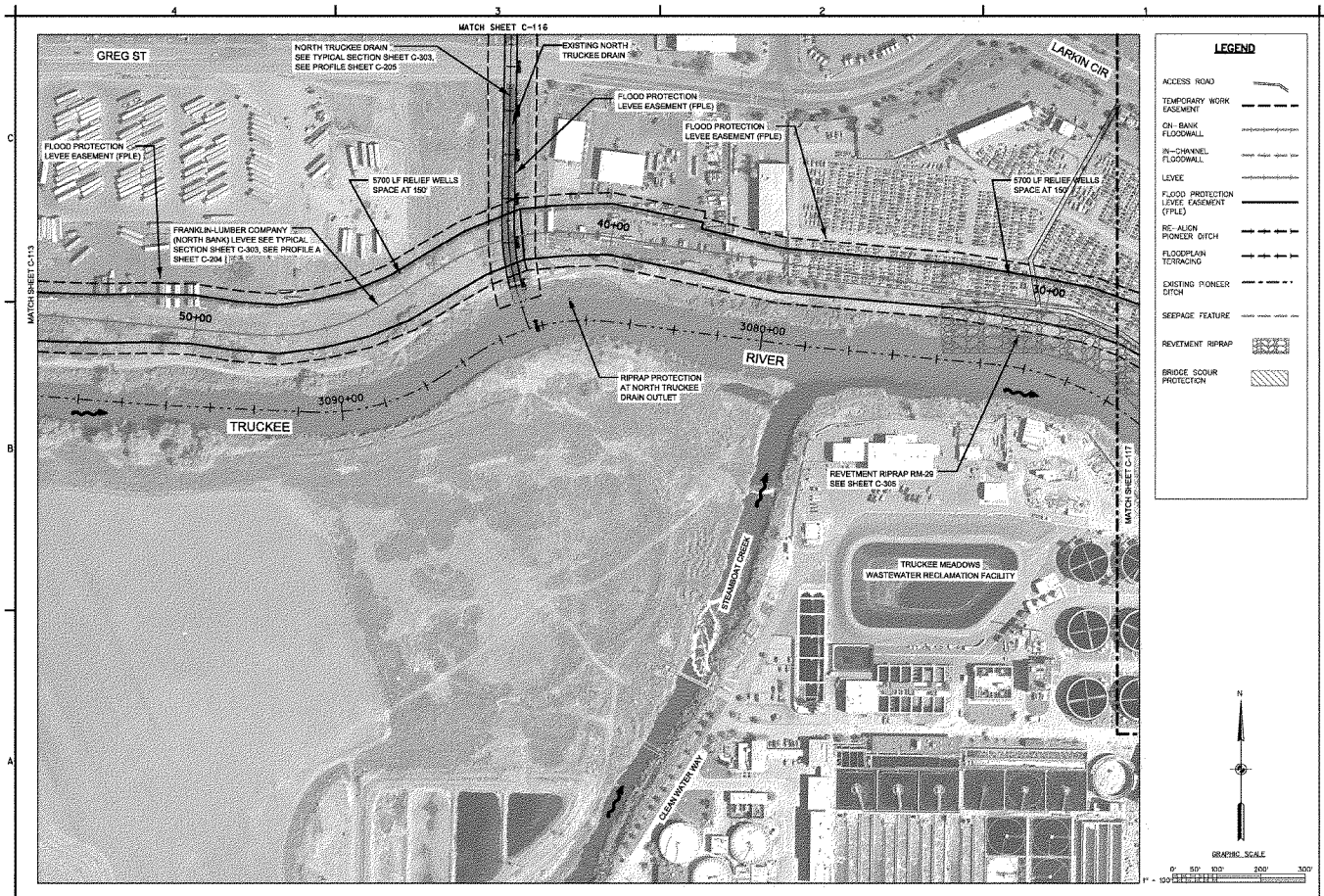
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CA 95814-2922

WASHOE & STOREY COUNTIES NEVADA
TRUCKEE MEADOWS
FLOOD CONTROL PROJECT
ALTERNATIVE 3 FLOODPLAIN TERRACE PLAN
PLAN
TRUCKEE MEADOWS

Sheet reference number:
C-113
Sheet 19 of 47

8.5.1 | PLOT DATE: 13-MAY-2013 | PLOT TIME: 08:44 | \\amethyst\truckee\Grr_els\CADD\Civil\B00_plan_set_2010-10\Draft_Report_Eng_Plans-02-2013\C-113-Civil Plan.dgn



US Army Corps of Engineers
Sacramento District

Symb	Description	Date Approved
A		

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Drawn by: LB
Checked by: LB
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Date: 1/2/13
Date Sign: 1/2/13
Date Plot: 1/2/13
Drawing Code: 01
Reviewed by: Tom Rickey
Reviewed by: Jim Boone
File name: FLOP Boone
Plot scale: 1=100
Plot date: Mar 13, 2013

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CA 95814-2922

WASHOE & STOREY COUNTIES
TRUCKEE MEADOWS
FLOOD CONTROL PROJECT
ALTERNATIVE 3 FLOODPLAIN TERRACE PLAN

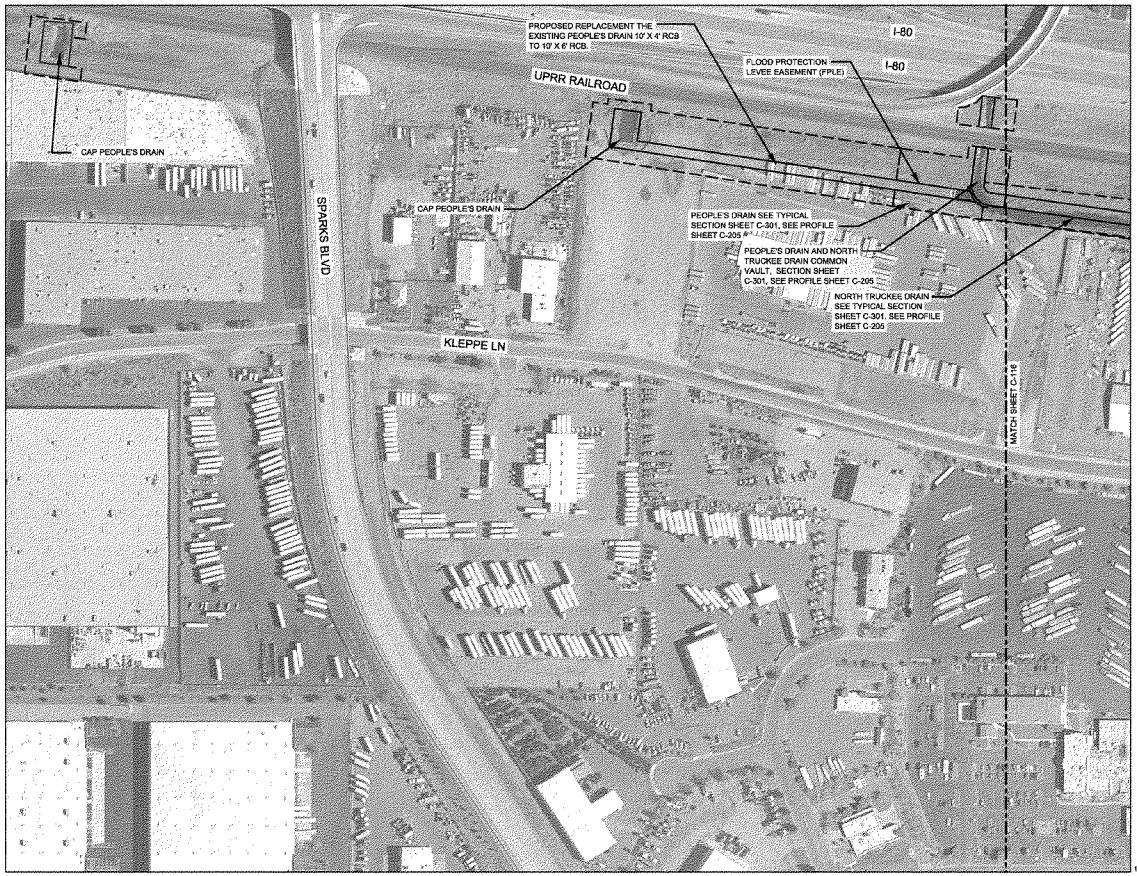
NEVADA

PLAN
TRUCKEE MEADOWS

Sheet reference number:
C-114
Sheet 20 of 47

963

8.X1 | PLOT DATE: 13-MAY-2013 | PLOT TIME: 08:45 | \\amethyst\truckee\Grr_els\CADD\Civil\B00_plan_set_2010-10\Draft_Report_Eng_Plans-02-2013\C-114-Civil Plan.dgn



US Army Corps of Engineers
Sacramento District

Date	Description

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
SACRAMENTO, CALIFORNIA

Designed by: LR
Drawn by: LR
Checked by: JAM
Reviewed by: Tom Kimball
Approved by: Tom Kimball
Date: Nov 2013
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Drawing code: DRAFTING CODE
File name: FILE NAME
Project Manager: Tom Kimball
Plot date: 13-MAY-2013
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SACRAMENTO DISTRICT
1325 J STREET
ROOM 1350
SACRAMENTO, CA 95814-2922

WASHOE & STOREY COUNTIES NEVADA
TRUCKEE MEADOWS
FLOOD CONTROL PROJECT
ALTERNATIVE 3 FLOODPLAIN TERRACE PLAN
PLAN
TRUCKEE MEADOWS

Sheet reference number:
C-115
Sheet 21 of 47

LEGEND

- ACCESS ROAD
- TEMPORARY WORK EASEMENT
- ON-BANK FLOODWALL
- IN-CHANNEL FLOODWALL
- LEVEE
- FLOOD PROTECTION LEVEE EASEMENT (FPLE)
- RE-ALIGN PIONEER DITCH
- FLOODPLAIN TERRACING
- EXISTING PIONEER DITCH
- SEEPAGE FEATURE
- REVETMENT RIPRAP
- BRIDGE SCOUR PROTECTION

US Army Corps of Engineers
Sacramento District

Symbol	Description	Date
A		
B		
C		
D		
E		
F		
G		

Designed by: LM
Date: 5/21
Drawn by: LM
Date: 5/21
Checked by: LM
Date: 5/21
Reviewed by: TJM
Date: 5/21
Approved by: TJM
Date: 5/21
Scale: 1"=100'
Date: 11-MAY-2011
Drawing No.: C-116
Sheet No.: 22 of 47
Project Manager: TJM
Project Engineer: TJM
File name: P:\08 Alternative 3\Truckee Meadows\C-116.dgn
Plot scale: 1"=100'
Plot date: 11-MAY-2011

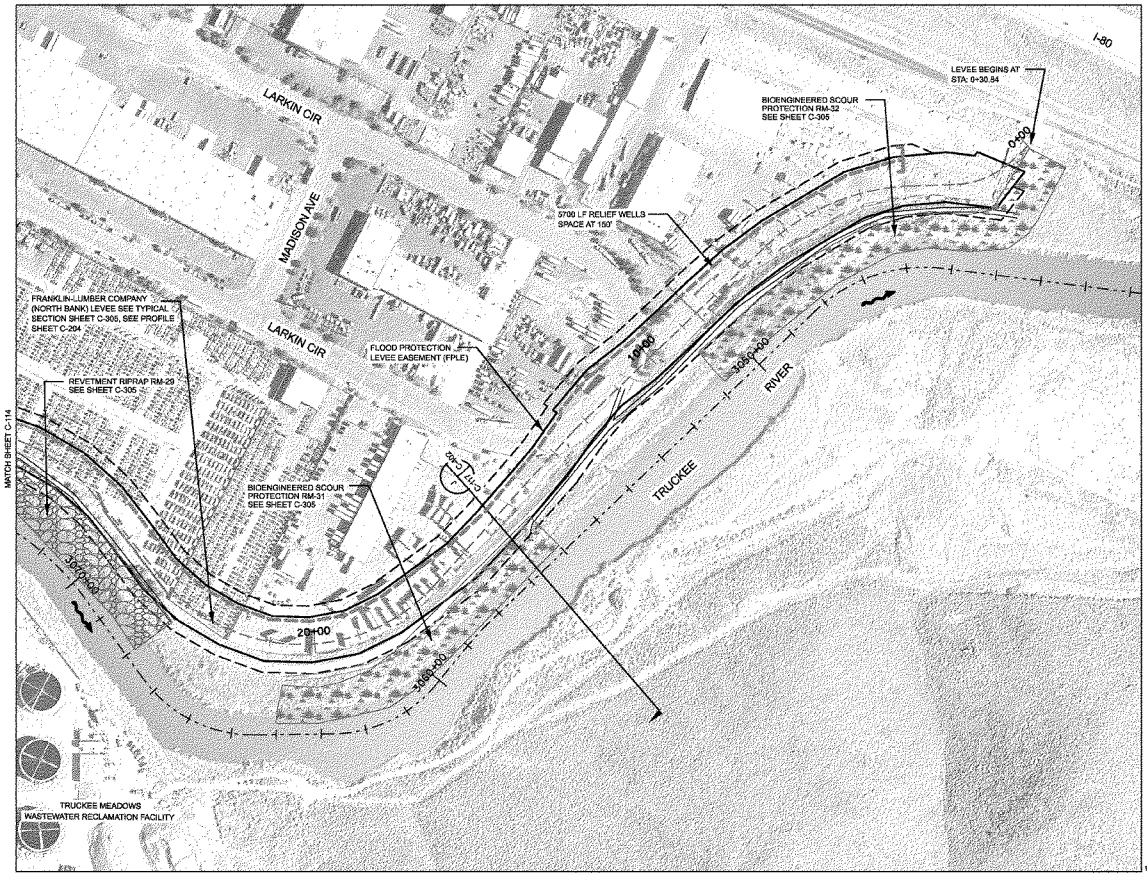
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CA 95814-2922

BARNES & STREET COUNTIES NEVADA
TRUCKEE MEADOWS
FLOOD CONTROL PROJECT
ALTERNATIVE 3 FLOODPLAIN TERRACE PLAN
PLAN
TRUCKEE MEADOWS

Sheet reference number:
C-116
Sheet 22 of 47

PLOT DATE: 13-MAY-2013 PLOT TIME: 08:46 \\amethyst\truckee\Grr_eis\CADD\Civil\BOD_plan_set_2010-10\Draft_Report_Eng_Plans-02-2013\C-116-Civil Plan.dgn



LEGEND

- ACCESS ROAD
- TEMPORARY WORK EASEMENT
- ON-BANK FLOODWALL
- IN-CHANNEL FLOODWALL
- LEVEE
- FLOOD PROTECTION LEVEE EASEMENT (FPLE)
- RE-ALIGN PIONEER DITCH
- FLOODPLAIN TERRACING
- EXISTING PIONEER DITCH
- SEEPAGE FEATURE
- REVETMENT RIPRAP
- BRIDGE SCOUR PROTECTION
- BIOENGINEERED SCOUR PROTECTION

US Army Corps of Engineers
Sacramento District

Mark	Date	Description	Drawn by
A			

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CA 95814-2922

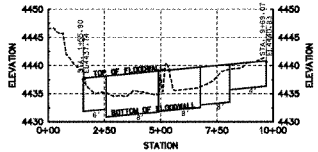
Designed by: LB
Date: 10/1
Scale: 1"=100'
Drawn by: DT/LB
Checked by: CDSM/RG CDSM
Reviewed by: TJM
Date: 10/1
Submitted by: SUBMITTED
Date: 10/1
File name: F:\for demo\C-117.dgn
Date/Time: 10/1 10:27

WASHOE & STOREY COUNTIES NEVADA
TRUCKEE MEADOWS
FLOOD CONTROL PROJECT
ALTERNATIVE 3 FLOODPLAIN TERRACE PLAN

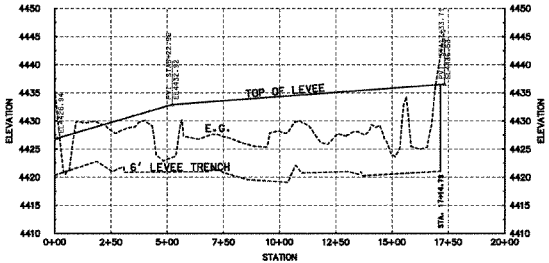
PLAN
TRUCKEE MEADOWS

Sheet reference number:
C-117
Sheet 23 of 47

PLOT DATE: 18-JUL-2013 PLOT TIME: 08:43 \\amethyst\truckee\Drr_eis\CADD\Civil\BOD_plan_set_2010-10\Draft_Report_Eng_Plans-02-2013\C-117-Civil Plan.dgn

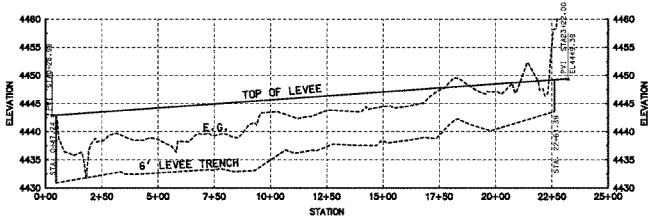


A C-200 GREG-GLENDALE (NORTH BANK) ON-BANK FLOODWALL

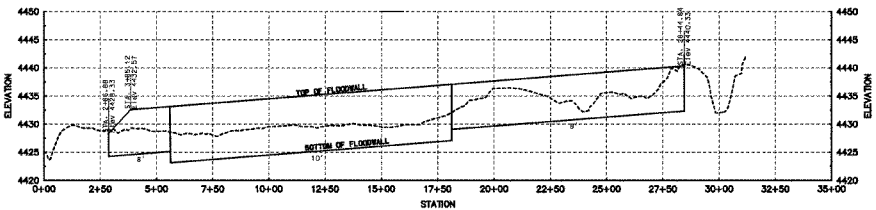


B C-200 GREG-GLENDALE (NORTH BANK) LEVEE

NOTE:
WAL MART LEVEE WAS COSTRUCTED BY OTHER.



