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General Investigation Reconnaissance Report

April 1997

Provo and Vicinity, Utah

US Army Corps of Engineers
Sacramento District

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1. Little Dell Lake, Salt Lake City Streams, Utah, Embankment Criteria and Performance Report, August 1994
2. Caliente Creek Stream Group Investigation California, Draft Feasibility Report, June 1987
3. Fanchier Creek Dam Fresno, California, Embankment Criteria and Performance Report, July 1994
4. Sacramento Metropolitan Area California: Final Feasibility Report and Final Environmental Impact Statement/Final Environmental Impact Report, February 1992
5. Geologic and Seismologic Investigation, Hidden and Buchanan Dams, Hensley Lake and Eastman Lake, Fresno and Chowchilla Rivers, California, December 1988
6. Sacramento River Flood Control Project, California, Mid-Valley Area, Phase III, Design Memorandum, Volumes 1 and 2, August 1995
7. Reconnaissance Report Yolo Bypass, California, March 1992
8. Provo and Vicinity, Utah, General Investigation Reconnaissance Report, April 1997
9. Sacramento-San Joaquin Delta, California, Draft Feasibility Report and Draft Environmental Impact Statement, October 1982

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REPLY TO
ATTENTION OF

PROVO AND VICINITY, UTAH

GENERAL INVESTIGATION RECONNAISSANCE REPORT

April 1997

U.S. Army Corps of Engineers
Sacramento District
South Pacific Division

SYLLABUS

This reconnaissance report has been prepared by the Sacramento District of the Corps of Engineers (Corps) as directed by Congress. The purpose of this study was to evaluate the flood and related water resource problems on the Provo River and its tributaries at Provo; determine the most appropriate means to resolve or minimize those problems; determine whether further, detailed studies are warranted in a feasibility phase and their associated cost; and assess the level of support of local interests in the identified solutions. The primary study area included the Provo River from the canyon mouth to Utah Lake and the eastside tributaries which drain the watershed on Federal land immediately east of Provo.

Provo City has a long history of being flooded by the Provo River and its tributaries, most recently in 1983, 1984, and 1986. Flood damages were extensive, but a substantial floodfight prevented millions of dollars in damages. Current Corps studies show that much of Provo is subject to flooding, and expected annual flood damages are estimated to be over $5 million.

Various structural and nonstructural measures were identified and initially considered to meet the planning objectives for flood damage reduction in recognition of associated problems and needs. Of the many potential combinations of measures, several were formulated into alternative plans to provide various levels of flood protection. Alternatives included nonstructural flood proofing, raising levees and adding floodwalls on the mainstem of the Provo River, and detention basins and conveyance improvements for the eastside drainages.

Each alternative was evaluated based on existing Corps guidance. Based on the plan formulation and analysis completed, structural improvements on two portions of the Provo River (Below I-15 and Moon River Road) and the Northeast Drainage (Mile High, Little Rock, and Rock Canyons) appear to be economically justified. With further refinement, it is believed that flood damage reduction improvements in other reaches of the Provo River and the Southeast Drainage could also be feasible. Improvements on the Provo River and Northeast Drainage that appear feasible at this time include:

- Provo River - Raise the existing levee on the left bank below Geneva Road. Build floodwalls on top of the existing levees on the right bank below Geneva Road, on both banks between Geneva Road and Interstate 15, and along the left bank adjacent to Moon River Road. The levee and floodwalls would decrease the chance of flooding from a 1 in 24 chance in any year to a 1 in 270 chance.

- Northeast Drainage - Enlarge the existing Mile High and Rock Canyon detention basins and associated conveyance pipelines and add conveyance pipeline on Little Rock Canyon to decrease the chance of flooding from a 1 in 20 chance in any year to a 1 in 49 chance.

The next step in the process toward implementing a flood damage reduction project is completing a feasibility study. The intent of that study would be to prepare a report for submittal to Congress for consideration in possible authorization of a project. A draft feasibility project study plan is included with this report. The cost for the study would need to be shared equally with the non-Federal sponsor; the study would take approximately 24 months to complete. The potential sponsor, Provo City, is now evaluating its ability to cost share the feasibility study. Contingent upon the willingness and ability of Provo City to be the non-Federal sponsor, this report recommends proceeding to the feasibility phase.

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CHAPTER I - INTRODUCTION

BACKGROUND

The study area includes the Provo River downstream from the canyon mouth to Utah Lake and the east side tributary drainages from Mile High Canyon on the north to Ironton Canyon on the south, within the city of Provo. Provo has been plagued by frequent floods from both the Provo River and eastside drainages for well over a century. This study authorization was requested by Provo City through the Utah Congressional delegation to address these serious flood concerns on the Provo River mainstem as well as the serious flood threat caused by the eastside drainage which results almost exclusively due to runoff from Federal Lands.

STUDY PURPOSE AND SCOPE

This reconnaissance report explains results of studies to identify flood and related water resource problems in the Provo area and determine if there are feasible alternatives for solving these problems. The Corps of Engineers initiated the investigation in late April 1996. The scope and primary study focus was as follows:

- Identify flooding and related water resource problems in the study area.
- Develop alternatives to alleviate flooding and related problems within the study area.
- Determine the potential economic feasibility of alternatives to resolve the problems.
- Determine the Federal interest in proceeding into a feasibility phase of the study.
- Provide an estimate of scope, time, and costs for the feasibility study.
- Determine if any non-Federal sponsor is willing and able to share the cost of potential feasibility studies.

STUDY AUTHORITY

Specific direction for conducting the current reconnaissance investigation was provided by language in the 28 September 1994 Resolution of the Committee on Public Works and Transportation, U.S. House of Representatives. The resolution reads:

> *Provo and Vicinity, Utah* - Resolved by the Committee on Public Works and Transportation of the United States House of Representatives, That the Secretary of the Army, is requested to review the report of the Chief of Engineers on the Jordan River Basin, published as House Document 213, Eighty-sixth

Congress, First Session, to determine whether modifications of the recommendations contained therein are advisable at this time, in the interest of flood damage reduction, environmental restoration and protection and related purposes along the streams draining into Utah Lake near Provo, Utah and vicinity.

STUDY AREA

The primary study area, shown on Plate 1, includes the Provo River from the canyon mouth to Utah Lake and the east side drainage from Mile High Canyon on the north to Ironton on the south within the corporate limits of Provo. Provo is located along the Wasatch Front just east of Utah Lake, 45 miles south of Salt Lake City. The Provo River Basin collects runoff from both the Uinta and Wasatch Mountain Ranges, north and east of the city of Provo. The eastside tributaries drain the west slope of the Wasatch Mountains immediately east of Provo.

PRIOR STUDIES AND REPORTS

Several pertinent prior studies and reports on the Provo River and its tributaries are:

Corps of Engineers

- The "Wasatch Front and Central Utah Study" included a cursory assessment of the Provo River. This special investigation, completed in September 1984, was conducted in response to specific Congressional authorization following widespread flooding throughout much of northern Utah during the spring of 1983.

- A Section 205 flood damage reduction reconnaissance study was completed in January 1988. Although further studies were identified, Provo City, the potential sponsor, was unable to cost share due to a depressed local economy at that time. Accordingly, the study report was not finalized or approved by higher authority.

Federal Emergency Management Agency (FEMA)

- Flood insurance studies were published for the city of Provo in August 1978 and updated in September 1988.

Local Agencies

- In 1986, the City of Provo completed a storm drainage master plan (under contract). This master plan identified significant flood damage reduction needs on the eastside drainages within Provo.

STUDY PARTICIPANTS AND COORDINATION

The Corps is conducting this study in cooperation with Provo City. Close coordination has been maintained between the sponsor and the Corps from the inception of the study.

In addition to Provo City, numerous Federal, State, and local agencies and individuals have participated in and were coordinated with during this study. Agencies included in coordination are listed below.

Other Federal Agencies. -

U.S. Fish and Wildlife Service
U.S. Forest Service - Uinta National Forest
U.S. Bureau of Reclamiation
Natural Resources Conservation Service
U.S. Geological Survey
Bureau of Land Management

State Agencies. -

Utah Division of Water Resources
Utah Division of Wildlife Resources
Utah Department of Environmental Quality
Utah Division of Air Quality
Utah Department of Transportation
Utah Historic Preservation Office
Utah Division of Water Rights

Local Entities (Provo City). -

Public Works Department
  Stormwater Service District
  Streets Division
Engineers Office
Assessors Office
Planning Department
Community Development
Emergency Management Office

Other Agencies and Individuals. -

Central Utah Water Conservancy District
Provo River Water Commissioner
Utah County Engineers Office

CHAPTER II - DESCRIPTION OF THE STUDY AREA

PHYSICAL AND ENVIRONMENTAL CONDITIONS

Population - According to the 1990 census, the population of the Provo metropolitan area, including Orem and other surrounding areas, was 261,600, of which 91,900 live within the city limits of Provo and the remainder live in Orem or adjacent suburbs. By 1995, the estimated population of Provo was 101,000, reflecting a 7 percent increase over the 1994 population estimate of 94,000.

Development and Economy - Provo is the Utah County seat. Initially, the economy of Provo was based on agriculture, but soon expanded to include commercial and manufacturing activities. In the early 1940's, one of the largest integrated steel plants in the western United states was built at a cost of $200 million to support the war effort. This new industry stimulated economic growth and continues today as a major employer. Brigham Young University (BYU), with 26,000 students, is one of the largest private schools in the Nation and is also important to Provo's economy. In recent years, several large computer and other technology-related companies have located in Provo. Provo is served by Interstate Highway 15 (I-15), State highways, an airport, and railroads.

Land Use - Provo City has expanded through the years to currently include approximately 25 square miles. Land in the study area is predominantly used for residential, commercial, and public purposes. The western portion of the study area is dominated by urban and some agricultural development, while the watershed east of Provo is primarily undeveloped land within the Uinta National Forest.

Vegetation - Although a variety of native plant species grow in the steeper, eastern half of the study area, the flatter, western bench is dominated by urban development. Nevertheless, although the Provo River is confined by urban encroachment within the city of Provo, a band of riparian vegetation persists along its banks and existing levees in the study area. Riparian vegetation in the lower portions of the study area is characterized by cottonwoods, willows, velvet ash, and tamarisk. Woody vegetation along Provo River levees consists mainly of cottonwoods.

At higher elevations within the study area watershed, vegetative communities change to include a variety of less water-tolerant plant species, including juniper, pinyon pine, sagebrush, oaks, Douglas fir, spruce, and quaking aspen. Patches of riparian vegetation, characterized by willows, cottonwood, alder, mountain maple, and dogwood, grow within and along the base of eastside drainages.

Wildlife - Due to urban and agricultural development in the study area, diverse, natural wildlife communities occur only at higher elevations within the eastern half of the study area in or near the Uinta National Forest.

Large mammals in the eastern portion of the study area include elk, mule deer, mountain lion, and possibly black bear. Smaller mammals expected throughout the study area include skunks, squirrels, and raccoons.

A variety of bird species, including raptors, game birds, and waterfowl, occur in the study area. Identified raptors include hawks, falcons, kestrels, and golden and bald eagles. Due to the wide-ranging habits of most raptors, it is possible that any known species may occur at any location within the study area where appropriate foraging, roosting, or nesting habitat grows. Identified game birds in the study area include pheasant and quail. Both of these species typically occur within riparian areas along the Provo River. Pheasant additionally may occur within and adjacent to agricultural and open fields, while quail may be present in vegetated areas throughout the region. Waterfowl typically forage and nest at lower elevations near the mouth of the Provo River and along the shores of Utah Lake.

Fish - The most common fish in downstream Utah Lake are nonnative species, including white bass, walleye, channel catfish, carp, and the native June sucker. Fish in the lower stretches of the Provo River reflect species composition in Utah Lake, while, farther upstream, species composition changes to include coldwater fish, such as brown trout, rainbow trout, and sculpin. As noted earlier, the Provo River is typically characterized by low or nonexistent summer flows. Although water users in the area retain the right to entirely divert Provo River flows, the listing of the June sucker as an endangered species under the Federal Endangered Species Act (ESA) and designation of the lower Provo River as critical habitat have limited diversions to preclude dewatering from mid-May to mid-July. Because the June sucker is known to inhabit the lower portion of the Provo River study reach, all alternatives formulated for the lower Provo River as part of this study will avoid impacts to the channel in order to be viable.

No fish species are known to occur in the eastside drainages due to the ephemeral nature and steep topography associated with these watercourses.

Endangered Species - Twelve special status species occur or may occur in the study area. Of these species, three are listed as endangered under the Federal Endangered Species Act, two are listed as threatened, two are candidates for listing; five are listed as sensitive species by the State of Utah; and four are listed as sensitive species by the U.S. Forest Service.

Environmental resources, including vegetation, wildlife, fish, and wetlands (including threatened and endangered species), as well as cultural and recreational resources, are all described in more detail in the Environmental Evaluation (Appendix A).

Cultural Resources - The study area was formerly occupied by the Ute tribe. European explorers first entered the study area in 1776. Mormon immigrants settled in the area starting in 1847,and Provo City was incorporated two years later in 1849, becoming one of the first cities in the state. Previous cultural resources investigations have been conducted in the study area. Six prehistoric sites are located within one-half mile of the Provo River downstream from I-15. No known sites exist upstream from I-15 adjacent to the Provo River or in any of the eastside canyons. Thirty-nine buildings and residences, as well as the Provo Downtown Historic District, are listed on the National Register of Historic Places.

Air Quality - Air quality in Utah County is monitored by the Utah Division of Air Quality. According to this agency, air quality in Utah County meets all applicable Federal and State standards except those for small particulate matter less than 10 microns in diameter (PM_{10}), and only within Provo city limits for carbon monoxide (CO). State air quality standards in Utah coincide with the Federally imposed National Ambient Air Quality Standards.

Primary factors contributing to high PM_{10} concentrations in Utah County are vehicular emissions and industrial processes, including steel, rock, and asphalt operations. The largest factor contributing to high CO concentrations within Provo city limits is vehicular emissions. Due to climatic and topographic features, including the Wasatch Range, PM_{10} and CO concentrations can exceed regulatory standards in the study area for extended periods of time, particularly during winter months.

Climate - The study area is climatically characterized by hot, dry summers and cold, wet, and snowy winters. Temperatures in the area range from over 100 °F in the summer to below zero °F in the winter. In general, higher elevations in the study area exhibit slightly lower temperatures. Annual precipitation ranges from approximately 17 inches at lower elevations to over 40 inches at higher elevations. Although most precipitation falls as snow, torrential summer storms also may contribute significant precipitation.

Topography - The topography of the study area is characterized by steep, narrow canyons in the mountains and mildly sloping alluvial fans and plains west of the Wasatch front. Channel capacity is typically much greater in the canyons than on the alluvial fans. Attenuation of high peak flows occurs on the eastside alluvial fans because of an increase of obstructions and storage which results from the broad, shallow flow. The elevations range from 4,490 feet near Utah Lake to over 11,000 feet in the headwaters.

Geology and Soils - Lower elevations in the study area comprise a mosaic of soil types. The most common soil association on the lower Utah Lake terrace is the Chipman-McBeth association, consisting of poorly drained, nearly level, silty clay loams. At slightly higher elevations within the study area, including the city of Provo, is the Steed-Pleasant Vale-Redola association, consisting of well-drained, nearly level to gently sloping, gravelly, loamy soils. Eastward of that association is the Welby-Hillfield association, consisting of well-drained, gently sloping to steep, loamy soils. Finally, the most common soil association along the foothills of the Wasatch Front is the Pleasant Grove-Cleverly-Kilburn association, comprising well-drained, gently sloping to steep, gravelly or stony, loamy soils. The Wasatch Range in the study area is composed predominantly of limestones (i.e., the Oquirrh formation), underlain by quartzite, dolomite, or more limestone. The Wasatch Fault runs in a northerly direction along the western base of the Wasatch Range.

Watershed - The Provo River Basin collects runoff from both the Uinta and Wasatch Mountain Ranges. The upper portion of the basin is bounded on the south by the Duchesne River drainage and on the north by the Weber River drainage. Elevations in the headwaters go up to 11,000 feet. Two reservoirs on the mainstem Provo River, at Jordanelle and Deer Creek Dams, provide flood control (Jordanelle) and water supply (Jordanelle and Deer Creek) to the region. About 123 square miles of the watershed below Deer Creek Reservoir is essentially unregulated except for irrigation diversions. (See Plate 2.)

Below Deer Creek Dam, the Provo River flows west for 10 miles through a narrow, rugged canyon in the Wasatch Mountain Range before reaching the city of Provo and emptying into Utah Lake. Major tributaries that flow into the Provo River below Deer Creek Dam, in the Provo River Canyon, are Provo Deer Creek, North Fork Provo River, and the South Fork Provo River.

The drainages that flow into Provo City from the east consists of two main watershed groups—Northeast and Southeast, due to their commingled floodflows. The Northeast Drainage which includes Rock, Little Rock, and Mile High Canyons (drainage area 10.3 square miles), drains into the northern neighborhoods of Provo, which consist of larger homes, schools, churches, and businesses. The Southeast Drainage, which includes Slide, Slate, and Buckley Draw Canyons (drainage area 8.3 square miles), drains into the southern neighborhoods of Provo, which consist of moderate and larger-sized homes, schools, churches, and many businesses. The channels have been eliminated by urbanization below the canyon mouths or below existing detention basins (see Existing Water Resource Projects below). Ironton Canyon, at the far south end of Provo, was considered to be a separate watershed because floodflows do not commingle with adjacent drainages except for extremely rare events (for a 0.2 percent [1 in 500] chance event, flows would commingle only slightly). The Ironton Drainage consists primarily of undeveloped land and a gravel pit.

EXISTING WATER RESOURCES PROJECTS

Existing Federal Water Resources Projects - Jordanelle Reservoir, located in the Provo River headlands of the Uinta Mountains, provides water supply and flood control for the Heber Valley, the city of Provo, and the metropolitan areas of Utah and Jordan River Valleys. Jordanelle Dam is approximately 6 miles north of Heber City, Utah, and 40 miles southeast of Salt Lake City (see Plate 2). Jordanelle Dam is a zoned earthfill structure with an impervious core. The crest of the dam is 40 feet wide, 3,820 feet long, and 299 feet above the streambed of the Provo River. Under contracts supervised by the U.S. Bureau of Reclamation (USBR), the embankment of the dam was completed in October 1992, and the initial filling of the reservoir began in April 1993. The reservoir has a storage capacity of 314,006 acre-feet. Under the Section 7 Program, the Corps is responsible for developing the operating criteria for and monitoring the flood control storage/releases in Jordanelle Reservoir. Reoperation of the reservoir is currently being considered. Completion of the reoperation evaluation is pending completion of an ongoing U.S. Fish and Wildlife study to be completed later this year. The USBR currently estimates that the downstream channel capacity of the Provo River is approximately 1,800 cfs below Deer Creek Reservoir. Therefore, these criteria were used in the development of hydrology for this study.

Deer Creek Reservoir is approximately 16 miles northeast of Provo, in the southwest corner of Heber Valley, on the Provo River. Deer Creek Dam is not operated for flood control. The drainage area of the Provo River at Deer Creek Dam is 560 square miles. Deer Creek dam is a zoned earthfill structure 150 feet high, with a crest length of 1,304 feet. The dam was constructed in 1938-41 by the USBR and is now operated by the Provo River Water Users Association. The reservoir has a storage capacity of 152,600 acre-feet at the top of the active conservation pool.

Existing Non-Federal Projects - On the Provo River, some water is diverted into canals for irrigation purposes. Intermittent local berms and levees of varying quality also exist through the study area. In the lowest reach of the river and adjacent to Utah Lake there is a levee which was built in anticipation of high lake levels in 1983.

In the Northeast Drainage, the largest existing project is a 102 acre-foot debris basin located about one-half mile below the mouth of Rock Canyon. Also, on Mile High Canyon there is a small, 1 acre-foot detention basin on the east side of Foothill Drive, about one-half mile below its canyon mouth.

On the Southeast Drainage, a series of three detention basins totaling 26 acre-feet are located about one-fourth mile below the Slate Canyon mouth. Also, there is a small 2 acre-foot detention basin on Slide Canyon about 1 mile below the canyon mouth. Newer areas of the city to the north have outfall lines to convey their stormwater flow. However, most development relies on curbs and gutters rather than on pipelines to get water to the Provo River. The local drainage system within the city is generally inadequate to handle even runoff from the urban areas, independent from the eastside watershed runoff.

CHAPTER III - WATER RESOURCES PROBLEMS AND NEEDS

FLOOD PROBLEMS

There are various water resource-related problems and needs in the study area. The primary problem is flood damage reduction, although other resource issues include environmental restoration and enhancement, water supply, and recreation. The remainder of this report will focus on identifying these needs and potential opportunities to address them.

Historic Flooding - Significant flooding has been observed in Provo due to high flows of the Provo River and high runoff from the canyons east of the city. Dozens of significant flood events in the last 120 years have resulted in substantial impacts to those who live and work in Provo. One of the first floods recorded was in 1876; the most recent was in 1986. The floods of record in the Provo River basin have occurred during the April through June snowmelt period and are shown in Table 1.

TABLE 1
Historical Floods,
Provo River

Year	Peak Discharge
1938	1,350
1951	1,240
1952	2,520
1957	1,330
1967	1,300
1973	1,270
1975	1,720
1980	1,330
1982	1,180
1983	2,420
1984	2,530
1986	1,760
(Discharge values obtained from USGS Gage No. 10163000, Provo River at Provo, Utah)	

Floodflows in the Provo River basin have historically resulted from melting snowpack, general rainstorms, and cloudbursts. Snowmelt floods have occurred primarily during the period April through June. Jordanelle Reservoir, completed in 1993, was built in part to reduce the chances of flooding along the Provo River. It will do much to prevent small to moderate snowmelt flood events. However, large snowmelt events and cloudburst storms centered downstream of the reservoir still threaten the city. Therefore, a serious residual problem exists as identified in the hydrology section below.

Historically, thunderstorm floods are relatively common in the region, particularly along the Wasatch Front. Generally, the areal extent of these floods is limited. As expected, flooding has been most widespread adjacent to the Provo River mainstem. However, serious flooding has taken place as the result of the eastside tributaries as well. Local citizens have tried to protect themselves with varying degrees of success, as shown in this photo of flooding downstream from Slate Canyon.

As part of this study, accounts of numerous floods on the eastside tributaries as well as the Provo River were located in published documents and newspaper articles. They highlight the severity of flooding on the two eastside drainages. However, specific data such as flood depths, durations, and resulting damages are very limited. A detailed narrative of historic flooding is contained in the Hydrology Office Report (Appendix B).

HYDROLOGY

As identified above, flooding in Provo typically has resulted primarily from spring snowmelt and summer and fall cloudburst events. Snowmelt floods in this region generally occur in May or June, but on rare instances can occur as early as April. Time of occurrence of these high flows depends upon the elevation of the snowfield and on the sequence and duration of melt-producing temperatures. Thunderstorms occur frequently in this region during the summer months and early fall, resulting in high intensity precipitation over small areas. General rainstorms can occur at any time of the year, although general rains in this region do not usually produce flooding when not associated with snowmelt or cloudburst events. Winter rainfloods, which are very rare, result from intense local storms associated with widespread general rainstorms that occur during the period from October through May. Additional details concerning these types of floods are contained in the Hydrology Office Report (Appendix B).

Flow-Frequency Analysis

Existing information was used for the cloudburst flow-frequency curves for the Provo River mainstem. The flow-frequency curves for the mainstem Provo River are comparable to those developed for the eastside basins. The largest floodflows from the eastside basins would be produced by a cloudburst storm centered over the Rock Canyon basin. The most severe flooding in the southern portion of Provo would result from a storm centered on Slate Canyon. Rainfall and loss rate criteria used to compute runoff are comparable to those used in the nearby studies. Unit hydrographs for all of the eastside basins were developed from the Wasatch Mountain S-graph.

Hydrographs of the 10, 2, 1, and 0.2 percent chance exceedence events (1 in 10, 50, 100, and 500 chance of occurrence in any one year—also known as the 10-, 50-, 100-, and 500-year events) were developed for the eastside basins from 6-hour rainfall depth-duration-frequency relationships and HEC-1 modeling. Basin parameters that affect the amount and timing of runoff used in the analysis are basin size, basin shape, channel length, and channel slope.

Cloudburst Rainfall Depth-Frequency and Temporal Distributions - The eastside basin watersheds were delineated on 10-, 50-, and 100-year 6-hour NOAA Atlas II rainfall maps to obtain area-weighted, basin average rainfall depths for cloudburst events. Areal reduction factors were applied to all subarea point rainfall depths based on the *Project Cloudburst* report. The *Project Cloudburst* report was also used to develop a temporal distribution. (This study used more than 50 rain gages in an area of about 350 square miles in the general vicinity of nearby Salt Lake City.) The average temporal distribution of these large events has been used with the NOAA Atlas II rainfall depths for the rainfall-runoff modeling of the eastside basins.

Rainfall Loss Analysis - Rainfall and rainfall losses vary with event frequency. Less antecedent rainfall is expected with more frequent events; therefore, initial and constant losses are higher, due to drier soil moisture conditions at the beginning of the storm. Initial losses must be satisfied before runoff begins, while the constant losses reflect the infiltration rate of the wetted soil after initial losses have been satisfied. Rainfall losses were estimated from soil transmissivity, from other Corps studies within the region, and from additional subarea characteristics such as vegetation and climatic factors. The principal basins were modeled using HEC-1.

Unit Hydrograph Development - No historical rainflood hydrographs were available; therefore, unit hydrographs were developed by synthetic procedures. The S-graph method was used to develop the flood hydrographs. These graphs, when smoothed, form a deformed "S" shape. The Wasatch Mountain S-graph has been selected for modeling the eastside basins. The Wasatch Mountain S-graph provides a hydrograph of typical shape for the region and may be used where no observed hydrograph is available to define hydrograph shape.

Basin Parameters - Basin n-values are unitless factors reflecting the roughness of the basin. Basin n-values were estimated from those determined in previous studies within the region and from subarea characteristics. Basin n-values range from 0.07 to 0.09. In this study, basin n-values are similar to those used in previous studies of watersheds near the study area. Physical dimensions of the basins were measured from USGS topographic maps.

Base Flow - Due to the expected antecedent conditions and the short duration of flow associated with cloudburst events, baseflow has not been incorporated into the rainfall-runoff models.

Channel Routing - Channel routings at the canyon mouths and upper alluvial fan were performed to account for channel losses in the alluvium. Large channel losses are expected in the highly permeable sediments. The estimated channel loss rates were applied to the stream channel sections which flow through sediments at or near the canyon mouths. The selected loss rates result in smooth flow-frequency curves and the low flows expected from 10 percent chance events.

Snowmelt Flow Frequency - A review of hydrology performed for other small basins in the study area found that the snowmelt frequency curves in these studies consistently had skews of from 0 to -1 and standard deviations of approximately 0.3 to 0.4. Therefore, a skew of 0.0, and standard deviation of 0.35, was used to develop the snowmelt curves in this study (excluding the Provo River). Given skew and standard deviation, a single flow-frequency value was required to define a curve.

The regulated snowmelt-frequency curve for the Provo River at the canyon mouth and at Interstate 15 is an estimated curve based on the curve developed for the Jordanelle Water Control Manual. The accepted nondamaging channel capacity for the Provo River below Jordanelle Reservoir has been increased from 1,200 cfs to 1,800 cfs. Based on the change in channel capacity, the curve was adjusted to reflect new operating criteria for a channel capacity of 1,800 cfs. Local snowmelt inflow below the dams is considered to be insignificant. Most snowmelt below the dams runs off before snow above the dams melts.

Combined Flow-Frequency Analyses - Combined (all event) flow-frequency curves were developed for the Provo River and the eastside drainages at selected concentration points. Each flow-frequency curve is for the combined frequency of runoff events from cloudburst storms and snowmelt. Significant runoff from general rainstorms is considered to have been from embedded cloudbursts; therefore, a separate component for general rain was not included. To compute the all-event flow-frequency curves, probability values from both the cloudburst and snowmelt flow-frequency curves were combined. All-event curves were then developed by drawing a graphical best-fit curve through the computed flow-frequency points. The Provo River curves are included as Plates 3 and 4. Peak Flow data for all study area streams are shown on Table 2.

TABLE 2
Provo Area Streams - Peak Flow-Frequency
Storm Centered Over Each Basin

Basin	D.A.* (Sq mi)	Peak Discharge[1] (cfs) Percent Chance Exceedence [2]			
		10 %	2 %	1 %	0.2 %
Provo R. at Canyon Mouth	606.6[3]	1800	2800	4400	8495
Provo R. at I-15 (d/s Cyn mouth)		1800	2300	4000	6807
Buckley Draw	0.88	16	236	490	1323
Ironton Cyn	1.22	23	300	632	1707
Little Rock Cyn	1.11	20	238	499	1346
Mile High Cyn	0.38	8	112	229	618
Rock Cyn Debris Basin Inflow	8.78	150	1052	2212	5973
Rock Cyn Debris Basin Outflow	8.78	130	549	1552	5973[4]
Slate Cyn Debris Basin Inflow	6.20	105	801	1642	4434
Slate Cyn Debris Basin Outflow	6.20	90	587	1434	4434[4]
Slide Cyn	1.21	20	276	583	1573

Notes:
* D.A. = Drainage Area
[1] Debris volume not included in reported peak flow.
[2] Combined frequency of snowmelt and cloudburst events.
[3] Regulated at Jordanelle and Deer Creek Dams
[4] Debris inflow fills basins, no significant flood control provided.

Flood Routing Through Debris Basins

Rock Canyon: A 102 acre-foot debris basin (at spillway crest) is located about one-half mile below the mouth of Rock Canyon. This basin was considered to be partially to completely full of debris in the study analyses. The basin has a 48-inch outfall pipeline (approximate capacity 200 cfs) to the Provo River. At the reconnaissance level of study, the basin was assumed to be first filled with the estimated debris yield (based on the debris yield-frequency curve), and the clear water hydrograph was then routed through the basin.

Slate Canyon: Slate Canyon has three small debris basins arranged in series. At the reconnaissance level of study, the upstream-most basin was assumed to be essentially filled with debris and ineffective as a floodwater detention facility.

Relationship to Corps Minimum Flow Criteria - Engineering Regulation 1165-2-21 identifies that generally a 10 percent chance exceedence peak flow of 800 cfs or greater is needed to establish Federal interest by the Corps in cost sharing a flood damage reduction project. One in 10 percent chance exceedence peak flows smaller than 800 cfs are usually considered a local drainage problem. Where 1 percent chance exceedence peak flows are near 1,800 cfs, an exception may be requested and granted. Much of the city of Provo is under a significant flood threat from cloudburst-type runoff that drains from steep hillsides to the east of the city. Most of the hillside lands are in Federal ownership. It is because of this threat from Federal lands that the city obtained Congressional authorization for this study. This type of alluvial fan flooding which results in widespread, mixed floodflows is typical in the western states and especially along the Wasatch Front of Utah. Because the potential for catastrophic effects from a flood event is so great, it is clear that solutions are needed—not individually, but collectively, since little good would be accomplished by formulating a plan on one tributary while ignoring a similar or even greater threat from the adjacent tributary. Also, natural storage and existing detention storage results in 10 percent flood discharges of less than 800 cfs.

Because of the high flood threat from commingling flows, it is believed that Rock, Slide, and Slate meet the criteria of the referenced regulation. Furthermore, in regard to the remaining eastside drainages, additional study guidance stating that "The flooding problems in the study need to be addressed and plans formulated without regard to the minimum flow criteria. There may be circumstances where there is a Federal interest in a flood control structure located in an area which does not meet the minimum flow criteria. Thus determination of the Federal interest may depend on the eligibility of a specific project feature for cost sharing." (Memorandum is included in Appendix G).

Concurrent Precipitation and Hydrographs - Because the damage location (Provo) is in an area where flood plains from more than one watershed coalesce, different storm centerings were considered, concurrent flows were developed from neighboring basins, and hydrographs were combined to develop composite flood plains. Because flows from Rock Canyon north combine with Rock Canyon and flow to the Provo River through Provo, while flows from basins south of Rock Canyon combine with Slate Canyon flows and flow to Utah Lake, at least two critical storm centerings were required. As Rock Canyon and Slate Canyon are by far the largest watersheds, generate the most runoff, and produce the largest flood plains, these basins were used for the critical storm centerings.

Concurrent precipitation is developed such that the subbasin at the storm center is given a precipitation depth based on the depth-area-duration (DAD) curve for that region and a point precipitation depth. Precipitation for the other basins is then developed such that the basin average precipitation for the total drainage area (all subbasins combined) also follows the depth-area-duration relationship described by the DAD curve. Concurrent precipitation was used to model concurrent hydrographs. Tables 3 and 4 present the concurrent peak events for storms centered on Rock and Slate Canyons, respectively. Also, these values do not include debris, which can reach as much as 25 percent of the total.

TABLE 3
Provo Area Streams, Peak Flow From Concurrent Rainfall
Cloudburst Storm Centered Over Rock Canyon

Basin	**D.A. (Sq mi)**	**Peak Discharge (cfs)[1] Percent Chance Exceedence**			
		10%	**2%**	**1%**	**0.2%**
Rock Cyn Debris Basin Inflow	8.78	150	1052	2212	5973
Rock Cyn Debris Basin Outflow	8.78	130	549	1552	5973 [2]
		Concurrent Flows			
Flows which commingle with Rock Canyon flows below canyon mouths, at Provo					
Little Rock Cyn	1.11	11	80	265	794
Mile High Cyn	0.38	4	27	105	283 [2]
Total Northeast Drainage inflow	10.3	165	1160	2582	7050
Total Northeast Drainage outflow	10.3	145	656	1922	7050

Notes:
* D.A. = Drainage Area
[1] Debris volume not included in reported peak flow.
[2] Debris inflow fills basins; no significant flood control provided.
All flows shown (except for Rock Canyon) are concurrent events to a cloudburst centered on Rock Canyon.

From a project design standpoint, the storm centerings over Rock and Slate Canyons may be thought of as two independent hydrologic analyses for two independent projects. Floodflows from the Northeast Drainage (Rock Canyon and its tributaries) do not commingle with floodflows from the Southeast Drainage (Slate Canyon and its tributaries); therefore, flood damage reduction features in the Northeast Drainage basin provide no benefits in the Southeast Drainage, and vice-versa. Therefore, flows from Table 3 were used as the basis for further hydraulic routings of the commingled flooding to evaluate project alternatives in the Northeast Drainage, and flows from Table 4 were used as the basis for hydraulic routings to evaluate project alternatives in the Southeast Drainage.

TABLE 4
Provo Area Streams, Peak Flow From Concurrent Rainfall
Cloudburst Storm Centered Over Slate Canyon

Basin	D.A. (Sq mi)	Peak Discharge (cfs)[1] Percent Chance Exceedence			
		10%	2%	1%	0.2%
Slate Cyn Debris Basin Inflow	6.20	39	801	1642	4434
Slate Cyn Debris Basin Outflow	6.20	0.00	587	1434	4434 [2]
		Concurrent Flows			
Flows which commingle with Slate Canyon flows below canyon mouths, at Provo					
Buckley Draw	0.88	5	138	330	891
Slide Cyn	1.21	6	154	388	1047
TOTALS					
Total Southeast Drainage Inflow (Excluding Ironton)	8.29	50	1093	2360	6372
Total Southeast Drainage Outflow (Excluding Ironton)	8.29	7	879	2152	6372 [2]
Ironton Cyn (Does not commingle exc for .02 event)	1.22	5	77	281	757

Notes:
* D.A. = Drainage Area
[1] Debris volume not included in reported peak flow.
[2] Debris inflow fills basins; no significant flood control provided.
All flows shown (except for Slate Canyon) are concurrent events to a cloudburst centered on Slate Canyon.

Probable Maximum Precipitation and Probable Maximum Floods - For design of detention basin spillways, probable maximum flood values are used. The Probable Maximum Precipitation (PMP) was developed as per HMR No. 49. Provo is located in an area of very high cloudburst PMP. The 1-hour, 1-square mile PMP (unadjusted for elevation, see below) for all of the study area is 10.0 inches. PMP cloudburst (local storm) precipitation is reduced 5 percent for each 1,000 feet above 5,000 feet of elevation. The basin average elevation was used as a basis for reducing the PMP based on elevation. All the eastside watersheds have an average elevation above 5,000 feet, resulting in downward adjustments to the 6-hour (total storm) PMP of approximately 4 to 16 percent. The basin average 6-hour rainfall for the eastside basins ranged from 10.0 to 12.7 inches. Maximum basin-average 15-minute precipitation ranges from 4.6 to 6.5 inches.

Extremely high runoff rates would result from a PMP storm. The high PMP in this region results in Probable Maximum Floods (PMF's) that are approximately 3 to 4 times greater than the computed 500-year events. Although large debris flows would accompany these events, only the clear water component of the PMF flow has been developed for this study. Debris considerations would be required for any flood damage reduction facility incorporating detention storage. In extreme events, detention basins would fill with debris, and therefore would not provide significant flood damage reduction by themselves (except to remove a portion of the debris volume from the hydrographs). Table 5 shows the PMF peak flows for each eastside basin (PMF value for the Provo River was not estimated, since detention storage on the lower river was determined not to be viable).

TABLE 5
Provo Area Streams, Peak Flow-Frequency
Cloudburst Probable Maximum Floods

Basin	D.A.* (Sq mi)	Peak Discharge (cfs)[1]
Buckley Draw	0.88	4,510
Ironton Cyn	1.22	5,960
Little Rock Cyn	1.11	4,450
Mile High Cyn	0.38	2,120[2]
Rock Cyn Debris Basin Inflow	8.78	17,840
Rock Cyn Debris Basin Outflow	8.78	17,840[2]
Slate Cyn Debris Basin Inflow	6.20	14,320
Slate Cyn Debris Basin Outflow	6.20	14,320[2]
Slide Cyn	1.21	5,420

* D.A. = Drainage area
[1] Debris volume not included in reported peak flow.
[2] Debris inflow fills basins, no significant flood control provided.

Debris/Mud-Rock Flows - Flash floods commonly discharge large volumes of debris as well as free water. This is particularly true in small drainage basins without frequent sustained flows high enough to flush debris, which may permit debris accumulation for many years. The debris is usually a mixture of mud, rocks, boulders, and plant materials. Cloudburst rainfall greatly exceeds the infiltration capacity of the soil and litter; thus, water quickly gathers into rills or waves of sheetflow. This overland flow then carries large amounts of debris into the main drainage channels. Typically, debris makes up approximately 10 to 25 percent of the flow volume in rare events from small arid and semiarid watersheds in the western U.S. Mud-rock flows may have debris concentrations that are much higher than 25 percent. The high viscosity of mud-rock flow enables it to maintain appreciable depth even on unconfined surfaces, which explains its great destructive and transportive power. Mud-rock flows are not readily diverted by obstacles in their path, but instead tend to override them. Although mud-rock flows have occurred on the study basins in the past, some researchers believe improved watershed management in the area appears to have reduced the risk from these events. Others believe that a "quiet" cloudburst period has produced a false sense of security to those living in the area. Geologic evidence shows that mud-rock flows did occur before the area was developed. The frequency of mud-rock flows cannot be identified without extensive studies, which are beyond the scope of this reconnaissance study. Therefore, a typical debris yield (approximately 15 percent of the total computed 1 percent chance inflow event volume) was routed into the Rock and Slate Canyon debris basins. The debris yield was computed using the PSIAC method, developed by the Pacific Southwest Interagency Committee.

Average Annual Debris Yield - Most of the PSIAC factors for basins in the study area contribute to a relatively low average annual debris yield. Using average (median) values would result in a much higher debris yield. Only the topography factor is on the high end of the range given (due to the very steep topography). Using the above factors, the average annual debris yield estimates for Rock and Slate Canyons are 1.8 and 1.2 acre-feet/year, respectively (0.2 ac-ft/sq mi/year). The 1 percent chance volumes computed for Rock Canyon and Slate Canyon were 85 and 23 acre-feet, respectively. Given the flow-frequency curves, a factor (multiplier) was selected which produced an average annual debris yield (integrated area under the curve) equaling the value provided by the PSIAC method. For Rock Canyon flood routings, the computed debris volume was assumed to occupy volume in the single debris basin before the hydrographs were routed through the basin. For Slate Canyon (where there are three debris/detention facilities), the first basin was assumed full of debris, and the second and third basins were assumed to be at full capacity (empty of water and debris) at the beginning of each cloudburst flood.

Utah Lake Stages - The period of record for the Utah Lake annual maximum stage data spans 113 years (1884 to present), including 111 years of data and 2 missing years of data (1992 and 1993). A stage-frequency curve was developed by plotting all the gaged data and drawing a best-fit smooth curve through the points by trial and error adjustment of the curve statistics. A smooth curve does not fully take into account regulation of the lake water-surface elevation, but provides an adequate approximation of the stage-frequency relationships for the purposes of this study. These data, shown on Table 6, were used to generate starting (downstream) water-surface elevations for the Provo River hydraulic model.

TABLE 6
Utah Lake Stage-Frequency Relationship

Exceedence (%)	Stage
10	4492.0
2	4494.0
1	4494.6
0.2	4495.9

Hydrology Analysis Summary - The 10, 2, 1, and 0.2 percent chance exceedence flow frequency values were computed for cloudburst events for the eastside basins, using HEC-1 rainfall-runoff modeling. Cloudburst flow-frequency curves for the Provo River mainstem were taken from an earlier analysis; however, the Provo River curves were checked for consistency with modeled results for the eastside basins. Snowmelt curves (for the eastside basins) were developed using regional information to obtain estimated curves using a CSM curve and a uniform skew and standard deviation for all basins. The Provo River snowmelt-frequency curve was developed for the Water Control Manual for Jordanelle Dam. All-event flow-frequency curves were developed by combining the snowmelt and cloudburst event probabilities. Hydrology data are contained in their entirety in Hydrology Office Report - Appendix B.

FLOOD PLAINS

Flood plains were developed for both the Provo River and the Northeast and Southeast Drainages. The major problem areas along the Provo River lie downstream and upstream from Interstate 15. Eastside flooding is also widespread, affecting homes, businesses, schools, and churches and other developments throughout much of Provo. Detailed flood plains and associated narratives for the Provo River and both eastside drainages are included in the Hydraulic Design Office Report (Attachment AA of Appendix D).

Provo River - An HEC-2 model was developed based on one originally developed for a Flood Insurance Study. The model was imported, reviewed, and modified as appropriate. Provo city representatives were concerned about possible deposition or degradation of the channel since the 1986 study. Four cross sections were resurveyed (by the city) in 1996 and compared to the 1986 sections. No significant changes were observed. Manning's roughness coefficients, or "n" values, of the original model were adjusted to fit recently observed high water marks. The resulting water-surface profiles are shown on Plate 5. The corresponding flood plains are shown on Plate 6 (a composite of the Provo River and Northeast and Southeast Drainage flood plains, which were developed separately). Water surface profiles and flood plains for the Provo River (as well as flood plains for the Northeast and Southeast Drainages) were developed for the flood events corresponding to the 2, 1, and 0.2 percent (1 in 50, 1 in 100, and 1 in 500) chance of occurrence in any one year.

As shown on these plates, the major problem area along the Provo River lies downstream from Interstate 15. Other specific problem areas are the industrial area and residential areas adjacent to Reams and Riverside Parks upstream from I-15, along Moon River Road, and adjacent to 2230 North Street. The 1 in 100 chance flood event does exceed channel capacities upstream from 2230 North, but primarily affects open space areas.

The 1 in 10 chance flow remains within the channel of the Provo River. Therefore, no flood plains have been developed for this event. For other flood events, Geotechnical Branch supplied the levee failure criteria to be used for this study. The Probable Non-Failure Point was identified to be 2 feet below the levee crown at the index point just downstream from Geneva Road. The 1 in 50 chance flood stays confined to the channel for most reaches. Along the golf course from 2230 North to 3700 North, the 50-year flow meanders close to the channel. Both overbanks are flooded around and just upstream from Interstate 15. Downstream from Geneva Road, the 1 in 50 chance event will flood both the left (south) and right (north) overbanks. The volume available is limited, and the flooded area is small compared to the 1 in 100 and 1 in 500 chance floods.

The 1 in 100 chance flood will be contained for most reaches with "out of channel" flooding through the golf course. The 1 in 100 chance flood also escapes on the left bank between University and State Street. Major 1 percent chance out-of-bank flows occur on both banks about 1 mile upstream from Interstate 15. On the right bank, out-of-channel flows are contained by rising ground. On the left bank, flow escapes the channel just downstream from a ridge which ends at Riverside Park, allowing 100-year flows into a residential area. Downstream from Interstate 15, overbank 1 percent chance flooding occurs on both sides (north and south of the river). Depths of flooding are about 1 foot. Once again, the bridge contains all the flow, but the banks downstream from the bridge are lower than the water-surface elevation exiting the bridge. The volumes of the hydrographs are sufficient to cover the flood plains shown.

The 1 in 500 chance flood and associated losses will be more extensive. The flooding is out-of-bank from near the canyon mouth to State Street. The 1 in 500 chance flood is contained by University Avenue bridge, but the flood is out of both banks just downstream. The right bank consists of rubble mounds with no continuity, and the left bank is at the 1 in 500 chance water-surface elevation and is lower than the 1 in 500 chance elevation downstream. Thus, flows escape both banks with no conditions for levee failure. At State Street, water escapes to the south (left bank) with some flow leaving the river and extending 1 mile south to Center Street and other flows paralleling the river. The 1 in 50 chance flood plain downstream from Interstate 15 is slightly larger than the 1 in 100 chance flood plain.

Northeast and Southeast Drainages - Flood plains for the Northeast and Southeast Drainages are also shown on Plate 6. The flood plains for the two eastside drainages were developed using the two-dimensional flood routing computer model FLO-2D. Flow depth and velocity are predicted at grid nodes and represent the grid element average values for a small timestep. The square grid element size is selected based on project needs. The model can simulate flow over complex topography and roughness, channel flow, flow exchange between the channel and the flood plain, and street and gully flow. The flow regime can vary between supercritical and subcritical flow as the floodwave moves down the flood plain, channels, and streets. Flood simulation can include application of several components such as rainfall, infiltration, bridge and culvert components, modeling the effects of buildings or other flow obstructions, sediment transport, and mud and debris flow.

A Manning's "n" value of 0.08 was applied to all elements of the flood plain. The current model does not contain grid element area reductions to account for structures or other flow obstructions. However, a few elements were completely blocked from flow near the location of the inflow hydrographs to get flow directed correctly. Several flood plain grid elevations were modified following initial runs to remove depressions, or ponding areas, within the flood plain. The elevations were modified after looking at a quad sheet to verify that no depression in the topography existed.

Most of both flood plains are characterized by wide, shallow, sheetflow flooding. There are, however, small areas of the flood plain, especially in the southeast area near the railroad tracks, which show isolated ponding areas.

RISK-BASED PROCEDURES

Risk-based models have been developed for the Provo River as well as for the Northeast and Southeast Drainages.

Traditionally, flood damage reduction planning by the Corps has accounted for uncertainty by using safety factors, freeboard, and other procedures that acknowledge uncertainty, but did not explicitly quantify it. That process was necessary because of the interaction of hydrologic, hydraulic, and economic factors and the complex mathematical relationships between them. However, advances in statistical hydrology and the availability of high-speed computerized analysis now make it possible to explicitly account for uncertainty. In addition, these advances and tools permit assessment of the reliability of flood damage-reduction plans and the long-term risk of capacity exceedence.

The risk-based procedure is described in Engineering Regulation 1105-2-101, "Risk Analysis Framework for Evaluation of Hydrology/Hydraulics and Economics in Flood Damage Reduction Studies," dated February 25, 1994. The circular defines the analysis as "an approach . . . that explicitly, and to the extent practical, analytically incorporates consideration of risk and uncertainty . . . so that the engineering and economic performance and associated reliability of the project can be expressed in terms of probability distributions."

Risk-based analysis was used to determine existing conditions, to formulate alternatives, and to analyze the with-project conditions. The section below briefly describes (1) the hydrologic and hydraulic conditions in the study area and (2) the methodology of the risk-based analysis used to formulate and evaluate alternative plans. The steps in the procedure for Provo include:

Existing Conditions - The existing (without-project) conditions for the risk-based evaluation assumed that existing local levees would remain and that no additional levees would be constructed.

Methodology - The risk-based analysis was completed using the MONTE computer program. MONTE is a Monte Carlo simulation using a Fortran-based program to compute expected annual damages (EAD), estimated annual exceedence probability, and reliability. Before a risk-based analysis can be performed, it is necessary to look at the unique hydrologic, hydraulic, and economic characteristics of the study area. The risk-based model used the following relationships that were developed for this study: Discharge-frequency curves, Stage-discharge curves, Stage-damage curves, and unregulated vs. regulated flow curves (on the Northeast and Southeast Drainages) under existing and project conditions.

Study Reaches - The study area was divided into three reaches—the flood prone area adjacent to the Provo River; the Northeast Drainage area affected by Mile High, Little Rock, and Rock Canyons; and the Southeast Drainage affected by Slide, Slate, and Buckley Draw Canyons.

Index Points - An index point was selected for each area to characterize its hydrologic, hydraulic, levee stability, and economic conditions. This point was used to (1) identify the uncertainties of Provo River and its tributaries, (2) identify the chance of exceedence afforded to Provo, and (3) determine the flood damage reduction benefits for the various flood damage reduction alternatives. The following index points were selected based on existing hydrologic information and results of the HEC-2 model. The selection of the index points shown below was based on identifying "critical points"; that is, low areas in the existing levee profile on the Provo River. On the Northeast and Southeast Drainages, the index point was selected as that point directly downstream from the largest tributary (Rock on the north and Slate on the south) along the line where the tributary floodflows were combined. (See Plate 7.) This plate also identifies non-exceedences under with-project conditions, which are discussed in the next chapter.)

- Provo River - Adjacent to the local levee just downstream from Geneva Road.
- Northeast Drainage - At 700 East on 2600 North Street, due west of Rock Canyon.
- Southeast Drainage - At 1100 East on 700 South Street, due west of Slate Canyon.

Hydrology (Discharge-Frequency Curves) - The discharge-frequency relationships previously shown in the hydrology section were used for this analysis. The analysis covered a broad range of frequencies for the Provo River and its tributaries. The flow-frequency data for the Provo River were taken from the curve "Provo River at I-15," which is just upstream from Geneva Road. Flow-frequency data for the Northeast and Southeast Drainages were developed by routing and combining the appropriate tributary flows. The hydrology risk component is developed from the flow-frequency relationships, and an *effective* period-of-record (N). For the eastside drainage analyses, models were developed without flow peak or volume data, because the drainages are ungaged. Model parameters were determined from regional information obtained from previous hydrology studies and soil surveys. Based on having no flow data for model calibration, and some regional information, the period-of-record selected for the eastside basin flow-frequency analyses was 15 years. The cloudburst analysis for the Provo River mainstem also used an N of 15 years. The regulated snowmelt curves for the mainstem Provo River, developed from gaged data and a reservoir operations model, have an effective period-of-record of 37 years.

Hydraulics (Stage-Discharge Curves) - The stage versus discharge rating relationship for the Provo River study area was derived using the HEC-2 computer program. Water-surface profiles were computed based on the assumption of steady-flow and rigid boundary conditions. This model used cross-section surveys with certain cross sections which were resurveyed for this study. Cross-section data of bridge openings were taken from construction drawings and field surveys.

The development of the stage-discharge relationships was based on various assumptions, base data, and modeling techniques used in the study. The project stage-discharge relationships, or rating curves, were developed using minimum, average, and maximum conditions. The average condition rating curve was used as input into the risk-based analysis. Stage-discharge relationships were determined for various flows at both index points using the HEC-2 hydraulic model. For sensitivity runs, maximum and minimum conditions "n" values (roughness factors) were applied. For the Provo River, a standard error of 0.83 foot was computed for the 1 percent chance event.

Synthetic stage-discharge relationships were developed for both the Northeast and Southeast Drainages, since no channel exists. Since the eastside stage-discharge relationships were not based on channel stage-discharge data, the standard error used in the risk-based models was zero.

Geotechnical Analysis (Probable Failure and Nonfailure Points) - Levees can fail for numerous reasons, and it is difficult to predict how and where they will fail. Levees have failed when the height of the water surface was significantly below the design flow. In other cases, floodflows have encroached into the design freeboard (or safety zone), but without levee breaching or significant damages.

To define these weak points, "probable nonfailure points" (PNP) and "probable failure points" (PFP) were defined along the levees. The PNP is the 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. By definition, the PNP is the point at which the chance of failure is 15 percent; for the PFP, the chance of failure is 85 percent. Based on geotechnical analysis, the probable failure and probable nonfailure points for Provo River index point were identified. The purpose of identifying these failure points is to establish standards of levee reliability (levee failure criteria) in accordance with Policy Guidance Letter 26. As part of this investigation, a geotechnical engineer made an analysis to determine the condition of existing levees. From this analysis, the identified probable failure points (depending on the reach of the river) ranged from 0.5 to 1 foot below the existing levee crown. The respective probable nonfailure points for the existing levees ranged between 1.5 and 2.5 feet below the existing levee crown. For the Northeast and Southeast Drainages, where there are no levees, the PNP and PFP were taken as the existing natural ground.

Flood Plains - Reconnaissance-level flood plains were developed using the HEC-2 and FLO-2D hydraulic models. Flood plains (using the levee break scenario at the PNP on the Provo River) were developed for the 2, 1, and 0.2 percent (1/50, 1/100, and 1/500) chance flows as shown on Plate 6. These flood plains were then used to develop the stage-damage relationship for the economic analysis.

Unregulated versus Regulated Flow - On the Provo River, there are no detention or storage facilities downstream from Deer Creek Reservoir in the study area; therefore, the regulated flow was the same as the unregulated flow. On the Northeast and Southeast Drainages, the respective tributary outflows were routed to the respective index point to determine the existing (and subsequently with-project) regulated flows.

Uncertainty - Hydrologic uncertainty is based on the equivalent record lengths as previously identified above. These periods of record were used to determine the uncertainty in flow-frequency. Hydraulic uncertainties primarily are associated with the stage-discharge relationship as described above. This is accounted for through the computation and use of a standard error associated with the stage-discharge relationship. Standard error values were also developed for regulated vs. unregulated flows on the eastside drainages. For this reconnaissance-phase study, additional economic variable uncertainties were not included. At the feasibility level, economic uncertainties in the structure and content values as well as first floor elevations will be included.

Results - As shown on Plate 7, results of the risk-based models indicate that under existing conditions there is a 1 in 24 chance of flooding in any one year on the Provo River; a 1 in 20 chance of flooding in any one year on the Northeast Drainage; and a 1 in 21 chance of flooding in any one year on the Southeast Drainage.

FLOOD DAMAGES

Potential flood damages along the Provo River and the eastside drainages are high. Expected annual flood damages along the Provo River have been estimated at almost $600,000. Expected annual damages for the Northeast and Southeast Drainages have been estimated at $2.57 million and $2.17 million, respectively. Collectively, expected annual damages for the whole study area under existing (without-project) conditions are over $5.3 million.

The purpose of this section is to present a summary of the economic analysis used to measure damages resulting from flooding and potential benefits derived from project alternatives. Damages and benefits are expressed as average annual values at a Federal discount rate of 7-3/8 percent with a project life of 50 years at October 1996 price levels. A brief description of each damage area follows:

Provo River (upstream to downstream) -

- 2230 North Street - the area east of the river consisting primarily of commercial and some residential development.
- Moon River Road - the area south of the river from University Blvd. to State St. consisting of commercial and residential development.
- Park Area - the area of residential development adjacent to Riverside and Reams Parks.
- Industrial Area - the small area south of the river upstream of I-15 consisting of small industrial businesses.
- Below I-15 - the largest area of the Provo River and includes development on both sides of the river. High density development with many residential units.

Northeast Area - The large area north of Brigham Young University. The flood plain starts just below the mountain canyons on the east to just east of the Provo River on the west. The area is primarily residential with some commercial and public development.

Southeast Area - The large area south of Brigham Young University. The area is bounded by the mountains on the east and University Boulevard on the west. The area consists of residential, commercial, and public development.

Each of the areas was broken into 2 percent, 1 percent, and 0.2 percent chance flood hazard zones (flood plains). Depths of flooding were based on the average depth for each flood plain.

Flood Plain Inventory - Using area maps with the flood plains depicted, an inventory of the study area was developed. For the areas along the Provo River, an inventory was developed on a structure-by-structure basis. Aerial photos, field inspection, Provo City zoning map, and parcel data were used to determine the number and type of structures.

Due to the size of the two eastside areas (over 6,000 acres for 0.2 percent chance flood plain), the number of structures on the Northeast and Southeast was estimated based on the number of acres inundated using the flood plain maps, Provo City Land Use Maps, regional data, and field inspection. Structural densities were developed per acre and were used to measure the number of structures in each flood plain based on the acreage of each reach. The number of structures for each land use category in the largest (0.2 percent chance) flood plain is displayed in Table 7.

TABLE 7
Total Number of Structures in the Study Area
(Based on the 0.2 percent Chance Flood Plain)

Reach	Residential	Mobile Homes	Commercial /Industrial	Public	Total
Provo River	1,205	228	168	10	1,611
Northeast	3,180	0	340	70	3,590
Southeast	4,170	0	440	90	4,700
Note: Structure counts are estimates for the two largest reaches (Northeast and Southeast) and numbers are rounded to nearest 10 units.					

Value of Damageable Property - Structure values were determined by estimating current values minus the value of the land. These structure values represent replacement costs minus depreciation. Local officials and realtors were contacted to estimate the average values of various structure types. These values were compared to estimates from sales data and field observations. For the two eastside reaches, total value estimates were obtained by examining the land use in each area and multiplying the acreage by the depreciated replacement cost of each structure type. Using this methodology, a value of damageable property per acre was established and then used with the acreage data to determine total values for each flood plain.

Values of structures in the Provo River flood plains were determined based on individual structure. For the commercial, mobile home, and public categories, structural characteristics were determined, and Marshall & Swift Valuation was used to estimate the values of each structure by square footage. For residential values, sales data and discussions with local realtors and developers were used to determine average values (minus land) for single-family homes, duplexes, and condominiums.

Content values were determined as a percentage of structure value by land use. Total depreciated values of property for all existing flood plain structures and contents by reach and land use are shown in Table 8.

TABLE 8
Value of Damageable Property
Structure & Content
October 1996 Prices, in $1,000's

Reach	Residential	Mobile Homes	Commercial /Industrial	Public	Total
Provo River	161,420	3,420	105,210	4,950	275,060
Northeast	594,500	0	270,200	36,100	900,800
Southeast	779,300	0	354,400	47,300	1,181,000

Future Growth and Development - Estimates for future growth were not included in this report. Analysis of future growth would not have a significant impact on the benefit analysis.

Flood Damage Evaluation - Damage susceptibility relationships were established as a function of structure and content values. Depth-damage relationships describe damages under different depths of flooding.

Damage Categories - Damages to structure and content were based on depth of flooding. For each structure, foundation height was subtracted from the average depth to arrive at the depth of flooding within the structure. Damages are a resultant product of an integration of flood depths, frequency of flooding, value of damageable property, and the percent damage to structure and content. Due to the shallow depths of flooding, structures with basements were especially susceptible to flood damage. At these shallow depths of flooding that may not inundate the first floor, the basements could still be fully inundated. Approximately 85 percent of all residential stuctures either have basements or are split level. On average, structure and content damage to residential basements account for a high percent of the total damages in the area. This is because almost all basements have living quarters, including bedrooms, bathrooms, and family rooms, similar in finish to main floor areas. Extensive flooding in these homes can result from even minimal depths of flooding. Other categories included in the analysis were auto and road damages and emergency costs.

Frequency-Damage and Stage-Damage Relationships - Using the DAMAGES program, the magnitude of damages was calculated based on frequency. Damage estimates were determined for 50-year, 100-year and 500-year flood plains. Damage values were then linked to an index stage by frequency for each reach. The frequency relationships used to develop the stage-damage curves for each reach are shown in Table 9.

TABLE 9
Stage-Damage Relationships
Values in October 1996 Prices (in $1,000's)

Stage in Feet	Damages to Structure & Content			Damages to Autos, Roads, & Emergency	Total Damage ($1,000's)
	Residential	Commercial /Industrial	Public		
Provo River					
4,519.0	0	0	0	0	0
4,519.1	4,389	5	0	235	4,629
4,520.9	11,704	360	107	765	12,936
4,523.1	41,737	5,788	350	1,886	49,761
Northeast Drainage					
4,794.5	0	0	0	0	0
4,794.8	33,500	1,100	300	500	35,400
4,795.0	86,700	3,300	900	1,200	92,100
4,795.5	99,100	4,100	1,100	1,200	105,500
Southeast Drainage					
4,588.5	0	0	0	0	0
4,588.8	40,800	1,400	400	700	43,300
4,589.0	73,700	2,800	700	1,100	78,300
4,589.5	130,000	5,300	1,400	1,900	138,600

Uncertainty in Stage Damage Relationships - As previously identified, for this reconnaissance study, no uncertainties were estimated for the damage evaluation. Further feasibility evaluation may include uncertainties in first-floor elevation, structure and content values, and depth-damage relationships. All Monte Carlo simulations done in this analysis assumed standard deviation for damages equal to zero.

Expected Annual Damages - Expected annual damages (EAD) were determined by weighing the estimated damages from varying degrees of flooding by their probability of occurring. Flow-frequency, inflow-outflow, flow-stage, and probable failure and non-failure points were incorporated with the stage-damage curve to estimate expected annual damages. Uncertainties in stage and flows were included. The Monte Carlo simulation program (MONTE) was used to calculate the numerical integration.

Without-Project Damages - Expected annual damages were estimated for existing without-project conditions for each reach. These annual damage figures with the probable exceedences from the MONTE results are displayed in Table 10. Expected annual damages for the study area are greater than $5 million under existing without-project conditions.

TABLE 10
Without Project
Expected Annual Damages
October 1996 Prices, in $1,000's

Damage Reach	Probable Exceedence	Expected Annual Damages
Provo River	0.041	$596.3
Northeast Drainage	0.048	$2,570.1
Southeast Drainage	0.049	$2,174.1

Basement Damages - Residential basements and the damages they incur from shallow flooding have major impact on expected annual damages. In this study, the majority of the residential units have basements (nearly 85 percent). If the basements could be flood proofed, the damages would be reduced dramatically. New Monte Carlo simulations were run using stage/damage curves where flooding to basements was assumed prevented by flood proofing. Table 11 shows the damage reduction from basement protection. Expected annual damages could be reduced by an average of about 70 percent by protecting or eliminating basement damage. (These data will be used to evaluate the nonstructural alternative.)

Data for benefits under with-project conditions will be presented along with alternative costs in the following chapter - Plan Formulation.

TABLE 11
Without-Project
Expected Annual Damages
With and Without Basement Damages
October 1996 Prices, in $1,000's

Damage Reach	Probable Exceedence	EAD Without Project	EAD Flood-proofed Basements	Reduction in Damages (Percent)
Provo River	0.041	$596.4	$318.4	47
Northeast Drainage	0.048	$2,570.1	$554.0	78
Southeast Drainage	0.049	$2,174.1	$489.1	78

ENVIRONMENTAL RESTORATION

Much of the Provo River through the study area has been channelized and/or confined by local berms and levees over the past century in an attempt to control high riverflows. Few instream pools exist upstream from the backwater influence of Utah Lake, and streamside vegetation is absent or limited in some areas. In addition, periodic seasonal dewatering has reduced the quality of instream habitat for fish, including the endangered June Sucker.

Environmental restoration and protection were identified in the authorizing language for this investigation. Therefore, an effort was made to search for opportunities to restore the environment. An evaluation was made and various resource agencies contacted to determine the potential for restoration. Because of the modified condition of the river, there are potential restoration sites in the study area and elsewhere. Several restoration projects are currently ongoing upstream from the study area in Provo Canyon and in the Heber Valley below Jordanelle Reservoir. Other restoration projects are being developed by the Utah Division of Wildlife Resources at the downstream end of the study reach (just above the confluence with Utah Lake) to improve habitat for the endangered June sucker. These projects and ongoing design efforts are currently being funded by another Federal agency (Department of Interior) as part of the Central Utah Project Completion Act. These restoration projects would appear to qualify under the Corps Aquatic Ecosystem Restoration Authority (Section 206). If the need arises, the Corps could step in under this authority to assist in these restoration efforts. Because these restoration efforts are ongoing with another Federal agency, the Corps will not pursue restoration projects as part of this study effort.

WATER SUPPLY

Although demand for water supply is expected to grow in the area as population growth continues, Provo City has identified that it has an ample water supply for the foreseeable future. Therefore, no further evaluation of water supply will be made as part of this study.

RECREATION

The need for recreation facilities will also grow with the rise in population. Provo has a well developed trail system in place along the Provo River throughout the study reach. This trail is heavily used for walking, running, and bicycling. Therefore, all alternatives formulated will include maintaining the trail. Local plans also exist for a future north/south trail along the east bench. Therefore, alternatives on the Northeast and Southeast Drainages will be developed to minimize conflicts with this trail system.

SUMMARY

There is a significant flood threat in Provo from the Provo River and from the eastside drainages. Under existing conditions, there is a 1 in 24 chance of flooding in any one year on the Provo River, a 1 in 20 chance on the Northeast Drainage, and a 1 in 21 chance on the Southeast Drainage. Expected annual damages total over $5.3 million.

As identified in the paragraphs above, the entire Provo River within the study reach is eligible for Corps involvement. Specific Provo River problem areas to be advanced to plan formulation are 2230 North Street, Moon River Road, Park, Industrial, and below I-15. Also, both eastside drainages pose serious flood threats and will be advanced into plan formulation. They are the Northeast Drainage consisting of Mile High, Little Rock, and Rock Canyons, and the Southeast Drainage consisting of Slide, Slate, and Buckley Draw Canyons. (The Ironton Drainage will not be advanced because it is very small and primarily undeveloped.)

Other water resource needs, including environmental restoration and water supply, have been or are being met by other local, State, and Federal entities and will therefore not be pursued further in plan formulation. Recreation, specifically maintaining the recreation trail, will be included in plan formulation.

CHAPTER IV - PLAN FORMULATION

This chapter summarizes the process of developing and evaluating plans to resolve the identified problems and needs. Plan formulation includes (1) establishing planning objectives, (2) developing formulation criteria, (3) identifying management measures, and (4) formulating and evaluating alternative plans.

PLANNING OBJECTIVES

The basic plan formulation objectives for this reconnaissance report are to:

- Reduce the risk of flooding and flood-related damages to the entire community of Provo City from the Provo River and eastside drainages by developing an implementable and economically justified plan.

- Contribute to National Economic Development (NED) consistent with protecting the Nation's environment, pursuant to national environmental statutes, applicable Executive Orders, and other Federal planning requirements.

FORMULATION CRITERIA

In general, alternative plans are formulated using appropriate combinations of flood control measures. The alternative plans should be formulated in consideration of four criteria: completeness, effectiveness, efficiency, and acceptability. Completeness is the extent to which a given alternative provides and accounts for all things necessary to ensure realization of the planned effects. Effectiveness is the extent to which an alternative alleviates the problems. Efficiency is the extent to which an alternative is the most cost-effective means of alleviating the problems, consistent with protecting the Nation's environment. Acceptability is the workability and viability of the alternative with respect to acceptance by local entities and the public. Specific criteria used in plan formulation include:

Technical Criteria

- Alternative plans should complement State, county, and other local flood control plans and projects in the study area.

- Alternative plans should be consistent with provisions of FEMA's National Flood Insurance Program (NFIP).

- Alternative plans should be complete and not result in induced flood damages to other areas.

- Because of the highly commingled flooding on the Northeast and Southeast Drainages, the flood problems in the study area need to be addressed and plans formulated without regard to the minimum flow criteria. There may be circumstances where there is a Federal interest in a flood control structure in an area which does not meet the minimum flow criteria. Thus, determination of the Federal interest may depend on the eligibility of a specific project feature for cost sharing. (Guidance memorandum is included in Appendix F.)

Economic Criteria

- Benefits and costs should be expressed in comparable terms as completely as possible. Evaluation of alternatives should be based on the same price level, interest rate, and project/economic life.

- Alternatives considered in detail should be economically feasible; total beneficial effects are equal to or exceed the total adverse effects associated with the objectives.

- Implementable plans developed should include identifying at least one alternative plan which has positive national economic development benefits.

Environmental Criteria

- Detrimental environmental effects should be avoided where possible; justifiable mitigation for unavoidable effects should be included. The priority for locating justifiable mitigation should be lands acquired for the other project features.

- Consideration should be given to evaluating and preserving historical, archeological, and other cultural resources.

Socioeconomic Criteria

- Consideration should be given to the safety, health, and social well-being of the affected community.

- Displacement of residents should be avoided whenever possible.

- Effects of local income, employment, business and industrial activity, and population distribution should be considered.

- Plans should be workable within the constraints of present and potential governmental structure, function, relationships, and associations in the study area.

FLOOD CONTROL MANAGEMENT MEASURES

Various measures were identified and initially considered to meet the planning objectives for flood damage reduction and in recognition of associated problems and needs. Following is a summary of each:

Nonstructural Measures

The purpose of nonstructural measures is to reduce flood damages rather than to control floodwater. Nonstructural measures may include raising structures, flood proofing, temporary evacuation, zoning, flood insurance, permanent relocation, and ring levees.

Raising Structures - Nonstructural measures include elevating structures above the base flood elevation. The high cost of elevating the large number of structures within the flood plain would preclude raising structures, especially in light of the fact that approximately 85 percent of the residential structures have basements or are split level and are not well suited to raising.

Flood Proofing - Flood proofing by constructing individual closures or constructing floodwalls to protect individual or small groups of structures was considered. This measure involves sealing buildings to ensure that floodwaters cannot get inside and is called dry flood proofing. All areas below the flood protection level are made watertight. Walls are coated with a waterproofing compound, or plastic sheeting is placed around the wall and covered. Openings, such as doors, windows, sewerlines, and vents, are closed—temporarily with removable closures or, where appropriate, permanently. This measure is well suited to Provo because most building walls and floors are not strong enough to withstand the hydrostatic pressure from more than 3 feet of water. In Provo's case, the average flood depth is less than 1 foot even for the 1 in 500 chance flood. Therefore, this measure was retained.

Temporary Evacuation (Flood Warning) - A monitoring and warning system could be used to alert those within the flood plain of imminent flood threat and to temporarily evacuate potentially affected areas. This measure could possibly provide some benefits adjacent to the Provo River where the stage increases gradually with the more frequent snowmelt events, but there would be little warning and evacuation time for the larger, cloudburst events along the Provo River as well as the Northeast and Southeast Drainages. Also, all permanent buildings and unprotected contents would still be subject to flooding. Temporary evacuation would, therefore, not contribute to a significant increase in the level of protection desired. The notification aspect of this measure is often used in conjunction with the flood proofing measure described above to allow time to install needed closures.

Zoning - Implementation of zoning ordinances could restrict new development within the flood plain. However, because the Provo flood plains are already highly developed, this measure would have little impact in reducing the existing flood threat. Flood plain zoning is currently in place under the auspices of the city's flood plain ordinance, which has been adopted as part of their inclusion in the National Flood Insurance Program.

Flood Insurance - Flood insurance would compensate flood victims for damages after a flood but does nothing to reduce the flood threat or the economic impacts as identified in the criteria above. The city currently participates in the National Flood Insurance Program.

Permanent Relocation - Lands and developments within the flood plain subject to serious flooding could be purchased. However, this measure would be difficult, if not impossible, to implement because much of the flood plain in Provo City is developed, making permanent relocation cost-prohibitive. Furthermore, Provo City would likely not consider such relocations due to the socioeconomic impacts.

Ring Levees - Ring levees could be selectively placed around individual homes or groups of homes. This could be useful in the areas not protected by a levee. However, this measure would not be practical for most of the study area due to the high level of existing development.

<u>Structural Measures</u>

Reservoir Storage - Reservoir storage could retain excess floodflows on the Provo River and/or its tributaries. Current flood reduction storage is available at the upstream Jordanelle Reservoir to protect against the frequent snowmelt events. Because of the highly developed nature of the valley downstream from the canyon mouth and the sensitive ecosystem upstream from the canyon mouth, this alternative was not given detailed consideration due to the associated high economic costs and environmental impacts.

Flood Detention Storage - Flood detention storage would act to reduce peak floodflows. Flood detention storage differs from reservoir storage in that no permanent pool or water conservation would take place. The sole purpose of a detention storage facility is to temporarily detain excess floodwater to limit downstream flow to the existing channel and nondamage capacity. Because of the very large potential design flow volumes required, it was determined that a detention reservoir (or reservoirs) would not be economically or environmentally viable on the Provo River. However, the cloudburst-type flood events on the Northeast and Southeast Drainages would be well-suited to detention storage. Accordingly, this measure was considered further.

Channel Improvements - Channel improvements would consist of enlarging and/or straightening the channel to convey additional floodflows. On the two eastside drainages, channel improvements would consist of developing channels downstream from the canyon mouths on each of the individual tributaries. Environmentally and economically, this measure would result in overwhelming impacts because of the riparian corridor and adjacent development which surrounds the Provo River throughout the study reach and the high level of development below each of the canyon mouths. Accordingly, this measure was not considered further.

Levees/Floodwalls - Levees and/or floodwalls along affected stream reaches would be developed to contain floodflows. Based on the nature of the problems previously identified, improvement of existing levees (constructed by others) along the Provo River warrants further consideration. Improvements to existing levees will require minor improvements at a few localized sites on Moon River Road to prevent future erosion. This measure was not considered applicable to the Northeast and Southeast Drainages, since no channels currently exist.

SUMMARY

Table 12 shows a summary of the potential flood control management measures and whether they were retained or deleted from further development at this time.

TABLE 12
Flood Control Management Measures Retained and Deleted

Measure(s)	Status
Raising Structures, Zoning, Flood Insurance, Permanent Relocation, & Ring Levees	Deleted - would not provide desired protection, little likelihood of implementation
Flood Proofing, Flood Warning	Retained - potential for use in alternative development
Reservoir Storage	Deleted - likely high economic and environmental cost and lack of practical site
Flood Detention Storage	Retained - high potential for implementation on the Northeast and Southeast Drainages
Channel Improvements	Deleted - eliminated due to environmental/economic impacts
Levees/Floodwalls	Retained - high potential for implementation on Provo River

MEASURES DELETED FROM FURTHER CONSIDERATION

Nonstructural and structural measures such as raising structures, temporary evacuation, zoning, flood insurance, permanent relocation, ring levees, reservoir storage, and channel improvements would not meet the stated objectives or be practical from an engineering standpoint and/or from an economic/environmental perspective. As identified above, separate environmental restoration and recreation measures will not be considered further although they are both integral parts of the flood damage reduction measures retained for further study.

MEASURES RETAINED FOR DETAILED STUDY

Measures retained for further study were selected based on several factors, including economic feasibility, sponsor desires and interest, and legislative directive. The measures retained include flood proofing, flood warning, detention storage, and levees/floodwalls.

DEVELOPMENT OF ALTERNATIVE PLANS

In addition to the no-action alternative, five alternatives were developed for the study area—one nonstructural flood proofing/flood warning alternative and four structural alternatives consisting of various levels of levee/floodwall improvements on the Provo River and detention basin and/or pipeline improvements on the Northeast and Southeast Drainages. These alternatives were reviewed and coordinated with the potential sponsor. Once preliminary designs were developed, the sponsor was again consulted to determine if any modifications were needed prior to real estate and cost estimates being developed.

No-Action Alternative

Under this alternative, no action would be taken by the Federal Government to alleviate flood problems and conditions in the study area. No action would mean that the existing flood threat would continue unchecked indefinitely. (This alternative represents the future without-project condition).

- Flooding would continue to cause problems on the Provo River for events greater than a 1 in 24 chance in any one year.
- Flooding on the Northeast and Southeast Drainages will continue even more frequently than on the Provo mainstem, with about a 1 in 20 chance in any year.
- Expected annual flood damages, estimated to be in excess of $5.3 million, would continue indefinitely.

Nonstructural Alternative

The nonstructural alternative, as previously mentioned, would consist of flood proofing residential buildings to ensure that floodwaters cannot get inside. All areas below the flood protection level are made watertight. Walls are coated with a waterproofing compound, or plastic sheeting is placed around the wall and covered. Openings, such as doors, windows, sewer lines, and vents, are closed—temporarily with removable closures or, where appropriate, permanently. A flood warning system would also be included in this alternative to alert residents of the need to install the temporary closures. One limitation of this alternative is that on the two eastside drainages there would be little warning time to install closures. Because there are so many homes with basements (or are split level), this alternative was specifically formulated to prevent this type of flooding. A flood plain management evaluation model was used to estimate an average cost per structure for flood proofing (see Basis of Design, Appendix D). Results of the model indicated that the basic average cost for a single-family residence would be approximately $16,600 to protect against the 1 percent (1/100) chance event; a basic flood warning system was also included in each of the three areas.

Impacts and Mitigation - Environmental impacts would be minimal for the flood proofing alternative and consist of minor disturbance of existing upland shrubbery adjacent to the residences during construction. It is not anticipated that any environmental mitigation would be required for this alternative. The cultural resource records check done as part of this study determined that there may be one or more historic structures within the area of potential effect; hence, 1 percent of the construction cost was added to the cost estimate for cultural resources preservation. Requirements of the National Historic Preservation Act concerning any cultural resources found during construction would be strictly complied with.

Costs, Benefits, and Accomplishments - The annual costs of this alternative are estimated to be $670,000 for the Provo River and $6,150,000 and $5,580,000 for the Northeast and Southeast Drainages, respectively. These costs, shown in Table 13, are based on October 1996 price levels, a 50-year period of analysis, and an interest rate of 7-3/8 percent.

TABLE 13
Nonstructural Alternative
Costs and Benefits
($1,000 - Rounded to nearest $10,000)

Item	Provo River	Northeast Drainage	Southeast Drainage	Total
First Costs				
Flood Proofing/Warning	$ 5,700	$52,250	$47,390	$105,340
Cultural Resource Preservation	60	520	470	1,050
Planning, Engineering, & Des	1,430	13,060	11,850	26,340
Construction Management	570	5,220	4,740	10,530
Total	$ 7,760	$71,050	$64,450	$143,260
Interest During Construction	$ 280	$2,570	$2,330	$5,180
Annual Costs				
Interest and Amortization	$ 610	$5,590	$5,070	$11,270
Operation, Maintenance, and Replacement	60	560	510	1,130
Total Annual Cost	$ 670	$6,150	$5,580	$12,400
Total Annual Benefit	$280	$2,020	$1,680	$3,980
Net Benefits	<$390>	<$4,130>	<$3,900>	<$8420>

As shown on the table above, annual benefits for the nonstructural alternative (and for each of the three reaches) are substantially less than the respective costs. Economic benefits for this (and all subsequent alternatives) were determined by taking the difference between annual damages without and with the alternative project in place.

This alternative would increase the level of flood protection for the vulnerable residential structures adjacent to the Provo River in Provo from a 1 in 24 chance of flooding to a 1 in 100 chance in any year and from about a 1 in 20 to a 1 in 100 chance in any one year on the Northeast and Southeast Drainages. (Because this alternative was formulated primarily to protect the highly vulnerable residential structures with basements, there would be some residual flood damages to the non-residential developments.)

Structural Alternatives

Four structural alternatives were developed based on the estimated most practicable combination of structural measures for each study area. (There may be other combinations of features; however, those selected appeared reasonable at this level of detail.)

Provo River - On the Provo River, three sizes of levee raising or new floodwalls on top of existing levees were identified for study in the five reaches. Tie-ins would be to high ground such as elevated road embankments, etc. Reconnaissance designs were developed based on the 2, 1, 0.2 percent (1/50, 1/100, 1/500) chance exceedence events. Because the levee/floodwall heights are 3 feet above the respective design water surfaces, the resulting risk-based levels of protection are significantly higher—1 in 76, 1 in 270, and 1 in 500+ as shown on Plate 7.

Except for the Industrial and Park areas, adjacent urban development and the existing riparian corridor would make it expensive to enlarge existing levees. Extending the vertical height of the existing levee by means of floodwalls would reduce costs and environmental impacts. Therefore, the alternatives were formulated using floodwalls in all reaches practicable. At the low (2 percent exceedence) design level, floodwalls can be used in all reaches. At the medium (1 percent exceedence) design level, only the left bank section below Geneva Road would require levee enlargement rather than the less impacting floodwall. At the high (0.2 percent exceedence) design level, levees would be required for all reaches. Table 14 summarizes those reaches that could beneficially use the floodwall design and those reaches which would require levee improvements.

TABLE 14
Provo River - Levee vs. Floodwall Summary

River Reach	River-bank[1]	Structural Features vs. Design Level		
		Low Level (2% exc.)	Medium Level (1% exc.)	High Level (0.2% exc.)
Below I-15 Area				
Downstream from Geneva Rd	Left	Floodwall	Levee	Levee
	Right	Floodwall	Floodwall	Levee
I-15 to Geneva Rd	Left	Floodwall	Floodwall	Levee
	Right	Floodwall	Floodwall	Levee
Industrial Area	Left	Levee	Levee	Levee
Park Area	Left	Levee	Levee	Levee
Moon River Area	Left	Floodwall	Floodwall	Levee
2230 North St Area	Left	Floodwall	Floodwall	Levee

[1] Facing downstream.

Northeast and Southeast Drainages - For the two eastside drainages, it was determined that detention storage at the 1 or 0.2 percent (1/100 or 1/500) chance design level would not be practicable because the large detention basins that would have to be constructed would displace the very homes and other facilities the basins are supposed to protect. Therefore, three levels of protection were formulated for both eastside drainages. At the request of Provo City, the low level of protection consists of only pipeline and, where feasible, short open channel improvements which would convey the 1 percent (1/100) chance exceedence snowmelt event. The medium level of protection would consist of enlarging and adding new detention basins upstream from the pipeline improvements included in the low protection alternative to approximately a 2 percent (1/50) exceedence design. The high level of protection would be essentially the same as the medium level of protection, except the detention basins would be somewhat larger. Each of the individual watersheds would have either a new detention basin installed or the existing basin enlarged (in the case of Mile High, Rock, and Slate Canyons). On Little Rock Canyon, it was determined that there is not a suitable site even for a small detention basin; therefore, alternative improvements for this watershed would consist of conveyance pipeline improvements only. Conveyance pipelines downstream from the new or improved detention basins were sized so as to pass the 1 percent (1/100) chance snowmelt outflows.

Flood control under the three sizes would be accomplished by the features listed below. Plates 8, 9, and 10 show the location of the features for the three levels of protection provided by the structural alternatives. Plate 11 shows a typical section for the major features. Details of the three sizes are contained in the Basis of Design, Appendix D. Associated Real Estate information is contained in the Real Estate Report, Appendix E.

<u>**Structural Alternative (Low Level Protection)**</u>

Features of the low level protection structural alternative as shown on Plate 8 include:

- **Provo River** - Raise the existing levees on the left bank at the Industrial and Park areas (just upstream from I-15) approximately 5,000 lineal feet. The levee would be trapezoidal with sideslopes of 3 horizontal to 1 vertical on the waterside and 2-1/2 horizontal to 1 vertical on the landside. (See Plate 11.) The levee crown would be 12 feet wide and would be used as a roadway for levee inspection and maintenance as well as for the recreation trail. This alternative also includes building floodwalls on top of existing levees on the left and right banks below I-15, along the left bank adjacent to Moon River Road, and on the left bank upstream from 2230 North Street for a total length of approximately 11,000 lineal feet.

- **Northeast Drainage** - Add approximately 20,000 lineal feet of conveyance pipelines on Mile High, Little Rock, and Rock Canyons from the canyon mouths to the Provo River. Improve a short 2,000-foot reach of existing open channel immediately upstream from the existing Mile High basin. (The open channel would also be improved under the medium and high structural alternatives.) No detention basin improvements are included in this alternative for this drainage or for the Southeast Drainage in order to evaluate the effectiveness of pipeline improvements only.

- **Southeast Drainage** - Add approximately 34,000 lineal feet of conveyance pipelines on Slide, Slate, and Buckley Draw Canyons. Two short 2,000-foot reaches of open channel would be developed downstream from the pipelines on Slate and Buckley Draw Canyons for this alternative, as well as for the medium and high structural alternatives.

Impacts and Mitigation - Environmental impacts would include minor disturbance of existing upland and riparian vegetation during construction. Caution would be required to prevent any disturbances channelside of the existing levees. No mitigation would be required for this alternative due to the extensive use of floodwalls through environmentally sensitive areas adjacent to the Provo River. Because the eastside features would consist of conveyance pipeline improvements only (mostly under existing streets), eastside environmental impacts would be temporary only, and no mitigation would be required. Standard construction practices would be used to avoid and minimize soil disturbance outside the immediate construction area.

A cultural resource records check was done as part of this study and determined that there are no sites within the area of potential effect. However, 1 percent of the construction cost was added to the cost estimate for cultural resources preservation in case any sites are identified in future studies or during construction. Requirements of the National Historic

Preservation Act concerning any additional cultural resources found during construction would be strictly complied with.

Costs, Benefits, and Accomplishments - The costs and benefits of this alternative are shown in Table 15. They are based on October 1996 price levels, a 50-year period of analysis, a 1-year construction period, and an interest rate of 7-3/8 percent.

TABLE 15
Structural Alternative - Low
Costs and Benefits
($1,000 - rounded to nearest $10,000)

Item	Provo River	Northeast Drainage	Southeast Drainage	Total
First Costs				
Lands and Damages	$3.350	$1,840	$1,260	$6,450
Fish and Wildlife (mitigation)	0	0	0	0
Levees and Channels	1,130	NA	NA	1,130
Conveyance Pipelines	NA	2,990	5,190	8,180
Cultural Resource Preservation	50	50	60	160
Planning, Engineering, & Design	280	750	1,300	2,330
Construction Management	110	300	520	930
Total	$4,920	$5,930	$8,330	$19,180
Interest During Construction	180	210	300	690
Annual Costs				
Interest and Amortization	$390	$470	$650	$1,510
Operation, Maintenance, and Replacement	10	10	20	40
Total Annual Cost	$400	$480	$670	$1,550
Total Annual Benefits	$190	$410	$200	$800
Net Benefits	<$210>	<$70>	<$470>	<$750>

As shown on the table above, total annual benefits for the low level structural alternative are substantially less than the respective costs. On the Provo River portion, this is primarily due to the lands costs, specifically, the high administrative costs associated with acquisition of lands held by the many different owners. There are 69 separate ownerships in the Provo River reach alone. The average cost for each acquisition (and related administration costs) is $30,000. This is based on actual costs incurred on other similar projects. Costs for the Northeast Drainage portion at this level of protection are only slightly less than the respective benefits. Costs for the Southeast Drainage portion are much greater than potential benefits.

This alternative would result in only a modest increase in the level of flood protection. The improved levees and floodwalls along the Provo River would decrease the chance of flooding from a 1 in 24 chance to a 1 in 76 chance in any year. On the Northeast and Southeast Drainages, conveyance improvements would decrease the chance of flooding from about a 1 in 20 chance to about a 1 in 25 chance in any year. (See Plate 7.)

Structural Alternative (Medium Level Protection)

Features of the medium level protection structural alternative are shown on Plate 9 and include:

- **Provo River** - Raise existing levees on the left bank below Geneva Road and at the Industrial and Park areas (just upstream from I-15) approximately 9,000 lineal feet. The levees would be trapezoidal with sideslopes of 3 horizontal to 1 vertical on the waterside and 2-1/2 horizontal to 1 vertical on the landside. (See Plate 11.) The levee crown would be 12 feet wide and would be used as a roadway for levee inspection and maintenance as well as for the recreation trail in the Industrial and Park areas. This alternative also includes building floodwalls on top of existing levees on the right bank below Geneva Road, on both banks between Geneva Road and Interstate 15, along the left bank adjacent to Moon River Road, and on the left bank upstream and downstream from 2230 North Street for a total length of approximately 8,000 lineal feet.

- **Northeast Drainage** - Enlarge existing detention basins on Mile High and Rock Canyons. Improve the outlet conveyance pipelines. Add conveyance pipeline on Little Rock Canyon. Total pipeline length is approximately 20,000 lineal feet.

- **Southeast Drainage** - Build new detention basins on Slide and Buckley Draw Canyons. Enlarge the existing detention basins on Slate Canyon. Improve the outlet conveyance pipelines on Slide, Slate, and Buckley Draw Canyons. Total pipeline length is approximately 34,000 lineal feet.

Impacts and Mitigation - Environmental impacts would include minor disturbance of existing upland and riparian vegetation during construction. Caution would be required to prevent any disturbances channelside of the existing levees. Mitigation totaling approximately 3 acres would be required for loss of about 1-1/2 acres on the left bank below Geneva Road as the result of enlarging the levee. Because the eastside tributaries are without water most of the year, project impacts would be limited, and mitigation would consist of approximately 1 acre to compensate for the loss of about 1/2 acre of emergent marsh at the existing Mile High detention basin. Standard construction practices would be used to avoid and minimize soil disturbance outside the immediate construction area.

A cultural resource records check was done as part of this study and determined that there are no sites within the area of potential effect. However, 1 percent of the construction cost was added to the cost estimate for cultural resources preservation in case any sites are identified in future studies or during construction. Requirements of the National Historic

Preservation Act concerning any additional cultural resources found during construction would be strictly complied with.

Costs, Benefits, and Accomplishments - Costs and benefits of this alternative are shown in Table 16. They are based on October 1996 price levels, a 50-year period of analysis, a 1-year construction period, and an interest rate of 7-3/8 percent.

TABLE 16
Structural Alternative - Medium
Costs and Benefits
($1,000 - rounded to nearest $10,000)

Item	Provo River	Northeast Drainage	Southeast Drainage	Total
First Costs				
Lands and Damages	$3,800	$2,660	$ 1,280	$7,740
Fish and Wildlife (mitigation)	190	50	0	240
Levees and Channels	1,540	NA	NA	1,540
Detention Basins/Pipelines	NA	6,320	10,560	16,880
Cultural Resource Preservation	50	90	120	260
Planning, Engineering & Design	430	1,590	2,640	4,660
Construction Management	170	640	1,060	1,870
Total	$6,180	$11,350	$15,660	$33,190
Interest During Construction	220	410	570	1,200
Annual Costs				
Interest and Amortization	$ 490	$890	$1,230	$2,610
Operation, Maintenance, and Replacement	10	20	30	60
Total Annual Cost	$ 500	$ 910	$ 1,260	$ 2,670
Total Annual Benefits	$390	$1,190	$890	$2,470
Net Benefits	<$110>	$280	<$370>	<$200>

As shown on the table above, total annual benefits for the medium level structural alternative are slightly less than the respective costs. As with the low alternative, this is primarily due to the land costs along the Provo River, specifically the high administrative costs associated with acquisition of lands held by the many different owners. Benefits for the Northeast Drainage portion are greater than the respective costs. The Southeast Drainage still has greater costs than benefits at this level of protection.

This alternative would significantly increase the level of flood protection along the Provo River from the existing 1 in 24 chance up to a 1 in 270 chance in any year. Also, the levees and floodwalls could be certifiable for flood plain management purposes. On the Northeast and Southeast Drainages, protection would increase from about the existing 1 in 20 chance of flooding to a 1 in 49 and 1 in 54 chance in any year, respectively.

Structural Alternative (High Level Protection)

Features of the high level protection structural alternative are shown on Plate 10 and include:

- **Provo River** - Raise existing levees on the left and right banks below I-15, on the left bank at the Industrial and Park areas (just upstream from I-15), along the left bank adjacent to Moon River Road, and on the left bank upstream and downstream from 2230 North Street, a total of approximately 17,000 lineal feet. The levees would be trapezoidal with sideslopes of 3 horizontal to 1 vertical on the waterside and 2-1/2 horizontal to 1 vertical on the landside. (See Plate 11.) The levee crown would be 12 feet wide and would be used as a roadway for levee inspection and maintenance as well as for the recreation trail through most of the areas.

- **Northeast Drainage** - Enlarge existing detention basins on Mile High and Rock Canyons. Improve the outlet conveyance pipelines. Add conveyance pipeline on Little Rock Canyon. Total pipeline length is approximately 20,000 lineal feet.

- **Southeast Drainage** - Build new detention basins on Slide and Buckley Draw Canyons. Enlarge the existing detention basins on Slate Canyon. Improve the outlet conveyance pipelines on Slide, Slate, and Buckley Draw Canyons. Total pipeline length is approximately 34,000 lineal feet.

Impacts and Mitigation - Environmental impacts would include minor disturbance of existing upland and riparian vegetation during construction. Caution would be required to prevent any disturbances channelside of the existing levees. Mitigation totaling approximately 8 acres would be required for loss of about 4 acres on the left bank below Geneva Road as the result of enlarging the levee. Because the eastside tributaries are without water most of the year, project impacts would be limited, and mitigation would consist of approximately 1 acre to compensate for the loss of about 1/2 acre of emergent marsh at the existing Mile High detention basin. Standard construction practices would be used to avoid and minimize soil disturbance outside the immediate construction area.

A cultural resource records check was done as part of this study and determined that there are no sites within the area of potential effect. However, 1 percent of the construction cost was added to the cost estimate for cultural resources preservation in case any sites are identified in future studies or during construction. Requirements of the National Historic Preservation Act concerning any additional cultural resources found during construction would be strictly complied with.

Costs, Benefits, and Accomplishments - Costs and benefits of this alternative are shown in Table 17. They are based on October 1996 price levels, a 50-year period of analysis, a 1-year construction period, and an interest rate of 7-3/8 percent.

TABLE 17
Structural Alternative - High
Costs and Benefits
($1,000 - rounded to nearest $10,000)

Item	Provo River	Northeast Drainage	Southeast Drainage	Total
First Costs				
Lands and Damages	$17,230	$2,770	$1,290	$21,290
Fish and Wildlife (mitigation)	420	50	0	470
Levees and Channels	2,310	NA	NA	2,310
Detention Basins	NA	7,960	12,350	20,310
Cultural Resource Preservation	200	110	140	450
Planning, Engineering & Design	680	2,000	3,090	5,770
Construction Management	270	800	1,230	2,300
Total	$21,110	$13,690	$18,100	$52,900
Interest During Construction	760	500	660	1,920
Annual Costs				
Interest and Amortization	$1,660	$1,080	$1,420	$4,160
Operation, Maintenance, and Replacement	40	30	40	110
Total Annual Cost	$1,700	$1,110	$1,460	$4,270
Total Annual Benefits	$540	$1,450	$1,110	$3,100
Net Benefits	<1160>	$340	<$350>	<$1170>

As shown on the table above, total annual benefits for the high level structural alternative are less than the respective costs. As with the low and medium alternatives, this is primarily due to the land costs along the Provo River, specifically the high administrative costs associated with acquisition of lands held by the many different owners. Benefits for the Northeast Drainage portion are greater than the respective costs. Benefits for the Southeast Drainage would still exceed costs at this level of study.

This alternative would substantially increase the level of flood protection for the affected development along the Provo River from the existing 1 in 24 chance up to a 1 in 500+ chance in any year. The levees would also be certifiable for flood plain management purposes. On the Northeast and Southeast Drainages, protection would increase from the existing 1 in 20 chance to a 1 in 65 and 1 in 72 chance in any year.

Combination Alternative

The annual costs for the three (low, medium, and high) complete area alternatives exceed the respective benefits. However, as shown on Tables 16 and 17, the Northeast Drainage portion of both the medium and high structural alternatives would generate net economic benefits and is, therefore, justified (costs are only slightly less than the respective benefits for the low alternative as well). Since the high level for the Northeast Drainage generates somewhat greater net benefits than the meduium level, it was included in this alternative. On the Provo River, two reaches, the large area below I-15 and the Moon River Road area, also have benefits greater than the associated costs at the medium level. Therefore, features of this combination alternative include:

- **Provo River** - This portion of the medium structural alternative would consist of raising the existing levee on the left bank below Geneva Road a total of approximately 4,000 lineal feet. Also, floodwalls would be built on top of existing levees on the right bank below Geneva Road, on both banks between Geneva Road and Interstate 15, and along the left bank adjacent to Moon River Road for a total length of approximately 6,000 lineal feet.

- **Northeast Drainage** - This portion of the high structural alternative would consist of enlarging existing detention basins on Mile High and Rock Canyons improving the outlet conveyance pipelines and adding a conveyance pipeline on Little Rock Canyon. Total pipeline length is approximately 20,000 lineal feet.

Impacts and Mitigation - Environmental impacts would include minor disturbance of existing upland and riparian vegetation during construction. Caution would be required to prevent any disturbances channelside of the existing levees. Mitigation totaling approximately 3 acres would be required for loss of about 1-1/2 acres on the left bank below Geneva Road as the result of enlarging the levee. Because the eastside tributaries are without water most of the year, project impacts would be limited, and mitigation would consist of approximately 1 acre to compensate for the loss of about 1/2 acre of emergent marsh at the existing Mile High detention basin. Standard construction practices would be used to avoid and minimize soil disturbance outside the immediate construction area.

A cultural resource records check done as part of this study determined that there are no sites within the area of potential effect. However, 1 percent of the construction cost was added to the cost estimate for cultural resources preservation in case any sites are identified in future studies or during construction. Requirements of the National Historic Preservation Act concerning any additional cultural resources found during construction would be strictly complied with.

Costs, Benefits, and Accomplishments - Costs and benefits of this alternative are shown in Table 18. They are based on October 1996 price levels, a 50-year period of analysis, a 1-year construction period, and an interest rate of 7-3/8 percent.

TABLE 18
Combination Alternative
Costs and Benefits
($1,000 - rounded to nearest $10,000)

Item	Provo River (Medium)		Northeast Drainage (High)	Total
	Below I-15	Moon River		
First Costs				
Lands and Damages	$1,980	$ 100	$2,770	$4,850
Fish and Wildlife (mitigation)	190	0	50	240
Levees and Channels	830	230	NA	1,060
Detention Basins/Pipelines	NA	NA	7,960	7,960
Cultural Resource Preservation	30	0	110	140
Planning, Engineering & Design	250	60	2,000	2,310
Construction Management	100	20	800	920
Total	$3,380	$ 410	$13,690	$17,480
Interest During Construction	120	10	500	630
Annual Costs				
Interest and Amortization	$250	$ 30	$1,080	$1,360
Operation, Maintenance, and Replacement	10	0	30	40
Total Annual Costs	$260	$ 30	$1,110	$1,400
Total Annual Benefits	$270	$40	$1,450	$1,760
Net Benefits	$10	$10	$340	$360

As shown on the table above, total annual benefits for this alternative are greater than the respective costs by apprriximately 25 percent. Combined benefits for the two Provo River reaches exceed costs by about 10 percent; benefits for the Northeast Drainage portion are 30 percent greater than the associated costs.

This alternative would significantly increase the level of flood protection for the affected development along the Provo River from the existing 1 in 24 chance up to a 1 in 270 chance in any year. The levees and floodwalls would also be certifiable for flood plain management purposes. On the Northeast Drainage, protection would increase from the existing 1 in 20 chance of flooding up to a 1 in 65 chance in any one year.

EVALUATION OF ALTERNATIVES

Potential project benefits identified below are based on the same price level, interest rate, project life, and implementation schedule used for estimating the project costs above. Table 19 is a summary comparison of the costs and benefits for all the alternatives.

TABLE 19
Summary of Costs and Benefits
($1,000 - rounded to nearest $10,000)

Item	No-Action Alternative	Non-Structural Alternative	Structural Alternatives			
			Low	Medium	High	Combination
First Cost	-	$143,260	$19,180	$33,180	$53,000	$17,480
Annual Cost	-	12,400	1,550	2,680	4,280	1,400
Annual Flood Damages	$5,340	1,360	4,540	2,860	2,240	3,580
Annual Benefits		$ 3,980	800	2,480	3,100	1,760
Net Benefits		<$8,420>	<750>	<200>	<1,180>	360
Relative Advantages	- No initial construction cost	- Significant increase in flood protection	- Moderate increase in flood protection	- Significant increase in flood protection - Northeast Drainage justified - Portions of Provo River justified	- Significant increase in flood protection - Northeast Drainage justified	- Economically feasible elements for reaches shown
Relative Disadvantages	- Flood threat continues	- Not Cost Effective	- Not Cost Effective	- Total costs slightly greater than benefits	- Not Cost Effective	- Only a portion of study area addressed

As shown above, the flood proofing alternative would result in substantially higher costs than benefits derived and, therefore, does not appear to be economically justified. However, flood proofing should still be considered in local future planning efforts for structures in those areas which are most vulnerable to flooding but are not highly developed.

Because there appear to be several justified portions of the structural alternatives, the combination alternative was developed. The combination alternative has positive net benefits on portions of Provo River and the Northeast Drainage. Further refinement, especially with regard to lands costs, could result in one or more feasible alternatives for the other areas of the Provo River at the feasibility level of study. On the Southeast Drainage, costs associated with the high structural alternative are slightly greater than the potential benefits; with further refinement, this area could also be feasible. Therefore, further feasibility-phase studies of the three areas are warranted. These are described in the following chapter.

CHAPTER V - FEASIBILITY-PHASE STUDIES

FEASIBILITY STUDY SCOPE

Because there appear to be several economically justified portions of the structural alternatives, there is a Federal interest in proceeding with the feasibility phase of study. The feasibility study scope, which identifies in detail all elements and costs of the proposed study, is included as the draft feasibility Project Study Plan (PSP) in Appendix F. The feasibility PSP includes a cost estimate and schedule.

The feasibility study would focus on refining the flood problems and on assessing other combinations of flood damage reduction measures developed in this reconnaissance study. A Net Economic Development (NED) plan would be identified based on plans developed and a basis of design for plans and specifications prepared.

Although refinements to the PSP are in progress, it is currently estimated that the feasibility study would require approximately 2 years to complete and cost about $1.5 million. (See Appendix F.) Approximate costs for feasibility studies of just one or two of the three areas are $1 million and $1.2 million, respectively. (These approximate costs are not substantially less than the study cost for all three areas due to the numerous analysis, reporting, and review requirements involved whether one, two, or all three areas are studied.)

NON-FEDERAL SPONSOR'S VIEWS AND PREFERENCES

The potential non-Federal sponsor is in agreement with the basic alternatives developed in this reconnaissance report and is currently determining its willingness and ability to cost share the feasibility study. A letter indicating the views of the potential non-Federal sponsor is included in Appendix G, Pertinent Correspondence.

PRELIMINARY FINANCIAL ANALYSIS

The non-Federal sponsor appears to be financially capable of funding its half of the feasibility study. This will be further documented prior to signing the feasibility cost-sharing agreement (a draft of which is also included in Appendix F).

CHAPTER VI - CONCLUSIONS

Major conclusions of the study are:

- There is a significant flood threat to major areas of Provo City.

- Historically, flood problems have occurred frequently in Provo along the Provo River and the eastside drainages. Flooding in the future could cause substantial damage to much of Provo City, including residential, commercial, public, and industrial structures.

- Even though the potential for loss of life from flooding on the Provo River and eastside drainages is fairly low due to moderate flood depths, the expected annual flood damages are very high—over $5.3 million.

- Both structural and nonstructural measures and alternatives have been considered. Portions of the alternative plans to solve the flooding problems are feasible.

- Based on the plan formulation and analysis completed, portions of the Provo River, as well as the Northeast Drainage, would likely yield positive net benefits and are, therefore, feasible. With further refinement, especially in regard to real estate costs, other portions of the Provo River and the Southeast Drainage could also become feasible. Therefore, further study of the three areas at the feasibility level is warranted.

- The potential non-Federal sponsor supports the structural alternatives identified which have been used as the basis for scoping feasibility studies as identified in the attached Project Study Plan (PSP—Appendix F). The potential sponsor is currently assessing its desire and financial capability to proceed with the feasibility study as indicated in its letter included in Appendix G.

CHAPTER VII - RECOMMENDATIONS

The results of this reconnaissance study indicate that there is a Federal interest in at least one potential flood damage reduction plan in the Provo, Utah, study area. This plan has local support, appears economically feasible, and has a non-Federal sponsor willing to cost share the feasibility phase. Therefore, I recommend that feasibility studies for Provo be approved.

D. F. Klasse

DOROTHY F. KLASSE
Colonel, Corps of Engineers
District Engineer

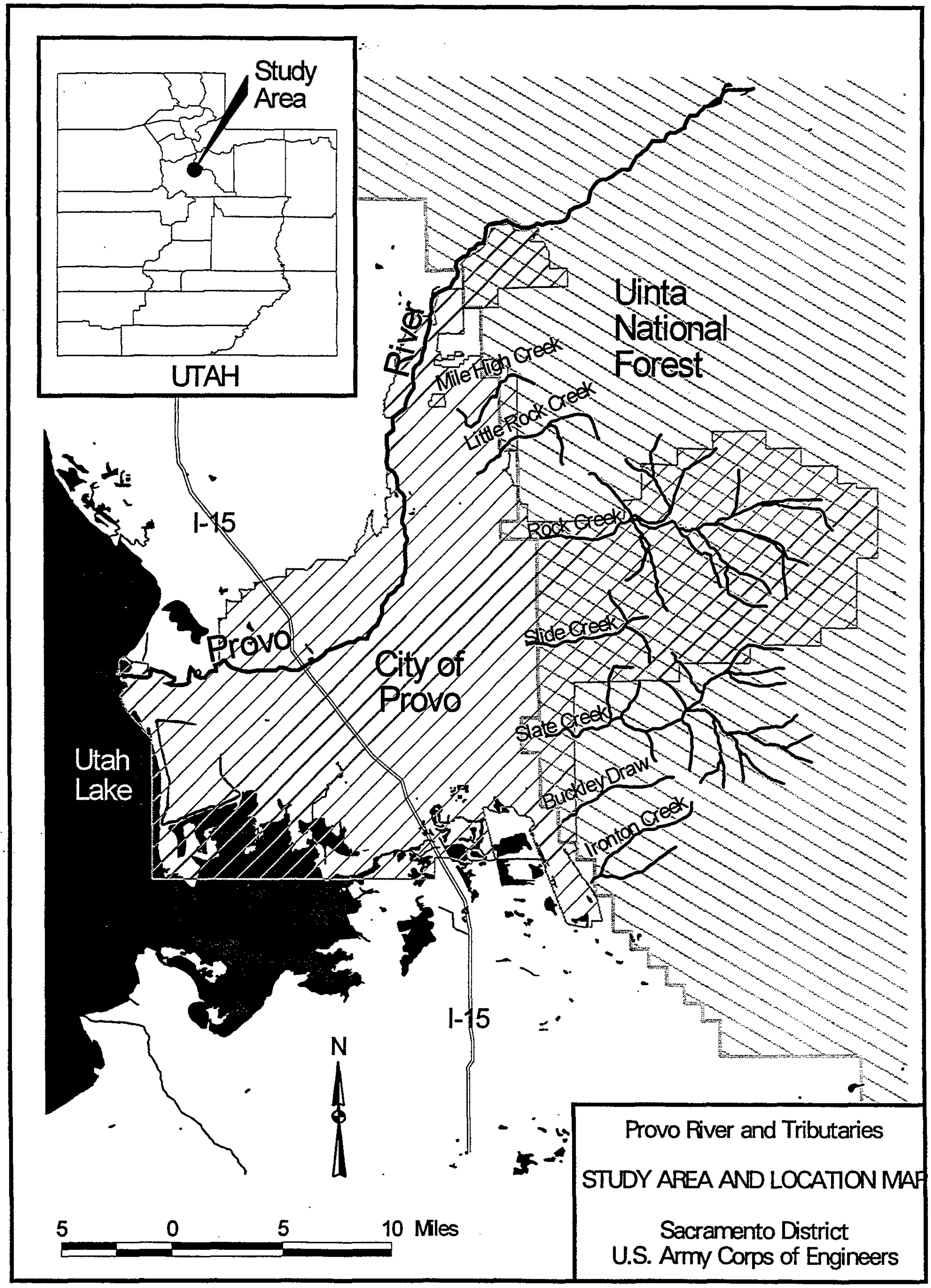
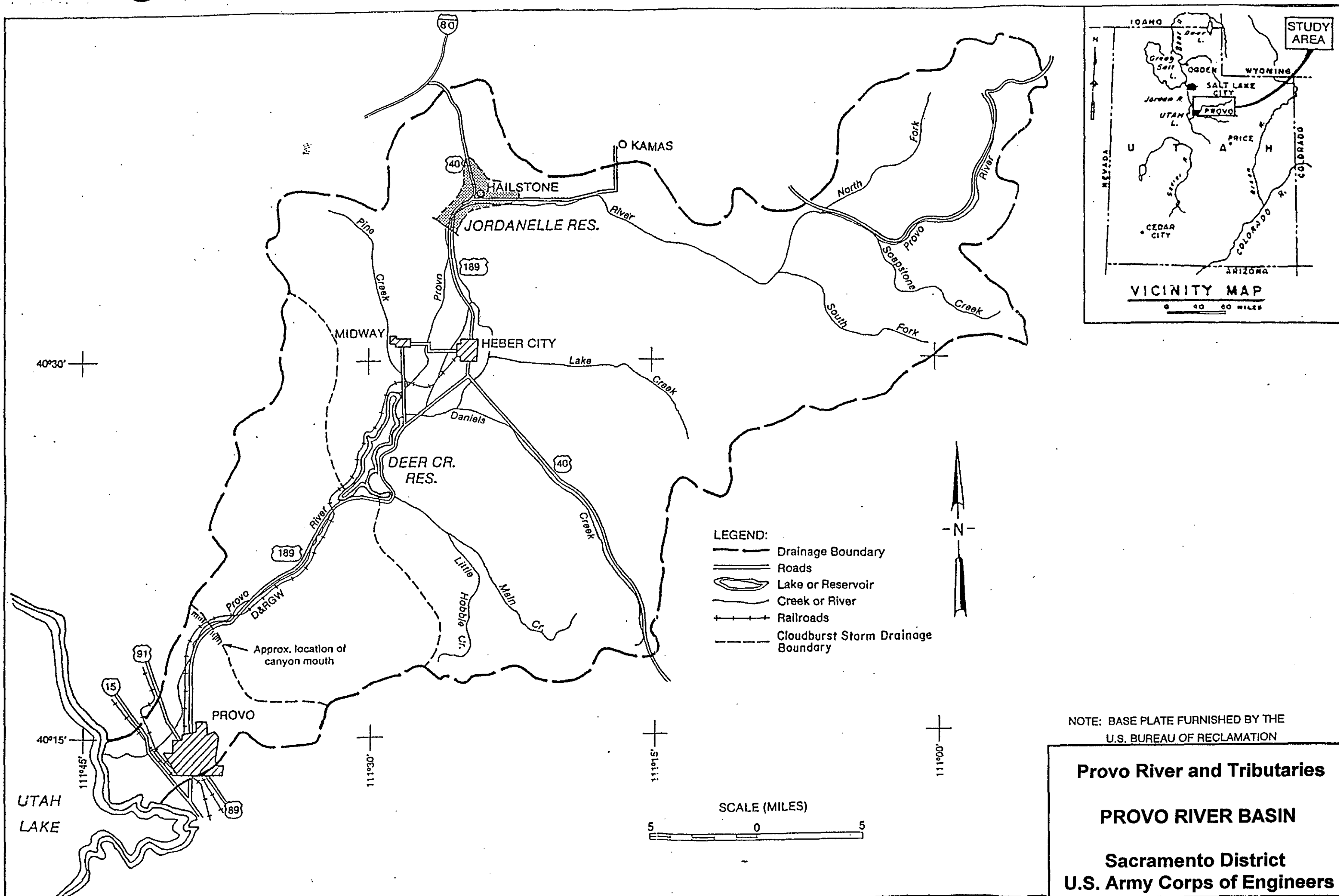

Study Area
UTAH
Uinta National Forest
River
Provo
Mile High Creek
Little Rock Creek
Rock Creek
Slide Creek
Slate Creek
Buckley Draw
Ironton Creek
City of Provo
Utah Lake
I-15
I-15
N
5 0 5 10 Miles
Provo River and Tributaries
STUDY AREA AND LOCATION MAP
Sacramento District
U.S. Army Corps of Engineers

PLATE 1



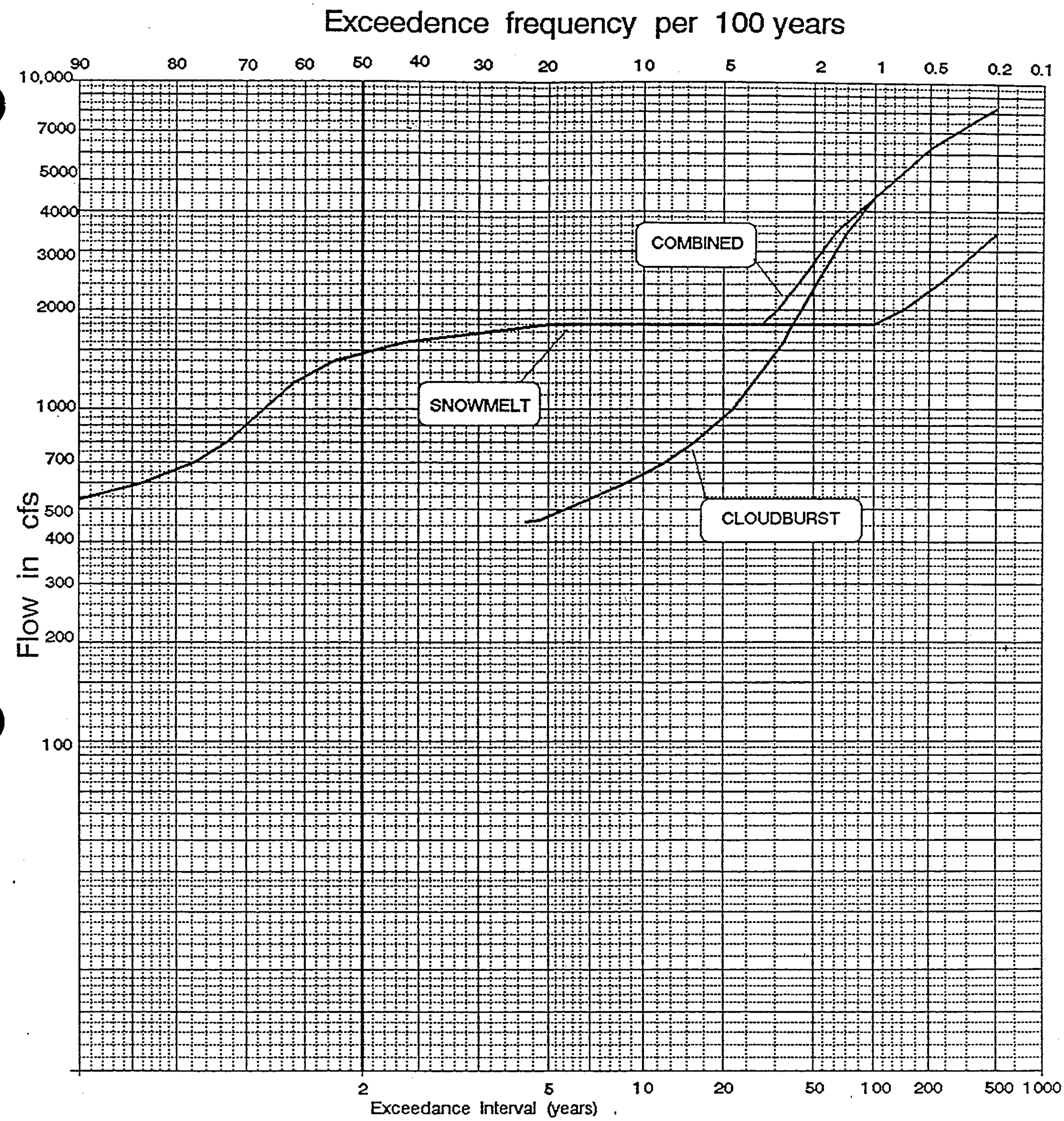
NOTE: BASE PLATE FURNISHED BY THE U.S. BUREAU OF RECLAMATION

Provo River and Tributaries

PROVO RIVER BASIN

Sacramento District
U.S. Army Corps of Engineers

PLATE 2

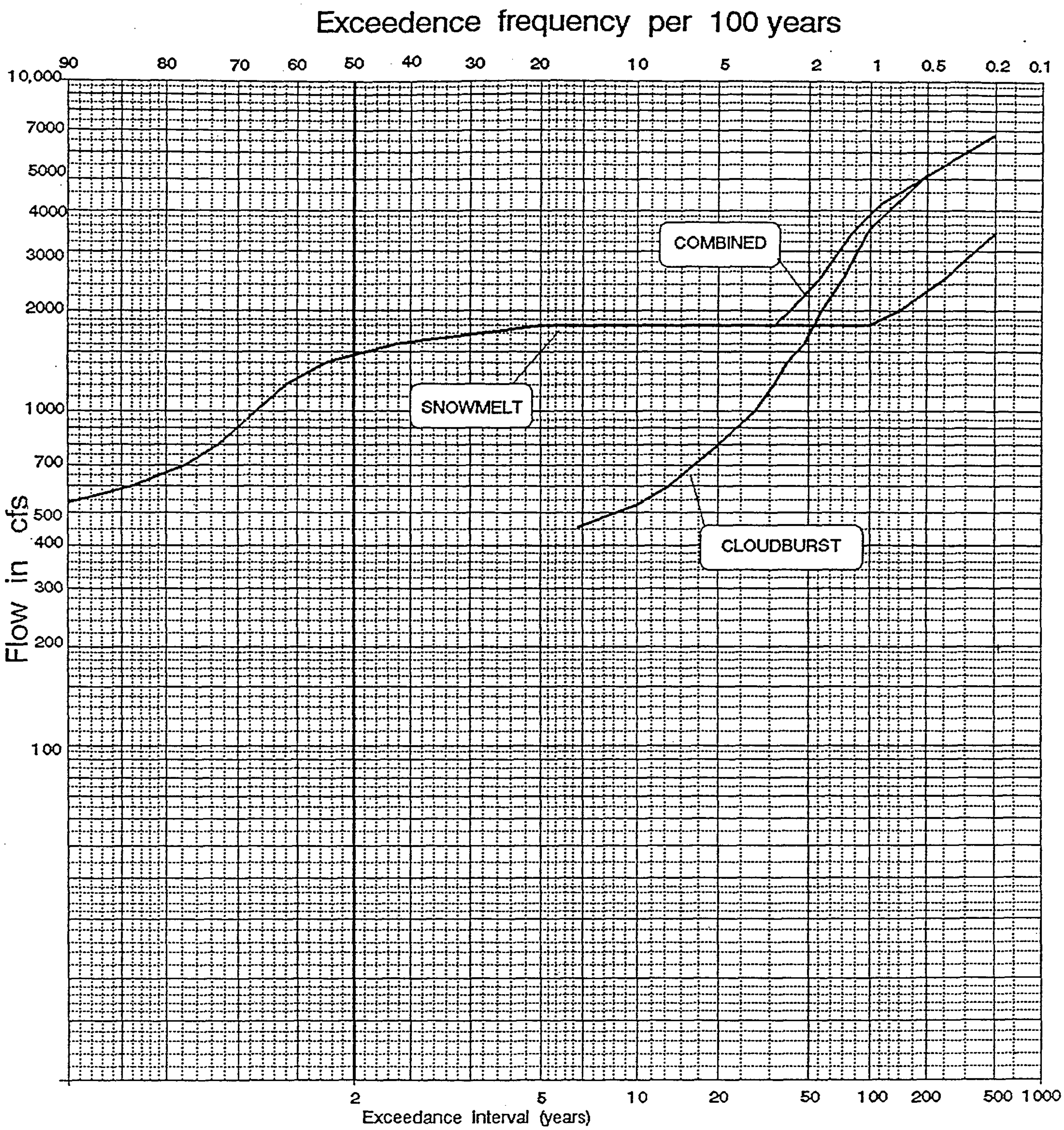


es: Cloudburst Events -
Discharges determined using HEC-1 modeling. Rainfall developed from NOAA ATLAS II.
Estimated concurrent reservoir release in Provo River = 150 cfs. Graphically drawn curves.

Provo River and Tributaries

PEAK FLOW FREQUENCY CURVES - PROVO RIVER AT CANYON MOUTH

Sacramento District
U.S. Army Corps of Engineers

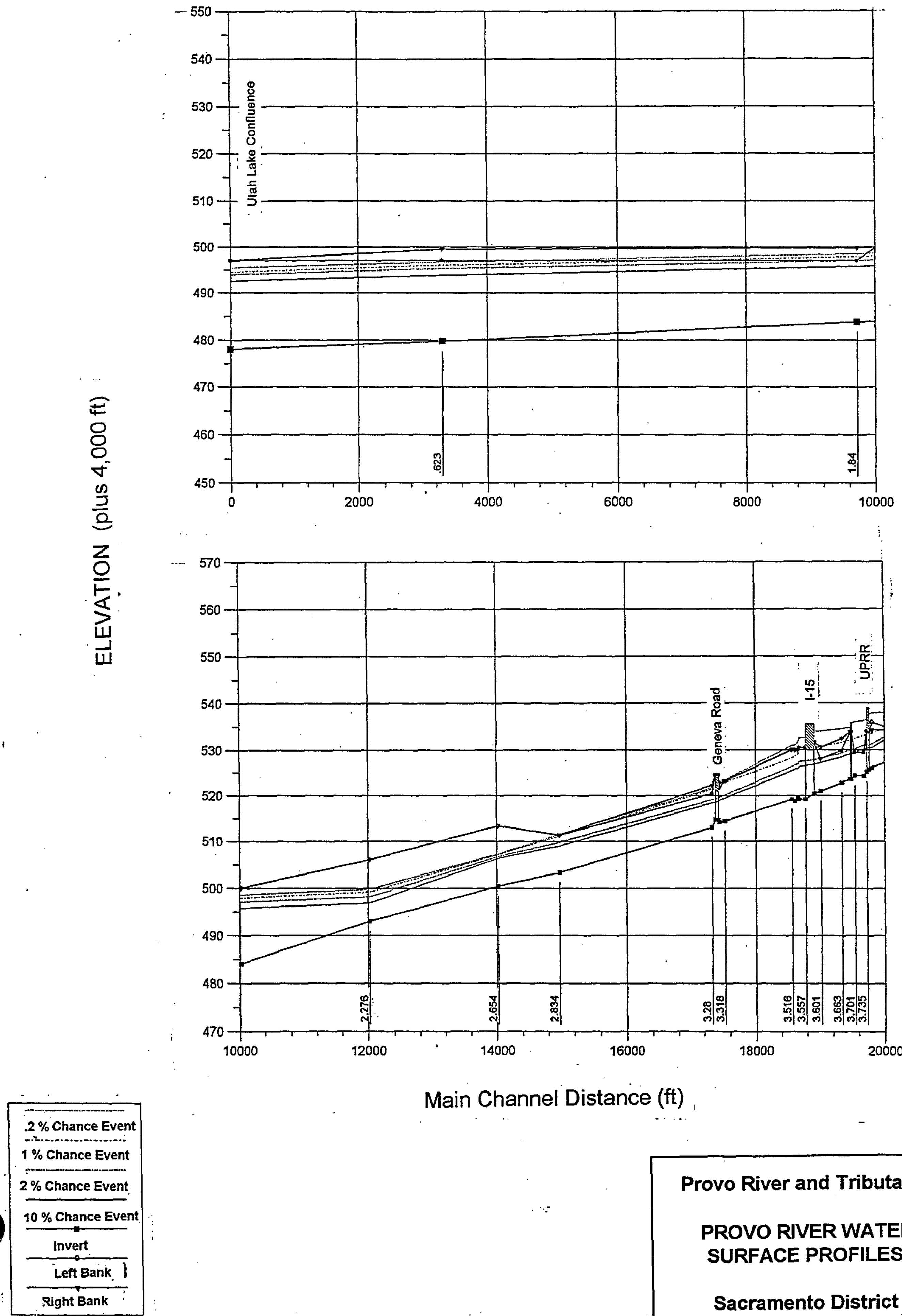


tes: Cloudburst Events -
Discharges determined using HEC-1 modeling. Rainfall developed from NOAA ATLAS II.
Estimated concurrent reservoir release in Provo River = 150 cfs. Graphically drawn curves.

Provo River and Tributaries

PEAK FLOW FREQUENCY CURVES - PROVO RIVER AT INTERSTATE 15

Sacramento District
U.S. Army Corps of Engineers

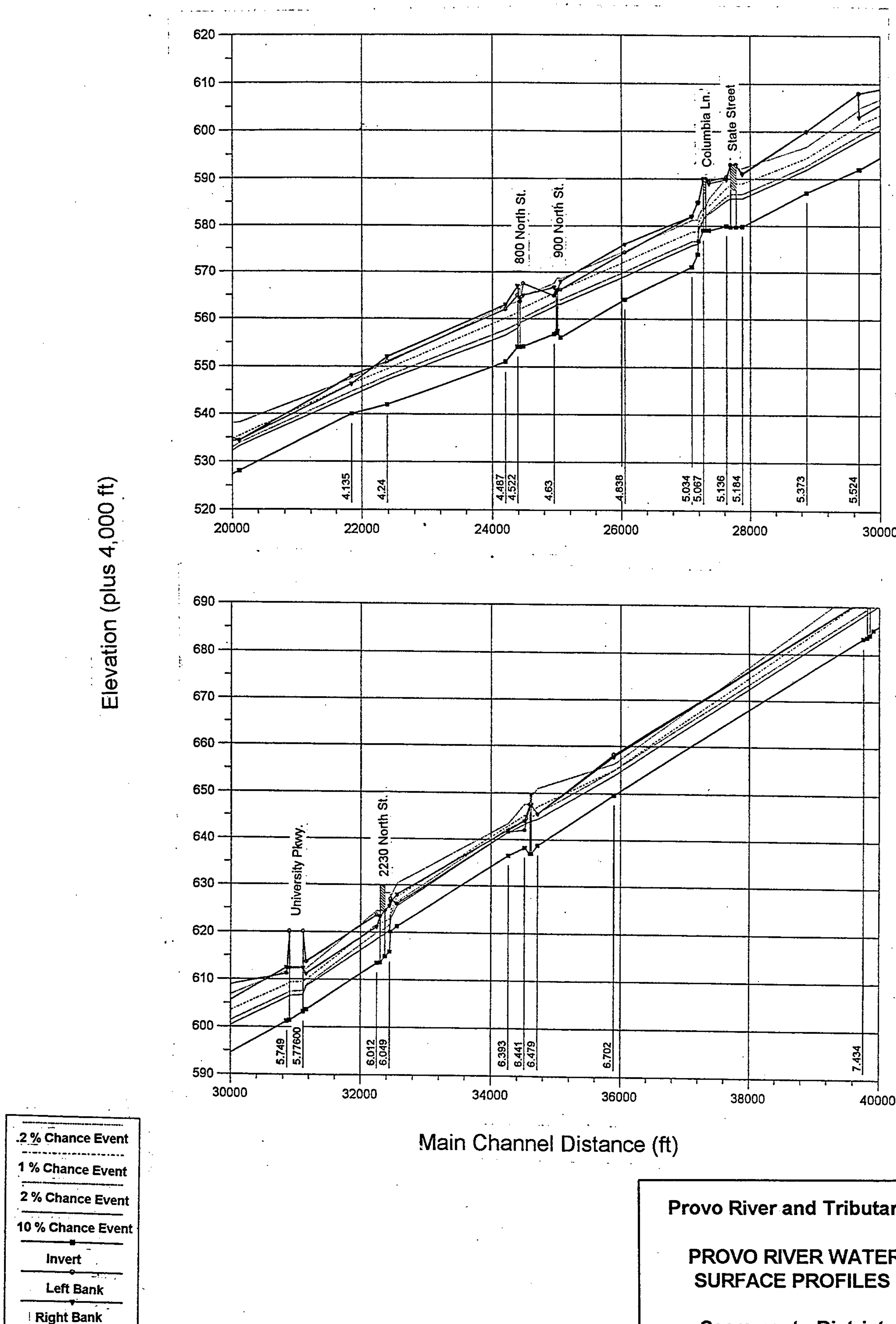


Provo River and Tributaries

PROVO RIVER WATER SURFACE PROFILES

Sacramento District
U.S. Army Corps of Engineers

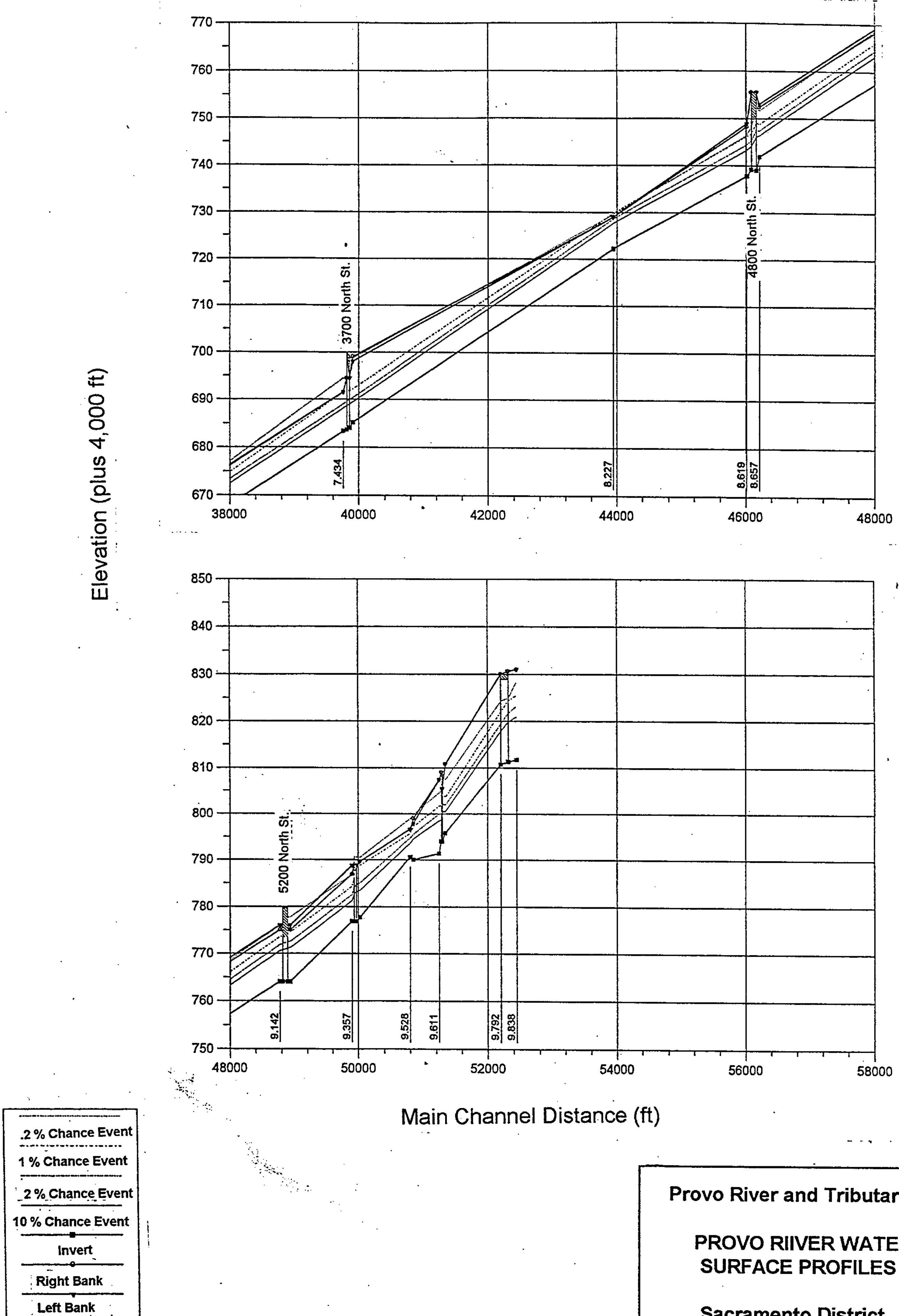
PLATE 5-1



Provo River and Tributaries

PROVO RIVER WATER SURFACE PROFILES

Sacramento District
U.S. Army Corps of Engineers



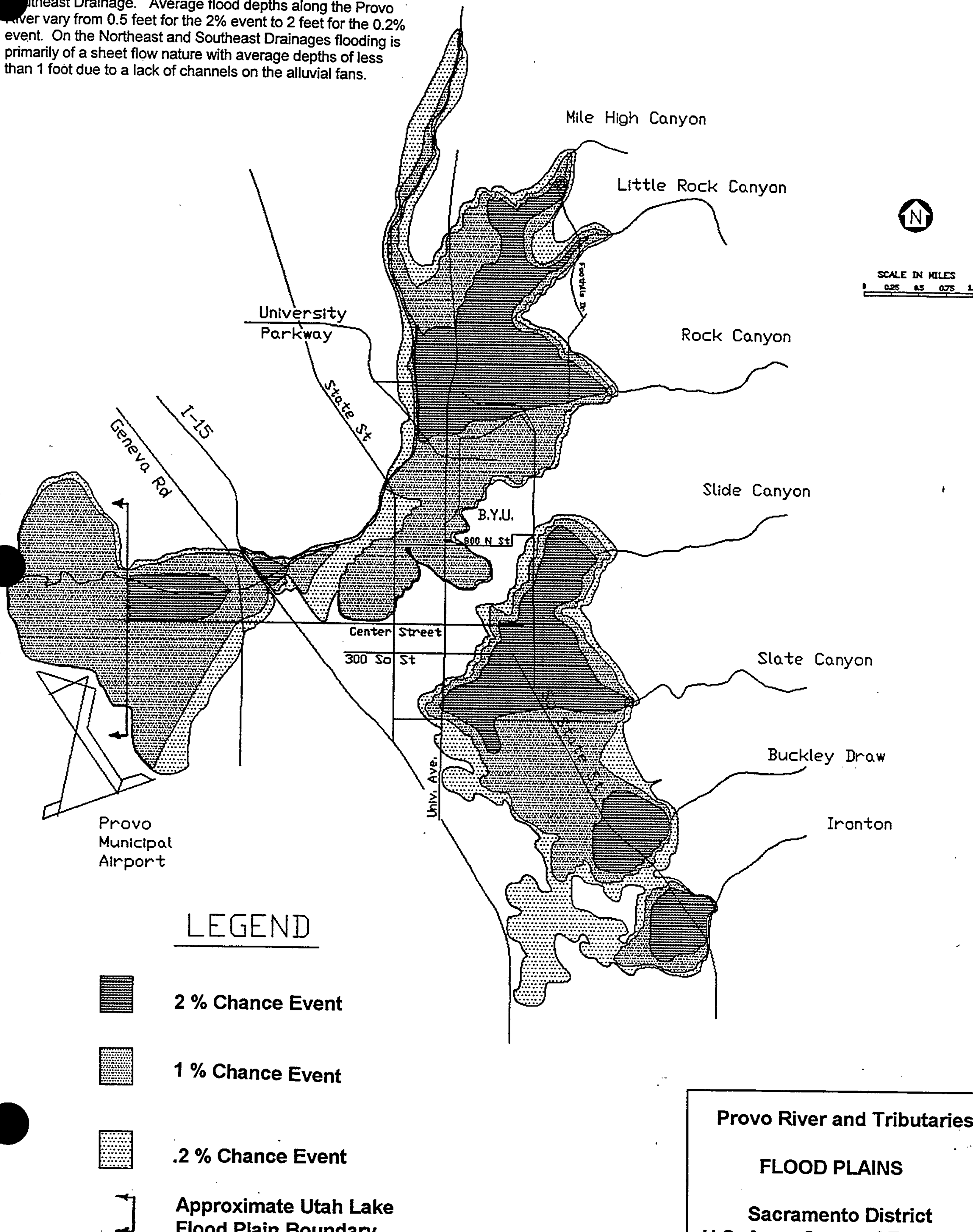
Provo River and Tributaries

PROVO RIIVER WATER SURFACE PROFILES

Sacramento District
U.S. Army Corps of Engineers

PLATE 5-3

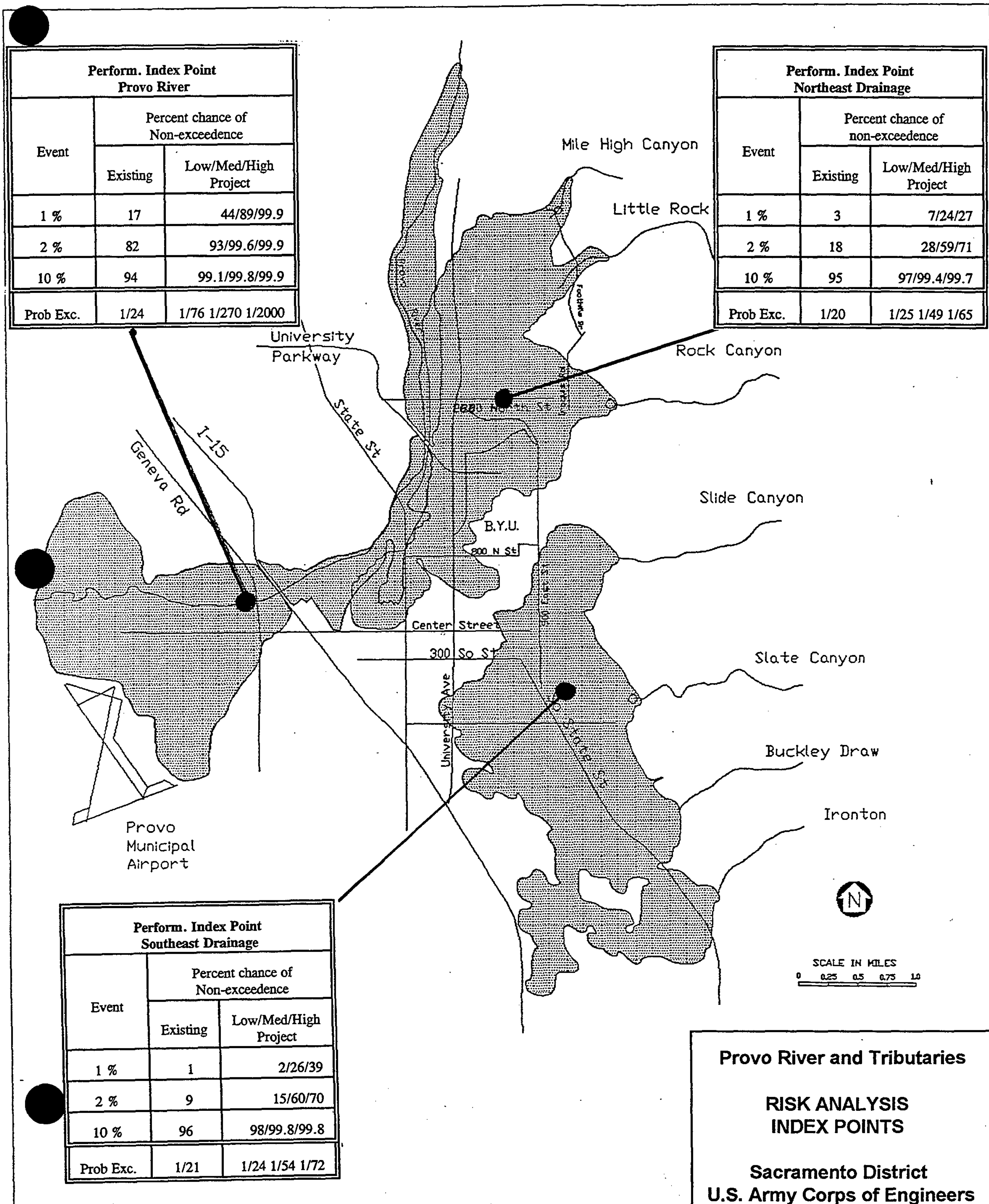
NOTE: This plate is a composite of the flood plains developed separately for the Provo River, Northeast Drainage, and Southeast Drainage. Average flood depths along the Provo River vary from 0.5 feet for the 2% event to 2 feet for the 0.2% event. On the Northeast and Southeast Drainages flooding is primarily of a sheet flow nature with average depths of less than 1 foot due to a lack of channels on the alluvial fans.



Provo River and Tributaries

FLOOD PLAINS

Sacramento District
U.S. Army Corps of Engineers



Perform. Index Point Provo River		
Event	Percent chance of Non-exceedence	
	Existing	Low/Med/High Project
1 %	17	44/89/99.9
2 %	82	93/99.6/99.9
10 %	94	99.1/99.8/99.9
Prob Exc.	1/24	1/76 1/270 1/2000

Perform. Index Point Northeast Drainage		
Event	Percent chance of non-exceedence	
	Existing	Low/Med/High Project
1 %	3	7/24/27
2 %	18	28/59/71
10 %	95	97/99.4/99.7
Prob Exc.	1/20	1/25 1/49 1/65

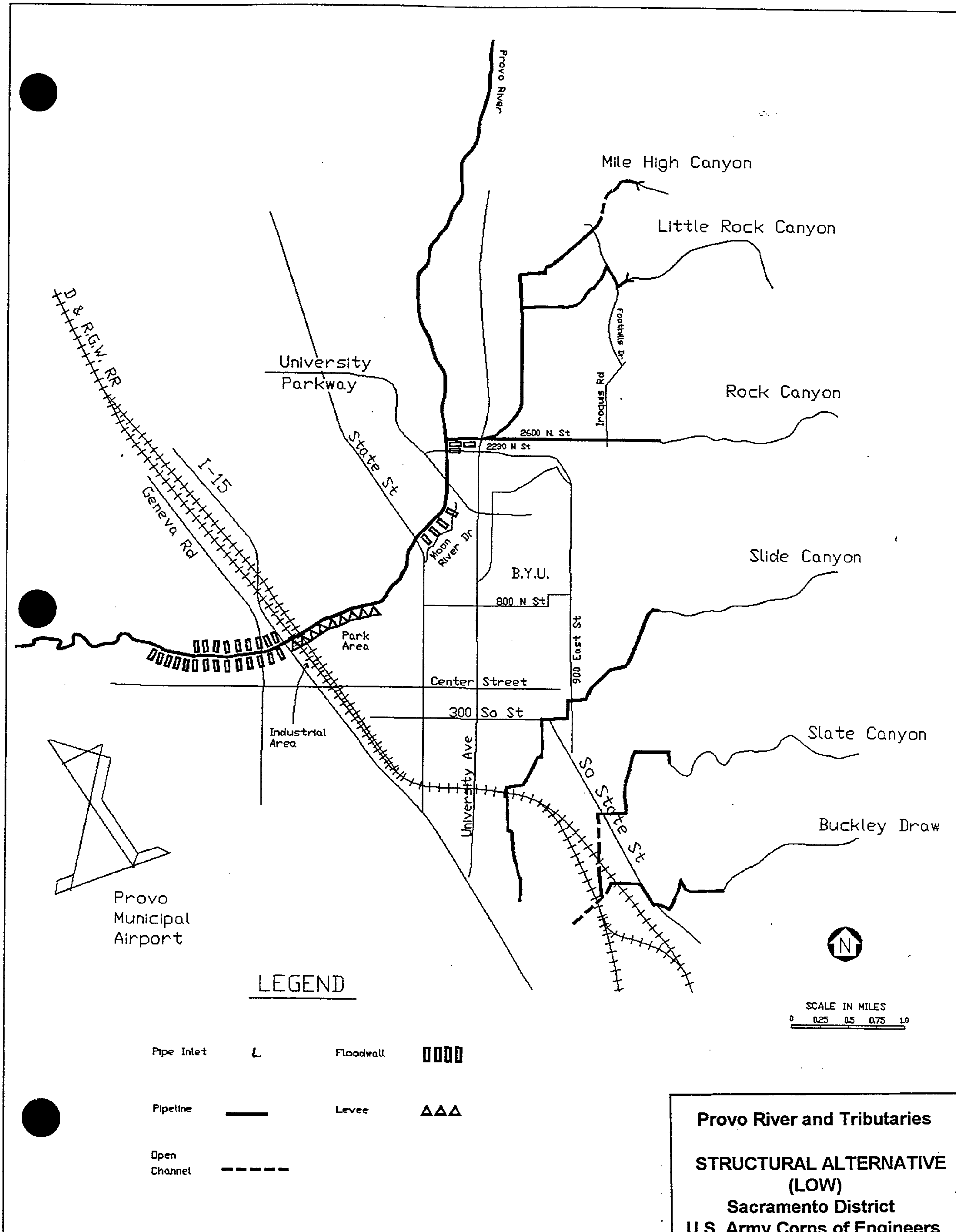
Perform. Index Point Southeast Drainage		
Event	Percent chance of Non-exceedence	
	Existing	Low/Med/High Project
1 %	1	2/26/39
2 %	9	15/60/70
10 %	96	98/99.8/99.8
Prob Exc.	1/21	1/24 1/54 1/72

Provo River and Tributaries

RISK ANALYSIS INDEX POINTS

Sacramento District
U.S. Army Corps of Engineers

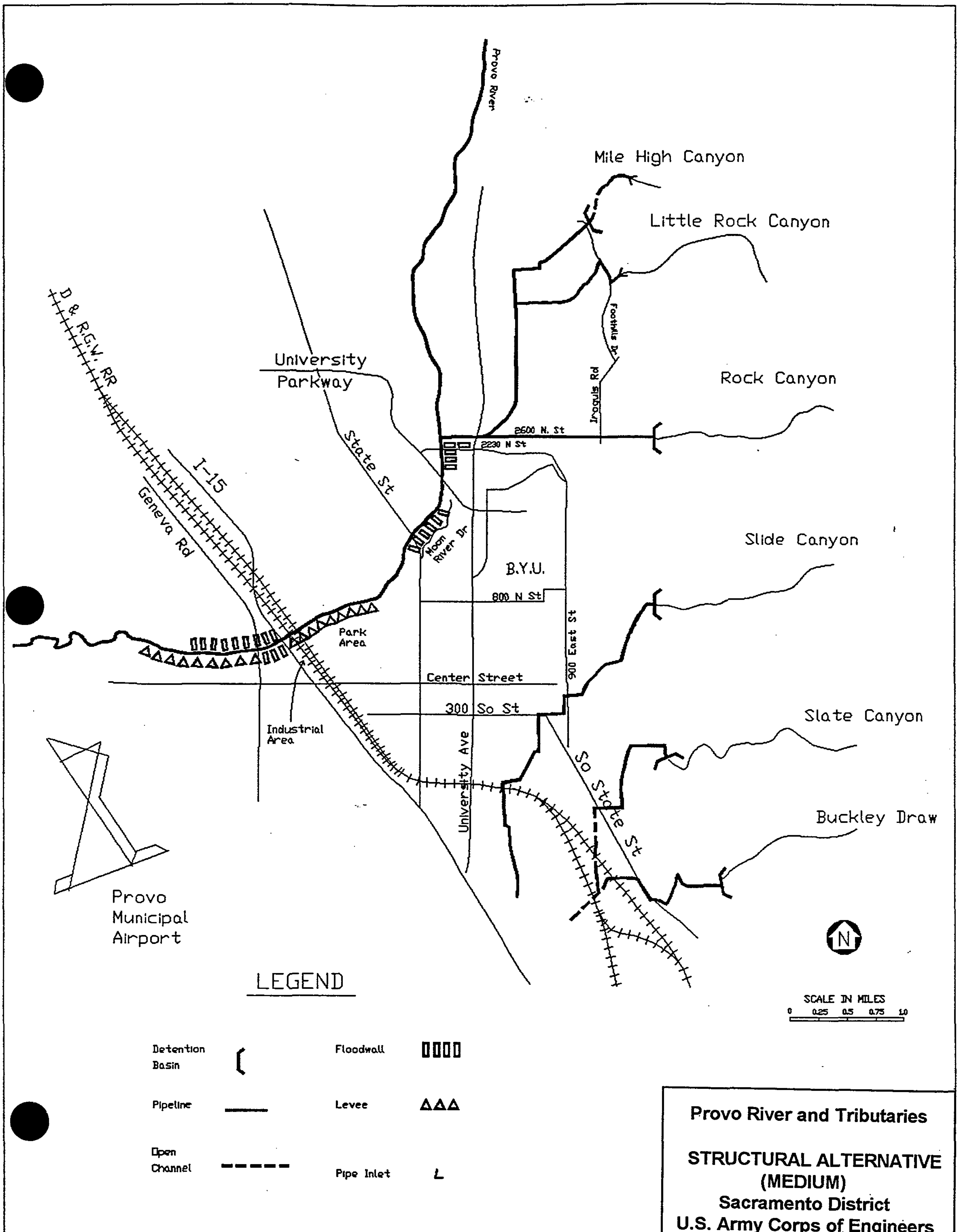
PLATE 7



Provo River and Tributaries

STRUCTURAL ALTERNATIVE (LOW)
Sacramento District
U.S. Army Corps of Engineers

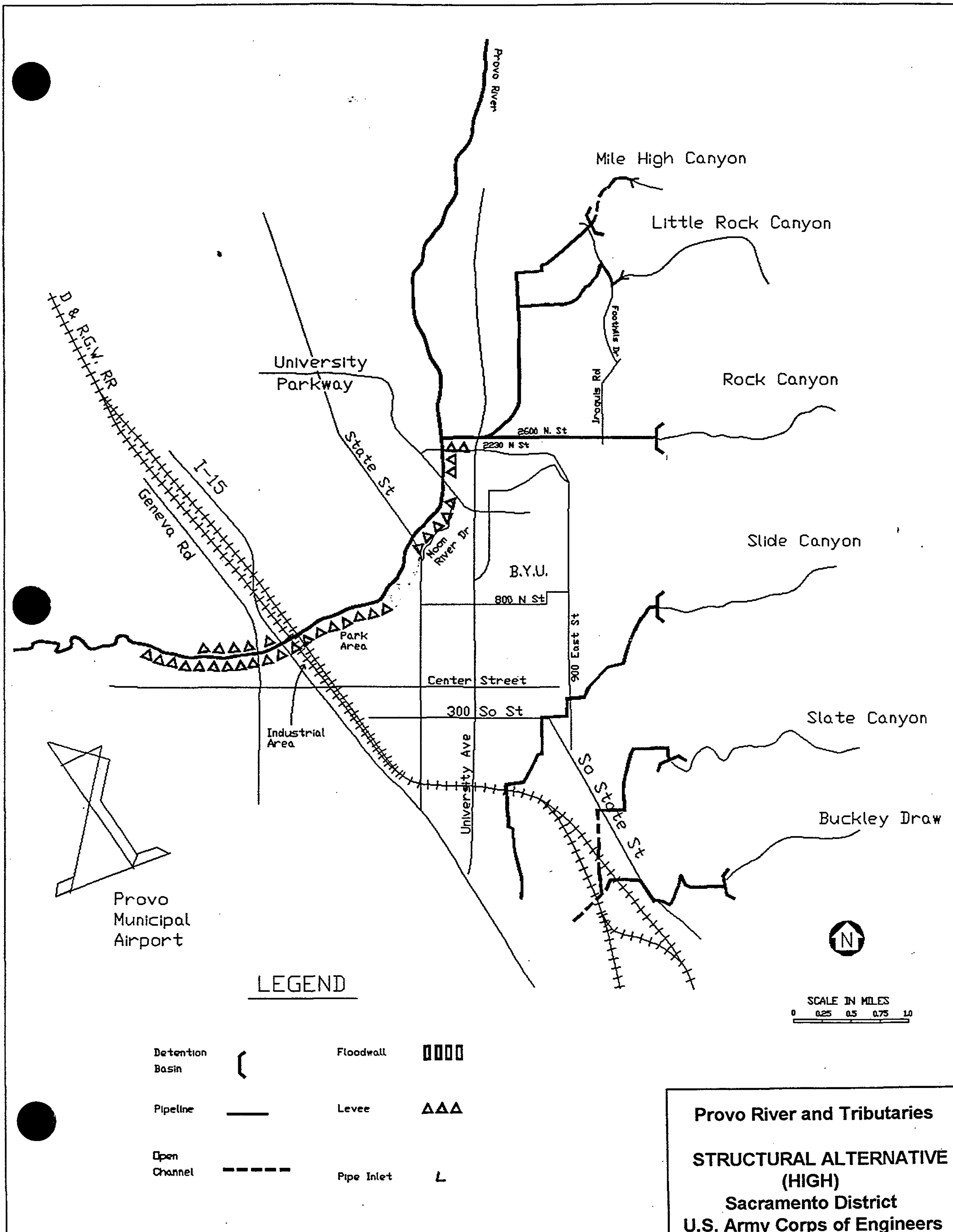
PLATE 8



Provo River and Tributaries

STRUCTURAL ALTERNATIVE (MEDIUM)
Sacramento District
U.S. Army Corps of Engineers

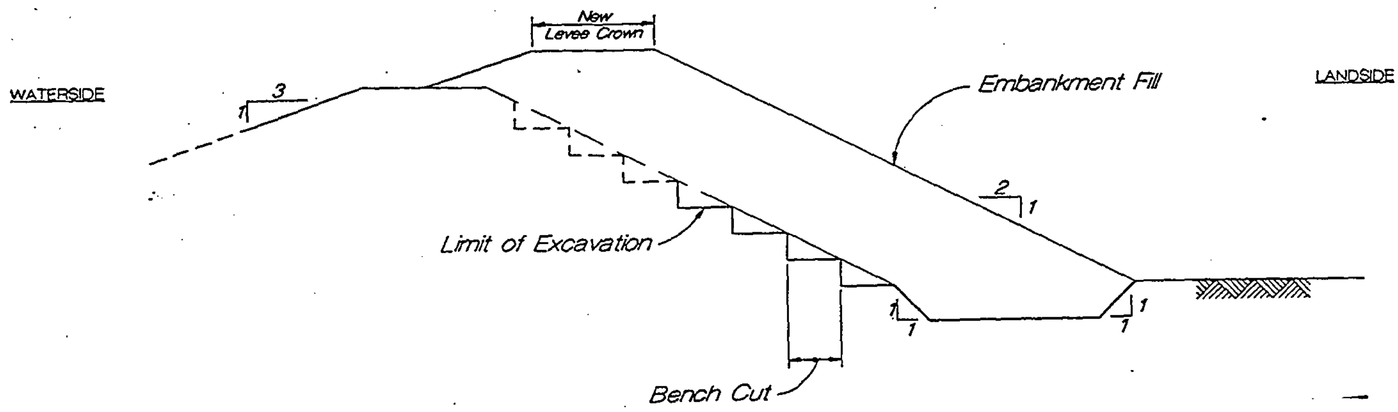
PLATE 9



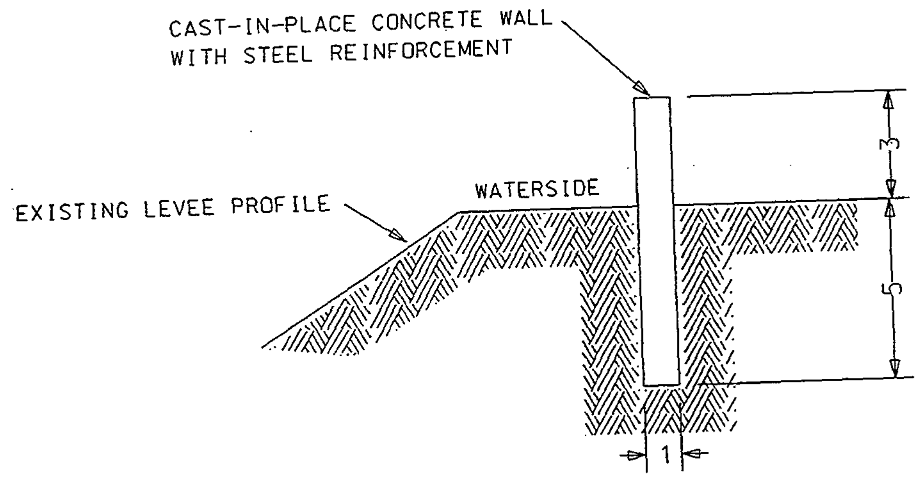
Provo River and Tributaries

STRUCTURAL ALTERNATIVE (HIGH)
Sacramento District
U.S. Army Corps of Engineers

PLATE 10

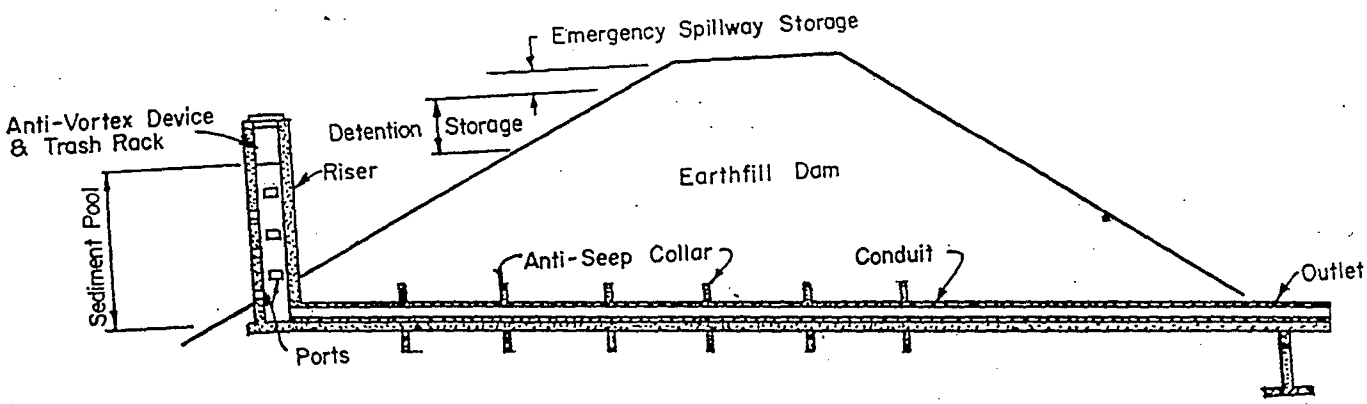


TYPICAL LEVEE IMPROVEMENT



DIMENSIONS SHOWN ARE IN FEET.
AVERAGE HEIGHTS ARE SHOWN.

TYPICAL FLOOD WALL



TYPICAL DETENTION BASIN

Provo River and Tributaries

TYPICAL SECTIONS

Sacramento District
U.S. Army Corps of Engineers

APPENDIX A

ENVIRONMENTAL EVALUATION

Final
Environmental Evaluation

Provo and Vicinity, Utah
Reconnaissance Investigation

Utah County, Utah

U.S. Army Corps of Engineers
Sacramento District
Environmental Resources Branch

March 1997

CONTENTS

1.0 Purpose and Need for Action

1.1 Proposed Action

The U.S. Army Corps of Engineers, at the request of the City of Provo and at the direction of Congress, undertook a reconnaissance-level study to determine a Federal interest in undertaking flood control measures in and adjacent to the City of Provo in Utah County, Utah (Figure 1). Proposed flood control measures evaluated during the study included: (1) raising or adding floodwalls to existing levees along the main stem of the Provo River immediately upstream and downstream of Interstate Highway 15, (2) fortifying levees along the mainstem of the Provo River immediately west of Brigham Young University along Moon River Drive, (3) constructing a levee or floodwall at 2230 North Street, and (4) constructing and/or enlarging flood detention basins and downstream conveyance within drainages located east of the main stem of the Provo River, including Mile High Canyon, Little Rock Canyon, Rock Canyon, Slide Canyon, Slate Canyon, and Buckley Canyon.

1.2 Purpose and Need

Flooding has become a growing concern for the City of Provo due to population growth and increased development along the base of the Wasatch Mountains and the main stem of the lower Provo River. The last major flooding in the Provo area occurred in the 1980's and affected homes and other property. During those floods, streets in foothill communities were sandbagged and used as diversion channels to avoid more widespread damage. Increased development along the foothills however has rendered unfeasible that method of reducing flood damage. In addition, erosion of constructed levees along the main stem of the Provo River has occurred in Provo along Moon River Drive between University Parkway and State Street. Major failure of levees in this location could result in extensive damage to homes, businesses, and other property in the area.

The purpose of this Environmental Evaluation was to evaluate the effects on the environment that would result from implementation of flood control measures in and near the City of Provo, Utah County, Utah. This report serves as a precursor to subsequent planning efforts and environmental impact documents required pursuant to Federal laws and regulations.

1.3 Authorization

This reconnaissance study was authorized by a resolution of the Committee on Public Works and Transportation of the U.S. House of Representatives adopted on September 28, 1994.

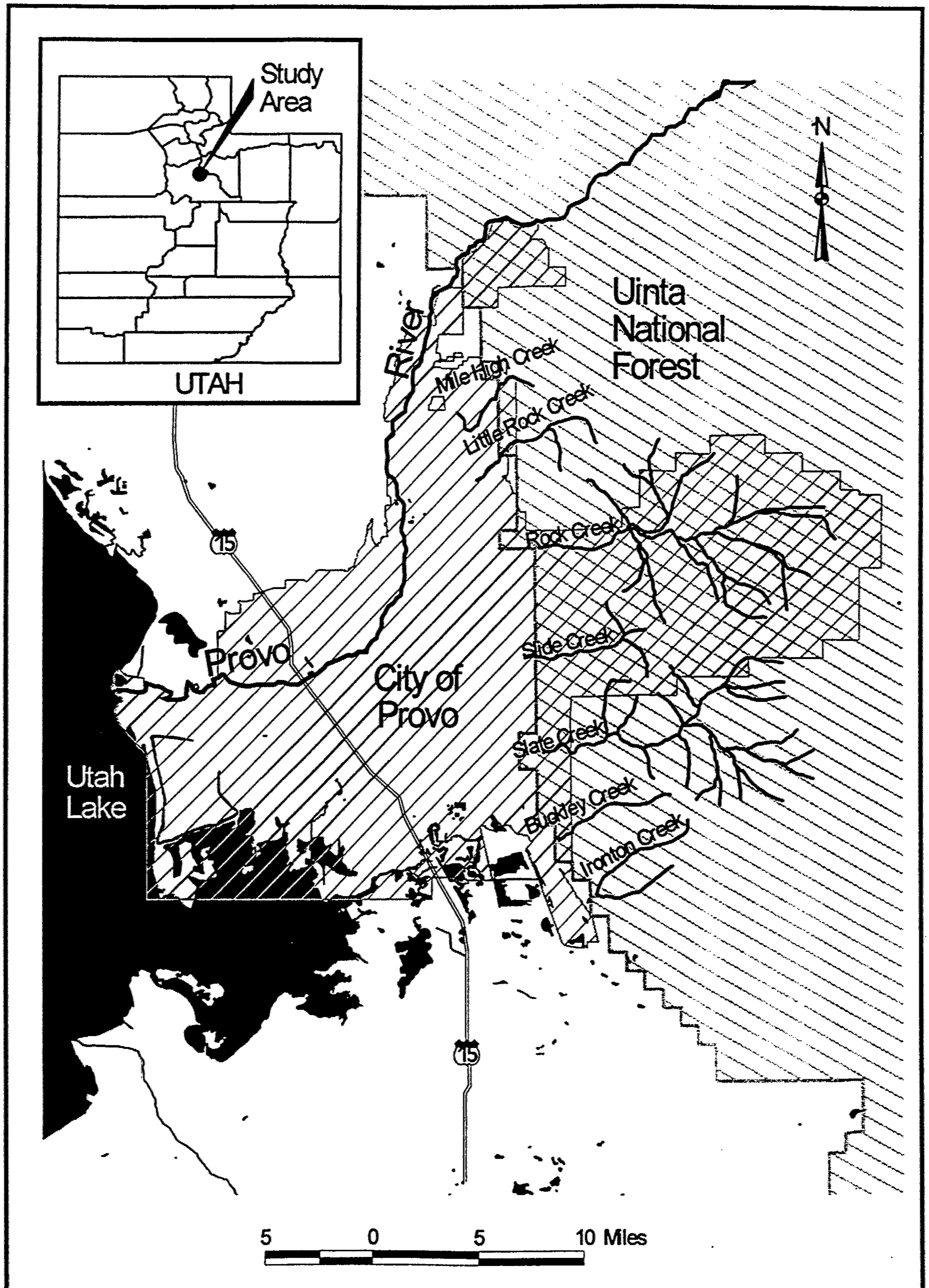


Figure 1. Provo River and Tributaries Study Area and Location Map, Sacramento District, U.S. Army Corps of Engineers.

