US Army Corps
of Engineers
Sacramento District

TRUCKEE MEADOWS, NEVADA

GENERAL RE-EVALUATION REPORT PHASE

F3 Milestone Conference

July 1999

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

TRUCKEE MEADOWS, NEVADA
RE-EVALUATION REPORT PHASE
F3 CONFERENCE PACKAGE

CHAPTER I – INTRODUCTION 1
- **STUDY AREA 1**
- **AUTHORITY 1**
- **PURPOSE AND SCOPE 2**
- **STUDY HISTORY 2**
  - **Truckee Meadows Project 3**
    - **Feasibility Study and Authorization 3**
    - **Preconstruction Engineering and Design (PED) 3**
- **PRIOR STUDIES AND REPORTS 4**

CHAPTER II - EXISTING WATER RESOURCES PROJECTS 6
- **TRUCKEE RIVER AND TRIBUTARIES PROJECT 6**
- **RENO FLOOD WARNING PROJECT 6**
- **OTHER PROJECTS 6**

CHAPTER III - PROBLEMS AND NEEDS 10
- **BASIN CONDITIONS 10**
  - **Location 10**
  - **Fish 12**
  - **Population 12**
  - **Land Use 12**
- **FLOODING 12**
  - **Historical Flooding 13**
  - **Influences on Flooding 13**
- **DISCHARGE FREQUENCY 14**
- **FLOOD PLAINS 15**
  - **Probable Failure and Probable Non-Failure Points 17**
- **FLOODING FREQUENCY 19**
- **FLOOD DAMAGES 20**
  - **Property and Businesses 20**
  - **Public Health and Safety 21**

Contamination from Toxic, Hazardous, and Related Waste.....22
Flood Cleanup and Resources Consumption 23
OTHER PROBLEMS AND OPPORTUNITIES.....23
Water Supply.....23
Ecosystem Problems 23

CHAPTER IV - PLAN FORMULATION PROCESS.....23
PLANNING OBJECTIVES.....24
PLANNING CONSIDERATIONS AND EVALUATION CRITERIA.....25

CHAPTER V - RESOURCES MANAGEMENT MEASURES.....25
FLOOD PROTECTION (DAMAGE REDUCTION).....26
Nonstructural Measures.....27
Flood Warning 27
Flood Proofing.....27
Flood Plain Evacuation.....28
New Upstream Storage.....28
Offstream Detention 29
Reoperation of Existing Upstream Reservoirs.....30
Lake Tahoe 31
Stampede, Prosser Creek, and Martis Creek Dams and Reservoirs 32
Redevelopment Measure In Reno.....33
Levees and Floodwalls.....35
Improvements Above Vista Reef.....36
Improvements at and Below Vista Reefs 37
ENVIRONMENTAL RESTORATION AND RECREATION.....37

CHAPTER VI – EVALUATION OF ALTERNATIVES 38
NO-ACTION 39
ALTERNATIVE A: 1988 WRDA AUTHORIZED PLAN 42
ALTERNATIVE B: FLOOD CONTROL PLAN.....42
ALTERNATIVE C: EXPANDED PLAN.....42

CHAPTER VII – STATUS OF GRR STUDY 43
ISSUES.....44
TECHNICAL STUDIES 45
SCHEDULE.....45

ATTACHMENTS

ATTACHMENT 1 ..... HYDROLOGY OFFICE REPORT
ATTACHMENT 2 .....HYDRAULIC DESIGN
ATTACHMENT 3 .....ENVIRONMENTAL ANALYSIS
ATTACHMENT 4 .....RECREATION AND RESTORAT

CHAPTER I – INTRODUCTION

STUDY AREA

The primary study area includes the Truckee River in Washoe County, Nevada, at and below Reno, Sparks, and the Truckee Meadows. The Truckee Meadows encompasses an area along the Truckee River from the central part of Reno on the west to the Virginia and Pah Rah Mountain Ranges on the east (see Figure 1), south along Steamboat Creek to Huffaker Hills, and includes Sparks to the north, as shown on Figure 2.

AUTHORITY

The initial Truckee Meadows (Reno-Sparks Metropolitan Area), Nevada, investigation was authorized under a resolution adopted February 7, 1964, by the Senate Committee on Public Works. The resolution directed an investigation of water resource problems in the Truckee Meadows, Reno-Sparks Metropolitan area, and a project authorization under the Flood Control Act of 1954, which authorized interim channel improvement on the Truckee River and tributaries, California and Nevada, for flood control.

The Truckee Meadows Investigation resulted in a project authorized under the Water Resources Development Act (WRDA) of 1988, 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."*

In addition, authority for this investigation comes from the Conference Report (House Resolution 1905) to the Energy and Water Development Appropriations Act of 1996, which directed the Secretary of the Army to initiate a general reevaluation report (GRR) for the Truckee Meadows Flood Control Project.

PURPOSE AND SCOPE

The GRR is being prepared to define the features, costs, and cost-sharing of a project for continued preconstruction, engineering and design (PED) and construction. This report analyzes the flooding problems and develops alternatives to reduce flood risks. The alternatives include the no action plan and various combinations of structural and non-structural measures. The economic, environmental, and other impacts of the alternatives will be evaluated for economic feasibility and the optimal alternative will be identified. If the optimal alternative is found to be feasible and the plan is still determined to be comparable to the WRDA 1988 authorized plan, the alternative will be recommended for implementation and carried forward to the completion of the PED phase. In the event that the recommended plan is not consistent with the authorized plan, the overall plans will need to be compared and the plan will likely need to be reauthorized by Congress.

STUDY HISTORY

Potential water resources problems, needs, and opportunities in the Truckee Meadows area have been intensively studied by Federal, State, and local agencies. These studies include wide-ranging subjects, including flood control, water quality and supply, fish and wildlife, and habitat evaluation and preservation.

Further flood control investigations included the Truckee Meadows investigation which began in 1965 to determine flood control improvements desired by local interests. A tentative flood control plan consisting of storage facilities on the Truckee River at Verdi, interceptor facilities on Steamboat Creek, and channel improvements in Truckee Meadows was identified. Local interests opposed the plan because it would have conflicted with proposed industrial development at Verdi. A later office study on Verdi Dam and Reservoir and other alternative reservoir sites did not receive State and local support, and the study was suspended in 1970.

In 1974, Washoe County requested the Corps to consider the economic feasibility of lowering the Vista reefs and channelizing the Trucker River. In a reassessment, the Corps determined that a channel enlargement alternative may be feasible. At the request of Washoe County and the cities of Reno and Sparks, the Corps prepared a reconnaissance report in September 1977 indicating that channel modification of the Truckee River between US 395 and Vista might be feasible. In 1978, the Washoe Council of Governments urged the Corps to continue with its studies and concentrate on levee and channel plans.

Truckee Meadows Project

Feasibility Study and Authorization

The Corps completed a feasibility report in 1985 that identified a project, then estimated to be the 1 in 100-year event, designed to pass a flow of 18,500 cfs through Reno. The flood control features of the recommended project included approximately 5 miles of floodwalls, 7 miles of levees, and the replacement of six bridges along the Truckee River. Some channel excavation would be required and a 900-acre detention basin and levees would be constructed to mitigate potential increases in downstream flooding due to upstream flood control measures. Mitigation of adverse effects of the flood control features on fish and wildlife resources would be accomplished through planting of riparian vegetation on 31 acres along the Truckee River and Steamboat Slough. The total estimated (1984) first cost of the project was $74.7 million and estimated first Federal cost was $39.2 million. Project benefits included $9.7 million for flood control and $2.4 million for recreation. The project was authorized by Congress in the WRDA 1988 (Public Law 100-76, November 17, 1988, Section 3, 10) which states: "...the following projects for water resources development and conservation and other purposes are authorized to be carried out by the Secretary substantially in accordance with the plans and subject to the conditions recommended in the respective reports designated in this subsection:...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; 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.".

Preconstruction Engineering and Design (PED)

In fiscal year 1988, PED for the project was initiated. The PED activities included evaluation of the authorized project for changed conditions, current laws, and applicable requirements since the project was initially studied and authorized. One major change under WRDA 1986 was in cost-sharing requirements. Another change was how real estate values are estimated. All lands, including publicly owned lands, must be included in the project cost estimate at fair market value regardless of ownership. As a result, real estate costs estimates significantly increased from the feasibility report. Another major change during PED was due to revised assumptions for determination of project benefits. 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. Another change in the project occurred when Washoe County, one of the local sponsors, requested that the proposed detention basin at the University of Nevada Agricultural Experiment Station farms be replaced with a detention basin at the Huffaker Hills site. The changes to the project features combined with the changed regulations resulted in a revised benefit-cost ratio less than unity, based on the information available at that time. Because the project appeared to lack economic feasibility, it was placed in

a deferred status.

Primarily at the request of Washoe County and Senator Harry Reid of Nevada, the Corps reinitiated investigation into potential flood and related problems and needs in mid-1996. This effort culminated in a reconnaissance study complete in August 1997. The basic conclusions of the reconnaissance study and report was that (1) there continues to be a substantial demonstrated flood problem in the study area, (2) besides 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 the cities of Reno and Sparks and Washoe County support increased flood protection in the area and support continuing PED studies with the first step being conducting a GRR.

PRIOR STUDIES AND REPORTS

Federal

- US Army Corps of Engineers, Truckee Meadows, Nevada, Reconnaissance Reevaluation Report, August 1997.
- US Army Corps of Engineers, Martis Creek Dam, Truckee River Basin, NV and CA, 1995 Test Fill Report, October 1996.
- US Army Corps of Engineers, Truckee Meadows, Reno-Sparks Metropolitan Area, Nevada, Office Report, May 1991.
- US Army Corps of Engineers, Truckee Meadows, Reno-Sparks Metropolitan Area, Nevada, Feasibility Report, February 1985.
- US Army Corps of Engineers, Water Control Manual, Truckee River Basin Reservoirs, Truckee River, Nevada and California, July 1985.
- US 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.
- US Geological Survey, Environmental and hydrologic settings of the Las Vegas Valley area

and the Carson and Truckee River Basins, NV and CA, Water Resources Investigations Report 96-4087, 1996.

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

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.