C C-200 GLENDALE-HWY 395 (WALMART) LEVEE



D C-200 GREG-GLENDALE (SOUTH BANK) ON-BANK FLOODWALL

US Army Corps of Engineers
Sacramento District

Symbol	Description	Date	Approved

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

Designed by: LJK
Drawn by: LJK
Reviewed by: DRAFT
Submitted by: SUBMITTED
Scale: NONE
Date: 13-MAY-2013
Plot date: 13-MAY-2013
File name: C-200-Civil Plan-Profile.dgn
Plot date: 13-MAY-2013
Plot time: 08:47
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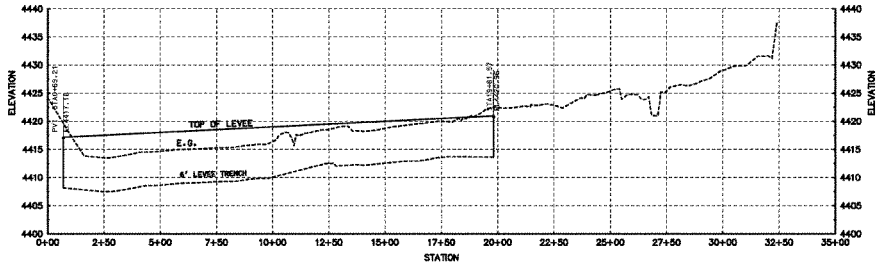
SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CA 95814-2922

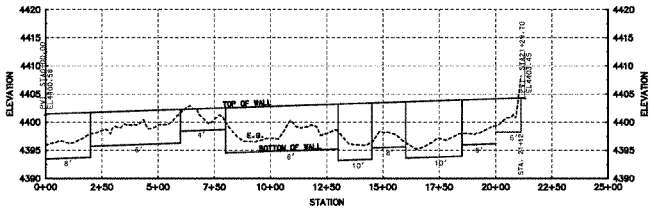
PLACER & STOREY COUNTIES NEVADA
TRUCKEE RIVER WATERSHED
FLOOD CONTROL PROJECT
ALTERNATIVE 3 FLOODPLAIN TERRACE PLAN
PROFILES
TRUCKEE MEADOWS

Sheet reference number:
C-200
Sheet 24 of 47

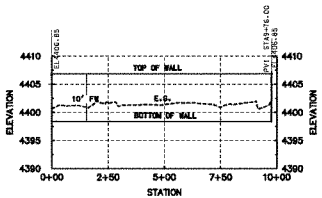
PLOT DATE: 13-MAY-2013 PLOT TIME: 08:47 \\amethyst\truckee\Grr_els\CADD\Civil\BOD_plan_set_2010-10\Draft_Report_Eng_Plans-02-2013\C-200-Civil Plan-Profile.dgn



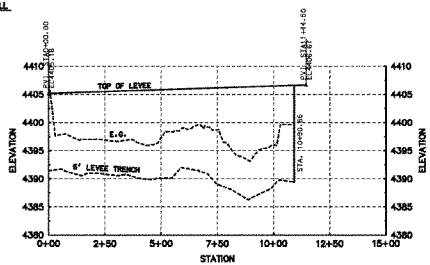
A C-201 ROCK-GREG (SOUTH BANK) LEVEE



B C-201 EAST McCARRAN (NORTH BANK) ON-BANK FLOODWALL



C C-201 McCARRAN-ROCK, WEST McCARRAN (NORTH BANK) ON-BANK FLOODWALL



D C-201 McCARRAN-ROCK, WEST McCARRAN (NORTH BANK) LEVEE

US Army Corps of Engineers
Sacramento District

Symbol	Description	Date

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

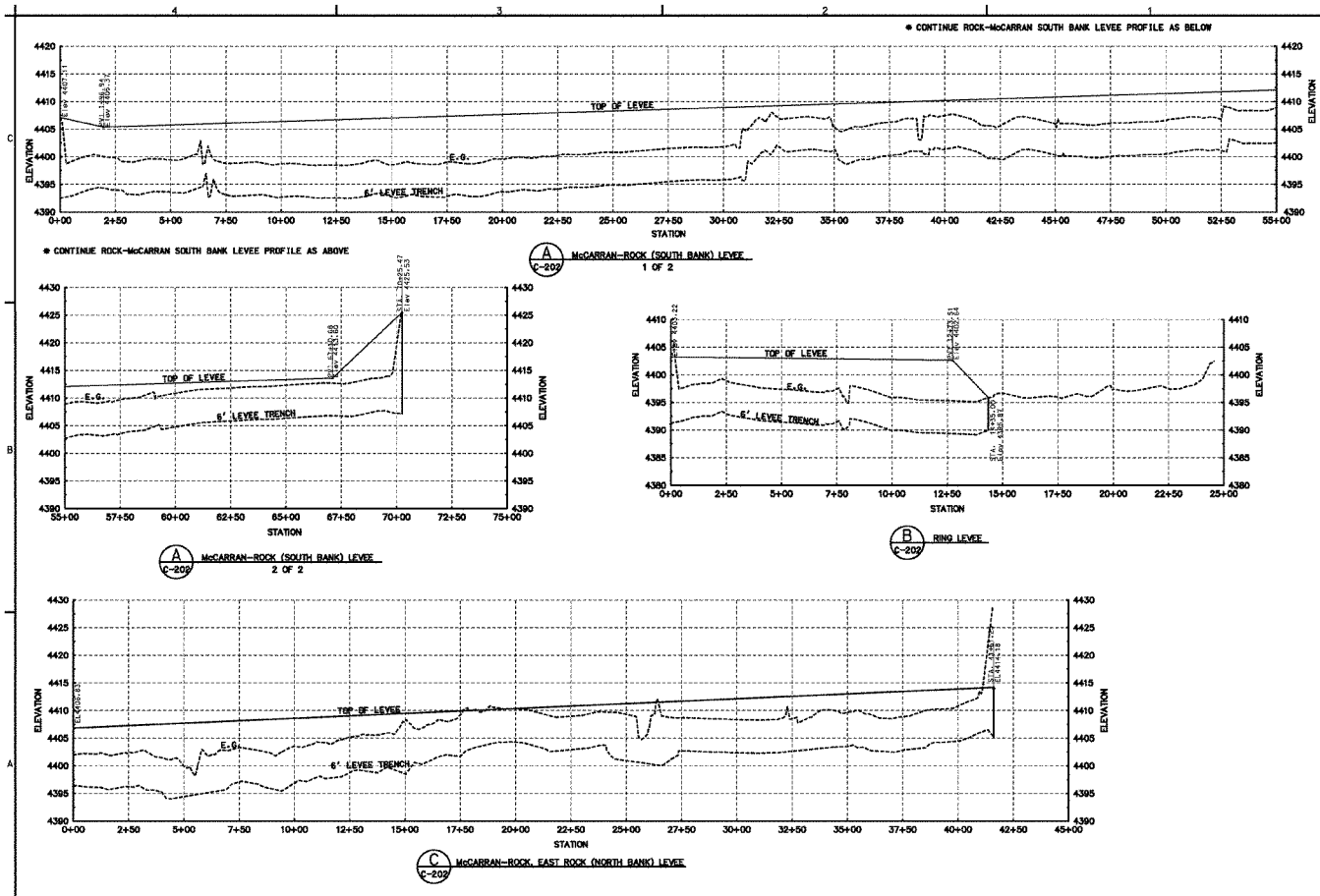
SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CA 95814-2922

Designed by/ SM
Drawn by/ SM
Checked by/ SM
Scale No.: 1
Date/ 1-MAY-2013
Reviewed by/ JAMES WEBB
Reviewed by/ DAVID PAGE
Approved by/ TIMOTHY SUBLETTE
Date/ 01-MAY-2013
File name/ FILE NAME
Plot date/ PLOT DATE
Plot scale/ 1:40 SCALE
Plot size/ 22X34 (D) SHEET

PLACER & STOREY COUNTIES NEVADA
TRUCKEE MEADOWS
FLOOD CONTROL PROJECT
ALTERNATIVE 3 FLOODPLAIN TERRACE PLAN
PROFILES
TRUCKEE MEADOWS

Sheet reference number:
C-201
Sheet 25 of 47

8.11 | PLOT DATE: 13-MAY-2013 PLOT TIME: 06:52 | \\amethyst\truckee\Grr_els\CADD\Civil\BOD_plan_set_2010-10\Draft_Report_Eng_Plans-02-2013\C-201-Civil Plan-Profile.dgn



US Army Corps of Engineers
Sacramento District

Description

Designed by: LW
Drawn by: LW
Reviewed by:
Approved by:
Scale No.: 1"=40' H 1"=10' V
Date: 3/19
Revision date: 07/08/13 CCBM
Revision date:
Revision date:
Date Issued: 3/19
Date Issued:
Date Issued:
FILE NAME: P100 series
FILE NAME: P100 series
SUBMITTING: Sacramento Rock Ski Area

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

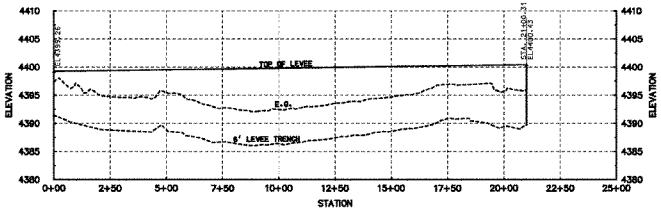
SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CA 95814-2922

NEVADA
MARIPOSA & STANISLAUS COUNTIES
TRUCKEE MEADOWS
FLOOD CONTROL PROJECT
ALTERNATIVE 3 FLOODPLAIN TOURAGE PLAN

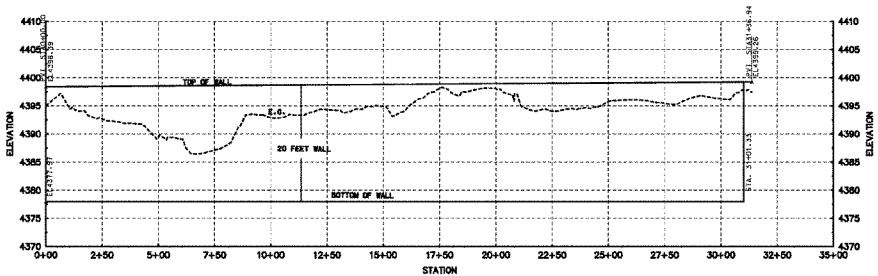
PROFILES
TRUCKEE MEADOWS

Sheet reference number:
C-202
Sheet 26 of 47

PLOT DATE: 13-MAY-2013 PLOT TIME: 06:52 \\amethyst\truckee\Grr_els\CADD\Civil\BOD_plan_set_2010-10\Draft_Report_Eng_Plans-02-2013\C-202-Civil Plan-Profile.dgn



A C-203 SPICE ISLAND, ARCH BUILDING (NORTH BANK) LEVEE



B C-203 FRANKLIN (NORTH BANK) IN-CHANNEL FLOODWALL

US Army Corps of Engineers Sacramento District

DEPARTMENT OF THE ARMY CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT 1325 J STREET SACRAMENTO, CA 95814-2922

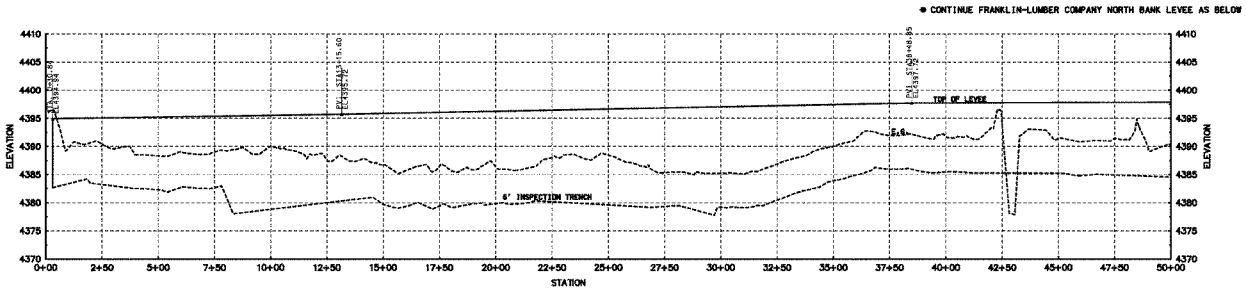
Designed by: LJH
Drawn by: TMH
Checked by: LJH
Reviewed by: TOM HOWARD
Submitted by: FILIP JOVANOVIC
Approved by: FILIP JOVANOVIC
Date: 04-13-2013
Scale: 1"=20'-0"
Date: 04-13-2013
Revisions: Description

NEVADA
WASHOE & STOREY COUNTIES
TRUCKEE MEADOWS
FLOOD CONTROL PROJECT
ALTERNATIVE 3 FLOODPLAIN TERRACE PLAN

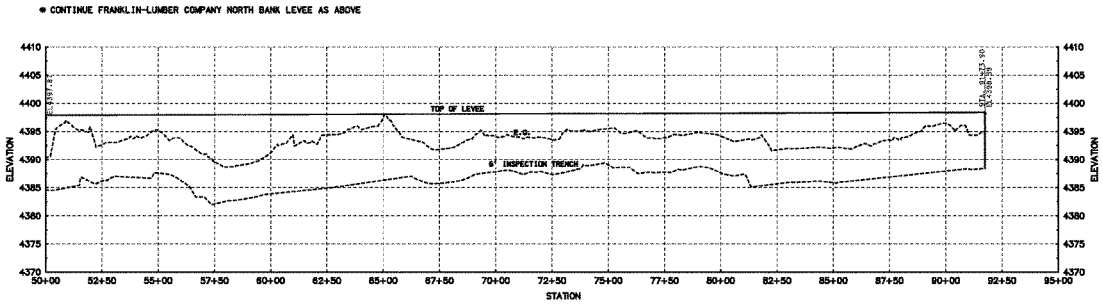
PROFILES
TRUCKEE MEADOWS

Sheet reference number:
C-203
Sheet 26 of 47

8.5:1 | PLOT DATE: 13-MAY-2013 PLOT TIME: 08:52 | \\amethyst\truckee\Grr_els\CADD\Civil\BOD_plan_set_2010-10\Draft_Report_Eng_Plans-02-2013\C-203-Civil Plan-Profile.dgn



A C-204 FRANKLIN LUMBER COMPANY (NORTH BANK) LEVEE
1 OF 2



A C-204 FRANKLIN LUMBER COMPANY (NORTH BANK) LEVEE
2 OF 2

US Army Corps of Engineers
Sacramento District

Date	Description

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CA 95814-2922

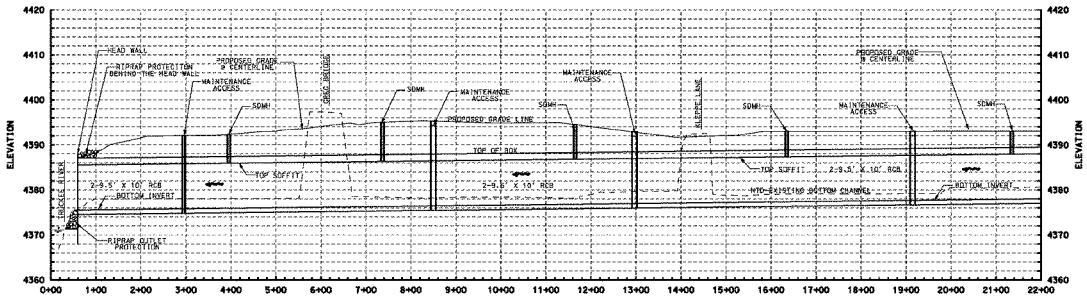
Designed by: LJT
Drawn by: LJT
Checked by: SAM
Scale: 1"=40'
Date: 11-MAY-2013
Reviewed by: SAM
Approved by: SAM
Date: 11-MAY-2013
Plot date: 13-MAY-2013
Plot time: 06:52
File name: C-204 Plan-Profile.dgn
SUBMITTED:
RECOMMENDED:
APPROVED:

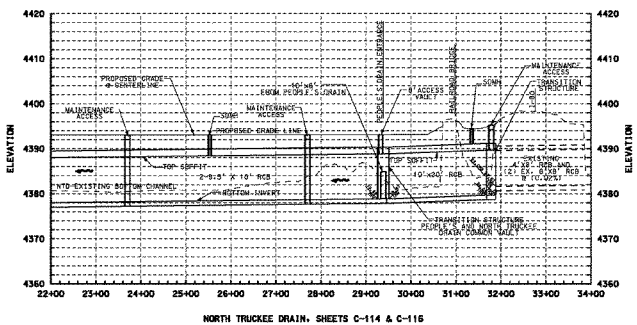
NEVADA
WASHOE & STOREY COUNTIES
TRUCKEE MEADOWS
FLOOD CONTROL PROJECT
ALTERNATIVE 3 FLOODPLAIN TERRACE PLAN

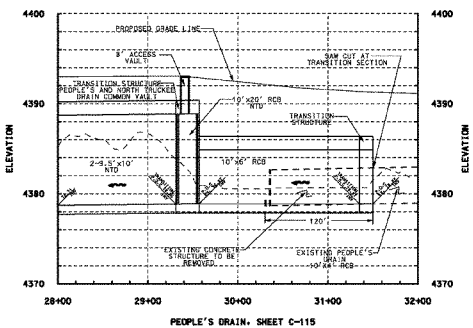
PROFILES
TRUCKEE MEADOWS

Sheet reference number:
C-204
Sheet 26 of 47

8.11 | PLOT DATE: 13-MAY-2013 PLOT TIME: 06:52 | \\amethyst\truckee\Grr_els\CADD\Civil\BOD_plan_set_2010-10\Draft_Report_Eng_Plans-02-2013\C-204-Civil Plan-Profile.dgn