1.4 Scope of Analysis

This Environmental Evaluation provides the following information: (1) baseline data on the existing and without-project environmental conditions within a designated study area (Figure 1), which includes the City of Provo and nearby lands, (2) an evaluation of potential effects on the environment that would result from implementation of proposed flood control alternatives, and (3) identification of mitigation measures to avoid, minimize, or offset negative effects to the environment that would result from implementation of the alternatives.

2.0 Alternatives and Potential Project Components

2.1 Introduction

This section presents a description of the no-action alternative and potential components which may be associated with the proposed flood control activities in the study area. For the purpose of describing proposed project components, seven sites were defined within which flood control measures may be implemented (Figure 2). Under each potential structural project component along the mainstem of the Provo River, three alternatives were considered at each site to address the 50, 100, and 500 year floods.

2.2 Description of Alternatives and Potential Project Components

2.2.1 No-Action Alternative. Under this alternative, no Federal action would be taken to reduce potential flood damage within the City of Provo.

2.2.2 Flood-Proofing Alternatives. The nonstructural flood-proofing alternatives would consist of sealing residential buildings to keep out floodwater. All parts of buildings below the 100 or 500 year flood level would be made watertight by using one or a combination of the following methods: coating walls with a waterproofing compound, placing plastic sheeting around walls, and temporarily or permanently closing openings--such as doors, windows, sewer lines, and vents.

2.2.3 Levee Work Below Interstate Highway I-15 Area. This structural component involves raising or adding floodwalls to existing levees along the Provo River immediately downstream of Interstate Highway 15. Construction activities would occur along approximately 3,350 contiguous feet on the north side of the river and 6,150 contiguous feet on the south side of the river for the 50, 100, or 500 year floods. A 20-feet wide permanent right of way exists on the landward side at the base of the existing levee.

2.2.4 Levee Work in the Industrial Area. This structural component involves raising or adding floodwalls to existing levees along the Provo River immediately upstream of Interstate Highway 15. Construction activities would occur along approximately 950 contiguous feet on the south side of the river for the 50, 100, or 500 year floods. A 20-feet wide permanent right of way exists on the landward side at the base of the existing levee.

2.2.5 Levee Work in the Park Area. This structural component involves raising or adding floodwalls to existing levees along the Provo River immediately upstream of the abandoned railroad bed east of Interstate Highway 15. Construction activities would occur along approximately 3,600 contiguous feet on the south side of the river for the 50, 100, or 500 year floods. A 20-feet wide permanent right of way exists on the landward side at the base of the existing levee.

2.2.6 Levee Work in the Moon River Bend Area. This structural component involves repairing eroded areas along and raising or adding floodwalls to existing levees along the Provo River between Columbia Lane and University Parkway. Construction activities would occur along approximately 3,600 contiguous feet on the south side of the river for the 50, 100, or 500 year floods. Two eroded areas would be repaired to pre-erosion conditions. A 20-feet wide permanent right of way exists on the landward side at the base of the existing levee.

2.2.7 Levee Work in the 2230 North Street Area. This structural component involves raising or adding floodwalls to existing levees along the Provo River immediately upstream and downstream of 2230 North Street and along the northern side of the adjacent hotel. For the 50 year flood, floodwalls would be constructed on the east side of the river immediately upstream of 2230 North Street for approximately 450 feet. For the 100 year flood, floodwalls would be constructed on the east side of the river approximately 1,000 feet downstream and 500 feet upstream of the river; an additional 550 feet of floodwall would be built perpendicular to the river at the north end of the proposed river wall. For the 500 year flood, levees would be constructed on the east side of the river approximately 1,000 feet downstream and 500 feet upstream of the river; an additional 550 feet of levee would be built perpendicular to the river at the north end of the proposed river levee.

3.0 Affected Environment

3.1 Introduction

This chapter describes relevant, existing environmental elements in the study area (Figure 1) that would affect and be affected by the proposed flood control alternatives if they were implemented.

3.2 Study Area

The proposed study area, located in central Utah County, Utah, encompasses roughly 43 square miles and includes the lower ten miles of the Provo River upstream of Utah Lake, the City of Provo, and U.S. National Forest Service land along the western Wasatch Front, including Mile High Canyon, Little Rock Canyon, Rock Canyon, Slide Canyon, Slate Canyon, and Buckley Canyon. Elevations in the study area range from approximately 11,000 feet at the upper end of Rock Canyon to less than 4,500 feet along the shore of Utah Lake. The western half of the study area comprises a relatively flat bench between the Wasatch Range and Utah Lake and varies in elevation from about 4,600 to 4,500 feet.

3.2.1 Climate. The study area is climatically characterized by hot, dry summers and cold, wet and snowy winters. Temperatures in the area range from over 100° Fahrenheit (F) in the summer to below -20° F in the winter (U.S. Army Corps of Engineers 1984). In general, higher elevations in the study area exhibit slightly lower temperatures. Annual precipitation ranges from approximately 17 inches at lower elevations to over 40 inches at higher elevations. Although most precipitation falls as snow, torrential summer storms also may contribute significant precipitation.

3.2.2 Soils and Geology. Lower elevations in the study area comprise a mosaic of soil types (U.S. Soil Conservation Service 1972). The most common soil association on the lower Utah Lake terrace is the Chipman-McBeth association, consisting of poorly drained, nearly level, silty clay loams. At slightly higher elevations within the study area, including the City of Provo, is the Steed-Pleasant Vale-Redola association, consisting of well-drained, nearly level to gently sloping, gravelly, loamy soils. Eastward of that association is the Welby-Hillfield association, consisting of well-drained, gently sloping to steep, loamy soils. Finally, the most common soil association along the foothills of the Wasatch Front is the Pleasant Grove-Cleverly-Kilburn association, comprising well-drained, gently sloping to steep, gravelly or stony, loamy soils. The Wasatch Range in the study area is composed predominantly of limestones (i.e., the Oquirrh formation), underlain by quartzite, dolomite, or more limestone (Hintze 1980). The Wasatch Fault runs in a northerly direction along the western base of the Wasatch Range.

3.2.3 Air Quality. Air quality in Utah County is monitored by the Utah Division of Air Quality. According to this agency (Symons 1996 pers. com.), air quality in Utah County meets all applicable Federal and State standards except those for small particulate matter less than ten microns in diameter (PM_{10}) and, only within Provo city limits, for carbon monoxide (CO). State air quality standards in Utah coincide with the Federally imposed National Ambient Air Quality Standards.

Primary factors contributing to high PM_{10} concentrations in Utah County are vehicular emissions and industrial processes, including steel, rock, and asphalt operations (Utah Division of Air Quality 1993). Brigham Young University also contributes to elevated PM_{10} levels in the study area. The largest factor contributing to high CO concentrations within Provo city limits is vehicular emissions. Due to climatic and topographic features, including the Wasatch Range, PM_{10} and CO concentrations can exceed regulatory standards in the study area for extended periods of time, particularly during winter months.

3.2.4 Demography and Land Use. According to the 1990 census, the population of the Provo metropolitan area, including Orem, was 261,600 of which 91,900 lived within the city limits of Provo with the remainder living in Orem or adjacent suburbs. By 1995, the estimated population of the City of Provo was 101,000 which reflected a seven percent increase over the 1994 population of 94,210 (Gleason 1996 pers. com.). More than 95 percent of the people living in Utah County reside in the greater Provo-Orem metropolitan area.

Land in the study area is predominantly used for residential, commercial, and public purposes. The western portion of the study area is dominated by urban and agricultural development associated with the City of Provo, while the eastern half of the area occurs on undeveloped land within the U.S. Department of Agriculture's Uinta National Forest (Edwards et al. 1995).

3.3 Water Resources

Dominant water features in the study area include the Provo River and associated drainages along the western Wasatch Front. These drainages include Mile High Canyon, Little Rock Canyon, Rock Canyon, Slide Canyon, Slate Canyon, and Buckley Canyon.

The Provo River is a perennial water source which originates in the Uinta Mountains in northeastern Utah at an elevation of about 11,000 feet (U.S. Army Corps of Engineers 1984). The river flows in a general southwesterly direction for approximately 60 miles until it terminates at Utah Lake at an elevation of 4,490 feet. The Provo River watershed encompasses roughly 680 square miles and contributes about 70 percent of Utah Lake's average annual inflow as the lake's largest, single tributary (Minshall et al. 1989). Although the annual flow of the Provo River immediately downstream of Deer Creek Reservoir and the Salt Lake Aqueduct (i.e., upstream of the study area) averages 372 cubic feet per second (cfs), annual flow at its confluence with Utah Lake averages only 204 cfs due to upstream water diversions (Minshall et al. 1989).

Stream flow data collected by the U.S. Geological Survey on the Provo River two miles upstream from its confluence at Utah Lake (station number 10163000, latitude 40° 14' 16", longitude 111° 41' 55") indicate that flows vary widely according to season (U.S. Geological Survey 1996). Low flows as measured from 1944 to 1995 typically occur during summer with August exhibiting the lowest average flow at about 21 cfs. High flows typically occur during late spring and early summer with June having the highest average flow at about 366 cfs. In 1995, the highest recorded flows in the lower Provo River (i.e., 1,200 cfs) occurred on May 26-27, while the lowest flows (i.e., 12 cfs) occurred on September 2.

The seven drainages along the east side of the study area support ephemeral streams which carry snowmelt and summer rainwater (U.S. Army Corps of Engineers 1984). Headwaters of the drainages range in elevation from about 6,000 feet (e.g., Mile High Canyon) to nearly 11,000 feet (e.g., Rock Canyon) with lower canyon mouths occurring at approximately 4,600 feet. Total watershed for the east-side drainages encompasses roughly 25 square miles with the largest watersheds belonging to Rock and Slate Canyons at about ten and six square miles respectively.

According to the Utah Division of Water Quality (1996), water quality in the mainstem of the Provo River in the study area is good and fully supports beneficial uses, including recreation and agriculture. Two water quality monitoring stations exist in the study area; one of the stations (Number 29) is situated towards the downstream end of the area, while the other station (Number 30) is located upstream towards the mouth of the Provo Canyon. No water quality data exists for the ephemeral streams which occur in the eastside drainages.

3.4 Vegetation and Wildlife

3.4.1 Vegetation. Although a variety of native plant species occur in the steeper, eastern half of the study area, the flatter, western bench is dominated by urban and agricultural development (Figure 2--Edwards et al. 1995). Wetland and riparian habitat occurs along much of the shore of Utah Lake, as well as along most of the levees lining the Provo River. Riparian vegetation along the along Utah Lake and the Provo River is characterized by Fremont cottonwood (*Populus fremontii*), willows (*Salix* spp.), and velvet ash (*Fraxinus velutina*). Wetlands along the shore of Utah Lake are characterized by cattail (*Typha latifolia*), bullrush (*Scirpus americanus*), and sedges (*Carex* spp.).

At higher elevations in the study area, vegetation includes less water-tolerant species, including juniper (*Juniperus* spp.), pinyon pine (*Pinus monophylla*), sagebrush (*Artemisia* spp.), oaks (*Quercus* spp.), Douglas fir (*Pseudosuga menziesii*), spruce (*Picea* spp.), and

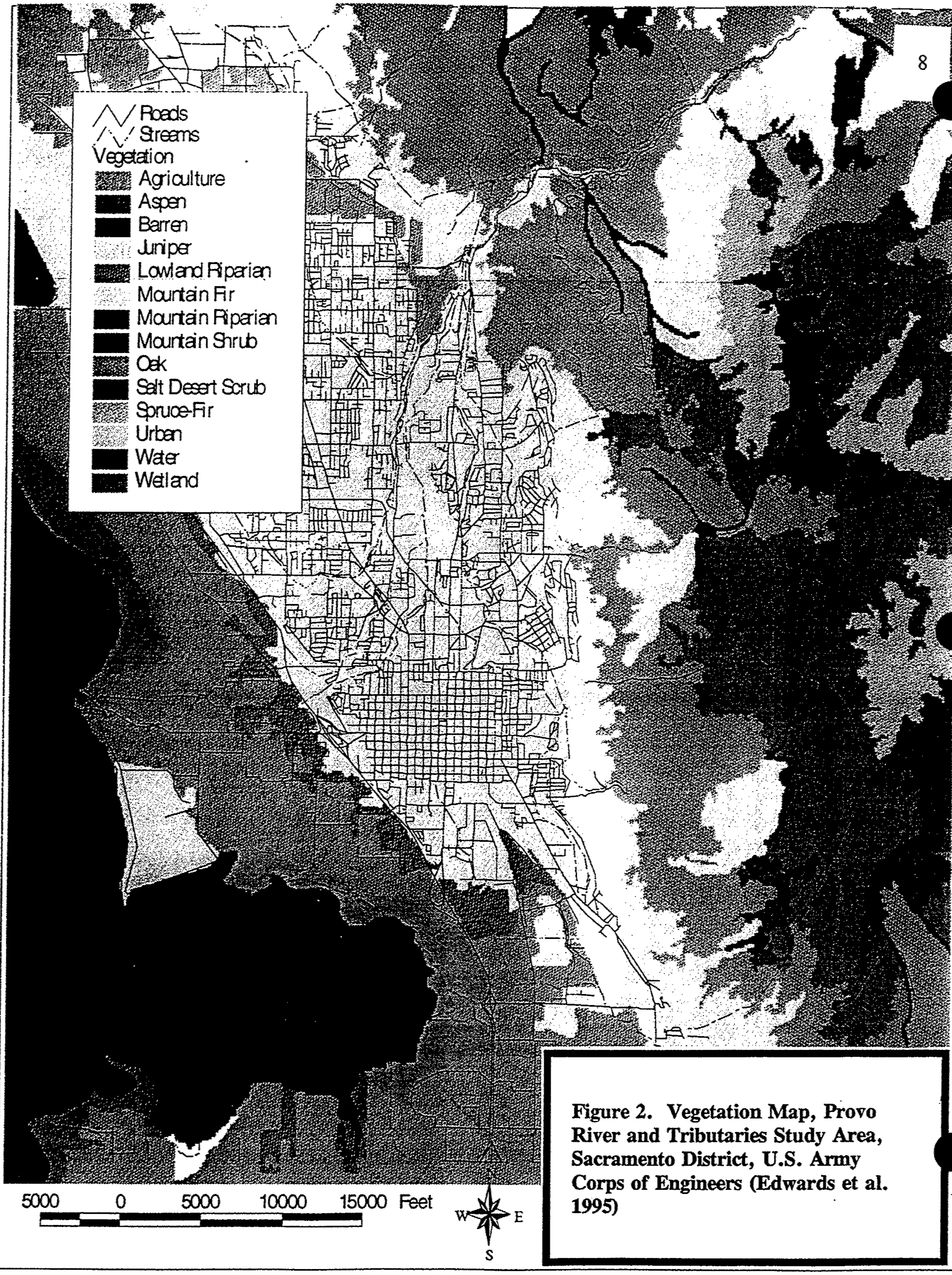


Figure 2. Vegetation Map, Provo River and Tributaries Study Area, Sacramento District, U.S. Army Corps of Engineers (Edwards et al. 1995)

quaking aspen (*Populus tremuloides*). Patches of riparian vegetation, dominated by willows (*Salix* spp.), narrowleaf cottonwood (*Populus angustifolia*), thinleaf alder (*Alnus tenuifolia*), mountain maple (*Acer glabrum*), and red-osier dogwood (*Cornus stolonifera*), also occur in some of the eastside drainages. Eastside areas with particularly notable stands of riparian vegetation include the mouth of Rock Canyon upstream of the existing detention basin and the uppermost of the three existing detention basins in Slate Canyon. In addition, a small emergent marsh exists in the existing detention basin at the mouth of Mile High Canyon.

3.4.2 Wildlife. Due to urban and agricultural development on the bench between Utah Lake and the Wasatch Front, the most diverse wildlife communities occur in the eastern half of the study area in or near the Uinta National Forest.

Large mammals present in the eastern portion of the study area, include elk, mule deer, mountain lion, and possibly black bear (Nunn 1996 pers. com.; Hoffman 1996 pers. com.). Most likely, these species would occur at higher elevations on gentler slopes but also may be found at lower elevations along developed trails. In addition, a herd of mountain goats inhabits Cascade Mountain at the northeastern corner of the study area. Smaller mammals present in the area include skunks, squirrels, and raccoons.

A variety of birds occur in the study area (Pritchett and Smith 1984). Identified raptors include eastern goshawk (*Accipiter gentilis*), sharp-shinned hawk (*Accipiter striatus*), Cooper's hawk (*Accipiter cooperi*), red-tailed hawk (*Buteo borealis*), Swainson's hawk (*Buteo swainsoni*), marsh hawk (*Circus cyaneus*), prairie falcon (*Falco mexicanus*), American kestrel (*Falco sparverius*), golden eagle (*Aquila chrysaetos*), and bald eagle (*Haliaeetus leucocephalus*). Due to the wide-ranging habits of most raptors, it is possible that any known species may occur at any location within the study area, where appropriate foraging, roosting, or nesting habitat occurs. Identified game birds in the study area include ring-necked pheasant (*Phasianus colchicus*) and California quail (*Lophortyx californicus*). According to Pritchett and Smith (1984), both of these species typically occur within riparian areas along the Provo River. Pheasant additionally may occur within and adjacent to agricultural and open fields, while quail may be present in vegetated areas throughout the region. Waterfowl typically forage and nest at lower elevations near the mouth of the Provo River and along the shores of Utah Lake.

3.5 Fish

The most common fish in Utah Lake are non-native species, including white bass, walleye, channel catfish, and carp, and the native June sucker (51 Federal Register 10851; March 31, 1986). Fish in the lower reaches of the Provo River reflect species composition in Utah Lake, while upstream species include colder water fish, such as brown trout, rainbow trout, and sculpin (Winget 1984).

Although water users along the Provo River retain the right to divert the entire flow of the river, the listing of the June sucker as an endangered species under the Federal Endangered Species Act and the associated designation of the lower Provo River as critical habitat has prevented dewatering of the river from mid-May to mid-July (U.S. Fish and Wildlife Service 1994). In addition to a required minimum flow in the lower river of at least 25 cfs, the Department of the Interior (DOI) owns rights to more than 10,000 acre-feet of water in the Provo River watershed. This water can be used as necessary by the DOI to ensure minimum flows of at least 25 cfs in the lower Provo River from mid-May through mid-July (Mizzi 1996 pers. com.).

No fish species are known to occur in the eastside drainages due to the ephemeral nature of the streams and steep topography of the watersheds (Winget 1984).

3.6 Special Status Species

Twelve special status species occur or may occur in the study area. Of these species, three are listed as endangered (E) under the Federal Endangered Species Act (ESA), two are listed as threatened (T) under the ESA, two are candidates (C) for listing under the ESA, five are listed as sensitive species by the State of Utah (USS), and four are listed as sensitive species by the U.S. National Forest Service (FSS). The list of special status species was prepared using information provided by the U.S. Fish and Wildlife Service (Freeman 1996 pers. com.), Utah Natural Heritage Division (Peterson 1996 pers. com.), and U.S. National Forest Service (Nunn 1996 pers. com.). Table 1 summarizes relevant information pertaining to these species.

Table 1. Special status species occurring or potentially occurring in the Provo and Vicinity study area.

Species	Status	Habitat Requirements	Distribution	Occurrence in Study Area
		Mammals		
big-eared bat *Plecotus townsendii*	FSS	Caves, tunnels, mines, and buildings. Prefers mesic sites.[1]	Throughout southwestern U.S.	Present in cave in Rock Canyon.[2]

Species	Status	Habitat Requirements	Distribution	Occurrence in Study Area
		Birds		
bald eagle *Haliaeetus leucocephalus*	T	Lakes, reservoirs, and rivers with large trees, snags, or rocks.[3]	Throughout the U.S.	May occur in area. Recorded occurrence at mouth of Provo Canyon.[4] Winter roosting habitat in area.[5]
peregrine falcon *Falco peregrinus*	E	Cliffs near open wetlands; cities, bridges, and tall buildings.[6]	Patchy throughout much of western U.S. and Gulf and eastern coasts.	Unlikely to occur in area. Historic nesting sites in Rock Canyon.[5] No recorded sitings in recent years.[2]
snowy plover *Charadrius alexandrinus*	USS	Beaches, dry mud or salt flats, sandy shores of rivers, lakes, and ponds.[7]	Patchy throughout southwestern U.S. Along Pacific and Gulf Coasts.[6]	May occur in study area, particularly near shore of Utah Lake.
		Amphibians		
spotted frog *Rana pretiosa*	C, USS	Grassy margins of permanent, quiet streams, lakes, ponds, springs, and marshes.[7]	Patchy throughout western U.S., including Idaho, Utah, and Washington.[8]	May occur along Provo River. Historic sitings in upper Provo River.[8]
		Fish		
June sucker *Chasmistes liorus*	E, USS	Utah Lake and lowest five miles of Provo River.[9]	Utah Lake and lowest five miles of Provo River, Utah.	Present in lower five miles of Provo River (designated critical habitat).[9]
		Invertebrates		
Utah valvata snail *Valvata utahensis*	E	Deep pools adjacent to rapids or in perennial flowing waters associated with springs on muddy bottoms with submerged aquatic vegetation.[10]	Snake River Basin, Idaho.	Not present. Believed extirpated in Utah.[10]

Species	Status	Habitat Requirements	Distribution	Occurrence in Study Area
Plants				
Deseret milk-vetch *Astragalus desereticus*	C	Sagebrush-juniper communities at mid elevations.[11]	Utah County, Utah.	Unlikely to occur in area. No known populations occur near area.
Garrett bladderpod *Lesquerella garrettii*	FSS, USS	Spruce-fir and alpine tundra communities. Often in talus or on rock outcrops at 9,000 feet or higher.[11]	Davis, Salt Lake, Utah, and Wasatch Counties, Utah.	Unlikely to occur in area but may be present at higher elevations.
King's woody aster *Aster kingii* var. *kingii*	FSS	Douglas fir-white fir, mountain brush, and cottonwood communities between 3,000-9,000 feet.[11]	Juab, Millard, Salt Lake, and Utah Counties, Utah.	May occur on limestone outcrops in area.[2]
Ute ladies tresses *Spiranthes diluvialis*	T, USS	Moist soils in mesic or wet meadows near springs, lakes, or perennial streams with relatively open vegetation.[12]	Colorado, Nevada, and Utah, including shore of Utah Lake.	Unlikely but may occur in wetlands near terminus of Provo River at Utah Lake.
Wasatch jamesia *Jamesia americana* var. *macrocalyx*	FSS	Mountian brush and spruce-fir communities between 3,700-10,000 feet. Mostly on cliffs or rocky places.[11]	Juab, Millard, Salt Lake, Utah, and Washington Counties, Utah.	Present in Rock Canyon.[2]

[1] Zeiner et al. 1990
[2] Nunn 1996 pers. com.
[3] 60 Federal Register 36,000; July 12, 1995
[4] Pritchett and Smith 1984
[5] Hoffman 1996 pers. com.
[6] National Geographic Society 1987
[7] Peterson 1996 pers. com.
[8] Mizzi 1996 pers. com.
[9] 51 Federal Register 10,851; March 31, 1986
[10] 57 Federal Register 59,244; December 14, 1992
[11] Welsh et al. 1987
[12] 57 Federal Register 2,048; January 17, 1992

3.7 Cultural Resources

The understanding of archeology in the study area is based on work conducted throughout the entire Great Basin, an area for which no evidence of human occupation exists prior to 8000 B.C. The study area was formerly occupied by the Ute tribe and, more specifically, by the Timpanogots, which were a Ute subgroup that lived in the area of Utah Lake. The Utes spoke one of two languages of the Southern Numbic branch of the Uto-

Aztecan linguistic family and their subsistance activities centered around hunting and gathering (Callaway et al. 1986; Steward 1938).

European explorers first entered the study area in 1776 as part of a Spanish expedition, the Dominguez-Escalante party. This expedition arrived at Utah Lake in September, proceeded south, and exited the present State boundaries near the future site of the City of St. George. Mormon immigration into Utah began in 1847 with the vanguard group settling on the shores of the Great Salt Lake in July of that year. In 1851, Brigham Young dispersed settling parties throughout the State, which soon forced the Timpanogots to move southward of Utah Lake. Eventually, the Timpanogots were settled on the Uintah Reservation with other western Ute groups (Billington 1956; Callaway et al. 1986).

Previous cultural resources investigations have been conducted within the study area, including excavation of mounds in the Utah Lake region as long ago as the 1870s. A literature review completed in 1984 for the Corps' Wasatch Front and Central Utah Flood Control Study identified four prehistoric sites within the study area. In addition, an updated records check showed six prehistoric sites located within one-half mile of the Provo River downstream of I-15. No known sites exist upstream of I-15 on the Provo River or in any of the six eastside canyons. Thirty-nine buildings and residences, as well as the Provo Downtown Historic District, are listed on the National Register of Historic Places.

3.8 Recreation

Due to its close proximity to urban areas and easy vehicular access, the Uinta National Forest has become a favored recreational area for thousands of outdoor enthusiasts. In the study area, Slate, Slide, and Rock Canyons contain developed trails and trailheads that are maintained by the National Forest Service and the City of Provo (Willis 1996 pers. com.). Rock Canyon in particular is popular for recreational activities, including hiking and rock climbing, and the City of Provo recently constructed a city park at the base of the canyon, which includes interpretive displays, restrooms, a parking lot, and play ground equipment (Thomas 1996 pers. com.). Although the existing detention basin at the mouth of Rock Canyon has been incorporated into the park, most of the constructed facilities occur northeast of the basin. In addition, Slate Canyon is an important access point to the Uinta National Forest. Although no formal statistics are available, a rough estimate by the National Forest Service indicates that perhaps 6,000 people pass through Slate Canyon every year (Willis 1996 pers. com.). Although no formal park currently exists at the base of Slate

Canyon, the City of Provo owns 60 acres of land in the area that has been designated as a future park site (Thomas 1996 pers. com.). Provo also owns approximately 15 acres at the mouth of Buckley Canyon, which is planned for development into a cemetery.

The City of Provo also has developed a parkway containing developed trails from the shore of Utah Lake to the mouth of Provo Canyon. The Provo River Parkway trail meanders back and forth across the Provo River and, along levees in the study area, is constructed out of either dirt or asphalt.

In addition to existing facilities in the study area, a major network of trails, collectively referred to as the Bonneville Shoreline Trail, is planned from Salt Lake City to southern Utah that would circumnavigate the historic shoreline of Bonneville Lake. In the study area, this trail is predicted to pass along the Wasatch Front near the base of the eastside drainages. Although the City of Provo has not yet officially designated any land to the project, many trail areas have been identified. In addition, the City currently is negotiating with Mountain Fuel to obtain easements along a gas pipeline at the base of the Wasatch Front that would complete up to 90 percent of the trail within the Provo city limits (Thomas 1996 pers. com.).

4.0 Environmental Consequences and Mitigation

4.1 Introduction

This chapter describes environmental consequences that would be expected if the various alternatives and project components described in Section 2 were implemented.

4.2 Water Resources

4.2.1 Effects on Water Resources. Water quality might be slightly affected by the proposed structural components. In addition, the timing of water flows would be affected by the structural components. Construction of the eastside canyon retention basins could have a particularly pronounced effect in attenuating peak flood flows and could affect flows in the mainstem of the Provo River.

4.2.2 Mitigation for Effects on Water Resources. Mitigation for water quality effects might include the erection of silt and debris barriers above the waterline near construction areas along the Provo River. In addition, in order to address possible endangered species concerns associated with Provo River flows, it might be necessary to study and provide evidence to the U.S. Fish and Wildlife Service (USFWS) that construction of detention basins in the eastside drainages would not significantly alter hydrologic cycles in the lower Provo River

4.3 Vegetation and Wildlife

4.3.1 Effects on Vegetation and Wildlife. Only two potential project components are expected to negatively affect vegetation; these components include levee work in the area downstream of I-15 under the 100 and 500 year flood-control alternatives and excavation of the existing detention basin at the base of Mile High Canyon. This conclusion is based on the following assumptions: (1) construction along the Provo River would occur only on the landward-side of levees, (2) floodwall placement and construction would not affect riparian vegetation, (3) the uppermost of the three existing detention basins in Slate Canyon would not be excavated, and (4) enlargement of the existing detention basin in Rock Canyon would not affect upstream vegetation.

Under the 100 year flood-control component for the area downstream of I-15, existing riparian vegetation would be negatively affected for approximately one third of 6,150 feet along the south side of the Provo River across an area 35 feet wide. The total area of riparian habitat that would be disturbed under this component would equal approximately 1.5 acres.

Under the 500 year flood-control component for the area downstream of I-15, existing riparian vegetation would be negatively affected for approximately one third of 6,150 feet along the south side of the Provo River and 3,350 feet along the northside of the river across an area 35 feet wide. The total area of riparian habitat that would be disturbed under this component would equal approximately 4 acres.

Excavation of the existing basin in Mile High Canyon would adversely affect approximately one half acre of emergent marsh habitat.

4.3.2 Mitigation for Effects on Vegetation and Wildlife. Levee work downstream of I-15 under the 100 and 500 year flood-control alternatives and excavation of the existing detention basin at the base of Mile High Canyon would require compensatory mitigation. Other work however, including the construction of floodwalls, would require that particular vegetation (e.g., mature riparian vegetation) be clearly identified and protected from injury during construction and excavation. Identification and protection of vegetation might entail marking plants with flagging tape or surrounding them with temporary orange fencing.

Under the 100 year flood-control component for the area downstream of I-15, approximately 1.5 acres of riparian habitat would be adversely affected. USFWS policy for mitigating losses of this type of habitat in the general vicinity of the project usually entails 2:1 mitigation and hence would require the creation and permanent maintenance of approximately 3 acres of riparian habitat.

Under the 500 year flood-control component for the area downstream of I-15, approximately 4 acres of riparian habitat would be adversely affected. USFWS policy for mitigating losses of this type of habitat in the general vicinity of the project usually entails 2:1 mitigation and hence would require the creation and permanent maintenance of approximately 8 acres of riparian habitat.

Excavation of the existing basin in Mile High Canyon would adversely affect approximately one half acre of emergent marsh habitat. USFWS policy for mitigating losses of this type of habitat in the general vicinity of the project usually entails 2:1 mitigation and hence would require the creation and permanent maintenance of approximately 1 acre of emergent marsh habitat.

4.4 Special Status Species

4.4.1 Effects on Special Status Species. All potential structural components may affect the endangered June sucker and the spotted frog if it occurs in the area . Other special status species that may be affected by the project include Ute ladies tresses and bald eagle. These species could be affected directly by construction-caused disturbance or death or indirectly through the adverse modification of habitat.

June sucker might be adversely affected by water-side construction or disturbance along the lower Provo River, particularly during the spring and early summer. Spotted frog might be affected by both waterside and landside construction or disturbance.

4.4.2 Mitigation for Effects on Special Status Species. Any activity which affects waters in or flowing into the lower Provo River most likely would require the completion of formal consultation with the USFWS pursuant to Section 7 of the Federal Endangered Species Act. As part of the Section 7 consultation process, mitigation measures would be identified if necessary. These measures might include the purchase and permanent protection of valuable habitats near the project area, restoration of degraded habitats, the creation of new habitats, or the reintroduction of populations.

4.5 Cultural Resources

4.5.1 Effects on Cultural Resources. Specific effects on cultural resources are difficult to assess at this level of study. Most of the Provo River and all of the eastside canyons have not yet been surveyed for cultural resources. Enough information exists however to determine that some of the alternatives, particularly the floodproofing alternatives, could affect significant cultural resources. In addition, prior to disturbance, existing diversion structures along the Provo River would need to be evaluated for National Register significance.

Impacts to certain cultural resources would occur with or without the undertaking of Federal flood control or restoration projects in the area. For instance, continuing urban expansion and agricultural practices could destroy prehistoric and historic sites, while natural processes such as erosion, root and rodent intrusion, flooding, and grazing could affect prehistoric sites. In addition, vandalism also often result in damage to historic or prehistoric sites.

4.5.2 Mitigation for Effects on Cultural Resources. Mitigation of adverse affects to cultural resources would be accomplished under a Memorandum of Agreement between the Corps, local sponsor, State Historic Preservation Officer, and the Advisory Council on Historic Properties as required by Section 106 of the National Historic Preservation Act of 1966, as amended: implementing regulations 36 CFR 800; and Engineering Regulation 1105-2-100. Avoidance or preservation of significant cultural resources would be given foremost consideration when selecting project alternatives. Other mitigation measures could include data recovery through scientific excavation, archival research, recordation, relocation, and purchase of areas with comparable cultural resources.

4.6 Recreation

4.6.1 Effects on Recreation. An extensive system of County Parks, trails, and other recreational facilities exist along the mainstem of the Provo River and at the mouths of the eastside drainages. Construction of floodwalls or raising existing levees would temporarily restrict the recreational use of particular areas during construction. In addition, construction of detention basins and associated structures along the eastside drainages could conflict with proposed or designated trailways.

4.6.2 Mitigation for Effects on Recreation. In most areas along the Provo River, existing conditions consist of evenly graded, gravel levee crowns; paved paths also exist in some areas however. Following construction, effected trails would need to be smoothly reconnected to previously existing trailways and trail surfaces would need to be graded and refinished. Existing recreation facilities in and adjacent to the existing detention basins at the mouths of Rock and Slate Canyons also would have to be restored to pre-construction conditions following project completion.

Prior to the final design and construction of any proposed detention structures, the County Department of Parks and Recreation should be consulted in order to ensure that the placement of basins does not conflict with the proposed expansion of the Bonneville Shoreline Trail along the Wasatch Front.

5.0 Environmental Restoration Opportunities

Virtually all of the lower stretches of the Provo River in the study area have been channelized and confined by levees in an attempt to control high river flows. In many areas, banks have been stabilized with rip-rap or concrete slabs. Few in-stream pools exist upstream of the influence of Utah Lake and streamside vegetation is absent or limited in many areas. In addition, periodic seasonal dewatering has reduced the quality of in-stream habitat for fish, including the endangered June sucker.

In light of the highly and artificially modified condition of the lower Provo River, many potential restoration sites occur in the study area. In fact, the Utah Department of Wildlife Resources (UDWR) recently released to the public a request for bids for restoring habitat in the Provo River. Although representatives from the UDWR highlighted two areas of particular interest during a meeting with Corps employees on February 4, 1997

(Figure 3), the recently released request for bids also solicits project designers to "accentuate existing river features (i.e., bars, riffles, runs, pools, channel shape, and bank shape), or. . .build features (i.e., bars, riffles, pools, thalweg channels, and banks) that subtly mimic natural channel features. . ." Construction of the selected restoration plans that are expected to result from the request for bids will be funded through Federal accounts related to the Central Utah Project and administered by the Utah Reclamation, Mitigation, and Conservation Commission. The State itself has limited funds for conducting restoration activities (e.g., the Wildlife Habitat Authorization Fund) and has been legislatively barred from acquiring additional public lands. Therefore, any restoration sites that would be retained by the State would have to be acquired through some form of landswap or other method that would not increase the State's total landholdings.

6.0 Future Studies

If this reconnaissance study proceeds into the feasibility phase, additional environmental documents would be required. These documents would be completed in cooperation with various Federal and State agencies, including the USFWS, the Utah Division of Wildlife Resources (UDWR), and the Utah State Historic Preservation Officer. Depending on the alternatives selected for further analysis, additional environmental studies would likely include:

1. <u>Coordination Act Report (CAR)</u>. The CAR would present detailed information on fish and wildlife in the study area and how they would be affected by project alternatives. The CAR would be prepared by either the USFWS or the UDWR and would include the results of a habitat evaluation procedures study identifying mitigation requirements, if any, for each alternative.

2. <u>Environmental Assessment (EA) or Environmental Impact Statement (EIS)</u>. If alternatives similar to those described in this reconnaissance study are considered in further detail during a feasibility phase, it is likely that only an EA would be required. If however it is determined that the project would result in greater loss of habitat than currently predicted or if endangered species would be affected, it might be necessary to complete an EIS.

3. <u>Biological Assessment (BA)</u>. If it appears possible that feasibility phase alternatives might affect species protected under the endangered species act (e.g., June

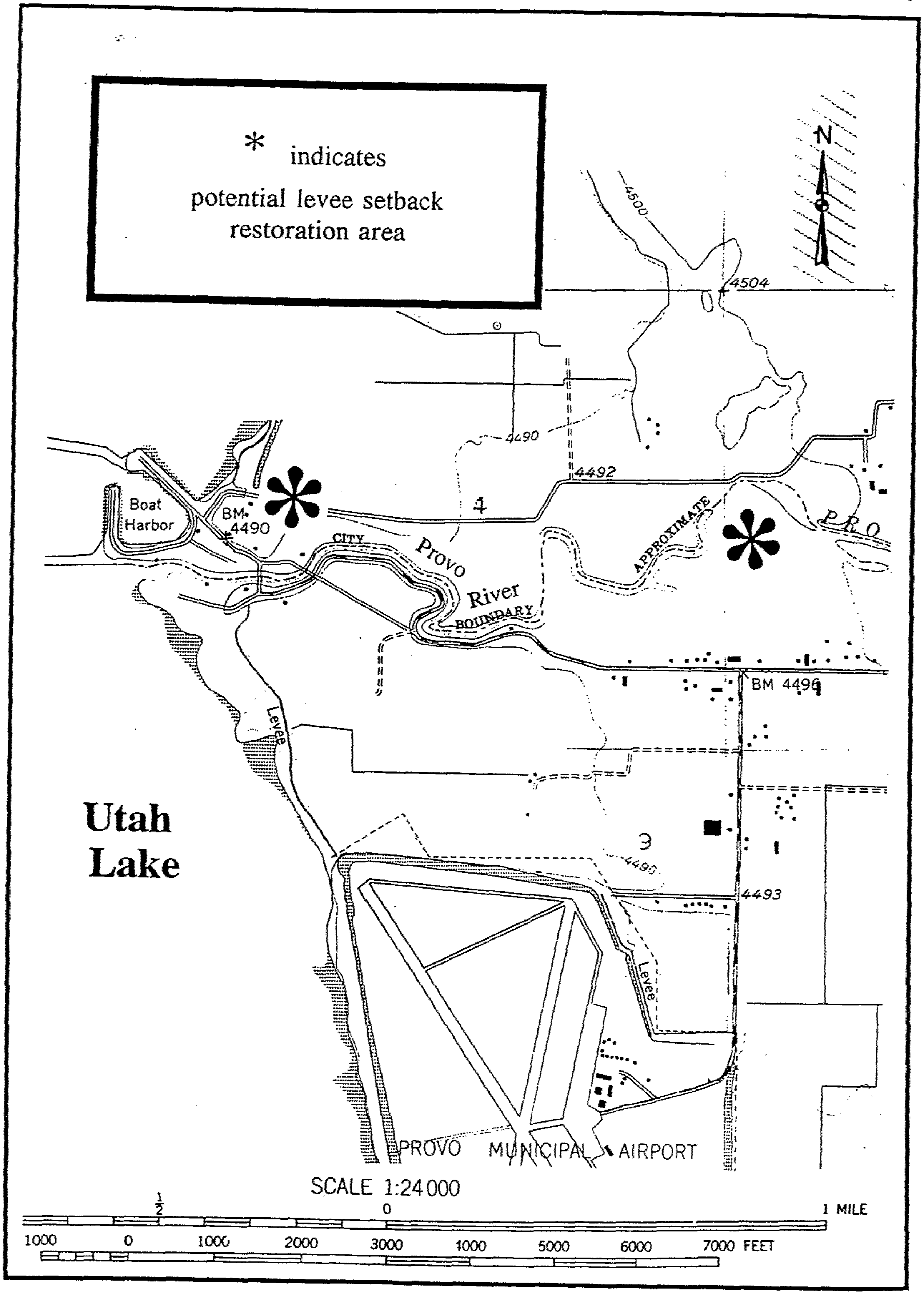


Figure 3. Potential Levee Setback Restoration Areas, Lower Provo River (Base Map: USGS 7.5' Provo Quadrangle). Sacramento District, U.S. Army Corps of Engineers.

sucker, spotted frog, bald eagle, Ute ladies tresses), it might be necessary to prepare and submit a BA to the USFWS. The June sucker is known to occur in the project area, but it may be necessary to conduct surveys to determine the presence or absence of spotted frog, bald eagle, and Ute ladies tresses. Receipt of a subsequent Biological Opinion from the USFWS if necessary can require up to 135 days following submittal of the BA.

4. Archeological/Cultural Resources Survey. A survey for archaeologically and culturally significant resources over unsurveyed portions of the project area might be required in order to comply with the National Historic Preservation Act.

7.0 Findings

According to Federal regulations (Federal Register 46:15, 23 January 1981), the definition of mitigation describes avoidance of environmental impacts as a primary objective, followed by minimization of impacts and finally addresses compensation for impacts to the environment. Pursuant to these regulations, the non-structural flood-proofing alternative is preferable to any structural alternative or component that would adversely affect water quality, vegetation, special status species, cultural resources, and recreation in the project area.

8.0 List of Preparers

Name, Expertise	Experience	Role
Chris Davis, Ecologist/Planner	Two years planning studies, Corps of Engineers	Report research and preparation.
Jerry Fuentes, Historian/Social Scientist	Five years planning studies, Corps of Engineers	Cultural resources research and preparation.
Mark Pelz, Ecologist/Planner	Two years planning studies, Corps of Engineers	Report review and graphics preparation.

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APPENDIX B

HYDROLOGY OFFICE REPORT

OFFICE REPORT MARCH 1997

HYDROLOGY FOR PROVO AND VICINITY, UTAH

RECONNAISSANCE STUDY

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Hydrology for Provo and Vicinity, Utah

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1. Introduction

1.1 Purpose and Scope. The purpose of this study was to evaluate the existing hydrologic conditions for the Provo River downstream of the canyon mouth, and basins directly east of the city of Provo. The watersheds east of Provo, on the steep western slope of the Wasatch Range, are collectively referred to as the "eastside" drainages. The principal eastside basins are Mile High Canyon, Little Rock Canyon, Rock Canyon, Slide Canyon, Slate Canyon, Buckley Draw, and Ironton Canyon.

1.2 Work Effort. As part of this study, HEC-1 rainfall-runoff models have been developed for the eastside drainages. The HEC-1 software was developed by the Hydrologic Engineering Center, U.S. Army Corps of Engineers, at Davis, California. Existing hydrology was evaluated and used for the Provo River mainstem. Preproject flow frequency relationships have been developed at selected concentration points for each basin for the 10-, 2-, 1-, and 0.2-percent chance exceedence flow events. These flow exceedence events are sometimes called the 10-, 50-, 100-, and 500-year floods. In addition, concurrent flow events from each basin have been developed for storms centered on Rock and Slate Canyons. A stage frequency curve has been developed for Utah Lake, and debris yield-frequency curves have been developed for Rock and Slate Canyons. A vicinity map and general map of the study area are shown on Chart 1. Peak flow frequency curves for the Provo River and eastside basins are shown on Charts 7 through 19. A stage frequency curve for Utah Lake is shown on Chart 20.

Based on 10-year/800 cfs and 100-year/1,800 cfs regulations, in-part because of detention at existing debris basins, only Rock Canyon of the eastside basins meets Federal Interest for a stand-alone project. Most of the damages occur where the eastside basin floodplains commingle. Rock and Slate Canyons are the principal streams contributing to the two floodplains at Provo. The total commingled 100-year flow below Rock Canyon exceeds 1,800 cfs, while the commingle flow below Slate Canyon does not meet this criteria for Federal Interest. Hydraulic Design Section performed the hydraulic routings below the canyon mouths, and developed the floodplains for the commingled flows.

1.3 Previous Studies and References. Information used to perform the hydrologic analysis for the Provo area streams was obtained from the following references.

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2. Discussion

This report presents a hydrologic analysis of streams producing flooding in the vicinity of Provo, Utah. Except for the mainstem Provo River, all of the watercourses in the study area have lost their natural stream channels in the valley areas due to urbanization. Widespread sheetflow flooding occurs as runoff leaves the steep mountain front and spreads across the fan and valley floor.

3. General Description of Study Area

3.1 Study Area Location. Provo, Utah, is located along the Wasatch Front just east of Utah Lake, and south of Salt Lake City. The Provo River Basin collects runoff from both the Uinta and Wasatch Mountain Ranges, north and east of Provo. The eastside basins drain the west slope of the Wasatch Mountains immediately east of Provo.

3.2 Climate. Normal annual precipitation in the study area varies from approximately 13 inches in central Provo, to 20 inches along the foothill line near Provo, and up to 50 inches on the Wasatch ridge line. The normal annual precipitation in the Provo River headwaters, in the Uinta Mountains, is approximately 40 inches. Normal annual precipitation over the basins varies with elevation as shown on Chart 3. Generally, the study area can be influenced by three types of systems: Tropical convective Pacific Air masses from the southwest in the spring and summer, Gulf of Alaska fronts from the northwest in the winter, and the Southern Utah Low (vertical movement of air) during the transition period from summer to winter. Occasionally, summer moisture from the Gulf of Mexico can also reach as far north as the study area. Significant precipitation from tropical Pacific air masses generally results from cloudburst events. The Southern Utah Low produces measurable moisture but not in the intensity of the Tropical Pacific storms or the totals of the Alaska Frontal storms.

Precipitation normally occurs over the area during every month. Thunderstorms, from tropical air masses, generally occur from June to October. The high intensity precipitation from these events usually does not last more than 60 to 90 minutes, and the areal extent of heavy precipitation is small. General rains, covering large areas, can occur from October through May, but are of low to moderate intensity. Precipitation in the mountains generally occurs as snow during the winter and early spring months. A large snowpack typically forms at higher elevations. Table 1 shows the monthly distribution of normal annual precipitation for five stations within the region. Note that although the Kamas gage is higher than both Heber City and Deer Creek, it receives less precipitation because of its location to the lee (north) side of the basin divide.

Table 1. Mean Monthly Precipitation

MONTH	Precipitation (depth in inches)				
	Provo (1) **El. 4,470 ft.**	**Salt Lake City (2)** **El. 4,220 ft.**	**Heber City** **El. 5,630 ft.**	**Deer Cr Dam** **El. 5,270 ft.**	**Kamas** **El. 7,480 ft.**
Jan	1.13	1.35	2.09	3.09	1.80
Feb	1.09	1.18	1.52	2.43	1.88
Mar	1.08	1.56	1.27	20.2	1.53
Apr	1.45	1.76	1.32	1.78	1.79
May	0.90	1.40	1.18	1.49	1.56
Jun	0.87	0.98	0.93	1.06	1.15
Jul	0.44	0.58	0.65	0.64	0.96
Aug	0.71	0.87	0.92	1.03	1.04
Sep	0.90	0.53	0.92	1.09	1.15
Oct	1.14	1.15	1.29	1.60	1.43
Nov	1.01	1.30	1.50	2.03	1.65
Dec	1.20	1.24	1.73	2.55	1.72
Ave. Annual	12.35	13.90	15.32	20.81	17.66

(1) Radio Station KAYK
(2) Salt Lake City A.P.

3.3 Temperatures. Temperatures in the study area show pronounced diurnal and seasonal variation, as well as variation with elevation. Table 2 shows the monthly mean daily high and monthly mean daily low temperatures for Provo at radio station KAYK. Temperatures at higher elevations are typically 15 to 20 degrees cooler. Table 3 shows the mean monthly temperatures for three selected stations in or near the Provo River basin. These temperatures are representative of the watershed's valley regions. Although at a lower elevation than Kamas, Deer Creek and Heber City are generally colder, because both are located within bowl shaped valleys receiving much less direct sunlight than the Kamas area.

Table 2. Mean Temperatures by Month, Provo, Utah

Month	Temperature (°F)	
	Mean Daily High	Mean Daily Low
Jan	38.4	15.7
Feb	45.0	21.0
Mar	53.7	25.8
Apr	63.3	32.4
May	74.1	40.0
Jun	83.1	46.9
Jul	91.6	53.3
Aug	89.3	51.8
Sep	80.2	41.8
Oct	67.4	33.0
Nov	51.4	25.4
Dec	39.9	18.5
Ave. Annual	64.7	33.7

Temperature observation at Radio KAYK, El. 4,470 ft.

Table 3. Mean Monthly and Annual Temperatures, Provo River Basin

MONTH	Temperature (°F)		
	Heber City El. 5,630 ft	**Deer Cr Dam El. 5,270 ft**	**Kamas El. 7,480 ft**
Jan	21.8	20.5	28.2
Feb	26.3	23.9	28.3
Mar	33.9	32.0	35.5
Apr	42.9	41.9	36.4
May	51.8	51.2	46.2
Jun	59.4	59.3	57.7
Jul	67.4	67.1	65.1
Aug	65.4	65.0	66.7
Sep	57.2	56.3	58.0
Oct	47.4	46.3	48.3
Nov	34.2	33.9	33.3
Dec	24.8	25.1	23.2
Ave. Annual	44.4	43.5	43.9
Source: NOAA 1951-1995			

3.4 Topography. The topography of the study area, below Deer Creek Dam, is characterized by steep, narrow canyons in the mountains, and mildly sloping alluvial fans and plains west of the Wasatch front. Channel capacity is typically much greater in the canyons than on the alluvial fans. Extreme attenuation of high peak flows occurs on the alluvial fans because of an increased manning's n-value and storage which results from the broad, shallow flow. The elevations range from 4,470 feet at Provo to over 11,000 feet in the headwaters.

3.5 Vegetation. Vegetation in the Provo River basin and eastside drainages consists of moderate conifer growth in the headwaters; chaparral and other brush in the lower mountain elevations (with deciduous trees in wetter sites); and sagebrush and native grasses in the foothills and valleys. Table 4 lists the distribution of vegetation by elevation zone.

Table 4. Distribution of Vegetation by Elevation Zone

Zone Description	Elevation Range (ft)
Alpine Zone - Scattered shrub	+ 11,000
Subalpine Conifer Zone - Dense Conifer forest (spruce, pine)	9,000 - 11,000
Montane Conifer - Aspen Zone - Light Conifer forest (fir, aspen, lodgepole pine)	8,000 - 9,000
Submontane - Foothill Shrub Zone - Mountain brush land	5,000 - 8,000
Mountain Valley Zone - Desert shrub and grass	4,500 - 5,000

3.6 Soils. Soils in the valleys and Provo Bench area are alluvial material and fairly to highly pervious west of the Wasatch Front foothill line. The climate and soils in the study area are very favorable for irrigated agriculture. Soils in the mountains are generally shallow, and there are large areas of exposed rock in the steep canyons areas of the Wasatch Range.

4. Description of Study Area Watersheds

4.1 General. Flooding in Provo results from runoff from both a relatively large river system, the Provo River, and small Wasatch Front watersheds immediately east of the city of Provo. The Provo River Basin collects runoff from a drainage area of over 600 square miles from both the Uinta and Wasatch mountain ranges. The eastside watersheds included in this study range in size from approximately 0.4 to 9 square miles.

4.2 Provo River. The Provo River Basin collects runoff from both the Uinta and Wasatch mountain ranges. The upper portion of the basin is bounded on the south by the Duchesne River and on the north by the Weber River. Elevations in the headwaters go up to 11,000 feet. U.S. Highway 189 runs parallel to the Provo River in the study area. Two reservoirs on the mainstem Provo River, at Jordanelle and Deer Creek dams, provide flood control and water supply to the region. Heber Valley, a major feature of the watershed, is located near the center of the Provo River basin. Heber Valley is about 40 square miles in area and has an average elevation of about 5,600 feet. About 123 square miles of the watershed, below Deer Creek Reservoir, is essentially unregulated. Deer Creek Reservoir is not operated for flood control.

Jordanelle Reservoir, located in the Provo River headlands of the Uinta Mountains, provides water supply and flood control for the Heber Valley, the city of Provo, and the metropolitan areas of Utah Valley and Jordan River Valley. Chart 4 shows the normal annual precipitation and climatological stations located in or near the study area. Jordanelle Dam is located approximately 6 miles north of Heber City, Utah, and 40 miles southeast of Salt Lake City, Utah.

Jordanelle Reservoir is part of the U.S. Bureau of Reclamation (USBR) Provo River Project, which includes Deer Creek Reservoir. A final water control plan for Jordanelle Reservoir has not yet been developed. The water control plan will be developed by the Corps of Engineers in cooperation with the USBR. The USBR is responsible for the administration of flood control operations. The Central Utah Water Conservancy District (CUWCD) is responsible for the safe and proper operation and maintenance of the dam and reservoir. The Provo River Project also includes transmountain diversions from the North Fork of the Duchesne River and the Weber River.

Jordanelle Dam is a zoned earthfill structure with an impervious core. The crest of the dam, at elevation 6,185 feet, is 40 feet wide, 3,820 feet long, and 299 feet above the streambed of the Provo River. Under contracts supervised by the USBR, excavation for Jordanelle Dam was initiated in June 1987. The embankment of the dam was completed in October 1992, and the initial filling of the reservoir began in April 1993. The reservoir has a storage capacity of 314,006 acre-feet at the gross pool elevation of 6,166.4 feet NGVD (National Geodetic Vertical Datum).

Deer Creek Reservoir is located approximately 16 miles northeast of Provo, Utah, in the southwest corner of Heber Valley, on the Provo River. Outflow from Jordanelle Dam flows into Deer Creek Reservoir. Deer Creek Dam is not operated for flood control. Below Deer Creek Dam, the Provo River flows west through the Wasatch Mountain Range in a narrow, rugged canyon for 10 miles before emptying into Utah Lake at Provo. Major tributaries that flow into the Provo River below Deer Creek Dam, in the Provo River Canyon, are Provo Deer Creek, North Fork Provo River, and the South Fork Provo River. The North and South Forks join the Provo River at Wildwood and Vivian Park, respectively. Several large canals divert water out of the Provo River between the canyon mouth and the city. The drainage area of the Provo River at Deer Creek Dam is 560 square miles.

Deer Creek Dam is a zoned earthfill structure 150 feet high, with a crest elevation of 5,425 feet NGVD, a parapet wall elevation of 5,428 feet, and a crest length of 1,304 feet. The dam was constructed by the USBR in 1938-1941, and is now operated by the Provo River Water Users Association (PRWUA). The reservoir has a storage capacity of 152,600 acre-feet at the top of the active conservation pool, at elevation 5,417 feet.

4.3 Mile High Canyon. Mile High Canyon, drainage area 0.38 square miles, drains into the Edgemont neighborhood of Provo, which consists of larger homes, a school, churches, and a few businesses. There is a small 1.1 acre-feet debris basin on the east side of Foothill Drive, near the canyon mouth.

4.4 Little Rock Canyon. Runoff from Little Rock Canyon, drainage area 1.11 square miles, flows into a street curb and gutter in a residential area and is eventually picked up by the downstream storm drain system. Flows eventually reach the Provo River through a series of pipelines and ditches that were originally designed as irrigation facilities. These facilities lack sufficient capacity for adequate stormwater conveyance. Development in the Little Rock Canyon floodplain consists of very large homes, a school, churches, and some businesses.

4.5 Rock Canyon. Rock Canyon, the largest of the eastside basins at 8.78 square miles, enters the Provo Bench area near the northern city limits of Provo. As with all of the eastside basins, the topography in Rock Canyon consists of very rugged, steep, and narrow canyons. Provo Peak, in the Rock Canyon headwaters, rises to an elevation of 11,068 feet. A 102 ac-ft debris basin, at spillway crest, is located about 0.5 miles below the mouth of Rock Canyon. This basin was considered to be partially to completely full of debris in the study analyses. The basin has a 48-inch outfall pipeline to the Provo River. The outlet capacity is approximately 280 cfs with a water surface at the spillway crest, and elevation 4,960 feet.

The Rock Canyon Creek channel disappears downstream from the debris dam in the vicinity of the Timpanogos Canal. Normally, runoff from Rock Canyon does not reach the Provo River because of high infiltration rates in the alluvial fan. There is no single, well defined channel to carry Rock Canyon runoff through the city of Provo to the Provo River. Development in the Rock Canyon Creek floodplain consists of large to very large homes, schools, churches, and businesses.

4.6 Slide Canyon. Slide Canyon is a small mountain watershed, drainage area 1.21 square miles, located south of Rock Canyon. Flow from Slide Canyon is normally absorbed by the existing irrigation system and the undeveloped pervious area below the canyon mouth. The stream channel has been obliterated due to agricultural practices and urban development. The single very small debris basin near the mouth of Slide Canyon does not provide significant control of flood events. Development in the Slide Canyon floodplain consists of medium to large size homes, apartments, schools, churches, and businesses.

4.7 Buckley Draw. Buckley Draw is a small mountain watershed, with a drainage area of 0.88 square miles, which drains into an area consisting of medium to larger size homes, apartments, schools, a county complex, a church, and several businesses.

4.8 Slate Canyon. Slate Canyon, the second largest eastside basin, drains an area of 6.20 square miles. Provo Peak, in the Slate Canyon headwaters, has an elevation of 11,068 feet. Slate Canyon drains into a series of three debris/detention basins. The two lower basins have a combined capacity of 41 acre-feet at spillway crest. The upper basin was considered to be full of debris during flow events and was discounted in the analyses. A large debris flow event may result in flows bypassing one or more of the debris basins. Basins 1 and 2 were considered to be ineffective for flood detention for the 2, 1, and 0.2 percent chance exceedence events. Presently, there is not an adequate outlet for these basins. The flow is diverted down an irrigation ditch and eventually into a street curb and gutter. During snowmelt flood conditions, flow is routed into a sandbagged channel along several major roadways to Utah Lake. Normally, flow from Slate Canyon combines with an irrigation and power plant outfall line known as Mill Race, which flows directly to Utah Lake (not the Provo River). Development in the Slate Canyon floodplain consists mainly of medium size homes, apartments, schools, churches, and businesses.

4.9 Ironton Canyon. Ironton Canyon, with a drainage area 1.22 square miles, drains into an area consisting mostly of businesses and gravel pits at this time.

4.10 Urbanized Area Improvements. The irrigation system in Provo serves as the principle operational storm drainage facility. The newer areas of the city to the north have major outfall lines to convey their stormwater flow. However, most development relies on curbs and gutters rather than pipelines to get water to these major conveyance structures. The industrial areas to the south and the urban areas to the west of downtown Provo rely heavily on the existing irrigation outfall system of ditches and canals. The local drainage system within the city is inadequate to handle even runoff from the urban areas, independent from the eastside basin runoff.

5. Precipitation / Storm Characteristics

5.1 Cloudburst Events. As reported in reference 3, 836 cloudburst floods were reported in Utah From 1939 to 1969. Many other floods took place in sparsely settled areas and went unrecorded. During this time, cloudburst floods were reported in every month except February and March, however, nearly 75 percent of these floods occurred in July or August. More than 30 percent of the recorded cloudburst floods occurred in the six county area along the Wasatch Front. Large debris flows sometimes accompanied these events.

In Utah, cloudbursts usually occur when moisture-laden air rises rapidly and is cooled, which results in a lowered dew point and therefore greatly diminished moisture-retaining capacity. Most cloudbursts in Utah occur during the summer, when unstable moisture-laden air masses move into the area from the South Pacific Ocean or the Gulf of Mexico. The lifting of the air mass usually occurs when the air mass moves across a mountain range, or is lifted by thermal convection currents. Cloudbursts produce intense precipitation in a localized area for a short period of time. Most of the precipitation from cloudburst storms in Utah occurs within an hour or less, and the area of torrential rain often covers less than 5 square miles. When the storms occur over mountainous areas the resulting floods are usually flashy and destructive. The 100-year, 6-hour point rainfall for the Wasatch Front, in the vicinity of Provo, is approximately 2.5 inches.

5.2 General Rains. General rains alone usually produce little flooding in the study area, due to low rainfall intensities, existing detention facilities, and the pervious soils on the fans and valleys. Cloudbursts occasionally occur as embedded cells within general rainstorms. An example would be the cloudburst observed during the large general rainstorm of January 29 - February 1, 1963. This event, centered in the vicinity of Deer Creek Dam, produced a total storm rainfall depth of 5.08 inches. Due to the small area of intense rainfall associated with the cloudburst, however, very little flooding resulted from this storm. Maximum daily inflow to Deer Creek Reservoir was approximately 6,000 acre-feet. If centered over a small watershed, a cloudburst within a general rainstorm could result in significant flooding.

6. Flood Characteristics

6.1 General. Flooding in the Provo River Basin and Wasatch Front streams typically results from snowmelt runoff or summer thunderstorms. Snowmelt floods in this region generally occur in May or June, but on rare instances can occur as early as April. Time of occurrence of these high flows depends upon the elevation of the snowfield and on the sequence and duration of melt-producing temperatures. Jordanelle Dam provides regulation of snowmelt floods in the upper Provo River. Thunderstorms occur frequently in this region during the summer months and early fall, resulting in high intensity precipitation over small areas. General rain storms can occur at any time, although general rains in this region do not generally produce flooding when not associated with snowmelt or cloudburst events. Winter rainfloods, which are very rare, result from intense local storms associated with widespread general rainstorms that occur from October through

May. Additional details concerning these three types of floods are discussed in the following paragraphs.

6.2 Cloudburst Floods. Thunderstorm floods are relatively common in the region. Such floods produce extremely high rates of flow and often have large sediment loads. These storms generally produce significant rainfall over areas of less than 20 square miles. The short, steep canyons and large ravines that drain the west-facing slope of the Wasatch Range are especially vulnerable to cloudburst floods. In the Provo area, examples are Snowslide and Lost Canyons in the lower Provo River Canyon. Floods from these two small, but exceptionally steep, canyons have repeatedly blocked the main canyon with debris, burying the railroad tracks and highway and destroying sections of the conduits carrying water to the Olmstead powerplant at the mouth of the canyon. Although Rock Canyon has not recently produced any large cloudburst flood events, early settlement in the Provo area experienced repeated flooding from this watershed. Flood problems were exacerbated by poor watershed management at that time. The fertile, but flood prone alluvial fans at the mouths of the canyons were formed in part from debris flows from cloudburst storms. Population centers, originally farms but increasingly urban areas, are concentrated on the alluvial fans.

6.3 Snowmelt Floods. Although not as severe as cloudburst floods, snowmelt floods are common in the study area. These floods are characterized by prolonged flows with some diurnal effects. Typically, maximum instantaneous peaks do not usually exceed the mean daily values by more than 10 percent. Significant snowmelt begins at lower elevations in later March or early April, while higher basins usually peak in May, with slow recessions through June and July. Occasionally there are general rainstorms which produce 1 to 2 inches of rain during the main snowmelt season. Although these storms produce some direct runoff and some melt due to rain on snow, the cloud cover, lower temperatures, and characteristically low precipitation intensity in this region are such that the net water available for immediate runoff is less than what would result from fair weather snowmelt alone.

Historically, the larger floods on the Provo River have occurred during the April through June snowmelt period. With the addition of Jordanelle Dam and Reservoir for flood control, Provo now has over a 100-year level of protection from snowmelt floods. The Provo River has channel capacity for up to approximately a 35-year cloudburst event, with a peak of 1,800 cfs, below Deer Creek Dam. Extensive flooding would not likely occur from a cloudburst event on the lower Provo River because of the short duration of flow. Total hydrograph volumes would be relatively low.

6.4 Flood History. The following accounts of rainfloods were taken from the *Project Cloudburst* report (reference 3, paragraph 1.3), and local newspapers. This partial record of observed floods does not include snowmelt or rainfloods from the Provo River mainstem.

> Between 1939 and 1969 Provo experienced reported cloudburst floods in 1954, 1959, 1962, 1967, and 1968. Only in 1968 was there more than 1 event per year, however, 4 occurred in this year.

May 26, 1954
Floods from cloudburst in several locations in Provo.

Aug 17, 1958
0.68 inches from cloudburst reported at Provo Airport. Flooding in Provo. "Peaks of Timpanogos sent muddy waters over 1600 North and through a street between U.S. 91 and Hwy 189 into Provo Canyon."

Sep 27, 1962
Downpour floods Provo business district. Only 0.17 inches recorded. Water 0.5 to 1.0 feet in depth at some street intersections. First floor and basements flooded in businesses and homes.

Apr 1-2, 1968
Heavy rain flooded many yards, some streets, and at least 1 home.

Aug 22, 1968
1.15 inches of rainfall recorded in Provo. Street flooding.

7. Flow Frequency Analyses

7.1 Introduction. The largest flood flows from the eastside basins would be produced by a cloudburst storm centered over the Rock Canyon basin. The most severe flooding in the southern portion of Provo would result from a storm centered on Slate Canyon. Rainfall and loss rate criteria used to compute runoff are comparable to those used in the Jordan River Basin Survey Report for Flood Control, July 1969. Unit hydrographs for all of the eastside basins were developed from the Wasatch Mountain S-graph presented in the Jordan River Survey Report. Basin parameters and rainfall losses are presented in Tables 5 and 6. Existing information was used for the cloudburst flow frequency curves for the Provo River mainstem. The flow frequency curves for the mainstem Provo River are comparable to those developed for the eastside basins. The estimated summertime flow in the Provo River from reservoir releases, concurrent to the cloudburst events, is 150 cfs. Peak flow frequency curves for the Provo River and eastside basins are shown on Charts 7 through 19.

Hydrographs of the 10-, 2-, 1-, and 0.2-percent chance exceedence flood events were developed for the eastside basins from 6-hour rainfall depth-duration-frequency relationships and HEC-1 modeling. Subbasin hydrographs at canyon mouths were provided to Hydraulic Design Section for hydrograph routing and combining to develop floodplain maps.

Basin parameters that affect the amount and timing of runoff used in the analysis are: basin size, basin shape, channel length, and channel slope. Basin parameters were measured from 1:24,000 scale topographic maps. Parameter L_{ca}, a basin shape parameter, is measured as a function of the stream channel length to the centroid (center of mass) of the basin. Table 6 lists the basin parameters used for each subbasin.

7.2 Hypothetical Cloudburst Rainfall Depth-Frequency and Temporal Distributions. The eastside basin watersheds were delineated on 10-, 50-, and 100-year 6-hour NOAA Atlas II rainfall maps to obtain area-weighted, basin average rainfall depths for cloudburst events. Areal reduction factors ranging from 0.97 to 0.80 were applied to all subarea point rainfall depths, based on findings in the *Project Cloudburst* study. The *Project Cloudburst* report was also used to develop a temporal distribution. This study used more than 50 rain gages, covering in an area of about 350 square miles, in the general vicinity of Salt Lake City. The nine largest observed events during the 6 year period of 1970 - 1975 were studied in detail. In this study, the relationship between the maximum one-, three-, and six-hour depth-area curves seems relatively consistent from storm to storm. The average temporal distribution of these large events has been used with the NOAA Atlas II rainfall depths for the rainfall-runoff modeling of the eastside basins. Tables 7, 8, and 9 provide basin average 6-hour rainfall frequency relationships used in the eastside basin rainfall-runoff modeling.

7.3 Rainfall Loss Analysis. Rainfall and rainfall losses vary with event frequency. Less antecedent rainfall is expected with more frequent events, therefore initial and constant losses are higher, due to drier soil moisture conditions at the beginning of the storm. Initial losses must be satisfied before runoff begins, while the constant losses reflect the infiltration rate of the wetted soil after initial losses have been satisfied. Table 5 lists the initial, constant, and "additional" losses, used in the rainfall-runoff analyses for the eastside basins. Additional losses are described in the following paragraph and Table 5.

There are not sufficient rainfall and concurrent runoff data available for a quantitative analysis of loss rates. Accordingly, rainfall losses were estimated from soil transmisivity, other COE studies within the region, and from additional subarea characteristics such as vegetation and climatic factors. Soil transmisivity was obtained from a Soil Conservation Service (SCS) Soil Survey, using the Hydrologic Soil Groups for the soils mapped in the area. The SCS in now the Natural Resources Conservation Service (NRCS). Soils in the study area are generally shallow, except in the fans and valley. The fans and valley were not incorporated into the HEC-1 models. Most areas within the basins are not heavily vegetated. Losses are generally higher in areas with heavy vegitation cover. Soil moisture conditions are typically dry during the cloudburst season, and occasionally moderately wet during the general rain season. General rain events were not modeled. Loss rates are approximately the same as those used in the 1970 Jordan River Survey Report Draft, although this study did not consider "additional losses." Additional losses were added so as to better model runoff from rock outcrop areas. The principal basins modeled using HEC-1 are shown in Table 3. For these watersheds, initial losses vary from 1.00 to 0.65 inches as a function of event frequency. Constant losses range from 0.25 to 0.20, also by event frequency. Additional losses range from 0.00 to 0.60 inches.

Table 5. Precipitation Losses for Hydrograph Computation [1]

Return Period (yrs)	Initial Loss (in)	Constant Loss (in/hr)	Additional Loss [2] (in)
10-yr	1.00	0.25	0.6
50-yr	0.75	0.22	0.2
100-yr	0.65	0.20	0.0
500-yr	0.65	0.20	0.0

(1) For MileHigh Canyon, Little Rock Canyon, Rock Canyon, Slide Canyon, Slate Canyon, Buckley Draw and Ironton Canyon.
(2) Additional losses are precipitation subtracted from total precipitation for storage losses on rock outcrops. Losses vary by return period due to antecedent precipitation (antecedent moisture conditions).

7.4 Unit Hydrograph Development. No historical rainflood hydrographs were available, therefore, unit hydrographs were developed by synthetic procedures. The S-graph method was used to develop the flood hydrographs. S-graphs for a particular basin are first derived by making discharge vs. time graphs for continuous, uniform, rainfall. This S-graph represents summed unit hydrographs over time. These graphs, when smoothed, form a deformed "S" shape. By converting the *Discharge* vs. *Time* S-graph to a graph of *Time in Percent of Lag Time* vs. *Discharge in Percent of Ultimate Discharge*, the S-graph may be applied to other basins with similar runoff characteristics. The Wasatch Mountain S-graph has been selected for modeling the eastside basins. The Wasatch Mountain S-graph provides a hydrograph of typical shape for the region, and may be used where no observed hydrograph is available to serve as a pattern.

7.5 Basin Parameters. Basin n-values are unitless factors reflecting the roughness of the basin. Basin n-values used in this study are similar to those used in previous studies of watersheds near the study area. Channel length (L) and channel length to basin centroid (Lca) were based on physical dimensions of the basins measured from U.S. Geological Survey (USGS) topographic maps.

Table 6 provides subbasin parameters and S-graphs used in the HEC-1 rainfall-runoff analysis. Basin n-values were estimated from those determined in previous studies within the region and from subarea characteristics. Basin n-values range from 0.07 to 0.09.

Table 6. Basin Parameters for Hydrograph Computation [1]

Basin	Basin Name	D.A. (Sq mi)	% Impervious	Initial Loss[2] (in)	Constnt Loss[2] (in/hr)	L (mi)	Lca (mi)	Slope (ft/ft)	Basin n-value	S-graph
E1	Mile High Cyn	0.38	20	0.65	0.2	1.52	0.80	0.269	0.075	Wasatch Mtn
L1	Little Rock Cyn	1.11	20	0.65	0.2	2.65	1.36	0.237	0.075	Wasatch Mtn
R1	Rock Cyn	8.78	30	0.65	0.2	5.83	2.96	0.200	0.075	Wasatch Mtn
S1	Slide Cyn	1.21	20	0.65	0.2	2.35	1.25	0.359	0.075	Wasatch Mtn
S2	Slate Cyn	6.20	30	0.65	0.2	4.81	2.84	0.258	0.075	Wasatch Mtn
B1	Buckley Draw	0.88	20	0.65	0.2	1.97	0.99	0.437	0.075	Wasatch Mtn
I1	Ironton Cyn	1.22	20	0.65	0.2	2.05	1.06	0.435	0.075	Wasatch Mtn

(1) Cloudburst storm centered over basin.
(2) 1% Chance Exceedence Event, see Table 5 for other precipitation loss information.

7.6 Base Flow. Due to the expected antecedent conditions and the short duration of flow associated with cloudburst events, baseflow has not been incorporated into the rainfall-runoff models.

7.7 Channel Routing. Channel routings at the canyon mouths and upper alluvial fan were performed to account for channel losses in the alluvium. Large channel losses are expected in the highly permeable sediments. The estimated channel loss rates were applied to the stream channel sections which flow through sediments at or near the canyon mouths. The loss rates selected are 90, 35, 10, and 10 percent of total flow for the 10-, 50-, 100-, and 500-year events, respectively. The selected loss rates result in smooth flow-frequency curves and the low flows expected from 10-year events. Given the high percent of rock outcrop in the basins, high channel losses are required to model reasonable 10-year events. Channel routings below the canyon mouths, and below debris basins, were performed by Hydraulic Design Section. Most of the hydrograph attenuation occurs on the alluvial fan below the canyon mouths.

7.8 Combined Flow Frequency Analyses. Combined (all event) flow frequency curves were developed for the eastside basins and the Provo River at selected concentration points. Each flow frequency curve is for the combined frequency of runoff events from cloudburst storms and snowmelt. Significant runoff from general rainstorms is considered to have been from embedded cloudbursts, therefore, a separate component for general rain was not included.

The combined frequency curve was developed from the following statistical relationship:

$$P_C = P_{CB} + P_S - (P_{CB} * P_S)$$

Where:

P_C = Combined Probability of specified flow occurring from general storm and/or cloudburst event.

P_{CB} = Probability of specified flow occurring from cloudburst event.

P_S = Probability of specified flow occurring from a snowmelt event.

To compute the all-event flow frequency curves, probability values taken from both the cloudburst and snowmelt flow frequency curves, for selected flow values, were used with the above equation. All-event curves were then developed by drawing a graphical best-fit curve through the computed flow frequency points.

7.9 Snowmelt Flow Frequency. A review of hydrology performed for other small basins in the study area found that the snowmelt frequency curves in these studies consistently had skews from 0 to -1, and standard deviations of approximately 0.3 to 0.4. Therefore, a skew of 0.0, and a standard deviation of 0.35, were used to develop the eastside basin snowmelt curves. The Provo River snowmelt curve came from the latest draft of the Jordanelle Water Control Manual. Given skew and standard deviation, a single flow frequency value was required to define a curve. For this study, 100-year snowmelt peak flow frequency values were developed for each basin from a 100-year snowmelt CSM (cfs per square mile) curve.

Snowmelt hydrographs were not provided to Hydraulic Design Section for the floodplain analyses. Most of the highly damaging runoff events would come from cloudburst storms. While snowmelt peak flows are small relative to cloudbursts peaks, the volume of large (rare) snowmelt events exceeds the storage volume of existing debris basins, therefore, little snowmelt flood control is provided by the basins. In other words, the 1-, and 2-day flows may only be 10 to 15 percent less than the peak, and the basins will reach conditions where inflow equals outflow at a time when flows remain relatively high. The snowmelt flow frequency curves do not show the effects of regulation by debris basins. Curves developed from a more detailed analysis might show a small amount of regulation, where a section of the curve "flattens", however, a detailed level of study is not required for the purposes of this study.

The regulated snowmelt-frequency curve for the Provo River at the canyon mouth and at Interstate 15 is an estimated curve based on the curve developed for the Jordanelle Water Control Manual. Reservoir releases are determined using a control point at Vivian Park, approximately 7 miles above the canyon mouth. The accepted channel capacity for the Provo River below Jordanelle Reservoir has been increased from 1,200 cfs to 1,800 cfs. Based on the change in channel capacity, the curve was adjusted to reflect new operating criteria for a channel capacity of 1,800 cfs. Local snowmelt inflow below the dams is considered to be insignificant. Most snowmelt below the dams runs off before melt above the dams occurs.

7.10 Concurrent Precipitation and Hydrographs. Because the damage location is in an area where floodplains from more than one watershed coalesce, different storm centerings were considered, concurrent flows were developed from neighboring basins, and hydrographs were combined to develop composite floodplains. Because flows from Rock Canyon north combine with Rock Canyon and flow to the Provo River through Provo, while flows from basins south of Rock Canyon combine with Slate Canyon flows and flow to Utah Lake, at least two critical storm centerings were required. As Rock Canyon and Slate Canyon are by far the largest watersheds, generate the most runoff, and produce the largest floodplains, these basins were used for the *critical* storm centerings.

Concurrent precipitation is developed so that the subbasin at the storm center is given a precipitation depth based on the depth-area-duration (DAD) curve for that region and a point precipitation depth. Precipitation for the other basins is then developed so that the basin average precipitation for the total drainage area (all subbasins combined) also follows the depth-area-duration relationship described by the DAD curve. Concurrent precipitation was used to model concurrent hydrographs. Tables 18 and 19 present the concurrent peak events for storms centered on Rock and Slate Canyons, respectively.

Table 7. Precipitation Depths used for Hydrograph Computation
Cloudburst Storm Centered Over Each Basin

Basin	D.A. (Sq mi)	6-Hr Precipitation (1) by Percent Chance Exceedence of Event (in)			
		10 %	2 %	1 %	PMP
Buckley Draw	0.88	1.65	1.77	1.90	12.67
Ironton Cyn	1.22	1.63	1.75	1.88	11.87
Little Rock Cyn	1.11	1.64	1.75	1.89	10.03
Mile High Cyn	0.38	1.67	1.81	1.95	11.53
Rock Cyn	8.78	1.70	1.86	1.99	10.33
Slate Cyn	6.20	1.59	1.76	1.89	11.88
Slide Cyn	1.21	1.63	1.75	1.88	11.60

Notes:
(1) Total Storm Basin Average Precipitation Depth

Table 8. Precipitation Depths used for Hydrograph Computation Cloudburst Storm Centered Over Rock Canyon

Basin	D.A. (Sq mi)	6-Hr Precipitation (1) by Percent Chance Exceedence of Event (in)		
		10 %	2 %	1 %
Rock Cyn (flows to Provo Riv)	8.78	1.70	1.86	1.99
		Concurrent Precipitation		
Basins which flow to Provo River at Provo				
Little Rock Cyn	1.11	1.30	1.42	1.52
Mile High Cyn	0.38	1.24	1.36	1.46
Basins which flow to Utah Lake at Provo				
Buckley Draw	0.88	1.36	1.38	1.49
Ironton Cyn	1.22	1.22	1.34	1.43
Slate Cyn	6.20	1.43	1.57	1.68
Slide Cyn	1.21	1.33	1.46	1.57

Notes:
(1) Total Storm Basin Average Precipitation Depth

Table 9. Precipitation Depths used for Hydrograph Computation
Cloudburst Storm Centered Over Slate Canyon

Basin	D.A. (Sq mi)	6-Hr Precipitation [1] by Percent Chance Exceedence of Event (in)		
		10 %	2 %	1 %
Slate Cyn (flows to Utah Lake)	6.20	1.59	1.76	1.89
		Concurrent Precipitation		
Basins which flow to Utah Lake at Provo				
Buckley Draw	0.88	1.43	1.58	1.69
Ironton Cyn	1.22	1.15	1.27	1.36
Slide Cyn	1.21	1.38	1.52	1.63
Basins which flow to Provo River at Provo				
Rock Cyn	8.78	1.27	1.41	1.51
Little Rock Cyn	1.11	1.11	1.23	1.32
Mile High Cyn	0.38	1.09	1.21	1.29

Notes:
(1) Total Storm Basin Average Precipitation Depth

8. Debris Yield/Debris Basin Floodwater Detention

8.1 Debris/Mud-Rock Flows. Flash floods commonly discharge large volumes of debris as well as free water. This is particularly true in small drainage basins without frequent sustained flows high enough to flush debris. Debris may accumulate over many years before a flood occurs. The debris is usually a mixture of mud, rocks, boulders, and plant materials. Cloudburst rainfall greatly exceeds the infiltration capacity of the soil and litter, thus water quickly gathers into rills or waves of sheet flow. This overland flow then carries large amounts of debris into the main drainage channels.

Debris piles up as it is pushed forward by the water; at narrow places in the channels the debris may form a temporary dam that retards the flow. Water can back up until the dam breaches, and the resulting debris-water mixture plunges down the canyon with terrific force, destroying everything in its path.

At the time of the peak flow, debris effectively scours the channel sides and bottom, enlarging the channel (especially in their lower reaches just inside the canyon mouths), however, large amounts of debris may be left behind during flow recession.

Typically, debris makes up approximately 10 to 25 percent of the flow volume in rare events from small arid and semi-arid watersheds in the western U.S. Mud-rock flows may have debris concentrations that are much higher than 25 percent. The high viscosity of mud-rock flow enables it to maintain appreciable depth even on unconfined surfaces, which explains its great destructive and transportive power. Mud-rock flows are not readily diverted by obstacles in their path, instead tending to override them. Although mud-rock flows have occurred on the study basins in the past, some researchers believe improved watershed management in the area appears to have reduced the risk from these events. Others believe that a "quiet" cloudburst period has produced a false sense of security to those living in the area. Geologic evidence shows that mud-rock flows did occur before the area was developed. The frequency of mud-rock flows cannot be identified without extensive studies, which are beyond the scope of this study. Therefore, a typical debris yield (approximately 15% of the total computed 100-year inflow event volume) was routed into the Rock and Slate Canyon debris basins. The debris yield was computed using the PSIAC method, developed by the Pacific Southwest Interagency Commitee of the Soil Conservation Service. Study area basin parameters for the PSIAC method are shown in Table 10.

Table 10. Basin Factors for PSIAC Debris Yield Estimate Rock and Slate Canyons

Factor Name	Factor Value Selected	Factor Range, Low to High
Geology	2	0 to 10
Soils	2	0 to 10
Climate	3	0 to 10
Runoff	7	0 to 20
Topography	18	0 to 20
Ground Cover	-5	-10 to -10
Land Use	-10	-10 to -10
Upland Erosion	5	0 to 25
Channel Erosion	4	0 to 25

8.2 Average Annual Debris Yield. Most of the PSIAC factors selected for basins in the study area contribute to a relatively low average annual debris yield. Using average (median) values would result in a much higher debris yield. Only the topography factor is on the high end of the given range, due to the very steep topography. Using the above factors, the average annual debris yield estimates for Rock and Slate Canyons are 1.8 and 1.2 acre-feet/year, respectively (0.2 acre-feet/sq. mi./year). The average annual debris yield does not provide a debris yield for any given year or return period. Debris yield in any given year is dependent on factors such as the magnitude of flood events, and fires within the basin. For the purposes of this study, fire history was discounted, and debris yield was considered dependent on flood magnitude from the flow frequency curve. In an environment like that in the study area, little or no debris is produced at the basin outlet in a typical year. Over a long period of record, a few very large debris flow events will make up most of the total debris yield for that period.

The average annual debris yield may be obtained from a debris yield-frequency graph by integrating the area under the frequency curve. Debris yield-frequency curves are commonly described by raising flow-frequency values to the 1.5 power. A factor is then used as a multiplier to obtain the debris yield value. The factor is site specific, and the value of the factor is in part dependent on unit conversions. The equation for the debris yield estimate is:

$$Qd = F^*(Qw)^{1.5}$$

Where:

Qd = debris yield in acre-feet
F = basin specific multiplier
Qw = flow in cfs

The 100-year Qd's computed for Rock Canyon and Slate Canyon were 85 and 23 acre feet, respectively. Given the flow frequency curves, a factor (multiplier) was selected which produced an average annual debris yield, equal to the integrated area under the curve, equaling the value provided by the PSIAC method. The values of this multiplier "F" for the Rock Canyon and Slate Canyon basins were 1/1200 and 1/1070, respectively. For Rock Canyon flood routings, the computed debris volume was assumed to occupy volume in the single debris basin before the hydrographs were routed through the basin. Slate Canyon has 3 debris/detention facilities. The upper basin was considered to be full of debris during all flow events and was discounted in the analyses. A large debris flow event may result in flows bypassing one or more of the debris basins. Basins 1 and 2 were considered to be ineffective for flood detention for the 2, 1, and 0.2 percent chance exceedence events. The third basins were assumed to be at full capacity (empty of water and debris) at the beginning of each cloudburst flood, although it provides little regulation of large events. At the present time there is not an adequate outlet for these basins. Charts 18 and 19 show the debris yield frequency curves for Rock and Slate Canyons, respectively.

9. Flood Routing Through Debris Basins

9.1 Rock Canyon. A 102 acre-feet debris basin is located about 0.5 miles below the mouth of Rock Canyon. This basin was considered to be partially to completely full of debris in the study analyses. The basin has a 48-inch outfall pipeline to the Provo River, which has a capacity of 280 cfs with the water surface at the spillway crest. At the reconnaissance level of study, the basin was assumed to be first filled with the estimated debris yield from the debris yield-frequency curve. The clear water hydrograph was then routed through the basin, taking into account the debris volume. The rating table for the basin was taken from the "As-Built" drawings (Rock Canyon Debris Basin Modifications, dated 7/92 as constructed) prepared by Rollins, Brown, and Gunnell, Inc., Provo, Utah. Tables 11 and 12 present the stage-storage and stage-discharge tables, which include spillway outflow. Shallow flow over the top of the dam may occur in rare events. Catastrophic failure, such that would produce a sudden burst of water below the dam, is not likely given the shallow overtopping and short duration of flow. Although a 15-minute time step was used for most of the rainfall-runoff computations and routings, a 1-minute time step was required for routings where flow over the top of a dam was modeled.

Table 11. Rock Canyon Debris Basin Stage-Storage Relationship With Basin Empty of Debris

Elevation (ft)	Storage (ac-ft)
4,945.0	7.5
4,955.0	58.0
4,960.0	101.5
4,961.0	108.0
4,962.0	115.0
4,963.0	122.0
4,964.0	136.5

Table 12. Rock Canyon Debris Basin Stage-Discharge Relationships Outlet Works and Spillway Flow Combined

Elevation (ft)	Combined Q (cfs)
4,940.0	0
4,945.0	130
4,955.0	235
4,960.0	280
4,961.0	375
4,962.0	553
4,963.0	790
4,964.0	1074

9.2 Slate Canyon. Slate Canyon has three small debris basins arranged in series. At the reconnaissance level of study, basin 1 was assumed to be essentially filled with debris, and ineffective as a floodwater detention facility. Rating tables for basins 2 and 3 were taken from the report, "Slate Canyon Dams Remedial Work, Phase I, Hydrology/Hydraulics Summary Report, dated February 1984 (by John M. Tettemer and Associates, Ltd., Los Angeles, California). Updated rating tables were not readily available for the current study, however, the 1984 tables are adequate at the reconnaissance level of study.

Table 13. Slate Canyon Basin 2 Stage-Storage Relationships

Elevation (ft)	Storage (ac-ft)
4,670.0	0.0
4,675.0	4.2
4,680.0	8.4
4,685.0	14.0
4,690.0	24.3
4,690.7	25.6
4,695.0	41.0
4,697.0	47.0

Table 14. Slate Canyon Basin 3 Stage-Storage Relationships

Elevation (ft)	Storage (ac-ft)
4,658.0	0.0
4,660.0	0.1
4,664.0	2.5
4,668.0	8.0
4,670.0	11.5
4,671.5	14.8
4,672.0	15.8
4,674.0	20.2
4,675.0	22.4

Table 15. Slate Canyon Basin 2 Stage-Discharge Relationships

Elevation (ft)	Spillway Q (cfs)	30-inch Outlet Q (cfs)	Combined Q (cfs)
4,686.0	0	0	0
4,686.5	31	0	31
4,688.0	199	0	199
4,690.0	315	0	315
4,690.7	320	0	320
4,692.0	331	110	441
4,694.0	348	450	798
4,696.0	365	915	1,280
4,697.0	372	1190	1,562

Table 16. Slate Canyon Basin 3 Stage-Discharge Relationships

Elevation (ft)	Spillway Q (cfs)	30-inch Outlet Q (cfs)	Combined Q (cfs)
4,658.0	0	0	0
4,660.0	0	16	16
4,664.0	0	50	50
4,668.0	0	70	70
4,671.5	0	81	81
4,672.0	72	84	156
4,674.0	314	92	396
4,675.0	540	96	636

Failure of the dam/outlet works was not judged to produce a peak significantly different from that resulting from overtopping of the dam. Dam failure was not studied in detail. In the 1984 study, the computed 100-year peak inflow to basin 1 was 1,600 cfs, while the computed 100-year outflow from basin 3 was 712 cfs. Although the computed peak inflow to basin 1 is approximately the same in the current analysis (1640 cfs), the latest routing shows a 100-year peak outflow of 1,626 cfs. The difference in the results between the old and new routings is primarily from a difference in the hydrograph volumes in the two analyses. These studies were performed assuming that the proposed 24-inch slide gate was closed. This operating condition produces spillway flow earlier and constitutes the most conservative review of the system. In addition, the current analysis assumed that basin 2 would likely be bypassed in a very large (rare) event, and may not provide detention of floodwaters. Basin 2 is not in line with basins 1 and 3, and a debris flow could easily force floodflows directly into basin 3.

9.3 Mile High Canyon - The small 1.1 acre-feet debris basin on Mile High Canyon would fill with debris in a 50-year or rarer event, and therefore would not provide significant flood control with these events. The basin outlet, a 24" conduit, is rated at 39 cfs. The 10-year event on Mile High Canyon (8 cfs) is inconsequential, and debris impacts flood control with rarer events, therefore detention at the basin has not been considered at this time.

Table 17. Provo Area Streams, Peak Flow-Frequency
Storm Centered Over Each Basin

Basin	D.A. (Sq mi)	Peak Flow (1) by Percent Chance Exceedence of Event(2) (cfs)			
		10 %	2 %	1 %	0.2 %
Buckley Draw	0.88	16	236	490	1,323
Ironton Cyn	1.22	23	300	632	1,707
Little Rock Cyn	1.11	20	238	499	1,346
Mile High Cyn	0.38	8	112	229	618
Provo R. at Canyon Mouth	606.6(3)	1,800	2,800	4,400	8,495
Provo R. at I-15 (d/s Cyn mouth)		1,800	2,300	4,000	6,807
Rock Cyn Debris Basin Inflow	8.78	150	1,052	2,212	5,973
Rock Cyn Debris Basin Outflow	8.78	130	354	2,117	5,973
Slate Cyn Debris Basin Inflow	6.20	105	801	1,642	4,434
Slate Cyn Debris Basin Outflow	6.20	90	762	1,626	4,434
Slide Cyn	1.21	20	276	583	1,573

Notes:
(1) Debris volume not included in reported peak flow.
(2) Combined frequency of snowmelt and cloudburst events.
(3) Regulated at Jordanelle and Deer Creek Dams
(4) Debris inflow fills basins, no significant flood control provided.
See Table 7 for precipitation depths used to compute the above peak flows.

Table 18. Provo Area Streams, Peak Flow from Concurrent Rainfall Cloudburst Storm Centered Over Rock Canyon

Basin	D.A. (Sq mi)	Peak Flow [1] by Percent Chance Exceedence of Event (cfs)			
		10 %	2 %	1 %	0.2 %
Rock Cyn Debris Basin Inflow	8.78	55	1,052	2,212	5,973
Rock Cyn Debris Basin Outflow	8.78	40	354	2,117	5,973 [2]
		Peak Flow from Concurrent Precipitation Event			
Flows which commingle with Rock Canyon flows below canyon mouths, at Provo					
Little Rock Cyn	1.11	4	80	265	794
Mile High Cyn	0.38	2	27	105	283 [2]
Flows which **do not** commingle with Rock Canyon flows below canyon mouths, at Provo					
Buckley Draw	0.88	5	67	252	680
Ironton Cyn	1.22	5	78	314	847
Slate Cyn Debris Basin Inflow	6.20	32	550	1,336	3,607
Slate Cyn Debris Basin Outflow	6.20	0	467	1,321	3,607 [2]
Slide Cyn	1.21	6	112	356	961

Notes:
(1) Debris volume not included in reported peak flow.
(2) Debris inflow fills basins, no significant flood control provided.
All flows shown (except for Rock Canyon) are concurrent events to a cloudburst centered on Rock Canyon.
See Table 19 for flow computed from a storm centered on Slate Canyon.

Table 19. Provo Area Streams, Peak Flow from Concurrent Rainfall Cloudburst Storm Centered Over Slate Canyon

Basin	D.A. (Sq mi)	Peak Flow [1] by Percent Chance Exceedence of Event (cfs)			
		10 %	2 %	1 %	0.2 %
Slate Cyn Debris Basin Inflow	6.20	39	801	1,642	4,434
Slate Cyn Debris Basin Outflow	6.20	0	762	1,626	4,434 [2]
		Peak Flow from Concurrent Precipitation Event			
Flows which commingle with Slate Canyon flows below canyon mouths, at Provo					
Buckley Draw	0.88	5	138	330	891
Ironton Cyn	1.22	5	77	281	757
Slide Cyn	1.21	6	154	388	1,047
Flows which **do not** commingle with Slate Canyon flows below canyon mouths, at Provo					
Little Rock Cyn	1.11	3	48	192	519
Mile High Cyn	0.38	1	18	78	211 [2]
Rock Cyn Debris Basin Inflow	8.78	33	571	1,391	3,756
Rock Cyn Debris Basin Outflow	8.78	24	212	785	3,756 [2]

Notes:
(1) Debris volume not included in reported peak flow.
(2) Debris inflow fills basins, no significant flood control provided.
All flows shown (except for Slate Canyon) are concurrent events to a cloudburst centered on Slate Canyon.
See Table 18 for flow computed from a storm centered on Rock Canyon.

Table 20. Provo Area Streams, Concurrent Flow
Cloudburst Storm Centered Over Rock Canyon or Snowmelt Event

Basin	D.A. (Sq mi)	Peak Flow (1) by Percent Chance Exceedence of Event(2) (cfs)			
		10 %	2 %	1 %	0.2 %
Rock Cyn Debris Basin Inflow	8.78	150	1,052	2,212	5,973
Rock Cyn Debris Basin Outflow	8.78	130	354	2,117	5,973 (3)
		Flow ***at Canyon Mouths***(4) Concurrent in Time w/ Rock Cyn Peak Flow (flow listed is not peak of hydrograph)			
Little Rock Cyn	1.11	11	16	130	600
Mile High Cyn (debris basin inflow and outflow)	0.38	4	5	37	150 (3)

Notes:
(1) Debris volume not included in reported peak flow.
(2) Combined frequency of snowmelt and cloudburst events. Little Rock and Mile High Canyons 10% chance exceedence event is snowmelt.
(3) Debris inflow fills basins, no significant flood control provided.
(4) Flows are not commingled (physically combined) at canyon mouths.
Little Rock and Mile High Canyon flows are concurrent events to a cloudburst centered on Rock Canyon.

Table 21. Provo Area Streams, Concurrent Flow
Cloudburst Storm Centered Over Slate Canyon or Snowmelt Event

Basin	D.A. (Sq mi)	Peak Flow (1) by Percent Chance Exceedence of Event(2) (cfs)			
		10 %	2 %	1 %	0.2 %
Slate Cyn Debris Basin Inflow	6.20	105	801	1,642	4,434
Slate Cyn Debris Basin Outflow	6.20	90	762	1,626	4,434 (3)
		Flow *at Canyon Mouths*(4) Concurrent in Time w/ Slate Cyn Peak Flow (flow listed is not peak of hydrograph)			
Buckley Draw	0.88	9	80	180	490
Ironton Cyn (5)	1.22	13	50	165	445
Slide Cyn	1.21	13	110	265	715

Notes:
(1) Debris volume not included in reported peak flow.
(2) Combined frequency of snowmelt and cloudburst events. Buckley, Ironton, and Slide Canyons 10% chance exceedence event is snowmelt.
(3) Debris inflow fills basins, no significant flood control provided.
(4) Flows are not commingled (physically combined) at canyon mouths.
(5) Flow from Ironton Canyon **does not commingle** downstream from canyon mouths with other listed basins in 10%, 2%, or 1% chance exceedence events. Flows do commingle downstream from canyon mouths in 0.2% chance exceedence event.

Buckley Draw, Ironton Canyon, and Slide Canyon flows are concurrent events to a cloudburst centered on Slate Canyon.

Table 22. Provo Area Streams, Combined Peak Flow-Frequency
Total Commingled Flow on Alluvial Fan at Provo

Basin	D.A.(1) (Sq mi)	Peak Flow (2) by Percent Chance Exceedence of Event(3) (cfs)			
		10 %	2 %	1 %	0.2 %
Rock Cyn + Tributaries	10.5	130	390	2,138	6,530
Slate Cyn + Tributaries	8.5	90	648	1,501	5,307

Notes:
(1) Approximate drainage area, varies by return period.
(2) Debris volume not included in reported peak flow.
(3) Combined frequency of snowmelt and cloudburst events.
(4) Debris inflow fills basins; no significant flood control provided.

10. Utah Lake Stages

The period of record for the Utah Lake annual maximum stage data spans 113 years (1884 to present), including 111 years of data and 2 missing years of data, 1992 and 1993. A stage-frequency curve was developed by plotting all of the gaged data and drawing a best fit smooth curve through the points via trial and error adjustment of the curve statistics. A smooth curve does not fully take into account regulation of the lake water surface elevation, but provides an adequate approximation of the stage frequency relationships for the purposes of this study. Regulation of the lake water surface elevation is apparent in the plotted data between the 2 and 10 year events, where the data points break most strongly from the plotted curve (see Chart 20).

The existing conditions stage frequency cannot be fully evaluated because the data is not completely homogeneous. A pumping station was installed in 1902 as a means to regulate lake levels. Headwork and dredging projects in the mid 1980's have changed the capacity of the lake outlet. A dam on the Jordan River, built in 1872, provided regulation before the earliest streamflow records.

11. Flow Frequency Risk and Uncertainty

The hydrology risk and uncertainty component is developed from the flow frequency relationships, and an *effective* period-of-record (N). For the Provo study eastside basin analyses, models were developed without flow peak or volume data, because the basins are ungaged. Model parameters were determined from regional information obtained from previous hydrology studies and soil surveys. Guidance from the Hydrologic Engineering Center (HEC) recommends an effective period-of-record for uncalibrated models of 10 to 15 years, if no regional model parameters are available. With regional information, an N of between 15 and 30 years would normally be selected. A period of record between 20 and 30 years is recommended for models calibrated to several events. For a typical flow frequency analysis for an unregulated stream, using gaged flow data, the effective period of record would equal the gage period of record. Based on having no flow data for model calibration, and some regional information, the period-of-record selected for the eastside basin flow frequency analyses was 15 years. The cloudburst analysis for the Provo River mainstem also used an N of 15 years. The regulated snowmelt curves for the mainstem Provo River, developed from gaged data and a reservoir operations model, have an effective period-of-record of 37 years.

12. Probable Maximum Precipitation and Probable Maximum Floods

12.1 Probable Maximum Precipitation (PMP). The Probable Maximum Precipitation was developed as per HMR No. 49 (reference 9, paragraph 1.3). Provo is located in an area of very high cloudburst PMP. The 1-hour, 1-square mile PMP (unadjusted for elevation, see below) for all of the study area is 10.0 inches. PMP local cloudburst storm precipitation is reduced 5 percent for each 1,000 feet above 5,000 feet of elevation. The basin average elevation was used as a basis for reducing the PMP based on elevation. All of the eastside watersheds have an average elevation above 5,000 feet, resulting in downward adjustments to the 6-hour (total storm) PMP of approximately 4 to 16 percent. The basin average 6-hour rainfall for the eastside basins ranged from 10.0 to 12.7 inches. Maximum basin-average 15-minute precipitation ranges from 4.6 to 6.5 inches.

12.2 Probable Maximum Flood (PMF). Extremely high runoff rates would result from a PMP storm. The high PMP in this region results in PMF's that are approximately 3 to 4 times greater than the computed 500-year events. Despite the seemingly high computed PMF's, other studies in the region have developed PMF's that are as much as 20 percent higher on a cfs per square mile basis. Differences in PMF CSM (cfs per square mile) within the region can mainly be attributed to adjustments made to the PMP for elevation, and basin size. For the eastside basins, the PMF-CSM values ranged from 2,000 to 5,100 cfs per square mile. By comparison, some small basins experienced over 7,000 cfs per square mile in the "Big Thompson Flood", which occured in Larimer County, Colorado, in July 31-August 1, 1979. Although floods of this magnitude are not believed to be physically possible in the Provo area, the Big Thompson flood demonstrates that tremendous floods have been observed in recent history, and should not be discounted when designing flood control facilities. The basin parameters used for 500-year events were selected to model the PMF events.

Although large debris flows would accompany these events, only the clear water component of the PMF flow has been developed for this study. Debris basins would be required for any flood control facility using detention basins. In extreme events, debris basins would fill with debris, and therefore would not provide significant flood control by themselves, except to remove a portion of the debris volume from the hydrographs. Table 23 shows the PMF peak flows for each eastside basin.

Table 23. Provo Area Streams, Peak Flow Frequency Cloudburst Probable Maximum Floods

Basin	D.A.* (Sq. mi.)	Peak Flow (1) (cfs)
Buckley Draw	0.88	4,510
Ironton Cyn	1.22	5,960
Little Rock Cyn	1.11	4,450
Mile High Cyn	0.38	2,120 (2)
Rock Cyn Debris Basin Inflow	8.78	17,840
Rock Cyn Debris Basin Outflow	8.78	17,840 (2)
Slate Cyn Debris Basin Inflow	6.20	14,320
Slate Cyn Debris Basin Outflow	6.20	14,320 (2)
Slide Cyn	1.21	5,420

(1) Debris volume not included in reported peak flow.
(2) Debris inflow fills basins, no significant flood control provided.
* D.A. - Drainage area.

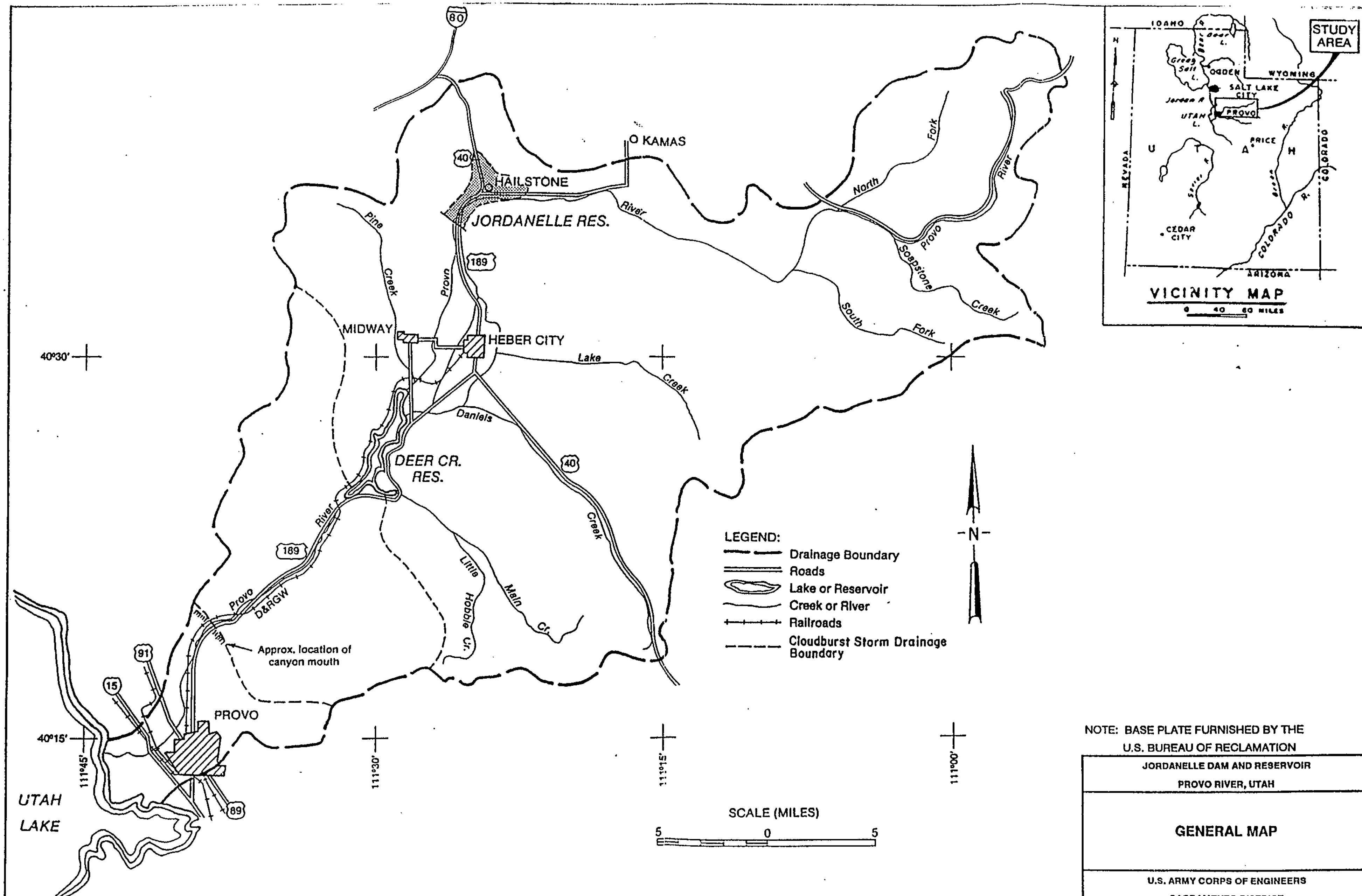
13. Applying Results from the Hydrologic Study

From a project design standpoint, the storm centerings over Rock and Slate Canyons may be thought of as two independent hydrologic analyses for two independent projects. Floodflows from Rock Canyon (and its tributaries) do not commingle with floodflows from Slate Canyon, therefore, flood control features in the Rock Canyon basin provide no benefits in the Slate Canyon watershed, and vise-versa. Tables 17, 18, 20, 22, and 23 should be used to evaluate project alternatives in the Rock Canyon watershed, and Tables 17, 19, 21, 22, and 23 should be used to evaluate project alternatives in the Slate Canyon watershed. Tables 17 and 23 present peak flows from storms centered over each eastside basin. Tables 18 and 19 present *peak* flows from storms centered over Rock and Slate Canyons, respectively. As the smaller basins do not peak at the same time as Rock or Slate Canyons, the peaks listed in Tables 18 and 19 are not concurrent in time with the peak flows from Rock or Slate Canyon. At the cross-section of the alluvial fan where flows coalese, recession flows from the smaller basins will combine with the peak flow from Rock or Slate Canyons to produce the peak combined flow. Tables 20 and 21 present the flows concurrent in time with the Rock and Slate Canyon peaks, respectively. The flows presented in Tables 20 and 21, after routing to the point where flows coalese, produce the floodplains prepared by Hydraulic Design Section. The combined, coalesed flow for the Rock and Slate Canyon storm centerings are shown in Table 22. Generally, snowmelt produces higher flows than cloudburst events for return periods of 10 years or less.

14. Results

14.1 General. The results from this study compare well with previous studies within the region. Modeled loss rates and other basin parameters are similar to those selected to model other basins within the region. The CSM curve in Chart 21 shows that the 100-year peak flows are comparable to those developed in other studies.

14.2 Summary of Analysis Procedures. The eastside basin cloudburst rainfall-runoff 10-, 2-, 1-, and 0.2- percent chance exceedence events were modeled using HEC-1. Cloudburst flow frequency curves for the Provo River mainstem were taken from an earlier analysis, however, the Provo River curves were checked for consistency with modeled results for the eastside basins. Snowmelt curves for the eastside basins were developed using regional information to obtain estimated curves using a CSM curve and a uniform skew and standard deviation for all basins. The Provo River snowmelt frequency curve was developed for the Water Control Manual for Jordanelle Dam. All-event flow frequency curves were developed by combining the snowmelt and cloudburst event probabilities. Peak flow frequency curves for the Provo River and eastside basins are shown on Charts 7 through 19. Tables 17 through 23 present the results from the flow frequency and PMF analyses.



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JORDANELLE DAM AND RESERVOIR
PROVO RIVER, UTAH

GENERAL MAP

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

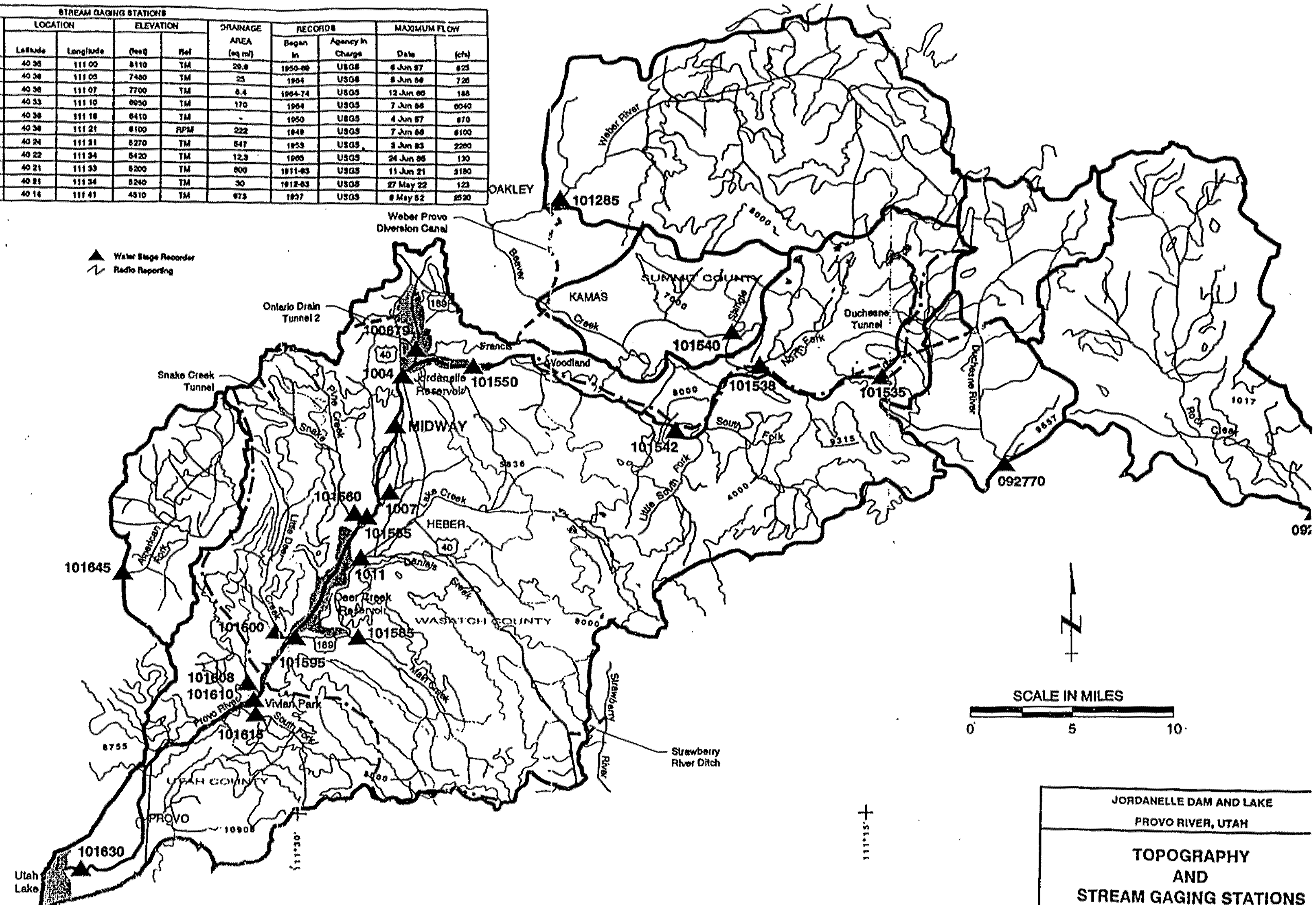
CHART 1

UT INDEX NO.	GAGING STATION	TYPE OF GAGE	LOCATION		ELEVATION		DRAINAGE AREA (sq mi)	RECORDS		MAXIMUM FLOW	
			Latitude	Longitude	(feet)	Ref		Began In	Agency In Charge	Date	(cfs)
101535	Provo River near Kamas	▲	40 35	111 00	8110	TM	29.8	1950-89	USGS	6 Jun 87	825
101538	N.F. Provo near Kamas	▲	40 36	111 03	7480	TM	25	1964	USGS	8 Jun 68	725
101540	Shingle Creek	▲	40 36	111 07	7700	TM	6.4	1964-74	USGS	12 Jun 86	188
101542	Provo River near Woodland	▲	40 33	111 10	6950	TM	170	1964	USGS	7 Jun 86	6040
101545	Weber-Provo Div Canal nr Woodland	▲	40 36	111 18	6410	TM	-	1950	USGS	4 Jun 87	870
101550	Provo River near Hailstone	▲	40 36	111 21	6100	RPM	222	1949	USGS	7 Jun 66	6100
101595	Provo below Deer Creek Reservoir	▲	40 24	111 31	5270	TM	547	1953	USGS	3 Jun 83	2280
101608	N.F. Provo near Wildwood	▲	40 22	111 34	5420	TM	12.3	1966	USGS	24 Jun 86	130
101610	Provo River at Vivian Park	▲	40 21	111 33	5200	TM	600	1911-83	USGS	11 Jun 21	3180
101615	S.F. Provo at Vivian Park	▲	40 21	111 34	5240	TM	30	1912-83	USGS	27 May 22	123
101630	Provo River at Provo	▲	40 14	111 41	4510	TM	673	1937	USGS	8 May 52	2520

LEGEND FOR STREAM GAGING STATIONS

USGS - U.S. Geological Survey
TM - Topographic Map
RPM - River Profile Map

▲ Water Stage Recorder
Radio Reporting

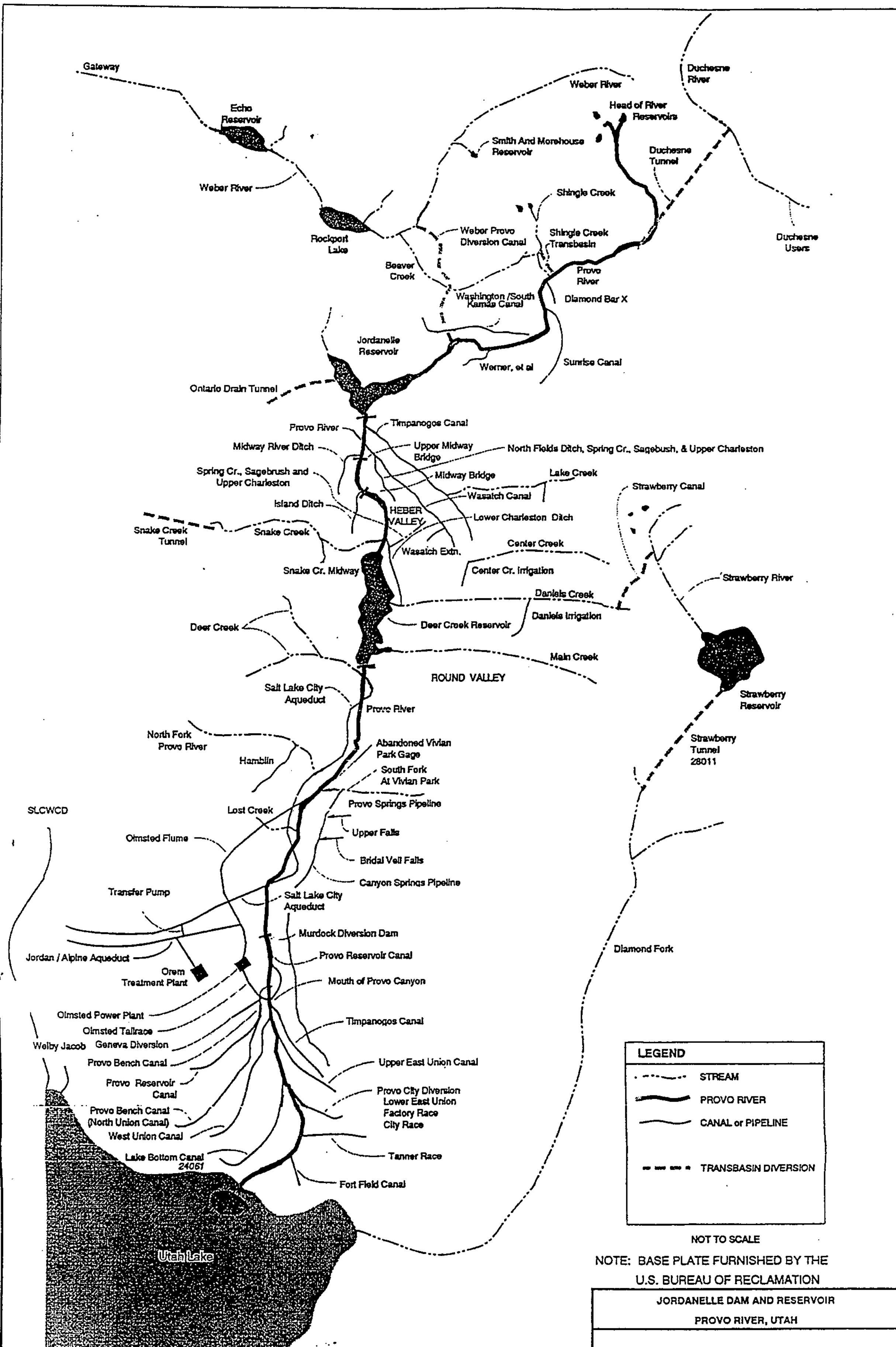


JORDANELLE DAM AND LAKE
PROVO RIVER, UTAH

TOPOGRAPHY AND STREAM GAGING STATIONS

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

CHART 2



NOT TO SCALE

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JORDANELLE DAM AND RESERVOIR
PROVO RIVER, UTAH

RELATED CONTROL FACILITIES

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

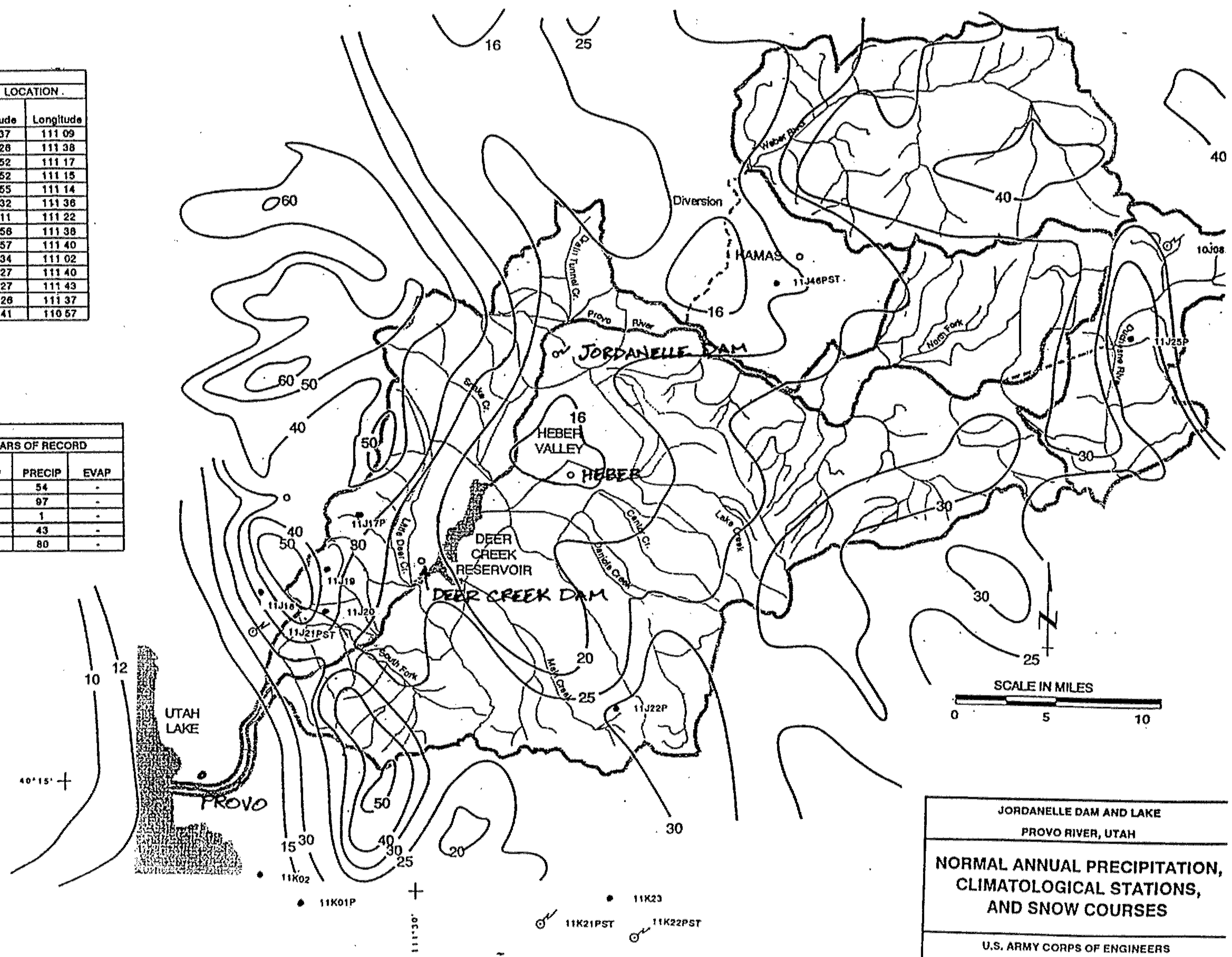
CHART 3

SNOW COURSES					
INDEX NUMBER	STATION	TYPE OF GAGE	ELEV IN FEET	LOCATION Latitude	LOCATION Longitude
11J46PST	Beaver Creek Divide	•	8000	41 37	111 09
11J20	Camp Altmont	•	7300	40 26	111 38
11K21PST	Clear Creek Ridge #1	o~	9200	39 52	111 17
11K22PST	Clear Creek Ridge #2	o~	8000	39 52	111 15
11K23	Clear Creek Ridge #3	•	6600	39 55	111 14
11J17P	Dutchman Ranger Station	•	7560	40 32	111 36
11J22P	Hobble Creek Summit	•	7420	40 11	111 22
11K01P	Payson Ranger Station	•	8050	39 56	111 38
11K02	Rock Bridge	•	6750	39 57	111 40
11J25P	Soapstone Ranger Station	•	7800	40 34	111 02
11J19	South Fork Ranger Station	•	6125	40 27	111 40
11J18	Timpanogos Cave	•	5523	40 27	111 43
11J21PST	Timpanogos Divide	o~	8140	40 26	111 37
10J08PST	Trial Lake	o~	9800	40 41	110 57

o~ Snowtell
• Snow Course

CLIMATOLOGICAL STATIONS							
STATION	TYPE OF SENSOR	ELEV IN FEET	LOCATION Latitude	LOCATION Longitude	YEARS OF RECORD TEMP	YEARS OF RECORD PRECIP	YEARS OF RECORD EVAP
DEER CREEK DAM	o	5269	40 24	111 32	54	54	-
HEBER	o	5628	40 30	111 25	96	97	-
JORDANELLE DAM	o~	6185	40 24	111 42	1	1	-
KAMAS	o	6475	40 39	111 17	42	43	-
SNAKE CREEK	o	6010	40 33	111 30	80	80	-
PROVO (KAYAK)	o						

o~ Telemetry Recording for Precipitation and Temp
o Recording for Precipitation and Temp



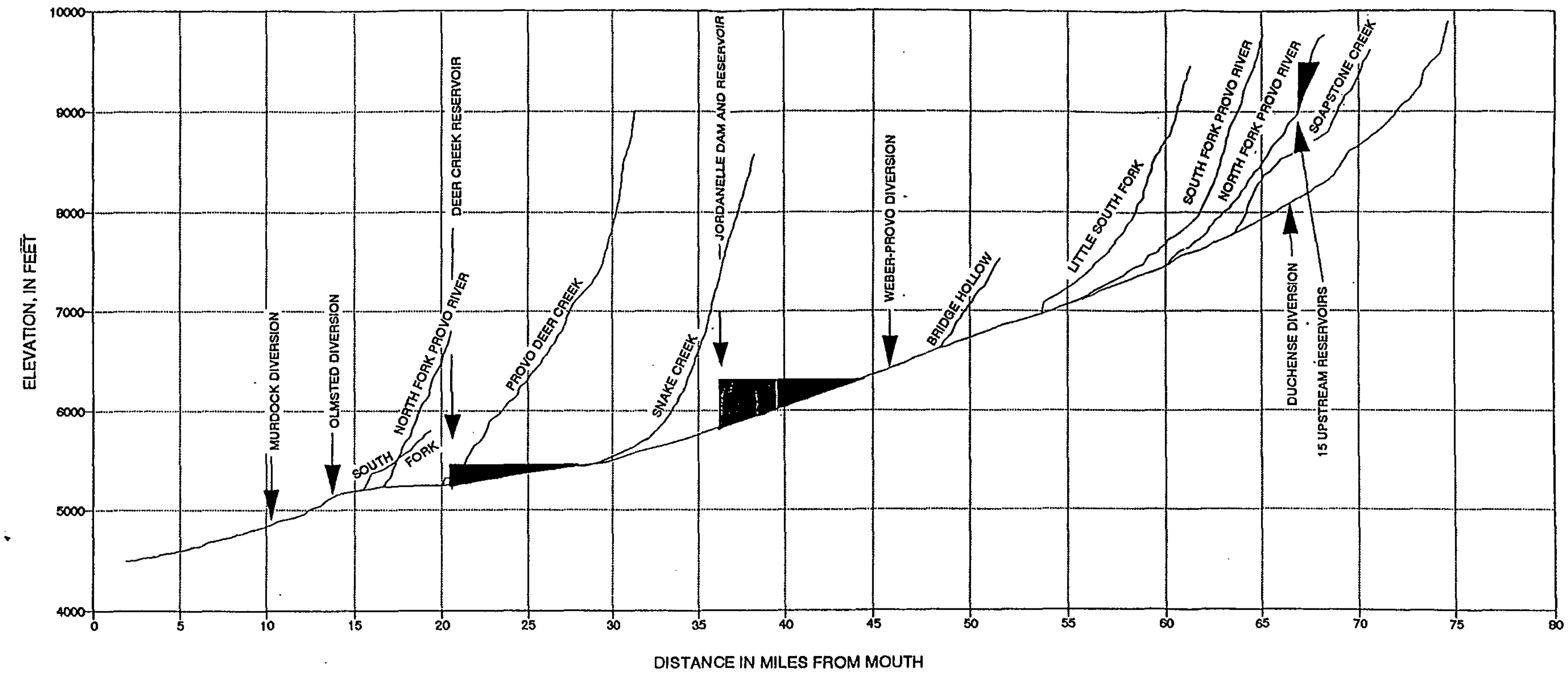
JORDANELLE DAM AND LAKE
PROVO RIVER, UTAH

NORMAL ANNUAL PRECIPITATION, CLIMATOLOGICAL STATIONS, AND SNOW COURSES

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

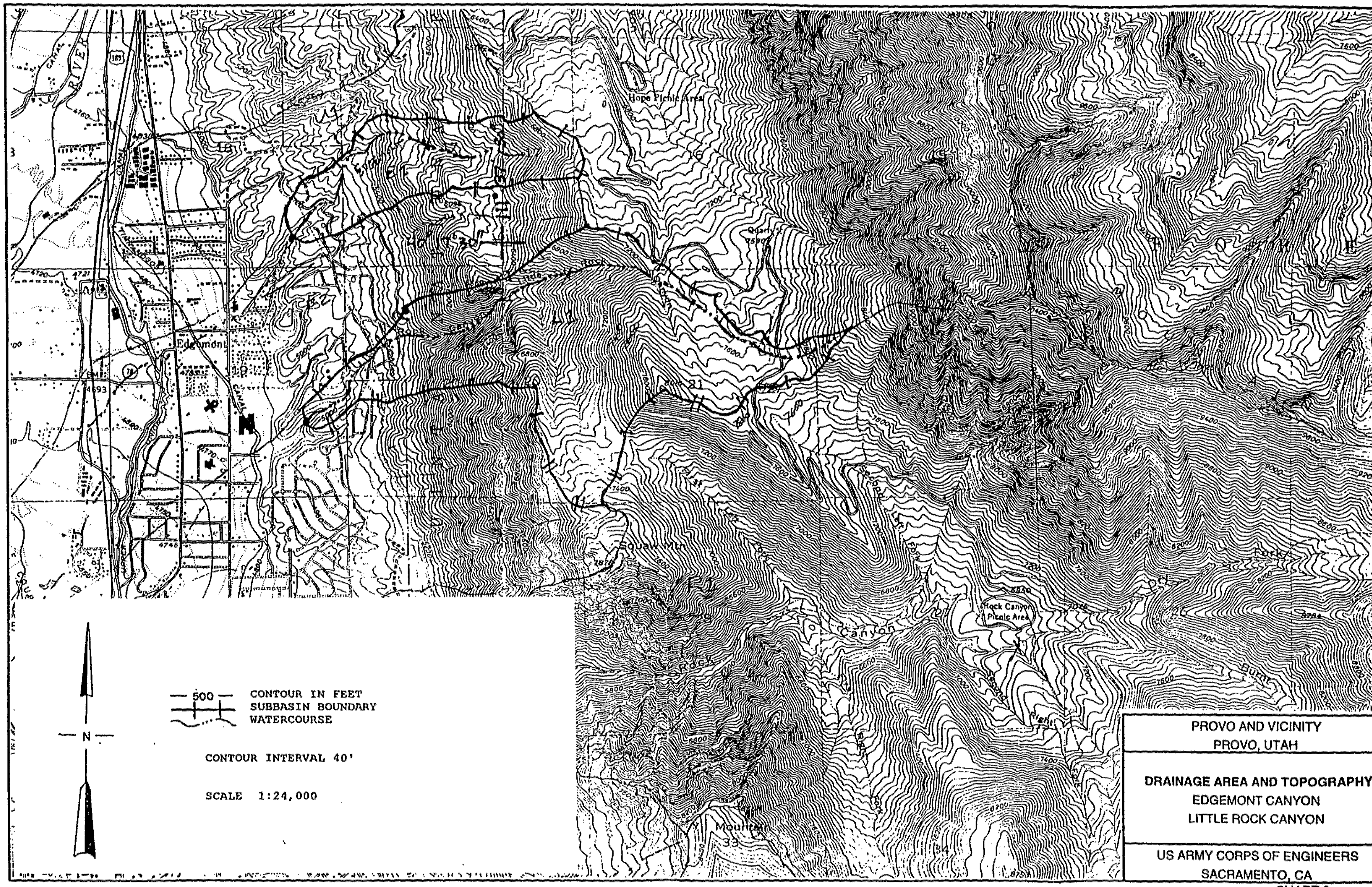
CHART 4

PROVO RIVER BASIN



PROVO AND VICINITY PROVO, UTAH
STREAM PROFILES PROVO RIVER AND TRIBUTARIES
US ARMY CORPS OF ENGINEERS SACRAMENTO, CA

CHART 5

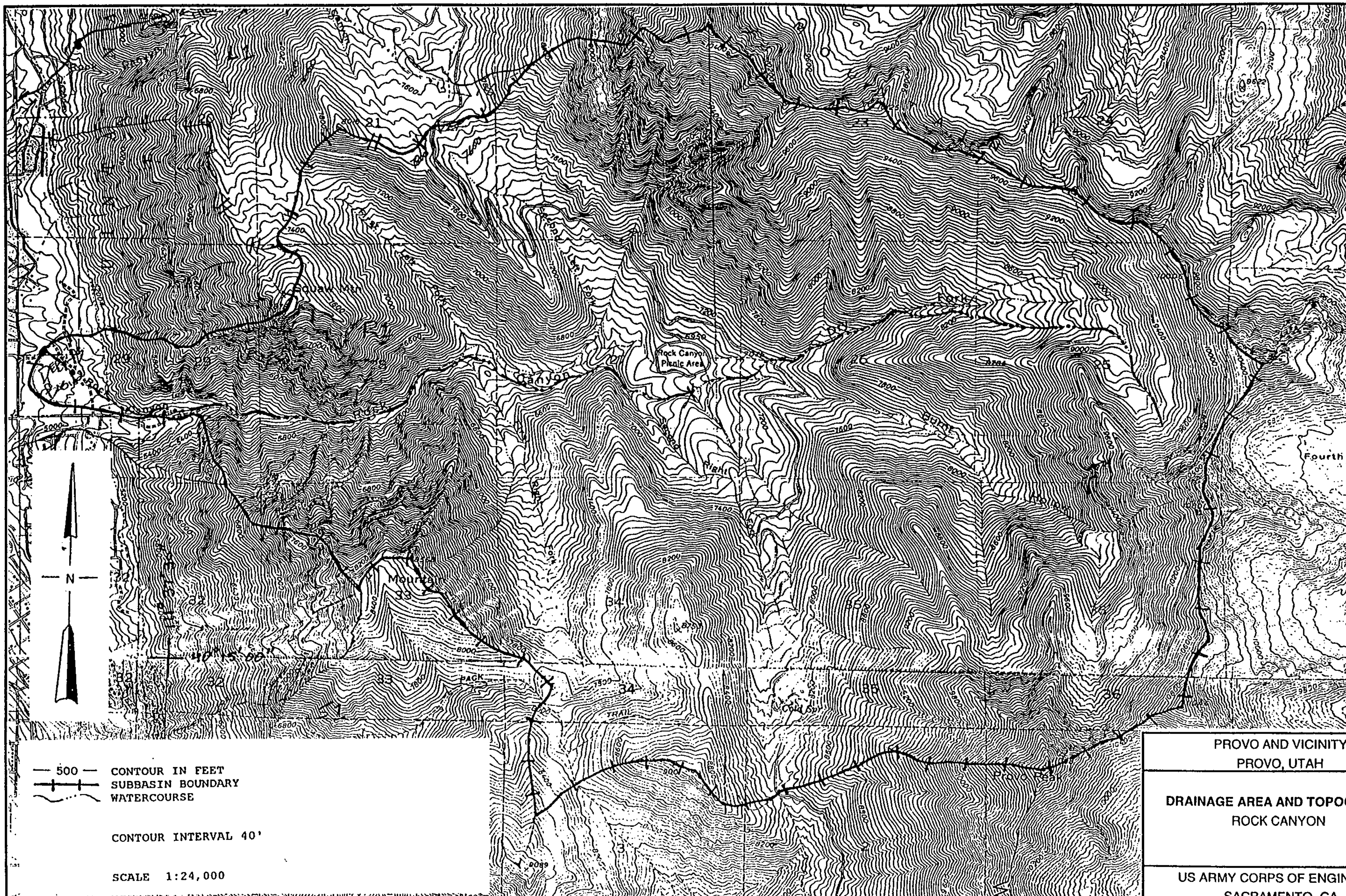


PROVO AND VICINITY
PROVO, UTAH

DRAINAGE AREA AND TOPOGRAPHY
EDGEMONT CANYON
LITTLE ROCK CANYON

US ARMY CORPS OF ENGINEERS
SACRAMENTO, CA

CHART 6a

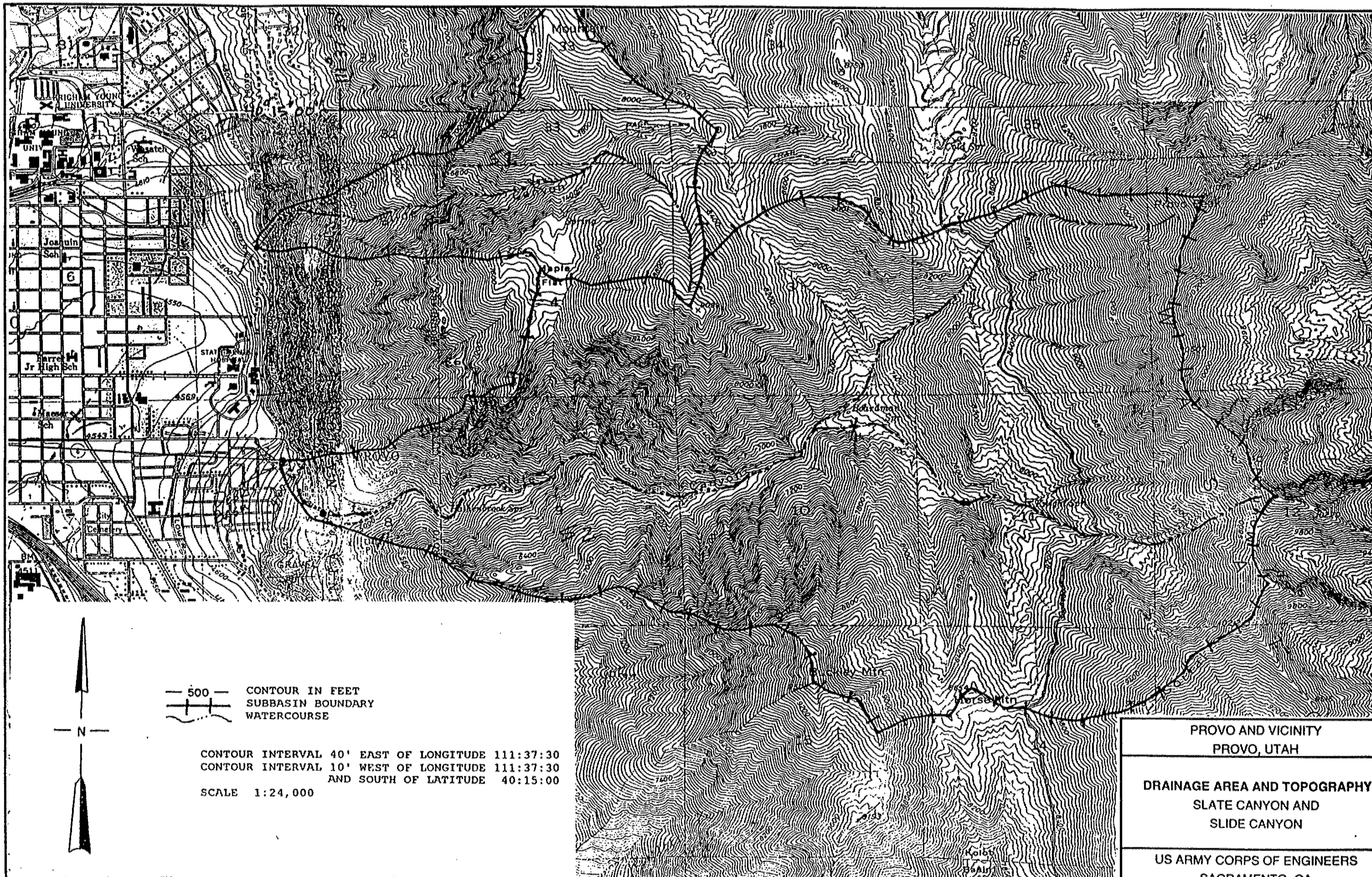


PROVO AND VICINITY
PROVO, UTAH

DRAINAGE AREA AND TOPOGRAPHY
ROCK CANYON

US ARMY CORPS OF ENGINEERS
SACRAMENTO, CA

CHART 6b



— 500 — CONTOUR IN FEET
SUBBASIN BOUNDARY
WATERCOURSE

CONTOUR INTERVAL 40' EAST OF LONGITUDE 111:37:30
CONTOUR INTERVAL 10' WEST OF LONGITUDE 111:37:30
AND SOUTH OF LATITUDE 40:15:00

SCALE 1:24,000

PROVO AND VICINITY
PROVO, UTAH

DRAINAGE AREA AND TOPOGRAPHY
SLATE CANYON AND
SLIDE CANYON

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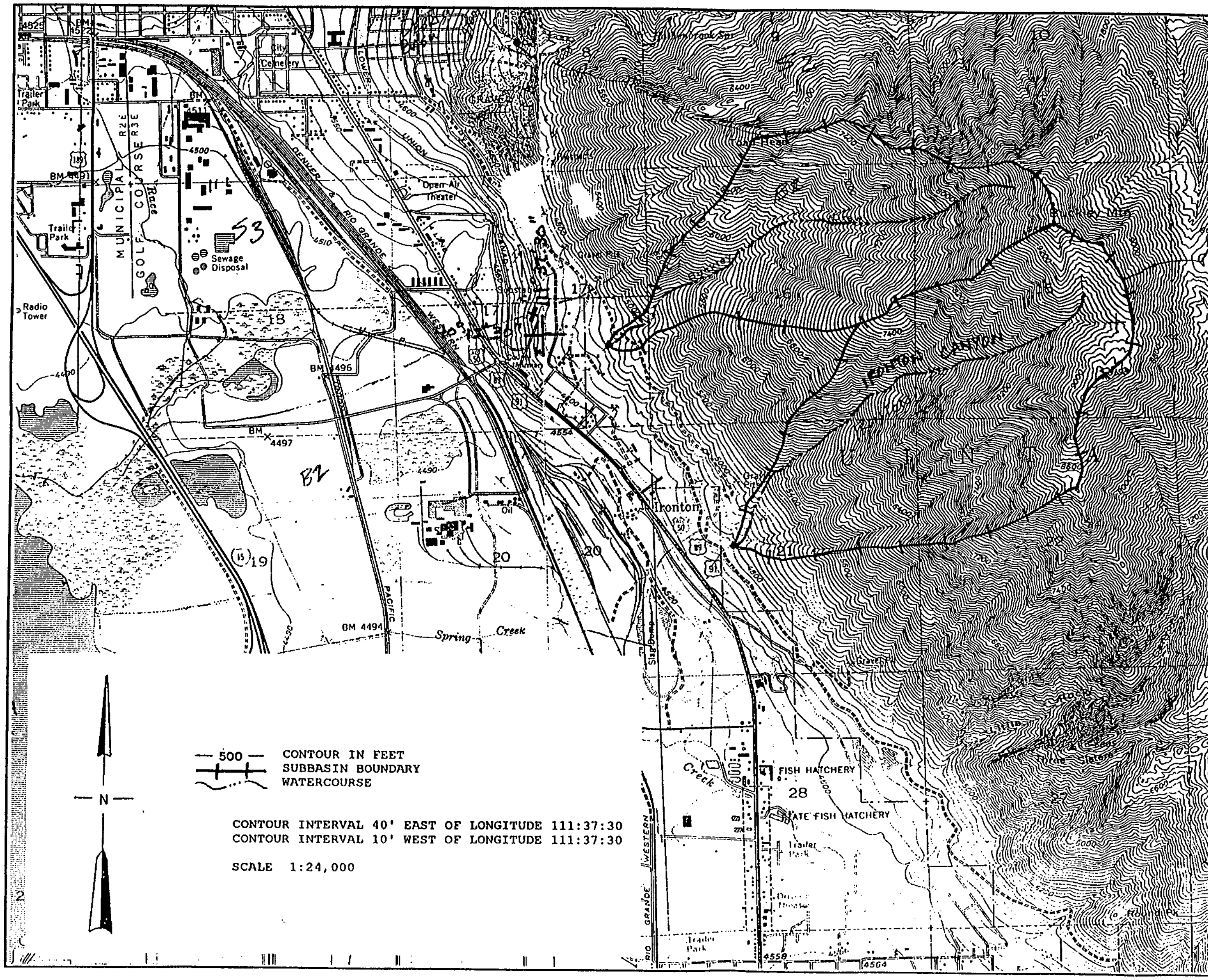
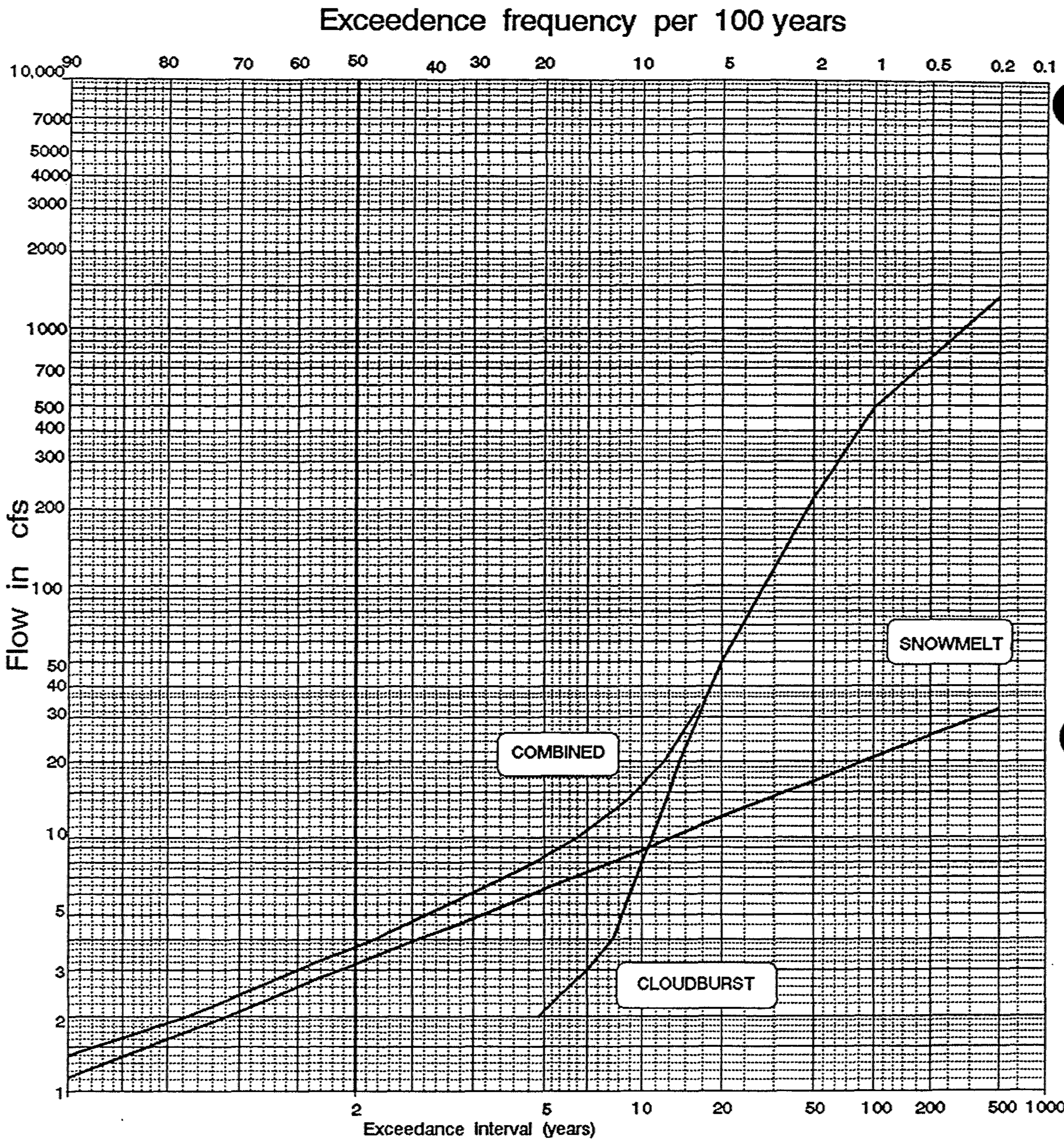
CHART 6c



PROVO AND VICINITY
PROVO, UTAH

DRAINAGE AREA AND TOPOGRAPHY
IRONTON CANYON AND
BUCKLEY DRAW

US ARMY CORPS OF ENGINEERS
SACRAMENTO, CA
CHART 6d



SUBAREA	D.A. (SQ. MI.)
Edgemont Cyn	0.38
Little Rock Cyn	1.11
Rock Cyn	8.78
Slide Cyn	1.21
Slate Cyn	6.20
Buckley Draw	0.88
Ironton Cyn	1.22

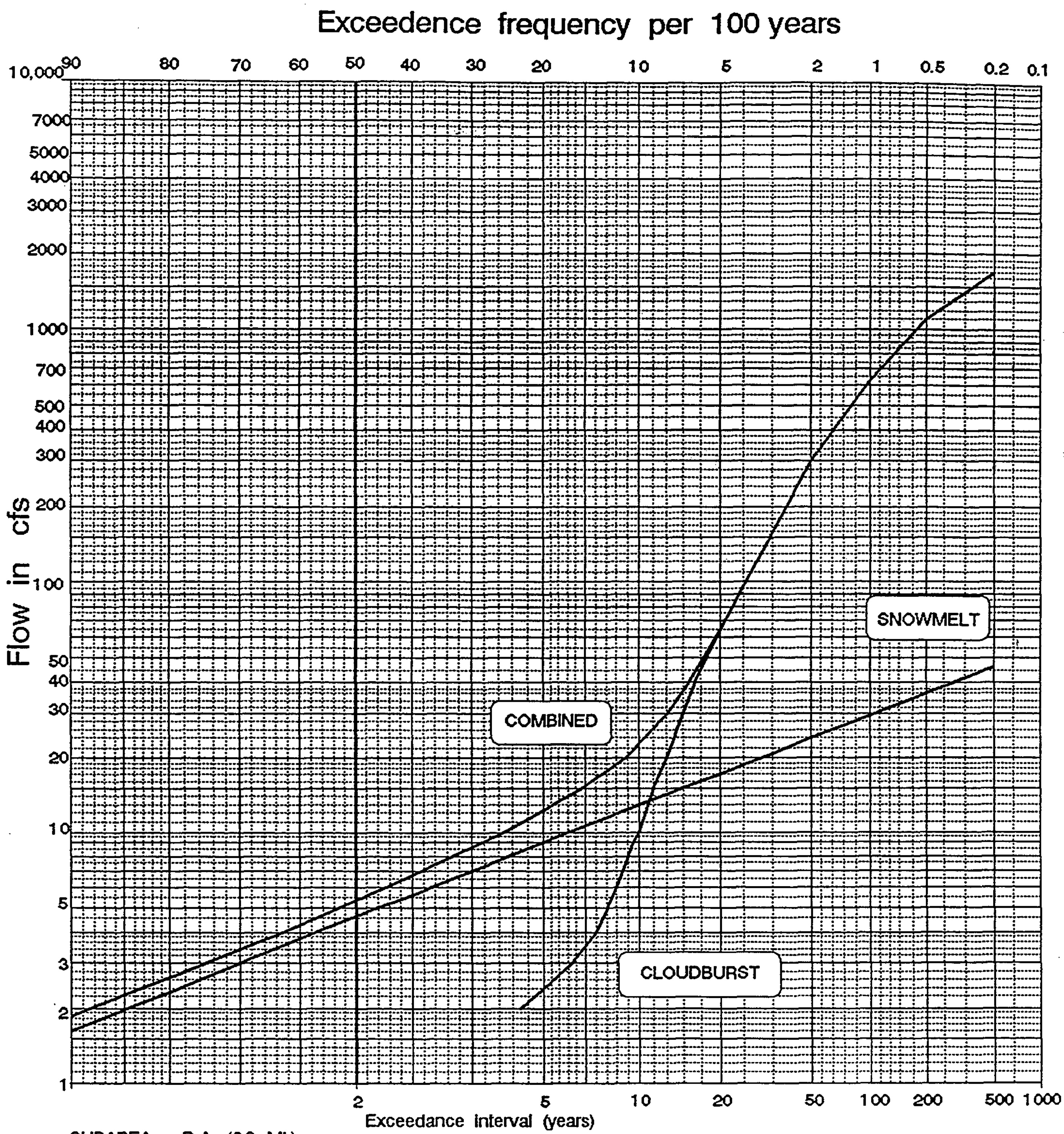
PROVO AND VICINITY
PROVO, UT

PEAK FLOW FREQUENCY CURVES
"EASTSIDE DRAINAGES"
BUCKLEY DRAW

Notes: Cloudburst Events -
Discharges determined using HEC-1 modeling. Rainfall developed from NOAA II & "project Cloucburst" report, 1976.
Estimated concurrent flow in Provo River = 150 cfs.
Graphically drawn curves.

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA
Prepared: G.R. Date: JUL 1996
File: PROVO5.WQ1

CHART 7



SUBAREA	D.A. (SQ. MI.)
Edgemont Cyn	0.38
Little Rock Cyn	1.11
Rock Cyn	8.78
Slide Cyn	1.21
Slate Cyn	6.20
Buckley Draw	0.88
Ironton Cyn	1.22

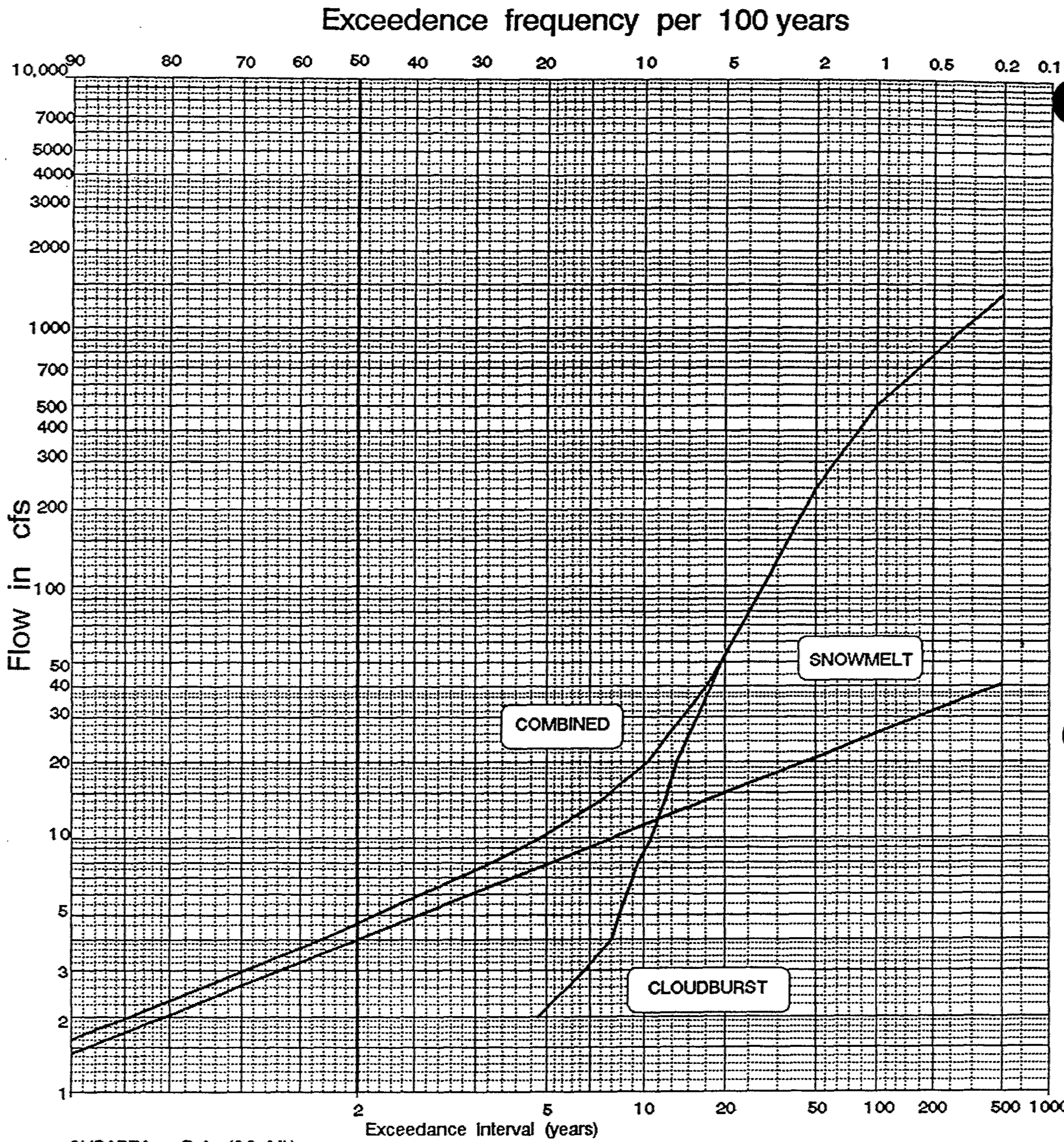
PROVO AND VICINITY, UTAH
PROVO, UT

PEAK FLOW FREQUENCY CURVES
"EASTSIDE DRAINAGES"
IRONTON CANYON

Notes: Cloudburst Events -
Discharges determined using HEC-1 modeling. Rainfall developed from NOAA II & "project Cloucburst" report, 1976.
Estimated concurrent flow in Provo River = 150 cfs.
Graphically drawn curves.

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA
Prepared: G.R. Date: JUL 1996
File: PROVO8.WQ1

CHART 8



SUBAREA	D.A. (SQ. MI.)
Edgemont Cyn	0.38
Little Rock Cyn	1.11
Rock Cyn	8.78
Slide Cyn	1.21
Slate Cyn	6.20
Buckley Draw	0.88
Ironton Cyn	1.22

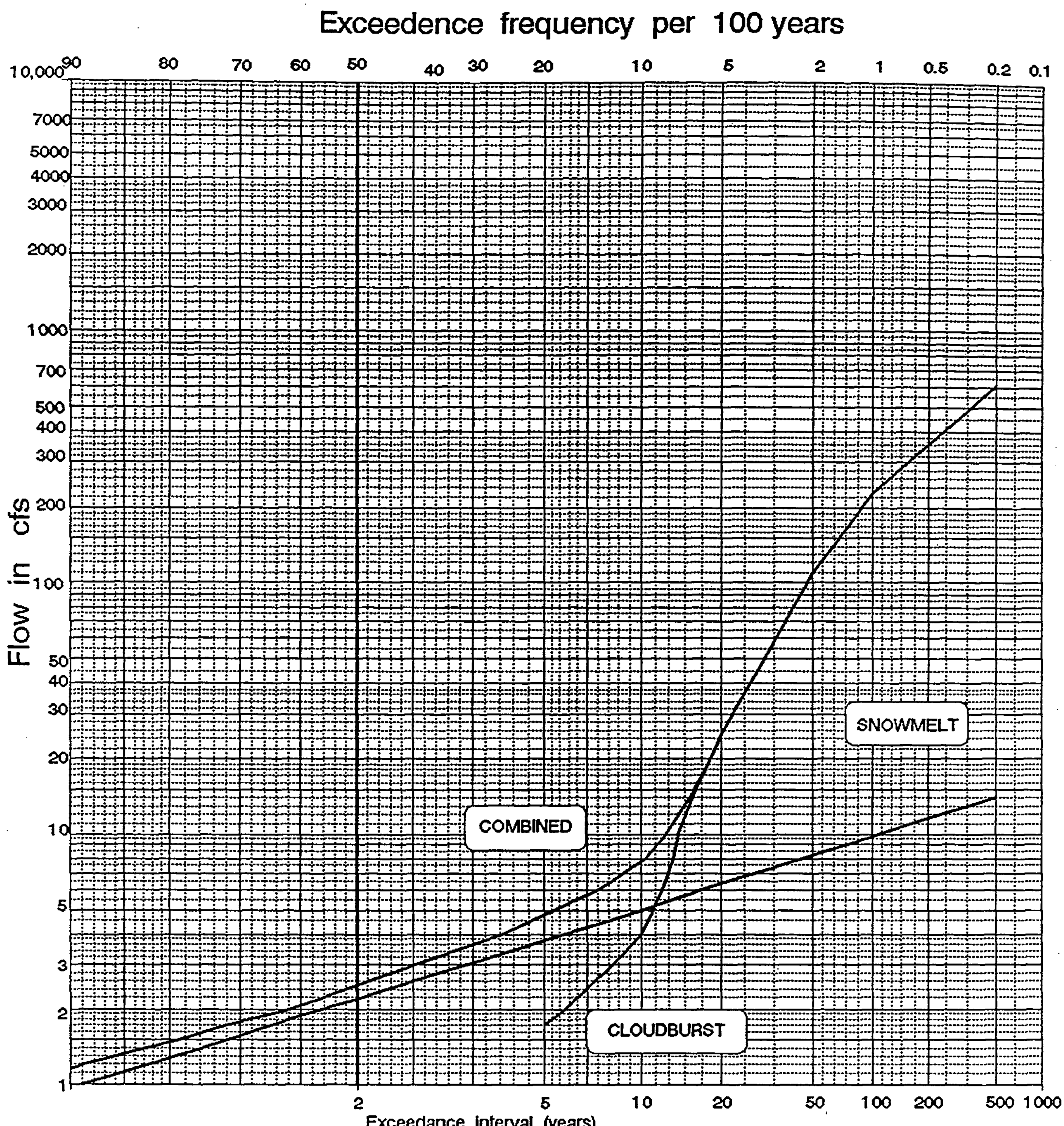
PROVO AND VICINITY, UTAH
PROVO, UT

PEAK FLOW FREQUENCY CURVES
"EASTSIDE DRAINAGES"
LITTLE ROCK CANYON

Notes: Cloudburst Events -
Discharges determined using HEC-1 modeling. Rainfall developed from NOAA II & "project Cloucburst" report, 1976.
Estimated concurrent flow in Provo River = 150 cfs.
Graphically drawn curves.