CHAPTER II - EXISTING WATER RESOURCES PROJECTS

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. 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 from 1,600 cfs to 2,500 cfs at lake level 6,228 ft and from 2,100 cfs to 3,300 cfs at lake level 6229.1 ft; providing downstream channel improvements from Lake Tahoe to Truckee; enlarging the Truckee River channel through Truckee Meadows by widening and straightening to increase the channel capacity from 3,000 cfs to 6,000 cfs; and snagging and clearing from Vista to Pyramid Lake to compensate for increased flows through Truckee Meadows.

RENO FLOOD WARNING PROJECT

The Corps is currently conducting a Section 205 study for the Reno Flood Warning System, Nevada with Washoe County and the cities of Reno and Sparks. The study has resulted in a selected plan which includes expanding the network of gages used for forecasting stages in the mainstem of the Truckee River, adding gages in the tributary catchments and provides 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 would increase 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 would allow 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 is scheduled to be implemented by February 2000.

OTHER PROJECTS

There are numerous lakes and reservoirs in the upper Truckee River watershed. Several that significantly influence floodflows 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 the Corps. The U.S. Bureau of Reclamation (BOR) owns Prosser Creek Dam and

Reservoir and Stampede and Boca Dams and Reservoirs. The Corps and the BOR mutually agree upon the flood control operating principles for the Truckee River basin reservoirs. However, the Corps is responsible for providing the flood control regulations. The physical features for each are shown in Table 2.1, and highlights of each are described 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, nonconsumptive 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 was constructed by the U.S. Bureau of Reclamation (USBR). It 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 5,970.0 feet. The outlet works are located in the right abutment and consist of a trashracked vertical shaft intake structure with sill elevation at 5,765.0 feet. The tower directs flow into a 12-foot parameter 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 under the water surface in the reservoir is at elevation 5,963.0 feet.

Boca Project. The Washoe County Water Conservation District operates Boca Dam and Reservoir, also constructed by the USBR. 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 5,605.0 feet. Boca Dam has a zoned, rolled earthfill embankment, and a rockfilled face. The structure rises about 100 feet above streambed.

Table 2-1
Principal Lakes and Reservoirs Providing
Flood Protection in 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.

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 5,521.0 feet. The capacity of the outlet works is 900 cfs when the water surface is at elevation 5,605.0 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 5,589.0 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 5,605.0 feet.

Prosser Creek Project. The Prosser Creek project was also constructed by the USBR. Prosser Creek Reservoir is about 255 miles long and 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 number 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 5,650.0 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 Project. The Corps constructed the Martis Creek project in 1972 primarily for flood control. Primary features include a reservoir, main dam, spillway, and outlet works. At gross pool (elevation 5,838.0 feet) Martis Creek extends about 2 miles upstream from the dam. The reservoir capacity is 20,400 acre-feet; at this level, the reservoir covers an area of 768 acres. The Martis Creek Dam is a rolled earthfill dam with maximum height above streambed of 113 feet and a crest length of 2,670 feet. The elevation of the top of the main dam is 5,858.0 ngvd; 5.1 feet of freeboard is provided above the spillway design flood pool. The dam has a crest width of 20 feet. The outlet works are located in the right abutment of the dam. A 5-foot by 5-foot shaft intake with sill elevation 5,780.0 feet leads to a 4-foot-square reinforced concrete conduit, which has a discharge capacity of 580 cfs at gross pool (elevation 5,838.0 feet). Two service and two emergency hydraulic slide gates, all 3 feet by 4-feet, are provided for control of flows. The ungated spillway has a crest length of 25 feet and crest elevation of 5,838 feet and is located 600 feet beyond the left end of the dam embankment. Spillway flows discharge through a chute ending in a flip bucket and re-enter Martis Creek at a point below the dam. Martis discharge capacity of the spillway is 4,060 cfs.

CHAPTER III - PROBLEMS AND NEEDS

BASIN CONDITIONS

Location

The Truckee River basin in eastern California and western Nevada as shown on Figure 1 encompasses about 3,060 square miles. The drainage area upstream from Reno includes 1,067 square miles of mountainous terrain on the eastern slope of the Sierra Nevada, the crest of which forms the western boundary of the basin.

The Truckee River begins at the northwestern shore of Lake Tahoe, where flows are regulated by an outlet structure. The river flows from the lake north about 15 miles to the town of Truckee, California, then turns northeast for about 40 miles to Reno, Nevada. Near Reno the river enters a vast meadow known as Truckee Meadows. Below Reno, the river flows about 50 miles east and north to Pyramid Lake, a remnant of prehistoric Lake Lahontan.

Truckee Meadows, the low meadow areas of about 10,000 acres immediately east of the Reno-Sparks Metropolitan area, is at the bottom of a bowl-shaped area about 10 miles wide and 16 miles long between the Sierra Nevada Mountains on the west and the Virginia and Pah Rah Ranges on the east. The walls of the "bowl" rise sharply on all sides.

The cities of Reno and Sparks in Washoe County, Nevada are located in the Truckee Meadows at an elevation of about 4,500 feet above sea level. Sparks is north of the Truckee River and immediately east of Reno in the Truckee Meadows. The topography is relatively flat, and much of the meadows become a flood plain for tributary streams. The flood plain is wide and expansive because a natural reef in the channel near Vista retards outflow of the Truckee River. Through the meadows, the river slope is very slight, with little change in elevation for several miles. Downstream from the meadows, the Truckee River flows through a narrow canyon, which in times of high flow acts as a dam with limited outflow potential. The river through this narrow canyon, often referred to as the Vista Reefs, has been widened and deepened in the past. During high flow, the backwater effect is considerable.

Climate and Precipitation

The upper part of the Truckee River basin is characterized by severe winters and short, mild summers. Precipitation is markedly less than on the western slopes of the Sierra Nevada. The climate within the Truckee Meadows area is generally dry and semiarid. The temperatures are generally moderate; Reno and Verdi have mean annual temperatures of 49 ^{o}F.

Reno's temperature varies from a recorded maximum of about 104 ^{o}F to a recorded minimum of -16 ^{o}F.

Normal annual precipitation over the drainage area between Lake Tahoe and Vista varies from 8 to 70 inches, with a basin mean of 26.5 inches. Precipitation usually falls from December to March as snow above elevation 5,000 feet, but some storms produce rain up to the highest elevations of the basin; snowfall may occur anywhere in the basin. The mean annual precipitation for Reno is 6.94 inches. Total snowfall for the city averages 25 inches per year, but is seldom on the ground for more than 3 or 4 days.

Floods in the Truckee River basin can be divided into three distinct types, general rain floods, cloudburst floods, and snowmelt floods. General rain floods, which occur during November through April, result from general rainstorms covering a large portion of the basin and are characterized by high peak flows and durations of 3 to 6 days. The total volume of runoff from such floods is relatively small.

General storms during the winter season of November through April originate over the Pacific Ocean and must cross the continuous barrier of the Sierra Nevada, which averages 8,000 feet in elevation. In the headwater areas of the Truckee River basin, precipitation associated with these storms is usually snowfall over 1 to 4 days. Local cloudbursts occur frequently in the summer, usually 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 floodflows on the smaller tributary streams, but do not have a major impact on flows in the Truckee River.

Cloudburst floods are characterized by high peak flows on tributary streams with short duration and low volume. These floods occur during the summer, can carry large amounts of debris and sediment, and can cause considerable damage on the smaller tributaries.

Snowmelt floods result from the melting of the snowpack during the late spring and early summer (April through July) and have relatively large volumes and long durations. The distribution of runoff during the flood period is dependent upon the water content of the snow and the variation in air temperatures; the rates of flow are generally higher in May and June. Snowmelt floods are essentially nondamaging in the Truckee Meadows area under existing conditions of upstream regulation.

Vegetation

Vegetation within the Truckee River basin is varied due to the wide range in elevation and

climate. Native vegetation cover types are coniferous forest, pinyon-juniper woodland, chaparral, sagebrush, riparian, marsh, meadow, and greasewood. The Truckee River region contains one of the principal areas of riparian growth in Nevada. A discontinuous ribbon of cottonwoods grows along the river. Removing trees to expand fields and pastures has reduced the width of the riparian habitat along the river. Grazing has tended to limit riparian growth. Much of the streamside vegetation was eliminated during the 1960's when the Truckee River was channelized from Reno to Nixon.

Fish

The Truckee River supports approximately 28 species of fish. Twelve species are sought-after game fish of the study area. Two species have special status designations: the Lahontan cutthroat trout, which is classified threatened on the Federal list, and the cui-ui, which is classified endangered on both the Federal and Nevada lists.

The Truckee River in Nevada from the California State line through Reno is considered good trout water. The principal species of fish in this reach are rainbow trout, brown trout, brook trout, cutthroat trout, mountain whitefish, and mountain sucker.

Population

The population growth in Washoe County, Nevada since 1990 when the last census was compiled shows population estimates of 157,000, 61,000, and 306,000 for Reno, Sparks, and Washoe County, respectively. The population in the urbanized areas of Reno and Sparks is estimated at 218,000. The growth in tourist and industrial business has caused an attraction to Reno and Sparks, resulting in a concentration of 71 percent of Washoe County's population in this area.

Land Use

Much of the Reno-Sparks and Truckee Meadows study area is highly developed. Land use within the area varies and includes residential (single-family, multiple, mobile home), commercial, industrial, public, and agricultural. Single-family residential units are the most numerous housing structures in the entire study area. There are also many multiple residential units (apartment buildings, condominium complexes), and mobile homes in the area. Commercial land use includes retail trade, service-oriented establishments, and motor freight transportation facilities. A majority of the service-oriented establishments, such as

the hotels and motels associated with the casinos, are located in downtown Reno. The Reno/Tahoe International Airport is located on the eastern boundary of Reno. Due to its excellent geographic proximity to the western states, many local and long distance trucking firms have

established offices/terminals in the Reno-Sparks area. Eastern and southern Sparks have a high degree of industrial land use. Manufacturers wholesale trade establishments, and warehouses are located there. Overall, public lands and properties comprise almost one-third of the study area. Public land use includes communication and utility services, as well as transportation, recreation, and educational services.

Agriculture is primarily located in the southern and eastern parts of Truckee Meadows; however, urban development pressures are intensifying in these areas. The main crop is hay, especially alfalfa hay. Much of the land is pasture used for cattle grazing.

