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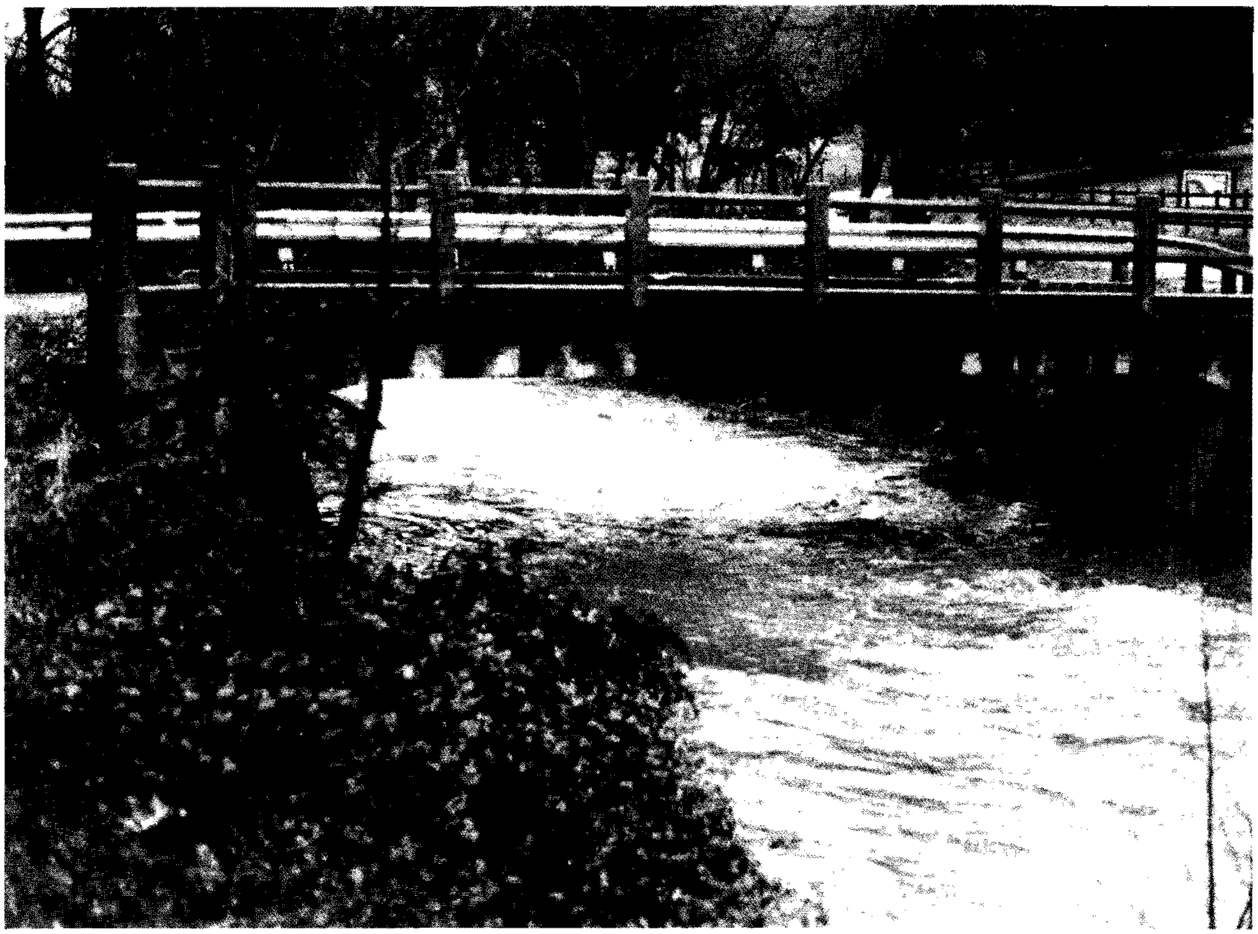

Placer County
Department of Public Works

Final Report

Auburn/Bowman Community Plan Hydrology Study

July 1992

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Serving the World's
Environmental Needs

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Consulting Engineers, Inc.

July 29, 1992

Robert J. Costa, Senior Engineer
County of Placer
Department of Public Works
11444 B Avenue, Building 104A
DeWitt Center
Auburn, CA, 95603

Subject: Auburn/Bowman Community Plan
Hydrology Study - Final Report

Dear Mr. Costa:

Enclosed is our final report for the Auburn/Bowman Community Plan Hydrology Study. The purpose of the study was to provide Placer County with the information and policies to manage the storm waters within the community plan area. It also includes consideration of required improvements and required funding for the improvements. The results from this study are intended to provide an approach for meeting existing and future flood and water quality control needs in the Auburn/Bowman Community Plan Area.

It has been a pleasure for us to complete this work for the County. If you have questions related to our study, or if we can be of further service, please do not hesitate to call.

Very truly yours,

JAMES M. MONTGOMERY,
CONSULTING ENGINEERS, INC.

Eric S Clyde, PE
Project Manager

Attachment

REGISTERED PROFESSIONAL ENGINEER
ERIC S. CLYDE
No. C048064
Exp. 12/31/95
CIVIL
STATE OF CALIFORNIA

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AUBURN/BOWMAN COMMUNITY PLAN HYDROLOGY STUDY

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AUBURN/BOWMAN COMMUNITY PLAN HYDROLOGY STUDY

EXECUTIVE SUMMARY

GOALS AND SCOPE

The Auburn/Bowman Community is a largely rural area located in the Sierra foothills in Placer County. The community, however, is experiencing rapid growth with much of the agricultural and open space land being developed for residential and commercial purposes. Placer County is currently updating its General Plan for the Auburn/Bowman Community (excluding the City of Auburn) and one concern in the formulation of the Plan is the potential of existing and future flooding along streams in the study area as well as degradation of water quality in the numerous streams, canals and reservoirs in the study area.

Flooding occurs when heavy rains cause streams to overflow their banks, flooding property and structures located adjacent to the stream. Streams also back up and overtop at culverts and bridges, blocking roads or making them unsafe for passage. Emergency services can also be restricted by the flooded roads. In addition, there are numerous open canals in the study area that can intercept sheet runoff from one part of the study area and spill it into another. Excessive spills from these canals may also increase the potential for downstream flooding.

Placer County is concerned not only with the existing flooding problems, but also with future problems that can result from the development occurring in the area. Continued development in the watersheds that comprise the study area has the potential for making existing flooding and water quality problems worse unless adequate steps are taken to plan and implement comprehensive area-wide solutions to the drainage problems.

Not only are the impacts of flooding a concern for this study, but also the water quality impacts from stormwater runoff in the study area. Water quality degradation from stormwater runoff is primarily the result of runoff carrying pollutants from the land surface (i.e., streets, parking lots, pastures) to the receiving waters (i.e., streams and lakes). This type of pollution is termed "non-point source" pollution due to the fact that the pollutants are typically spread out over the land surface area (as opposed to point source pollution that refers to a specific managed source of pollution such as an industrial or wastewater treatment plant outfall to a stream). Non-point source pollution is of specific concern in the Auburn/Bowman Community Plan area not only because of the potential water quality impacts on streams, but also because of potential impacts on the numerous reservoirs and canals in the study area. In addition, the changing land uses (i.e., conversion of agricultural land to residential) in the study area may also have an adverse impact on future water quality due to increased pollutant loads.

Satisfactory solutions to the drainage problems in the study area cannot always be provided on a site by site basis because of possible adverse downstream impacts of any proposed solution. These downstream impacts must be taken into consideration when planning flood control projects and setting flood control policies. The purpose of this drainage study is to provide Placer County with the information and policies necessary to manage the storm waters within the study area. It also includes consideration of required improvements and the associated funding programs to accomplish the improvements. The results from this study are intended to provide an approach for meeting existing and future flood and water quality control needs in the study area.

MAJOR ASSUMPTIONS

The following paragraphs contain a list of the major assumptions used in the Auburn/Bowman Hydrology study.

- *The land use estimates for existing watershed conditions are based on a 1990 survey by Placer County Planning Department.* Placer County Planning Department performed a land use survey of the entire study area in which residential, commercial and industrial developments were identified and mapped. The results from this survey were utilized in developing the present conditions hydrology.
- *The land use estimates for projected future watershed conditions are based on full buildout according to the proposed community plan (Alternative 2).* A consistent set of land use designations was developed and applied to all areas of the watershed based on general plan information from the Placer County Planning Department. If the selected general plan is amended drastically, it may be necessary to make adjustments in the flood control plan to match those changes.
- *The following flood control and water quality management measures were considered as part of the flood control plan:*
    - Regional stormwater detention basins
    - Local, on-site stormwater detention basins
    - Bridge and culvert replacement
    - Rock Creek Reservoir Protection
    - Canal Protection
    - Best Management Practices
    - Channel improvements and levees
    - Floodplain management program
    - Flood warning and water quality monitoring system
- *Where bridge and culvert improvements are recommended, the design capacities were calculated assuming no other mitigation measures were in effect.* This assumption was necessary because it was not possible to know when or if other mitigation measures will be constructed.

FINDINGS

The following paragraphs contain a summary of the principal findings of this study.

1. *The magnitude of the potential peak flood flow increases due to development will vary throughout the study area from 2 to 22 percent within individual watersheds, depending on the level of development.* In areas where extensive development is planned, such as Rock Creek watershed, flows may increase up to 22 percent, while areas with little or no future development (i.e., Orr Creek and Dry Creek watersheds) will have insignificant increases in flow.