US Army Corps of Engineers
Sacramento District

Date	Description

Designed by: LM
Drawn by: LM
Scale: N/A
Date: 11/08
Reviewed by: [illegible]
Approved by: [illegible]
Date Approved: [illegible]
Horiz: Height: 11 in not 22 in full size
Vert: Scale: 1:1
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Plot scale: [illegible]
Plot time: [illegible]
Signature: [illegible]

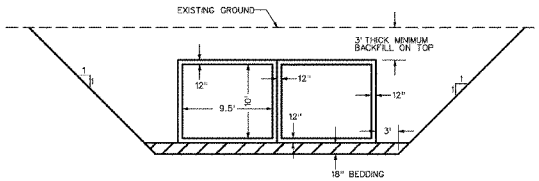
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CA 95814-2922

NEVADA
MARKLE & STONEY COUNTIES
TRUCKEE RIVER
FLOOD CONTROL PROJECT
ALTERNATIVE 3 FLOODPLAIN TERRACE PLAN

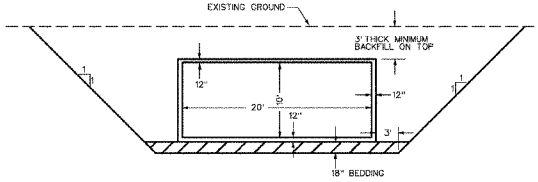
PROFILES
NORTH TRUCKEE DRAIN

Sheet reference number:
C-205
Sheet 29 of 47



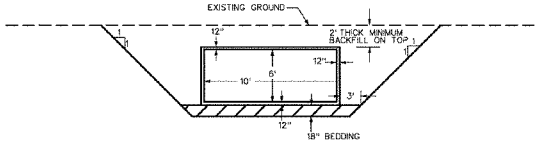
TYPICAL SECTION FOR NORTH TRUCKEE DRAIN REALIGNMENT (A / C-301)

NOT TO SCALE



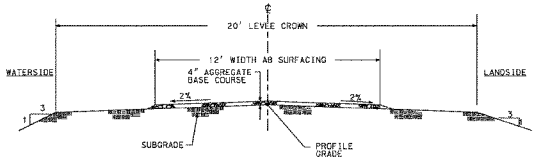
TYPICAL SECTION FOR NORTH TRUCKEE DRAIN AT I-80 AND RAILROAD REALIGNMENT (B / C-301)

NOT TO SCALE



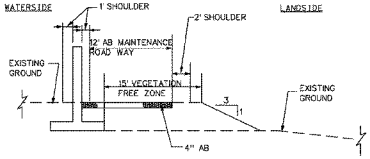
TYPICAL SECTION FOR PEOPLE'S DRAIN REALIGNMENT (C / C-301)

NOT TO SCALE



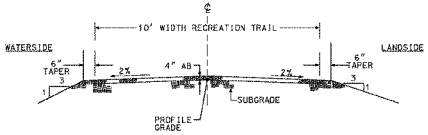
MAINTENANCE ROAD CREST DETAIL (D / C-301)

NOT TO SCALE



FLOODWALL WITH MAINTENANCE ROAD TYPICAL SECTION (E / C-301)

NOT TO SCALE



RECREATION TRAIL TYPICAL SECTION (F / C-301)

NOT TO SCALE

US Army Corps of Engineers
Sacramento District

Symbol	Description	Date

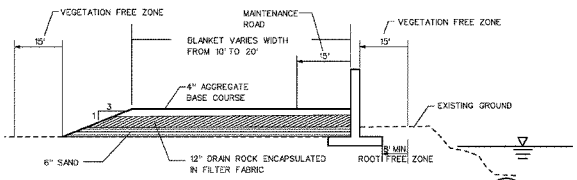
Designed (y) LM
Drawn (y) LM
Scale No.: 1
Date: 1/8
Reviewed (y) DAN
Reviewed (y) TOM STRAND
Approved (y) SUSAN LAURINE
Chief, Engineering Division (y) MICHAEL SMITH
Chief, Design Branch (y) JEFFREY MORRISON
Chief, Plan Formulation Section (y) MARK SCHOLZ

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CA 95814-2922

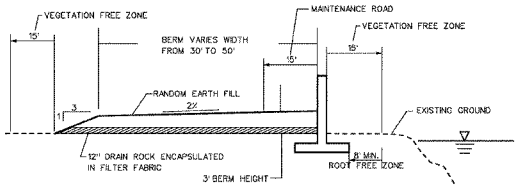
NEVADA
MARIPOSA & STANISLAUS COUNTIES
CALIFORNIA
FLOOD CONTROL PROJECT
ALTERNATIVE 3 FLOODPLAIN TERRACE PLAN
MISCELLANEOUS
TYPICAL SECTIONS

Sheet reference number:
C-301
Sheet 30 of 47



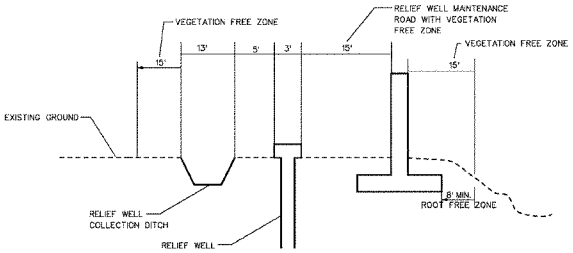
TYPICAL DRAINAGE BLANKET SECTION WITH ON-BANK FLOODWALL (A / C-302)

NOT TO SCALE



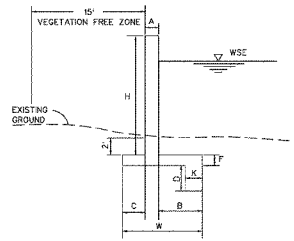
TYPICAL SEEPAGE BERM SECTION WITH ON-BANK FLOODWALL (B / C-302)

NOT TO SCALE



TYPICAL SECTION FOR RELIEF WELL WITH ON-BANK FLOODWALL (C / C-302)

NOT TO SCALE

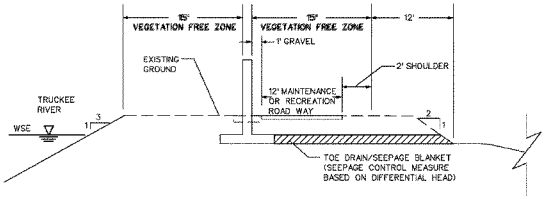


ON-BANK FLOODWALL DIMENSION TABLE

Wall H	Dimensions(Feet)						
	A	W	B	C	F	K	D
4	1.00	4.00	1.67	1.33	1.00	0.00	0.00
6	1.00	7.00	3.67	2.33	1.00	0.00	0.00
8	1.25	11.0	6.25	3.50	1.25	0.00	0.00
10	1.50	12.0	6.50	4.00	1.15	1.20	2.50
12	2.00	14.5	7.75	4.75	1.50	1.50	3.50
14	2.00	17.0	9.25	5.75	1.50	1.30	4.00

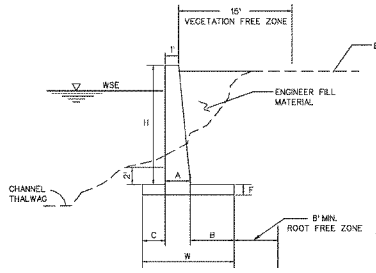
ON-BANK FLOODWALL STRUCTURAL DESIGN (D / C-302)

NOT TO SCALE



FLOODWALL WITH MAINTENANCE ROAD TYPICAL SECTION

NOT TO SCALE



FLOODWALL DIMENSION TABLE

Wall H	Dimensions(Feet)				
	A	W	C	B	F
10	1.00	10.00	2.00	7.00	1.00
12	1.25	12.00	2.375	8.375	1.25
14	1.50	14.00	2.75	9.75	1.50
16	1.75	16.00	3.125	11.125	1.75
18	2.00	18.00	3.50	12.5	2.00
20	2.25	20.00	3.75	14.0	2.25
22	2.50	22.00	4.50	15.0	2.50
24	2.75	24.00	5.25	16.0	2.75
26	3.00	26.00	5.25	17.75	3.00
28	3.25	28.00	5.75	19.0	3.25
30	3.50	32.00	6.50	22.0	3.50

IN-CHANNEL FLOODWALL WITH TOE DRAIN STRUCTURAL DESIGN (F / C-302)

NOT TO SCALE

US Army Corps of Engineers
Sacramento District

Symbol	Date	Description
A		

Designed by: Lt
Drawn by: Lt
Scale No.: 1
Reviewed by: Brown
Date: 1/15
Reviewed by: Brown
Date: 1/15
Submitted by: Brown
Date: 1/15
Date: 1/15

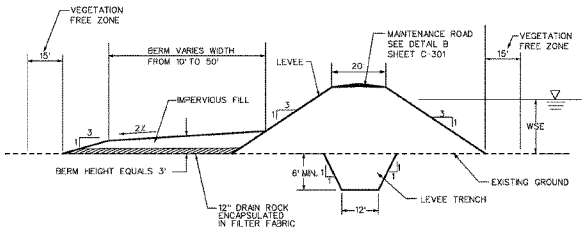
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CA 95814-2922

Contract No. W912EF-11-B-0033
Contract No. W912EF-11-B-0033

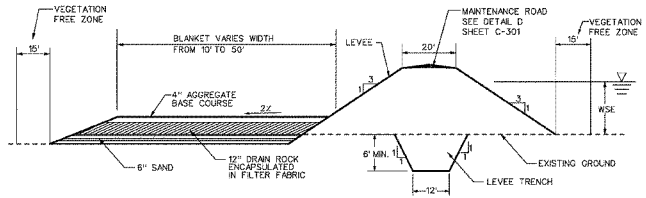
NEVADA
PLACER & STANISLAUS COUNTIES
FLOOD CONTROL PROJECT
ALTERNATIVE 5 FLOODPLAIN TERRACE PLAN
FLOODWALL
TYPICAL SECTIONS

Sheet reference number:
C-302
Sheet 31 of 47



TYPICAL SEEPAGE BERM SECTION WITH LEVEE (F / C-303)

NOT TO SCALE



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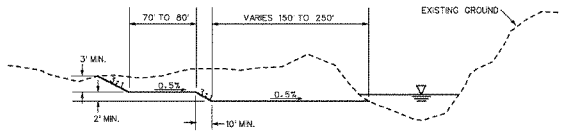
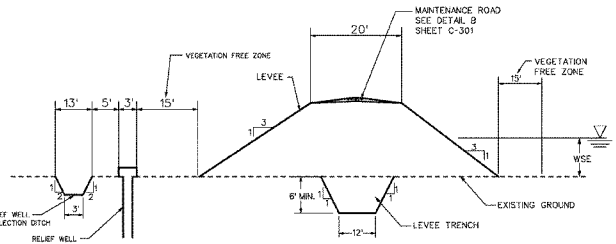
NOT TO SCALE



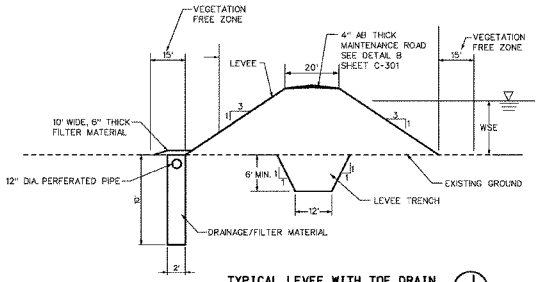
TYPICAL FLOODPLAIN TERRACING WITH HIGH AND LOW BENCHES (I / C-303)

NOT TO SCALE



TYPICAL SECTION FOR RELIEF WELL WITH LEVEE (G / C-303)

NOT TO SCALE



TYPICAL LEVEE WITH TOE DRAIN (J / C-303)

NOT TO SCALE

US Army Corps of Engineers
Sacramento District

Date	Description

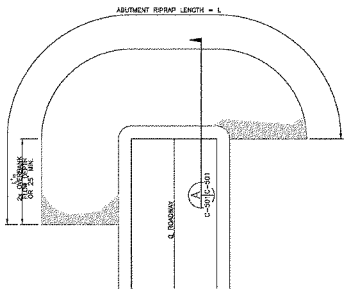
Designed by: LM
Drawn by: SAP
Reviewed by: Reviewed by
Submitted by: Tom Grimes
Date: 04/01/13
Scale: 1"=10'
Date: 04/01/13
Scale: 1"=10'
Revision No. 1/6
Revision Date: 02/07/13
Revision Date: 02/07/13
Revision Date: 02/07/13
Revision Date: 02/07/13
Revision Date: 02/07/13
Revision Date: 02/07/13

DEPARTMENT OF THE ARMY
US ARMY CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CA 95814-2922

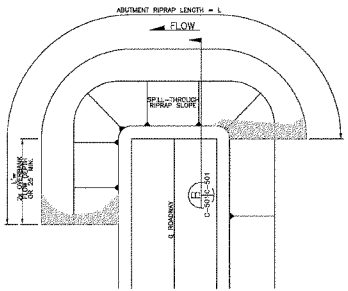
NEVADA
WASHOE & STOREY COUNTIES
TRUCKEE RIVER
FLOOD CONTROL PROJECT
ALTERNATIVE 3 FLOODPLAIN TERRACE PLAN
LEVEE
TYPICAL SECTIONS

Sheet reference number:
C-303
Sheet 32 of 47



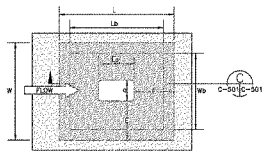
PLAN

RIPRAP AT VERTICAL WALL ABUTMENT (DOWNTOWN RENO TO TRUCKEE MEADOWS ONLY) 1 C-501 C-501



PLAN

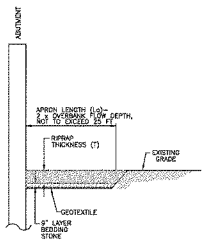
RIPRAP SPILL-THROUGH SLOPE AND APRON DETAIL 2 C-501 C-501



PLAN

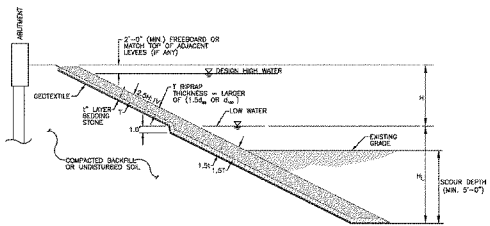
RIPRAP AT PIERS 3 C-501 C-501

NOTES:
1. PIER WIDTH = "a" (NORMAL TO FLOW).
2. RIPRAP EXTENT = 2x TOTAL SCOUR DEPTH, MIN (2a).



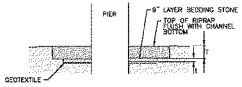
SECTION A C-501 C-501

NOTES:
1. TOP OF APRON SHALL BE FLUSH WITH EXISTING GRADE.
2. INCREASE RIPRAP THICKNESS BY 50% FOR PLACEMENT UNDER WATER.



SECTION B C-501 C-501

NOTES:
1. MINIMUM RIPRAP THICKNESS T=3dw. DEPTH OF CONTRACTION SCOUR PLUS LONG TERM DEGRADATION OR DEPTH OF BED FORM TROUGH (0.2x DEPTH OF FLOW), WHICHEVER IS GREATER.
2. IN THE EXTERIOR, 3/2 THAT OF RIPRAP (ALL AROUND).
3. INCREASE RIPRAP THICKNESS BY 50% FOR PLACEMENT UNDER WATER.



SECTION C C-501 C-501

US Army Corps of Engineers Sacramento District

Symbol	Description	Date Approved

Designed by: LM
Drawn by: LM
Reviewed by: Stephen Cobb
Reviewed by: Tom Gibbons
Project Manager by: Ed Bergmann
Scale: 1=40-0; F1 to not 1=40-0; F2 to 1=20
Date: 3/15
Sheet No.: 33 of 47

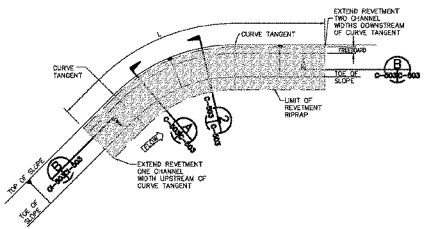
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CA 95814-2922

DESIGN
CONSTRUCTION
SUPPORT
SURVEYING
REAL ESTATE

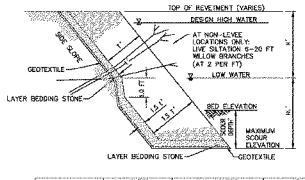
WASHOE & STOREY COUNTIES
NEVADA
TRUCKEE MEADOWS
FLOOD CONTROL PROJECT
ALTERNATIVE 3 FLOODPLAIN TOURAGE PLAN
DETAILS
SCOUR PROTECTION DETAILS

Sheet reference number:
C-304
Sheet 33 of 47



PLAN

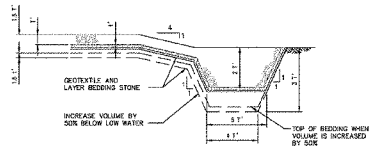
REVETMENT RIPRAP 1 C-503C-503
NTS



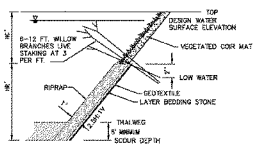
	LEVEES	NON-LEVEES	OTHER
TOP OF REVETMENT	TO TOP OF LEVEE	2 FT ABOVE HIGH WATER	TO ELEV. OF FACILITY
SIDE SLOPE	3H:1V	2.5H:1V	2.5H:1V

	ABOVE LOW WATER	BELOW LOW WATER
RIPRAP THICKNESS T		1.5 T
LAYER BEDDING STONE	t = 6 IN.	1.5 t = 9 IN.