FLOODING

Historical Flooding

The Reno-Sparks-Truckee Meadows area has a long history of floods. Early accounts indicate that flooding or periods of high water occurred during December 1861, January and February 1862, December 1867, January 1886, and May 1890. Melting snow, cloudbursts, and heavy general rains causes floods in the Reno-Sparks-Truckee Meadows area. Rain floods, which normally occur during the period October through March (characterized by high peak flows and short duration), have caused the major flood problems in the area. Since 1900, significant damaging rain floods occurred in 1907, 1909, 1928, 1937, 1950, 1955, 1963, 1986, and 1997. Since about 1960, flood control works, consisting of reservoirs and channel modifications, have reduced the magnitude and frequency of flooding in the area. The 1950, 1955, 1986, and 1997 floods were similar in magnitude and were the most damaging because they occurred after residential and business areas of Reno began to spread to the south and southwest.

The November 1950 flood resulted from a rapid succession of warm rainstorms that melted most of the early snow cover. A maximum peak flow of 19,900 cfs was recorded at Reno. The peak flow at Vista was estimated to be about 10,000 cfs. Most of the area flooded was agricultural lands, but many commercial and industrial establishments and residences were inundated. In the Truckee Meadows, floodwaters inundated about 3,800 acres of agricultural lands, and destroyed or damaged crops, farm and ranch buildings, irrigation facilities and utilities.

The December 1955 flood was due to a combination of 15 inches of melted snow on top of 13 inches of rain within a 3-day period. The peak flows recorded at Reno and Vista were 20,800 cfs and 15,000 cfs, respectively. The flood inundated about 9,900 acres and caused severe flood damages in the cities of Reno and Sparks. Damages were reduced by half in comparison to the damages incurred during the 1950 flood event due to advanced preparations, flood fighting, and better channel conditions. The Reno-Tahoe Airport was inundated and air traffic was curtailed for several days.

The storms of February 1986 severely affected northwestern Nevada. The peak flows at Reno ands Vista were 14,400 cfs and 15,200 cfs, respectively. Flood fighting with the use of 500,000 sandbags helped to greatly reduce the flood damages in downtown Reno.

In late December 1996, snowstorms built up a large (more than 180 percent of normal) snowpack in the higher elevations of the Sierra Nevada, as well as in the valleys along the eastern Sierra Nevada front. A subtropical storm system originating in the central Pacific Ocean near the Hawaiian Islands subsequently brought heavy, unseasonably warm rain to the Sierra Nevada on December 30, 1996, through January 3, 1997. The intense rainfall and snowmelt caused devastating floods throughout northern California and western Nevada. The peak flow at Reno was recorded at 18,200 cfs by the USGS. About $450 million in projected damages and two deaths were attributed to floodwaters along the Truckee River. Flooding was extensive in downtown Reno at the Reno/Tahoe International Airport and in the industrial area of Sparks, Nevada.

Influences on Flooding

Lake Tahoe. 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, would a rainflood produce significant releases from Lake Tahoe. Significant releases normally occur well after the peak has occurred at Farad or Reno.

Although the outflow from Lake Tahoe was 10 to 15 percent of the total peak flow at Farad and Reno in 1997, Lake Tahoe outflow typically 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, typically occur during or after the snowmelt season. During the rainflood season, releases from Lake Tahoe exceed 200 cfs less than half the time. Releases of 1,000 cfs or greater occur only about 5 percent of the time. The Lake Tahoe pool elevation exceeded the maximum permissible elevation during the 1997 flood.

Reno/Truckee Meadows Area. The Truckee Meadows area, located south of I-80 and to the southeast of the cities of Reno and Sparks, is subject to severe flooding during periods of high runoff from the Truckee River and its primary tributary, Steamboat Creek. Steamboat Creek originates at the outlet of Washoe Lake, drains the southern and eastern part of Truckee Meadows, and enters the Truckee River near Vista. Evans and Dry Creeks 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 Mount Rose and flow east in steep, narrow canyons to enter the Truckee River east of Reno.

DISCHARGE FREQUENCY

Rain flood flow-frequency curves were updated through water years 1998 at index points at Farad, Reno, and Vista. Frequency curves developed for the Truckee River represent unregulated and regulated conditions of water resource development. Unregulated conditions represent a runoff regime without Boca, Stampede, Prosser, and Martis Creek Reservoirs, but include the effects of Lake Tahoe, Independence Lake, and Donner Lake. Regulated conditions represent the effects of Boca, Stampede, Prosser, and Martis Creek Reservoirs. The 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.

In the 1985 feasibility report, the estimated discharge for the 1 in 100 year event at Reno was computed at about 18,500 cfs. This flow has been used by the Federal Emergency Management Agency (FEMA) to identify areas subject to flooding for flood insurance purposes. However, incorporating hydrologic data since the mid-1980's has resulted in estimated peak flow for specific frequency events higher then primarily thought. Peak flows for certain frequency events are shown in Table III-1. The currently estimated 1 in 100 chance peak flow at Reno in any given year is about 20,700 cfs, in which the discharge- frequency was developed using adjusted criteria in Bulletin 17B.

Table III-1
Estimated Peak Flow
Truckee River at Reno, Nevada [1]

Exceedence (chance of occurrence in any 1 year)	Peak Flow (cfs)
1/20	9,200
1/50	14,800
1/100	20,700
1/500	63,000

The 1997 peak flows used in the hydrology are those provided by the U.S. Geologic Service (USGS). Because of the procedure used by the Corps' to perform a statistical analysis, adjustments to the 1997 peak flow of up to 30 percent would not significantly impact the flow frequency relationships. However, it would impact what the frequency of the 1997 peak flow is based on the regulated peak flow frequency curve. Table III-2 compares the 1997 flood at Reno with the 100-year flood.

Table III-2
Flood Event Comparison - Regulated Condition
Truckee River at Reno
1997 and 100-Year Flood (Computed Probability)

Duration	USGS 1997 Flood Flow (cfs)	100-Year Flood (cfs)	Difference (%)
Peak	18,200	20,700	-12.0
Mean 3-Day	12,686	13,152	-3.5
Mean 7-Day	9,894	9,391	+5.4

The discrepancy in the 100-year peak flow estimate between the Corps and USGS is mainly due to differences in how the statistical analyses are performed. The USGS used a log-Pearson Type III statistical analysis of the gaged peak flows at Farad and Reno for the period 1970-97 (the period after construction of Stampede Dam). This data included

regulation and would exhibit a high level of uncertainty because of the short 28-year record. However, a statistical analysis of regulated flows would not be recommended because regulated data does not generally fit an analytical statistical distribution.

For the purpose of the GRR study, the Corps' statistical analysis is used to evaluate performance of the existing flood control system and any proposed flood control alternatives, as well as complete an economics analysis. To accomplish this task, the Corps' statistical analysis incorporated the period of record (1907-97) with regulation removed. The statistical analysis was performed on the computed, unregulated flows for the peak 1-, 3-, 7-, 15- and 30-day durations. From these volume-frequency relationships, hypothetical unregulated hydrographs for selected frequencies were developed. The hydrographs were then routed through the reservoirs to evaluate the existing system and potential alternatives.

All design flows used in plan formulation are based on regulated condition frequency curves. The regulated and unregulated peak flow-frequency curves for Farad, Reno, and Vista are shown in Figures 3, 4 and 5. The hypothetical regulated peak flows at Vista were derived from the FLO-2D hydraulic model of the Truckee Meadows. A detailed description on the development of the without project hydrology is included in Attachment 1, Hydrology.

FLOOD PLAINS

The Reno-Sparks-Truckee Meadows area experienced high flows and storage of large volumes of water near or within town limits over a dozen times since the early 1900's, and most recently in January 1997. The downtown section of Reno is partially in a steep-banked reach of the river. The reach through downtown Reno, also recognized as the central business district, consists of dense urban development that includes residential, commercial, and public uses; casinos; and hotels. The city of Reno is currently in the process of redeveloping several blocks of riverfront property in the downtown Reno reach. The flood plain will experience a sheetflow of water back into the river from basically two areas where water overflows the banks. During times of high flow, structures within the first several blocks of the river tend to become inundated to up to 6 feet or so when the river more or less flows through this part of town. This flow pattern has been documented more than once in recent times.

The downstream section of the area of interest begins more or less just east of Highway 395. The river emerges from the more channelized upstream reach onto a broad plain historically known as the Truckee Meadows. It is this area that receives the greatest inundation. This 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. This area has several distinct land uses. Included in this reach is the Reno/Tahoe International Airport to the south. Flooding around the airport consisted of sheetflow up to McCarran Boulevard. Also included in this area is the Truckee Meadows and the city of Sparks industrial area. This is one of the most rapidly developing industrial areas and also includes commercial

and public uses. Flooding consists of both ponding and sheetflow. Farther southeast, the land use is predominantly rural cropland and comprises the land owned and operated by the University of Nevada Agricultural Experiment Station. Much of this land is used as pasture. Further south of the University Farms land, the area has grown rapidly over the past few years, and there is additional pressure to further develop the remaining lands, with the exception of the wetlands. Residential subdivisions in this area include Hidden Valley, Rosewood Lakes, Donner Springs, and Double Diamond, to name a few. Flood problems in this area are aggravated by flows from Steamboat Creek and Boynton Slough.

For this study, the area has been geographically broken in two main reaches based on the type of flooding in each area - the area west of Highway 395 including Reno, and the area east of Highway 395 to Vista. The hydraulic analysis of existing flood conditions was performed using the FLO-2D model in-lieu of earlier hydraulic models. The FLO-2D model takes into account flow both down the channel and out into the flood plain. The FLO-2D model estimates of flood flow volume and peak, and flood plain delineation, were felt to be more accurate. The 1997 flood event was used to calibrate the FLO-2D model. The calibrated model was then applied to delineate the flood plain inundation corresponding to the 5, 2, 1, and 0.2 percent chance exceedence flood events. This was accomplished by inputting the hypothetical hydrographs for Reno and the local hydrograph between Reno and Vista. The 1 and 0.2 percent chance exceedence flood events are shown in Figures 6 and 7. The floodplain delineations also included field-mapped and photographed high-water data, aerial photographs, video, and survey. For economic analysis, the flood plain areas were segmented into five sub-reaches. These sub-reaches are described as follows:

- Sub-Reach 1- Mogul to McCarran Blvd West-This reach consists of residential, commercial, public and industrial buildings.

- Sub-Reach 2- Downtown Reno-West McCarran Blvd to Hwy 395, north to Oddle Blvd and south to East Moana Lane - This reach includes casinos, offices, hotels, public and residential areas.