2. *Many of the bridges and culverts in the watershed are inadequate to pass the 100-year flows for both existing and future conditions.* Approximately 70% of the bridges and culverts were determined to be inadequate to pass the 100-year peak flow. In most cases, the flood flows will back up upstream of the bridge or culvert and will then flow across the roadway, interfering with traffic and emergency services. This flow can also damage the road embankment and bridge or culvert structure and endanger motorists. Flood damages can occur to structures upstream of the bridge due to the increased water levels.

3. *Flooding will occur with the 100-year flood under existing conditions along Dry Creek Road.* The Dry Creek channel adjacent to Dry Creek Road was the only area identified where the channel was inadequate to pass the 100-year flood without the flooding of the existing roadway. Specifically, flooding of up to 2 to 3 feet has been known to occur on Dry Creek Road between Dry Creek Road bridge and Twin Pines Trail bridge during a major storm event (March 1986).

4. *Local or on-site detention basins may be effective in reducing local and regional flooding problems due to development.* The implementation of on-site detention for new developments will eliminate increased flows just downstream of each detention basin. The greatest impact of local detention will be on Rock Creek watershed where the increase in future flows can be reduced from about 22 percent of existing to 8 percent. In North Ravine the increase in flows over present conditions is estimated to be approximately 8 percent. However, with local detention, the future flows can be reduced to about the same flows as occur under present conditions. In the Dry and Orr Creek watersheds the future flows increase only 3 percent over the present conditions and local detention can reduce these increases to existing conditions.

5. *Due to the lack of suitable sites in the study area, local regional detention basins were not included in the recommended improvements and policies.* Regional detention has proven to be an effective method in mitigating increased flows from urbanization in many instances. However, due to the relatively steep nature of the watersheds and the present level of development, no suitable sites were identified for a regional detention basin within the study area.

6. *Any significant clearing of the vegetation in floodplains and channels in the watershed will cause an overall increase in the magnitude of flood flows throughout the watershed.* Local exceptions should occur only where inadequate channel and/or floodplain capacity is currently causing flood damages along the stream. Other than these few exceptions,

channel clearing should be prohibited throughout the watershed. Any filling in the stream channel or floodplain may also cause local flooding due to increased water surface elevation and the resulting loss of flow capacity and storage. The loss of storage may also cause increased flooding impacts downstream.

7. *There are numerous canals in the study area that may be subject to water quality degradation through the interception of stormwater runoff.* As development of lands adjacent to these open canals occurs, the likelihood for increased pollutant levels increases. In addition to the potential impacts on canal water quality, urbanization may also result in increased flows into the canals from surface water runoff. These increased flows may cause damage to the canals by overtopping, erosion, or other structural damages to the canals or spill structures on the canals.

RECOMMENDED PLAN

The following paragraphs describe the elements of the recommended improvements and policies as part of the Auburn/Bowman Hydrology study.

Structural Alternatives

1. *Regional Detention Basins*. Regional detention basins were not recommended inside the study area due to efficacy of local, on-site detention basins in reducing peak flood flows, and the lack of suitable sites. A need for regional detention basins outside the study area was identified as part of the Coon Creek and Auburn Ravine study done previously (CH2M-Hill, 1992). These regional detention basins are needed to reduce both the peak flows and volumes resulting from development in the Coon Creek and Auburn Ravine watersheds.

2. *Bridge and Culvert Replacement*. Approximately 70% percent of the bridges and culverts in the Auburn/Bowman Community Plan study area are inadequate to pass the 100-year flood without overtopping. However, not all of these bridges and culverts are recommended for replacement. Some of the crossings in rural areas have been designed as low flow crossings and as such would not be damaged from high flows. In addition, other crossings were built in such a way within the floodplain that it would not be feasible to pass the 100-year flows without significant channel improvements and modifications (in addition to replacement of the crossing). Of the 48 total crossings identified as being inadequate to pass the 100-year flood, 26 are recommended for replacement.

3. *Channel Improvements*. A local channel improvement project should be considered for Dry Creek between Dry Creek Road bridge and Twin Pines Trail bridge to provide 25-year protection of the road. The Dry Creek channel in this area (adjacent to Dry Creek Road) was the only channel identified in this study where the stream channel was inadequate to pass the 25 and 100-year flows without impacting existing structures (i.e., Dry Creek Road). A hydraulic analysis of this stream reach indicated that it was not feasible to provide 100-year protection of the road without significant channel excavation

and clearing. However, 25-year protection should be provided through moderate channel excavation and the maintenance of a clear channel and floodplain (i.e., removal of blackberries and other undergrowth in the channel and overbanks).

4. *Rock Creek Reservoir Protection* The various structural methods considered for protection of Rock Creek Reservoir included a bypass channel around the reservoir, sedimentation basins upstream of the reservoir, and constructed wetlands upstream of the reservoir. Both the bypass channel and sedimentation basins are considered to be viable methods of protecting the water quality in the reservoir from pollutants associated with urban runoff. However, due to site constraints and the large size of the upstream watersheds, constructed wetlands were not considered to be an effective method for treating the runoff and thereby protecting the reservoir water quality.

   For protection of the reservoir from pollutants associated with stormwater runoff as well as protecting the downstream water quality, it is recommended that both a bypass channel and sedimentation basins be constructed. The bypass channel will provide protection for the reservoir by routing runoff around the reservoir while the sedimentation basins will provide a degree of treatment of this runoff by settling out solids prior to discharge into the bypass channel.

Nonstructural Alternatives

1. *Local, On-site Detention.* Local, on-site detention facilities are recommended for all future developments in the Auburn/Bowman Community Plan study area as indicated on Figure 6-2. These local detention facilities should be designed to reduce post-development flows from the 2- through 100-year storms to pre-development levels.

   It is understood that in many cases suitable sites that would allow a particular development to collect and store stormwater before release into a major stream, are not available. In these cases the developer should instead contribute an in-lieu of local detention fee to a fund that could be used to construct off-site local detention basins, improve the local conveyance facilities, and/or construct regional detention facilities to replace the local, on-site detention that was not constructed.

   Adequate maintenance of the local detention basins is essential if they are to maintain their effectiveness in reducing peak flows. A means must be found to ensure that the local detention basins are maintained adequately.

2. *Floodplain Management.* Continuing enforcement of floodplain management ordinances, grading ordinances, and policies to control development in the floodplain and prevent modification of natural channels or removal of vegetation is needed.

   Changes in the natural channel of major streams and/or the removal of existing vegetation in their floodplains can substantially increase downstream flood flows. Prohibitions against channel and floodplain modification are stated in most general plan policies; however, these policies are not believed to be fully enforceable and are not fully enforced at the present time. Flooding problems can also be exacerbated by modifications of minor tributary channels and their floodplains.

- *Floodplain Mapping.* Floodplain mapping is essential to provide direction for the Placer County Planning Department as land is developed along the streams in the Auburn/Bowman Community Plan area. As part of this study the approximate 100-year floodplain (for Future flows) was delineated for Orr Creek, Dry Creek, Rock Creek and North Ravine. This mapping should be extended and updated for the area on a one-time basis because the increase in runoff from future development is not expected to significantly affect the floodplain boundaries. The cost for floodplain mapping is estimated to be $550,000.
- *Channel and Floodplain Clearing.* Control of channel and floodplain clearing throughout the watershed is an important facet of the recommended plan. Clearing channels and floodplains of the existing vegetation will increase flood flows downstream. The dense vegetation existing in the channels and floodplains throughout the watershed is a flood retarding feature. It is recommended that floodplain management and grading ordinances and policies be enacted where such ordinances and policies are not already in place. These ordinances should restrict the removal of riparian vegetation from the channels and floodplains of major streams in the Auburn/Bowman Community Plan area except where removal and maintenance are required to solve existing local flooding problems.

3. *Canal Protection* In order to protect the canals from increased water quality degradation and increased flows as a result of new developments, it is recommended that the following canal protection measures be implemented to prevent any future increase in pollutant loadings or interception of stormwater runoff from occurring as a result of new development in the study area.
    - *Land Use Controls* A zoning ordinance should be implemented which limits the development of commercial, industrial and multi-family residential developments directly upstream of an open canal. The ordinance should state that a 100-foot setback is required from the uphill bank of a canal, with a 50-foot setback required from the downhill bank of a canal.
    - *Drainage Controls.* No new development uphill of an open canal should be allowed to let storm drainage enter the canal through a storm drainage collection system.
    - *Canal Encasement.* Canals should be encased in new residential developments with lot sizes of two acres or less, in new residential subdivisions where roads are constructed within 100 feet of a canal, and in commercial, industrial, institutional and multi-family residential developments. Canals should be encased in new residential developments with lot sizes of three acres or less if the canal carries the raw water supply for a downstream water treatment plant.
    - *Canal Fencing* Fencing should be required for canals that are not encased but which are within rural residential developments with lot sizes of five acres or less. The requirement for fencing along open canals in other developments should be determined on a case by case basis depending on the location and size of buildings, parking lots, roads and other improvements, the canal size and downstream water

use, and the presence or use of hazardous or toxic materials. The location of the fences as well as their design and construction should be approved by the County Engineer as well as the responsible canal agency.

4. *Best Management Practices.* Best Management Practices (BMPs) can be effective methods in removing pollutants from stormwater runoff (i.e., oil/grit separators, detention ponds) as well as in controlling the pollutants at their source (i.e., street cleaning, public education). A list of BMPs applicable to the Auburn/Bowman Community Plan area is presented in Section Four. This list is not exhaustive; however, it does present the most common BMPs in use in other rural and urban areas as well as at construction sites.

   In order to provide water quality protection of the streams, canals, and reservoirs in the study area, it is recommended that all new developments be required to implement appropriate BMPs such that the net increase in pollutant loads from the development is minimized. The specific BMPs and their design should be approved by the County Engineer prior to development of a site.