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA
Prepared: G.R. Date: JUN 1996
File: PROVO6.WQ1

CHART 9



SUBAREA	D.A. (SQ. MI.)
Edgemont Cyn	0.38
Little Rock Cyn	1.11
Rock Cyn	8.78
Slide Cyn	1.21
Slate Cyn	6.20
Buckley Draw	0.88
Ironton Cyn	1.22

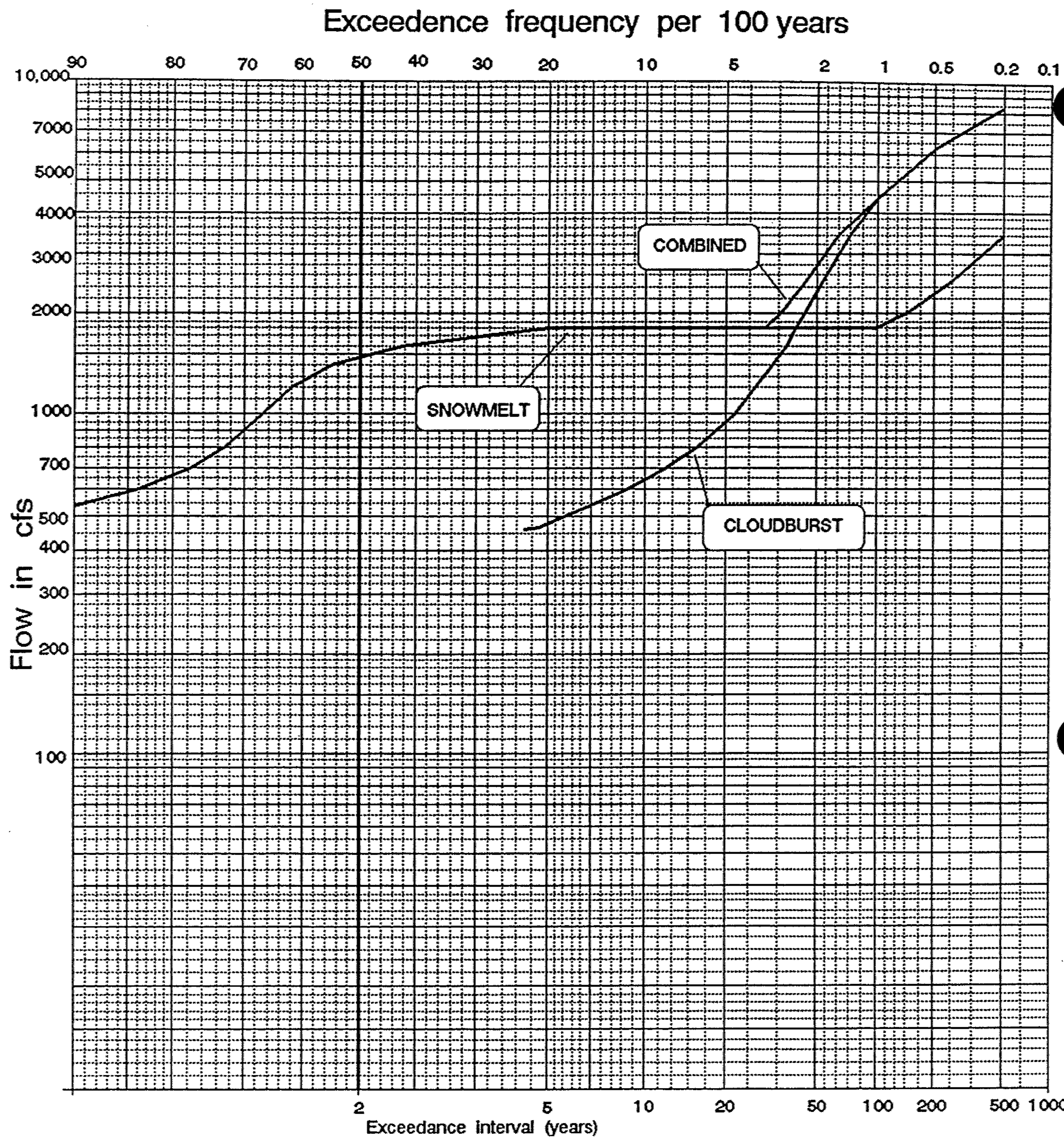
PROVO AND VICINITY
PROVO, UT

PEAK FLOW FREQUENCY CURVES
"EASTSIDE DRAINAGES"
MILE HIGH CANYON

Notes: Cloudburst Events -
Discharges determined using HEC-1 modeling. Rainfall developed from NOAA II & "Project Cloucburst" report, 1976.
Estimated concurrent flow in Provo River = 150 cfs.
Graphically drawn curves.

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA
Prepared: G.R. Date: JUL 1996
File: PROVO4.WQ1

CHART 10



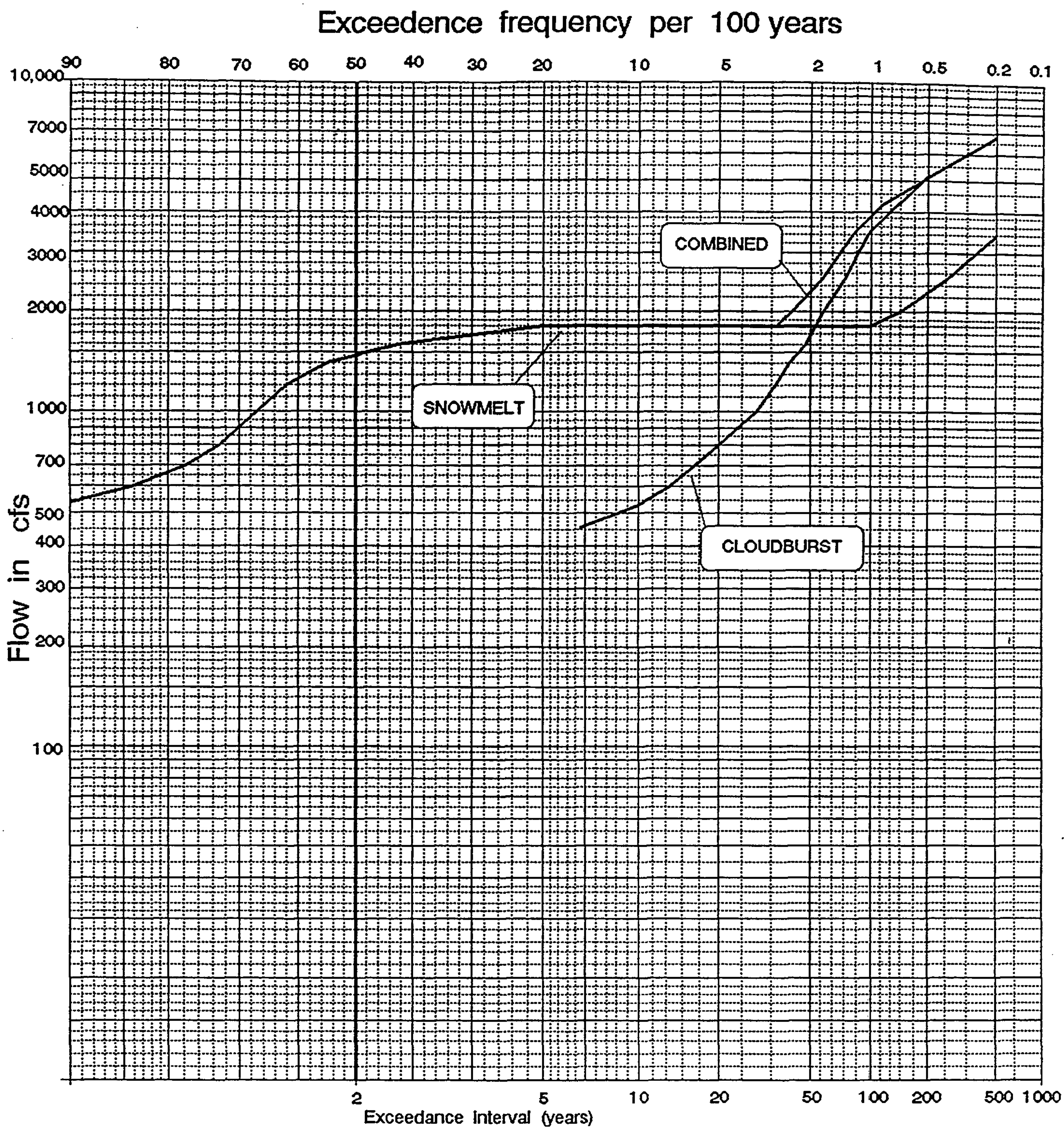
PROVO AND VICINITY, UTAH
PROVO, UT

ESTIMATED
PEAK FLOW FREQUENCY CURVES
PROVO RIVER AT CANYON MOUTH

Notes: Cloudburst Events -
Discharges determined using HEC-1 modeling. Rainfall developed from NOAA ATLAS II.
Estimated concurrent reservoir release in Provo River = 150 cfs. Graphically drawn curves.

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA
Prepared: G.R. Date: JUl 1996
File: PROVO11WQ1

CHART 11



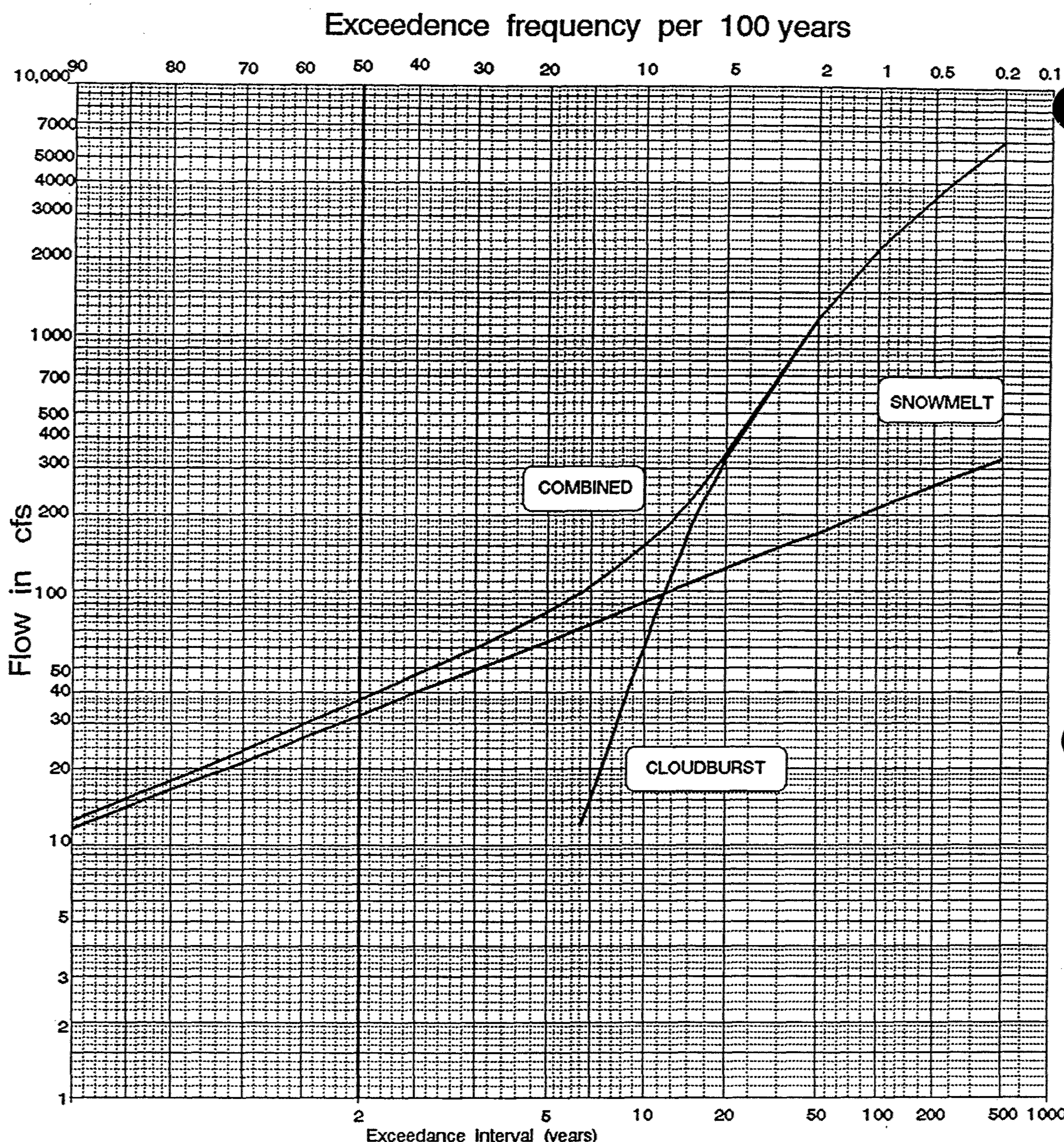
PROVO AND VICINITY, UTAH
PROVO, UT

ESTIMATED
PEAK FLOW FREQUENCY CURVES
PROVO RIVER AT I-15

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA
Prepared: G.R. Date: JUl 1996
File: PROVO12WQ1

CHART 12

Notes: Cloudburst Events -
Discharges determined using HEC-1 modeling. Rainfall developed from NOAA ATLAS II.
Estimated concurrent reservoir release in Provo River = 150 cfs. Graphically drawn curves.



SUBAREA	D.A. (SQ. MI.)
Edgemont Cyn	0.38
Little Rock Cyn	1.11
Rock Cyn	8.78
Slide Cyn	1.21
Slate Cyn	6.20
Buckley Draw	0.88
Ironton Cyn	1.22

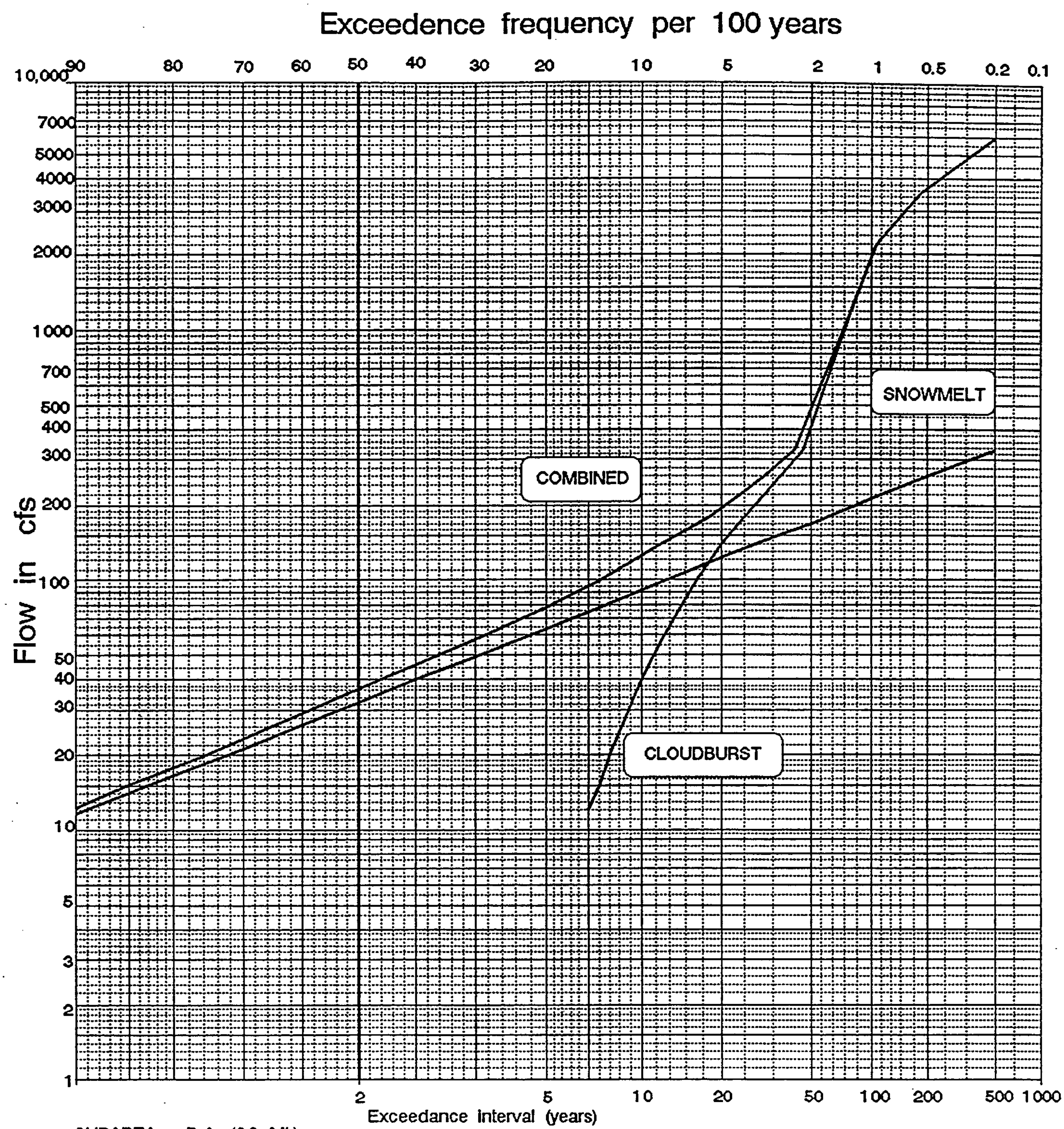
PROVO AND VICINITY, UTAH
PROVO, UT

PEAK FLOW FREQUENCY CURVES
"EASTSIDE DRAINAGES"
ROCK CANYON
DEBRIS BASIN INFLOW W/O DEBRIS

Notes: Cloudburst Events -
Discharges determined using HEC-1 modeling. Rainfall developed from NOAA II & "Project Cloucburst" report, 1976.
Estimated concurrent flow in Provo River = 150 cfs.
Graphically drawn curves.

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA
Prepared: G.R. Date: JUL 1996
File: PROVO10.WQ1

CHART 13



SUBAREA	D.A. (SQ. MI.)
Edgemont Cyn	0.38
Little Rock Cyn	1.11
Rock Cyn	8.78
Slide Cyn	1.21
Slate Cyn	6.20
Buckley Draw	0.88
Ironton Cyn	1.22

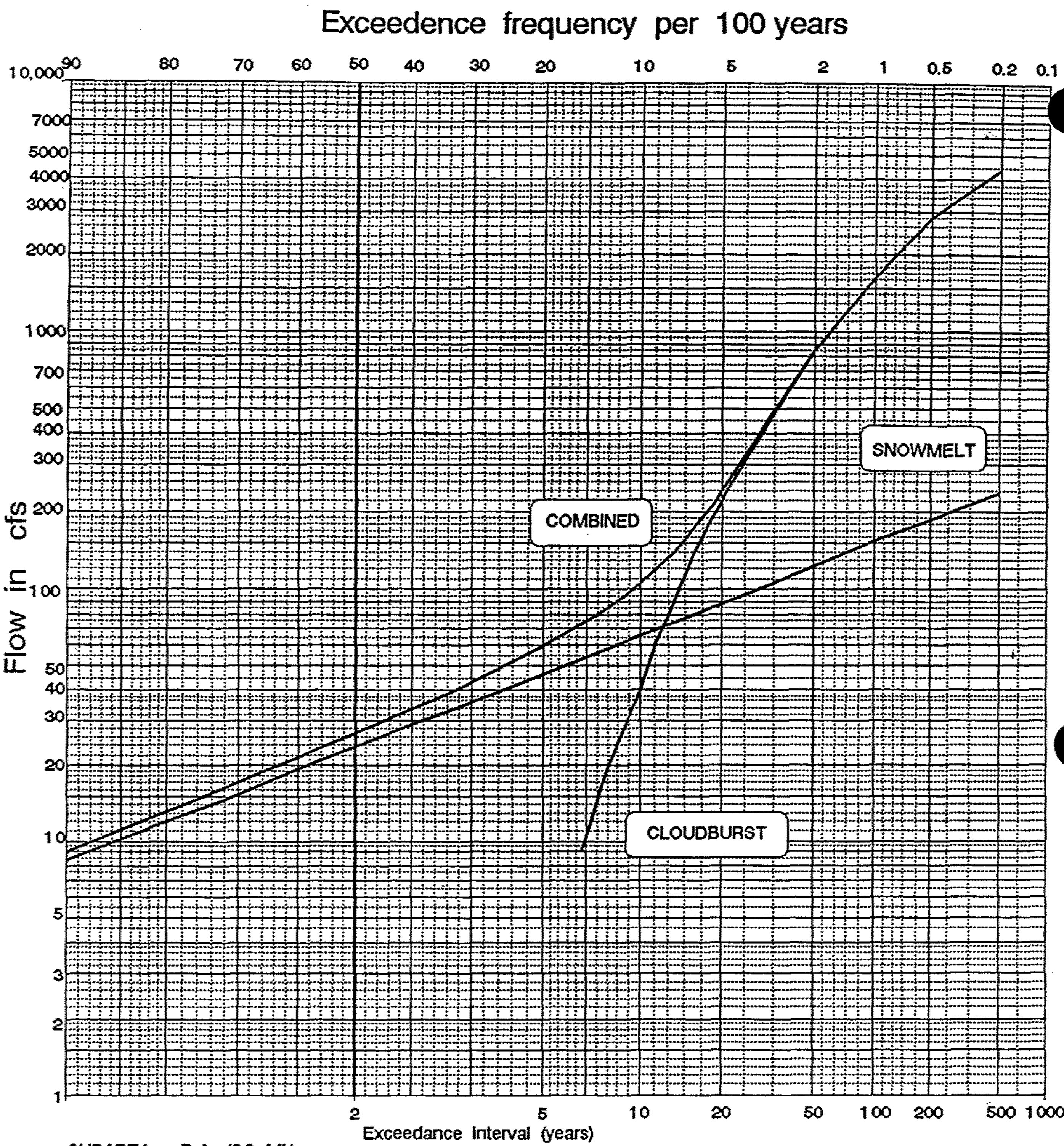
PROVO AND VICINITY, UTAH
PROVO, UT

PEAK FLOW FREQUENCY CURVES
"EASTSIDE DRAINAGES"
ROCK CANYON
DEBRIS BASIN OUTFLOW

Notes: Cloudburst Events -
Discharges determined using HEC-1 modeling. Rainfall developed from NOAA II & "Project Cloucburst" report, 1976.
Estimated concurrent flow in Provo River = 150 cfs.
Graphically drawn curves.

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA
Prepared: G.R. Date: JUL 1996
File: PROVO13.WQ1

CHART 14



SUBAREA	D.A. (SQ. MI.)
Edgemont Cyn	0.38
Little Rock Cyn	1.11
Rock Cyn	8.78
Slide Cyn	1.21
Slate Cyn	6.20
Buckley Draw	0.88
Ironton Cyn	1.22

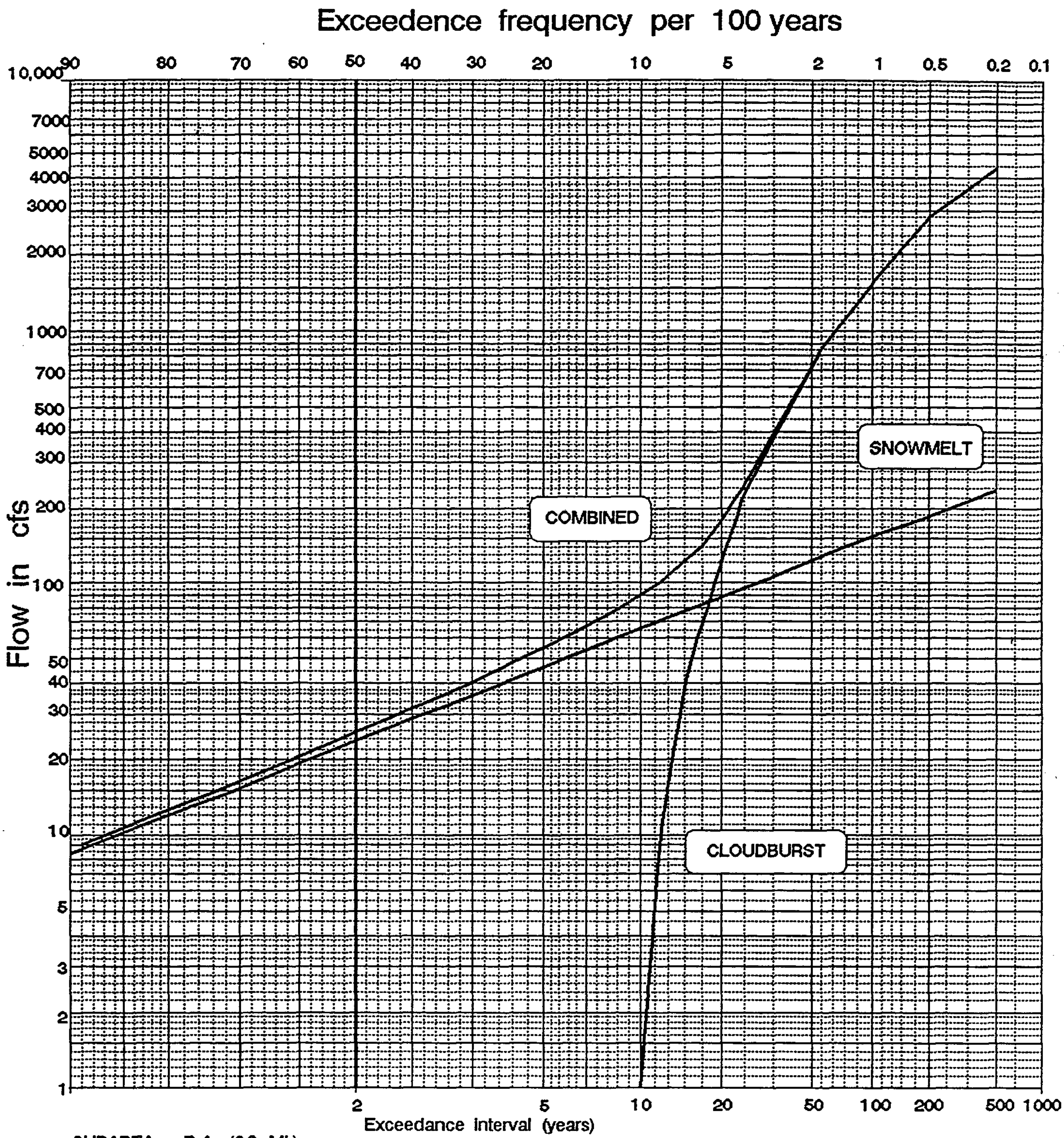
PROVO AND VICINITY, UTAH
PROVO, UT

PEAK FLOW FREQUENCY CURVES
"EASTSIDE DRAINAGES"
SLATE CANYON
DEBRIS BASIN INFLOW W/O DEBRIS

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA
Prepared: G.R. Date: JUN 1996
File: PROVO9.WQ1

CHART 15

Notes: Cloudburst Events -
Discharges determined using HEC-1 modeling. Rainfall developed from NOAA II & "Project Cloucburst" report, 1976.
Estimated concurrent flow in Provo River = 150 cfs.
Graphically drawn curves.



SUBAREA	D.A. (SQ. MI.)
Edgemont Cyn	0.38
Little Rock Cyn	1.11
Rock Cyn	8.78
Slide Cyn	1.21
Slate Cyn	6.20
Buckley Draw	0.88
Ironton Cyn	1.22

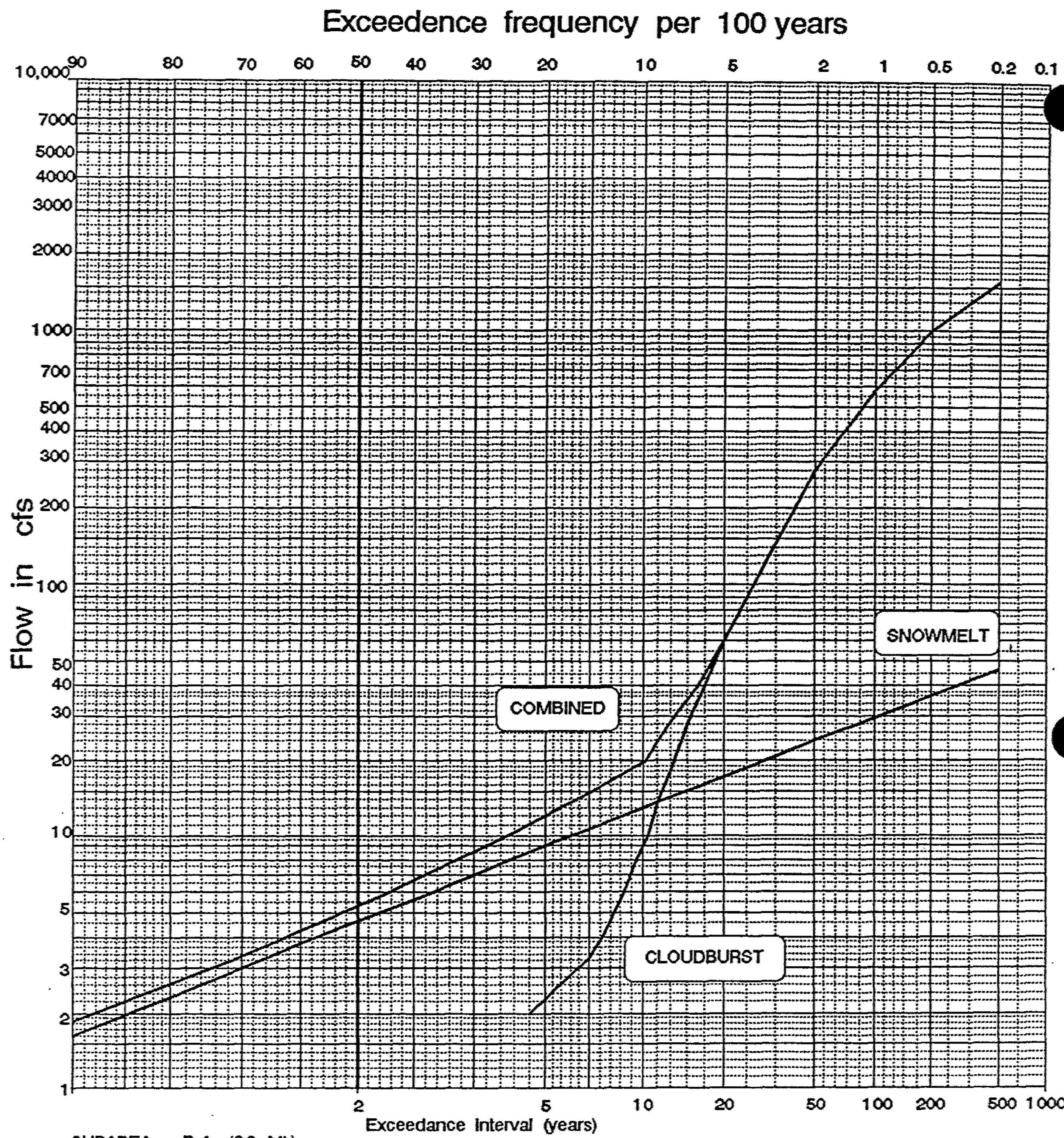
PROVO AND VICINITY, UTAH
PROVO, UT

PEAK FLOW FREQUENCY CURVES
"EASTSIDE DRAINAGES"
SLATE CANYON
DEBRIS BASIN OUTFLOW

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA
Prepared: G.R. Date: JUN 1996
File: PROVO14.WQ1

CHART 16

Notes: Cloudburst Events -
Discharges determined using HEC-1 modeling. Rainfall developed from NOAA II & "Project Cloucburst" report, 1976.
Estimated concurrent flow in Provo River = 150 cfs.
Graphically drawn curves.



SUBAREA	D.A. (SQ. MI.)
Edgemont Cyn	0.38
Little Rock Cyn	1.11
Rock Cyn	8.78
Slide Cyn	1.21
Slate Cyn	6.20
Buckley Draw	0.88
Ironton Cyn	1.22

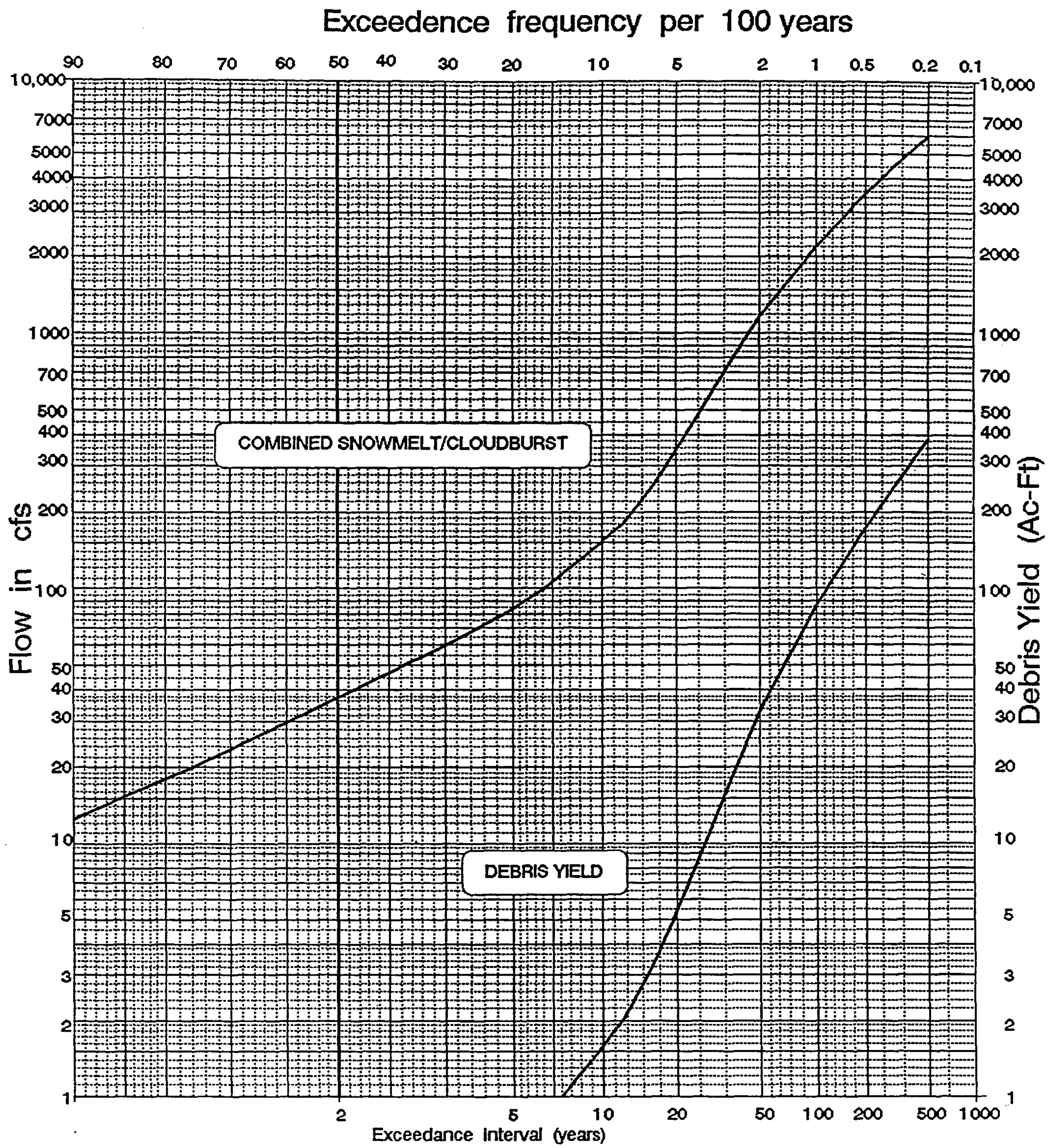
PROVO AND VICINITY, UTAH
PROVO, UT

PEAK FLOW FREQUENCY CURVES
"EASTSIDE DRAINAGES"
SLIDE CANYON

Notes: Cloudburst Events -
Discharges determined using HEC-1 modeling. Rainfall developed from NOAA II & "project Cloucburst" report, 1976.
Estimated concurrent flow in Provo River = 150 cfs.
Graphically drawn curves.

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA
Prepared: G.R. Date: JUL 1996
File: PROVO7.WQ1

CHART 17



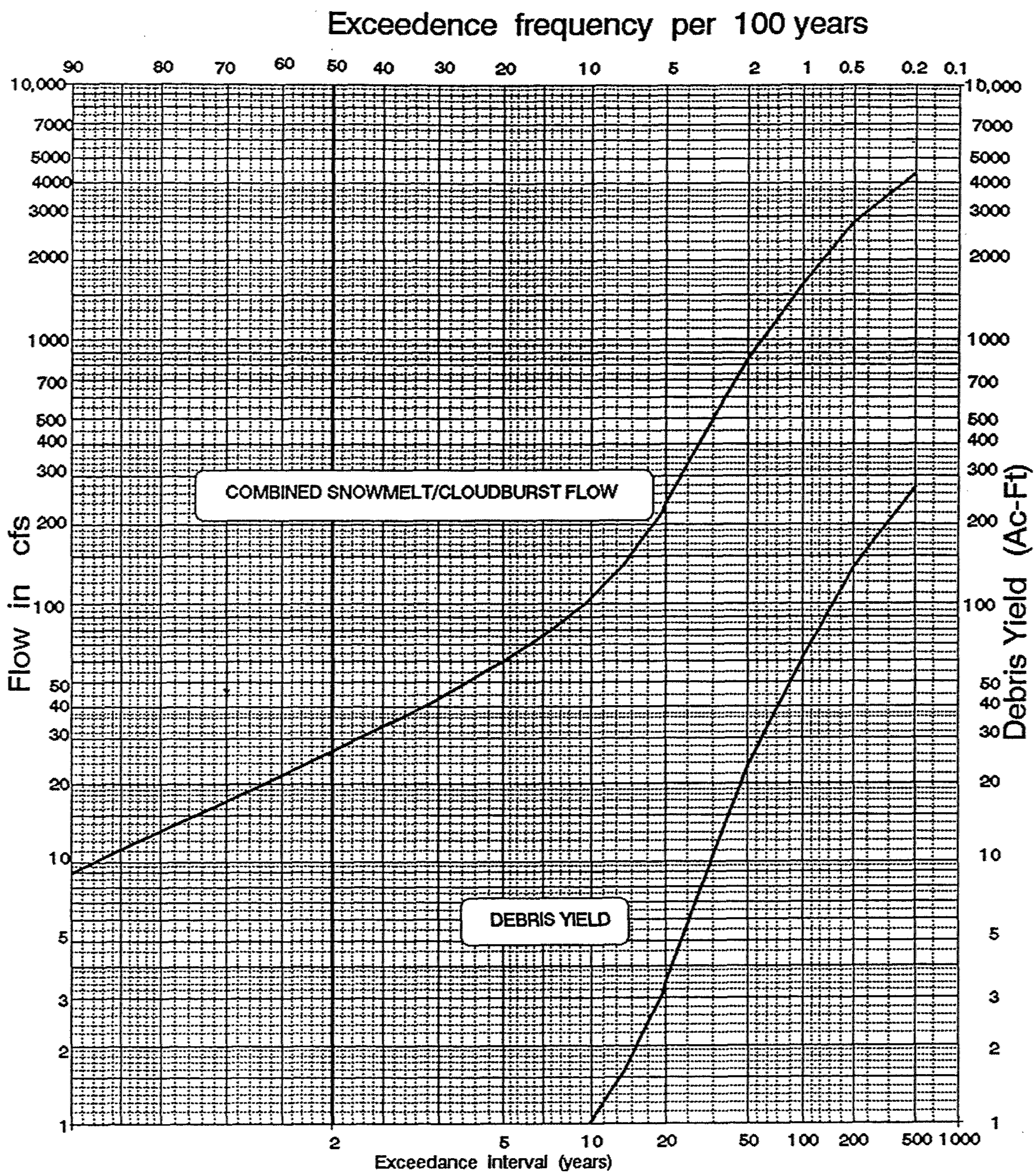
SUBAREA	D.A. (SQ. MI.)
Edgemont Cyn	0.38
Little Rock Cyn	1.11
Rock Cyn	8.78
Slide Cyn	1.21
Slate Cyn	6.20
Buckley Draw	0.88
Ironton Cyn	1.22

PROVO AND VICINITY
PROVO, UT

PEAK FLOW FREQUENCY CURVE AND DEBRIS YIELD "EASTSIDE DRAINAGES" ROCK CANYON

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA
Prepared: G.R. Date: AUG 1996
File: RCDEBRIS.WQ1

CHART 18



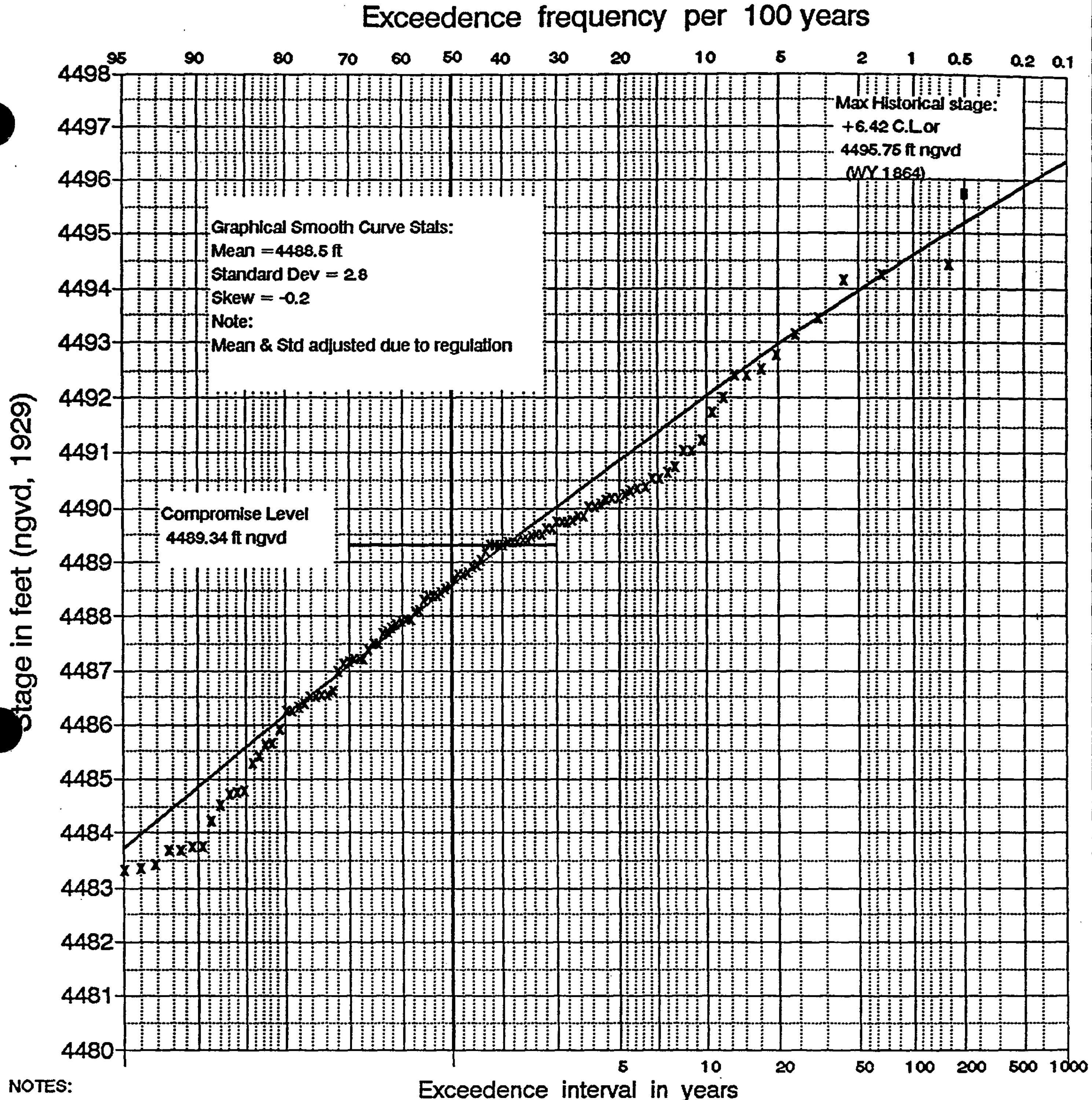
SUBAREA	D.A. (SQ. MI.)
Edgemont Cyn	0.38
Little Rock Cyn	1.11
Rock Cyn	8.78
Slide Cyn	1.21
Slate Cyn	6.20
Buckley Draw	0.88
Ironton Cyn	1.22

PROVO AND VICINITY
PROVO, UT

**PEAK FLOW FREQUENCY CURVE
AND DEBRIS YIELD
"EASTSIDE DRAINAGES"
SLATE CANYON**

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA
Prepared: G.R. Date: AUG 1996
File: SDEBRIS.WQ1

CHART 19



NOTES:
1. Stage data recorded on the first day of each month.
2. Lake level regulated after 1872 by a dam on the Jordan River and after 1902 by a pumping station. Headwork and dredging projects in mid 1980's changed outlet capacity.
3. Period of record is 1884 to 1996; 1992 & 1993 are missing.
4. Plotting positions based on 113 years of record, 1884-1996; 111 years in systematic record.
5. Datum of gage is 4,489.4 ft, which is 0.06 ft above compromise level. Stages are recorded with respect to the compromise level.
6. Existing conditions cannot be fully evaluated because ability to regulate lake level changed during period of record.

PROVO AND VICINITY
PROVO, UT

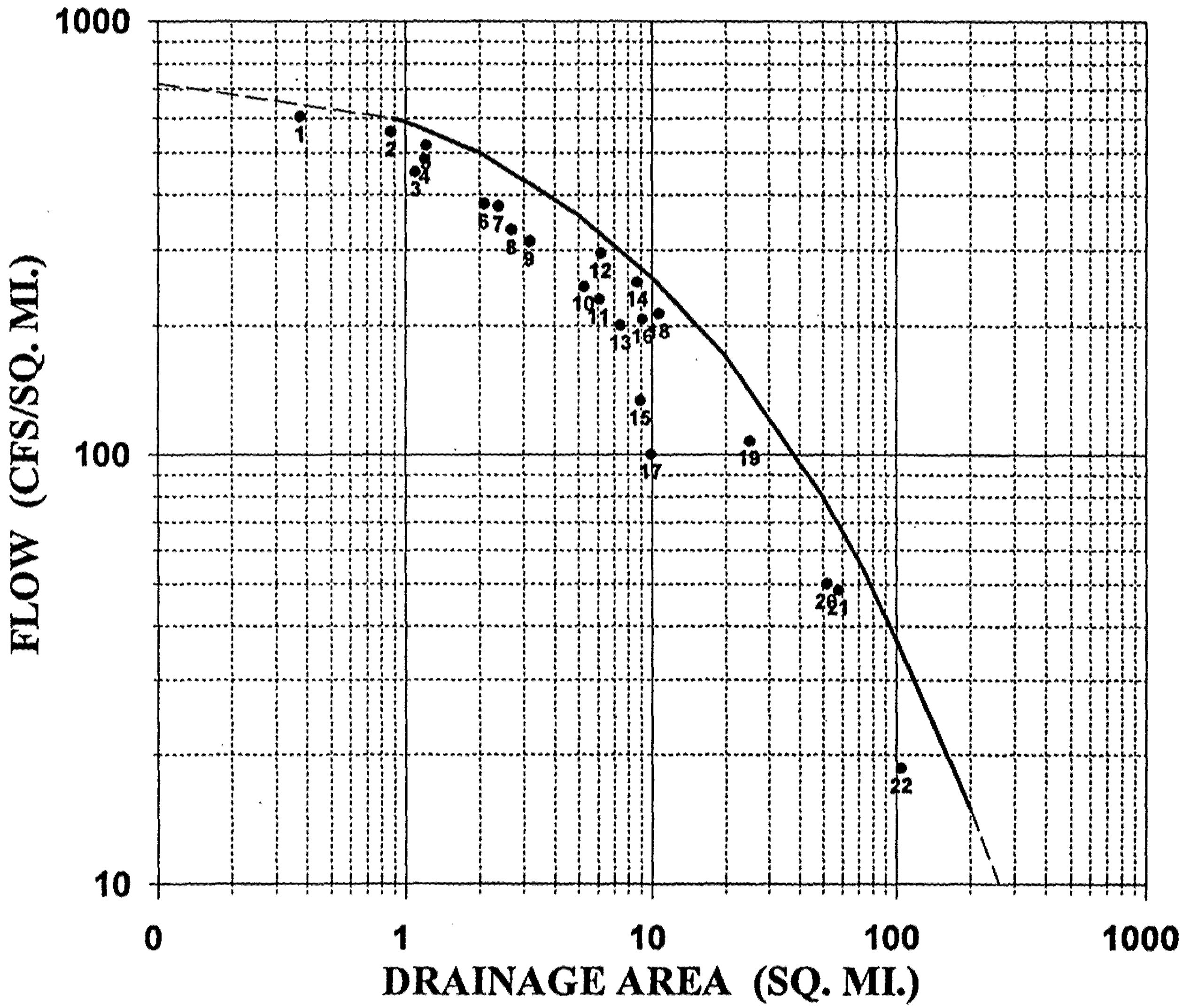
STAGE FREQUENCY CURVE
UTAH LAKE NEAR LEHI, UTAH

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: RFC / GAR Date: SEP. 30, 1996

Drawn: File : UTLKSFQ2.WQ1

CHART 20



	BASIN	D.A.
1	EDGEMONT CYN	0.38
2	BUCKLEY DRAW	0.88
3	L. ROCK CYN	1.11
4	SLIDE CYN	1.21
5	IRONTON CYN	1.22
6	PARRISH CR	2.1
7	RICKS CR	2.4
8	STEED CR	2.7
9	CENTERVILLE CR	3.2
10	BARTON CR	5.3
11	STONE CR	6.1
12	SLATE CYN	6.2
13	STONE CR	7.5
14	ROCK CYN	8.78
15	DRY CR	9
16	MILL CR	9.2
17	WILLOW CR	10
18	FARMINGTON CR	10.8
19	DRY CR	25.1
20	PARLEYS CR	52
21	L. COTTONWOOD	57.8
22	HOBBLE CR	105

PROVO AND VICINITY
PROVO, UT

100-YEAR PEAK FLOW
CSM ENVELOPE CURVE

G.R. 8 FEB 1995
FILE: PROV-CSM.WB1

US ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

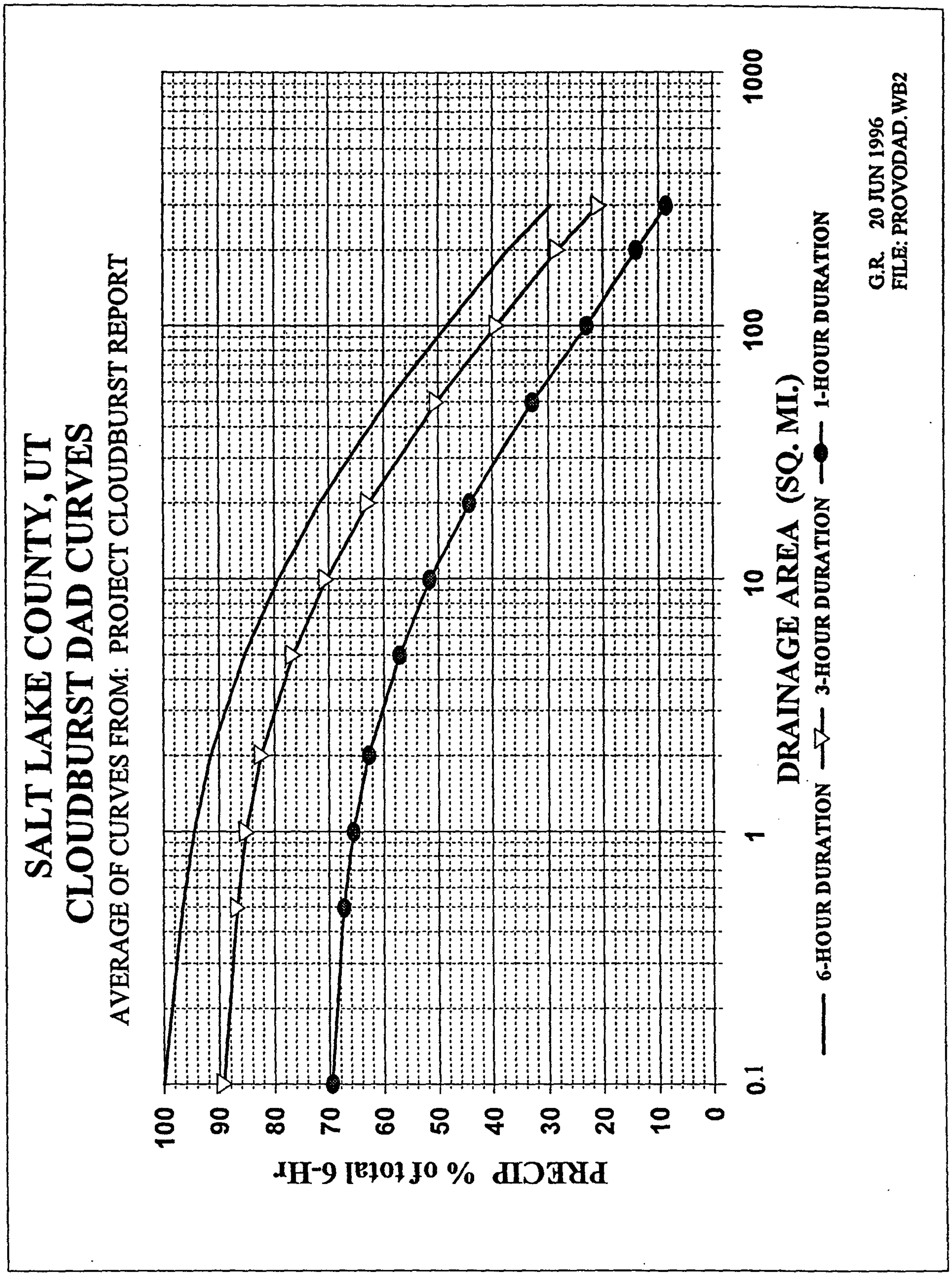

SALT LAKE COUNTY, UT
CLOUDBURST DAD CURVES
AVERAGE OF CURVES FROM: PROJECT CLOUDBURST REPORT
PRECIP % of total 6-Hr
100
90
80
70
60
50
40
30
20
10
0
0.1
1
10
100
1000
DRAINAGE AREA (SQ. MI.)
6-HOUR DURATION
3-HOUR DURATION
1-HOUR DURATION
G.R. 20 JUN 1996
FILE: PROVODAD.WB2

CHART 22

APPENDIX C

ECONOMIC ANALYSIS

RECONNAISSANCE STUDY

ECONOMIC ANALYSIS

PROVO, UTAH AND VICINITY

U.S. Army Corps Of Engineers
Sacramento District
Economics Branch
APRIL 1997

ECONOMIC ANALYSIS
Provo, Utah and Vicinity
Reconnaissance Studies
April 1997

I. INTRODUCTION

The purpose of this report is to present the economic analysis used to measure the beneficial contributions of flood control projects for the community of Provo, Utah. All economic benefits have been developed in accordance with ER 1105-2-100. This report presents a description of the methodology used to develop damages resulting from flooding and benefits derived from project alternatives. Damages and benefits are expressed as average annual values at a federal discount rate of 7-3/8 percent with a project life of 50 years. All damages and benefits are expressed in October 1996 price levels.

Provo Area

The city of Provo is in Utah County . The region is home to Brigham Young University (BYU has over 27,000 full-time students) and several other smaller colleges. The city of Provo has a population of over 100,000, with the Provo/Orem Metropolitan area greater than 300,000. The area has many high tech firms, including two of the nations largest software developers.

II. FLOOD PLAIN

Damage Reaches

The study area comprises of three main reaches and three corresponding index points (see Figure 1.) These reaches are: 1.) Provo River, 2.) North Eastside Drainage, & 3.) South Eastside Drainage.

The Provo River reach was separated into five damage sub-reaches for the economic analysis. A description of the five sub - reaches along the Provo River and two reaches on the Eastside Drainage follows:

Provo River Sub-Reaches (See Figure 2)

A. 2230 North Street - area on the eastside of the river - primarily commercial.

B. Moon River Road - area from University Blvd. to State St. - mix of commercial and residential.

C. Park Area - this includes the residential area from Riverside Park to Reams Park.

D. Industrial Area - small area on the south side of the river south of Reams Park - consists of small industrial business.

E. Below I-15 - largest reach of the Provo River. Includes development on both sides of the river. High density area with many residential units.

Eastside Drainage Reaches (See Figure 3)

N. North East Area - large area north of BYU. The floodplain starts just below the Wasach mountain canyons on the east to just east of the Provo river on the west. The area is residential with some commercial and public.

S. South East Area - large area south of BYU. The area is bounded by the mountains on the east and University Blvd. on the west. The area is residential with some commercial and public.

Each of the seven sub -reaches were broken down into 50-year, 100-year, and 500-year flood hazard zones (flood plains.) Average depths for all reaches are shown in Table 1 below . The approximate acreages for each floodplain by sub-reach are given in Table 2.

TABLE 1
Average Depth By Sub-Reach and Flood Plain

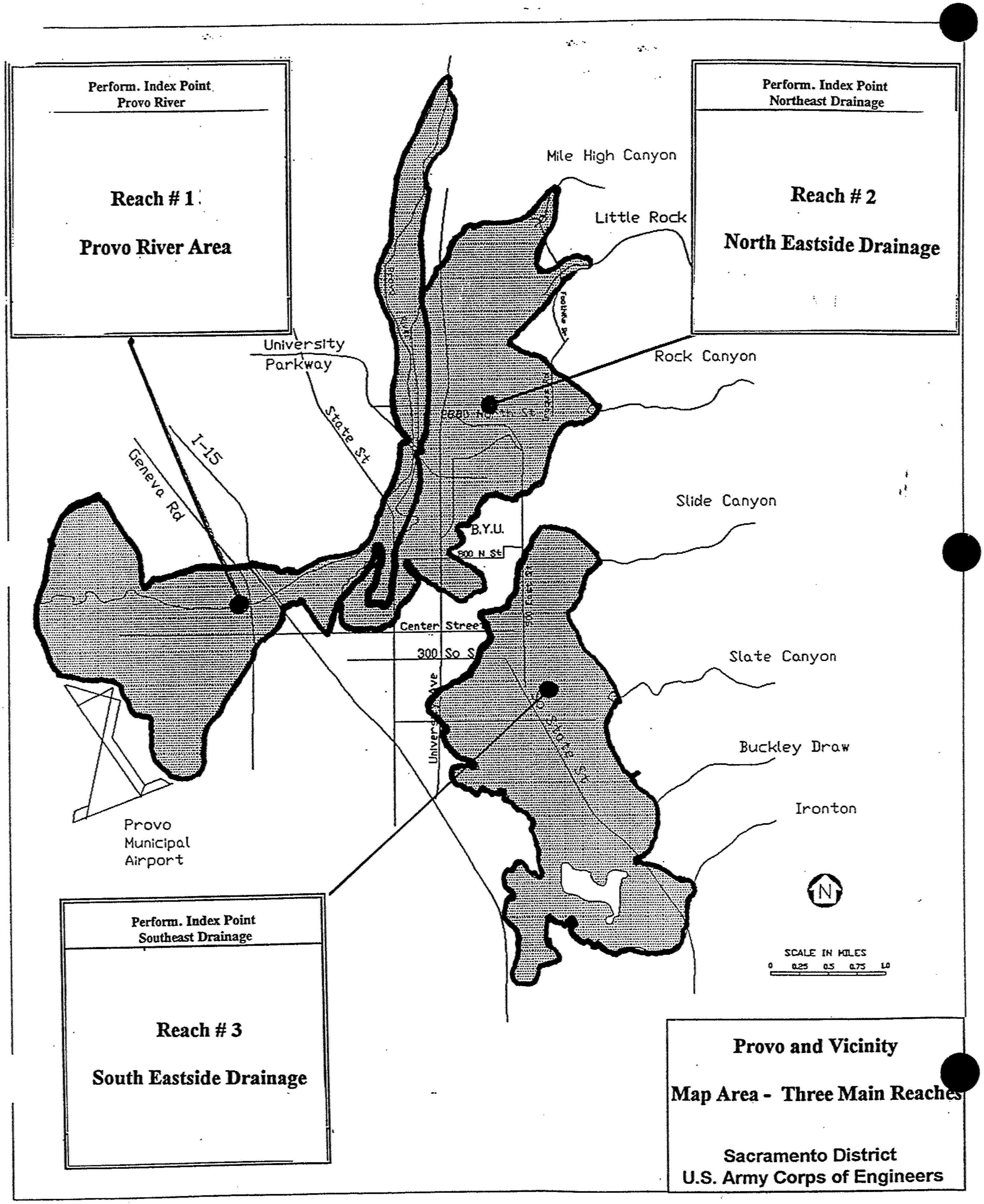
Reach	50 Year in feet	100 Year in feet	500 Year in feet
PROVO RIVER SUB-REACHES			
2230 North Street Area	0.0	0.5	1.0
Moon River Road	0.0	0.5	1.0
Park Area	0.0	0.5	1.0
Industrial Area	0.0	0.5	1.0
Below I-15	0.5	0.5 to 1.0	1.0 to 2.0
EAST SIDE DRAINAGE REACHES			
North East	0.2	0.3	0.3
South East	0.2	0.3	0.3

TABLE 2
Total Acreage By Sub-Reach and Flood Plain

Reach	50 Year Acres	100 Year Acres	500 Year Acres
PROVO RIVER SUB - REACHES			
2230 North Street Area	0	10	10
Moon River Road	0	20	250
Park Area	0	40	180
Industrial Area	0	20	30
Below I-15	180	500	550
Provo River Total =	**180**	**590**	**1,020**
EAST SIDE DRAINAGE REACHES			
North East	**1,100**	**2,600**	**2,700**
South East	**1,400**	**2,200**	**3,500**

Note: For the large reaches, North East, and South East, acre totals were rounded to nearest hundred acres. The Provo River sub- reaches were rounded to nearest ten acres.

FIGURE 1



Perform. Index Point
Provo River
Reach # 1
Provo River Area
Perform. Index Point
Northeast Drainage
Reach # 2
North Eastside Drainage
Mile High Canyon
Little Rock
Rock Canyon
Slide Canyon
Slate Canyon
Buckley Draw
Ironton
University Parkway
State St
I-15
Geneva Rd
B.Y.U.
800 N St
Center Street
300 So St
University Ave
State St
Provo Municipal Airport
Perform. Index Point
Southeast Drainage
Reach # 3
South Eastside Drainage
N
SCALE IN MILES
0 0.25 0.5 0.75 1.0
Provo and Vicinity
Map Area - Three Main Reaches
Sacramento District
U.S. Army Corps of Engineers

FIGURE 2

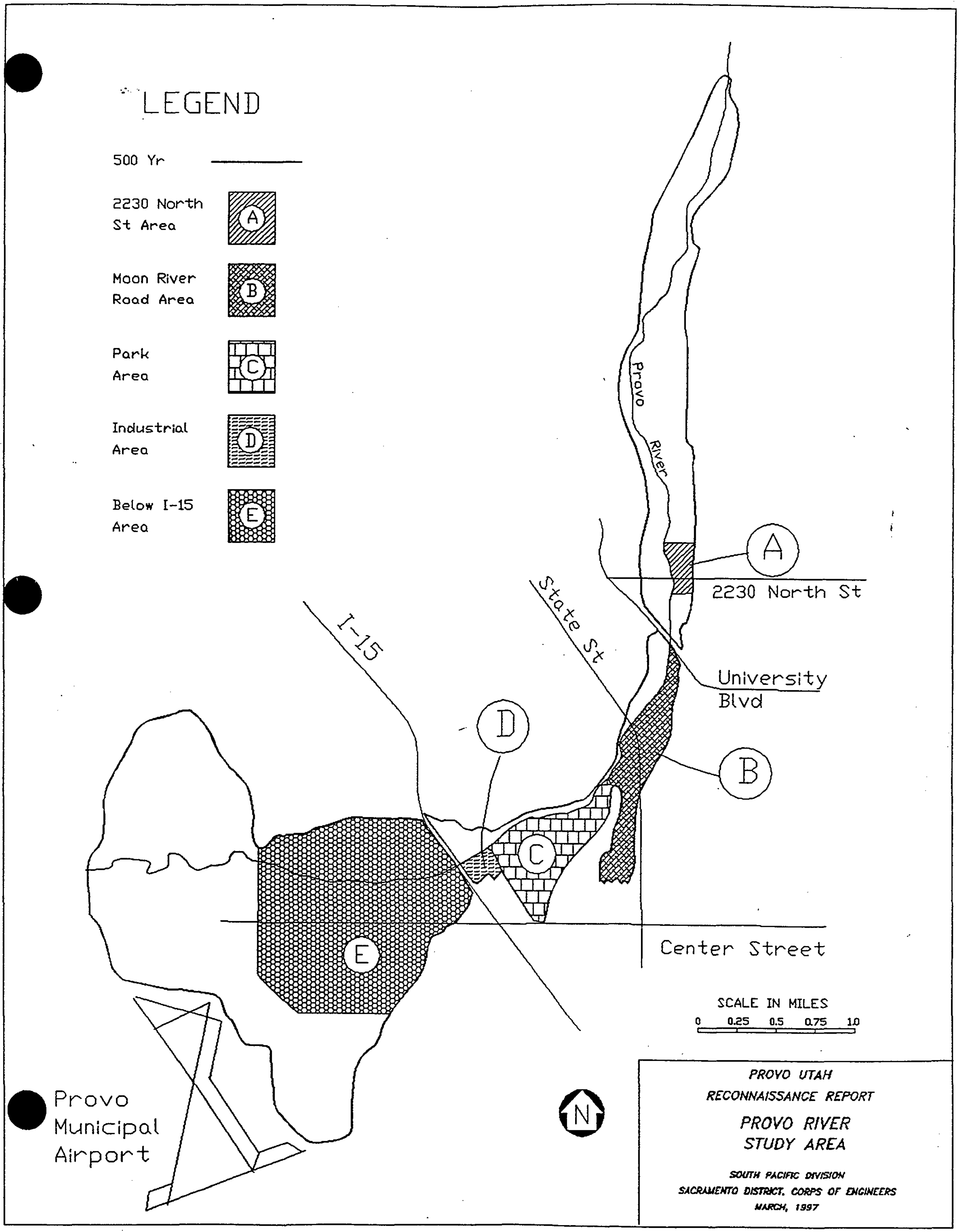
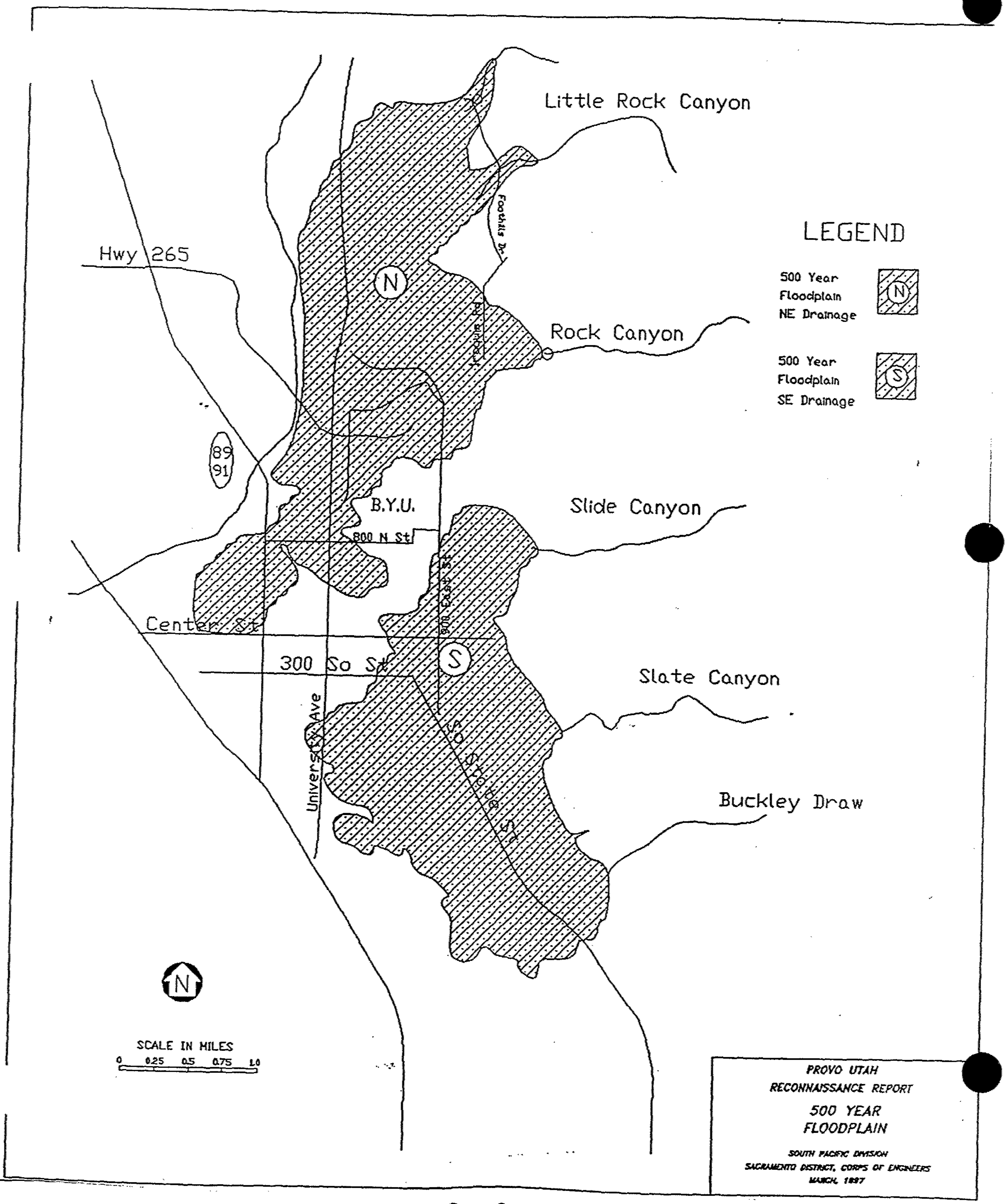

LEGEND
500 Yr
2230 North St Area
A
Moon River Road Area
B
Park Area
C
Industrial Area
D
Below I-15 Area
E
Provo River
A
2230 North St
State St
I-15
University Blvd
D
B
C
E
Center Street
SCALE IN MILES
0 0.25 0.5 0.75 1.0
Provo Municipal Airport
N
PROVO UTAH
RECONNAISSANCE REPORT
PROVO RIVER
STUDY AREA
SOUTH PACIFIC DIVISION
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
MARCH, 1997

FIGURE 3


Little Rock Canyon
Foothills Dr
LEGEND
500 Year Floodplain NE Drainage
500 Year Floodplain SE Drainage
Hwy 265
N
Rock Canyon
89
91
B.Y.U.
Slide Canyon
800 N St
900 East St
Center St
300 So St
S
Slate Canyon
University Ave
So State St
Buckley Draw
SCALE IN MILES
0 0.25 0.5 0.75 1.0
PROVO UTAH
RECONNAISSANCE REPORT
500 YEAR
FLOODPLAIN
SOUTH PACIFIC DIVISION
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
MARCH, 1997

Flood Plain Inventory

Using area maps with the flood plain depicted, an inventory of the study area was developed. Due to the size of the East Side area (over 6,000 acres for 500 year flood plain) the estimated number of structures were determined for the North East and South East reaches based on the number of acres inundated. Total number of structures for the entire area by land use were estimated using the Provo City Land Use Maps, regional data, flood plain maps, and field inspection. Structural densities were developed per acre and were used to measure the number structures in the 50 year, 100 year and 500 year flood plains based on the acreage of the two reaches.

For the sub- reaches along the Provo River, the inventory was developed on a structure by structure basis. Aerial photos, field inspection, Provo City Zoning map, and parcel data was used to determine the number and type of structures. The number of structures for each land use category and flood plain is displayed in Tables 3 and 4. Definition of land use categories are shown below.

- Residential - one story and split-level single family homes, with and without basements, duplexes, town homes and apartments (measured in housing units.) A sub category for mobile homes was used on the Provo River sub- reaches.

- Commercial/Industrial - offices, retail, restaurants, warehouses, light & technical assembly plants.

- Public - schools, public utilities & offices, police and fire stations, and churches.

TABLE 3
Total Number of Structures in The Study Area
Provo River Sub-Reaches

Sub-Reach	Residential	Mobile Home	Commercial / Industrial	Public	Total
500 Year Flood Plain					
2230 North Street Area	8	0	4	1	13
Moon River Road	206	0	144	0	350
Park Area	299	80	0	4	383
Industrial Area	0	0	10	0	10
Below I-15	692	148	10	5	855
Provo River Total =	**1,205**	**228**	**168**	**10**	**1,611**
100 Year Flood Plain					
2230 North Street Area	8	0	4	1	13
Moon River Road	66	0	10	0	76
Park Area	65	80	0	1	146
Industrial Area	0	0	1	0	1
Below I-15	632	148	5	4	789
Provo River Total =	**771**	**228**	**20**	**6**	**1,025**
50 Year Flood Plain					
2230 North Street Area	0	0	0	0	0
Moon River Road	0	0	0	0	0
Park Area	0	0	0	0	0
Industrial Area	0	0	0	0	0
Below I-15	227	0	2	0	229
Provo River Total =	**227**	**0**	**2**	**0**	**229**

TABLE 4
Total Number of Structures in The Study Area
EAST SIDE Reaches

Reach	Residential	Commercial/ Industrial	Public	Total
500 Year Flood Plain				
North East	3,180	340	70	3,590
South East	4,170	440	90	4,700
100 Year Flood Plain				
North East	3,050	330	70	3,450
South East	2,630	280	60	2,970
50 Year Flood Plain				
North East	1,300	140	30	1,470
South East	1,670	180	40	1,890

Note : Structure counts are estimates for the two largest reaches (North East, South East,) numbers are rounded to nearest ten units.

Value of Damageable Property

Structure values were determined by estimating current values minus the value of the land. These structure values represent replacement costs minus depreciation. Local officials and realtors were contacted to estimate the average values of various structure types. These values were compared to estimates from sales data and field observations. For the two largest reaches, total value estimates were obtained by examining the land use in each area and multiplying the acreage by the depreciated replacement cost of each structure type. Using this methodology, a value of damageable property per acre was established and then used with the acre data to determine total values for each floodplain. Composite values per acre (structure and content values for all land uses) were estimated at $330,000 per acre for the total area and used for the East Side reaches.

Values of structures in the Provo River sub-reach floodplains were determined based on individual structure. For commercial, mobile homes, and public values, structure characteristics were determined and Marshall & Swift Valuation was used to estimate the values of each structure by square footage. For residential values, sales data, discussions with local Realtors and developers were used to determine average values (minus land) for single family, duplexes, and condominiums in each area.

Content values were determined as a percentage of structure value by land use. The ratio of content to structure for each building type was based on information from other district studies.

Content Value Percentages

Residential	= 50 %
Commercial/Industrial	= 100 %
Public	= 50 %

Total depreciated values of property for all existing flood plain structures and contents by sub-reach and land use are shown in Table 5.

TABLE 5
Value of Damageable Property
In the Study Area
Structure & Content
October 1996 Prices, in $1,000's

Reach	Residential	Mobile Homes	Commercial/ Industrial	Public	Total
PROVO RIVER SUB - REACHES					
2230 North Street Area	1,800	0	6,400	60	8,260
Moon River Road	25,800	0	92,200	0	118,000
Park Area	40,400	1,200	0	1,550	43,150
Industrial Area	0	0	4,000	0	4,000
Below I-15	93,420	2,220	2,610	3,400	101,650
Provo River Total =	**161,420**	**3,420**	**105,210**	**5,010**	**275,060**
EAST SIDE DRAINAGE REACHES					
North East	**594,500**	**0**	**270,200**	**36,100**	**900,800**
South East	**779,300**	**0**	**354,400**	**47,300**	**1,181,000**

Future Growth and Development

Estimates for future growth were not included in this report. Due to the minimal depth of flooding and the ease to which flood proofing can be performed, future development can occur even under without project conditions. Analysis of future growth will not have a significant impact on the benefit analysis.

III. FLOOD DAMAGE EVALUATION

Depth-Damage Curves

Damage susceptibility relationships were established as a function of structure and content values. Depth-damage relationships describe the damages that occur under different depths of flooding. The curves used in this study are based on the 1988 FEMA curves for residential structure and content, and the TVA curves for commercial and public. The residential curves for structures with basements were taken from a similar area study (the 1991 Upper Jordan, Utah Study.) These basement curves, representative of structures in Utah, were compiled using the FEMA curves and adjusting the percentages based on suggestions from several appraisers from the Salt Lake City area in Utah. The depth damage relationships used in this analysis are shown in Table 6.

Table 6
Depth Damage Relationships
Depth based on Ground Water Level

Category		0.0 Feet	0.5 Feet	1.0 Feet	2.0 Feet
Residential- One Story With Basement	Structure	0%	13%	21%	36%
	Content	0%	27%	36%	55%
Residential- Split With Basement	Structure	0%	13%	16%	27%
	Content	0%	23%	27%	36%
Residential No Basement	Structure	0%	8%	11%	17%
	Content	0%	0%	17%	28%
Commercial/ Industrial/ Public	Structure	0%	5%	7%	11%
	Content	0%	0%	4%	18%

Note damages based on an average foundation height of ½ foot.

Damage Categories

Structure and Content

Damages to structure and content were based on depth of flooding. For each structure, foundation height was subtracted from the average depth to arrive at the depth of flooding within the structure. Damages are a resultant product of an integration of flood depths, frequency of flooding, value of damageable property and the percent damage to structure and content.

Due to the shallow depths of flooding, structures with basements were especially susceptible to flood damage. At these shallow depths of flooding, that may not inundate the first floor, the basements could still be fully inundated. Based on field inspection and conversations with local Realtors, residential distribution of units with basements is as follows:

Residential Structures

25 %	Split levels or Two Story with Basements
60 %	One Floor with Basements
15 %	One Floor no Basements

The Below I-15 sub-reach has less homes with basements. All homes in this reach built since the late 1980's must be above grade due to the high water table in the area. Only the older homes in the Below I-15 sub-reach have basements (about 25%.)

Damages to Basements in Utah

The basements in Utah (and particularly in the Provo and Salt Lake City) are rather unique. Most of the homes are built with lower levels that are partially underground with four feet to six feet below ground level. A typical home might have 1,200 square feet of living space in the upper level above ground and another 1,200 square feet below. New homes have been built with the upper level finished, and then the homeowner or contractor finishes the lower level after the first few years in the home. These lower level basements have living quarters comparable with the upstairs with bedrooms (with windows at or below ground level), bathrooms and living rooms. Flooding can occur at very low water levels as most homes have either windows or separate entryways below ground level. Shallow flooding can inundate the entire basement causing greater damage than homes without basements. On average , structure and content damage to residential basements account for nearly 75 % of the total damages in the study. See Attachment 1 for photographs of homes with basements in Provo, Utah.

Emergency Costs

Emergency costs were computed to account for evacuation and reoccupation of residences and neighborhoods inundated. The number of people affected, duration of flooding and the cost per person per day were used to determine emergency costs by reach and event.

Automobile Damages

Damages to automobiles were based on the estimated number of vehicles present in the area during the event and the depth of water inside the vehicle. On average, auto damages would be very low due to the shallow depths of flooding.

Road Damages

Road damages were estimated by measuring the road mileage for a representative sample (two 600 acre blocks located in the 500 year floodplain East Side) of the Provo Area. Using average depths of flooding a dollar-damage per mile for each flood event was calculated. Damages for the sample were converted to road damages per acre. The damage per acre figure was multiplied by the number of acres for each reach and event.

Frequency Damage and Stage Damage Relationships

Using the DAMAGES program, the magnitude of damages were calculated based on frequency. Damage estimates were determined for 50 year, 100 year and 500 year flood plains. Damage values were then linked to an index stage by frequency for each reach. The frequency relationships used to develop the stage damage curves for each sub-reach are shown in Tables 7 and 8.

Uncertainty in Stage Damage Relationships

For this reconnaissance report, no uncertainties were estimated for the damage evaluation. Further evaluation may include uncertainties in first-floor elevation, structure and content values, and depth-damage relationships. All Monte Carlo simulations done in this analysis assumed standard deviation for damages equal to zero.

TABLE 7
FREQUENCY STAGE DAMAGE RELATIONSHIPS
Provo River Sub-Reaches
Values in October 1996 Prices (in $1,000's)

Frequency in Years	Stage in Feet	Damages to Structure & Content			Damages to Autos, Roads, & Emergency	Total Damage ($1,000's)
		Residential	Commercial /Industrial	Public		
SUB - REACH - 2230 NORTH STREET						
45	4,519.0	0	0	0	0	0
50	4,519.1	0	0	0	0	0
100	4,520.9	273	149	3	9	434
500	4,523.1	474	352	4	9	839
SUB - REACH - MOON RIVER ROAD						
45	4,519.0	0	0	0	0	0
50	4,519.1	0	0	0	0	0
100	4,520.9	757	160	0	48	965
500	4,523.1	8,131	5,073	0	182	13,386
SUB - REACH - PARK AREA						
45	4,519.0	0	0	0	0	0
50	4,519.1	0	0	0	0	0
100	4,520.9	2,031	0	36	49	2,116
500	4,523.1	16,217	0	108	227	16,552
SUB - REACH - INDUSTRIAL AREA						
45	4,519.0	0	0	0	0	0
50	4,519.1	0	0	0	0	0
100	4,520.9	0	10	0	2	12
500	4,523.1	0	220	0	3	223

Frequency in Years	Stage in Feet	Damages to Structure & Content			Damages to Autos, Roads, & Emergency	Total Damage ($1,000's)
		Residential	Commercial /Industrial	Public		
SUB - REACH BELOW I-15						
45	4,519.0	0	0	0	0	0
50	4,519.1	4,389	5	0	235	4,629
100	4,520.9	8,643	41	68	657	9,409
500	4,523.1	16,915	143	238	1,465	18,761

TABLE 7-a
FREQUENCY STAGE DAMAGE RELATIONSHIPS
TOTAL - PROVO RIVER REACH
Values in October 1996 Prices (in $1,000's)

Frequency in Years	Stage in Feet	Total Damage ($1,000's)
TOTAL REACH - PROVO RIVER		
45	4,519.0	0
50	4,519.1	4,629
100	4,520.9	12,936
500	4,523.1	49,761

TABLE 8
FREQUENCY STAGE DAMAGE RELATIONSHIPS
EAST SIDE Drainage Reaches
Values in October 1996 Prices (in $1,000's)

Frequency in Years	Stage in Feet	Damages to Structure & Content			Damages to Autos, Roads, & Emergency	Total Damage ($1,000's)
		Residential	Commercial /Industrial	Public		
REACH - NORTH EAST SIDE						
25	4,794.5	0	0	0	0	0
50	4,794.8	33,500	1,100	300	500	35,400
100	4,795.0	86,700	3,300	900	1,200	92,100
500	4,795.5	99,100	4,100	1,100	1,200	105,500
REACH - SOUTH EAST SIDE						
20	4,588.5	0	0	0	0	0
50	4,588.8	40,800	1,400	400	700	43,300
100	4,589.0	73,700	2,800	700	1,100	78,300
500	4,589.5	130,000	5,300	1,400	1,900	138,600

Expected Annual Damages

Expected annual damages (EAD) were determined by weighing the estimated damages from varying degrees of flooding by their probability of occurring. Flow-frequency, inflow-outflow, flow-stage, and probable failure and non-failure points were incorporated with the stage damage curve to estimate expected annual damages. Uncertainties in stage and flows were included. The Monte Carlo simulation program (MONTE) was used to calculate the numerical integration.

Without Project Damages

Expected annual damages were estimated for existing without project conditions for each sub-reach. These annual damage figures with the probable exceedances from the MONTE results are displayed in Table 9. Expected annual damages for the study area are greater than $ 5 million under existing without project conditions.

TABLE 9
WITHOUT PROJECT
EXPECTED ANNUAL DAMAGES
October 1996 Prices, in $1,000's

DAMAGE REACH	PROBABLE EXCEEDANCE	EXPECTED ANNUAL DAMAGES
PROVO RIVER SUB - REACHES		
2230 North Street Area	0.041	$11.4
Moon River Road	0.041	$88.9
Park Area	0.041	$129.1
Industrial Area	0.041	$1.5
Below I-15	0.041	$338.4
Provo River Total =		**$569.3**
EAST SIDE DRAINAGE REACHES		
North East	0.048	**$2,570.1**
South East	0.049	**$2,174.1**

Damages using Traditional Non-MONTE Methods

The uncertainties used in the Monte Carlo simulation have a dramatic effect on damages where flooding is shallow. The stage damage curve in this analysis was developed without calculated uncertainties. A sensitivity analysis was performed to see the affect of the remaining inputs where uncertainties were used. For comparison, a conventional integration of the area under the frequency/damage curve was performed. The damage evaluation procedure was in accordance with Policy Guidance Letter No. 26. In this calculation, uncertainties in flow and stage were assumed to be zero and the probable non-failure and probable failure points were estimated as 15% and 85% of expected damage value. The comparison can be seen in Table 10. The Monte Carlo simulation, with uncertainties, can increase damages significantly over the traditional integration.

TABLE 10
WITHOUT PROJECT
EAD Comparison
October 1996 Prices, in $1,000's

AREA	TRADITIONAL INTEGRATION			MONTE CARLO		PERCENT CHANGE due to MONTE CARLO
	Freq. of PNP in years	Freq. of PFP in years	Expected Annual Damages	Freq. of Exceedance in years	Expected Annual Damages	
2230 North	45	135	$7.8	24	$11.4	46%
Moon River	45	135	$88.6	24	$88.9	0%
Park Area	45	135	$115.5	24	$129.1	12%
Industrial	45	135	$1.4	24	$1.5	7%
Below I-15	45	135	$179.3	24	$338.4	89%
Provo Total			**$392.6**		**$569.3**	**45%**
North East	25	25	**$1,993.0**	20	**$2,570.1**	**29%**
South East	20	20	**$2,402.0**	21	**$2,174.1**	**-9%**

Basement Damages

Residential basements and the damages they incur from shallow flooding has a major impact on expected annual damages. In this study, the majority of the residential units have basements (nearly 85%.) If the basements could be flood proofed the damages would be reduced dramatically. New Monte Carlo simulations were run using stage/damage curves where flooding to basements was assumed prevented by flood proofing. Table 11 shows the damage reduction from basement protection. Expected annual damages could be reduced by almost 75 % by protecting or eliminating basement damage.

TABLE 11
WITHOUT PROJECT
EXPECTED ANNUAL DAMAGES
With and Without Basement Damages
October 1996 Prices, in $1,000's

DAMAGE REACH	PROB. EXCEED.	EAD Without Project	EAD Floodproofed Basements	Reduction in Damages %
2230 North Street Area	0.041	$11.4	$7.3	36%
Moon River Road	0.041	$88.9	$55.6	37%
Park Area	0.041	$129.1	$41.7	68%
Industrial Area	0.041	$1.5	$1.5	0%
Below I-15	0.041	$338.4	$212.3	37%
Provo Total =		**$569.3**	**$318.4**	**44%**
North East	0.048	**$2,570.1**	**$554.0**	**78%**
South East	0.049	**$2,174.1**	**$489.1**	**78%**

IV. BENEFIT EVALUATION

Inundation Reduction Benefits

Flood damage reduction benefits were estimated by subtracting with project residual damages from without project damages. Expected annual damages from the Monte Carlo simulation were compared under without and with project conditions to determine average annual benefits.

Project Conditions

Provo River

Benefits from the Provo River sub-reaches (2230 North Street, Moon River, Park Area, Industrial Area, and Below I-15) were estimated for various sized levee projects. Top of Levee, PNP, and PFP elevations were increased to simulate project conditions and the Monte Carlo model was run for each sub-reach. With project residual damages and benefits are displayed in Table 12. The corresponding benefit curves for the five sub-reaches are shown in Figures 4 through 8. The benefit curve for the total Provo Reach is given in Figure 9.

East side Drainages

Benefits from the North East and South East areas were estimated for the development of detention with conveyance. Inflow -Outflow relationships in the Monte Carlo model were changed to simulate project conditions. Three projects were analyzed.

1. Low Protection - contains only conveyance (no additional detention) capable of handling very low flows
2. Medium Protection - conveyance with moderate sized detention
3. High Protection - conveyance with larger sized detention

With project residual damages and benefits for these three project alternatives are displayed in Table 13. The corresponding benefit curves are shown in Figures 10 and 11.

TABLE 12
AVERAGE ANNUAL BENEFITS
October 1996 Prices, 7 3/8 % Interest Rate (in $1,000's)

Reach Top of Levee	Without Project		With Project		Average Annual Benefits
	Probable Exceedance	EAD	Probable Exceedance	EAD	
Sub Reach : 2230 North Street Area					
4522 Feet	0.041	11.4	0.0131	7.7	$3.7
4524 Feet	0.041	11.4	0.0037	3.0	$8.4
4526 Feet	0.041	11.4	0.0005	1.0	$10.4
Sub Reach : Moon River Road					
4522 Feet	0.041	88.9	0.0131	83.6	$5.3
4524 Feet	0.041	88.9	0.0037	46.6	$42.3
4526 Feet	0.041	88.9	0.0005	6.6	$82.3
Sub Reach : Park Area					
4522 Feet	0.041	129.1	0.0131	109.1	$20.0
4524 Feet	0.041	129.1	0.0037	57.9	$71.2
4526 Feet	0.041	129.1	0.0005	8.1	$121.0
Sub Reach : Industrial Area					
4522 Feet	0.041	1.5	0.0131	1.4	$0.1
4524 Feet	0.041	1.5	0.0037	0.8	$0.7
4526 Feet	0.041	1.5	0.0005	0.1	$1.4
Sub Reach : Below I-15					
4522 Feet	0.041	338.4	0.0131	173.5	$164.9
4524 Feet	0.041	338.4	0.0037	67.3	$271.1
4526 Feet	0.041	338.4	0.0005	9.2	$329.2

TABLE 12-a
AVERAGE ANNUAL BENEFITS
October 1996 Prices, 7 3/8 % Interest Rate (in $1,000's)

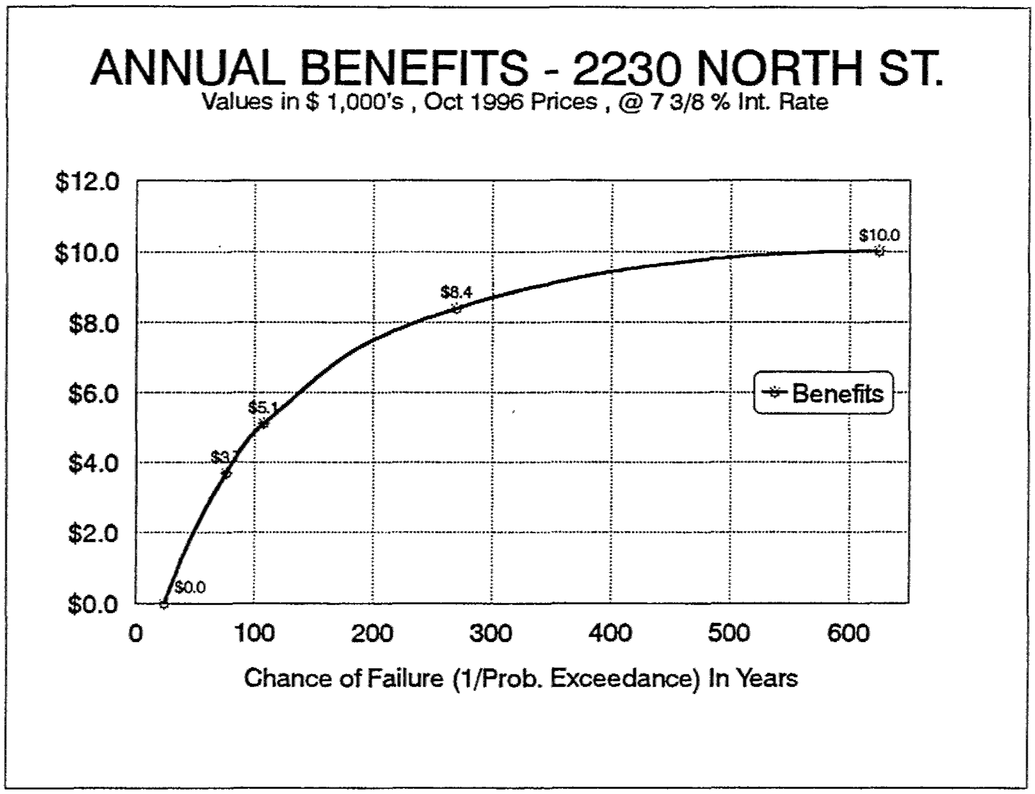
Reach Top of Levee	Without Project		With Project		Average Annual Benefits
	Probable Exceedance	EAD	Probable Exceedance	EAD	
Total Provo River Reach					
4522 Feet	0.041	569.3	0.0131	375.3	$194.0
4524 Feet	0.041	569.3	0.0037	175.6	$393.7
4526 Feet	0.041	569.3	0.0005	25.0	$544.3

TABLE 13
AVERAGE ANNUAL BENEFITS
October 1996 Prices, 7 3/8 % Interest Rate (in $1,000's)

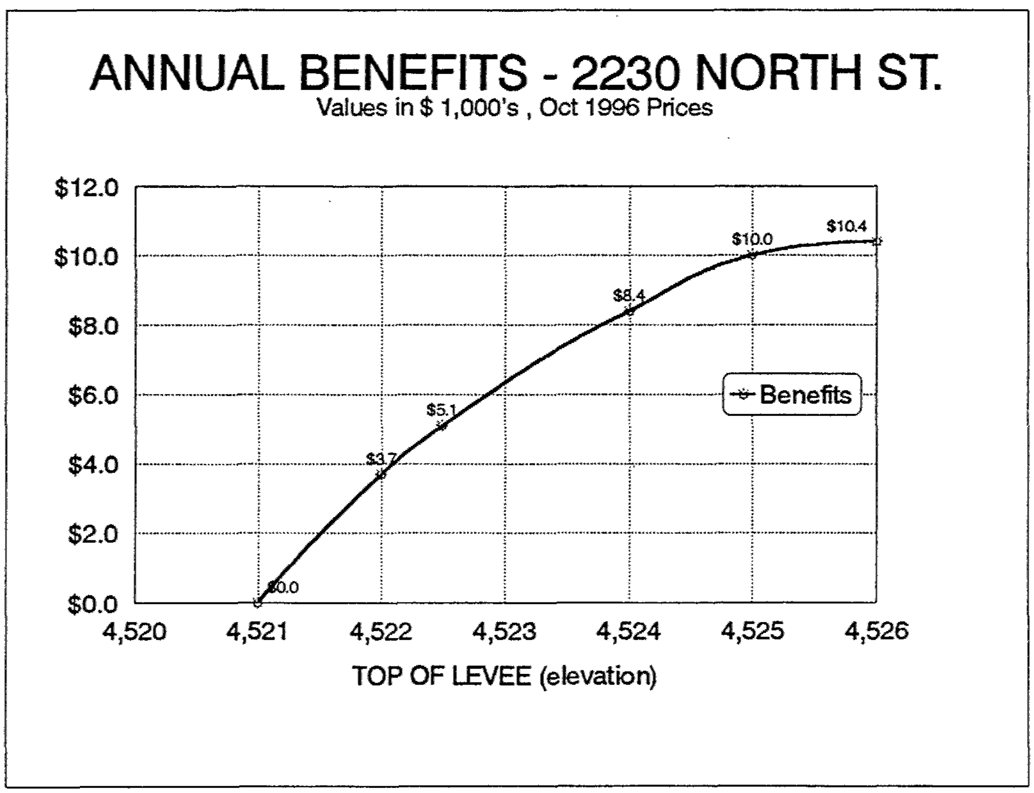
Reach Level of Protection	Without Project		With Project		Average Annual Benefits
	Probable Exceedance	EAD	Probable Exceedance	EAD	
North East					
Low Protection	0.0493	2,570	0.0396	2,156	$414
Medium Protection	0.0493	2,570	0.0203	1,376	$1,194
High Protection	0.0493	2,570	0.0154	1,123	$1,447
South East					
Low Protection	0.0479	2,174	0.0412	1,979	$195
Medium Protection	0.0479	2,174	0.0184	1,281	$893
High Protection	0.0479	2,174	0.0100	822	$1,352

Note : In the main report, the High Protection alternative for the South East Reach represents a project that provides a lower level of protection. Benefits in this Table 13 are based on the MONTE R&U runs. Benefits in the main report for the High Alternative represent a point taken from the benefit curve in Figure 9 correlated to a 0.0139 probable exceedance and providing $1.11 million in average annual benefits.

Figure 4

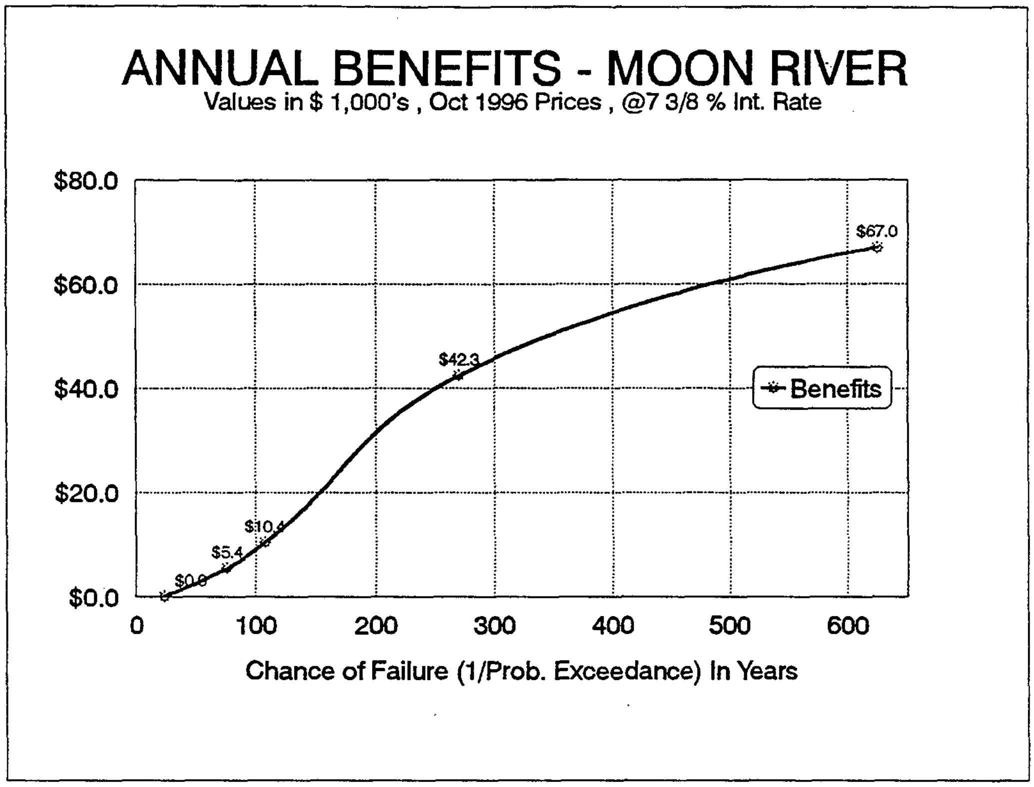


ANNUAL BENEFITS - 2230 NORTH ST.
Values in $ 1,000's , Oct 1996 Prices , @ 7 3/8 % Int. Rate
$12.0
$10.0
$8.0
$6.0
$4.0
$2.0
$0.0
0
100
200
300
400
500
600
Chance of Failure (1/Prob. Exceedance) In Years
$0.0
$5.1
$8.4
$10.0
Benefits



ANNUAL BENEFITS - 2230 NORTH ST.
Values in $ 1,000's , Oct 1996 Prices
$12.0
$10.0
$8.0
$6.0
$4.0
$2.0
$0.0
4,520
4,521
4,522
4,523
4,524
4,525
4,526
TOP OF LEVEE (elevation)
$0.0
$3.7
$5.1
$8.4
$10.0
$10.4
Benefits

Figure 5


ANNUAL BENEFITS - MOON RIVER
Values in $ 1,000's , Oct 1996 Prices , @7 3/8 % Int. Rate
$80.0
$60.0
$40.0
$20.0
$0.0
0
100
200
300
400
500
600
Chance of Failure (1/Prob. Exceedance) In Years
$67.0
$42.3
$10.4
$5.4
$0.0
Benefits

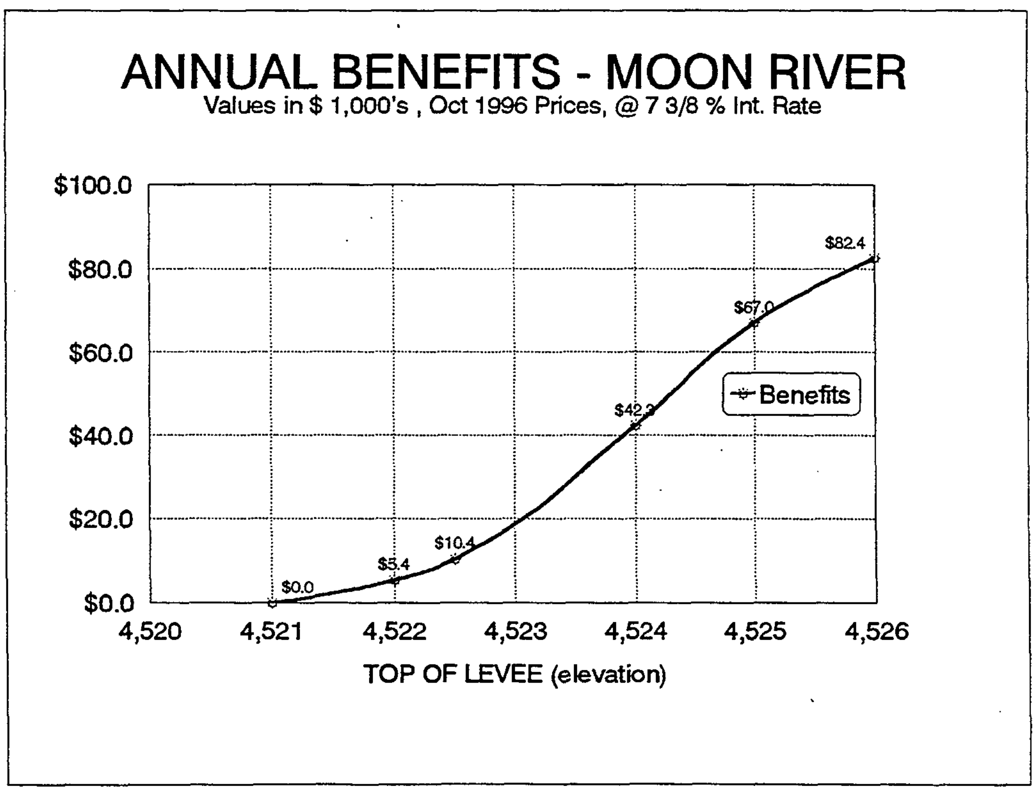
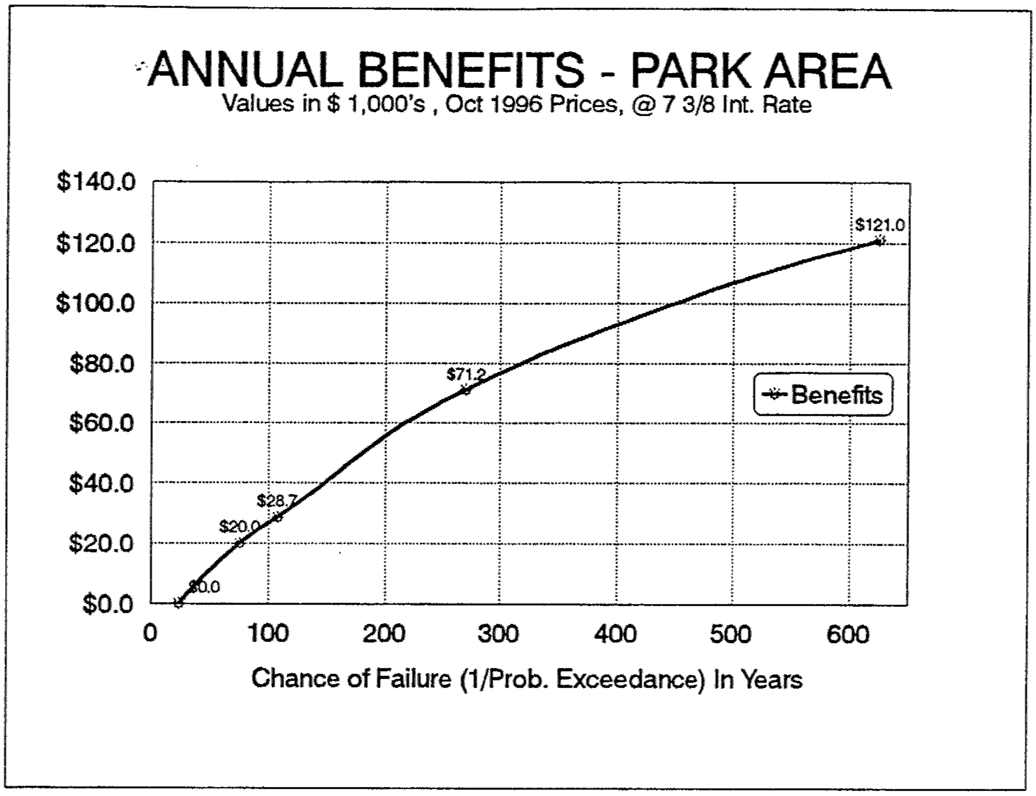
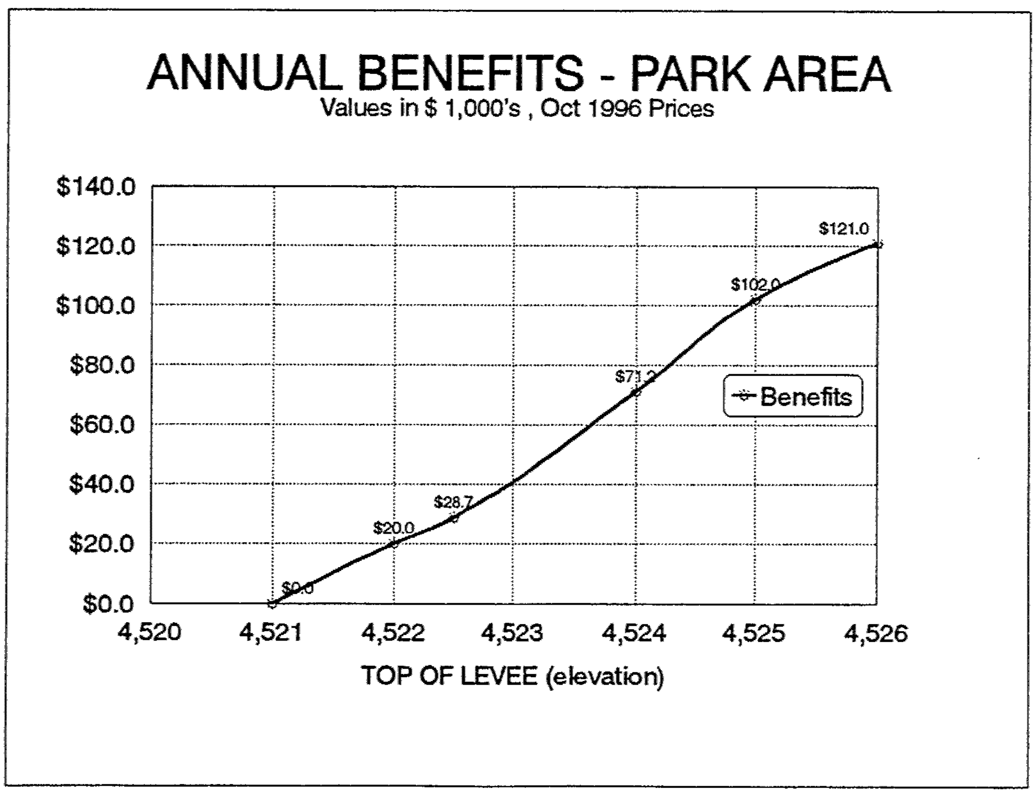

ANNUAL BENEFITS - MOON RIVER
Values in $ 1,000's , Oct 1996 Prices, @ 7 3/8 % Int. Rate
$100.0
$80.0
$60.0
$40.0
$20.0
$0.0
4,520
4,521
4,522
4,523
4,524
4,525
4,526
TOP OF LEVEE (elevation)
$82.4
$67.0
$42.3
$10.4
$5.4
$0.0
Benefits

Figure 6

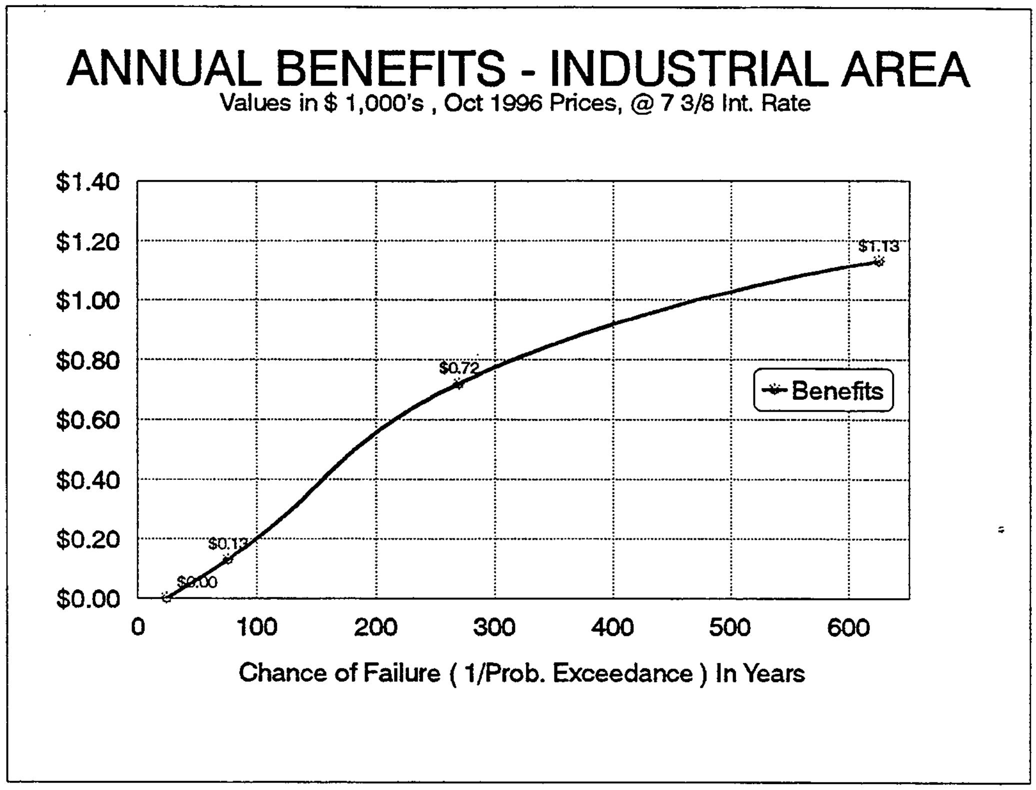


ANNUAL BENEFITS - PARK AREA
Values in $ 1,000's , Oct 1996 Prices, @ 7 3/8 Int. Rate
$140.0
$120.0
$100.0
$80.0
$60.0
$40.0
$20.0
$0.0
0
100
200
300
400
500
600
Chance of Failure (1/Prob. Exceedance) In Years
$121.0
$71.2
$28.7
$20.0
$0.0
Benefits

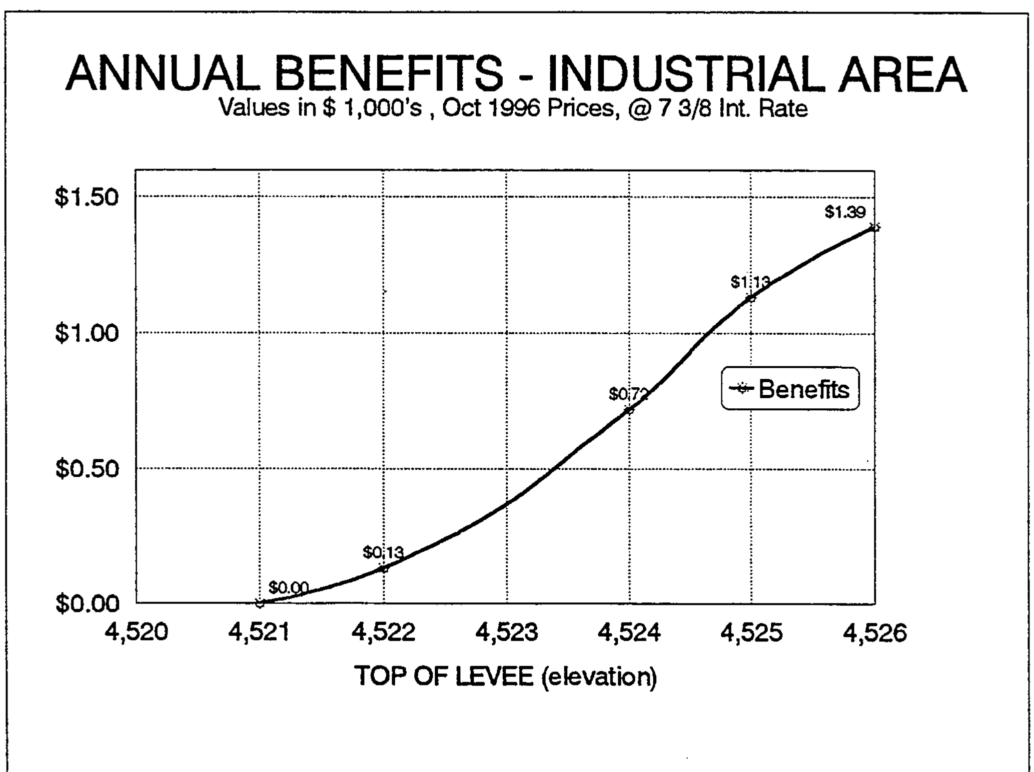


ANNUAL BENEFITS - PARK AREA
Values in $ 1,000's , Oct 1996 Prices
$140.0
$120.0
$100.0
$80.0
$60.0
$40.0
$20.0
$0.0
4,520
4,521
4,522
4,523
4,524
4,525
4,526
TOP OF LEVEE (elevation)
$121.0
$102.0
$71.2
$28.7
$20.0
$0.0
Benefits

Figure 7

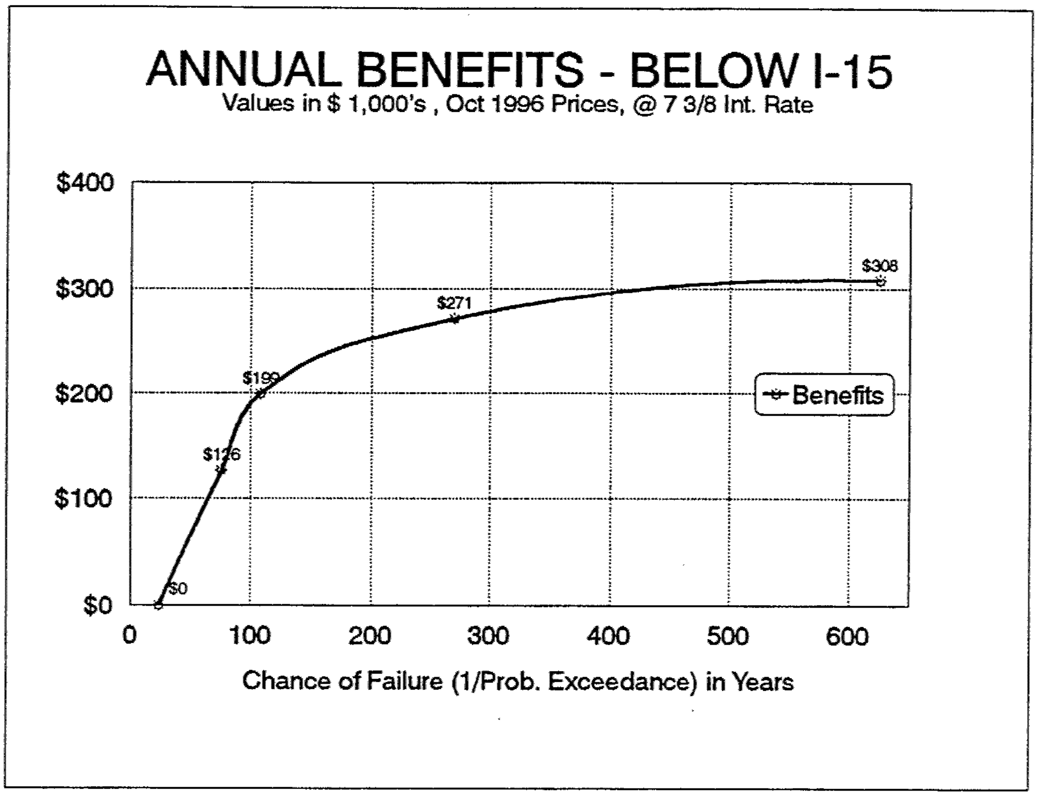


ANNUAL BENEFITS - INDUSTRIAL AREA
Values in $ 1,000's , Oct 1996 Prices, @ 7 3/8 Int. Rate
$1.40
$1.20
$1.00
$0.80
$0.60
$0.40
$0.20
$0.00
0
100
200
300
400
500
600
Chance of Failure (1/Prob. Exceedance) In Years
$1.13
$0.72
$0.13
$0.00
Benefits

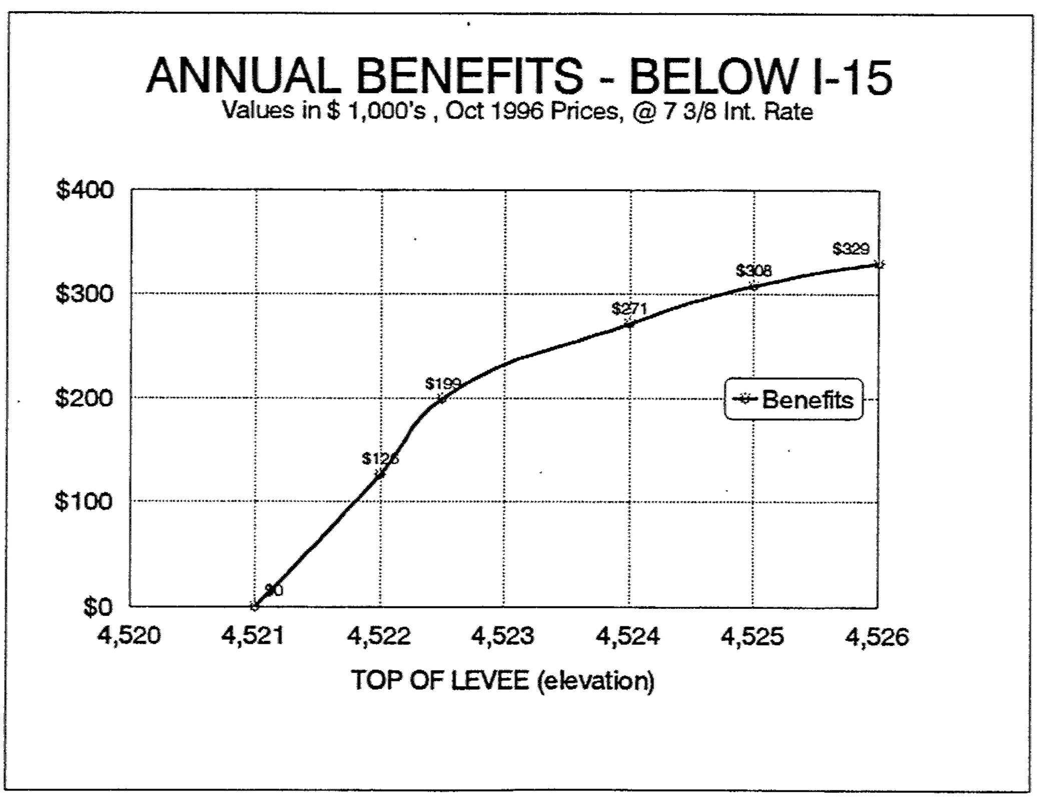


ANNUAL BENEFITS - INDUSTRIAL AREA
Values in $ 1,000's , Oct 1996 Prices, @ 7 3/8 Int. Rate
$1.50
$1.00
$0.50
$0.00
4,520
4,521
4,522
4,523
4,524
4,525
4,526
TOP OF LEVEE (elevation)
$1.39
$1.13
$0.72
$0.13
$0.00
Benefits

Figure 8

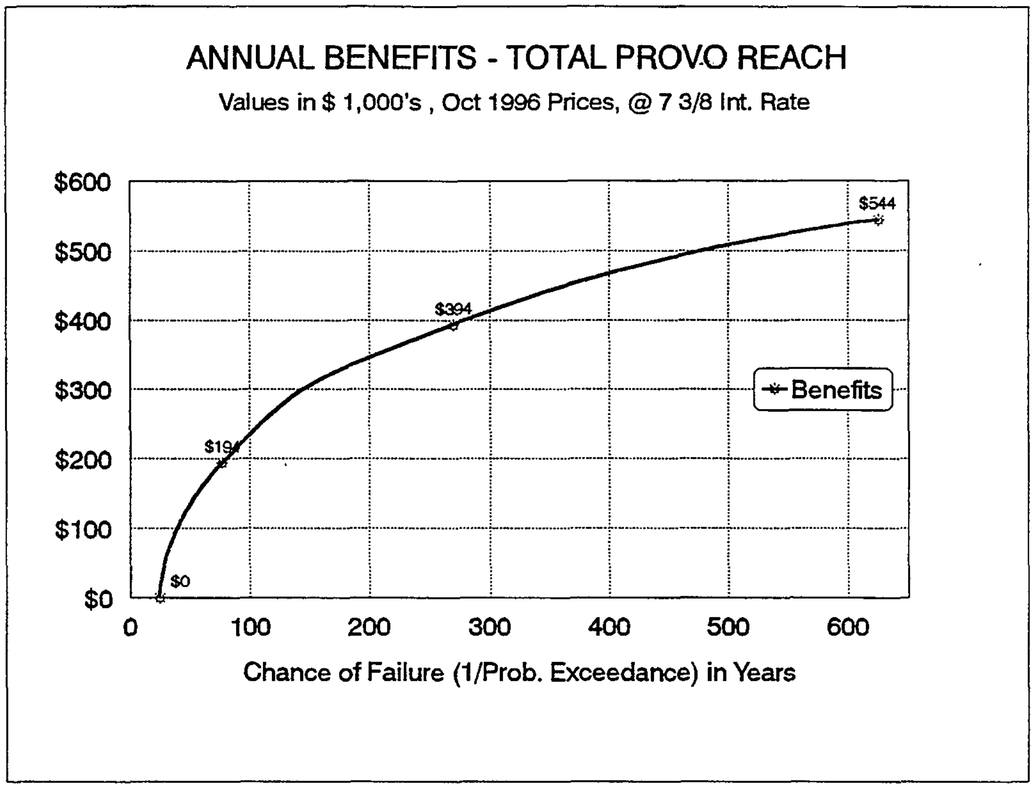


ANNUAL BENEFITS - BELOW I-15
Values in $ 1,000's , Oct 1996 Prices, @ 7 3/8 Int. Rate
$400
$300
$200
$100
$0
0
100
200
300
400
500
600
Chance of Failure (1/Prob. Exceedance) in Years
$308
$271
$199
$126
$0
Benefits

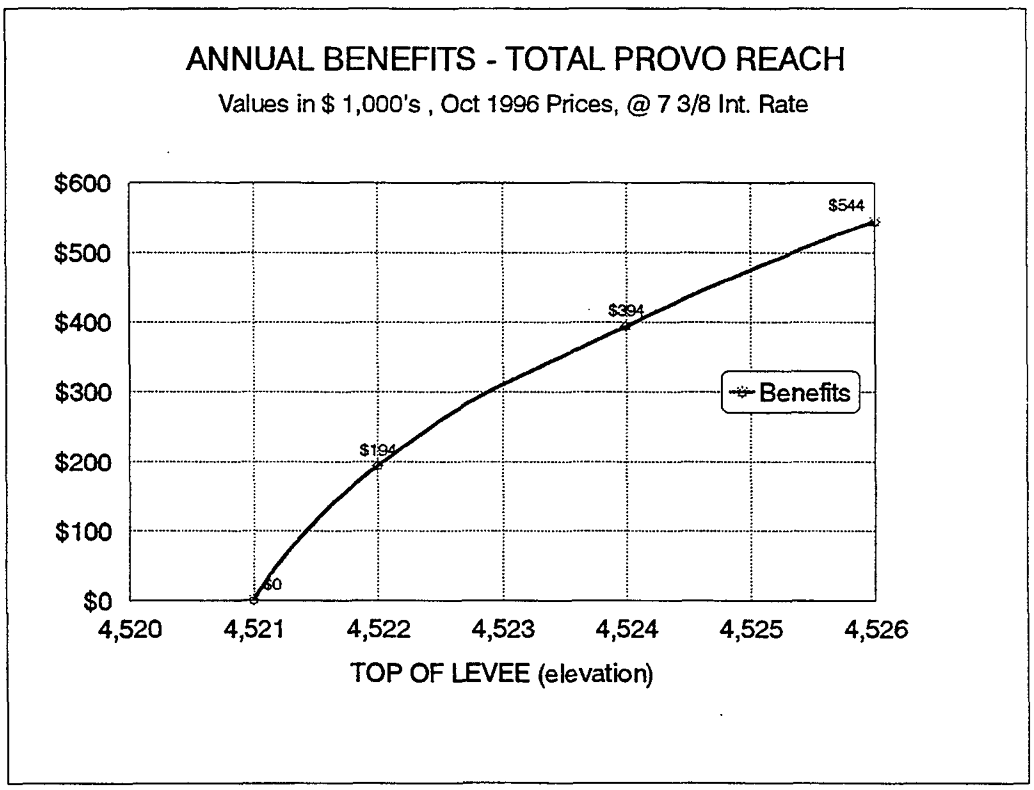


ANNUAL BENEFITS - BELOW I-15
Values in $ 1,000's , Oct 1996 Prices, @ 7 3/8 Int. Rate
$400
$300
$200
$100
$0
4,520
4,521
4,522
4,523
4,524
4,525
4,526
TOP OF LEVEE (elevation)
$329
$308
$271
$199
$126
$0
Benefits

Figure 9

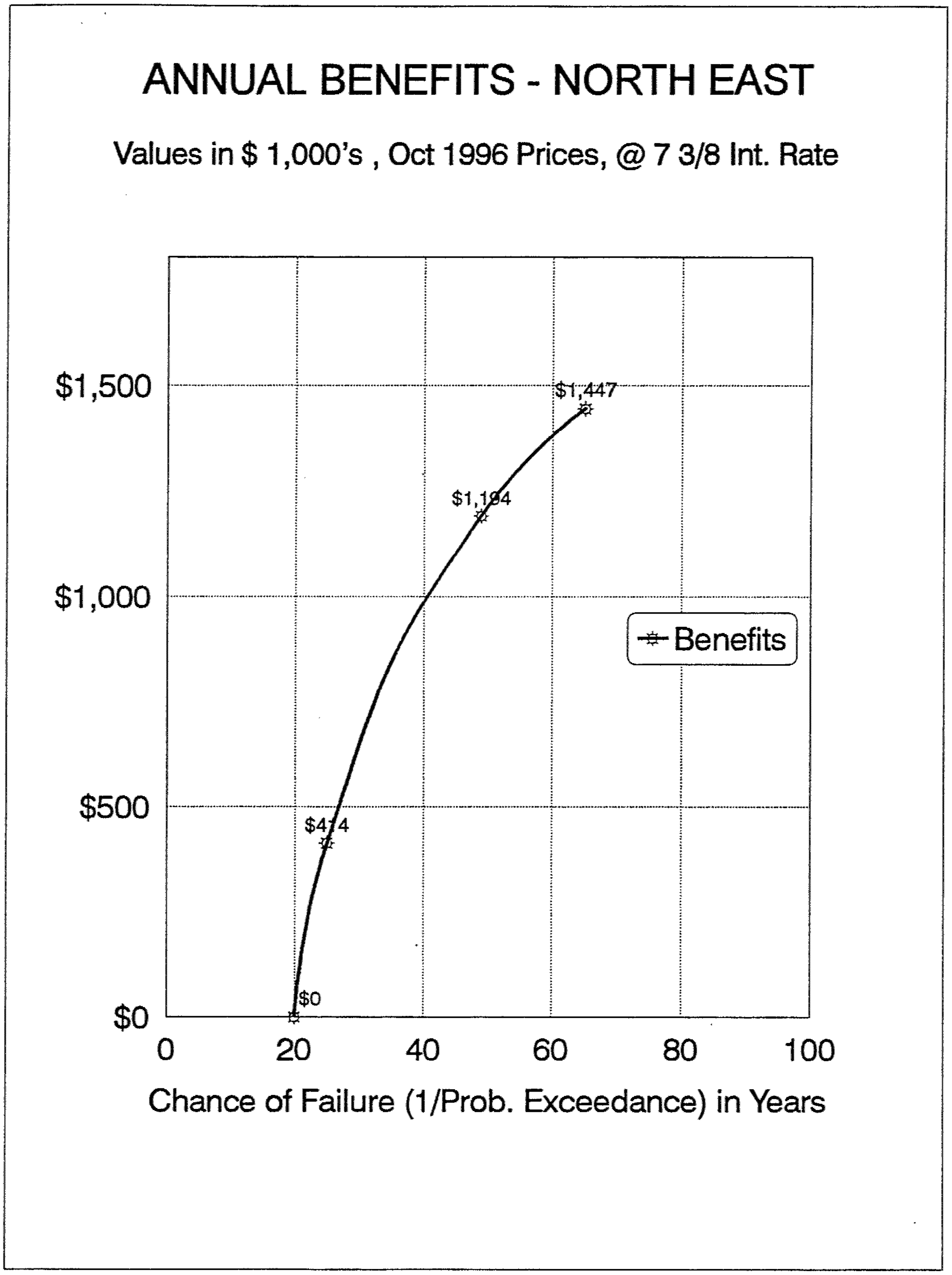


ANNUAL BENEFITS - TOTAL PROVO REACH
Values in $ 1,000's , Oct 1996 Prices, @ 7 3/8 Int. Rate
$600
$500
$400
$300
$200
$100
$0
0
100
200
300
400
500
600
Chance of Failure (1/Prob. Exceedance) in Years
Benefits
$544
$394
$194
$0



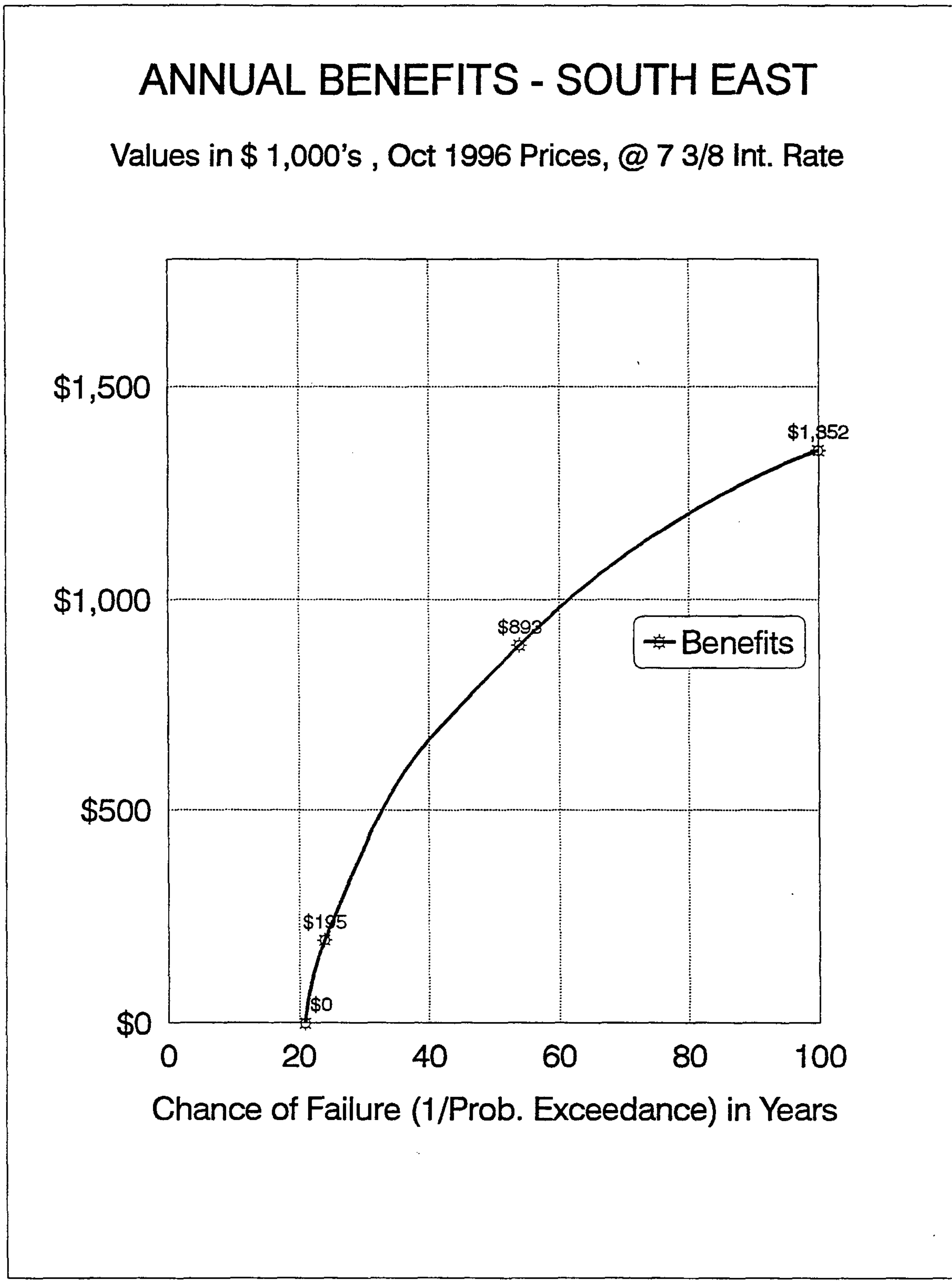
ANNUAL BENEFITS - TOTAL PROVO REACH
Values in $ 1,000's , Oct 1996 Prices, @ 7 3/8 Int. Rate
$600
$500
$400
$300
$200
$100
$0
4,520
4,521
4,522
4,523
4,524
4,525
4,526
TOP OF LEVEE (elevation)
Benefits
$544
$394
$194
$0

Figure 10



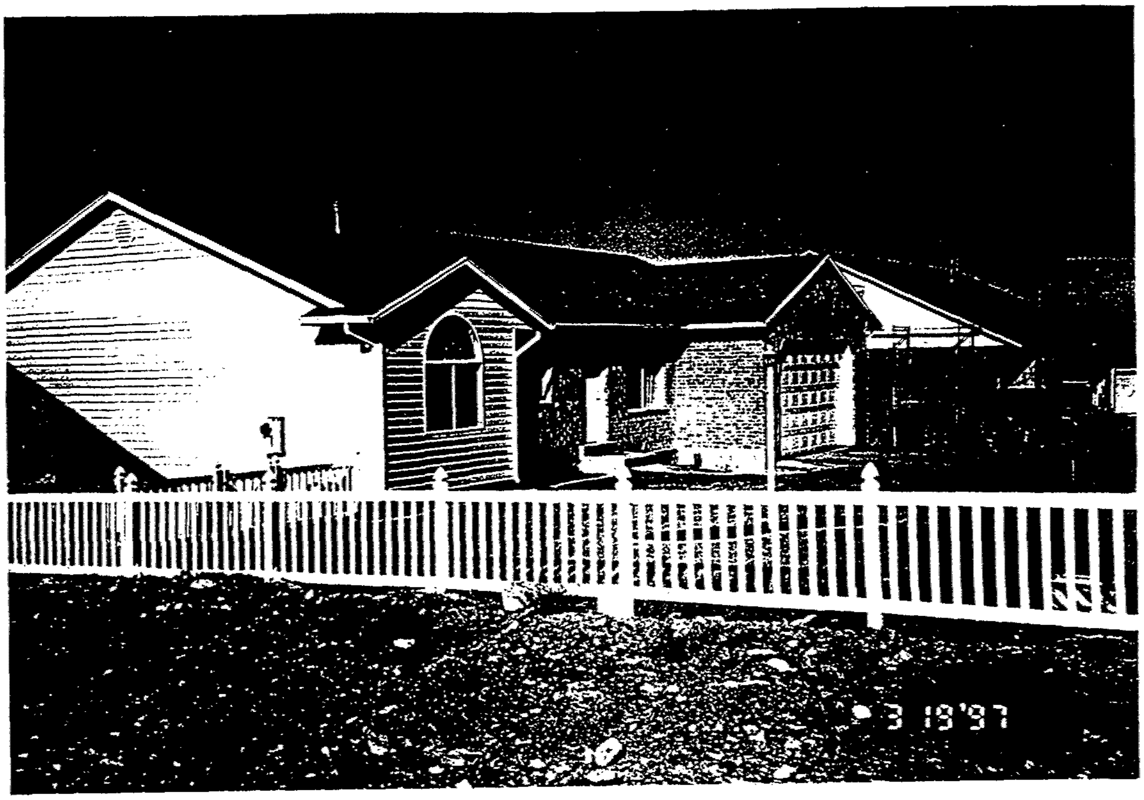
ANNUAL BENEFITS - NORTH EAST
Values in $ 1,000's , Oct 1996 Prices, @ 7 3/8 Int. Rate
$1,500
$1,000
$500
$0
$1,447
$1,194
$414
$0
Benefits
0
20
40
60
80
100
Chance of Failure (1/Prob. Exceedance) in Years

Figure 11



ANNUAL BENEFITS - SOUTH EAST
Values in $ 1,000's , Oct 1996 Prices, @ 7 3/8 Int. Rate
$1,500
$1,000
$500
$0
0
20
40
60
80
100
Chance of Failure (1/Prob. Exceedance) in Years
$1,352
$893
$195
$0
Benefits

ATTACHMENT 1
Photos of Provo Homes and Basements



Above Photo of typical one-story with basement. The upper level is above grade, but a second level is below in basement.

Above is a view of the same house from the side. Notice the basement window below ground level. Rooms such as bedrooms with living quarters are required to have windows for emergency exit. Window allows light (or flood water) to enter but does not provide a view.

ATTACHMENT 1
Photos of Provo Homes and Basements

Above Photo of split-level with basement. The lower level is sunk about four feet. Besides having window entries at ground level, there is also a below ground level door entry in the back.

Recently constructed one-story with basement. Notice windows and side door entry on the left.

ATTACHMENT 1
Photos of Provo Homes and Basements

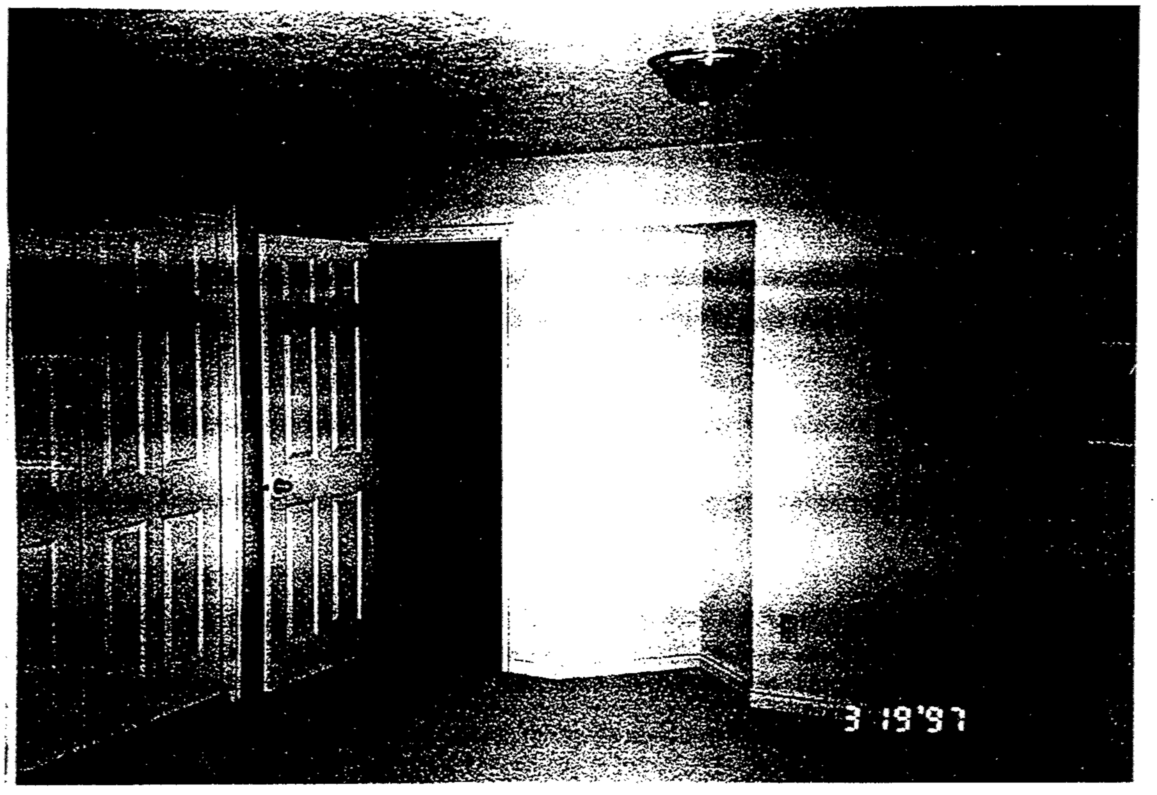
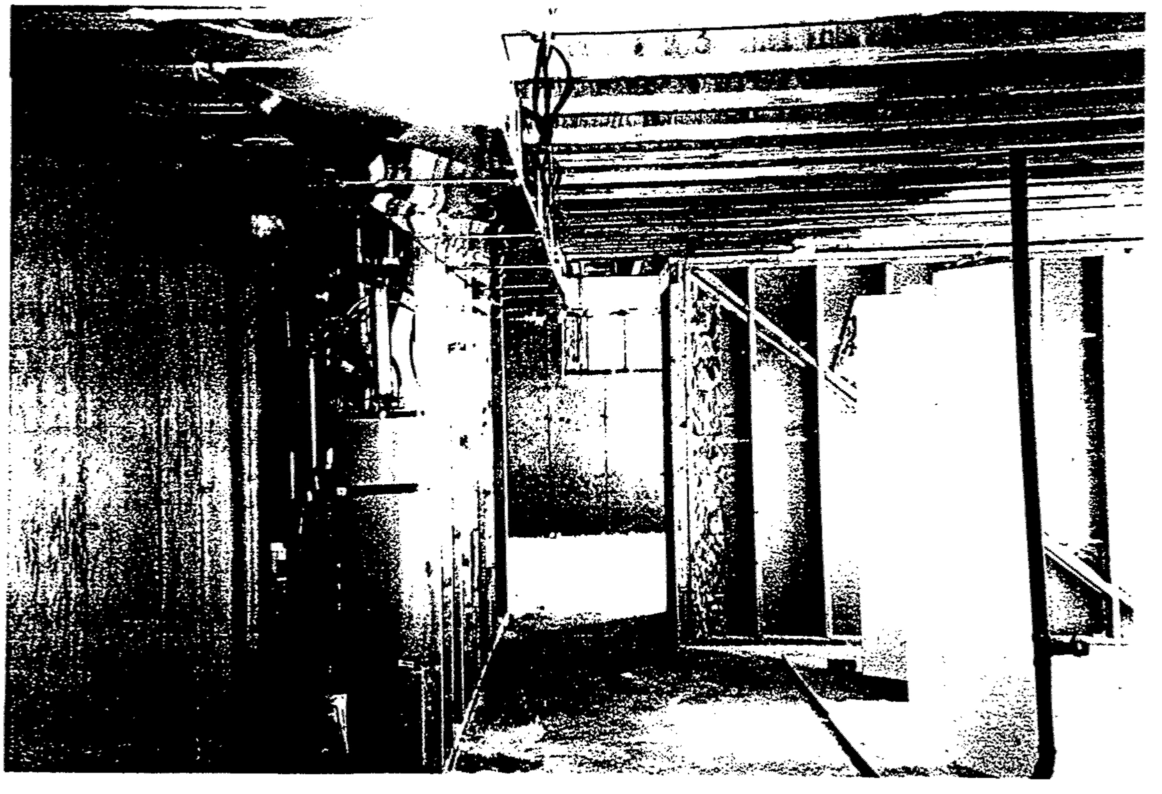


Photo of finished basement bedroom. The basement has full carpeting, insulated walls, CH&A, and completed fixtures. Down the hall is a full bathroom.



Above is a photo of an unfinished basement. The buyer can purchase the home unfinished and later complete the walls and flooring.

ATTACHMENT 1
Photos of Provo Homes and Basements

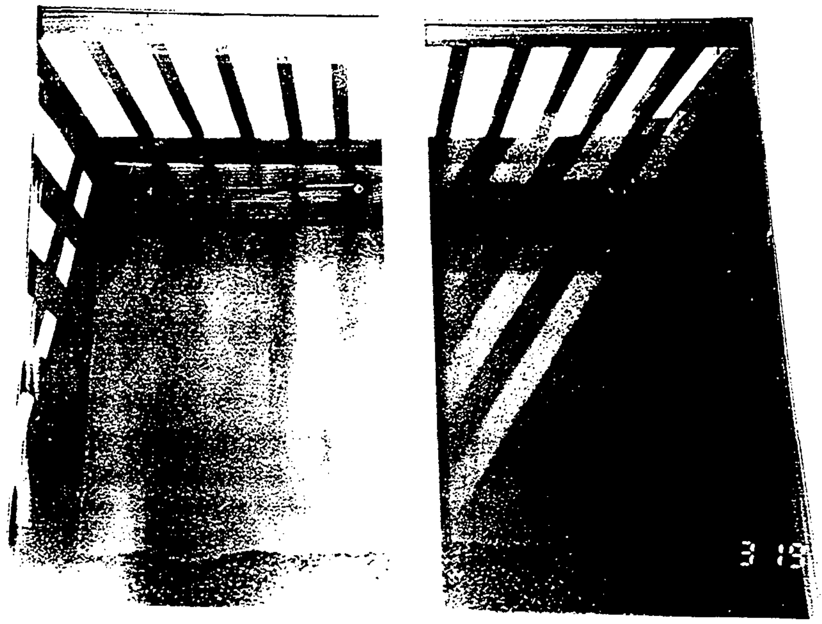


Photo of basement window from inside.

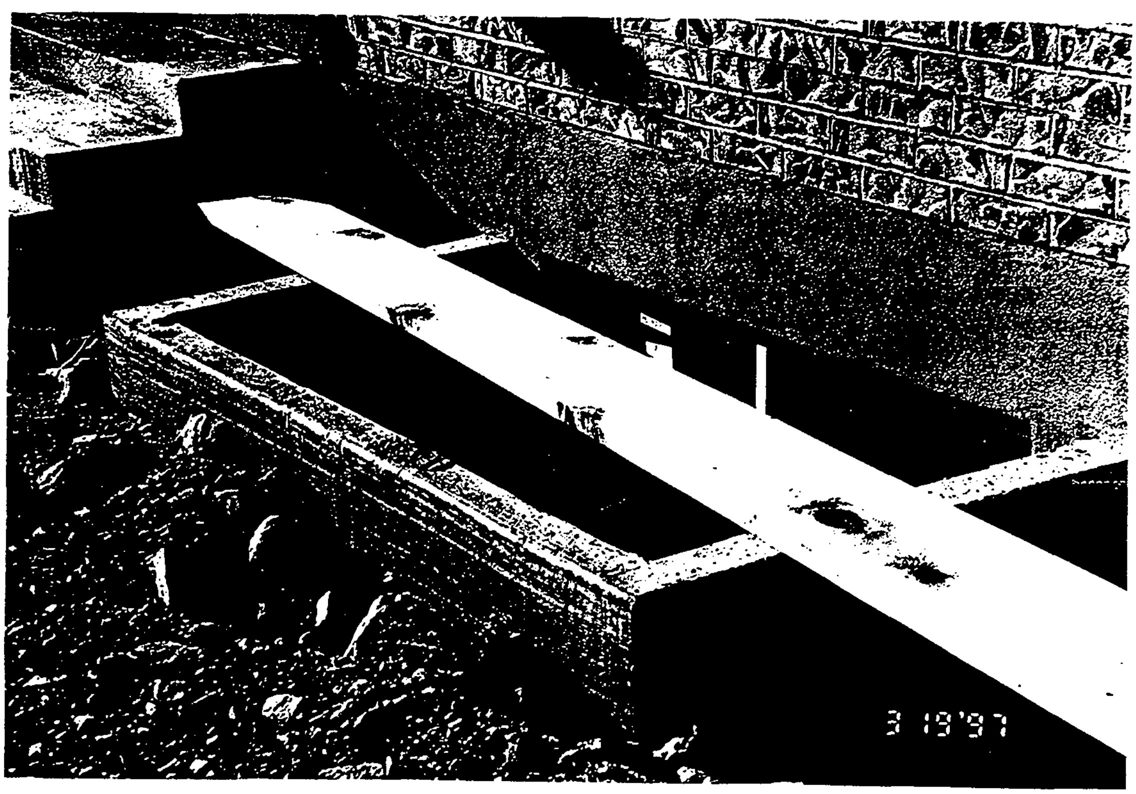


Photo of basement window from outside.

APPENDIX D

BASIS OF DESIGN
(including Hydraulic Design Office Report)

PROVO, UTAH
RECONNAISSANCE
BASIS OF DESIGN AND COST ESTIMATE

March 1997

PROVO, UTAH
BASIS OF DESIGN AND COST ESTIMATE
RECONNAISSANCE REPORT
1997

TABLE OF CONTENTS

TABLE OF CONTENTS - continued

PLATES

ATTACHMENTS

CHAPTER 1 - GENERAL INFORMATION

AUTHORIZATION

Specific direction for this reconnaissance investigation is provided by language in the 28 September 1994 Resolution of the Committee on Public Works and Transportation, U.S. House of Representatives.

PURPOSE

The purpose of this Basis of Design is to summarize the engineering studies performed for the reconnaissance investigation.

GENERAL LOCATION

Provo is located along the Wasatch Front just east of Utah Lake, 45 miles south of Salt Lake City, Utah. The Provo River Basin collects runoff from both the Uinta and Wasatch Mountain Ranges, north and east of the city of Provo.

The primary study area (Plate 1) includes the Provo River from the canyon mouth to Utah lake and the eastside drainages within the corporate limits of Provo. The eastside drainages include Mile High Canyon, Little Rock Canyon, Rock Canyon, Slide Canyon, Slate Canyon, Buckley Canyon, and Ironton Canyon.

CHAPTER 2 - PROPOSED ALTERNATIVES

Various measures were identified and initially considered. The following is a brief description of each alternative.

NO ACTION ALTERNATIVE

Under this alternative, the without-project condition would continue. A description of the without-project condition is included in the main report. No action would be taken by the Federal Government to alleviate flood problems and conditions in the study area.

FLOOD PROOFING ALTERNATIVE

The nonstructural flood proofing alternative would consist of sealing residential buildings to ensure that floodwater would not be able to get inside. All areas below the flood protection level are made watertight. Walls are coated with a waterproofing compound, or plastic sheeting is placed around the wall and covered. Openings, such as doors, windows, sewer lines, and vents, are closed - temporarily, with removable closures, or where appropriate, permanently. Because there are so many homes with basements (or which are split level), this alternative was specifically formulated to prevent this type of flooding.

LEVEE/FLOODWALL/DETENTION BASIN ALTERNATIVE

This alternative was developed based on the most practicable combination of structural measures for each individual reach of the study area. On the Provo River, it was considered that in order to be certifiable, the levees/floodwalls, would have to pass a 1/100-year flow with 3 feet of freeboard and have a reliability of 90 percent. On the Northeast and Southeast drainages, full 1/100-year protection was not viewed as obtainable as construction of sizable detention basins would require removal of many of the structures they would be designed to protect. Therefore, a 1/50 exceedence frequency was utilized.

<u>Provo River</u>

On the Provo River, the structural alternative would consist of raising levees or building floodwalls on top of existing levees in five areas identified for study. The five areas along the river are shown on Plates 2 through 7 and listed below in Table 2-1. Designs and costs were developed for all areas at low, medium, and high levels of protection. The levels of protection chosen were the 1/50 year, 1/100 year, and 1/500 year events.

This alternative was formulated using floodwalls (refer to Plate 17) in all reaches practicable due to adjacent urban development and a flourishing riparian corridor. The floodwalls would require less real estate and have fewer environmental impacts than the levees. Table 2-1 identifies which areas are targeted for floodwalls and which are targeted for levees.

TABLE 2-1 - PROJECT FEATURES

Area	Bank	1/50-Year Level	1/100-Year Level	1/500-Year Level
Below I15				
(I15 to Geneva Rd)	Left	Floodwall	Levee	Levee
	Right	Floodwall	Floodwall	Levee
(Downstream of Geneva Rd)	Left	Floodwall	Floodwall	Levee
	Right	Floodwall	Floodwall	Levee
Industrial Area	Left	Levee	Levee	Levee
Park Area	Left	Levee	Levee	Levee
Moon River Area	Left	Floodwall	Floodwall	Levee
2230 North St. Area	Left	Floodwall	Floodwall	Levee

The proposed levees would have a crown width of 12 feet, landside slopes of 2 ½ H on 1V, and waterside slopes of 3H on 1V. In most areas, the new levees will be keyed into the existing levees (refer to Plates 14 and 15). The height of the levees will vary with a maximum height of about 10 feet.

<u>Northeast and Southeast Drainages</u>

For the contributing eastside watershed, it was determined that detention storage up to the 1/100 exceedance level would not be practicable. Therefore, detention storage was formulated to the 1/50 year exceedance frequency. Refer to the Hydraulic Design Office Report (Attachment AA) for plates showing the eastside drainages.

Designs and costs were developed for the eastside drainages at low, medium, and high levels of protection. The designs for the low level of protection were based on conveyance facilities sized to contain the 100-year snowmelt flow. The designs for the medium level of protection were based on detention facilities sized to handle the 50-year cloudburst and downstream conveyance facilities sized for the 100-year snowmelt. The designs for the high level of protection were based on detention facilities sized to handle the 80-year cloudburst (approximately) and downstream conveyance sized for the 100-year snowmelt.

For the level which includes detention facilities, each of the individual watersheds would have either a new detention basin installed or the existing one enlarged (in the case of Mile High, Rock and Slate Canyons). It was determined that no suitable site exists even for a small detention basin on Little Rock Canyon, therefore, alternative improvements for this watershed will consist of conveyance improvements only. Conveyance facilities downstream of the new/improved detention basins were sized to pass the 100-year snowmelt flow below the intended/existing detention sites.

Alternative Features

The medium level of protection was used to formulate the alternative (1/100 for the river). High and low level costs are presented in this document for comparison purposes.

- Provo River, Levees - Raise existing levees on the left bank below Geneva Road and at the Industrial and Park areas (just upstream from I-15) for a total of approximately 8,700 lineal feet. The levee would have sideslopes of 3 horizontal on 1 vertical on the waterside and 2 ½ horizontal on 1 vertical on the landside. The levee crown width would be 12 feet.

- Provo River, Floodwalls - Construct floodwalls on top of existing levees on the right bank below Geneva Road, on both banks between Geneva Road and Interstate 15, along the left bank adjacent to Moon River Road and on the left bank upstream of 2230 North Street for a total length of approximately 8,300 lineal feet.

- Northeast Drainage - Enlarge existing detention basins on Rock and Mile High Canyons sized for the 50 year cloudburst flow. Construct conveyance to pass the 100 year snowmelt flow. Increase existing conveyance on Little Rock Canyon to pass the 50 year cloudburst flow.

- Southeast Drainage - Construct new detention basins on Slide and Buckley Canyons to pass the 50-year cloudburst flow. Enlarge existing detention basins on Slate Canyon. Construct conveyance downstream of Slide, Slate and Buckley Canyons to pass the 100-year snowmelt flow.

CHAPTER 3 - PROJECT DESIGN

TOPOGRAPHY

The topography of the study area, below Deer Creek Dam, is characterized by steep, narrow canyons in the mountains, and mildly sloping alluvial fans and plains west of the Wasatch front. Channel capacity is much greater in the canyons than on the alluvial fans. Extreme attenuation of high peak flows occurs on the alluvial fans because of an increased manning's n-value and storage which results from the broad, shallow flow. The elevations range from 4,470 feet at Provo to over 11,000 feet in the headwaters.

The following topographic information was used for this study:

- USGS Quadrangle "Provo, Utah", 1948 photorevised 1975, scale 1"=2000', contour interval of 40 feet

- Topographic data provided by the City of Provo in AutoCAD format. Contour interval ranging from 2 to 5-foot. The mapping was developed between 1984 and 1986.

HYDROLOGY

Climate

Normal annual precipitation in the study area varies from approximately 13 inches in central Provo, to 20 inches along the foothill line near Provo, and up to 50 inches on the Wasatch ridge line. The normal annual precipitation in the Provo River headwaters, in the Uinta Mountains, is approximately 40 inches. Normal annual precipitation over the basins varies with elevation (shown on Chart 3, Hydrology Report, attached to the main report). Generally, the study area can be influenced by three types of systems: Tropical convective Pacific air masses from the southwest in the spring and summer, Gulf of Alaska fronts from the northwest in the winter, and the Southern Utah Low (vertical movement of air) during the transition period from summer to winter. Occasionally, summer moisture from the Gulf of Mexico can also reach as far north as the study area. Significant precipitation from tropical Pacific air masses generally results from cloudburst events. The Southern Utah Low produces measurable moisture but not in the intensity of the Tropical Pacific storms or the totals of the Alaska Frontal storms.

Precipitation normally occurs over the area during every month. Thunderstorms, from tropical air masses, generally occur from June to October. The high intensity precipitation from these events usually does not last more than 60 to 90 minutes, and the areal extent of heavy precipitation is small. General rains, covering large areas, can occur from October through May, but are of low to moderate intensity. Precipitation in the mountains generally occurs as snow during the winter and early spring months. A large snowpack typically forms at higher elevations.

The Hydrology Report (Appendix B, to the main report) presents a hydrologic analysis of streams producing flooding in the vicinity of Provo, Utah. Except for the mainstem Provo River, all of the watercourses in the study area have lost their natural stream channels in the valley areas due to urbanization. Widespread sheetflow flooding occurs as runoff leaves the steep mountain front and spreads across the fan and valley floor.

HEC-1 rainfall-runoff models were developed for the eastside drainages. Existing hydrology was evaluated and used for the Provo River mainstem. Preproject flow frequency relationships have been developed at selected concentration points for each basin for the 10-, 2-, 1-, and 0.2-percent chance exceedence flow events. In addition, concurrent flow events from each basin have been developed for storms centered on Rock and Slate Canyons. A stage frequency curve has been developed for Utah Lake, and debris yield-frequency curves have been developed for Rock and Slate Canyons.

Existing Flood Problems

Flooding in the Provo River Basin and Wasatch Front streams typically results from snowmelt runoff or summer thunderstorms. Snowmelt floods in this region generally occur in May or June, but on rare instances can occur as early as April. Time of occurance of these high flows depends upon the elevation of the snowfield and on the sequence and duration of melt-producing temperatures. Jordanelle Dam provides regulation of snowmelt floods in the upper Provo River. Thunderstorms occur frequently in this region during the summer months and early fall, resulting in a high intensity precipitation over small areas. General rainfloods can occur at any time, although general rains in this region do not generally produce flooding when not associated with snowmelt or cloudburst events. Winter rainfloods, which are very rare, result from intense local storms associated with widespread general rainstorms that occur from October through May.

HYDRAULIC ANALYSIS

General

Hydraulic Design section was tasked with: 1) Providing floodplain delineations of seven Wasatch Range drainage basins (referred to as eastside drainages) which are located to the east of the city of Provo, 2) The hydraulic design for the flood control improvements of the eastside drainages, and 3) Determining the water surface elevation standard of error for flood control improvements (project condition) along the Provo River. The Hydraulic Design Office Report is included as Attachment AA to this Basis of Design.

Eastside Floodplain Delineations

Reconnaissance level floodplain delineations were developed for the 50, 100, and 500 year events for the eastside drainages. The eastside drainages include Mile High Canyon, Little Rock Canyon, Rock Canyon, Slide Canyon, Slate Canyon, Buckley Canyon, and Ironton Canyon. The floodplains for these eastside basins were developed using the two-dimensional flood routing computer model FLO-2D. Details of this model are provided in the Hydraulic Design Office Report (Attachment AA).

Results

The existing condition floodplain delineations for the eastside drainages are shown on Plates 2 through 7 of the Hydraulic Design Office Report. Plates 2 through 4 are with a storm centering on Slate Canyon and Plates 5 through 7 are with a storm centering on Rock Canyon. The floodplains are plotted to display floodplain depth. Flood flows from Little Rock Canyon, Rock Canyon and Mile High Canyon commingle over the floodplain, and Slide Canyon, Slate Canyon, and Buckley Canyon commingle over the floodplain (Ironton was dropped as part of the study because it does not commingle with any of the other drainages).

Eastside Drainages, Flood Control

During the floodplain delineation of the eastside drainages the determination that flood flows from Little Rock Canyon, Rock Canyon and Mile High Canyon commingle over the floodplain, and Slide Canyon, Slate Canyon, and Buckley Canyon commingle over the floodplain results in two separate sets of floodplains, and therefore, two separate project analyses. The Northern project includes Mile High Canyon, Little Rock Canyon, and Rock Canyon. The Southern project includes Slide Canyon, Slate Canyon, and Buckley Canyon.

Flood control improvements to the eastside drainages include sizing detention basins for each canyon and providing conveyance improvements downstream of the detention basins. Improvements consist of developing detention basins at or near each canyon mouth such that the 50-year cloudburst will be detained, and to provide conveyance improvements downstream of the detention basins for the 100-year snowmelt event. The 100-yr snowmelt peak flows and the 50-yr cloudburst peak flows are shown in Table 3-1 below.

TABLE 3-1 - PEAK FLOWS

Basin	100-yr Snowmelt Peak	50-yr Cloudburst Peak
Mile High Canyon	10 cfs	112 cfs
Little Rock Canyon	26 cfs	238 cfs
Rock Canyon	210 cfs	1052 cfs
Slide	30 cfs	276 cfs
Slate	155 cfs	801 cfs
Buckley	21 cfs	236 cfs

TABLE 3-2 - BASIN STORAGE VOLUME*

Basin	50 Yr Cloudburst Storage (ac-ft)	Spillway Elevation (ft)
Mile High	16.0	5083.5
Rock	133.0	4967.5
Slide	9.6	4882.5
Slate	60.9	4690.7
Buckley	9.2	4834.2

*Volumes shown assume a certain amount of debris. Refer to the Hydraulic Design office report for the debris volumes.