- Sub-Reach 3- South of Interstate 80, east of Reno/Tahoe International Airport - Rosewood Lakes/Hidden Valley- This area contains agricultural wetlands with structures limited to a few homes along perimeter roads. This reach also consists of residential, public and commercial structures further south.

- Sub-Reach 4- Reno/Tahoe International Airport west of McCarran Boulevard- This reach consists of the airport, commercial, and industrial buildings.

- Sub-Reach 5- North of Interstate 80 - Sparks industrial- This reach consists of residential, commercial, public and industrial buildings.

Probable Failure and Probable Non-Failure Points

Levees can fail for several reasons, and it is difficult to predict how and where they will fail. Levees have failed when the stage, or height, of the water surface was significantly below the design flow. In other cases, floodflows have encroached into the design freeboard (or safety level), but without levee breaching or significant damages. Furthermore, floodwater moving at erosive velocities for miles along the waterside slope of the levees need only encounter a single weak spot in the system to cause a breach and, potentially, uncontrolled, life-threatening flooding.

These weak points along the levees were defined by probable non-failure points (PNP) and probable failure points (PFP). The PNP is the highest water-surface elevation at which levee failure is highly unlikely. Conversely, the PFP is the water-surface elevation at which levee failure is highly likely. For this study, the PNP is the point at which the chance of failure is 15 percent; for the PFP, the chance of failure is 85 percent. The PNP and PFP values were based on the results of field inspections and levee performance. For this study area, PNP's ranged from 2 to 5 feet below the levee crown, and PFP's ranged from 0.5 to 1.0 foot below the levee crown.

Two index points (1 and 2) for the two sub-flood plain areas were selected to represent the without-project condition and the weakest area in the levee based on potential levee failure and for the expected annual damages (EAD) evaluation, based on existing hydrologic, hydraulic, and geotechnical information. In addition, a third index point was selected at Tracy, Nevada, to evaluate the need for hydraulic mitigation. These index points are shown in Table III-3.

Table III-3
Index Points

Stream	Area	Index Point	Location
Truckee River	1	1	Near Sierra Street, Reno
Truckee River	2	2	South Rock Blvd, Sparks
Truckee River	---	3	At Tracy Gage [1]

[1] The index point at Vista gage is used for performance analysis for hydraulic mitigation under without and with project conditions.

Through the downtown Reno reach, the effectiveness and stability of the existing floodwalls along the north and south banks of the Truckee River were re-evaluated. Although there was relatively no historical data pertaining to the design and construction of the floodwalls, visual inspections and information from previous studies were used. Visual inspections indicated the occurrence of scouring in numerous locations, specifically along the northern floodwall between Virginia and Lake Streets. The occurrence and effect of undermining on the floodwall

foundation material due to scouring and erosion has reduced the stability of the existing floodwalls. This reduction in stability translated to an increased chance of flooding due to undermining, approximately doubling the probability of flooding in any given year.

Because of the unique geography at the Vista reach, the lowest PNP, translated at South Rock Boulevard index point based on the difference in water-surface elevation, is below the ground elevation. Therefore, the study team used the data from the 1985 flood plains, 1986 and 1997 levee performance, new water-surface elevations, and economic nondamaging frequencies to derive a set of PNP and PFP to represent the reach at the South Rock Boulevard index point. The PNP was set at 1 foot below the top of levee crown, and the PNP was set at 2 feet below the levee crown. Due to the complexity of the flood plain, all flood plain information within each of the two areas has been correlated to stages at index points 1 and 2.

FLOODING FREQUENCY

The estimated probability of flooding in the study area varies from about a 1 in 15 chance for the reaches east of Highway 395. For the downtown Reno reach, the probability of the chance of flooding in any year existing condition is 1 in 45; the reduction in floodwall stability increases the probability of flooding in any year to 1 in 26.

FLOOD DAMAGES

Major flooding in an urban environment has many adverse consequences, including monetary damages and loss of real property. Monetary loss is the primary way of depicting flood damages and assessing the effectiveness of flood protection alternatives. However, floods have many other disturbing, nonmonetary effects. Among these are effects on public health and safety, damages from toxic and hazardous waste contamination, and loss of environmental resources in the flood plain. Following are brief descriptions of potential monetary and nonmonetary consequences of flooding in Truckee Meadows area.

Property and Businesses

Damageable property in the Truckee Meadows flood plain consists of commercial, industrial, residential, and public buildings. Additional effects on the day-to-day business of the Reno-Sparks Metropolitan area would be significant. Many businesses would be forced to close, at least temporarily, during flooding and cleanup afterward, resulting in lost revenues and wages. Estimates of existing structures within the flood plains are shown in Table III-4. Residential structures comprise the largest portion of the total followed by industrial and commercial units.

The total depreciated values of property in the 500-year flood plain for all existing structures and contents by land use equal $3 billion as shown in Table III-5. Estimates for future growth were not included in this study.

Table III-4
Total Number of Damageable Units in the Study Area

LAND USE	500-year	100-year	50-year	20-year
Residential	22,842	4,147	1,712	1,004
Commercial	1,898	537	124	62
Industrial	786	469	311	86
Public	64	26	12	6
Total	25,590	5,179	2,159	1,158

Physical damages caused by inundation losses or flood fighting preparation costs are the main types of flood damages within the flood plain. 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.

Table III-5
Value of Damageable Property in the Study Area
for the 500-Year Flood Plain
($1,000, Oct 99 price levels)

Sub-Reach	Residential	Commercial	Industrial	Public	Total
1	20,800	230,000	700	35,800	287,300

2	1,700	99,700	447,700	0	549,100
3	122,700	415,000	352,100	2,500	892,300
4	0	62,700	632,600	900	696,200
5	224,200	41,200	175,200	600	441,200
6	4,800	0	0	4,000	8,800
TOTAL	482,300	857,800	1,608,300	57,800	3,006,200

Estimates of equivalent annual flood damages (EAD) were determined by weighing the estimated damages from varying degrees of flooding by their probability of occurring. Flow frequency, flow stage, and PNPs and PFPs were incorporated with stage-damage curves to estimate the EAD. The types of damages evaluated include structure (residential, commercial, industrial, public, and casino related), contents (household items, furniture, office equipment, merchandise), agriculture, emergency costs, roads, automobiles, and traffic disruption. Residential and industrial structures and contents appear to make up a majority of the damages.

Estimated annual damages are _____ million based on October 1999 prices for existing without-project conditions.

Public Health and Safety

Nearly 218,000 people reside within the flood plain of the cities of Reno and Sparks. The effect of levee failure and resultant flooding on human life would depend on the flood magnitude, population at risk, flood warning time, and evacuation routes. It would not be unreasonable to expect as many as 25 fatalities during a very large flood. In addition to loss of life, major flooding could result in life-threatening injury and spread of some communicable diseases. Just evacuating the flood plain in anticipation of a flood could result in traffic accidents and other injuries associated with the rapid displacement of nearly 218,000 people.

Contamination from Toxic, Hazardous, and Related Waste

Flooding would result in significant releases of toxic and hazardous substances from above-ground tanks and drums containing heating oil, fuel oil, liquid propane, and kerosene; agricultural chemicals such as herbicides, pesticides, solvents, and fertilizers; many commercial and industrial chemicals; and untreated wastewater. Widespread flooding could also result in ground-water contamination.

Flood Cleanup and Resources Consumption

Major flooding would likely generate larger quantities of flood-related debris, most of which would have to be hauled to local landfills. Also, rebuilding or relocating homes, businesses, and related infrastructure would require additional natural resources.

OTHER PROBLEMS AND OPPORTUNITIES

Water Supply

Sierra Pacific Power Company provides water service to a majority of the present population of the Truckee Meadows area under a water service franchise. Future water needs associated with increased urban development are projected to exceed water rights currently owned by Sierra Pacific. It is projected that the city of Reno will need over 70,000 acre-feet of water a year by the year 2000; the current supply is over 43,000 acre-feet (1985).

Ground water can be pumped during a drought year at a safe yield of 12,000 acre-feet a year, according to Sierra Pacific Power Company. However, in recent years ground water had been pumped at a rate higher than that recommended by Sierra Pacific for drought years.

Ecosystem Problems

The rapidly expanding industrial and residential development and farming in Truckee Meadows have resulted in a loss of valuable fish and wildlife habitat along the Truckee River. Below Vista, the Truckee River still supports a somewhat marginal population of coldwater fish. The threatened Lahontan cutthroat trout and endangered cui-ui require special management considerations for population recovery. Basic habitat quality problems are water temperature and nutrient load. Over the years, the marshlands, seasonally flooded areas, and riparian vegetation along the Truckee River and Steamboat Creek have been greatly reduced. Over half of the bird species present in the study area are dependent upon riparian and marsh vegetation as a major habitat component.

As part of the environmental studies, a bird survey along the Truckee River and a Habitat Evaluation Procedure (HEP) analysis on baseline conditions have been completed. The HEP prepared by the U.S. Fish and Wildlife Service in 1993 will also be utilized. Restoration features will be evaluated to assist in the recovery of the endangered cui-ui, and threatened Lahontan cutthroat trout, migratory waterfowl, as well as re-institution of more suitable instream flow to the Truckee River to benefit the endangered cui-ui and assist in the recruitment of cottonwood seedlings. The wildlife restoration plan is likely to be centered around setback levees downstream of highway 395 and along Steamboat Creek.

CHAPTER IV - PLAN FORMULATION PROCESS

Plan formulation is the process of developing a range of plans to resolve the flood problems and, if possible, related water resource needs (environmental restoration and recreation). Federal criteria must be followed in evaluating individual flood protection measures, which are then combined into alternatives that best address the planning objectives. Finally, the alternatives are compared, and the plan that maximizes national economic development (NED) benefits is identified and a plan will be recommended for construction. Deviations from the NED plan are allowed if justified and supported by the non-Federal cost-sharing partner. Numerous measures and alternatives have been formulated from prior studies and again were reevaluated during the reconnaissance reevaluation study completed in 1997. The Truckee Meadows, NV General Reevaluation Report (GRR) phase encompasses previous planning objectives and criteria taking into account the changing conditions in the study area. During plan formulation for the Truckee Meadows GRR Investigation, the following methodology are being used in formulating and selecting a plan to be recommended for implementation:

· Define flood and related water resources problems and needs in the study area.