5. *Regional Monitoring Program.* It is recommended that the County implement a monitoring program that includes seven stations for stream level and precipitation monitoring in addition to automatic water quality samplers at each of the seven locations. In addition, two extra monitoring stations at Rock Creek at Bell Road and at Rock Creek Reservoir (water quality monitoring only) will provide additional data on the Rock Creek Reservoir and the upper Rock Creek watershed (where significant development is anticipated over the next twenty years).

   This monitoring program is designed to provide data (flow and water quality) throughout the Auburn/Bowman Community Plan area to determine the influence changing land use conditions have on the quantity and quality of storm water runoff. The seven locations were selected to provide data for all of the primary watersheds in the study area including Orr Creek, Dry Creek, Rock Creek and North Ravine. Stream level and precipitation data from the proposed monitors will be sent to the Flood Control District base station where it can be used to provide flooding forecasts for lower portions of the Coon Creek and Auburn Ravine watersheds. The estimated capital cost of the recommended regional monitoring program is $97,500.

6. *Rates and Charges.* Placer County or the Placer County Flood Control and Water Conservation District should collect fees to fund flood control services. These fees should be collected either as a benefit assessment or as rates and charges for services. County fees may be assessed and collected through establishment of a County Service Area (CSA) zone of benefits. Revisions to the District's enabling legislation may be needed before rates and charges can be used as a major funding source. The rates and charges should be set at a level to collect $455,000 annually for the Auburn/Bowman Area. This includes ongoing services and debt service on capital improvements. The ongoing services include maintenance, engineering, insurance, monitoring, and water quality studies. The capital improvements costs are the ones which cannot be allocated to new development. Billing rates should vary based on a properties land use, location and size. Initial recommended

billing rates for single family homes vary from $63 per house per year in the Rock Creek Zone, to a high of $326 per house per year for homes in the Dry Creek Zone.

7. *Funding for Flood Control Services Related to New Development.* A total of 5.3 million dollars should be collected from new development in the Dry Creek Watershed to fund regional flood control capital improvements necessitated by that development. The simplest way to collect those funds would be through a development fee. That development fee should vary based on the property use, location and size. Recommended single family home development fees vary from $658 per house in Rock Creek Zone to $3,414 per house in the Orr Creek Zone.

SECTION 1
INTRODUCTION

PURPOSE

The Auburn/Bowman Community is a largely rural area located in the Sierra foothills in Placer County. The community, however, is experiencing rapid growth with much of the agricultural and open space land being developed for residential and commercial purposes. Placer County is currently updating its General Plan for the Auburn/Bowman Community (excluding the City of Auburn) and one concern in the formulation of the Plan is the potential of existing and future flooding along streams in the study area.

Flooding occurs when heavy rains cause streams to overflow their banks, flooding property and structures located adjacent to the stream. Streams also back up at culverts and bridges, blocking roads or making them unsafe. Emergency services can also be restricted by the flooded roads. In addition, there are numerous open canals in the study area which can intercept sheet runoff from one part of the study area and spill it into another. Excessive spills from these canals may also increase the potential for downstream flooding.

Placer County is concerned, not only with the existing flooding problems, but also with future problems which can result from the development occurring in the area. Continued development in the watersheds that comprise the study area has the potential for making existing flooding problems worse unless adequate steps are taken to plan and implement comprehensive watershed-wide solutions to the drainage problems.

Satisfactory solutions to the flooding problems in the study area cannot be provided on a site by site basis because of the possible adverse downstream impacts of any proposed solution. Also, the cumulative downstream impacts can be significant even when local flooding problems appear to be insignificant. These downstream impacts must be taken into consideration when planning flood control projects and setting flood control policies. The purpose of this drainage study is to provide Placer County with the information and policies necessary to manage the storm waters within the study area. It also includes consideration of required improvements and the associated funding programs to accomplish the improvements. This Flood Control Plan is intended to provide an approach for meeting existing and future flood control needs in the study area. Implementation of the plan will require additional detailed planning, design, and Environmental Impact Review.

WATERSHED DESCRIPTIONS

The Auburn/Bowman area covers approximately 41.5 square miles and is contained in portions of six different drainage basins; Bear River, Orr Creek, Dry Creek (including Rock Creek), Auburn Ravine (including North Ravine), Mormon Ravine, Dutch Ravine and the American River (North

TABLE 1-1

WATERSHEDS IN AUBURN/BOWMAN COMMUNITY

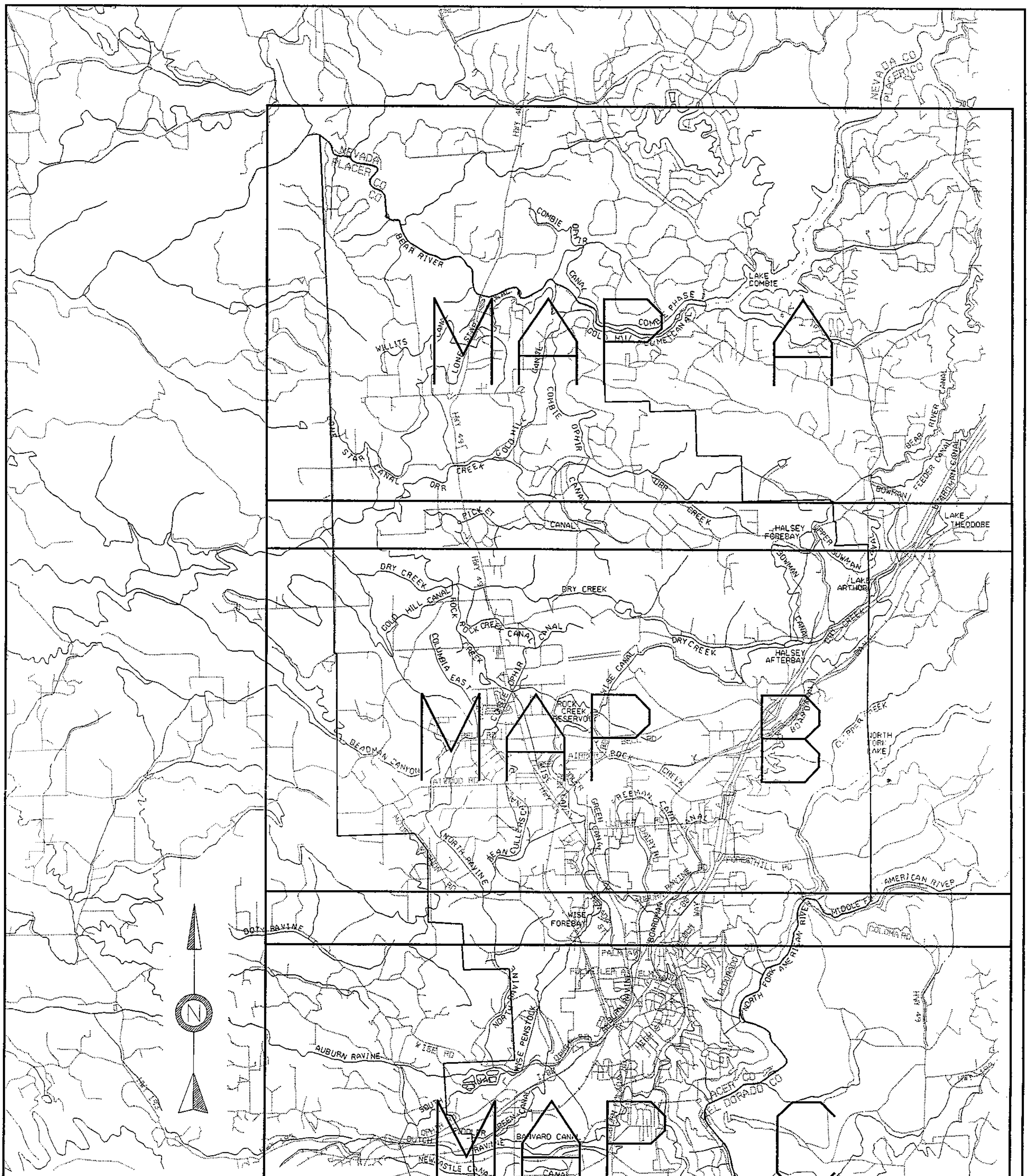
Watershed	Area (Square Miles)
Bear River	2.1
Orr Creek	9.3
Dry Creek	15.5
Rock Creek	4.3
Auburn Ravine	10.8
North Ravine	4.6
Mormon Ravine	1.4
Dutch Ravine	1.0
American River	9.8
Deadman's Canyon	1.0

Fork). Each watershed and the respective areas that are in the study area (or that contribute flows to the study area) are listed in Table 1-1.

A map of the study area and watersheds is presented in Figure 1-1. Over 85% of the study area is drained by the Orr Creek, Dry Creek and Auburn Ravine watersheds whereas the Bear River, American River, Mormon Ravine and Dutch Ravine watersheds together make up less than 15% of the total study area. The Area Map in Figure 1-1 also shows the watershed and subbasin boundaries that were used in developing the model. Rectangles, representing detailed map coverage, are shown on the Index Map, Figure 1-2.

The Orr Creek watershed is located in the northern portion of the study area and drains water from east to west across the study area. A small portion of the watershed (approximately one square mile) is located northeast outside the study area. The Dry Creek watershed is located south of the Orr Creek watershed and also drains water from east to west across the study area. Approximately 1.7 square miles of the Dry Creek watershed is located outside the study area to the north and east. Rock Creek, a major tributary to Dry Creek, drains approximately 4.3 square miles in the southern portion of the watershed. Dry Creek and Orr Creek meet approximately 2000 feet outside the western boundary of the study area to form Coon Creek.