**Three basins exist at Slate Canyon. Basin 1 is small and was ignored in the analysis.

GEOTECHNICAL

General

Soil Design Section was requested to provide a site inspection, evaluate the existing Provo River levees and detention basins, and provide stable levee and typical floodwall cross sections. The detention basins were not evaluated for structural stability or seepage. No explorations were done for this study. The Soil Design Section PNP/PFP Office Memorandum is included as Attachment BB to this Basis of Design.

Probable Failure and Probable Non-Failure Points

The Probable Non-Failure Point (PNP) and Probable Failure Point (PFP) values are water surface elevations selected for use in the Risk and Uncertainty Analyses (R&U). The PNP is that water surface elevation where failure of the levee is unlikely. The PFP is that water surface elevation where there is a high probability of failure. For the R&U Analyses, the PNP is assigned a 15% chance of failure and the PFP is assigned an 85% chance of failure. Guidelines for selecting the PNP/PFP values are provided in ETL 1110-2-328. Depending on availability of subsurface information, considerations used in selecting these values generally include the results of slope stability and seepage analyses, past performance, visual inspections of the levee, and to a large degree, geotechnical engineering judgement.

The PNP/PFP values in this report are of reconnaissance level based on information obtained from past performance, limited soil information, engineering judgement and field observation. Soil classification and descriptions are based on field observations of surface materials only. The PNP/PFP values provided in this report are referenced from the lowest levee height for the reach described.

Levee and Floodwall Design

The proposed levees would have a crown width of 12 feet, landside slopes of 2 ½ H on 1V, and waterside slopes of 3H on 1V. The new levees will be keyed into the existing levees (refer to Plates 14, 15, and 16). The height of this levee will vary with a maximum height of about 10 feet.

The proposed floodwall will be of reinforced concrete and have an approximate width at the top of 6 inches and range in height from zero to 4 feet above the existing levee surface. The footing of the floodwall will range in depth with a maximum depth of about 7 feet.

Borrow Areas

Potential borrow sites within the study area were identified during the field visit. An exploration program was not conducted as a part of this study but is recommended prior to construction to determine the availability of suitable materials.

RELOCATIONS AND UTILITIES

At this time, no relocations have been identified.

CHAPTER 4 - REAL ESTATE

Real Estate Report not available at time of writing.

CHAPTER 5 - OPERATION AND MAINTENANCE

GENERAL

It will be the responsibility of the local sponsor to accept the project after completion and ensure that all operation and maintenance is in accordance with federal regulations.

MAINTENANCE REQUIREMENTS

Periodic maintenance of the levee and around various appurtenances will be required maintain the levee elevation design capacity.

Maintenance requirements will be discussed in detail in the operation and maintenance manual. In general, an engineer experienced in making determinations shall make inspections of all structures following each flood and make recommendations for corrective action.

OPERATION AND MAINTENANCE MANUAL

Subsequent to the completion of the design of the project features , an operation and maintenance manual will be prepared by the Sacramento District, in coordination with the local sponsor and affected agencies. The manual will be provided to the local sponsors.

CHAPTER 6 - COST ESTIMATES

BASIS OF COST ESTIMATES

The cost estimates presented below are reconnaissance level costs based on 1 October 1996 price levels.

FLOOD PROOFING ALTERNATIVE

A Flood Plain Management Evaluation Model was used to estimate an average per structure cost of flood proofing. Results of the model indicated that the basic average cost would be approximately $16,600, per structure, to protect against the 100-year event. A flood warning system will also be included in this alternative at an estimated cost of $25,000 per area.

TABLE 6-1 - ESTIMATED ALTERNATIVE COSTS
(RECONNAISSANCE LEVEL)

Area	First Costs	IDC*	Annual Costs
Provo River	$7,760,000	$280,000	$670,000
Northeast	$71,050,000	$2,570,000	$6,150,000
Southeast	$64,450,000	$2,330,000	$5,580,000

*IDC- Interest During Construction

LEVEE/FLOODWALL/DETENTION BASIN ALTERNATIVE

TABLE 6-1 - ESTIMATED PROJECT FIRST COSTS
(RECONNAISSANCE LEVEL)

Reach	Low	Medium	High
Downstream of I15- I-15 to Geneva Rd	1,619,700	2,261,500	3,249,100
Downstream of Geneva Rd	1,016,700	1,121,300	5,691,300
Industrial	342,200	366,400	438,700
Park	1,490,900	1,602,000	1,880,200
Moon River	192,700	407,700	7,940,300
2230 North St	256,300	419,700	1,908,000
Mile High Canyon	1,146,700	1,284,600	1,288,200
Little Rock Canyon	2,097,400	3,054,100	3,532,100
Rock Canyon	2,685,200	7,009,300	8,873,800
Slate Canyon	2,095,900	4,517,800	6,193,500
Slide Canyon	4,879,700	6,932,000	7,700,400
Buckley Canyon	1,358,300	4,206,600	4,207,600
TOTAL FIRST COSTS	$19,181,500	$33,183,100	$52,903,200

TABLE 6-2 - INTEREST DURING CONSTRUCTION
(RECONNAISSANCE LEVEL)

Reach	Low	Medium	High
Provo River	178,100	224,000	764,400
Northeast Drainages	214,700	411,000	496,000
Southeast Drainages	301,800	567,000	655,600
TOTAL - IDC	$694,600	$1,202,000	$1,916,000

TABLE 6-3 - ANNUAL COSTS
(RECONNAISSANCE LEVEL)

Reach	Low	Medium	High
Provo River	397,000	498,000	1,703,000
Northeast Drainages	478,000	915,000	1,105,000
Southeast Drainages	672,000	1,263,000	1,460,000
TOTAL - ANNUAL COSTS	$1,547,000	$2,676,000	$4,268,000

PLATES

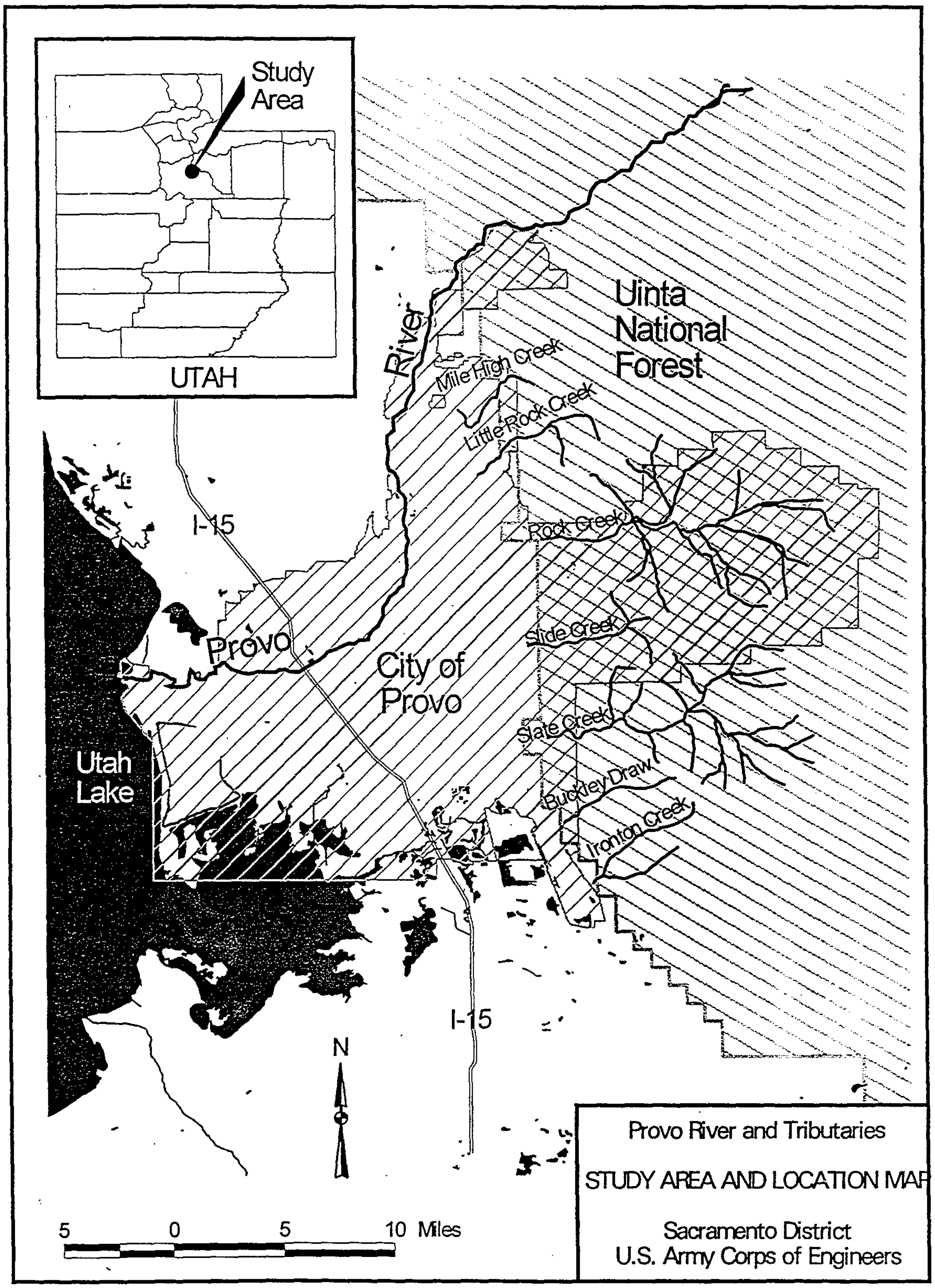
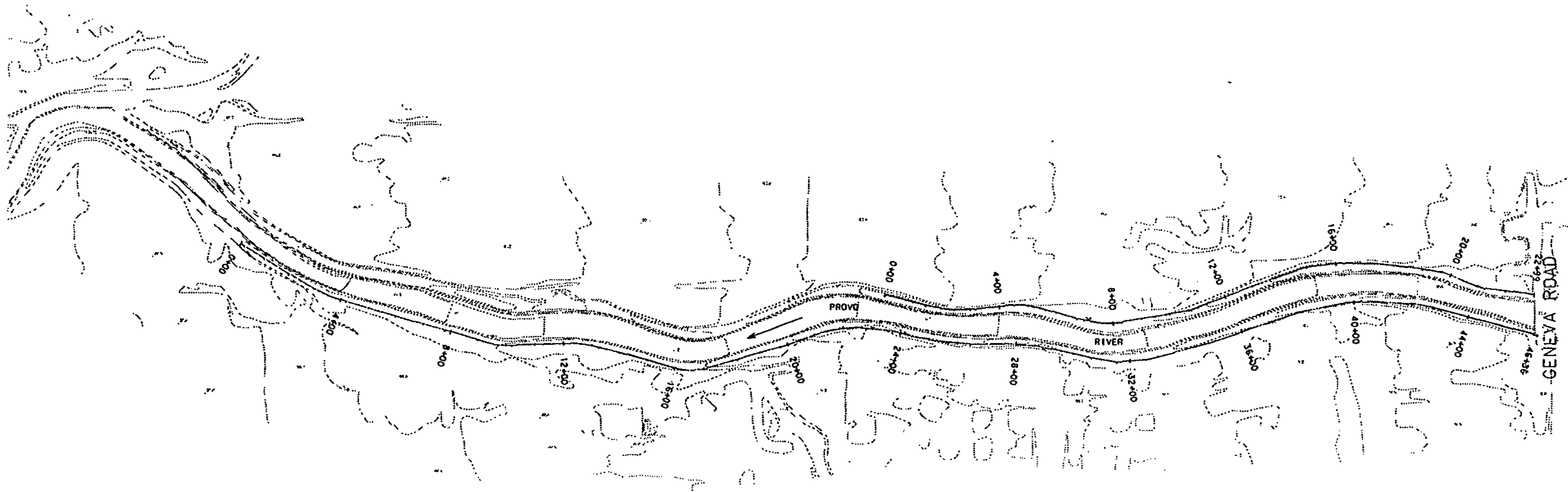

Study Area
UTAH
Uinta National Forest
River
Provo
Mile High Creek
Little Rock Creek
Rock Creek
Slide Creek
Slate Creek
Buckley Draw
Ironton Creek
City of Provo
I-15
Utah Lake
I-15
N
5 0 5 10 Miles
Provo River and Tributaries
STUDY AREA AND LOCATION MAP
Sacramento District
U.S. Army Corps of Engineers

PLATE 1



NOTES:

WHERE L IS LEVEE AND FW IS FLOODWALL

	50YR	100YR	500YR
LEFT BANK	FW	L	L
RIGHT BANK	FW	FW	L

LENGTH (IN FEET) OF EACH FEATURE

	50YR	100YR	500YR
LEFT BANK	4086	4086	4086
RIGHT BANK	2300	2300	2300

FOR REAL ESTATE PURPOSES, IT WAS ASSUMED THAT A WIDTH OF 6 FT WOULD BE REQUIRED FOR A FLOODWALL AND A WIDTH OF 20' BEYOND THE LEVEE TOE WOULD BE REQUIRED FOR THE LEVEE ALTERNATIVES

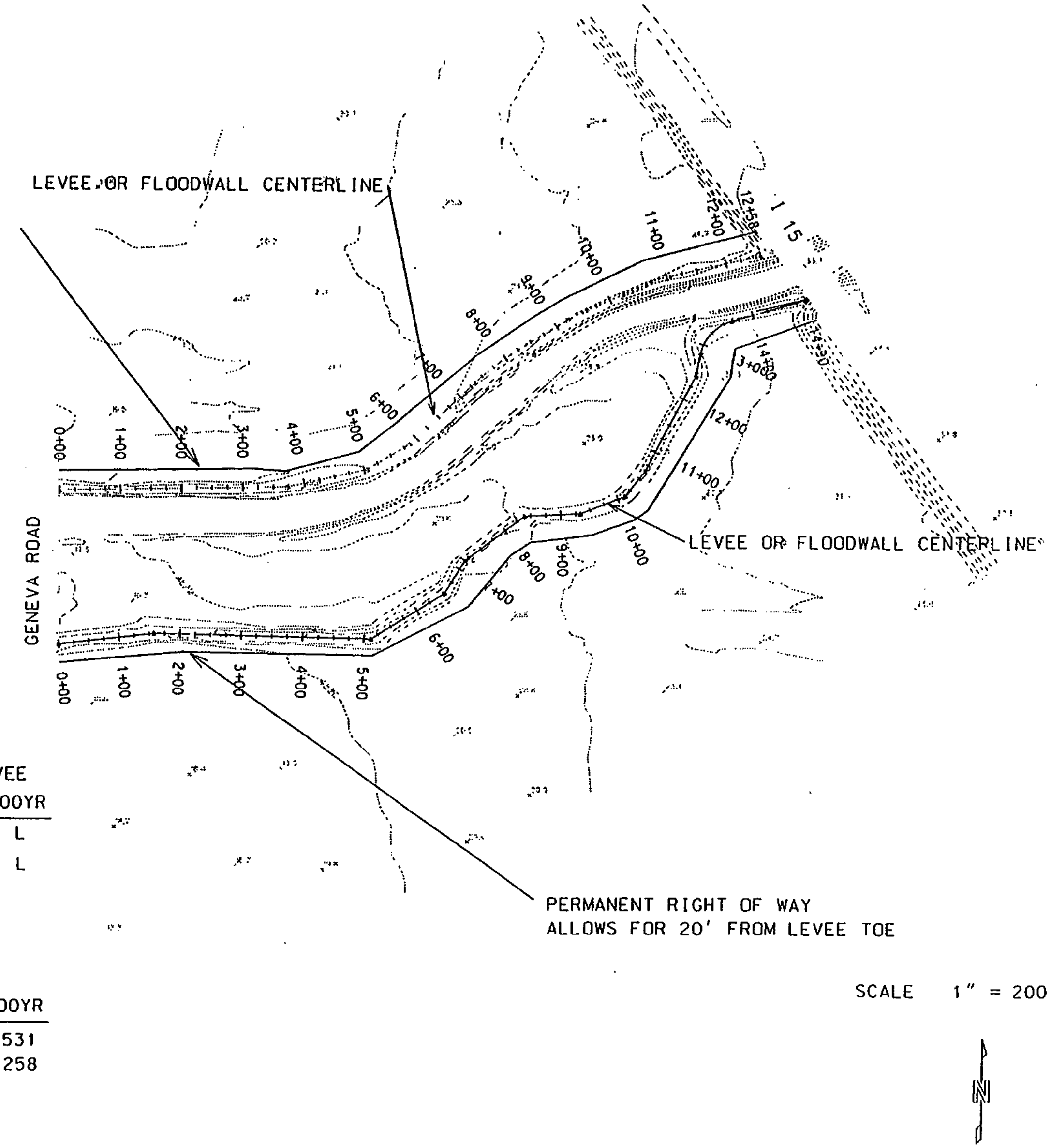
SCALE 1" = 400'

N

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

PROVO
UTAH
DOWNSTREAM OF GENEVA ROAD
PLAN VIEW

Sheet reference number: 2



NOTES:

* WHERE FW IS FLOODWALL AND L IS LEVEE

	50YR	100YR	500YR
LEFT BANK	FW	FW	L
RIGHT BANK	FW	FW	L

FEATURE LENGTHS IN FEET

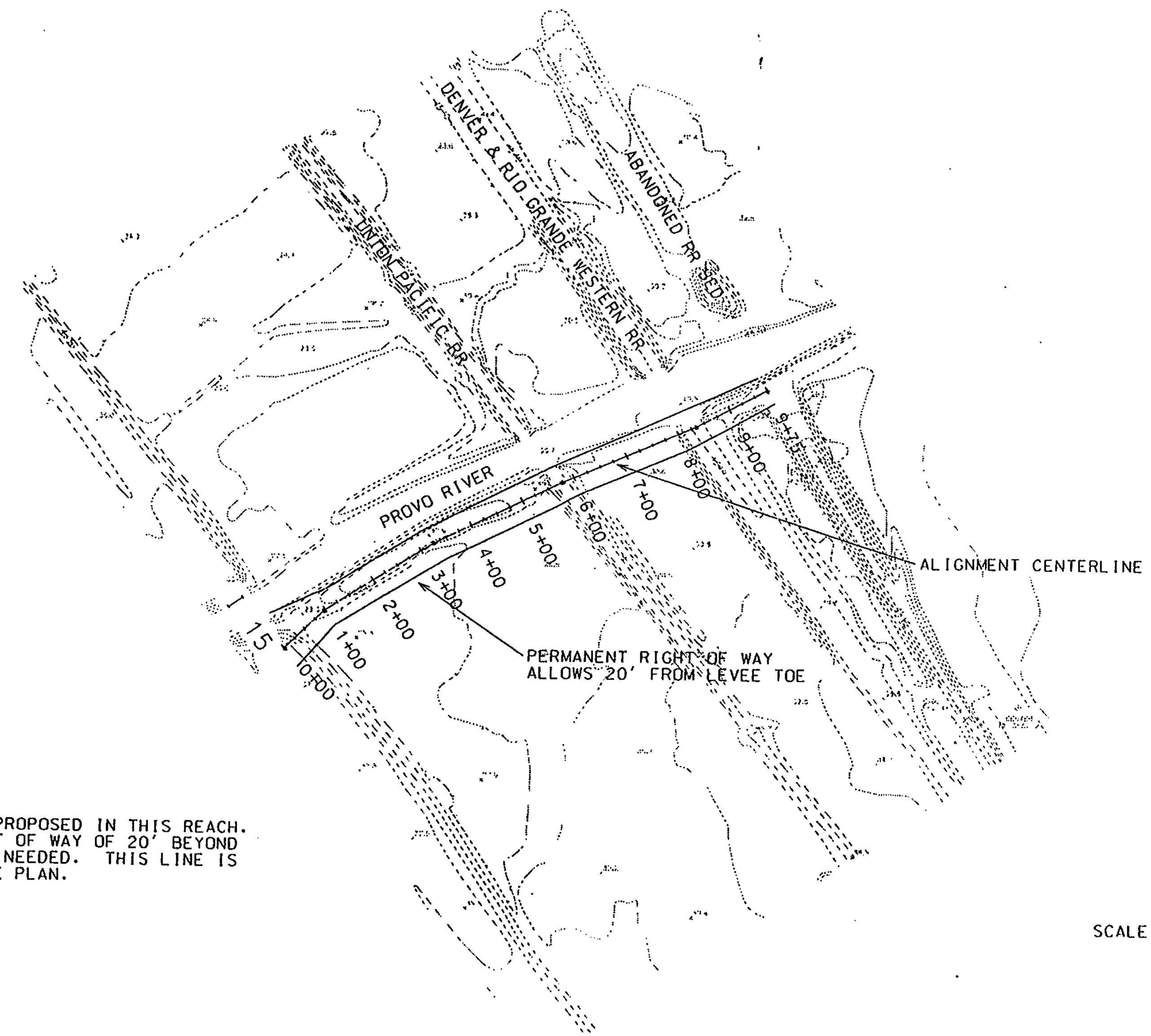
	50YR	100YR	500YR
LEFT BANK	1531	1531	1531
RIGHT BANK	1258	1258	1258

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

PROVO
UTAH

I15 TO GENEVA ROAD
PLAN VIEW

Sheet reference number: 3



LEVEES ONLY ARE PROPOSED IN THIS REACH.
A PERMANENT RIGHT OF WAY OF 20' BEYOND
THE LEVEE TOE IS NEEDED. THIS LINE IS
DELINEATED ON THE PLAN.

SCALE 1" = 200'

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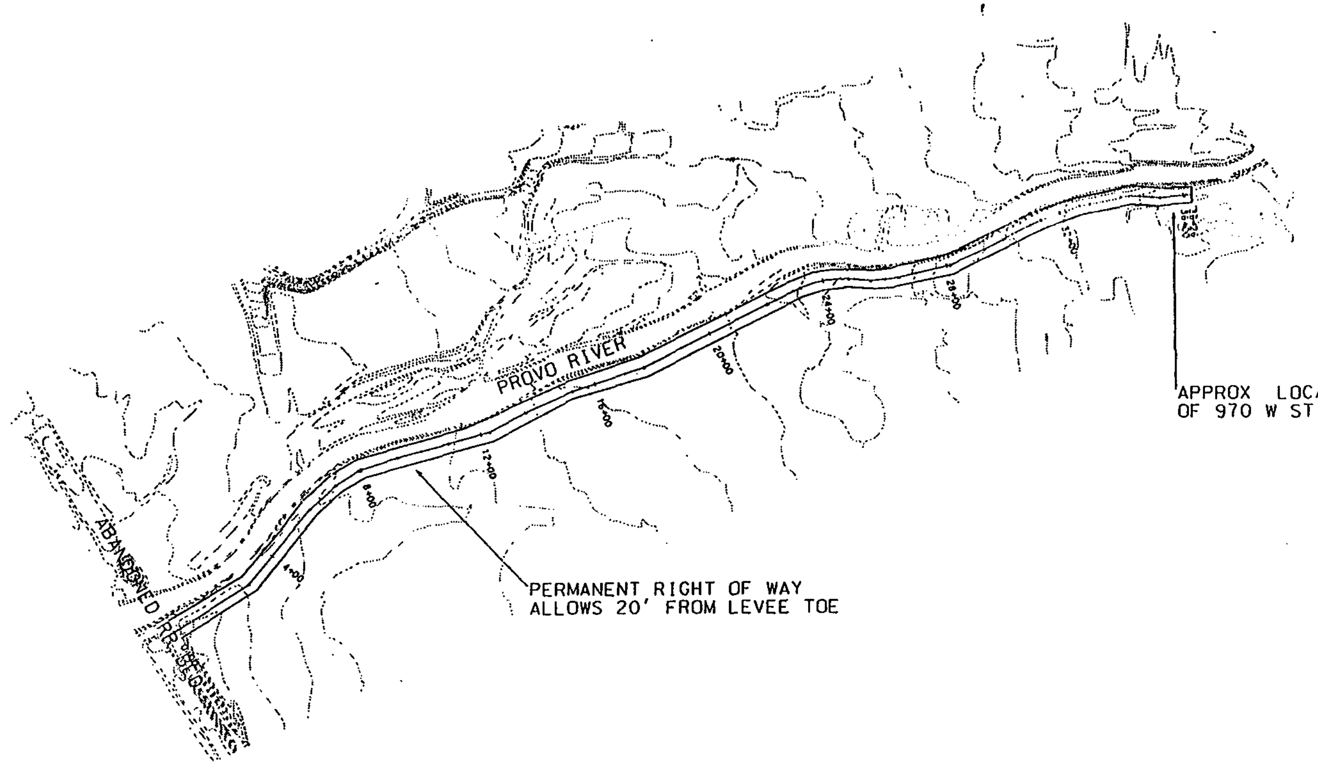
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

PROVO
UTAH

INDUSTRIAL AREA
PLAN VIEW

Sheet reference number: 4



LEVEES ONLY ARE PROPOSED IN THIS REACH. A PERMANENT RIGHT OF WAY OF 20' BEYOND THE LEVEE TOE IS NEEDED. THIS LINE IS DELINEATED ON THE PLAN.

SCALE 1" = 400'

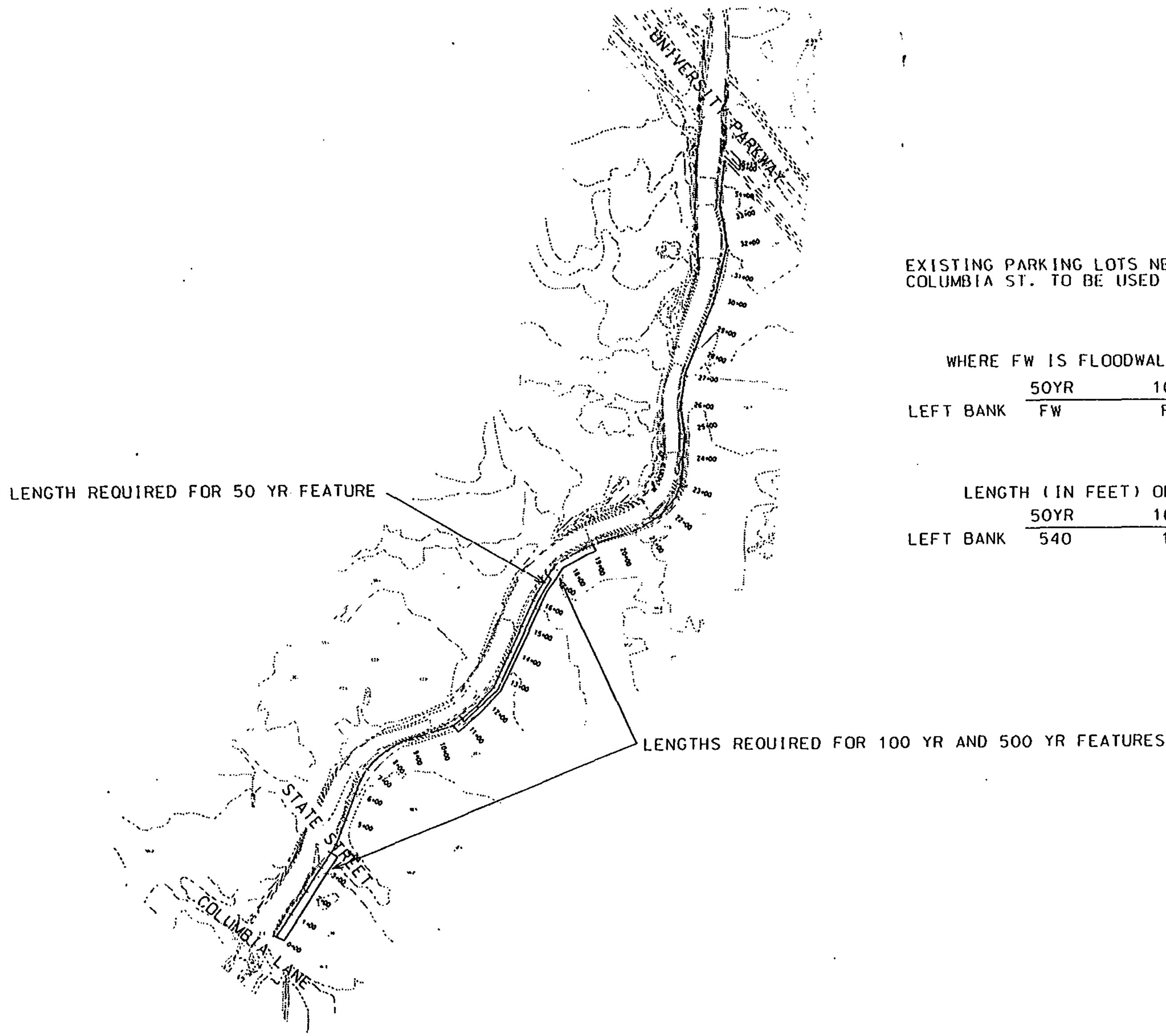
N

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

PROVO
UTAH

PARK AREA
PLAN VIEW

Sheet reference number: 5



EXISTING PARKING LOTS NEAR STATE ST. AND COLUMBIA ST. TO BE USED FOR STAGING AREAS.

WHERE FW IS FLOODWALL AND L IS LEVEE

	50YR	100YR	500YR
LEFT BANK	FW	FW	L

LENGTH (IN FEET) OF FEATURE

	50YR	100YR	500YR
LEFT BANK	540	1050	1050

SCALE 1" = 400'

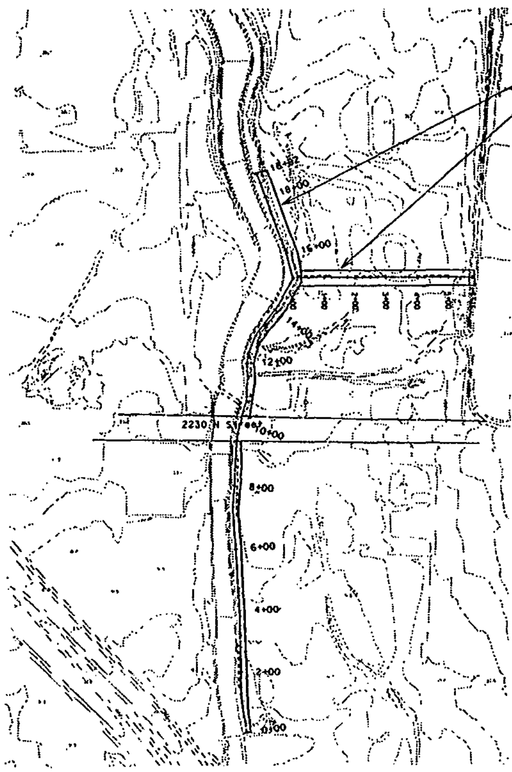
N

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

PROVO
UTAH

MOON RIVER
PLAN VIEW

Sheet reference number: 6



PROPOSED LEVEE RIGHT OF WAY REQUIREMENTS (500 YR LEVEL OF PROTECTION)

NOTES:

DASHED LINE REPRESENTS LENGTH REQUIRED FOR 50 YR LEVEL OF PROTECTION

LENGTH REQUIRED FOR 100 YR LEVEL OF PROTECTION IS SIMILAR TO THAT FOR THE 500 YR LEVEL WITH THE DIFFERENCE BEING THAT THE 100 YR LEVEL IS SLIGHTLY SHORTER AT ALL ENDS.

WHERE L IS LEVEE AND FW IS FLOODWALL

	50 YR	100 YR	500 YR
LEFT BANK	FW	FW	L

LENGTH (IN FEET) OF EACH FEATURE

	50 YR	100 YR	500 YR
LEFT BANK	1160	2190	2380

FOR REAL ESTATE PURPOSES, IT WAS ASSUMED THAT A WIDTH OF 6 FT WOULD BE REQUIRED FOR A FLOODWALL AND A WIDTH OF 20 FT BEYOND THE LEVEE TOE WOULD BE REQUIRED FOR THE LEVEE ALTERNATIVE.

THE RIGHT OF WAY FOR THE 500 YR LEVEL OF PROTECTION LEVEE IS SHOWN.

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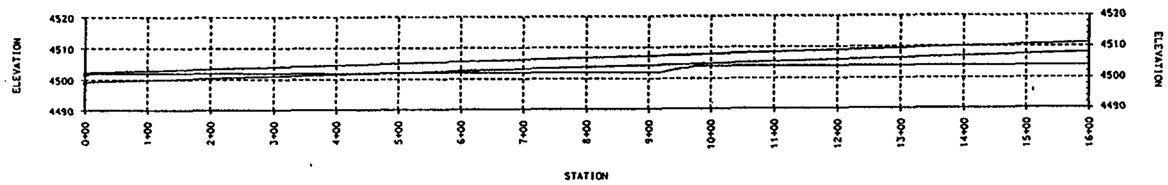
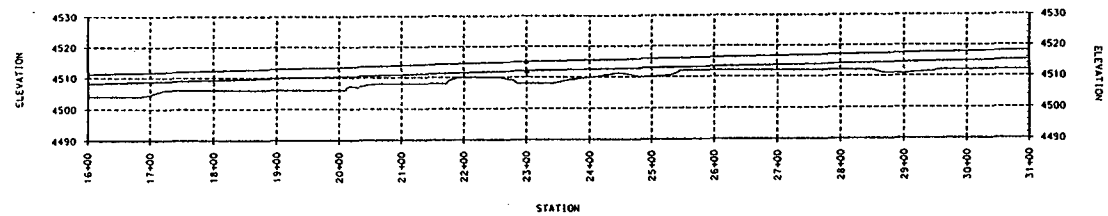
PROVO
UTAH
2230 NORTH AREA
PLAN VIEW

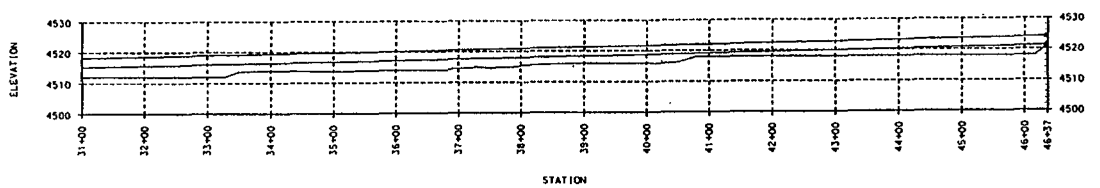
Sheet reference number: 7

THIS REACH TIES INTO THE REACH IMMEDIATELY UPSTREAM (I15 TO GENEVA RD). THE REACHES WERE SPLIT ONLY FOR EASE OF DESIGN. THEY ARE CONSIDERED ONE REACH IN THE FORMULATION.

DOWNSTREAM OF GENEVA RD, LEFT BANK 100 YR PROFILES







LEFT BANK
100 YR SHOWN ON PROFILES ABOVE

PROPOSED LEVEE
PROFILE ELEVATION DATA (IN FT)

STATION	50 YR	100 YR	500 YR
0+00	4498.2	4502.3	4505.2
23+00	4512.8	4515.1	4517.7
46+37	4522.1	4524.1	4526.3

WATER SURFACE
PROFILE ELEVATION DATA (IN FT)

STATION	50 YR	100 YR	500 YR
0+00	4496.9	4499.3	4502.2
23+00	4509.8	4512.1	4514.6
46+37	4519.1	4521.1	4523.3

RIGHT BANK

PROPOSED LEVEE
PROFILE ELEVATION DATA (IN FT)
100 YR SHOWN ON PROFILES ABOVE

STATION	50 YR	100 YR	500 YR
0+00	4512.8	4515.1	4517.7
23+75	4522.1	4524.1	4526.3

WATER SURFACE
PROFILE ELEVATION DATA (IN FT)

STATION	50 YR	100 YR	500 YR
0+00	4509.8	4512.1	4514.7
23+75	4519.1	4521.1	4523.3

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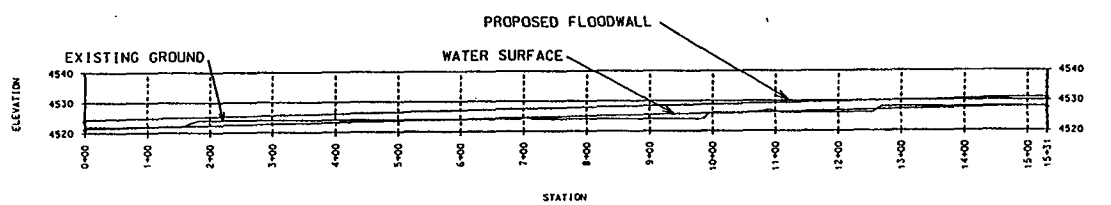
PROVO
UTAH
DOWNSTREAM OF GENEVA ROAD
PROFILES

Sheet reference number: 8

I15 TO GENEVA RD. LEFT BANK 100 YR PROFILES



LEFT BANK

PROPOSED LEVEE
PROFILE ELEVATION DATA (IN FT)
100 YR SHOWN ON PROFILES ABOVE

STATION	50 YR	100 YR	500 YR
0+00	4522.3	4524.3	4526.4
15+31	4529.9	4531.1	4533.3

WATER SURFACE
PROFILE ELEVATION DATA (IN FT)

STATION	50 YR	100 YR	500 YR
0+00	4519.3	4521.5	4523.4
15+31	4526.9	4528.1	4530.3

RIGHT BANK

PROPOSED LEVEE
PROFILE ELEVATION DATA (IN FT)
100 YR SHOWN ON PROFILES ABOVE

STATION	50 YR	100 YR	500 YR
0+00	4522.3	4524.3	4526.4
12+73	4529.9	4531.1	4533.3

WATER SURFACE
PROFILE ELEVATION DATA (IN FT)

STATION	50 YR	100 YR	500 YR
0+00	4519.3	4521.5	4523.4
12+73	4526.9	4528.1	4530.3

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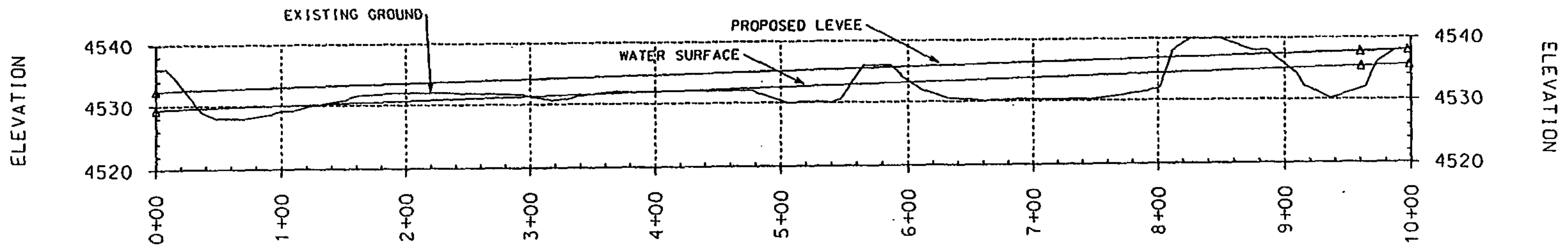
I15 TO GENEVA ROAD
PROFILES

Sheet reference number: 9

INDUSTRIAL AREA, 100 YEAR PROFILES



LEFT BANK

PROPOSED LEVEE
PROFILE ELEVATION DATA (IN FT)
100 YR SHOWN ON PROFILES ABOVE

STATION	50 YR	100 YR	500 YR
0+00	4530.6	4532.4	4535.7
15+31	4536.9	4538.3	4542.0

WATER SURFACE
PROFILE ELEVATION DATA (IN FT)
100 YR SHOWN ON PROFILES ABOVE

STATION	50 YR	100 YR	500 YR
0+00	4527.6	4532.4	4535.7
15+31	4533.9	4538.3	4542.0

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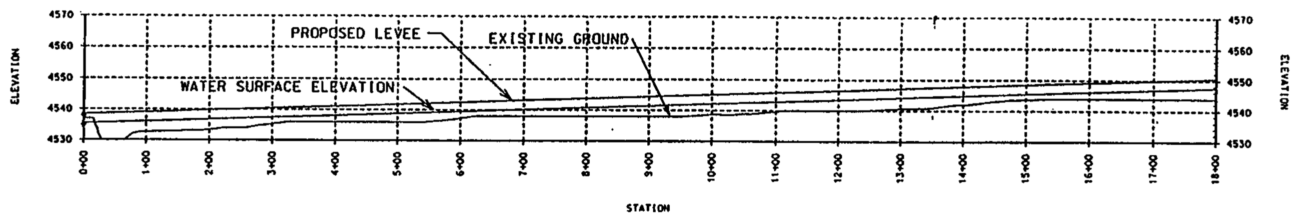
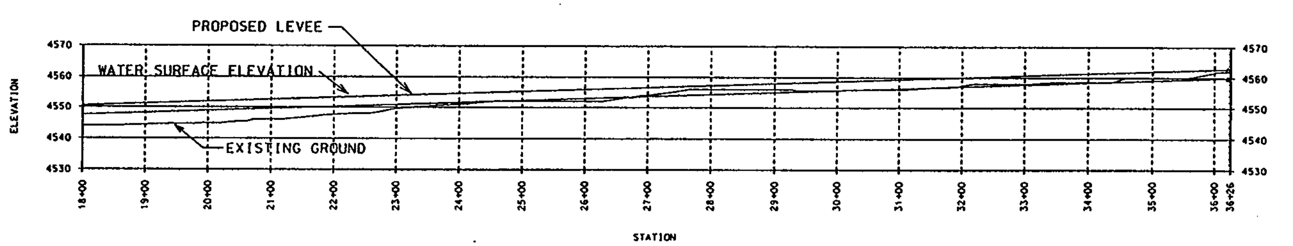
UTAH

INDUSTRIAL AREA
PROFILES

Sheet reference number: 10

PARK AREA, 100 YEAR PROFILES





LEFT BANK

PROPOSED LEVEE
PROFILE ELEVATION DATA (IN FT)
100 YR SHOWN ON PROFILES ABOVE

STATION	50 YR	100 YR	500 YR
0+00	4536.9	4538.3	4542.0
15+31	4560.7	4563.0	4566.1

WATER SURFACE
PROFILE ELEVATION DATA (IN FT)
100 YR SHOWN ON PROFILES ABOVE

STATION	50 YR	100 YR	500 YR
0+00	4533.9	4535.3	4539.0
15+31	4557.7	4558.0	4563.1

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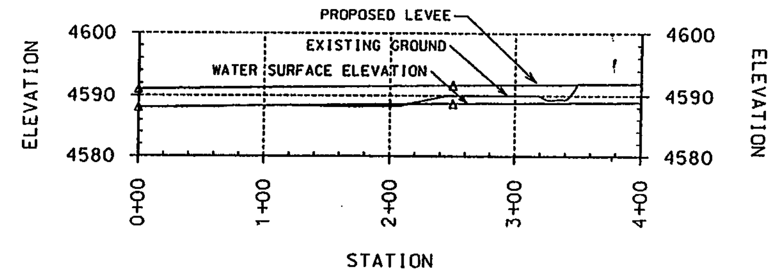
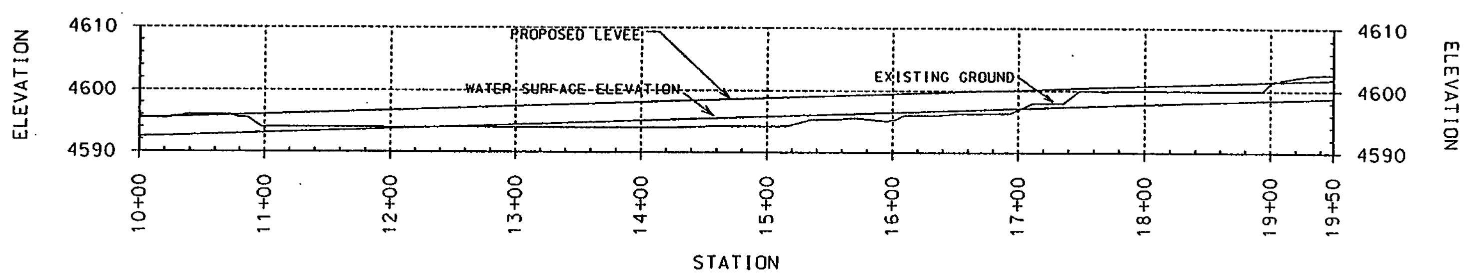
PARK AREA
PROFILES

Sheet reference number: 11

MOON RIVER, 100 YEAR PROFILES





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PROPOSED LEVEE
PROFILE ELEVATION DATA (IN FT)
100 YR SHOWN ON PROFILES ABOVE

STATION	50 YR	100 YR	500 YR
0+00		4591.1	4594.0
11+00	4593.8	4596.1	4600.0
14+00	4595.9	4598.1	4601.8
17+00	4597.9	4600.1	4603.7
19+00		4601.5	4604.9

WATER SURFACE
PROFILE ELEVATION DATA (IN FT)
100 YR SHOWN ON PROFILES ABOVE

STATION	50 YR	100 YR	500 YR
0+00		4588.1	4591.0
11+00	4590.8	4593.1	4597.0
14+00	4592.9	4595.1	4598.8
17+00	4594.9	4597.1	4600.7
19+00		4598.5	4601.9

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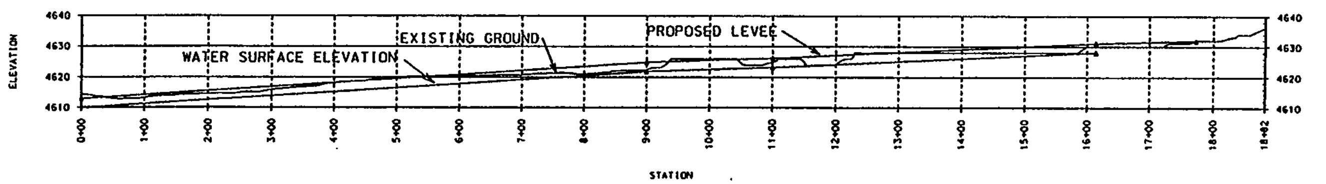
2230 NORTH STREET. 100 YEAR PROFILES



LEFT BANK

PROPOSED LEVEE
PROFILE ELEVATION DATA (IN FT)
100 YR SHOWN ON PROFILES ABOVE

STATION	50 YR	100 YR	500 YR
0+00	N/A	4612.9	4616.6
9+00	4622.9	4624.9	4626.9
11+00	4624.6	4626.2	4630.2
16+14	4629.4	4631.1	4634.0

WATER SURFACE
PROFILE ELEVATION DATA (IN FT)
100 YR SHOWN ON PROFILES ABOVE

STATION	50 YR	100 YR	500 YR
0+00	N/A	4609.9	4613.6
11+00	4619.9	4621.9	4623.9
14+00	4621.6	4623.2	4627.2
17+00	4626.4	4628.1	4631.0

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UTAH
2230 NORTH STREET
PROFILES

Sheet reference number: 13

ATTACHMENT AA

PROVO RECONNAISSANCE STUDY
PROVO, UTAH

HYDRAULIC DESIGN OFFICE REPORT

APRIL 1997

CIVIL DESIGN BRANCH
SACRAMENTO DISTRICT CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

PROVO RECONNAISSANCE STUDY

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PROVO RIVER RECONNAISSANCE STUDY

SECTION 1 - INTRODUCTION

1.01 Purpose and Scope. The purpose of this study is to provide reconnaissance level flood control improvements for the city of Provo, Utah. Hydraulic Design Section was tasked with: 1) Providing floodplain delineations of seven Wasatch Range drainage basins (eastside drainages) which are located to the east of the city of Provo, 2) The hydraulic design for the flood control improvements of the eastside drainages, 3) Floodplain delineation of the Provo River, and 4) Determining the water surface elevation standard error for flood control improvements (project condition) along the Provo River.

1.02 Study Area. The project study area includes the Provo River, the city of Provo, and the eastside drainages (drainages located to the east of the city). The study area is shown on Plate 1.

SECTION 2 - EASTSIDE FLOODPLAIN DELINEATIONS

2.01 General. Reconnaissance level floodplain delineations were developed for the 50, 100, and 500 year events for the eastside drainages. The eastside drainages include Mile High Canyon, Little Rock Canyon, Rock Canyon, Slide Canyon, Slate Canyon, Buckley Canyon, and Ironton Canyon (see Plate 1).

2.02 Model. The floodplains for the Provo eastside basins were developed using the two-dimensional flood routing computer model FLO-2D. FLO-2D is a physical process based finite difference model which routes flood hydrographs (and rainfall runoff if this option is used) over unconfined surfaces using a diffusive wave approximation to the momentum equation. Flow depth and velocity are predicted at grid nodes and represent the grid element average values for a small time step. The square grid element size is selected based on project needs, but typically range from 50 to 1000 feet per side. The model can simulate flow over complex topography and roughness, channel flow, flow exchange between the channel and the floodplain, and street and gully flow. The flow regime can vary between supercritical and subcritical flow as the floodwave moves down the floodplain, channels, and streets. Flood simulation can include application of several components such as rainfall, infiltration, bridge and culvert components, modeling the effects of buildings or other flow obstructions, sediment transport, and mud and debris flow. Particular model features/components are initiated with on/off switches in a control file.

2.03 Model Input.

a. Grid. Each FLO-2D element is represented by a grid node which is identified by a grid element/node number, its x and y coordinates, and elevation. The grid elements were selected to be 400 foot per side. The topographic information used to create the grid was from DEM's (digital elevation models) of USGS quad sheets within the study area. A gridded surface was then created from the DEM's using Inroads (Intergraph Civil Site Design software). The gridded surface was developed at the selected FLO-2D grid size of 400 feet.

b. Floodplain. A global Manning's "n" value of 0.08 was applied to all elements of the floodplain. The current model does not contain grid element area reductions to account for structures or other flow obstructions. However, a few elements were completely blocked from flow near the location of the inflow hydrographs in order get flow directed its correct direction. Several floodplain grid elevations were modified following initial runs to remove depressions, or ponding areas, within the floodplain. The elevations were modified after looking at a quad sheet to verify that no depression in the topography existed.

c. Hydrology. Inflow hydrographs were provided for each drainage basin (at the mouth of the each canyon) for two different storm centerings. The storm centerings were on the two largest drainage basins, Rock Canyon and Slate Canyon. The 50-year hydrograph on Rock Canyon was reduced by 100 cfs due to an existing drainage pipe at the mouth of the canyon which has a capacity of 200 cfs (as indicated in the Storm Drainage Master Plan for the city of Provo). For events greater than the 50-year, flows were not reduced because the reduction of 100 cfs would not cause a significant difference in the extent of the floodplain. There are existing debris basins on Rock Canyon and Slate Canyon. The hydrographs for the 50-year event are located in the vicinity of the basin spillways. For the 100 and 500 year events, the hydrographs are input at a location within the basin or the just upstream of the basin. Based on the debris basin rating curves it is likely the 50-year event will pass through the outlet works and over the spillway, but the 100 and 500 year events are likely to overtop the debris basin. When the basins are overtopped, flow will be spread over a wider area at the debris basins and take on different flow paths.

2.04 Results. The existing condition floodplain delineations for the eastside drainages are shown on Plates 2 through 7. Plates 2 through 4 are with a storm centering on Slate Canyon and Plates 5 through 7 are with a storm centering on Rock Canyon. The floodplains are plotted to display floodplain depth. Flood flows from Little Rock Canyon, Rock Canyon and Mile High Canyon commingle over the floodplain, and Slide Canyon, Slate Canyon, and Buckley Canyon commingle over the floodplain (Ironton Canyon does not commingle with any of the other drainages). Flood flows were determined along a cross section where the floodplains commingled. The commingled flows for Little Rock, Rock Canyon and Mile High Canyons are for a storm centering over Rock Canyon. The commingled flows for Slide, Slate Canyon, and Buckley Canyons are for a storm centering over Slate Canyon. Table 1 represents the peak commingled flows.

TABLE 1 - PEAK COMMINGLED FLOOD FLOWS

Peak Commingled Flows (cfs)		
50-Year Event	**100-Year Event**	**500-Year Event**
***Slate Canyon Centering** - Slide, Slate and Buckley Canyons*		
648	1501	5308
***Rock Canyon Centering** - Mile High, Little Rock, and Rock Canyons*		
390	2138	6531

There are areas of the floodplain, especially the southern area near the railroad tracks, which show isolated ponding areas. It is difficult to say weather these depths are valid. Many of the floodplain elevations in this area have already been adjusted based on the USGS quad sheet information as indicated in paragraph 2.03.b., but it is possible that elevation errors exist in the USGS DEM's. The DEM's do not contain railroad track embankment. The FLO-2D elements which contain the railroad tracks were not modified to reflect any embankment, therefore all floodplain results assume no embankments along the railroad tracks. Embankments were not added because of the uncertainty of the embankment elevation and the location, if any, of any culverts passing through the embankments.

SECTION 3 - EASTSIDE DRAINAGES, FLOOD CONTROL

3.01 General - During the floodplain delineation of the eastside drainages (see Section 2) it was determined that flood flows from Little Rock Canyon, Rock Canyon and Mile High Canyon commingle over the floodplain, and Slide Canyon, Slate Canyon, and Buckley Canyon commingle over the floodplain (Ironton Canyon does not commingle with any of the other drainages). This results in two separate sets of floodplains, and therefore, two separate project analyses. The Northern project includes Mile High Canyon, Little Rock Canyon, and Rock Canyon. The Southern project includes Slide Canyon, Slate Canyon, and Buckley Canyon. Flood conditions analyzed for the Northern project are based on a storm centering over Rock Canyon while flood conditions for the Southern project are based on a storm centering over Slate Canyon (refer to the Hydrology Appendix for more information).

Flood control improvements to the eastside drainages include sizing detention basins for each canyon and providing conveyance improvements downstream of the detention basins. Improvements consist of developing detention basins at or near each canyon mouth (except Ironton which is not part of the project, see previous paragraph) such that the 50-year cloudburst will be detained, and to provide conveyance improvements downstream of the detention basins for the 100-year snowmelt event. This design condition is referred to as the Middle Level Project in the main report. Following the development of the designs for the original tasking, it was desired to come up with a design providing greater protection. The greater level of design, referred to as the High Level Project in the main report, is a low level of detail design and is described in paragraphs 3.03.b.4 and 3.03.c.4.

3.02 Design Parameters.

a. Topography - The topography used to lay out the detention basins and to determine storage information was provided by the City of Provo in AutoCAD format. The contour interval varies between 2 foot and 5-foot. The mapping was developed between 1984 and 1986. The AutoCAD files were imported into Intergraph and 3D terrain models were developed (using Inroads) in the area of each of the detention basin locations.

b. Detention Basin sizing - Storage-elevation data was developed for each prospective basin location using Inroads. This was done by creating a shape of the basin area, setting the shape to various elevations, and then computing the volume between the shape and the base terrain model (actual topography) at each shape elevation. Data was gathered to a storage volume of at least the 50-year cloudburst volume.

Each basin was designed to accommodate the 50-year debris volume, 10 years of estimated annual debris accumulation, and the 50-year clear water storage requirement with the unregulated outlet works, sized to convey the 100-year peak snowmelt flow, in operation. In sizing the detention basins it was assumed that a storm was centered over the basin being designed. Table 2 shows the peak 50-yr cloudburst and 100-year snowmelt flows for each canyon. The debris volumes were assumed to exist in the basin prior to routing flows through the basin. The gross pool elevation, or spillway elevation, was then set at the maximum pool elevation obtained from the routed 50-year cloudburst event.. All routings were performed using HEC-1. The PSIAC method was used for determining debris yield volumes for flood events and for average annual debris yield. Refer to the Hydrology appendix for the debris yield assumptions, parameters and debris yield curves. Based on the information provided in the Hydrology report, the estimated 50-year debris volumes and volume of 10 years of average annual debris for each drainage basin are shown in Table 3.

TABLE 2. PEAK FLOWS

Basin	100-yr Snowmelt Peak	50-yr Cloudburst Peak
Mile High Canyon	10 cfs	112 cfs
Little Rock Canyon	26 cfs	238 cfs
Rock Canyon	210 cfs	1052 cfs
Slide Canyon	30 cfs	276 cfs
Slate Canyon	155 cfs	801 cfs
Buckley Canyon	21 cfs	236 cfs

TABLE 3. - DEBRIS VOLUMES

Drainage Basin	50-year debris volume (ac-ft)	10 yrs of average annual debris, (ac-ft)
Mile High Canyon	1.1	0.8
Little Rock Canyon	3.2	2.2
Rock Canyon	33	17.6
Slide Canyon	3.6	2.4
Slate Canyon	23	12.4
Buckley Canyon	3.2	1.8

c. Outlet Works - Under design conditions it is assumed that flow is not released through the outlet works until the water elevation is greater than the elevation of debris. The debris elevation was determined from the storage elevation curves (see Appendix for storage elevation curves for each basin). The outlet works are designed to be a circular concrete conduit with a minimum diameter of 3-foot (Corps criteria). The outlet works conduit will have an entrance at the basin/conduit invert elevation that will contain a trash rack. The outlet works conduit is sized such that, as a minimum, the 100-year snowmelt peak is conveyed (see Table 2 for the 100-yr snowmelt peaks). A rectangular concrete drop inlet type pipe riser will be located near the outlet works entrance to allow flow to enter the outlet works if the entrance becomes blocked by debris. The riser will have rectangular ports to allow water to enter the riser and outlet works conduit as it rises in the detention basin. The top of the riser will be set at an elevation above the expected debris elevation and such that head on the riser under the 50-year peak flow will pass through the riser without any flow over the spillway. A trash rack will be will be constructed on top of the riser. Typical outlet works details are shown on Plate 8.

The outlet works rating curves are based on an inlet control assumption with the control being the at the outlet works conduit (rather than the riser). The rating curve was developed for the outlet works conduit using a FHWA (Federal Highway Administration) chart for inlet control for concrete pipes and the orifice equation. The assumption was made that this rating would still be valid when the entrance to the conduit is blocked and flow is through the riser ports and over the riser spillway (top of the riser). The outlet works conduit will be on a minimum slope of 3%.

d. Spillway Design - Each detention basin spillway was designed to pass the cloudburst probable maximum flood (PMF). The PMF for each canyon is shown on Table 4. Spillways were designed as a broad crested weir with a weir coefficient, C, of 2.9 for all spillways. The length of the spillway was selected such that the head on the spillway was between 5 and 10 feet.

TABLE 4 - PROBABLE MAXIMUM PEAK FLOWS

Drainage Basin	PMF peak flows (cfs)
Mile High Canyon	2,120
Little Rock Canyon	4,450
Rock Canyon	17,840
Slide Canyon	5,420
Slate Canyon	14,320
Buckley Canyon	4,510

e. Pipeline Design - Downstream of the detention basins, flows will generally conveyed through pipelines, which in most cases will be the same size as the outlet works conduit. These pipes were sized based on a normal depth computation with a slope of 2%. Pipes were assumed to be concrete. Open channel flow will exist in the pipelines at the 100-year snowmelt peaks, but may be pressure flow during the cloudburst peaks. For pipes unrelated to the outlet of the detention basins (see Mile High Canyon and Little Rock Canyon, paragraph 3.03), sizing the pipe at the inlet was based on inlet control, and determining the required size downstream of the inlet was based on a normal depth computation.

3.03 Design Results.

a. General - Due to the development of the city Provo at or near the mouths of the canyons, selecting an area to place a detention basin was very limited. Sites were selected near the canyon mouths while trying to avoid impacts to development in the area. The sites were chosen based on aerial photography dated between 1984 and 1986, as well as more recent street maps. Plate 9 shows the general location of the Northern area project detention basins. Plate 10 shows the general location of the Southern area project detention basins. Because there has been a considerable amount of development on the eastside benches since the dating of aerial photography, detention basin locations shown in this study may not be acceptable due to development which is not shown on the mapping. Conveyance improvements downstream of the detention basin will generally follow similar alignments of existing storm water drainage pipes along the city streets. The pipelines were sized according to paragraph 3.02.e. The pipeline alignments and sizes are shown in the Basis of Design report.

b. The Northern Area Project

1) Mile High Canyon - Due to the development at the mouth of the canyon, there is no area to construct a detention basin; however, there is an existing ponding area at Foothill Dr (downstream from the canyon mouth) that currently acts as a detention basin. This is the selected site for the detention basin (see Plate 11). Foothill Drive will act as the dam. There is no requirement to raise the existing roadway elevation to provide additional storage. A 2-foot pipe currently exists under Foothill Blvd. A new outlet works will be required. The outlet works will include a 3-foot diameter conduit and a riser. Foothill drive will act as the spillway.

In order to get the 50-year cloudburst flow (112 cfs) into the basin a pipeline with a concrete head wall must be installed at the mouth of the canyon the collect the flows. A 5-foot diameter pipe has been sized at the inlet. This results in a head water depth of 4.7 feet. Since the pipeline will be on a gradient no less than 8% the pipe can transition to a 3-foot diameter downstream of the entrance. The new pipeline is about 500-foot in length and will discharge in the ravine upstream of the detention basin (see Plate 11). There is an existing 2-foot diameter pipe which begins at the canyon mouth discharges in the ravine upstream of the detention basin. This pipe was neglected in the sizing of the new pipeline.

Table 5 provides design condition storage-elevation data and rating curve data for the Mile High Basin. The storage elevation and rating curve data was developed for the following conditions:

50-year debris volume in basin = 1.1 ac-ft
10-years of debris in basin = 0.8 ac-ft
Elevation of basin with debris (1.9 ac-ft total) in basin = 5069'
Outlet invert = 5063'
Flow not released from through outlet until elevation 5069'
Outlet pipe diameter = 3.0
Spillway elevation (top of road) = 5083.5'

TABLE 5 - MILE HIGH CANYON
STORAGE-ELEVATION, RATING CURVE DATA - DESIGN CONDITION

Elevation	Depth (ft)	Storage (ac-ft)	Outlet Works Flow (cfs)	Spillway Flow (cfs)	Total Flow (cfs)
5069	0.0	0.0	0.0	0.0	
5070	1.0	0.1	10.0	0.0	
5075	6.0	4.8	70.0	0.0	
5080	11.0	10.7	105.0	0.0	
5085	16.0	18.0	130.0	537.0	667.0
5087	18.0	20.9	138.3	2025.0	2163.0
5089	20.0	23.8	146.4	5170.0	5316.4

2) Little Rock Canyon - The area around Little Rock Canyon is mostly developed, leaving only one potential area to place a detention basin. The area just upstream of Foothill Drive was studied and found to have an inadequate area for the required storage. Therefore, a pipeline was designed to contain the

50-year cloudburst (238 cfs). The inlet will be located at the mouth of the canyon. The new pipeline will follow the alignment of the existing 2-foot pipe which is located at the canyon mouth. A 7-foot diameter pipe with a head wall structure is required at the inlet to collect the water. The head water depth will be 6.3 feet. The 7-foot diameter pipe can transition down to a 54-inch downstream of the inlet (see Plate 12).

3) **Rock Canyon** - An existing detention basin exists at Rock Canyon. This basin will be raised to a crest elevation of 4974.5-feet (see Plate 13). The current basin elevation crest is at 4964.0 feet. The current outlet works conduit (48-inches) is adequately sized to convey the 100-year snowmelt event. Table 6 provides storage-elevation data and rating curve information for the design condition. The design condition data is as follows:

Spillway Elevation = 4967.5'
Spillway Length = 350'
50-year Debris Volume = 33 ac-ft
10 years on annual debris deposition = 17.6 ac-ft
Basin Elevation with debris (50.6 ac-ft) = 4953.5 ft
Outlet conduit diameter = 4 feet
Outlet works invert = 4940.0'

TABLE 6 - ROCK CANYON
STORAGE-ELEVATION, RATING CURVE DATA - DESIGN CONDITION

Elevation	Depth (ft)	Storage (ac-ft)	Outlet Works Flow (cfs)	Spillway Flow (cfs)	Total Flow (cfs)
4940	0.0	0.0	0.0	0.0	0.0
4945	0.0	0.0	0.0	0.0	0.0
4950	0.0	0.0	0.0	0.0	0.0
4955	1.5	9.4	21.0	0.0	21.0
4960	6.5	47.0	120.0	0.0	120.0
4965	11.5	104.4	185.0	0.0	185.0
4968	14.5	135:0	210.0	500.0	710.0
4970	16.5	155.4	230.0	4080.0	4310.0
4972	18.5	183.0	245.8	9700.0	9945.8
4974	20.5	210.0	260.2	16820.0	17080.0
4975	21.5	224.4	267.2	20850.0	21117.0

4) **Additional Design** - Following the development of the designs for the original tasking, it was desired to come up with a design providing greater protection. Storage-elevation data exists for Rock Canyon up to elevation 4980'. By assuming the same Rock Canyon spillway design as above (paragraph 3.03.b.3), the spillway elevation would be at 4973.0' with a crest elevation of 4980'. A volume of 80-acre-

feet of debris was assumed to be in the basin. A 100-year hydrograph routing results in an estimated storage capacity prior to spilling of the 85-year event. A 100-year level protection was assumed at Little Rock Canyon, although a pipe was not sized for this flow. At Mile High Canyon, existing storage provided greater protection than the 100-year level. The above three combinations account for the greater level of protection design for the Northern area. This is referred to as the High Level Project, North Area, in the main report. It should be noted that there was a very low level of detail performed for this design.

c. The Southern Area Project

1) Slide Canyon - Slide Canyon detention basin is located at the mouth of the canyon as shown on Plate 14. It is located as far into the canyon mouth as possible to avoid an existing golf course. The golf course was constructed after the aerial photography was developed. It is difficult to determine if the selected location is in conflict with the golf course. The 50-year basin design is as follows :

Dam crest elevation = 4889.0'
Spillway elevation = 4882.5'
Spillway Length = 125'
Outlet conduit diameter = 3.0'
Outlet works invert elev. = 4855'
Total debris volume (see Table 3) = 6.0 ac-ft
Debris elevation = 4971.5'

Table 7 shows the storage elevation and rating curve data for the 50-year design condition.

TABLE 7 - SLIDE CANYON
STORAGE-ELEVATION, RATING CURVE DATA - DESIGN CONDITION

Elevation	Depth (ft)	Storage (ac-ft)	Outlet Works Flow (cfs)	Spillway Flow (cfs)	Total Flow (cfs)
4855	0.0	0.0	0.0	0.0	0.0
4860	0.0	0.0	0.0	0.0	0.0
4865	0.0	0.0	0.0	0.0	0.0
4870	0.0	0.0	0.0	0.0	0.0
4871.5	0.0	0.0	0.0	0.0	0.0
4875	3.5	2.5	40.0	0.0	40.0
4880	8.5	6.7	90.0	0.0	90.0
4883	11.5	9.7	105.0	128.2	233.0
4885	13.5	11.7	115.0	1432.9	1548.0
4890	18.5	17.6	140.3	7445.6	7586.0

2) Slate Canyon - Three basins exist at Slate Canyon. The lower two basins (basin #2 and basin#3) were modified to contain the 50-year design event. See Plate 15. Basin #1 was ignored in the analysis. Remedial repairs to the Slate Canyon Basin were designed Tettemer & Associates in 1984. Existing storage elevation data and rating curve data from the 1984 remedial repairs were used for basin #2 up until the elevation that modifications were required for this study. Modifications include; 1) raising basin #2 and basin #3 to the same elevation such that they perform as one basin under flood events, 2) eliminating the existing spillway on basin #2, 3) constructing a spillway between basin #2 and basin #3 such that water will spill from basin #2 to basin #3 when it basin #2 is full, 4) constructing new outlet works for basin #3, and 5) expanding the spillway on basin #3 to handle the PMF. The design conditions assume basin #2 is filled with debris to the spillway elevation (between elevation #2 and elevation #3) with remainder of the debris volume in basin #3. The 50-year basin design is as follows :

Dam crest elevation (basin # 2 and basin# 3) = 4697.5'
Spillway elevation beween basin #2 and # 3 = 4690.7'
Spillway Length between basin #2 and basin #3 = 100'
Spillway elevation at basin #3 = 4690.7'
Spillway length of basin #3 = 280'
Outlet conduit diameter (basin #3) = 4.0'
Outlet works invert elev. (basin #3) = 4660.0'
Total debris volume (see Table 3) = 35.4 ac-ft
Debris elevation (basin #3) = 4666.5'

Table 8 shows the storage elevation and rating curve data for the 50-year design condition

TABLE 8 - SLATE CANYON
STORAGE-ELEVATION, RATING CURVE DATA - DESIGN CONDITION

Elevation	Depth (ft)	Storage (ac-ft)	Outlet Works Flow (cfs)	Spillway Flow (cfs)	Total Flow (cfs)
4666.5	0.0	0.0	0.0	0.0	0.0
4670	3.5	7.5	60.0	0.0	60.0
4675	8.5	19.0	150.0	0.0	150.0
4680	13.5	31.5	200.0	0.0	200.0
4685	18.5	44.7	245.8	0.0	245.8
4690	23.5	58.9	280.6	0.0	280.6
4690.7	24.2	60.9	285.1	0.0	285.1
4692	25.5	66.4	293.3	1204.0	1497.0
4694	27.5	77.4	305.5	4868.0	5173.0
4697	30.5	93.7	323.0	12840.0	13163.0
4697.5	31.0	96.5	326.0	14399.0	14724.0

3) Buckley Canyon - Buckley Canyon is located at the mouth of the canyon as shown on Plate 16. The 50-year basin design is as follows :

Dam crest elevation = 4840.0'
Spillway elevation = 4834.2'
Spillway Length = 125'
Outlet conduit diameter = 3.0'
Outlet works invert elevation = 4820.0'
Total debris volume (see Table 3) = 6.0 ac-ft
Debris elevation = 4827.8'

Table 9 shows the storage elevation and rating curve data for the 50-year design condition.

TABLE 9 - BUCKLEY CANYON
STORAGE-ELEVATION, RATING CURVE DATA - DESIGN CONDITION

Elevation	Depth (ft)	Storage (ac-ft)	Outlet Works Flow (cfs)	Spillway Flow (cfs)	Total Flow (cfs)
4827.8	0.0	0.0	0.0	0.0	0.0
4830	2.2	2.7	21.0	0.0	21.0
4834.2	6.4	9.2	70.0	0.0	70.0
4835	7.2	10.5	80.0	259.0	339.0
4838	10.2	16.3	100.0	2685.0	2785.0
4840	12.2	20.1	110.0	5064.0	5174.0

4) Additional Design - As with the Northern area project, it was desired to come up with a design providing greater protection for the Southern area as well. The level of detail for this design is very low. No additional storage data was developed for Buckley Canyon, and therefore, remained unchanged. Additional storage-elevation data exists for Slate Canyon up to elevation 4705 feet and Slide Canyon to elevation 4900 feet. Spillway elevation were set at 4698.2 feet and 4893.5 feet for Slate and Slide Canyon, respectively. The spillway designs are the same as above. Additional debris volumes were added to both basins. The 100 and 500-year hydrographs were routed through the basins. The estimated storage capacities are 60-year for Slate Canyon and 95-year for Slide Canyon. These combinations are the greater level of protection design for the Southern area. This is referred to as the High Level Project, South Area, in the main report.

3.04 Sensitivities. Following the design of the detention basins, a sensitivity analysis was performed on each of the basins (Middle Level Project only). In addition to routing flood flows for the design condition, sensitivity routings were performed for a minimum basin condition and a maximum basin condition. The minimum basin condition assumes that there is no debris volume in the basin when the hydrographs were routed. The maximum condition assumes a debris volume in the basin to be the same as the design condition, but assumes that the outlet works are 50% blocked with debris. Routings were performed for the 50, 100, and 500-year events for each condition. No sensitivities were run on the greater level of protection (High Level Project) designs (see paragraphs 3.03.b.4 and 3.03c.4). The sensitivities for the High Level Project were adopted from those determined for the Middle Level Project.

3.05 Inflow vs Outflow. The results of the sensitivity analysis are used in the risk based model. An Inflow vs. Outflow curve was developed for the Northern and Southern area projects. This curve was developed for the Middle Level Projects only. The inflow to the Northern area curve is the sum of the peak flows from Mile High, Little Rock and Rock Canyons with the storm centered over Rock Canyon. The outflow portion of the curve is the peak commingled flood flows. The commingled flows were determined using FLO-2D. The commingled flows were summed across the same section that was used in determining the existing condition commingled flood flows (see paragraph 2.04). The inflow to the Southern area curve is the sum of the peak flows from Slide, Slate and Buckley Canyons with the storm centered over Slate Canyon. The outflow is the sum of peak floodplain outflows that were routed through the basins located on Slide, Slate and Buckley Canyons. These outflows do not represent the commingled flood flows (as with the Northern area project). Providing the commingled floodplain flows would give lower flood flows (as well as greater project benefits) due to the routing effect, from the detention basins to the section where flows commingle, and the timing of the hydrographs from each basin. Since the benefit to cost ratio was well below 1.0, it was determined that the increased benefits using the commingled flows would not be enough to raise the benefit to cost ratio to a value near 1.0. Therefore, the commingled flows for the Southern area project were not determined. Table 10 displays the inflow, outflow, and deviations determined from the sensitivity analysis for the Northern and Southern Area - Middle Level Projects. Table 11 displays the inflow, outflow, and deviations (as determined from the Middle Level Project sensitivity analysis), for the Northern and Southern Area - High Level Projects. The inflow versus outflow curves for the Middle Level Projects display the minimum, maximum, and design (average) conditions. See Plates 17 and 18.

SECTION 4 - PROVO RIVER

4.01 General. The Provo River floodplain delineation was developed by the Sacramento District's Regional Planning Branch and is provided in Appendix B. This section documents the results of hydraulic work on determining standard error for the project on the Provo River.

4.02 Overview of Stage-Discharge Uncertainty. The determination of stage-discharge uncertainty requires accounting for the uncertainness due to factors including debris or other obstructions, variation in hydraulic roughness, scour or sediment deposition and other factors. Many of the factors which are estimated for modeling purposes are time-dependent, both seasonally as well as during any particular event. Many also vary both laterally and longitudinally in the channel and adjacent floodplain. It is recommended that only data values for flows above bank-full be used, since low flows are generally not of interest in flood studies. The objective is to calculate uncertainty in stage, not discharge.

Computed water surface profiles provide the basis for nearly all stage-discharge ratings for Corps studies. Published methods and guidelines for interpreting the accuracy and therefor, the uncertainty in computed stages are lacking. Currently, estimated uncertainties are based on analytical studies of gauged ratings (when available) or sensitivity studies to determine the stability of computed profiles. Professional judgement is required to validate the reasonable limits for uncertainty.

Models are limited by the inability to model exactly the complex nature of the hydraulic processes. Data used in the model is also not exact, introducing errors in the model geometry and coefficients used to describe the physical setting.

The measure used to define the uncertainty of the stage-discharge relationship is the standard deviation. Standard deviation may be determined in a number of ways, most often by determining the "reasonable" upper and lower bounds of stage and dividing the range by 4.

4.03 Hydraulic Results. For this study, a sensitivity analysis was performed. The computer model HEC-2 was used. An existing HEC-2 model prepared for an earlier flood plain study was utilized. The model was altered and run numerous times to reflect variances in stage due to hydraulic roughness, sediment and debris. The upper and lower bounds of stage were estimated for various discharges. Professional judgement was applied to estimate the "reasonable" upper and lower bounds of stage. Manning's "n" was varied to plus-or-minus 20%, sediment from 1 to 2 ft. in the channel and obstructions/debris from 10 to 25 percent at bridges. A summation run with a combination of the above was also performed to determine the upper bound.

The standard deviation was found by determining the range from the upper bound to the profile generated from the existing model and dividing this by 2. This was done because the lower bound generated from the various model runs was somewhat closer to the existing model profile than the upper bound.

4.04 Conclusions. The results at river mile 3.28 (a representative section in the project area) are as follows:

Flow (cfs)	Std Dev (ft)
1000	0.87
2000	1.02
3000	0.87
4000	0.83
5000	0.87
6000	0.92
7000	0.99
8000	1.03

A rating curve for river mile 3.28 plus/minus standard deviation is shown on Plate 19.

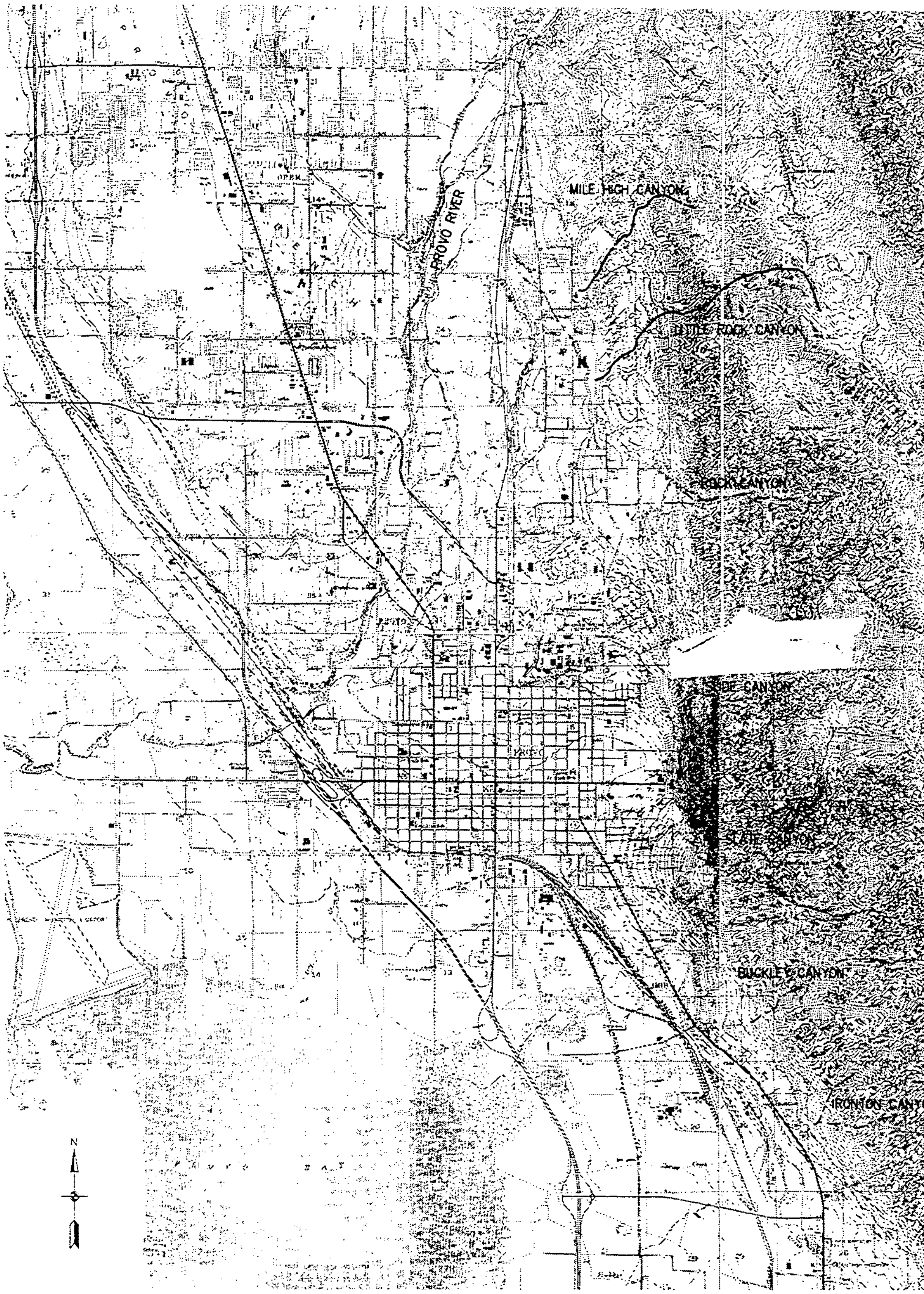
TABLE 10. MIDDLE LEVEL PROJECT INFLOW VS OUTFLOW

Event	Inflow (cfs)	Outflow (cfs)	Lower Deviation	Higher Deviation
North Area Project				
10-year	165	0	0	0
25-year	540	0	0	100
50-year	1159	0	0	254
100-year	2582	1312	946	181
500-year	7050	5639	133	282
Southern Area Project				
10-year	127	0	0	0
25-year	340	0	0	50
50-year	1093	0	0	219
100-year	2360	1510	752	177
500-year	7129	5777	242	253

TABLE 11. HIGH LEVEL PROJECT INFLOW VS OUTFLOW

Event	Inflow (cfs)	Outflow (cfs)	Lower Deviation	Higher Deviation
North Area Project				
10-year	165	0	0	0
25-year	540	0	0	100
50-year	1159	0	0	127
100-year	2582	730	730	181
500-year	7050	5500	133	282
Southern Area Project				
10-year	127	0	0	0
25-year	340	0	0	50
50-year	1093	0	0	219
100-year	2360	1440	752	177
500-year	7129	5733	242	253

PLATES



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Sheet 1 of

PROVO RECONNAISSANCE STUDY

STUDY AREA

DEPARTMENT OF THE ARMY
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Submitted by:	File name: study.dgn Plot date: Plot scale: 1" = 4000'

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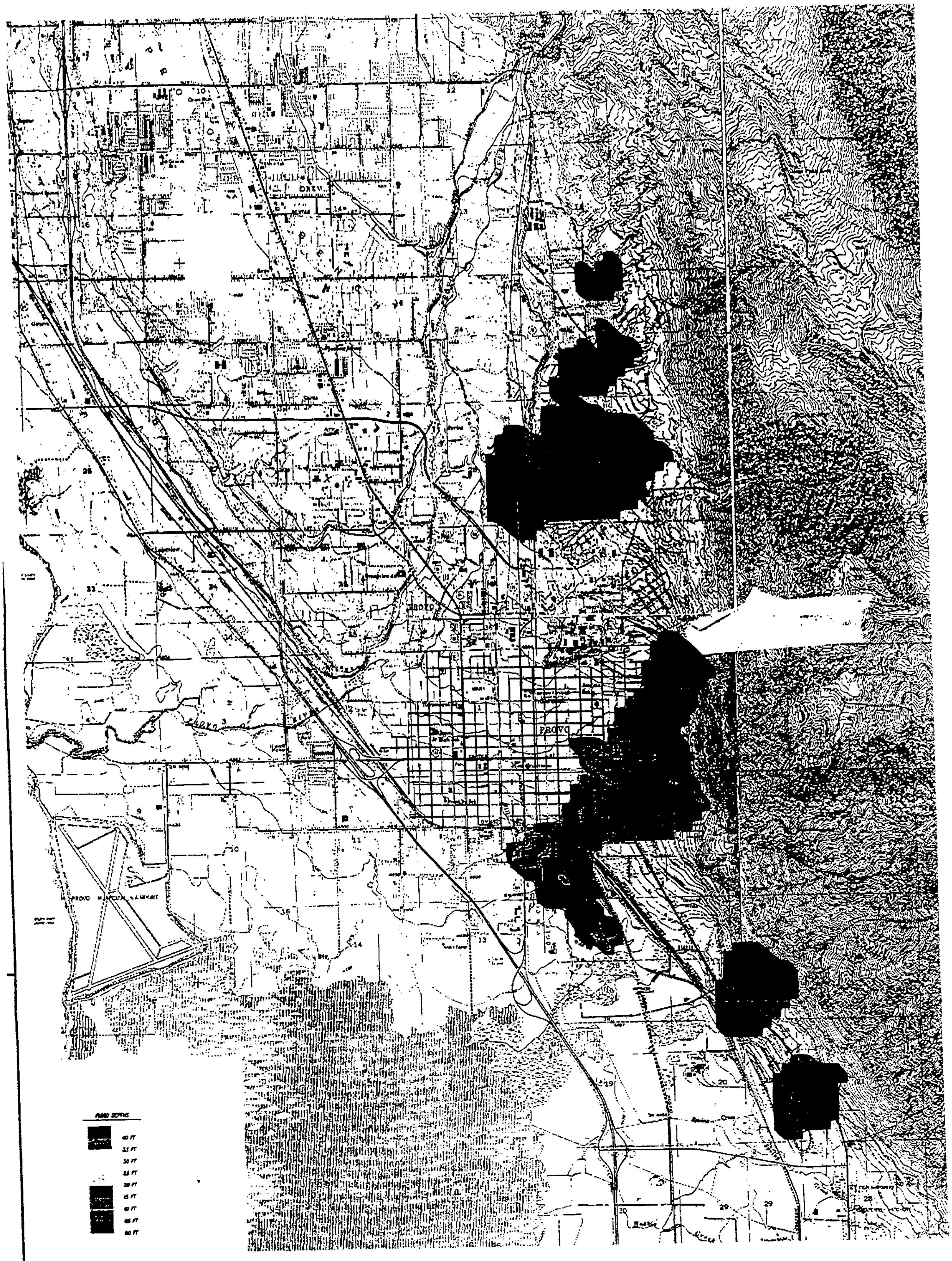

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Sheet of

PROVO RECONNAISSANCE STUDY
EAST SIDE FLOODPLAINS

STORM CENTERED OVER SLATE CANYON
50 YEAR FLOODPLAIN

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

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Submitted by:	Plot date: 07 Oct 96; Plot scale: 1" = 4000'

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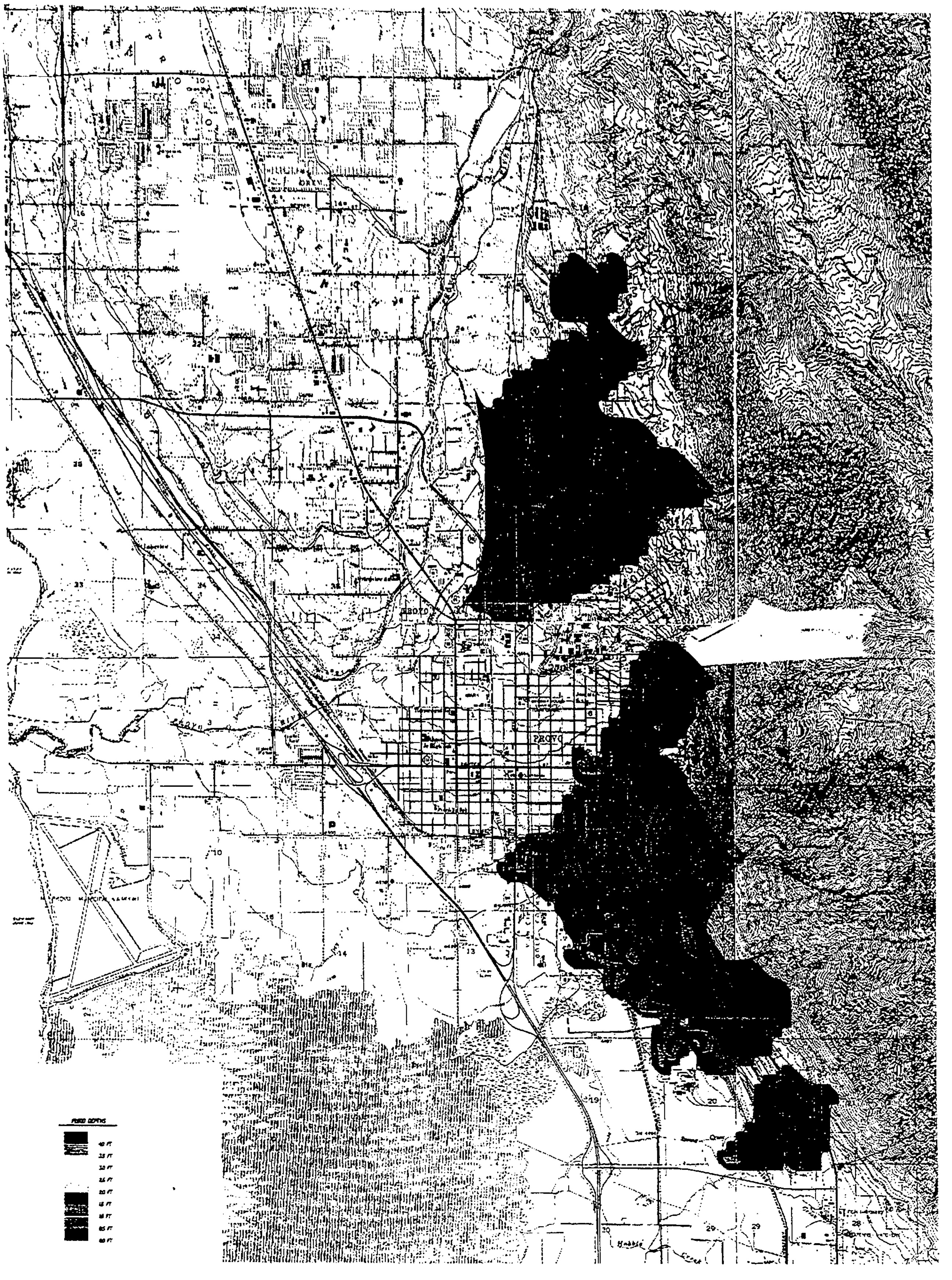

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PROVO RECONNAISSANCE STUDY
EAST SIDE FLOODPLAINS

STORM CENTERED OVER SLATE CANYON
100 YEAR FLOODPLAIN

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

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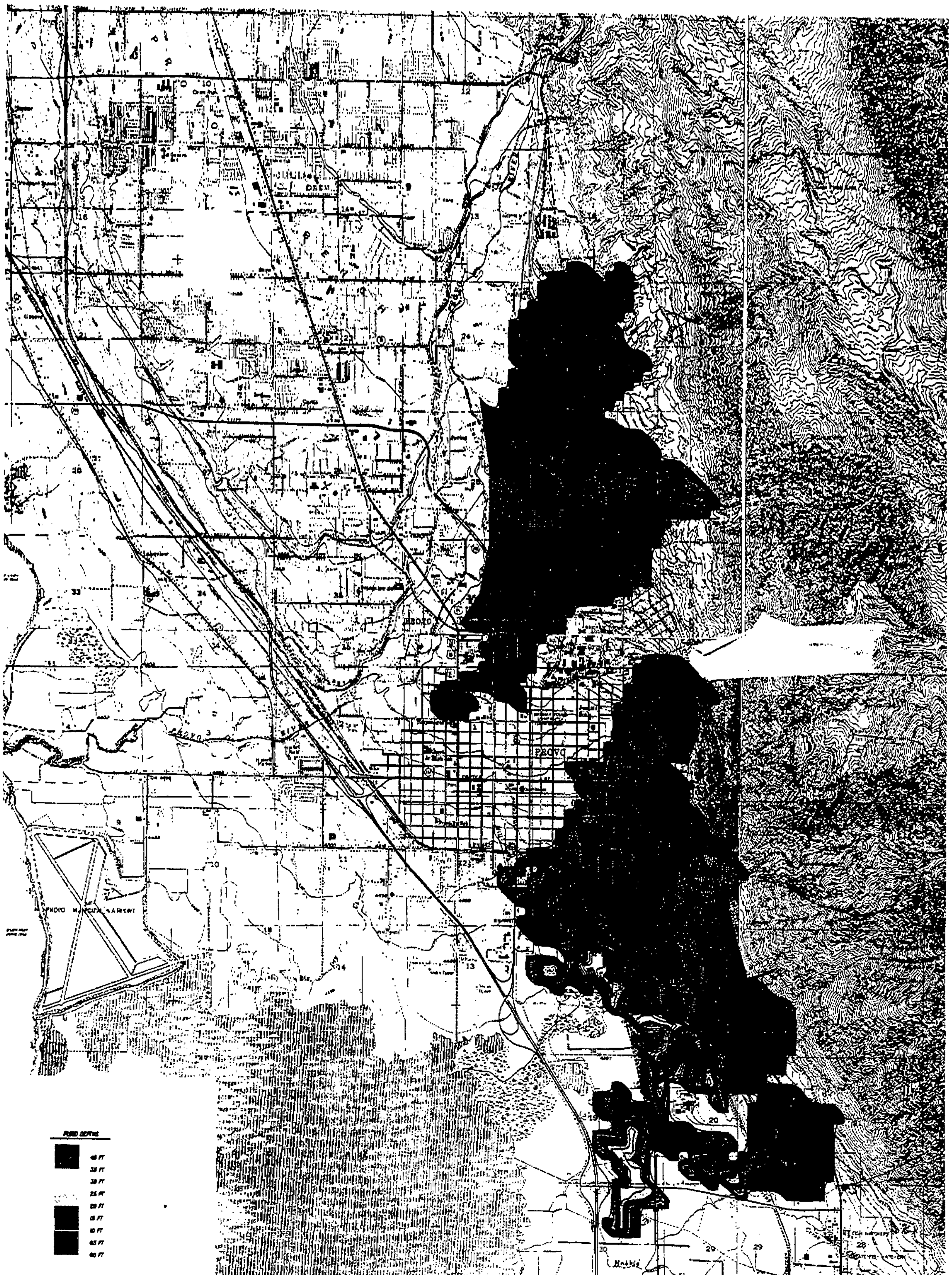

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PROVO RECONNAISSANCE STUDY
EAST SIDE FLOODPLAINS

STORM CENTERED OVER SLATE CANYON
500 YEAR FLOODPLAIN

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

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Date:

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Reviewed by:

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Submitted by:

Plot date: 07 Oct 96

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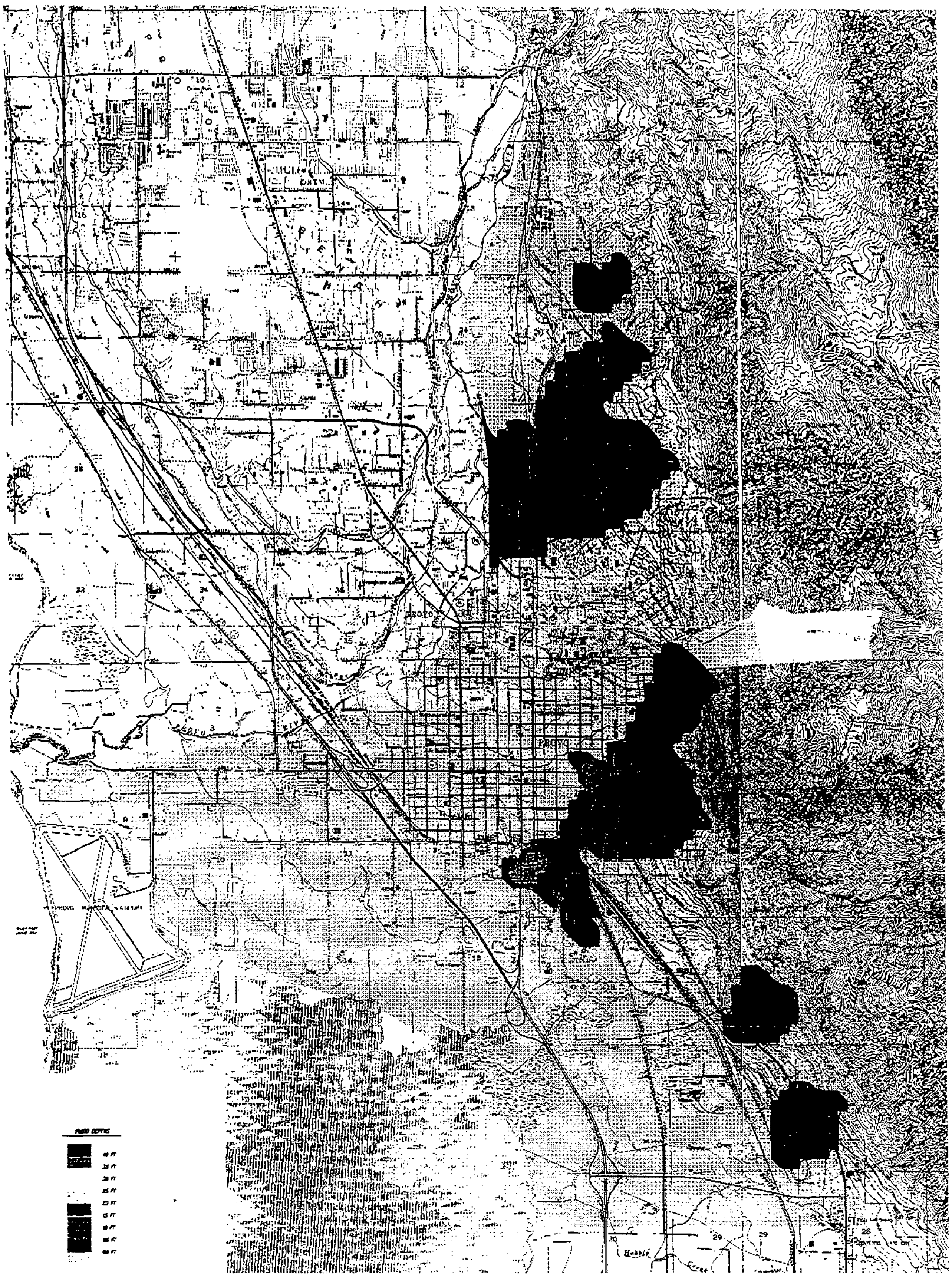

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PROVO RECONNAISSANCE STUDY
EAST SIDE FLOODPLAINS

STORM CENTERED OVER ROCK CANYON
50 YEAR FLOODPLAIN

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

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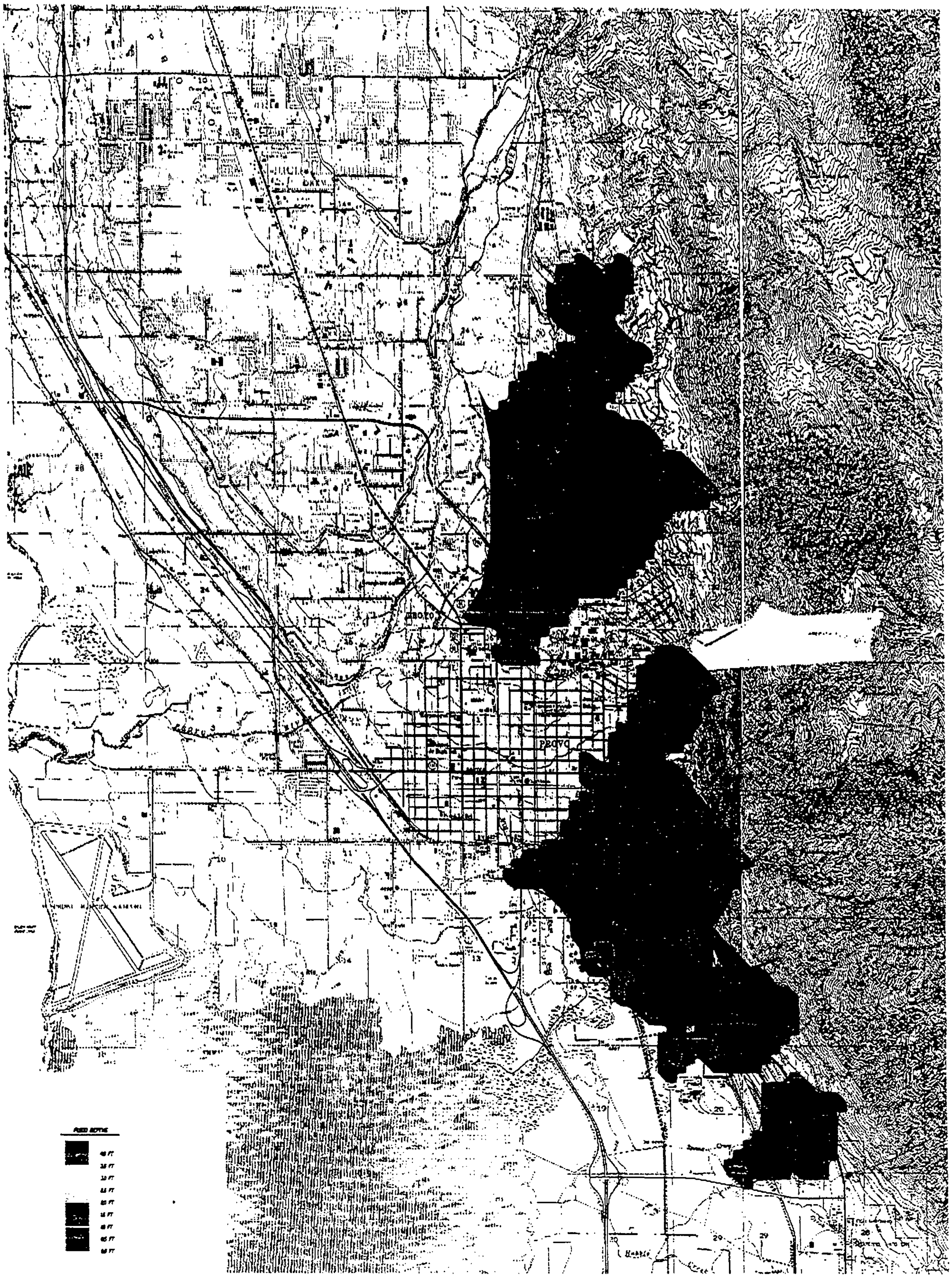

PROVO RECONNAISSANCE STUDY
EAST SIDE FLOODPLAINS

STORM CENTERED OVER ROCK CANYON
100 YEAR FLOODPLAIN

DEPARTMENT OF THE ARMY
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SACRAMENTO, CALIFORNIA

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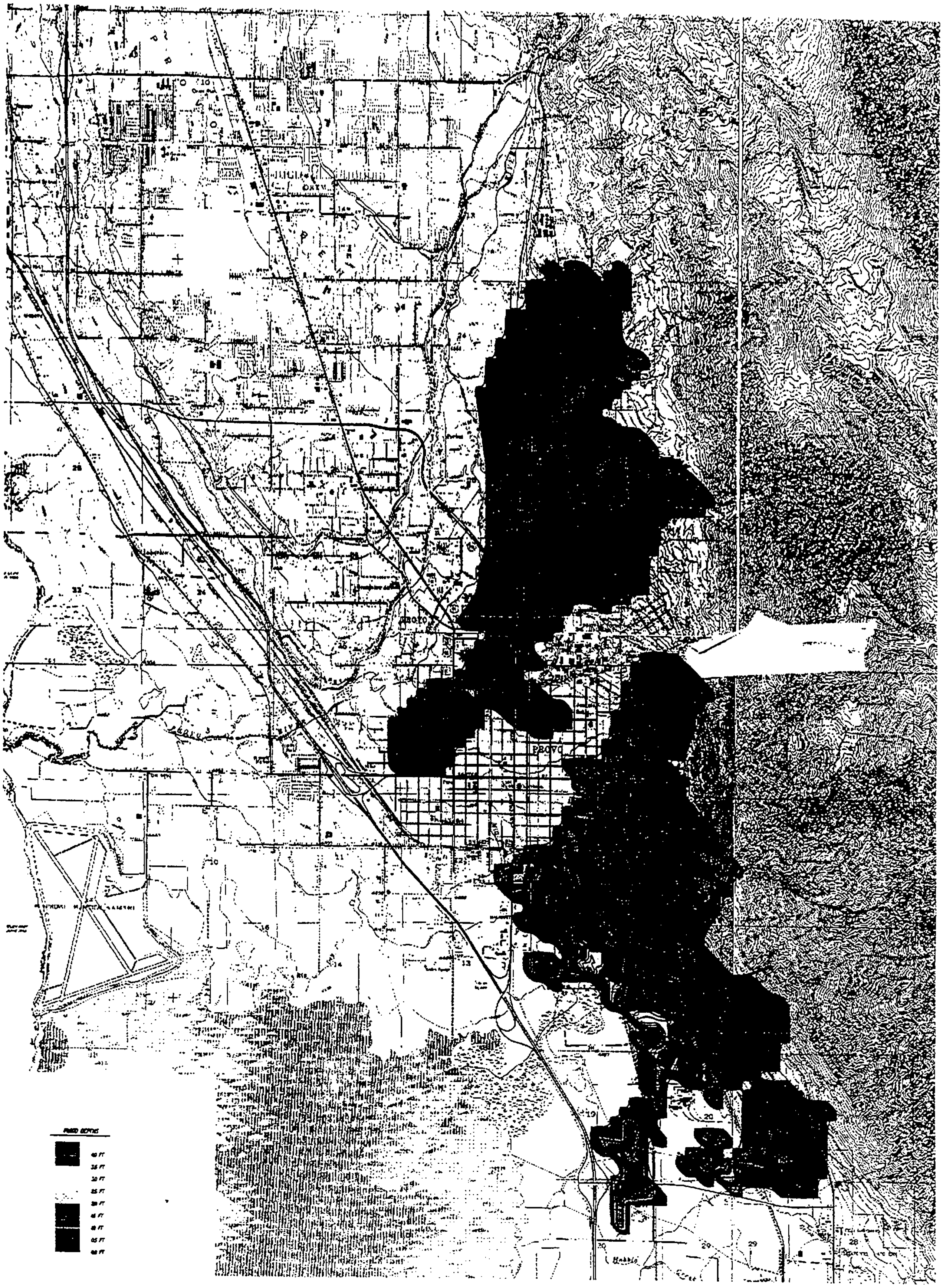

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PROVO RECONNAISSANCE STUDY
EAST SIDE FLOODPLAINS

STORM CENTERED OVER ROCK CANYON
500 YEAR FLOODPLAIN

DEPARTMENT OF THE ARMY
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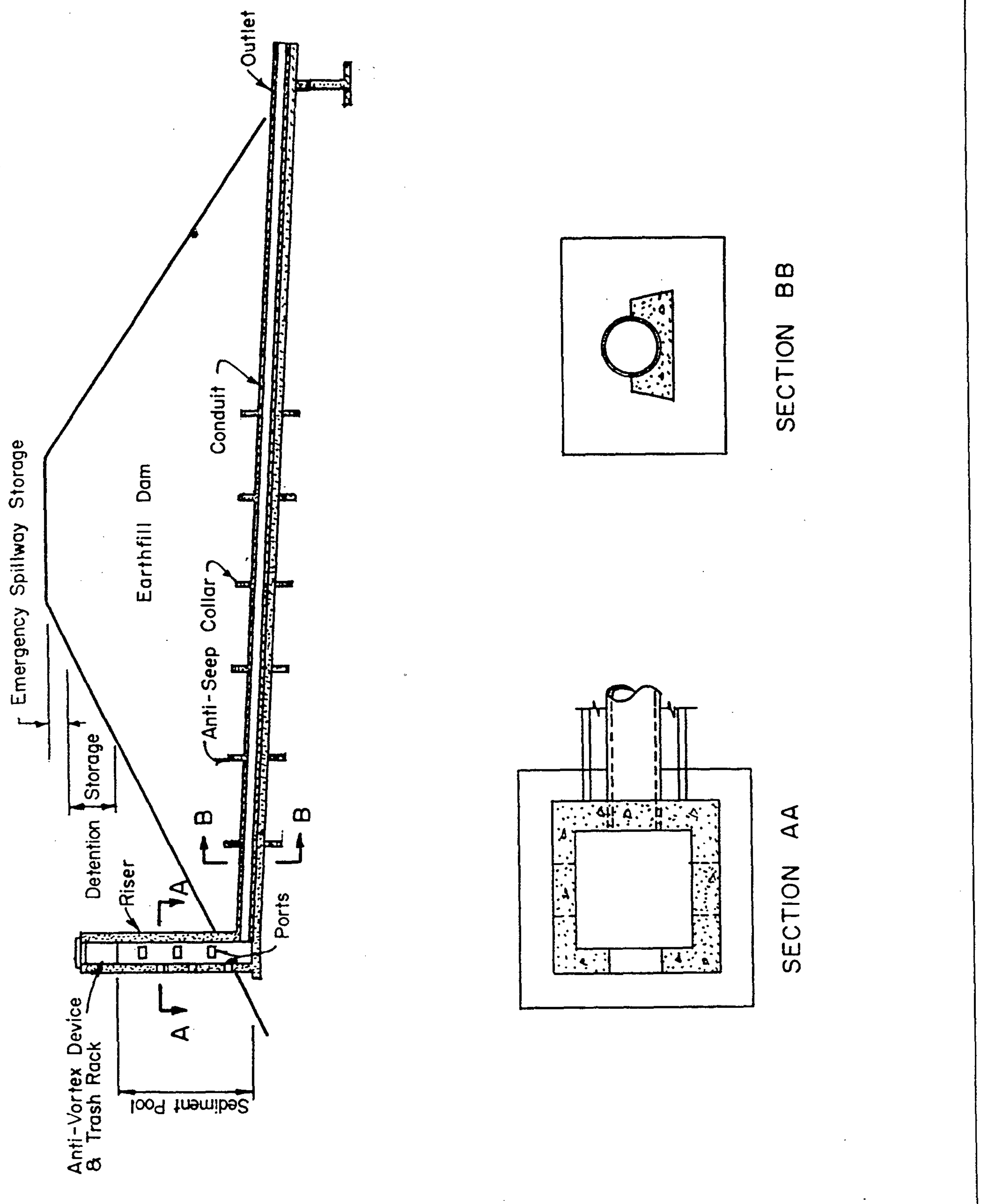
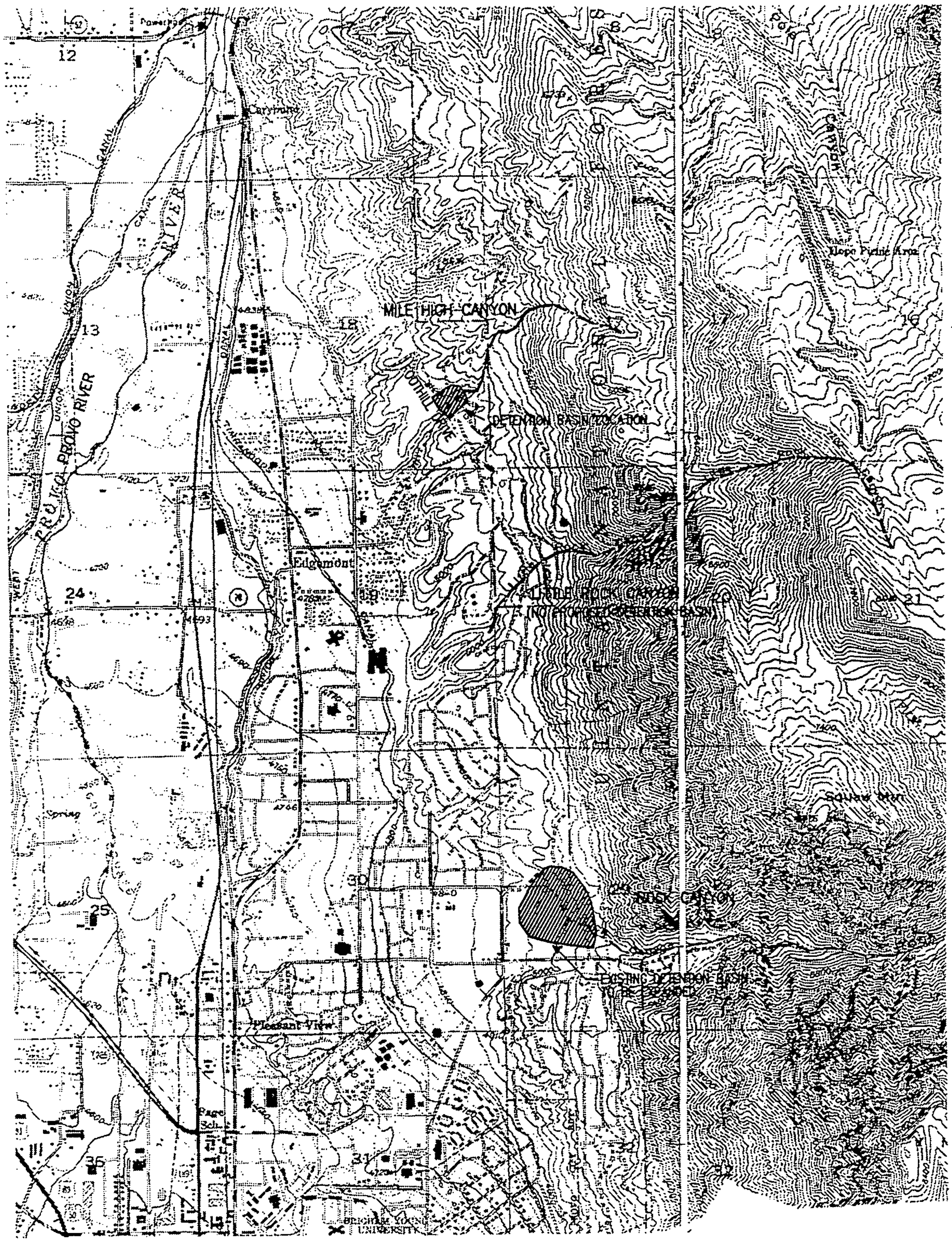


PROVO RECONNAISSANCE STUDY

TYPICAL OUTLET WORKS DETAILS

PLATE 8



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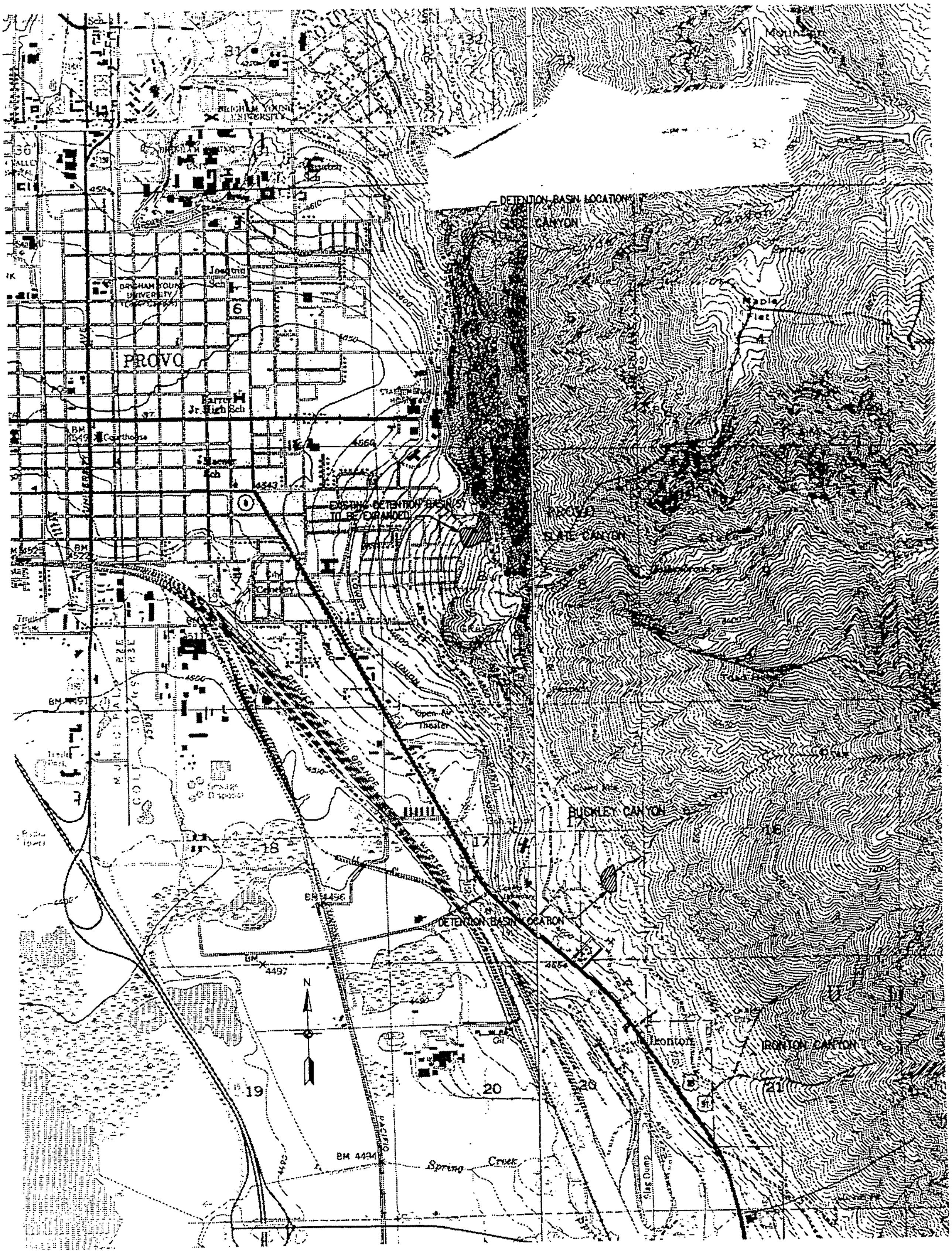

PROVO RECONNAISSANCE STUDY

SOUTHERN AREA PROJECT,
DETENTION BASIN LOCATIONS

DEPARTMENT OF THE ARMY
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SACRAMENTO, CALIFORNIA

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PROVO RECONNAISSANCE STUDY

MILE HIGH CANYON
DETENTION BASIN AND PIPELINE

DEPARTMENT OF THE ARMY
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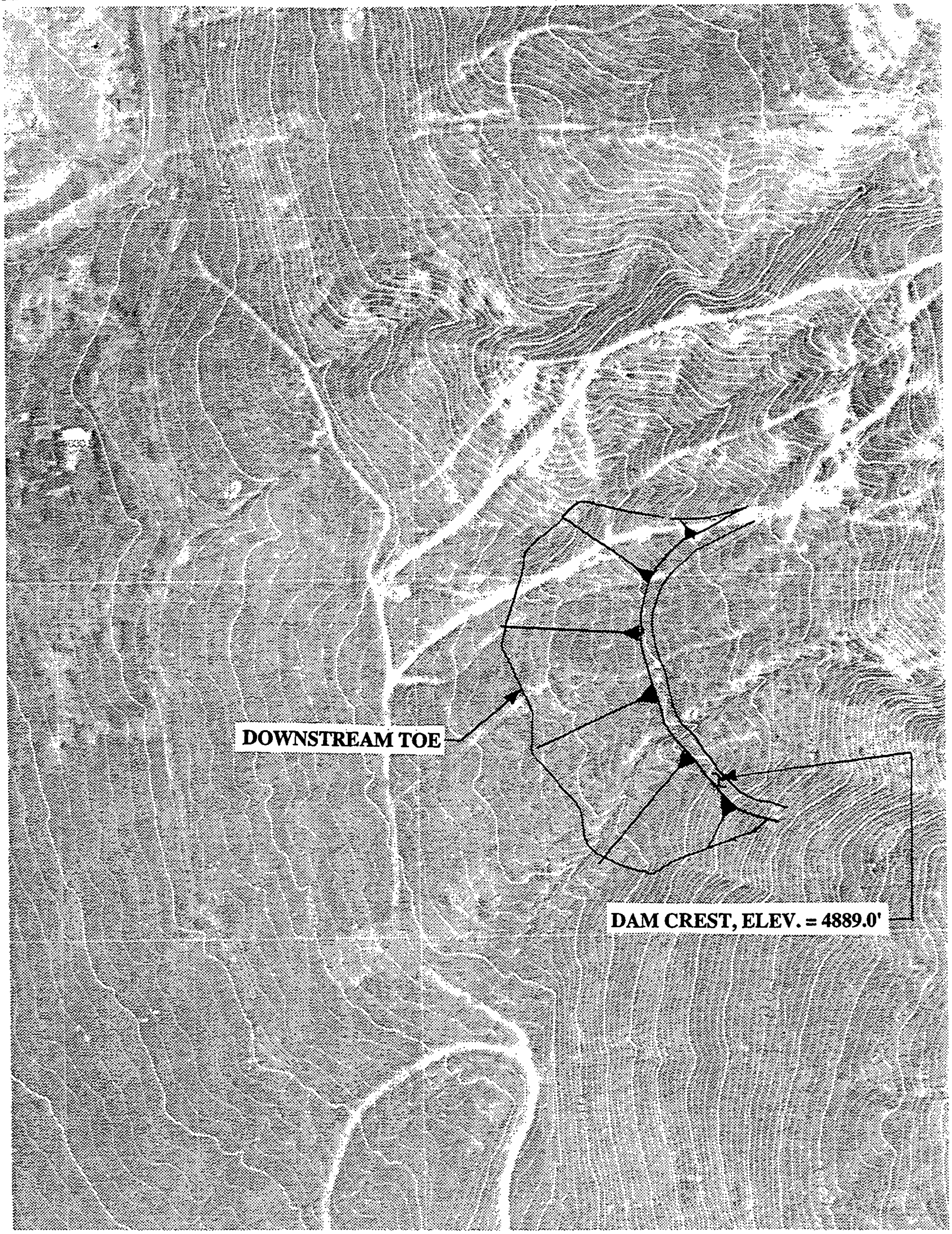

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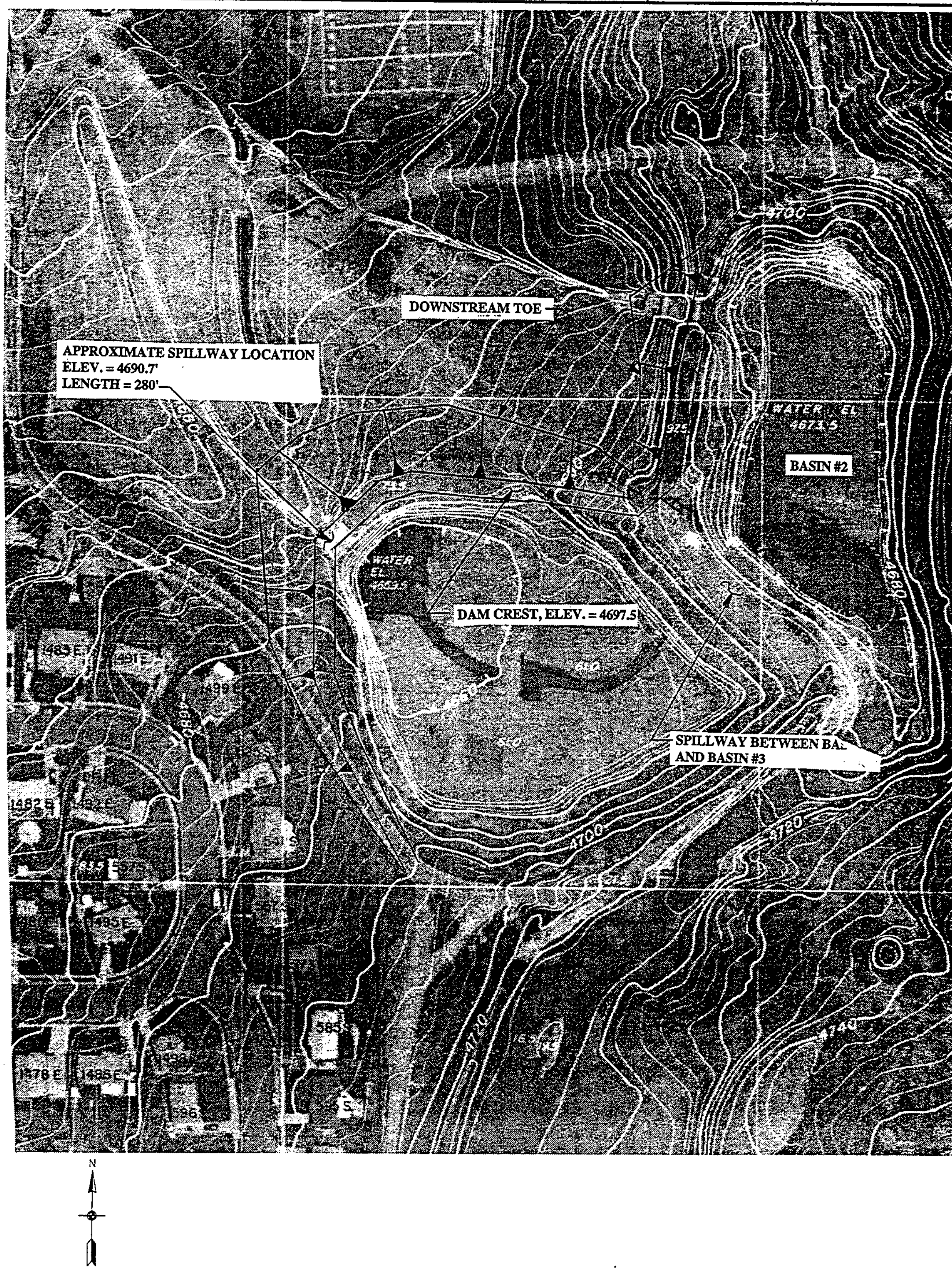
PROVO RECONNAISSANCE STUDY

SLIDE CANYON DETENTION BASIN

PLATE 14



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PROVO RECONNAISSANCE STUDY

SLATE CANYON DETENTION BASIN

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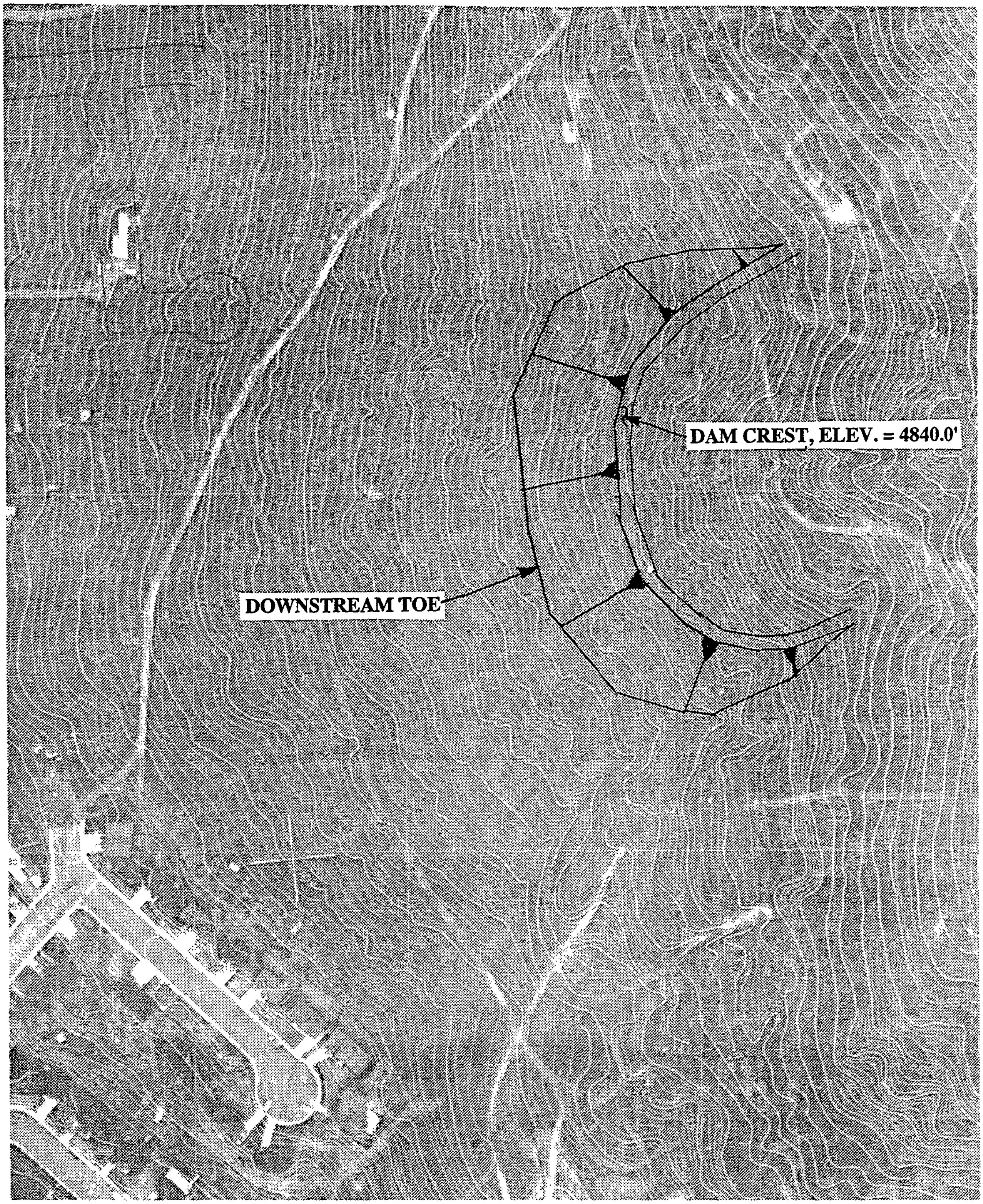

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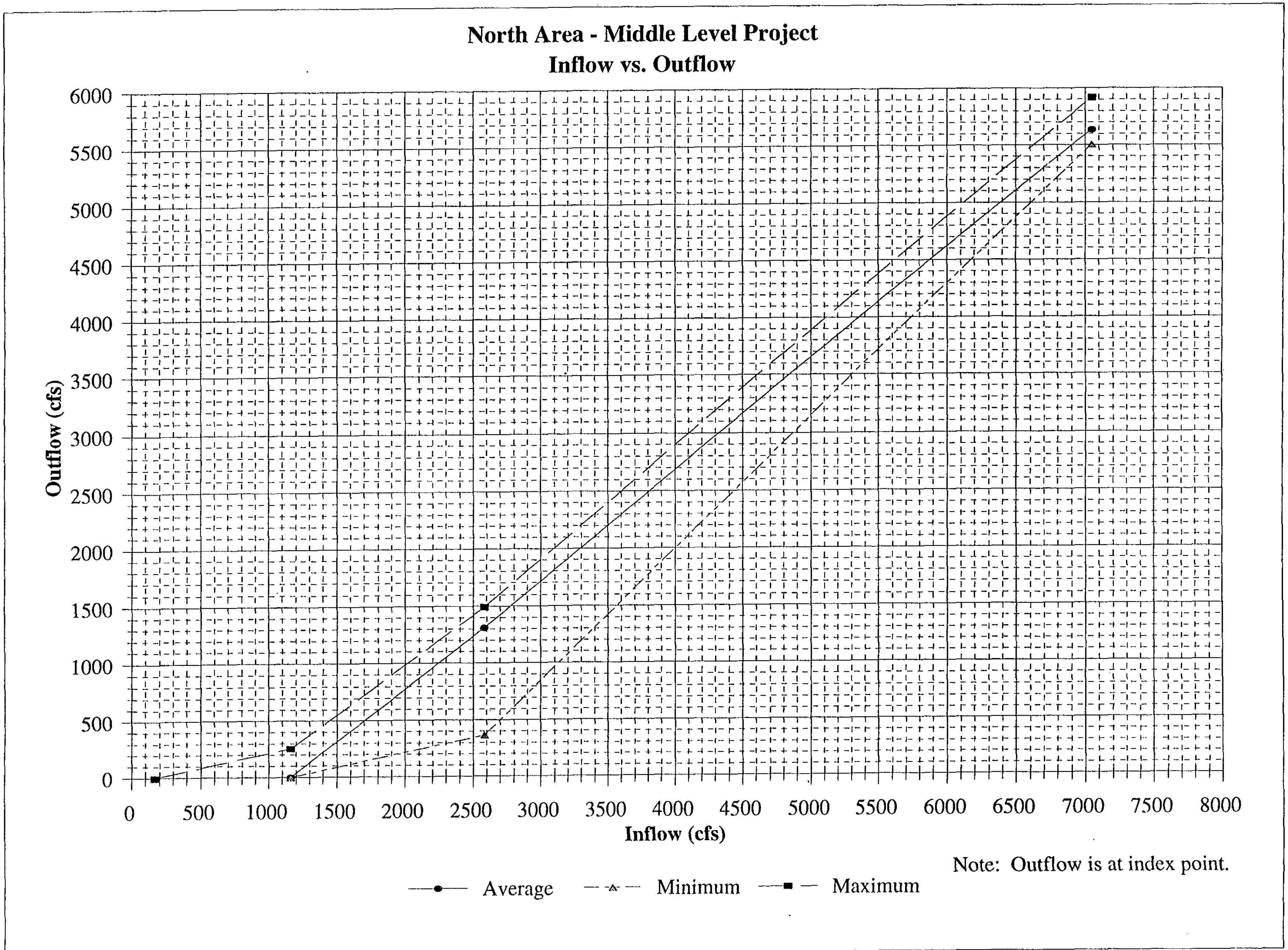
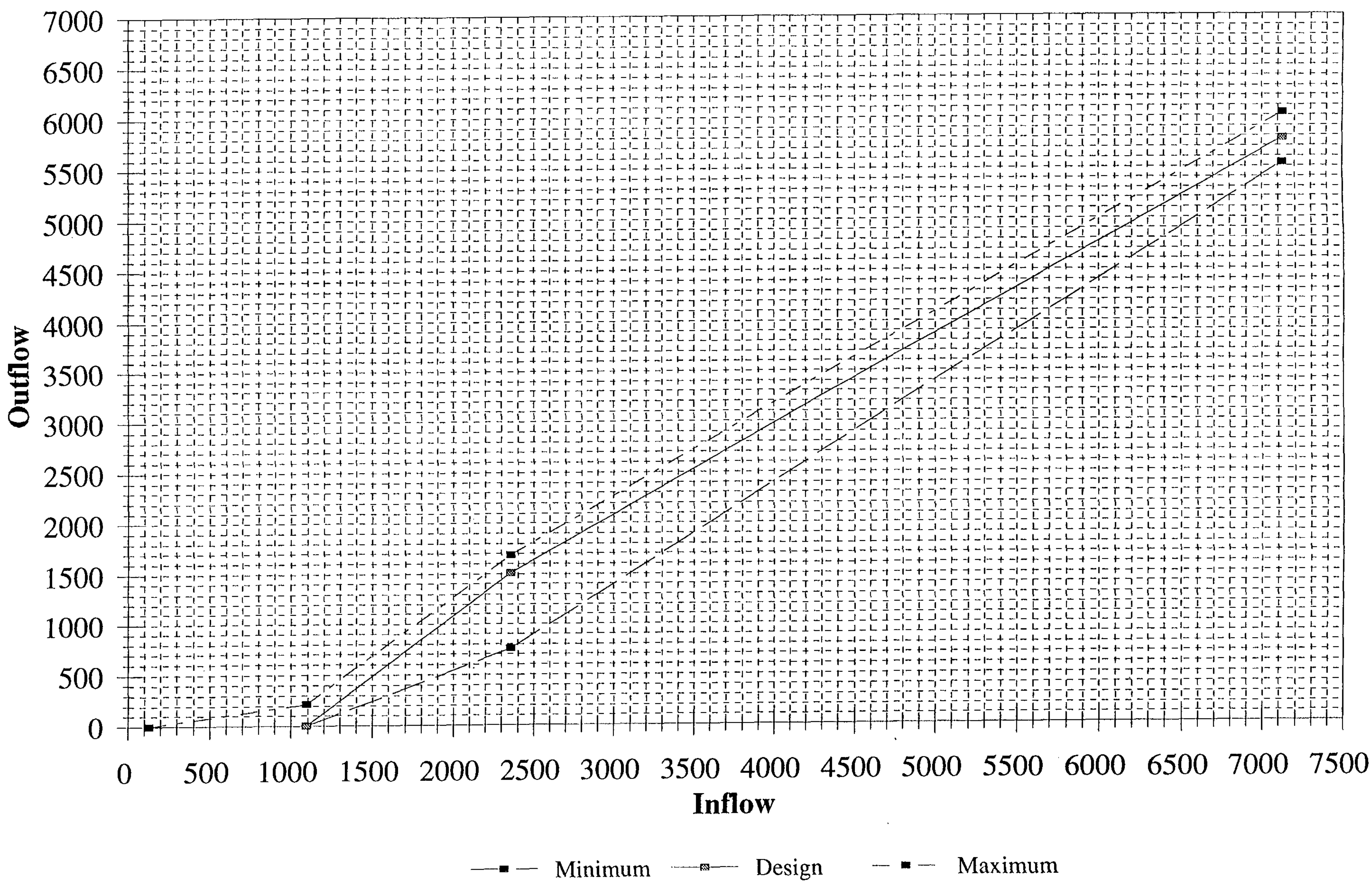
PROVO RECONNAISSANCE STUDY

BUCKLEY CANYON
DETENTION BASIN

PLATE 16


North Area - Middle Level Project
Inflow vs. Outflow
Outflow (cfs)
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
6500
7000
7500
8000
Inflow (cfs)
Note: Outflow is at index point.
Average
Minimum
Maximum

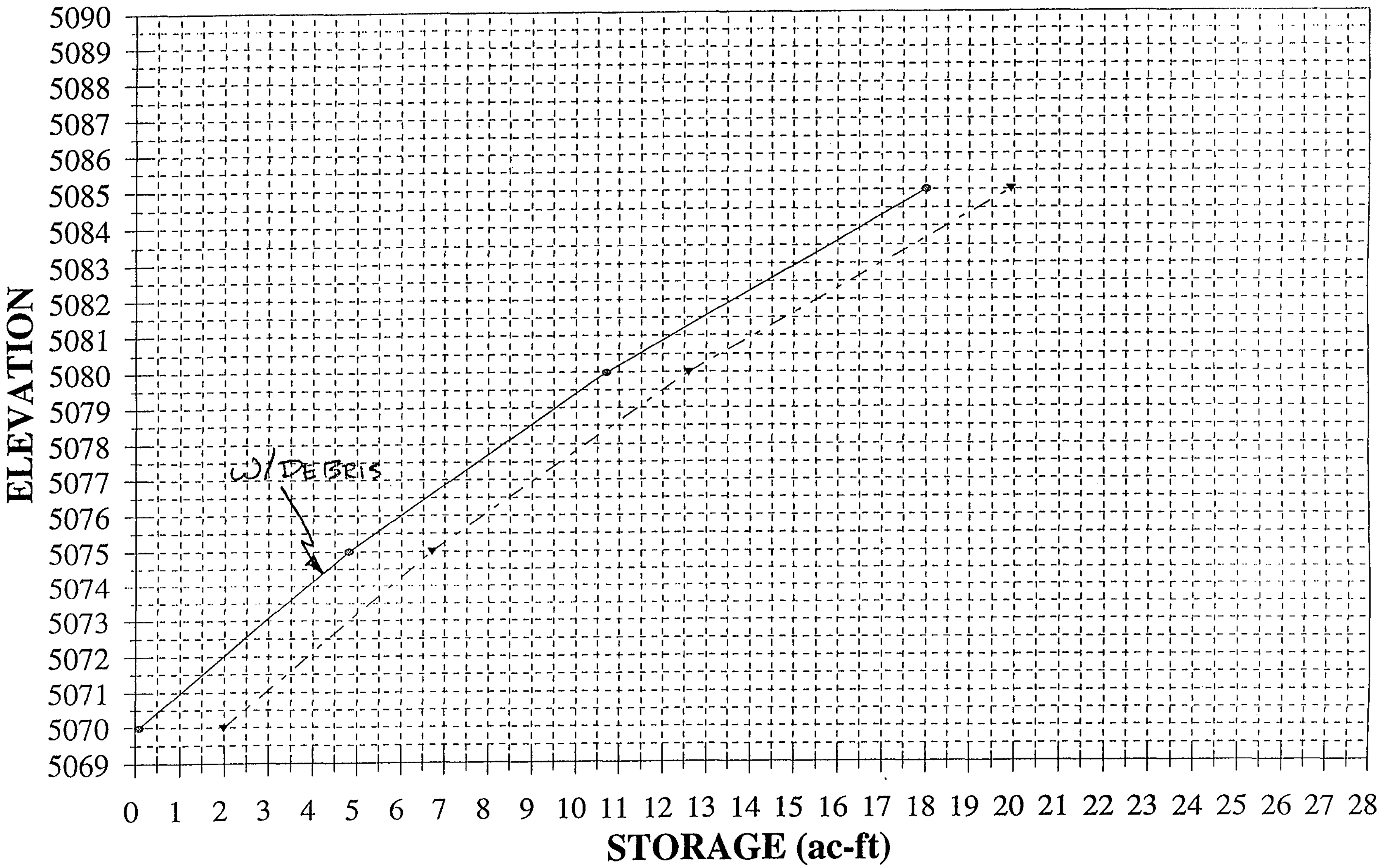
Southern Area - Middle Level Project
Inflow vs. Outflow



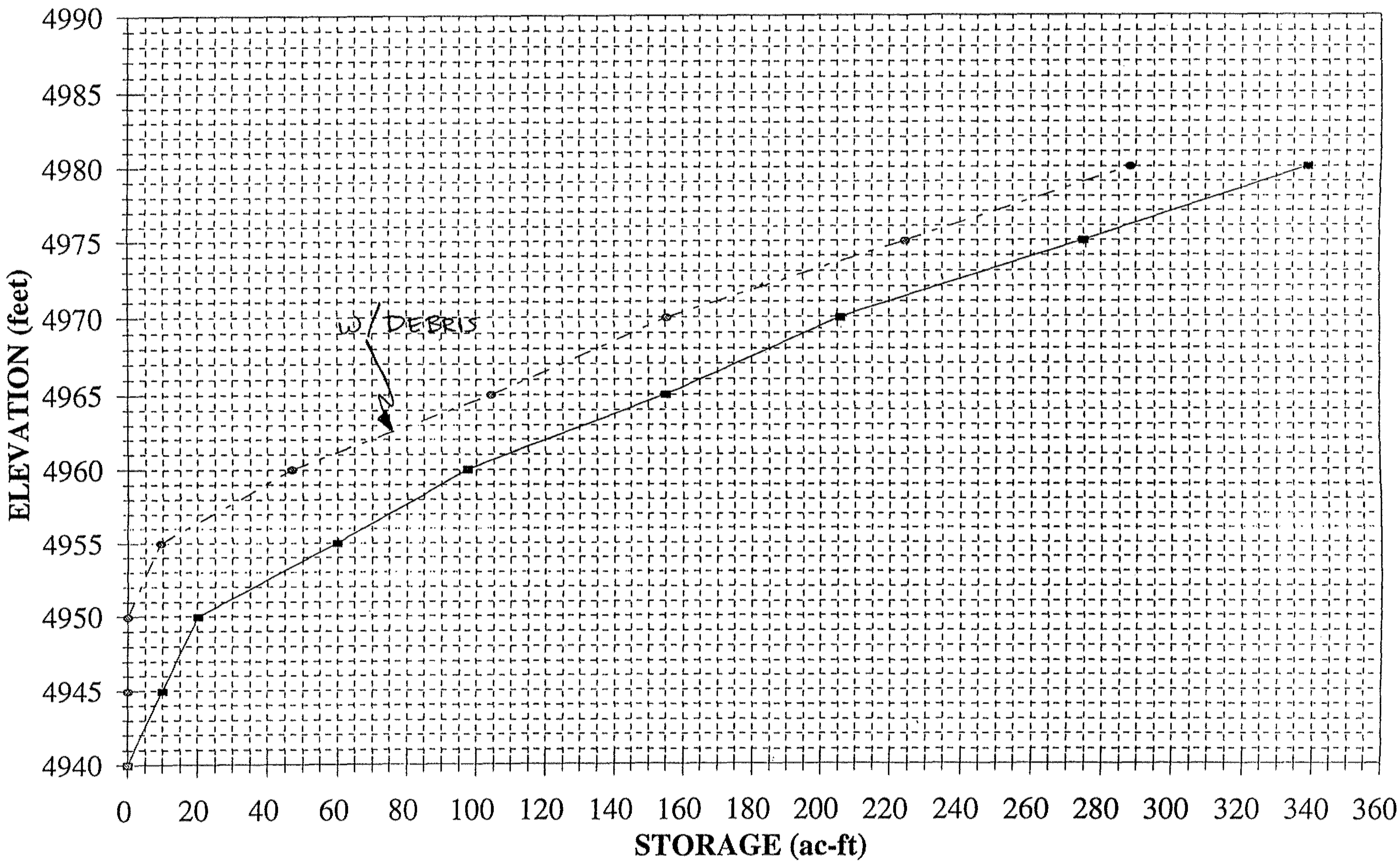
APPENDIX A

STORAGE ELEVATION CURVES

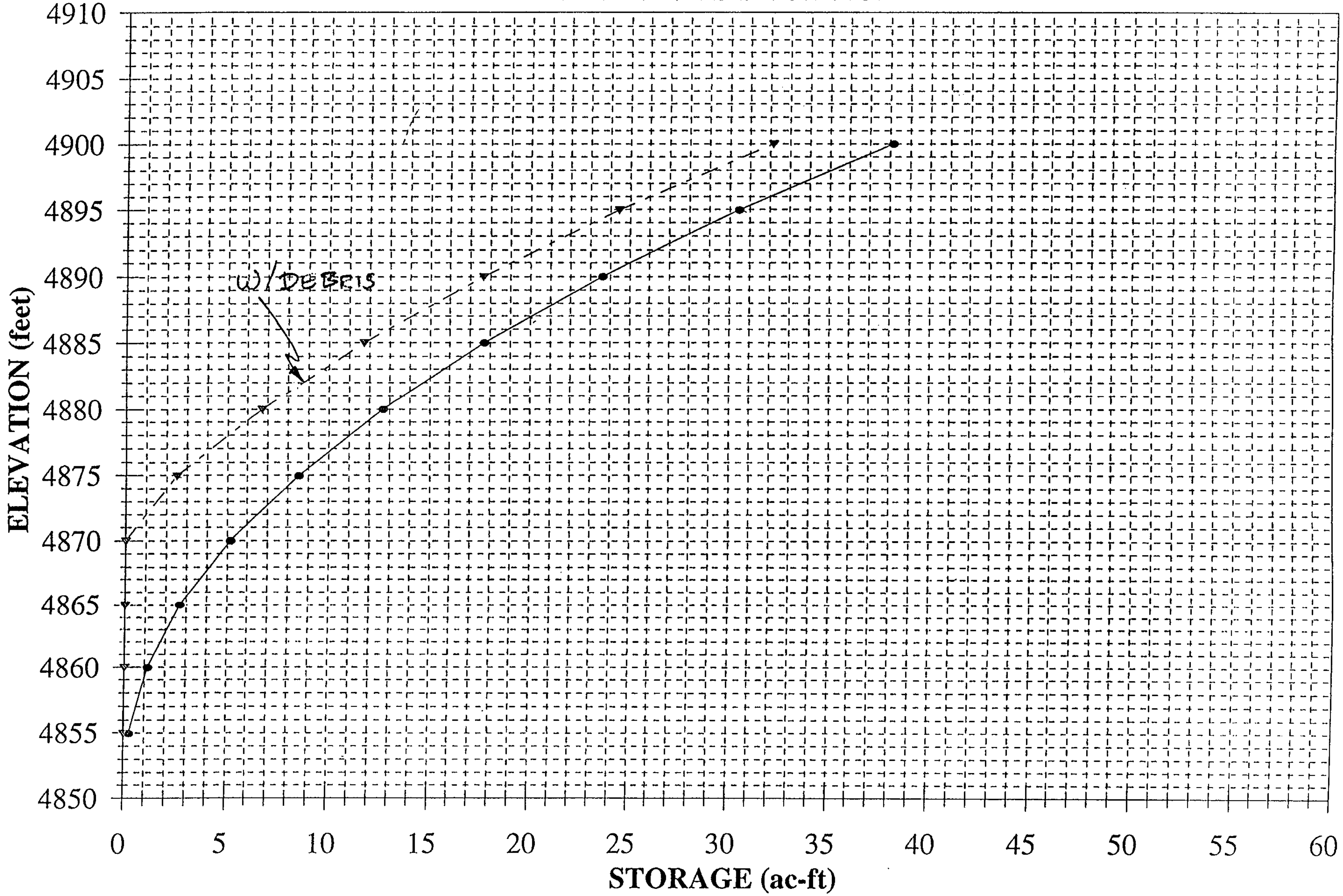
MILE HIGH
ELEVATION VS STORAGE



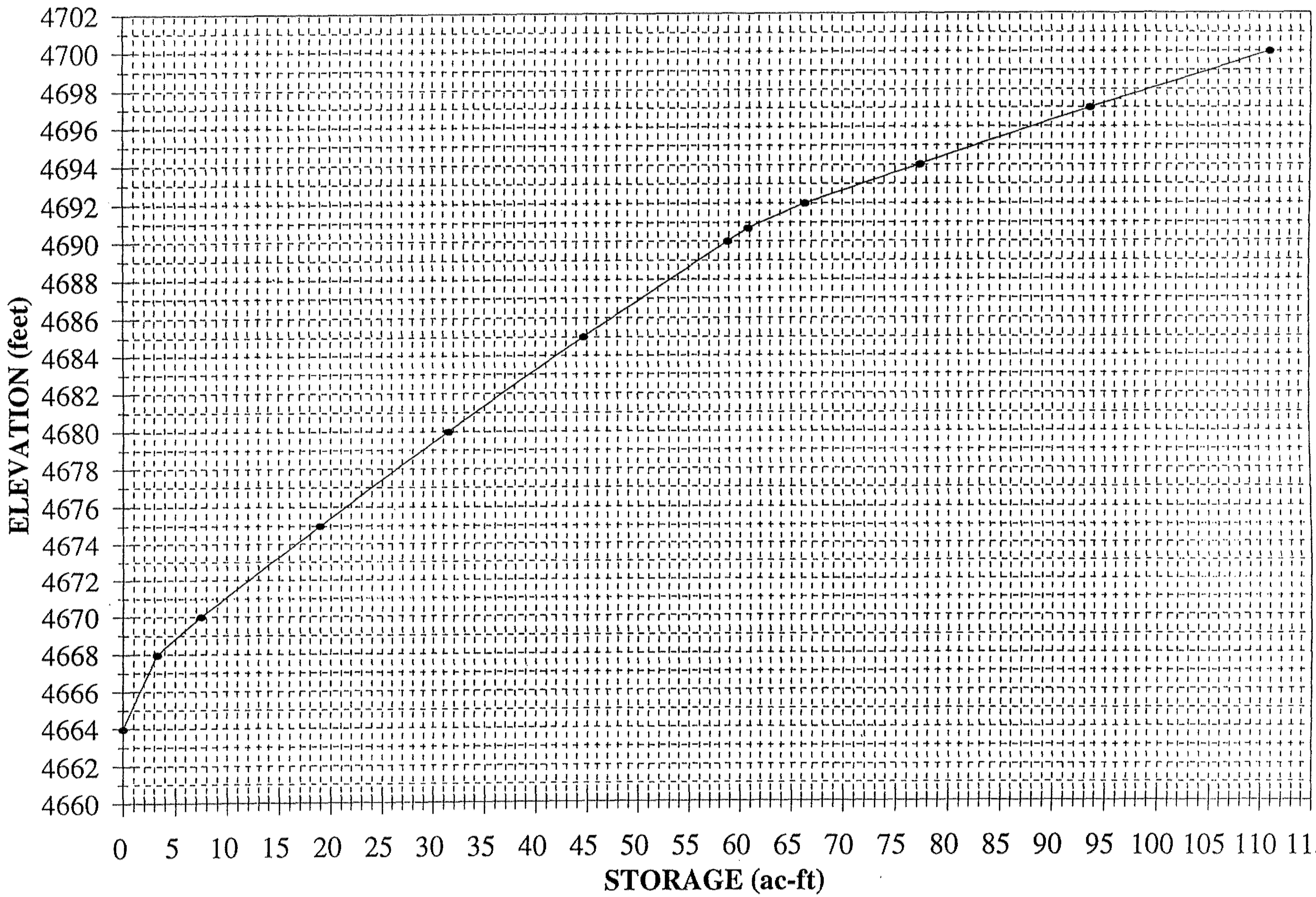
ROCK CANYON
ELEVATION VS. STORAGE



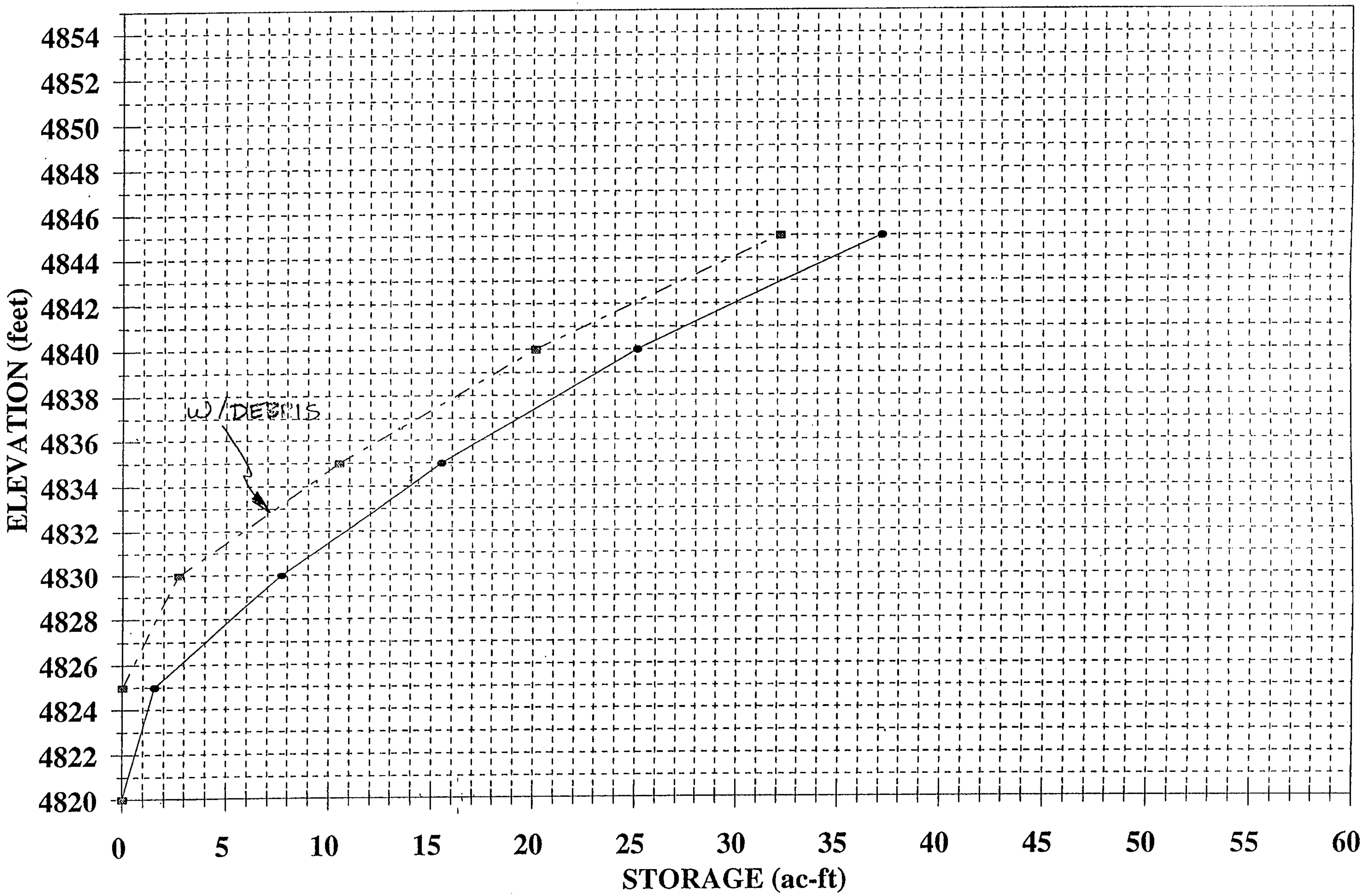
SLIDE CANYON
ELEVATION VS STORAGE



SLATE CANYON
ELEVATION VS. STORAGE



BUCKLEY CANYON
ELEVATION VS. STORAGE



7/11/92

APPENDIX B

PROVO RIVER FLOODPLAINS

FLOOD PLAIN STUDY RECONNAISSANCE

PROVO RIVER
PROVO, UTAH

DECEMBER 1996

FLOOD PLAIN STUDY, PROVO RIVER, UTAH

This is a revision to previous (October 1996) submittal for the Provo River Reconnaissance study.

HYDROLOGY

The combined frequency curves for the Provo River were developed by Water Management Section, and are contained in the Hydrology section of this report. A summary of the 1996 flows used for the Provo River flood plain analysis are:

1996

Location	10-yr	50-yr	100-yr	500-yr
Canyon Mouth	1,800	2,800	4,400	8,300
Interstate 15	1,800	2,300	3,900	6,700

The flows in the 1986 computer model listing provided by Great Basin Section and in the September 1988 Flood Insurance Study are:

1988

Below Canyon Mouth	1,800	2,600	3,200	3,800

HYDRAULICS

An HEC-2 (Hydrologic Engineering Center, Generalized Computer Program, Version 4.6, released February 1991) Water Surface Profile model was provided by Great Basin Branch. This model originally may have been developed by the Bureau of Reclamation for a flood insurance study of 1977, updated by Rollins, Brown, and Gunnell, Inc. for a Flood Insurance Study in 1986, and then used for a Reconnaissance study in 1986. The model was imported, reviewed, and modified by Regional Planning Branch. It was noted that the cross sections increase in stationing from right to left looking downstream, rather than the conventional left to right looking downstream. Consequently, when channel losses are determined from the HEC-2 output, the left and right designations must be transposed. If the HEC-2 model is to be used for other than Reconnaissance evaluation, many further modifications should be made to the model.

Modifications were made to the station names for ease of location along the channel. Stationing is in miles from Utah Lake along the thalweg.

Provo city representatives were concerned about possible deposition or degradation of the channel since the 1986 study. Four cross sections were resurveyed (by the city) in 1996 and compared to the

1986 sections. No significant changes were observed.

The roughness coefficient, "N" values, of the original model were increased to attempt to reduce the frequency of the critical depths which were computed in the HEC-2 model. The original model displayed a large number of critical depth computations. Generally, these critical depth determinations occur when a balanced solution cannot be found by the program and, rather than stop computations, the program continues with an assumption of critical depth. This critical depth represents a minimum water surface elevation accompanied by a high velocity head. The water surface thus generated is less than that which would occur in the natural channel as a result of the turbulence created by the flow entering and exiting critical depth. The simplest adjustment to a model, to produce a water surface which is more likely to occur in the natural channel, is to increase the roughness values, thereby raising the water surface and reducing the frequency of occurrence of critical depths. This results in a water surface profile which is above critical depth and accounts for the actual energy of the flow, and is a better representation of the water surface which will occur. The water surface resulting from the "N" value increase fit the flooding extent of the last observed high water.

The 100-year flow for 1996 is approximately the same as the existing (1988) FEMA 500-year flood, so, that flood plain (FEMA 500-year) is a check on the approximate extent of flooding for the current 100-year event.

The frequency curves show separate snowmelt and cloudburst hydrographs and a combined curve. The combined curve was used for the 50-, 100-, and 500-year flows. The snowmelt (controlled) was used for the 10-year flood. See Charts 8, Jul 1996, "Provo River at Canyon Mouth" and "Provo River at I-15"

FLOODPLAINS

High water, and a mobilized flood fight along select reaches, occurred in 1983. Observations from that event were used to confirm this flood plain determination. These floodplains are sufficient for the intended reconnaissance study but may be below the standard required for a flood insurance application. The HEC-2 model could be modified with more cross sections to define the bank and levee conditions, cross sections could be extended further into the overbank flow areas, and bridge modeling could be refined.

The 10- year flood remains within the channel of the Provo River. No flood plains have been developed for this flood.

Great Basin Branch supplied the levee failure criteria to be used for this study. For those reaches with flow on the levees, the attached table was used.

TABLE 1

	REACH	PNP Feet Below Levee Crown
1	Moon River Bend Left Bank	2.5
2	Bank Parking Lot to Moon River Apartments Left Bank	2.0
3	Paul Ream Wilderness Park to DRGWRR Bridge Left Bank	1.5
4	DRGWRR Bridge to I-15 Bridge Left Bank	2.5
5	Geneva Road Upstream to I-15 Bridge Left and Right Banks	1.5
6	Geneva Road Downstream	
	Left Bank	2.0
	Right Bank	1.5

The 50-year flood stays confined to the channel for most reaches. Along the golf course from 2230 North to 3700 North (river mile 6 to 8.7) the 50-year meanders close to the channel. Both overbanks are flooded around and just upstream of the Interstate 15. Downstream of Geneva Road, the 50-year will flood both the left (south) and right (north) overbanks. The volume available is limited and the flooded area is small compared to the 100- and 500-year floods.

The 100-year is out of bank through the golf course, river mile 6 to 7. Major 100-year out of bank flows occur on both banks at section "J", mile 4.135, upstream of Interstate 15. On the right bank, out of channel flows are contained by rising ground. On the left bank, flow escapes the channel just downstream of a ridge which ends at section "J", allowing 100-year flows into a residential area. The next out of bank flow occurs at Interstate 15 on both banks, with no levees to consider. Downstream of Interstate 15, flows occur for the 100-year and 500-year floods on both the left and right banks. Once again, the bridge contains all the flow but the banks downstream of the bridge are lower than the water surface elevation exiting the bridge. The volumes of the hydrographs are sufficient to cover the flood plains shown.

The new 100-year flood (shown in blue on the quadrangle flood map for Provo River) will be contained for most reaches with "out of channel" flooding occurring through the golf course (river mile 6 to 7, 3700 N to 2230 N streets). The 100-year also escapes on the left bank between University and State Street. Major 100-year out of bank flows occur on both banks at section "J", mile 4.135, one mile upstream of Interstate 15. On the right bank, out of channel flows are contained by rising ground. On the left bank, flow escapes the channel just downstream of a ridge which ends at section "J", allowing 100-year flows into a residential area. Downstream of Interstate 15, overbank 100-year flooding occurs on both sides (north and south of the river). Depths of flooding are about 1 foot deep. Once again, the bridge contains all the flow but the banks downstream of the bridge are lower than the water surface elevation exiting the bridge. The volumes of the hydrographs are sufficient to cover the flood plains shown.

The 500-year flood losses will be more extensive (shown in red on the flood map). The flooding is out of bank from near the canyon mouth to Highway 91 (State Street). The 500-year flood is contained by University Avenue bridge, but the flood is out of both banks just downstream at cross section "T", mile 5.749. The right bank consists of rubble mounds with no continuity and the left bank is at the 500-year water surface elevation and lower than the 500-year elevation downstream. Thus, flows escape both banks with no conditions for levee failure. At State Street, water escapes to the south (left bank) with some flow leaving the river and extending 1 mile south to Center Street and other flows paralleling the river. The floodplain downstream of Interstate 15 is somewhat larger than the 100-year.

Supporting data attached to this discussion are: a 1 page flood plain map drawn on a portion of a quadrangle map; summary and detailed water surface profiles for the four frequencies for the flow contained in the channel; a second HEC-2 series run for channel rating; profile plots for the four flows in channel; and a plot of the channel cross sections used in the model (the overbank shading designates non-effective flow areas). About 20 maps (1 inch = 400 feet) are available which show the floodplain in more detail.