SECTION A C-503C-503
NTS



SECTION B C-503C-503
NTS



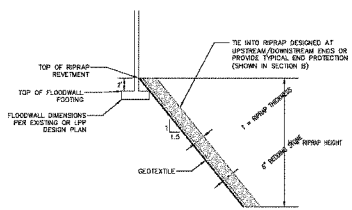
(DOWNTOWN RENO TO TRUCKEE MEADOWS)

SITE NAME	USACE RIPRAP CLASS	UPSTREAM HEC-RAS XS	DOWNSTREAM HEC-RAS XS	H_a	H_c	RIPRAP THICKNESS T	BEDDING STONE THICKNESS t	MAX SCOUR DEPTH	REVETMENT EXTENT LENGTH L
				(ft)	(ft)	(ft)	(ft)	(ft)	(ft)
RM-31	1	11233.97	10411.34	17.7	9.4	1.1	0.9	10.1	749
RM-32	1	9901.985	8388.34	51.6	9.6	1.1	0.9	14.6	941

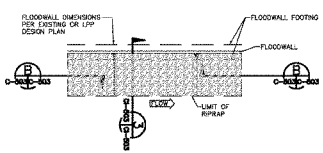
(VISTA TO PYRAMID LAKE)

SITE NAME	USACE RIPRAP CLASS	UPSTREAM HEC-RAS XS	DOWNSTREAM HEC-RAS XS	H_a	H_c	RIPRAP THICKNESS T	BEDDING STONE THICKNESS t	MAX SCOUR DEPTH	REVETMENT EXTENT LENGTH L
				(ft)	(ft)	(ft)	(ft)	(ft)	(ft)
RL-09	1	135768.3	134385.3	16.9	16.8	0.75	0.75	8.7	882
RL-61	2	134285.3	133839.3	23.6	19.6	1.00	0.75	11.9	364
RL-64	2	28358	26219.84	28.8	16.8	0.90	0.75	16.2	1330

BIOENGINEERING SITES 2 C-503C-503
NTS



IN-CHANNEL FLOODWALL PROTECTION SECTION 3 C-503C-503
NTS



IN-CHANNEL FLOODWALL PROTECTION PLAN 4 C-503C-503
NTS

US Army Corps of Engineers Sacramento District

Symbol	Description	Date Approved

DEPARTMENT OF THE ARMY 1325 J STREET SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT 1325 J STREET ROOM 1480 SACRAMENTO, CA 95814-2922

Designed by: LM
Dwn by: LM
Scale: NONE
Date: 1/29/13
Reviewed by: DAVID HOLLOWAY
Submitted by: TIMOTHY SYLVESTER
Approved by: FILIN HAMM / PAUL BERRY
Date: 1/29/13
SUBMITTED: SYLVESTER
APPROVED: HAMM / BERRY

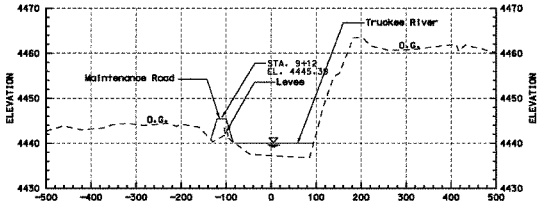
WASHOE & STOREY COUNTIES NEVADA
FLOOD CONTROL PROJECT
ALTERNATIVE 3 FLOODPLAIN TERRACE PLAN
DETAILS-2
SCOUR PROTECTION DETAILS

Sheet reference number:
C-305
Sheet 34 of 47

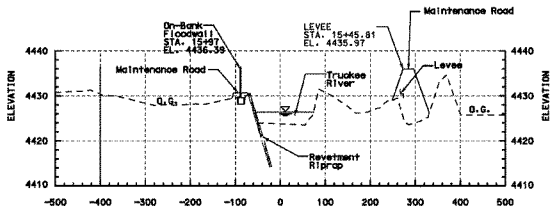
977

NOTE:

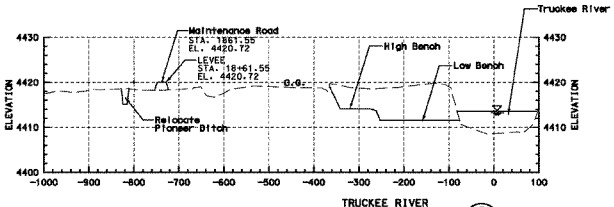
WALMART LEVEE WAS CONSTRUCTED BY OTHERS.



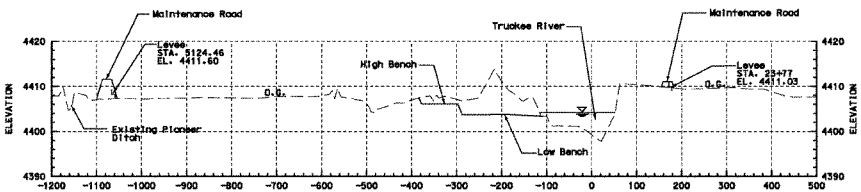
TRUCKEE RIVER
GLENDALE - HWY 395 (WAL MART) LEVEE
RIVER STA: 3346+70 C-101 A C-400



TRUCKEE RIVER
GREG - GLENDALE FLOODWALL & LEVEE
RIVER STA: 3321+65 C-102 B C-400



TRUCKEE RIVER
ROCK - GREG LEVEE
RIVER STA: 3292+50 C-103 C C-400



TRUCKEE RIVER
McCARRAN - ROCK, EAST ROCK LEVEE
AND ROCK - McCARRAN LEVEE
RIVER STA: 3256+70 C-106 D C-400

US Army Corps of Engineers
Sacramento District

Mark	Date	Description	Drawn	Chkd
A				
B				
C				
D				
E				

Date Approved

Designed by: LJK
Dwn by: LJK
Ckd by: LJK
Scale: NONE
Date: Nov 2013
Reviewed by: DPOM/PQ CODEI
Reviewed by: Team Members
Submitted by: FILE NAME
FILE NAME
SIGNATURE
Submitted for Approval: SIGNATURE
Recommended for Approval: SIGNATURE

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

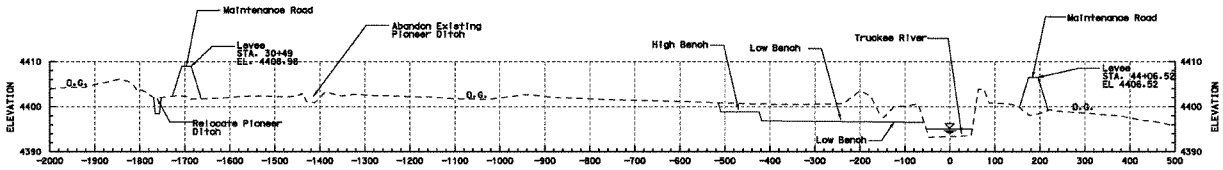
SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CA 95814-2922

NEVADA

WASHOE & STOREY COUNTIES
TRUCKEE MEADOWS
FLOOD CONTROL PROJECT
ALTERNATIVE 3 FLOODPLAIN TERRACE PLAN

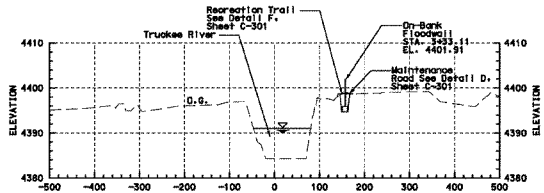
CROSS SECTIONS
TRUCKEE MEADOWS

Sheet reference number:
C-400
Sheet 35 of 47



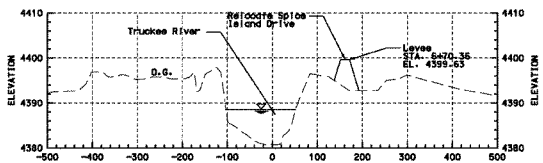
TRUCKEE RIVER
WEST McCARRAN LEVEE,
McCARRAN BY PASS, AND
McCARRAN - ROCK LEVEE

RIVER STA: 3221+75 (E) C-107 | C-401



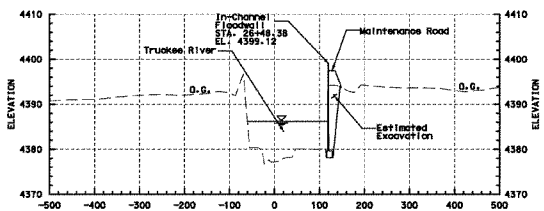
TRUCKEE RIVER
EAST McCARRAN ON - BANK FLOODWALL

RIVER STA: 3191+75 (F) C-110 | C-401



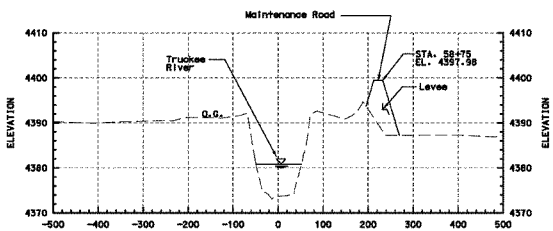
TRUCKEE RIVER
SPICE ISLAND LEVEE

RIVER STA: 3171+70 (G) C-111 | C-401



TRUCKEE RIVER
FRANKLIN IN-CHANNEL FLOODWALL

RIVER STA: 3159+70 (H) C-111 | C-401



TRUCKEE RIVER
FRANKLIN-LUMBER LEVEE

RIVER STA: 3101+75 (I) C-113 | C-401

US Army Corps of Engineers
Sacramento District

Symbol	Description	Date
A		

Designed by: LEF
Drawn by: SAM
Reviewed by: TJR
Scale: 1:20
Date: 1/29/13
Revision: Initial - File not plotted
Detailing CODE:
Reviewed by:
Submitted by:
File name: FINAL SHEET
Plot date: 13-MAY-2013
SUBMITTED: RECOMMENDED: APPROVED:

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CA 95814-2922

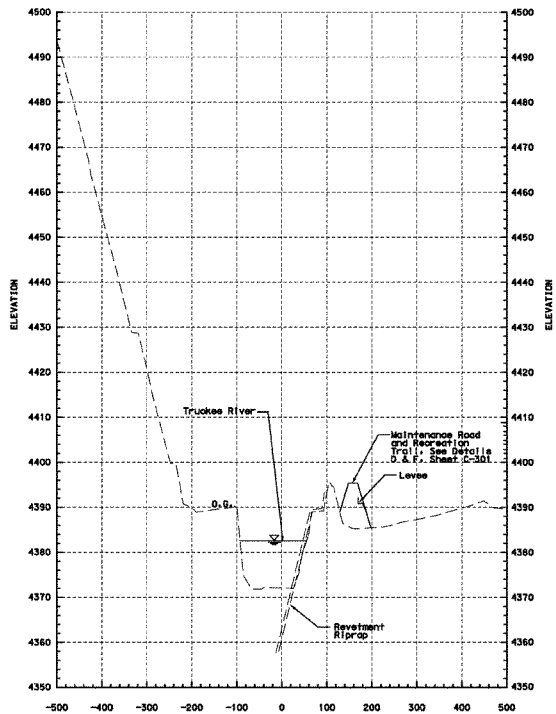
MARIN & SONOMA COUNTIES
TRUCKEE MEADOWS
FLOOD CONTROL PROJECT
ALTERNATIVE 5 FLOODPLAIN TERRACE PLAN

NEVADA

CROSS SECTIONS
TRUCKEE MEADOWS

Sheet reference number:
C-401
Sheet 36 of 47

8.11 | PLOT DATE: 13-MAY-2013 | PLOT TIME: 08:54 | \\amethyst\truckee\Grr_els\CADD\Civil\B00_plan_set_2010-10\Draft_Report_Eng_Plans-02-2013\C-401-Civil Plan-Cross Section.dgn



TRUCKEE RIVER
FRANKLIN-LUMBER LEVEE
RIVER STA: 3056+70 C-402 C-117

US Army Corps of Engineers
Sacramento District

Symbol	Description	Date	Approved

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CA 95814-2922

Designed by: LM
Drawn by: LM
Scale No.: 1"=40'-0" H 1"=10'-0" V
Reviewed by: STOW/TG COOK
Date: 01-MAY-2013
Reviewed by: TOM/STEVE
Date: 01-MAY-2013
Submitted: SUBMITTED
Recommended: RECOMMENDED
Approved: APPROVED
Rev. 1/1/8

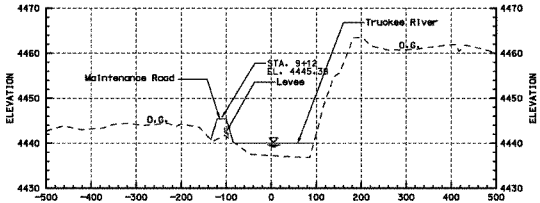
WASHOE & STOREY COUNTIES NEVADA
TRUCKEE MEADOWS
FLOOD CONTROL PROJECT
ALTERNATIVE 3 FLOODPLAIN TERRACE PLAN
CROSS SECTIONS
TRUCKEE MEADOWS

Sheet reference number:
C-402
Sheet 37 of 47

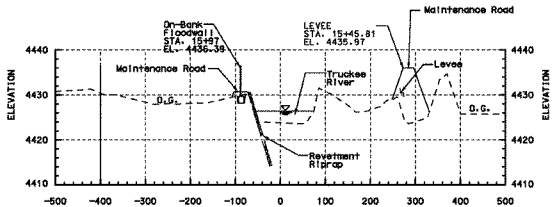
8.5.1 | PLOT DATE: 13-MAY-2013 PLOT TIME: 06:54 | \\amethyst\truckee\Grr_els\CADD\Civil\BOD_plan_set_2010-10\Draft_Report_Eng_Plans-02-2013\C-402-Civil Plan-Cross Section.dgn

NOTE:

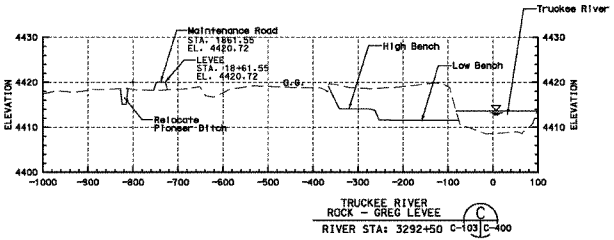
WALMART LEVEE WAS CONSTRUCTED BY OTHERS.



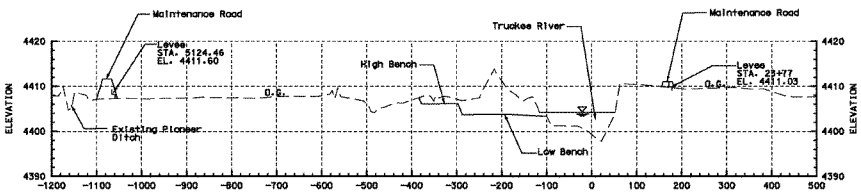
TRUCKEE RIVER
GLENDALE - HWY 395 (WAL MART) LEVEE
RIVER STA: 3346+70 C-101 C-400 (A)



TRUCKEE RIVER
GREG - GLENDALE FLOODWALL & LEVEE
RIVER STA: 3321+65 C-102 C-400 (B)



TRUCKEE RIVER
ROCK - GREG LEVEE
RIVER STA: 3292+50 C-103 C-400 (C)



TRUCKEE RIVER
McCARRAN - ROCK, EAST ROCK LEVEE
AND ROCK - McCARRAN LEVEE
RIVER STA: 3256+70 C-106 C-400 (D)

US Army Corps of Engineers
Sacramento District

Mark	Date	Description	Approved
A			

Designed by: LM
Drawn by: LM
Checked by: DM
Scale: No.
Date: 1/16
Design file no: 1-2-3-4-5-6
Drawing code:
Reviewed by:
Submitted by:
Submitted by:
SIGNATURE
File name:
Plot date:
Plot scale:
Plot time:

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
1325 J STREET
INDUSTRIAL DESIGN
SACRAMENTO, CA 95814-2922

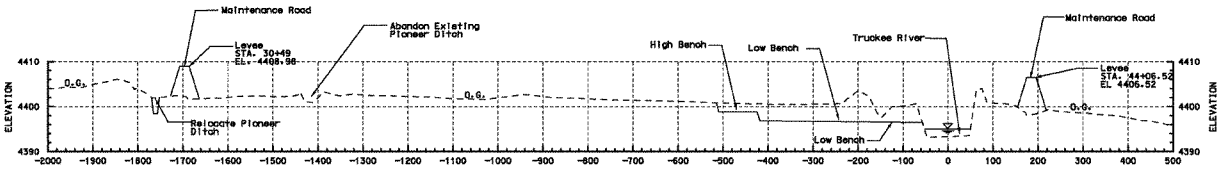
WASHOE & STOREY COUNTIES
CONSOLIDATED PLANS
FLOOD CONTROL PROJECT
ALTOONAPITT (FLOOD ABP)

NEVADA

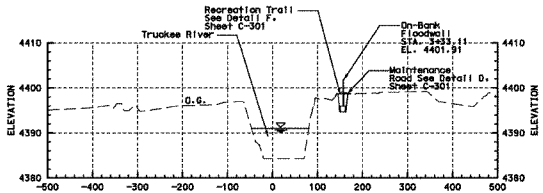
CROSS SECTIONS
TRUCKEE MEADOWS

Sheet reference number:
C-400
Sheet 35 of 47

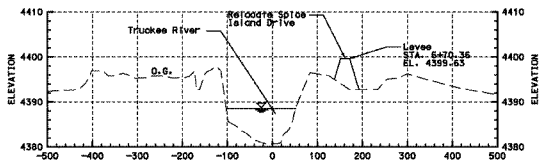
PLOT DATE: 13-MAR-2013 PLOT TIME: 12:57 \\amethyst\truckee\Grr_eis\CADD\Civil\BOD_plan_set_2010-10\Draft_Report_Eng_Plans-02-2013\C-400-Civil Plan-Cross Section.dgn