Auburn Ravine is located in the southern portion of the study area with the head waters primarily located within the City of Auburn. The upper portion of Auburn Ravine drains most of Auburn with a flow pattern to the south and west. North Ravine is a primary tributary to Auburn Ravine and drains the eastern portion of the Auburn Ravine watershed that is located in the study area. North Ravine generally drains water from north to south and the confluence with Auburn Ravine is located in the study area approximately one mile from the western boundary.



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DEPARTMENT OF PUBLIC WORKS

AUBURN/BOWMAN
COMMUNITY PLAN
HYDROLOGY/DRAINAGE STUDY

INDEX MAP

SCALE
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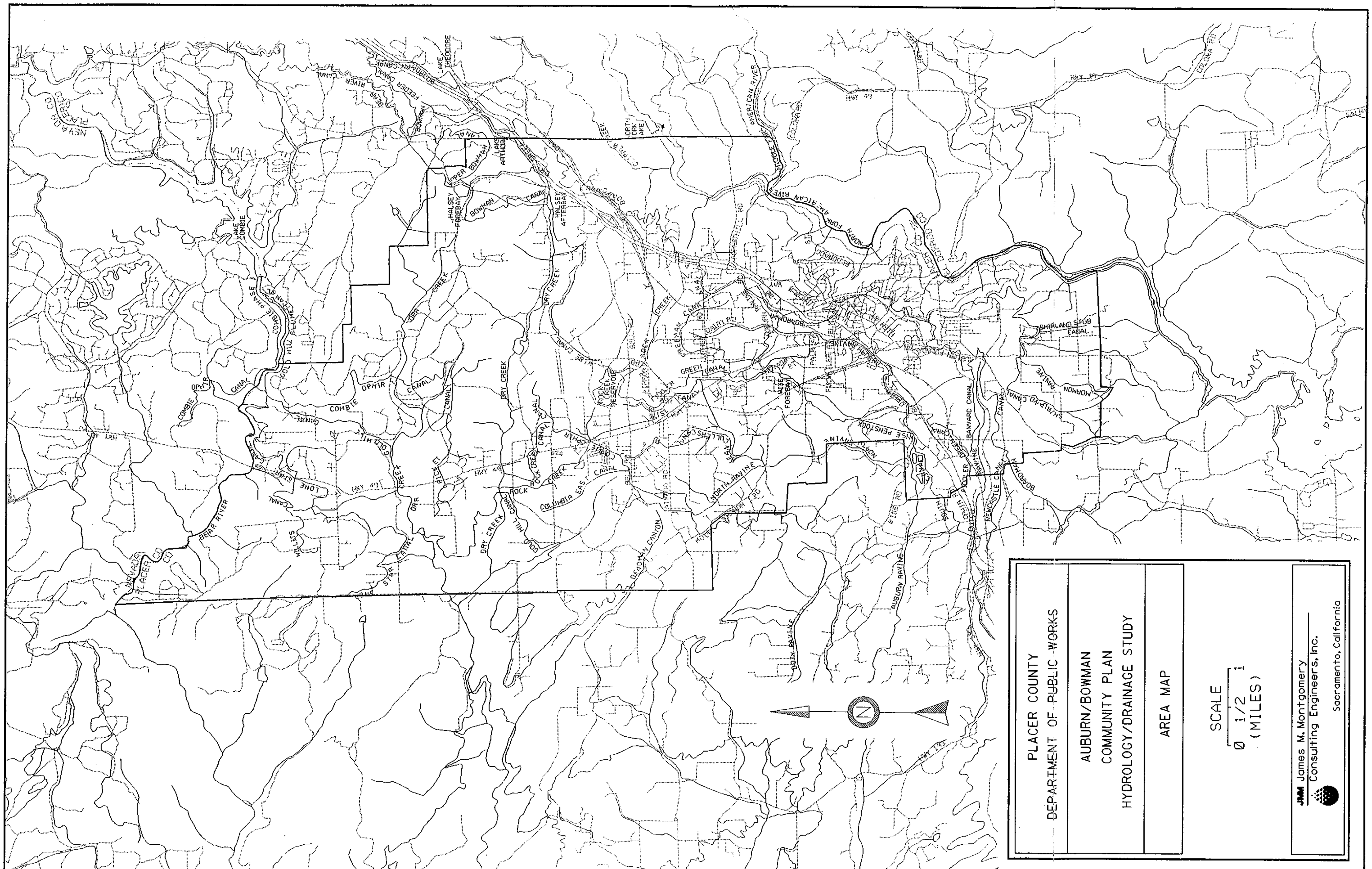
Consulting Engineers, Inc.
Sacramento, California

FIGURE 1-2


PLACER COUNTY
DEPARTMENT OF PUBLIC WORKS
AUBURN/BOWMAN
COMMUNITY PLAN
HYDROLOGY/DRAINAGE STUDY
AREA MAP
SCALE
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(MILES)
JMM James M. Montgomery
Consulting Engineers, Inc.
Sacramento, California
N

FIGURE 1-1

The very northern portion of the study area is drained by a portion of the Bear River watershed. This area consists primarily of small unnamed tributaries that drain water north directly into the Bear River. The very eastern portion of the study area is drained by the American River watershed. As with the Bear River, this portion of the study area consists primarily of small, short drainage basins which flow directly into the North Fork of the American River. The exception to this is Clipper Creek which drains approximately five square miles outside the study area and then drains into the North Fork within the study Area boundaries.

Headwaters of Mormon Ravine and Dutch Ravine watersheds are located in the very southern portion of the study area. The general drainage pattern is to the south for Mormon Ravine and to the west for Dutch Ravine. In addition, the headwaters for Deadman's Canyon are also located within the western portion of the study area adjacent to the Dry Creek and Auburn Ravine watersheds. Deadman's Canyon flows into Coon Creek approximately two miles outside the study area boundary.

Topography

The entire study area is located in the foothills of the Sierra Nevada Mountains and the watersheds in the study area are characterized by relatively steep slopes and moderate relief. Elevations in the study area range from approximately 800 feet (msl) in the southern portion of the study area to over 2000 feet (msl) in upper Dry Creek and Orr Creek watersheds. Overall, most of the study area has elevations ranging from 1000 to 1500 feet (msl).

Soils

Soils in the study area have been given hydrologic classifications by the Soil Conservation Service (SCS) in the Placer County Soil Survey (1978). These classifications divide the soils based on infiltration rates and runoff potential and are:

- Group A - Low runoff potential. Soils having high infiltration rates even when thoroughly wetted and consisting chiefly of deep, well- to excessively-drained sands or gravels.
- Group B - Moderately low runoff potential. Soils having moderate infiltration rates when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately well to well-drained soils with fine to moderately coarse textures. These soils have a moderate rate of water transmission.
- Group C - Moderately high runoff potential. Soils having slow infiltration rates when thoroughly wetted and consisting chiefly of soils with a layer that impedes downward movement of water, or soils with moderately fine to fine texture. These soils have a slow rate of water transmission.
- Group D - High runoff potential. Soils having very slow infiltration rates when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very slow rate of water transmission.

The soils within the study area are predominantly Group D - high runoff potential. Only in the northeastern portion of the study area do any significant amounts of Group B or Group C type soils occur. Figures 1-3A to 1-3C are maps showing the distribution of the various hydrologic soil types occurring throughout the study area.

Land Use

The types of land use that occur in a watershed are significant in determining the amount of runoff that results from a given amount of rainfall. Much of the difference in runoff from different land uses can be attributed to the difference in the percentage of the land that is impervious (paved or covered by buildings) for each land use type. Another important factor that is determined by the type of land use is the condition, or hydraulic efficiency, of the smaller tributaries and streams in an area. For example, an area that is mostly rural residential will have streams that are largely in their natural state, with relatively inefficient hydraulic properties. This results in a slower and less intense concentration of runoff from the area. In comparison, the small tributary streams in a commercial area will most likely be improved. This improvement in the efficiency of the hydraulic properties causes the runoff in those tributary streams to reach the main streams and combine together more quickly, producing a faster and more intense concentration of runoff from the area.

Existing land use maps were obtained from the Placer County Planning Department which had performed a field survey of the land use of the entire study area (including Auburn) in 1990. The land use in the study area varies widely, from agricultural, to residential, to commercial. Most of the commercial land use is located in the City of Auburn and along the Highway 49 corridor south of Dry Creek. The areas outside of the city limits and the Highway 49 corridor are predominantly rural, agriculture and open space. Table 1-2 contains a listing of the land use categories used in this study.

Placer County has developed several alternative land use plans for the Auburn/Bowman Community (excluding the City of Auburn) - one of which will be incorporated in the final General Plan. The alternatives range from very limited development of the study area to much more extensive development of the area. For the purpose of this study, Alternative 2 (an intermediate plan) was utilized in the analysis of future land use conditions. This plan calls for continued commercial development along the Highway 49 corridor along with the conversion of much of the agriculture and open space land to rural estates and rural residential areas.

Figures 1-4A to 1-4C present the land use maps for Future conditions in the study area.