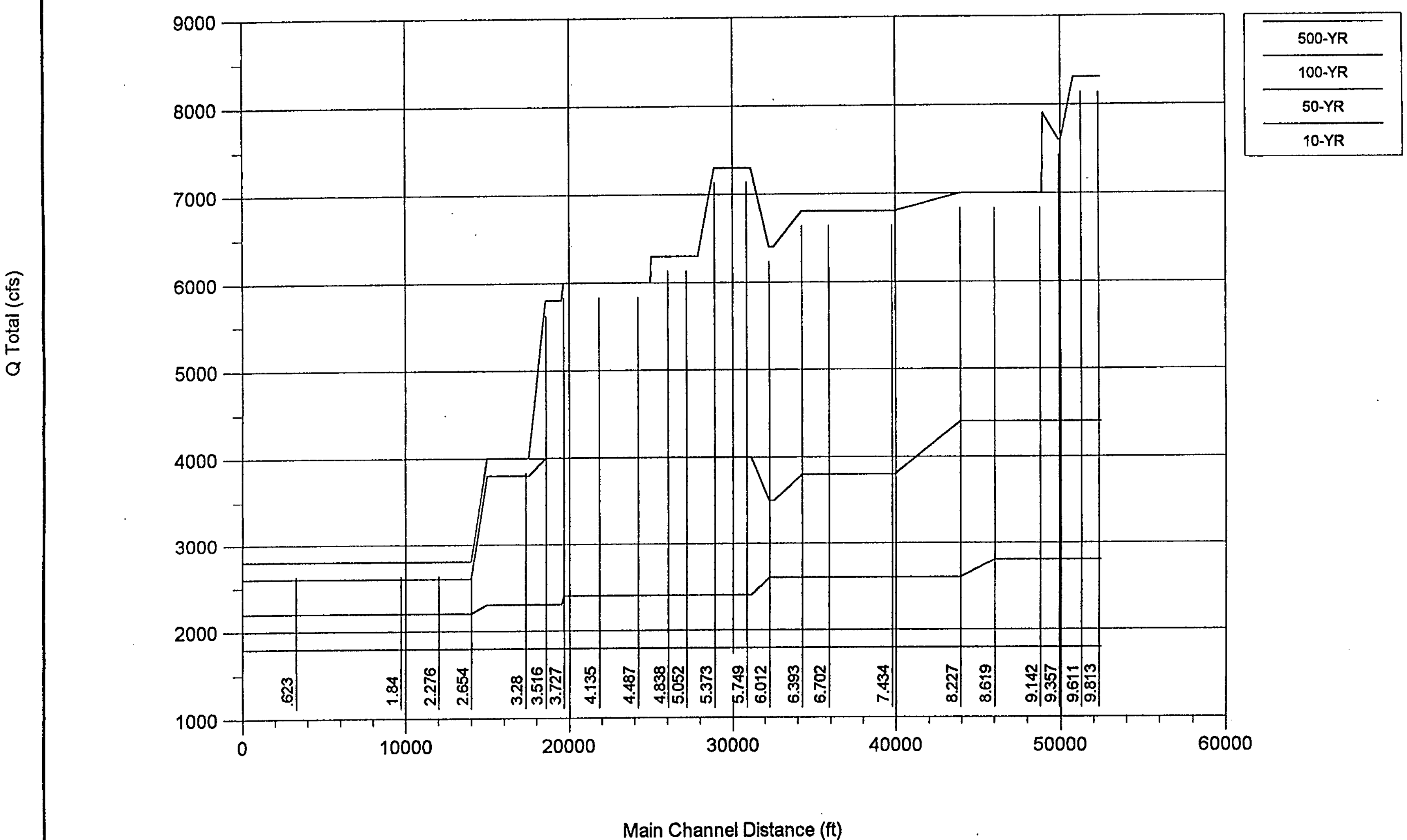
December 12, 1996

FLOOD PLAIN MAP


LEGEND
500-YEAR FLOOD PLAIN BOUNDARY
100-YEAR FLOOD PLAIN BOUNDARY
50-YEAR FLOOD PLAIN BOUNDARY
SCALE IN FEET
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
CITY OF PROVO, UTAH COUNTY
UTAH
PROVO RIVER
RECONNAISSANCE FLOOD PLAIN STUDY
FLOODED AREA MAP
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
DECEMBER 1996
N
OREM
PROVO
Orem Sta
Geneva Sch
Sharon Sch
Lincoln H S
Spencer School
Lakeview
Grandview Sch
Utah Valley Hospital
Jr. High Sch
Powerhouse
8TH NORTH ST
GENEVA ROAD
CENTER ST
500-YR
100-YR
50-YR
PROVO

HEC-2 CHANNEL FLOWS FOUR FREQUENCIES

PROVO RIVER Plan: Plan 04 12/10/96
Channel Flow Only



12/96

FOUR FREQUENCIES OF FLOW ASSOCIATED WITH CHANNEL

HEC-RAS Plan: Plan 04 Reach: 1 12/10/96

River Sta.	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width
	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)
9.838	8300.00	811.70	828.44	825.27	830.09	0.007016	10.30	805.55	79.93
9.838	4400.00	811.70	825.51	822.69	826.43	0.005690	7.70	571.50	79.84
9.838	2800.00	811.70	823.22	819.84	824.01	0.007069	7.11	393.68	74.92
9.838	1800.00	811.70	820.98	818.20	821.70	0.005661	6.81	264.29	44.63
9.813	8300.00	811.30	824.87	824.87	828.38	0.022543	15.03	552.06	79.76
9.813	4400.00	811.30	824.41	821.79	825.54	0.007759	8.53	515.66	78.67
9.813	2800.00	811.30	821.77	819.44	822.96	0.008206	8.77	319.25	48.42
9.813	1800.00	811.30	819.89	817.80	820.81	0.007873	7.69	234.14	42.41
9.80249	Bridge								
9.792	8300.00	810.70	824.27	824.27	827.78	0.022541	15.03	552.08	79.76
9.792	4400.00	810.70	822.05	821.69	824.12	0.019226	11.54	381.35	74.53
9.792	2800.00	810.70	819.45	818.84	821.55	0.017628	11.62	240.91	42.92
9.792	1800.00	810.70	817.92	817.20	819.49	0.016407	10.05	179.08	38.02
9.63	8300.00	795.80	807.46	806.80	810.57	0.016127	14.16	586.25	239.12
9.63	4400.00	795.80	803.61	803.61	806.41	0.022391	13.44	327.33	111.09
9.63	2800.00	795.80	801.86	801.86	804.14	0.023889	12.12	231.09	53.01
9.63	1800.00	795.80	800.51	800.51	802.34	0.025130	10.85	165.95	45.42
9.62	8300.00	794.00	808.84	802.00	809.64	0.002304	7.17	1160.40	91.91
9.62	4400.00	794.00	804.49	799.35	805.00	0.002421	5.73	767.47	87.29
9.62	2800.00	794.00	802.24	798.00	802.61	0.002238	4.85	577.87	81.22
9.62	1800.00	794.00	800.51	796.99	800.77	0.002052	4.08	441.44	76.56
9.61899	Bridge								
9.618	8300.00	794.00	805.00	805.00	808.71	0.020434	15.44	537.45	217.24
9.618	4400.00	794.00	801.81	801.81	804.61	0.022391	13.44	327.33	111.09
9.618	2800.00	794.00	800.06	800.06	802.34	0.023889	12.12	231.09	53.01
9.618	1800.00	794.00	798.71	798.71	800.54	0.025130	10.85	165.95	45.42
9.611	8300.00	791.40	804.61	802.53	806.89	0.010267	12.12	684.98	240.77
9.611	4400.00	791.40	801.73	799.30	803.06	0.007822	9.26	475.01	127.76
9.611	2800.00	791.40	800.03	797.52	800.93	0.006428	7.63	367.12	61.17
9.611	1800.00	791.40	798.50	796.14	799.15	0.005621	6.43	280.10	53.86
9.537	8300.00	790.00	799.90	798.96	802.35	0.013026	12.55	663.49	572.00
9.537	4400.00	790.00	797.21	796.48	798.90	0.014855	10.44	421.66	564.04
9.537	2800.00	790.00	795.57	795.11	797.00	0.017150	9.58	292.36	74.20
9.537	1800.00	790.00	794.54	794.05	795.59	0.016434	8.22	219.00	67.98

HEC-RAS Plan: Plan 04 Reach: 1 12/10/96 (continued)

River Sta.	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)
9.528	8300.00	790.60	798.93	798.33	801.63	0.014752	13.39	663.37	579.99
9.528	4400.00	790.60	795.67	795.48	797.93	0.022573	12.07	364.40	71.97
9.528	2800.00	790.60	794.75	794.20	796.12	0.017260	9.38	298.43	71.94
9.528	1800.00	790.60	793.63	793.28	794.69	0.019648	8.27	217.71	71.90
9.38	7600.00	777.70	790.54	788.08	792.63	0.008763	11.59	655.68	1299.99
9.38	4400.00	777.70	788.81	785.08	789.85	0.005529	8.18	537.85	1291.59
9.38	2800.00	777.70	784.98	783.36	786.24	0.009642	9.00	311.17	52.68
9.38	1800.00	777.70	783.44	782.06	784.37	0.009442	7.74	232.47	49.39
9.37	7600.00	776.90	790.57	787.29	792.10	0.006042	10.17	819.93	1299.99
9.37	4400.00	776.90	788.72	784.28	789.55	0.004102	7.37	633.41	1298.23
9.37	2800.00	776.90	784.69	782.56	785.75	0.007553	8.28	338.27	53.77
9.37	1800.00	776.90	783.16	781.26	783.92	0.006873	6.96	258.64	50.51
9.36649	Bridge								
9.363	7600.00	776.90	789.16	787.28	791.52	0.010775	12.33	616.25	1268.99
9.363	4400.00	776.90	786.02	784.28	787.79	0.010742	10.69	411.61	1256.47
9.363	2800.00	776.90	784.14	782.56	785.42	0.009834	9.06	309.08	52.59
9.363	1800.00	776.90	782.70	781.26	783.61	0.009096	7.65	235.39	49.51
9.357	7600.00	776.90	786.90	786.90	790.88	0.022489	16.02	474.52	244.67
9.357	4400.00	776.90	784.26	784.26	787.19	0.022510	13.75	319.97	54.71
9.357	2800.00	776.90	782.55	782.55	784.85	0.024015	12.17	230.15	50.43
9.357	1800.00	776.90	781.27	781.27	783.06	0.025736	10.75	167.49	47.22
9.173	7900.00	764.00	777.71	772.88	778.59	0.003001	7.52	1053.51	652.00
9.173	4400.00	764.00	774.57	770.71	775.13	0.002968	5.98	735.44	649.14
9.173	2800.00	764.00	772.58	769.51	772.99	0.003060	5.17	541.28	644.31
9.173	1800.00	764.00	771.20	768.62	771.49	0.002805	4.34	415.15	638.80
9.165	7000.00	764.00	777.74	772.36	778.42	0.002336	6.65	1056.30	652.00
9.165	4400.00	764.00	774.42	770.71	775.00	0.003160	6.10	720.82	648.98
9.165	2800.00	764.00	772.43	769.51	772.86	0.003315	5.31	526.93	643.70
9.165	1800.00	764.00	771.06	768.62	771.37	0.003068	4.47	403.04	638.26
9.15749	Bridge								
9.15	7000.00	764.00	775.36	772.36	776.51	0.005457	8.60	814.06	650.74
9.15	4400.00	764.00	773.79	770.71	774.48	0.004195	6.68	658.38	648.31
9.15	2800.00	764.00	772.07	769.51	772.57	0.004033	5.67	493.50	642.26

HEC-RAS Plan: Plan 04 Reach: 1 12/10/96 (continued)

River Sta.	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width
	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)
9.15	1800.00	764.00	770.74	768.62	771.09	0.003841	4.81	374.29	636.94
9.142	7000.00	764.00	776.00	772.38	776.12	0.000939	3.74	3606.20	1000.00
9.142	4400.00	764.00	773.56	770.71	774.30	0.004688	6.92	635.45	631.56
9.142	2800.00	764.00	771.85	769.51	772.39	0.004571	5.92	473.33	368.37
9.142	1800.00	764.00	770.53	768.62	770.93	0.004456	5.05	356.48	165.62
8.657	7000.00	741.90	751.65	750.62	754.02	0.013798	12.36	566.15	78.41
8.657	4400.00	741.90	748.76	748.76	751.22	0.023453	12.59	349.38	71.55
8.657	2800.00	741.90	747.40	747.40	749.28	0.025190	10.99	254.84	68.35
8.657	1800.00	741.90	746.42	746.42	747.83	0.026862	9.55	188.41	66.00
8.647	7000.00	739.00	752.27	747.92	753.28	0.003939	8.06	868.83	582.92
8.647	4400.00	739.00	749.13	746.15	749.95	0.004737	7.26	605.68	83.85
8.647	2800.00	739.00	747.52	744.75	748.07	0.004182	5.95	470.49	82.57
8.647	1800.00	739.00	746.14	743.58	746.53	0.003829	5.00	359.98	78.09
8.63950	Bridge								
8.632	7000.00	739.20	748.46	748.46	751.49	0.021993	13.96	501.48	83.83
8.632	4400.00	739.20	746.79	746.79	749.07	0.023114	12.10	363.50	80.14
8.632	2800.00	739.20	745.42	745.42	747.25	0.024603	10.85	258.06	70.94
8.632	1800.00	739.20	744.18	744.18	745.76	0.025779	10.07	178.77	56.84
8.619	7000.00	737.80	746.51	746.51	749.68	0.021522	14.29	489.93	952.89
8.619	4400.00	737.80	746.26	744.64	747.62	0.009564	9.34	471.11	939.92
8.619	2800.00	737.80	744.48	743.28	745.54	0.010512	8.26	338.91	71.82
8.619	1800.00	737.80	743.35	742.30	744.10	0.009888	6.94	259.55	68.92
8.227	7000.00	722.20	729.52	729.52	731.88	0.022378	12.33	567.59	122.00
8.227	4400.00	722.20	729.87	728.18	730.68	0.006977	7.22	611.07	122.00
8.227	2600.00	722.20	728.63	726.91	729.13	0.005945	5.63	461.64	117.08
8.227	1800.00	722.20	727.71	726.16	728.10	0.006166	5.05	356.60	109.70
7.463	6800.00	685.10	698.65	693.73	699.19	0.002528	6.38	1576.26	685.08
7.463	3800.00	685.10	692.20	690.98	693.83	0.012975	10.25	370.58	65.71
7.463	2600.00	685.10	690.37	689.77	691.92	0.016083	9.98	260.59	57.13
7.463	1800.00	685.10	689.43	688.85	690.60	0.015523	8.68	207.48	55.27
7.453	6800.00	684.00	698.76	692.37	699.02	0.001207	5.02	2395.91	509.60
7.453	3800.00	684.00	691.87	689.97	693.20	0.009355	9.22	411.93	59.84
7.453	2600.00	684.00	689.89	688.87	691.11	0.012621	8.87	293.10	59.79
7.453	1800.00	684.00	688.94	688.01	689.84	0.011964	7.62	236.15	59.77

HEC-RAS Plan: Plan 04 Reach: 1 12/10/96 (continued)

River Sta.	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width
	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)
7.44900	Bridge								
7.445	6800.00	683.60	694.48	691.55	696.37	0.008828	11.04	616.11	60.00
7.445	3800.00	683.60	691.66	689.18	692.78	0.007257	8.50	447.31	59.94
7.445	2600.00	683.60	689.57	688.06	690.58	0.009406	8.08	321.83	59.89
7.445	1800.00	683.60	688.65	687.22	689.36	0.008094	6.74	267.11	59.87
7.434	6800.00	683.30	694.50	691.28	695.81	0.005311	9.18	741.13	299.99
7.434	3800.00	683.30	691.42	688.89	692.34	0.006338	7.68	494.50	79.53
7.434	2600.00	683.30	688.96	687.81	690.01	0.010419	8.22	316.15	67.48
7.434	1800.00	683.30	688.12	686.99	688.86	0.009209	6.93	259.79	66.04
6.702	6800.00	649.60	656.24	656.24	658.97	0.021628	13.27	512.51	593.16
6.702	3800.00	649.60	654.96	654.32	656.40	0.014930	9.62	395.16	588.64
6.702	2600.00	649.60	654.83	653.40	655.54	0.007683	6.79	383.18	588.17
6.702	1800.00	649.60	653.77	652.70	654.36	0.008634	6.18	291.06	584.43
6.479	6800.00	638.70	650.96	646.52	651.28	0.001496	4.62	1553.25	550.00
6.479	3800.00	638.70	647.08	645.12	647.48	0.004309	5.10	776.84	200.00
6.479	2600.00	638.70	645.65	643.57	646.09	0.008205	5.36	490.08	200.00
6.479	1800.00	638.70	644.36	642.80	644.88	0.007477	5.76	312.75	91.19
6.46	6800.00	637.00	649.25	645.55	650.88	0.006386	10.24	664.13	301.00
6.46	3800.00	637.00	645.82	643.16	646.89	0.006452	8.29	458.39	259.95
6.46	2600.00	637.00	644.80	642.04	645.46	0.004689	6.55	397.04	259.92
6.46	1800.00	637.00	643.94	641.18	644.36	0.003448	5.21	345.70	259.89
6.45800	Bridge								
6.456	6800.00	637.00	647.53	645.55	649.81	0.011215	12.12	560.90	301.00
6.456	3800.00	637.00	645.62	643.16	646.75	0.006989	8.51	446.53	259.94
6.456	2600.00	637.00	644.67	642.04	645.36	0.004972	6.67	389.55	259.92
6.456	1800.00	637.00	643.86	641.18	644.29	0.003609	5.28	340.64	259.89
6.441	6800.00	638.20	647.62	645.49	648.81	0.006564	8.79	781.01	112.00
6.441	3800.00	638.20	645.18	643.92	646.06	0.008490	7.53	508.34	112.00
6.441	2600.00	638.20	644.14	643.05	644.83	0.009376	6.66	391.96	112.00
6.441	1800.00	638.20	643.23	642.37	643.82	0.010396	6.13	294.34	102.18
6.393	6800.00	636.50	643.46	643.46	646.06	0.019253	13.03	544.68	111.00
6.393	3800.00	636.50	642.97	641.53	643.96	0.008235	8.02	489.87	111.00
6.393	2600.00	636.50	642.41	640.49	643.00	0.005699	6.19	427.95	111.00

HEC-RAS Plan: Plan 04 Reach: 1 12/10/96 (continued)

River Sta.	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width
	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)
6.393	1800.00	636.50	641.49	639.67	641.94	0.005490	5.35	336.70	87.63
6.071	6400.00	621.20	630.39	628.39	630.90	0.003828	6.71	1353.39	499.99
6.071	3500.00	621.20	627.50	627.19	628.38	0.010287	8.01	569.17	442.11
6.071	2600.00	621.20	626.42	625.92	627.63	0.016246	8.90	315.50	204.06
6.071	1800.00	621.20	625.57	625.16	626.58	0.017327	8.03	224.10	75.09
6.052	6400.00	620.10	627.50	627.00	629.99	0.017626	12.66	505.41	386.31
6.052	3500.00	620.10	624.49	624.49	626.69	0.026189	11.89	294.31	357.03
6.052	2600.00	620.10	623.71	623.71	625.51	0.027206	10.77	241.39	67.01
6.052	1800.00	620.10	622.91	622.91	624.33	0.028954	9.56	188.38	66.99
6.049	6400.00	615.90	628.37	624.01	629.46	0.003941	8.40	766.41	75.00
6.049	3500.00	615.90	622.82	621.70	624.25	0.011845	9.60	364.65	66.91
6.049	2600.00	615.90	621.61	620.84	622.90	0.013843	9.12	285.18	64.26
6.049	1800.00	615.90	620.62	619.95	621.64	0.014229	8.08	222.85	62.10
6.036	6400.00	614.90	628.24	623.01	629.17	0.003012	7.75	831.95	75.00
6.036	3500.00	614.90	622.20	620.70	623.45	0.009648	8.97	390.24	67.75
6.036	2600.00	614.90	620.72	619.84	621.95	0.012826	8.89	292.35	64.50
6.036	1800.00	614.90	619.57	618.95	620.61	0.014915	8.20	219.51	61.98
6.02899	Bridge								
6.022	6400.00	613.60	624.48	621.72	626.01	0.006835	9.91	647.57	75.00
6.022	3500.00	613.60	621.90	619.39	622.80	0.005928	7.63	458.96	69.93
6.022	2600.00	613.60	620.27	618.54	621.14	0.007554	7.48	347.68	66.35
6.022	1800.00	613.60	619.01	617.65	619.72	0.008192	6.76	266.30	63.61
6.012	6400.00	613.50	624.46	621.37	625.58	0.005078	8.71	846.17	177.51
6.012	3500.00	613.50	621.66	619.03	622.48	0.005416	7.28	484.14	89.63
6.012	2600.00	613.50	619.88	618.16	620.74	0.007602	7.42	350.46	69.65
6.012	1800.00	613.50	618.54	617.27	619.28	0.008761	6.91	260.48	64.50
5.805	7300.00	603.60	612.20	612.20	615.31	0.019076	14.17	526.20	101.63
5.805	4000.00	603.60	609.94	609.58	612.00	0.018477	11.52	347.31	69.47
5.805	2400.00	603.60	608.86	608.05	610.04	0.013309	8.74	274.61	65.34
5.805	1800.00	603.60	608.53	607.37	609.32	0.009486	7.10	253.63	64.10
5.796	7300.00	603.20	612.33	610.88	614.23	0.010846	11.06	659.97	89.43
5.796	4000.00	603.20	609.47	608.84	610.99	0.015376	9.89	404.40	89.30
5.796	2400.00	603.20	607.52	607.57	609.09	0.027053	10.03	239.29	79.69
5.796	1800.00	603.20	606.66	606.99	608.35	0.041908	10.44	172.34	75.26

HEC-RAS Plan: Plan 04 Reach: 1 12/10/96 (continued)

River Sta.	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)
5.77600	Bridge								
5.756	7300.00	601.40	612.18	610.25	613.86	0.009005	10.43	700.22	89.42
5.756	4000.00	601.40	609.34	608.17	610.58	0.011124	8.95	446.95	89.00
5.756	2400.00	601.40	607.38	606.81	608.50	0.015697	8.50	282.22	78.94
5.756	1800.00	601.40	606.51	606.21	607.59	0.020098	8.37	215.18	74.46
5.749	7300.00	601.20	611.78	609.68	613.49	0.008797	10.57	786.00	526.60
5.749	4000.00	601.20	608.93	607.19	610.17	0.008815	8.92	448.51	75.14
5.749	2400.00	601.20	607.04	605.65	607.95	0.009024	7.66	313.29	67.67
5.749	1800.00	601.20	606.19	604.96	606.95	0.009125	7.00	257.08	64.39
5.525	7300.00	592.00	604.88	600.97	606.01	0.004612	8.51	859.43	395.16
5.525	4000.00	592.00	601.46	598.48	602.28	0.005134	7.28	549.27	383.09
5.525	2400.00	592.00	599.26	596.91	599.88	0.005276	6.34	378.60	72.39
5.525	1800.00	592.00	598.24	596.19	598.78	0.005374	5.85	307.58	67.44
5.524	7300.00	592.00	604.48	601.20	605.92	0.006366	9.65	756.62	657.81
5.524	4000.00	592.00	601.18	598.60	602.20	0.006354	8.11	493.09	265.73
5.524	2400.00	592.00	599.07	596.96	599.81	0.006272	6.93	346.44	65.39
5.524	1800.00	592.00	598.08	596.23	598.71	0.006282	6.34	283.95	61.58
5.373	7300.00	587.00	596.80	595.51	599.00	0.012267	11.90	613.59	85.23
5.373	4000.00	587.00	594.44	592.99	595.81	0.010322	9.40	425.47	74.35
5.373	2400.00	587.00	592.74	591.39	593.70	0.009557	7.85	305.83	66.51
5.373	1800.00	587.00	591.96	590.68	592.73	0.009090	7.05	255.16	62.89
5.184	6300.00	579.80	592.25	587.32	592.89	0.002993	6.42	983.16	220.99
5.184	4000.00	579.80	589.02	585.78	589.65	0.003857	6.35	629.53	94.22
5.184	2400.00	579.80	586.73	584.50	587.23	0.004502	5.65	424.59	85.86
5.184	1800.00	579.80	585.80	583.94	586.22	0.004776	5.21	345.32	82.84
5.165	6300.00	579.70	592.34	585.07	592.58	0.001320	3.86	1631.63	224.90
5.165	4000.00	579.70	589.06	583.90	589.30	0.001552	3.93	1017.10	149.30
5.165	2400.00	579.70	586.74	582.94	586.91	0.001293	3.32	722.46	117.97
5.165	1800.00	579.70	585.77	582.55	585.91	0.001265	2.96	608.26	117.94
5.15649	Bridge								
5.148	6300.00	579.70	591.11	585.07	591.44	0.001988	4.59	1372.12	196.56
5.148	4000.00	579.70	588.71	583.91	588.98	0.001721	4.14	966.50	141.28
5.148	2400.00	579.70	586.74	582.94	586.91	0.001296	3.32	721.86	117.97

HEC-RAS Plan: Plan 04 Reach: 1 12/10/96 (continued)

River Sta.	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width
	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)
5.148	1800.00	579.70	585.77	582.55	585.91	0.001268	2.96	607.77	117.94
5.136	6300.00	579.90	590.26	586.67	591.19	0.004928	7.73	814.94	110.64
5.136	4000.00	579.90	588.07	585.10	588.77	0.004374	6.68	598.94	91.97
5.136	2400.00	579.90	586.28	583.76	586.74	0.003917	5.45	440.53	85.12
5.136	1800.00	579.90	585.37	583.15	585.75	0.003907	4.94	364.29	81.68
5.084	6300.00	579.00	585.77	585.77	588.52	0.021724	13.30	473.71	86.59
5.084	4000.00	579.00	584.27	584.20	586.32	0.022232	11.51	347.66	80.91
5.084	2400.00	579.00	582.91	582.86	584.44	0.024501	9.95	241.22	75.62
5.084	1800.00	579.00	582.59	582.25	583.65	0.018808	8.28	217.51	73.81
5.075	6300.00	579.00	584.17	584.17	586.75	0.023935	12.88	489.30	95.16
5.075	4000.00	579.00	584.38	582.83	585.34	0.008482	7.85	509.43	95.21
5.075	2400.00	579.00	581.72	581.72	583.08	0.028196	9.37	256.05	94.61
5.075	1800.00	579.00	582.45	581.25	582.92	0.007279	5.53	325.35	94.78
5.07099	Bridge								
5.067	6300.00	579.00	584.17	584.17	586.75	0.023949	12.88	489.21	95.16
5.067	4000.00	579.00	582.83	582.83	584.73	0.025513	11.06	361.69	94.86
5.067	2400.00	579.00	581.72	581.72	583.08	0.028199	9.37	256.04	94.61
5.067	1800.00	579.00	581.26	581.25	582.37	0.028862	8.44	213.17	94.51
5.054	6300.00	576.70	582.24	582.24	585.03	0.024329	13.39	470.61	84.95
5.054	4000.00	576.70	580.79	580.79	582.85	0.025957	11.52	347.14	84.91
5.054	2400.00	576.70	579.62	579.62	581.08	0.027757	9.68	247.88	84.88
5.054	1800.00	576.70	579.10	579.10	580.31	0.029571	8.84	203.71	84.87
5.052	6300.00	573.80	581.27	578.99	582.52	0.007630	8.99	700.76	93.93
5.052	4000.00	573.80	578.78	577.63	579.92	0.011158	8.56	467.25	93.89
5.052	2400.00	573.80	576.64	576.52	577.90	0.024739	9.01	266.31	93.85
5.052	1800.00	573.80	576.05	576.05	577.18	0.029607	8.52	211.33	93.84
5.034	6300.00	571.10	581.18	576.44	581.93	0.003292	6.96	905.82	89.98
5.034	4000.00	571.10	578.70	575.05	579.24	0.003194	5.85	683.32	89.94
5.034	2400.00	571.10	576.64	573.91	577.00	0.003133	4.82	497.82	89.90
5.034	1800.00	571.10	575.75	573.41	576.04	0.003076	4.30	418.21	89.89
4.838	6300.00	564.10	574.54	572.62	576.38	0.009719	10.86	580.19	376.21
4.838	4000.00	564.10	572.24	570.69	573.69	0.010276	9.68	413.25	67.92
4.838	2400.00	564.10	570.07	569.04	571.25	0.011978	8.74	274.63	59.73
4.838	1800.00	564.10	569.05	568.30	570.13	0.013614	8.33	215.98	55.90

HEC-RAS Plan: Plan 04 Reach: 1 12/10/96 (continued)

River Sta.	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)
4.649	6300.00	556.10	568.55	564.62	569.68	0.004644	8.53	740.33	380.99
4.649	4000.00	556.10	566.23	562.69	567.04	0.004434	7.19	556.38	375.41
4.649	2400.00	556.10	564.06	561.04	564.62	0.004019	5.98	401.38	67.26
4.649	1800.00	556.10	563.09	560.30	563.53	0.003715	5.33	337.43	63.57
4.639	6000.00	557.50	568.81	562.72	569.36	0.002003	5.96	1010.86	381.00
4.639	4000.00	557.50	566.37	561.47	566.77	0.002003	5.07	788.94	91.00
4.639	2400.00	557.50	564.14	560.33	564.40	0.001802	4.06	590.42	88.95
4.639	1800.00	557.50	563.13	559.83	563.33	0.001711	3.60	500.58	88.93
4.63749	Bridge								
4.636	6000.00	557.00	568.43	562.19	568.96	0.001907	5.86	1047.82	391.00
4.636	4000.00	557.00	566.27	560.98	566.64	0.001728	4.85	830.18	391.00
4.636	2400.00	557.00	564.14	559.83	564.36	0.001435	3.78	634.62	88.97
4.636	1800.00	557.00	563.13	559.33	563.30	0.001308	3.30	544.74	88.94
4.63	6000.00	556.80	567.56	564.66	568.78	0.005705	8.92	712.84	424.99
4.63	4000.00	556.80	565.47	563.06	566.47	0.006442	8.05	497.44	376.79
4.63	2400.00	556.80	563.51	561.51	564.23	0.006314	6.80	352.78	69.56
4.63	1800.00	556.80	562.58	560.81	563.17	0.006303	6.21	289.79	65.71
4.539	6000.00	554.20	564.92	561.59	565.95	0.005943	8.12	738.60	605.73
4.539	4000.00	554.20	562.38	560.03	563.35	0.006604	7.94	503.83	81.24
4.539	2400.00	554.20	560.33	558.52	561.07	0.006933	6.92	346.96	71.80
4.539	1800.00	554.20	559.54	557.82	560.13	0.006463	6.17	291.68	68.17
4.53	6000.00	554.10	564.23	561.17	565.59	0.006976	9.37	640.42	562.00
4.53	4000.00	554.10	561.89	559.72	562.98	0.007865	8.39	476.70	69.95
4.53	2400.00	554.10	559.90	558.38	560.68	0.008398	7.11	337.39	69.89
4.53	1800.00	554.10	559.14	557.55	559.77	0.008107	6.32	284.74	69.87
4.52600	Bridge								
4.522	6000.00	554.10	563.67	561.17	565.22	0.008695	9.97	601.56	559.75
4.522	4000.00	554.10	561.28	559.72	562.60	0.010544	9.22	434.01	69.93
4.522	2400.00	554.10	559.02	558.38	560.20	0.015870	8.69	276.29	69.86
4.522	1800.00	554.10	558.09	557.55	559.22	0.021202	8.53	211.09	69.84
4.487	6000.00	551.00	562.68	558.68	563.91	0.005124	8.90	684.51	150.02
4.487	4000.00	551.00	560.16	556.96	561.15	0.005367	7.95	503.00	64.78
4.487	2400.00	551.00	557.69	555.29	558.43	0.005636	6.87	349.58	59.45

HEC-RAS Plan: Plan 04 Reach: 1 12/10/96 (continued)

River Sta.	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width
	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)
4.487	1800.00	551.00	556.61	554.56	557.23	0.005743	6.28	286.65	57.12
4.24	6000.00	542.00	550.67	548.72	552.06	0.008589	9.46	634.07	163.37
4.24	4000.00	542.00	549.49	547.28	550.40	0.006552	7.63	524.31	89.96
4.24	2400.00	542.00	548.04	545.86	548.60	0.005154	6.01	399.49	82.23
4.24	1800.00	542.00	547.26	545.23	547.71	0.004756	5.34	336.97	78.07
4.135	6000.00	540.00	547.53	545.79	548.17	0.005316	7.10	1135.66	544.84
4.135	4000.00	540.00	546.47	544.43	547.04	0.005381	6.41	809.06	510.32
4.135	2400.00	540.00	544.77	543.20	545.38	0.006694	6.26	383.52	156.96
4.135	1800.00	540.00	543.88	542.65	544.42	0.007675	5.92	303.93	86.86
3.808	6000.00	528.00	538.13	534.78	539.22	0.005026	8.38	715.80	80.00
3.808	4000.00	528.00	535.34	533.34	536.37	0.007115	8.12	492.90	80.00
3.808	2400.00	528.00	533.85	531.89	534.49	0.005971	6.41	374.32	77.88
3.808	1800.00	528.00	533.19	531.25	533.67	0.005163	5.57	323.28	74.69
3.751	6000.00	526.00	537.82	532.77	538.18	0.001707	4.96	1300.27	679.99
3.751	4000.00	526.00	533.48	531.57	534.23	0.006595	6.97	573.75	614.00
3.751	2400.00	526.00	531.22	530.42	532.03	0.011861	7.20	333.35	598.27
3.751	1800.00	526.00	530.44	529.91	531.20	0.014665	6.99	257.47	593.13
3.742	6000.00	525.70	537.76	531.29	538.11	0.001192	4.84	1319.07	145.00
3.742	4000.00	525.70	533.47	530.17	533.93	0.002883	5.44	734.87	109.97
3.742	2400.00	525.70	531.20	529.07	531.58	0.003917	4.94	485.62	109.83
3.742	1800.00	525.70	530.40	528.59	530.71	0.004101	4.52	397.83	107.15
3.73850	Bridge								
3.735	6000.00	525.20	536.59	530.99	537.04	0.001643	5.38	1118.86	112.00
3.735	4000.00	525.20	533.44	529.81	533.86	0.002505	5.22	766.80	109.97
3.735	2400.00	525.20	531.18	528.68	531.51	0.003162	4.63	517.91	109.75
3.735	1800.00	525.20	530.37	528.19	530.64	0.003147	4.18	430.80	107.07
3.727	6000.00	524.30	536.32	530.96	536.95	0.002427	6.32	948.72	90.00
3.727	4000.00	524.30	533.17	529.64	533.73	0.003251	6.02	664.79	90.00
3.727	2400.00	524.30	530.95	528.31	531.36	0.003631	5.16	464.78	90.00
3.727	1800.00	524.30	530.18	527.71	530.50	0.003410	4.55	395.92	90.00
3.701	5800.00	524.30	535.98	530.83	536.60	0.002512	6.32	917.68	90.00
3.701	4000.00	524.30	532.52	529.64	533.20	0.004338	6.60	606.48	90.00
3.701	2300.00	524.30	530.23	528.22	530.74	0.005390	5.75	399.95	90.00
3.701	1800.00	524.30	529.41	527.71	529.88	0.005766	5.48	328.63	84.70

HEC-RAS Plan: Plan 04 Reach: 1 12/10/96 (continued)

River Sta.	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width
	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)
3.691	5800.00	523.60	535.69	530.18	536.45	0.002794	7.00	831.58	76.00
3.691	4000.00	523.60	532.21	528.87	532.97	0.004372	7.01	570.44	73.32
3.691	2300.00	523.60	530.02	527.46	530.50	0.004011	5.60	410.78	72.37
3.691	1800.00	523.60	529.22	526.96	529.62	0.003945	5.09	353.41	72.03
3.68949	Bridge								
3.688	5800.00	523.60	534.75	530.18	535.66	0.003749	7.65	759.92	76.00
3.688	4000.00	523.60	532.10	528.87	532.89	0.004555	7.11	562.89	73.27
3.688	2300.00	523.60	529.92	527.46	530.43	0.004222	5.69	404.13	72.33
3.688	1800.00	523.60	529.13	526.96	529.55	0.004182	5.19	346.94	71.99
3.663	5800.00	522.80	534.57	529.96	535.16	0.002525	6.19	937.83	402.99
3.663	4000.00	522.80	531.65	528.63	532.27	0.004130	6.29	635.82	400.73
3.663	2300.00	522.80	529.35	527.29	529.83	0.004692	5.61	409.98	386.46
3.663	1800.00	522.80	528.47	526.82	528.92	0.005370	5.37	334.91	383.74
3.601	5800.00	520.90	534.02	528.06	534.47	0.001613	5.39	1078.62	402.99
3.601	4000.00	520.90	530.69	526.73	531.16	0.002655	5.46	732.65	402.99
3.601	2300.00	520.90	528.14	525.39	528.50	0.003415	4.85	474.15	398.00
3.601	1800.00	520.90	527.16	524.92	527.50	0.003482	4.67	385.22	385.57
3.582	5800.00	520.40	533.88	527.55	534.31	0.001545	5.23	1108.65	108.00
3.582	4000.00	520.40	530.44	526.33	530.90	0.002514	5.41	740.02	103.30
3.582	2300.00	520.40	527.84	525.00	528.19	0.002912	4.75	484.62	92.71
3.582	1800.00	520.40	526.83	524.52	527.16	0.003345	4.58	393.44	88.63
3.56950	Bridge								
3.557	5800.00	519.20	532.76	526.35	533.18	0.001508	5.19	1117.40	108.00
3.557	4000.00	519.20	530.09	525.13	530.45	0.001806	4.83	828.92	106.73
3.557	2300.00	519.20	527.61	523.79	527.85	0.001734	3.99	576.59	96.66
3.557	1800.00	519.20	526.57	523.33	526.79	0.001849	3.76	478.82	92.46
3.538	5800.00	519.20	532.58	526.33	533.02	0.001559	5.32	1092.76	208.99
3.538	4000.00	519.20	529.86	525.12	530.25	0.002045	5.03	795.03	204.45
3.538	2300.00	519.20	527.40	523.79	527.67	0.001963	4.19	549.37	192.75
3.538	1800.00	519.20	526.35	523.33	526.59	0.002103	3.97	453.88	187.79
3.535	5800.00	519.40	531.60	527.81	532.90	0.005189	9.15	633.87	265.99
3.535	4000.00	519.40	528.98	526.12	530.13	0.006470	8.60	465.23	62.12
3.535	2300.00	519.40	526.87	524.18	527.58	0.005213	6.76	340.33	56.14

HEC-RAS Plan: Plan 04 Reach: 1 12/10/96 (continued)

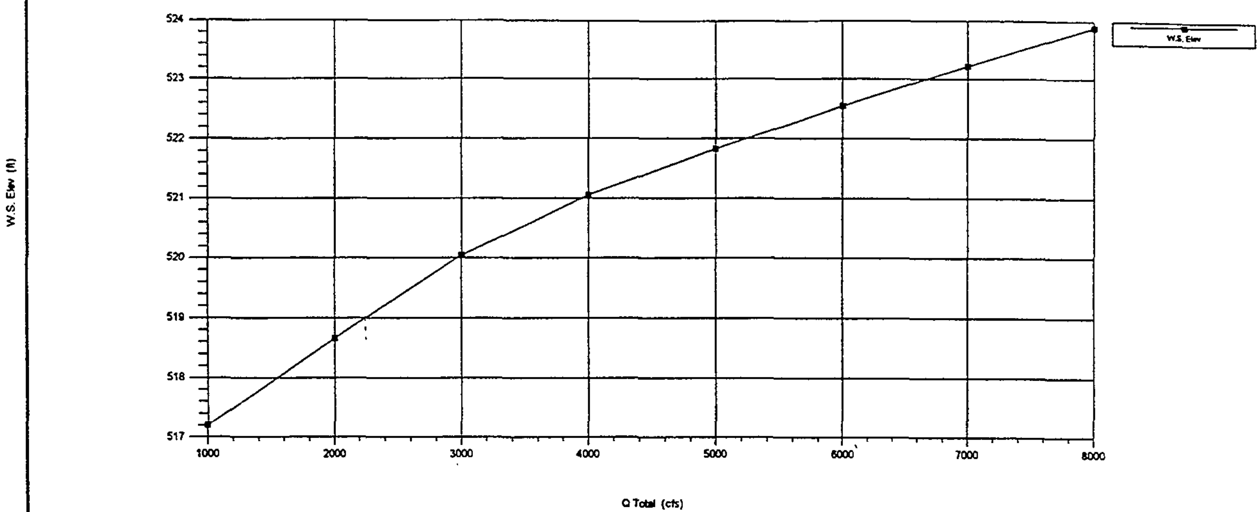
River Sta.	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width
	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)
3.535	1800.00	519.40	525.90	523.50	526.51	0.005210	6.27	287.24	53.39
3.526	5800.00	518.80	531.09	526.49	532.59	0.006452	9.85	588.67	150.00
3.526	4000.00	518.80	528.71	524.81	529.81	0.005992	8.43	474.42	147.98
3.526	2300.00	518.80	526.75	522.95	527.32	0.003814	6.04	380.61	147.94
3.526	1800.00	518.80	525.81	522.33	526.26	0.003420	5.37	335.42	147.93
3.516	5800.00	519.20	530.91	527.42	532.23	0.005927	9.20	630.47	652.00
3.516	4000.00	519.20	528.22	525.65	529.46	0.007635	8.92	448.22	643.23
3.516	2300.00	519.20	526.35	523.69	527.07	0.005570	6.84	336.19	636.08
3.516	1800.00	519.20	525.41	523.03	526.03	0.005380	6.31	285.25	632.50
3.318	4000.00	514.40	523.44	519.86	524.09	0.011640	6.48	617.52	92.00
3.318	3800.00	514.40	522.86	519.69	523.55	0.004093	6.66	570.81	80.59
3.318	2300.00	514.40	520.14	518.36	520.79	0.006461	6.46	356.14	77.27
3.318	1800.00	514.40	519.50	517.85	520.03	0.006073	5.85	307.69	74.27
3.303	4000.00	514.20	523.15	519.30	523.65	0.002686	5.67	707.38	498.00
3.303	3800.00	514.20	522.71	519.15	523.22	0.002975	5.73	664.15	496.88
3.303	2300.00	514.20	519.72	517.96	520.27	0.005745	5.94	387.15	87.93
3.303	1800.00	514.20	519.08	517.51	519.54	0.005701	5.43	331.30	85.84
3.299	4000.00	514.70	523.08	519.55	523.59	0.002988	5.72	699.24	697.72
3.299	3800.00	514.70	522.63	519.41	523.15	0.003322	5.81	654.55	697.69
3.299	2300.00	514.70	519.44	518.28	520.12	0.008621	6.60	348.61	92.25
3.299	1800.00	514.70	518.76	517.85	519.38	0.009804	6.28	286.51	90.61
3.29550	Bridge								
3.292	4000.00	514.70	521.71	519.54	522.49	0.005857	7.09	564.05	477.97
3.292	3800.00	514.70	521.46	519.40	522.23	0.006066	7.05	539.30	371.43
3.292	2300.00	514.70	519.32	518.28	520.04	0.009609	6.83	336.77	91.94
3.292	1800.00	514.70	518.63	517.85	519.30	0.011200	6.55	274.74	90.30
3.28	4000.00	514.00	521.62	518.41	522.16	0.003393	5.91	677.56	778.60
3.28	3800.00	514.00	521.35	518.28	521.89	0.003479	5.85	650.34	777.98
3.28	2300.00	514.00	519.11	517.14	519.57	0.004712	5.41	425.51	770.04
3.28	1800.00	514.00	518.40	516.69	518.79	0.004941	5.03	357.69	767.44
2.834	4000.00	503.30	511.55	508.52	512.19	0.005420	6.44	621.59	592.00
2.834	3800.00	503.30	511.18	508.37	511.85	0.005334	6.56	579.32	577.57
2.834	2300.00	503.30	509.78	507.12	510.19	0.003421	5.12	449.03	556.11
2.834	1800.00	503.30	509.05	506.64	509.38	0.003288	4.65	386.94	553.53

HEC-RAS Plan: Plan 04 Reach: 1 12/10/96 (continued)

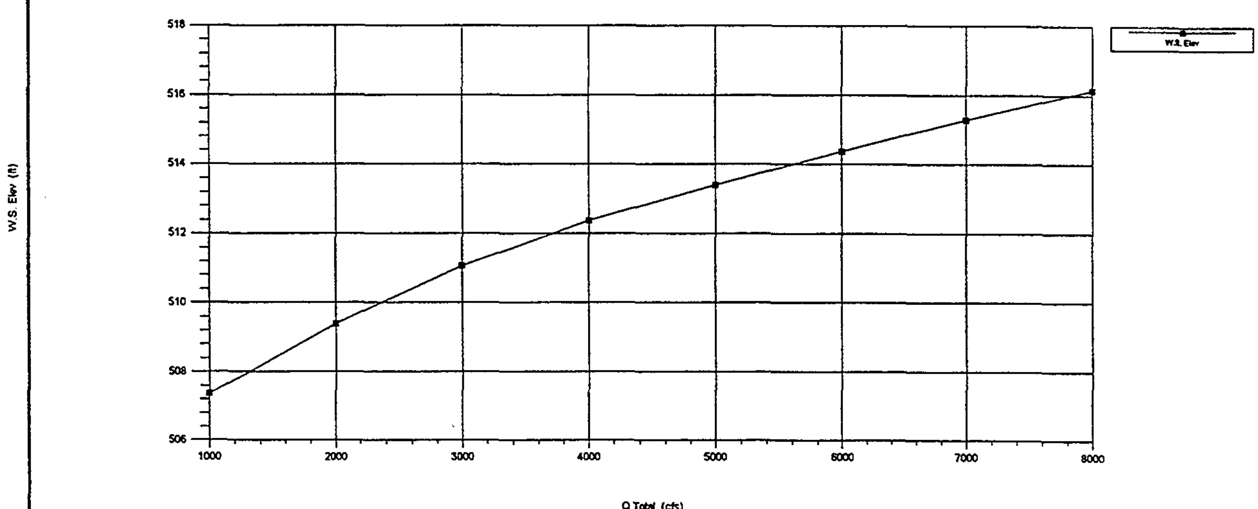
River Sta.	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width
	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)
2.654	2800.00	500.40	507.32	504.33	507.83	0.003632	5.73	488.62	81.28
2.654	2600.00	500.40	507.16	504.14	507.63	0.003382	5.46	476.22	80.81
2.654	2200.00	500.40	506.71	503.77	507.10	0.003070	5.00	440.02	79.42
2.654	1800.00	500.40	506.39	503.36	506.69	0.002453	4.34	414.89	78.44
2.276	2800.00	493.00	499.78	496.93	500.31	0.003892	5.86	477.48	80.86
2.276	2600.00	493.00	499.18	496.74	499.75	0.004614	6.05	429.43	79.01
2.276	2200.00	493.00	498.21	496.37	498.81	0.005893	6.20	354.71	76.05
2.276	1800.00	493.00	496.88	495.96	497.65	0.010762	7.03	255.87	71.93
1.897	2800.00	484.00	498.63	488.18	498.72	0.000297	2.48	1129.30	96.15
1.897	2600.00	484.00	497.99	487.99	498.08	0.000300	2.43	1068.65	94.37
1.897	2200.00	484.00	497.12	487.60	497.20	0.000268	2.23	987.67	91.94
1.897	1800.00	484.00	495.83	487.19	495.89	0.000257	2.07	871.10	88.32
1.84	2800.00	483.80	498.50	490.02	498.61	0.000448	2.64	1062.03	617.88
1.84	2600.00	483.80	497.86	489.78	497.97	0.000482	2.64	986.56	616.33
1.84	2200.00	483.80	497.00	489.28	497.09	0.000470	2.48	886.97	613.23
1.84	1800.00	483.80	495.69	488.73	495.78	0.000517	2.42	744.19	606.15
.623	2800.00	479.70	496.73	485.38	496.78	0.000194	1.85	1510.17	153.70
.623	2600.00	479.70	495.95	485.15	496.01	0.000208	1.87	1393.16	147.98
.623	2200.00	479.70	495.25	484.66	495.29	0.000183	1.70	1291.00	142.79
.623	1800.00	479.70	493.83	484.16	493.87	0.000191	1.64	1095.76	132.31
0	2800.00	478.00	495.40	487.32	495.59	0.000855	3.51	796.74	91.58
0	2600.00	478.00	494.50	487.05	494.70	0.000979	3.63	716.45	86.84
0	2200.00	478.00	494.00	486.47	494.17	0.000826	3.27	673.68	84.21
0	1800.00	478.00	492.50	485.81	492.66	0.000934	3.25	553.29	76.32

HEC-2 SERIES RATING COMPUTATIONS

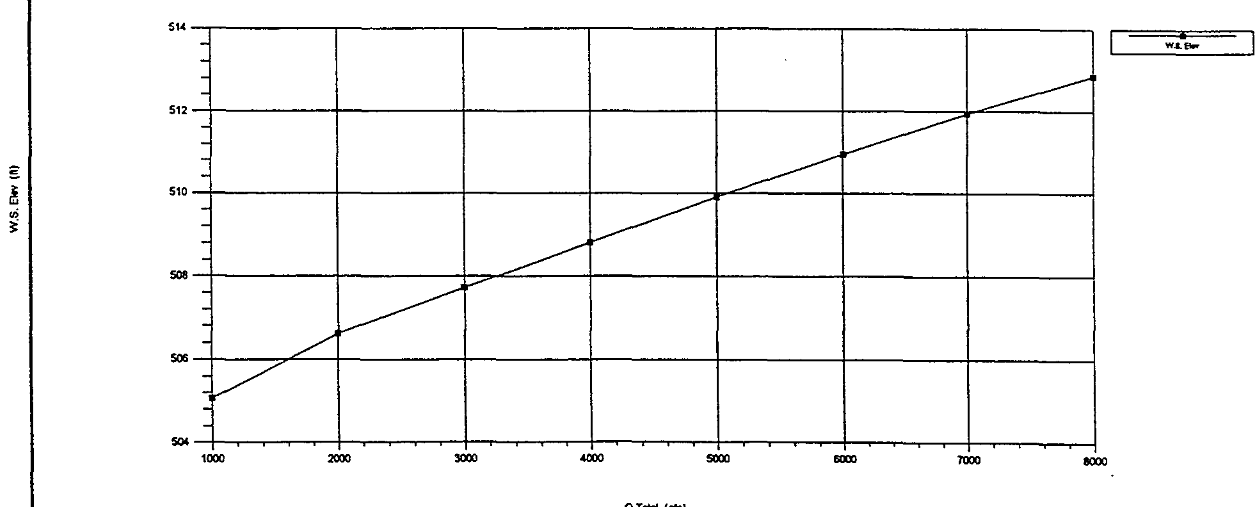
PROVO RIVER Plan: Plan 03 12/9/96
3.28



PROVO RIVER Plan: Plan 03 12/9/96
2.834



PROVO RIVER Plan: Plan 03 12/9/96
2.654



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1****************************************            **************************************
 * HEC-2 WATER SURFACE PROFILES            *          * U.S. ARMY CORPS OF ENGINEERS    *
 *                                         *      * HYDROLOGIC ENGINEERING CENTER       *
 * Version  4.6.2;  May 1991               *          * 609 SECOND STREET, SUITE D      *
 *                                         *      * DAVIS, CALIFORNIA 95616-4687        *
 * RUN DATE   09DEC96   TIME   15:51:42    *          *      (916) 756-1104             *
****************************************              **************************************
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X     X XXXXXXX  XXXXX          XXXXX
X     X X        X     X       X     X
X     X X        X                   X
XXXXXXX XXXX     X       XXXXX  XXXXX
X     X X        X             X
X     X X        X     X       X
X     X XXXXXXX  XXXXX         XXXXXXX
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THIS RUN EXECUTED 09DEC96   15:51:43

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HEC-2 WATER SURFACE PROFILES

Version  4.6.2;  May 1991
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SERIES RATING FLOW WITH FOUR FREQ RUNS OF TOTAL FLOW AVAILABLE

ALL SECTIONS ASSUMED LOOKING UPSTREAM

THIS IS AN ARCHIVAL RUN ALL DATA AND RESULTS ARE SAVED ON UNIT 96

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AC
T1     PROVO FLOOD STUDY 11/26/96- PROVO R HATCH EDITED 5/96  N=.045,.07
T2     SERIES RATING CHANNEL PROVO 16                   , X1 RIVER MILES
T3     PROVO16 LAKE WSEL 10 YR=492.5; 50 YR=494.0; 100 YR=494.5; 500 YR=495.4
T4     bt card sections dup gr cards, x1-9 elev increas added to cards, RAS
T5     qt cards w/ new flows & modified bridge mile 5.06 and new at 9.1, 8/6/96
T6     NC=.045 11/21/96 PROVO16

J1  ICHECK   INQ     NINV    IDIR    STRT    METRIC   HVINS    Q       WSEL    FQ

               2                                      495.4

J2  NPROF   IPLOT   PRFVS   XSECV   XSECH    FN     ALLDC   IBW     CHNIM   ITRACE

     1        -1                      -1

J3  VARIABLE CODES FOR SUMMARY PRINTOUT

    38      43      23       1      24      13      14      15       4      26
    39      40

J5  LPRNT   NUMSEC            ********REQUESTED SECTION NUMBERS********

   -10     -10

NC     .07     .07     .05      .1      .3

QT      11    6200    3700    2200    1800    8000    7000    6000    5000    4000
QT    3000    2000

X1     0.0       5     100     200       0       0       0
X3      10                      99     500     201     500
GR     500       0     497     100     478     150     497     200     500     300
 section fits l/ds so left and right elevations are switched for plots

X1    .623      11     990    1230    3300    3300    3300              400
X3      10
GR    92.5     990    99.3    1000      91    1010    80.8    1030    79.7    1050
GR    80.2    1060    81.4    1070    84.4    1080      89    1110    92.5    1170
GR    98.5    1230
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     A----A   PROVO18 SERIES CHANNEL RATING , LOSSES MILE 2.8-3.3
X1   1.840     11     520     640    6423    6423    6423            400
X3    10                     519     520     641     520
GR    93       0     96.3    500      97     520    91.5     540    90.1     560
GR   83.9     580    83.8    600     90.4    620      99     640    91.5     680
GR    90     1600

X1   1.897     10      0     100     300     300     300             400
X3    10
GR   100       0      95      7       89      13    84.5      20      84      45
GR    84      55     84.5     80      89      87      95      93     100     100

X1   2.276      4      0     100    2000    2000    2000             400
X3    10
GR   106       0      93      20      93      80     106     100

X1   2.654      4      0     100    2000    2000    2000            407.4
X3    10
GR   106       0      93      20      93      80     106     100


QT    11     6700    3900    2300    1800
QT
 left & right banks switched for plot of channel banks    LK U/S
     B----B   FULL FLOW RESTORED, LOSSES FROM 2.8-3.3
X1   2.834     14     500     620     950     950     950             500
X3    10                     499     530     621     530
GR     7       0       7     470    11.3     500    10.4     520     4.3     530
GR   3.3      540     3.5    570     3.9     580     4.7     590      6      600
GR    12      610     12     620      8      630      5     1000
 LEFT & RIGHT BANKS CHECKED BY GR BASIN BR 12/96 LOOKING U/S

     C----C   FULL FLOW, LOSSES DOWNSTREAM
X1   3.280      9     675     780    2354    2354    2354             500
X3    10                     674     530     781     530
GR    16       0     20.4    675      14     683    14.3     720      14     757
GR    18      770    22.2    780      15     800      13    1600

X1   3.292     13     600    698.8     60      60      60             500
X3    10
GR   20.8      0     24.4    600     18.5   600.1    15.7     610    14.7     616
GR   14.7     626    14.7    636     15.4    646    15.5     676    16.8     686
GR   22.1    698.7   24.4   698.8    20.8   1600

SB   1.05     1.6     2.6            78.6      3     540     1.4    514.6   514.6
X1   3.299     13     600    698.8     40      40      40             500
X2                     1    520.8   521.3
X3    10                     599     530     700     530   520.8   520.8
BT     4       0    520.8   520.8    600    524.4   520.8   698.8   524.4   520.8
BT   760     520.8  520.8
GR   20.8      0     24.4    600     18.5   600.1    15.7     610    14.7     616
GR   14.7     626    14.7    636     15.4    646    15.5     676    16.8     686
GR   22.1    698.7   24.4   698.8    20.8   1600
1
 09DEC96    15:51:43                                              PAGE   3



X1   3.303     12     600     696      20      20      20             500
X3    10                     599     540     697     540
GR   20.5      0      19     400     22.8    600    15.4     610    14.2     616
GR   14.2     626    14.4    636     15.1    646    15.2     676    16.5     686
GR   21.8     696     19    1000

     D----D
X1   3.318     10     600     680      80      80      80             500
X3    10                     599     540     681     540
GR    24     460      19     470      20     600    15.9     610    15.2     620
GR   14.6     640    14.4    660      15     670      23     680      19     980


X1   3.516     11     600     670    1045    1045    1045             500
X3    10                     599     540     671     540
GR   24.3      0      23     580      30     600    24.8     615    19.7     619
GR   19.2     620    19.2    640     19.2    660      30     670    26.8     680
GR   22.8     980

     E----E
X1   3.526      9     200     248      50      50      50             500
X3    10                     199     540     249     540
GR    24       0      29     100      30     200    18.8    200.1   18.8     224
GR   18.8    247.9    30     248      29     300      24     500
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X1   3.535      6     200     265      49      49      49              500
X3     10                     199     540     266     540
GR     29       0      30     200    19.4     215    19.4     250      30     265
GR     29     400

X1   3.538     11     100     208      15      15      15              500
X3     10                      99     540     209     540
GR     26       0    30.4     100    22.9     110    21.7     120    20.2     150
GR   19.2     170    20.6     180    23.8     190      26     193    30.4     208
GR     26     400


X1   3.557      8       0     108     100     100     100              500
X3     10
GR   30.4       0    22.9      10    21.7      20    20.2      50    19.2      70
GR   20.6      80    23.8      90    30.4     108

SB            1.6     2.6              68             880       2   520.4   519.2
X1   3.582      8       0     108     136     136     136            501.2
X2                      1   530.4   535.6
X3     10                                             531     531
BT      2       0   535.6   530.4     108   535.6   530.4
GR   30.4       0    22.9      10    21.7      20    20.2      50    19.2      70
GR   20.6      80    23.8      90    30.4     108
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      F-----F   NARROW SECTION DUE TO LIMITED EFFECTIVE FLOW BRIDGES
X1   3.601     10     300     403     100     100     100              500
X3     10                     299     550     404     550
GR     26       0    30.5     300    24.6     310      23     320    21.9     350
GR   20.9     370    22.3     380    25.6     390    27.7     393      28     403

      G-----G
X1   3.663     10     300     403     325     325     325            501.9
X3     10                     299     550     404     550
GR     26       0    30.5     300    24.6     310      23     320    21.9     350
GR   20.9     370    22.3     380    25.6     390    27.7     393      28     403

X1   3.688     10     100     174     132     132     132              500
X3     10                      99     550     175     550
GR   35.8       0    33.8     100    26.3   100.1    25.3     110    24.1     120
GR   23.8     140    23.6     160    24.2     170    33.8     174    35.8     270

SB            1.6     2.6              74             630           525.3   525.3
X1   3.691     10     100     174      18      18      18              500
X2                      1   533.8   535.8
X3     10                      99     550     175     550
BT      2       0   535.8   533.8     270   535.8   533.8
GR   35.8       0    33.8     100    26.3   100.1    25.3     110    24.1     120
GR   23.8     140    23.6     160    24.2     170    33.8     174    35.8     270

      H-----H   NARROW SECTION DUE TO LIMITED EFFECTIVE FLOW BRIDGES
X1   3.701      8     200     290      50      50      50              500
X3     10
GR   29.4     200      26     220    24.8     230    24.5     250    24.3     270
GR   24.9     280    29.7     285    29.9     290


QT     11    7300    4000    2400    1800
QT

X1   3.727      8     200     290     140     140     140              500
X3     10
GR   29.4     200      26     220    24.8     230    24.5     250    24.3     270
GR   24.9     280    29.7     285    29.9     290

X1   3.735     14     100     210      41      41      41              500
X3     10                      99     550     211     550
GR     39       0      34     100    30.1   100.1      27     110    25.7     120
GR   26.5     130    25.6     150    25.2     160    25.2     180    25.8     190
GR   28.2     200    31.2   209.9      34     210      39     300

SB   1.05     1.6     2.6              78     3.5     735       2     526     526
X1   3.742     12     100     210      35      35      35
X2                      1     534     539
X3     10                      75     550     220     550     534     534
BT      2       0     539     534     300     539     534
GR    539       0     534     100   530.1   100.1     527     110   525.7     120
GR    526     130   526.2     150   526.2     190   528.2     200   531.2   209.9
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GR     534     210     539     300

       I-----I
X1   3.751      15     500     640      50      50      50              500
X3      10                     499     550     680     550
GR      30       0    35.9     500    35.2     510    32.3     520    29.2     530
GR    27.9     540    28.7     550    27.8     570      26     580      26     600
GR      28     610    30.4     620    33.4     630    34.2     640      34     800

X1   3.808       4     100     180     300     300     300              500
X3      10
GR    34.3     100      28     115      28     165    34.3     180

       J-----J
X1   4.135      10     250     360    1724    1724    1724              500
X3      10                     200             400
GR      46       0      45     100      46     190      48     250      40     270
GR      40     340    45.4     350    46.4     360      44     530      46     560

X1    4.24       6     300     400     550     550     550
X3      10
GR     552       0     551     300     542     330     542     380     552     400
GR     550     600


       K-----K
X1   4.487       7     100     170    1814    1814    1814              500
X3      10
GR      64       0      62     100      51     110      51     155      63     170
GR      63     195      61     250

X1   4.522      11     490     580     185     185     185              500
X3      10                     489     570     581     570
GR      62       0      65     490    63.6     500    55.1   500.1    54.1     520
GR    54.5     557      58   557.1      58   569.9    63.6     570      67     580
GR      65     800

SB             1.6     2.6              56             760    .583   554.1   554.1
X1   4.530      11     500     570      40      40      40
X2                       1     567     570
X3      10                     499     580     571     580     567     567
BT       5     490     565   563.6     500   567.6   563.6     520     570   566.4
BT     570     565   563.6     580     567   563.6
GR     562       0     565     490   563.6     500   555.1   500.1   554.1     520
GR   554.5     557     558   557.1     558   569.9   563.6     570     567     580
GR     565     800

       L-----L
X1   4.539       9     500     620      50      50      50              500
X3      10                     499     600     621     600
GR      63       0    67.5     500    62.4     525    54.9     540    54.2     560
GR    54.2     585    63.8     610      65     620      62     800
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       M-----M
X1   4.630      10     300     380     477     477     477              500
X3      10                     299     600     425     600
GR      64       0    64.9     300    58.4     310      57     320    56.8     330
GR    56.8     340    57.6     350      59     360    66.7     380      65     580

X1   4.636       8     300     389      33      33      33              500
X3      10                     299     600     400     600
GR      66       0      66     290    65.6     300      57   300.1      57   388.9
GR    65.6     389      66     400      66     580

SB             1.6     2.6              89             760       1   557.5     557
X1   4.639       8     300     389      17      17      17            500.5
X2                       1   566.1   567.1
X3      10                     299     600     390     600     567     567
BT       2       0   566.1     566     580   566.1     566
GR      66       0      66     290    65.6     300      57   300.1      57   388.9
GR    65.6     389      66     400      66     580

       N-----N
X1   4.649      10     300     380      50      50      50              500
X3      10                     299     600     381     600
GR      66       0    66.2     300    57.7     310    56.3     320    56.1     330
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GR   56.1     340     56.9    350     60.3    360     68      380     68      580

X1   4.838    10      300     380     1000    1000    1000            508
X3   10                   299     600     381     600
GR   66       0       66.2    300     57.7    310     56.3    320     56.1    330
GR   56.1     340     56.9    350     60.3    360     68      380     68      580


     O----O
X1   5.034    6       300     390     1035    1035    1035            500
X3   10
GR   83.7     0       82      300     71.1    300.1   71.1    389.9   82      390
GR   87       490

X1   5.052    6       300     394     92      92      92          500
X3   10
GR   84       0       85      300     73.8    300.1   73.8    393.9   85      394
GR   87       500

     P----P
X1   5.054    8       300     394     14      14      14          500
X3   10
GR   84       0       85      300     83      300.1   83      309     76.7    309.1
GR   76.7     393.9   85      394     87      500
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X1   5.067    8       300     396     70      70      70          500
X3   10
GR   89.5     0       90      300     87      300.1   79      301     79      395
GR   87       395.9   90      396     89.5    500

SB   1.25     1.6     2.6             96          768         579     579
X1   5.075    8       300     396     38      38      38          500
X2                1       587     589.5
X3   10                                               587     587
BT   6        0       589.5   589.5   300     590     590     300.1   590     587
BT   395.9    590     587     396     590     590     500     589.5   589.5
GR   89.5     0       90      300     87      300.1   79      301     79      395
GR   87       395.9   90      396     89.5    500


X1   5.084    12      100     210     50      50      50          500
X3   10
GR   92       0       89.5    100     87.5    105     83      115     80.6    125
GR   79       145     79      175     79      185     85.5    195     88.6    200
GR   89       210     89.5    400

     Q----Q
X1   5.136    12      100     210     275     275     275         500.9
X3   10                   99      600     211     600
GR   92       0       89.5    100     87.5    105     83      115     80.6    125
GR   79       145     79      175     79      185     85.5    195     88.6    200
GR   89       210     89.5    400


X1   5.148    8       0       240     65      65      65          500
X3   10
GR   93       0       87.7    100     79.7    100.1   79.7    158     81.5    158.1
GR   81.5     217.9   87.7    218     93      240

SB   1.05     1.6     2.6             118     2       814         580.6   580.6
X1   5.165    8       0       240     85      85      85          500
X2                1       587.7   591.2
X3   10                                               588     588
BT   2        0       593     587.7   260     593     587.7
GR   93       0       87.7    100     79.7    100.1   79.7    158     81.5    158.1
GR   81.5     217.9   87.7    218     93      240


     R----R
X1   5.184    10      100     220     100     100     100             500
X3   10                   99      600     221     600
GR   92       0       91.2    100     88.6    110     81.8    120     79.8    130
GR   81.8     160     81.8    190     90.4    205     91      220     91.2    400
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X1   5.373    4       0       100     1000    1000    1000            500
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X3     10
GR    100       0      87      30      87      70     100     100

      S----S
X1  5.524       8     340     440     796     796     796             500
X3     10
GR    100       0     102     300     108     340      92     370      93     410
GR    108     440     101     450     104     700
 SECTION 5.525 ADDED TO SHOW LEFT LEVEE DISCONTINUITY 11/96

X1  5.525       8     340     440      10      10      10             500
X3     10                     339     620     441     620
GR    100       0     102     300     108     340      92     370      93     410
GR    103     440     101     450     104     700

      T----T 5.756 BRIDGE MODIFIED 8/96
X1  5.749      10     500     590    1177    1177    1177             600
X3     10
GR     12       0    11.2     500     2.5     520     1.3     530     1.2     550
GR    1.7     560     2.4     570     8.8     580    12.5     590      10     700

X1  5.756      14     100   189.5      42      42      42             600
X3     10
GR     20       0      20     100     9.4   100.1     5.4     114       5     144
GR    1.4     150     1.4     175     3.4   179.5     9.4   189.4    12.4   189.5
GR     19     200    17.2    1100      18    1600      20    2000

SB   1.05     1.6     2.6              40     1.5     682       2   603.2   601.4
X1  5.796      14     100   189.5     208     208     208             600
X2                      1   614.2   617.2
X3     10                                             615     615
BT      5       0     620     620     100     620     620   100.1     620   613.2
BT  189.5   619.5   613.2     200   619.5   619.5
GR     20       0      20     100     9.4   100.1     5.4     114       5     144
GR    3.2     150     3.2     175     3.4   179.5     9.4   189.4    12.4   189.5
GR     19     200    17.2    1100      18    1600      20    2000

      U----U
X1  5.805       9     100     180      50      50      50             600
X3     10
GR     20       0    13.7     100     4.9     120     3.7     130     3.6     150
GR    4.1     160     4.8     170    11.2     180      16     300

      V----V
X1  6.012       9     100     180    1093    1093    1093           609.9
X3     10
GR     20       0    13.7     100     4.9     120     3.7     130     3.6     150
GR    4.1     160     4.8     170    11.2     180      16     300
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X1  6.022       9     300     373      52      52      52             600
X3     10                     299     650     374     650
GR     28       0    23.3     300    15.3     310    14.7     320    13.6     340
GR     15     355    14.8     365    23.3     373    24.5     600

SB            1.6     2.6              40             550     1.8   614.9   613.6
X1  6.036       9     300     373      73      73      73           601.3
X2                      1   624.6   629.8
X3     10                     299     650     374     650
BT      4       0   629.3   624.6     300   629.8   624.6     373   629.8   624.6
BT    600   625.8   624.6
GR     28       0    23.3     300    15.3     310    14.7     320    13.6     340
GR     15     355    14.8     365    23.3     373    24.5     600

      W----W
X1  6.049                              70      70      70               1
X3     10                     299     650     374     650

X1  6.052      10     300     375      15      15      15             600
X3     10                     299     650     400     650
GR     24       0      27     290      27     300    20.1   300.1    20.1     367
GR   26.3   367.1    26.3     375    25.8     376    25.8     390      29     400

      X----X
X1  6.071      15     400     490     100     100     100             600
X3     10                     200     650     500     650
GR     27       0    29.7     230    26.5     250      26     400      24     410
GR     22     420    21.2     430    21.7     440    22.2     450    22.5     460
GR   22.4     470    26.8     480      28     490      28     550      27     700
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QT     11     7800     4200     2600     1800
QT

      Y-----Y
X1   6.393      17     1490     1580     1702     1702     1702               600
X3     10                   1489      660     1600      660
GR     50       20      44      560      42      580      42     1210      38     1220
GR     41     1260     41.6    1490      40     1500     36.5    1510     36.5    1560
GR     39     1570      42     1580      42     1600      41     1800      38     1810
GR     43     1850      43     1900

      Z-----Z
X1   6.441      24     1500     1610      250    • 250      250               600
X3     10                   1499      650     1611      650
GR     49      490      44      650      44     1100      42     1120      39     1125
GR     42     1130      43     1350      43     1370      42     1500     41.3    1515
GR     41     1525     39.1    1535     38.2    1545     38.7    1565     39.9    1575
GR    41.7    1585      42     1587      44     1610     43.5    1650      39     1655
GR    42.5    1660      43     1820      44     1850      45     1900
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X1   6.456      11      400      460       80       80       80               600
X3     10                    399      650      500      650
GR    43.5       0      43      200     47.5     400     39.8    400.1     37.9   , 410
GR     37      420     37.5     440     38.7·    450     41.5    459.9     47.5     460
GR     43      700

SB            1.6      2.6               60              620               637      637
X1   6.460      11      400      460       20       20       20               600
X2                   1      647      650
X3     10                    399      660      500      660      647      647
BT      4      200      643      643      400      650    647.5     460      650    647.5
BT     700     643      643
GR    43.5       0      43      200     47.5     400     39.8    400.1     37.9     410
GR     37      420     37.5     440     38.7     450     41.5    459.9     47.5     460
GR     43      700

      AA-----AA
X1   6.479      19     1370     1540      100      100      100               600
X3     10                   1350      660     1550      660
GR     48      400      45      750      48      950      45     1250      45     1300
GR    45.5    1370      44     1400     44.5    1410     41.8    1415     41.5    1425
GR    39.6    1435     38.7    1445     39.2    1465     40.4    1475     42.2    1485
GR    44.5    1487     45.5    1540     45.5    1600      46     1670

      BB-----BB  FEMA AB
X1   6.702      12      500      610     1180     1180     1180               600
X3     10                    499      660      611      660
GR     52        0     58.2     500      58      510     51.5     520      50      530
GR    49.6     560     50.3     570     49.8     580     50.1     590     52.8     600
GR    57.8     610      53     1000

      CC-----CC
X1   7.434      12      200      280     3865     3865     3865               600
X3     10                    199      700      300      700
GR     92        0     91.5     200     89.5     210     85.1     214     83.8     220
GR    83.3     230     83.4     250     83.6     260     84.8     264     86.5     276
GR    91.5     280      93      600

X1   7.445      10      200      260       57       57       57               600
X3     10
GR    100        0     94.5     200     86.7    200.1     85      210     83.6     220
GR    83.7     240     83.9     250     83.9    259.9    94.5     260      96      700

SB            1.6      2.6               60              600              684.5    683.7
X1   7.453      17      200      260       43       43       43
X2                   1    694.5    699.2                  0
X3     10        0       0        0        0        0        0      695      695
BT     -6        0      700      700    193.5    698.9    698.9     200    699.2    694.5
BT             260    699.2    694.5    262.6    699.2    694.5    703.3     696      696
GR    700        0      700      100    698.9    193.5    694.5     200    687.5    200.1
GR   685.8     210    684.4     220      684      221    684.4     222    684.5     240
GR   684.7     250    684.7    259.8     694     259.9   694.5     260    694.5    262.6
GR    696      700      696    703.3
1
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      DD-----DD  FEMA AC
X1   7.463      12      200      296       50       50       50               600
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X3    10
GR    94       0      99     200    94.4     210    91.3     230    86.9     234
GR    85.6   240    85.1     250    85.2     270    85.4     280    86.6     284
GR    98     296      96     700


QT    11    8300    4400    2800    1800
QT

      EE----EE
X1  8.227     19     390     510    4035    4035    4035             700
X3    10                    389     750     511     750
GR    31       0      27      30      27     370      29     390    25.8     410
GR    27.6   420    23.7     430    24.3     440    24.4     450    23.7     460
GR    23.4   470    22.8     480    22.2     490    23.2     500      29     510
GR    28     520    24.7     535      26     620      29     650

      FF----FF  FEMA AD
X1  8.619     14    1000    1100    2070    2070    2070             700
X3    10
GR    50       0      45     100      45     900    48.3    1000      47    1020
GR    41    1030    39.8    1040    39.6    1050    39.2    1060      39    1070
GR    39    1080    37.8    1090    48.9    1100      50    1400

X1  8.632      9     500     584      68      68      68             700
X3    10
GR    51       0    55.5     500      46   500.1    42.9     525    39.2     535
GR    39.2   555    47.9   583.9    55.5     584      51    1600

SB           1.6     2.6            53.4             660     1.7   741.4   739.2
X1  8.647      9     500     584      82      82      82
X2                     1   750.4   755.5
X3    10                    499     760     585     760     751     751
BT     4       0     751   750.4     500   755.5   750.4     584   755.5   750.4
BT  1600     751   750.6
GR   751       0   755.5     500   745.6   500.1   740.7     525   739.2     535
GR   739     555   747.9   583.9   755.5     584     751    1600

      GG----GG  FEMA AE
X1  8.657     13     500     600      50      50      50             700
X3    10                    499     760     601     760
GR    54       0    52.4     500    51.9     520    45.1     530    43.9     540
GR    43.7   550    43.2     560    43.2     570    43.2     580    41.9     590
GR    53     600    52.5     620      54    1600

X1  9.142     13     600     700    2560    2560    2560
X3    10
GR   770       0     775     550     775     600   773.5     601     768     610
GR   766.4   621     764     640   766.2     664     768     686   773.5     699
GR   776     700     775     800     770    1000
1
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X1  9.150     13     600     700      40      40      40
X3    10                    599     780     701     780
GR   770       0     775     550     775     600   773.5     601     768     610
GR   766.4   621     764     640   766.2     664     768     686   773.5     699
GR   776     700     775     800     770    1000

SB           1.6     2.6              42             580     3.9     764     764
X1  9.165     13     600     700      80      80      80
X2                     1   773.5     770
X3    10                    599     780     701     780
BT     8       0     770     770     550     775     775     600   779.7   773.5
BT   601   779.7   773.5     699   779.7   773.5     700   779.7     776     800
BT   775     775    1000     770     770
GR   770       0     775     550     775     600   773.5     601     768     610
GR   766.4   621     764     640   766.2     664     768     686   773.5     699
GR   776     700     775     800     770    1000

X1  9.173     13     600     700      40      40      40
X3    10                    599     780     701     780
GR   770       0     775     550     775     600   773.5     601     768     610
GR   766.4   621     764     640   766.2     664     768     686   773.5     699
GR   776     700     775     800     770    1000

      HH----HH  FEMA AF
X1  9.357     10     200     270     970     970     970             700
X3    10                    199     800     271     800
GR    86       0      86     180    86.9     200    79.2     210    77.3     220
GR    76.9   230    76.9     240    77.5     250    85.8     260    88.8     270
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X1   9.363    13   1200   1268    32     32     32            700
X3    10                  1199    800   1269    800
GR    86       0   88.8   1200    87.7  1200.1  85.8   1210    77.5   1220
GR   76.9   1230   76.9   1240    77.3   1250   79.2   1260    87.7   1267.9
GR   88.8   1268   86.4   1290    90     1700

SB           1.6    2.6           36            580    1.4   776.7   776.7
X1   9.370    13   1200   1268    37     37     37            700
X2                  1    787.7   788.8
X3    10                  1199    800   1300    800    788    788
BT     6    1200  788.8  787.7  1200.1  788.8  787.7   1210   789.1   787.7
BT   1260  789.1  787.7 1267.9   788.8  787.7   1268  788.8   787.7
GR    86       0   88.8   1200    87.7  1200.1  85.8   1210    77.5   1220
GR   76.9   1230   76.9   1240    77.3   1250   79.2   1260    87.7   1267.9
GR   88.8   1268   86.4   1290    90     1700

     II-----II FEMA AG
X1   9.380    13   1200   1268    50     50     50            700.8
X3    10                  1199    800   1300    800
GR    86       0   88.8   1200    87.7  1200.1  85.8   1210    77.5   1220
GR   76.9   1230   76.9   1240    77.3   1250   79.2   1260    87.7   1267.9
GR   88.8   1268   86.4   1290    90     1700
1
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     JJ-----JJ
X1   9.528     6    500    572    780    780    780           700
X3    10                   480    800    580    800
GR    97       0   96.6    500    90.6   500.1  90.6   571.9   96.6    572
GR    99     700

X1   9.537    10    500    590    50     50     50            700
X3    10                   499    810    591    810
GR    97       0    102    480    99     500    92.8   510     90.8    520
GR    90     530   90.6    550    91.1   560    97.9   590     100     620

     KK-----KK
X1   9.611     6     50    140    393    393    393           700
X3    10
GR   130       0  107.4     50    91.4    85    91.4   110    107.4    140
GR   100     400

X1   9.618     6     50    140    35     35     35            700
X3    10
GR   130       0    109     50    94      85    94     110     109     140
GR   100     400

SB           1.6    2.6           50            630     2     794     794
X1   9.620     9     50    140    15     15     15
X2                   1     803    809
X3    10                    49    820    141    820    802     802
BT     6       0    830    830    50     809   805.5    85     809     803
BT   110     809    803    140    809   805.5   141    809     809
GR   830       0    809     49   805.5    50    794     51     794      85
GR   794     110  805.5    140    809    141    800    400

     LL-----LL
X1   9.630     6     50    140    50     50     50            701.8
X3    10
GR   130       0    109     50    94      85    94     110     109     140
GR   100     400

     MM-----MM
X1   9.792    12    200    280    853    853    853           800
X3    10
GR    30       0     30    200    24.3  200.1   14.3   223.6   11.3    230
GR   10.7    238     12    245    14.3   250    21.3   256     21.3   279.9
GR    30     280     40    350

SB           1.6    2.6           18            860    1.76  811.3   810.7
     NN-----NN
X1   9.813    12    200    280    114    114    114           800.6
X2                   1    828.9   830
X3    10                                        829    829
BT     2     200    830   828.9   280    830   828.9
GR    30       0     30    200    24.3  200.1   14.3   223.6   11.3    230
GR   10.7    238     12    245    14.3   250    21.3   256     21.3   279.9
GR    30     280     40    350
1
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     00----00
X1   9.838     12     200     280     132     132     132             801
X3    10
GR    30        0      30     200     24.3   200.1    14.3   223.6    11.3     230
GR   10.7     238      12     245     14.3     250    21.3     256    21.3   279.9
GR    30      280      40     350
T1
T2
T3

J1 ICHECK   INQ    NINV    IDIR    STRT    METRIC   HVINS    Q     WSEL    FQ

              3                                     494.5

J2 NPROF    IPLOT   PRFVS   XSECV   XSECH    FN     ALLDC   IBW    CHNIM   ITRACE

     2          -1                      -1

T1
T2
T3

J1 ICHECK   INQ    NINV    IDIR    STRT    METRIC   HVINS    Q     WSEL    FQ

              4                                     494.0

J2 NPROF    IPLOT   PRFVS   XSECV   XSECH    FN     ALLDC   IBW    CHNIM   ITRACE

     3          -1                      -1

T1
T2
T3

J1 ICHECK   INQ    NINV    IDIR    STRT    METRIC   HVINS    Q     WSEL    FQ

              5                                     492.5

J2 NPROF    IPLOT   PRFVS   XSECV   XSECH    FN     ALLDC   IBW    CHNIM   ITRACE

     4          -1                      -1

T1
T2
T3

J1 ICHECK   INQ    NINV    IDIR    STRT    METRIC   HVINS    Q     WSEL    FQ

              6                                      494

J2 NPROF    IPLOT   PRFVS   XSECV   XSECH    FN     ALLDC   IBW    CHNIM   ITRACE

     5          -1                      -1

T1
T2
T3
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J1 ICHECK   INQ    NINV    IDIR    STRT    METRIC   HVINS    Q     WSEL    FQ