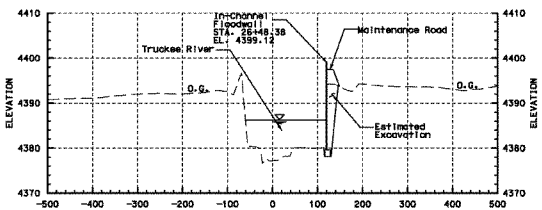
TRUCKEE RIVER
WEST McCARRAN LEVEE,
McCARRAN BY PASS, AND
McCARRAN - ROCK LEVEE
RIVER STA: 3221+75 (E) C-107 | C-401



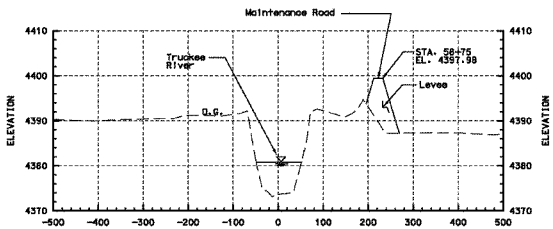
TRUCKEE RIVER
EAST McCARRAN ON - BANK FLOODWALL
RIVER STA: 3191+75 (F) C-110 | C-401



TRUCKEE RIVER
SPICE ISLAND LEVEE
RIVER STA: 3171+70 (G) C-111 | C-401



TRUCKEE RIVER
FRANKLIN IN-CHANNEL FLOODWALL
RIVER STA: 3159+70 (H) C-111 | C-401



TRUCKEE RIVER
FRANKLIN-LUMBER LEVEE
RIVER STA: 3101+75 (I) C-113 | C-401

US Army Corps of Engineers
Sacramento District

Date	Description

Designed by: LM
Dwn by: LM
Ckd by: LM
Scale No.: 1"=50'
Date: 1/28/13
Reviewed by: Stanley Colon
Submitted by: Tom Hofmann
Reviewed by: ELIMADORE
Submitted by: Kathy Thomas
File name: Plot date: Plot time:

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

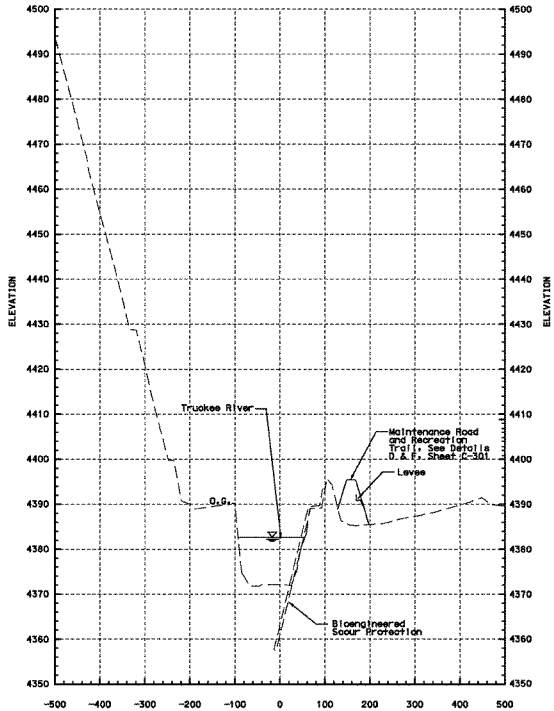
SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CA 95814-2922

PLACER & STORED COUNTIES
NEVADA
TRUCKEE MEADOWS
FLOOD CONTROL PROJECT
ALTERNATIVE 3 (1:50 AEP)

CROSS SECTIONS
TRUCKEE MEADOWS

Sheet reference number:
C-401
Sheet 36 of 47

PLOT DATE: 13-MAR-2013 PLOT TIME: 12:53 \\amethyst\truckee\Grr_els\CADD\Civil\B00_plan_set_2010-10\Draft_Report_Eng_Plans-02-2013\C-401-Civil Plan-Cross Section.dgn



TRUCKEE RIVER
FRANKLIN-LUMBER LEVEE
RIVER STA: 3056+70 C-402 C-117

US Army Corps of Engineers
Sacramento District

Symbol	Description	Date	Approved
A			
B			
C			
D			
E			
F			

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

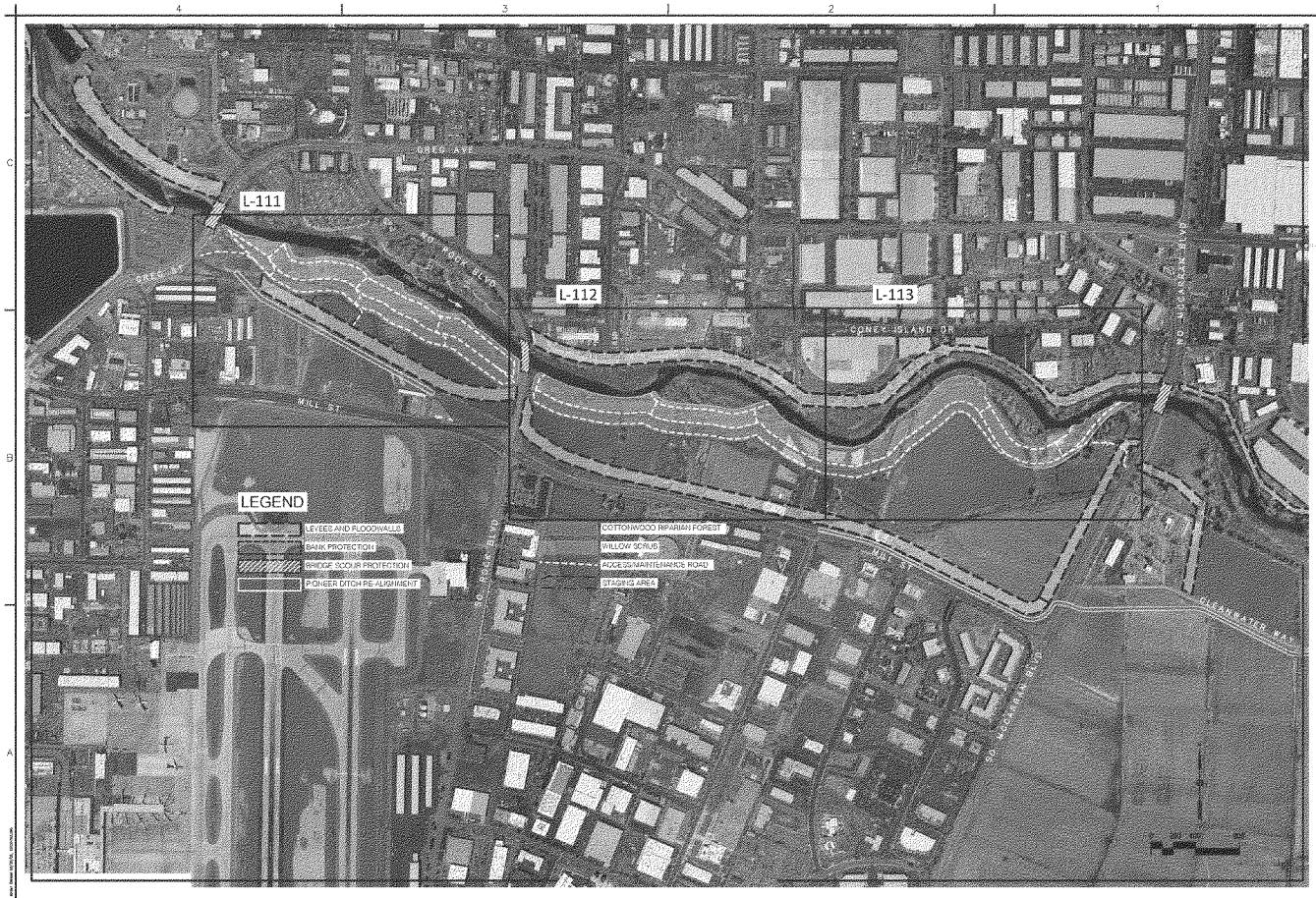
SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 J STREET
SACRAMENTO, CA 95814-2922

Designed by: LM
Drawn by: LM
Scale: NONE
Reviewed by: [illegible]
Submitted by: [illegible]
SIGNATURE
Date: [illegible]
Rev. 11/96
Design file no: Header file no: 1325-J-1-TB
Drawing code: [illegible]
File name: [illegible]
Plot date: [illegible]
Plot scale: [illegible]

WASHOE & STOREY COUNTIES NEVADA
TRUCKEE RIVERS
FLOOD CONTROL PROJECT
ALTERNATIVE 3 FLOODPLAIN TERRACE PLAN
CROSS SECTIONS
TRUCKEE MEADOWS

Sheet reference number:
C-402
Sheet 37 of 47

a.1.1 | PLOT DATE: 18-JUL-2013 PLOT TIME: 08:34 | \\amethyst\truckee\Drr_els\CADD\Civil\BOD_plan_set_2010-10\Draft_Report_Eng_Plans-02-2013\C-402-Civil Plan-Cross Section.dgn



US Army Corps of Engineers
Sacramento District

Prepared for | Date | Sign Off | Drawn by | Checked by | Approved by | Date | Sign Off | Drawing Title | Drawing Number | Scale | Date | Revision | Sheet

CITY OF LIVE OAK
SUTTER COUNTY, CALIFORNIA
SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CA 95814-2922

Contract No.
Date Approved
Date Contract Awarded
Date Contract Completed

RIVER & STREET CLEARES
TRUCKEE MEADOWS
FLOOD CONTROL PROJECT
ALTERNATIVE 1 FLOODPLAIN INTERVISE PLAN

REVEGETATION PLAN
TRUCKEE MEADOWS OVERVIEW

Sheet reference number:
L-101
Sheet 38 of 47

06-11-2013

US Army Corps of Engineers
Sacramento District

Date	Description

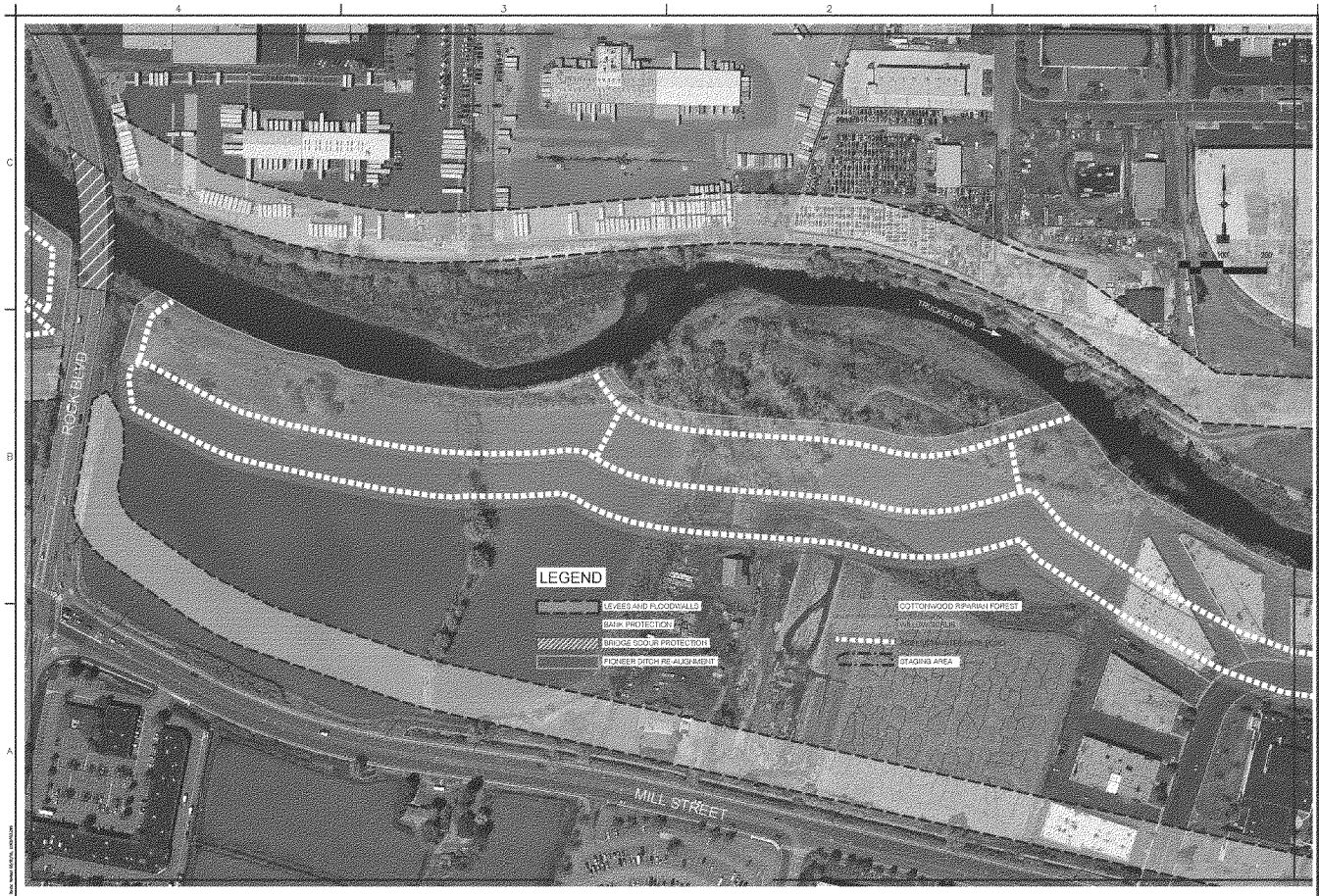
Designed by: Date:
Drawn by: Date:
Reviewed by: Drawing Date:
Approved by: Date:
Contract No.: Drawing No. etc.:
Sheet No.:
Date:

DIVISION OF U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CA 95814-2922

NOVA
BOUCHE & STANLEY CLAWITES
TRUCKEE MEADOWS
FLOOD CONTROL PROJECT
ALTERNATIVE 1 FLOODPLAIN TERRACE PLAN
REVEGETATION PLAN
CHANNEL TERRACE REVEGETATION

Sheet reference number:
L-111
Sheet 39 of 47

05-11-2010



US Army Corps of Engineers
Sacramento District

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DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CA 95814-2922

SUBMITTED

RECOMMENDED

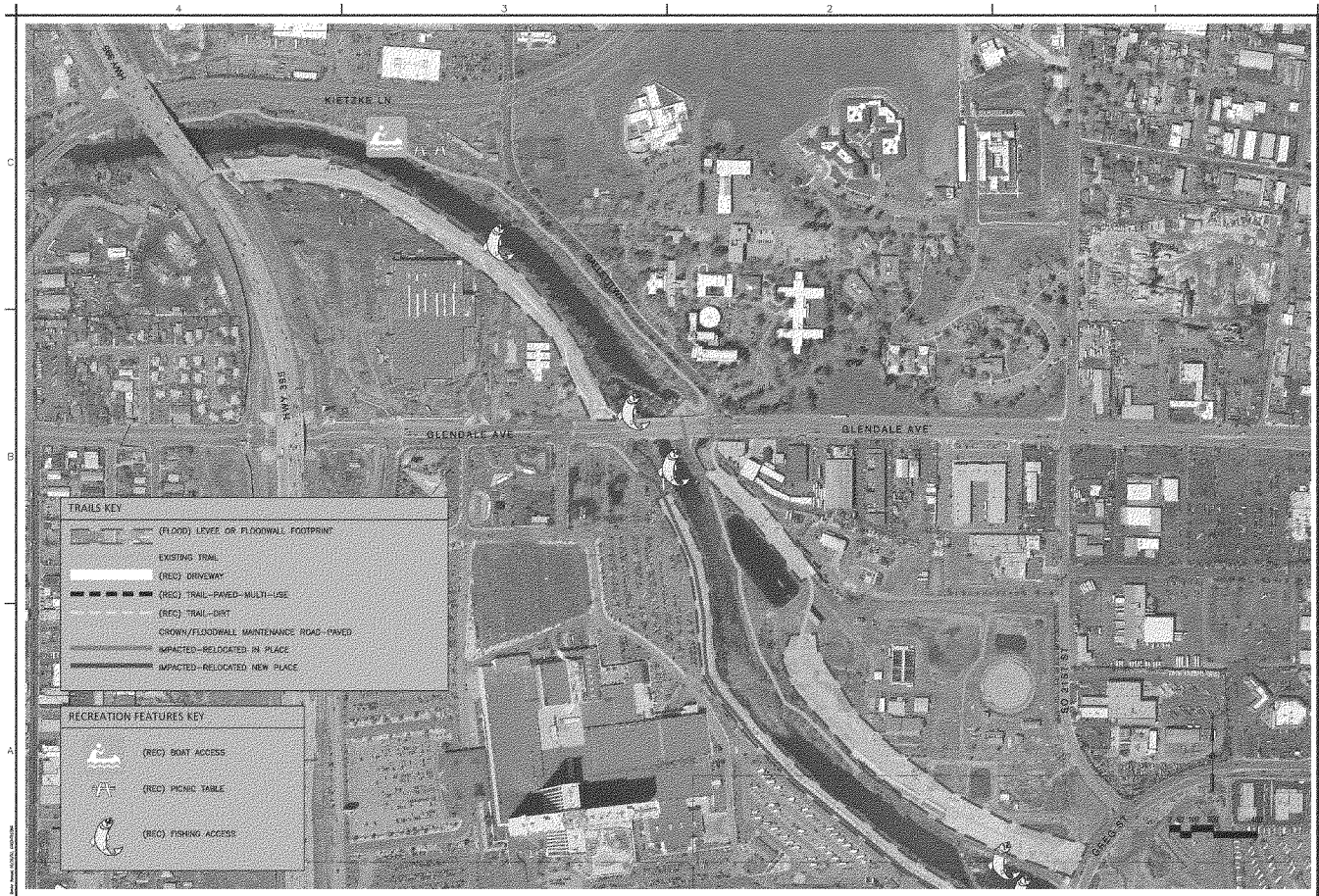
ROSEVILLE & STERLING COMMUNITIES
TRUCKEE MEADOWS
FEASIBILITY STUDY
ALTERNATIVE 1 FLOODPLAIN TERRACE PLAN