Canals and Reservoirs

An extensive network of canals and reservoirs are located in study area. The canals are owned and operated by three different agencies; Placer County Water Agency (PCWA), Nevada Irrigation District (NID) and Pacific Gas and Electric Company (PG&E). The source of water for most of the canals is the Bear River and Lake Combie to the north. In general, most canals transport the water from north to south through the study area with many side diversions and spills located within the study area.. Some of the canals are used solely for water supply purposes

TABLE 1-2

GENERALIZED LAND USE CODES

Code	Description	Definition
COMM	Commercial, Professional, Industrial, Highways	Self explanatory
HDR	High Density Residential	4-10 Dwelling Units/Acre
MDR	Medium Density Residential	2-4 Dwelling Units/Acre
LDR	Low Density Residential	0.4-0.9 Acre Minimum
RLDR	Rural Low Density Residential	0.9-2.3 Acre Minimum
RR	Rural Residential	2.3-5 Acre Minimum
RE	Rural Estates	5-20 Acre Minimum
OS	Open Space (undeveloped)	Self explanatory

JMM James M. Montgomery Consulting Engineers, Inc.

Sacramento, California

PLACER COUNTY

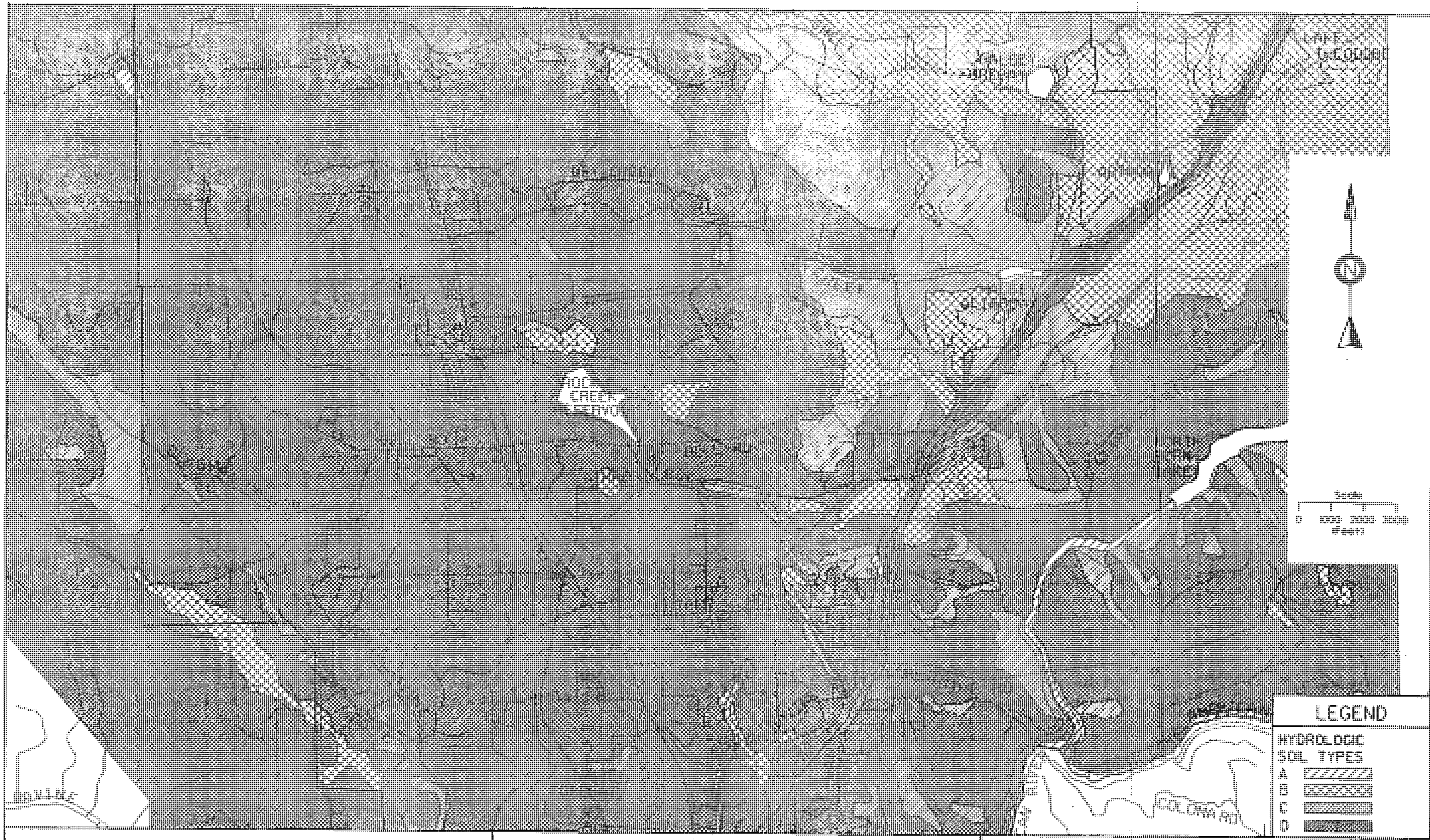
DEPARTMENT OF PUBLIC WORKS

AUBURN/BOWMAN WATERSHED

HYDROLOGIC SOIL TYPES

MAP A

FIGURE I-3A



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Sacramento, California

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AUBURN/BOWMAN WATERSHED
HYDROLOGIC SOIL TYPES
MAP B

FIGURE I-3B

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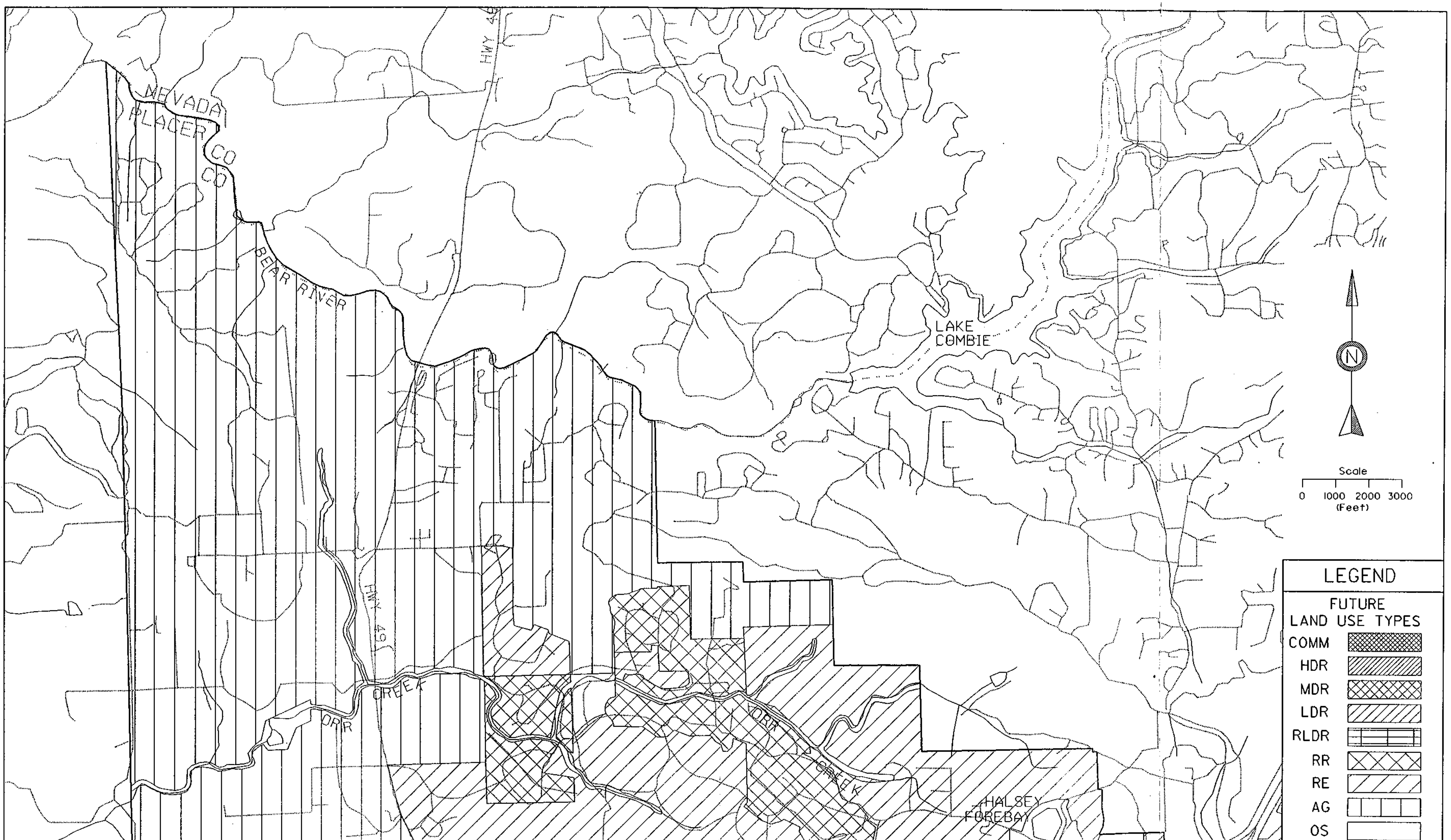
AUBURN/BOWMAN WATERSHED
HYDROLOGIC SOIL TYPES
MAP C