              7                                      494

J2 NPROF    IPLOT   PRFVS   XSECV   XSECH    FN     ALLDC   IBW    CHNIM   ITRACE

     6          -1                      -1

T1
T2
T3

J1 ICHECK   INQ    NINV    IDIR    STRT    METRIC   HVINS    Q     WSEL    FQ

              8                                      494

J2 NPROF    IPLOT   PRFVS   XSECV   XSECH    FN     ALLDC   IBW    CHNIM   ITRACE

     7          -1                      -1

T1
```

T2
T3

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
		9					494			

J2	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLDC	IBW	CHNIM	ITRACE
	8	-1			-1					

T1
T2
T3

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
		10					494			

J2	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLDC	IBW	CHNIM	ITRACE
	9	-1			-1					

T1
T2
T3

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
		11					493			

J2	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLDC	IBW	CHNIM	ITRACE
	10	-1			-1					

T1
T2

T3

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
		12					492			

J2	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLDC	IBW	CHNIM	ITRACE
	15	-1			-1					

THIS RUN EXECUTED 09DEC96 15:52:47

****
HEC-2 WATER SURFACE PROFILES

Version 4.6.2; May 1991
****

NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

PROVO16 LAKE WSEL 10 YR=

SUMMARY PRINTOUT

SECNO	Q	XLBEL	CWSEL	RBEL	QLOB	QCH	QROB	TOPWID	VCH	XLCH	ELTRD
.000	6200.00	497.00	495.40	497.00	.00	6200.00	.00	91.58	7.78	.00	.00
.000	3700.00	497.00	494.50	497.00	.00	3700.00	.00	86.84	5.16	.00	.00
.000	2200.00	497.00	494.00	497.00	.00	2200.00	.00	84.21	3.27	.00	.00
.000	1800.00	497.00	492.50	497.00	.00	1800.00	.00	76.32	3.25	.00	.00
.000	8000.00	497.00	494.00	497.00	.00	8000.00	.00	84.21	11.87	.00	.00
.000	7000.00	497.00	494.00	497.00	.00	7000.00	.00	84.21	10.39	.00	.00

	.000	6000.00	497.00	494.00	497.00	.00	6000.00	.00	84.21	8.91	.00	.00
	.000	5000.00	497.00	494.00	497.00	.00	5000.00	.00	84.21	7.42	.00	.00
	.000	4000.00	497.00	494.00	497.00	.00	4000.00	.00	84.21	5.94	.00	.00
	.000	3000.00	497.00	493.00	497.00	.00	3000.00	.00	78.95	5.07	.00	.00
	.000	2000.00	497.00	492.00	497.00	.00	2000.00	.00	73.68	3.88	.00	.00
*	.623	6200.00	492.50	499.33	498.50	.00	6200.00	.00	240.00	2.59	3300.00	.00
*	.623	3700.00	492.50	496.89	498.50	.00	3700.00	.00	217.46	2.02	3300.00	.00
*	.623	2200.00	492.50	495.24	498.50	.00	2200.00	.00	196.50	1.48	3300.00	.00
*	.623	1800.00	492.50	493.86	498.50	.00	1800.00	.00	179.05	1.47	3300.00	.00
*	.623	8000.00	492.50	500.43	498.50	.00	8000.00	.00	240.00	3.01	3300.00	.00
*	.623	7000.00	492.50	499.62	498.50	.00	7000.00	.00	240.00	2.84	3300.00	.00
*	.623	6000.00	492.50	498.79	498.50	.00	6000.00	.00	238.62	2.65	3300.00	.00
*	.623	5000.00	492.50	497.89	498.50	.00	5000.00	.00	230.08	2.44	3300.00	.00
*	.623	4000.00	492.50	496.94	498.50	.00	4000.00	.00	218.11	2.17	3300.00	.00
*	.623	3000.00	492.50	495.49	498.50	.00	3000.00	.00	199.67	1.95	3300.00	.00
*	.623	2000.00	492.50	493.82	498.50	.00	2000.00	.00	178.56	1.64	3300.00	.00

	SECNO	Q	XLBEL	CWSEL	RBEL	QLOB	QCH	QROB	TOPWID	VCH	XLCH	ELTRD
	1.840	6200.00	497.00	502.39	499.00	2.61	6195.82	1.57	122.00	4.04	6423.00	.00
	1.840	3700.00	497.00	499.37	499.00	.96	3698.94	.10	122.00	3.16	6423.00	.00
*	1.840	2200.00	497.00	496.96	499.00	.00	2200.00	.00	115.09	2.48	6423.00	.00
*	1.840	1800.00	497.00	495.74	499.00	.00	1800.00	.00	107.85	2.40	6423.00	.00
	1.840	8000.00	497.00	503.97	499.00	3.67	7993.78	2.55	122.00	4.64	6423.00	.00
	1.840	7000.00	497.00	503.06	499.00	3.08	6994.93	1.99	122.00	4.33	6423.00	.00
	1.840	6000.00	497.00	502.08	499.00	2.47	5996.12	1.42	122.00	4.01	6423.00	.00
	1.840	5000.00	497.00	500.95	499.00	1.82	4997.37	.82	122.00	3.67	6423.00	.00
	1.840	4000.00	497.00	499.69	499.00	1.14	3998.64	.22	122.00	3.31	6423.00	.00
	1.840	3000.00	497.00	498.06	499.00	.36	2999.64	.00	118.84	2.95	6423.00	.00
*	1.840	2000.00	497.00	496.06	499.00	.00	2000.00	.00	109.72	2.55	6423.00	.00
	1.897	6200.00	500.00	502.58	500.00	.00	6200.00	.00	100.00	4.07	300.00	.00
	1.897	3700.00	500.00	499.53	500.00	.00	3700.00	.00	98.67	3.04	300.00	.00
	1.897	2200.00	500.00	497.08	500.00	.00	2200.00	.00	91.83	2.24	300.00	.00
*	1.897	1800.00	500.00	495.87	500.00	.00	1800.00	.00	88.44	2.06	300.00	.00
	1.897	8000.00	500.00	504.18	500.00	.00	8000.00	.00	100.00	4.76	300.00	.00
	1.897	7000.00	500.00	503.26	500.00	.00	7000.00	.00	100.00	4.40	300.00	.00
	1.897	6000.00	500.00	502.27	500.00	.00	6000.00	.00	100.00	4.03	300.00	.00
	1.897	5000.00	500.00	501.13	500.00	.00	5000.00	.00	100.00	3.63	300.00	.00
	1.897	4000.00	500.00	499.85	500.00	.00	4000.00	.00	99.59	3.20	300.00	.00
	1.897	3000.00	500.00	498.22	500.00	.00	3000.00	.00	95.02	2.75	300.00	.00
*	1.897	2000.00	500.00	496.20	500.00	.00	2000.00	.00	89.36	2.21	300.00	.00
*	2.276	6200.00	506.00	504.55	506.00	.00	6200.00	.00	95.53	6.90	2000.00	.00
*	2.276	3700.00	506.00	501.07	506.00	.00	3700.00	.00	84.85	6.32	2000.00	.00
*	2.276	2200.00	506.00	498.19	506.00	.00	2200.00	.00	75.98	6.23	2000.00	.00
*	2.276	1800.00	506.00	496.91	506.00	.00	1800.00	.00	72.05	6.96	2000.00	.00
*	2.276	8000.00	506.00	506.46	506.00	.00	8000.00	.00	100.00	7.36	2000.00	.00
*	2.276	7000.00	506.00	505.40	506.00	.00	7000.00	.00	98.15	7.14	2000.00	.00
*	2.276	6000.00	506.00	504.24	506.00	.00	6000.00	.00	94.61	6.90	2000.00	.00
*	2.276	5000.00	506.00	502.95	506.00	.00	5000.00	.00	90.64	6.67	2000.00	.00
*	2.276	4000.00	506.00	501.50	506.00	.00	4000.00	.00	86.18	6.43	2000.00	.00
*	2.276	3000.00	506.00	499.69	506.00	.00	3000.00	.00	80.60	6.37	2000.00	.00
*	2.276	2000.00	506.00	497.38	506.00	.00	2000.00	.00	73.51	6.82	2000.00	.00
	2.654	6200.00	513.40	511.17	513.40	.00	6200.00	.00	93.14	7.52	2000.00	.00
	2.654	3700.00	513.40	508.49	513.40	.00	3700.00	.00	84.88	6.32	2000.00	.00
	2.654	2200.00	513.40	506.73	513.40	.00	2200.00	.00	79.45	4.99	2000.00	.00
*	2.654	1800.00	513.40	506.38	513.40	.00	1800.00	.00	78.38	4.36	2000.00	.00
	2.654	8000.00	513.40	512.87	513.40	.00	8000.00	.00	98.36	8.10	2000.00	.00
	2.654	7000.00	513.40	511.96	513.40	.00	7000.00	.00	95.54	7.79	2000.00	.00
	2.654	6000.00	513.40	510.98	513.40	.00	6000.00	.00	92.54	7.44	2000.00	.00
	2.654	5000.00	513.40	509.94	513.40	.00	5000.00	.00	89.35	7.02	2000.00	.00
	2.654	4000.00	513.40	508.85	513.40	.00	4000.00	.00	85.96	6.50	2000.00	.00
	2.654	3000.00	513.40	507.74	513.40	.00	3000.00	.00	82.58	5.73	2000.00	.00
*	2.654	2000.00	513.40	506.63	513.40	.00	2000.00	.00	79.17	4.61	2000.00	.00

SECNO	Q	XLBEL	CWSEL	RBEL	QLOB	QCH	QROB	TOPWID	VCH	XLCH	ELTRD
2.834	6700.00	511.30	514.68	512.00	3.49	6693.79	2.73	122.00	6.78	950.00	.00
2.834	3900.00	511.30	512.15	512.00	.72	3899.12	.17	122.00	5.70	950.00	.00
2.834	2300.00	511.30	509.78	512.00	.00	2300.00	.00	85.30	5.13	950.00	.00
2.834	1800.00	511.30	509.05	512.00	.00	1800.00	.00	82.86	4.66	950.00	.00
2.834	8000.00	511.30	516.18	512.00	4.75	7991.22	4.03	122.00	6.85	950.00	.00
2.834	7000.00	511.30	515.32	512.00	3.91	6992.90	3.19	122.00	6.57	950.00	.00

2.834	6000.00	511.30	514.41	512.00	3.00	5994.71	2.29	122.00	6.28	950.00	.00
2.834	5000.00	511.30	513.44	512.00	2.01	4996.66	1.33	122.00	5.96	950.00	.00
2.834	4000.00	511.30	512.41	512.00	.95	3998.69	.36	122.00	5.59	950.00	.00
2.834	3000.00	511.30	511.07	512.00	.00	3000.00	.00	103.45	5.31	950.00	.00
2.834	2000.00	511.30	509.39	512.00	.00	2000.00	.00	84.01	4.82	950.00	.00
3.280	6700.00	520.40	523.35	522.20	3.42	6695.37	1.21	107.00	7.80	2354.00	.00
3.280	3900.00	520.40	521.19	522.20	.61	3899.38	.00	103.59	6.17	2354.00	.00
3.280	2300.00	520.40	519.11	522.20	.00	2300.00	.00	96.05	5.40	2354.00	.00
3.280	1800.00	520.40	518.40	522.20	.00	1800.00	.00	93.43	5.04	2354.00	.00
3.280	8000.00	520.40	524.06	522.20	4.55	7993.27	2.17	107.00	8.57	2354.00	.00
3.280	7000.00	520.40	523.40	522.20	3.61	6995.08	1.31	107.00	8.10	2354.00	.00
3.280	6000.00	520.40	522.72	522.20	2.64	5996.85	.52	107.00	7.57	2354.00	.00
3.280	5000.00	520.40	521.99	522.20	1.64	4998.36	.00	105.52	6.98	2354.00	.00
3.280	4000.00	520.40	521.18	522.20	.63	3999.37	.00	103.58	6.33	2354.00	.00
3.280	3000.00	520.40	520.08	522.20	.00	3000.00	.00	99.56	5.76	2354.00	.00
3.280	2000.00	520.40	518.67	522.20	.00	2000.00	.00	94.43	5.22	2354.00	.00
3.292	6700.00	524.40	523.44	524.40	.00	6700.00	.00	98.74	9.13	60.00	.00
3.292	3900.00	524.40	521.31	524.40	.00	3900.00	.00	96.76	7.43	60.00	.00
* 3.292	2300.00	524.40	519.32	524.40	.00	2300.00	.00	91.94	6.83	60.00	.00
* 3.292	1800.00	524.40	518.64	524.40	.00	1800.00	.00	90.32	6.53	60.00	.00
* 3.292	8000.00	524.40	525.31	524.40	1903.20	3233.40	2863.39	1600.00	3.52	60.00	.00
3.292	7000.00	524.40	523.50	524.40	.00	7000.00	.00	98.75	9.46	60.00	.00
3.292	6000.00	524.40	522.83	524.40	.00	6000.00	.00	98.71	8.90	60.00	.00
3.292	5000.00	524.40	522.11	524.40	.00	5000.00	.00	98.66	8.29	60.00	.00
3.292	4000.00	524.40	521.32	524.40	.00	4000.00	.00	96.77	7.61	60.00	.00
3.292	3000.00	524.40	520.24	524.40	.00	3000.00	.00	94.18	7.09	60.00	.00
* 3.292	2000.00	524.40	518.90	524.40	.00	2000.00	.00	90.96	6.68	60.00	.00
3.299	6700.00	524.40	523.44	524.40	.00	6700.00	.00	98.74	9.12	40.00	521.30
3.299	3900.00	524.40	521.51	524.40	.00	3900.00	.00	97.24	7.16	40.00	521.30
3.299	2300.00	524.40	519.42	524.40	.00	2300.00	.00	92.20	6.64	40.00	521.30
3.299	1800.00	524.40	518.74	524.40	.00	1800.00	.00	90.55	6.33	40.00	521.30
* 3.299	8000.00	524.40	523.77	524.40	.00	8000.00	.00	98.76	10.42	40.00	521.30
3.299	7000.00	524.40	523.50	524.40	.00	7000.00	.00	98.75	9.46	40.00	521.30
3.299	6000.00	524.40	522.83	524.40	.00	6000.00	.00	98.71	8.90	40.00	521.30
3.299	5000.00	524.40	522.11	524.40	.00	5000.00	.00	98.66	8.28	40.00	521.30
3.299	4000.00	524.40	521.51	524.40	.00	4000.00	.00	97.24	7.34	40.00	521.30
3.299	3000.00	524.40	520.35	524.40	.00	3000.00	.00	94.43	6.93	40.00	521.30
3.299	2000.00	524.40	519.01	524.40	.00	2000.00	.00	91.19	6.48	40.00	521.30

SECNO	Q	XLBEL	CWSEL	RBEL	QLOB	QCH	QROB	TOPWID	VCH	XLCH	ELTRD
3.303	6700.00	522.80	523.64	521.80	.83	6696.88	2.28	98.00	8.90	20.00	.00
3.303	3900.00	522.80	521.69	521.80	.00	3900.00	.00	94.29	6.89	20.00	.00
3.303	2300.00	522.80	519.71	521.80	.00	2300.00	.00	87.88	5.96	20.00	.00
3.303	1800.00	522.80	519.07	521.80	.00	1800.00	.00	85.80	5.45	20.00	.00
3.303	8000.00	522.80	524.04	521.80	1.54	7995.27	3.19	98.00	10.10	20.00	.00
3.303	7000.00	522.80	523.72	521.80	.97	6996.57	2.47	98.00	9.20	20.00	.00
3.303	6000.00	522.80	523.05	521.80	.15	5998.41	1.43	98.00	8.62	20.00	.00
3.303	5000.00	522.80	522.34	521.80	.00	4999.55	.45	96.37	7.97	20.00	.00
3.303	4000.00	522.80	521.70	521.80	.00	4000.00	.00	94.33	7.05	20.00	.00
3.303	3000.00	522.80	520.58	521.80	.00	3000.00	.00	90.70	6.47	20.00	.00
3.303	2000.00	522.80	519.32	521.80	.00	2000.00	.00	86.62	5.68	20.00	.00
3.318	6700.00	520.00	523.90	523.00	6.25	6692.71	1.03	82.00	10.26	80.00	.00
3.318	3900.00	520.00	522.00	523.00	2.54	3897.46	.00	79.75	7.79	80.00	.00
3.318	2300.00	520.00	520.13	523.00	.05	2299.95	.00	77.41	6.47	80.00	.00
3.318	1800.00	520.00	519.49	523.00	.00	1800.00	.00	74.38	5.86	80.00	.00
3.318	8000.00	520.00	524.34	523.00	7.72	7990.39	1.89	82.00	11.62	80.00	.00
3.318	7000.00	520.00	523.99	523.00	6.58	6992.21	1.20	82.00	10.60	80.00	.00
3.318	6000.00	520.00	523.37	523.00	5.30	5994.41	.29	82.00	9.84	80.00	.00
3.318	5000.00	520.00	522.68	523.00	3.94	4996.05	.00	80.60	9.01	80.00	.00
3.318	4000.00	520.00	522.03	523.00	2.64	3997.36	.00	79.78	7.95	80.00	.00
3.318	3000.00	520.00	520.96	523.00	1.02	2998.98	.00	78.45	7.15	80.00	.00
3.318	2000.00	520.00	519.75	523.00	.00	2000.00	.00	75.32	6.13	80.00	.00
3.516	6700.00	530.00	531.41	530.00	1.86	6696.28	1.85	72.00	10.06	1045.00	.00
3.516	3900.00	530.00	528.51	530.00	.00	3900.00	.00	64.33	8.36	1045.00	.00
3.516	2300.00	530.00	526.33	530.00	.00	2300.00	.00	56.01	6.86	1045.00	.00
3.516	1800.00	530.00	525.41	530.00	.00	1800.00	.00	52.51	6.31	1045.00	.00
3.516	8000.00	530.00	532.61	530.00	3.69	7992.64	3.67	72.00	10.66	1045.00	.00
3.516	7000.00	530.00	531.70	530.00	2.30	6995.42	2.28	72.00	10.20	1045.00	.00
3.516	6000.00	530.00	530.85	530.00	1.03	5997.95	1.02	72.00	9.58	1045.00	.00
3.516	5000.00	530.00	529.90	530.00	.00	5000.00	.00	69.64	8.93	1045.00	.00
3.516	4000.00	530.00	528.66	530.00	.00	4000.00	.00	64.90	8.40	1045.00	.00
3.516	3000.00	530.00	527.38	530.00	.00	3000.00	.00	60.01	7.57	1045.00	.00
3.516	2000.00	530.00	525.80	530.00	.00	2000.00	.00	54.00	6.53	1045.00	.00

3.526	6700.00	530.00	531.56	530.00	2.08	6695.83	2.08	50.00	10.95	50.00	.00
3.526	3900.00	530.00	528.89	530.00	.00	3900.00	.00	47.98	8.07	50.00	.00
3.526	2300.00	530.00	526.73	530.00	.00	2300.00	.00	47.94	6.05	50.00	.00
3.526	1800.00	530.00	525.81	530.00	.00	1800.00	.00	47.93	5.37	50.00	.00
3.526	8000.00	530.00	532.63	530.00	4.10	7991.80	4.10	50.00	12.06	50.00	.00
3.526	7000.00	530.00	531.82	530.00	2.55	6994.90	2.55	50.00	11.21	50.00	.00
3.526	6000.00	530.00	531.05	530.00	1.19	5997.61	1.20	50.00	10.22	50.00	.00
3.526	5000.00	530.00	530.17	530.00	.08	4999.83	.09	50.00	9.18	50.00	.00
3.526	4000.00	530.00	529.02	530.00	.00	4000.00	.00	47.98	8.17	50.00	.00
3.526	3000.00	530.00	527.79	530.00	.00	3000.00	.00	47.96	6.97	50.00	.00
3.526	2000.00	530.00	526.20	530.00	.00	2000.00	.00	47.93	5.65	50.00	.00

	SECNO	Q	XLBEL	CWSEL	RBEL	QLOB	QCH	QROB	TOPWID	VCH	XLCH	ELTRD
	3.535	6700.00	530.00	532.25	530.00	2.80	6694.40	2.80	67.00	9.89	49.00	.00
	3.535	3900.00	530.00	529.14	530.00	.00	3900.00	.00	62.55	8.21	49.00	.00
	3.535	2300.00	530.00	526.85	530.00	.00	2300.00	.00	56.09	6.78	49.00	.00
	3.535	1800.00	530.00	525.90	530.00	.00	1800.00	.00	53.39	6.27	49.00	.00
	3.535	8000.00	530.00	533.55	530.00	4.69	7990.63	4.68	67.00	10.49	49.00	.00
	3.535	7000.00	530.00	532.57	530.00	3.25	6993.50	3.25	67.00	10.03	49.00	.00
	3.535	6000.00	530.00	531.61	530.00	1.85	5996.31	1.84	67.00	9.45	49.00	.00
	3.535	5000.00	530.00	530.57	530.00	.47	4999.07	.47	67.00	8.81	49.00	.00
	3.535	4000.00	530.00	529.28	530.00	.00	4000.00	.00	62.97	8.26	49.00	.00
	3.535	3000.00	530.00	527.96	530.00	.00	3000.00	.00	59.21	7.44	49.00	.00
	3.535	2000.00	530.00	526.30	530.00	.00	2000.00	.00	54.53	6.47	49.00	.00
*	3.538	6700.00	530.40	533.41	530.40	2.12	6695.76	2.11	110.00	5.68	15.00	.00
*	3.538	3900.00	530.40	529.93	530.40	.00	3900.00	.00	105.80	4.86	15.00	.00
*	3.538	2300.00	530.40	527.38	530.40	.00	2300.00	.00	93.70	4.19	15.00	.00
*	3.538	1800.00	530.40	526.35	530.40	.00	1800.00	.00	88.79	3.97	15.00	.00
*	3.538	8000.00	530.40	534.86	530.40	3.22	7993.58	3.21	110.00	5.99	15.00	.00
*	3.538	7000.00	530.40	533.76	530.40	2.39	6995.24	2.38	110.00	5.76	15.00	.00
*	3.538	6000.00	530.40	532.67	530.40	1.54	5996.94	1.53	110.00	5.46	15.00	.00
*	3.538	5000.00	530.40	531.49	530.40	.63	4998.74	.63	110.00	5.15	15.00	.00
*	3.538	4000.00	530.40	530.09	530.40	.00	4000.00	.00	106.54	4.88	15.00	.00
*	3.538	3000.00	530.40	528.60	530.40	.00	3000.00	.00	99.49	4.50	15.00	.00
*	3.538	2000.00	530.40	526.78	530.40	.00	2000.00	.00	90.86	4.06	15.00	.00
	3.557	6700.00	530.40	533.60	530.40	.00	6700.00	.00	108.00	5.55	100.00	.00
	3.557	3900.00	530.40	530.14	530.40	.00	3900.00	.00	106.94	4.67	100.00	.00
	3.557	2300.00	530.40	527.60	530.40	.00	2300.00	.00	96.61	4.00	100.00	.00
	3.557	1800.00	530.40	526.57	530.40	.00	1800.00	.00	92.45	3.76	100.00	.00
	3.557	8000.00	530.40	535.04	530.40	.00	8000.00	.00	108.00	5.87	100.00	.00
	3.557	7000.00	530.40	533.94	530.40	.00	7000.00	.00	108.00	5.62	100.00	.00
	3.557	6000.00	530.40	532.85	530.40	.00	6000.00	.00	108.00	5.32	100.00	.00
	3.557	5000.00	530.40	531.68	530.40	.00	5000.00	.00	108.00	5.00	100.00	.00
	3.557	4000.00	530.40	530.29	530.40	.00	4000.00	.00	107.57	4.70	100.00	.00
	3.557	3000.00	530.40	528.81	530.40	.00	3000.00	.00	101.54	4.31	100.00	.00
	3.557	2000.00	530.40	527.00	530.40	.00	2000.00	.00	94.20	3.86	100.00	.00
*	3.582	6700.00	531.60	533.54	531.60	.00	6700.00	.00	108.00	9.11	136.00	535.60
*	3.582	3900.00	531.60	530.46	531.60	.00	3900.00	.00	103.38	5.30	136.00	535.60
	3.582	2300.00	531.60	527.83	531.60	.00	2300.00	.00	92.69	4.75	136.00	535.60
	3.582	1800.00	531.60	526.83	531.60	.00	1800.00	.00	88.64	4.57	136.00	535.60
	3.582	8000.00	531.60	536.38	531.60	.00	8000.00	.00	108.00	5.80	136.00	535.60
	3.582	7000.00	531.60	535.01	531.60	.00	7000.00	.00	108.00	5.69	136.00	535.60
*	3.582	6000.00	531.60	532.92	531.60	.00	6000.00	.00	108.00	8.16	136.00	535.60
*	3.582	5000.00	531.60	531.89	531.60	.00	5000.00	.00	108.00	6.80	136.00	535.60
*	3.582	4000.00	531.60	530.61	531.60	.00	4000.00	.00	103.97	5.44	136.00	535.60
	3.582	3000.00	531.60	529.02	531.60	.00	3000.00	.00	97.55	5.02	136.00	535.60
	3.582	2000.00	531.60	527.24	531.60	.00	2000.00	.00	90.33	4.64	136.00	535.60

	SECNO	Q	XLBEL	CWSEL	RBEL	QLOB	QCH	QROB	TOPWID	VCH	XLCH	ELTRD
*	3.601	6700.00	530.50	534.76	528.00	3.14	6696.86	.00	104.00	5.82	100.00	.00
*	3.601	3900.00	530.50	530.83	528.00	.14	3899.86	.00	104.00	5.22	100.00	.00
	3.601	2300.00	530.50	528.13	528.00	.00	2300.00	.00	98.98	4.86	100.00	.00
	3.601	1800.00	530.50	527.16	528.00	.00	1800.00	.00	86.57	4.68	100.00	.00
	3.601	8000.00	530.50	536.50	528.00	4.31	7995.69	.00	104.00	6.01	100.00	.00
	3.601	7000.00	530.50	535.15	528.00	3.42	6996.58	.00	104.00	5.87	100.00	.00
*	3.601	6000.00	530.50	533.88	528.00	2.48	5997.52	.00	104.00	5.66	100.00	.00
*	3.601	5000.00	530.50	532.55	528.00	1.48	4998.52	.00	104.00	5.41	100.00	.00
*	3.601	4000.00	530.50	531.00	528.00	.25	3999.75	.00	104.00	5.23	100.00	.00
	3.601	3000.00	530.50	529.29	528.00	.00	3000.00	.00	100.95	5.09	100.00	.00
	3.601	2000.00	530.50	527.55	528.00	.00	2000.00	.00	87.80	4.77	100.00	.00

3.663	6700.00	532.40	535.28	529.90	2.50	6697.50	.00	104.00	6.63	325.00	.00
3.663	3900.00	532.40	531.69	529.90	.00	3900.00	.00	101.80	6.09	325.00	.00
3.663	2300.00	532.40	529.34	529.90	.00	2300.00	.00	87.45	5.61	325.00	.00
3.663	1800.00	532.40	528.47	529.90	.00	1800.00	.00	84.73	5.38	325.00	.00
3.663	8000.00	532.40	536.94	529.90	3.87	7996.13	.00	104.00	6.77	325.00	.00
3.663	7000.00	532.40	535.66	529.90	2.83	6997.17	.00	104.00	6.67	325.00	.00
3.663	6000.00	532.40	534.46	529.90	1.79	5998.21	.00	104.00	6.48	325.00	.00
3.663	5000.00	532.40	533.23	529.90	.59	4999.41	.00	104.00	6.26	325.00	.00
3.663	4000.00	532.40	531.84	529.90	.00	4000.00	.00	102.05	6.11	325.00	.00
3.663	3000.00	532.40	530.38	529.90	.00	3000.00	.00	99.58	5.90	325.00	.00
3.663	2000.00	532.40	528.80	529.90	.00	2000.00	.00	85.75	5.52	325.00	.00
3.688	6700.00	533.80	535.43	533.80	1.59	6696.83	1.58	76.00	8.29	132.00	.00
3.688	3900.00	533.80	532.11	533.80	.00	3900.00	.00	73.27	6.93	132.00	.00
3.688	2300.00	533.80	529.92	533.80	.00	2300.00	.00	72.33	5.69	132.00	.00
3.688	1800.00	533.80	529.13	533.80	.00	1800.00	.00	71.99	5.19	132.00	.00
3.688	8000.00	533.80	536.99	533.80	3.42	7993.17	3.41	76.00	8.65	132.00	.00
3.688	7000.00	533.80	535.77	533.80	2.00	6996.00	2.00	76.00	8.39	132.00	.00
3.688	6000.00	533.80	534.67	533.80	.71	5998.59	.71	76.00	7.97	132.00	.00
3.688	5000.00	533.80	533.53	533.80	.00	5000.00	.00	73.88	7.49	132.00	.00
3.688	4000.00	533.80	532.25	533.80	.00	4000.00	.00	73.33	6.98	132.00	.00
3.688	3000.00	533.80	530.92	533.80	.00	3000.00	.00	72.76	6.29	132.00	.00
3.688	2000.00	533.80	529.43	533.80	.00	2000.00	.00	72.12	5.42	132.00	.00
3.691	6700.00	533.80	536.38	533.80	2.43	6695.15	2.42	76.00	7.62	18.00	535.80
3.691	3900.00	533.80	532.21	533.80	.00	3900.00	.00	73.31	6.84	18.00	535.80
3.691	2300.00	533.80	530.01	533.80	.00	2300.00	.00	72.37	5.60	18.00	535.80
3.691	1800.00	533.80	529.22	533.80	.00	1800.00	.00	72.03	5.09	18.00	535.80
3.691	8000.00	533.80	537.40	533.80	3.72	7992.56	3.72	76.00	8.38	18.00	535.80
3.691	7000.00	533.80	536.62	533.80	2.73	6994.54	2.73	76.00	7.80	18.00	535.80
* 3.691	6000.00	533.80	534.66	533.80	.00	6000.00	.00	76.00	8.72	18.00	535.80
3.691	5000.00	533.80	533.62	533.80	.00	5000.00	.00	73.93	7.40	18.00	535.80
3.691	4000.00	533.80	532.34	533.80	.00	4000.00	.00	73.37	6.89	18.00	535.80
3.691	3000.00	533.80	531.02	533.80	.00	3000.00	.00	72.80	6.20	18.00	535.80
3.691	2000.00	533.80	529.53	533.80	.00	2000.00	.00	72.16	5.32	18.00	535.80

SECNO	Q	XLBEL	CWSEL	RBEL	QLOB	QCH	QROB	TOPWID	VCH	XLCH	ELTRD
3.701	6700.00	529.40	536.71	529.90	.00	6700.00	.00	90.00	6.81	50.00	.00
3.701	3900.00	529.40	532.50	529.90	.00	3900.00	.00	90.00	6.45	50.00	.00
3.701	2300.00	529.40	530.22	529.90	.00	2300.00	.00	90.00	5.76	50.00	.00
3.701	1800.00	529.40	529.41	529.90	.00	1800.00	.00	84.71	5.47	50.00	.00
3.701	8000.00	529.40	537.81	529.90	.00	8000.00	.00	90.00	7.39	50.00	.00
3.701	7000.00	529.40	536.97	529.90	.00	7000.00	.00	90.00	6.95	50.00	.00
* 3.701	6000.00	529.40	535.41	529.90	.00	6000.00	.00	90.00	6.93	50.00	.00
3.701	5000.00	529.40	533.97	529.90	.00	5000.00	.00	90.00	6.79	50.00	.00
3.701	4000.00	529.40	532.64	529.90	.00	4000.00	.00	90.00	6.48	50.00	.00
3.701	3000.00	529.40	531.26	529.90	.00	3000.00	.00	90.00	6.09	50.00	.00
3.701	2000.00	529.40	529.73	529.90	.00	2000.00	.00	85.85	5.62	50.00	.00
3.727	7300.00	529.40	537.01	529.90	.00	7300.00	.00	90.00	7.22	140.00	.00
3.727	4000.00	529.40	533.10	529.90	.00	4000.00	.00	90.00	6.08	140.00	.00
3.727	2400.00	529.40	530.95	529.90	.00	2400.00	.00	90.00	5.16	140.00	.00
3.727	1800.00	529.40	530.18	529.90	.00	1800.00	.00	90.00	4.55	140.00	.00
3.727	8000.00	529.40	538.22	529.90	.00	8000.00	.00	90.00	7.15	140.00	.00
3.727	7000.00	529.40	537.36	529.90	.00	7000.00	.00	90.00	6.71	140.00	.00
3.727	6000.00	529.40	535.87	529.90	.00	6000.00	.00	90.00	6.61	140.00	.00
3.727	5000.00	529.40	534.53	529.90	.00	5000.00	.00	90.00	6.36	140.00	.00
3.727	4000.00	529.40	533.26	529.90	.00	4000.00	.00	90.00	5.95	140.00	.00
3.727	3000.00	529.40	531.93	529.90	.00	3000.00	.00	90.00	5.42	140.00	.00
3.727	2000.00	529.40	530.49	529.90	.00	2000.00	.00	90.00	4.73	140.00	.00
3.735	7300.00	534.00	537.36	534.00	2.61	7294.79	2.60	112.00	6.09	41.00	.00
3.735	4000.00	534.00	533.38	534.00	.00	4000.00	.00	109.96	5.26	41.00	.00
3.735	2400.00	534.00	531.18	534.00	.00	2400.00	.00	109.75	4.63	41.00	.00
3.735	1800.00	534.00	530.37	534.00	.00	1800.00	.00	107.06	4.18	41.00	.00
3.735	8000.00	534.00	538.55	534.00	3.39	7993.22	3.39	112.00	6.02	41.00	.00
3.735	7000.00	534.00	537.66	534.00	2.63	6994.74	2.63	112.00	5.68	41.00	.00
3.735	6000.00	534.00	536.16	534.00	1.54	5996.92	1.54	112.00	5.62	41.00	.00
3.735	5000.00	534.00	534.82	534.00	.46	4999.08	.46	112.00	5.44	41.00	.00
3.735	4000.00	534.00	533.52	534.00	.00	4000.00	.00	109.97	5.16	41.00	.00
3.735	3000.00	534.00	532.17	534.00	.00	3000.00	.00	109.89	4.79	41.00	.00
3.735	2000.00	534.00	530.68	534.00	.00	2000.00	.00	108.09	4.31	41.00	.00
3.742	7300.00	534.00	539.18	534.00	203.77	7017.41	78.82	145.00	5.15	35.00	539.00
3.742	4000.00	534.00	533.42	534.00	.00	4000.00	.00	109.96	5.49	35.00	539.00
3.742	2400.00	534.00	531.21	534.00	.00	2400.00	.00	109.83	4.94	35.00	539.00
3.742	1800.00	534.00	530.39	534.00	.00	1800.00	.00	107.15	4.53	35.00	539.00
3.742	8000.00	534.00	540.11	534.00	262.61	7639.83	97.56	145.00	5.21	35.00	539.00
3.742	7000.00	534.00	539.29	534.00	199.69	6723.47	76.83	145.00	4.89	35.00	539.00

	3.742	6000.00	534.00	537.44	534.00	102.33	5853.30	44.37	145.00	5.00	35.00	539.00
	3.742	5000.00	534.00	535.56	534.00	20.03	4967.15	12.83	145.00	5.15	35.00	539.00
	3.742	4000.00	534.00	533.84	534.00	.00	4000.00	.00	109.99	5.16	35.00	539.00
	3.742	3000.00	534.00	532.20	534.00	.00	3000.00	.00	109.89	5.05	35.00	539.00
	3.742	2000.00	534.00	530.71	534.00	.00	2000.00	.00	108.19	4.63	35.00	539.00

	SECNO	Q	XLBEL	CWSEL	RBEL	QLOB	QCH	QROB	TOPWID	VCH	XLCH	ELTRD
	3.751	7300.00	535.90	539.26	534.20	2.27	6851.87	445.86	181.00	5.06	50.00	.00
*	3.751	4000.00	535.90	533.42	534.20	.00	4000.00	.00	114.11	7.05	50.00	.00
*	3.751	2400.00	535.90	531.22	534.20	.00	2400.00	.00	99.29	7.19	50.00	.00
*	3.751	1800.00	535.90	530.44	534.20	.00	1800.00	.00	94.12	6.99	50.00	.00
	3.751	8000.00	535.90	540.21	534.20	2.81	7452.43	544.76	181.00	5.01	50.00	.00
	3.751	7000.00	535.90	539.36	534.20	2.21	6564.33	433.46	181.00	4.80	50.00	.00
	3.751	6000.00	535.90	537.51	534.20	1.10	5733.87	265.03	181.00	5.17	50.00	.00
	3.751	5000.00	535.90	535.60	534.20	.00	4911.94	88.06	175.76	5.83	50.00	.00
*	3.751	4000.00	535.90	533.85	534.20	.00	4000.00	.00	120.98	6.47	50.00	.00
*	3.751	3000.00	535.90	532.20	534.20	.00	3000.00	.00	105.65	6.93	50.00	.00
*	3.751	2000.00	535.90	530.74	534.20	.00	2000.00	.00	96.11	6.99	50.00	.00
*	3.808	7300.00	534.30	539.37	534.30	.00	7300.00	.00	80.00	8.96	300.00	.00
	3.808	4000.00	534.30	535.33	534.30	.00	4000.00	.00	80.00	8.13	300.00	.00
*	3.808	2400.00	534.30	533.86	534.30	.00	2400.00	.00	77.88	6.41	300.00	.00
*	3.808	1800.00	534.30	533.18	534.30	.00	1800.00	.00	74.68	5.57	300.00	.00
*	3.808	8000.00	534.30	540.20	534.30	.00	8000.00	.00	80.00	9.07	300.00	.00
*	3.808	7000.00	534.30	539.45	534.30	.00	7000.00	.00	80.00	8.52	300.00	.00
*	3.808	6000.00	534.30	537.90	534.30	.00	6000.00	.00	80.00	8.61	300.00	.00
	3.808	5000.00	534.30	536.55	534.30	.00	5000.00	.00	80.00	8.48	300.00	.00
	3.808	4000.00	534.30	535.44	534.30	.00	4000.00	.00	80.00	7.99	300.00	.00
	3.808	3000.00	534.30	534.41	534.30	.00	3000.00	.00	80.00	7.17	300.00	.00
*	3.808	2000.00	534.30	533.41	534.30	.00	2000.00	.00	75.76	5.88	300.00	.00
	4.135	7300.00	548.00	548.74	546.40	171.07	6812.50	316.42	200.00	8.57	1724.00	.00
	4.135	4000.00	548.00	546.75	546.40	.00	3970.41	29.59	146.87	6.87	1724.00	.00
	4.135	2400.00	548.00	544.77	546.40	.00	2400.00	.00	90.77	6.26	1724.00	.00
	4.135	1800.00	548.00	543.88	546.40	.00	1800.00	.00	86.87	5.92	1724.00	.00
	4.135	8000.00	548.00	549.14	546.40	245.50	7360.80	393.70	200.00	8.77	1724.00	.00
	4.135	7000.00	548.00	548.44	546.40	125.01	6605.34	269.65	200.00	8.67	1724.00	.00
	4.135	6000.00	548.00	548.05	546.40	65.97	5742.10	191.93	200.00	7.98	1724.00	.00
	4.135	5000.00	548.00	547.46	546.40	.00	4895.97	104.03	148.64	7.48	1724.00	.00
	4.135	4000.00	548.00	546.70	546.40	.00	3974.03	25.97	146.74	6.94	1724.00	.00
	4.135	3000.00	548.00	545.61	546.40	.00	3000.00	.00	96.06	6.51	1724.00	.00
	4.135	2000.00	548.00	544.20	546.40	.00	2000.00	.00	88.26	6.03	1724.00	.00
	4.240	7300.00	551.00	552.06	552.00	185.33	6757.08	357.59	600.00	8.77	550.00	.00
	4.240	4000.00	551.00	549.83	552.00	.00	4000.00	.00	91.70	7.22	550.00	.00
	4.240	2400.00	551.00	548.04	552.00	.00	2400.00	.00	82.22	6.01	550.00	.00
	4.240	1800.00	551.00	547.26	552.00	.00	1800.00	.00	78.07	5.34	550.00	.00
	4.240	8000.00	551.00	552.40	552.00	401.46	7043.90	554.63	600.00	8.75	550.00	.00
	4.240	7000.00	551.00	551.96	552.00	144.28	6855.72	.00	387.91	9.01	550.00	.00
	4.240	6000.00	551.00	551.35	552.00	9.68	5990.32	.00	203.47	8.55	550.00	.00
	4.240	5000.00	551.00	550.67	552.00	.00	5000.00	.00	96.22	7.89	550.00	.00
	4.240	4000.00	551.00	549.83	552.00	.00	4000.00	.00	91.75	7.21	550.00	.00
	4.240	3000.00	551.00	548.76	552.00	.00	3000.00	.00	86.04	6.53	550.00	.00
	4.240	2000.00	551.00	547.53	552.00	.00	2000.00	.00	79.49	5.59	550.00	.00

	SECNO	Q	XLBEL	CWSEL	RBEL	QLOB	QCH	QROB	TOPWID	VCH	XLCH	ELTRD
	4.487	7300.00	562.00	563.05	563.00	30.95	7168.54	100.50	202.63	10.26	1814.00	.00
	4.487	4000.00	562.00	559.97	563.00	.00	4000.00	.00	64.38	8.15	1814.00	.00
	4.487	2400.00	562.00	557.69	563.00	.00	2400.00	.00	59.46	6.86	1814.00	.00
	4.487	1800.00	562.00	556.61	563.00	.00	1800.00	.00	57.11	6.29	1814.00	.00
	4.487	8000.00	562.00	563.31	563.00	57.41	7787.11	155.47	215.34	10.87	1814.00	.00
	4.487	7000.00	562.00	563.05	563.00	29.76	6873.72	96.53	202.68	9.84	1814.00	.00
	4.487	6000.00	562.00	562.27	563.00	.84	5999.16	.00	82.95	9.30	1814.00	.00
	4.487	5000.00	562.00	561.19	563.00	.00	5000.00	.00	67.02	8.76	1814.00	.00
	4.487	4000.00	562.00	559.96	563.00	.00	4000.00	.00	64.37	8.15	1814.00	.00
	4.487	3000.00	562.00	558.63	563.00	.00	3000.00	.00	61.47	7.39	1814.00	.00
	4.487	2000.00	562.00	556.99	563.00	.00	2000.00	.00	57.94	6.48	1814.00	.00
	4.522	7300.00	565.00	564.35	567.00	.00	7300.00	.00	77.54	11.20	185.00	.00
	4.522	4000.00	565.00	561.18	567.00	.00	4000.00	.00	69.93	9.37	185.00	.00
*	4.522	2400.00	565.00	559.02	567.00	.00	2400.00	.00	69.86	8.69	185.00	.00
*	4.522	1800.00	565.00	557.95	567.00	.00	1800.00	.00	57.03	8.91	185.00	.00
	4.522	8000.00	565.00	564.73	567.00	.00	8000.00	.00	81.42	11.73	185.00	.00
	4.522	7000.00	565.00	564.22	567.00	.00	7000.00	.00	76.30	10.90	185.00	.00

	4.522	6000.00	565.00	563.42	567.00	.00	6000.00	.00	69.99	10.29	185.00	.00
	4.522	5000.00	565.00	562.36	567.00	.00	5000.00	.00	69.96	9.81	185.00	.00
	4.522	4000.00	565.00	561.17	567.00	.00	4000.00	.00	69.93	9.38	185.00	.00
*	4.522	3000.00	565.00	559.89	567.00	.00	3000.00	.00	69.89	8.91	185.00	.00
*	4.522	2000.00	565.00	558.41	567.00	.00	2000.00	.00	69.85	8.58	185.00	.00
	4.530	7300.00	563.60	564.94	563.60	.00	7300.00	.00	70.00	10.93	40.00	570.00
	4.530	4000.00	563.60	561.83	563.60	.00	4000.00	.00	69.95	8.47	40.00	570.00
	4.530	2400.00	563.60	559.89	563.60	.00	2400.00	.00	69.89	7.13	40.00	570.00
*	4.530	1800.00	563.60	559.09	563.60	.00	1800.00	.00	69.87	6.40	40.00	570.00
	4.530	8000.00	563.60	565.30	563.60	.00	8000.00	.00	70.00	11.77	40.00	570.00
	4.530	7000.00	563.60	564.80	563.60	.00	7000.00	.00	70.00	10.57	40.00	570.00
	4.530	6000.00	563.60	564.01	563.60	.00	6000.00	.00	70.00	9.63	40.00	570.00
	4.530	5000.00	563.60	562.95	563.60	.00	5000.00	.00	69.98	9.08	40.00	570.00
	4.530	4000.00	563.60	561.83	563.60	.00	4000.00	.00	69.95	8.47	40.00	570.00
	4.530	3000.00	563.60	560.64	563.60	.00	3000.00	.00	69.91	7.71	40.00	570.00
*	4.530	2000.00	563.60	559.40	563.60	.00	2000.00	.00	69.88	6.62	40.00	570.00
*	4.539	7300.00	567.50	566.22	565.00	.00	7298.73	1.27	114.71	8.28	50.00	.00
	4.539	4000.00	567.50	562.33	565.00	.00	4000.00	.00	80.98	8.01	50.00	.00
	4.539	2400.00	567.50	560.32	565.00	.00	2400.00	.00	71.80	6.92	50.00	.00
	4.539	1800.00	567.50	559.51	565.00	.00	1800.00	.00	68.05	6.21	50.00	.00
*	4.539	8000.00	567.50	566.90	565.00	.00	7997.85	2.15	118.08	8.32	50.00	.00
*	4.539	7000.00	567.50	565.95	565.00	.00	6999.08	.92	113.40	8.22	50.00	.00
	4.539	6000.00	567.50	564.79	565.00	.00	6000.00	.00	105.08	8.27	50.00	.00
	4.539	5000.00	567.50	563.54	565.00	.00	5000.00	.00	89.93	8.28	50.00	.00
	4.539	4000.00	567.50	562.32	565.00	.00	4000.00	.00	80.96	8.02	50.00	.00
	4.539	3000.00	567.50	561.09	565.00	.00	3000.00	.00	75.34	7.43	50.00	.00
	4.539	2000.00	567.50	559.81	565.00	.00	2000.00	.00	69.43	6.44	50.00	.00

	SECNO	Q	XLBEL	CWSEL	RBEL	QLOB	QCH	QROB	TOPWID	VCH	XLCH	ELTRD
	4.630	7300.00	564.90	568.59	566.70	4.96	7062.03	233.01	126.00	9.48	477.00	.00
	4.630	4000.00	564.90	565.47	566.70	.49	3999.51	.00	77.80	8.05	477.00	.00
	4.630	2400.00	564.90	563.51	566.70	.00	2400.00	.00	69.55	6.81	477.00	.00
	4.630	1800.00	564.90	562.58	566.70	.00	1800.00	.00	65.71	6.21	477.00	.00
	4.630	8000.00	564.90	569.13	566.70	5.72	7658.74	335.54	126.00	9.72	477.00	.00
	4.630	7000.00	564.90	568.37	566.70	4.63	6801.63	193.74	126.00	9.36	477.00	.00
	4.630	6000.00	564.90	567.53	566.70	3.43	5922.56	74.01	126.00	8.98	477.00	.00
	4.630	5000.00	564.90	566.53	566.70	1.99	4998.00	.00	80.55	8.62	477.00	.00
	4.630	4000.00	564.90	565.47	566.70	.49	3999.51	.00	77.80	8.05	477.00	.00
	4.630	3000.00	564.90	564.31	566.70	.00	3000.00	.00	72.89	7.32	477.00	.00
	4.630	2000.00	564.90	562.90	566.70	.00	2000.00	.00	67.04	6.43	477.00	.00
*	4.636	7300.00	565.60	569.47	565.60	3.22	7218.97	77.81	101.00	6.51	33.00	.00
*	4.636	4000.00	565.60	566.28	565.60	.32	3996.89	2.80	101.00	4.84	33.00	.00
*	4.636	2400.00	565.60	564.14	565.60	.00	2400.00	.00	88.97	3.78	33.00	.00
*	4.636	1800.00	565.60	563.13	565.60	.00	1800.00	.00	88.94	3.30	33.00	.00
*	4.636	8000.00	565.60	570.00	565.60	3.80	7899.09	97.11	101.00	6.83	33.00	.00
*	4.636	7000.00	565.60	569.24	565.60	2.97	6927.09	69.94	101.00	6.36	33.00	.00
*	4.636	6000.00	565.60	568.41	565.60	2.12	5953.55	44.32	101.00	5.87	33.00	.00
*	4.636	5000.00	565.60	567.41	565.60	1.21	4978.46	20.33	101.00	5.38	33.00	.00
*	4.636	4000.00	565.60	566.28	565.60	.32	3996.89	2.79	101.00	4.84	33.00	.00
*	4.636	3000.00	565.60	565.02	565.60	.00	3000.00	.00	88.99	4.21	33.00	.00
*	4.636	2000.00	565.60	563.48	565.60	.00	2000.00	.00	88.95	3.47	33.00	.00
	4.639	7300.00	566.10	569.38	566.10	2.91	7294.18	2.91	91.00	6.90	17.00	567.10
*	4.639	4000.00	566.10	566.30	566.10	.00	4000.00	.00	89.00	5.17	17.00	567.10
	4.639	2400.00	566.10	564.14	566.10	.00	2400.00	.00	88.95	4.06	17.00	567.10
	4.639	1800.00	566.10	563.14	566.10	.00	1800.00	.00	88.93	3.59	17.00	567.10
	4.639	8000.00	566.10	569.90	566.10	3.52	7992.96	3.52	91.00	7.25	17.00	567.10
	4.639	7000.00	566.10	569.16	566.10	2.66	6994.69	2.65	91.00	6.75	17.00	567.10
	4.639	6000.00	566.10	568.34	566.10	1.77	5996.46	1.77	91.00	6.22	17.00	567.10
	4.639	5000.00	566.10	567.35	566.10	.83	4998.34	.83	91.00	5.71	17.00	567.10
*	4.639	4000.00	566.10	566.30	566.10	.00	4000.00	.00	89.00	5.17	17.00	567.10
	4.639	3000.00	566.10	565.02	566.10	.00	3000.00	.00	88.97	4.49	17.00	567.10
	4.639	2000.00	566.10	563.49	566.10	.00	2000.00	.00	88.94	3.76	17.00	567.10
	4.649	7300.00	566.20	569.13	568.00	3.65	7295.22	1.12	82.00	9.30	50.00	.00
	4.649	4000.00	566.20	566.32	568.00	.04	3999.96	.00	76.65	7.10	50.00	.00
*	4.649	2400.00	566.20	564.06	568.00	.00	2400.00	.00	67.27	5.98	50.00	.00
*	4.649	1800.00	566.20	563.09	568.00	.00	1800.00	.00	63.58	5.33	50.00	.00
	4.649	8000.00	566.20	569.63	568.00	4.42	7993.77	1.81	82.00	9.70	50.00	.00
*	4.649	7000.00	566.20	568.92	568.00	3.32	6995.83	.85	82.00	9.12	50.00	.00
*	4.649	6000.00	566.20	568.13	568.00	2.18	5997.77	.05	82.00	8.52	50.00	.00
*	4.649	5000.00	566.20	567.17	568.00	.89	4999.10	.00	78.85	7.96	50.00	.00
	4.649	4000.00	566.20	566.32	568.00	.04	3999.96	.00	76.64	7.10	50.00	.00
*	4.649	3000.00	566.20	564.91	568.00	.00	3000.00	.00	70.47	6.52	50.00	.00
*	4.649	2000.00	566.20	563.43	568.00	.00	2000.00	.00	64.86	5.56	50.00	.00

	SECNO	Q	XLBEL	CWSEL	RBEL	QLOB	QCH	QROB	TOPWID	VCH	XLCH	ELTRD
	4.838	7300.00	574.20	575.43	576.00	1.70	7298.30	.00	79.52	11.26	1000.00	.00
*	4.838	4000.00	574.20	572.20	576.00	.00	4000.00	.00	67.79	9.74	1000.00	.00
*	4.838	2400.00	574.20	570.07	576.00	.00	2400.00	.00	59.72	8.74	1000.00	.00
*	4.838	1800.00	574.20	569.05	576.00	.00	1800.00	.00	55.89	8.34	1000.00	.00
	4.838	8000.00	574.20	575.98	576.00	2.71	7997.29	.00	80.96	11.55	1000.00	.00
	4.838	7000.00	574.20	575.19	576.00	1.27	6998.72	.00	78.89	11.12	1000.00	.00
	4.838	6000.00	574.20	574.35	576.00	.08	5999.92	.00	76.72	10.61	1000.00	.00
	4.838	5000.00	574.20	573.38	576.00	.00	5000.00	.00	72.24	10.13	1000.00	.00
*	4.838	4000.00	574.20	572.20	576.00	.00	4000.00	.00	67.79	9.74	1000.00	.00
*	4.838	3000.00	574.20	570.96	576.00	.00	3000.00	.00	63.11	9.10	1000.00	.00
*	4.838	2000.00	574.20	569.41	576.00	.00	2000.00	.00	57.24	8.47	1000.00	.00
*	5.034	7300.00	582.00	582.10	582.00	.15	7299.83	.02	109.91	7.38	1035.00	.00
*	5.034	4000.00	582.00	578.71	582.00	.00	4000.00	.00	89.94	5.85	1035.00	.00
*	5.034	2400.00	582.00	576.64	582.00	.00	2400.00	.00	89.90	4.82	1035.00	.00
*	5.034	1800.00	582.00	575.76	582.00	.00	1800.00	.00	89.89	4.30	1035.00	.00
*	5.034	8000.00	582.00	582.69	582.00	25.16	7971.99	2.85	224.93	7.65	1035.00	.00
*	5.034	7000.00	582.00	581.83	582.00	.00	7000.00	.00	90.00	7.26	1035.00	.00
*	5.034	6000.00	582.00	580.88	582.00	.00	6000.00	.00	89.98	6.83	1035.00	.00
*	5.034	5000.00	582.00	579.83	582.00	.00	5000.00	.00	89.96	6.37	1035.00	.00
*	5.034	4000.00	582.00	578.71	582.00	.00	4000.00	.00	89.94	5.85	1035.00	.00
*	5.034	3000.00	582.00	577.46	582.00	.00	3000.00	.00	89.92	5.25	1035.00	.00
*	5.034	2000.00	582.00	576.06	582.00	.00	2000.00	.00	89.89	4.49	1035.00	.00
*	5.052	7300.00	585.00	582.20	585.00	.00	7300.00	.00	93.95	9.25	92.00	.00
*	5.052	4000.00	585.00	578.78	585.00	.00	4000.00	.00	93.89	8.55	92.00	.00
*	5.052	2400.00	585.00	576.64	585.00	.00	2400.00	.00	93.85	8.97	92.00	.00
*	5.052	1800.00	585.00	576.05	585.00	.00	1800.00	.00	93.84	8.52	92.00	.00
*	5.052	8000.00	585.00	582.77	585.00	.00	8000.00	.00	93.96	9.49	92.00	.00
*	5.052	7000.00	585.00	581.92	585.00	.00	7000.00	.00	93.95	9.17	92.00	.00
*	5.052	6000.00	585.00	580.97	585.00	.00	6000.00	.00	93.93	8.91	92.00	.00
*	5.052	5000.00	585.00	579.92	585.00	.00	5000.00	.00	93.91	8.70	92.00	.00
*	5.052	4000.00	585.00	578.78	585.00	.00	4000.00	.00	93.89	8.55	92.00	.00
*	5.052	3000.00	585.00	577.51	585.00	.00	3000.00	.00	93.87	8.62	92.00	.00
*	5.052	2000.00	585.00	576.21	585.00	.00	2000.00	.00	93.84	8.83	92.00	.00
*	5.054	7300.00	585.00	582.85	585.00	.00	7300.00	.00	84.97	13.99	14.00	.00
*	5.054	4000.00	585.00	580.79	585.00	.00	4000.00	.00	84.91	11.53	14.00	.00
*	5.054	2400.00	585.00	579.61	585.00	.00	2400.00	.00	84.88	9.73	14.00	.00
*	5.054	1800.00	585.00	579.10	585.00	.00	1800.00	.00	84.87	8.83	14.00	.00
*	5.054	8000.00	585.00	584.65	585.00	.00	8000.00	.00	93.98	11.60	14.00	.00
*	5.054	7000.00	585.00	584.69	585.00	.00	7000.00	.00	93.98	10.09	14.00	.00
*	5.054	6000.00	585.00	582.07	585.00	.00	6000.00	.00	84.95	13.17	14.00	.00
*	5.054	5000.00	585.00	581.44	585.00	.00	5000.00	.00	84.93	12.42	14.00	.00
*	5.054	4000.00	585.00	580.79	585.00	.00	4000.00	.00	84.91	11.53	14.00	.00
*	5.054	3000.00	585.00	580.07	585.00	.00	3000.00	.00	84.89	10.48	14.00	.00
*	5.054	2000.00	585.00	579.27	585.00	.00	2000.00	.00	84.87	9.16	14.00	.00

	SECNO	Q	XLBEL	CWSEL	RBEL	QLOB	QCH	QROB	TOPWID	VCH	XLCH	ELTRD
	5.067	7300.00	590.00	584.74	590.00	.00	7300.00	.00	95.29	13.43	70.00	.00
*	5.067	4000.00	590.00	582.81	590.00	.00	4000.00	.00	94.86	11.11	70.00	.00
*	5.067	2400.00	590.00	581.71	590.00	.00	2400.00	.00	94.61	9.38	70.00	.00
	5.067	1800.00	590.00	581.26	590.00	.00	1800.00	.00	94.51	8.44	70.00	.00
	5.067	8000.00	590.00	585.29	590.00	.00	8000.00	.00	95.42	13.42	70.00	.00
	5.067	7000.00	590.00	585.10	590.00	.00	7000.00	.00	95.37	12.11	70.00	.00
*	5.067	6000.00	590.00	583.99	590.00	.00	6000.00	.00	95.12	12.71	70.00	.00
*	5.067	5000.00	590.00	583.42	590.00	.00	5000.00	.00	94.99	11.97	70.00	.00
*	5.067	4000.00	590.00	582.81	590.00	.00	4000.00	.00	94.86	11.11	70.00	.00
*	5.067	3000.00	590.00	582.15	590.00	.00	3000.00	.00	94.71	10.10	70.00	.00
	5.067	2000.00	590.00	581.41	590.00	.00	2000.00	.00	94.54	8.78	70.00	.00
*	5.075	7300.00	590.00	586.59	590.00	.00	7300.00	.00	95.71	10.15	38.00	589.50
*	5.075	4000.00	590.00	584.39	590.00	.00	4000.00	.00	95.21	7.85	38.00	589.50
*	5.075	2400.00	590.00	583.05	590.00	.00	2400.00	.00	94.91	6.29	38.00	589.50
*	5.075	1800.00	590.00	582.45	590.00	.00	1800.00	.00	94.78	5.54	38.00	589.50
*	5.075	8000.00	590.00	586.97	590.00	.00	8000.00	.00	95.79	10.59	38.00	589.50
	5.075	7000.00	590.00	586.37	590.00	.00	7000.00	.00	95.66	10.02	38.00	589.50
*	5.075	6000.00	590.00	585.80	590.00	.00	6000.00	.00	95.53	9.31	38.00	589.50
*	5.075	5000.00	590.00	585.12	590.00	.00	5000.00	.00	95.38	8.63	38.00	589.50
*	5.075	4000.00	590.00	584.39	590.00	.00	4000.00	.00	95.21	7.85	38.00	589.50
*	5.075	3000.00	590.00	583.58	590.00	.00	3000.00	.00	95.03	6.93	38.00	589.50
*	5.075	2000.00	590.00	582.65	590.00	.00	2000.00	.00	94.82	5.81	38.00	589.50

*	5.084	7300.00	589.50	586.38	589.00	.00	7300.00	.00	88.93	13.85	50.00	.00
*	5.084	4000.00	589.50	584.28	589.00	.00	4000.00	.00	81.00	11.44	50.00	.00
*	5.084	2400.00	589.50	583.13	589.00	.00	2400.00	.00	76.64	9.29	50.00	.00
*	5.084	1800.00	589.50	582.59	589.00	.00	1800.00	.00	73.83	8.26	50.00	.00
*	5.084	8000.00	589.50	586.78	589.00	.00	8000.00	.00	90.48	14.20	50.00	.00
*	5.084	7000.00	589.50	586.20	589.00	.00	7000.00	.00	88.24	13.69	50.00	.00
*	5.084	6000.00	589.50	585.58	589.00	.00	6000.00	.00	85.87	13.12	50.00	.00
*	5.084	5000.00	589.50	584.92	589.00	.00	5000.00	.00	83.36	12.46	50.00	.00
*	5.084	4000.00	589.50	584.28	589.00	.00	4000.00	.00	81.00	11.44	50.00	.00
*	5.084	3000.00	589.50	583.58	589.00	.00	3000.00	.00	78.37	10.21	50.00	.00
*	5.084	2000.00	589.50	582.77	589.00	.00	2000.00	.00	74.87	8.65	50.00	.00
*	5.136	7300.00	590.40	590.97	589.90	.42	7298.56	1.02	112.00	8.17	275.00	.00
*	5.136	4000.00	590.40	588.06	589.90	.00	4000.00	.00	91.91	6.70	275.00	.00
*	5.136	2400.00	590.40	586.21	589.90	.00	2400.00	.00	84.84	5.53	275.00	.00
*	5.136	1800.00	590.40	585.37	589.90	.00	1800.00	.00	81.67	4.94	275.00	.00
*	5.136	8000.00	590.40	591.44	589.90	.97	7997.40	1.63	112.00	8.47	275.00	.00
*	5.136	7000.00	590.40	590.76	589.90	.21	6999.02	.77	112.00	8.04	275.00	.00
*	5.136	6000.00	590.40	590.03	589.90	.00	5999.96	.04	110.06	7.60	275.00	.00
*	5.136	5000.00	590.40	589.04	589.90	.00	5000.00	.00	95.88	7.24	275.00	.00
*	5.136	4000.00	590.40	588.06	589.90	.00	4000.00	.00	91.91	6.70	275.00	.00
*	5.136	3000.00	590.40	586.96	589.90	.00	3000.00	.00	87.67	6.02	275.00	.00
*	5.136	2000.00	590.40	585.66	589.90	.00	2000.00	.00	82.78	5.15	275.00	.00

	SECNO	Q	XLBEL	CWSEL	RBEL	QLOB	QCH	QROB	TOPWID	VCH	XLCH	ELTRD
*	5.148	7300.00	593.00	591.92	593.00	.00	7300.00	.00	215.18	4.74	65.00	.00
*	5.148	4000.00	593.00	588.70	593.00	.00	4000.00	.00	141.06	4.14	65.00	.00
*	5.148	2400.00	593.00	586.68	593.00	.00	2400.00	.00	117.97	3.36	65.00	.00
*	5.148	1800.00	593.00	585.77	593.00	.00	1800.00	.00	117.94	2.96	65.00	.00
*	5.148	8000.00	593.00	592.46	593.00	.00	8000.00	.00	227.63	4.82	65.00	.00
*	5.148	7000.00	593.00	591.68	593.00	.00	7000.00	.00	209.73	4.70	65.00	.00
*	5.148	6000.00	593.00	590.85	593.00	.00	6000.00	.00	190.57	4.54	65.00	.00
*	5.148	5000.00	593.00	589.79	593.00	.00	5000.00	.00	166.16	4.41	65.00	.00
*	5.148	4000.00	593.00	588.70	593.00	.00	4000.00	.00	141.06	4.14	65.00	.00
*	5.148	3000.00	593.00	587.49	593.00	.00	3000.00	.00	117.99	3.70	65.00	.00
*	5.148	2000.00	593.00	586.09	593.00	.00	2000.00	.00	117.95	3.10	65.00	.00
	5.165	7300.00	593.00	593.47	593.00	.00	7300.00	.00	240.00	3.85	85.00	593.00
	5.165	4000.00	593.00	589.06	593.00	.00	4000.00	.00	149.34	3.93	85.00	591.20
	5.165	2400.00	593.00	586.68	593.00	.00	2400.00	.00	117.97	3.35	85.00	591.20
	5.165	1800.00	593.00	585.77	593.00	.00	1800.00	.00	117.94	2.96	85.00	591.20
	5.165	8000.00	593.00	594.06	593.00	.00	8000.00	.00	240.00	3.92	85.00	591.20
	5.165	7000.00	593.00	593.19	593.00	.00	7000.00	.00	240.00	3.82	85.00	593.00
	5.165	6000.00	593.00	591.97	593.00	.00	6000.00	.00	216.29	3.87	85.00	593.00
	5.165	5000.00	593.00	590.48	593.00	.00	5000.00	.00	182.05	3.99	85.00	591.20
	5.165	4000.00	593.00	589.06	593.00	.00	4000.00	.00	149.34	3.93	85.00	591.20
	5.165	3000.00	593.00	587.63	593.00	.00	3000.00	.00	118.00	3.63	85.00	591.20
	5.165	2000.00	593.00	586.09	593.00	.00	2000.00	.00	117.95	3.10	85.00	591.20
*	5.184	7300.00	591.20	593.34	591.00	1.80	7296.19	2.01	122.00	6.57	100.00	.00
*	5.184	4000.00	591.20	589.02	591.00	.00	4000.00	.00	94.23	6.35	100.00	.00
*	5.184	2400.00	591.20	586.68	591.00	.00	2400.00	.00	85.68	5.72	100.00	.00
*	5.184	1800.00	591.20	585.79	591.00	.00	1800.00	.00	82.84	5.22	100.00	.00
*	5.184	8000.00	591.20	593.89	591.00	2.37	7995.06	2.58	122.00	6.78	100.00	.00
*	5.184	7000.00	591.20	593.07	591.00	1.54	6996.71	1.75	122.00	6.48	100.00	.00
*	5.184	6000.00	591.20	591.89	591.00	.45	5998.92	.64	122.00	6.40	100.00	.00
*	5.184	5000.00	591.20	590.42	591.00	.00	5000.00	.00	102.38	6.52	100.00	.00
*	5.184	4000.00	591.20	589.02	591.00	.00	4000.00	.00	94.23	6.35	100.00	.00
*	5.184	3000.00	591.20	587.59	591.00	.00	3000.00	.00	88.63	6.00	100.00	.00
*	5.184	2000.00	591.20	586.10	591.00	.00	2000.00	.00	83.83	5.39	100.00	.00
*	5.373	7300.00	600.00	597.14	600.00	.00	7300.00	.00	86.78	11.36	1000.00	.00
*	5.373	4000.00	600.00	594.44	600.00	.00	4000.00	.00	74.35	9.40	1000.00	.00
	5.373	2400.00	600.00	592.78	600.00	.00	2400.00	.00	66.67	7.79	1000.00	.00
	5.373	1800.00	600.00	591.97	600.00	.00	1800.00	.00	62.91	7.05	1000.00	.00
*	5.373	8000.00	600.00	597.62	600.00	.00	8000.00	.00	88.99	11.69	1000.00	.00
*	5.373	7000.00	600.00	596.93	600.00	.00	7000.00	.00	85.83	11.21	1000.00	.00
*	5.373	6000.00	600.00	596.32	600.00	.00	6000.00	.00	83.02	10.47	1000.00	.00
*	5.373	5000.00	600.00	595.38	600.00	.00	5000.00	.00	78.69	10.05	1000.00	.00
*	5.373	4000.00	600.00	594.44	600.00	.00	4000.00	.00	74.35	9.40	1000.00	.00
*	5.373	3000.00	600.00	593.43	600.00	.00	3000.00	.00	69.71	8.50	1000.00	.00
	5.373	2000.00	600.00	592.25	600.00	.00	2000.00	.00	64.21	7.32	1000.00	.00

SECNO	Q	XLBEL	CWSEL	RBEL	QLOB	QCH	QROB	TOPWID	VCH	XLCH	ELTRD

5.524	7300.00	608.00	604.34	608.00	.00	7300.00	.00	85.82	9.80	796.00	.00
5.524	4000.00	608.00	601.18	608.00	.00	4000.00	.00	73.56	8.12	796.00	.00
5.524	2400.00	608.00	599.05	608.00	.00	2400.00	.00	65.33	6.95	796.00	.00
5.524	1800.00	608.00	598.09	608.00	.00	1800.00	.00	61.58	6.34	796.00	.00
5.524	8000.00	608.00	604.90	608.00	.00	8000.00	.00	87.99	10.08	796.00	.00
5.524	7000.00	608.00	604.09	608.00	.00	7000.00	.00	84.86	9.67	796.00	.00
5.524	6000.00	608.00	603.16	608.00	.00	6000.00	.00	81.26	9.28	796.00	.00
5.524	5000.00	608.00	602.24	608.00	.00	5000.00	.00	77.69	8.72	796.00	.00
5.524	4000.00	608.00	601.18	608.00	.00	4000.00	.00	73.56	8.12	796.00	.00
5.524	3000.00	608.00	599.93	608.00	.00	3000.00	.00	68.71	7.43	796.00	.00
5.524	2000.00	608.00	598.43	608.00	.00	2000.00	.00	62.89	6.56	796.00	.00
5.525	7300.00	608.00	604.77	603.00	.00	7297.99	2.01	94.96	8.61	10.00	.00
5.525	4000.00	608.00	601.45	603.00	.00	4000.00	.00	83.08	7.29	10.00	.00
5.525	2400.00	608.00	599.25	603.00	.00	2400.00	.00	72.33	6.36	10.00	.00
5.525	1800.00	608.00	598.25	603.00	.00	1800.00	.00	67.45	5.85	10.00	.00
5.525	8000.00	608.00	605.35	603.00	.00	7997.21	2.79	96.04	8.87	10.00	.00
5.525	7000.00	608.00	604.50	603.00	.00	6998.33	1.66	94.45	8.51	10.00	.00
5.525	6000.00	608.00	603.54	603.00	.00	5999.50	.50	92.64	8.18	10.00	.00
5.525	5000.00	608.00	602.57	603.00	.00	5000.00	.00	88.56	7.75	10.00	.00
5.525	4000.00	608.00	601.45	603.00	.00	4000.00	.00	83.08	7.29	10.00	.00
5.525	3000.00	608.00	600.15	603.00	.00	3000.00	.00	76.74	6.74	10.00	.00
5.525	2000.00	608.00	598.60	603.00	.00	2000.00	.00	69.16	6.03	10.00	.00
5.749	7300.00	611.20	611.80	612.50	104.03	7195.97	.00	469.42	10.50	1177.00	.00
5.749	4000.00	611.20	608.94	612.50	.00	4000.00	.00	75.16	8.91	1177.00	.00
5.749	2400.00	611.20	607.05	612.50	.00	2400.00	.00	67.69	7.65	1177.00	.00
5.749	1800.00	611.20	606.18	612.50	.00	1800.00	.00	64.38	7.01	1177.00	.00
* 5.749	8000.00	611.20	612.53	612.50	736.50	6990.94	272.55	700.00	9.34	1177.00	.00
5.749	7000.00	611.20	611.60	612.50	35.09	6964.90	.00	340.54	10.44	1177.00	.00
5.749	6000.00	611.20	610.87	612.50	.00	6000.00	.00	84.81	9.95	1177.00	.00
5.749	5000.00	611.20	609.97	612.50	.00	5000.00	.00	80.33	9.45	1177.00	.00
5.749	4000.00	611.20	608.94	612.50	.00	4000.00	.00	75.16	8.91	1177.00	.00
5.749	3000.00	611.20	607.80	612.50	.00	3000.00	.00	70.62	8.20	1177.00	.00
5.749	2000.00	611.20	606.48	612.50	.00	2000.00	.00	65.53	7.24	1177.00	.00
5.756	7300.00	620.00	612.17	612.40	.00	7300.00	.00	89.42	10.43	42.00	.00
5.756	4000.00	620.00	609.34	612.40	.00	4000.00	.00	89.02	8.94	42.00	.00
5.756	2400.00	620.00	607.39	612.40	.00	2400.00	.00	78.99	8.48	42.00	.00
* 5.756	1800.00	620.00	606.50	612.40	.00	1800.00	.00	74.40	8.40	42.00	.00
5.756	8000.00	620.00	612.32	612.40	.00	8000.00	.00	89.43	11.21	42.00	.00
5.756	7000.00	620.00	612.07	612.40	.00	7000.00	.00	89.41	10.13	42.00	.00
5.756	6000.00	620.00	611.36	612.40	.00	6000.00	.00	89.38	9.57	42.00	.00
5.756	5000.00	620.00	610.43	612.40	.00	5000.00	.00	89.34	9.19	42.00	.00
5.756	4000.00	620.00	609.34	612.40	.00	4000.00	.00	89.02	8.94	42.00	.00
5.756	3000.00	620.00	608.17	612.40	.00	3000.00	.00	82.98	8.67	42.00	.00
5.756	2000.00	620.00	606.81	612.40	.00	2000.00	.00	76.02	8.41	42.00	.00

SECNO	Q	XLBEL	CWSEL	RBEL	QLOB	QCH	QROB	TOPWID	VCH	XLCH	ELTRD
5.796	7300.00	620.00	613.65	612.40	.00	7300.00	.00	89.44	9.38	208.00	617.20
5.796	4000.00	620.00	609.48	612.40	.00	4000.00	.00	89.30	9.87	208.00	617.20
5.796	2400.00	620.00	607.55	612.40	.00	2400.00	.00	79.79	9.96	208.00	617.20
5.796	1800.00	620.00	606.68	612.40	.00	1800.00	.00	75.35	10.36	208.00	617.20
5.796	8000.00	620.00	614.33	612.40	.00	8000.00	.00	89.45	9.54	208.00	617.20
5.796	7000.00	620.00	612.23	612.40	.00	7000.00	.00	89.42	10.76	208.00	617.20
5.796	6000.00	620.00	611.50	612.40	.00	6000.00	.00	89.39	10.25	208.00	617.20
5.796	5000.00	620.00	610.57	612.40	.00	5000.00	.00	89.35	9.96	208.00	617.20
5.796	4000.00	620.00	609.48	612.40	.00	4000.00	.00	89.30	9.87	208.00	617.20
5.796	3000.00	620.00	608.32	612.40	.00	3000.00	.00	83.75	9.87	208.00	617.20
5.796	2000.00	620.00	606.98	612.40	.00	2000.00	.00	76.88	10.18	208.00	617.20
5.805	7300.00	613.70	613.63	611.20	.00	7120.35	179.65	140.76	11.38	50.00	.00
5.805	4000.00	613.70	609.94	611.20	.00	4000.00	.00	69.50	11.50	50.00	.00
* 5.805	2400.00	613.70	608.84	611.20	.00	2400.00	.00	65.31	8.76	50.00	.00
* 5.805	1800.00	613.70	608.52	611.20	.00	1800.00	.00	64.03	7.13	50.00	.00
5.805	8000.00	613.70	614.37	611.20	3.44	7659.34	337.22	170.06	11.18	50.00	.00
5.805	7000.00	613.70	612.10	611.20	.00	6982.75	17.25	98.94	13.80	50.00	.00
5.805	6000.00	613.70	611.46	611.20	.00	5999.35	.65	81.52	13.10	50.00	.00
5.805	5000.00	613.70	610.71	611.20	.00	5000.00	.00	72.43	12.44	50.00	.00
5.805	4000.00	613.70	609.94	611.20	.00	4000.00	.00	69.50	11.50	50.00	.00
5.805	3000.00	613.70	609.17	611.20	.00	3000.00	.00	66.52	10.17	50.00	.00
* 5.805	2000.00	613.70	608.63	611.20	.00	2000.00	.00	64.48	7.69	50.00	.00
6.012	7300.00	623.60	623.91	621.10	.42	7058.77	240.82	155.03	10.77	1093.00	.00
* 6.012	4000.00	623.60	621.94	621.10	.00	3991.69	8.31	97.29	7.96	1093.00	.00
6.012	2400.00	623.60	619.72	621.10	.00	2400.00	.00	69.02	7.08	1093.00	.00
6.012	1800.00	623.60	618.55	621.10	.00	1800.00	.00	64.54	6.89	1093.00	.00
6.012	8000.00	623.60	624.09	621.10	1.50	7699.52	298.98	162.39	11.49	1093.00	.00
* 6.012	7000.00	623.60	624.49	621.10	5.96	6659.39	334.65	178.76	9.49	1093.00	.00

*	6.012	6000.00	623.60	623.77	621.10	.07	5821.10	178.83	149.46	9.03	1093.00	.00
*	6.012	5000.00	623.60	622.94	621.10	.00	4933.39	66.61	124.60	8.52	1093.00	.00
*	6.012	4000.00	623.60	621.94	621.10	.00	3991.69	8.31	97.29	7.96	1093.00	.00
*	6.012	3000.00	623.60	620.72	621.10	.00	3000.00	.00	72.87	7.31	1093.00	.00
	6.012	2000.00	623.60	618.97	621.10	.00	2000.00	.00	66.12	6.95	1093.00	.00
	6.022	7300.00	623.30	624.10	623.30	.99	7298.01	1.00	75.00	11.82	52.00	.00
	6.022	4000.00	623.30	622.21	623.30	.00	4000.00	.00	70.60	8.33	52.00	.00
	6.022	2400.00	623.30	620.08	623.30	.00	2400.00	.00	65.92	7.17	52.00	.00
	6.022	1800.00	623.30	619.02	623.30	.00	1800.00	.00	63.64	6.74	52.00	.00
	6.022	8000.00	623.30	624.26	623.30	1.36	7997.26	1.37	75.00	12.70	52.00	.00
	6.022	7000.00	623.30	624.52	623.30	1.56	6996.88	1.56	75.00	10.79	52.00	.00
	6.022	6000.00	623.30	623.91	623.30	.59	5998.82	.59	75.00	9.93	52.00	.00
	6.022	5000.00	623.30	623.16	623.30	.00	5000.00	.00	72.71	9.10	52.00	.00
	6.022	4000.00	623.30	622.21	623.30	.00	4000.00	.00	70.60	8.33	52.00	.00
	6.022	3000.00	623.30	621.03	623.30	.00	3000.00	.00	68.02	7.52	52.00	.00
	6.022	2000.00	623.30	619.39	623.30	.00	2000.00	.00	64.43	6.89	52.00	.00

	SECNO	Q	XLBEL	CWSEL	RBEL	QLOB	QCH	QROB	TOPWID	VCH	XLCH	ELTRD
	6.036	7300.00	624.60	626.92	624.60	2.98	7294.04	2.98	75.00	10.01	73.00	629.80
	6.036	4000.00	624.60	622.56	624.60	.00	4000.00	.00	68.53	9.64	73.00	629.80
	6.036	2400.00	624.60	620.52	624.60	.00	2400.00	.00	64.05	8.60	73.00	629.80
	6.036	1800.00	624.60	619.57	624.60	.00	1800.00	.00	61.98	8.19	73.00	629.80
*	6.036	8000.00	624.60	628.00	624.60	4.32	7991.37	4.31	75.00	9.90	73.00	629.80
	6.036	7000.00	624.60	627.18	624.60	3.11	6993.77	3.11	75.00	9.35	73.00	629.80
	6.036	6000.00	624.60	625.41	624.60	.83	5998.33	.84	75.00	9.70	73.00	629.80
	6.036	5000.00	624.60	623.51	624.60	.00	5000.00	.00	70.62	10.39	73.00	629.80
	6.036	4000.00	624.60	622.56	624.60	.00	4000.00	.00	68.53	9.64	73.00	629.80
	6.036	3000.00	624.60	621.39	624.60	.00	3000.00	.00	65.98	8.92	73.00	629.80
	6.036	2000.00	624.60	619.89	624.60	.00	2000.00	.00	62.69	8.34	73.00	629.80
	6.049	7300.00	625.60	627.21	625.60	2.15	7295.69	2.16	75.00	10.78	70.00	.00
	6.049	4000.00	625.60	623.24	625.60	.00	4000.00	.00	67.83	10.18	70.00	.00
	6.049	2400.00	625.60	621.39	625.60	.00	2400.00	.00	63.78	8.85	70.00	.00
	6.049	1800.00	625.60	620.62	625.60	.00	1800.00	.00	62.07	8.10	70.00	.00
	6.049	8000.00	625.60	628.23	625.60	3.61	7992.78	3.61	75.00	10.64	70.00	.00
	6.049	7000.00	625.60	627.42	625.60	2.32	6995.37	2.32	75.00	10.11	70.00	.00
	6.049	6000.00	625.60	625.79	625.60	.10	5999.79	.11	75.00	10.48	70.00	.00
	6.049	5000.00	625.60	624.18	625.60	.00	5000.00	.00	69.89	10.92	70.00	.00
	6.049	4000.00	625.60	623.24	625.60	.00	4000.00	.00	67.83	10.18	70.00	.00
	6.049	3000.00	625.60	622.14	625.60	.00	3000.00	.00	65.43	9.38	70.00	.00
	6.049	2000.00	625.60	620.87	625.60	.00	2000.00	.00	62.65	8.39	70.00	.00
*	6.052	7300.00	627.00	627.56	626.30	.88	7168.43	130.69	96.49	14.06	15.00	.00
*	6.052	4000.00	627.00	624.89	626.30	.00	4000.00	.00	67.05	12.47	15.00	.00
*	6.052	2400.00	627.00	623.51	626.30	.00	2400.00	.00	67.00	10.53	15.00	.00
*	6.052	1800.00	627.00	622.91	626.30	.00	1800.00	.00	66.99	9.56	15.00	.00
*	6.052	8000.00	627.00	627.96	626.30	1.85	7810.75	187.40	97.76	14.46	15.00	.00
*	6.052	7000.00	627.00	627.37	626.30	.48	6892.00	107.52	95.90	13.91	15.00	.00
*	6.052	6000.00	627.00	626.74	626.30	.00	5955.72	44.27	92.92	13.29	15.00	.00
*	6.052	5000.00	627.00	625.66	626.30	.00	5000.00	.00	67.07	13.43	15.00	.00
*	6.052	4000.00	627.00	624.89	626.30	.00	4000.00	.00	67.05	12.47	15.00	.00
*	6.052	3000.00	627.00	624.05	626.30	.00	3000.00	.00	67.02	11.34	15.00	.00
*	6.052	2000.00	627.00	623.12	626.30	.00	2000.00	.00	66.99	9.91	15.00	.00
*	6.071	7300.00	626.00	631.03	628.00	2679.93	4555.61	64.46	300.00	6.56	100.00	.00
*	6.071	4000.00	626.00	628.08	628.00	794.30	3205.41	.28	259.88	7.47	100.00	.00
	6.071	2400.00	626.00	626.22	628.00	4.54	2395.46	.00	144.47	8.74	100.00	.00
	6.071	1800.00	626.00	625.58	628.00	.00	1800.00	.00	75.10	8.03	100.00	.00
*	6.071	8000.00	626.00	631.57	628.00	3085.86	4835.92	78.22	300.00	6.51	100.00	.00
*	6.071	7000.00	626.00	630.80	628.00	2506.59	4434.95	58.46	300.00	6.58	100.00	.00
*	6.071	6000.00	626.00	629.97	628.00	1930.96	4031.13	37.90	300.00	6.71	100.00	.00
*	6.071	5000.00	626.00	629.11	628.00	1374.22	3608.70	17.08	266.29	6.92	100.00	.00
*	6.071	4000.00	626.00	628.08	628.00	794.30	3205.41	.28	259.88	7.47	100.00	.00
*	6.071	3000.00	626.00	626.89	628.00	174.98	2825.02	.00	233.18	8.63	100.00	.00
	6.071	2000.00	626.00	625.80	628.00	.00	2000.00	.00	76.74	8.29	100.00	.00

	SECNO	Q	XLBEL	CWSEL	RBEL	QLOB	QCH	QROB	TOPWID	VCH	XLCH	ELTRD
*	6.393	7800.00	641.60	643.95	642.00	5.44	7626.62	167.94	111.00	13.67	1702.00	.00
	6.393	4200.00	641.60	642.98	642.00	2.04	4158.24	39.72	111.00	8.84	1702.00	.00
*	6.393	2600.00	641.60	642.36	642.00	.71	2593.34	5.95	111.00	6.25	1702.00	.00
*	6.393	1800.00	641.60	641.49	642.00	.00	1800.00	.00	87.61	5.35	1702.00	.00
*	6.393	8000.00	641.60	644.04	642.00	5.69	7813.69	180.61	111.00	13.80	1702.00	.00
*	6.393	7000.00	641.60	643.54	642.00	4.36	6879.52	116.12	111.00	13.20	1702.00	.00

*	6.393	6000.00	641.60	643.02	642.00	2.98	5937.17	59.85	111.00	12.53	1702.00	.00
*	6.393	5000.00	641.60	642.79	642.00	2.15	4962.05	35.81	111.00	10.94	1702.00	.00
	6.393	4000.00	641.60	642.86	642.00	1.80	3966.43	31.77	111.00	8.64	1702.00	.00
*	6.393	3000.00	641.60	642.62	642.00	1.12	2983.38	15.50	111.00	6.80	1702.00	.00
*	6.393	2000.00	641.60	641.76	642.00	.07	1999.93	.00	90.21	5.54	1702.00	.00
*	6.441	7800.00	642.00	648.22	644.00	9.68	7784.03	6.29	112.00	9.30	250.00	.00
	6.441	4200.00	642.00	645.53	644.00	5.71	4192.19	2.10	112.00	7.73	250.00	.00
	6.441	2600.00	642.00	644.14	644.00	3.41	2596.52	.08	112.00	6.66	250.00	.00
	6.441	1800.00	642.00	643.23	644.00	1.79	1798.21	.00	102.20	6.13	250.00	.00
*	6.441	8000.00	642.00	648.33	644.00	9.88	7983.64	6.49	112.00	9.39	250.00	.00
*	6.441	7000.00	642.00	647.75	644.00	8.86	6985.65	5.49	112.00	8.89	250.00	.00
*	6.441	6000.00	642.00	647.12	644.00	7.79	5987.77	4.44	112.00	8.35	250.00	.00
*	6.441	5000.00	642.00	646.30	644.00	6.68	4990.08	3.23	112.00	7.96	250.00	.00
	6.441	4000.00	642.00	645.37	644.00	5.45	3992.71	1.84	112.00	7.60	250.00	.00
	6.441	3000.00	642.00	644.50	644.00	4.03	2995.48	.49	112.00	6.99	250.00	.00
	6.441	2000.00	642.00	643.49	644.00	2.24	1997.76	.00	105.13	6.25	250.00	.00
	6.456	7800.00	647.50	648.01	647.50	.59	7724.50	74.91	101.00	13.10	80.00	.00
	6.456	4200.00	647.50	645.92	647.50	.00	4200.00	.00	59.95	9.05	80.00	.00
	6.456	2600.00	647.50	644.67	647.50	.00	2600.00	.00	59.92	6.68	80.00	.00
*	6.456	1800.00	647.50	643.86	647.50	.00	1800.00	.00	59.89	5.28	80.00	.00
	6.456	8000.00	647.50	648.10	647.50	.75	7910.63	88.62	101.00	13.30	80.00	.00
	6.456	7000.00	647.50	647.65	647.50	.10	6968.98	30.92	101.00	12.26	80.00	.00
	6.456	6000.00	647.50	647.16	647.50	.00	6000.00	.00	59.99	11.13	80.00	.00
	6.456	5000.00	647.50	646.52	647.50	.00	5000.00	.00	59.97	9.98	80.00	.00
	6.456	4000.00	647.50	645.78	647.50	.00	4000.00	.00	59.95	8.77	80.00	.00
	6.456	3000.00	647.50	645.01	647.50	.00	3000.00	.00	59.93	7.32	80.00	.00
*	6.456	2000.00	647.50	644.09	647.50	.00	2000.00	.00	59.90	5.64	80.00	.00
	6.460	7800.00	647.50	648.01	647.50	.60	7724.26	75.14	101.00	13.10	20.00	650.00
	6.460	4200.00	647.50	646.14	647.50	.00	4200.00	.00	59.96	8.80	20.00	650.00
	6.460	2600.00	647.50	644.80	647.50	.00	2600.00	.00	59.92	6.55	20.00	650.00
	6.460	1800.00	647.50	643.94	647.50	.00	1800.00	.00	59.89	5.21	20.00	650.00
	6.460	8000.00	647.50	648.10	647.50	.76	7910.32	88.92	101.00	13.29	20.00	650.00
	6.460	7000.00	647.50	647.66	647.50	.10	6968.91	30.98	101.00	12.26	20.00	650.00
	6.460	6000.00	647.50	647.88	647.50	.31	5953.84	45.85	101.00	10.23	20.00	650.00
	6.460	5000.00	647.50	646.63	647.50	.00	5000.00	.00	59.97	9.86	20.00	650.00
	6.460	4000.00	647.50	645.99	647.50	.00	4000.00	.00	59.96	8.54	20.00	650.00
	6.460	3000.00	647.50	645.16	647.50	.00	3000.00	.00	59.93	7.17	20.00	650.00
	6.460	2000.00	647.50	644.18	647.50	.00	2000.00	.00	59.90	5.55	20.00	650.00

	SECNO	Q	XLBEL	CWSEL	RBEL	QLOB	QCH	QROB	TOPWID	VCH	XLCH	ELTRD
*	6.479	7800.00	645.50	650.85	645.50	276.40	7404.20	119.40	200.00	5.41	100.00	.00
	6.479	4200.00	645.50	647.53	645.50	83.68	4078.92	37.40	200.00	5.07	100.00	.00
	6.479	2600.00	645.50	645.65	645.50	2.94	2596.31	.75	200.00	5.37	100.00	.00
*	6.479	1800.00	645.50	644.36	645.50	.00	1800.00	.00	91.17	5.76	100.00	.00
*	6.479	8000.00	645.50	651.01	645.50	286.69	7589.73	123.58	200.00	5.43	100.00	.00
*	6.479	7000.00	645.50	650.18	645.50	234.89	6662.73	102.37	200.00	5.31	100.00	.00
*	6.479	6000.00	645.50	649.62	645.50	189.67	5727.05	83.28	200.00	4.94	100.00	.00
*	6.479	5000.00	645.50	648.33	645.50	127.28	4816.02	56.70	200.00	5.12	100.00	.00
	6.479	4000.00	645.50	647.31	645.50	72.59	3895.00	32.41	200.00	5.07	100.00	.00
	6.479	3000.00	645.50	646.15	645.50	18.93	2973.24	7.83	200.00	5.22	100.00	.00
*	6.479	2000.00	645.50	644.70	645.50	.00	2000.00	.00	111.56	5.77	100.00	.00
*	6.702	7800.00	658.20	656.78	657.80	.00	7800.00	.00	96.10	13.82	1180.00	.00
*	6.702	4200.00	658.20	654.93	657.80	.00	4200.00	.00	89.55	10.69	1180.00	.00
	6.702	2600.00	658.20	654.83	657.80	.00	2600.00	.00	89.19	6.78	1180.00	.00
	6.702	1800.00	658.20	653.77	657.80	.00	1800.00	.00	85.44	6.18	1180.00	.00
*	6.702	8000.00	658.20	656.88	657.80	.00	8000.00	.00	96.45	13.94	1180.00	.00
*	6.702	7000.00	658.20	656.35	657.80	.00	7000.00	.00	94.56	13.38	1180.00	.00
*	6.702	6000.00	658.20	655.75	657.80	.00	6000.00	.00	92.43	12.85	1180.00	.00
*	6.702	5000.00	658.20	655.15	657.80	.00	5000.00	.00	90.31	12.13	1180.00	.00
*	6.702	4000.00	658.20	654.94	657.80	.00	4000.00	.00	89.56	10.18	1180.00	.00
	6.702	3000.00	658.20	654.90	657.80	.00	3000.00	.00	89.43	7.70	1180.00	.00
	6.702	2000.00	658.20	654.16	657.80	.00	2000.00	.00	86.81	6.16	1180.00	.00
*	7.434	7800.00	691.50	695.10	691.50	4.74	7564.75	230.50	101.00	9.59	3865.00	.00
*	7.434	4200.00	691.50	692.05	691.50	.43	4189.67	9.90	101.00	7.69	3865.00	.00
	7.434	2600.00	691.50	688.96	691.50	.00	2600.00	.00	67.47	8.24	3865.00	.00
	7.434	1800.00	691.50	688.12	691.50	.00	1800.00	.00	66.04	6.93	3865.00	.00
*	7.434	8000.00	691.50	695.24	691.50	4.96	7749.88	245.16	101.00	9.68	3865.00	.00
*	7.434	7000.00	691.50	694.53	691.50	3.87	6821.66	174.47	101.00	9.17	3865.00	.00
*	7.434	6000.00	691.50	693.79	691.50	2.76	5887.01	110.23	101.00	8.60	3865.00	.00
*	7.434	5000.00	691.50	692.97	691.50	1.59	4945.75	52.66	101.00	7.99	3865.00	.00
*	7.434	4000.00	691.50	691.76	691.50	.14	3997.44	2.41	101.00	7.66	3865.00	.00
	7.434	3000.00	691.50	689.80	691.50	.00	3000.00	.00	70.17	8.03	3865.00	.00
	7.434	2000.00	691.50	688.22	691.50	.00	2000.00	.00	66.22	7.50	3865.00	.00

SECNO	Q	XLBEL	CWSEL	RBEL	QLOB	QCH	QROB	TOPWID	VCH	XLCH	ELTRD
7.445	7800.00	694.50	694.87	694.50	1.85	7783.22	14.93	185.09	12.16	57.00	.00
7.445	4200.00	694.50	692.22	694.50	.00	4200.00	.00	59.95	8.73	57.00	.00
7.445	2600.00	694.50	689.56	694.50	.00	2600.00	.00	59.89	8.08	57.00	.00
7.445	1800.00	694.50	688.65	694.50	.00	1800.00	.00	59.87	6.74	57.00	.00
7.445	8000.00	694.50	695.01	694.50	4.15	7962.39	33.46	229.17	12.28	57.00	.00
7.445	7000.00	694.50	694.40	694.50	.00	7000.00	.00	60.00	11.45	57.00	.00
7.445	6000.00	694.50	693.76	694.50	.00	6000.00	.00	59.98	10.47	57.00	.00
7.445	5000.00	694.50	693.05	694.50	.00	5000.00	.00	59.97	9.42	57.00	.00
7.445	4000.00	694.50	691.96	694.50	.00	4000.00	.00	59.94	8.59	57.00	.00
7.445	3000.00	694.50	690.24	694.50	.00	3000.00	.00	59.91	8.28	57.00	.00
7.445	2000.00	694.50	688.85	694.50	.00	2000.00	.00	59.87	7.17	57.00	.00

SECNO	Q	XLBEL	CWSEL	RBEL	QLOB	QCH	QROB	TOPWID	VCH	XLCH	ELTRD
* 7.453	7800.00	694.50	698.73	694.50	16.40	4765.97	3017.63	509.56	5.79	43.00	699.20
7.453	4200.00	694.50	692.42	694.50	.00	4200.00	.00	59.85	9.45	43.00	699.20
7.453	2600.00	694.50	689.88	694.50	.00	2600.00	.00	59.79	8.90	43.00	699.20
7.453	1800.00	694.50	688.93	694.50	.00	1800.00	.00	59.77	7.63	43.00	699.20
* 7.453	8000.00	694.50	697.70	694.50	10.62	5696.90	2292.48	508.03	7.48	43.00	699.20
* 7.453	7000.00	694.50	697.05	694.50	6.14	5539.55	1454.31	507.07	7.67	43.00	699.20
7.453	6000.00	694.50	694.01	694.50	.00	6000.00	.00	59.90	11.11	43.00	699.20
7.453	5000.00	694.50	693.25	694.50	.00	5000.00	.00	59.87	10.12	43.00	699.20
7.453	4000.00	694.50	692.16	694.50	.00	4000.00	.00	59.85	9.32	43.00	699.20
7.453	3000.00	694.50	690.52	694.50	.00	3000.00	.00	59.81	9.08	43.00	699.20
7.453	2000.00	694.50	689.15	694.50	.00	2000.00	.00	59.77	8.04	43.00	699.20
* 7.463	7800.00	699.00	698.56	698.00	.00	6739.58	1060.42	499.05	7.46	50.00	.00
7.463	4200.00	699.00	692.77	698.00	.00	4200.00	.00	70.01	10.26	50.00	.00
7.463	2600.00	699.00	690.37	698.00	.00	2600.00	.00	57.13	9.97	50.00	.00
7.463	1800.00	699.00	689.43	698.00	.00	1800.00	.00	55.29	8.65	50.00	.00
* 7.463	8000.00	699.00	698.25	698.00	.00	7179.35	820.65	498.37	8.22	50.00	.00
7.463	7000.00	699.00	696.82	698.00	.00	7000.00	.00	90.05	9.43	50.00	.00
7.463	6000.00	699.00	694.67	698.00	.00	6000.00	.00	83.07	10.81	50.00	.00
7.463	5000.00	699.00	693.70	698.00	.00	5000.00	.00	76.94	10.47	50.00	.00
7.463	4000.00	699.00	692.50	698.00	.00	4000.00	.00	67.99	10.23	50.00	.00
7.463	3000.00	699.00	690.93	698.00	.00	3000.00	.00	58.22	10.25	50.00	.00
7.463	2000.00	699.00	689.66	698.00	.00	2000.00	.00	55.76	9.04	50.00	.00
* 8.227	8300.00	729.00	730.05	729.00	2.21	8295.57	2.21	122.00	13.15	4035.00	.00
* 8.227	4400.00	729.00	729.89	729.00	1.00	4398.00	1.00	122.00	7.19	4035.00	.00
* 8.227	2800.00	729.00	728.78	729.00	.00	2800.00	.00	118.28	5.84	4035.00	.00
* 8.227	1800.00	729.00	727.70	729.00	.00	1800.00	.00	109.66	5.06	4035.00	.00
* 8.227	8000.00	729.00	730.07	729.00	2.18	7995.63	2.18	122.00	12.61	4035.00	.00
8.227	7000.00	729.00	730.66	729.00	2.75	6994.51	2.74	122.00	9.94	4035.00	.00
8.227	6000.00	729.00	730.92	729.00	2.61	5994.77	2.61	122.00	8.15	4035.00	.00
8.227	5000.00	729.00	730.31	729.00	1.62	4996.76	1.62	122.00	7.55	4035.00	.00
8.227	4000.00	729.00	729.64	729.00	.65	3998.70	.65	122.00	6.87	4035.00	.00
* 8.227	3000.00	729.00	728.98	729.00	.00	3000.00	.00	119.87	5.96	4035.00	.00
* 8.227	2000.00	729.00	727.96	729.00	.00	2000.00	.00	111.67	5.21	4035.00	.00
* 8.619	8300.00	748.30	748.31	748.90	5609.64	2690.36	.00	1065.70	4.17	2070.00	.00
8.619	4400.00	748.30	746.25	748.90	.00	4400.00	.00	76.35	9.37	2070.00	.00
8.619	2800.00	748.30	744.54	748.90	.00	2800.00	.00	71.96	8.16	2070.00	.00
8.619	1800.00	748.30	743.36	748.90	.00	1800.00	.00	68.95	6.91	2070.00	.00
* 8.619	8000.00	748.30	748.30	748.90	5403.36	2596.64	.00	1065.55	4.03	2070.00	.00
* 8.619	7000.00	748.30	747.74	748.90	.00	7000.00	.00	90.39	11.85	2070.00	.00
8.619	6000.00	748.30	747.81	748.90	.00	6000.00	.00	91.45	10.05	2070.00	.00
8.619	5000.00	748.30	746.74	748.90	.00	5000.00	.00	77.61	9.85	2070.00	.00
8.619	4000.00	748.30	745.84	748.90	.00	4000.00	.00	75.32	9.11	2070.00	.00
8.619	3000.00	748.30	744.74	748.90	.00	3000.00	.00	72.48	8.39	2070.00	.00
8.619	2000.00	748.30	743.60	748.90	.00	2000.00	.00	69.56	7.23	2070.00	.00

SECNO	Q	XLBEL	CWSEL	RBEL	QLOB	QCH	QROB	TOPWID	VCH	XLCH	ELTRD
* 8.632	8300.00	755.50	749.15	755.50	.00	8300.00	.00	83.85	14.84	68.00	.00
* 8.632	4400.00	755.50	746.77	755.50	.00	4400.00	.00	80.05	12.18	68.00	.00
* 8.632	2800.00	755.50	745.40	755.50	.00	2800.00	.00	70.70	10.91	68.00	.00
* 8.632	1800.00	755.50	744.16	755.50	.00	1800.00	.00	56.65	10.12	68.00	.00
* 8.632	8000.00	755.50	748.99	755.50	.00	8000.00	.00	83.85	14.67	68.00	.00
* 8.632	7000.00	755.50	748.43	755.50	.00	7000.00	.00	83.83	14.04	68.00	.00
8.632	6000.00	755.50	748.08	755.50	.00	6000.00	.00	83.82	12.77	68.00	.00
* 8.632	5000.00	755.50	747.19	755.50	.00	5000.00	.00	81.44	12.65	68.00	.00
* 8.632	4000.00	755.50	746.46	755.50	.00	4000.00	.00	79.01	11.88	68.00	.00
* 8.632	3000.00	755.50	745.62	755.50	.00	3000.00	.00	73.18	11.02	68.00	.00
* 8.632	2000.00	755.50	744.45	755.50	.00	2000.00	.00	59.83	10.30	68.00	.00

*	8.647	8300.00	755.50	751.39	755.50	.00	8300.00	.00	83.90	10.43	82.00	755.50
*	8.647	4400.00	755.50	749.14	755.50	.00	4400.00	.00	83.85	7.26	82.00	755.50
*	8.647	2800.00	755.50	747.52	755.50	.00	2800.00	.00	82.59	5.95	82.00	755.50
*	8.647	1800.00	755.50	746.14	755.50	.00	1800.00	.00	78.10	5.00	82.00	755.50
	8.647	8000.00	755.50	752.33	755.50	.00	8000.00	.00	83.93	11.24	82.00	755.50
	8.647	7000.00	755.50	751.74	755.50	.00	7000.00	.00	83.91	9.83	82.00	755.50
	8.647	6000.00	755.50	750.93	755.50	.00	6000.00	.00	83.89	8.43	82.00	755.50
*	8.647	5000.00	755.50	749.67	755.50	.00	5000.00	.00	83.86	7.69	82.00	755.50
*	8.647	4000.00	755.50	748.77	755.50	.00	4000.00	.00	83.84	6.95	82.00	755.50
*	8.647	3000.00	755.50	747.75	755.50	.00	3000.00	.00	83.33	6.12	82.00	755.50
*	8.647	2000.00	755.50	746.46	755.50	.00	2000.00	.00	79.12	5.20	82.00	755.50
*	8.657	8300.00	752.40	751.44	753.00	.00	8300.00	.00	77.92	15.09	50.00	.00
*	8.657	4400.00	752.40	748.74	753.00	.00	4400.00	.00	71.51	12.65	50.00	.00
*	8.657	2800.00	752.40	747.39	753.00	.00	2800.00	.00	68.31	11.04	50.00	.00
*	8.657	1800.00	752.40	746.38	753.00	.00	1800.00	.00	65.93	9.66	50.00	.00
	8.657	8000.00	752.40	753.08	753.00	.87	7999.12	.00	102.00	11.45	50.00	.00
	8.657	7000.00	752.40	752.04	753.00	.00	7000.00	.00	85.00	11.70	50.00	.00
	8.657	6000.00	752.40	750.83	753.00	.00	6000.00	.00	76.47	11.94	50.00	.00
*	8.657	5000.00	752.40	749.19	753.00	.00	5000.00	.00	72.59	13.13	50.00	.00
*	8.657	4000.00	752.40	748.43	753.00	.00	4000.00	.00	70.79	12.25	50.00	.00
*	8.657	3000.00	752.40	747.57	753.00	.00	3000.00	.00	68.75	11.26	50.00	.00
*	8.657	2000.00	752.40	746.60	753.00	.00	2000.00	.00	66.44	9.97	50.00	.00
*	9.142	8300.00	775.00	775.01	776.00	3137.12	5162.88	.00	699.60	6.63	2560.00	.00
*	9.142	4400.00	775.00	773.57	776.00	.00	4400.00	.00	98.07	6.91	2560.00	.00
*	9.142	2800.00	775.00	771.86	776.00	.00	2800.00	.00	91.44	5.90	2560.00	.00
*	9.142	1800.00	775.00	770.55	776.00	.00	1800.00	.00	86.21	5.02	2560.00	.00
*	9.142	8000.00	775.00	775.03	776.00	3043.90	4956.10	.00	699.61	6.35	2560.00	.00
*	9.142	7000.00	775.00	775.00	776.00	.00	7000.00	.00	99.60	9.00	2560.00	.00
*	9.142	6000.00	775.00	774.43	776.00	.00	6000.00	.00	99.00	8.31	2560.00	.00
*	9.142	5000.00	775.00	774.11	776.00	.00	5000.00	.00	98.64	7.25	2560.00	.00
*	9.142	4000.00	775.00	773.16	776.00	.00	4000.00	.00	96.67	6.69	2560.00	.00
*	9.142	3000.00	775.00	772.09	776.00	.00	3000.00	.00	92.37	6.05	2560.00	.00
*	9.142	2000.00	775.00	770.83	776.00	.00	2000.00	.00	87.34	5.22	2560.00	.00

	SECNO	Q	XLBEL	CWSEL	RBEL	QLOB	QCH	QROB	TOPWID	VCH	XLCH	ELTRD
*	9.150	8300.00	775.00	773.90	776.00	.00	8300.00	.00	98.44	12.39	40.00	.00
	9.150	4400.00	775.00	773.80	776.00	.00	4400.00	.00	98.32	6.67	40.00	.00
	9.150	2800.00	775.00	772.07	776.00	.00	2800.00	.00	92.31	5.66	40.00	.00
	9.150	1800.00	775.00	770.75	776.00	.00	1800.00	.00	87.03	4.78	40.00	.00
*	9.150	8000.00	775.00	774.06	776.00	.00	8000.00	.00	98.60	11.68	40.00	.00
	9.150	7000.00	775.00	775.35	776.00	.22	6999.78	.00	100.74	8.61	40.00	.00
	9.150	6000.00	775.00	774.75	776.00	.00	6000.00	.00	99.33	7.97	40.00	.00
	9.150	5000.00	775.00	774.35	776.00	.00	5000.00	.00	98.91	7.00	40.00	.00
	9.150	4000.00	775.00	773.39	776.00	.00	4000.00	.00	97.59	6.45	40.00	.00
	9.150	3000.00	775.00	772.31	776.00	.00	3000.00	.00	93.26	5.81	40.00	.00
	9.150	2000.00	775.00	771.04	776.00	.00	2000.00	.00	88.18	4.98	40.00	.00
*	9.165	8300.00	775.00	775.50	776.00	.00	8300.00	.00	100.80	13.18	80.00	770.00
*	9.165	4400.00	775.00	774.28	776.00	.00	4400.00	.00	98.83	6.99	80.00	770.00
	9.165	2800.00	775.00	772.43	776.00	.00	2800.00	.00	93.73	5.31	80.00	770.00
	9.165	1800.00	775.00	771.08	776.00	.00	1800.00	.00	88.31	4.45	80.00	770.00
*	9.165	8000.00	775.00	775.40	776.00	.00	8000.00	.00	100.76	12.70	80.00	770.00
*	9.165	7000.00	775.00	775.67	776.00	.00	7000.00	.00	100.87	11.11	80.00	770.00
*	9.165	6000.00	775.00	775.20	776.00	.00	6000.00	.00	100.68	9.53	80.00	770.00
*	9.165	5000.00	775.00	774.78	776.00	.00	5000.00	.00	99.36	7.94	80.00	770.00
*	9.165	4000.00	775.00	773.91	776.00	.00	4000.00	.00	98.43	6.35	80.00	770.00
	9.165	3000.00	775.00	772.67	776.00	.00	3000.00	.00	94.71	5.45	80.00	770.00
	9.165	2000.00	775.00	771.37	776.00	.00	2000.00	.00	89.49	4.65	80.00	770.00
*	9.173	8300.00	775.00	777.72	776.00	2.70	8295.75	1.55	102.00	7.90	40.00	.00
*	9.173	4400.00	775.00	774.73	776.00	.00	4400.00	.00	99.31	5.86	40.00	.00
	9.173	2800.00	775.00	772.58	776.00	.00	2800.00	.00	94.31	5.17	40.00	.00
	9.173	1800.00	775.00	771.21	776.00	.00	1800.00	.00	88.85	4.32	40.00	.00
*	9.173	8000.00	775.00	777.43	776.00	2.38	7996.38	1.24	102.00	7.83	40.00	.00
*	9.173	7000.00	775.00	777.21	776.00	1.93	6997.16	.91	102.00	7.00	40.00	.00
*	9.173	6000.00	775.00	776.24	776.00	.95	5998.95	.10	102.00	6.65	40.00	.00
*	9.173	5000.00	775.00	775.44	776.00	.22	4999.78	.00	100.78	6.08	40.00	.00
*	9.173	4000.00	775.00	774.23	776.00	.00	4000.00	.00	98.78	5.70	40.00	.00
	9.173	3000.00	775.00	772.83	776.00	.00	3000.00	.00	95.29	5.32	40.00	.00
	9.173	2000.00	775.00	771.51	776.00	.00	2000.00	.00	90.04	4.52	40.00	.00
*	9.357	8300.00	786.90	787.58	788.80	1.18	8298.82	.00	66.93	16.01	970.00	.00
*	9.357	4400.00	786.90	784.25	788.80	.00	4400.00	.00	54.69	13.78	970.00	.00
*	9.357	2800.00	786.90	782.54	788.80	.00	2800.00	.00	50.41	12.19	970.00	.00
*	9.357	1800.00	786.90	781.26	788.80	.00	1800.00	.00	47.21	10.76	970.00	.00
*	9.357	8000.00	786.90	787.36	788.80	.69	7999.31	.00	66.20	15.87	970.00	.00
*	9.357	7000.00	786.90	786.59	788.80	.00	7000.00	.00	62.22	15.39	970.00	.00

	SECNO	Q	XLBEL	CWSEL	RBEL	QLOB	QCH	QROB	TOPWID	VCH	XLCH	ELTRD
*	9.357	6000.00	786.90	785.71	788.80	.00	6000.00	.00	58.34	14.93	970.00	.00
*	9.357	5000.00	786.90	784.80	788.80	.00	5000.00	.00	56.08	14.28	970.00	.00
*	9.357	4000.00	786.90	783.85	788.80	.00	4000.00	.00	53.69	13.43	970.00	.00
*	9.357	3000.00	786.90	782.77	788.80	.00	3000.00	.00	51.00	12.42	970.00	.00
*	9.357	2000.00	786.90	781.54	788.80	.00	2000.00	.00	47.90	11.09	970.00	.00

	SECNO	Q	XLBEL	CWSEL	RBEL	QLOB	QCH	QROB	TOPWID	VCH	XLCH	ELTRD
	9.363	8300.00	788.80	789.62	788.80	1.07	8297.80	1.14	70.00	12.82	32.00	.00
*	9.363	4400.00	788.80	786.02	788.80	.00	4400.00	.00	57.49	10.69	32.00	.00
*	9.363	2800.00	788.80	784.14	788.80	.00	2800.00	.00	52.59	9.07	32.00	.00
*	9.363	1800.00	788.80	782.70	788.80	.00	1800.00	.00	49.51	7.65	32.00	.00
	9.363	8000.00	788.80	789.40	788.80	.70	7998.53	.77	70.00	12.64	32.00	.00
	9.363	7000.00	788.80	788.62	788.80	.00	7000.00	.00	67.97	12.08	32.00	.00
	9.363	6000.00	788.80	787.72	788.80	.00	6000.00	.00	67.80	11.58	32.00	.00
*	9.363	5000.00	788.80	786.68	788.80	.00	5000.00	.00	61.50	11.10	32.00	.00
*	9.363	4000.00	788.80	785.58	788.80	.00	4000.00	.00	55.67	10.33	32.00	.00
*	9.363	3000.00	788.80	784.40	788.80	.00	3000.00	.00	53.13	9.31	32.00	.00
*	9.363	2000.00	788.80	783.02	788.80	.00	2000.00	.00	50.19	7.97	32.00	.00
*	9.370	8300.00	788.80	791.67	788.80	3.53	7776.93	519.54	101.00	9.89	37.00	788.80
	9.370	4400.00	788.80	786.72	788.80	.00	4400.00	.00	61.78	9.70	37.00	788.80
	9.370	2800.00	788.80	784.70	788.80	.00	2800.00	.00	53.79	8.26	37.00	788.80
	9.370	1800.00	788.80	783.16	788.80	.00	1800.00	.00	50.51	6.96	37.00	788.80
*	9.370	8000.00	788.80	791.33	788.80	3.10	7531.36	465.54	101.00	9.86	37.00	788.80
	9.370	7000.00	788.80	790.11	788.80	1.49	6713.61	284.90	101.00	9.86	37.00	788.80
	9.370	6000.00	788.80	788.63	788.80	.00	5892.70	107.30	98.45	10.15	37.00	788.80
	9.370	5000.00	788.80	787.43	788.80	.00	5000.00	.00	66.16	10.02	37.00	788.80
	9.370	4000.00	788.80	786.23	788.80	.00	4000.00	.00	58.79	9.43	37.00	788.80
	9.370	3000.00	788.80	784.97	788.80	.00	3000.00	.00	54.37	8.48	37.00	788.80
	9.370	2000.00	788.80	783.50	788.80	.00	2000.00	.00	51.22	7.25	37.00	788.80
	9.380	8300.00	789.60	791.78	789.60	2.85	7853.67	443.48	101.00	10.61	50.00	.00
	9.380	4400.00	789.60	787.03	789.60	.00	4400.00	.00	58.79	10.38	50.00	.00
	9.380	2800.00	789.60	784.99	789.60	.00	2800.00	.00	52.69	8.99	50.00	.00
	9.380	1800.00	789.60	783.44	789.60	.00	1800.00	.00	49.38	7.75	50.00	.00
	9.380	8000.00	789.60	791.45	789.60	2.38	7607.60	390.01	101.00	10.60	50.00	.00
	9.380	7000.00	789.60	790.27	789.60	.68	6784.47	214.85	101.00	10.64	50.00	.00
	9.380	6000.00	789.60	788.83	789.60	.00	6000.00	.00	67.86	11.12	50.00	.00
	9.380	5000.00	789.60	787.75	789.60	.00	5000.00	.00	63.22	10.68	50.00	.00
	9.380	4000.00	789.60	786.53	789.60	.00	4000.00	.00	55.99	10.11	50.00	.00
	9.380	3000.00	789.60	785.26	789.60	.00	3000.00	.00	53.28	9.20	50.00	.00
	9.380	2000.00	789.60	783.77	789.60	.00	2000.00	.00	50.11	8.03	50.00	.00
*	9.528	8300.00	796.60	798.50	796.60	154.41	8091.47	54.12	100.00	14.25	780.00	.00
	9.528	4400.00	796.60	796.40	796.60	.00	4400.00	.00	71.99	10.57	780.00	.00
	9.528	2800.00	796.60	794.75	796.60	.00	2800.00	.00	71.94	9.39	780.00	.00
*	9.528	1800.00	796.60	793.63	796.60	.00	1800.00	.00	71.90	8.27	780.00	.00
*	9.528	8000.00	796.60	798.38	796.60	137.92	7813.72	48.36	100.00	13.96	780.00	.00
*	9.528	7000.00	796.60	798.03	796.60	91.54	6876.44	32.02	100.00	12.87	780.00	.00
	9.528	6000.00	796.60	797.78	796.60	60.29	5918.78	20.93	100.00	11.48	780.00	.00
	9.528	5000.00	796.60	796.97	796.60	9.11	4988.32	2.57	100.00	10.89	780.00	.00
	9.528	4000.00	796.60	795.97	796.60	.00	4000.00	.00	71.98	10.36	780.00	.00
	9.528	3000.00	796.60	794.96	796.60	.00	3000.00	.00	71.95	9.57	780.00	.00
	9.528	2000.00	796.60	793.86	796.60	.00	2000.00	.00	71.91	8.53	780.00	.00

	SECNO	Q	XLBEL	CWSEL	RBEL	QLOB	QCH	QROB	TOPWID	VCH	XLCH	ELTRD
	9.537	8300.00	799.00	800.00	797.90	1.37	8294.84	3.78	92.00	12.39	50.00	.00
	9.537	4400.00	799.00	797.16	797.90	.00	4400.00	.00	83.76	10.53	50.00	.00
	9.537	2800.00	799.00	795.57	797.90	.00	2800.00	.00	74.21	9.57	50.00	.00
	9.537	1800.00	799.00	794.54	797.90	.00	1800.00	.00	67.96	8.23	50.00	.00
	9.537	8000.00	799.00	799.82	797.90	1.02	7995.59	3.39	92.00	12.25	50.00	.00
	9.537	7000.00	799.00	799.16	797.90	.00	6997.98	2.02	92.00	11.79	50.00	.00
	9.537	6000.00	799.00	798.54	797.90	.00	5999.21	.79	90.26	11.14	50.00	.00
	9.537	5000.00	799.00	797.75	797.90	.00	5000.00	.00	87.28	10.69	50.00	.00
	9.537	4000.00	799.00	796.75	797.90	.00	4000.00	.00	81.28	10.42	50.00	.00
	9.537	3000.00	799.00	795.77	797.90	.00	3000.00	.00	75.41	9.76	50.00	.00
	9.537	2000.00	799.00	794.75	797.90	.00	2000.00	.00	69.27	8.56	50.00	.00
	9.611	8300.00	807.40	804.56	807.40	.00	8300.00	.00	78.46	12.19	393.00	.00
*	9.611	4400.00	807.40	801.75	807.40	.00	4400.00	.00	67.06	9.23	393.00	.00
*	9.611	2800.00	807.40	800.03	807.40	.00	2800.00	.00	60.06	7.63	393.00	.00
*	9.611	1800.00	807.40	798.51	807.40	.00	1800.00	.00	53.87	6.42	393.00	.00
	9.611	8000.00	807.40	804.38	807.40	.00	8000.00	.00	77.71	12.01	393.00	.00
	9.611	7000.00	807.40	803.76	807.40	.00	7000.00	.00	75.22	11.30	393.00	.00

	9.611	6000.00	807.40	803.01	807.40	.00	6000.00	.00	72.17	10.64	393.00	.00
	9.611	5000.00	807.40	802.26	807.40	.00	5000.00	.00	69.09	9.79	393.00	.00
*	9.611	4000.00	807.40	801.39	807.40	.00	4000.00	.00	65.58	8.84	393.00	.00
*	9.611	3000.00	807.40	800.28	807.40	.00	3000.00	.00	61.10	7.84	393.00	.00
*	9.611	2000.00	807.40	798.85	807.40	.00	2000.00	.00	55.26	6.69	393.00	.00
*	9.618	8300.00	809.00	804.96	809.00	.00	8300.00	.00	72.49	15.54	35.00	.00
*	9.618	4400.00	809.00	801.80	809.00	.00	4400.00	.00	58.80	13.46	35.00	.00
*	9.618	2800.00	809.00	800.05	809.00	.00	2800.00	.00	51.24	12.13	35.00	.00
*	9.618	1800.00	809.00	798.70	809.00	.00	1800.00	.00	45.35	10.90	35.00	.00
*	9.618	8000.00	809.00	804.75	809.00	.00	8000.00	.00	71.58	15.41	35.00	.00
*	9.618	7000.00	809.00	804.02	809.00	.00	7000.00	.00	68.41	14.96	35.00	.00
*	9.618	6000.00	809.00	803.22	809.00	.00	6000.00	.00	64.97	14.46	35.00	.00
*	9.618	5000.00	809.00	802.36	809.00	.00	5000.00	.00	61.22	13.87	35.00	.00
*	9.618	4000.00	809.00	801.41	809.00	.00	4000.00	.00	57.10	13.15	35.00	.00
*	9.618	3000.00	809.00	800.30	809.00	.00	3000.00	.00	52.28	12.33	35.00	.00
*	9.618	2000.00	809.00	799.00	809.00	.00	2000.00	.00	46.65	11.18	35.00	.00
*	9.620	8300.00	805.50	808.38	805.50	.69	8298.61	.69	91.65	7.43	15.00	809.00
*	9.620	4400.00	805.50	804.38	805.50	.00	4400.00	.00	86.98	6.30	15.00	809.00
*	9.620	2800.00	805.50	802.25	805.50	.00	2800.00	.00	81.22	4.84	15.00	809.00
*	9.620	1800.00	805.50	800.52	805.50	.00	1800.00	.00	76.56	4.08	15.00	809.00
*	9.620	8000.00	805.50	807.89	805.50	.44	7999.13	.44	91.37	7.46	15.00	809.00
	9.620	7000.00	805.50	806.50	805.50	.00	7000.00	.00	90.57	9.82	15.00	809.00
	9.620	6000.00	805.50	805.84	805.50	.00	6000.00	.00	90.19	8.42	15.00	809.00
*	9.620	5000.00	805.50	805.00	805.50	.00	5000.00	.00	88.65	7.04	15.00	809.00
*	9.620	4000.00	805.50	803.92	805.50	.00	4000.00	.00	85.73	5.85	15.00	809.00
*	9.620	3000.00	805.50	802.55	805.50	.00	3000.00	.00	82.04	4.98	15.00	809.00
*	9.620	2000.00	805.50	800.90	805.50	.00	2000.00	.00	77.58	4.25	15.00	809.00

	SECNO	Q	XLBEL	CWSEL	RBEL	QLOB	QCH	QROB	TOPWID	VCH	XLCH	ELTRD
*	9.630	8300.00	810.80	806.76	810.80	.00	8300.00	.00	72.49	15.53	50.00	.00
*	9.630	4400.00	810.80	803.60	810.80	.00	4400.00	.00	58.80	13.46	50.00	.00
*	9.630	2800.00	810.80	801.87	810.80	.00	2800.00	.00	51.30	12.10	50.00	.00
*	9.630	1800.00	810.80	800.51	810.80	.00	1800.00	.00	45.42	10.85	50.00	.00
*	9.630	8000.00	810.80	806.55	810.80	.00	8000.00	.00	71.59	15.41	50.00	.00
	9.630	7000.00	810.80	806.37	810.80	.00	7000.00	.00	70.83	13.82	50.00	.00
	9.630	6000.00	810.80	805.39	810.80	.00	6000.00	.00	66.60	13.65	50.00	.00
*	9.630	5000.00	810.80	804.16	810.80	.00	5000.00	.00	61.24	13.87	50.00	.00
*	9.630	4000.00	810.80	803.20	810.80	.00	4000.00	.00	57.09	13.16	50.00	.00
*	9.630	3000.00	810.80	802.11	810.80	.00	3000.00	.00	52.34	12.30	50.00	.00
*	9.630	2000.00	810.80	800.81	810.80	.00	2000.00	.00	46.70	11.14	50.00	.00
	9.792	8300.00	830.00	824.58	830.00	.00	8300.00	.00	79.84	14.39	853.00	.00
	9.792	4400.00	830.00	821.29	830.00	.00	4400.00	.00	48.83	13.52	853.00	.00
	9.792	2800.00	830.00	819.45	830.00	.00	2800.00	.00	42.90	11.64	853.00	.00
	9.792	1800.00	830.00	817.92	830.00	.00	1800.00	.00	38.02	10.05	853.00	.00
	9.792	8000.00	830.00	824.41	830.00	.00	8000.00	.00	79.84	14.19	853.00	.00
*	9.792	7000.00	830.00	823.41	830.00	.00	7000.00	.00	77.73	14.45	853.00	.00
	9.792	6000.00	830.00	822.87	830.00	.00	6000.00	.00	76.47	13.54	853.00	.00
	9.792	5000.00	830.00	822.51	830.00	.00	5000.00	.00	75.61	12.03	853.00	.00
	9.792	4000.00	830.00	820.87	830.00	.00	4000.00	.00	47.48	13.10	853.00	.00
	9.792	3000.00	830.00	819.71	830.00	.00	3000.00	.00	43.74	11.91	853.00	.00
	9.792	2000.00	830.00	818.27	830.00	.00	2000.00	.00	39.10	10.41	853.00	.00
*	9.813	8300.00	830.60	827.47	830.60	.00	8300.00	.00	79.91	10.92	114.00	830.00
*	9.813	4400.00	830.60	824.50	830.60	.00	4400.00	.00	78.88	8.42	114.00	830.00
	9.813	2800.00	830.60	822.17	830.60	.00	2800.00	.00	73.37	8.11	114.00	830.00
*	9.813	1800.00	830.60	819.89	830.60	.00	1800.00	.00	42.40	7.69	114.00	830.00
*	9.813	8000.00	830.60	827.27	830.60	.00	8000.00	.00	79.90	10.76	114.00	830.00
*	9.813	7000.00	830.60	826.69	830.60	.00	7000.00	.00	79.89	10.04	114.00	830.00
*	9.813	6000.00	830.60	825.87	830.60	.00	6000.00	.00	79.86	9.50	114.00	830.00
*	9.813	5000.00	830.60	824.94	830.60	.00	5000.00	.00	79.84	8.97	114.00	830.00
*	9.813	4000.00	830.60	823.95	830.60	.00	4000.00	.00	77.60	8.33	114.00	830.00
	9.813	3000.00	830.60	822.48	830.60	.00	3000.00	.00	74.13	8.14	114.00	830.00
*	9.813	2000.00	830.60	820.31	830.60	.00	2000.00	.00	43.75	7.93	114.00	830.00
	9.838	8300.00	831.00	828.77	831.00	.00	8300.00	.00	79.94	9.97	132.00	.00
	9.838	4400.00	831.00	825.55	831.00	.00	4400.00	.00	79.84	7.65	132.00	.00
	9.838	2800.00	831.00	823.54	831.00	.00	2800.00	.00	75.69	6.70	132.00	.00
	9.838	1800.00	831.00	820.99	831.00	.00	1800.00	.00	44.64	6.81	132.00	.00
	9.838	8000.00	831.00	828.55	831.00	.00	8000.00	.00	79.93	9.82	132.00	.00
	9.838	7000.00	831.00	827.85	831.00	.00	7000.00	.00	79.91	9.23	132.00	.00
	9.838	6000.00	831.00	827.00	831.00	.00	6000.00	.00	79.88	8.69	132.00	.00
	9.838	5000.00	831.00	826.09	831.00	.00	5000.00	.00	79.86	8.09	132.00	.00
	9.838	4000.00	831.00	825.07	831.00	.00	4000.00	.00	79.31	7.45	132.00	.00
	9.838	3000.00	831.00	823.80	831.00	.00	3000.00	.00	76.31	6.85	132.00	.00
	9.838	2000.00	831.00	821.43	831.00	.00	2000.00	.00	46.06	7.03	132.00	.00

SUMMARY OF ERRORS AND SPECIAL NOTES

WARNING SECNO= .623 PROFILE= 1 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= .623 PROFILE= 2 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= .623 PROFILE= 3 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= .623 PROFILE= 4 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= .623 PROFILE= 5 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= .623 PROFILE= 6 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= .623 PROFILE= 7 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= .623 PROFILE= 8 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= .623 PROFILE= 9 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= .623 PROFILE= 10 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= .623 PROFILE= 11 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO= 1.840 PROFILE= 3 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 1.840 PROFILE= 4 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 1.840 PROFILE= 11 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO= 1.897 PROFILE= 4 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 1.897 PROFILE= 11 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO= 2.276 PROFILE= 1 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 2.276 PROFILE= 2 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 2.276 PROFILE= 3 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 2.276 PROFILE= 4 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 2.276 PROFILE= 5 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 2.276 PROFILE= 6 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 2.276 PROFILE= 7 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 2.276 PROFILE= 8 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 2.276 PROFILE= 9 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 2.276 PROFILE= 10 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 2.276 PROFILE= 11 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO= 2.654 PROFILE= 4 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 2.654 PROFILE= 11 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO= 3.292 PROFILE= 3 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 3.292 PROFILE= 4 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 3.292 PROFILE= 5 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 3.292 PROFILE= 11 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO= 3.299 PROFILE= 5 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO= 3.538 PROFILE= 1 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 3.538 PROFILE= 2 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 3.538 PROFILE= 3 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 3.538 PROFILE= 4 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 3.538 PROFILE= 5 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 3.538 PROFILE= 6 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO= 3.538 PROFILE= 7 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 3.538 PROFILE= 8 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 3.538 PROFILE= 9 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 3.538 PROFILE= 10 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 3.538 PROFILE= 11 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO= 3.582 PROFILE= 1 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 3.582 PROFILE= 2 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 3.582 PROFILE= 7 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 3.582 PROFILE= 8 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 3.582 PROFILE= 9 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO= 3.601 PROFILE= 1 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 3.601 PROFILE= 2 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 3.601 PROFILE= 7 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 3.601 PROFILE= 8 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 3.601 PROFILE= 9 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO= 3.691 PROFILE= 7 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO= 3.701 PROFILE= 7 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO= 3.751 PROFILE= 2 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 3.751 PROFILE= 3 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

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WARNING SECNO=    3.751  PROFILE=  4  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    3.751  PROFILE=  9  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    3.751  PROFILE= 10  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    3.751  PROFILE= 11  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO=    3.808  PROFILE=  1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    3.808  PROFILE=  3  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    3.808  PROFILE=  4  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    3.808  PROFILE=  5  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    3.808  PROFILE=  6  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    3.808  PROFILE=  7  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    3.808  PROFILE= 11  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO=    4.522  PROFILE=  3  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    4.522  PROFILE=  4  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    4.522  PROFILE= 10  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    4.522  PROFILE= 11  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO=    4.530  PROFILE=  4  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    4.530  PROFILE= 11  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO=    4.539  PROFILE=  1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    4.539  PROFILE=  5  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    4.539  PROFILE=  6  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO=    4.636  PROFILE=  1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    4.636  PROFILE=  2  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
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WARNING SECNO=    4.636  PROFILE=  3  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    4.636  PROFILE=  4  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    4.636  PROFILE=  5  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    4.636  PROFILE=  6  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    4.636  PROFILE=  7  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    4.636  PROFILE=  8  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    4.636  PROFILE=  9  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    4.636  PROFILE= 10  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    4.636  PROFILE= 11  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO=    4.639  PROFILE=  2  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    4.639  PROFILE=  9  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO=    4.649  PROFILE=  3  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    4.649  PROFILE=  4  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    4.649  PROFILE=  6  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    4.649  PROFILE=  7  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    4.649  PROFILE=  8  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    4.649  PROFILE= 10  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    4.649  PROFILE= 11  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO=    4.838  PROFILE=  2  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    4.838  PROFILE=  3  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    4.838  PROFILE=  4  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    4.838  PROFILE=  9  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    4.838  PROFILE= 10  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    4.838  PROFILE= 11  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO=    5.034  PROFILE=  1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    5.034  PROFILE=  2  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    5.034  PROFILE=  3  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    5.034  PROFILE=  4  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    5.034  PROFILE=  5  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    5.034  PROFILE=  6  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    5.034  PROFILE=  7  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    5.034  PROFILE=  8  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    5.034  PROFILE=  9  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    5.034  PROFILE= 10  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    5.034  PROFILE= 11  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO=    5.052  PROFILE=  1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    5.052  PROFILE=  2  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    5.052  PROFILE=  3  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
CAUTION SECNO=   5.052  PROFILE=  4  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   5.052  PROFILE=  4  MINIMUM SPECIFIC ENERGY
WARNING SECNO=    5.052  PROFILE=  5  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    5.052  PROFILE=  6  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    5.052  PROFILE=  7  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    5.052  PROFILE=  8  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    5.052  PROFILE=  9  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=    5.052  PROFILE= 10  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
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CAUTION SECNO= 5.052 PROFILE= 11 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 5.052 PROFILE= 11 MINIMUM SPECIFIC ENERGY

CAUTION SECNO= 5.054 PROFILE= 1 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 5.054 PROFILE= 1 MINIMUM SPECIFIC ENERGY
CAUTION SECNO= 5.054 PROFILE= 2 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 5.054 PROFILE= 2 MINIMUM SPECIFIC ENERGY
CAUTION SECNO= 5.054 PROFILE= 3 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 5.054 PROFILE= 3 MINIMUM SPECIFIC ENERGY
CAUTION SECNO= 5.054 PROFILE= 4 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 5.054 PROFILE= 4 MINIMUM SPECIFIC ENERGY
CAUTION SECNO= 5.054 PROFILE= 5 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 5.054 PROFILE= 5 MINIMUM SPECIFIC ENERGY
CAUTION SECNO= 5.054 PROFILE= 6 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 5.054 PROFILE= 6 MINIMUM SPECIFIC ENERGY
CAUTION SECNO= 5.054 PROFILE= 7 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 5.054 PROFILE= 7 MINIMUM SPECIFIC ENERGY
CAUTION SECNO= 5.054 PROFILE= 8 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 5.054 PROFILE= 8 MINIMUM SPECIFIC ENERGY
CAUTION SECNO= 5.054 PROFILE= 9 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 5.054 PROFILE= 9 MINIMUM SPECIFIC ENERGY
CAUTION SECNO= 5.054 PROFILE= 10 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 5.054 PROFILE= 10 MINIMUM SPECIFIC ENERGY
CAUTION SECNO= 5.054 PROFILE= 11 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 5.054 PROFILE= 11 MINIMUM SPECIFIC ENERGY

CAUTION SECNO= 5.067 PROFILE= 2 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 5.067 PROFILE= 2 MINIMUM SPECIFIC ENERGY
CAUTION SECNO= 5.067 PROFILE= 3 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 5.067 PROFILE= 3 MINIMUM SPECIFIC ENERGY
CAUTION SECNO= 5.067 PROFILE= 7 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 5.067 PROFILE= 7 MINIMUM SPECIFIC ENERGY
CAUTION SECNO= 5.067 PROFILE= 8 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 5.067 PROFILE= 8 MINIMUM SPECIFIC ENERGY
CAUTION SECNO= 5.067 PROFILE= 9 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 5.067 PROFILE= 9 MINIMUM SPECIFIC ENERGY
CAUTION SECNO= 5.067 PROFILE= 10 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 5.067 PROFILE= 10 MINIMUM SPECIFIC ENERGY

WARNING SECNO= 5.075 PROFILE= 1 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 5.075 PROFILE= 2 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 5.075 PROFILE= 3 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 5.075 PROFILE= 4 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 5.075 PROFILE= 5 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 5.075 PROFILE= 7 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 5.075 PROFILE= 8 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 5.075 PROFILE= 9 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 5.075 PROFILE= 10 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 5.075 PROFILE= 11 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

CAUTION SECNO= 5.084 PROFILE= 1 CRITICAL DEPTH ASSUMED
1

CAUTION SECNO= 5.084 PROFILE= 1 MINIMUM SPECIFIC ENERGY
WARNING SECNO= 5.084 PROFILE= 2 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 5.084 PROFILE= 3 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 5.084 PROFILE= 4 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
CAUTION SECNO= 5.084 PROFILE= 5 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 5.084 PROFILE= 5 MINIMUM SPECIFIC ENERGY
CAUTION SECNO= 5.084 PROFILE= 6 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 5.084 PROFILE= 6 MINIMUM SPECIFIC ENERGY
CAUTION SECNO= 5.084 PROFILE= 7 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 5.084 PROFILE= 7 MINIMUM SPECIFIC ENERGY
CAUTION SECNO= 5.084 PROFILE= 8 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 5.084 PROFILE= 8 MINIMUM SPECIFIC ENERGY
WARNING SECNO= 5.084 PROFILE= 9 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 5.084 PROFILE= 10 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 5.084 PROFILE= 11 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO= 5.136 PROFILE= 1 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 5.136 PROFILE= 2 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 5.136 PROFILE= 3 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 5.136 PROFILE= 4 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 5.136 PROFILE= 5 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 5.136 PROFILE= 6 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 5.136 PROFILE= 7 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 5.136 PROFILE= 8 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 5.136 PROFILE= 9 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 5.136 PROFILE= 10 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 5.136 PROFILE= 11 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

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WARNING SECNO=     5.148  PROFILE=  1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=     5.148  PROFILE=  2  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=     5.148  PROFILE=  3  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=     5.148  PROFILE=  4  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=     5.148  PROFILE=  5  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=     5.148  PROFILE=  6  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=     5.148  PROFILE=  7  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=     5.148  PROFILE=  8  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=     5.148  PROFILE=  9  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=     5.148  PROFILE= 10  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=     5.148  PROFILE= 11  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO=     5.184  PROFILE=  1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=     5.184  PROFILE=  2  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=     5.184  PROFILE=  3  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=     5.184  PROFILE=  4  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=     5.184  PROFILE=  5  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=     5.184  PROFILE=  6  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=     5.184  PROFILE=  7  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=     5.184  PROFILE=  8  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=     5.184  PROFILE=  9  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=     5.184  PROFILE= 10  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=     5.184  PROFILE= 11  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
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WARNING SECNO=     5.373  PROFILE=  1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=     5.373  PROFILE=  2  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=     5.373  PROFILE=  5  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=     5.373  PROFILE=  6  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=     5.373  PROFILE=  7  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=     5.373  PROFILE=  8  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=     5.373  PROFILE=  9  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=     5.373  PROFILE= 10  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

CAUTION SECNO=     5.749  PROFILE=  5  CRITICAL DEPTH ASSUMED
CAUTION SECNO=     5.749  PROFILE=  5  MINIMUM SPECIFIC ENERGY

WARNING SECNO=     5.756  PROFILE=  4  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO=     5.805  PROFILE=  3  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=     5.805  PROFILE=  4  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=     5.805  PROFILE= 11  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO=     6.012  PROFILE=  2  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=     6.012  PROFILE=  6  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=     6.012  PROFILE=  7  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=     6.012  PROFILE=  8  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=     6.012  PROFILE=  9  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=     6.012  PROFILE= 10  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO=     6.036  PROFILE=  5  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