· Establish specific planning objectives to address the problems and needs.

· Identify management measures and complete alternative plans to address the planning objectives.

· Compare and evaluate the alternative plans and select a plan to recommend for implementation.

PLANNING OBJECTIVES

Planning objectives were established to serve as guidelines for formulating and evaluating plans to address the problems and realize the opportunities identified in the study area. The following objectives were used to formulate flood protection alternatives:

- Reduce flood damages to residential, commercial, industrial, public, and

agricultural properties in the Reno-Sparks Metropolitan area from overflows of the Truckee River and its tributaries. The parameters utilized to measure the contribution of each plan to this objective are reduction of inundation damages and/or minimization of residual inundation damages.

- Preserve or restore environmental resources along the Truckee River compatible with the flood control objective.

- Enhance recreation opportunities incidental to the other objectives.

PLANNING CONSIDERATIONS AND EVALUATION CRITERIA

Water and related land resources plans are formulated to alleviate problems and take advantage of opportunities at the National, State, and local levels in ways that contribute to the NED objectives. The following criteria relate to the problems and opportunities in the Reno-Sparks Metropolitan area and provide the basis for objectively and consistently evaluating the alternatives.

· Completeness, or the extent to which an alternative provides and accounts for the investments and actions necessary to ensure that planned effects are realized and are capable of being physically implemented.

· Effectiveness, or the extent to which an alternative alleviates specified problems and achieves the specified objectives, including fully compensating or offsetting adverse hydraulic impacts to other areas (i.e., not induce flooding or increase the risk of damaging flooding in adjacent areas).

· Efficiency, or the extent to which an alternative plan is the most cost-effective means of alleviating specified problems and realizing opportunities, consistent with protecting the Nation's environment.

· Acceptability, or the workability of an alternative with respect to acceptance by the public, State, and local entities and its compatibility with existing laws, regulations, and public policies.

CHAPTER V - RESOURCES MANAGEMENT MEASURES

FLOOD PROTECTION (DAMAGE REDUCTION)

After numerous coordination meetings with the local sponsor and other entities, a number of flood control measures, both nonstructural and structural, have been identified to help formulate a plan to increase the level of flood protection from Truckee River overflows. The structural measures included upstream detention, offstream detention, reoperation of upstream reservoirs, channel and levee modifications above Vista Reefs, and channel improvement at and below Vista Reefs to pass larger flows along the Truckee River. Information from previous studies was also utilized and price levels were updated in order to aid in the formulation of initial measures until technical information is updated as part of the GRR study.

Nonstructural Measures

The threat floods pose on human life cannot be expressed in dollar amounts. The dilemma of the continuing threat to human life, mounting flood damages, and ever increasing costs for flood control structures results from the fact that we encroach upon lands subject to flooding, otherwise known as flood plain lands, more rapidly than flood control projects can be built. Further, we can reasonably expect future floods to be greater than those for which most project can economically be built.

Nonstructural measures were considered in accordance with Corps' regulations, which require that a nonstructural plan be included in a full array of alternatives. Most structural flood damage reduction measures are directed at the source of flooding. Their purpose is to change the direction of floodflows, decrease the area of inundation, alter the timing of floodflows, or store floodflows. In contrast, most nonstructural measures are directed at flood damage reduction of individual property through land use restrictions and other actions. In order to protect lives and prevent or minimize flood damage, a flood plain management approach can be used that involves control over the use of flood plain lands, separately or in combination with control of floodwaters by ways of conventional measures, nonconventional measures, or a combination of these approaches. Conventional measures involve control of floodwater by dams, levees, channel modifications, or other structures. Nonconventional measures involve control over the use and development of flood plain lands by zoning ordinances, building codes, subdivision regulations, and other related measures such as flood proofing and temporary and permanent evacuation, and flood warning systems. Objectives of flood plain management include reducing the loss to existing developments, reducing the impact of remaining problems, restoring lost natural resource values, recreation

and open space, and groundwater recharge. Ultimately, the power to control the uses of flood

plains rests with the local governments.

The goal of nonconventional measures is to mold flood plain use and development in such a way that flood hazards are reduced and flood damages are minimized without changing the flood plain. The nonstructural measures that were identified for further analysis include (1) flood warning, (2) flood proofing, and (3) flood plain evacuation.

Flood Warning

The Corps is currently coordinating a Section 205 study for the Reno Flood Warning System, Nevada with Washoe County and the cities of Reno and Sparks. The study has resulted in a selected plan which includes expanding the network gages used for forecasting stages in the mainstem of the Truckee River, adding gages in the tributary catchments and provides 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 would increase 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 would allow 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 Flood Warning System is scheduled to be implemented by February 2000.

Flood Proofing

Flood proofing structures involves raising existing structures so that habitable portions are above the expected flood level. Flood proofing could also involve the construction of walls or levees around individual homes or pockets of homes to hold back floodwater. For developed portions of Truckee Meadows, there is nowhere to construct a "ring levee" system without extensive relocations. Raising structures above the flood level is possible if the lower portion of the structure is used only for parking or storage. The lower portion is expected to flood and is designed to equalize hydrostatic flood forces on exterior walls by allowing entry and exit of floodwater. An analysis was completed on the American River project in Sacramento, which includes extensive development in the flood plain and has similar flooding problems to the Truckee Meadows. Estimates of costs were established to raise a typical slab-on-grade house 5 feet above grade, including all finish work. From the floodplain analysis, there are an estimated 4,100 residential structures in the flood plain with a 1 percent chance of flooding. Therefore, the cost to raise residential structures would be about $82 million to flood proof only a portion of the structures located within the flood plain.

Flood Plain Evacuation

For flood plain evacuation, which includes evacuating buildings from 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 involves the acquisition of lands by purchase (through the power of eminent domain if necessary), removal of improvements, and relocation of the population. Lands acquired in this manner could be devoted to agriculture, parks, or other uses that would not interfere with floodflows. Evaluation on the feasibility of nonstructural measures is done on a structure by structure basis. The factors used in assessing the costs and benefits of flood plain evacuation are:

- Replacement of structure in-kind
- Acquisition of land and additional lands if relocating structure to higher ground
- Demolition costs associated with removal of slab, asphalt
- Costs associated with cleanup of hazardous or toxic waste
- Design and construction costs associated with relocated building
- Potential economic losses associated with the time required to relocate the structure

Two structures were looked at in detail for floodplain evacuation at the downstream end of the study area and adjacent to the Truckee River: Sparks Auto Wrecking located at Larkin Circle and East Sparks Industrial building located at Spice Island Drive. Information was obtained from the Washoe County GIS database and real estate assessor's rolls on the value of structures and land. For the Sparks Auto Wrecking located on about 6 acres of land, the value of structures was estimated at approximately $204,000 and the land value with improvements was approximately $3 million. For the east Sparks Industrial buildings located on about 22 acres of land, the value of structures was approximately $2.4 million and the land value was approximately $7.6 million. The costs to relocate these structures from just land acquisition costs, not to mention the other costs associated with relocation of these structures, would far exceed the benefits from the reduction of flood damages.

Flood proofing or flood plain evacuation of structures from the flood plain would not be economically feasible and will not be considered for further evaluation due to the large flood plain, large numbers of residential, commercial, industrial, and industrial structures in the flood plain, high flood depths, and the high costs associated with flood proofing or flood plain evacuation. However, the Reno/Sparks Metropolitan area participates in the National Flood Insurance Program (NFIP) and any future developments are required to be constructed above FEMA's base flood elevation. Increased efforts in flood plain zoning restrictions are being considered by numerous non-Federal entities and are likely to be implemented under either without- or with-project conditions that would apply to future construction, but would not affect existing structures.

New Upstream Storage

Several relatively large capacity upstream detention storage facilities along the Truckee River. The majority of the sites are located within California. Table V-1 and Figure 8 show a summary of the upstream storage dams and reservoirs previously evaluated by the Corps in

previous studies to reduce floodflows through Reno and Sparks as well as to reduce likely scope of structural flood control measures needed to pass floodflows through the developed areas.

The existing risk of flooding in Reno is 1 in 26 chance in any year. As shown in Table V-1, the upstream detention dams could result in increased level of protection in Reno ranging from a 1 in 45 to a 1 in 100 chance of flooding in any year. Very preliminary construction costs (less lands, easements, rights-of-way, relocation, and environmental mitigation) were updated to 1998 price levels and would range from about $33 million for a relatively low increased level of flood protection to about $652 million for a 1 in 100 chance of flooding in any year. It is believed that once other costs are added, the total costs significantly exceed potential flood damage reduction benefits. In addition, based on recent planning experiences in other areas, it is unlikely that there would be the degree of institutional support necessary to improve a flood detention dam on the Truckee River or other major tributary. Accordingly, because of the estimated lack of economic feasibility and likely difficulties in implementing any upstream detention storage, this measure is not being considered for further study.

Table V-1
New Upstream Storage Evaluated Previously

Site	Percent Chance of Exceedence in any year	Description	Cost Without LERRDs or Mitigation[1] ($ million)
Lawton Dam and Reservoir	1 in 100	Located on the Truckee River about 3.5 miles upstream from Reno; 35,000 acre-foot reservoir with earthfill dam; relocation of about 7 miles of SPRR track required; reconstruction of 1 mile of Interstate Highway 80; and abandonment of the existing Washoe powerplant.	$238
Hirschdale Dam and Reservoir	1 in 75	The 28,000 acre-foot dam and reservoir would be located on the Truckee River 1 mile downstream from Hirschdale with earthfill dam; relocation of about 5.5 miles of SPRR double track; reconstruction of 1 mile of Interstate 80.	$109
Truckee Dam and Reservoir	1 in 45	Located on the Truckee River near the town of Truckee, California, a 38,000 acre-foot reservoir with earthfill dam; relocation of about 6 miles of SPRR double track; reconstruction of 1 mile of Interstate 80.	$130
Gateway Dam and Reservoir	1 in 45	This 20,000 acre-foot reservoir and dam would be constructed on the Truckee River near Gateway, 1 mile upstream from the town of Truckee; relocation of about 5.5 miles of State Highway 89.	$65
Truckee River Tributary Reservoirs above Reno	1 in 45	Storage on tributary streams, such as Dog Creek, Hunter Creek, Bronco Creek, Gray Creek, and other small tributaries upstream from Reno, as many as 10 reservoirs required to provide control equal to storage on the main stem, since the drainage areas are a small percentage of the total drainage basin.	$65 each or $652 total

[1] Relative construction costs were derived as part of Truckee Meadows Investigation updated to 1998 price levels. Neither land costs nor environmental mitigation were included.