FIGURE I-3C



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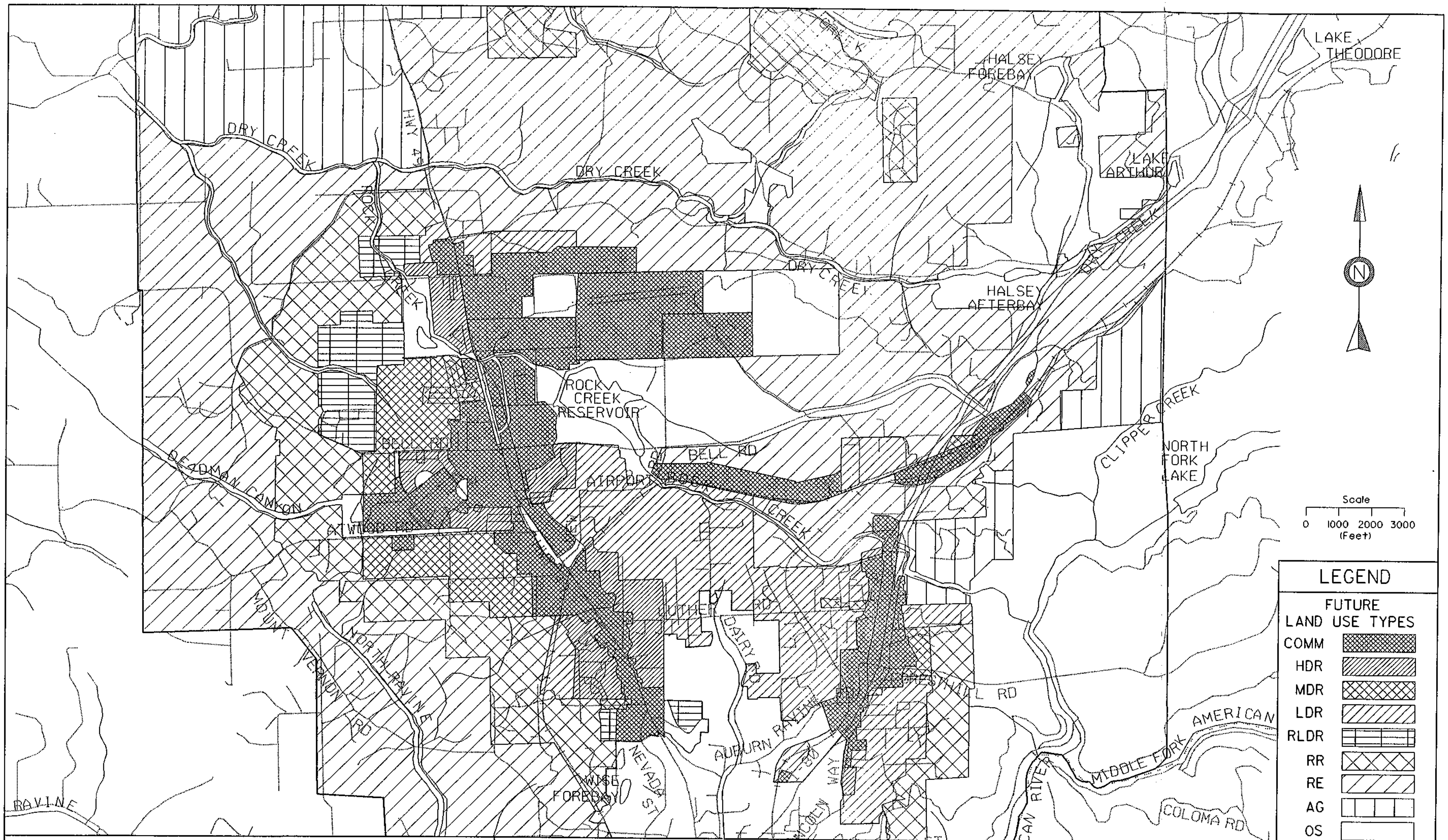
AUBURN/BOWMAN WATERSHED

GENERAL PLAN LAND USE

MAP A

FIGURE I-4A



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AUBURN/BOWMAN WATERSHED
GENERAL PLAN LAND USE
MAP B

FIGURE I-4B

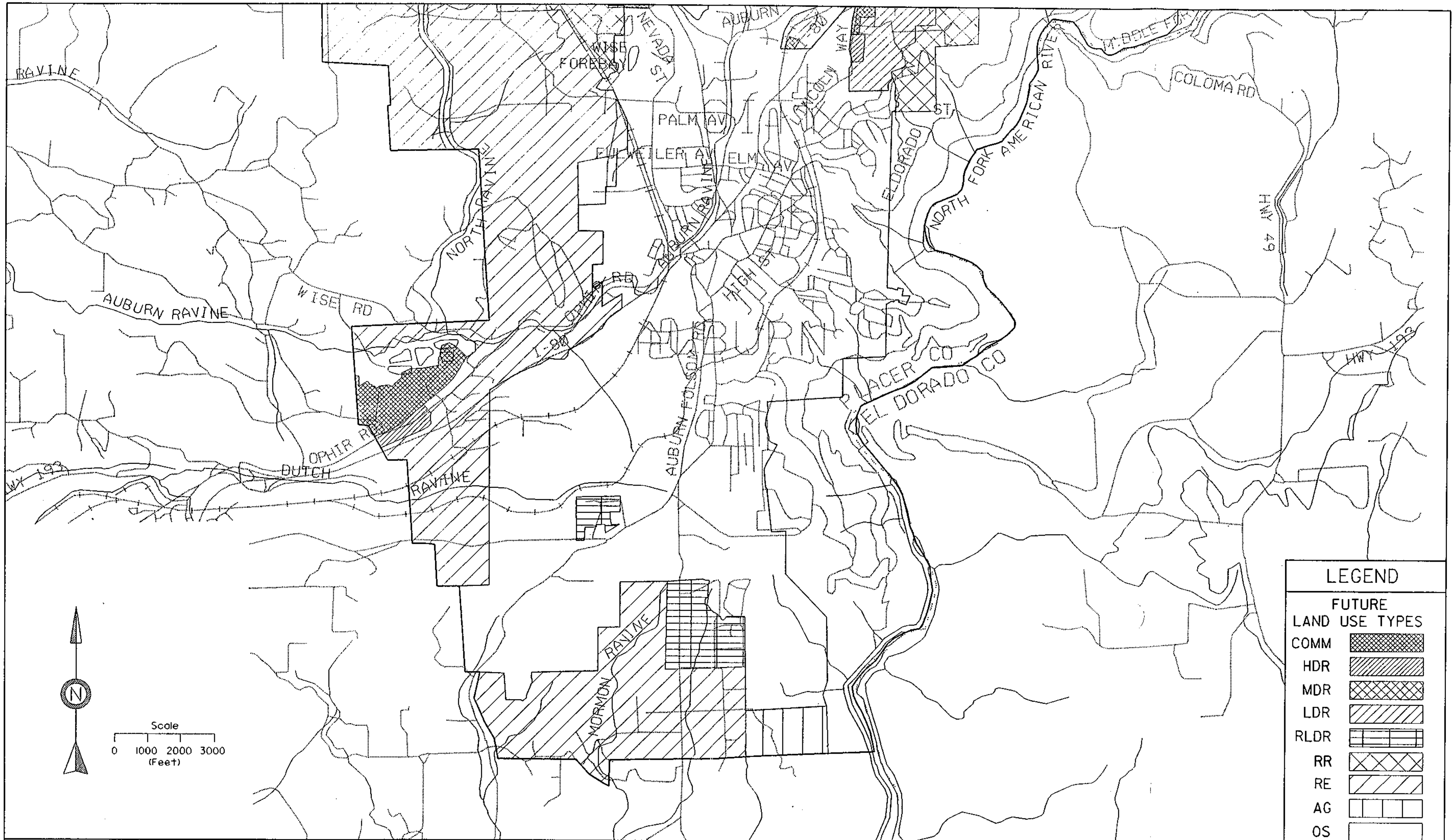

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FIGURE I-4C

(municipal and agricultural) whereas others are also used for power generation. There are also five reservoirs in the study area ranging in surface area from less than three acres to over fifty acres. Most of these reservoirs are used primarily for storing and diverting water to canals. A listing of all canals and reservoirs are presented in Tables 1-3 and 1-4. Figures 1-5a to 1-5c are maps indicating canal systems and spill locations.

Nevada Irrigation District maintains canals in the northwestern portion of the study area. The primary canals operated by NID are the Combie-Ophir, Lone Star, and Gold Hill Canals. Smaller canals include the Pickett, Rock Creek, Columbia, and Bean Cullers Canals. These canals are all used exclusively for water supply (agriculture and domestic) and are not encased except for short portions of: the Combie-Ophir Canal (approximately 900 feet in the vicinity of Bell Road); Rock Creek Canal (1,100 feet); Columbia Canal (3,800 feet); and Bean Cullers Canal (700 feet). In addition NID operates a small reservoir on Orr Creek located approximately one mile upstream of the confluence of Orr Creek and Dry Creek. Nevada Irrigation District releases water from Combie-Ophir Canal to a tributary of Orr Creek in the very northern area of the study area and this water is later diverted to Gold Hill Canal via the small reservoir on Orr Creek.

Placer County Water Agency operates and maintains canals primarily in the eastern portion of the study area. These canals include the Boardman, Fiddler Green, Bowman, Shirland, and Freeman Canals. Boardman Canal extends from the northeastern portion of the study area across to the southwestern corner and is the primary canal operated by PCWA in the study area. As with the NID canals, these canals are operated solely for water supply purposes, and only small portions of these canals have been encased. PCWA also operates two small reservoirs, Lake Arthur and Lake Theodore, that are used to supply water to their canal system in the event of an interruption in supply.