CAUTION SECNO=     6.052  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=     6.052  PROFILE=  1  MINIMUM SPECIFIC ENERGY
CAUTION SECNO=     6.052  PROFILE=  2  CRITICAL DEPTH ASSUMED
CAUTION SECNO=     6.052  PROFILE=  2  MINIMUM SPECIFIC ENERGY
CAUTION SECNO=     6.052  PROFILE=  3  CRITICAL DEPTH ASSUMED
CAUTION SECNO=     6.052  PROFILE=  3  MINIMUM SPECIFIC ENERGY
CAUTION SECNO=     6.052  PROFILE=  4  CRITICAL DEPTH ASSUMED
CAUTION SECNO=     6.052  PROFILE=  4  MINIMUM SPECIFIC ENERGY
CAUTION SECNO=     6.052  PROFILE=  5  CRITICAL DEPTH ASSUMED
CAUTION SECNO=     6.052  PROFILE=  5  MINIMUM SPECIFIC ENERGY
CAUTION SECNO=     6.052  PROFILE=  6  CRITICAL DEPTH ASSUMED
CAUTION SECNO=     6.052  PROFILE=  6  MINIMUM SPECIFIC ENERGY
CAUTION SECNO=     6.052  PROFILE=  7  CRITICAL DEPTH ASSUMED
CAUTION SECNO=     6.052  PROFILE=  7  MINIMUM SPECIFIC ENERGY
CAUTION SECNO=     6.052  PROFILE=  8  CRITICAL DEPTH ASSUMED
CAUTION SECNO=     6.052  PROFILE=  8  MINIMUM SPECIFIC ENERGY
CAUTION SECNO=     6.052  PROFILE=  9  CRITICAL DEPTH ASSUMED
CAUTION SECNO=     6.052  PROFILE=  9  MINIMUM SPECIFIC ENERGY
CAUTION SECNO=     6.052  PROFILE= 10  CRITICAL DEPTH ASSUMED
CAUTION SECNO=     6.052  PROFILE= 10  MINIMUM SPECIFIC ENERGY
CAUTION SECNO=     6.052  PROFILE= 11  CRITICAL DEPTH ASSUMED
CAUTION SECNO=     6.052  PROFILE= 11  MINIMUM SPECIFIC ENERGY

WARNING SECNO=     6.071  PROFILE=  1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
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WARNING SECNO=     6.071  PROFILE=  2  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
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WARNING SECNO= 6.071 PROFILE= 5 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 6.071 PROFILE= 6 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 6.071 PROFILE= 7 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 6.071 PROFILE= 8 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 6.071 PROFILE= 9 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 6.071 PROFILE= 10 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

CAUTION SECNO= 6.393 PROFILE= 1 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 6.393 PROFILE= 1 MINIMUM SPECIFIC ENERGY
WARNING SECNO= 6.393 PROFILE= 3 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 6.393 PROFILE= 4 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
CAUTION SECNO= 6.393 PROFILE= 5 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 6.393 PROFILE= 5 MINIMUM SPECIFIC ENERGY
CAUTION SECNO= 6.393 PROFILE= 6 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 6.393 PROFILE= 6 MINIMUM SPECIFIC ENERGY
CAUTION SECNO= 6.393 PROFILE= 7 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 6.393 PROFILE= 7 MINIMUM SPECIFIC ENERGY
WARNING SECNO= 6.393 PROFILE= 8 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 6.393 PROFILE= 10 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 6.393 PROFILE= 11 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO= 6.441 PROFILE= 1 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 6.441 PROFILE= 5 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 6.441 PROFILE= 6 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 6.441 PROFILE= 7 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 6.441 PROFILE= 8 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO= 6.456 PROFILE= 4 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 6.456 PROFILE= 11 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO= 6.479 PROFILE= 1 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 6.479 PROFILE= 4 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 6.479 PROFILE= 5 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
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WARNING SECNO= 6.479 PROFILE= 7 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 6.479 PROFILE= 8 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 6.479 PROFILE= 11 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

CAUTION SECNO= 6.702 PROFILE= 1 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 6.702 PROFILE= 1 MINIMUM SPECIFIC ENERGY
WARNING SECNO= 6.702 PROFILE= 2 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
CAUTION SECNO= 6.702 PROFILE= 5 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 6.702 PROFILE= 5 MINIMUM SPECIFIC ENERGY
CAUTION SECNO= 6.702 PROFILE= 6 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 6.702 PROFILE= 6 MINIMUM SPECIFIC ENERGY
CAUTION SECNO= 6.702 PROFILE= 7 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 6.702 PROFILE= 7 MINIMUM SPECIFIC ENERGY
CAUTION SECNO= 6.702 PROFILE= 8 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 6.702 PROFILE= 8 MINIMUM SPECIFIC ENERGY
WARNING SECNO= 6.702 PROFILE= 9 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO= 7.434 PROFILE= 1 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 7.434 PROFILE= 2 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 7.434 PROFILE= 5 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 7.434 PROFILE= 6 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 7.434 PROFILE= 7 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 7.434 PROFILE= 8 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 7.434 PROFILE= 9 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO= 7.453 PROFILE= 1 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 7.453 PROFILE= 5 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 7.453 PROFILE= 6 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO= 7.463 PROFILE= 1 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
CAUTION SECNO= 7.463 PROFILE= 5 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 7.463 PROFILE= 5 MINIMUM SPECIFIC ENERGY

CAUTION SECNO= 8.227 PROFILE= 1 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 8.227 PROFILE= 1 MINIMUM SPECIFIC ENERGY
WARNING SECNO= 8.227 PROFILE= 2 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 8.227 PROFILE= 3 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 8.227 PROFILE= 4 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 8.227 PROFILE= 5 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 8.227 PROFILE= 10 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 8.227 PROFILE= 11 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

CAUTION SECNO= 8.619 PROFILE= 1 WSEL ASSUMED BASED ON MIN DIFF
CAUTION SECNO= 8.619 PROFILE= 1 20 TRIALS ATTEMPTED TO BALANCE WSEL
CAUTION SECNO= 8.619 PROFILE= 5 WSEL ASSUMED BASED ON MIN DIFF
CAUTION SECNO= 8.619 PROFILE= 5 20 TRIALS ATTEMPTED TO BALANCE WSEL

CAUTION SECNO= 8.619 PROFILE= 6 WSEL ASSUMED BASED ON MIN DIFF
CAUTION SECNO= 8.619 PROFILE= 6 20 TRIALS ATTEMPTED TO BALANCE WSEL

CAUTION SECNO= 8.632 PROFILE= 1 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 8.632 PROFILE= 1 MINIMUM SPECIFIC ENERGY
CAUTION SECNO= 8.632 PROFILE= 2 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 8.632 PROFILE= 2 MINIMUM SPECIFIC ENERGY
CAUTION SECNO= 8.632 PROFILE= 3 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 8.632 PROFILE= 3 MINIMUM SPECIFIC ENERGY
CAUTION SECNO= 8.632 PROFILE= 4 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 8.632 PROFILE= 4 MINIMUM SPECIFIC ENERGY
CAUTION SECNO= 8.632 PROFILE= 5 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 8.632 PROFILE= 5 MINIMUM SPECIFIC ENERGY
CAUTION SECNO= 8.632 PROFILE= 6 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 8.632 PROFILE= 6 MINIMUM SPECIFIC ENERGY
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CAUTION SECNO= 8.632 PROFILE= 9 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 8.632 PROFILE= 9 MINIMUM SPECIFIC ENERGY
CAUTION SECNO= 8.632 PROFILE= 10 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 8.632 PROFILE= 10 MINIMUM SPECIFIC ENERGY
1

CAUTION SECNO= 8.632 PROFILE= 11 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 8.632 PROFILE= 11 MINIMUM SPECIFIC ENERGY

WARNING SECNO= 8.647 PROFILE= 1 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 8.647 PROFILE= 2 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 8.647 PROFILE= 3 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 8.647 PROFILE= 4 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
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WARNING SECNO= 8.647 PROFILE= 9 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 8.647 PROFILE= 10 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO= 8.647 PROFILE= 11 CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

CAUTION SECNO= 8.657 PROFILE= 1 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 8.657 PROFILE= 1 MINIMUM SPECIFIC ENERGY
CAUTION SECNO= 8.657 PROFILE= 2 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 8.657 PROFILE= 2 MINIMUM SPECIFIC ENERGY
CAUTION SECNO= 8.657 PROFILE= 3 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 8.657 PROFILE= 3 MINIMUM SPECIFIC ENERGY
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CAUTION SECNO= 8.657 PROFILE= 8 MINIMUM SPECIFIC ENERGY
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CAUTION SECNO= 8.657 PROFILE= 9 MINIMUM SPECIFIC ENERGY
CAUTION SECNO= 8.657 PROFILE= 10 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 8.657 PROFILE= 10 MINIMUM SPECIFIC ENERGY
CAUTION SECNO= 8.657 PROFILE= 11 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 8.657 PROFILE= 11 MINIMUM SPECIFIC ENERGY

CAUTION SECNO= 9.142 PROFILE= 1 WSEL ASSUMED BASED ON MIN DIFF
CAUTION SECNO= 9.142 PROFILE= 1 20 TRIALS ATTEMPTED TO BALANCE WSEL
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CAUTION SECNO= 9.142 PROFILE= 6 20 TRIALS ATTEMPTED TO BALANCE WSEL
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1

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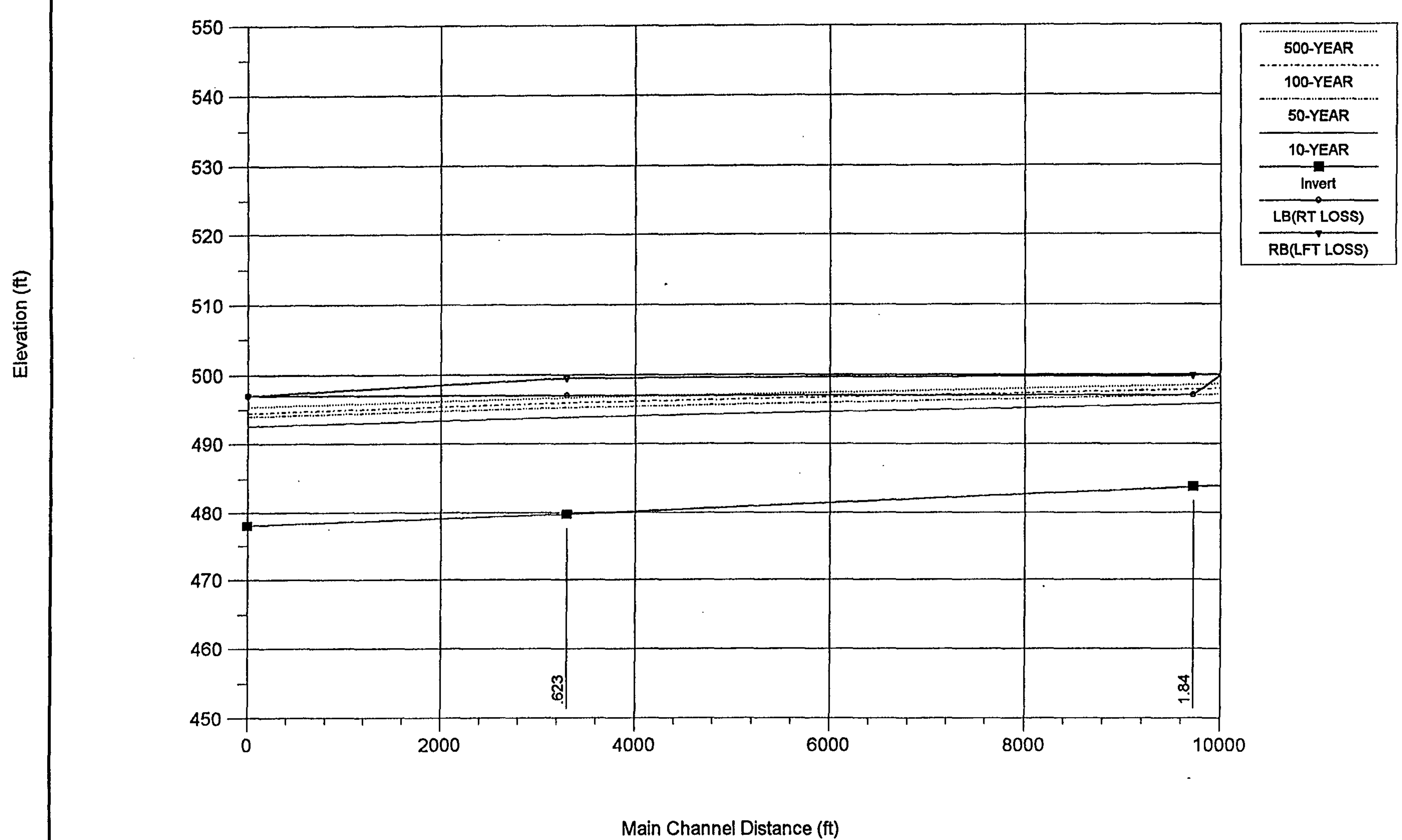
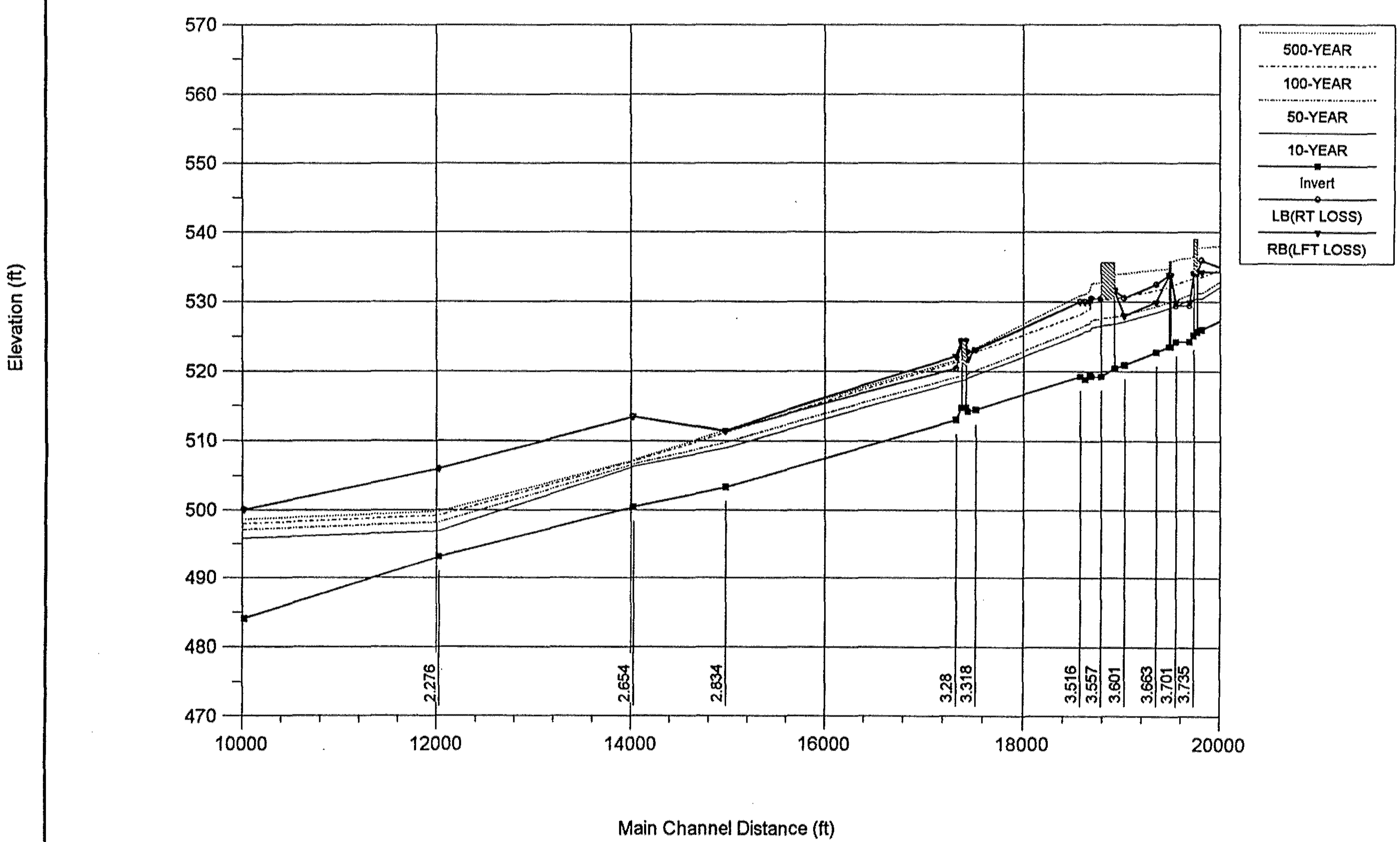
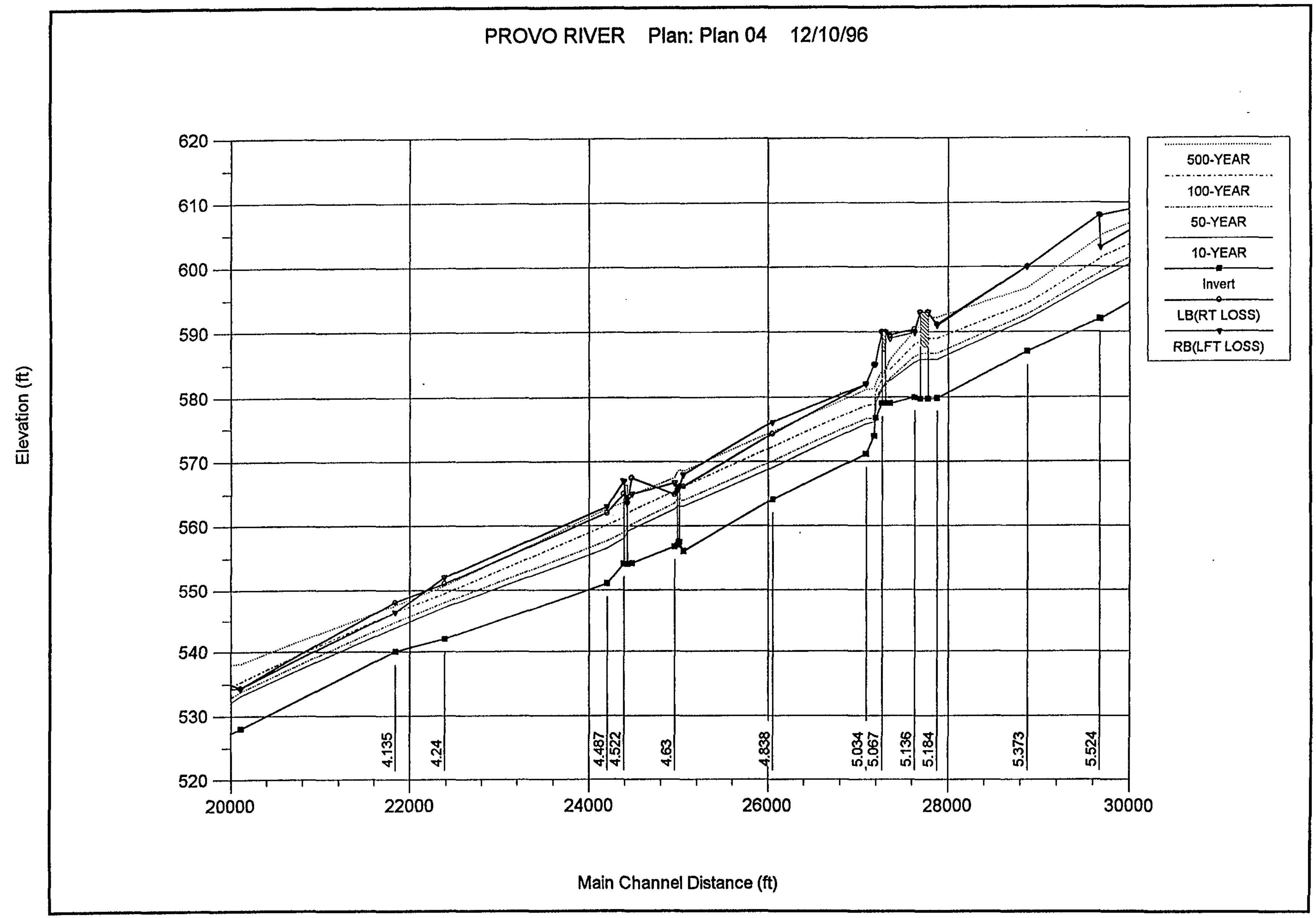
PROFILES

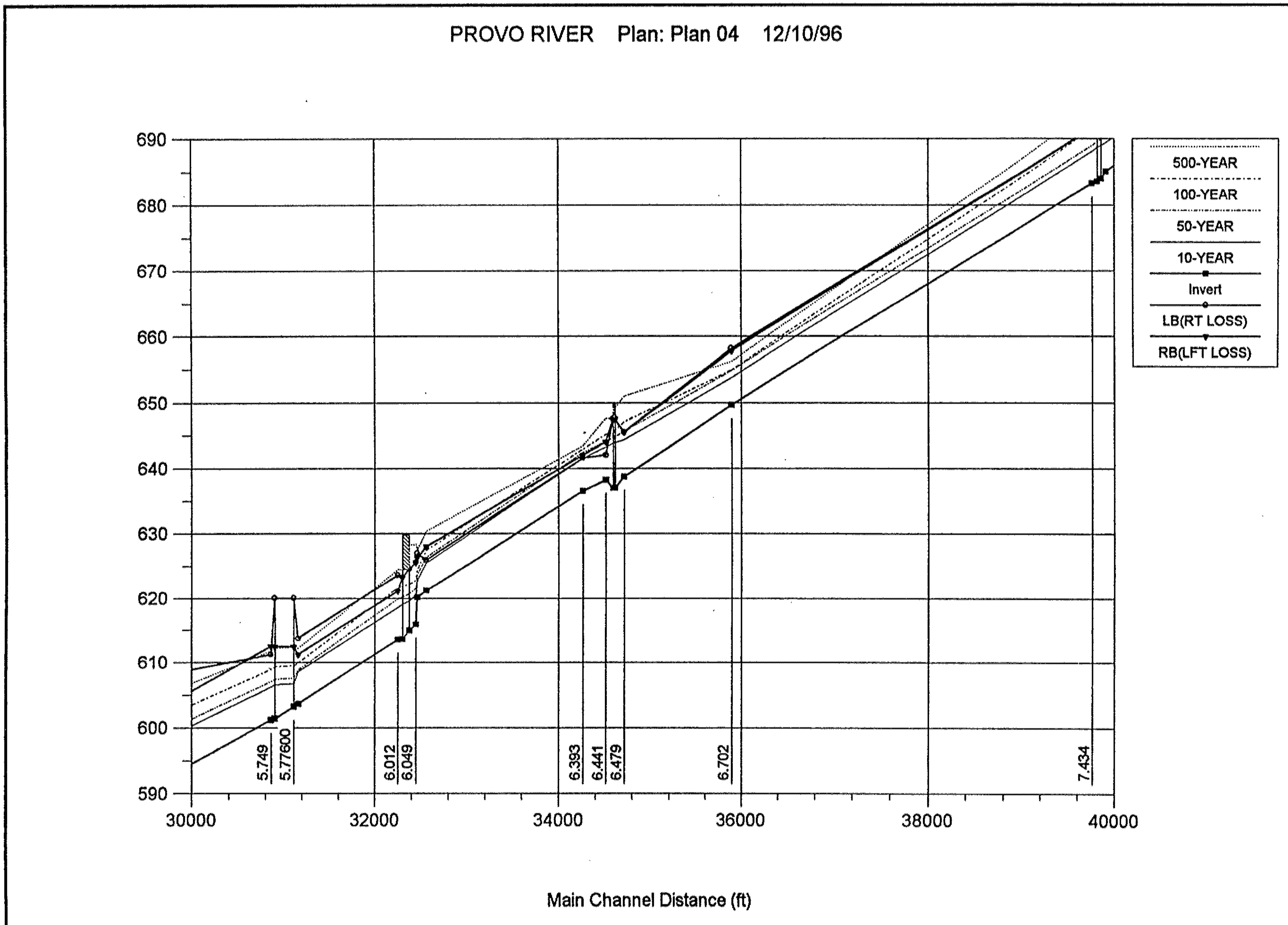
PROVO RIVER   Plan: Plan 04   12/10/96



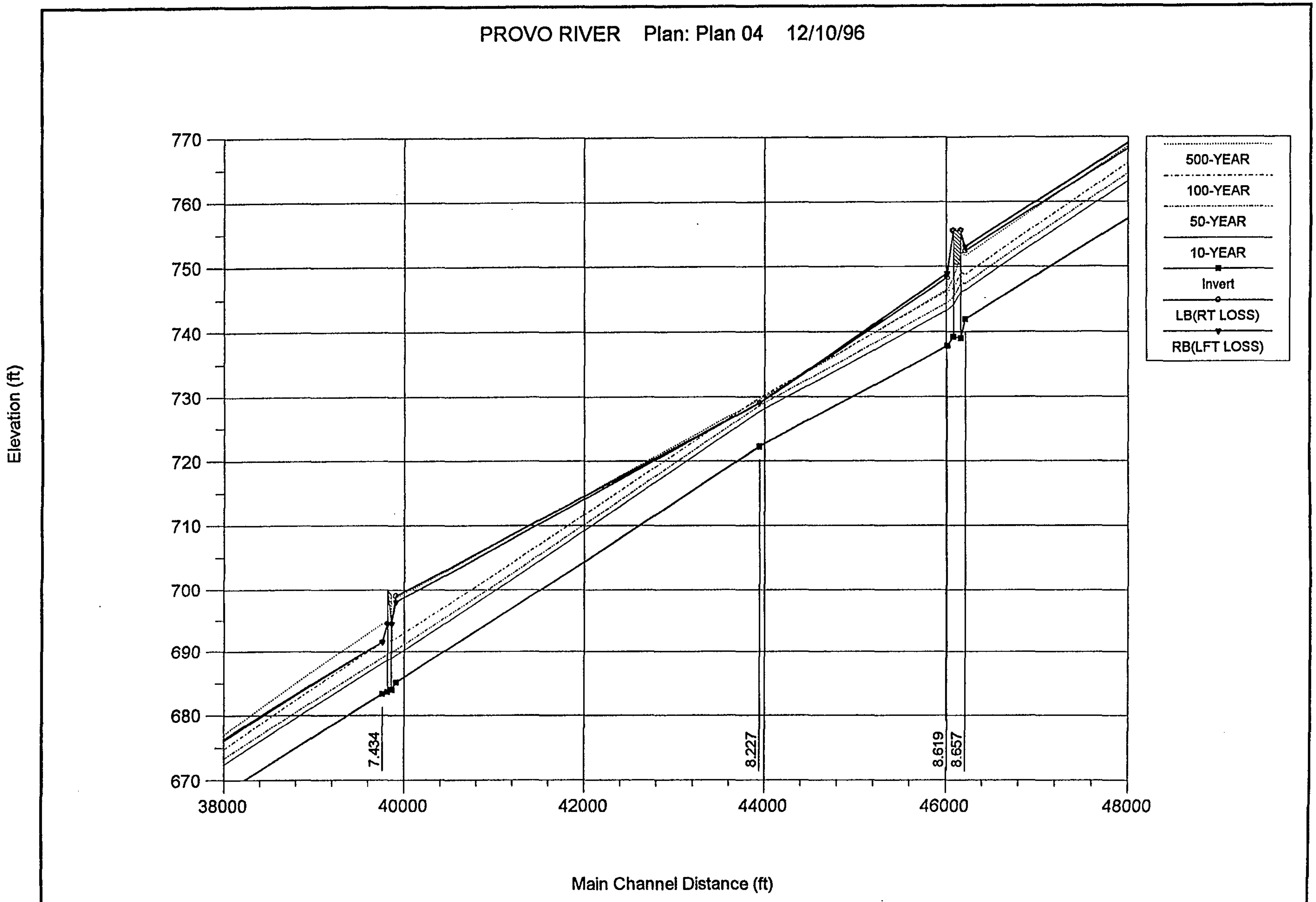
PROVO RIVER Plan: Plan 04 12/10/96



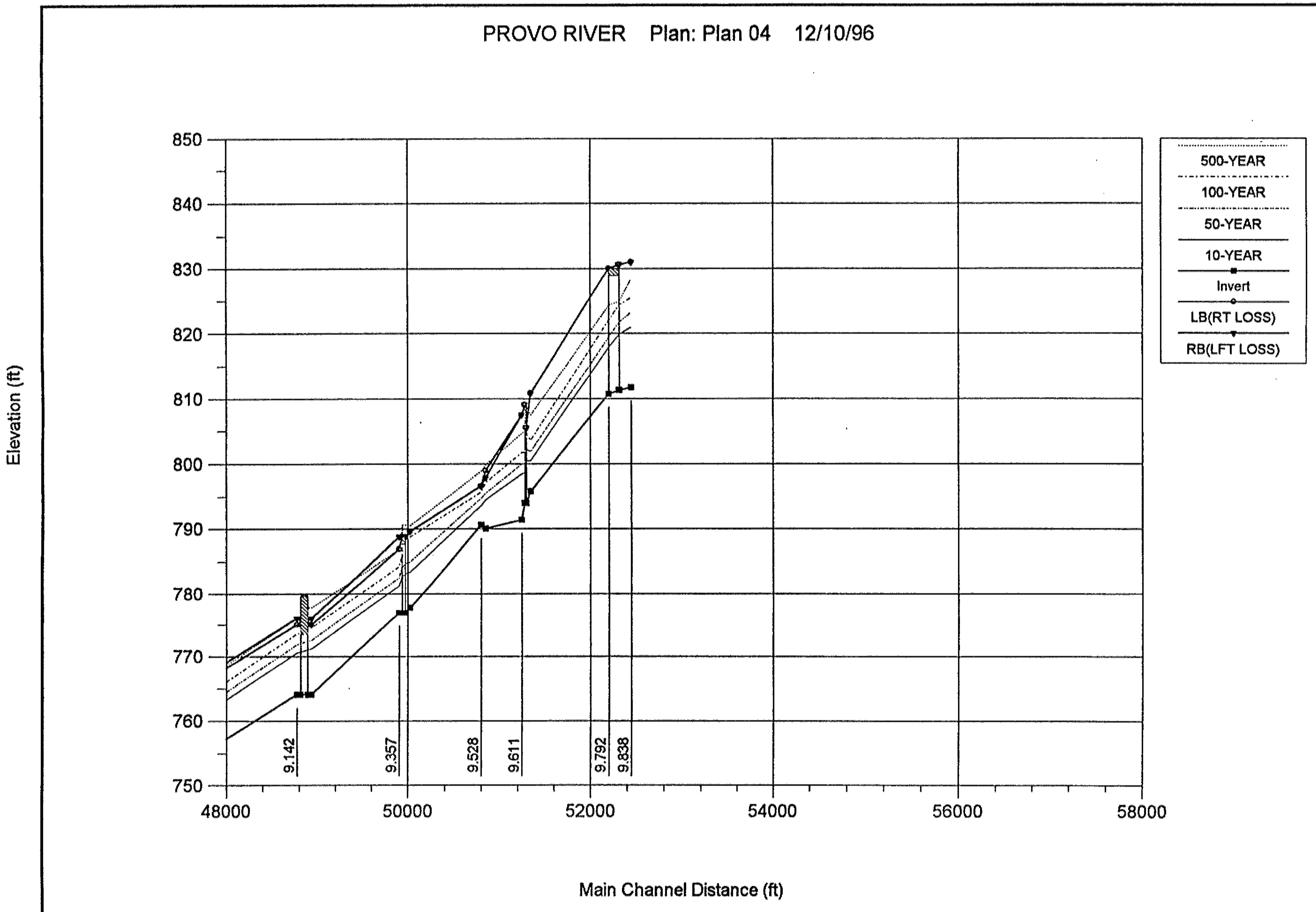

PROVO RIVER Plan: Plan 04 12/10/96
Elevation (ft)
Main Channel Distance (ft)
620
610
600
590
580
570
560
550
540
530
520
20000
22000
24000
26000
28000
30000
4.135
4.24
4.487
4.522
4.63
4.838
5.034
5.067
5.136
5.184
5.373
5.524
500-YEAR
100-YEAR
50-YEAR
10-YEAR
Invert
LB(RT LOSS)
RB(LFT LOSS)



PROVO RIVER Plan: Plan 04 12/10/96
Elevation (ft)
690
680
670
660
650
640
630
620
610
600
590
30000
32000
34000
36000
38000
40000
Main Channel Distance (ft)
5.749
5.77600
6.012
6.049
6.393
6.441
6.479
6.702
7.434
500-YEAR
100-YEAR
50-YEAR
10-YEAR
Invert
LB(RT LOSS)
RB(LFT LOSS)



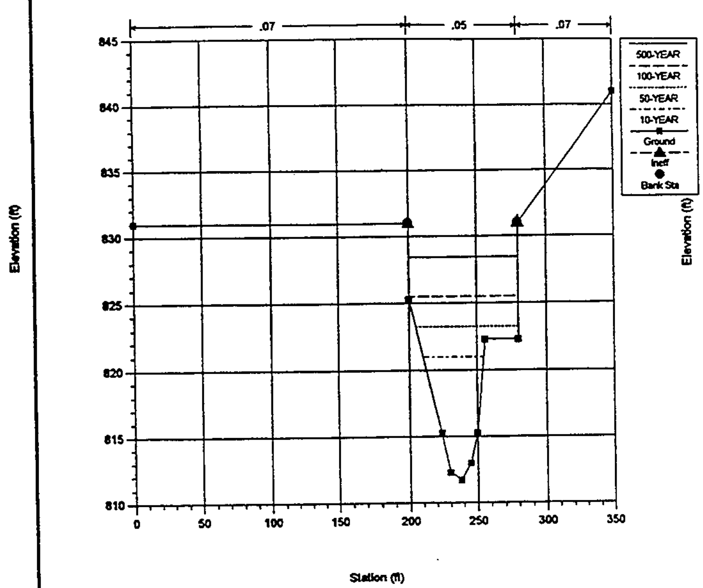
PROVO RIVER Plan: Plan 04 12/10/96
Elevation (ft)
770
760
750
740
730
720
710
700
690
680
670
38000
40000
42000
44000
46000
48000
Main Channel Distance (ft)
7.434
8.227
8.619
8.657
500-YEAR
100-YEAR
50-YEAR
10-YEAR
Invert
LB(RT LOSS)
RB(LFT LOSS)


PROVO RIVER Plan: Plan 04 12/10/96
Elevation (ft)
850
840
830
820
810
800
790
780
770
760
750
48000
50000
52000
54000
56000
58000
Main Channel Distance (ft)
9.142
9.357
9.528
9.611
9.792
9.838
500-YEAR
100-YEAR
50-YEAR
10-YEAR
Invert
LB(RT LOSS)
RB(LFT LOSS)

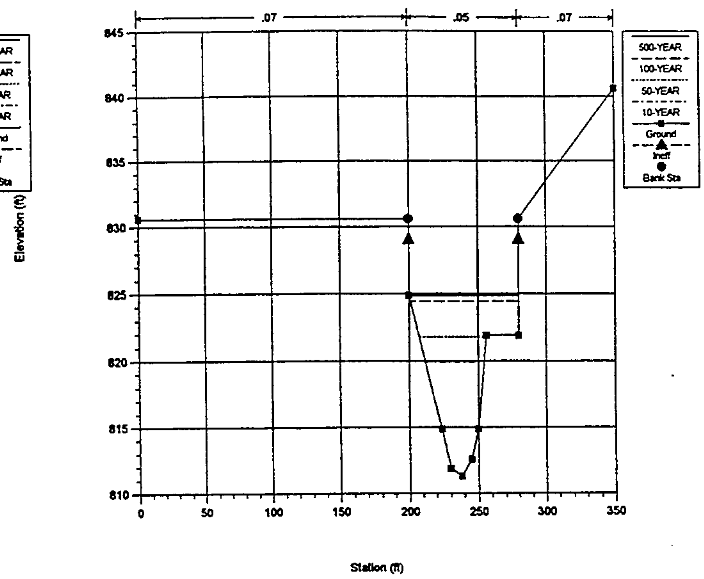
CROSS SECTIONS

SECTIONS ASSUMED LOOKING UPSTREAM 12/96

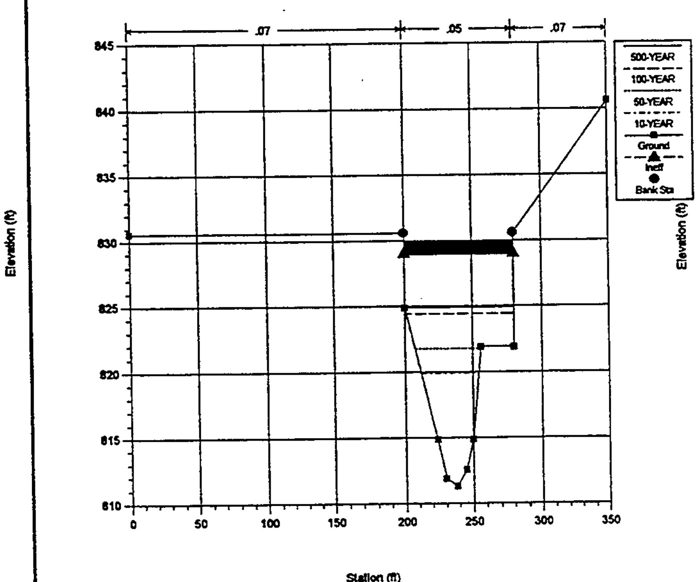
PROVO RIVER Plan: Plan 04 12/10/96
9.838 Channel Flow Only



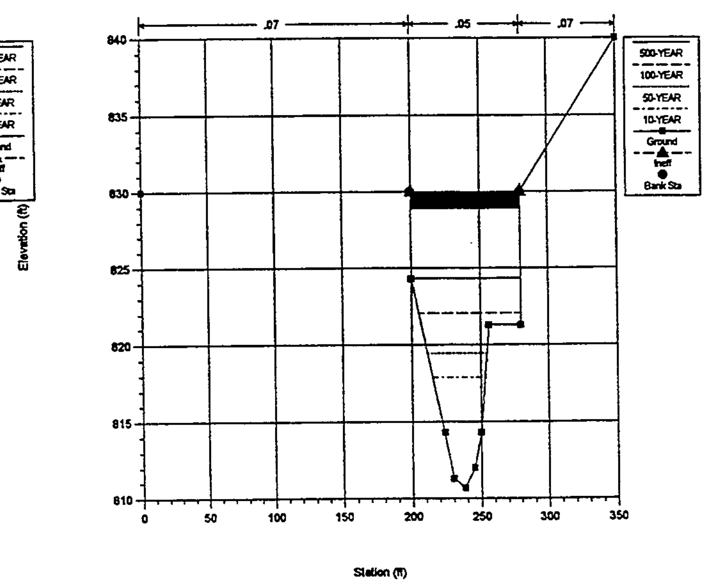
PROVO RIVER Plan: Plan 04 12/10/96
9.813 Channel Flow Only



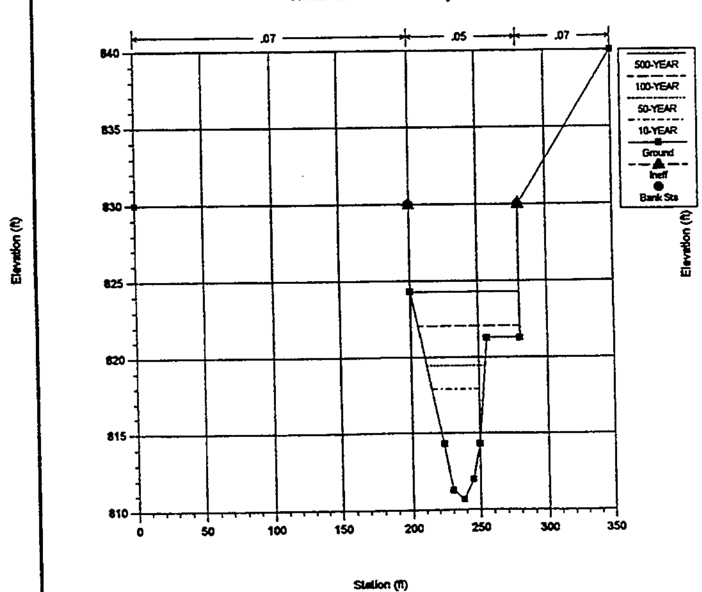
PROVO RIVER Plan: Plan 04 12/10/96
Upstream Inside Bridge # 17 Channel Flow Only



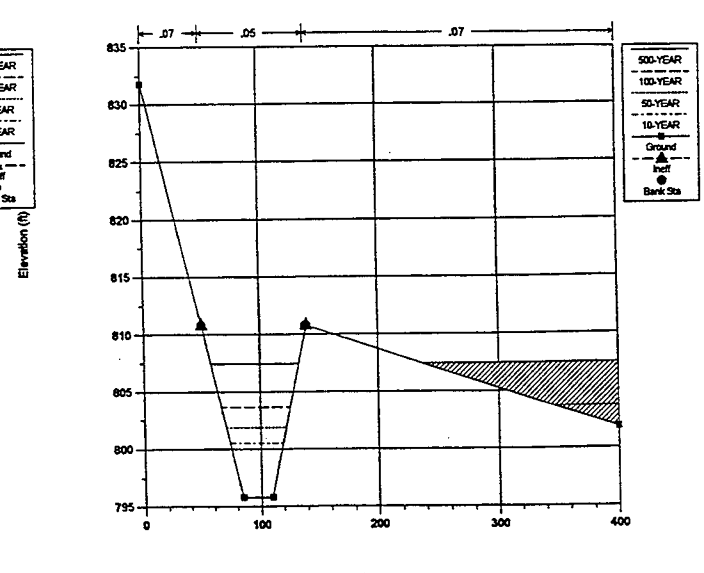
PROVO RIVER Plan: Plan 04 12/10/96
Downstream Inside Bridge # 17 Channel Flow Only



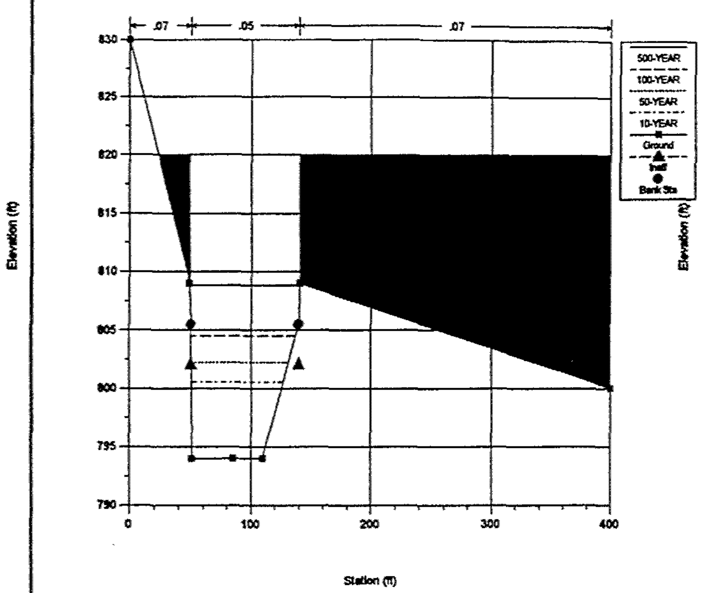
PROVO RIVER Plan: Plan 04 12/10/96
9.792 Channel Flow Only



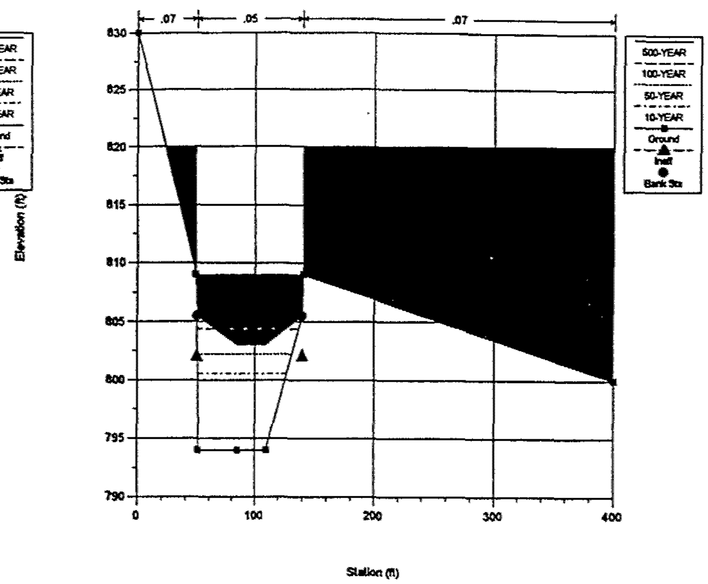
PROVO RIVER Plan: Plan 04 12/10/96
9.63 Channel Flow Only



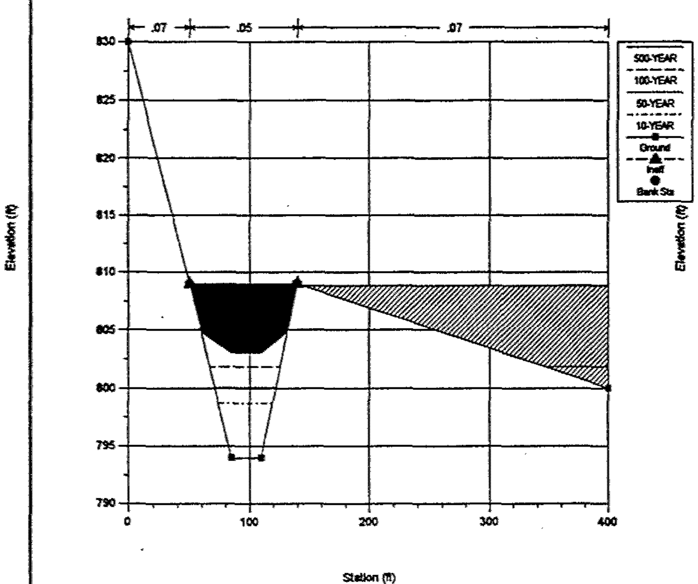
PROVO RIVER Plan: Plan 04 12/10/96
9.62 Channel Flow Only



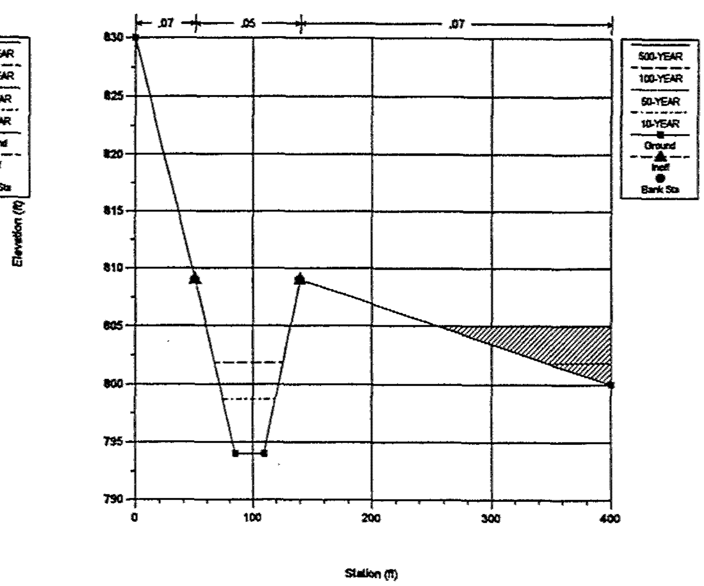
PROVO RIVER Plan: Plan 04 12/10/96
Upstream Inside Bridge # 16 Channel Flow Only



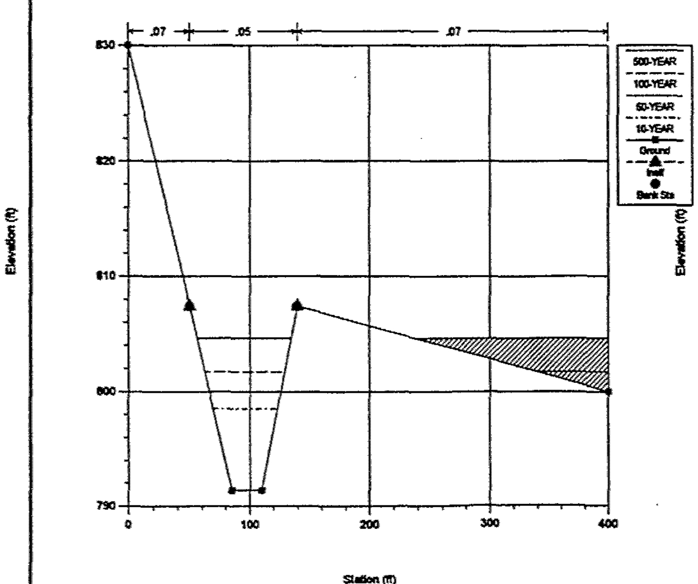
PROVO RIVER Plan: Plan 04 12/10/96
Downstream Inside Bridge # 16 Channel Flow Only



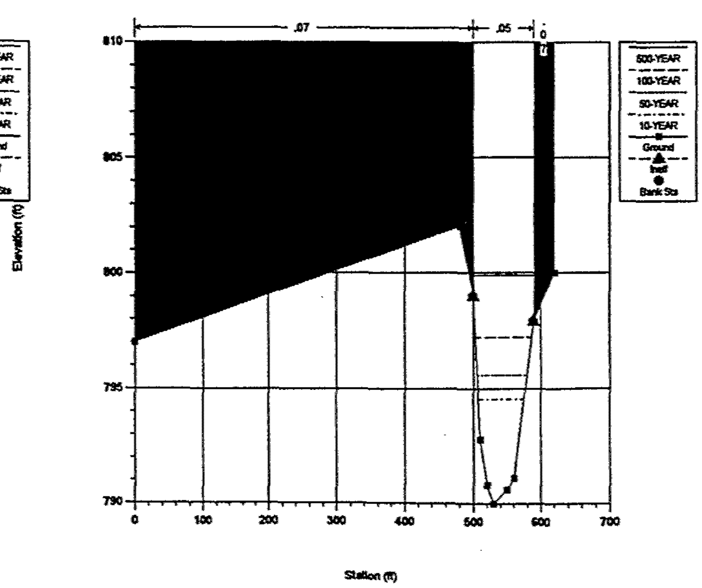
PROVO RIVER Plan: Plan 04 12/10/96
9.618 Channel Flow Only



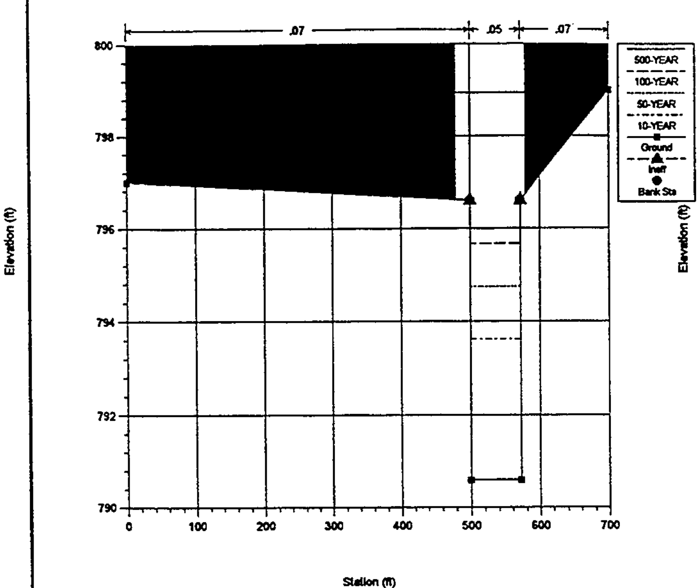
PROVO RIVER Plan: Plan 04 12/10/96
9.611 Channel Flow Only



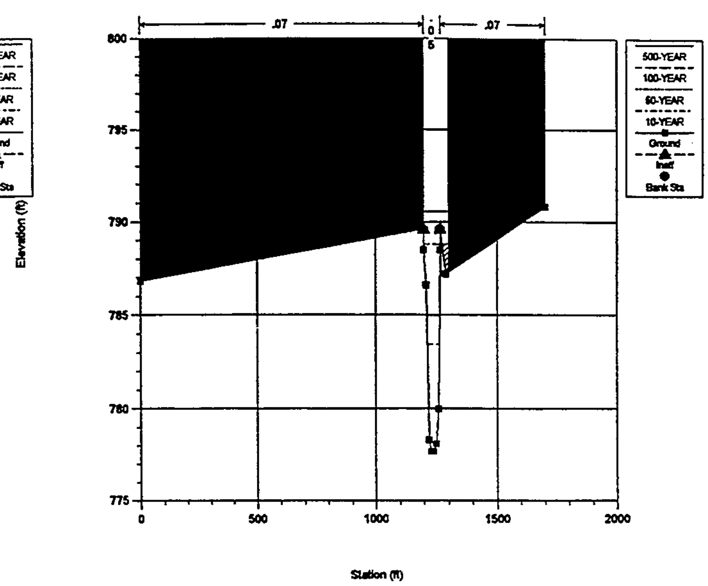
PROVO RIVER Plan: Plan 04 12/10/96
9.537 Channel Flow Only



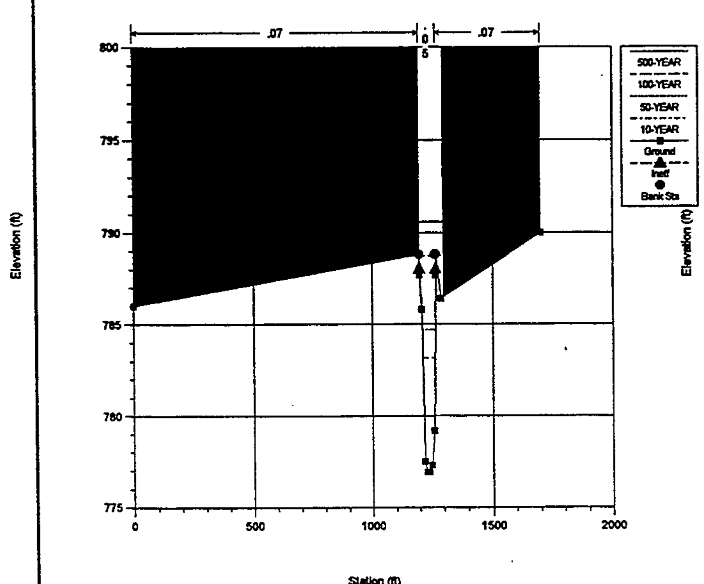
PROVO RIVER Plan: Plan 04 12/10/96
9.528 Channel Flow Only



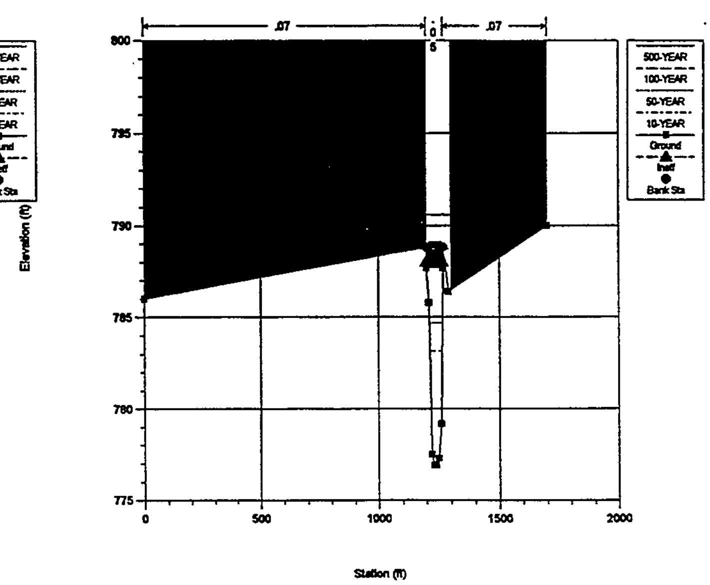
PROVO RIVER Plan: Plan 04 12/10/96
9.38 Channel Flow Only



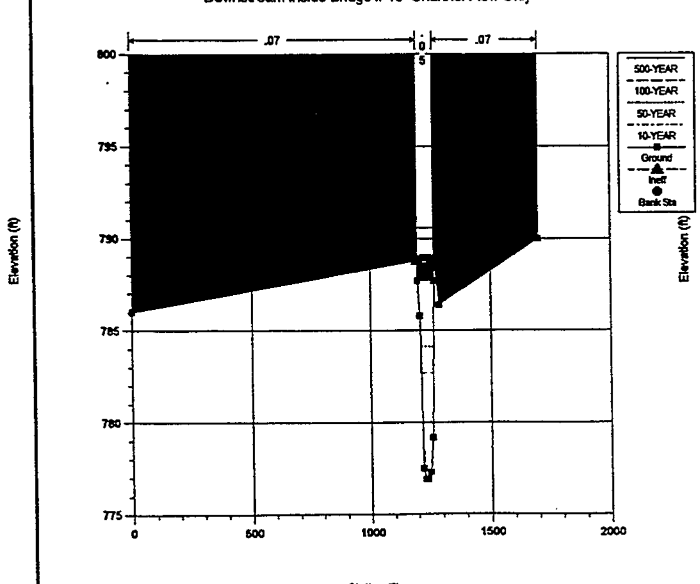
PROVO RIVER Plan: Plan 04 12/10/96
9.37 Channel Flow Only



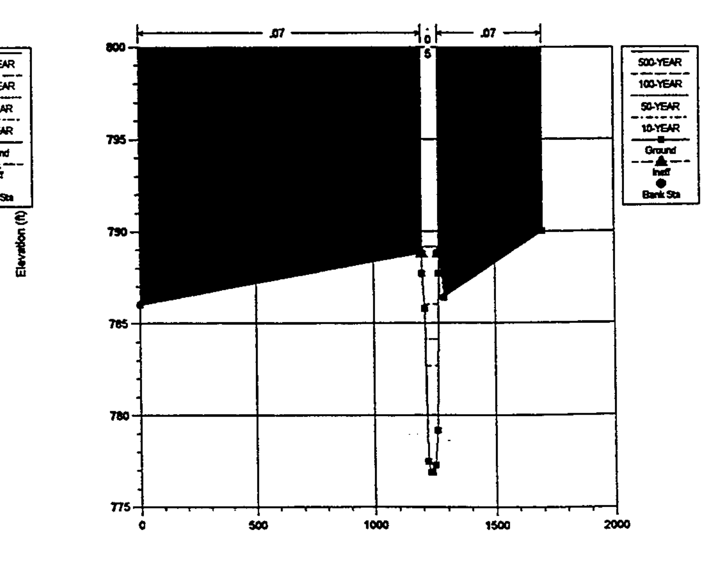
PROVO RIVER Plan: Plan 04 12/10/96
Upstream Inside Bridge # 15 Channel Flow Only



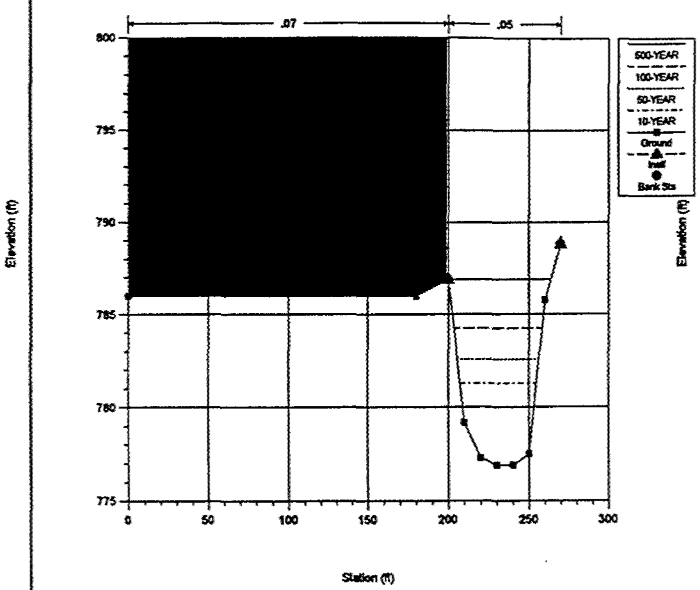
PROVO RIVER Plan: Plan 04 12/10/96
Downstream Inside Bridge # 15 Channel Flow Only



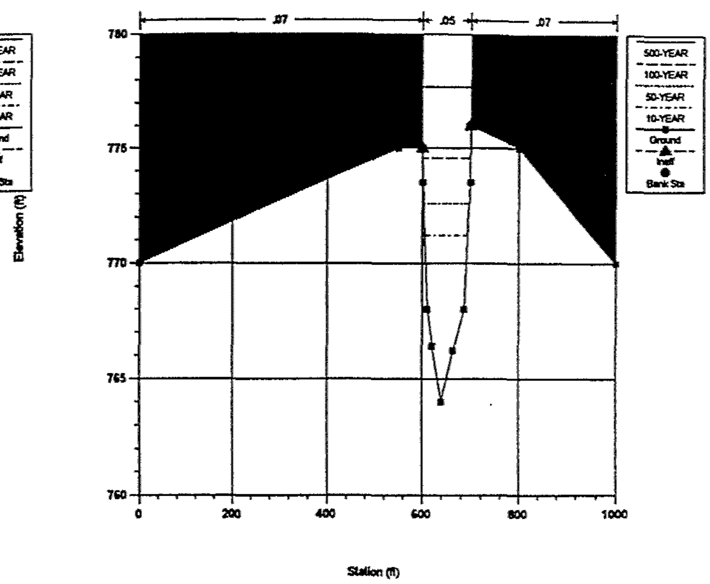
PROVO RIVER Plan: Plan 04 12/10/96
9.363 Channel Flow Only



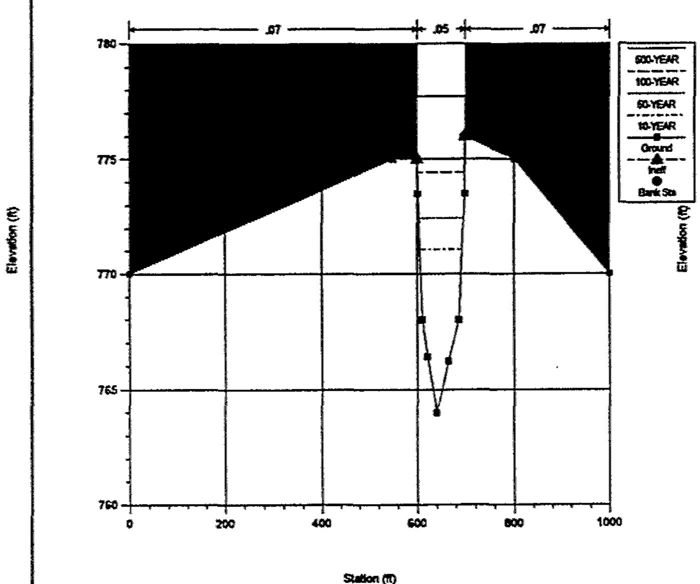
PROVO RIVER Plan: Plan 04 12/10/96
9.357 Channel Flow Only



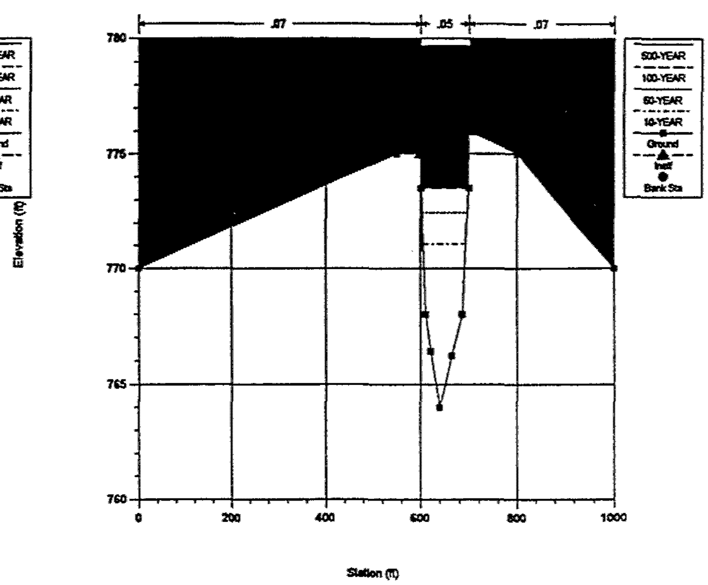
PROVO RIVER Plan: Plan 04 12/10/96
9.173 Channel Flow Only



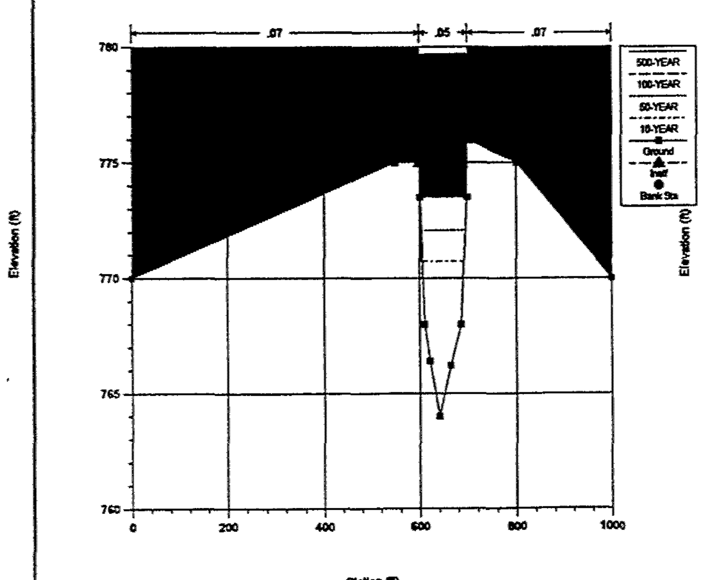
PROVO RIVER Plan: Plan 04 12/10/96
9.165 Channel Flow Only



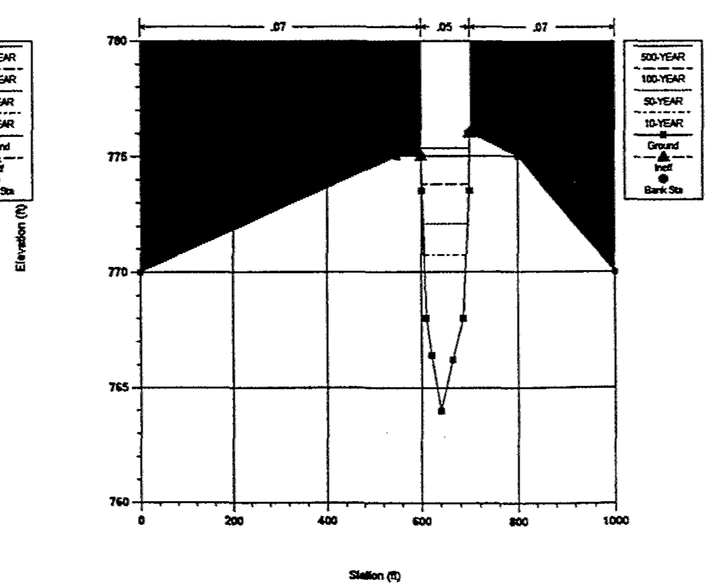
PROVO RIVER Plan: Plan 04 12/10/96
Upstream Inside Bridge # 14 Channel Flow Only



PROVO RIVER Plan: Plan 04 12/10/96
Downstream Inside Bridge # 14 Channel Flow Only



PROVO RIVER Plan: Plan 04 12/10/96
9.15 Channel Flow Only



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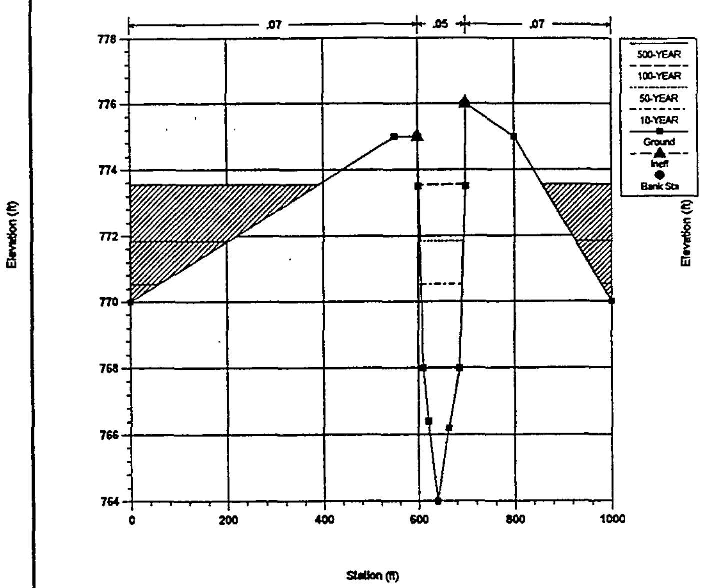
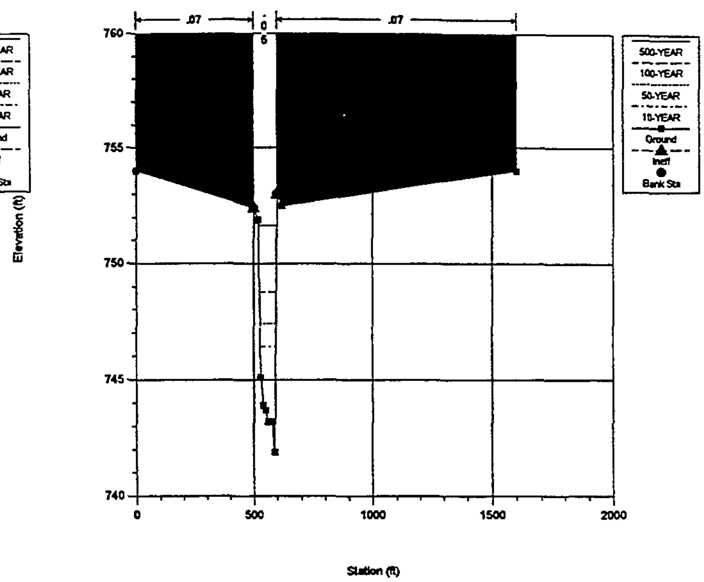
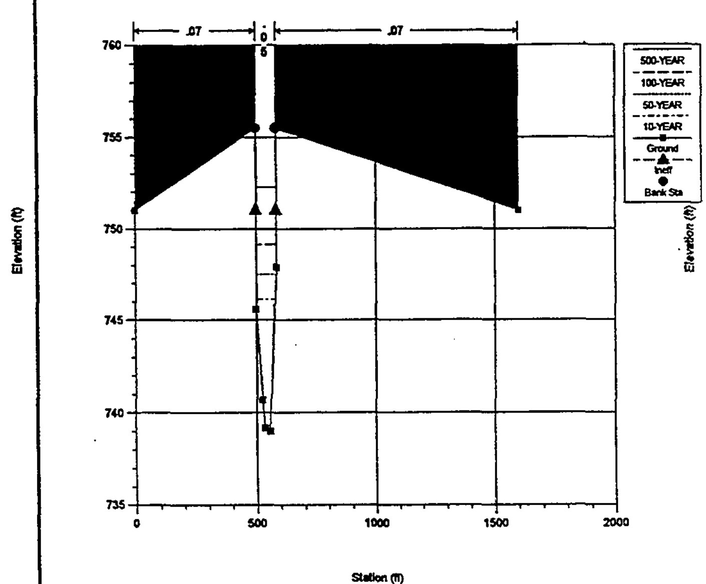
9.142 Channel Flow Only



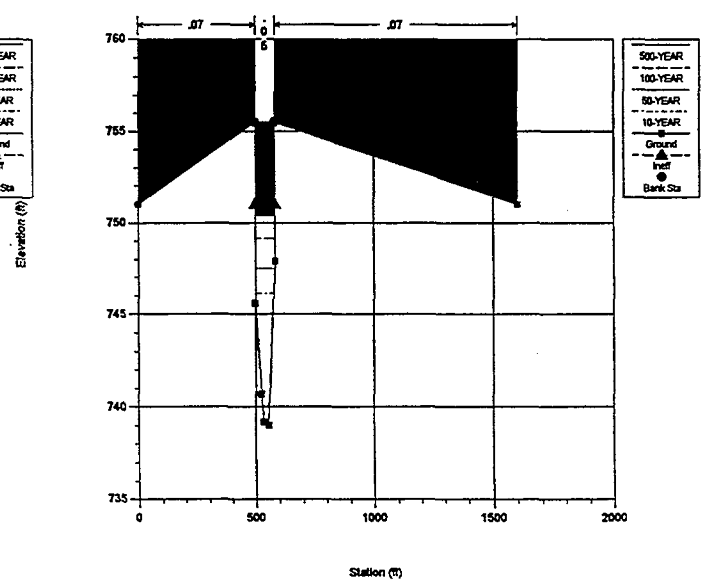
PROVO RIVER Plan: Plan 04 12/10/96
8.657 Channel Flow Only



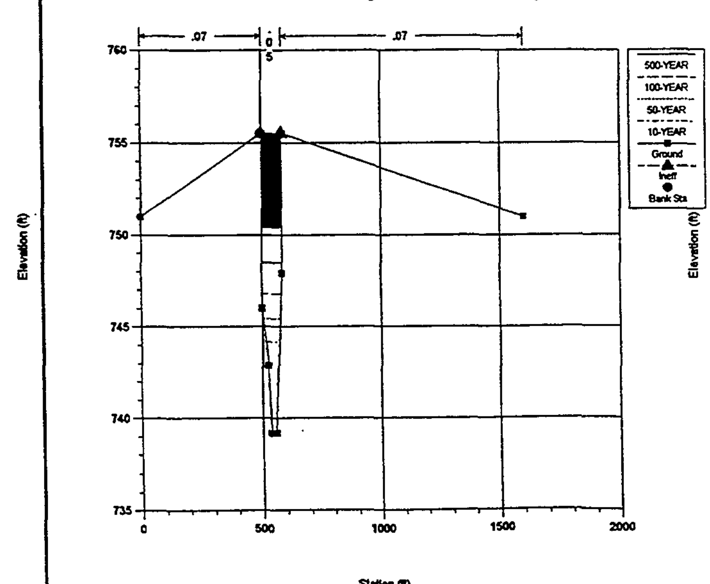
PROVO RIVER Plan: Plan 04 12/10/96
8.647 Channel Flow Only



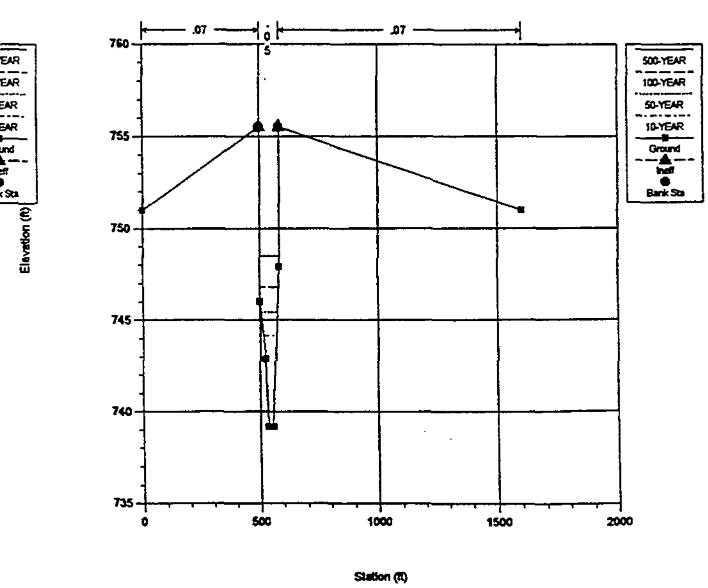
PROVO RIVER Plan: Plan 04 12/10/96
Upstream Inside Bridge # 13 Channel Flow Only



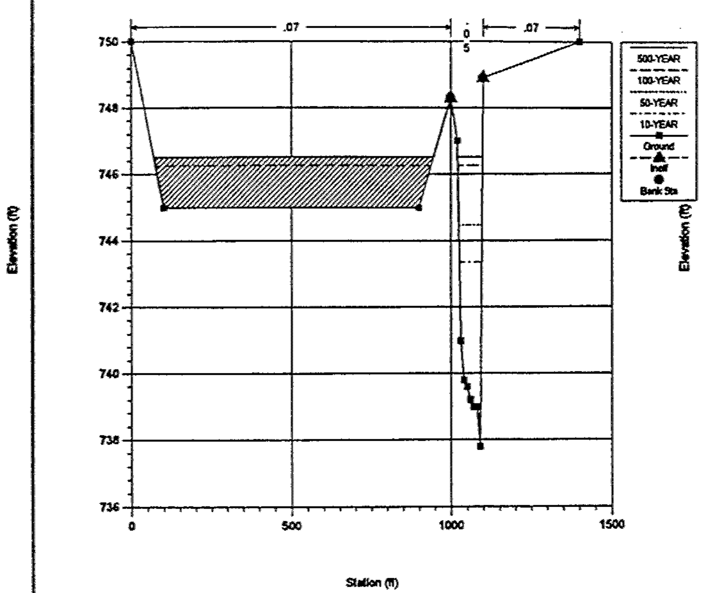
PROVO RIVER Plan: Plan 04 12/10/96
Downstream Inside Bridge # 13 Channel Flow Only



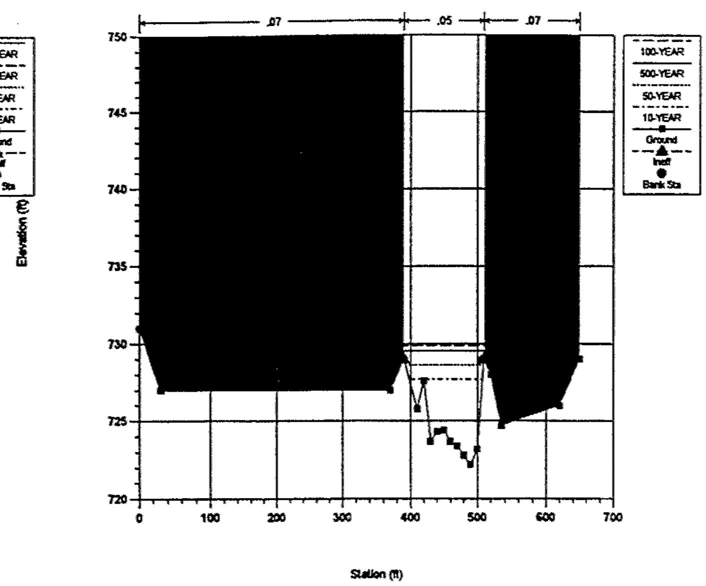
PROVO RIVER Plan: Plan 04 12/10/96
8.632 Channel Flow Only



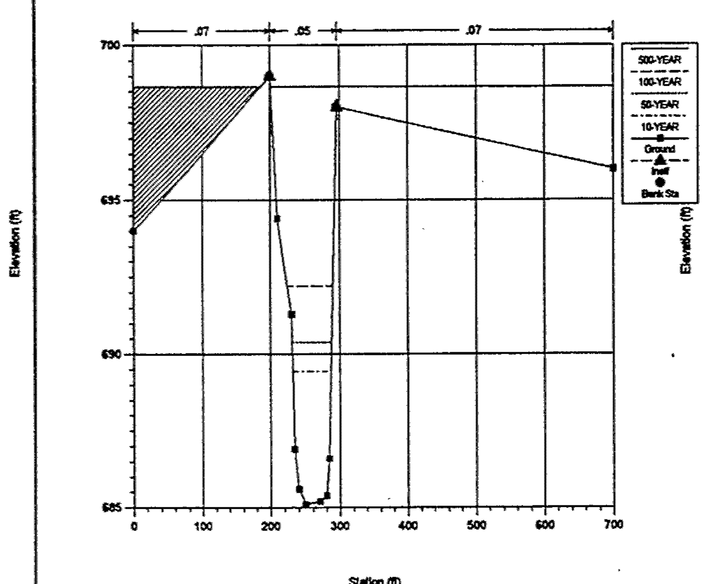
PROVO RIVER Plan: Plan 04 12/10/96
8.619 Channel Flow Only



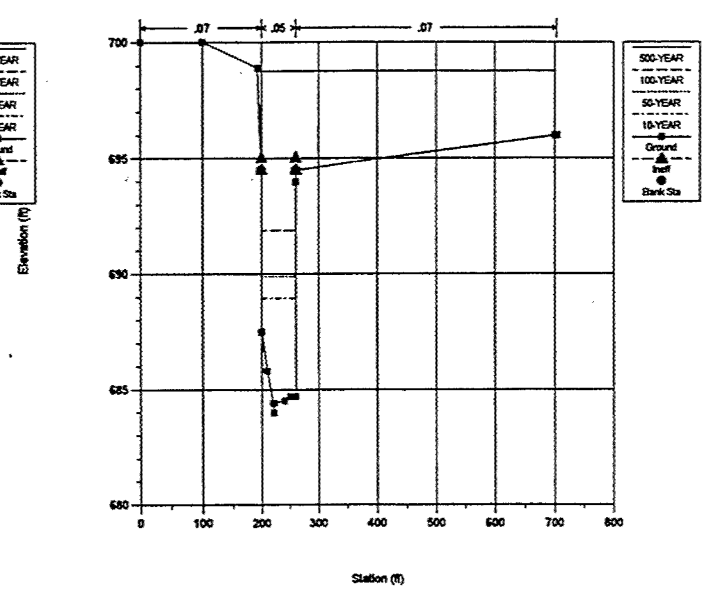
PROVO RIVER Plan: Plan 04 12/10/96
8.227 Channel Flow Only



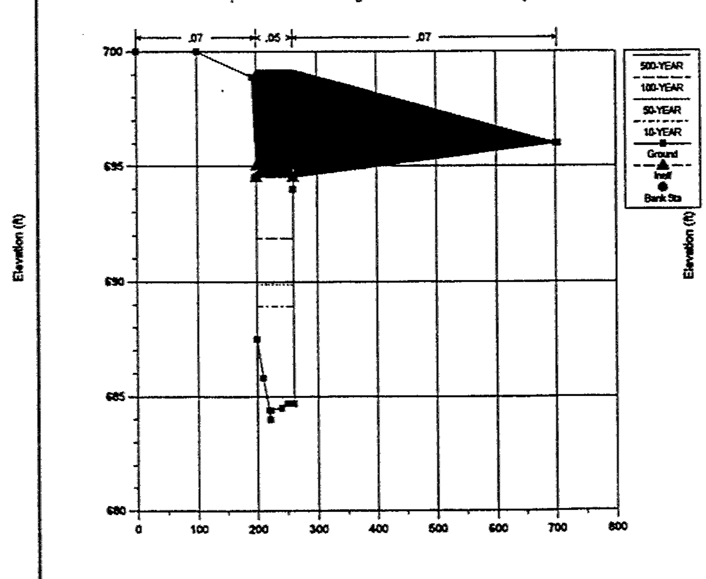
PROVO RIVER Plan: Plan 04 12/10/96
7.463 Channel Flow Only



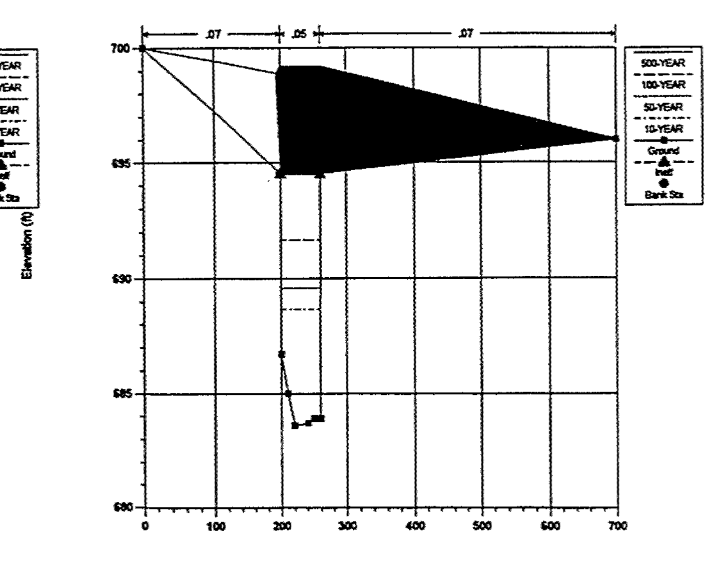
PROVO RIVER Plan: Plan 04 12/10/96
7.453 Channel Flow Only



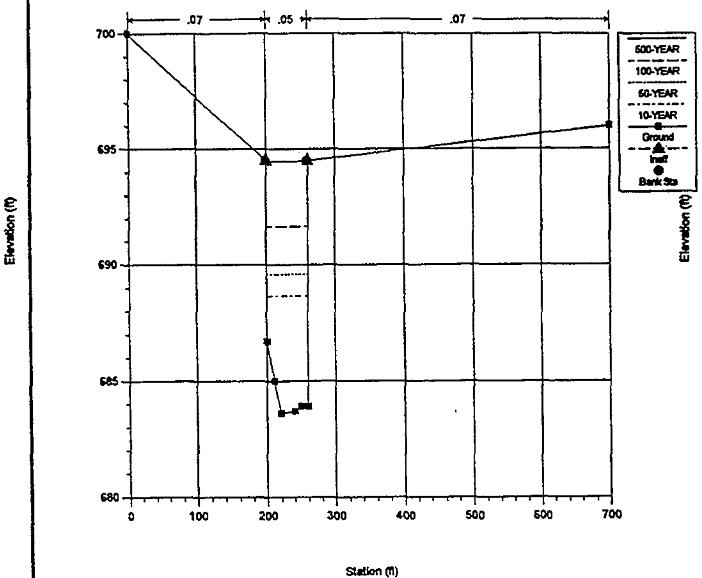
PROVO RIVER Plan: Plan 04 12/10/96
Upstream Inside Bridge # 12 Channel Flow Only



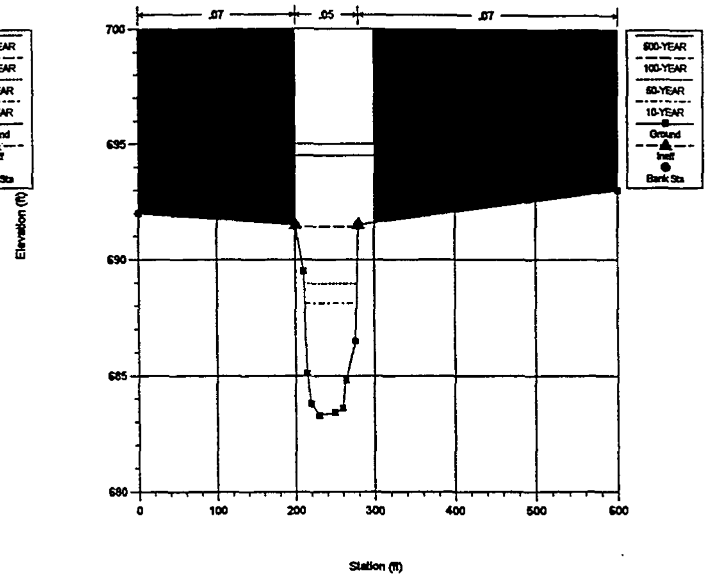
PROVO RIVER Plan: Plan 04 12/10/96
Downstream Inside Bridge # 12 Channel Flow Only



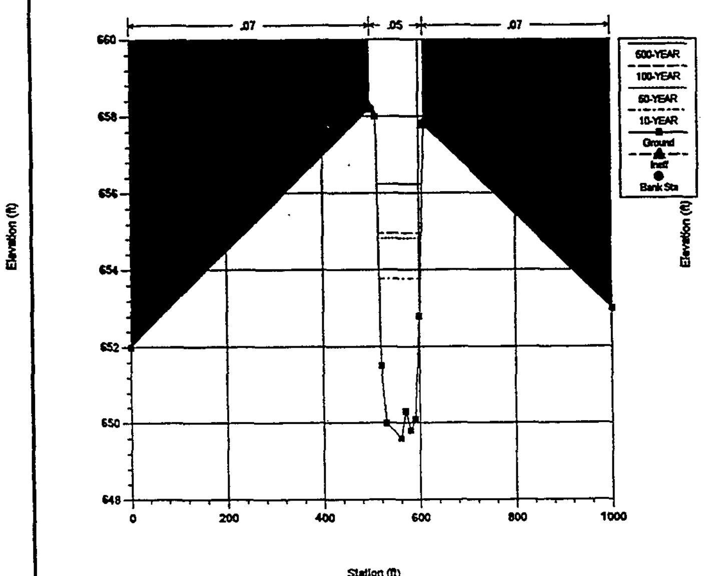
PROVO RIVER Plan: Plan 04 12/10/96
7.445 Channel Flow Only



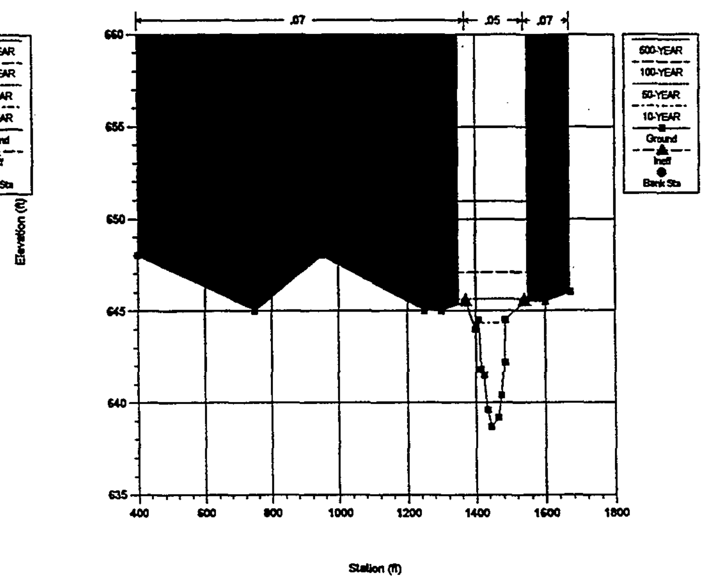
PROVO RIVER Plan: Plan 04 12/10/96
7.434 Channel Flow Only



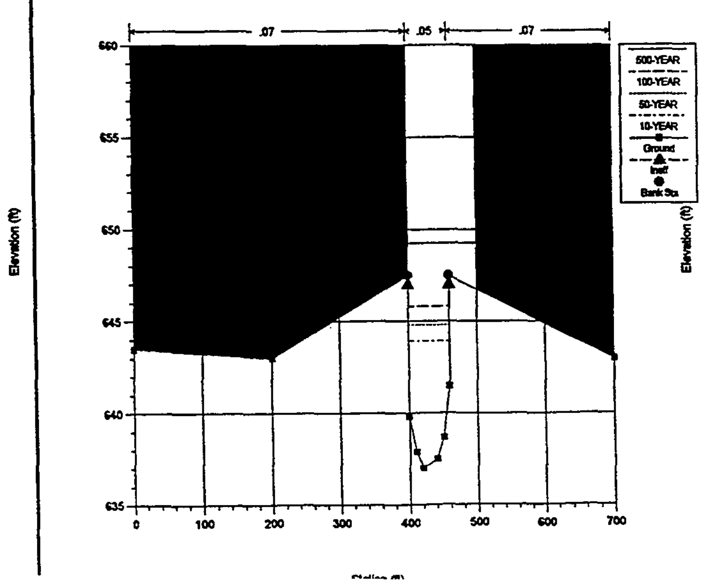
PROVO RIVER Plan: Plan 04 12/10/96
6.702 Channel Flow Only



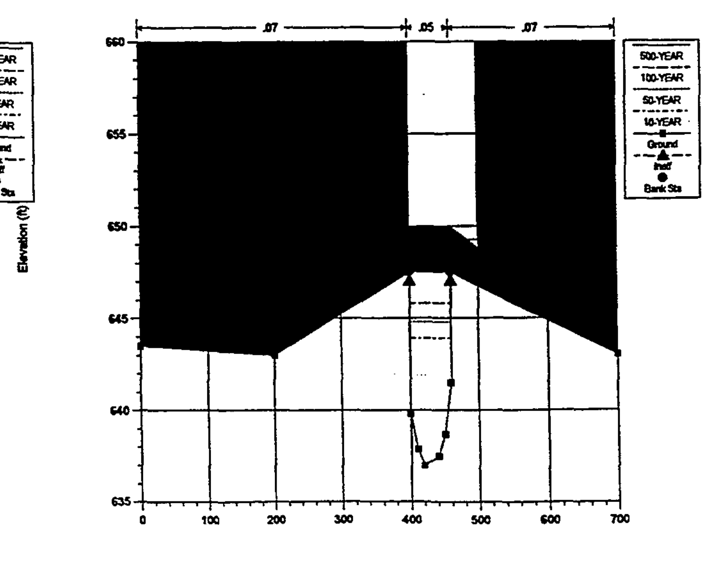
PROVO RIVER Plan: Plan 04 12/10/96
6.479 Channel Flow Only



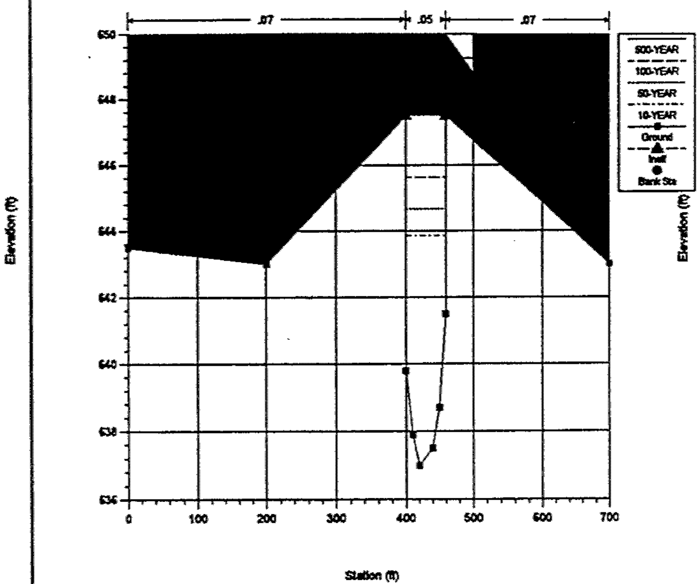
PROVO RIVER Plan: Plan 04 12/10/96
6.46 Channel Flow Only



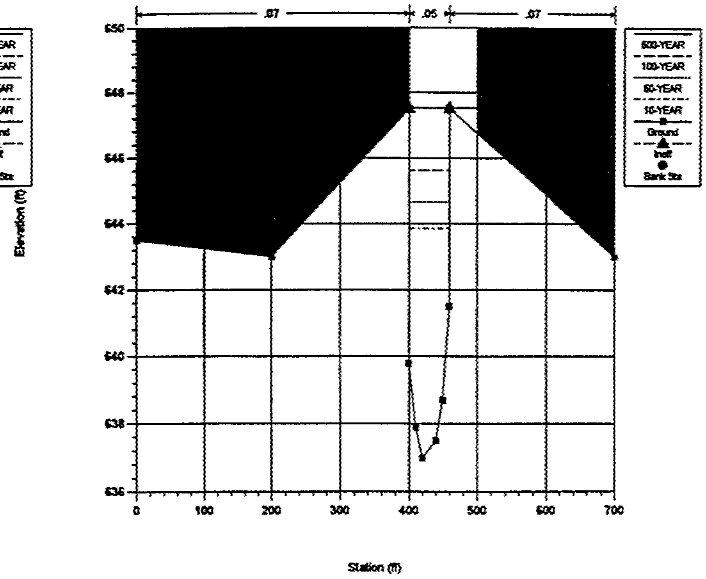
PROVO RIVER Plan: Plan 04 12/10/96
Upstream Inside Bridge # 11 Channel Flow Only



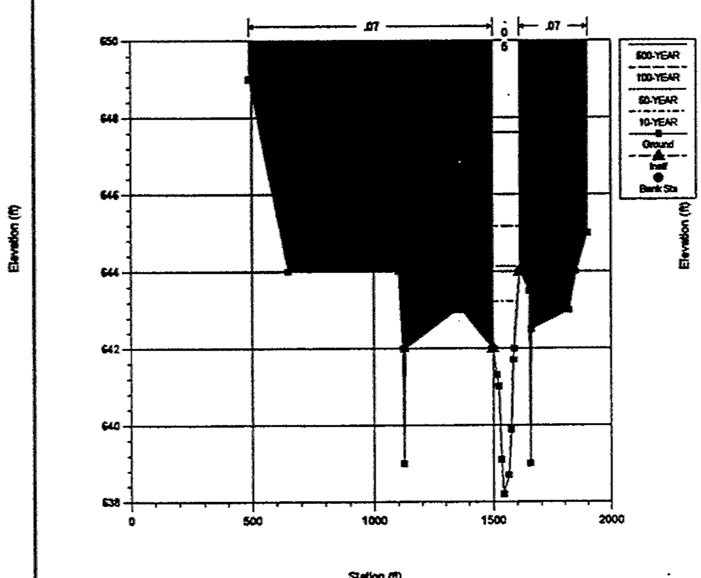
PROVO RIVER Plan: Plan 04 12/10/96
Downstream Inside Bridge # 11 Channel Flow Only



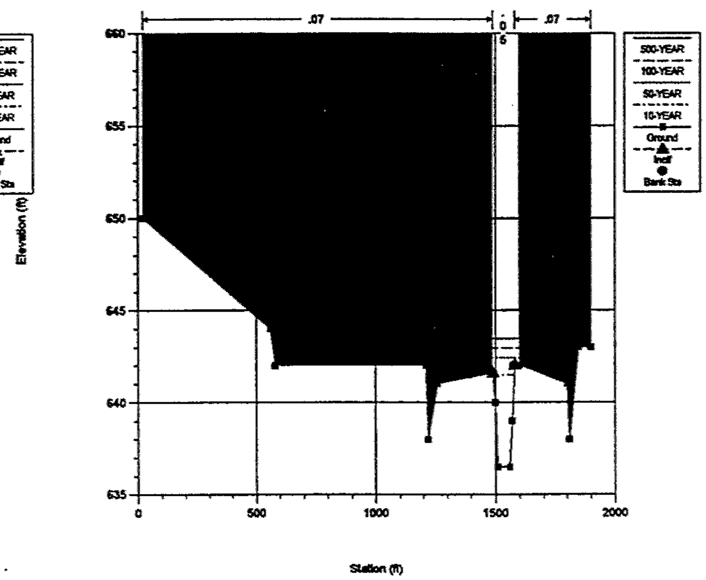
PROVO RIVER Plan: Plan 04 12/10/96
6.456 Channel Flow Only



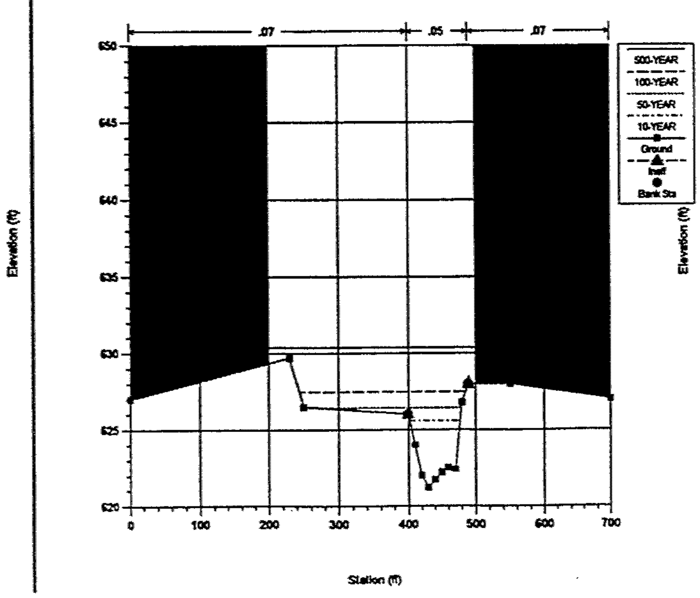
PROVO RIVER Plan: Plan 04 12/10/96
6.441 Channel Flow Only



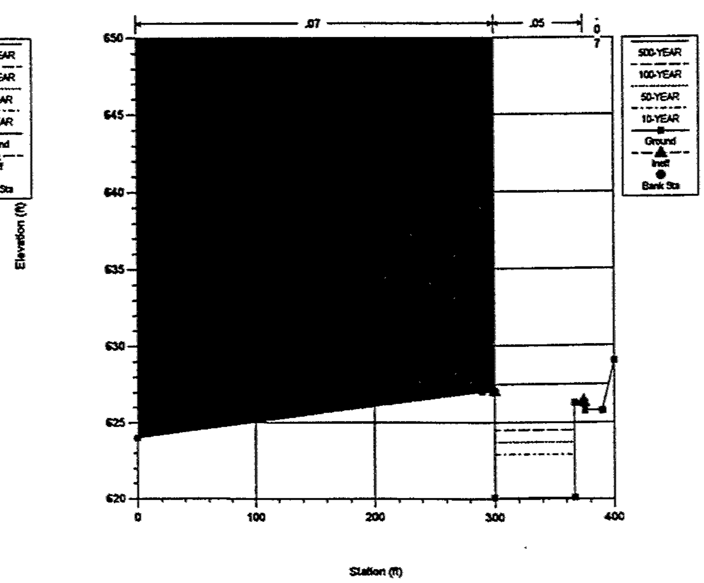
PROVO RIVER Plan: Plan 04 12/10/96
6.393 Channel Flow Only



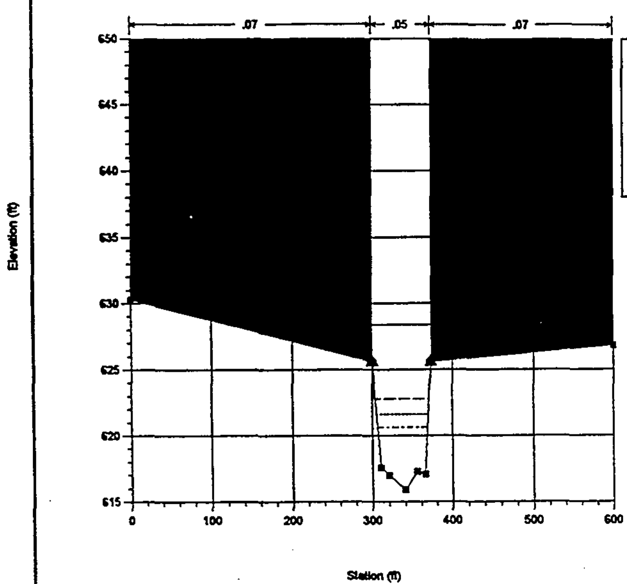
PROVO RIVER Plan: Plan 04 12/10/96
6.071 Channel Flow Only



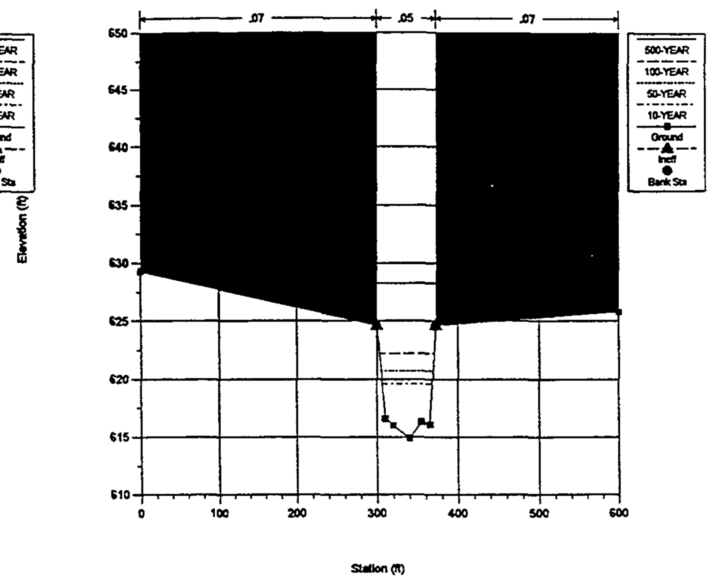
PROVO RIVER Plan: Plan 04 12/10/96
6.052 Channel Flow Only



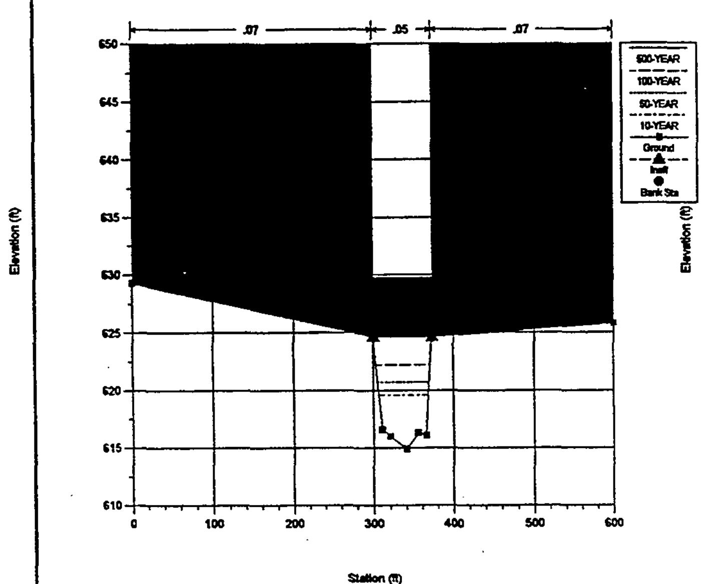
PROVO RIVER Plan: Plan 04 12/10/96
6.049 Channel Flow Only



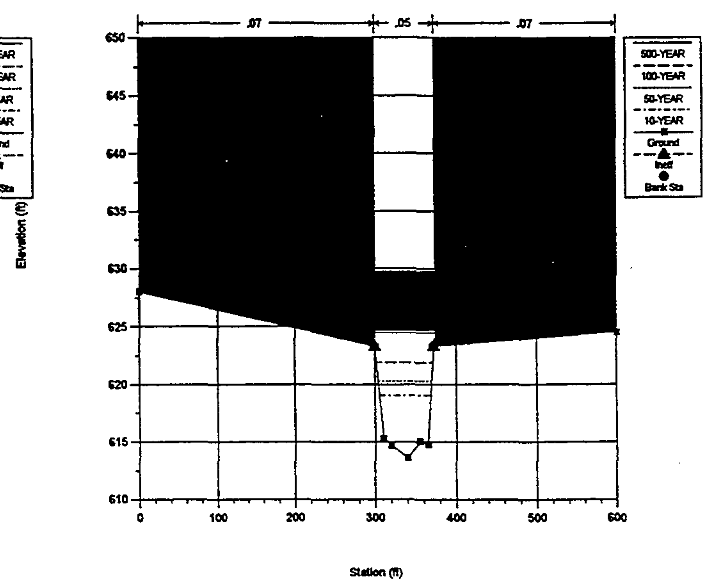
PROVO RIVER Plan: Plan 04 12/10/96
6.036 Channel Flow Only



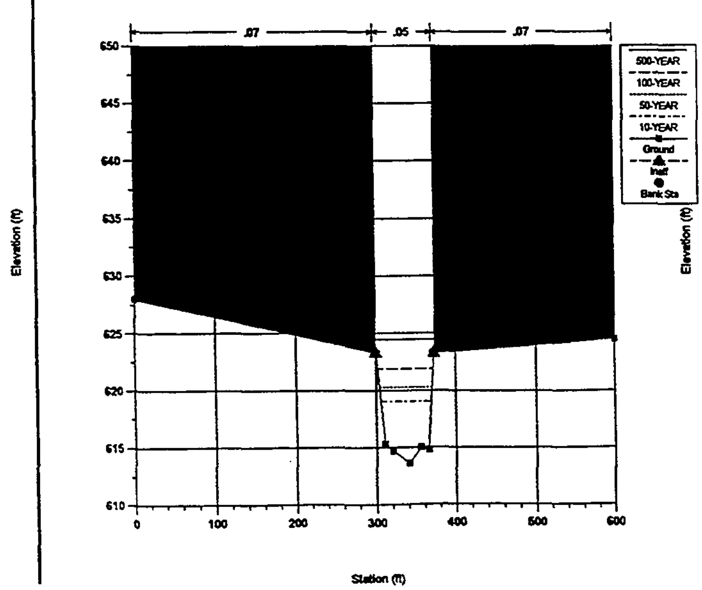
PROVO RIVER Plan: Plan 04 12/10/96
Upstream Inside Bridge # 10 Channel Flow Only



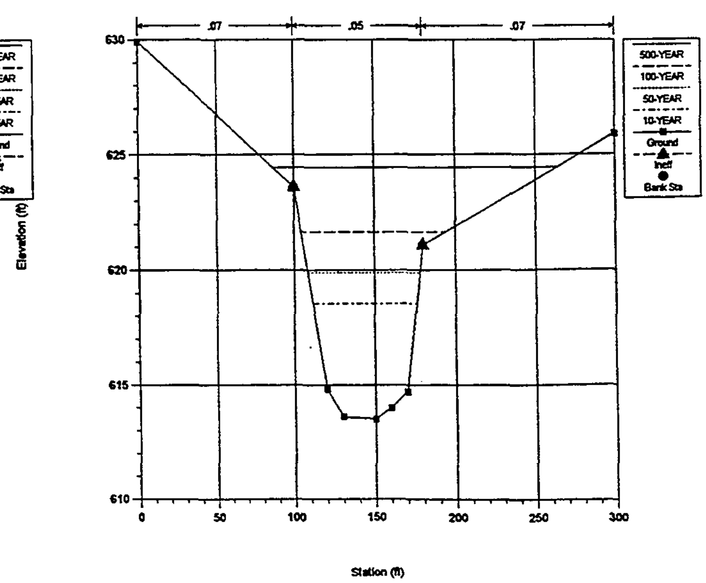
PROVO RIVER Plan: Plan 04 12/10/96
Downstream Inside Bridge # 10 Channel Flow Only



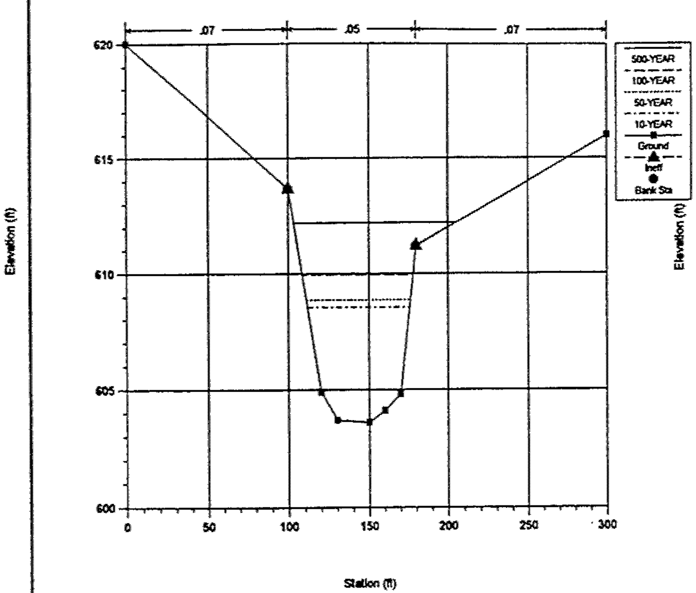
PROVO RIVER Plan: Plan 04 12/10/96
6.022 Channel Flow Only



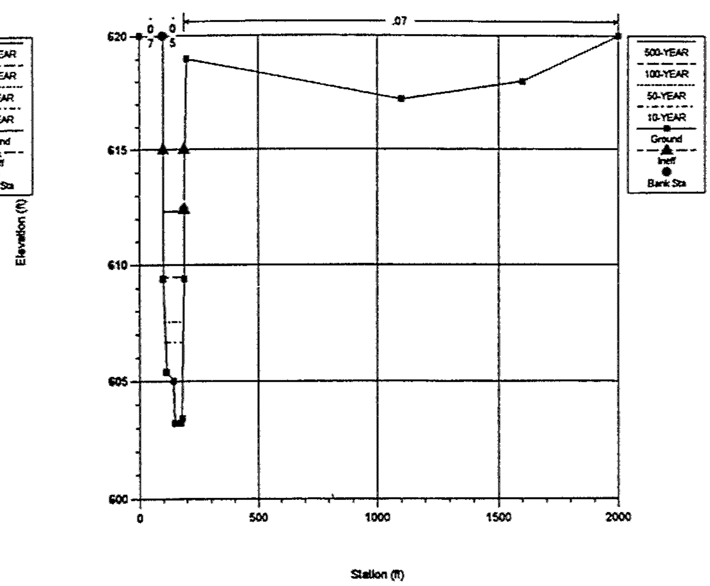
PROVO RIVER Plan: Plan 04 12/10/96
6.012 Channel Flow Only



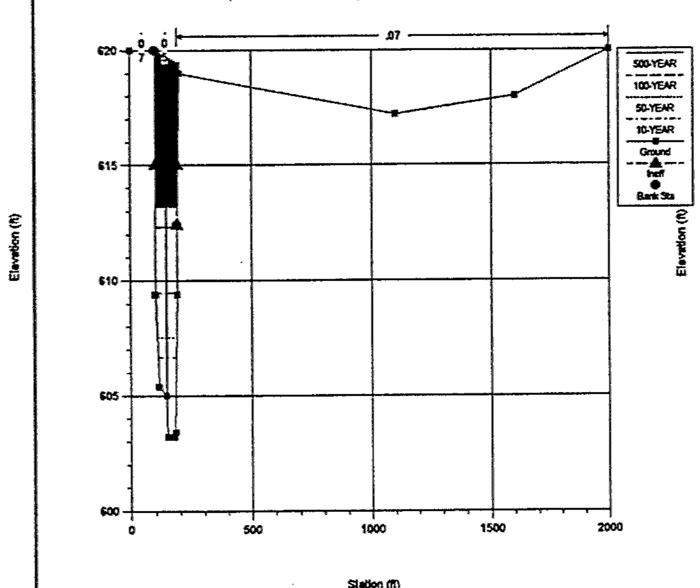
PROVO RIVER Plan: Plan 04 12/10/96
5.805 Channel Flow Only



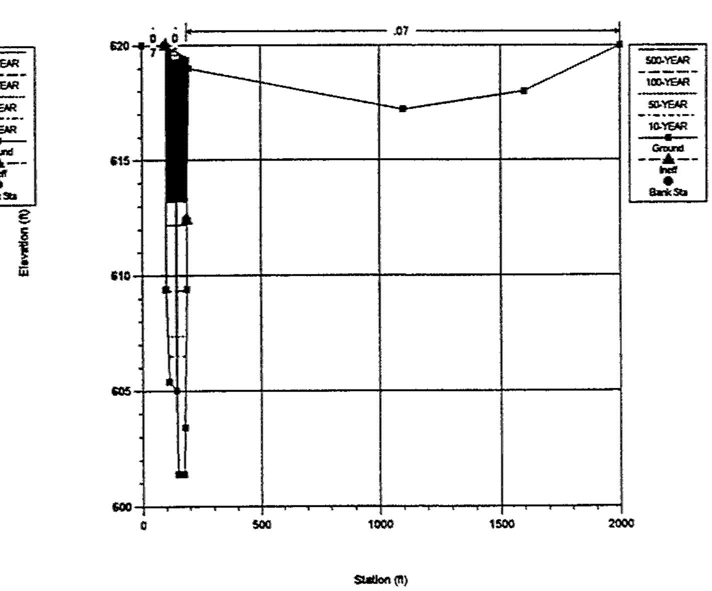
PROVO RIVER Plan: Plan 04 12/10/96
5.796 Channel Flow Only



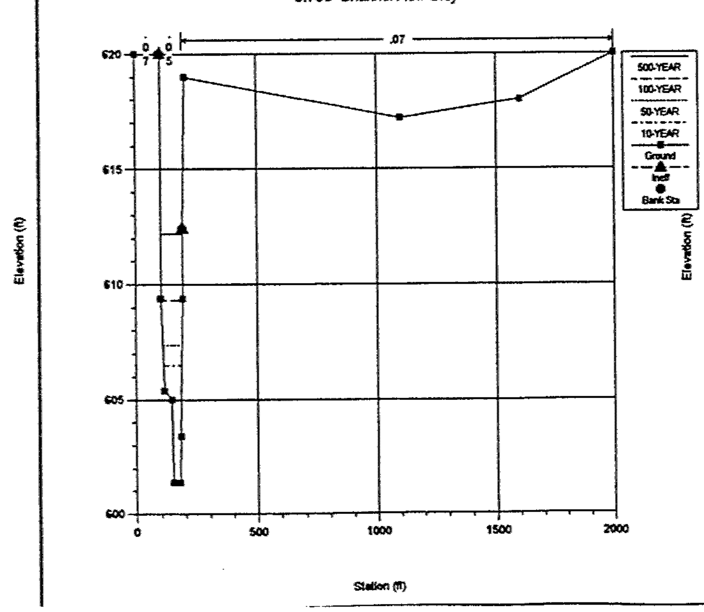
PROVO RIVER Plan: Plan 04 12/10/96
Upstream Inside Bridge # 9 Channel Flow Only



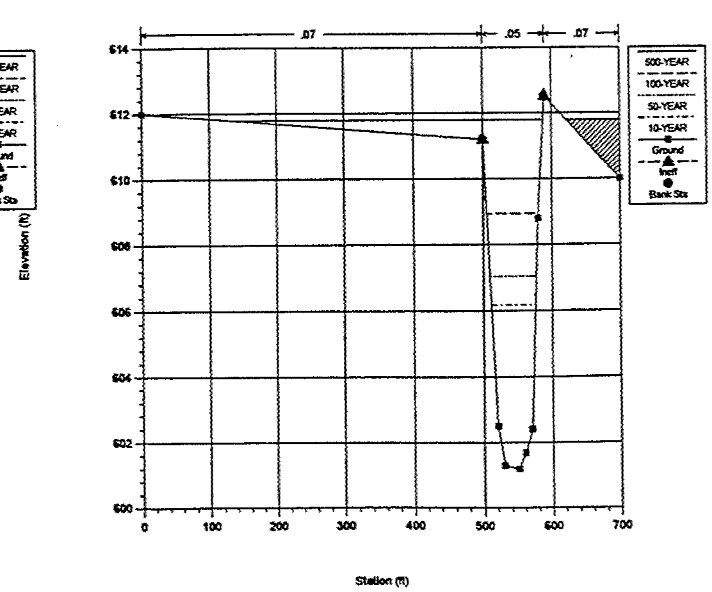
PROVO RIVER Plan: Plan 04 12/10/96
Downstream Inside Bridge # 9 Channel Flow Only



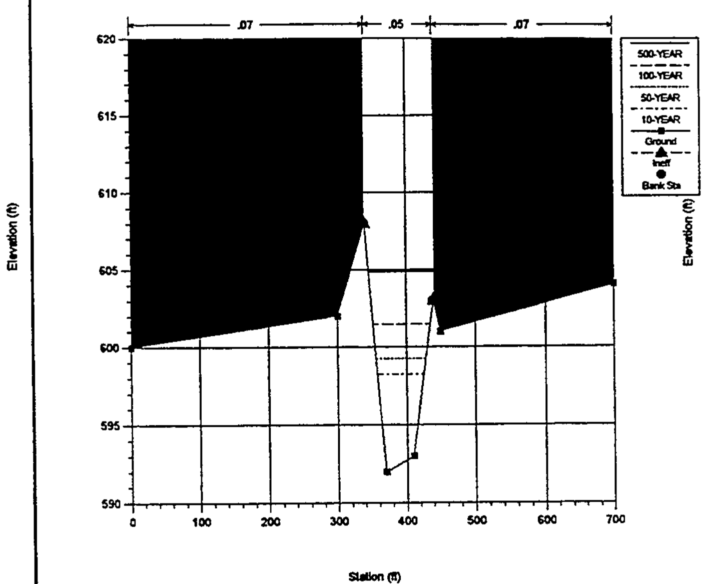
PROVO RIVER Plan: Plan 04 12/10/96
5.756 Channel Flow Only



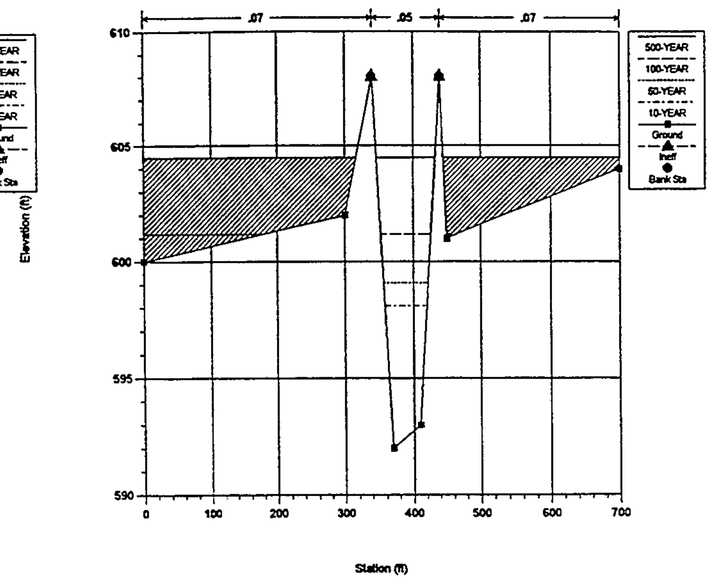
PROVO RIVER Plan: Plan 04 12/10/96
5.749 Channel Flow Only



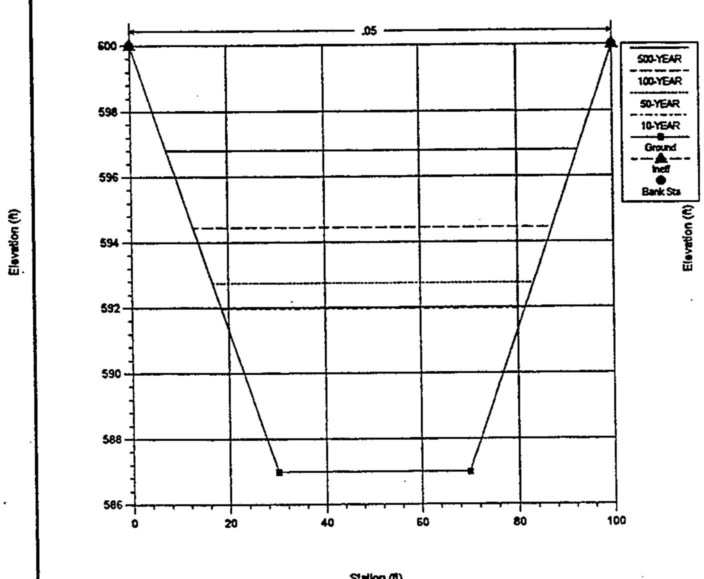
PROVO RIVER Plan: Plan 04 12/10/96
5.525 Channel Flow Only



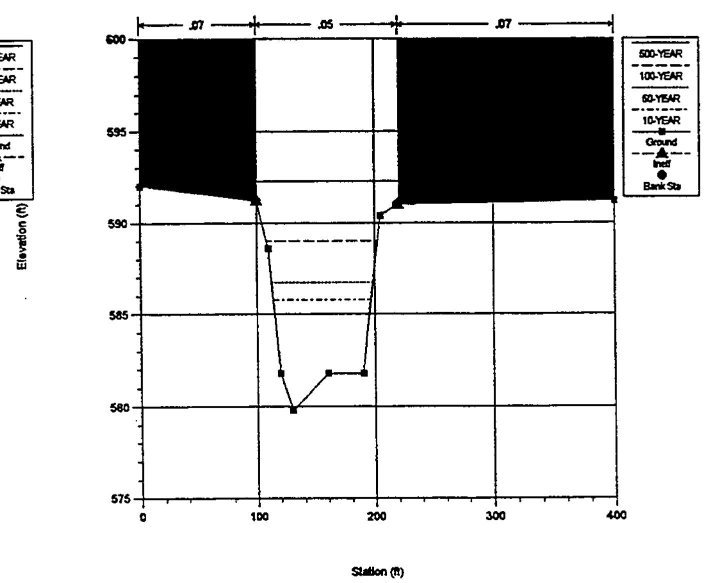
PROVO RIVER Plan: Plan 04 12/10/96
5.524 Channel Flow Only



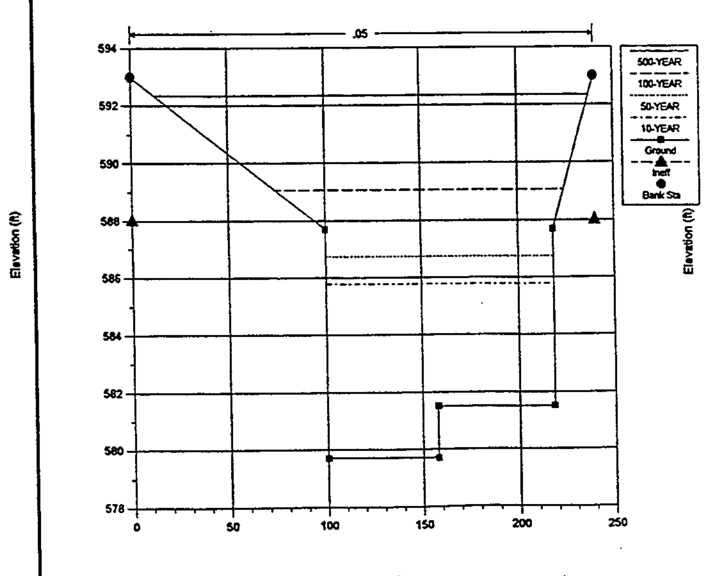
PROVO RIVER Plan: Plan 04 12/10/96
5.373 Channel Flow Only



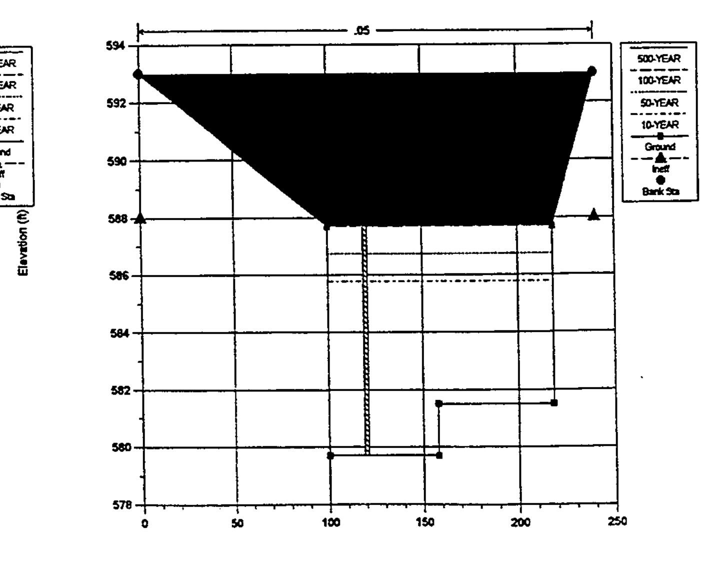
PROVO RIVER Plan: Plan 04 12/10/96
5.184 Channel Flow Only



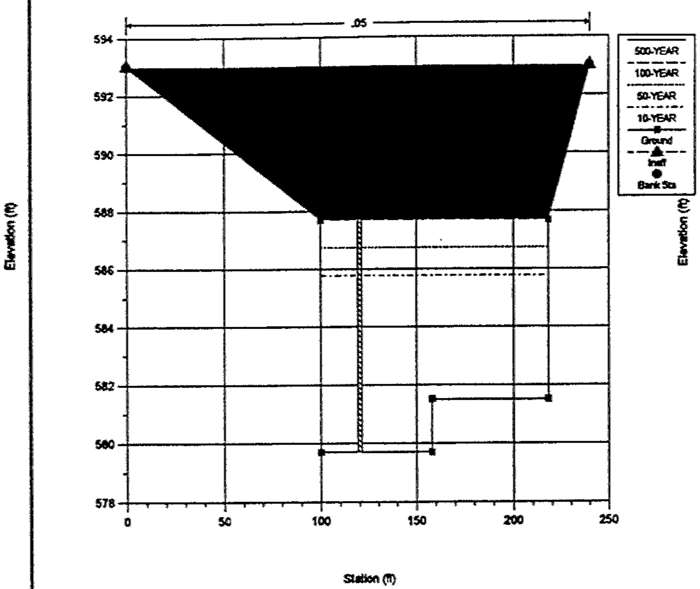
PROVO RIVER Plan: Plan 04 12/10/96
5.165 Channel Flow Only



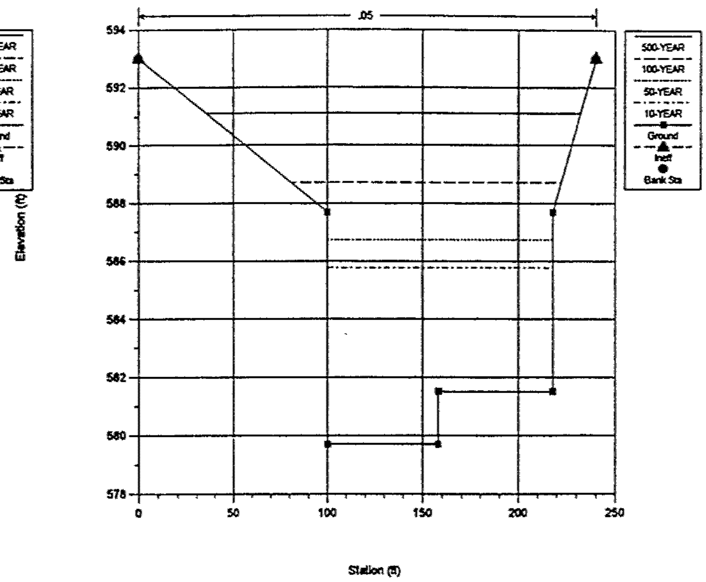
PROVO RIVER Plan: Plan 04 12/10/96
Upstream Inside Bridge # 8 Channel Flow Only



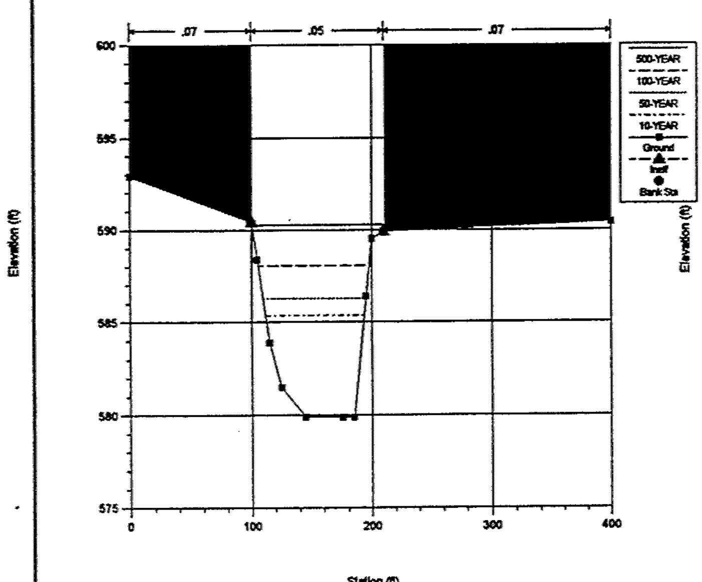
PROVO RIVER Plan: Plan 04 12/10/96
Downstream Inside Bridge # 8 Channel Flow Only



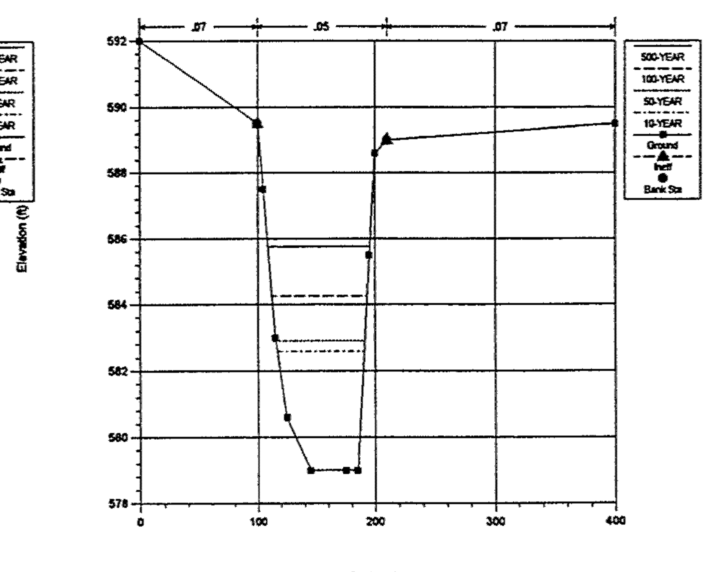
PROVO RIVER Plan: Plan 04 12/10/96
5.148 Channel Flow Only



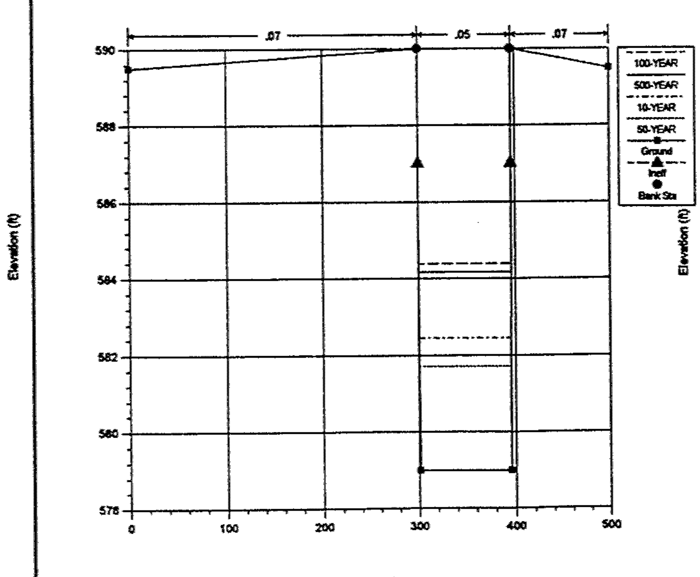
PROVO RIVER Plan: Plan 04 12/10/96
5.136 Channel Flow Only



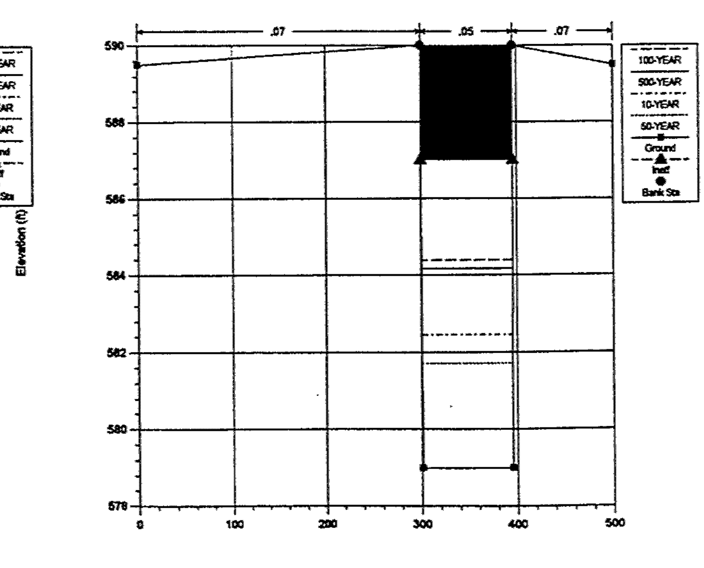
PROVO RIVER Plan: Plan 04 12/10/96
5.084 Channel Flow Only



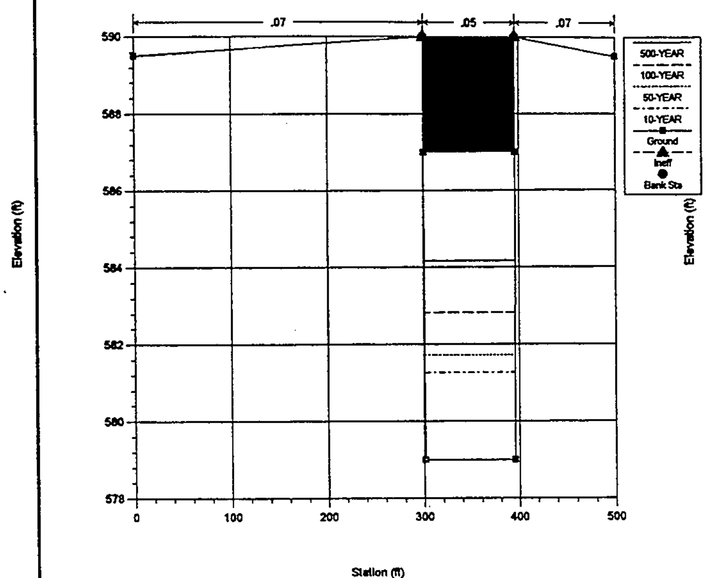
PROVO RIVER Plan: Plan 04 12/10/96
5.075 Channel Flow Only



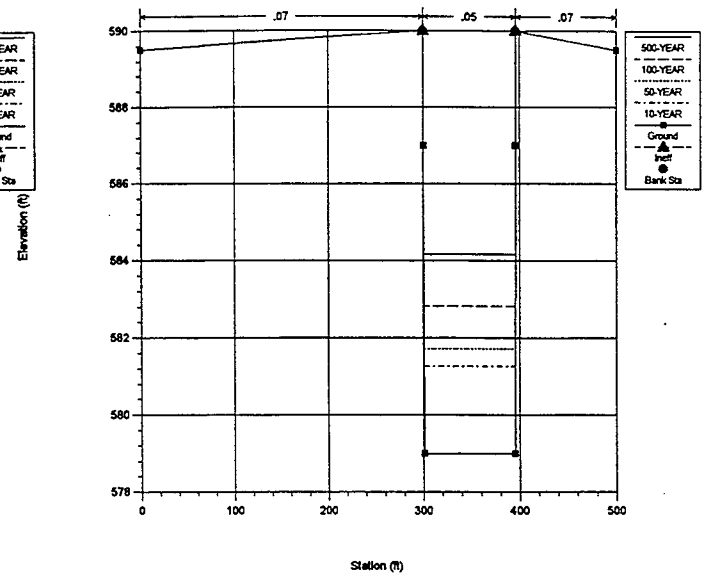
PROVO RIVER Plan: Plan 04 12/10/96
Upstream Inside Bridge # 7 Channel Flow Only



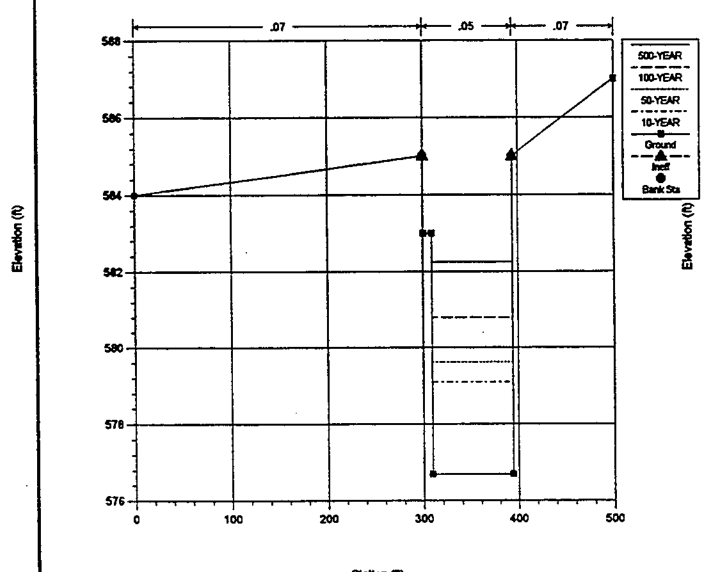
PROVO RIVER Plan: Plan 04 12/10/96
Downstream Inside Bridge # 7 Channel Flow Only



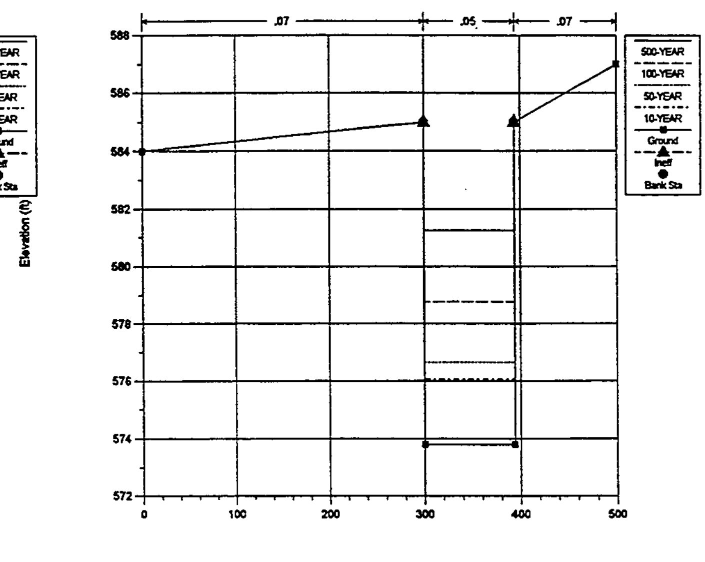
PROVO RIVER Plan: Plan 04 12/10/96
5.067 Channel Flow Only



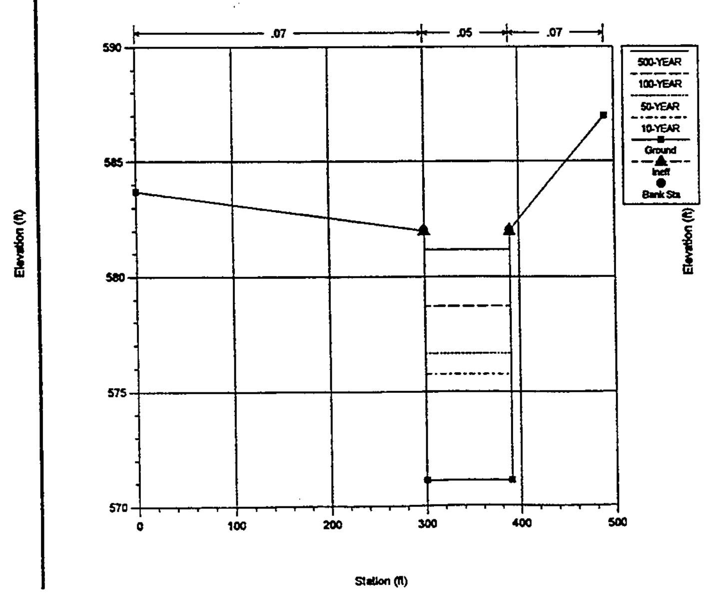
PROVO RIVER Plan: Plan 04 12/10/96
5.054 Channel Flow Only



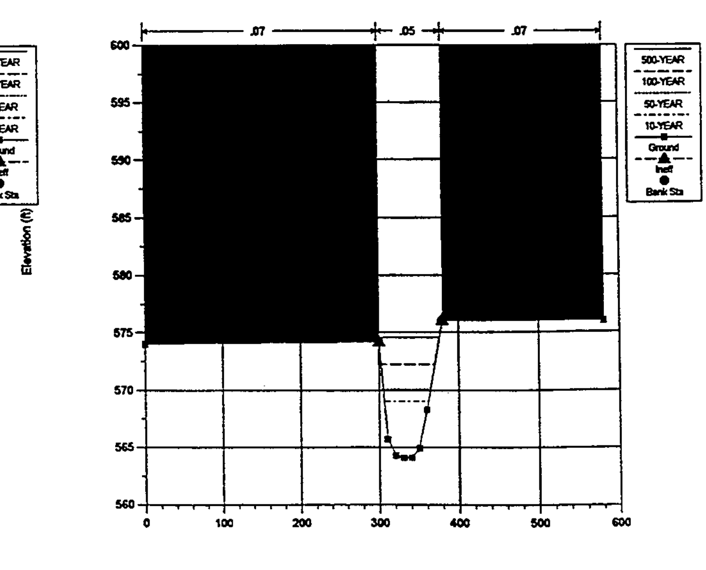
PROVO RIVER Plan: Plan 04 12/10/96
5.052 Channel Flow Only



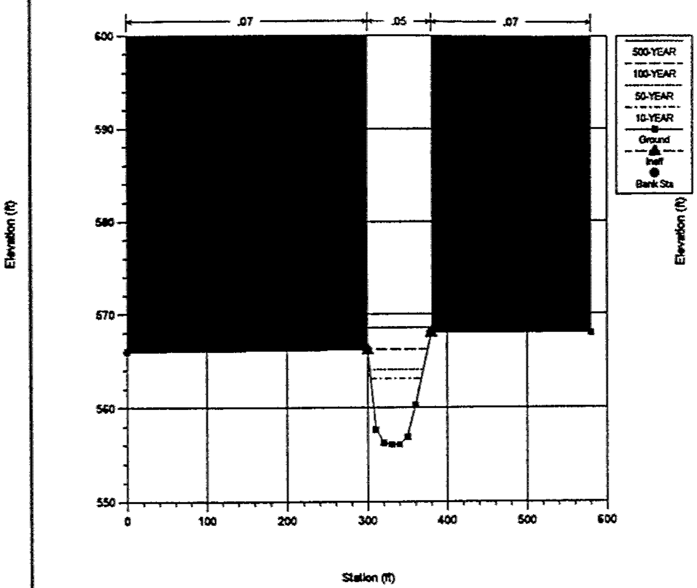
PROVO RIVER Plan: Plan 04 12/10/96
5.034 Channel Flow Only



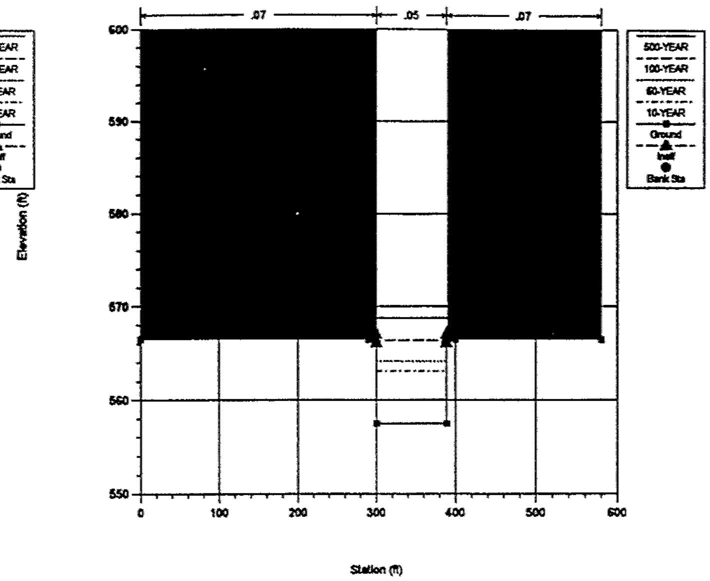
PROVO RIVER Plan: Plan 04 12/10/96
4.838 Channel Flow Only



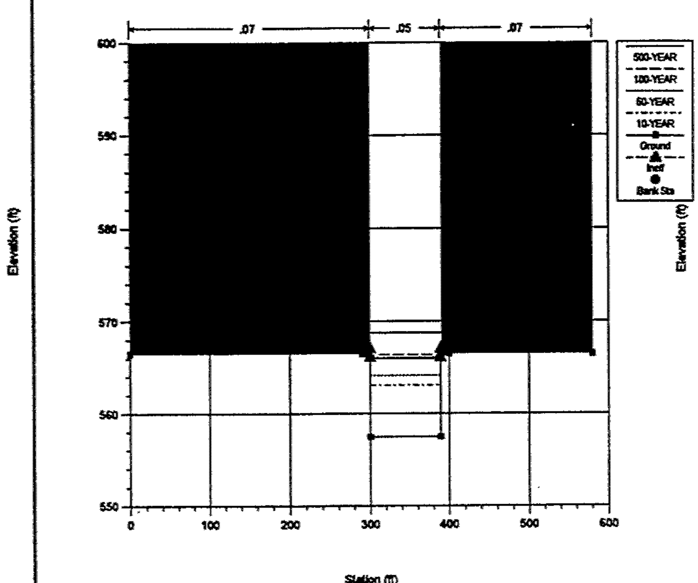
PROVO RIVER Plan: Plan 04 12/10/96
4.649 Channel Flow Only



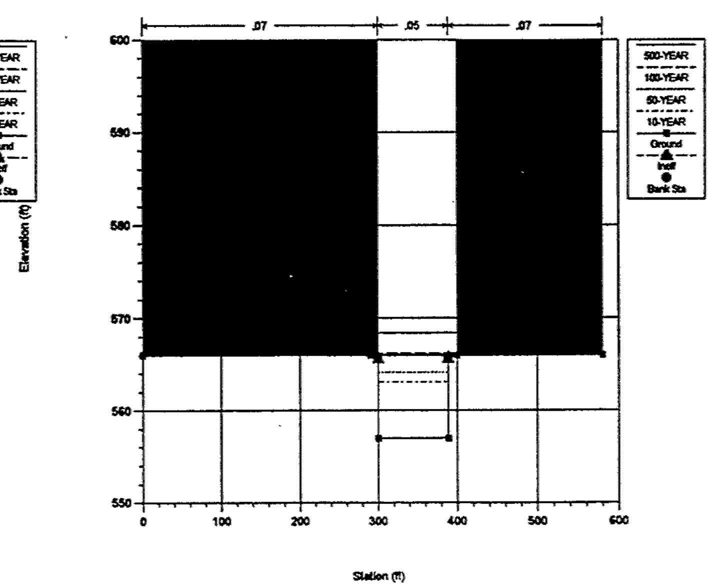
PROVO RIVER Plan: Plan 04 12/10/96
4.639 Channel Flow Only



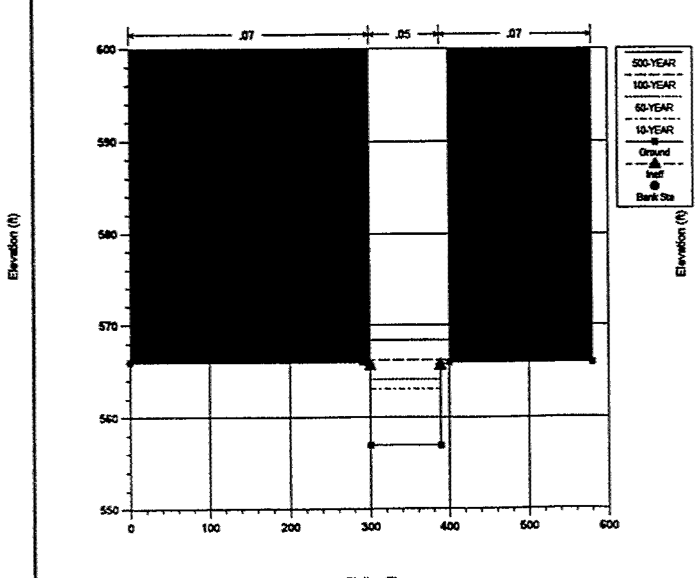
PROVO RIVER Plan: Plan 04 12/10/96
Upstream Inside Bridge # 6 Channel Flow Only



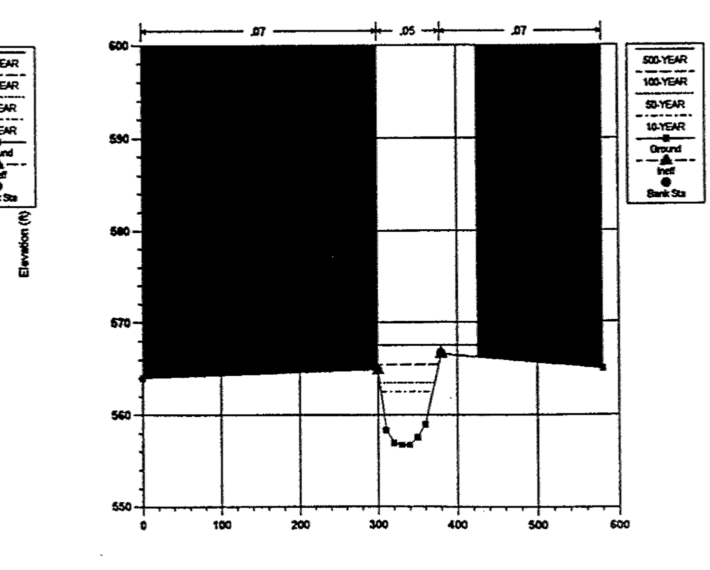
PROVO RIVER Plan: Plan 04 12/10/96
Downstream Inside Bridge # 6 Channel Flow Only



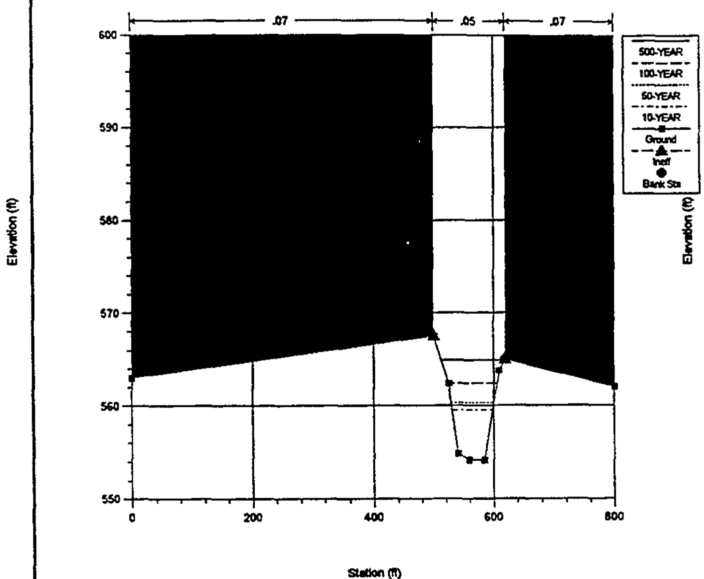
PROVO RIVER Plan: Plan 04 12/10/96
4.636 Channel Flow Only



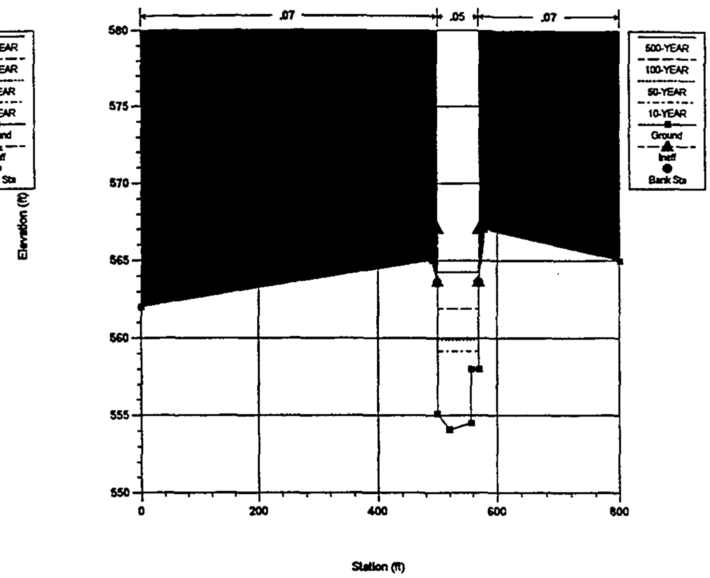
PROVO RIVER Plan: Plan 04 12/10/96
4.63 Channel Flow Only



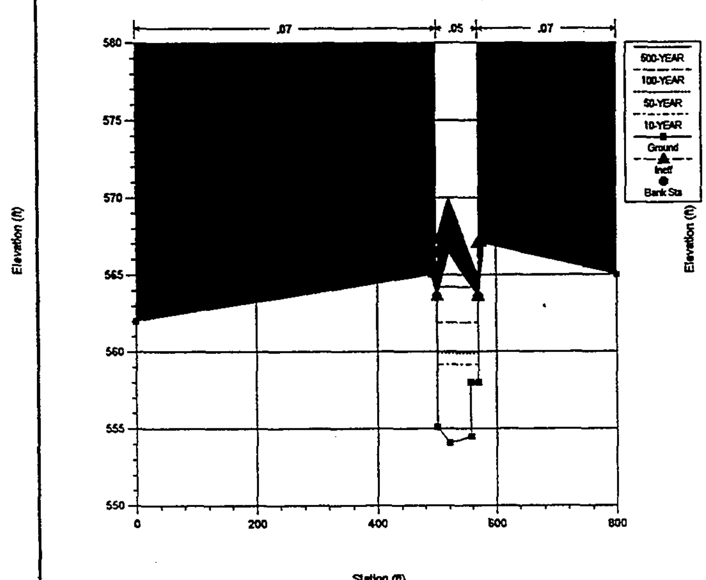
PROVO RIVER Plan: Plan 04 12/10/96
4.539 Channel Flow Only



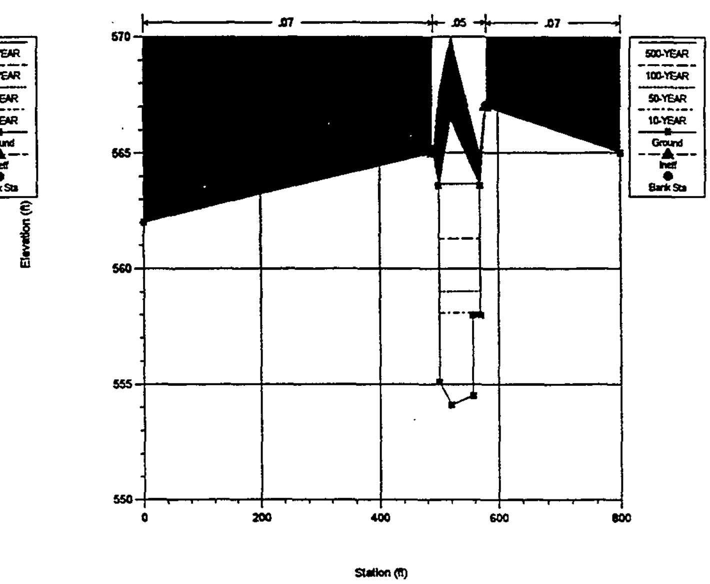
PROVO RIVER Plan: Plan 04 12/10/96
4.53 Channel Flow Only



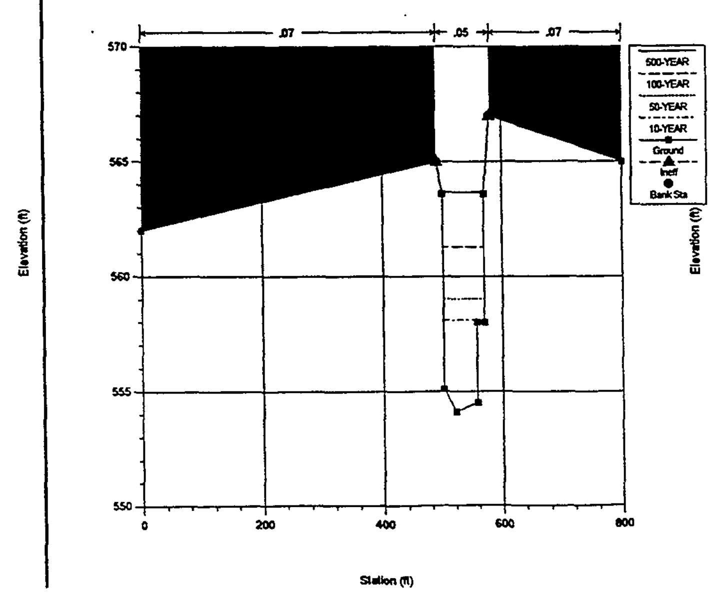
PROVO RIVER Plan: Plan 04 12/10/96
Upstream Inside Bridge # 5 Channel Flow Only



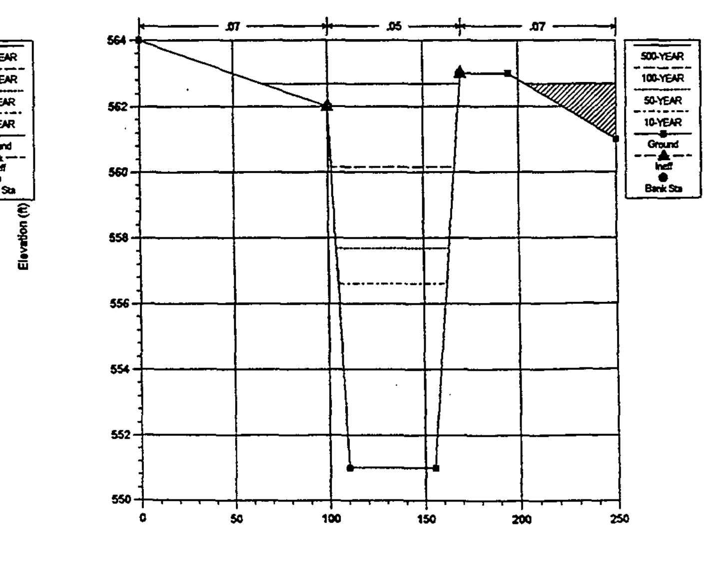
PROVO RIVER Plan: Plan 04 12/10/96
Downstream Inside Bridge # 5 Channel Flow Only



PROVO RIVER Plan: Plan 04 12/10/96
4.522 Channel Flow Only



PROVO RIVER Plan: Plan 04 12/10/96
4.487 Channel Flow Only



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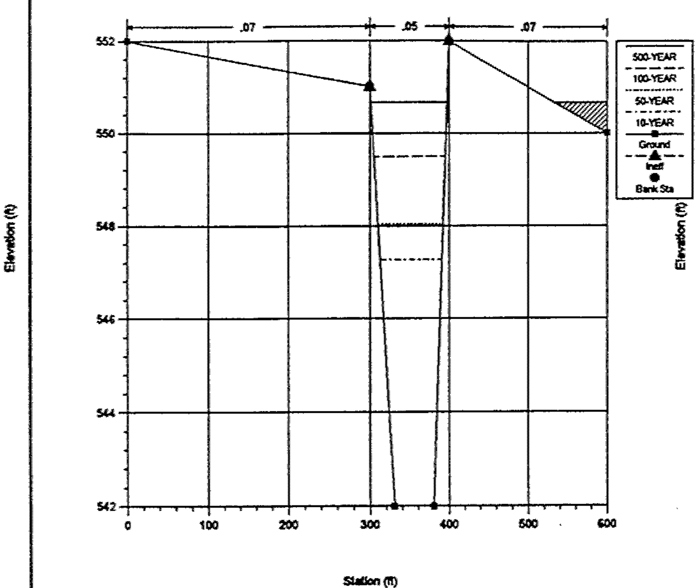
4.24 Channel Flow Only



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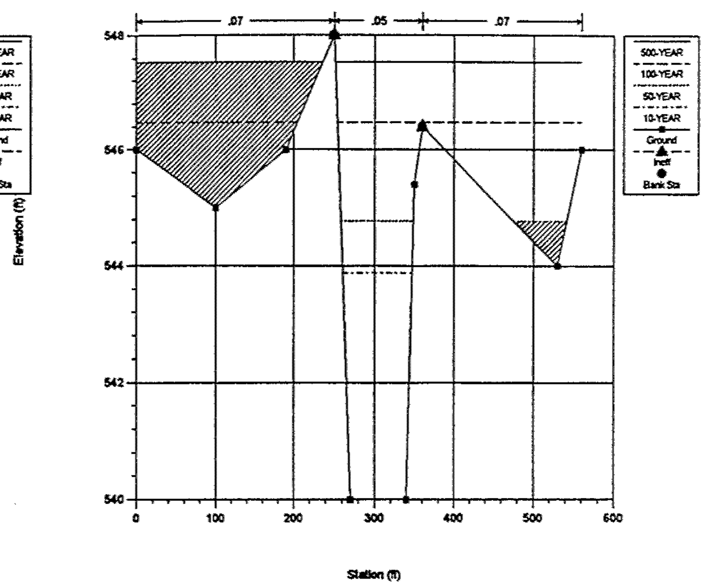

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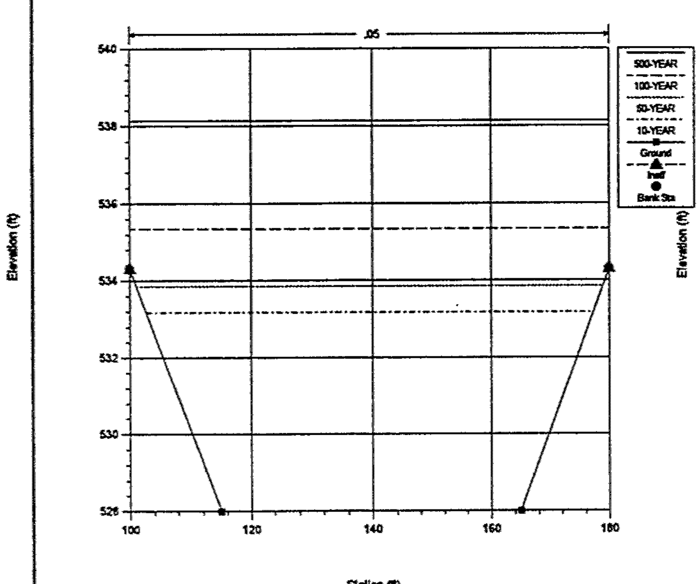

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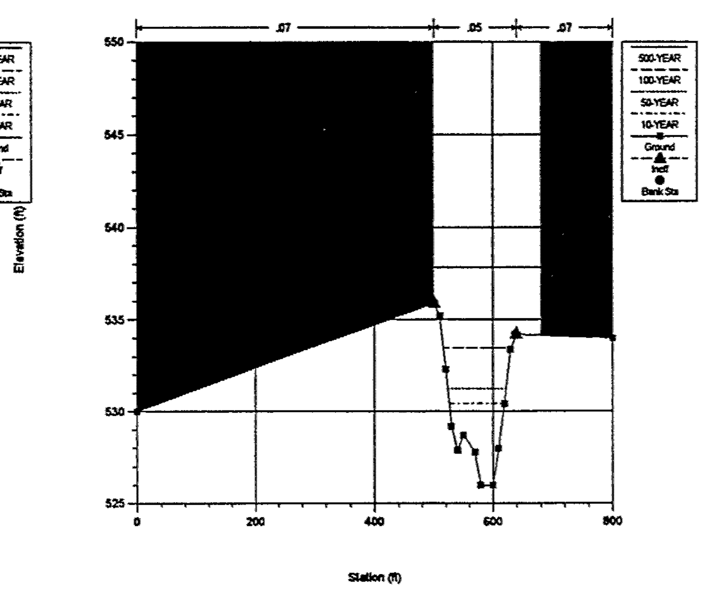

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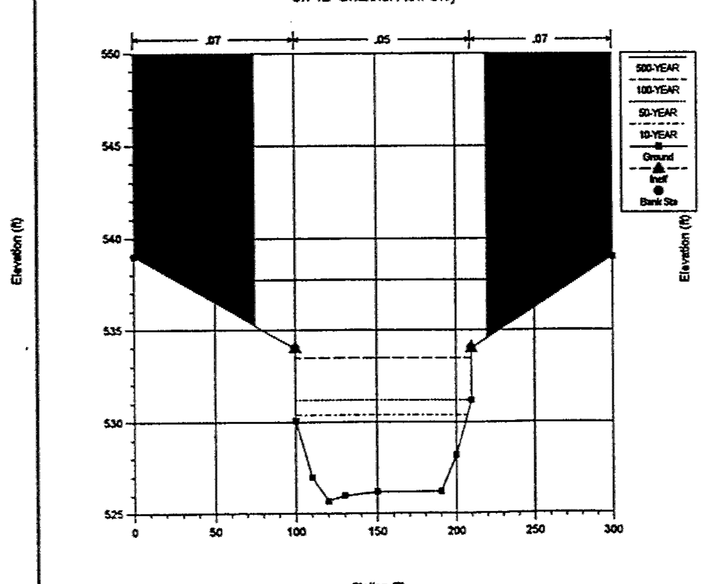

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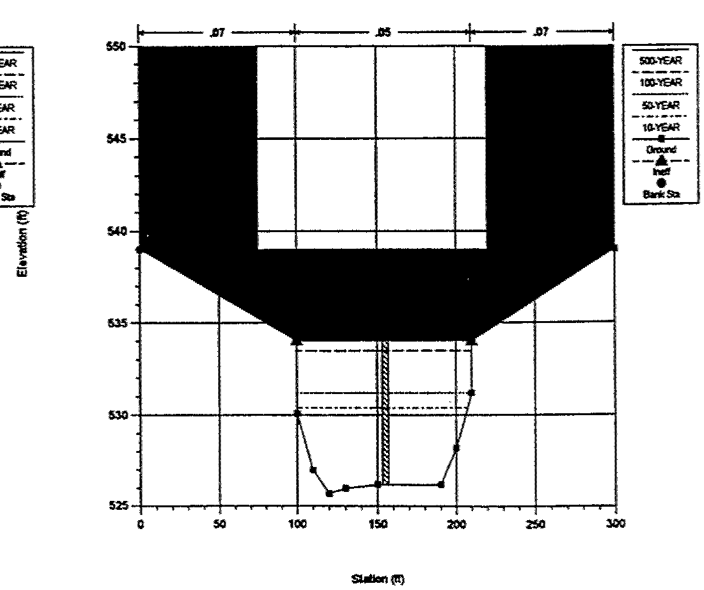
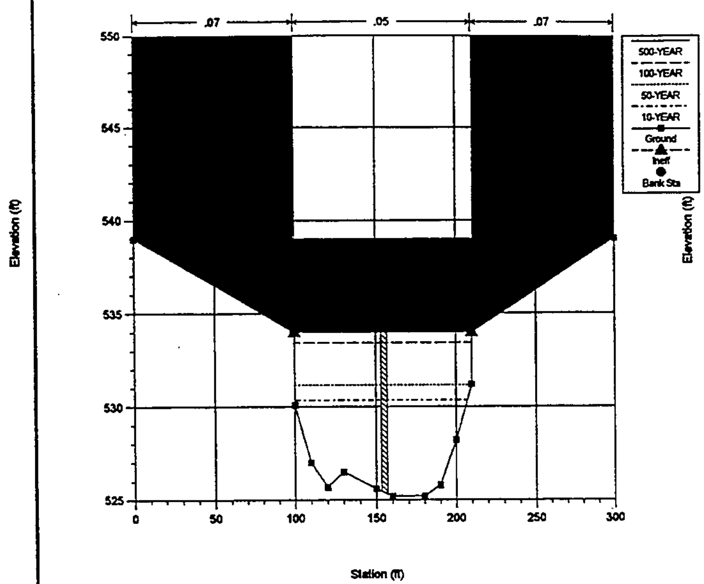
Upstream Inside Bridge # 4 Channel Flow Only



PROVO RIVER Plan: Plan 04 12/10/96
Downstream Inside Bridge # 4 Channel Flow Only



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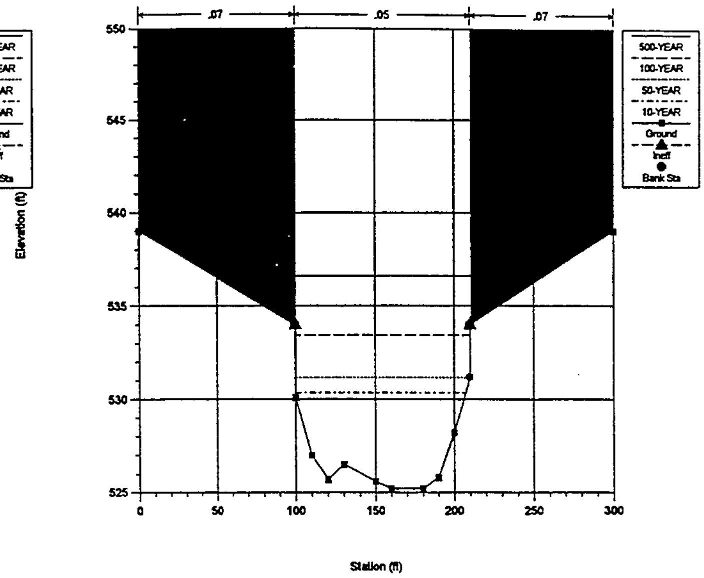

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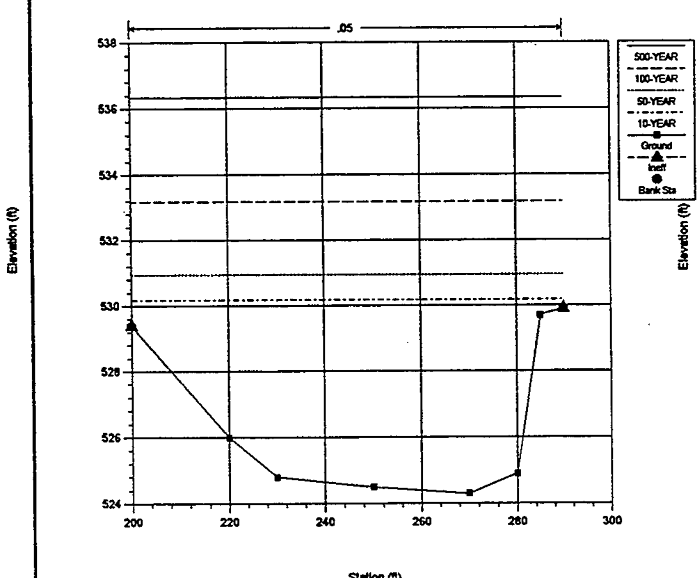

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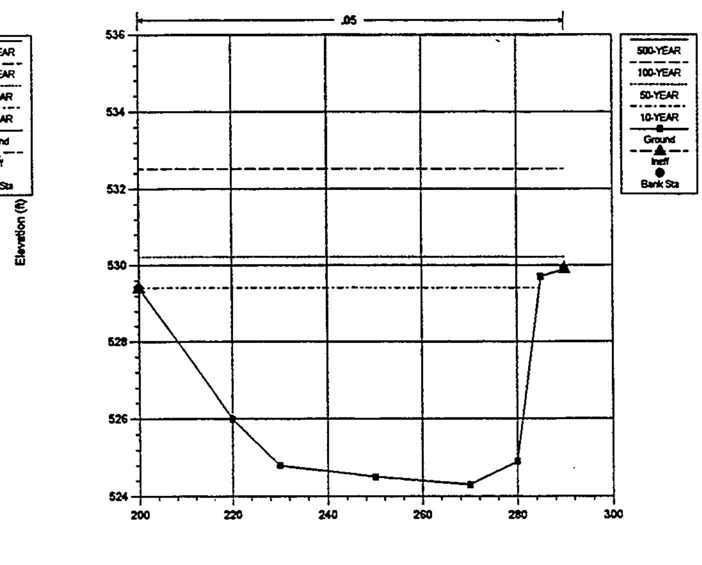

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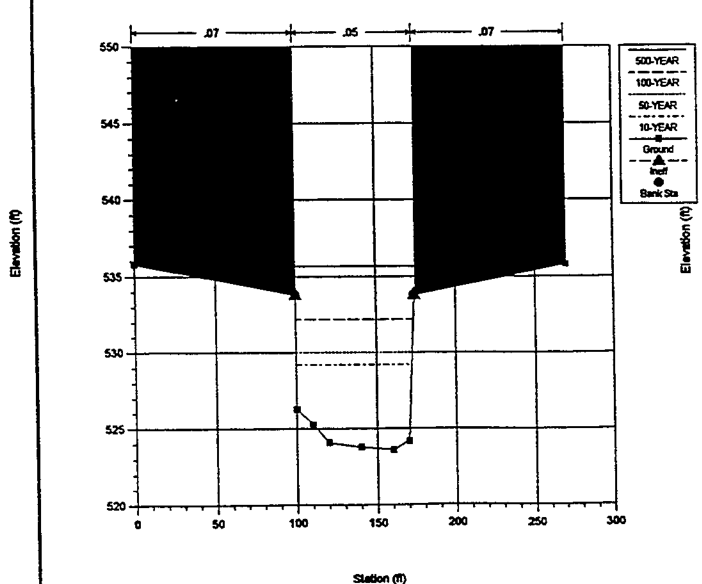

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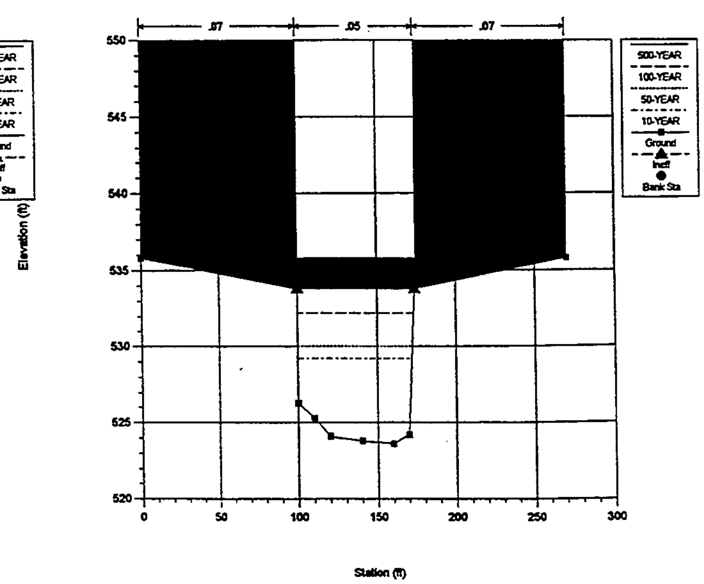
Upstream Inside Bridge # 3 Channel Flow Only



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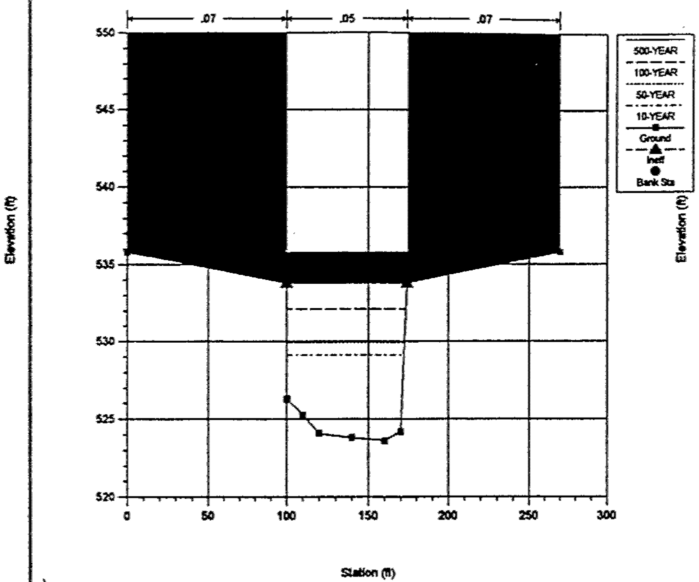
Downstream Inside Bridge # 3 Channel Flow Only



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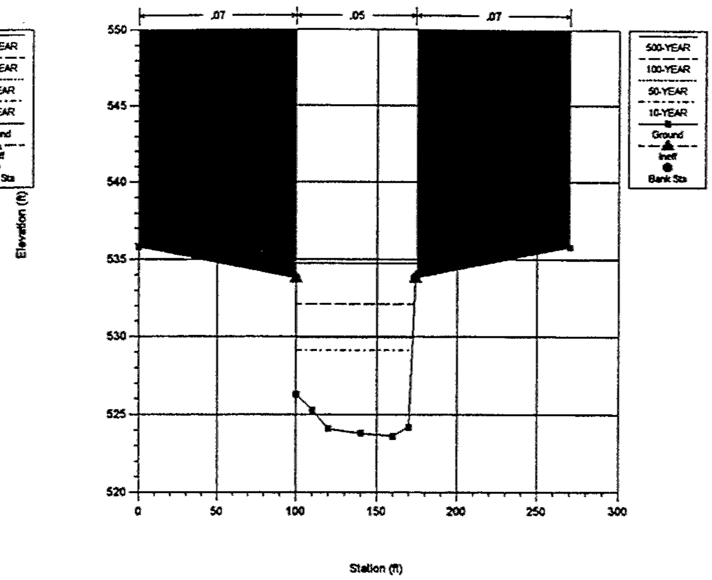

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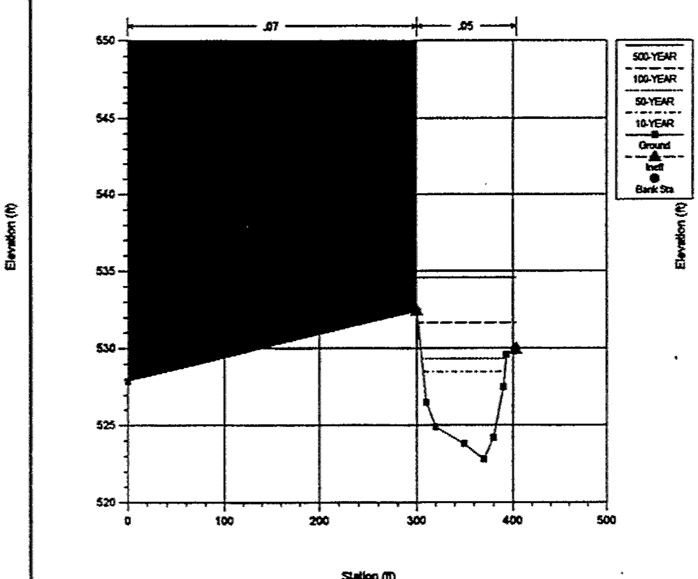

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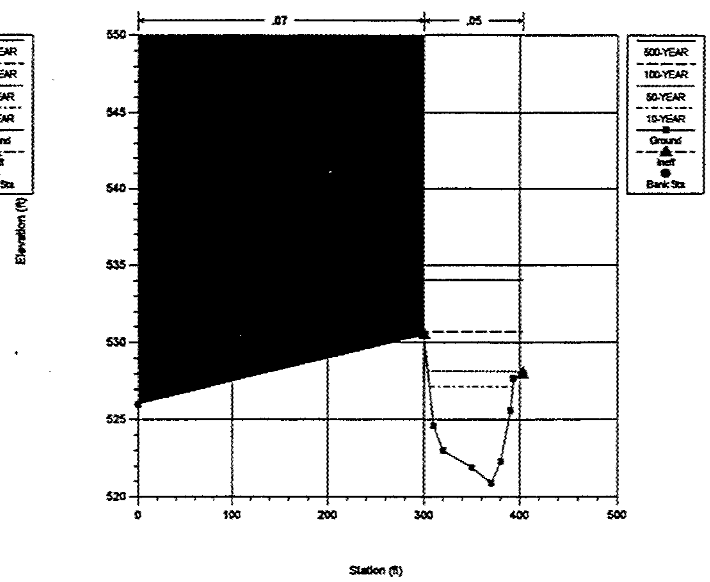

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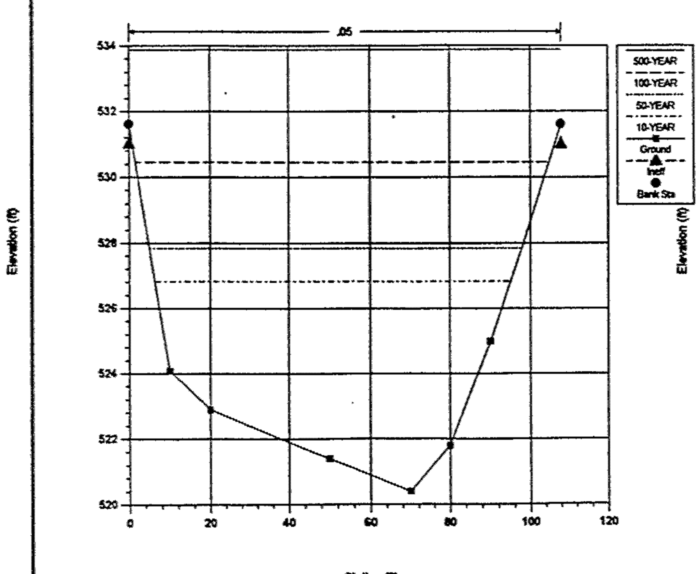

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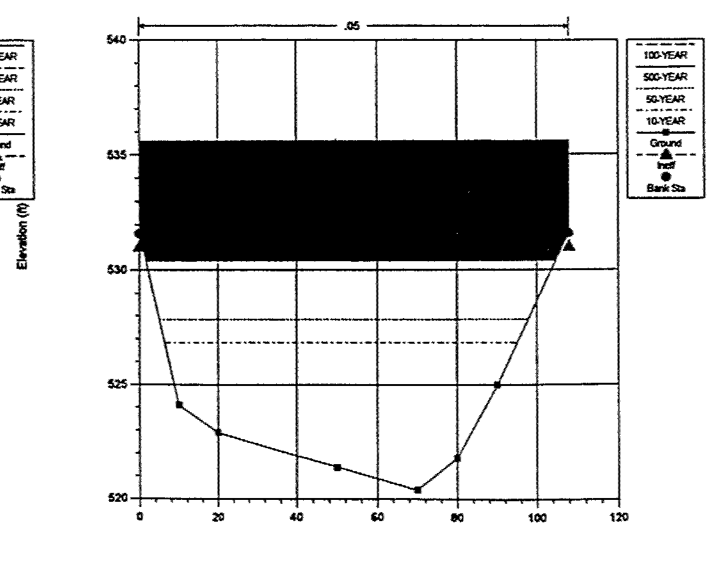
Upstream Inside Bridge # 2 Channel Flow Only



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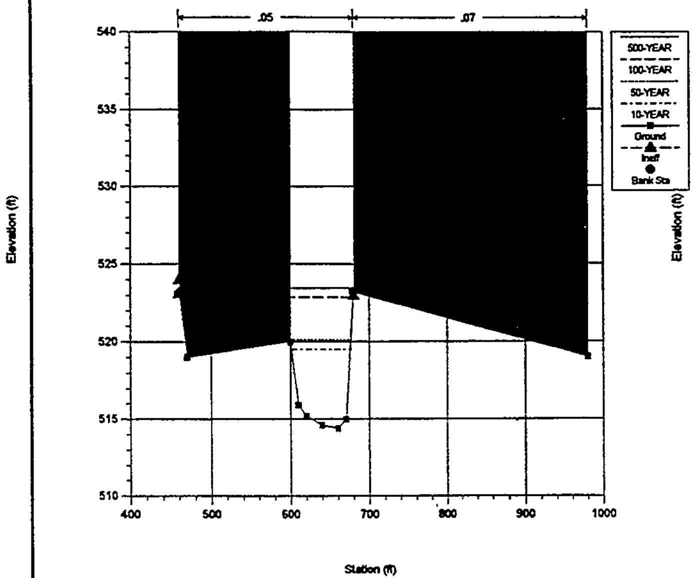

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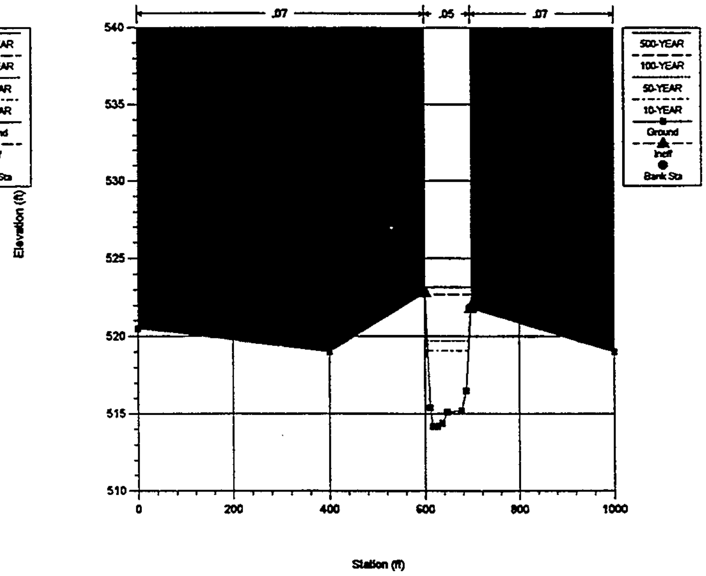

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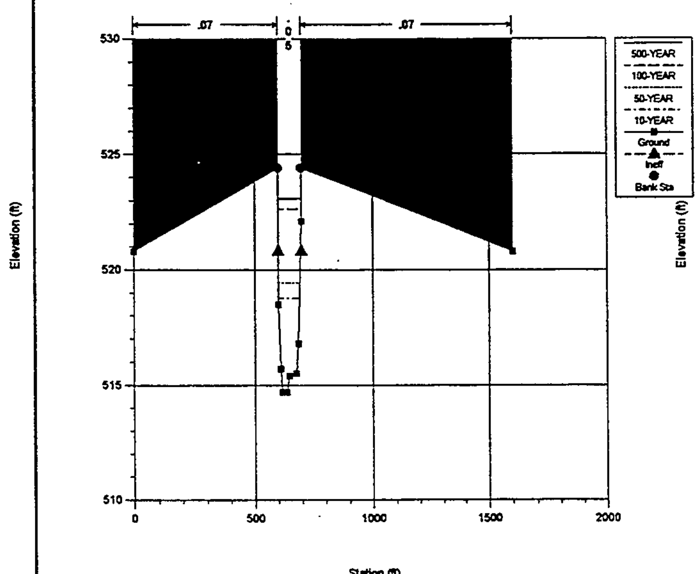
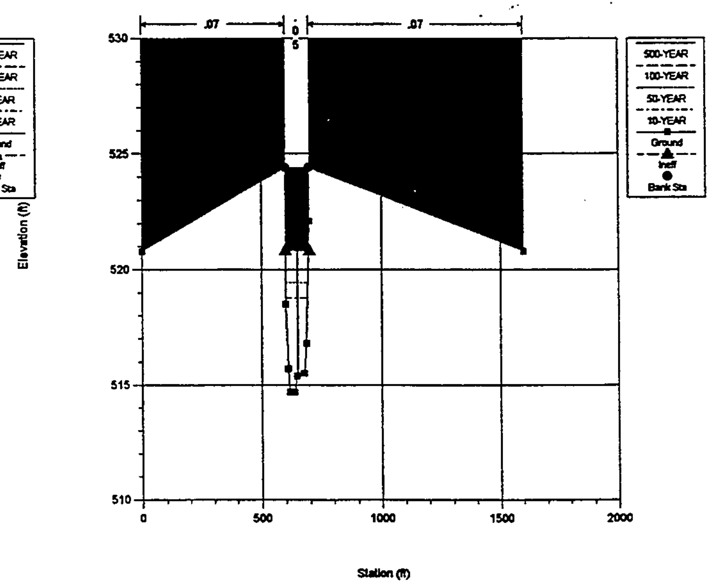
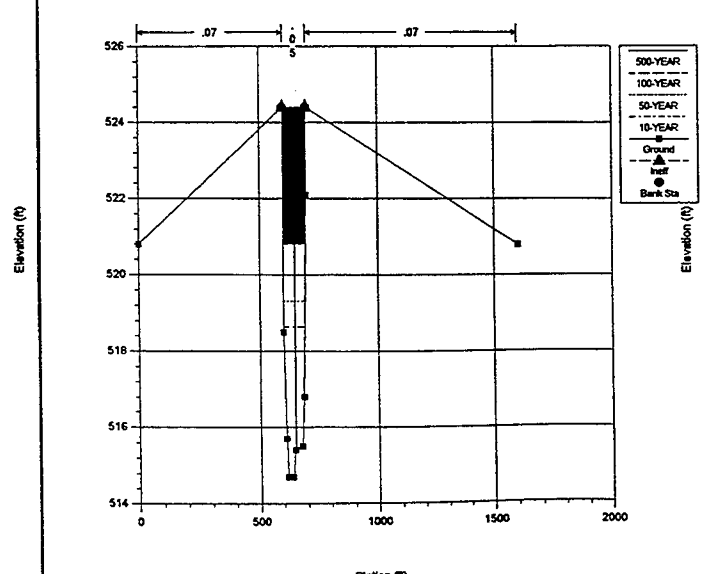


PROVO RIVER Plan: Plan 04 12/10/96
Upstream Inside Bridge # 1 Channel Flow Only



PROVO RIVER Plan: Plan 04 12/10/96
Downstream Inside Bridge # 1 Channel Flow Only



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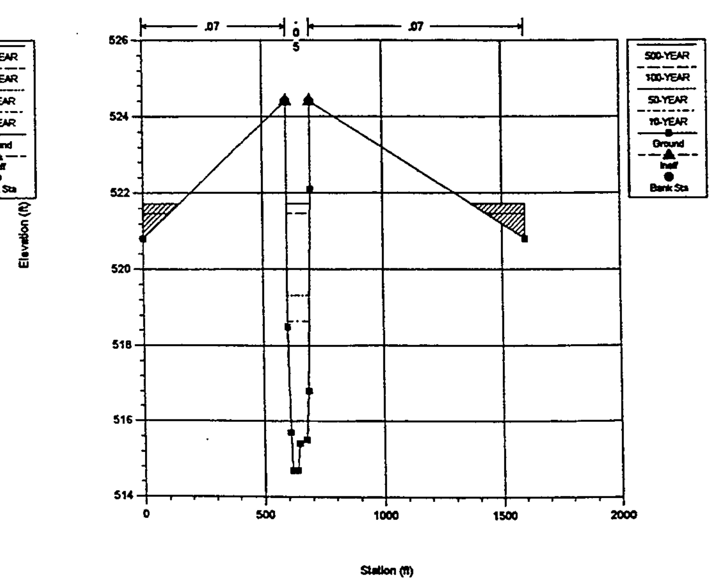

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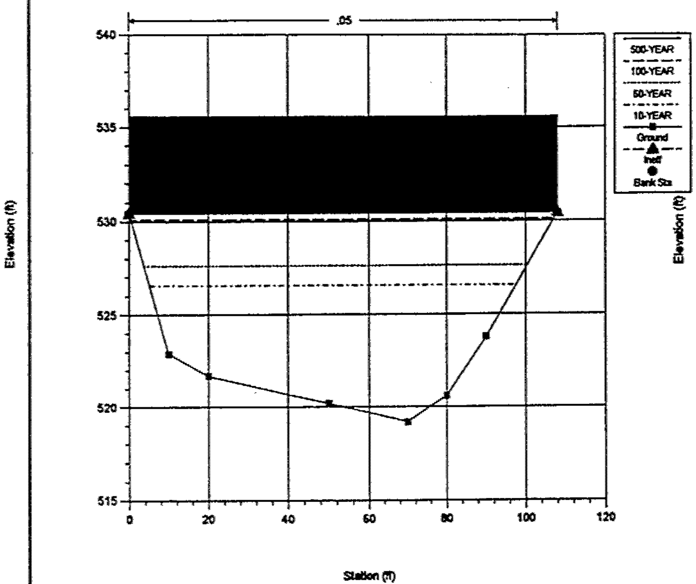
Downstream Inside Bridge # 2 Channel Flow Only



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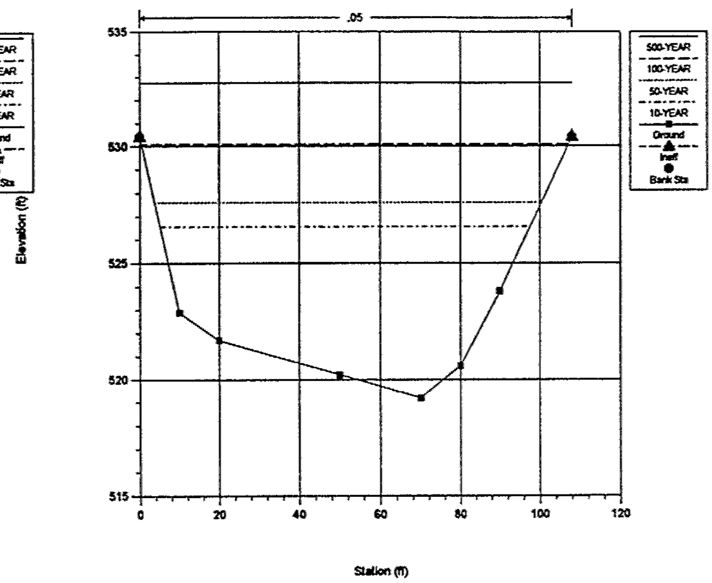

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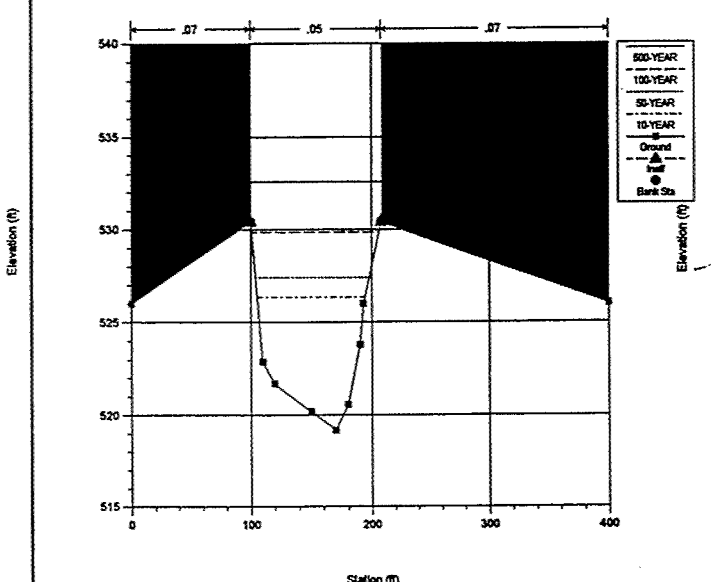

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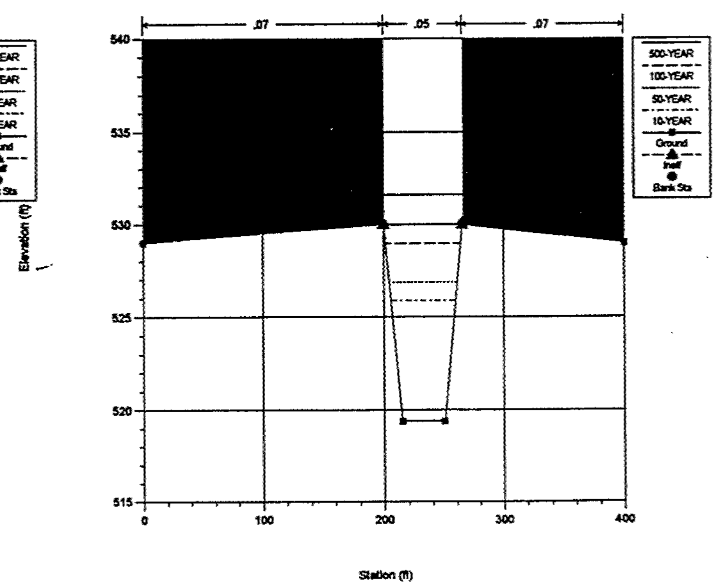

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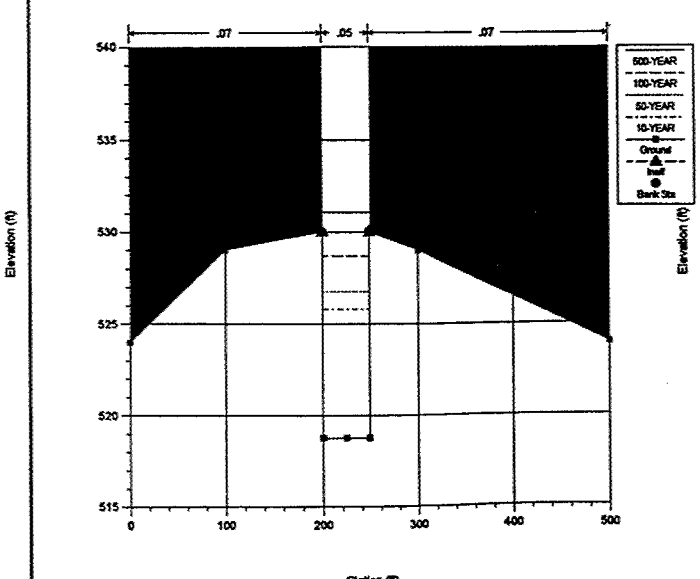

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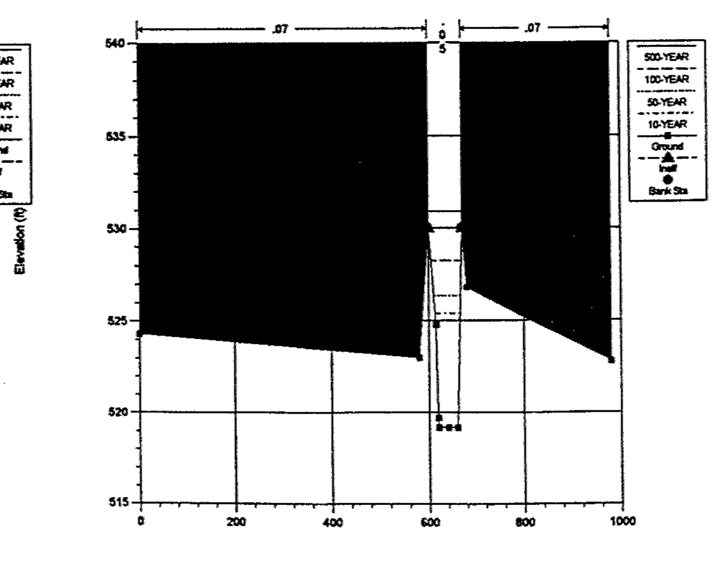

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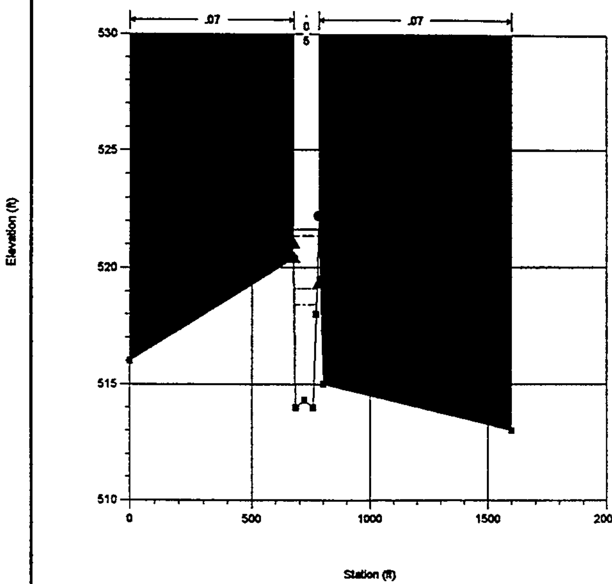

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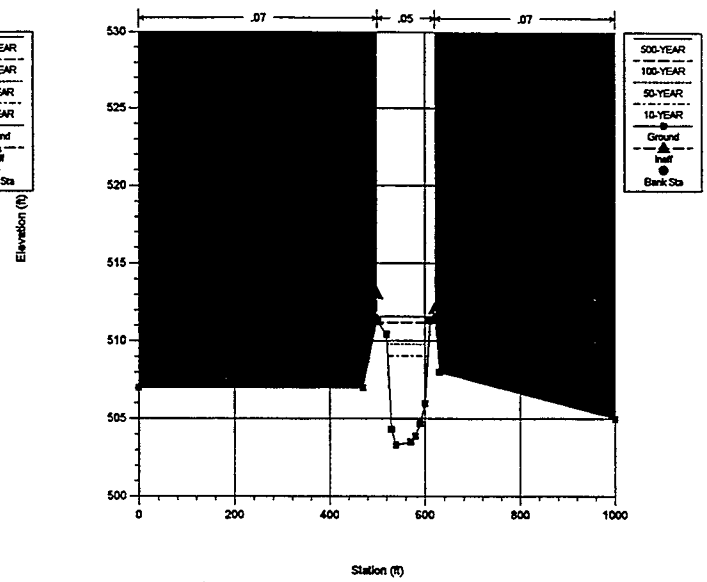

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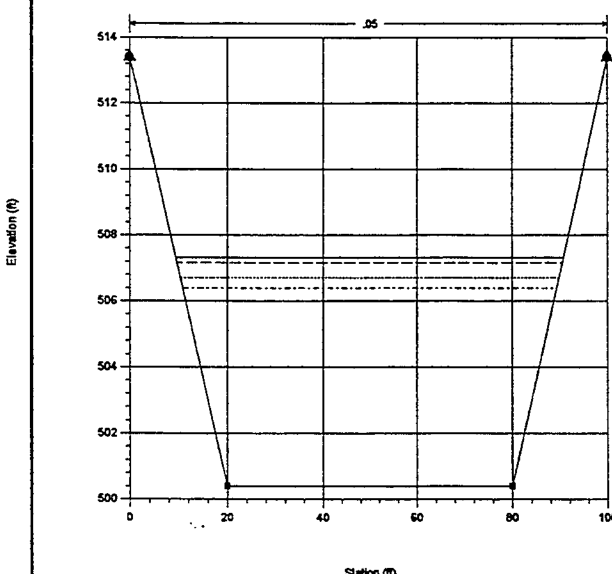

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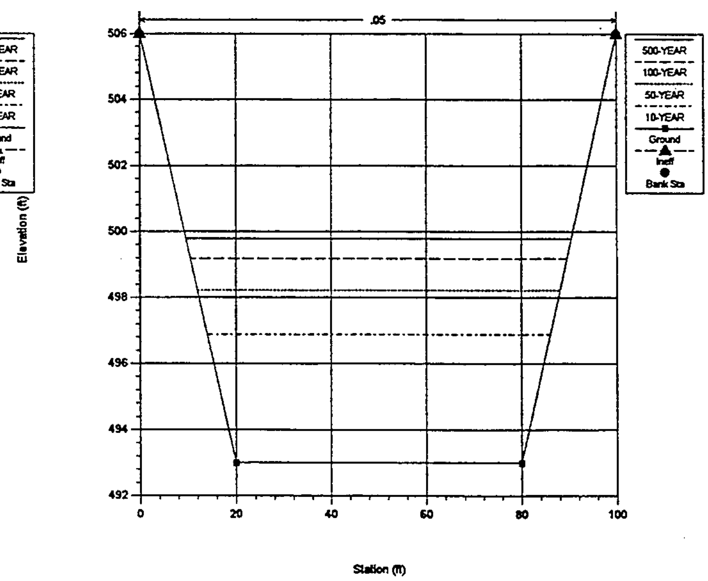

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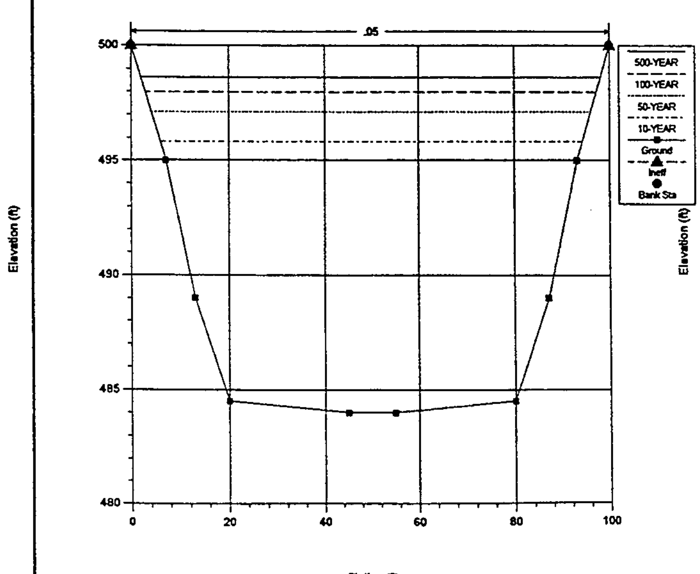

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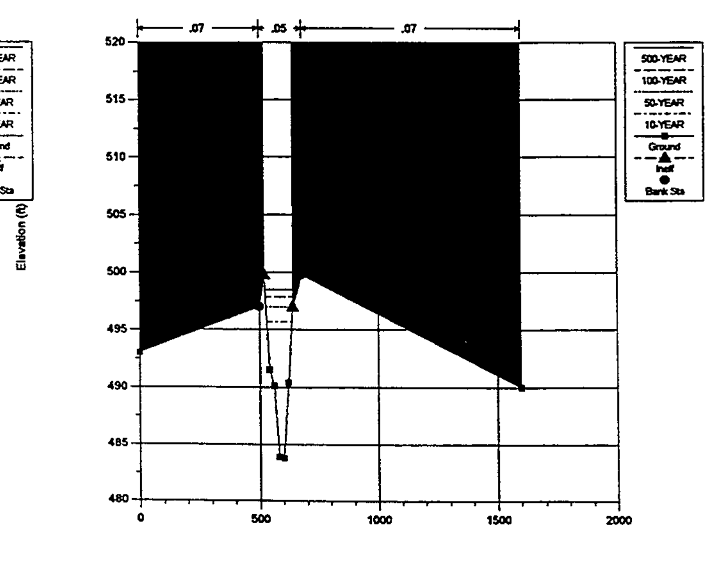

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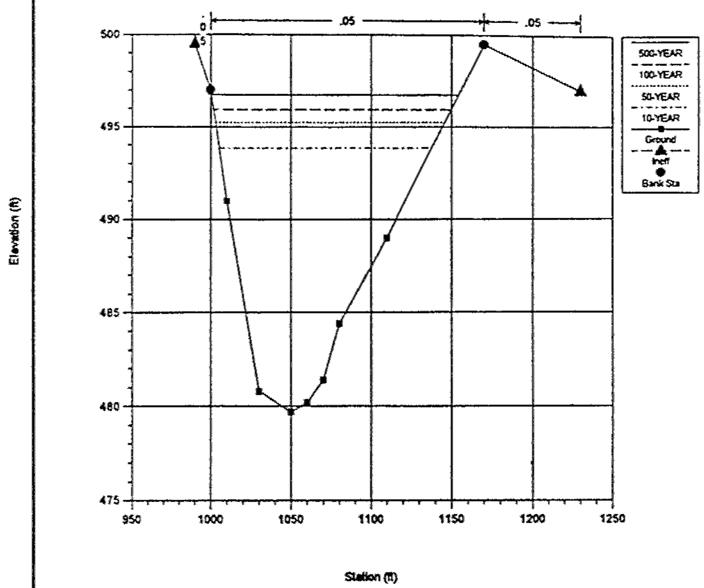


PROVO RIVER RECONNAISSANCE STUDY
EASTSIDE FLOODPLAINS

1. **Purpose.** To provide floodplain delineations of seven Wasatch Range drainage basins which are located to the east of the city of Provo. Reconnaissance level floodplain delineations were developed for the 50, 100, and 500 year events.

2. **Model.** The floodplains for the Provo eastside basins were developed using the two-dimensional flood routing computer model FLO-2D. FLO-2D is a physical process based finite difference model which routes flood hydrographs (and rainfall runoff if this option is used) over unconfined surfaces using a diffusive wave approximation to the momentum equation. Flow depth and velocity are predicted at grid nodes and represent the grid element average values for a small timestep. The square grid element size is selected based on project needs, but typically range from 50 to 1000 feet per side. The model can simulate flow over complex topography and roughness, channel flow, flow exchange between the channel and the floodplain, and street and gully flow. The flow regime can vary between supercritical and subcritical flow as the floodwave moves down the floodplain, channels, and streets. Flood simulation can include application of several components such as rainfall, infiltration, bridge and culvert components, modeling the effects of buildings or other flow obstructions, sediment transport, and mud and debris flow. Particular model features/components are initiated with on/off switches in a control file.

3. **Model Input.**

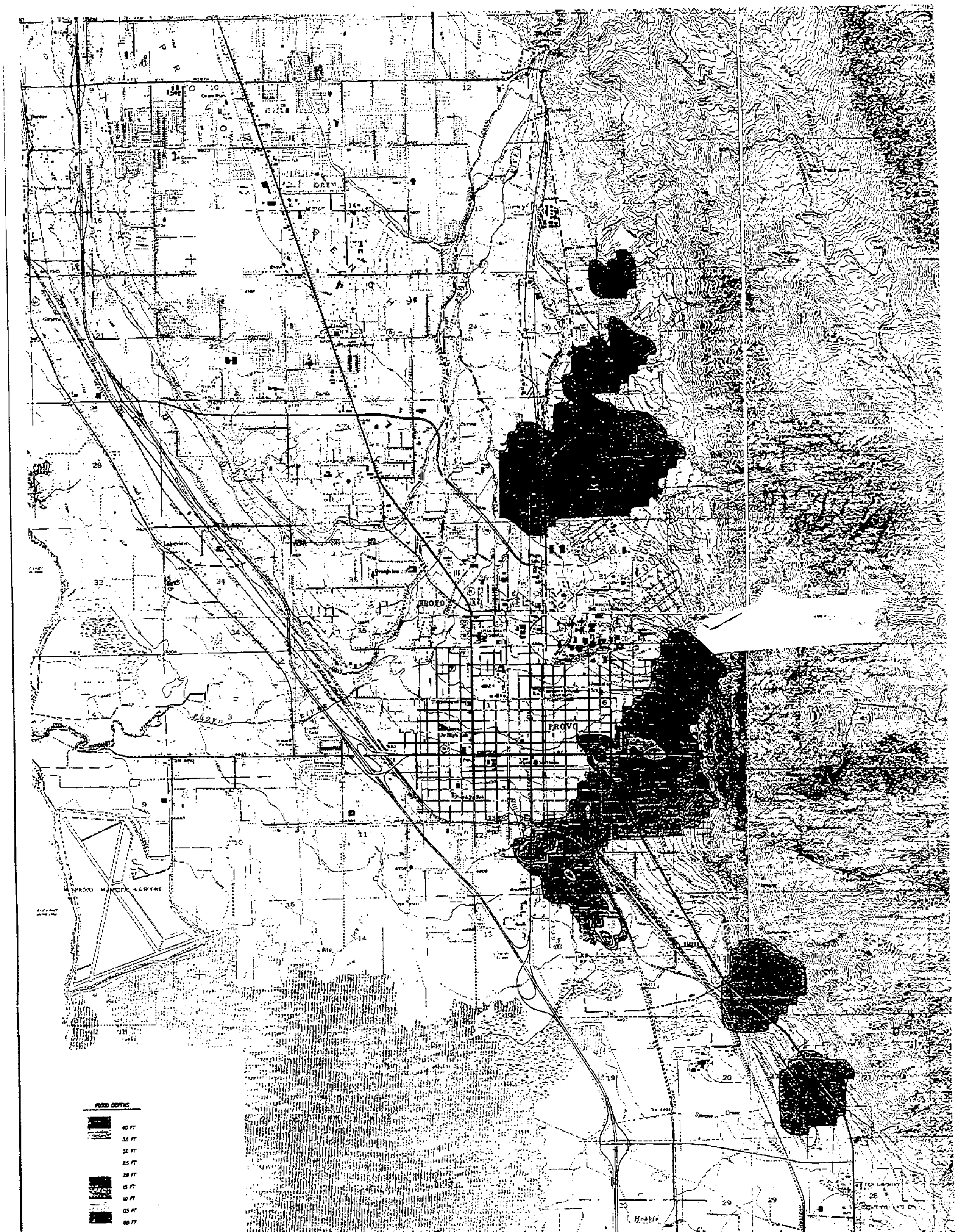
a. Grid. Each FLO-2D element is represented by a grid node which is identified by a grid element/node number, its x and y coordinates, and elevation. The grid elements were selected to be 400 foot per side. The topographic information used to create the grid was from DEM's (digital elevation models) of USGS quad sheets within the study area. A gridded surface was then created from the DEM's using Inroads (Intergraph Civil Site Design software). The gridded surface was developed at the selected FLO-2D grid size of 400 feet.

b. Floodplain. A global Manning's "n" value of 0.08 was applied to all elements of the floodplain. The current model does not contain grid element area reductions to account for structures or other flow obstructions. However, a few elements were completely blocked from flow near the location of the inflow hydrographs in order get flow directed its correct direction. Several floodplain grid elevations were modified following initial runs to remove depressions, or ponding areas, within the floodplain. The elevations were modified after looking at a quad sheet to verify that no depression in the topography existed.

c. Hydrology. Inflow hydrographs were provided for each drainage basin (at the mouth of the each canyon) for two different storm centerings. The storm centerings were on the two largest drainage basins, Rock Canyon and Slate Canyon. The 50-year hydrograph on Rock Canyon was reduced by 100 cfs due to an existing drainage pipe at the mouth of the canyon which has a capacity of 200 cfs (as indicated in the Storm Drainage Master Plan for the city of Provo). For events greater than the 50-year, flows were not reduced because the reduction of 100 cfs would not cause a significant difference in the extent of the floodplain. There are existing debris basins on Rock Canyon and Slate Canyon. The hydrographs for the 50-year event are located in the vicinity of the basin spillways. For the 100 and 500 year events, the hydrographs are input at a location within the basin or the just upstream of the basin. Based on the debris basin rating curves it is likely the 50-year event will pass through the outlet works and over the spillway, but the 100 and 500 year events are likely to overtop the debris basin. When the basins are overtopped, flow will be spread over a wider area at the debris basins and take on different flow paths.

4. Results. The existing condition floodplain delineations for the eastside drainages are shown on Plates 1 through 6. Plates 1 through 3 are with a storm centering on Slate Canyon and Plates 3 through 6 are with a storm centering on Rock Canyon. The floodplains are plotted to display floodplain depth. There are areas of the floodplain, especially the southern area near the railroad tracks, which show isolated ponding areas. It is difficult to say weather these depths are valid. Many of the floodplain elevations in this area have already been adjusted based on the USGS quad sheet information as indicated in paragraph 2.b., but it is possible that elevation errors exist in the USGS DEM's. The DEM's do not contain railroad track embankment. The FLO-2D elements which contain the railroad tracks were not modified to reflect any embankment, therefore all floodplain results assume no embankments along the railroad tracks. Embankments were not added because of the uncertainty of the embankment elevation and the location, if any, of any culverts passing through the embankments.

PLATES



Sheet reference number: 1

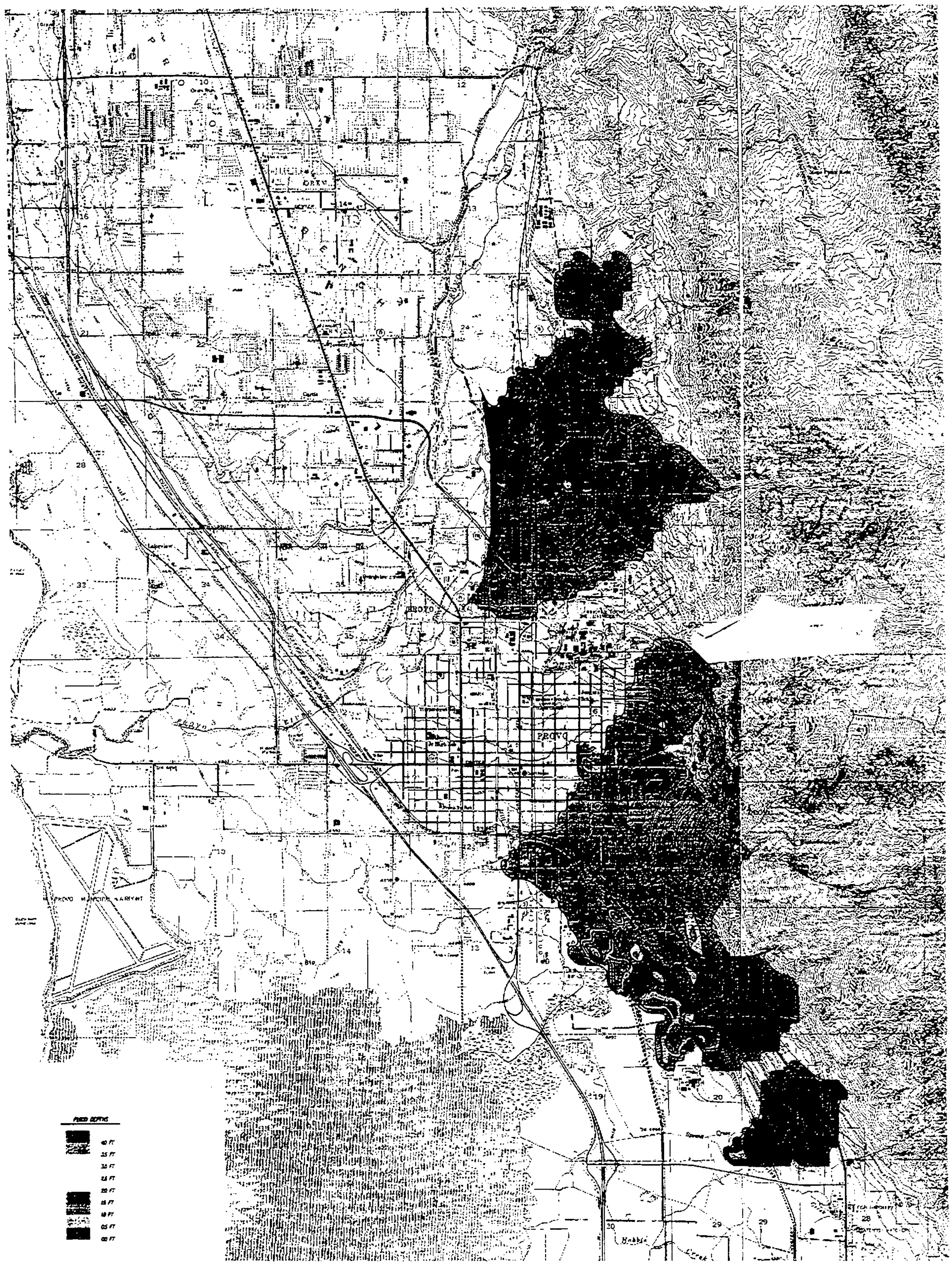
Sheet 1 of 6

PROVO RECONNAISSANCE STUDY
EAST SIDE FLOODPLAINS

STORM CENTERED OVER SLATE CANYON
50 YEAR FLOODPLAIN

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

Designed by: O. Helsby		Date:	Rev.
Dwn by:	Ckd by:	Design file no:	
Reviewed by:		SPEC. No.:	
Submitted by:		Plot date: 07 Oct 96 Plot scale: 1" = 4000'	



Sheet reference number: 2
Sheet 2 of 6

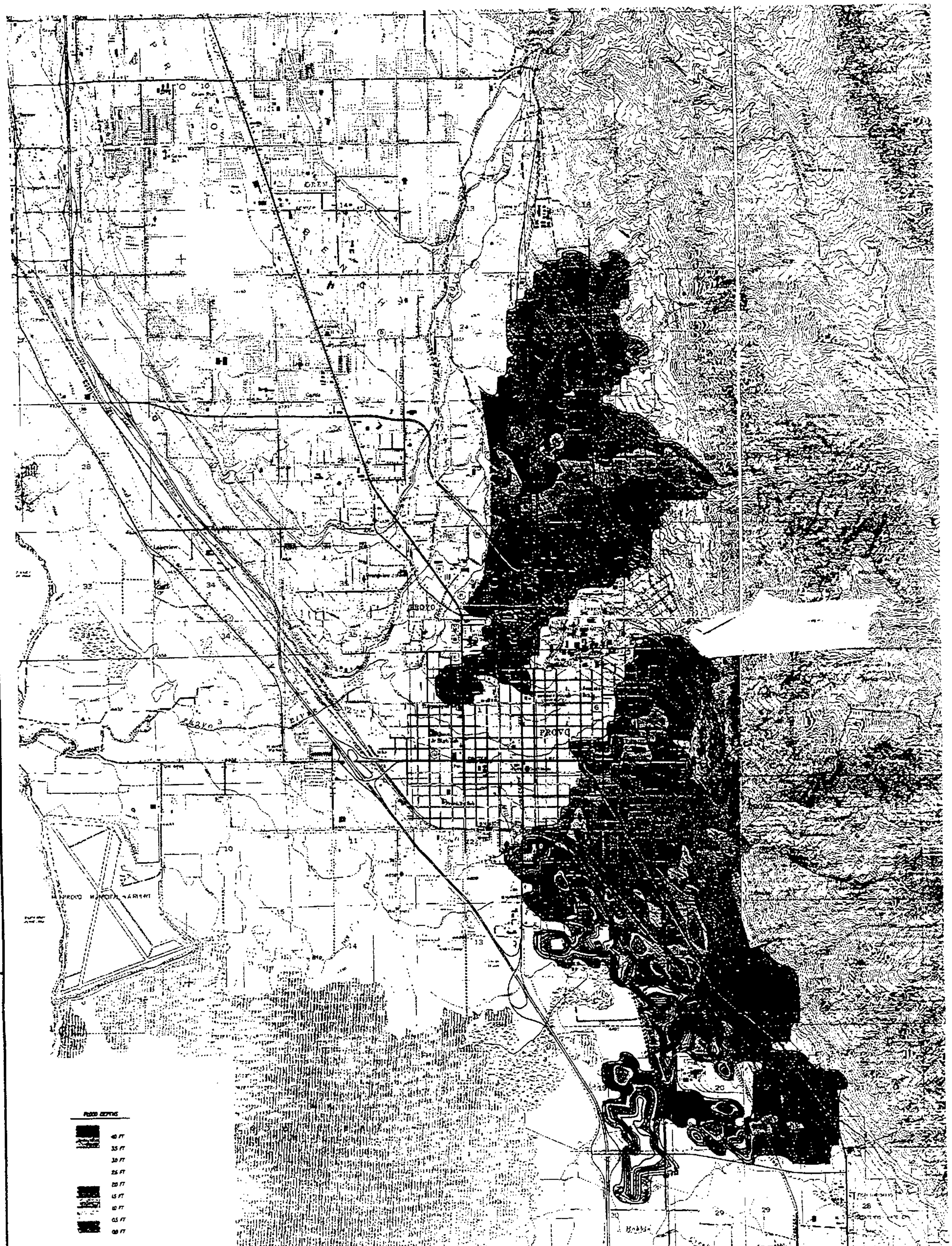
PROVO RECONNAISSANCE STUDY
EAST SIDE FLOODPLAINS

STORM CENTERED OVER SLATE CANYON
100 YEAR FLOODPLAIN

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

Designed by: D. Hesby	Date:	Rev.
Dwn by: / Ckd by:	Design file no:	
Reviewed by:	SPEC. No.:	
Submitted by:	Plot date: 07 Oct 98	

Symbol	Description	Date	Approved	Symbol	Description	Date	Approved



Sheet reference number: 3

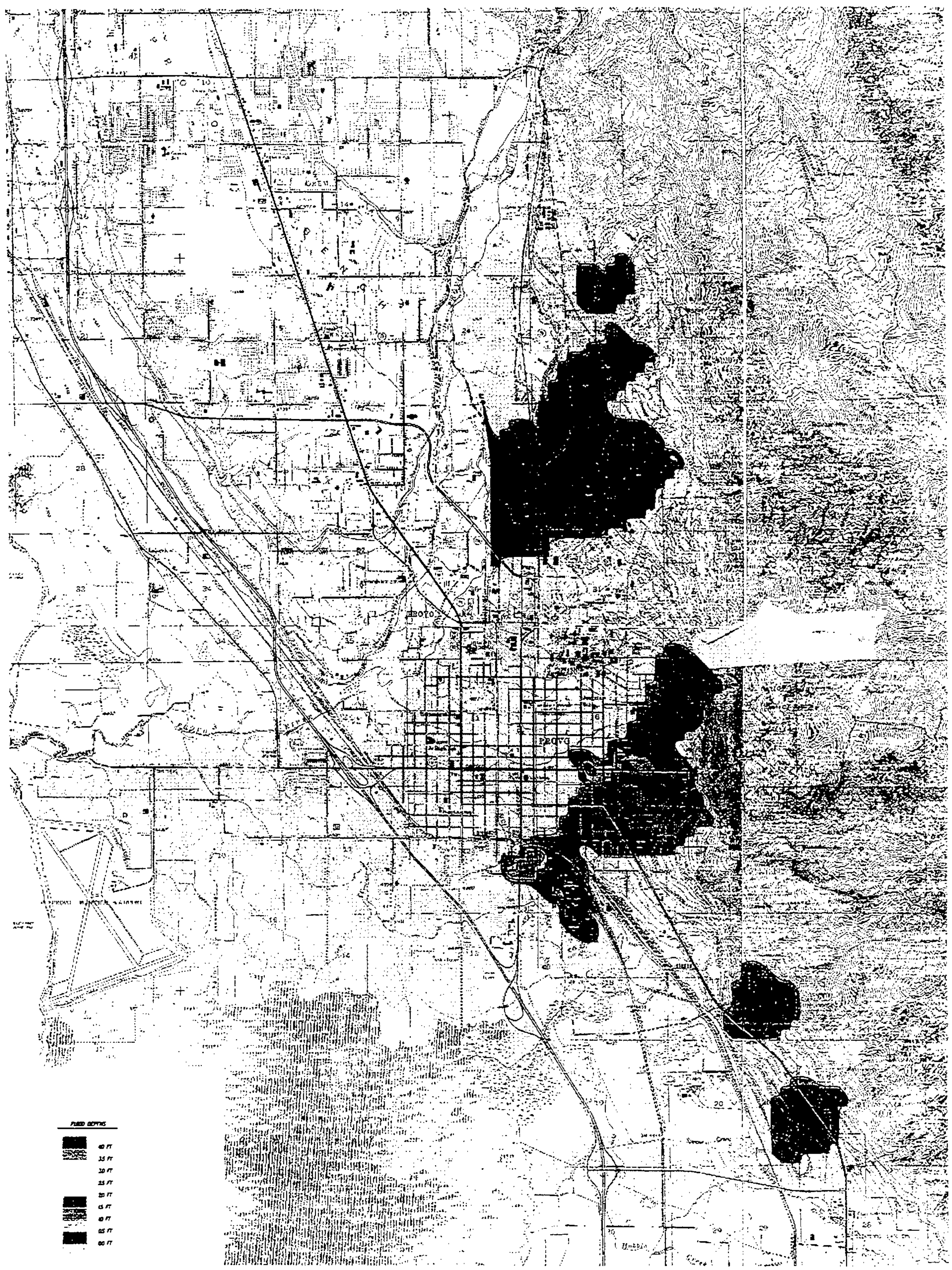
Sheet 3 of 6

PROVO RECONNAISSANCE STUDY
EAST SIDE FLOODPLAINS

STORM CENTERED OVER SLATE CANYON
500 YEAR FLOODPLAIN

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

Designed by: O. Haleby	Date:
Dwn by: / Ckd by:	Design file no:
Reviewed by:	SPEC. No.:
Submitted by:	Plot date: 07 Oct 96



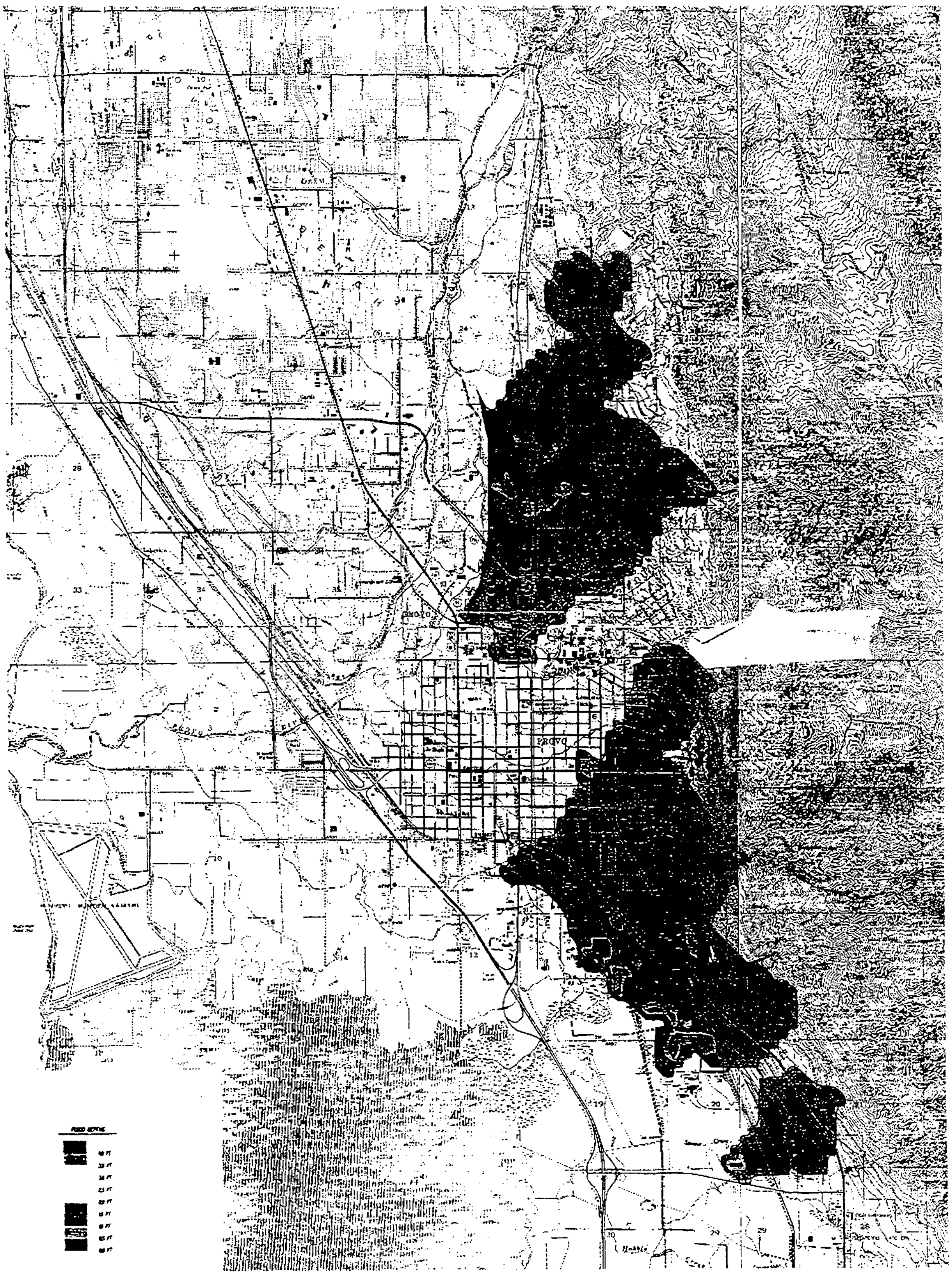
Sheet reference number: 4	Sheet 4 of 6

PROVO RECONNAISSANCE STUDY
EAST SIDE FLOODPLAINS

STORM CENTERED OVER ROCK CANYON
50 YEAR FLOODPLAIN

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

Designed by: D. Halsby	Date:	Rev.
Dwn by: / Ckd by:	Design file no:	
Reviewed by:	SPEC. No.:	
Submitted by:	Plot date: 07 Oct 98 Plot scale: 1" = 4000'	



Sheet reference number: 5
Sheet 5 of

PROVO RECONNAISSANCE STUDY
EAST SIDE FLOODPLAINS

STORM CENTERED OVER ROCK CANYON
100 YEAR FLOODPLAIN

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

Designed by: D. Holiday	Date:	Rev.
Dwn by:	Ckd by:	Design file no:
Reviewed by:		SPEC. No.:

ATTACHMENT BB

CESPK-ED-GS (1105-2-10a) 20 September 1996

MEMORANDUM FOR Chief, Design and Studies Section, (Attn. K. Christiansen)

SUBJECT: Provo, Utah and Vicinity Levee Reconnaissance Study of the Provo River

1. **Introduction.** The American River/Great Basin Branch is conducting a Reconnaissance Study of flood related problems associated with the Provo River and the tributary east side drainage for Provo, Utah (Vicinity Map - Figure 1). The Provo River has a long history of periodic flooding. Soil Design Section, Geotechnical Branch, was requested by Design and Studies Section, Work Order Request AA203-96-2-1, to provide a site inspection and evaluate the existing Provo River levees and detention basins. PNP and PFP values are to be assigned to the various reaches studied during this reconnaissance. A summary of the selected values, Table 1, is enclosed. The detention basins were not evaluated for structural stability or seepage.

2. **General.** PNP and PFP values are water surface elevations selected for use in R & U (Risk and Uncertainty) Analyses. The PNP (Probable Non-Failure Point) is that water surface elevation where failure of the levee is unlikely. The PFP (Probable Failure Point) is that water surface elevation where there is a high probability of failure. For the R&U Analyses, the PNP is assigned a 15% chance of failure and the PFP is assigned an 85% chance of failure. Guidelines for selecting the PNP/PFP values are provided in ETL 1110-2-328. Depending on the availability of subsurface information, considerations used in selecting these values generally include the results of slope stability and seepage analyses, past performance, visual inspections of the levee, and to a large degree, geotechnical engineering judgement.

The PNP/PFP values in this report are of reconnaissance level based on information obtained from past performance, limited soil information, and engineering judgement. Soil classification and descriptions are based on field observations of surface materials only. The PNP/PFP values provided in this report are referenced from the lowest levee height for the reach described.

3. The first reach of study, Moon River Bend, is located between river mile 4.7 and 4.9 (Figure 2). This area entailed inspecting only the left bank. The right bank landside is as yet essentially undeveloped and was not evaluated at this time. Damage from scour to the left bank levee within this reach was moderate to heavy during the 1983 and 1984 floods and flood fighting action prevented the levee from breaching in 1984. The levee crown varies from 7.0 feet wide at the Site 1 location (Photo 1) to 11 feet wide along the remainder of the reach. Levee heights range from 3 to 5 feet. Waterside slope is about 1V:1.5 to 2H and landside slope is about 1V:1.5H. The waterside slope is moderately to heavily vegetated with 10 to 15 feet high shrubs and 4 to 6 inch caliper trees. The landside slope is vegetated with both grasses and low shrubs. The surface of the levee consists of what was field identified as mostly cobbles and coarse grain material with small amounts of non-plastic fine material (less than 5 to 10 percent by volume). Based on the above geometry and flood history, a PNP of 2.5 feet beneath the levee crown and a PFP of 1.0 feet beneath the levee crown are the selected values for this reach.

4. Reach 2 begins about 400 feet upstream of the Route 89 bridge at the end of the bank parking lot and continues upstream, left bank only, for an additional 450 feet, or near the beginning of the Moon River Apartments (Figure 2). The levee crown width ranges between 11 and 27 feet and the levee varies in height from 2 to 4.5 feet. Waterside vegetation is primarily trees and tall shrubs. Landside vegetation is generally grass and low shrubs. Waterside slope is about 1V:1.5H and landside slope is about 1V:3H. The levee surface material is essentially the same as Reach 1, described above in Paragraph 3. Site 2 (Photo 2) illustrates the amount of damage sustained during the 1984 flood season. Waterside erosion is found at various localized points on the reach and appear to be situated where there is sparse vegetation and foot traffic has exacerbated the erosion process. Based on this geometry and flood history, a PNP of 2.0 feet beneath the levee crown and a PFP of 1.0 feet beneath the levee crown are selected for this reach.

5. The third area of study, Reach 3, is about 500 feet in length, beginning at the Paul Ream Wilderness Park and ending downstream at the Denver and Rio Grande Western Railroad (DRGWRR) bridge (Figure 3). This reach's investigation is limited to the left bank only. The levee appears to consist of mostly native surface material of cobbles, gravel and sand graded to prevent flood water from flowing out of the river channel. The crown is about 2 to 4 feet in width along the park and widens downstream to a width of 10 to 12 feet. The crown has an aggregate base surface and is used primarily as a hiking/biking trail. The levee ranges from 2 to 3.5 feet in height. Large caliper trees dominate the waterside and the landside is sod (Photo 3). The levee slope on the landside ranges from 1V:4 to 5. The waterside slope is less than 1V:2H. Based on this geometry and past flood history, a PNP of 1.5 and a PFP of 1.0 are selected.

6. Reach 4 continues from the DRGWRR bridge downstream to the Interstate 15 (I-15) overpass (Figure 3). The levee in this section is about 500 feet in length, has a levee crown of about 12 feet and ranges in height from 0 feet (between the Union Pacific (UP) bridge and the DRGWRR bridge) to 4 feet. The waterside slope is about 1V:2H and the landside slope ranges from about 1V:3H (between the UP and I-15 bridges) to no levee (between the UP and DRGWRR bridges (Panorama Photo 4)). This flat area is where the landside elevation rises to the elevation of the top of the levee. Based on this geometry and the existing levee conditions, a PNP of 2.5 and a PFP of 0.5 are selected.

7. The next reach studied, Reach 5, includes the downstream levees between the I-15 overpass and Geneva Road, a distance of about 1700 feet (Figure 3). The left bank levee begins by separating a mobile home park from the river and then becomes a setback levee (about 200 feet) that encompasses a KOA campground which is situated along the river channel. The right bank levee has an adjacent mobile home park near the Geneva Road bridge. This levee was difficult to study as park residents have erected fences and plantings that interfered with a more thorough investigation. Both left and right bank levees have landside slopes of about 1V:4H and waterside slopes of about 1V:2H. The waterside slopes are heavily vegetated with large and small trees. The landside slope on the left bank levee is a maintained grass field (Photo 5). The levee crowns

on both sides are about 10 to 11 feet in width. Levee heights on both sides range from 4 to 5 feet. Based on this geometry and the field conditions at the time of the study, a left and right bank PNP of 1.5 feet beneath the levee crown and a PFP of 0.5 feet beneath the levee crown are the selected values.

8. The last reach in this investigation, Reach 6, is downstream of the Geneva Road bridge. The right bank is an open hiking/biking trail that begins at Geneva Road and continues to Utah Lake, a distance of about three miles (Figure 4). Only about 4,200 feet of that distance was evaluated for this report (just downstream of the Corporate limits on the right bank). The crown width for the levee ranges from 20 to 40 feet and an aggregate base course lies over the levee material. The levee height varies from 2.5 to 3.5 feet. The landside slope is about 1V:2H and the waterside slope is about 1V:1.5 to 2H. The waterside slope is also heavily vegetated. Field classification reveals the levee material is similar to that of the other levees investigated for this study, ie., a cobble, gravel and sand consistency with small amounts of non-plastic fine material (less than 15%). Based on the geometry and existing conditions, a PNP of 1.5 and a PFP of 0.5 are selected.

For the left bank, encroachment onto the levee by landowners prevented a more thorough investigation nearer to the Geneva Road (Photo 7), but an evaluation of the existing conditions for the entire reach is submitted since only a small section of the levee was physically not reviewed. The levee on the left bank ranged from 3.5 feet near Geneva Road to 8 feet near the end of the study, a distance of about 4,200 feet (Figure 4). The levee crown is about 10 to 15 feet in width. Waterside slopes are about 1V:2H and landside slopes are about the same. The levee consists of mostly cobbles, gravel, and sand with small traces of fine material (Photo 8). Where the levee was open for study, the surface is rocky with sparse grass. A culvert passes through the levee at a location about 3,200 feet downstream from Geneva Road and re-enters the river through a return culvert about 800 feet further downstream. These culverts appear to be open and were installed to furnish water for agriculture use in nearby fields. As a result of this existing structure, an open slough exists between the river levee and a bordering subdivision for a distance of about 800 feet on the landside of the levee. Based on the geometry and the current conditions of the levee, a PNP of 2.0 and a PFP of 0.5 are selected.

9. The Rock Creek Canyon Detention Basin offers 100-year flood detention for flood water (snowmelt only) flowing out of Rock Creek Canyon. This is an engineered structure with sodded slopes and is well-maintained with 1V:3H upstream and downstream slopes (Photo 9). There is a concrete spillway incorporated into the structure with a grouted, cobble channel that flows onto and into the adjacent downstream neighborhood (Figure 5).

10. The Slate Canyon Detention Basin levees were reviewed as part of the Provo study. These detention basins are comprised of three separate basins. The water from these basins eventually discharge onto 1450 East Street and then flow through the downstream neighborhood (Figure 6). The basins were originally gravel pits that were retrofitted with minor engineering for detaining

flood water, for short durations, and debris. The upstream detention basin (Basin No. 1) outfalls through a 36-inch-diameter corrugated metal pipe into the second detention basin (Basin No. 2) downstream. There is minor encroachment in this first basin with various structures by adjacent property owners. In particular, a satellite dish antenna has been installed on the perimeter of this basin as seen in Photo 10. This basin also has a non-engineered perimeter levee. Water essentially flows out of Slate Canyon and is channeled to the outfall pipe mentioned above. Water that cannot pass through the outfall pipe is dispersed over the outfall pipe road and flows into the downstream second detention basin. This road appears highly erodible and consists mainly of loosely compacted cobbles, gravel and sand material.

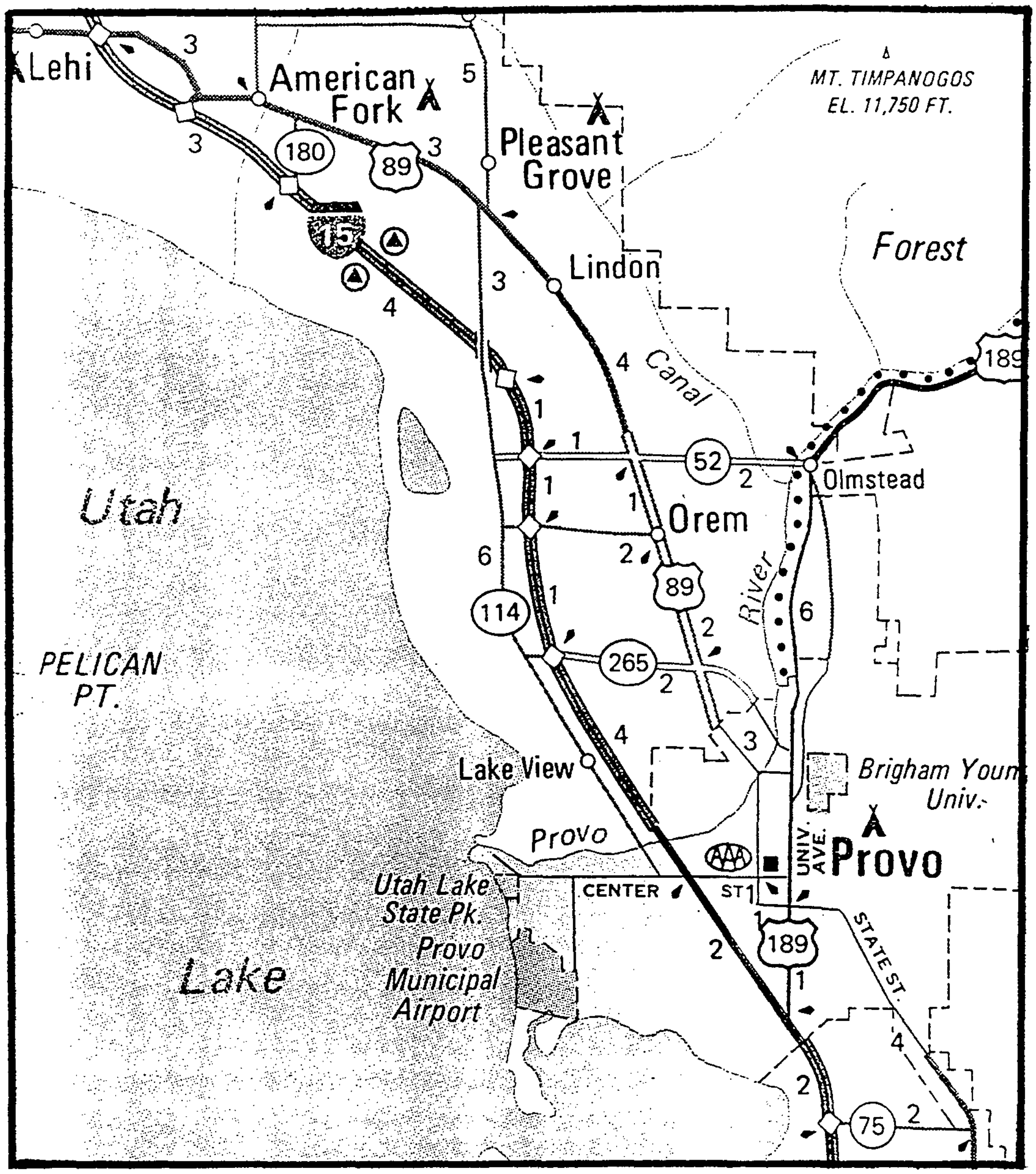
The second downstream detention basin (Basin No. 2) for Slate Canyon is a larger, better defined basin. Water outfalls into this basin from a 36-inch-diameter pipe seen in upper center of Photo 11. This basin has a concrete and stone spillway structure on the downstream section. This basin also has incorporated into it a gated tunnel structure which is used to divert water into a tertiary basin. After the 1983/1984 flood season, the basin was enlarged and the spillway modified to prevent erosion along the upstream spillway abutments (Photo 12).

The last detention, the furthest downstream (Basin No. 3), is essentially a non- engineered basin. The downstream containment banks of this basin are non-engineered native beds of sand, gravel and cobbles with small lenses of fine material. There is a concrete spillway that discharges into the neighborhood. This spillway was engineered into the containment bank of the basin on material that appears to be highly erodible. In terms of stability and seepage, these perimeter banks are questionable. At the time of this field work, it was noted that there is a satellite dish antennae complex constructed within the basin (Panorama Photo 13).

EDWARD E. FLINT
Civil Engineer

Encl. (4)
- Vicinity Map (1)
- Reach Location Map (4)
- Photographs (13)
- Summary Table (1)

cc: American River/Great Basin Branch
(Scott Stoddard)



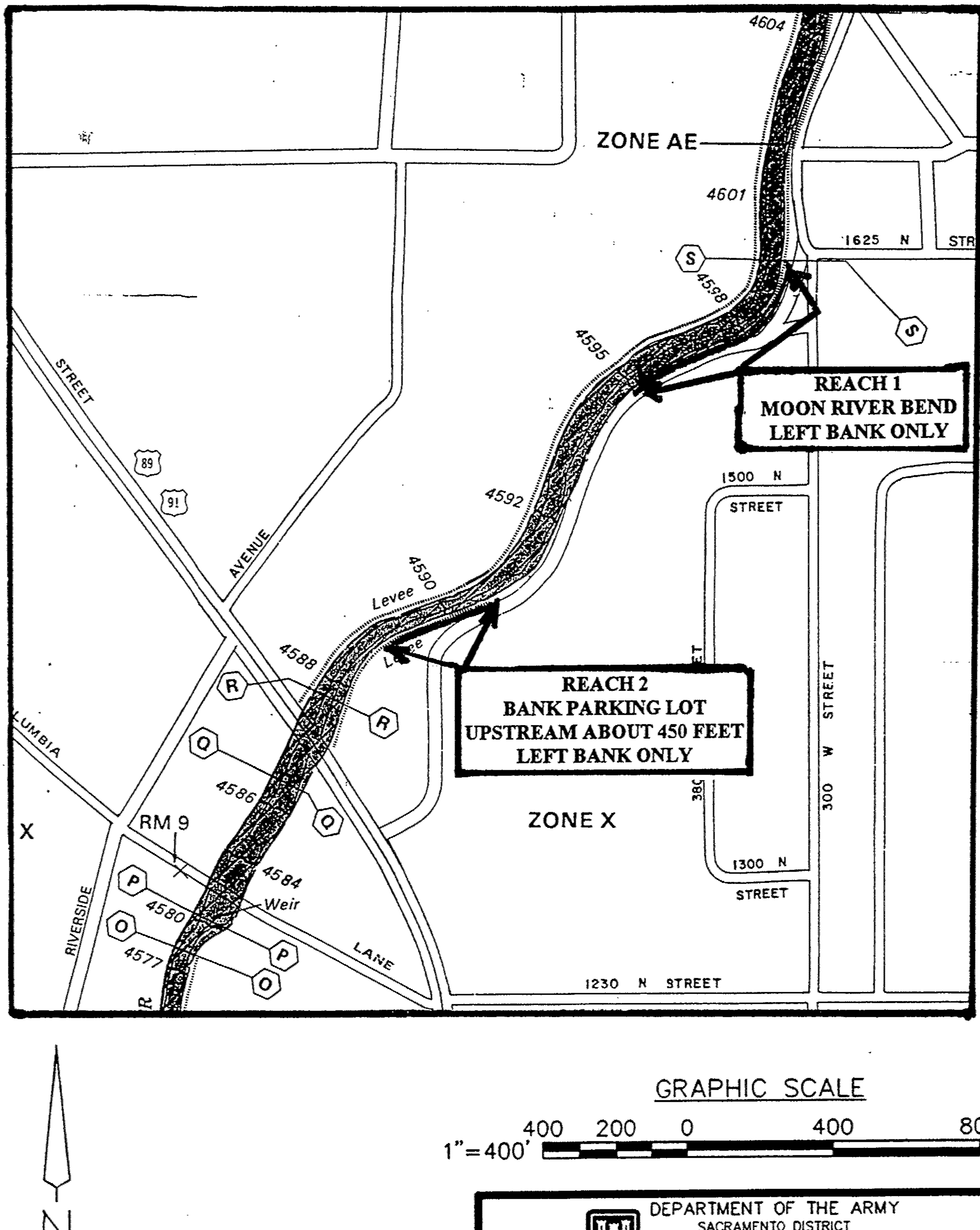
GRAPHIC SCALE

Scale in Miles

0 1 2 3 4 5 6

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED BY: E. E. FLINT	PROVO	UTAH
DRAWN: E. E. FLINT	**VICINITY MAP**	
CHECKED:		
DATE: SEP 1996	SCALE: AS SHOWN	FIGURE: FIG. 1

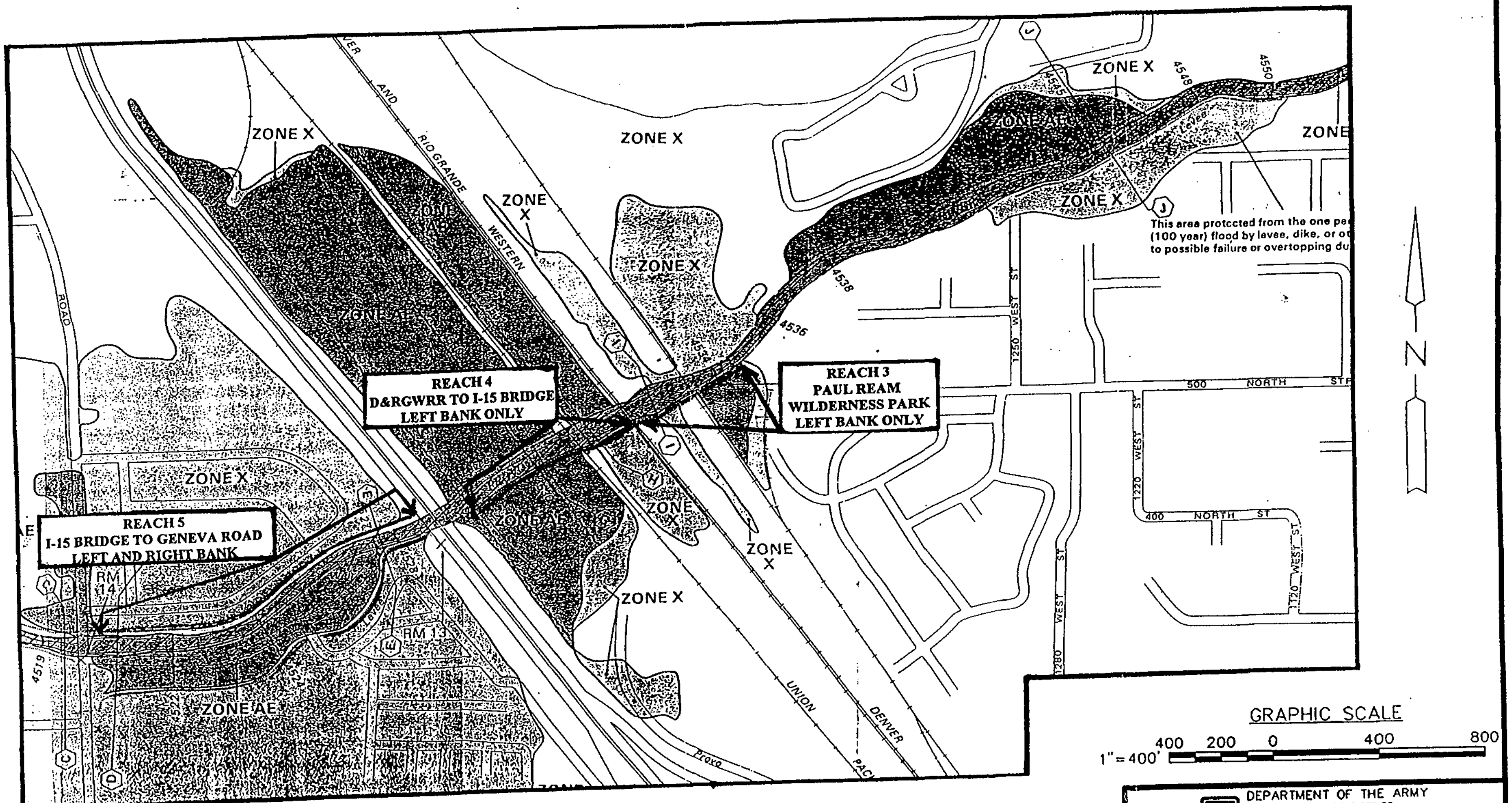


GRAPHIC SCALE

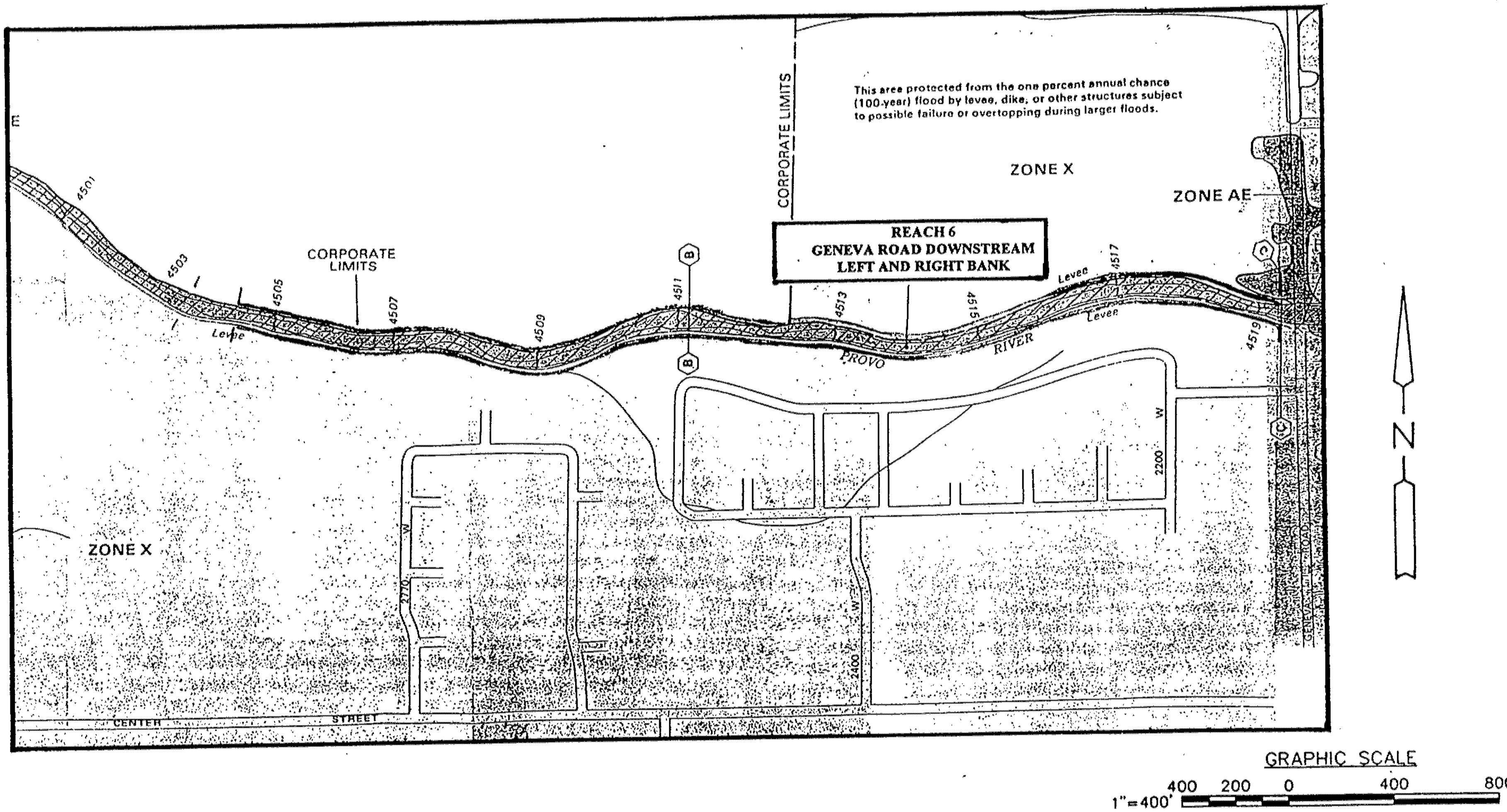
400 200 0 400 800

1"=400'

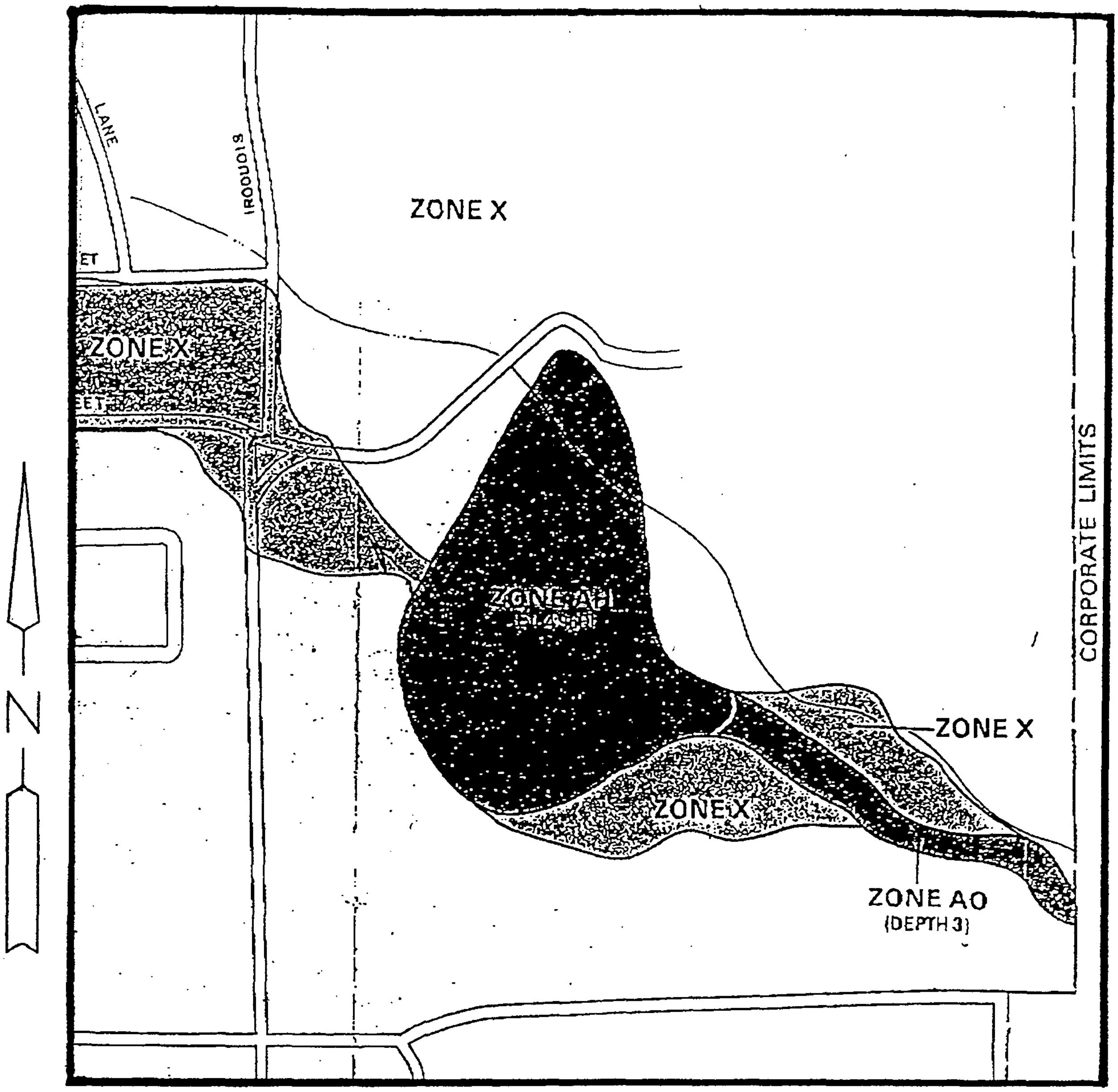
DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA	
DESIGNED BY: E. E. FLINT DRAWN: E. E. FLINT CHECKED:	PROVO UTAH PROVO RIVER PNP/PFP REACHES 1 AND 2 LOCATION MAP
DATE: SEP 1996	SCALE: AS SHOWN — FIGURE: FIG. 2



DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA		
DESIGNED BY: E. E. FLINT DRAWN: E. E. FLINT CHECKED:	PROVO UTAH PROVO RIVER PNP/PFP REACHES 3, 4 AND 5 LOCATION MAP	
DATE: SEP 1996	SCALE: AS SHOWN	FIGURE: FIG. 3



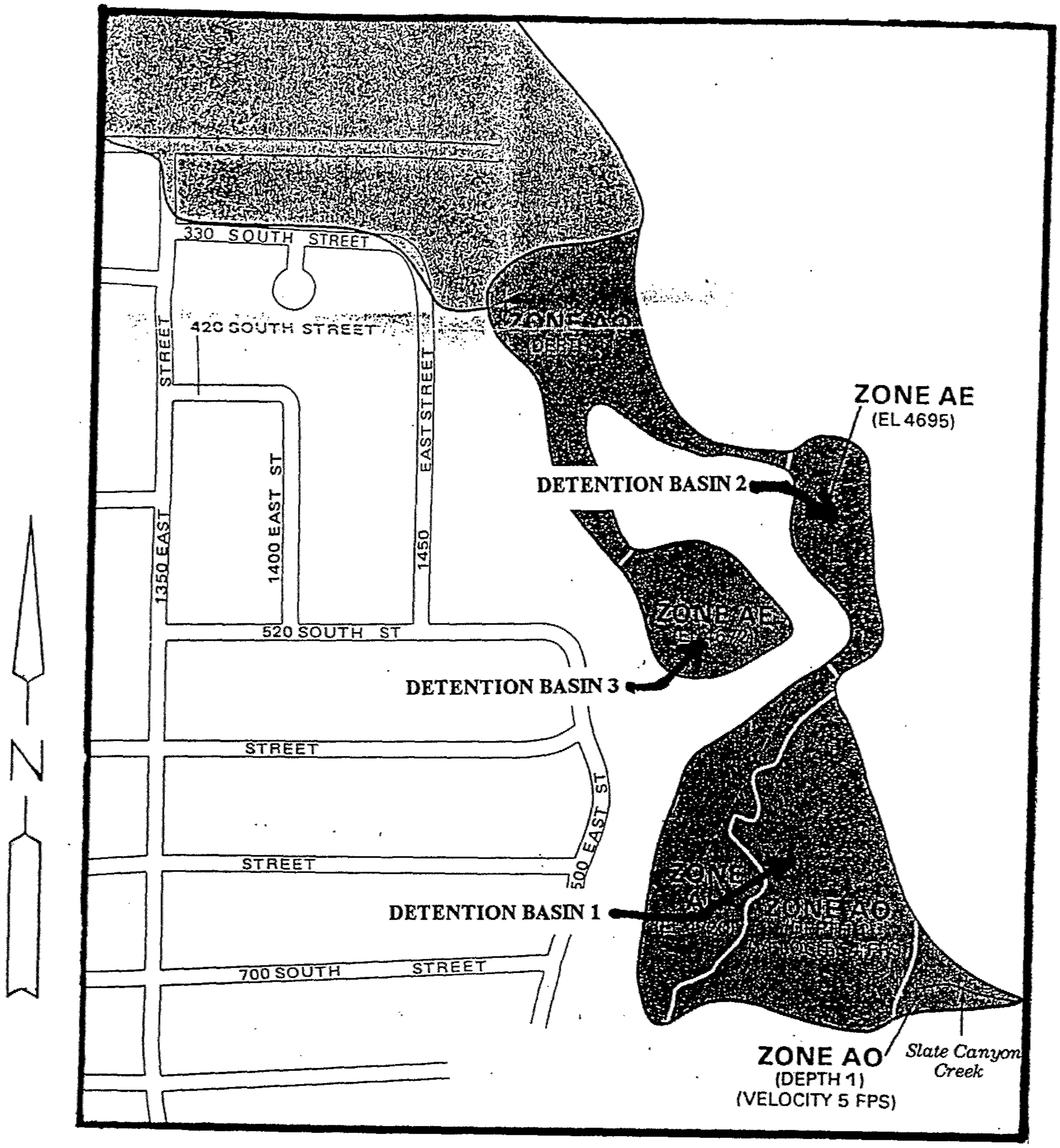
DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA		
DESIGNED BY: E. E. FLINT DRAWN: E. E. FLINT CHECKED:	PROVO UTAH PROVO RIVER PNP/PFP REACH 6 LOCATION MAP	
DATE: SEP 1996	SCALE: AS SHOWN	FIGURE: FIG. 4



GRAPHIC SCALE

1"=400' 400 200 0 400 800

DEPARTMENT OF THE ARMY SACRAMENTO DISTRICT CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA	
DESIGNED BY: E. E. FLINT	PROVO UTAH
DRAWN: E. E. FLINT	ROCK CREEK CANYON DETENTION BASIN LOCATION MAP
CHECKED:	
DATE: SEP 1996	SCALE: AS SHOWN — FIGURE: FIG. 5



GRAPHIC SCALE

1"=400' 400 200 0 400 800

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DESIGNED BY: E. E. FLINT	PROVO	UTAH
DRAWN: E. E. FLINT	SLATE CAÑYON CREEK DETENTION BASIN VICINITY MAP	
CHECKED:		
DATE: SEP 1996	SCALE: AS SHOWN	FIGURE: FIG. 6

Photo 1 - Site 1- Reach 1 - Left Bank - Looking Downstream
Scour Area. Crown is Only About 8 feet Wide at this Location.

Photo 2 - Site 2 - Reach 2 - Left Bank - Looking Downstream. Scour Area
Near Outside Bend in River. Levee is only About 5 feet Wide in this Area.

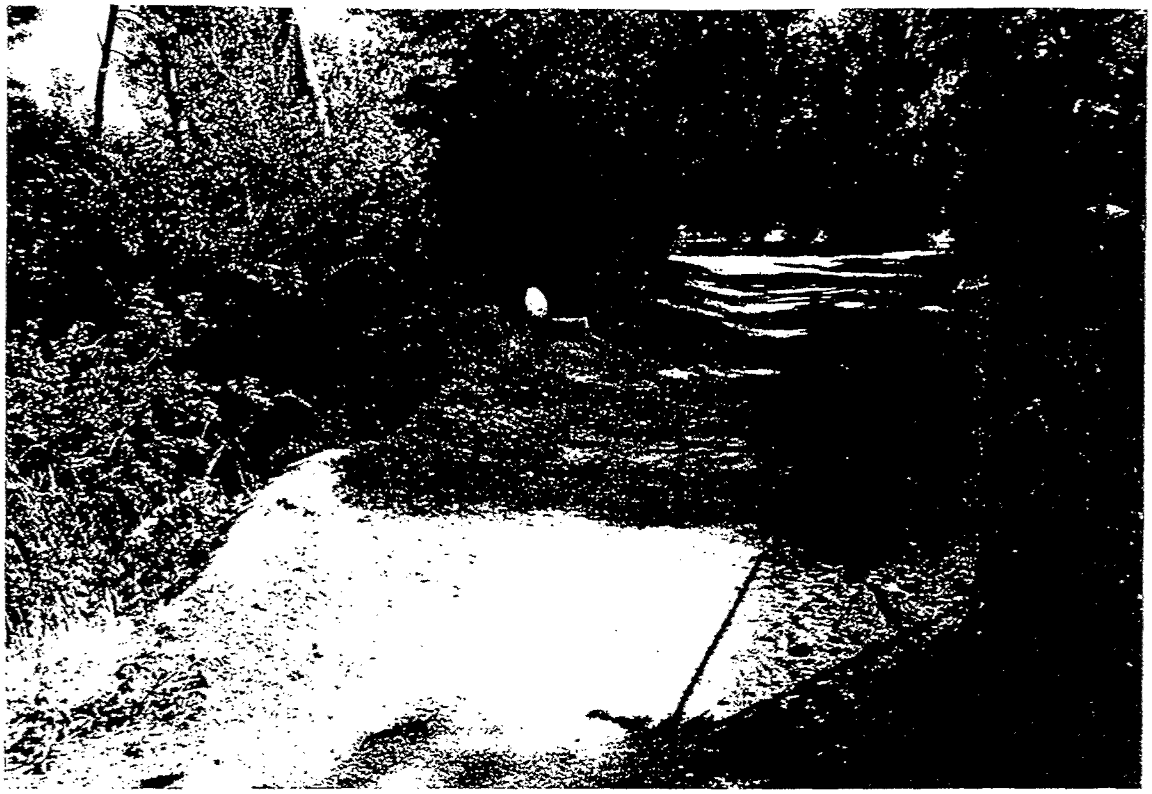


Photo 3 - Paul Ream Wilderness Park. Non-engineered Levee About 2 to 4 feet Wide on Crown. Heavily Vegetated on Waterside

Panorama Photo 4 - Area Between UP Bridge and DRGWRR Bridge. Area has History of Flooding

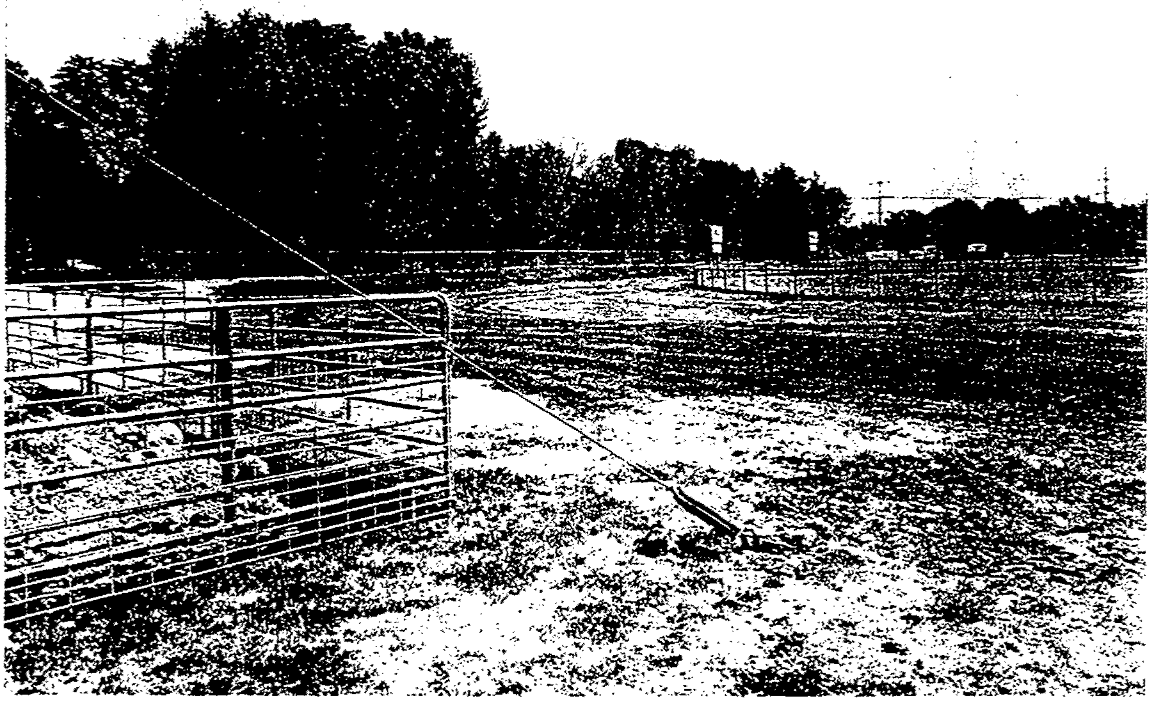


Photo 5 - Looking Upstream - Left Bank - From Geneva Road to I-15.
Levee is Setback 200 feet from River.

Photo 6 - Reach 6 - Looking Downstream - Right Bank - From Geneva Road.

Photo 7 - Reach 6 - Looking Downstream - Left Bank - From Geneva Road. Note Encroachment by Property Owners onto Levee

Photo 8 - Reach 6 - Left Bank - Looking Upstream. Levee Consists of Cobbles, Gravel and Sand, with Fines. Heavily Vegetated on Both Waterside (Left View) and Landside (Right View).

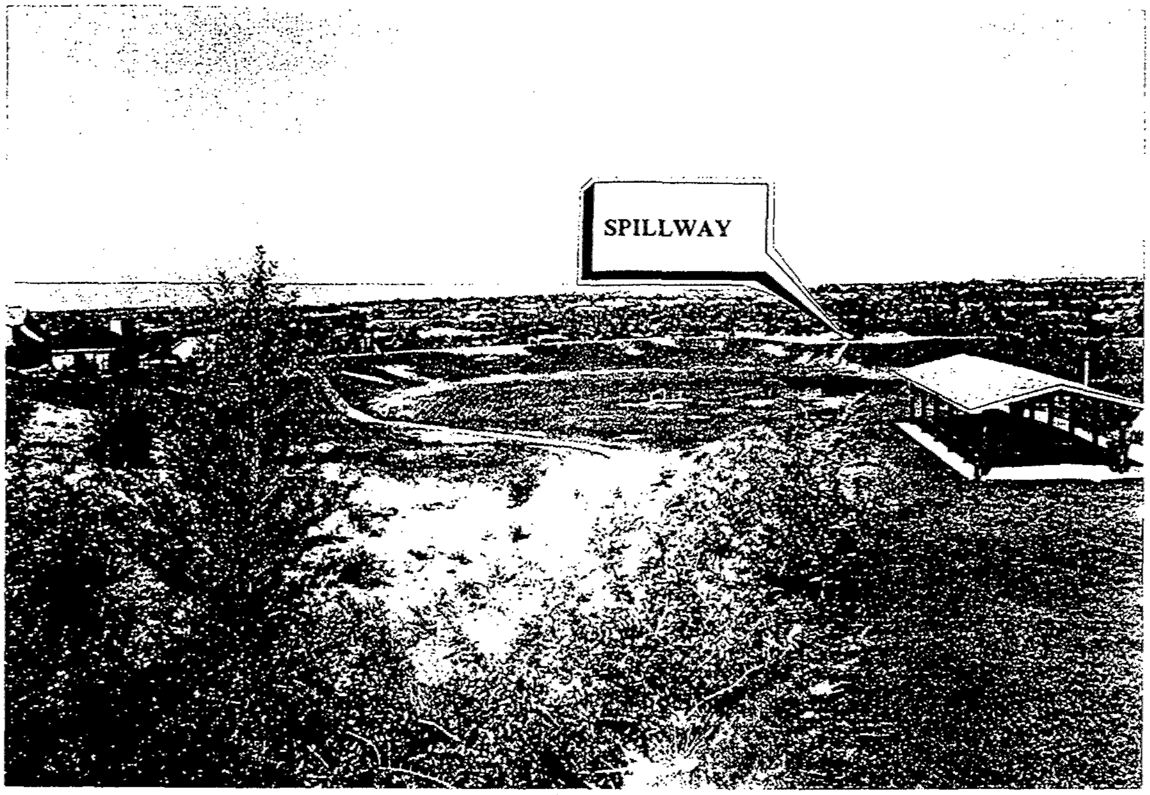


Photo 9 - Rock Creek Detention Basin - Engineered 100 Year Flood Protection.

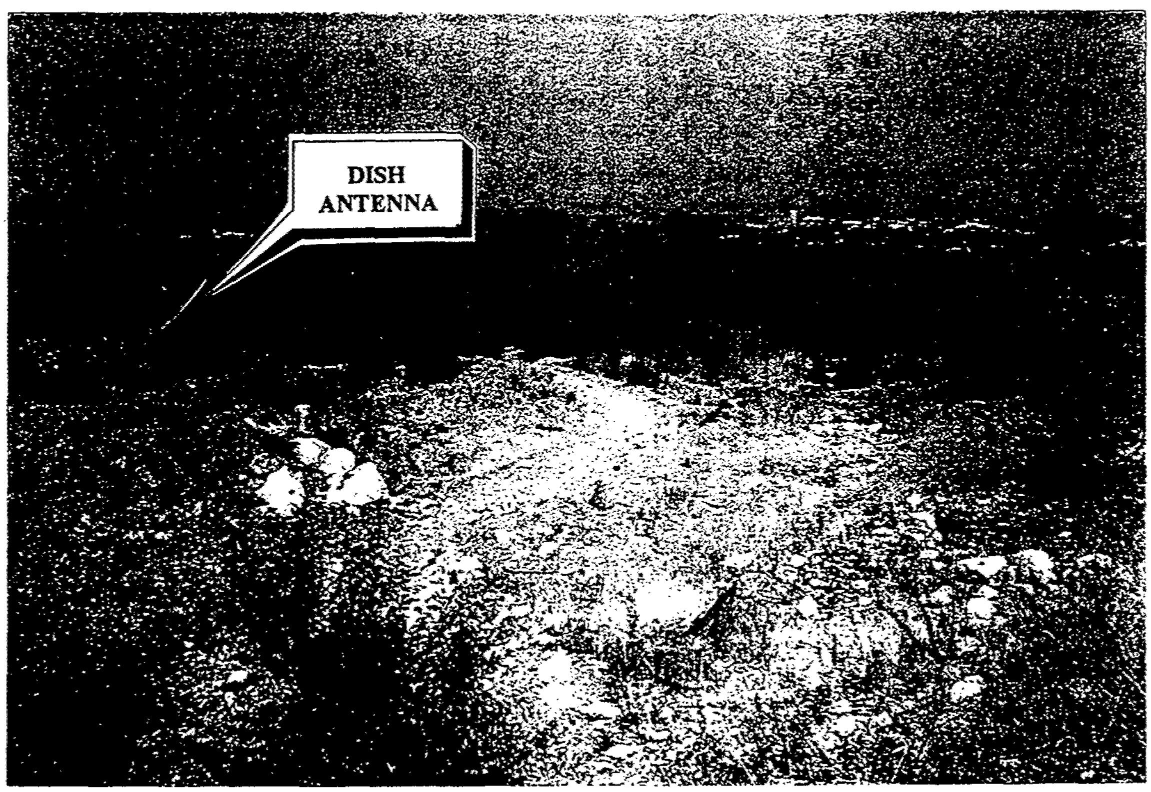


Photo 10 - Slate Canyon - Upper Detention Basin. Non-engineered. Note Satellite Antenna Within Basin.

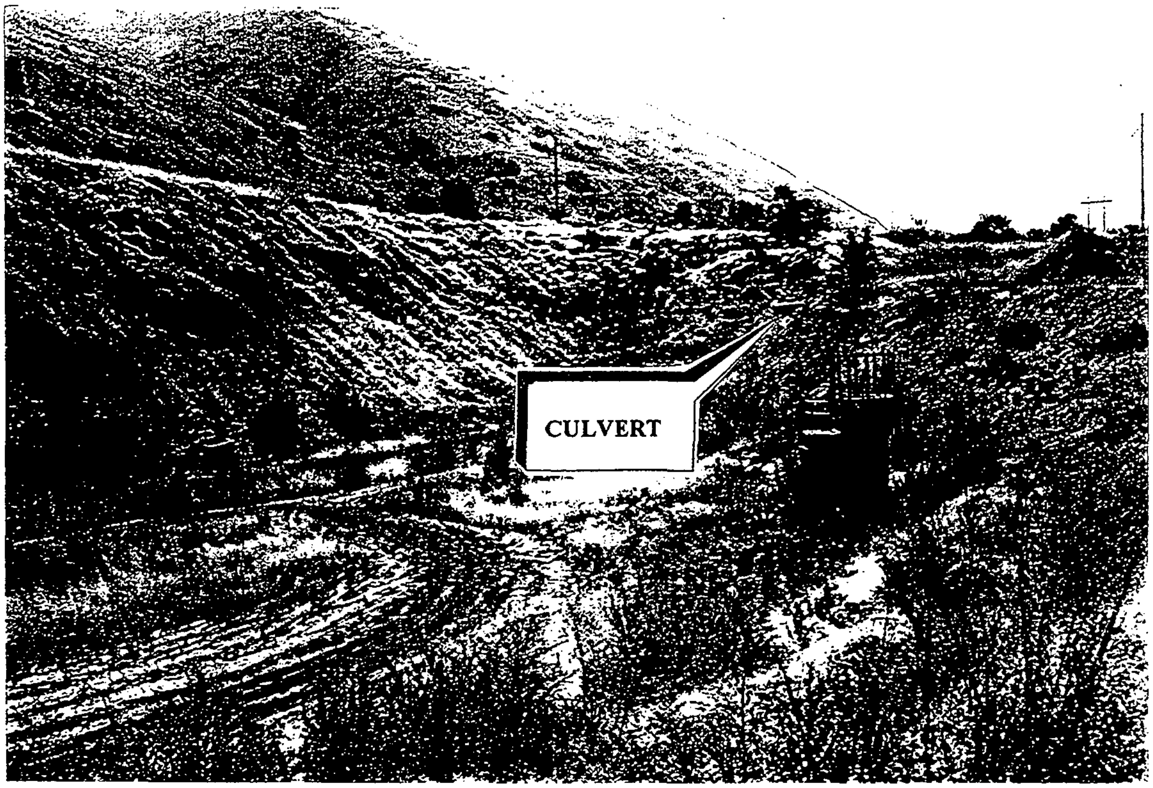


Photo 11 - Slate Canyon - Middle Detention Basin. Upper Right Center is Inflow Pipe from Upper Basin. Middle Center is Gated Structure to Lower Detention Basin

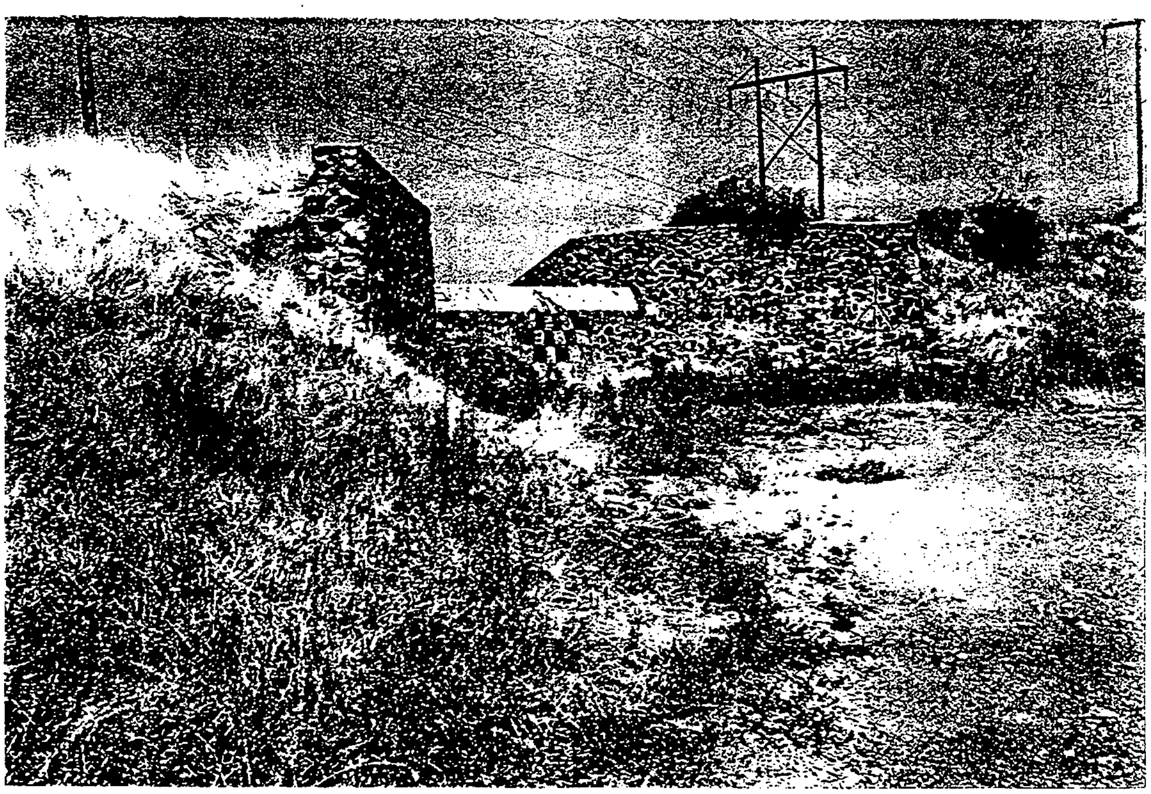


Photo 12 - Slate Canyon - Spillway for Middle Basin. Wing Walls Added To Prevent Erosion of Abutments During Flood Events.

Photo 13 - Slate Canyon - Lower Detention Basin. Note Native Material to Left and Right of Concrete Spillway at far Right. Also note Dish Antennae Complex within Basin.

CESPK-ED-GS (1105-2-10a)
SUBJECT: Provo, Utah and Vicinity Levee Reconnaissance Study of the Provo River

TABLE 1

PNP/PFP SUMMARY		
REACH	**PNP Feet Below Levee Crown**	**PFP Feet Below Levee Crown**
(1) Moon River Bend (about 571 feet) Left Bank	2.5	1.0
(2) Bank Parking Lot to Moon River Apartments (about 400 feet) Left Bank	2.0	1.0
(3) Paul Ream Wilderness Park to DRGWRR Bridge (about 500 feet) Left Bank	1.5	1.0
(4) DRGW RR Bridge to I-15 Bridge (about 500 feet) Left Bank	2.5	0.5
(5) Geneva Road Upstream to I-15 Bridge Left Bank Right Bank	 1.5 1.5	 0.5 0.5
(6) Geneva Road Downstream Left Bank Right Bank	 2.0 1.5	 0.5 0.5

APPENDIX E

REAL ESTATE REPORT

APPENDIX E
REAL ESTATE SECTION
PROVO, UTAH
RECONNAISSANCE STUDY

1. INTRODUCTION

This report presents the real property requirements for the Provo And Vicinity, Utah Project which is located in and around the City of Prove, Utah. The study objective is to develop alternative structural flood control measures and related water resource problems. The Corps authorization for this study is the 28 September 1994 Resolution of the Committee on Public Works and Transportation of the House of Representatives

2. GENERAL DESCRIPTION OF REAL PROPERTY REQUIREMENTS

The study is broken into three major areas; the Provo River from the canyon mouth to Utah Lake, and two areas of the drainage basin, on the east side of the Wasatch Range, from Mile High Canyon on the north to Ironton on the south, within the corporate limits of the metropolitan community of Provo, Utah. Additionally a mitigation requirement, area undefined and assumed to be agricultural land, was identified.

This report addresses five reaches of the Provo River, the two drainage areas consisting of detention basins and/or downstream conveyance systems, that is made up of open channnels and pipelines, and the mitigation area requirement (each having a low, medium and high alternative). For simplicity in describing each component, only the acreage for the high alternative will be referenced.

PROVO RIVER REACHES

a. Below Interstate Highway I-15 - located from I-15 downstream to below Geneva Road approximately 4,000 feet.. Land use is comprised of residential and agricultural. Approximately 6.5 acres on the left bank and 2.3 acres on the right bank would be acquired.

b. Industrial Area - located immediately upstream of Interstate Highway I-15. Land use is consists primarily of industrial. Approximately 0.50 acres would be acquired on the left bank.

c. Park Area - located at the Paul Ream Wilderness Park and ending downstream at the railroad bed east of I-15. Land use is primarily residential. Approximately 2.00 acres would be acquired on the left bank.

d. Moon River Area - located between Columbia Land and University Parkway. Land use is residential and commercial. Approximately 2.8 acres would be acquired on the left bank.

e. 2230 North Street Area - located immediately upstream and downstream of 2230 North Street. Land use is commercial and industrial. Approximately 1.5 acres would be acquired on the left bank.

DRAINAGE AREAS

a. Northeast Drainage - consists of detention basins and water conveyance systems located at the mouths of Mile High, Little Rock and Rock Canyons. Land use is mountain land, residential and residential acreage with tentative subdivision map approval. Approximately 23 acres would be acquired.

b. Southeast Drainage - consists of the detention basins and water conveyance systems located at the mouths of Slide, Slate and Buckley Canyons. Land use is mountain land. Approximately 18 acres would be acquired.

3. ESTATES

Lands within the study area have been valued as permanent flood control easements which are tantamount to fee as they are perpetual and will leave no rights or any significant value to the property owners. The real estate to be acquired ranges in size from approximately 0.5 acres to 23 acres depending on the alternative selected.

4. PL 91-646 RELOCATIONS

The relocation of persons and personal property pursuant to Public Law 91-646 does not apply. As the project definition becomes more clear an investigation will be done if necessary.

5. MARKETABLE RESOURCES

There are no known marketable resources (timber, gas, oil or minerals) noted in the study area. It is unknown if any mining or harvesting operations have taken place in the vicinity either now or in the past.

6. FACILITY AND UTILITY RELOCATIONS

Separate real estate costs have not been established for the relocation of utilities since the location of the facility or utility relocation, if any, has not been identified. Further investigations will be needed regarding the ownership of both personal and real property rights in the these facilities or utilities and their right-of-way.

7. SPONSOR

The potential non-Federal sponsor of the project is the City of Provo, Utah. The sponsor has not been apprised of the real estate procedures and requirements of the project.,

8. BASELINE COST ESTIMATE

A Reconnaissance Level Cost Estimate, as prepared by the Real Estate appraisal Branch, Sacramento District, was the basis upon which the land cost estimates were generated. Costs are estimated at the October 1996 price levels. All lands, regardless of ownership, have been estimated at fair market value. Contingencies take into account severance damage, unknown property splits, undetected improvements and any additional costs involved in the application of PL 91-646. Determination of administrative costs were based on total number of ownerships per alternative multiplied by $30,000 per ownership (See Table 1 , Baseline Cost Estimate for Real Estate).

9. HAZARDOUS AND TOXIC WASTE

No conditions indicating the possible presence of hazardous materials were observed during the inspection by the appraiser. However, not all of the subject lands were inspected due to access difficulty.

TABLE 1
PROVO AND VICINITY
BASELINE COST ESTIMATE FOR REAL ESTATE

ALTERNATIVES	LANDS (LERRDs)	ADMINISTRATIVE COSTS (# Ownerships)	TOTAL
Below I-15 Low Alternative	$ 351,000	$ 1,260,000 (42 Ownerships)	$ 1,611,000
Below I-15 Medium Alternative	$ 664,000	$ 1,260,000 (42 Ownerships)	$ 1,924,000
Below I-15 High Alternative	$ 5,407,500	$ 1,260,000 (42 Ownerships)	$ 6,667,500
Industrial Area Low Alternative	$ 43,000	$ 210,000 (7 Ownerships)	$ 253,000
Industrial Area Medium Alternative	$ 43,000	$ 210,000 (7 Ownerships)	$ 253,000
Industrial Area High Alternative	$43,000	$ 210,000 (7 Ownerships)	$ 253,000
Park Area Low Alternative	$ 800,000	$ 450,000 (15 Ownerships)	$ 1,250,000
Park Area Medium Alternative	$ 800,000	$ 450,000 (15 Ownerships)	$ 1,250,000
Park Area High Alternative	$ 800,000	$ 450,000 (15 Ownerships)	$ 1,250,000
Moon River Area Low Alternative	$ 33,000	$ 30,000 (1 Ownership)	$ 63,000
Moon River Area Medium Alternative	$ 66,000	$ 30,000 (1 Ownership)	$ 96,000
Moon River Area High Alternative	$ 7,426,000	$ 30,000 (1 Ownership)	$ 7,456,000

2230 N. St. Area Low Alternative	$ 52,500	$ 120,000 (4 Ownerships)	$ 172,500
2230 N. St. Area Medium Alternative	$ 98,000	$ 120,000 (4 Ownerships)	$ 218,000
2230 N. St. Area High Alternative	$ 1,376,000	$ 120,000 (4 Ownerships)	$ 1,496,000
Northeast Drainage Low Alternative	$ 1,419,000	$ 420,000 (14 Ownerships)	$ 1,839,000
Northeast Drainage Medium Alternative	$ 2,201,000	$ 420,000 (14 Ownerships)	$ 2,621,000
Northeast Drainage High Alternative	$ 2,310,500	$ 420,000 (14 Ownerships)	$ 2,730,500
Southeast Drainage Low Alternative	$ 1,140,500	$ 120,000 (4 Ownerships)	$ 1,260,500
Southeast Drainage Medium Alternative	$1,163,000	$ 120,000 (4 Ownerships)	$ 1,283,000
Southeast Drainage High Alternative	$ 1,167,500	$ 120,000 (4 Ownerships)	$ 1,287,500
Mitigation 1 Acre	$ 9,000	$ 30,000 (1 Ownership)	$ 39,000
Mitigation 3 Acres	$ 27,000	$ 30,000 (1 Ownership)	$ 57,000
Mitigation 8 Acres	$ 72,000	$ 30,000 (1 Ownership)	$ 102,000

APPENDIX F

DRAFT
FEASIBILITY COST SHARING AGREEMENT
AND
PROJECT STUDY PLAN

US Army Corps
of Engineers
Sacramento District

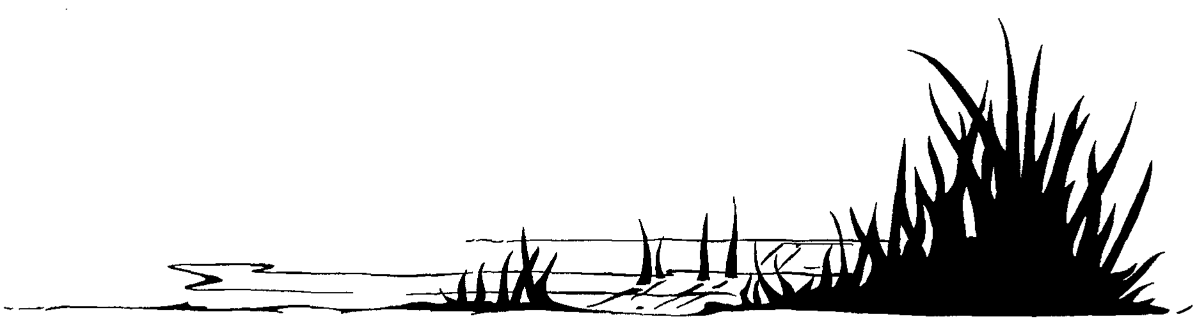
PROVO RIVER, UTAH, AND VICINITY

DRAFT FEASIBILITY PHASE
COST SHARING AGREEMENT
AND
DRAFT PROJECT STUDY PLAN

April 1997

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

With Assistance From
The City of Provo, Utah



AGREEMENT
BETWEEN THE DEPARTMENT OF THE ARMY
AND
PROVO CITY
FOR THE PROVO AND VICINITY, UTAH FEASIBILITY STUDY

THIS AGREEMENT is entered into this _________ day, of _____, 19__, by and between the Department of the Army (hereinafter the "Government"), represented by the District Engineer executing this Agreement, and Provo City hereinafter the "Sponsor"),

WITNESSETH, that

WHEREAS, the Congress (Senate and/or House Committees) has authorized the Corps of Engineers to conduct a study of the Provo River and Vicinity, Utah pursuant to a September 28, 1994 resolution of the United States House of Representatives Committee on Public Works and Transportation ; and

WHEREAS, the U.S. Army Corps of Engineers has conducted a reconnaissance study of the Provo River and vicinity in Provo, Utah with a view to determine the advisability of providing modifications in the interest of flood damage reduction pursuant to this authority, and has determined that further study in the nature of a "Feasibility Phase Study" (hereinafter the "Study") is required to fulfill the intent of the study authority and to assess the extent of the Federal interest in participating in a solution to the identified problem; and

WHEREAS, Section 105 of the Water Resources Development Act of 1986 (Public Law 99-662, as amended) specifies the cost sharing requirements applicable to the Study;

WHEREAS, the Sponsor has the authority and capability to furnish the cooperation hereinafter set forth and is willing to participate in study cost sharing and financing in accordance with the terms of this Agreement; and

WHEREAS, the Sponsor and the Government understand that entering into this Agreement in no way obligates either party to implement a project and that whether the Government supports a project authorization and budgets it for implementation depends upon, among other things, the outcome of the Study and whether the proposed solution is consistent with the <u>Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies</u> and with the budget priorities of the Administration;

NOW THEREFORE, the parties agree as follows:

ARTICLE I - DEFINITIONS

For the purposes of this Agreement:

A. The term "Study Costs" shall mean all disbursements by the Government pursuant to this Agreement, from Federal appropriations or from funds made available to the Government by the Sponsor, and all negotiated costs of work performed by the Sponsor pursuant to this Agreement. Study Costs shall include, but not be limited to: labor charges; direct costs; overhead expenses; supervision and administration costs; the costs of participation in Study Management and Coordination in accordance with Article IV of this Agreement; the costs of contracts with third parties, including termination or suspension charges; and any termination or suspension costs (ordinarily defined as those costs necessary to terminate ongoing contracts or obligations and to properly safeguard the work already accomplished) associated with this Agreement.

B. The term "estimated Study Costs" shall mean the estimated cost of performing the Study as of the effective date of this Agreement, as specified in Article III.A. of this Agreement.

C. The term "excess Study Costs" shall mean Study Costs that exceed the estimated Study Costs and that do not result from mutual agreement of the parties, a change in Federal law that increases the cost of the Study, or a change in the scope of the Study requested by the Sponsor.

D. The term "study period" shall mean the time period for conducting the Study, commencing with the release to the U.S. Army Corps of Engineers Sacramento District of initial Federal feasibility funds following the execution of this Agreement and ending when the Assistant Secretary of the Army (Civil Works) submits the feasibility report to the Office of Management and Budget (OMB) for review for consistency with the policies and programs of the President.

E. The term "PSP" shall mean the Project Study Plan, which is attached to this Agreement and which shall not be considered binding on either party and is subject to change by the Government, in consultation with the Sponsor.

F. The term "negotiated costs" shall mean the costs of in-kind services to be provided by the Sponsor in accordance with the PSP.

G. The term "fiscal year" shall mean one fiscal year of the Government. The Government fiscal year begins on October 1 and ends on September 30.

ARTICLE II - OBLIGATIONS OF PARTIES

A. The Government, using funds and in-kind services provided by the Sponsor and funds appropriated by the Congress of the United States, shall expeditiously prosecute and complete the Study, in accordance with the provisions of this Agreement and Federal laws, regulations, and policies.

B. In accordance with this Article and Article III.A., III.B. and III.C. of this Agreement, the Sponsor shall contribute cash and in-kind services equal to fifty (50) percent of Study Costs other than excess Study Costs. The Sponsor may, consistent with applicable law and regulations, contribute up to 25 percent of Study Costs through the provision of in-kind services. The in-kind services to be provided by the Sponsor, the estimated negotiated costs for those services, and the estimated schedule under which those services are to be provided are specified in the PSP. Negotiated costs shall be subject to an audit by the Government to determine reasonableness, allocability, and allowability.

C. The Sponsor shall pay a fifty (50) percent share of excess Study Costs in accordance with Article III.D. of this Agreement.

D. The Sponsor understands that the schedule of work may require the Sponsor to provide cash or in-kind services at a rate that may result in the Sponsor temporarily diverging from the obligations concerning cash and in-kind services specified in paragraph B. of this Article. Such temporary divergences shall be identified in the quarterly reports provided for in Article III.A. of this Agreement and shall not alter the obligations concerning costs and services specified in paragraph B. of this Article or the obligations concerning payment specified in Article III of this Agreement.

E. If, upon the award of any contract or the performance of any in-house work for the Study by the Government or the Sponsor, cumulative financial obligations of the Government and the Sponsor would result in excess Study Costs, the Government and the Sponsor agree to defer award of that and all subsequent contracts, and performance of that and all subsequent in-house work, for the Study until the Government and the Sponsor agree to proceed. Should the Government and the sponsor require time to arrive at a decision, the Agreement will be suspended in accordance with Article X., for a period of not to exceed six months. In the event the Government and the sponsor have not reached an agreement to proceed by the end of their 6 month period, the Agreement may be subject to termination in accordance with Article X.

F. No Federal funds may be used to meet the Sponsor's share of Study Costs unless the Federal granting agency verifies in writing that the expenditure of such funds is expressly authorized by statute.

G. The award and management of any contract with a third party in furtherance of this Agreement which obligates Federal appropriations shall be exclusively within the control of the Government. The award and management of any contract by the Sponsor with a third party in furtherance of this Agreement which obligates funds of the Sponsor and does not obligate Federal appropriations shall be exclusively within the control of the Sponsor, but shall be subject to applicable Federal laws and regulations.

ARTICLE III - METHOD OF PAYMENT

A. The Government shall maintain current records of contributions provided by the parties, current projections of Study Costs, current projections of each party's share of Study Costs, and current projections of the amount of Study Costs that will result in excess Study Costs. At least quarterly, the Government shall provide the Sponsor a report setting forth this information. As of the effective date of this Agreement, estimated Study Costs are $1.495 million and the Sponsor's share of estimated Study Costs is $747,500. In order to meet the Sponsor's cash payment requirements for its share of estimated Study Costs, the Sponsor must provide a cash contribution currently estimated to be $407,500. The dollar amounts set forth in this Article are based upon the Government's best estimates, which reflect the scope of the study described in the PSP, projected costs, price-level changes, and anticipated inflation. Such cost estimates are subject to adjustment by the Government and are not to be construed as the total financial responsibilities of the Government and the Sponsor.

B. The Sponsor shall provide its cash contribution required under Article II.B. of this Agreement in accordance with the following provisions:

1. For purposes of budget planning, the Government shall notify the Sponsor by August 1st of each year of the estimated funds that will be required from the Sponsor to meet the Sponsor's share of Study Costs for the upcoming fiscal year.

2. No later than 30 calendar days prior to the scheduled date for the Government's issuance of the solicitation for the first contract for the Study or for the Government's anticipated first significant in-house expenditure for the Study, the Government shall notify the Sponsor in writing of the funds the Government determines to be required from the Sponsor to meet its required share of Study Costs for the first fiscal year of the Study. No later than 15 calendar days thereafter, the Sponsor shall present to the Government an irrevocable letter of credit acceptable to the Government for the required funds.

3. For the second and subsequent fiscal years of the Study, the Government shall, no later than 60 calendar days prior to the beginning of the fiscal year, notify the Sponsor in writing of the funds the Government determines to be required from the Sponsor to meet its required share of Study Costs for that fiscal year, taking into account any temporary divergences identified under Article II.C. of this Agreement. No later than 30 calendar days prior to the beginning of the fiscal year, the Sponsor shall make the full amount of the required funds available to the Government through the funding mechanism specified in paragraph B.2. of this Article.

4. The Government shall draw from the letter of credit provided by the Sponsor such sums as the Government deems necessary to cover the Sponsor's share of contractual and in-house fiscal obligations attributable to the Study as they are incurred.

5. In the event the Government determines that the Sponsor must provide additional funds to meet its share of Study Costs, the Government shall so notify the Sponsor in writing. No later than 60 calendar days after receipt of such notice, the Sponsor shall make the full amount of the additional required funds available through the funding mechanism specified in paragraph B.2. of this Article.

C. Within ninety (90) days after the conclusion of the Study Period or termination of this Agreement, the Government shall conduct a final accounting of Study Costs, including disbursements by the Government of Federal funds, cash contributions by the Sponsor, the amount of any excess Study Costs, and credits for the negotiated costs of the Sponsor, and shall furnish the Sponsor with the results of this accounting. Within thirty (30) days thereafter, the Government, subject to the availability of funds, shall reimburse the Sponsor for the excess, if any, of cash contributions and credits given over its required share of Study Costs, other than excess Study Costs, or the Sponsor shall provide the Government any cash contributions required for the Sponsor to meet its required share of Study Costs other than excess Study Costs.

D. The Sponsor shall provide its cash contribution for excess Study Costs as required under Article II.C. of this Agreement by delivering a check payable to "FAO, USAED, SACRAMENTO" to the District Engineer as follows:

1. After the project that is the subject of this Study has been authorized for construction, no later than the date on which a Project Cooperation Agreement is entered into for the project; or

2. In the event the project that is the subject of this Study is not authorized for construction by a date that is no later than 5 years of the date of the final report of the Chief of Engineers concerning the project, or by a date that is no later than 2 years after the date of the termination of the study, the Sponsor shall pay its share of excess costs on that date (5 years after the date of the Chief of Engineers or 2 year after the date of the termination of the study).

ARTICLE IV - STUDY MANAGEMENT AND COORDINATION

A. To provide for consistent and effective communication, the Sponsor and the Government shall appoint named senior representatives to an Executive Committee. Thereafter, the Executive Committee shall meet regularly until the end of the Study Period.

B. Until the end of the Study Period, the Executive Committee shall generally oversee the Study consistently with the PSP.

C. The Executive Committee may make recommendations that it deems warranted to the District Engineer on matters that it oversees, including suggestions to avoid potential sources of dispute. The Government in good faith shall consider such recommendations. The Government has the discretion to accept, reject, or modify the Executive Committee's recommendations.

D. The Executive Committee shall appoint representatives to serve on a Study Management Team. The Study Management Team shall keep the Executive Committee informed of the progress of the Study and of significant pending issues and actions, and shall prepare periodic reports on the progress of all work items identified in the PSP.

E. The costs of participation in the Executive Committee (including the cost to serve on the Study Management Team) shall be included in total project costs and cost shared in accordance with the provisions of this Agreement.

ARTICLE V - DISPUTES

As a condition precedent to a party bringing any suit for breach of this Agreement, that party must first notify the other party in writing of the nature of the purported breach and seek in good faith to resolve the dispute through negotiation. If the parties cannot resolve the dispute through negotiation, they may agree to a mutually acceptable method of non-binding alternative dispute resolution with a qualified third party acceptable to both parties. The parties shall each pay 50 percent of any costs for the services provided by such a third party as such costs are incurred. Such costs shall not be included in Study Costs. The existence of a dispute shall not excuse the parties from performance pursuant to this Agreement.

ARTICLE VI - MAINTENANCE OF RECORDS

A. Within 60 days of the effective date of this Agreement, the Government and the Sponsor shall develop procedures for keeping books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to this Agreement to the extent and in such detail as will properly reflect total Study Costs. These procedures shall incorporate, and apply as appropriate, the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to state and local governments at 32 C.F.R. Section 33.20. The Government and the Sponsor shall maintain such books, records, documents, and other evidence in accordance with these procedures for a minimum of three years after completion of the Study and resolution of all relevant claims arising therefrom. To the extent permitted under applicable Federal laws and regulations, the Government and the Sponsor shall each allow the other to inspect such books, documents, records, and other evidence.

B. In accordance with 31 U.S.C. Section 7503, the Government may conduct audits in addition to any audit that the Sponsor is required to conduct under the Single Audit Act of 1984, 31 U.S.C. Sections 7501-7507. Any such Government audits shall be conducted in accordance with Government Auditing Standards and the cost principles in OMB Circular No. A-87 and other applicable cost principles and regulations. The costs of Government audits shall be included in total Study Costs and shared in accordance with the provisions of this Agreement.

ARTICLE VII - RELATIONSHIP OF PARTIES

The Government and the Sponsor act in independent capacities in the performance of their respective rights and obligations under this Agreement, and neither is to be considered the officer, agent, or employee of the other.

ARTICLE VIII - OFFICIALS NOT TO BENEFIT

No member of or delegate to the Congress, nor any resident commissioner, shall be admitted to any share or part of this Agreement, or to any benefit that may arise therefrom.

ARTICLE IX - FEDERAL AND STATE LAWS

In the exercise of the Sponsor's rights and obligations under this Agreement, the Sponsor agrees to comply with all applicable Federal and State laws and regulations, including Section 601 of Title VI of the Civil Rights Act of 1964 (Public Law 88-352) and Department of Defense Directive 5500.11 issued pursuant thereto and published in 32 C.F.R. Part 195, as well as Army

Regulations 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army".

ARTICLE X - TERMINATION OR SUSPENSION

A. This Agreement shall terminate at the conclusion of the Study Period, and neither the Government nor the Sponsor shall have any further obligations hereunder, except as provided in Article III.C.; provided, that prior to such time and upon thirty (30) days written notice, either party may terminate or suspend this Agreement. In addition, the Government shall terminate this Agreement immediately upon any failure of the parties to agree to extend the study under Article II.E. of this agreement, or upon the failure of the sponsor to fulfill its obligation under Article III. of this Agreement. In the event that either party elects to terminate this Agreement, both parties shall conclude their activities relating to the Study and proceed to a final accounting in accordance with Article III.C. and III.D. of this Agreement. Upon termination of this Agreement, all data and information generated as part of the Study shall be made available to both parties.

B. Any termination of this Agreement shall not relieve the parties of liability for any obligations previously incurred, including the costs of closing out or transferring any existing contracts.

IN WITNESS WHEREOF, the parties hereto have executed this Agreement, which shall become effective upon the date it is signed by the District Engineer for the U.S. Army Corps of Engineers, Sacramento District.

DEPARTMENT OF THE ARMY	PROVO CITY
BY______________________	BY____________________
Colonel, Corps of Engineers District Engineer Sacramento District	Mayor, Provo City

Attachment - Project Study Plan

CONCURRENCE PAGE
Sacramento District,
U.S. Army Corps of Engineers

We, the undersigned, concur with the Project Study Plan dated April 1997 for the Provo River, Utah and Vicinity. We understand that this is a "living" management document that will be updated as needed through the process stated within.

NAME	TITLE	SIGNATURE DATE
Larry Johnson	Project Manager	______________________
Lewis A.Whitney	Deputy DE for PM	______________________
Merritt Rice	Ch, American River/ Great Basin Br	______________________
Scott Stoddard	Study Manager	______________________
Walter Yep	Ch, Planning Div	______________________
Brian Doyle	Ch, Engineering Div	______________________
Don Dennis	Ch, Construction Ops Div	______________________
Ruth Ann Iames	Ch, Contracting Div	______________________
Carl Korman	Ch, Office of Counsel	______________________
Marvin Fisher	Ch, Real Estate Div	______________________
Hugh Damesyn	Ch, Resource Mgt. Off	______________________
Dorothy F. Klasse	Colonel, Corps of Engineers District Engineer	______________________

CONCURRENCE PAGE
Non-Federal Sponsor

The undersigned concurs with the Project Study Plan, dated April 1997 for The Provo River, Utah and Vicinity. I understand that this is a "living" management document that will be updated as needed through the process stated within.

NAME	TITLE	SIGNATURE	DATE
George Stewart	Mayor Provo, Utah	____________________	______

PROJECT STUDY PLAN
TABLE OF CONTENTS

CHAPTER 1 - INTRODUCTION

PURPOSE AND SCOPE OF PROJECT STUDY PLAN

The main purpose of the Project Study Plan (PSP) is to establish the scope, schedule, and cost associated with the feasibility phase of project development. The PSP ensures that the work required for the feasibility phase of the Provo River, Utah and Vicinity Investigation for the City of Provo, Utah has been thoroughly formulated and considered. The PSP will serve as the historical record of the execution of the feasibility study.

The PSP was developed and the study will be managed using as many existing reports, computer programs and data bases, and project management procedures as possible, while still meeting the requirements of ER 1105-2-100 and ER 5-7-1. The PSP is organized to serve ongoing day-to-day study management by the team members and to minimize the amount of work required to update it. Each study team member receives a copy of this PSP and any updates.

RESULTS OF RECONNAISSANCE STUDY

The major findings in the reconnaissance study are:

- There is a significant flood threat to major areas of Provo City.
- Historically, flood problems have occurred frequently along the Provo River and its tributaries in Provo. Flooding in the future could cause substantial damage to much of Provo City, including residential, commercial, public, and industrial structures.
- The expected annual flood damages from the Provo River and the eastside drainages are estimated at over $5 million.
- A plan to solve some of the flooding problems in the study area is feasible. Both structural and nonstructural measures and alternatives were considered.
- Based on reconnaissance-level plan formulation and economic analysis, portions of the structural alternative on the Provo River and Northeast Drainage would yield positive net benefits and are, therefore, eligible for further investigation at the feasibility phase. With further refinement, there is also a likelihood that the remaining portions of the Provo River and the Southeast Drainage may have other potential solutions which could be justified and warrant further investigation.

FEASIBILITY STUDY

Purpose

The objective of this feasibility study is focuses on:

- Define the flood risks posed by the subject streams.
- Identify potential flood control measures and describe the most feasible ones in detail.
- Formulate the NED plan.
- Formulate other alternatives, as appropriate, and identify the locally preferred plan.
- Identify a plan to be tentatively recommended for construction.
- Develop a project management plan (PMP) to guide the design and construction efforts.

Geographical Area

The study area covers approximately 24 square miles of mountainous area and 24 square miles of potentially developable or existing developed area on the valley floor. The study area is located on the eastern side of Utah Valley, bordered on the east by the Wasatch Mountain Range and on the west by Utah Lake. The Provo River extends from the northeastern corner of the study area and flows in a south and west direction eventually reaching Utah Lake. The Provo River originates in the Wasatch Mountains to the north and east of the study area. Deer Creek Reservoir and Jordanelle Reservoir located upstream control the rate of flow in the Provo River. Smaller drainage areas south of Provo Canyon along the east side of the study area also generate tributary flow into the drainage area. These smaller drainages include; Mile High, Little Rock, Rock, Slide, Slate, and Buckley Draw Canyons. (Ironton Canyon, at the far south end of the study area was determined not to warrant further study.) Figure 1 illustrates the study area boundaries used for this report.

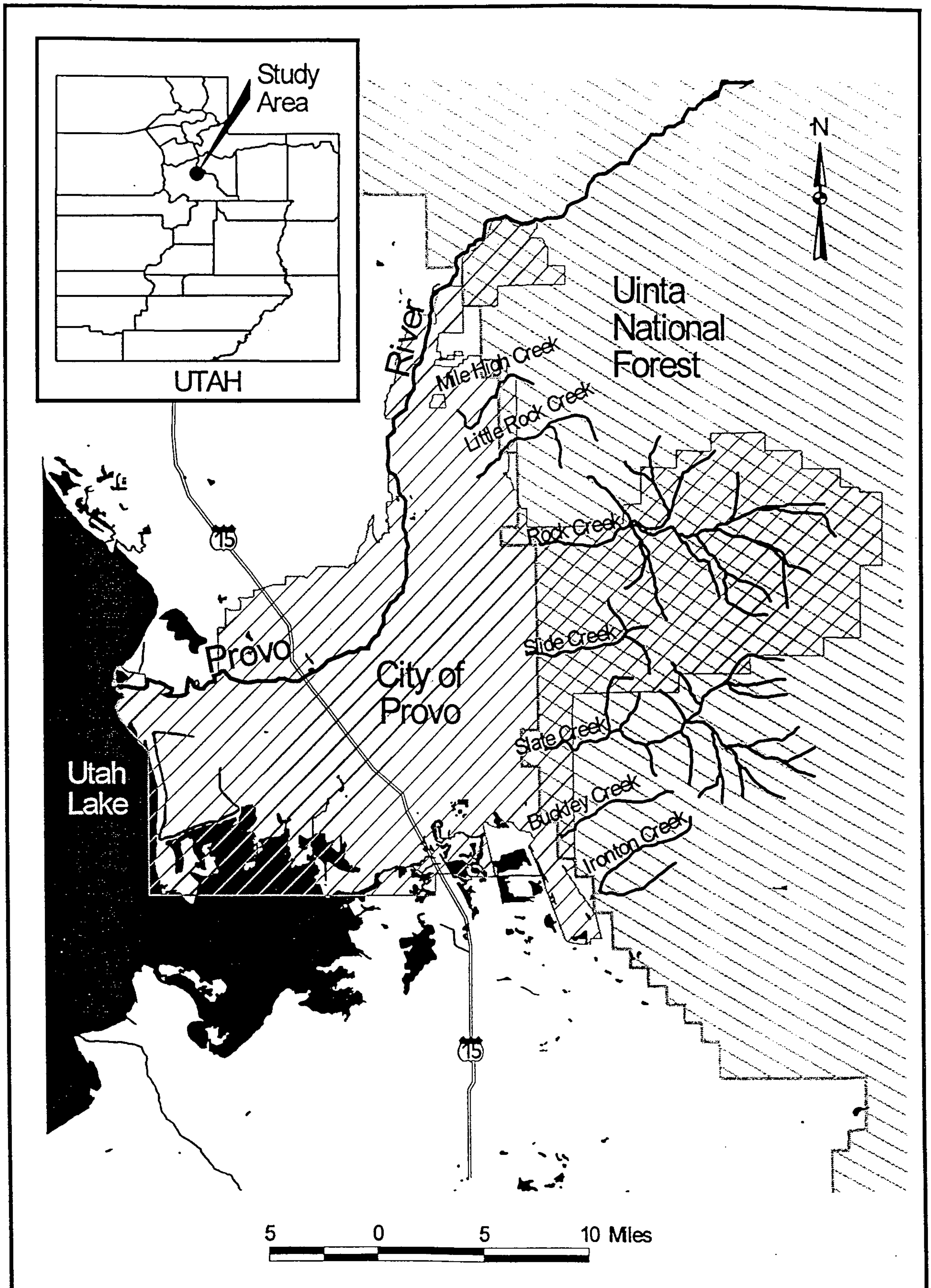


Figure 1. Provo River and Tributaries Study Area and Location Map, Sacramento District, U.S. Army Corps of Engineers.

Preliminary Alternatives

To meet the goals of the feasibility study, two main areas will be addressed: (1)flood control improvements along the Provo River, and (2) flood control improvements on the tributary Northeast and Southeast Drainages. These features are discussed below:

- Provo River flood control alternatives

  ▸ Raise existing levees where needed..

  ▸ Construct new levees where needed.

  ▸ Construct floodwalls where encroachment or other factors would preclude levee construction or be more advantageous than levee construction.

  ▸ Evaluate nonstructural alternatives in those areas of less development to determine if a cost effective solution exists.

- Northeast and Southeast Drainage flood control alternatives

  ▸ Construct new detention basins/pipeline improvements on Slide and Buckley Draw Canyons.

  ▸ Enlarge existing detention basins and associated pipelines on Mile High, Rock, and Slate Canyons.

  ▸ Determine whether improved pipelines or a detention basin is most appropriate on Little Rock Canyon.

CHAPTER 2 - MANAGEMENT OF STUDY

GENERAL

The study will be managed at three basic levels: Corps Project Review Board (PRB), Study Management Team (SMT), and Executive Committee. The following is a description of each. The City of Provo will participate in study management. In order to manage this cost-shared study, an Executive Committee and an SMT will be formed. This management structure will be formalized in the Feasibility Cost-Sharing Agreement (FCSA).

Project Review Boards

PRBs have been established at three levels within the Corps to evaluate the status and progress on all studies, projects, and programs. One PRB includes HQUSACE. The HQUSACE PRB is chaired by the Director of Civil Works or designee and includes the chiefs of the elements whose functions are integral to the USACE role in the civil works project. The HQUSACE PRB will review the study only if it determines that it needs intensive management at that level or if recommended by the South Pacific Division (SPD) PRB. The HQUSACE PRB will facilitate resolution of major study issues, concerns, or problems through Corps functional channels. The HQUSACE PRB meets bimonthly.

The second PRB will be chaired by the SPD Commander or designee and includes the chiefs of the elements whose functions are integral to the role of the Division in civil works projects. The SPD PRB will review monthly the project executive summary (PES) for compliance with the PSP and provide comments to the District. The SPD PRB will facilitate resolution or elevate to the Division Commander or higher authority major issues raised during the study, monitor study contingencies and cost changes against the approved study cost estimate, and take appropriate action on schedule and cost change requests (SACCR), in accordance with ER 5-7-1.

A third PRB will be held by the Sacramento District and chaired by the District Commander or designee. It will include the chiefs of the elements whose functions are integral to the role of the District in the civil works project. The District PRB will review monthly the PES report (along with others in the District) for compliance with the PSP and provide comments to the project manager. The District PRB will facilitate resolution or elevate to SPD major issues raised during the study, monitor study contingencies and costs of changes against the approved study cost estimate. A SACCR would be initiated if the approved schedule or/and FCSA cost estimate is substantially changed. SACCR's can be initiated by the project manager, team members, or sponsor depending on changes in the scope and cost estimates as required in the FCSA. The District PRB also will approve the PSP and any significant changes identified by the SMT and recommend by the project manager in accordance with ER 5-7-1. The sponsor will attend the District PRB meetings at his discretion.

Study Management Team

The SMT will include representatives from the Corps and the City of Provo. This team will ensure appropriate scope of the studies, guide in their accomplishment, and participate in selection of potential solutions. The team will be directly involved in establishing mutual roles and in focusing on the critical issues. Corps representatives will include the study manager and the Chief of American River/Great Basin Branch. The team will recommend to an Executive Committee the tasks to be conducted and extent of planning and evaluation to be carried out in the feasibility phase. The team will also report to the committee on the results of studies and recommend alternative courses of action for project implementation.

SMT meetings will be held regularly throughout the feasibility phase. Meetings will be held at approximately 1-month intervals, but may be more frequent. Current SMT members are listed on Table 1.

Table 1
Study Management Team Members

Organization	Name/Title	Address	Phone
Corps of Engineers CESPK-PD-A	Merritt Rice Chief, Am Riv/Gr Bsn Br	1325 J Street Sacramento, CA 95814	(916) 557-6761 (916) 557-7856 FAX
Corps of Engineers CESPK-PD-A	Scott Stoddard Study Manager	125 S. State St. Rm. 2225 SLC, UT 84138	(801) 524-6890 (916) 524-6893 FAX
Corps of Engineers CESPK-PM-C	Larry Johnson Project Manager	1325 J Street Sacramento, CA 95814	(916) 557-7834 (916) 557-7848 FAX
Corps of Engineers CESPK-ED-D	Kim Christiansen Technical Manager	1325 J Street Sacramento, CA 95814	(916) 557-6630 (916) 557-7846 FAX
Corps of Engineers CESPK-RE-C	Carol Johnson Real Estate Mgr.	1325 J Street Sacramento, CA 95814	(916) 557-6841 (916) 557-7855 FAX
Corps of Engineers CESPK-PD-R	Chris Davis Environmental Coord	1325 J Street Sacramento, CA 95814	(916) 557-7506 (916) 557-7856 FAX
City of Provo Stormwater Service District	Gregory Beckstrom, District Engineer	1377 South 350 East Provo, UT 84606	(801) 379-6720 (801) 379-6778 FAX

Executive Committee

The Executive Committee will include the District Engineer (or her designee), the Chief of Planning Division and the Chief of Programs and Project Management Division. The sponsor, The City of Provo, will provide one representative, along with one primary technical advisor. Those representing The City of Provo will be equal partners with the Corps representatives on the committee. The District Engineer and her counterpart from Provo City will co-chair the committee. The Executive Committee will manage the overall study by (1) maintaining a working knowledge of the feasibility study, (2) assisting in resolving emerging policy issues, (3) ensuring that evolving study results and policies are consistent and coordinated, (4) directing the SMT, and (5) ratifying decisions made by the SMT.

The Executive Committee will participate in Issue Resolution Conferences (IRCs). The committee is also responsible for resolving any disputes that may arise during the study. The committee will agree on the solutions and study direction, which may include termination. At least one IRC will be held prior to the public distribution of the draft feasibility report to ensure that all issues are resolved before the final report is submitted to higher authority. Additional IRCs will be held, as required, throughout the study to resolve any problems that may arise. Current Executive Committee members are identified on Table 2.

Table 2
Executive Committee Members

Organization	Name/Title	Address	Phone
Corps of Engineers CESPK-DE	Dorothy F. Klasse, Colonel District Engineer	1325 J Street Sacramento, CA 95814	(916) 557-7490
Corps of Engineers CESPK-DDP	Lewis A. Whitney Deputy District Engr for Project Management	1325 J Street Sacramento, CA 95814	(916) 557-7832
Corps of Engineers CESPK-PD	Walter Yep Chief, Planning Division	1325 J Street Sacramento, CA 95814	(916) 557-6699
City of Provo Public Works Dept.	Merril Bingham, Director	1377 South 350 East Provo, UT 84606	(801) 379-6770

STUDY MANAGEMENT TOOLS

Over the course of the feasibility study, the Corps will prepare a series of reports and other information documents useful in overall study management. They are available to the study sponsor and are as follows:

Budgetary Documents

The budget analyst and the project manager prepare and submit budgetary documents on the study to higher headquarters. These documents, which summarize study status, expenditures to date, and Federal budget requirements for the following year, are part of a package to Congress to support the President's annual budget request.

Project Executive Summary Report

The project manager prepares the PES report monthly with input from the study sponsors and the study manager. This report will be sent to the Executive Committee, study team members, and the District and Division PRBs. Once the report is submitted to SPD, it may not be changed, but may be annotated. This report will be the principal document for reporting study status issues, milestone forecasts and approvals, and study cost forecasts and approvals.

Monthly Status Report

The study manager will prepare the status report monthly with assistance from SMT members. In the status report, the study manager will report on each study task currently under way or about to be initiated. This report also will document all important dates and milestones, meetings, task completions, etc., and expenditures for Federal and non-Federal funds compared to the approved PSP budgets. The monthly status report will support the PES report. The series of status reports, along with other documents in this PSP, will serve as the record of study progress.

Funds Management Report

The budget analyst will update the funds management report monthly and distribute copies to the study manager and the project manager. This report documents budgets and expenditures for each task, resource, and manner of effort (hired labor, contracts, etc.) for the current Federal fiscal year.

Schedule and Cost Change Request

The SACCR is the form by which changes to the schedule and FCSA cost estimate will be formalized. Changes may be initiated in coordination with the study team. Requests can be made to change the study scope, cost, or milestones. The initiator of the SACCR provides information to the Project Manager for approval of impact-assessment, evaluation of study impacts, and coordination with other SMT members. Local sponsor representatives on the SMT will review and agree to changes proposed by the SACCR before subsequent action by the appropriate level of approval in accordance with ER 5-7-1. Changes to work orders will be negotiated with the initiator of the work order.

The PM is authorized to revise project schedules that do not impact the major milestones. Changes which extend major milestones require approval of the SPD PRB.

Work Orders/Detailed Scopes of Work

The work orders include scopes of work for each work element. Work orders may be in draft form and will be replaced by final versions when final effort and funds are agreed to.

Work orders will be distributed by the project manager and the study manager through the Corps work order system. Work orders will be based on the scopes of work negotiated with Corps technical elements. Work orders will be initiated by the project manager to the appropriate Corps division at the beginning of each fiscal year. Work orders expire at the end of each fiscal year and must be renegotiated for a new fiscal year. The series of work orders, along with other documents in this PSP, will serve as the record of study progress.

Safety and Security Report

The safety and security report contains documentation (if needed) to identify and describe any unique safety and security measures that must be implemented before or during field investigations.

CHAPTER 3 - WORK ELEMENTS AND STUDY COST ESTIMATE

CODE OF ACCOUNTS

For accounting and administrative purposes all tasks, including in-kind services, will be organized in a "Code of Accounts" format as required by ER 1105-2-100. This cost code has been broken down into a series of subaccounts covering project activities during the feasibility phase. In general, the subaccounts relate to activities performed by a specific technical or administrative work element within the Corps. In-kind services performed by the City of Provo are incorporated into the Work Breakdown Structure (WBS) as a cost figure. Responsible functional elements for each account code are described in detail later in this PSP. The Code of Accounts organization of tasks is called a Work Breakdown Structure. Table 3 provides a sample code of accounts work breakdown structure to be used for accounting and administrative purposes.

Table 3
Sample Code of Accounts/Work Breakdown Structure Administrative and Accounting System

Level Number	Level Description	Example	
		Accounting Code	Name
1	Project/Subproject	(none)	Provo River, Utah
2	Product	J	Feasibility Report
3	Subproduct	(none)	(not applicable to this feasibility study)
4	Activity	JA	Engineering Appendix
5	Subactivity	JAA	Surveys and Mapping
6	Work Element	JAA-1	Detailed Site Maps

STUDY COST

All feasibility study costs are required to be cost-shared between the Corps and the non-Federal sponsor on a 50-50 basis. Further, the non-Federal sponsor may provide a maximum of half of it total share as in-kind services toward the study. The feasibility study cost estimate for the Provo, Utah and Vicinity investigation is about $1.5 million. The cost estimate for each major WBS is presented in Table 4. The cash adjustment is the non-Federal cash contribution.

Table 4 - Cost Estimate

WBS Task	Federal	Non - Federal	Total
JJA Surveys	8,000	150,000	158,000
JAB H & H Studies	125,000	0	125,000
JAC Geotechnical Studies	120,000	65,000	185,000
JAE Engineering and Design	100,000	0	100,000
JBA Economic Analysis	80,000	5,000	85,000
JB Institutional/ Social Studies	3,000	5,000	8,000
JCA Real Estate	95,000	0	95,000
JDA Environmental Studies	37,000	3,000	40,000
JEA Fish & Wildlife	14,000	0	14,000
JFA HTRW Studies	2,000	0	2,000
JGA Cultural Resources Report	18,000	0	18,000
JHA Cost Estimates	30,000	0	30,000
JIA Public Involvement	3,000	30,000	33,000
JJA Plan Formulation	70,000	5,000	75,000
JKA Report Doc and Prep	80,000	5,000	85,000
JPA Study Management	253,000	72,000	325,000
JPL Program & Project Mgt	42,000	0	42,000
MOD Technical Review*	25,000	0	25,000
YOD Washington Review*	50,000	0	50,000
Total	1,155,000	340,000	1,495,000
Cash Adjustment	(407,500)	407,500	
50% of Study Cost	747,500	747,500	

* MOD and YOD are included in JPA task description.

DETAILED DESCRIPTION OF WORK

Below is a detailed description of the major feasibility phase tasks needed to meet the objectives identified in Chapter 1. Specifically, feasibility phase tasks focus on the scope of effort for the Provo River and the two eastside drainages.

The description of feasibility study efforts below is organized based upon a work breakdown structure and study products. At the beginning of each task, either the Corps or the local sponsors may review any planned in-kind work or contract of the other for adequacy. At the conclusion of each task, either the Corps or the local sponsor may review and approve the results of the work before it is considered complete. Review and assessment of the adequacy of the task will be accomplished by the SMT and its technical staff. Also, described is a cost estimate of the amount of funds required to complete each task. All work elements that make up the feasibility study through the Division Engineers public notice and Washington level review process are described in this section. The work elements are listed in the code of accounts order described earlier in this PSP.

The PSP forms the basis for estimating the total study cost and respective shares of the Sacramento District, Corps of Engineers (Corps), and the local sponsor, the City of Provo, Utah (sponsor). The PSP is the basis for defining scope and assigning tasks between the Corps and the non-Federal sponsors. The PSP provides a common understanding between non-Federal sponsor, the South Pacific Division (SPD), the Sacramento District, and Headquarters offices of the Corps and provides a basis for managing and monitoring the study. The content and level of detail of the PSP will change over the duration of the study.

DETAILED WORK EFFORT BASED ON WBS

Table 5 and the narratives which follow describe each study activity. Table 5 presents information in the following categories:

- **Tasks:** Tasks, or work elements, are organized by the WBS. Column A provides a task number identifier. Column B lists the Corps organizational element with primary responsibility for the work activity. Each task has a WBS code (e.g., JAA-1) listed in Column C. Each task description is shown in Column D.

- **Level of Effort:** The level of effort is identified in Column E. This shows the estimated number of person days required to carry out the specified task (not the number of calendar days available to accomplish the effort).

- **Charge Type:** The remaining columns list and sum the various types of study costs which include the following:

♦ **Labor Charges**: Corps total labor charges (Column I) include effective, indirect (Departmental Overhead), and overhead (District Overhead) charges. Effective rate charges (Column F) are derived from the rate of pay, leave, and benefits for staff assigned to a task. Indirect (Column G), or departmental overhead, charges reflect non-project specific costs associated with the appropriate organizational element within the Corps District (e.g., Planing Division) and covers such costs as space rental costs, training, and the Division Chief's and other select individuals labor. Overhead (Column H), or District overhead, charges reflect non-project specific costs associated with select elements within the Corps District such as the Resource Management Office, Information Management, EEO Office, the Office of Counsel, etc.