Offstream Detention

Two types of small-scale temporary detention storage were considered in the study area along the Truckee River immediately upstream from Reno as shown on Figure 9. They include (1) side-channel detention which is a diversion of riverflow through a weir into a detention basin adjacent to the river channel and (2) off-channel detention which is a diversion of the river through weir and channel into a detention basin located near the river.

For both the side-channel and off-channel detention basins, gravity-feed diversions and pumped diversions were considered. Gravity-feed diversions entail construction of a diversion channel that is at, or near, the riverbed grade. The detention basin would need to be excavated and levees placed as needed around the basin to retain the water due to the slopes. A weir would control inflow to the basin; water would not enter the basin unless the water surface in the river exceeded the weir elevation. For example, the elevation of the weir could be set so that flow would not enter the basin until the Truckee River exceeded 15,000 cfs. Flow would be returned to the river through an at-grade channel or pipe. Pumped diversion would require installation of a fish screen at the mouth of the diversion. Diverted water would then be pumped to the diversion basin. Water would be returned to the river via a gravity-feed channel.

A 140-acre side-channel diversion was identified within a sharp bend in the Truckee River, near Truckee and the mouth of Union Valley. The majority of the overbank area within the bend could be included in an impoundment area. Some excavation of the site would be needed to lower the area to the approximate level of the diversion weir. Construction of 22-foot levees would provide up to 2,800 acre-feet of storage. Water would be diverted through a side weir when the depth exceeds a certain point. Estimated construction costs for this measure, not including land and environmental mitigation costs, range from about $25 million for a pump inlet to about $76 million for a gravity flow diversion.

Off-channel storage was considered at three locations along the Truckee River. One site (East Truckee site) was located near the confluence of the Truckee River and Martis Creek. The second (North Flat site) was located near Verdi, just downstream from the confluence of Bull Ranch Creek and the Truckee River. The third (Fleish site) was located just upstream from Verdi. Estimated costs, excluding land costs, for developing a 13,600 acre-foot facility at the East Truckee site range from about $110 million for a pump inlet concept to over $430 million for a gravity feed concept. Costs for developing a 1,800 acre-foot basin at the North Flat site range from about $13 to $27 million, excluding land costs. Costs for a 1,600 acre-foot basin at Fleish would be about $8 million, excluding land costs.

Based primarily on the excessive real estate costs and/or only a slight reduction in the percent chance of exceedence to Reno is realized, this measure was eliminated from further consideration in this report.

Reoperation of Existing Upstream Reservoirs

Expanding the flood control capacity of Lake Tahoe and modify spillways at Stampede, Boca, Prosser Creek and Martis Creek Reservoirs to help minimize overbank flooding downstream from these facilities was re-evaluated for this study. Boca Dam was not evaluated because no additional storage is available for flood control.

Lake Tahoe

A re-evaluation of Lake Tahoe storage and releases during large flood events was completed in order to determine whether Lake Tahoe could effectively be operated for flood control with no significant adverse impacts to Lake Tahoe development or to the revised Truckee River Operating Agreement. A coincident frequency analysis was completed to determine the combined frequency of high lake stages and large rainflood events. This analysis included coordination with the Federal Watermaster and other interested/affected entities.

Criteria was developed by which a precautionary release would be made from Lake Tahoe storage to free up a volume sufficient to absorb inflow for a period suitable to remove the Lake Tahoe contribution from the peak flow at Reno. Using January 1997 as an example, the peak flow at Reno absent Lake Tahoe release would have been approximately 15,700 cfs. The flow at Reno for this event was above 15,700 cfs for 25 hours. During this 25 hours, the average release from Lake Tahoe was 2,410 cfs, equivalent to a volume of about 5,000 acre feet. The Lake Tahoe release during this event was the maximum recorded release during the time of peak flow in the Truckee River at Reno. If an equivalent volume had been released earlier, Lake Tahoe release could have been curtailed during the period when Reno flow exceeded 15,700 cfs, thereby reducing the peak flow at Reno from 18,200 cfs to 15,700 cfs without increasing the Lake Tahoe water surface elevation above that which actually occurred as can be seen in Figure 10.

The January 1997 flood event was also unique in that historical record of the discharge at the dam at Tahoe City showed that since the completion of the current dam, the discharge had exceeded 2,000 cfs in only 5 out of 86 years as shown in Table V-2.

Table V-2
Historical Occurrences of Lake Tahoe Outflow in Excess of 2,000 cfs
(Period of Record: 1913-1998)

Water Year	Peak Mean Daily Flow (cfs)	Number of Days Mean Daily Flow above 2,000 cfs
1969	2,620	8
1984	2,320	59
1986	2,410	33
1996	2,210	3
1997	2,630	82

Using January 1997 as a guide, the following procedure was evaluated in terms of a precautionary drawdown procedure for Lake Tahoe. The goal of this procedure is to remove Lake Tahoe's contribution to the peak flow at Reno without negatively impacting Lake Tahoe's water surface elevation. It is not designed to prevent the lake level from exceeding the legal limit of 6,229.1 feet if that were to occur absent the procedure. The procedure defines criteria that would be used in making the following two decisions: 1) whether or not to make the precautionary release, and 2) whether or not to curtail the Lake Tahoe release and when. The decision making criteria are as follows:

1. Criteria to Initiate Precautionary Release
    a. Lake Tahoe water surface elevation greater that 6,227.5 ft. (Lake Tahoe datum).
    b. Long-term weather forecast indicates potential for significant subtropical storm event.

2. Criteria to Require Curtailment of Lake Tahoe Release
    a. Truckee River at Reno discharge is forecast to exceed 15,700 cfs in 14 hours. The 14 hour forecast provides a 3 hour buffer based on the Lake Tahoe to Reno travel time of 11 hours.

The January 1997 event precautionary release volume was estimated at 5,000 acre feet, which is equivalent to a 1,000 cfs release for approximately 60 hours or a 1,500 cfs release for 40 hours. In using the January 1997 volume of 5,000 acre feet, the Lake Tahoe precautionary release procedure would be unlikely to have negative impacts on water supply. The following would need to occur for there to be any water supply impacts:

- The precautionary release of 5,000 acre feet is made.
- The anticipated storm does not occur and that which does occur is insufficient to restore the 5,000 acre feet.
- The above occurs at the beginning of a long-term drought similar to that which occurred from 1987 through 1994.

Preliminary analysis indicates that this measure could result in a decrease in the likelihood

of flooding in Reno by a 1 in 4 chance in any given year. Although it would be a very rare occurrence and the net increase in flood protection is relatively small, this measure appears to be highly economically feasible and is being evaluated further.

Stampede, Prosser Creek, and Martis Creek Dams and Reservoirs

This measure consists of increasing the effective flood control storage space in Stampede, Prosser Creek, and Martis Creek Reservoirs. At Stampede and Prosser Creeks, the analysis consists of increasing the capacity by raising and lengthening the existing spillways. At Martis Creek, the analysis includes increasing the allowable flood control storage space by 5,000 acre-feet.

Spillways are not gated at Stampede and Prosser Creek Reservoirs. Raising the spillways provides an increase in storage space in the reservoirs before the spillway crest is overtopped. Both a 5-foot and a 10-foot raise were considered at each reservoir. A 5-foot spillway raise at Stampede and Prosser Creeks results in an increase of about 17,600 and 3,900 acre-feet of storage, respectively. A 10-foot raise results in an increased capacity of about 36,000 and 8,300 acre-feet, respectively. The spillways at both dams would require lengthening to ensure maintenance of the without-project outlet capacity and outflow at gross pool elevation.

Preliminary costs to raise the spillway at Stampede for a 5- and 10-foot raise were estimated at $10 million and $36 million, respectively. At Prosser Creek, the costs were about $8 million and $60 million, respectively. Reoperation and spillway raising of Stampede and Prosser Creek Dams and increasing the allowable flood control storage in Martis Creek Reservoir would only provide benefits during high frequency events; for example, 1 in 400 chance of occurring in any given year. No increase in flood benefits during low frequency events (1 in 100 chance) would be realized. This measure would not provide any benefit during floods of magnitudes equivalent up to about the 1 in 100 chance event. This effect was experienced in January 1997 because no releases were being made into the Truckee River from Prosser, Boca, and Stampede Dams, which would have added to the maximum flows at Reno. About 300 cfs released from Martis Creek Dam added to the peak at Reno; however, inflows were over 2,000 cfs at the time. This release was made to limit the rate of rise of the Martis Creek Reservoir pool. The remaining flow was due to releases from Lake Tahoe (about 2,400 cfs, or 10-15 percent of the peak at Reno); the uncontrolled local areas above Reno and below Lake Tahoe contributed most of the flow. With a 10-foot spillway raise at Stampede and Prosser Creek Dams, there would be no change in peak flows through Reno at the 100-year frequency event; at the 200-year event, the peak flows through Reno would be lower by 200 cfs.

Currently, the maximum allowable water-surface elevation at Martis Creek Reservoir is 5,810 feet. An increase of 5,000 acre-feet (to 11,000 acre-feet) would require raising the maximum pool elevation to approximately 5,823 feet. The modifications required to safely accommodate this higher storage would be extensive.

Due to the high costs associated with the spillway raising and the insignificant increase in flood protection downstream from the facilities, these measures were not considered further.

Redevelopment Measure In Reno

The flood control measures for the downtown Reno reach extend from Booth Street to Wells Avenue. The existing structures and flood control facilities through the downtown reach are as follows: Booth Street Bridge, Keystone Avenue Bridge, Arlington Avenue Bridge (North and South), Sierra Street Bridge, Virginia Street Bridge, Center Street Bridge, Lake Street Bridge, East 2nd Street Bridge, Keunzli Street Bridge, and floodwalls. The existing flood control facilities are unable to provide protection from a 1 in 100 chance of flooding. The existing floodwalls and embankment heights are unstable and are insufficient to provide consistent protection through the reach. All bridges through this reach, with the exception of the Center Street bridge, do not have adequate cross sectional flow area to pass up to the 1 in 100 percent chance exceedence flood event.