Pacific Gas and Electric Company operates and maintains canals in the study area primarily for the purpose of water supply and power generation. The primary canal maintained by PG&E in the study area for power generation is the Wise Canal which carries water from north to south through the study area. The Wise Canal is the largest canal in the study area (capacity over 500 cfs) and is not encased except in short segments where the water is diverted into penstocks. The following is a brief description of the source and operation of the Wise Canal and associated reservoirs located in the study area:

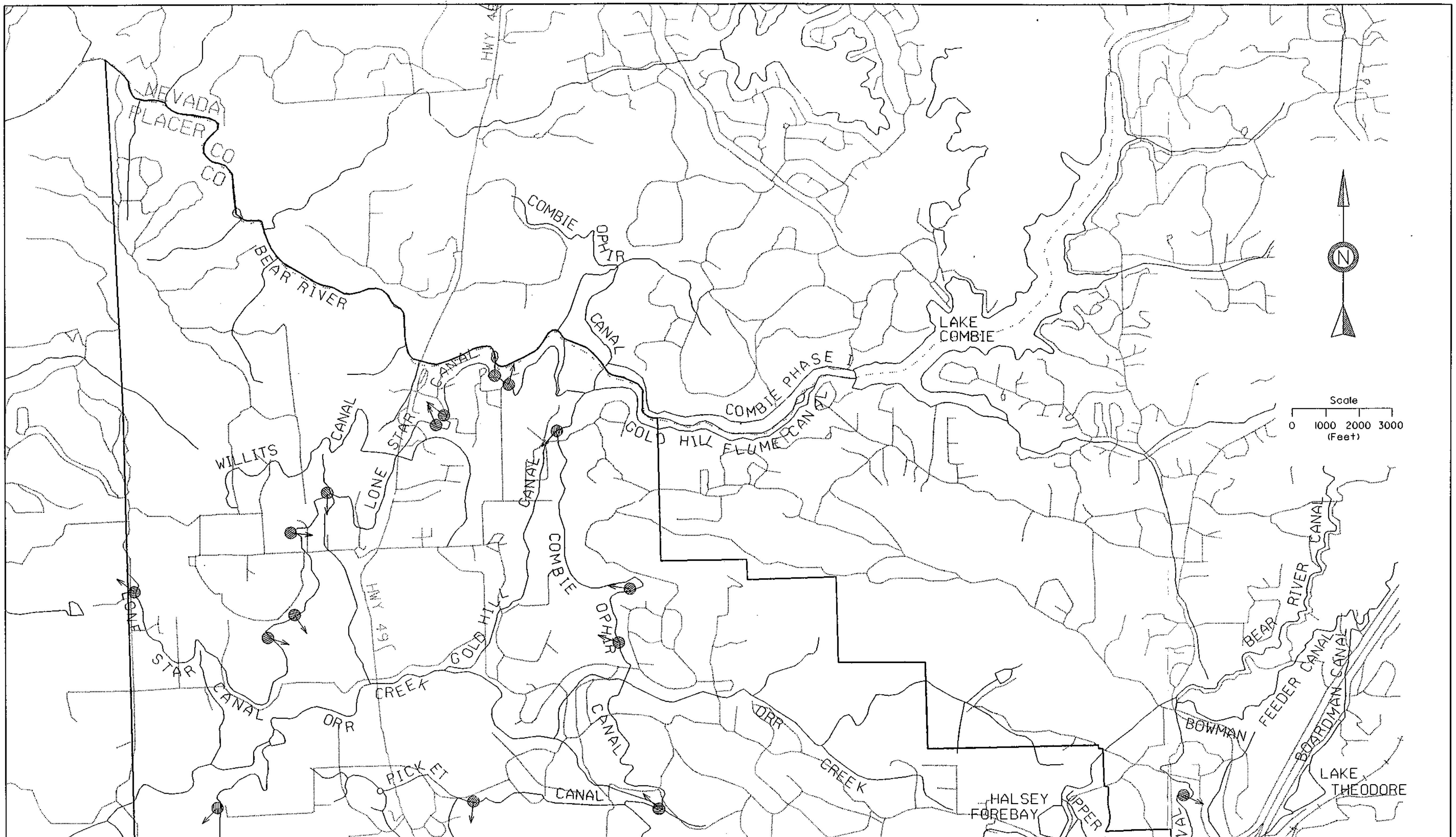
The Bear River Canal releases water to Halsey Forebay located in the northeastern portion of the study area. This water is the released via a penstock to Halsey Powerhouse and Halsey Afterbay (located on upper Dry Creek). The water is then diverted from the Afterbay to Wise Canal. This segment of the canal transports the water from upper Dry Creek watershed to Rock Creek watershed and is released into Rock Creek Lake (owned by PG&E). Water is then diverted from Rock Creek Lake into a lower section of Wise Canal passing into the Auburn Ravine watershed, and ending up in the Wise Forebay. At the Wise Forebay the canal water enters into a penstock and is carried to Wise Powerhouse located along the Auburn Ravine. From here canal water is released both to Auburn Ravine and South Canal.

TABLE 1-3
CANALS IN AUBURN/BOWMAN COMMUNITY

PG&E CANALS
Upper Bowman
Wise
Middle Fiddler Green
Lower Fiddler Green, lower 1/2
South Canal
PCWA CANALS
Shockley
Lower Bowman
Boardman
Fiddler Green Boardman Diversion
Shirland and Shirland Stub
Upper Banvard
Lower Fiddler Green, upper 1/2
Freeman
NID CANALS
Combie-Ophir
Lone Star
Gold Hill
Pickett
Kemper (East and West)
Willits
Oest
Rock Creek
Columbia (East, West)
Bean Cullers

TABLE 1-4
RESERVOIRS IN AUBURN/BOWMAN COMMUNITY

Reservoir	Agency	Surface Area (Acres)
Orr Creek	NID	2.8
Dry Creek	Private	11.5
Halsey Forebay	PG&E	15.1
Halsey Afterbay	PG&E	7.3
Rock Creek	PG&E	54.2
Wise Forebay	PG&E	4.1
McCrary	PCWA	0.9



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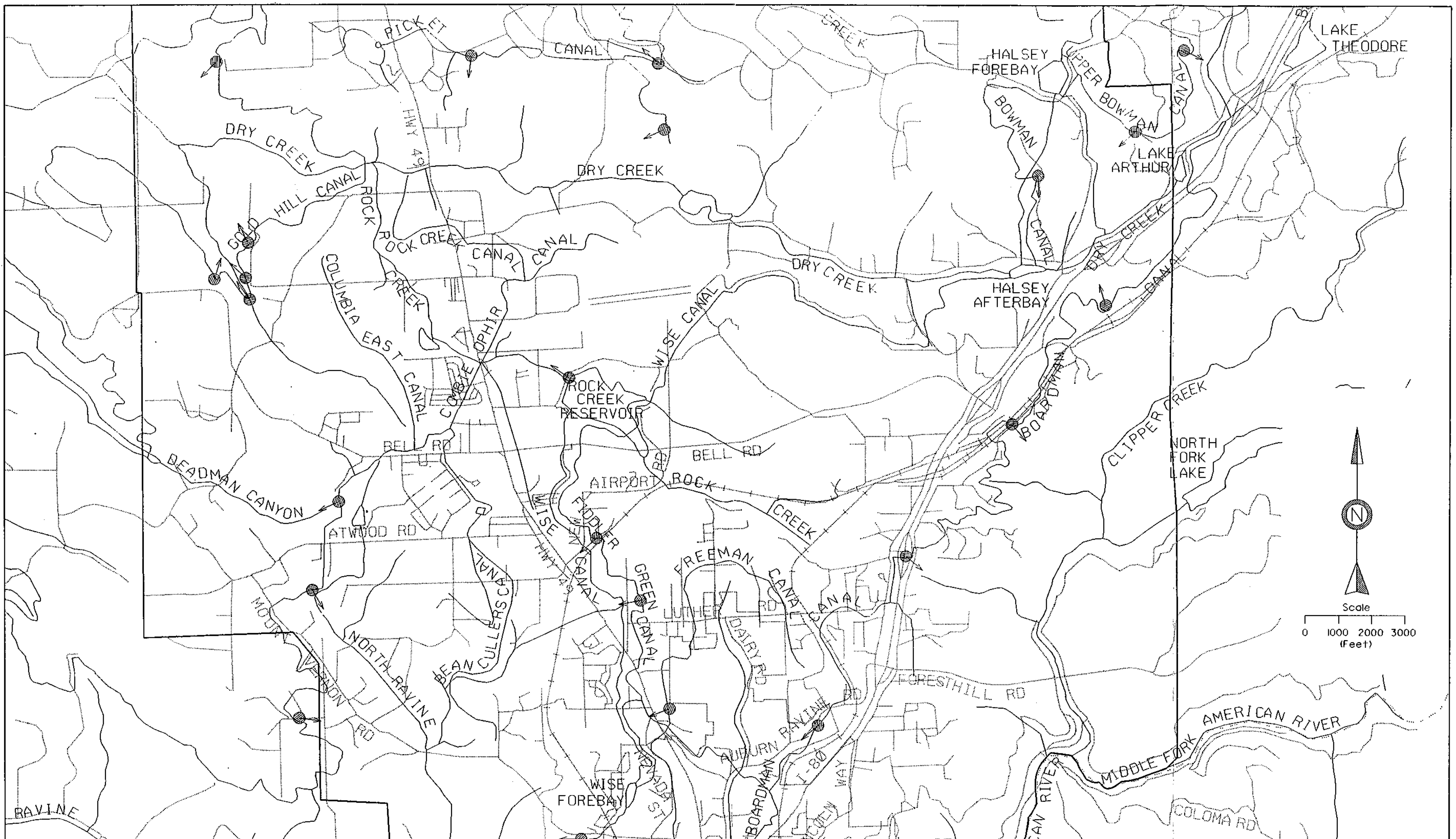
AUBURN/BOWMAN WATERSHED
CANALS AND SPILL LOCATIONS
MAP A