♦ **Miscellaneous Costs (OE)**: These costs reflect charges for printing, photographic services, room or equipment rental, etc. as shown in Column J.

♦ **Other Agency(OA)/Other COE Cost**: These charges, shown in Column K reflect costs associated with work funded by the Corps but completed by other Federal agencies such as the Fish and Wildlife Service.

♦ **Contract Costs (AE):** These charges reflect costs associated with work done by private firms funded through the Corps as shown in Column L..

♦ **Sponsor In-Kind Contribution:** These costs, shown in Column M, reflect the value of work directly accomplished by staff of the non-Federal sponsor or its contractors and all associated expenses.

♦ **Travel Charges:** These charges reflect costs of governmental vehicle use, per diem, etc. as shown in Column N.

Following Table 5 is a detailed description of each study activity by WBS account.

Table 5 - Detailed Study Cost Estimate

TASK NO.	CORPS ORG. CODE	WBS CODE	TASK DESCRIPTION	EFFORT (Person-days)	EFFECTIVE RATE ($/Day)	INDIRECT RATE (Percent)	OVERHEAD RATE (Percent)	LABOR $	OE(Misc) $	OA $	AE $	SPONSOR IN-KIND $	TRAVEL $	TOTAL Subtask	Task
A	B	C	D	E	F	G	H	I	J	K	L	M	N		
	GK	JAA	Surveys and Mapping												
1	GK	JAA-1	Surveys and Mapping	19	204	0.6	0.38	7,674	0	0	0	150,000	326	158,000	
			Subtotal	19											158000
		JAB	Hydrology & Hydraulic Studies/Report												
2	CB	JAB-1	Without Project Hydrology	61	310	0.6	0.38	37,470	0	0	0	0	0	37,470	
3	CN	JAB-2	Flood Plains	32	310	0.6	0.38	19,656	0	0	0	0	1,035	20,691	
4	CN	JAB-3	Induced Flooding Analysis	3	310	0.6	0.38	1,843	0	0	0	0	0	1,843	
5	CN	JAB-4	Hydraulic Design	105	310	0.6	0.38	64,497	0	0	0	0	500	64,997	
			Subtotal	201											125000
		JAC	Geotechnical Studies Report												
6	GG	JAC-1	Baseline Geology & Soils Data	59	250	0.6	0.38	29,205	0	0	0	65,000	500	94,705	
7	GS	JAC-1	Baseline Geology & Soils Data	59	260	0.6	0.38	30,373	0	0	0	0	0	30,373	
8	GG	JAC-2	Geology & Soils Design	59	250	0.6	0.38	29,205	0	0	0	0	0	29,205	
9	GS	JAC-2	Geology & Soils Design	59	260	0.6	0.38	30,373	0	0	0	0	344	30,717	
			Subtotal	236											185000
		JAE	Engineering & Design Analysis Report												
10	CF	JAE-1	Technical Management	70	256	0.6	0.38	35,482	0	0	0	0	0	35,482	
11	CF	JAE-2	Preliminary Designs & Costs	10	256	0.6	0.38	5,069	0	0	0	0	0	5,069	
12	CM	JAE-3	Structural Design	8	310	0.6	0.38	4,914	0	0	0	0	0	4,914	
13	CF	JAE-4	Design & Quantities	57	256	0.6	0.38	28,892	0	0	0	0	1,313	30,205	
14	CF	JAE-5	Draft Basis of Design	29	256	0.6	0.38	14,700	0	0	0	0	0	14,700	
15	CF	JAE-6	Final Basis of Design	19	256	0.6	0.38	9,631	0	0	0	0	0	9,631	
			Subtotal	193											100000
		JBA	Economic Analysis/Report												
16	BK	JBA-1	Economic Damages	81	270	0.4	0.38	38,929	0	0	0	5,000	1,182	45,111	
17	BK	JBA-2	Benefit Analysis	52	270	0.4	0.38	24,991	0	0	0	0	0	24,991	
18	BK	JBA-3	Draft Economic Appendix	21	270	0.4	0.38	10,093	0	0	0	0	0	10,093	
19	BK	JBA-4	Final Economic Appendix	10	270	0.4	0.38	4,806	0	0	0	0	0	4,806	
			Subtotal	164											85000
		JB	Institutional & Social Studies/Report												
20	BP	JBB-1	Social Resources Assessment	2	225	0.4	0.38	800	0	0	0	1,500	125	2,425	
21	BE	JBC-1	Institutional Studies	1	318	0.4	0.38	567	0	0	0	500	0	1,067	
22	BE	JBD-1	Local Financing Plan	1	318	0.4	0.38	567	0	0	0	3,000	0	3,567	
23	BK	JBD-1	Local Financing Plan	1	270	0.4	0.38	481	0	0	0	0	0	481	
24	WG	JBD-1	Local Financing Plan	1	245	0.5	0.38	461	0	0	0	0	0	461	
			Subtotal	6											8000
		JC	Real Estate Studies												
		JCA	Real Estate Supplement/Plan												

Table 5 - Detailed Study Cost Estimate

25	WB	JCA-1	Coordination	16	330	0.5	0.38	9,926	0	0	0	0	500	10,426	
26	WB	JCA-2	Preparation of Real Estate Supplement	8	330	0.5	0.38	4,963	0	0	0	0	0	4,963	
	WB	JCA-3	Review & Revise Report Documents	5	330	0.5	0.38	3,102	0	0	0	0	0	3,102	
		JCB	Gross Appraisal Report												
27	WG	JCB-1	Preparation of Gross Appraisal	84	280	0.5	0.38	44,218	0	0	0	0	1,008	45,226	
		JCC	Preliminary Real Estate Acq. Maps												
28	WC	JCC-1	Real Estate Map Preparaton	18	250	0.5	0.38	8,460	0	0	0	0	0	8,460	
		JCD	All Other Real Estate Analysis/Doc.												
29	WB	JCD-1	Physical Taking Analysis	6	330	0.5	0.38	3,722	0	0	0	0	0	3,722	
30	WB	JCE-1	Preliminary Attorney Opinion/Comp.	11	330	0.5	0.38	6,824	0	0	0	0	0	6,824	
31	WB	JCF-1	Rights of Entry	5	330	0.5	0.38	3,102	0	0	0	0	0	3,102	
32	WC	JCG-1	Baseline Real Estate Cost Estimate	5	250	0.5	0.38	2,350	0	0	0	0	0	2,350	
33	WB	JCG-2	Real Estate Input to PMP	4	330	0.5	0.38	2,482	0	0	0	0	0	2,482	
34	WB	JCG-3	Institutional Financial Cabability Anal.	7	330	0.5	0.38	4,343	0	0	0	0	0	4,343	
			Subtotal	169											95000
		JDA	Environmental Studies/Reports												
35	BP	JDA-1	Public Soping	3	253	0.4	0.38	1,352	0	0	0	3,000	0	4,352	
36	BP	JDA-2	Alternatives Fromulation Participation	4	253	0.4	0.38	1,802	0	0	0	0	0	1,802	
37	BP	JDA-3	FWS Coordination Act Administration	6	253	0.4	0.38	2,703	0	0	0	0	0	2,703	
38	BP	JDA-4	HEP Analysis	10	253	0.4	0.38	4,505	0	0	0	0	500	5,005	
39	BP	JDA-5	Threatened & Enangered Species	11	253	0.4	0.38	4,956	0	0	0	0	0	4,956	
40	BP	JDA-6	Mititation Plan/Incremental Analysis	8	253	0.4	0.38	3,604	0	0	0	0	0	3,604	
41	BP	JDA-7	Water Quality Assessment	3	253	0.4	0.38	1,352	0	0	0	0	0	1,352	
42	BP	JDA-8	Wetlands Assessment	3	253	0.4	0.38	1,352	0	0	0	0	0	1,352	
43	BP	JDA-9	Air Quality Assessment	1	253	0.4	0.38	451	0	0	0	0	0	451	
44	BP	JDA-10	Other Resources Assessment	3	253	0.4	0.38	1,352	0	0	0	0	0	1,352	
45	BP	JDA-11	Fish & Wildlife Enhancement	0	253	0.4	0.38	0	0	0	0	0	0	0	
46	BP	JDA-12	Recreaton	1	253	0.4	0.38	451	0	0	0	0	0	451	
47	BP	JDA-13	Draft EA/FONSI Preparation	15	253	0.4	0.38	6,758	0	0	0	0	457	7,215	
48	BP	JDA-14	Public Review & Comment	5	253	0.4	0.38	2,253	0	0	0	0	0	2,253	
49	BP	JDA-15	Final EA/FONSI	5	253	0.4	0.38	2,253	0	0	0	0	0	2,253	
50	BP	JDA-16	Record of Decision	2	253	0.4	0.38	901	0	0	0	0	0	901	
			Subtotal	80											40000
		JEA	Fish & Wildlife Coordination Act Report												
51	BP	JEA-1	Draft Coordination Act Report	0	253	0.4	0.38	0	0	11,200	0	0	0	11,200	
52	BP	JEA-2	Final Coordination Act Report	0	253	0.4	0.38	0	0	2,800	0	0	0	2,800	
			Subtotal	0											14000
		JFA													
53	EA	JFA-1	HTRW Studies, Report Preparation	4	243	0.6	0.38	1,925	0	0	0	0	75	2,000	
			Subtotal	4											2000
		JGA													
54	BP	JGA-1	Cultural Resources Report Preparation	17	253	0.4	0.38	7,659	0	0	10,000	0	341	18,000	
			Subtotal	17											18000
		JHA													

Table 5 - Detailed Study Cost Estimate

55	HA	JHA-1	Alternative Cost	20	257	0.6	0.38	10,195	0	0	0	0	0	10,195	
56	HA	JHA-2	Draft MCACES Cost	34	257	0.6	0.38	17,331	0	0	0	0	436	17,767	
57	HA	JHA-3	Final MCACES Cost	4	257	0.6	0.38	2,039	0	0	0	0	0	2,039	
			Subtotal	58											30000
		JIA	Public Involvment												
58	BE	JIA-1	Public Workship Mail List/Invitation	1	318	0.4	0.38	567	0	0	0	2,000	0	2,567	
59	BE	JIA-2	Public Workshop Preparation	1	318	0.4	0.38	567	0	0	0	10,000	0	10,567	
60	BE	JIA-3	Public Woprkshop Memorandum	1	318	0.4	0.38	567	0	0	0	2,000	0	2,567	
61	BE	JIA-4	Public Outreach Sessions	0	318	0.4	0.38	0	0	0	0	0	0	0	
62	BE	JIA-5	Public Meeting Mailing List/Invitation	1	318	0.4	0.38	567	0	0	0	2,000	0	2,567	
63	BE	JIA-6	Public Meeting Preparation	1	318	0.4	0.38	567	0	0	0	14,000	166	14,733	
			Subtotal	5											33000
		JJA	Plan Formulation & Evaluation Reports												
64	BE	JJA-1	F3 Conference/Report	15	318	0.4	0.38	8,501	0	0	0	500	500	9,501	
65	BP	JJA-1	F3 Conference/Report	2	253	0.4	0.38	901	0	0	0	0	0	901	
66	BE	JJA-2	F4 Conference/Report	15	318	0.4	0.38	8,501	0	0	0	500	500	9,501	
67	BP	JJA-2	F4 Conference/Report	2	253	0.4	0.38	901	0	0	0	0	0	901	
68	BE	JJC-01	Plan Formulation	78	318	0.4	0.38	44,205	5,000	0	0	4,000	540	53,745	
69	BP	JJC-01	Plan Formulation	1	253	0.4	0.38	451	0	0	0	0	0	451	
			Subtotal	113											75000
		JKA	Report Documentation & Preparation												
70	BE	JKA-1	Draft Feassibility Report Preparation	39	318	0.4	0.38	22,103	10,000	0	0	2,500	0	34,603	
71	BP	JKA-1	Draft Feassibility Report Preparation	5	253	0.4	0.38	2,253	0	0	0	0	0	2,253	
72	BE	JLA-1	Final Feassibility Report Preparation	23	318	0.4	0.38	13,035	15,000	0	0	2,000	0	30,035	
73	BP	JLA-1	Final Feassibility Report Preparation	5	253	0.4	0.38	2,253	0	0	0	0	0	2,253	
74	BE	JPL-1	Draft Project Management Plan	26	318	0.4	0.38	14,735	0	0	0	0	622	15,357	
75	BE	JPZ-3	Sponsor Letter Of Intent	0	318	0.4	0.38	0	0	0	0	500	0	500	
			Subtotal	98											85000
		JPA	Study Management												
76	BE	JPA-1	Study Management, Public Workshop	5	318	0.4	0.38	2,834	0	0	0	2,000	500	5,334	
77	BE	JPA-2	Study Management, F3 Conference	90	318	0.4	0.38	51,006	0	0	0	20,000	500	71,506	
78	BE	JPA-3	Study Management, F4 Conference	90	318	0.4	0.38	51,006	0	0	0	20,000	500	71,506	
79	BE	JPA-4	Study Mamt, Draft Feasibility Report	80	318	0.4	0.38	45,339	0	0	0	15,000	2,000	62,339	
80	BD	JPA-4	Study Mamt, Draft Feasibility Report	5	272	0.4	0.38	2,421	0	0	0	0	0	2,421	
81	HA	JPA-4	Study Mamt, Draft Feasibility Report	3	257	0.6	0.38	1,529	0	0	0	0	0	1,529	
82	WB	JPA-4	Study Mamt, Draft Feasibility Report	3	330	0.5	0.38	1,861	0	0	0	0	0	1,861	
83	CB	JPA-4	Study Mamt, Draft Feasibility Report	3	310	0.6	0.38	1,843	0	0	0	0	0	1,843	
84	CF	JPA-4	Study Mamt, Draft Feasibility Report	3	256	0.6	0.38	1,521	0	0	0	0	0	1,521	
85	CN	JPA-4	Study Mamt, Draft Feasibility Report	3	310	0.6	0.38	1,843	0	0	0	0	0	1,843	
86	GS	JPA-4	Study Mamt, Draft Feasibility Report	3	260	0.6	0.38	1,544	0	0	0	0	0	1,544	
87	BK	JPA-4	Study Mamt, Draft Feasibility Report	3	270	0.4	0.38	1,442	0	0	0	0	0	1,442	
88	BE	JPA-5	Study Mamt, FRC	49	318	0.4	0.38	27,770	0	0	0	10,000	2,000	39,770	
89	BE	JPA-6	Study Management, Public Meeting	35	318	0.4	0.38	19,836	0	0	0	5,000	691	25,527	
90	BE	JJA-7	Study Mamt, Final Feasibility Report	88	318	0.4	0.38	49,873	0	0	0	0	0	49,873	

Table 5 - Detailed Study Cost Estimate

91	BD	JJA-7	Study Mamt, Final Feasibility Report	5	272	0.4	0.38	2,421	0	0	0	0	0	2,421	
92	HA	JJA-7	Study Mamt, Final Feasibility Report	2	257	0.6	0.38	1,019	0	0	0	0	0	1,019	
93	WB	JJA-7	Study Mamt, Final Feasibility Report	2	330	0.5	0.38	1,241	0	0	0	0	0	1,241	
94	CB	JJA-7	Study Mamt, Final Feasibility Report	2	310	0.6	0.38	1,229	0	0	0	0	0	1,229	
95	CF	JJA-7	Study Mamt, Final Feasibility Report	2	256	0.6	0.38	1,014	0	0	0	0	0	1,014	
96	CN	JJA-7	Study Mamt, Final Feasibility Report	2	310	0.6	0.38	1,229	0	0	0	0	0	1,229	
97	GS	JJA-7	Study Mamt, Final Feasibility Report	2	260	0.6	0.38	1,030	0	0	0	0	0	1,030	
98	BK	JJA-7	Study Mamt, Final Feasibility Report	2	270	0.4	0.38	961	0	0	0	0	0	961	
99	BE	JPA-8	Study Mgmt. Public Notice Materials(YOD)	0	318	0.4	0.38	0	0	0	0	0	0	0	
			Subtotal (inc Technical Review)	482											350000
		JPL	Program & Project Management												
100	NC	JPI-1	Monthly Reports Preparation	22	340	1.2	0.38	19,298	0	0	0	0	823	20,121	
101	NC	JPZ-1	Budget Documents	2	340	1.2	0.38	1,754	0	0	0	0	0	1,754	
102	NA	JPZ-1	Budget Documents	23	300	1.2	0.38	17,802	0	0	0	0	0	17,802	
103	NC	JPZ-2	Final Audit Preparaton	0	340	1.2	0.38	0	0	0	0	0	0	0	
104	NA	JPZ-2	Final Audit Preparaton	3	300	1.2	0.38	2,322	0	0	0	0	0	2,322	
			Subtotal	50											42000
105	z	YOD	Washington Level Review	0	301	0.6	0.38	0	50,000	0	0	0	0	50,000	50000
Total								**1,033,017**	**80,000**	**14,000**	**10,000**	**340,000**	**17,984**	**1,495,001**	149500

JAA SURVEYS AND MAPPING

- ***Description:***

1. JAA-1 Detailed Channel/Levee/Basin Mapping: If existing data is insufficient for desired level of accuracy, Corps will develop scope of work for aerial survey and associated topographic data, coordinate with the sponsor, and review final product for compliance. Sponsor will issue and administer contract for aerial survey. Survey will consist of the Provo River from 2000 feet upstream of 2230 north downstream about 17,000 lineal feet to below Geneva Road for a width of 100 feet from the centerline of the channel using 2 foot contour intervals. The aerial survey should also include the "Northeast and Southeast Areas" alluvial fans consisting of Mile High, Little Rock, and Rock Canyons from the canyon mouths to the Provo River and Slide, Slate, and Buckley Draw drainages to the potential terminus of flow near I-15 at the south end of the city. Spot survey existing levees on the Provo River and detention basins on Rock, Mile High, and Slate Canyons. Spot survey possible alignments for conveyance pipelines from detention basins to the Provo River. Locate and use existing data where possible. Where existing 2 foot contour maps are of sufficient accuracy and coverage, spot survey as needed. Total estimated cost for completing this task is $158,000 - $8,000 Corps (Survey Section) and $150,000 Sponsor.

- ***Responsible Sacramento District Element:***
  Engineering Division, Survey Section

- ***Costs:***

➜ Sacramento District Labor

Sacramento District Elements	***Effort (in person-days)***
Survey Section	19
Subtotal, Sacramento District:	$8,000
➜ Contract Cost:	0
➜ Other Agency/Other COE Cost:	0
➜ Miscellaneous Costs:	0
➜ Sponsor In-Kind Contribution:	150,000
➜ Total Cost:	$158,000

JAB HYDROLOGY AND HYDRAULIC STUDIES/REPORT

- ***Description:***

This task will be accomplished by the Corps. Study tasks include the river and eastside (hydrology and detention basin operation) analysis, hydrology and hydraulic design reports. Existing information and data developed by the Corps, and others will be used to complete the analyses.

1. JAB-1 Without Project-Condition Hydrology: Water Management Section will have primary responsibility. Hydraulic Design Section will also have a major role in the determination of the influence of city drainage improvements and flood plain development on both existing and future without-project hydrology.

Water Management Section will analyze rainfall and snowmelt patterns likely to induce flooding along the Provo River, and East Side Streams. Use HEC-2 model for the Provo River. Use Flo-2D Model for the east side streams.

Water Management Section will review and update the existing hydrologic model(s) of the East Side Creeks drainage area and revise the model as appropriate to meet study needs and Corps criteria. Work includes developing stage-frequency and/or flow-frequency curves. This work will be done in coordination with Hydraulic Design Section and the City of Provo. Hydraulic Design Section will work with Water Management Section and the city to develop detention basin location, configuration, design and volume assumptions and to route future 2, 1, and 0.2 percent flows. Water Management Section will add the effect of debris laden flows along the east side drainages. Water Management Section will add the effect of urbanization and city drainage plan features to the drainage model to simulate existing and future conditions. Work also includes incorporating any new channel modifications that affects routing.

Flow-Frequency Uncertainties - Uncertainties in the flow-frequency relationships are based on frequency curve statistics and associated equivalent length of record. Flow-frequency curves will be developed based on different project alternatives. Statistics for these curves will be developed from procedures in Bulletin 17B. The equivalent record length for these curves will be developed from guidelines presented in EC 1105-2-205.

Stage-Frequency Uncertainties - If Risk-Based analyses are necessary in areas where stage-frequency curves will be developed, the error band about the stage-frequency curve will be based on uncertainties of hydraulic characteristics such as n-value.

Stage-Discharge Relationship - The uncertainty in the stage-discharge relationship is a function of the boundary roughness and hydraulic loss coefficients. Rating curves will be developed at selected locations representing maximum and minimum hydraulic conditions. The statistics from these curves will be used in the risk-based analysis.

Regulated Outflow Relationship - For upstream storage sites, curves will be developed representing the uncertainty between inflow and outflow. The uncertainty will be a function of the hydraulic characteristics of the diversion facility into the storage site and the outlet works, sediment inflow and anticipated debris. Water Management Section will determine flow/frequency uncertainty bounds. This data will be used for risk-based analysis.

Run LIMIT program to interface stage-frequency curves into the risk-based analysis.

Prepare narrative office report suitable for incorporation into the draft engineering appendix for the draft feasibility report, including plates, charts and tables. Total estimated cost (Water Management Section) for completing this task is $38,000.

2. JAB-2 Without-Project Flood Plains and Depths: Collect supplemental data as required to further define and detail flood plains. Review and revise most recent HEC-2 database to accurately reflect without-project channel and flood plain conditions. Routings will be done for the 10, 2, 1,0.5, and 0.2 chance flows. Geotechnical Branch will supply PNP and PFP elevations. Set levees to fail at the PNP, provide PFP failure frequency. Attend Study Team Management meetings and milestone conferences as needed. Total estimated cost (Hydraulic Design Section) for completing this task is $20,000.

3. JAB-3 Induced Flooding Analysis: Perform with-project hydrology, New hydrology studies will also include determining the uncertainty of the flow-frequency relationship for use in a risk-based analysis. Attend study team meetings and coordinate with sponsor hydrologic engineering staff. Prepare a narrative office report suitable for incorporation into the draft engineering appendix for the draft feasibility report, including plates, charts and tables. Total estimated cost (Hydraulic Design Section) for completing this task is $2,000.

4. JAB-4 Hydraulic Design: Conduct field investigations. Perform sediment engineering investigation of basin and channels (including channel stability analyses of preproject and project conditions), develop hydraulic design of channel modification (including channel dimensioning, bank protection, levee design, provide flow/depth uncertainty relationship for conducting risk-based analyses, determine induced flooding potential and need for hydraulic mitigation, and provide input to Water Management Section for interior flood analyses. Produce plans and profiles of improvements. Also develop hydraulic design of detention basins and outlet culvert (including basin and culvert dimensioning, basin bank protection, basin and culverts, provide uncertainty relationship for conducting risk-based analyses. Prepare narrative office report suitable for incorporation into the draft engineering appendix to the draft feasibility report. Attend study team meetings and coordinate with sponsor hydrologic engineering staff. Total estimated Corps cost (Hydraulic Design Section) for completing this task is $65,000.

- ***Responsible Sacramento District Element:***
  Engineering Division, Civil Design Branch

- ***Costs:***

→ Sacramento District Labor

Sacramento District Elements	***Effort (in person-days)***
Water Management Section	61
Hydraulic Design Section	140

Subtotal, Sacramento District:	$125,000
→ Contract Cost:	0
→ Other Agency/Other COE Cost:	0
→ Miscellaneous Costs:	0
→ Sponsor In-Kind Contribution:	0
→ Total Cost:	$125,000

JAC GEOTECHNICAL STUDIES REPORT

- ***Description:***

This task will be performed by the Corps and Sponsor. Geology and Soil Design Sections will conduct field investigations and prepare a soils design report for inclusion in the engineering design appendix. Existing geology and soil design information will be used.

1. JAC-1 Baseline Geology and Soils Data: Conduct field investigations of existing project levee locations along the Provo River. Levee locations are as outlined in the Reconnaissance Report. Check non-engineered levees for integrity. Perform PNP/PFP analyses as required on Provo River levees. Map existing levees and condition thereof. Propose upgrade, infill and replacement of levees where required to meet alternative level of protection.

Investigate existing detention basins along the east side creeks. Conduct field investigations of detention basins on Mile High Canyon, Rock Canyon and Slate Canyon Creeks. Investigate the integrity of the existing basins for potential enlargement. Conduct PNP/PFP analysis of the existing basins. Investigate non-engineered basins for integrity, and usefulness as detention basins for alternative levels. Investigate the effect of antenna foundations (currently anchored in basins) on basin soils.

Investigations will include exploratory drill holes and trenching as needed. Laboratory testing of samples collected during the explorations will be conducted by at a soils lab provided by the Sponsor. Corps' design criteria, primarily EM 1110-2-1913, "Design and Construction of Levees," will be used in evaluating the structural integrity of the existing levees and detention basin walls. Guidance provided in ETL 1110-2-328, "Reliability Assessment of Existing Levees for Benefit Determination, 22 May 1993," will be used in determining the PNP and PFP values. This guidance prescribes using stability criteria and past performance in selecting these values. Although stability is considered in the selection of the PNP and PFP, where levees have performed during flooding, past performance is weighed more heavily in the selection of the PNPs and PFPs. Work will be done by Geology and Soils Design Sections in accordance to their function expertise. Total estimated cost for completing this task is $125,000 - $60,000 Corps (Geotechnical Branch) and $65,000 Sponsor.

2. JAC-2 Geology and Soils Design: Prepare design analysis for modification of existing levees and design of new levees and basins (Soil Design), and assess side slope stability along river and levees and basin levees. Identify borrow and disposal areas (Geology), conduct explorations for foundation conditions (Geology). Prepare narrative office report suitable for incorporation into the engineering appendix of the feasibility report (Geology and Soil Design) including discussion of areal geology (Geology), seismic assessment (Geology), and groundwater studies. Total estimated Corps cost for completing this task is $60,000.

- ***Responsible Sacramento District Element:***
  Engineering Division, Geotechnical Branch, Soils Design Section

- ***Costs:***

➔ Sacramento District Labor

Sacramento District Elements	***Effort (in person-days)***
Soil Design Section	118
Geology Section	118
Subtotal, Sacramento District:	$120,000
➔ Contract Cost:	0
➔ Other Agency/Other COE Cost:	0
➔ Miscellaneous Costs:	0
➔ Sponsor In-Kind Contribution:	65,000
➔ Total Cost:	$185,000

JAE ENGINEERING AND DESIGN ANALYSIS REPORT WITH PRELIMINARY DRAWINGS

- ***Description:***

This task will be performed by the Corps and includes technical management throughout the study, designs, quantities, and the basis of design. All tasks except Structural Design will be the responsibility of Design and Studies Section.

1. JAE-1 Technical Management: Manage and coordinate Engineering Division technical elements (Water Management, Hydraulic Design, Geotechnical, Civil Design, and Cost Engineering Branches). Assure work is adequate and appropriate for the feasibility study. As a member of the SMT, attend and participate in meetings and respond to SMT requests. Coordinate and help plan Engineering Division activities during design and construction phases; provide input to the PMP. This overall management task is ongoing throughout the duration of the study. Total estimated cost for completing this task is $35,000.

2. JAE-2 Preliminary Design and Costs: Coordinate with study management and attend plan formulation meetings. Prepare preliminary designs and first and annual cost estimates of two alternatives. The purpose of this estimate is to establish general economic feasibility given study findings to date. Costs may be based on designs and backup data connected with the reconnaissance report basis of design. Costs will be reported to the study manager for inclusion in the F3 Conference Report. Price levels and interest rates to be provided by the study manager upon request. Total estimated cost (Design and Studies Section) for completing this task is $5,000.

3. JAE-3 Structural Design: Develop structural designs for hydraulic structures and other project features. Total estimated cost for completing this task is $5,000.

4. JAE-4 Design and Quantities: Coordinate all technical engineering division design effort with Planning Division and sponsor, issue work order requests and monitor study team progress (Design and Studies Section). Prepare design and quantities for channel enlargement and levee modification/floodwalls, utility relocations, basin outlet works, underground pipe systems required, develop taking plan(s) for real estate including project acquisitions, disposal areas, and temporary construction easements, develop operation and maintenance considerations including assessing baseline performance, develop planning and engineering and a construction schedule (all above is Design and Studies Section), and develop quantities for detention basin(s) (Design and Studies Section). Prepare preliminary narrative and plates in support of the F4 Conference Report (Design and Studies Section). Attend study team meetings and conduct field investigations of the study area. Total estimated cost for completing this task is $30,000.

5. JAE-5 Draft Basis of Design: Prepare narrative and plates for the draft basis of

design to the draft feasibility report. Incorporate the documentation into the Draft Engineering Appendix. Total estimated cost for completing this task is $15,000.

6. JAE-6 Final Basis of Design: Revise draft basis of design based on public, agency, and Corps of Engineers SPD & HQ comments. Incorporate the documentation into the Final Engineering Appendix. Prepare engineering and design input to the PMP. Total estimated cost for completing this task is $10,000.

- ***Responsible Sacramento District Element:***
  Engineering Division, Civil Design Branch, Design and Studies Section

- ***Costs:***

→ Sacramento District Labor

Sacramento District Elements	***Effort (in person-days)***
Design & Studies Section	185
Structural Design Section	8

Subtotal, Sacramento District:	$100,000
→ Contract Cost:	0
→ Other Agency/Other COE Cost:	0
→ Miscellaneous Costs:	0
→ Sponsor In-Kind Contribution:	0
→ Total Cost:	$100,000

JBA ECONOMIC ANALYSIS/REPORT

- ***Description:***

This task will be performed by the Corps. The work will require floodplain maps and without- and with-project stage data, which will be prepared under Hydrology and Hydraulic Studies/Report Subactivity and provided to Economics Branch through the Technical Study Manager.

1. JBA-1 Economic Damages: This task includes obtaining flood plain maps and gathering and compiling property and structure characteristics such as foundation heights, square footage, number of stories including basements, usage, and type of construction for those structures located within the flood plains.

The value of structures will be determined using three types of data: (1) assessor's data, (2) real estate sales data, and (3) replacement cost and depreciation information in the Marshall

& Swift Real Estate Appraisal Handbook. One of the three will be used to determine the initial values. One of the remaining two will then be used to set the statistical parameters (e.g., ± 10% of value). The value of contents used will depend on the land use category. For commercial establishments, field surveys for will be used. For industrial properties, interviews conducted in the study area will be used. These will be reviewed and revised if necessary. Residential contents will be based on studies that have been done outside of the District.

First floor elevations will be determined using contour maps (2-foot or 5-foot contour intervals, depending on availability). The statistical uncertainties associated with these maps is already noted in the risk analysis EC 1105-2-205. Depth/percent damage relationships will be based primarily on FIA curves. Historical flood damage information will also be collected and used wherever it is appropriate.

A risk-based analysis will be done to help quantify uncertainties in the flood damage estimates. The critical key variables that will be evaluated include structure first-floor elevations, structure values, and content values.

Flood damages will be evaluated, and flood control benefits of the various alternatives and the selected plan will be determined. Existing conditions and future land use development projections will also be evaluated. Damages evaluation will be used to help formulate alternatives and will be documented in the F3 Conference Report. Total estimated cost for completing this task is $45,000 - $40,000 Corps and $5,000 Sponsor.

2. JBA-2 Benefit Analysis: Once flood damages are estimated, the following benefit categories will be determined: inundation reduction benefits, location benefits, savings in flood proofing costs, advanced bridge replacement, transportation cost savings, emergency cost savings, and employment benefits. Other potential benefits associated with incidental purposes will also be examined. Benefits will be calculated for each alternative.

In addition, Economics Branch will assist American River/Great Basin Branch running Monte Carlo simulations using hydrology, hydraulics, and economics probability distributions (see work element JJA-2). Monte Carlo simulations will be run in coordination with technical study management and the sponsor to assess alternatives and select a plan. Benefits will be documented in the F4 Conference Report. Total estimated Corps cost for completing this task is $25,000.

3. JBA-3 Draft Economic Appendix: A draft economic appendix will be prepared for inclusion in the technical documentation for the draft feasibility study and will include development of benefits for each alternative. Tasks will include responding to in-house and F4 conference comments, preparing materials, including text, tables, and plates, for inclusion in the appendix, assisting in plan formulation, responding to comments, and attending team meetings to report on findings. Total estimated Corps cost for completing this task is $10,000.

4. JBA-4 Final Economics Appendix: Based on comments from the draft feasibility report review, the public review, and the Feasibility Review Conference, documentation of economic studies will be finalized in a final economic appendix to be attached to the final feasibility report. Provide economics input to the PMP. Total estimated cost for completing this task is $5,000.

- ***Responsible Sacramento District Element:***
  Planning Division, Economics Branch

- ***Costs:***

→ Sacramento District Labor

Sacramento District Elements	***Effort (in person-days)***
Economics Branch	164

Subtotal, Sacramento District:	$80,000
→ Contract Cost:	0
→ Other Agency/Other COE Cost:	0
→ Miscellaneous Costs:	0
→ Sponsor In-Kind Contribution:	5,000
→ Total Cost:	$85,000

JB INSTITUTIONAL & SOCIAL STUDIES/REPORT

- ***Description:***

Social resources baseline conditions, including land use, population, public facilities, and other relevant demographic and community data will be determined. Institutional studies and financial analysis will be prepared.

1. JBB-1 Social Resources Assessment: Determine social resources baseline conditions, including land use, population, public facilities, and other relevant demographic and community data; determine alternative impacts to resource and appropriate mitigation, if any. Corps will assess social impacts as they pertain to the EA. The sponsor will assess and report on social impacts as required by state and local regulations. Corps and the sponsor will coordinate to avoid duplication of effort. Social resources documentation will be part of the EA/FONSI. Total estimated cost for completing this task is $2,500 - $1,000 Corps (Environmental Analysis Section) and $1,500 Sponsor.

2. JBC-1 Institutional Studies: Institutional studies are required to assess the acceptability and implementability of the selected plan from a local interests perspective. Both

the sponsor and Corps will identify, if they exist, any way the proposed action would be in conflict with community interests. General acceptance or nonacceptance of the proposed action that may not have been explored during public involvement will be identified and reported on. Total estimated cost for completing this task is $1,000 - $500 Corps (American River/Great Basin Branch) and $500 Sponsor.

3. JBD-1 Local Financing Plan: This work element includes the effort required to establish Provo Cities' capability to finance their portion of the project costs, to determine the cost allocations between the Corps of Engineers and the sponsor, and to determine the best method of financing the project costs.

The sponsor will document its financial capability and prepare a Local Financing Plan. The plan will include the funding sources for project construction and credit analysis (i.e., bond rating). Corps will advise the sponsor on plan requirements and review the plan before it is finalized. Real Estate and Economics Branch will review the local financing plan. Total estimated cost for completing this task is $4,500 - $1,500 Corps (American River/Great Basin and Economics Branches and Real Estate Division) and $3,000 Sponsor.

- ***Responsible Sacramento District Element:***
  Environmental Analysis Section (Social Resources Assessment)
  American River/Great Basin Branch (Institutional Studies and Financing Plan)

- ***Costs:***

➜ Sacramento District Labor

Sacramento District Elements	***Effort (in person-days)***
Environmental Analysis Section	2
American River/Great Basin Branch	2
Real Estate Division	1
Economics Branch	1
Subtotal, Sacramento District:	$3,000
➜ Contract Cost:	0
➜ Other Agency/Other COE Cost:	0
➜ Miscellaneous Costs:	0
➜ Sponsor In-Kind Contribution:	5,000
➜ Total Cost:	$8,000

JC REAL ESTATE STUDIES

■ ***Description:***

This task includes Real Estate supplement/plan, gross appraisal, acquisition, and other real estate analysis. Detailed task descriptions follow:

JCA - REAL ESTATE SUPPLEMENT/PLAN

1. JCA-1 Coordination: This task will be completed by the Corps and includes, but is not limited to, CESPK-RE participation in team meetings, negotiation of work requirements, coordination with other offices on Project data needed for Real Estate's major study products, and monitoring of progress and findings associated with Real Estate study products. Total estimated Corps cost (Acquisition Branch) for completing this task is $10,000.

2. JCA-2 Preparation of Real Estate Supplement: This work includes preparation of the Real Estate Supplement (RES) which is an overall plan describing the minimum real estate requirements for the project requirements (see ER 405-1-12, Draft Chapter 12). Total estimated Corps cost (Acquisition Branch) for completing this task is $5,000.

3. JCA-3 Review and Revise Report Documents: Includes all CESPK-RE activity involved in reviewing the Feasibility Report and responding to Division comment. Total estimated Corps cost (Acquisition Branch) for completing this task is $3,000.

JCB - Gross Appraisal Report

1. JCB-1 Preparation of Gross Appraisal: This work includes preparation of a detailed estimate of all real estate costs associated with acquisition of the Project's real property requirements. (See ER 405-1-12, Draft Chapter 12, Section III, Appraisals, paragraph 12-12b and Real Estate Policy Guidance Letter Number 3, Guidance for Preparation of Gross Appraisals.) Total estimated Corps cost (Appraisal Branch) for completing this task is $45,000.

JCC - Preliminary Real Estate Acquisition Maps

1. JCC-1 Real Estate Map Preparation: Determine tract ownership and acreage. Prepare real estate preliminary and final take line drawings. Total estimated Corps cost (Planning and Control Branch) for completing this task is $8,500.

JC - All Other Real Estate Analyses/Documents

1. JCD-1 Physical Takings Analysis: This task is to evaluate if project development hydraulically impacts property, by taking or diminishing property or rights for the publics'

use, i.e., by modifying the frequency, depth, or duration of water upon the property. Total estimated Corps cost (Acquisition Branch) for completing this task is $4,000.

2. JCE-1 Preliminary Attorney's Opinion of Compensability: Investigation and attorney's determination, if owners of facility's or utility's affected by the project have a vested interest and compensable interest in the property, with regard to the real estate taking. If so, the obligation or liability of the Government is the cost of providing substitute facilities or utilities, if necessary, for existing publicly owned roads and utilities as well as existing privately owned railroads and utilities. Total estimated Corps cost (Acquisition Branch) for completing this task is $7,000.

3. JCF-1 Rights of Entry: Real Estate will coordinate requests and work with the sponsor to obtain rights of entry (ROE) for the survey, HTRW, cultural resource, and geotechnical exploration work required. ROE must be obtained before any testing can be done on privately owned property. Total estimated Corps cost (Acquisition Branch) for completing this task is $3,000.

4. JCG-1 Baseline Real Estate Cost Estimate: Accounting for the Project's total estimated real estate cost in Code of Accounts format as required by EC 1110-2-528 under Feature Codes 01, Lands and Damages. This estimate of total real estate cost should include estimated costs for all Federal and sponsor activities necessary for completion of the project. Total estimated Corps cost (Planning and Control Branch) for completing this task is $2,500.

5. JCG-2 Real Estate Input to PMP: Ensures that the Real Estate Supplement is provided to the PM and its components are properly incorporated into PMP. Also includes Chief of Real Estate Division endorsement of the PMP which certifies that the real estate requirements, including schedule of acquisition, are adequately and accurately included in the PMP. Total estimated Corps cost (Acquisition Branch) for completing this task is $2,500.

6. JCG-3 Institutional Financial Capability Analysis: Review the sponsor's financial arrangements required to implement the recommended plan and determine their financial capability. Total estimated Corps cost (Acquisition Branch) for completing this task is $4,500.

- ***Responsible Sacramento District Element:***
  Real Estate Division, Acquisition Branch

- ***Costs:***

→ Sacramento District Labor

Sacramento District Elements	*Effort (in person-days)*
Acquisition Branch	62
Appraisal Branch	84
Planning and Control Branch	23

	Subtotal, Sacramento District:	$95,000
➔	Contract Cost:	0
➔	Other Agency/Other COE Cost:	0
➔	Miscellaneous Costs:	0
➔	Sponsor In-Kind Contribution:	
➔	Total Cost:	$95,000

JDA - ENVIRONMENTAL STUDIES/REPORT

- ***Description:***

This group of tasks includes all environmental analyses including HEP, preparation of the draft and final Environmental Assessment, Fish and Wildlife Service coordination, threatened and endangered species coordination, etc. Environmental data available from the reconnaissance phase will be used. Environmental Analysis Section of Environmental Resources Branch will be the responsible Corps element for these tasks.

1. JDA-1 Public Scoping Activities: Prepare and distribute a notice of intent; assist with mailing list for notice and invitation to a public workshop; assist with public workshop and other public involvement activities. Local responsibilities include assuring that DEQ and other state and local regulations concerning public involvement are met. Total estimated cost for completing this task is $4,200 - $1,200 Corps and $3,000 Sponsor.

2. JDA-2 Alternative Formulation Participation: Participate in developing alternatives, general coordination with other elements, attend study team meetings, advise on environmental aspects of alternatives. Total estimated Corps cost for completing this task is $1,900

3. JDA-3 FWS Coordination Act Administration: The Corps will write a scope of work and transfer funds to FWS for biological surveys, HEP analysis, and draft and final Coordination Act Reports. Work also includes supervising FWS work and providing FWS with required information such as description of alternatives, map of areas affected, etc. Total estimated Corps cost for completing this task is $2,500.

4. JDA-4 HEP Analysis: Participate in a HEP team. The team will consist of one representative each from the Corps, the sponsor, and FWS. A representative from the Utah Division of Wildlife Resources may also be on the HEP team, but that person's salary would not be funded by this Federal study. All team members must be HEP certified. The work includes attending meetings, mapping, field work to assess habitats, choosing indicator species, and identifying mitigation alternatives. The team will produce a HEP report which

will document baseline conditions and impacts from the selected plan. The Corps will provide project description, maps, etc. Total estimated Corps cost for completing this task is $4,900.

5. JDA-5 Threatened and Endangered Species: Complete the Section 7 process to satisfy the Endangered Species Act. Corps will perform Section 7 consultation with the FWS, and prepare Biological Data Report. and a Biological Assessment. Total estimated Corps cost for completing this task is $4,900.

6. JDA-6 Mitigation Plan/Incremental Analysis: The Corps will have the major responsibility for this work. Based on reported impacts, develop rough estimates of required mitigation and mitigation costs for alternative plans; develop a more detailed mitigation plan and costs for the selected plan. The sponsor will select mitigation sites, subject to approval by the Corps. Total estimated Corps cost for completing this task is $3,700.

7. JDA-7 Water Quality Assessment: The Corps will complete a water quality assessment, 404(b)(1) analysis, and mitigation plan. review the plan. Total estimated Corps cost for completing this task is $1,200.

8. JDA-8 Wetlands Assessment: Delineate wetlands in study area for Section 404 requirements and state and local laws; determine impacts of alternative plans to wetlands and mitigation requirements. The task will include field surveys, mapping, and report preparation. Total estimated Corps cost for completing this task is $1,200.

9. JDA-9 Air Quality Assessment: Perform an air quality baseline assessment, determine impacts of alternatives, and develop appropriate mitigation. Total estimated Corps cost for completing this task is $600.

10. JDA-10 Other Resources Assessment: Determine baseline conditions, assess alternative impacts, and formulate appropriate mitigation for resources not described elsewhere. The Corps will be responsible for an HTRW write up based on the HTRW Studies and report accomplished under a separate activity in this PSP. The Corps will also be responsible for baseline studies and impacts to land use. Traffic, noise, visual resources, and cumulative and growth inducing impacts will also be evaluated. Total estimated Corps cost for completing this task is $1,200.

11. JDA-11 Fish and Wildlife Enhancement: Although opportunities for wildlife enhancement may exist, there is no willing sponsor for enhancement at this time. If a fish and wildlife enhancement does come forward, the sponsor will prepare a brief preliminary plan and a SACCR to develop the enhancement plan to feasibility level of detail. Therefore, the total estimated Corps cost for completing this task is $ 0.

12. JDA-12 Recreation: The recreation plan will consist of replacing the existing trail on the Provo River levees and other affected facilities, if any. Total estimated Corps cost for

completing this task is $600.

13. JDA-13 Draft EA/FONSI Preparation: Examine NEPA, and other environmental related regulations, organize and format data, describe alternatives, including construction durations, borrow and disposal areas, etc., Corps will assemble and reproduce Draft EA/FONSI. The sponsor will write and provide material specific to the EA/FONSI that the Corps will incorporate into the draft EA/FONSI. Reproduction and distribution of reports is covered under Draft Feasibility Report Documentation. The Corps and the sponsor will coordinate to avoid duplicate effort. Total estimated Corps cost for completing this task is $7,400.

14. JDA-14 Public Review and Comment: Help prepare for and attend public meeting, administer statutory comment period, address and incorporate public comments. The sponsor will prepare a report documenting and summarizing comments both written and oral on the draft feasibility report and draft EA/FONSI. The Corps will be responsible for addressing comments. Total estimated Corps cost for completing this task is $2,500.

15. JDA-15 Final EA/FFONSI Preparation: Incorporate changes and comments from Draft EA/FONSI, assemble into Final EA/FONSI. Reproduction and distribution of reports is covered under Final Feasibility Report Preparation. Total estimated Corps cost for completing this task is $2,500.

16. JDA-16 Record of Decision: Prepare a Record Decision, submit to the Federal Register. Total estimated Corps cost for completing this task is $700.

- ***Responsible Sacramento District Element:***
  Planning Division, Environ. Res. Branch, Environ. Analysis Section

- ***Costs:***

➜ Sacramento District Labor

Sacramento District Elements	***Effort (in person-days)***
Environmental Analysis Section	80
Subtotal, Sacramento District:	$37,000
➜ Contract Cost:	0
➜ Other Agency/Other COE Cost:	0
➜ Miscellaneous Costs:	0
➜ Sponsor In-Kind Contribution:	3,000
➜ Total Cost:	$40,000

JEA FISH AND WILDLIFE COORDINATION ACT REPORT

- *Description:*

This effort is for the US Fish and Wildlife Service to prepare the draft and final Fish and Wildlife Coordination Act Report (CAR). Work will include environmental data collection and evaluation of environmental resources of the study area.

1. JEA-1 Draft Coordination Act Report: This task includes work to be conducted by the Fish and Wildlife Service (FWS). Work will include environmental data collection and evaluation of the environmental resources of the study area. The FWS will review alternative plans and assess alternative impacts of the environmental values of the study area. The FWS will offer recommendations concerning Fish and Wildlife enhancement. As part of this work effort the FWS will be participate as a team member in HEP evaluation. The Draft Fish and Wildlife Coordination Act Report will be incorporated as an attachment to the draft EA/FONSI. Total estimated FWS cost for completing this task is $11,200.

2. JEA-2 Final Coordination Act Report: This task includes work to be conducted by the FWS. Work will include incorporating changes resulting from review of the Draft EA./FONSI, Draft Feasibility Report, and Draft Coordination Act Report. The Final Fish and Wildlife Coordination Act Report will be incorporated as an attachment to the Final EA/FONSI. Total estimated FWS cost for completing this task is $2,800.

- ***Responsible Sacramento District Element:***
  Planning Division, Environ. Res. Branch, Environ. Analysis Section

- ***Costs:***

→ Sacramento District Labor

Sacramento District Elements	***Effort (in person-days)***
Environmental Analysis Section (Included in JDA-3)	0
Subtotal, Sacramento District:	$0
→ Contract Cost:	0
→ Other Agency/Other COE Cost:	14,000
→ Miscellaneous Costs:	0
→ Sponsor In-Kind Contribution:	0
→ Total Cost:	$14,000

JFA HTRW STUDIES/REPORT

- ***Description:***

1. JFA-1 HTRW Studies, Report Preparation: Conduct field investigations of study reaches of the Provo River and eastside drainages. Make a site inspection of all study reaches to identify any undocumented HTRW sites, develop contingency plan to identify any undocumented HTRW sites, develop contingency plan to identify responsible agency and outline a course of action in the event HTRW sites are discovered during construction. Prepare a brief narrative report suitable for incorporation into the engineering appendix to the feasibility study. Total estimated cost for completing this task is $2,000.

- ***Responsible Sacramento District Element:***
  Engineering Division, Environmental Engineering Branch

- ***Costs:***

→ Sacramento District Labor

Sacramento District Elements	*Effort (in person-days)*
Environmental Engineering Br	4
Subtotal, Sacramento District:	$2,000
→ Contract Cost:	0
→ Other Agency/Other COE Cost:	0
→ Miscellaneous Costs:	0
→ Sponsor In-Kind Contribution:	0
→ Total Cost:	$2,000

JGA CULTURAL RESOURCES REPORT

- ***Description:***

1. JGA-1 Cultural Resources Report Preparation: The cultural resources studies to be performed by the Corps will determine the impacts of the alternative plans on any historical, architectural, and archeological resources in the project area. A field survey to locate cultural sites, in accordance with the National Historic Preservation Act of 1966, may need to be performed. A report to document the survey results, outline significant past and present cultural resources, and describe impacts of each alternative on cultural resources will be prepared and coordinated with the State Historic Preservation Officer. Any sites discovered during the survey will be evaluated for the National Register of Historic Places.

Corps labor is for writing scope of work, supervising contract, reviewing contract products, and coordinating with the State Historic Preservation Officer. Total estimated cost for completing this task is $18,000 - $8,000 Corps and $10,000 contract.

- ***Responsible Sacramento District Element:***
  Planning Division, Environ. Res. Branch, Environ. Analysis Section

- ***Costs:***

→ Sacramento District Labor

Sacramento District Elements	***Effort (in person-days)***
Environmental Analysis Section	17
Subtotal, Sacramento District:	$8,000
→ Contract Cost:	10,000
→ Other Agency/Other COE Cost:	0
→ Miscellaneous Costs:	0
→ Sponsor In-Kind Contribution:	0
→ Total Cost:	$18,000

JHA COST ESTIMATES

- ***Description:***

This task will be performed by the Corps. Feasibility-level baseline cost estimates will be developed for the selected plan. These estimates will be the total cost (Federal and non-Federal) of implementing the project. Detailed first and annual costs estimates will be developed in the MCACES format for the recommended plan.

1. JHA-1 Alternative Costs: Develop plan formulation alternative cost estimates (code of accounts format) for channel and levee improvements. Cost figures will be included in the F4 Conference Report. Attend study team meetings. Total estimated cost for completing this task is $10,000.

2. JHA-2 Draft MCACES Cost Estimate: Develop plan formulation alternative cost estimates in code of accounts format and feasibility level baseline cost estimate, MCACES format, for the selected plan. These estimates will be the total cost (Federal and non-Federal) of implementing the project, including construction costs, lands, easements, rights-of-way, relocations, disposal areas, mitigation, engineering and design and construction management. Detailed first and annual cost estimates, including operation, maintenance, repair, replacement and rehabilitation (OMRR&R), inspection plan, interest during construction, and replacement

costs will be developed in the MCACES format for the selected plan, in accordance with Engineering Circular (EC) 1110-2-538, Civil Works Projects Cost Estimates Code of Accounts and EC 110-2-263, Civil Works Project Construction Cost Estimating. OMRR&R costs will be estimated based on known OMRR&R requirements and costs at existing, similar facilities. The sponsor that will be responsible for OMRR&R of the completed project will be consulted regarding their OMRR&R experience on existing levees. A narrative draft basis of estimate will be prepared and included in the draft engineering appendix to the draft feasibility report. Total estimated cost for completing this task is $18,000.

3. JHA-3 Final MCACES Cost Estimate: Final plan formulation alternative cost estimates in MCACES format, for the selected plan. The basis of estimate will be finalized following technical review and included in the final engineering appendix to the feasibility report. Total estimated cost for completing this task is $2,000.

- ***Responsible Sacramento District Element:***
  Engineering Division, Cost Engineering Branch

- ***Costs:***

→ Sacramento District Labor

Sacramento District Elements	***Effort (in person-days)***
Cost Engineering Branch	58
Subtotal, Sacramento District:	$30,000
→ Contract Cost:	0
→ Other Agency/Other COE Cost:	0
→ Miscellaneous Costs:	0
→ Sponsor In-Kind Contribution:	0
→ Total Cost:	$30,000

JIA PUBLIC INVOLVEMENT

- ***Description:***

This task will be performed jointly by the Corps and the non-Federal sponsor. This task primarily consists of coordinating the study scope, results, and solutions with the public; conducting public meetings and workshops; and responding to public inquiries. The non-Federal sponsor will have the major responsibility in preparing for the public workshop and for obtaining a meeting place for public meetings, inviting the public, and printing and distributing announcements.

1. JIA-1 Public Workshop Mail List/Invitation: The Corps will update the mail list used for the reconnaissance study, and provide mailing labels to the sponsor. The sponsor will contribute to and review the list. The sponsor will prepare the invitation to the public workshop, with input and review by the Corps. The sponsor will print and distribute the invitation using the mail list. Postage will be paid by the sponsor. Total estimated cost for completing this task is $2,400 - $400 Corps and $2,000 Sponsor.

2. JIA-2 Public Workshop Preparation: The sponsor will have the major responsibility for the Public Workshop. The purpose of the public workshop is to distribute information regarding the feasibility study and give the public an opportunity to comment on the scope of the study and the issues to be addressed. Work includes planning and setting the agenda for the workshop, logistics such as finding a suitable meeting place, setting up and manning a sign-in table, providing audio visual equipment and other materials, development and delivery of presentations, and actual conduct of the public workshop. The Corps will review presentations, aid in production of presentation materials, and be available at the workshop to aid in making presentations, act as technical resources, perform recording duties, etc. Total estimated cost for completing this task is $11,000 - $1,000 Corps and $10,000 Sponsor.

3. JIA-3 Public Workshop Memorandum: The Sponsor will have the major responsibility for writing a memorandum documenting and summarizing the results of the Public Workshop. A draft memorandum will be circulated to and reviewed by the Corps. Incorporate comments into the final memorandum. Total estimated cost for completing this task is $2,200 - $200 Corps and $2,000 sponsor.

4. JIA-4 Public Outreach Sessions: These may be held, if desired, at the disgression of the sponsor - no study funds will be allocated for this effort.

5. JIA-5 Public Meeting Mailing List/Invitation: The Corps will update the mailing list. The sponsor will prepare public meeting invitation. The invitation will include a summary of the draft feasibility report, draft EA/FONSI, a description of alternatives, and meeting information. The invitation will be reviewed by the Corps. The sponsor will print and distribute the invitation. Total estimated cost for completing this task is $2,400 - $400 Corps and $2,000 sponsor.

6. JIA-6 Public Meeting Preparation: The sponsor will have the major responsibility for the public meeting. The purpose of the public meeting is to provide an opportunity for public comments on the draft feasibility report and draft EA/FONSI. Work includes planning and setting the agenda for the meeting, development and delivery of presentations, actual conduct of the meeting, and logistics such as finding a suitable meeting place, setting up and manning a sign-in table, and providing audio visual equipment. Testimony will be documented by a court reporter. The Corps will review presentations, aid in production of presentation materials, and be available at the meeting to aid in making presentations, act as technical resources, perform recording duties, etc. Total estimated cost for completing this

task is $15,000 - $1,000 Corps and $14,000 sponsor.

- ***Responsible Sacramento District Element:***
  Planning Division, American River/Great Basin Branch

- ***Costs:***

→ Sacramento District Labor

Sacramento District Elements	*Effort (in person-days)*
American River/Great Basin Branch	5

Subtotal, Sacramento District:	$3,000
→ Contract Cost:	0
→ Other Agency/Other COE Cost:	0
→ Miscellaneous Costs:	0
→ Sponsor In-Kind Contribution:	30,000
→ Total Cost:	$33,000

JJA PLAN FORMULATION AND EVALUATION REPORTS

- ***Description:***

This task will be performed jointly by the Corps and the non-Federal sponsor as part of the in-kind work. Plan formulation includes reviewing and refining the plans selected for study during the feasibility phase in accordance with ER 1105-2-100 and other plans developed during the course off study. This task also includes preparation of the F-3 and F-4 conference reports.

1. JJA-1 F3 Conference/Report: This work element covers the actual initial plan formulation process as well as preparation of the F3 Conference Report. The Corps and the sponsor will review flood control problems and opportunities that have been identified under hydrology, hydraulics, geotechnical, and economic studies. They will identify critical issues, and develop methods and preliminary alternatives for screening. Alternative formulation will use guidance issued at the RRC. Included will be nonstructural alternatives and phased construction to address future hydrology. Alternatives will be formulated with the participation of the Study Management Team and technical elements. The Corps will be responsible for writing, editing, and preparing graphics for the F3 Conference Report. This report will document the feasibility study through preliminary alternative formulation. The task includes printing and distributing of the F3 Conference Report and technical attachments. The sponsor will review rough drafts. Total estimated cost for completing this task is $10,500 - $10,000 Corps and $500 sponsor.

2. JJA-2 F4 Conference Report: This work element covers the actual plan formulation process as well as preparation of the F4 Conference Report. The Corps and the sponsor will perform detailed formulation of alternative plans based on guidance from the F3 Conference. Alternatives (including nonstructural and phased-construction alternatives) will be developed so that technical elements may assess and quantify hydraulic design, hydrology, geotechnical design, benefits, hydraulic impact, and environmental impact. American River/Great Basin Branch will run Monte Carlo simulations employing different levee heights and configurations. Economics Branch and the sponsor will assist and advise American River/Great Basin Branch regarding flood control measures to include in the Monte Carlo analysis. Alternatives will be compared in accordance to Corps guidance to identify the NED plan. In addition, the Tentatively Selected Plan will be identified, based on local preferences. Costs and benefits of each alternative will be established. Alternatives will be formulated with the participation of the Study Management Team and technical elements.

The Corps will be responsible for writing, editing, and preparing graphics for the F4 Conference Report. This report will document the feasibility study through alternatives evaluation. The task includes printing and distributing of the F4 Conference Report and technical attachments. This report will be similar to a rough draft feasibility report. The Sponsor will review F4 Conference Report drafts. Total estimated cost for completing this task is $10,500 - $10,000 Corps and $500 sponsor.

3. JJC-01 Plan Formulation: This activity includes general plan formulation activities for resolving the identified flood problems. Efforts include coordination meetings to discuss design criteria and plan formulation considerations. The estimated cost of this effort is $54,000 - $50,000 Corps and $4,000 sponsor

- ***Responsible Sacramento District Element:***
  Planning Division, American River/Great Basin Branch

- ***Costs:***

→ Sacramento District Labor

Sacramento District Elements	***Effort (in person-days)***
American River/Great Basin Branch	108
Public Involvement and Reports Unit	5
Subtotal, Sacramento District:	$70,000
→ Contract Cost:	0
→ Other Agency/Other COE Cost:	0
→ Miscellaneous Costs(repro, etc.)	0
→ Sponsor In-Kind Contribution:	5,000
→ Total Cost:	$75;000

JKA REPORT DOCUMENTATION AND PREPARATION

- *Description:*

This task will be performed primarily by the Corps. The task will include collecting and assembling all pertinent data, reproducing, and distributing the draft and final reports which include all technical appendixes and the draft project management plan.

1. JKA-1 Draft Feasibility Report Preparation: The Corps will be responsible for writing, editing, and preparing graphics for the Draft Feasibility Report. The task includes printing and distributing of the report and technical appendixes. Reproduction costs are included under this work element as "Miscellaneous Costs". The Engineering Technical Manager (Design and Studies Section) will be responsible for assembling the Draft Engineering Appendix in accordance with ER 1110-2-1150. The Sponsor will review the report (tasked under Study Management, Draft Feasibility Report). Total estimated cost for completing this task is $37,500 - $35,000 Corps (including $10,000 reproduction expenses) and $2,500 sponsor.

2. JLA-1 Final Feasibility Report Preparation: The Corps will be responsible for writing, editing, and preparing graphics for the Final Feasibility Report. The task includes printing and distributing of the report and technical appendixes. Reproduction costs are included under this work element as "Miscellaneous Costs". The Engineering Technical Manager (Design and Studies Section) will be responsible for assembling the Final Engineering Appendix. The Sponsor will review the report (tasked under Study Management, Final Feasibility Report). Total estimated cost for completing this task is $32,000 - $30,000 Corps (including $15,000 reproduction expenses) and $2,000 sponsor.

3. JPL-1 Draft Project Management Plan (PMP): A draft PMP will be prepared specifying work roles and responsibilities regarding design, construction, and operation and maintenance of the project. This task will require close coordination with the study manager, technical elements, and the sponsor. The draft PMP will be based on study results available at time of preparation. The draft PMP will be submitted with the draft feasiblitity report. Total estimated Corps cost for completing this task is $15,000.

4. JPZ-3 Sponsor Letter of Intent: The sponsor will write a letter expressing intent to cost share the cost of design and construction of the project and operate and maintain the completed project. The sponsor will express its understanding of cost-share responsibilities regarding design, construction and operations and maintenance. Total estimated sponsor cost for completing this task is $500.

- ***Responsible Sacramento District Element:***
  Planning Division, American River/Great Basin Branch

■ ***Costs:***

→ Sacramento District Labor

Sacramento District Elements	***Effort (in person-days)***
American River/Great Basin Branch	88
Public Involvement and Reports Unit	10

Subtotal, Sacramento District:	$55,000
→ Contract Cost:	0
→ Other Agency/Other COE Cost:	0
→ Miscellaneous Costs(repro, etc.)	25,000
→ Sponsor In-Kind Contribution:	5,000
→ Total Cost:	$85,000

JPA STUDY MANAGEMENT

■ ***Description:***

This task will be performed by the Corps and the sponsor. Responsibility for day-to-day technical management of the study lies with the Corps Planning Division in cooperation with the sponsor. Study management will monitor schedule and budget and coordinate technical studies required in support of the milestone conferences over the 24 month duration.

1. JPA-1 Study Management, Public Workshop: Both the Corps and the sponsor will refine the Public Involvement plan and assure that it meets environmental and other needs, conceptually formulate and review materials developed for the public workshop, and review workshop findings and propose modifications to the plan of study, if necessary, based on public comment. The study manager will attend and may make technical presentations at the public workshop.

Corps study management tasks include day-to-day management of the execution of the feasibility study. This includes monitoring schedule and budget, setting the agenda for and participating in Study Management Team meetings, coordinating with and writing work orders to Corps technical elements, writing miscellaneous correspondence, providing coordination and input to Project Management, and coordinating with the sponsor. The sponsor will monitor schedule and budget of, and coordinate in-kind work elements. These tasks will also be done in other phases of the study, and apply to the study management work elements (JPA) listed below. Total estimated cost for completing this task is $5,000 - $3,000 Corps and $2,000 sponsor.

2. JPA-2 Study Management, F3 Conference: The Corps will monitor and coordinate technical studies required in support of the F3 milestone conference. Similarly, the sponsor will monitor and coordinate in-kind technical studies and other activities required in support of the F3 Conference. Under this work element, both the Corps and the sponsor will attend the F4 Conference. This item covers the study management costs associated with the estimated 8 months between the study initiation and F3 conference. This effort also includes technical review of the draft F3 feasibility report and associated writing/editing efforts to finalize the F3 Documentation report. Corps and sponsor general study management responsibilities also applicable to this work element are described above in JPA-1, Study Management, Public Meeting. Total estimated cost for completing this task is $85,000 - $65,000 Corps and $20,000 sponsor.

3. JPA-3 Study Management, F4 Conference: The Corps will monitor and coordinate technical studies required in support of the F4 milestone conference. Similarly, the sponsor will monitor and coordinate in-kind technical studies and other activities required in support of the F4 Conference. Under this work element, both the Corps and the sponsor will attend the F4 Conference. This item covers the study management costs associated with the estimated 8 months between the F3 and F4 conferences. This effort also includes technical review of the F4 conference materials and associated writing/editing efforts identified in the Quality Control Plan. Corps and sponsor general study management responsibilities also applicable to this work element are described above in JPA-1, Study Management, Public Meeting. Total estimated cost for completing this task is $80,000 - $60,000 Corps and $20,000 sponsor.

4. JPA-4 Study Management, Draft Feasibility Report: The Corps will monitor and coordinate technical studies and other activities required in support of the draft report. Similarly, the sponsor will monitor and coordinate in-kind technical studies and other activities required in support of the draft report. This item covers the study management costs associated with the estimated 2 months between the F4 conference and the submittal of the draft report for review. Corps and sponsor general study management responsibilities also applicable to this work element are described above in JPA-1, Study Management, Public Meeting. Total estimated cost for completing this task is $65,000 - $50,000 Corps and $15,000 sponsor.

5. JPA-5 Study Management, Feasibility Review Conference (FRC): The Corps will monitor and coordinate technical studies required in support of the FRC. The study management team will be responsible for providing technical backup material to the review team and providing an agenda for the FRC. Similarly, the sponsor will monitor and coordinate in-kind technical studies and other activities required in support of the FRC. Under this work element, the sponsor will attend the FRC. This item covers the study management costs associated with the estimated 2 months between the submittal of the draft report and the FRC. This effort also includes technical review of the draft feasibility report and associated writing/editing efforts in preparation for submittal to the review team. Corps and sponsor general study management responsibilities also applicable to this work element are described

above in JPA-1, Study Management, Public Meeting. Total estimated cost for completing this task is $40,000 - $30,000 Corps and $10,000 sponsor.

6. JPA-6 Study Management, Public Meeting: Both the Corps and the sponsor will conceptually formulate and review materials developed for the public meeting, help write and review a memorandum documenting and summarizing results of the public review period, review the results of the public comment period and propose responses to comments. Corps and sponsor study management will attend and may make technical presentations at the public workshop. Corps and sponsor general study management responsibilities also applicable to this work element are described above in JPA-1, Study Management, Public Meeting. Total estimated cost for completing this task is $25,000 - $20,000 Corps and $5,000 sponsor.

7. JPA-7 Study Management, Final Report: The Corps will monitor and coordinate technical studies and other activities required in support of the final report. Similarly, the sponsor will monitor and coordinate in-kind technical studies and other activities required in support of the final report. This effort also includes technical review of the final feasibility report and associated writing/editing efforts to finalize the report. Corps and sponsor general study management responsibilities also applicable to this work element are described above in JPA-1, Study Management, Public Meeting. Total estimated Corps cost for completing this task is $50,000.

8. JPA-8 Study Management, Public Notice Materials: The Corps will prepare public notice materials necessary for releasing the Division Engineers Notice, distributing the final report to the public and Washington Level Review process. Total estimated Corps cost for completing this task is $50,000.

- ***Responsible Sacramento District Element:***
  Planning Division, American River/Great Basin Branch

- ***Costs:***

→ Sacramento District Labor

Sacramento District Elements	***Effort (in person-days)***
American River/Great Basin Branch	437
Various District Elements (Technical Review)	45

Subtotal, Sacramento District:	$278,000
→ Contract Cost:	0
→ Other Agency/Other COE Cost:	0
→ Miscellaneous Costs:	50,000
→ Sponsor In-Kind Contribution:	72,000
→ Total Cost:	$400,000

JPL PROGRAM & PROJECT MANAGEMENT

- ***Description:***

This task will be performed by the Corps. It includes involvement by the Programs and Project Management Division, which is responsible for monitoring funds and schedules and managing the project programming, updates of the project study plan, and final audit.

1. JPI-1 Monthly Reports Preparation: Corps will update the periodic reports listed under the PSP section on Study Management Tools. The monthly reports include Project Executive Summary Report Other reports are justification sheet, PB-6 update and schedule and cost change request. Total estimated Corps cost for completing this task is $20,000.

2. JPZ-1 Budget Documents, Financial Reports: Corps will prepare monthly Funds Management Reports and other budget documents for use by managers and by the sponsor. This work requires working with the study manager to explain expenditures and develop spending schedules. Total estimated Corps cost for completing this task is $20,000.

3. JPZ-2 Final Audit Preparation: Near the completion of the study, the Corps will prepare a final audit to assure local contributions are at their proper level and settle any debts or credits. Total estimated Corps cost for completing this task is $2,000.

- ***Responsible Sacramento District Element:***
  Programs & Project Mgmt. Division, Civil Works Branch,
  Sac Basin/East Area Unit

- ***Costs:***

→ Sacramento District Labor

Sacramento District Elements	***Effort (in person-days)***
Sac Basin/East Area Unit	24
Programs Management Branch	26

Subtotal, Sacramento District:	$42,000
→ Contract Cost:	0
→ Other Agency/Other COE Cost:	0
→ Miscellaneous Costs:	0
→ Sponsor In-Kind Contribution:	0
→ Total Cost:	$42,000

CHAPTER 4 - MILESTONES AND STUDY SCHEDULE

DESCRIPTION OF MILESTONES

A system of milestones has been established to help monitor and manage the study through completion. Following is a highlight of each milestone.

Initiate Feasibility Study (F1)

The feasibility work allowance is received, and first Corps charges are made.

Public Workshop (F2)

The purpose of the public workshop is to present results of the reconnaissance study, to describe the feasibility study, and to solicit public views and issues. The public workshop will be organized and conducted by the non-Federal sponsors with Corps participation and technical support.

Conference #1 (F3)

The purpose of the F3 conference is to review study findings to date concerning the Provo River and eastside drainages and needs (described in quantitative terms), the array of alternatives consistent with the Federal interest, and analysis of impact of alternatives including first cut of benefits and impacts. This meeting will be a key decision point as the issue of Federal and non-Federal interest will be revisited. Interim conclusions from the F3 Conference will indicate the feasibility and likelihood of project implementation. At this milestone, the study sponsor may wish to review its commitment to completion of the study, if they perceive there is a low probability of a positive study recommendation.

Any proposed non-Federal interests' preferred alternative will be identified. Background material in the form of the "F3 Conference Report" will be sent to SPD at least 2 weeks prior to the conference.

The designs and costs presented at the F3 conference will be at a preliminary level of detail. Designs need only be to the minimum detail needed to roughly estimate quantities and costs.

Conference #2 (F4)

The purpose of the F4 conference is to review the selection of the recommended plan. Evaluation criteria and process will be presented. Problem identification, impact analysis, benefit analysis and selection criteria will be reviewed, as well as the issue of continuing Federal and non-

Federal sponsor interest. The non-Federal sponsor's ability to pay will be reviewed. The status of the EIS, including cultural resources evaluation and fish and wildlife issues will be discussed. The background material will be submitted to SPD 2 weeks before the conference.

Technical Review Conference (TRC) (F5A)

This conference is optional. It would be held upon the request of SPD or HQUSACE if there are specific technical or policy issues that must be resolved before the Draft Report is submitted for public review. The conference is normally held in the District office or in the immediate project area and may include a field trip to the project site. The Washington-level review team will evaluate the feasibility study and/or the PMP using Corps general evaluation guidelines. Representatives from OASA(CW), HQUSACE, Division, District, and the non-Federal sponsor will participate in the TRC. The TRC will be held and the project guidance memorandum (PGM) prepared by HQUSACE prior to release of the draft feasibility report for public review.

Submit Draft Report to SPD (F5)

Upon clearance by SPD, the draft report (or other pre-conference documentation) including the draft PMP will be forwarded to HQUSACE in preparation for the feasibility review conference (Milestone F5A).

Field Level Coordination (F6)

Upon compliance with PGM requirements, the draft feasibility report and NEPA document will be distributed for formal field-level coordination.

Final Public Meeting (F7)

The District will present results of the study, conclusions, and recommendations to the public. Division representatives will usually attend.

Submit Final Report to SPD (F8)

The District will submit the final feasibility report in accordance with guidance in ER 1105-2-100 and include technical documentation report and mailing list for Division Engineer public notice.

Division Engineer Public Notice (F9)

The Division Engineer will issue the public notice and transmit the final feasibility report to HQUSACE for Washington-level processing.

CHAPTER 5 - FEASIBILITY STUDY SCHEDULE

The final feasibility report and EIS is scheduled to be submitted to SPD (F8) in approximately 24 months after initiation of the feasibility study. The signing of the FCSA is scheduled to take place 1 month prior to initiation of the study (F1). The Division Engineer's issuance of the public notice (F9), which completes the feasibility phase, is scheduled 2 months after the final feasibility report and EIS is submitted for Washington-level review. It is expected that processing the feasibility report through Washington-level review to Congress will add up to 6 months to the feasibility phase period.

The following chart shows the proposed schedule of study activities for this feasibility study. This chart shows all milestones and associated activities which must occur between each milestone.

	Activity Name	Duration	A97	O97	N97	D97	J98	F98	M98	A98	M98	J98	J98	A98	S98	O98	N98	D98	J99	F99	M99	A99	M99	J99	J99	A99	S99	O99
1	F1-INITIATE STUDY																											
2	Monthly ReportsPreparation	730	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX			
3	Budget Documents /Flincial Reports	730	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX			
4	Study Management	47	XXXX	XXX																								
5	Public Workshop	13		XXX																								
6	Public Scoping Activities	9		XX																								
7	Public Workshop Memorandum	1		X																								
8	F2 Public Workshop			X																								
9	Study Management	199		X	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXX																	
10	Surveys	90	XXXX	XXXX	XXXX																							
11	Environmental Assessment	53		X	XXXX	X																						
12	Plan Formulation	27			XX	XX																						
13	Baseline Geology and Soils	20		XX	X																							
14	Geology and Soils Design	20			XX	X																						
15	Geotech Report	20						XXX																				
16	Design Hydraulics	80			XX	XXXX	XXXX																					
17	Hydrology and Hydraulics Report	66						XXX	XXXX	XXX																		
18	Prelinimary Designs and Costs	120					XXXX	XXXX	XXXX	XXXX																		
19	F3 Conference Report	20							X	XX																		
20	F3 Conference										X																	
21	Study Management	207									XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX		XXXX									
22	Design and Quantities	40									XXXX	X																
23	Environmental Study	107							XXXX	XXXX	XXXX	XX																
24	Alternative Costs	66												X	XXXX	XXXX												
25	F4 Conference Report	20														X	XX											
26	F4 Conference																X											
27	Study Management	84															X	XXXX	XXXX	XXX								
28	Draft Report	53																X	XXXX	XX								
29	Local Financial Plan	1																		X								
30	Inst. Financial Capability Analysis	5																		X								
31	Draft Report																			X								
32	Draft PMP	20																		XX	X							
33	Feasibility Review Conference	27																		XX	XX							
34	Feasibility Review Conference																				X							
35	Study Management	47																			X	XXXX	X					
36	Public Meetomg Mailing List/Inv..	1																				X						
37	Public Meeting																						X					
38	EIS Public Comment Responce	7																					X					
39	Study Management	73																					XX	XXXX	XXXX			
40	Final Draft	29																							XXX	X		
41	Sponsor Letter of Intent	7																								X		
42	F-8 - Final Report																									X		
43	F-9 Public Notice Materials	7																								X		
44	Record of Decision	7																								X		
45	Final Feasibility Phase Audit	7																								X		
46	Washington Level Review																											
47	Chiefs Report	80																								XX	XXXX	XXXX

CHAPTER 6 - QUALITY CONTROL PLAN

1. REFERENCE: CESPD Regulation 1110-1-8, Directorate of Engineering and Technical Services, Quality Management Plan, 31 May 1996.

2. OBJECTIVE: The objective of this quality control plan (QCP) is to ensure the Provo, Utah Feasibility study is of high quality by establishing the appropriate level of evaluation of technical products and processes to ensure that they meet customer requirements and comply with applicable laws, regulations, and sound technical practices of the disciplines involved.

The Sacramento District will be responsible for technical review for the feasibility study, consistent with the Sacramento District Planning Division Quality Management Plan and associated technical review implementation guidance. South Pacific Division will provide quality assurance and can provide technical and planning management support to the District as needed in resolving major technical issues.

3. GUIDELINES: Products will be reviewed for compliance with appropriate public laws; engineering regulations, circulars, and manuals; planning and policy guidance; and standard engineering and scientific practices.

4. LEVEL OF DETAIL OF REVIEW: Study products will be reviewed at a feasibility level of detail. All issues raised during the final review will be documented in a comment, response, action required, and action taken format. Products will be reviewed for:

- Consistency with the approved Project Study Plan (PSP) and identification of any modification or deviations in scope, magnitude of outputs, or costs
- Compliance with established policy and other appropriate guidance
- Adequacy of the scope of the document
- Appropriateness of all planning, engineering, design, and environmental assumptions and methods, including development of without project assumptions
- Appropriateness of data used, including level of detail
- Appropriateness of alternatives evaluated
- Consistency
- Accuracy
- Comprehensiveness
- Reasonableness of results

4. PRODUCTS FOR REVIEW: The technical review team (TRT) will review the following documents:

- F3 Report
- F4 Report
- Environmental Assessment (EA)
- Technical Appendixes
- Draft Project Cooperation Agreement (PCA)

Appropriate TRT members will also review the following study products prior to their incorporation into the overall study (seamless review):

- Plan formulation
- Hydraulic design
- Structural design
- Design plates and quantities
- Cost estimates
- Economic analysis
- Real estate assessment

5. REVIEW SCHEDULE: Seamless review will occur throughout the study process as required. Final document review will be performed according to the following schedule:

• F3 conference report	May 98
• F4 conference report	Jan 99
• Draft Report and EA	May 99
• Submit final report/EA/technical appendixes to SPD	Aug 99

6. REVIEW COST ESTIMATE: $25,000

7. KNOWN POLICY QUESTIONS: None.

8. MAJOR TECHNICAL ISSUES: None.

9. PROJECT MANAGEMENT AND TECHNICAL REVIEW TEAMS: The current study management team is identified in Table 1. The proposed Technical Review Team is identified in Table 2.

Table 1
Study Team Members

Organization	Name/Title	Address	Phone
Corps of Engineers CESPK-PD-A	Merritt Rice Branch Chief	1325 J Street Sacramento, CA 95814	(916) 557-6761 Fax: -7856
Corps of Engineers CESPK-PD-A	Scott Stoddard Study Manager	2225 Federal Bldg SLC, UT 84138	(801) 524-6890 Fax: -6893
Corps of Engineers CESPK-ED-D	Kim Christiansen Technical Manager	1325 J Street Sacramento, CA 95814	(916) 557-6630 Fax: -7851
Corps of Engineers CESPK-ED-D	Gregg Reynolds Hydrology	1325 J Street Sacramento, CA 95814	(916) 557-7136 Fax: -7863
Corps of Engineers CESPK-ED-D	Donald Helsby Hydraulic Design	1325 J Street Sacramento, CA 95814	(916) 557-6691 Fax: -7863
Corps of Engineers CESPK-ED-G	Ed Flint Geotechnical	1325 J Street Sacramento, CA 95814	(916) 557-7427 Fax: -6803
Corps of Engineers CESPK-RE-C	Carol Johnson Real Estate	1325 J Street Sacramento, CA 95814	(916) 557-6841 Fax: -7855
Corps of Engineers CESPK-PD-E	Kurt Keilman Economics	1325 J Street Sacramento, CA 95814	(916)557-5289 Fax: -7856
Corps of Engineers CESPK-PD-R	Chris Davis Environmental Coordinator	1325 J Street Sacramento, CA 95814	(916) 557-6719 Fax: -7856
Corps of Engineers CESPK-PM-C	Larry Johnson Project Management	1325 J Street Sacramento, CA 95814	(916) 557-7834 Fax: -7856
City of Provo Stormwater Service District	Gregory Beckstrom, District Engineer	1377 South 350 East Provo, UT 84606	(801) 379-6720 Fax: -6778

Table 2
Technical Review Team Members

Name/Location	Review Responsibility	Experience	Phone
Ron Milligan CEPSPK-PD-S	Review team chairperson Plan Formulation	13 yrs plng experience, Registered civil engineer	(916) 557-6726 Fax: -7856
Tore Pearson CESPK-ED-D	Engineering and design	13 yrs civ des/10 yrs mil design,registered civ eng	(916) 557-6687 Fax: -6803
Chuck Richmond CESPK-ED-G	Geotechnical/ Foundations & Matls	15 years geotechnical engineering experience	(916) 557-5381 Fax: -6803
Mike Deering CESPK-ED-D	Hydraulic Design/ Flood Plains	18 years Hydraulic Des Registered civil Engineer	(916) 557-7250 Fax: -7846
Jeff Harris CESPK-ED-D	Hydrology	16 years Hydrologic Eng Registered civil Engineer	(916) 557-7250 Fax: -7846
Teresa Pacheco CESPK-PD-E	Economics	10 years economic analysis experience	(916) 557-6740 Fax: -7856
Patricia Roberson CESPK-PD-R	Environmental	11 years env coordinator for planning studies	(916) 557-6705 Fax: -7856
Carol Johnson CEPK-RE-PC	Real Estate	16 years real estate experience	(916) 557-6841 Fax: -7885
Lisa Clay CESPK-OC	Legal	9 years in SPK Office of Counsel	(916) 557-5295 Fax: -5118
Don Delporto CESPK-CO	Constructability	29 yrs elec/gen engr registered engineer	(916) 557-7775 Fax: -7861
Merril Bingham Provo City	Non-Federal Sponsor Review	Public Works Director Registered Engineer	(801) 370-6770 Fax: -6778

APPENDIX A - TECHNICAL REQUIREMENTS

The work to be performed consists of a feasibility level effort per the attached schedules and budgets to determine the best solution to resolve flood problems along the Provo River and eastside drainages. This work includes preparation of an environmental assessment (EA), cost and benefit evaluations, the necessary survey and geotechnical investigations, a hydraulic analysis, design calculations and drawings, preparation of an MCACES cost estimate, real estate investigations, a recreation analysis, study management, and coordination with local, State, and Federal agencies as well as environmental/other interest groups and the public. The scope of studies in terms of content and level of detail for the feasibility stage effort are as defined and required by the following documents:

ER 5-7-1 dtd 30 September 1992	"Project Management" Department of the Army regulation for the overall management of civil works projects.
ER 220-2-2 dtd 4 March 1988 33 CFR 230	"Procedures for Implementing NEPA" Department of Army regulation on environmental quality.
ER 405-1-12 (Ch. 12) dtd 28 May 1991	"Real Estate Handbook - Local Cooperation" Department of the Army regulation establishing guidelines for real estate activities for local cooperation agreements.
ER 1105-2-100 dtd 28 December 1990	"Planning Guidance" Department of the Army regulation on policy and guidance for the conduct of civil works planning studies.
ER 1110-2-1150	"Engineering and Design for Civil Works Projects"
ER 1165-2-131	"Local Cooperation Agreement for New Starts" Department of the Army regulation for developing and processing local cooperation agreements.
EC 1110-2-263	"Civil Works Construction Cost Engineering" Department of the Army circular establishing accounting standards for preparing cost estimates for civil projects.
EC 1110-2-538	"Civil Works Project Cost Estimating - Code of Accounts" Department of the Army circular establishing accounting standards for preparing cost estimates for civil projects.
EM 1110-2-1301	"Cost Estimates - Planning and Design Stages"
U.S. Water Resources Council Publication dtd 10 March 1983	"Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation

APPENDIX G

PERTINENT CORRESPONDENCE

DEPARTMENT OF THE ARMY
U.S. ARMY ENGINEER DISTRICT, SACRAMENTO
CORPS OF ENGINEERS
1325 J STREET
SACRAMENTO, CALIFORNIA 95814-2922

REPLY TO
ATTENTION OF

CESPK-PD-A (1105)

7 January 1997

MEMORANDUM FOR Commander, South Pacific Division, ATTN: CESPD-ET-P (Conley)

SUBJECT: Provo and Vicinity, Utah, Reconnaissance Study - Exception to 800 cfs Rule

1. Reference ER 1165-2-21, 30 Oct 80 Flood Damage Reduction Measures in Urban Areas.

2. As identified in the 19 November 1996 R3 conference and associated documentation on the subject investigation, much of the city of Provo is under a significant flood threat not only from Provo River but also from runoff of Federal lands directly to the east. This rapidly expanding city is located at the western toe of the Wasatch Front Mountains. Because of the topography, floodflows from the three northern tributaries commingle near the canyon mouths, as do the three southern tributaries, creating two large flood plains. These flood plains pose very serious threats and the potential for catastrophic damages (see enclosure). This type of alluvial fan flooding which results in widespread, commingled flows is typical all along the Wasatch Front. This eastside flood problem is one of the primary reasons that the city obtained Congressional authorization for this study.

3. Average annual flood damages for the north and south flood plains are estimated at \$1.8 million and \$2.5 million, respectively. Solutions to this type of potential major flooding can only be addressed by considering the contributing drainages as collective systems. Little benefit could be accomplished by formulating a plan on one drainage while ignoring a similar or even greater threat from the adjacent runoff areas. Combined peak flows from the drainages creating the north and south flood plains are both greater than 1,800 cfs (2,487 cfs on the north and 2,344 cfs on the south) for the 1 percent event. However, natural storage and limited detention storage on several of the tributaries results in the 10-percent flood discharge being less than 800 cfs.

4. Paragraph 7a(3) of the referenced ER requires the Division Engineer to grant exceptions to the 800 cfs, 10-percent flood discharge criterion whenever the discharge for the 1-percent flood exceeds 1,800 cfs; and when the reason that the 10-percent flood discharge is less than 800 cfs is attributable to a hydrologic disparity (pervious soils, natural storage, or detention basins or diversions with limited capacity). Based on the serious consequences from flooding to much of the Provo area and recognition that the peak flows for the 1-percent flood exceed 1,800 cfs, it is requested you grant that exception for the eastside drainage to Provo.

CESPK-PD-A
SUBJECT: Provo and Vicinity, Utah, Reconnaissance Study - Exception to 800 cfs Rule

5. Contact Mr. Scott Stoddard, Study Manager at (801) 524-6890 regarding any questions about this request.

FOR THE COMMANDER:

Walter Yep

Encl
as

WALTER YEP
Chief, Planning Division

CESPD-ET-P (CESPK-PD-A/7 Jan 97) (1105) 1st End Mr. Conley/415-977-8162
SUBJECT: Provo and Vicinity, Utah, Reconnaissance Study - Exception to 800 cfs Rule

DA, South Pacific Division, Corps of Engineers, 333 Market Street, Room 923
San Francisco, CA 94105-2195 24 January 1997

FOR Commander, Sacramento District, ATTN: CESPK-PD

1. Rock and Slate/Slide Canyons meet all the criteria of the referenced regulation and are granted an exception to the 800 cfs rule. Edgemont Canyon, Ironton Canyon and Buckley Draw, do not meet the criteria and are not granted an exception.

2. The flooding problems in the study need to be addressed and plans formulated without regards to the minimum flow criteria. There may be circumstances where there is a Federal interest in a flood control structure located in an area, which does not meet the minimum flow criteria. Thus, determination of the Federal interest may depend on the eligibility of a specific project feature for cost-sharing. Additional and more detailed comments are included as Enclosure 2.

FOR THE COMMANDER:

ROBERT F. VINING
Chief, Planning Division

2 Encls
1. nc
added 1 encl
2. Cmts

CESPD-ET-P 24 January 1996
MEMORANDUM FOR CESPK-PD-A

SUBJECT: Provo and Vicinity, Utah, Reconnaissance Study - Exception to the 800 cfs Rule

1. Following are comments on the subject request by the Sacramento District.

a. General Observations: The fact by itself, that the flows commingle in a flood plain is not a valid argument for or against establishing a Federal Interest. In some cases, even though flood control works may be located upstream where the criteria is not met, the works themselves may have a Federal Interest if they provide sufficient benefits downstream where there is a Federal Interest. However, in other cases such as channelization, there would be no Federal Interest until the criteria are met. The flooding problems should be identified and plans formulated to address those problems without regard to the minimum flow criteria. Then an analysis of cost sharing and determination of the Federal Interest would occur after a plan was proposed. And those works necessary for the plan to function but which did not meet the criteria would simply be a local cost.

b. Drainage Basins Data:

Basin	Size	100Year (1)	Federal Interest?	Comments
	(Sq. Mi.)	(cfs)		
Mile High Canyon	.38	240	Unlikely	Fed. interest is unlikely for such a low 100-year flow
Little Rock Canyon	1.11	500	Maybe	Flows do not commingle near the canyon mouths
Rock Canyon (inflow) Rock Canyon (outflow)	8.18	2200 1500	Yes	Federal Interest at the Debris Basin, and DS
Slide Canyon	1.21	600	Yes	Flows appear to commingle w/ Slate Canyon
Slate Canyon (inflow) Slate Canyon (outflow)	6.2	1300 1600	Yes	Flows appear to commingle w/ Slide Canyon w/ flows from drainage in between
Ironton Canyon	1.22	650	Unlikely	Flows do not commingle
Buckley Draw	.88	500	Unlikely	Fed. interest is unlikely for such a distant and low flow

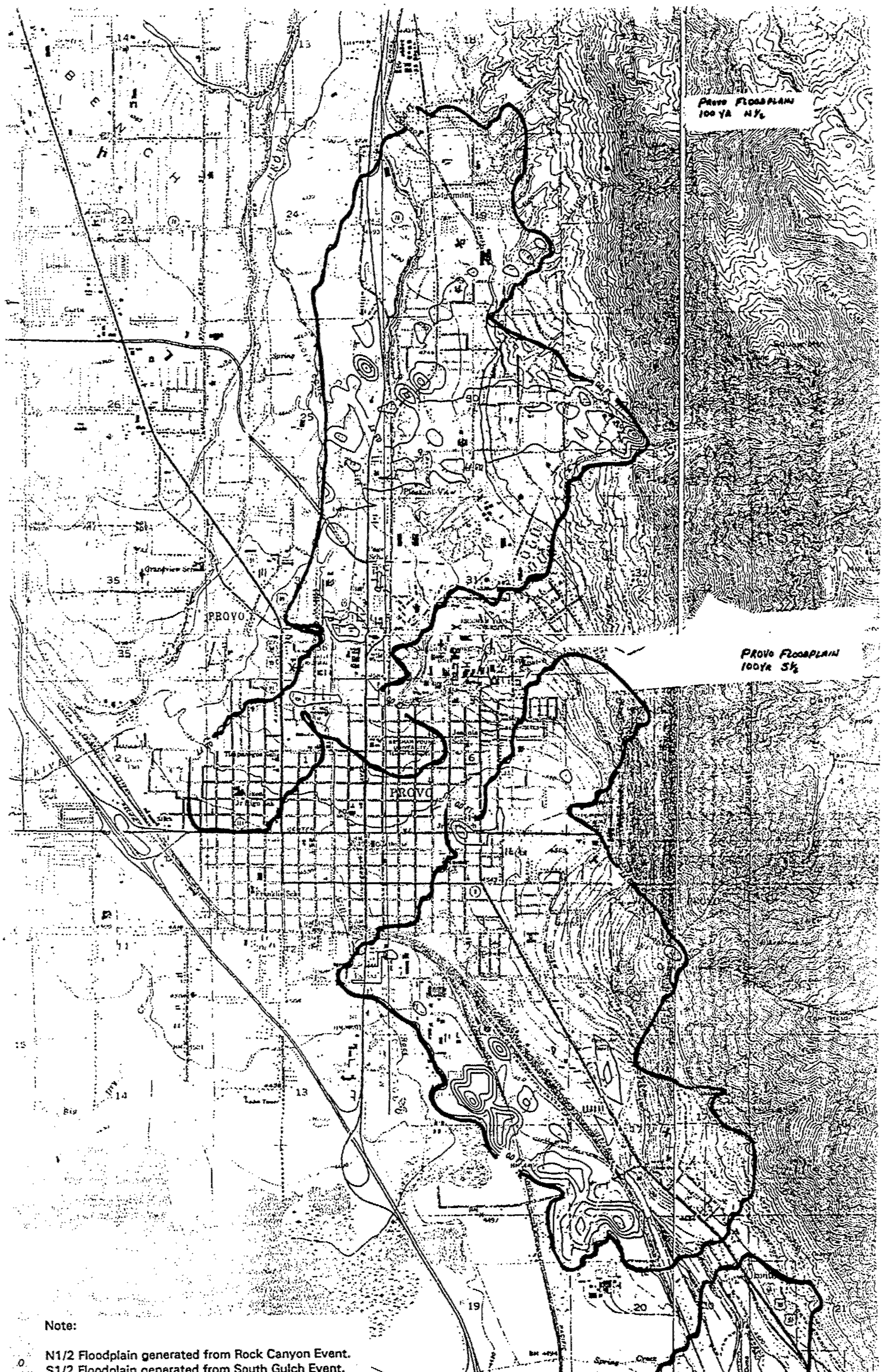
(1) Flows based on draft office report dated October 1996, Charts 7 - 19

(1) From an examination of the "Drainage Area and Topography" and "Peak Flow Frequency Curves" charts contained in the draft Hydrology Office Report, the Edgemont Canyon, Ironton Canyon and Buckley Draw do not meet the minimum criteria for Federal Involvement. Their 100-year flows are very low and they appear very distant from the other canyon mouths. It seems like a stretch that their 100 year flows would be additive.

(2) The peak 100 year inflow (2200 cfs) at the Rock Canyon Debris Basin meets the criteria of ER 1165-2-21, and may be exempted from the 800 cfs, 10 percent flood discharge criteria (800 cfs rule).

(3) From an examination of Chart 6c -- Drainage Area and Topography, Slate Canyon and Slide Canyon, the peak flows appear to commingle near the canyon mouths. Therefore, the peak flows may be added for the 100-year event for the purposes of granting an exemption to the 800 cfs rule. In addition, there is a flow contribution from and area between the two canyons which would also contribute peak flows to the flood plain. The Slide Canyon and Slate Canyon floodplain may be exempted from the 800 cfs rule.

(4) At the point where the flows from Little Rock Canyon meet the flows from Rock Canyon, there would be a Federal Interest, since the Federal Interest is already established on Rock Canyon. The type and location of the proposed flood control works would determine if there was a Federal interest on Little Rock Canyon.



PROVO FLOODPLAIN 100 YR N1/2
PROVO FLOODPLAIN 100YR S1/2
PROVO
PROVO
Note:
N1/2 Floodplain generated from Rock Canyon Event.
S1/2 Floodplain generated from South Gulch Event.

Enclosure

The City of
Provo, Utah

Provo
STORM WATER

April 22, 1997

Colonel Dorothy K. Klasse
District Engineer
US Army Corps of Engineers
1325 J Street
Sacramento, CA 95814

Attn: Planning Division

Dear Colonel:

This is to inform you of the intention of the City of Provo to be the non-Federal sponsor for the Provo, Utah Feasibility Flood Control Study.

We have reviewed with your staff the findings of the reconnaissance investigation. I understand that over the next several weeks, our staffs will continue to coordinate a project study plan defining the specific scope, schedule, and cost for the feasibility study which is currently estimated at approximately $1.5 million. We are now in the process of determining our ability to financially participate in this study.

I understand that the feasibility study will need to be cost-shared equally between Provo City and the Corps and that we will be able to complete up to one-half of our share as in-kind services. I further understand that the project study plan and cost-sharing terms will be negotiated and included in a Feasibility Cost Sharing Agreement.

We look forward to working closely with you.

Sincerely,

Merril L. Bingham, P.E.
Public Works Director

MLB/dr

Storm Water
Service District

[illegible] South [illegible]
P.O. Box [illegible]
Provo, Utah [illegible]

[illegible]