Some of the measures being evaluated include increasing the channel capacity by laying back or terracing back floodwalls adjacent to the channel, thus providing the potential to carry more water in the channel during flood stage; channelization by reconstructing the channel immediately upstream of the Arlington Avenue, Sierra, and Virginia Street Bridges; placing wide culverts at each end of the bridges under the first street adjacent to the bridge in order to pass additional floodflows through the bridges; and removing existing bridges and replacing them in-kind or with new spans over the entire terraced river. These bridges would be above flood stage, and their foundations would be out of the river channel. The Virginia Street Bridge is listed on the National Registry. In addition, other objectives through the downtown Reno reach include preserving the aesthetic values along the Truckee River, such as recreation areas, existing parks, and cultural areas.

Criteria to the problems and opportunities provided a basis for evaluating the measures through the downtown Reno reach are as follows:

- Low Operation and Maintenance (O&M) - The measures should emphasize low operational requirements and annual maintenance costs.

- Emergency Operations - Measures should consider and accommodate the flood warning system.
- Residual Land Values - The measures should preserve or enhance the residual land values of the properties adjacent and in proximity to the Truckee River in downtown Reno to ensure designs are compatible and complimentary to the redevelopment plans.
- Debris - The measures should minimize the effects of debris accumulation during flood events.

Seven options have been retained for further evaluation to increase the safe channel carrying capacity of the Truckee River through downtown Reno and reduce the chance of flooding in the study area to 1 in 100 in any given year. The options are as follows:

- Option 1 - Bridge Replacement at Sierra, Virginia and Lake Streets, traditional vertical floodwalls, channelization, and culverts at the new bridges.
- Option 2 - In-kind Bridge Replacement at Sierra, Virginia and Lake Streets, traditional vertical floodwalls, channelization, and culverts at the new bridges.
- Option 3 - Bridge Replacement at Sierra, Virginia and Lake Streets and traditional vertical floodwalls.
- Option 4 - Bridge Replacement at Sierra, Virginia and Lake Street, traditional vertical floodwalls and culverts at the new bridges.
- Option 5 - Bridge Replacement at Sierra, Virginia and Lake Streets, traditional vertical floodwalls and channelization.
- Option 6 - In-kind Bridge Replacement at Sierra, Virginia and Lake Streets, terraced floodwalls, channelization, and culverts at the new bridges.
- Option 7 - In-kind Bridge Replacement at Sierra, Virginia and Lake Streets, aesthetic vertical floodwalls, channelization, and culverts at the new bridges.

Levees and Floodwalls

Improvements Above Vista Reef

This measure consists of constructing new levees and floodwalls and modifying the channel to allow passage of an increasing amount of floodflows through the study area. After further coordination with the sponsor, a need to preserve the flood plain and remaining open space was identified. Although the flood plain has been rapidly developing, there are open space/agricultural areas south of the Truckee River downstream of Greg Street and within the University Farms area. Along with reducing the risk of flooding, there is a potential to incorporate recreation features and environmental restoration features within a setback area. If environmental restoration features can be incorporated into a setback levee

area, consistent with the flood control objective, some of the costs associated with the setback levee may be allocated toward environmental restoration purpose. This could influence the cost/benefit.

Two measures have been selected to be evaluated further: (1) levees and floodwalls that closely followed the WRDA 1988 project alignment downstream of highway 395, and (2) a setback levee alternative that incorporates setback levees south of the Truckee River between Greg Street to McCarran Boulevard and channel benching up to 300 feet downstream of McCarran Boulevard to Vista. Five separate water surface profiles were developed for each of

the two measures in order to compare costs versus benefits and identify the optimal plan size. The two measures include flood protection features and updated design assumptions and construction concerns based on current conditions.

In the authorized Truckee River Project, a detention storage facility at University Farms was included in the project to lessen potential induced flooding along the Truckee River downstream from Vista. However, at the request of the local study sponsor in 1991, an alternative 6,300 acre-foot flood-control-only detention basin at Huffaker Hills with a diversion tunnel was suggested for consideration. The detention basin would be located on Steamboat Creek approximately 5 river miles upstream from the Truckee River confluence. The Huffaker Hills site was reconsidered as part of this study. However, it was determined to be economically unacceptable. The Huffaker Hills area is experiencing rapid residential and commercial development growth and real estate costs are nearly fourteen times that of University Farms. In addition to high real estate costs, geologic investigations revealed that materials at the damsite are not suitable for a dam foundation. Four earthquake faults are known to occur along a needed diversion tunnel alignment. The geologic investigations revealed that additional support would be required for the tunnel because of the shallowness of the cover and unknown variables, such as weathering, fracturing and other physical properties.

The University of Nevada, Reno (UNR) is in the process of developing a master plan for education and research purposes within the University Farms area. Future development proposals would include a research park/biotechnology center located in the northwestern portion of the Farms area. The close proximity of the Farms area to the University campus is a major factor in the master planning. Close coordination with UNR is ongoing for development of a feasible project that would have a minimal effect on the use of their lands.

This measure was retained for inclusion in flood protection plans to include a detention basin at UNR Farms.

Improvements at and Below Vista Reefs

This measure consists of increasing the channel capacity at the downstream end of the study area from McCarran Boulevard to the Vista Reefs by placing a benched area south of

the Truckee River, up to 300 feet wide. The benched area would act as an overflow area with the purpose of reducing the amount of backwater that occurs at Vista, due to both Truckee River and Steamboat Creek floodflows, and potentially reduce the amount of structural measures needed through the upstream reaches. The Vista Reefs are located at the downstream end of the study area and consist of a bedrock outcrop that provides a fixed point on the riverbed. The river cross section narrows as the river enters the Truckee River Canyon. These horizontal and vertical controls of the cross section constrict the movement of water out of the Truckee Meadows and into the canyon. There have been efforts to improve the flow past Vista by lowering the elevation of the outcropping. Recent studies have indicated that these past actions have resulted in downcutting of the Truckee River up to 15 feet up at McCarran Boulevard. Potential downcutting

of the channel is being evaluated as part of the hydraulic analysis. Because the Truckee River backwater extends a significant distance up both of the river and Steamboat Creek, any improvement in Truckee River backwater would reduce the extent of flooding. This measure is currently being evaluated with the hydraulic model to determine the extent of hydraulic impacts downstream of the reefs and the effectiveness of the widening the reefs from a economic standpoint.

In summary, the measures that were retained for further evaluation to incorporate into alternatives include flood proofing/ flood plain evacuation, Lake Tahoe precautionary release, flood control options through the downtown Reno reach, levee and floodwall options between Hwy 395 to Vista, setback levee/floodwall downstream of Vista, and improvements at and below Vista Reefs.

ENVIRONMENTAL RESTORATION AND RECREATION

The following environmental restoration measures are being evaluated to increase the habitat values along the Truckee River.

- Restore fish and wildlife habitat sites along the Truckee River with riparian vegetation planting on eroding banks and berms.

- Remove structural barriers to migration of terrestrial and aquatic species. Structural barriers should be removed or modified to allow fish passage. Gaps in the riparian forest that occur because of flow modifications should be filled.

- Modify land use, instream, and flood control activities to reduce disturbance of riparian corridor. When possible, set aside the low flood plain as open space (the Cities of Reno and Sparks own the land on at least one bank of the river), minimize vegetation clearing, use biotechnical bank protection measures when possible, and use setback levees when necessary to preserve the low flood plain.

- Maximize the value of existing fair and good quality habitats. Concentrate expenditures on making the best habitat better. Riparian forest infill or removal of migration barriers will not only have value at the site but will increase the value of the whole system.

The Truckee River is the most important water-oriented recreation resource in the region. Demand for recreation facilities increases as the population increases. The current number of recreation facilities in the study area is inadequate for existing and future demand. Additional public recreation access to the Truckee River is needed for fishing, swimming, rafting/tubing, picnicking, bicycling, walking, and jogging. There is also a demand for parks

and paths in the Truckee Meadows area. Portions of the river have already been developed for recreation access. River resources in the city of Sparks are well developed, and Reno also has some developed features. The opportunity exists to connect these developed features. Planned recreation developments by the cities of Reno and Sparks will assist in meeting the needs and demands for a river-oriented recreation corridor. Additional recreation developments would be required to fully satisfy this need for the area.

Two conceptual features are being evaluated as part of this study, in accordance with Corps criteria and guidance, and will be incidental to the flood control features. They include a mix of multi-purpose day use facilities- bike and pedestrian paths, river overlooks/observation decks, public seating areas, picnic sites, and interpretive signs/exhibits. The first plan will follow a flood- control only project. The second plan will be compatible with a flood control/restoration project. Recreation benefits of each plan will be evaluated.

Numerous coordination meetings were held with the sponsor to coordinate environmental restoration needs consistent with the flood control objective and recreation needs incidental to the flood control objective. Areas along and adjacent to the river corridor were looked at on a reach by reach basis and ideas as shown in Table V-3 are being incorporated into the restoration and recreation plans.

Table V-3
Restoration and Recreation Needs

REACH	DESCRIPTION
Highway 395 to Greg Street	Potential point bar near Glendale Boulevard; replacement of existing recreation trails on the north and south sides of river; esthetic treatment of floodwalls within this reach.
Greg Street to Rock Boulevard	Setback levee south of the river to Mill Street to create riparian forest, wetlands; grade setback area for natural cottonwood recruitment; consideration for Airport Authority/FAA requirement which limits tree heights to 30 feet; preserve Rock Park; continue recreation trail on the north side of river; extend new recreation trail on south side of river.
Rock Boulevard to McCarran Blvd	Setback levee south of the river to Mill Street to create riparian forest, wetlands; grade setback area for natural cottonwood recruitment; establish riparian corridor up to 200 foot width; preserve Glendale Park; continue recreation trail on the north side of river; extend new recreation trail on south side of river.
McCarran Blvd to Steamboat Creek	Coordinate compatible uses of restoration and recreation with UNR Farms; preserve Cottonwood Park; create a bench south of the river and east of University Farms facilities to allow for restoration area; concerns with public access to the Farms property if maintained as research facility
Steamboat Creek	Potential realignment of Steamboat Creek at confluence with Truckee River to accommodate expansion of water treatment plant; coordinate with Airport Authority on existing wetlands restoration project; bench entire stretch of creek to allow for riparian restoration; high boron content prohibits tree growth

CHAPTER VI – EVALUATION OF ALTERNATIVES

A final array of alternatives was formulated based on the resource management measures carried forward through the initial screening process. This array of plans demonstrates the trade-offs between reduction in the percent chance exceedence of flooding, channel capacity improvement, bridge replacement, detention facilities and hydraulic mitigation needs, and levees and floodwalls.