REVEGETATION PLAN
CHANNEL TERRACING REVEGETATION

Sheet reference number:
L-112
Sheet 40 of 47

05-11-2013

LEGEND
LEVEES AND FLOODWALLS
BANK PROTECTION
BRIDGE SCOUR PROTECTION
POWER LINE RELOCATION
COTTONWOOD DRAINAGE FOREST
WILDLIFE CORRIDOR
ACCESS MAINTENANCE ROAD
STAGING AREA
CONEY ISLAND DR
MCCARRAN BLVD
L-113



US Army Corps of Engineers
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File date: 05-09-2013

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CA 95814-2922

NEVADA

NEVADA & DISTRICT COUNTIES
TRUCKEE MEADOWS
FLOOD CONTROL PROJECT
AUGMENTING LAND PLAN SERVICE PLAN
RECREATION PLAN
ALTERNATIVE C
RELOCATE BALLOONS

Sheet reference number:
RC-101
Sheet 42 of 47

05-11-2013

US Army Corps of Engineers
Sacramento District

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Reviewed by:
Submitted by: Chief, Design Branch
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SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT
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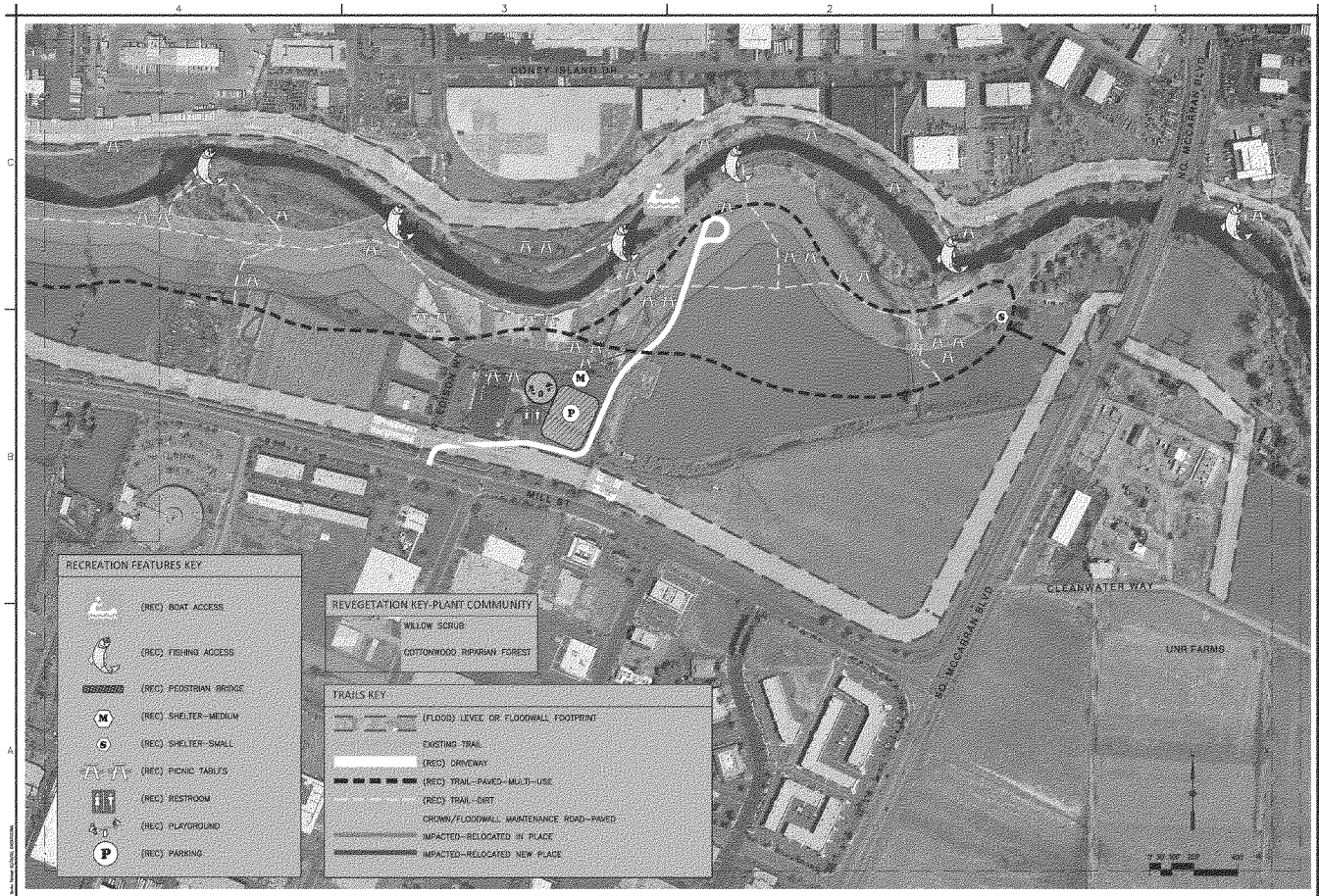
WORK
SIMONS & STERNY COUNTIES
TRUCKEE MEADOWS
FLOOD CONTROL PROJECT
ALTERNATIVE LAND PLAN TERRACE PLAN
RECREATION PLAN
ALTERNATIVE C
TRUCKEE MEADOWS

Sheet reference number:
RC-102
Sheet 43 of 47

05-11-2015



US Army Corps of Engineers Sacramento District

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DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CA 95814-2922

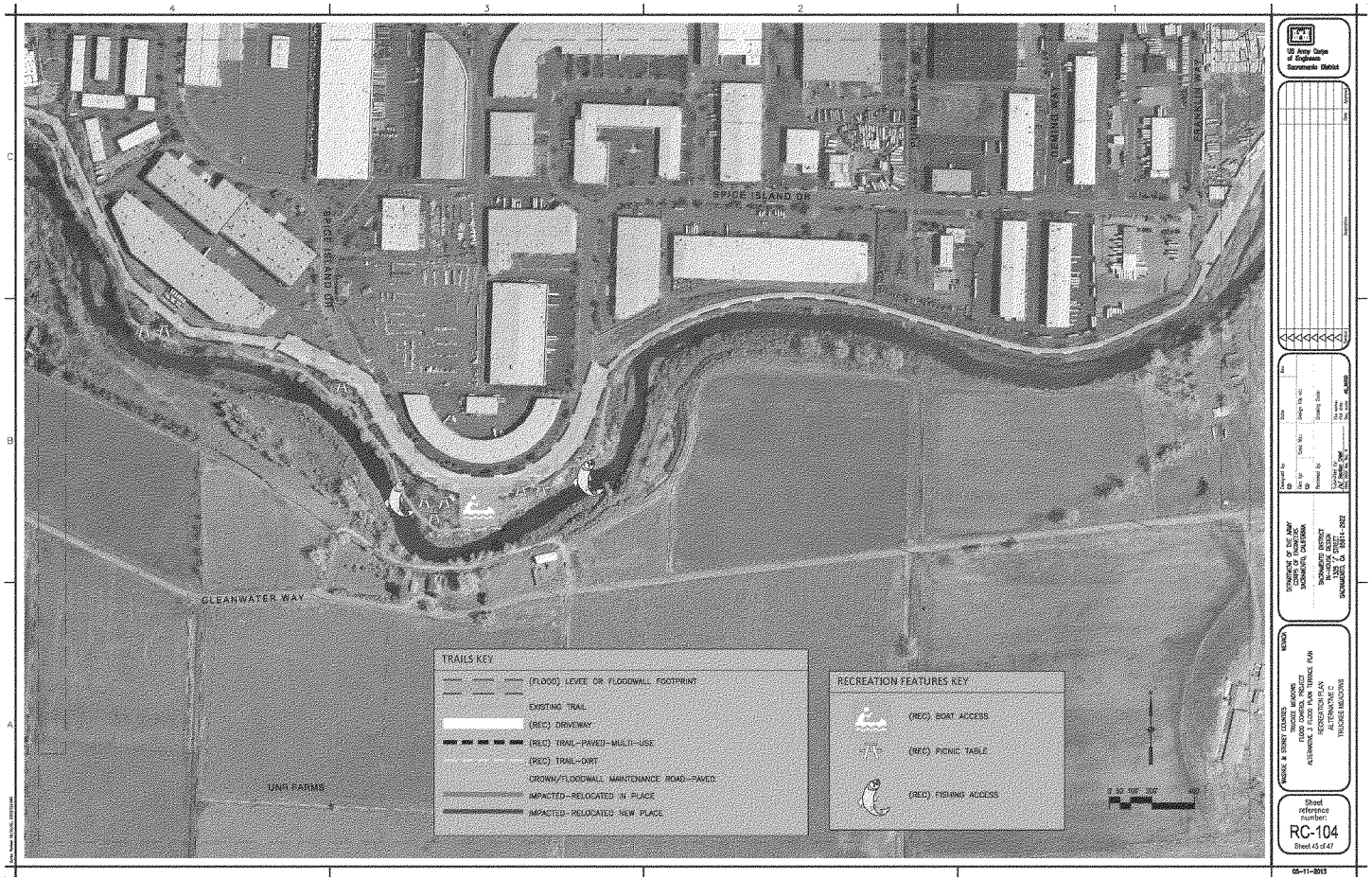
REVISIONS

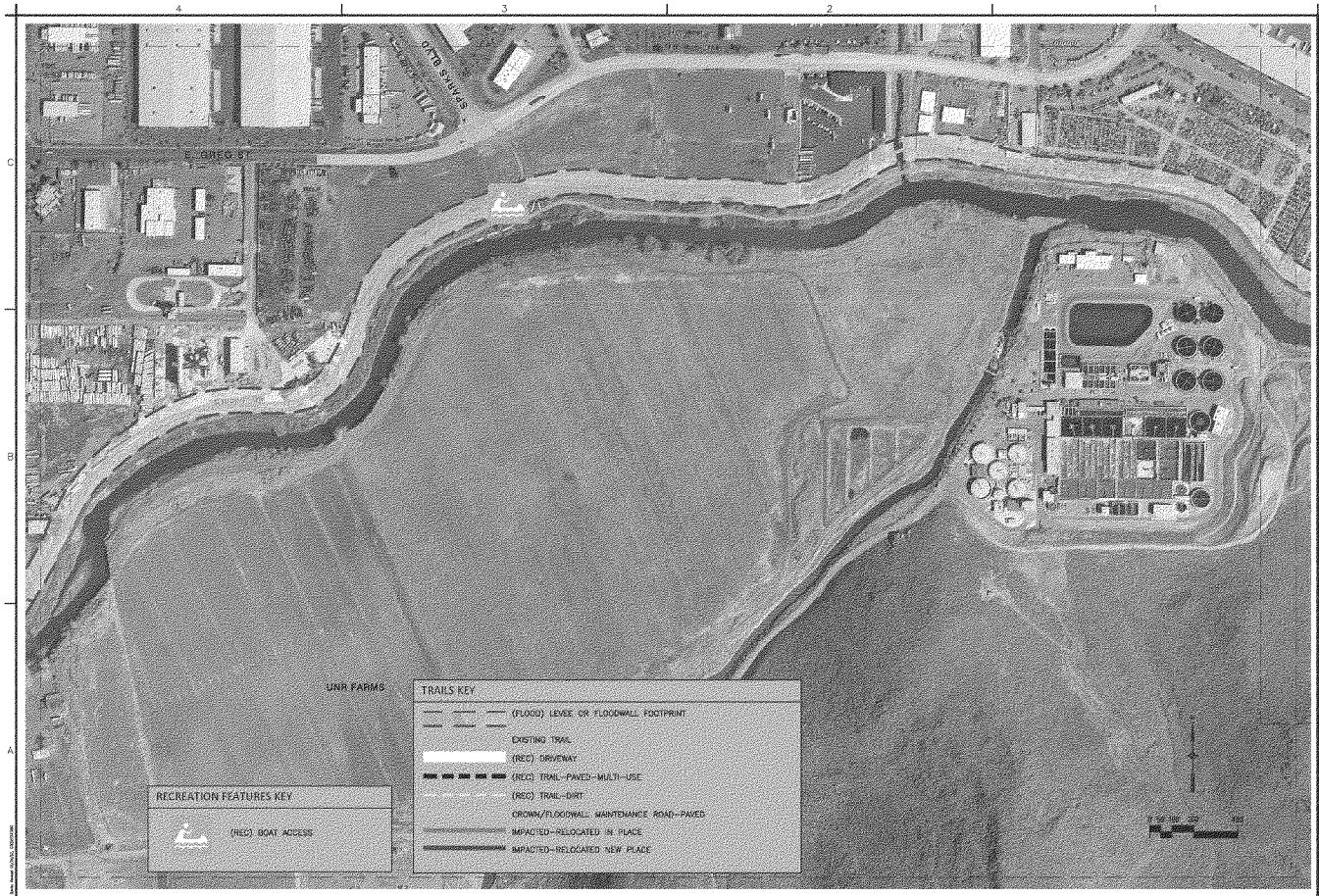
ENGINEERS & ECOLOGY CONSULTANTS
TRUCKEE MEADOWS
FLOOD CONTROL PROJECT
ALTERNATIVE 3, LOCAL PLAN, LEVEE, PLAN
RECREATION PLAN
ALTERNATIVE C
TRUCKEE MEADOWS

Sheet reference number:
RC-103
Sheet 44 of 47

05-11-2013

990


SPACE ISLAND DR
CLEANWATER WAY
UNR FARMS
TRAILS KEY
(FLOOD) LEVEE OR FLOODWALL FOOTPRINT
EXISTING TRAIL
(REC) DRIVEWAY
(REC) TRAIL-PAVED-MULTI-USE
(REC) TRAIL-DIRT
CROWN/FLOODWALL MAINTENANCE ROAD-PAVED
IMPACTED-RELOCATED IN PLACE
IMPACTED-RELOCATED NEW PLACE
RECREATION FEATURES KEY
(REC) BOAT ACCESS
(REC) PICNIC TABLE
(REC) FISHING ACCESS
US Army Corps of Engineers Sacramento District
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CA 95814-2922
NORTH
NATURAL & ENTRY CLEARED
TRACKED MEADOWS
CLEANWATER WAY TRAILS
ALTERNATIVE C LOOP PLAN TRAILS PLAN
RECREATION PLAN
ALTERNATIVE C
TRACKED MEADOWS
Sheet reference number:
RC-104
Sheet 45 of 47
05-11-2015



US Army Corps of Engineers
Sacramento District

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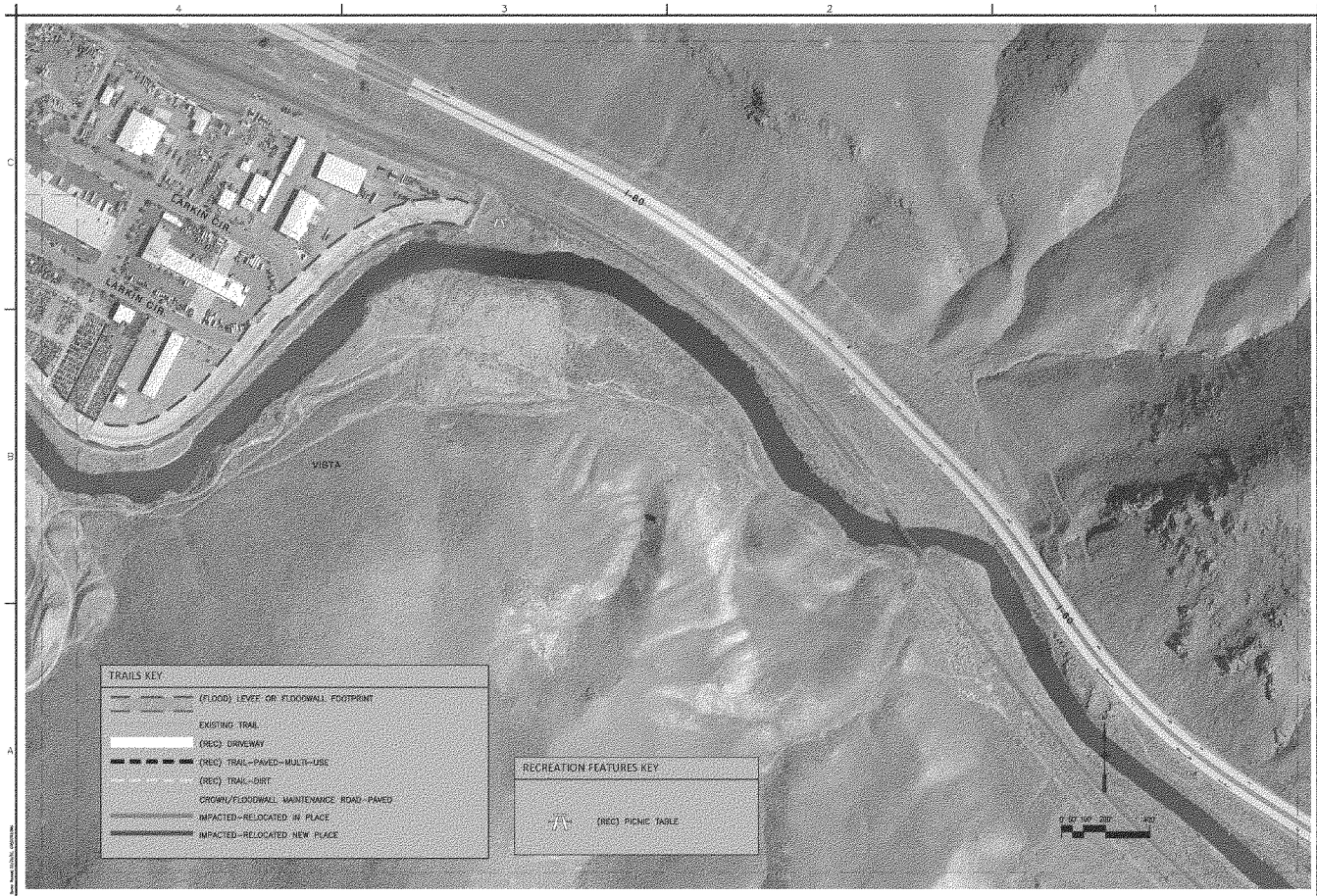
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
1325 J STREET
SACRAMENTO, CA 95814-2922

NONCO
NORTHEAST CONNECTOR
TRONCO MEADOWS
FLOOD TERRACE ALTERNATIVE
ALTERNATIVE 1 CORE PLAN TENTATIVE PLAN
RECREATION PLAN
ALTERNATIVE C
RELOCATE BOAT RAMP

Sheet reference number:
RC-105
Sheet 46 of 47

05-11-2013



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DEPARTMENT OF THE ARMY
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1325 J ST.
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Sacramento County
File name: 1-RC-106.dwg
Plot date: 05-09-13, 10:14
Plot scale: 1=40
Plot by: Chad
CAD system: MicroStation V8

NOTICE

NORTH & SOUTH CONNECTS
TRACKER MEADOWS
CITY OF SACRAMENTO
AUGMENTING FLOOD PLAIN TERRACE PLAN
RECREATION PLAN
ALTERNATIVE C
RELOCATE BALLOONS

Sheet reference number:
RC-106
Sheet 47 of 47

05-11-2013

Truckee Meadows General Re-Evaluation Report (GRR)
Final Report
Washoe County, Nevada

FLOOD RISK MANAGEMENT PROJECT

APPENDIX E
EXECUTIVE ORDER 11988 ANALYSIS

Planning Division
Sacramento District

December 2013

ADDENDUM TO TRUCKEE MEADOWS FLOOD CONTROL PROJECT, NEVADA
FINAL GENERAL REEVALUATION REPORT
APPENDIX E - Executive Order 11988 Analysis
22 MAY 2014

The following information is provided in response to policy review comments by the Administration and is intended to provide further information supporting the Executive Order 11988 analysis. This information is provided as an addendum to Appendix E, sections f, g and h.

f. The project uses the southern natural floodplain of the Truckee River to store flood waters during floods. Use of the floodplain during flood events retains floodplain function and enhances groundwater recharge and natural deposition of sediments. The natural floodplain retains its open space, aesthetics, and use by native species. Use of the natural floodplain for flood storage also allows for the continuation of agricultural practices on UNR Farms.

The setback levees and floodplain terracing provides open space, recreation, education opportunities, and reduces the height of the levees, allowing for a more appealing viewshed for residents and recreation users. Floodplain terracing provides increased space for wildlife and natural habitat succession.

g. The use of the natural floodplain will have a beneficial effect on natural floodplain values and provides for the continued use of the land in agricultural education. Setback levees and floodplain terracing increase the floodplain values and have beneficial effects including open space, recreation and aesthetics.

h. The recommended plan has beneficial effects to floodplain values including the retention of open space, flood water storage, groundwater recharge, natural sediment deposition, aesthetics, opportunity for recreation, continued wildlife usage, and increased opportunity for natural aquatic habitats.

Truckee Meadows, Nevada General Reevaluation Report (GRR)
Executive Order (EO) 11988 Compliance

1. Purpose. This report documents the results of the analysis of the Truckee Meadows, Nevada GRR to demonstrate compliance with EO 11988.

2. References.

a. Executive Order (EO) 11988, Floodplain Management, May 24, 1977.

b. Water Resources Council, Floodplain Management Guidelines for Implementing E.O. 11988, February 10, 1978 (43 FR 6030).

c. ER 1165-2-26, Implementation of Executive Order 11988 on Flood Plain Management, March 30, 1984.
– Note: this ER does not address the critical infrastructure and critical floodplain (0.2 ACE) requirements specified in the WRC Guidelines.

d. ASA(CW) Memorandum to the Director of Civil Works, March 7, 2013, subject: Sutter Basin, California – Deviation from the National Economic Development Plan.

e. Section 2031 – Water Resources Principles and Guidelines, Water Resources Development Act of 2007

3. Background. EO 11988 requires Federal agencies to avoid to the extent possible the long and short-term adverse impacts associated with the occupancy and modification of flood plains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative. In accomplishing this objective, "*each agency shall provide leadership and shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health, and welfare, and to restore and preserve the natural and beneficial values served by flood plains in carrying out its responsibilities.*"

The Water Resources Council Floodplain Management Guidelines for implementation of EO 11988 (Reference 2.b.) require an eight-step process for agency decision-making on projects that have potential impacts to or within the floodplain. The eight steps reflect the decision-making process required in Section 2(a) of the EO. The eight steps are incorporated into the guidance below.

EO 11988 and its supporting Guidelines are consistent with Section 2031 of WDRA 2007 (Reference 2.e.), which defines the National Water Resources Policy as, "*... all water resources projects should reflect national priorities, encourage economic development, and protect the environment by—*
(1) seeking to maximize sustainable economic development;

(2) seeking to avoid the unwise use of floodplains and flood-prone areas and minimizing adverse impacts and vulnerabilities in any case in which a floodplain or flood-prone area must be used; and
(3) protecting and restoring the functions of natural systems and mitigating any unavoidable damage to natural systems."

Section 2031 also instructed the Secretary of the Army, among other things, to ensure that public safety is assessed and incorporated in the formulation of alternatives and recommended plans. In addition, Section 2033 of WRDA 2007 requires feasibility studies for flood damage reduction to calculate the following for a proposed project: the residual risk of flooding, the residual risk of loss of human life, and the residual risk to human safety.

4. Compliance with EO 11988, Floodplain Management.

The following information is provided to summarize how the Truckee Meadows, Nevada General Reevaluation Report (GRR) has documented compliance with Executive Order 11988. To comply with EO 11988, projects are formulated and recommended that, to the extent possible, avoid, minimize and/or mitigate adverse effects associated with use of the floodplain, and avoid inducing incompatible development in the floodplain unless there is no practicable alternative. Achieving flood risk management objectives generally cannot avoid locating actions in riverine or coastal floodplains.

a. Describe the existing floodplain management activities.

The existing floodplain management activities include:

- Washoe County and the cities of Reno and Sparks, Nevada currently participate in the National Flood Insurance Program (NFIP) administered by the Federal Emergency Management Agency (FEMA). Therefore, any future development proposed within the jurisdictional boundaries of these local agencies is required to be constructed above FEMA's base flood elevation. Increased efforts in flood plain zoning restrictions are also being considered by these agencies and are likely to be implemented under either the with- or without-project condition and would apply to any future development.

- A comprehensive floodplain management plan will be developed within one year after the date of signing a project partnership agreement, as required by Section 402 of the Water Resources Development Act of 1986, as amended. The plan should address issues such as public outreach, preparedness, and emergency response for both pre- and post-disaster scenarios. The floodplain management plan would also address other issues within the floodplain, including controlling or limiting development, ordinances to ensure flood storage within the floodway, and other concerns.

- As required by the model PPA language, the non-Federal sponsor will publicize floodplain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in adopting regulations, or taking other actions, to prevent unwise future development and to ensure compatibility with protection levels

provided by the project. The non-Federal sponsor will continue to participate in and comply with applicable Federal floodplain management and flood insurance programs. The sponsor currently operates a website (http://www.washoecounty.us/pubworks/fema.htm) that provides the public information on flooding problems, participation in the NFIP, and local guidelines.

- Washoe County has passed a local ordinance (No. 1457) within Critical Flood Storage zones calling for "no adverse impacts." This ordinance calls for mitigation for any grading or fill; establishing a 1 unit of storage be created for each unit of fill within the Critical Flood Storage zone.

b. Determine if the proposed action would be in the base floodplain.

The features and effects of the recommend plan are located within the base floodplain in Reno and Sparks, Nevada. The features of the recommended plan must be located in the base floodplain to perform their basic function of flood risk reduction.

c. Identify and evaluate practicable alternatives to locating the action in the base floodplain.

Potential alternatives without project features in the base floodplain were identified and evaluated. These included reoperation of upstream reservoirs; non-structural measures such as floodplain evacuation, flood proofing or home elevations; levees, floodwalls, detention basins, channelization, and dedication of natural floodplain to flood storage,

A total of 11 preliminary alternatives were considered in the Truckee Meadows Reach of the project and were screened to a final array of three alternatives. A detailed description of these plans and the plan formulation process can be found in Chapter 3 of the GRR.

There are no practicable alternatives to locating the recommended plan (NED Plan) in the base floodplain as these alternatives would be cost prohibitive or ineffective. Compliance with EO 11988 was considered in developing and evaluating alternatives.

d. Would the proposed action would induce development in the base floodplain?

No Induced Development
The recommended plan would not induce development in the base floodplain because all of the base floodplain would remain subject to the same FEMA National Flood Insurance Program (NFIP) development restrictions as in the without-project condition. The recommended plan levees and floodwalls would not meet NFIP levee system evaluation requirements as a result of their intended level of performance. The levees and floodwalls would not contain the 1% annual chance exceedance flood with at least 90% assurance (as required for NFIP certification by EC 1110-2-6067) nor would they provide the minimum freeboard required by FEMA for NFIP certification. Therefore, the recommended plan would not reduce the area of the base floodplain regulated under the NFIP, or increase the amount of potentially developable land. In fact, the recommend plan could increase the size of the base floodplain in the vicinities of the North

Truckee Drain and UNR Farms, depending upon the specific measures chosen by local interests to avoid induced flooding of existing structures in those areas in compliance with NFIP requirements.

Because there would be no induced development, there would be no adverse effects on natural and beneficial floodplain values as a result of induced development. The recommended plan would restore and preserve natural and beneficial floodplain values by incorporating environmentally sustainable design features including revegetated floodplain terraces and other flood overflow areas in place of existing development. The recommended plan would also provide increased access to the river corridor for recreation and aesthetic enjoyment of the floodplain.

Existing Land Use

The Truckee Meadows reach has several distinct land uses that are affected by the current floodplain. The Reno-Tahoe International Airport (RNO) is located in this reach south of the Truckee River. Also included in this reach is the industrial area for the City of Sparks. It also includes commercial and public uses. According to the City of Reno Master Plan, official land use designations include: Special Planning Area, Unincorporated Transition, Single Family Residential, Mixed Residential, Urban Residential/Commercial, Public Facility, Industrial, and Parks/ Recreation/Open Space. According to the City of Sparks Master Plan, official land use designations include Rural Residential, Tourist Commercial, Industrial, Public Facility, and Open Space/Rural Reserve. According to the Washoe County Master Plan, official land use designations include Rural, Rural Residential, Urban Residential, Suburban Residential, Commercial, and Open Space. According to the Storey County Master Plan, land use designations for the River District include agricultural, recreational, residential, industrial, and commercial development.

Along the north bank in this reach, uses immediately adjacent to the river include public parks, a paved bicycle trail running along the entire length of the north bank up to the Union Pacific Railroad tracks at the Sparks City limit, and undeveloped lands. North of the park land, uses vary from commercial to industrial to public utilities. There is a mobile home park west of Rock Boulevard. However, the majority of the uses in this area are commercial or industrial. Between McCarran Boulevard and the Sparks eastern city limit, the use is almost entirely industrial, with warehouses and storage yards established throughout the area between Greg Street and the river. Commercial and industrial uses dominate along the North Truckee Drain from the Truckee River north to Prater Way. Much of the drain north of I-80 is adjacent to paved roadways, including Sparks Boulevard to its west. North of Prater Way, the drainage is located between northbound and southbound Sparks Boulevard in predominantly residential areas.

The Grand Sierra Resort and Casino, as well as commercial/industrial uses, are located along the south bank of the river just downstream of Highway 395 to Greg Street. However, other than an industrial/commercial complex along Edison Way, the Sagewinds Drug and Alcohol Rehabilitation Center along McCarran Boulevard, and sporadic buildings associated with the UNR Farms activities, current land use along the south bank up to Steamboat Creek is either agricultural or open space. The TMWRF is located on the east side of the Steamboat Creek confluence. South of the river and east of McCarran Boulevard, the land use is predominantly

rural cropland and includes the land owned and operated by UNR Farms, the majority of which is used as pasture.

South of the UNR Farms land along Steamboat Creek, the area has grown rapidly over the past few years to include residential subdivisions. There is additional pressure to further develop the remaining lands, with the exception of the existing wetlands, into residential subdivisions and associated commercial areas. Residential subdivisions in this area include Hidden Valley, Rosewood Lakes, Donner Springs, and Double Diamond.

The UNR Farms property is 1,068 acres, of which a major portion has been improved to serve the intensive needs of researchers and as a demonstration facility to meet the instructional requirements of the College of Agriculture. The UNR Farms includes a meat processing plant; an animal health, research, isolation, and surgery unit; experimental and demonstration feed lots; intensive agronomic and horticultural research plot areas; and soil and lysimeter research units.

Residential growth along Steamboat Creek south of UNR Farms has been extremely rapid in recent years. Subdivisions have been constructed on either side of the creek south to Mira Loma Drive. In addition to the Rosewood Lakes golf course, located on the west side of the creek, the Hidden Valley residential community and golf course are located on the east side of the creek. Farther south along Steamboat Creek, residential and recreational development transitions to pastureland and open space between Mira Loma Drive and Alexander Lake Road.

South of Pembroke Drive, Boynton Slough flows into the creek at the Rosewood Lakes Golf Course. Land uses along Boynton Slough are primarily commercial and industrial as the slough flows away from RNO, changing to more residential and recreational uses between East McCarran Boulevard and Steamboat Creek. There are residential developments along Perro Lane between Longley Lane and East McCarran Boulevard.
Along Steamboat Creek south of Bella Vista Ranch Road most of the land currently is designated as Minor Improvements: wells, septic, and outbuildings. Land use generally is pastureland; however, there are gravel mining operations along Bella Vista Road and Desert Way. From approximately South Meadows Parkway south, two subdivisions (Centex I and Centex II) are under construction within the Steamboat Creek floodplain. South of Alexander Lake, there are two existing smaller detention basins that receive drainage from Whites Creek and Thomas Creek. South of these existing basins is the Double Diamond residential development area consisting of single-family and townhouse/condominium residences.

Land Use/Zoning Plans
The Truckee Meadows Regional Planning Agency (TMRPA) was created by the State of Nevada to provide comprehensive planning for the entire area within the boundaries of Washoe County except for the Lake Tahoe Basin. All incorporated cities within the County boundaries, except within the Tahoe Basin, are also subject to the jurisdiction of the TMRPA. The TMRPA developed and adopted the Truckee Meadows Regional Plan in 1991, with the latest update adopted in 2007. This comprehensive regional plan focuses on coordinating plans of local governments, including Washoe and Storey Counties, the Cities of Reno and Sparks, and other entities in the Truckee Meadows service areas as they relate to land use planning, infrastructure, resource management, and implementation strategies. The TMRPA is responsible for

implementing the Truckee Meadows Regional Plan. The County and City master plans, comprehensive plans, area plans, and specific plans must conform to the goals, policies, and principles established in the regional plan. The regional plan includes goals and policies under four modules for development in southern Washoe County over the next 20 years. These modules are (1) Regional Form and Pattern; (2) Natural Resource Management; (3) Public Services and Facilities; and, (4) Implementation of the Plan (Washoe County, 1996). The plan also defines the spheres of influence (SOI) for the incorporated cities. Zoning/land use plans that limit development in the project area, including, State of Nevada, Washoe County, City of Sparks, and City of Reno plans, are described in Chapter 5 of the Truckee Meadows, Nevada Environmental Impact Statement.

e. Identify the impacts in the base floodplain of the proposed action and any induced development.

The primary impact to the base floodplain are the direct and indirect effects on existing land uses, resulting in the conversion of agricultural, business/commercial/ industrial, and recreation/open space land uses to flood risk management uses.

The remaining flood risk management features would be located on land use designations that are compatible with the plan's flood performance requirements or would only require an easement along the edge of parcels. Direct and indirect effects to existing and planned land use would be less than significant.

The UNR Farms area is an agricultural area that is subject to regular overflow and backwater effects from without-project flooding. The plan calls for designated overflow under design conditions, maintaining existing floodplain values. Additionally, the use of environmentally sustainable designs for the floodplain terraces will maintain floodplain values and provide additional public access. The plan will provide additional open space and recreational opportunities. The floodplain terraces provide an aesthetic benefit by creating opens space between levees and floodwalls and reducing the height of those structures, allowing for a more acceptable viewshed for the community. The plan would not conflict with any existing habitat conservation plan or natural community conservation plan, nor would it physically divide an established community in the Truckee Meadows reach.

The plan would not be expected to divide an established community because all of the communities in the area are already subject to existing limitations on growth and community cohesion as a result of being located in the vicinity of a natural watercourse. Consequently, any changes in land use associated with implementation of the Recommended Plan would not likely result in physically dividing an established community.

While the plan would require relatively minor changes in land use designations within the proposed flood risk management system, the changes are not anticipated to significantly alter the goals of the affected community plans while addressing the flood risk reduction needs of these communities. Finally, no reductions to the FEMA base floodplain will result from the plan and existing local ordinances strictly regulate further development in the base floodplain (Ordinance 1457). Therefore, the plan would not directly or indirectly support development in the floodplain.

f. Describe measures available to minimize adverse impacts on natural and beneficial floodplain values

In order to minimize or avoid significant effects to resources within the project area, many best management practices (BMPs) and mitigation measures have been adopted or incorporated into the plan. The plan uses environmentally sustainable design of the flood risk management features, including revegetation of floodplain terraces with native species, to avoid or minimize significant adverse effects.

While ecosystem restoration was considered during early formulation, no restoration is proposed as part of the plan. The Truckee River within the Truckee Meadows reach runs through a highly urbanized area and the habitat values are limited.

g. Describe the effect of the above topics on any reevaluation of alternatives and on the final plan selection

EO 11988 was considered during plan formulation and is evidenced by the formulation of alternatives that made use of the natural floodplain storage on UNR Farms. This aspect of the plan ensures that future development will not take place there.