NO-ACTION

The Corps of Engineers is required to consider the option of "No Action" as one of the alternatives in order to comply with the requirements of the National Environmental Policy Act of 1969 (NEPA). With the No Action plan, which is synonymous with the "Future Without Project Condition", it is assumed that no flood protection project would be implemented by the Federal Government or by local interests. The No Action plan forms the basis against which all other alternative plans are measured.

The Federal Government would take no action to implement a specific plan to increase the level of flood protection to the Reno-Sparks Metropolitan area. It is believed that, lacking implementation of a long term project to reduce the risk of flooding, residences and developments in the Truckee Meadows floodplain would remain at a high risk of flooding (1 in 26 chance of flooding in any given year upstream of highway 395, and 1 in 15 chance of flooding in any given year downstream of highway 395).

The average annual equivalent flood damages in the study area would be about $____ million. In addition to the damages directly caused by flooding, other effects would be to (1) public health and safety, including injuries during evacuation of the floodplain and spread of communicable disease; (2) contamination of hazardous and toxic substances and possibly to ground water; and (3) environmental resources, such as riparian and wildlife habitat.

ALTERNATIVE A: 1988 WRDA AUTHORIZED PLAN

The Corps completed a feasibility report in 1988 that identified a project which was designed to safely pass a flow of 18,500 cfs through Reno. It is currently estimated that this project would reduce the chance of flooding in the project area to about 1 in 75 in any given year. The flood control features of the plan included approximately 5 miles of floodwalls, 7 miles of levees, and the replacement of six bridges along the Truckee River. Some channel

excavation would be required and a 900-acre detention basin and levees would be constructed to mitigate potential increases in downstream flooding due to upstream flood control measures. Mitigation of adverse effects of the flood control features on fish and wildlife resources would be accomplished through planting of riparian vegetation on 31 acres along the Truckee River and Steamboat Slough. The total estimated first cost of the project, updated to 1999 prices, is $105.7 million and estimated first Federal cost is $55.5 million. Project benefits include $13.7 million for flood control and $3.4 million for recreation. Figure 11 shows a general layout of the authorized project plan.

ALTERNATIVE B: FLOOD CONTROL PLAN

This alternative is similar to the 1988 WRDA Authorized plan and primarily consists of (1) increasing the safe channel carrying capacity of the Truckee River through the Truckee Meadows area to 20,700 cfs, (2) implementing various structural and nonstructural improvements along the Truckee River in Reno, and (3) improving Lake Tahoe operation for flood control. Figure 12 shows the location of the basic plan features. To offset the potential of hydraulic impacts along the lower Truckee River, the plan includes detention storage in the Truckee Meadows area. The plan includes recreation facilities such as biking trails and parks incidental to the flood control features and environmental restoration features such as riparian zones and wetlands into the plan.

Specific components of this plan include the following:

- 3 miles of levees and 8 miles of floodwall along the Truckee River, Steamboat Creek and Boynton Slough from Hwy 395 downstream to Vista.
- Detention facility at UNR Farms. The detention facility would be sized to store approximately 6,200 acre-feet. The detention facility would be bound by the Truckee River to the north, McCarran Blvd to the west, Pembroke Lane to the south, and Steamboat Creek to the east.
- Floodwalls along the North Truckee Drain from Truckee River to Interstate 80. The left bank levee would tie into Interstate 80 embankment. Along Peoples Ditch, north-south oriented floodwalls would be required on the right and left bank of two portions of the Peoples Ditch north of Interstate 80 starting in the vicinity of North Truckee Drain.
- Downtown Reno features in the reach of the Truckee River from Booth Street downstream to near Highway 395 increasing the channel capacity by terracing back levees adjacent to the channel, thus providing the potential to carry more water in the channel during flood stage, and removing existing bridges and replacing them with new spans over the entire terraced river.
- Lake Tahoe Precautionary Release - This plan element consists of making precautionary releases from Lake Tahoe in order to remove Lake Tahoe's contribution to the peak flow at Reno without negatively impacting Lake Tahoe's water surface elevation.

ALTERNATIVE C: EXPANDED PLAN

This alternative would be designed to safely pass a flow of 20,700 cfs. It would provide a

reduction in the flood risk to about a 1 in 100 without adversely impacting existing developments primarily in the Truckee Meadows area. The plan primarily consists of (1) a series of levees and floodwalls with a maximum height of 5 feet and channel improvements from Hwy 395 to Vista, (2) implementing various structural and nonstructural improvements along the Truckee River in downtown Reno, (3) using setback levees on the south bank of the Truckee River downstream of Greg Street for flood storage, environmental mitigation and restoration purposes, (4) widening the Vista reefs up to 300 feet to pass additional flow downstream of the reefs, (5) overflow area at the UNR Farms and hydraulic mitigation features between Vista to Pyramid Lake, and (6) improvement of Lake Tahoe operation for flood control. Figure 13 shows the location of the basic plan features. The plan includes recreation facilities such as biking trails and parks incidental to the flood control features and environmental restoration features such as riparian zones and wetlands.

This plan would reduce the risk of flooding in the study area to about 1 in ---- in any given year. Levee and channel modifications providing greater deduction in flood risk would result in encroachments on existing developments within the project area. It is believed that these encroachments may not be acceptable to local landowners.

Specific components of this plan include the following:

- 3 miles of levees and 11 miles of floodwall along the Truckee River, Steamboat Creek and Boynton Slough from Hwy 395 downstream to Vista with a maximum height of 5 feet.
- To offset the potential of hydraulic impacts within the UNR Farms area, the plan includes hydraulic mitigation features along the lower Truckee River to reduce flooding impacts at the UNR Farms.
- Floodwalls along the North Truckee Drain from Truckee River to Interstate 80. The left bank levee would tie into Interstate 80 embankment. Along Peoples Ditch, north-south oriented floodwalls would be required on the right and left bank of two portions of the Peoples Ditch north of Interstate 80 starting in the vicinity of North Truckee Drain.
- Downtown Reno features in the reach of the Truckee River from Booth Street downstream to near Highway 395 increasing the channel capacity by terracing back levees adjacent to the channel, thus providing the potential to carry more water in the channel during flood stage, and removing existing bridges and replacing them with new spans over the entire terraced river.
- Lake Tahoe Precautionary Release - This plan element consists of making precautionary releases from Lake Tahoe in order to remove Lake Tahoe's contribution to the peak flow at Reno without negatively impacting Lake Tahoe's water surface elevation.

CHAPTER VII – STATUS OF GRR STUDY

ISSUES

Studies to identify the flood control and related water resource problems in the Truckee Meadows have been completed. Without project hydrology and hydraulic modeling have been developed. However, coordination with the sponsors brought about concerns in the hydrologic and hydraulic analyses. The sponsor had concerns regarding the development of the without project hydrology, the type of hydraulic modeling used for the study area, the assumptions that went into the hydraulic model, and the result of the hydraulic model. The Corps has tasked its contractor to perform an independent review of the hydrology and hydraulic modeling in response to these concerns. Follow up technical meetings are currently being coordinated in order to resolve issues and proceed with the GRR study.

TECHNICAL STUDIES

Technical analysis and coordination with the sponsor is ongoing. Plan formulation of specific alternatives and eventually the recommended plan are continuing in order to reduce the risks of flooding and improve the related water resource needs. The status of the current studies are identified as follows:

- Hydraulics- The hydraulic model utilizing the FLO-2D hydraulic modeling program has been developed and calibrated to the January 1997 flood event. The without project flood plains for the 5, 2, 1, and 0.2 percent exceedence events have been developed. The stage-frequency curves developed at specific index points for Truckee River are being reviewed and updated as required. The results of the physical modeling using FLO-2D is being incorporated into the following measures: levee, floodwall, setback levee, improvements downstream at and below Vista reefs and bridge modifications. The detention basin(s) is being evaluated for use to mitigate downstream effects of project modifications.

- Designs and Estimates - Preliminary designs and cost estimates of two alternatives for optimization studies from the Highway 395 to Vista reach have been completed. Further refinement of the project alternatives is being coordinated. Structural designs for hydraulic structures, nonstructural measures, and other project features are being coordinated. Evaluation and refinement of the detention basin is ongoing. Design parameters include utility relocations, basin outlet works, underground pipe systems required, disposal and borrow areas, and temporary construction easements.

- Geotechnical - Design parameters and soil types are being evaluated for the levee and floodwall designs. Design factors include 3:1 levee side slopes due to the soil types and the placement of relief wells in the levee design to account for potential seepage through levees.

- Real Estate - Real estate maps to determine tract ownership, acreage, and project take lines is being completed. The detailed estimate of all real estate costs associated with the acquisition of the project real property requirements has been initiated.

- Environmental – A baseline HEP analysis to document baseline conditions has been completed and further HEP analysis on the impacts from the alternatives analysis is ongoing. Environmental restoration studies include identifying opportunities to increase the value of riparian and aquatic habitats along the Truckee River by maximizing the values of the available area for multiple species, evaluating the removal of structural barriers to allow fish passage, and maximizing the value of existing fair and good quality habitats along the Truckee River and tributaries. Conceptual plans have been developed and are being modified for consistency with the flood control objective. Recreation plans incidental to the flood control objective have been developed and consist of replacing the existing trail on the Truckee River levees and other affected facilities, if any, a mix of multi-purpose day use facilities bike and pedestrian paths, river overlooks/observation decks, public seating areas, picnic sites, and interpretive signs/exhibits

- Economics- Benefit categories for evaluation include inundation reduction, savings in flood proofing costs, bridge replacement and traffic rerouting, business losses, and intensification benefits. Without project damages analysis to be completed by end of June 1999.

SCHEDULE

The study schedule has been revised to take into account delays in the development of the without project conditions and the additional coordination with the sponsors on the technical studies. Following is a list of study milestones, their approved date, and revised dates. The revised study schedule has been coordinated with the sponsors.

Milestone	Description	Date
F3	Conference #1	07/29/99
F4	Conference #2	12/15/99
F5/F6	Draft GRR to Public	04/20/00
F7	Public Meeting	05/05/00
F8	Final GRR to SPD	07/28/00
F9	DE Public Notice	08/28/00