No unmitigated effects on floodplain values have been identified.

h. Findings and explanation

Summary
The recommended plan would not induce development within the floodplain as there is no reduction to the Federal Emergency Management Agency (FEMA) National Flood Insurance Program (NFIP) base floodplain. Thus the with-project base floodplain would remain subject to the same FEMA National Flood Insurance Program (NFIP) development restrictions as in the without-project condition.

Compliance with EO 11988 was considered in developing and evaluating alternatives. Options to reduce risk without changes within the base floodplain were considered. There are no practicable alternatives to locating the recommended plan in the base floodplain as these alternatives would be cost prohibitive or ineffective.

Public Input
The public and concerned resource agencies have been invited to participate in all phases of the Truckee Meadows Flood Control Project since the initiation of the General Reevaluation Study in 1996. This has included opportunities to comment on the 1997 Reconnaissance Report (GRR), the Notice of Intent to prepare an Environmental Impact Statement (EIS), the Public Scoping Meeting conducted in 1999, and public workshops in 2000, 2003, and 2005. Additional efforts were made to solicit public input and feedback on the Truckee Meadows Flood Control Project planning efforts, including: disseminating information through a project web site and

newsletters; creating opportunities for comment and discussion through public meetings and workshops, and the opportunity to review and provide comments on the draft GRR and EIS.

Public concerns about flood protection included: the reduction of existing and potential flood damage to private and public properties and facilities, potential high maintenance costs for a flood control project, the length of time required to complete the project; noise impacts on adjacent landowners during construction, and removing properties from the "100-year" floodplain. All pertinent scoping concerns have been considered in the preparation of this document.

The high level of interest expressed by the public resulted in development of a community-based planning process, initiated by the local project sponsors. The Truckee Meadows Community Coalition was formed in 2000. A diverse array of community members representing environmental, business, and neighborhood groups spent many hours establishing their goals and objectives.

In addition to the Truckee Meadows Community Coalition, the Pyramid Lake Paiute Tribe's (PLPT) has been involved in the planning process. The Tribe's fundamental concerns are induced flows from a project in the Truckee Meadows, changes to water quality conditions that could affect native fisheries, and adverse impacts to their lands.

Throughout the process, USACE worked closely with representatives of the Truckee Meadows Community Coalition, PLPT, and non-Federal sponsor and has addressed, considered, and where possible, incorporating comments and suggestions.

i. Critical Actions

Critical Infrastructure within the 0.2% floodplain includes:

Health Care Facilities	4
Fire Stations	5
Police Stations	5
Schools	8

Interstate -80: The major East-West Interstate Highway that averages over 130,000 vehicles per day at the intersection with State Highway 395. Portions were closed during the 1997 event of record.

Union Pacific Railroad: The transcontinental railway line runs along the Truckee River through the project area. Since acquisition of the Southern Pacific Railroad by the Union Pacific in 1996, the number of trains through Reno have increased from 15 to an estimated 34.

Sparks Solvent/Fuel Site (jet fuel, kerosene, other fuels): Operations at the terminal have included the storage, distribution, and loading of gasoline, heating oil, diesel fuels, military fuels, and fuel additives. Rail-yard operations have included maintenance, cleaning, refueling, and storage of railroad engines and other rolling stock. Currently, Union Pacific Railroad (UPRR) no

longer performs fueling operations at the site. Remediation at the site was initiated in 1995 and is ongoing.

Nevada Air National Guard Facility: The Nevada Air National Guard maintains the 152nd Airlift Wing to the southwest of the Reno-Tahoe International Airport's main terminal. This facility is a significant unit critical to the State of Nevada. It has a primary wartime mission of providing rapid airlift and airdrop of cargo and troops.

Truckee Meadows Water Reclamation Facility (TMWRF): Capacity of 40 million gallons per day serving both Reno and Sparks. TMWRF is a biological nutrient removal plant that uses separate nitrification and denitrification processes for nitrogen removal and biological and chemical processes for phosphorus removal. Reclaimed water is discharged to the Truckee River or is pumped to effluent reuse sites in the cities of Reno and Sparks.

Reno-Tahoe International Airport: The second busiest commercial airport in Nevada. The 61st busiest commercial airport in the nation. This airport saw significant flooding and damages in the 1997 flood event.

Bridges: Virginia Street, and Sierra Street Bridges in downtown Reno.

While the project does provide flood risk reduction benefits to TMWRF and to the Airport (up to approximately the mean 1% annual chance), the 0.2% annual chance flood would overtake the proposed project and these areas would be flooded similarly to without project conditions.

The proposed action would not create an added dimension to the flood disaster in the event of a 0.2% annual chance flood.

There is ample warning time under both without and with-project conditions to mobilize buildings such as hospitals, schools and nursing homes under both without and with project conditions. While evacuations routes would eventually be compromised, it is highly likely that most of the floodplain would already be evacuated by that time. The 2010 Evacuation Plan estimates that the minimum evacuation time for the entire population of Reno/Sparks would be 10 hours if all evacuation routes are available.

j. Document Additional Public Safety Considerations

Public Safety

The threat to public safety from flooding includes exposure to floodwaters, accidents during evacuation, and accidents during flood fighting. Life safety concerns in the study area are limited due to increased warning times and limited residential areas within the floodplain.

Washoe County approved an Evacuation, Sheltering and Mass Care Plan in 2008 and updated the plan in 2010. The purpose of this plan is to provide for the orderly and coordinated evacuation, sheltering and The purpose of this plan is to provide for the orderly and coordinated evacuation, sheltering and mass care of all or any part of the population of Washoe County if it is

determined that such action is the most effective means available for protecting the population from the effects of an emergency situation. Action is the most effective means available for protecting the population from the effects of an emergency situation. Localized and extensive flooding events are considered high risk by the plan and are covered by recommended actions to evacuate, shelter and care for the affected population.

Warning times. USACE conducted a Section 205 small flood control study for the Reno Flood Warning System, Nevada, with Washoe County and the cities of Reno and Sparks in 1998. The study resulted in a selected plan that includes expanding the network of gages used for forecasting stages in the mainstem of the Truckee River, adding gages in the tributary catchments and providing flood watch for forecasting tributary stages, providing the storm watch data filing and display tool for local jurisdictions, and developing the preparedness plan for the Reno-Sparks area. This plan increased the flood warning time from 8 to 14 hours on the Truckee River and from zero to 2 hours for the North Truckee Drain and Steamboat Creek basins. The plan allowed the River Forecast Center to improve the accuracy of its flood forecasts for the mainstem Truckee River, provide local jurisdictions with storm watch data for monitoring tributary stream levels, and improve flood response planning and implementation. The project was constructed in 2000 and is considered in-place and part of the without-project condition.

Population. The 2010 population for Sparks was 90,264. Based on a projected population of 590,490 for Washoe County in the year 2030, the average annual growth rate is 1.32 percent. Pressure to develop the area closer to the Truckee River will continue to be managed by local ordinances that require that there be no net loss of flood storage in the Truckee Meadows area. Truckee Meadows is expected to develop in areas outside the floodplain.

Limited residential areas. There are an estimated 7,600 people residing in the base 1% floodplain and an estimated 36,400 residing in the base 0.2% floodplain.

Structures in the Floodplain

The number of structures by land use and floodplain are displayed below for the Meadows area under without and with project conditions:

Without Project

Damage Category	Annual Chance Exceedance Flood Event						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
RES	0	3	15	292	1,115	4,803	7,983
COM	0	4	12	99	153	408	470
CASINOS	0	0	0	0	0	11	13
PUB	0	7	14	57	85	238	262
IND	0	9	55	269	433	627	728
TOTAL	**0**	**23**	**96**	**717**	**1,786**	**6,087**	**9,456**

With Project

Damage Category	Annual Chance Exceedance Flood Event						
	20% (1/5)	10% (1/10)	5% (1/20)	2% (1/50)	1% (1/100)	0.5% (1/200)	0.2% (1/500)
RES	0	3	15	265	1,077	4,803	7,983
COM	0	1	1	6	18	408	470
CASINOS	0	0	0	0	0	11	13
PUB	0	1	1	6	20	238	262
IND	0	0	0	0	10	627	728
TOTAL	**0**	**5**	**17**	**277**	**1,125**	**6,087**	**9,456**

Major Environmental Effects

Construction of the flood risk management features of the Recommended Plan would detrimentally affect fish and wildlife habitat. The Recommended Plan would cause temporary and permanent losses of riparian habitat from construction activities required for excavations, floodwalls, and levees, affecting 28.3 acres of native riparian habitat.

The NED Plan would remove about 7,200 linear feet of riparian river shading. However, the plan would avoid long-term effects to water temperature through revegetation of floodplain terraces and implementation of bioengineering techniques in scour protection features.

The Recommended Plan would remove approximately 1.1 acres of existing wetland habitat primarily associated with Pioneer Ditch and the North Truckee Drain. However, the NED Plan would reestablish connection of the river to its historic floodplain through excavation and revegetation of floodplain terraces that are exposed to seasonal inundation.

In-channel construction activities would represent a temporary disturbance to fisheries habitat. Construction of in-channel floodwalls and scour protection features for the NED Plan would involve temporary disturbance of 3.7 acres of river bottom and the permanent loss of approximately 2.5 acres of open water habitat along the river margin and the North Truckee Drain. However, following completion of construction activities, river bottom habitat conditions are expected to be similar to existing conditions. Bottom dwelling organisms are expected to repopulate to pre-project levels within 6 months.

Increased turbidity levels and water temperatures also represent a potential adverse effect to the Federally listed threatened Lahontan cutthroat trout (Oncorhynchus clarki henshawi) (LCT) and endangered cui-ui lake sucker (Chasmistes cujus). The current population of LCT2 is being sustained by a stocking program carried out by USFWS, Pyramid Lake Paiute Tribe, and NDOW because existing water temperature conditions do not support survival of juveniles in and downstream of the project area.

The Recommended Plan would convert about 30 acres of prime and unique farmland and 19 acres of farmland with statewide and local importance would be converted for levee construction. While the overall acreage of land available for agriculture would be reduced in portions of the Truckee Meadows reach, the conversion of land for flood risk management would

reduce the danger of catastrophic floods and benefit the remaining agricultural land by improving groundwater recharge and nutrient exchange through construction of the floodplain terraces.

In all cases the potential adverse environmental effects would be reduced to a less-than-significant level through project design, construction practices, preconstruction surveys and analysis, regulatory requirements, and best management practices. No compensatory mitigation would be required. A National Pollutant Discharge Elimination System (NPDES) general construction permit would be required. A Storm Water Pollution Prevention Plan (SWPPP) and Spill Prevention Control and Countermeasures Plan (SPCCP) would be developed by the contractor prior to construction.

Effects on Threatened and Endangered Fish Species

Work in the river channel to construct in-channel floodwalls and scour protection features could result in direct injury and/or mortality to the threatened Lahontan cutthroat trout (Oncorhynchus clarki henshawi) and disturbance to fisheries habitat. Excavation and fill could increase fine sediment input.

Fish and aquatic invertebrate assemblages could be indirectly affected by increased erosion, sedimentation, and water turbidity during construction within the channel. Excessive sediment quantities deposited in stream channels can degrade aquatic habitat. Increased turbidity could result in increased fish mortality, reduced feeding opportunities, and could cause fish to avoid biologically important habitat.

To reduce these construction-related effects to a less-than-significant level, erosion control and spill prevention plans would be developed and BMPs implemented.

Construction of flood risk management features in the Truckee Meadows reach would result in loss of near-shore woody vegetation and other riparian vegetation. Riparian vegetation generally includes the woody vegetation and cover structures associated with stream banks that function to provide shade; sediment, nutrient, and chemical regulation; stream bank stability; and input of woody debris and leaves that provide cover and serve as substrates for food-producing invertebrates. Most of the riparian habitat function within the construction footprint of in-channel floodwalls and scour protection features is provided by relatively young, narrow willow stands adjacent to the channel and a small number of mature cottonwood stands. Loss of this vegetation would have a direct effect on water temperature conditions in the Truckee Meadows reach, and to a lesser degree, indirectly affect water temperature conditions in the Lower Truckee River reach. Any increase in water temperature resulting from loss of riparian vegetation is considered a significant effect due to potential adverse effects on trout populations and juvenile fish.

While the increase in water temperature from construction-related activities could represent a significant short-term effect to fisheries, it is important to note that native fish species such as the Lahontan cutthroat trout and cui-ui have adapted to highly variable temperature regimes that are typical for their native habitat range. Lahontan cutthroat trout are noted for their ability to live in Nevada streams and can survive in water where temperatures exceed 27 degrees Celsius for short periods and prolonged exposure to 25 degree Celsius temperatures. During PED phase, further analysis of existing conditions can identify any specific areas of particular concern. Project implementation may be adapted to avoid these particular areas.

Long-term adverse effects would be associated with all levee and floodwall features throughout the Truckee Meadows reach. While revegetation of disturbed sites would be implemented immediately following construction, it would take several years for the riparian vegetation to reestablish itself within the current riparian zone. Slight increases in water temperature may occur until full reestablishment of near shore woody vegetation is reached. However, proposed revegetation of the floodplain terraces following construction and implementation of bioengineering techniques within scour protection features would represent a net increase in riparian habitat and near-shore woody vegetation.

k. Residual Risk

Residual floodplains. Residual flooding for areas not located behind the proposed line of protection is due to flooding from the Truckee River and main tributaries. Residual flooding to areas located behind the line of defense is due to a combination of flooding from interior runoff and mainsteam/tributary flooding during overtopping events.

Induced flooding. The project will increase the water surface elevations in two areas of the project. This increase in water surface elevation is due to the loss of storage in the floodplain. That is, construction of the proposed line of protection along the north side of the Truckee River results in the loss of storage in the commercial Sparks area which is removed from the Truckee River floodplain. This will result in an increase in water surface elevations between 0.0 and 0.6 feet compared to the without-project condition.

In the UNR Farms and southern periphery (Steamboat South and Hidden Valley EIA's) the USACE-estimated with-project 1% ACE flood elevations would exceed the first floor elevations of an estimated 900 existing structures (mostly single-family residences and multiplex apartment buildings). An estimated additional 175 residences that are outside of the USACE without-project 1% ACE floodplain would be within the limits of the with-project floodplain, but it is estimated that their first floors would still be above the with-project flood elevation. The estimated increase in the 2% ACE flood elevations would affect about 22 existing structures south of UNR Farms (Steamboat South and Hidden Valley EIA's), most of which would have an estimated increase of 0.2 to 0.4 foot.

The 1% ACE flood elevation on both sides of the North Truckee Drain (NTD) immediately north of I-80 would be increased by approximately 0.5 to 1 foot due to backwater effects in the NTD.

Population at Risk. As shown by the residual floodplain map, the majority of the flooding reduction occurs in the principal deep flooded areas, which are primarily non-residential. Flooding in most residential areas is fairly shallow, infrequent and has relatively high warning times. Because of this, the population at risk (PAR) living within the floodplains does not change substantially from the without to the with project condition. The table below summarizes the residual PAR, which includes the home raises for NFIP compliance.

ACE Event	Population living within residual floodplain boundary	
	Without	Alt 3
10%	0	0
5%	30	30
2%	2,200	2,000
1%	7,600	5,500
0.50%	27,500	26,700
0.20%	36,400	36,400

I. Managing Residual Risk

Residual risk will be managed using a combination of floodplain management, emergency management, and flood warning systems. These include:

Floodplain Management Plan. A comprehensive floodplain management plan will be developed within one year after the date of signing a project partnership agreement. The plan should address issues such as public outreach, preparedness, and emergency response for both pre- and post-disaster scenarios. The floodplain management plan would also address other issues within the floodplain, including controlling or limiting development, ordinances to ensure flood storage within the floodway, and other concerns.

Emergency management. The Washoe County Emergency Management and Homeland Security operates on a regional level and partners with several other local emergency response agencies to provide preparedness, response, mitigation, and recovery services for the County. An Evacuation, Sheltering and Mass Care Plan, updated in 2010, provide a coordinated response to emergency situations at a local, regional, and national level. The Regional Emergency Operations Center serves Washoe County, Reno, and Sparks as a single, permanently established, ready-to-operate location to perform individual and/or integrated emergency response services in support of jurisdictional emergencies or larger regional emergencies and disasters involving two or more jurisdictions. The Washoe County Emergency Management Program functions as a coordination agency during a disaster, providing such assistance as may be needed by the affected communities to safeguard life and property. The intent is to assess and address the effects of the event and use the Incident Command System as part of the National Incident Management System during the response phase.

Flood Warning systems. The National Weather Service forecast office in Reno provides the watches, warnings, and advisories for the entire study area. Information during the response phase of an emergency is provided by the Emergency Alert System. The Emergency Alert System is the new system adopted by the Federal Communications Commission to replace the old Emergency Broadcast System and is a universal tool to route emergency messages to the public swiftly and efficiently. The Washoe County Emergency Alert System also includes a

Flood Warning System, which is a web-based application enabling flood hazard information to be readily available during flood events as well as for general monitoring purposes.

Emergency Services (police, fire, medical services). The Cities of Reno and Sparks have their respective fire and police departments servicing their city boundaries. Washoe and Storey Counties also provide fire and emergency service throughout their respective counties. Fire service to the unincorporated areas of Washoe County within the project area is currently provided by the Truckee Meadows Fire Protection District, Sierra Fire Protection District, and several volunteer fire stations located within the unincorporated area within Washoe County. The Washoe County Sheriff's Office is responsible for all law enforcement patrol duties in the unincorporated area of the county, the service of civil process, records retention, issuing concealed weapons permits, court security, forensic investigation, criminal investigation, and all search and rescue functions within the county.

FOR CONTINUATION OF HOUSE DOCUMENT 114-24

TRUCKEE MEADOWS, NEVADA: FINAL GENERAL REEVALUATION REPORT AND ENVIRONMENTAL IMPACT STATEMENT, MARCH 2014

SEE PART 2