FIGURE I-5A



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AUBURN/BOWMAN WATERSHED
CANALS AND SPILL LOCATIONS
MAP B

FIGURE I-5B

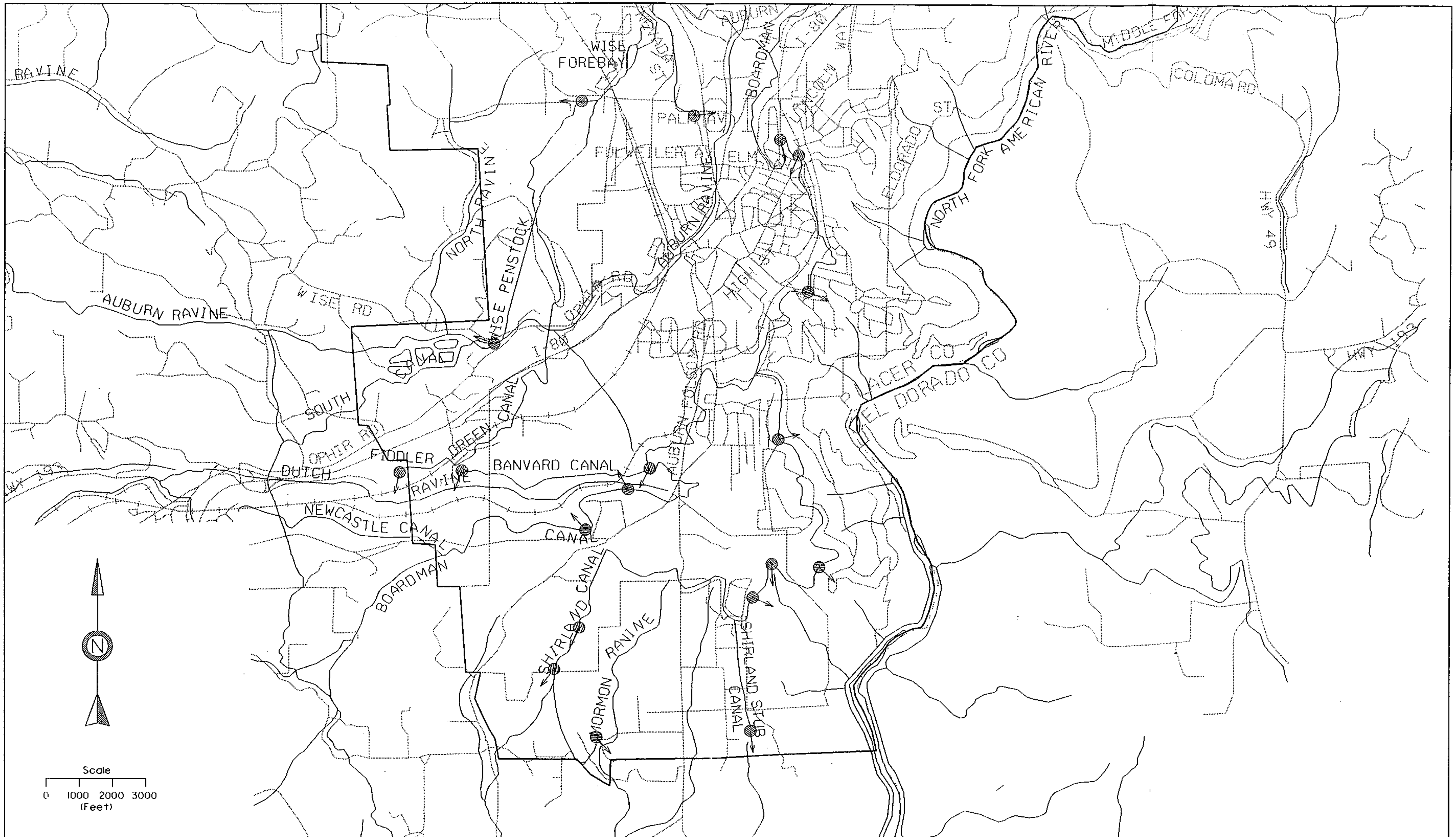

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FIGURE I-5C

The Wise Canal differs from other smaller water supply canals in the study area in that the Wise Canal has no spill points except for those into reservoirs. An emergency spill for the canal is located at the Wise Forebay and would spill to a small tributary of the North Ravine. However, this is designed to be used only in the event of penstock failure and has not been used to date.

INVENTORY OF STREAM CROSSINGS

Many of the problems that occur as a result of flooding are related to inadequate conveyance structures (culverts or bridges) at stream crossings. Table 1-5 lists all the stream crossings in the watershed that were examined as part of this study. Also included in Table 1-5 are other major points of interest in the watershed. The crossing number can be used to locate the stream crossing on Figures 1-6A to 1-6C.

RELEVANT PREVIOUS STUDIES

The following is a list of relevant previous studies:

- Dairy Road Watershed Master Plan (Draft), CH2M HILL, August 1991.
- Flood Insurance Study, Placer County - Unincorporated Areas CA, Placer County, CA. FEMA, Revised January 1987.

TABLE 1-5
LIST OF STREAM CROSSINGS AND MAJOR POINTS OF INTEREST

CROSSING NUMBER	STREAM	CROSSING
1	**ORR CREEK**	INFLOW TO COON CR.
2		BELL RD.
3		TRIB. CONFLUENCE
4		TRIB. CONFLUENCE
5		HWY 49 (State)
6		TRIB. CONFLUENCE
7		W. STANLEY DR.
8		TRIB. CONFLUENCE
9		E. STANLEY DR.
10		COMBIE-OPHIR SIPHON
11		CHRISTIAN VALLEY RD.
12		TRIB. CONFLUENCE
13		STUDY BOUNDARY
14		TRIB. CONFLUENCE
15	**ORR CR TRIB #1**	LITTLE CREEK RD. (Private)
16	**ORR CR TRIB #2**	VIRGINIA WAY
17		KENNETH WY. (Private)
17	**ORR CR TRIB #3**	LONE STAR RD.
19	**DRY CREEK**	INFLOW TO COON CR
20		BELL RD.
21		TRIB. CONFLUENCE
22		ROCK CR. CONFLUENCE
23		HWY 49 (State)
24		TRIB. CONFLUENCE
25		BLUE GRASS RD.
26		BELOW DAM
27		INFLOW TO RES.
28		DRY CR. ROAD
29		TWIN PINES TRAIL. (Private)
30		HAINES RD.
31		HALSEY AFTBAY OUTFLOW
32		BOWMAN RD.
33		LAKE ARTHUR RD.
34		LAKE ARTHUR RD.
35		BELOW LAKE ARTHUR
36	**DRY CR TRIB #1**	DRY CREEK RD.

TABLE 1-5 (continued)

CROSSING NUMBER	STREAM	CROSSING
37	**DRY CR TRIB #2**	DRY CREEK RD.
38	**DRY CR TRIB #3**	BLACK OAK RD.
39	**DRY CR TRIB #4**	DRY CREEK RD
40	**DRY CR TRIB #5**	JOGGER RD.
41	**DRY CR TRIB #6**	HOE RD. (Private)
42		HUBBARD RD. (Private)
43		JOEGER RD.
44	**ROCK CREEK**	INFLOW TO DRY CREEK
45		JOEGER RD.
46		SHERWOOD WY.
47		DRY CREEK RD.
48		RICHARDSON RD.
49		HWY 49 (State)
50		ROCK CREEK RD.
51		ROCK CR LAKE OUTFLOW
52		ROCK CR LAKE INFLOW
53		BELL RD.
54		NEW AIRPORT RD.
55		CRYSTAL SPRINGS RD.
56		TRIB. CONFLUENCE
57		CREEKVIEW CT.
58		RAILROAD
59	**ROCK CR TRIB #1**	RAILROAD
60	**ROCK CR TRIB #2**	NEW AIRPORT RD.
61		BELL RD.
62	**ROCK CR TRIB #3**	LOCALE LN.
63	**ROCK CR TRIB #4**	ROCK CREEK RD.
64		BELL RD.
65	**NORTH RAVINE**	WISE RD.
66		WARREN WY. (Private)
67		CALNICK RD. (Private)
68		BELOW MILLERTOWN RD.
69		TRIB. CONFLUENCE
70		MILLERTOWN RD.

TABLE 1-5 (continued)

CROSSING NUMBER	STREAM	CROSSING
71		MT. VERNON RD.
72		HARRIS RD. (Private)
73		VISTA ROBLE RD. (Private)
74		ATWOOD RD.
75	N. RAV. TRIB #1	KEMPER RD. (Private)
76	N. RAV. TRIB #2	HIDDEN OAKS LN. (Private)
77		RAILROAD
78		HWY 49 (State)
79		PEAR RD. (Private)
80	N. RAV. TRIB #3	MILLERTOWN RD.
81		MT. VERNON RD.
82	N. RAV. TRIB #4	MILLERTOWN RD.
83		BAR RANCH RD. (Private)
84	AUBURN RAVINE	AUBURN RAVINE OUTFLOW
85		N. RAVINE CONFLUENCE
86		WISE RD.
87		OPHIR RD.
88		OPHIR RD.
89		FORGOTTEN RD. (Abandoned)
90	AUBURN R. TRIB	I-80 (State)
91		RAILROAD
92	DUTCH RAVINE	RAILROAD
93		AUBURN-FOLSOM RD.
94	MORMON RAVINE	SHIRLAND RD.
95	MORMON R. TRIB	NO NAME RD
96		ANDREGG RD.
97	AMER. RIVER TRIB #1	HWY 49 (State)
98	AMER. RIVER TRIB #2	HWY 49 (State)
99	DEADMAN CANYON	JOEGER RD.
100		OAK CREEK CT.

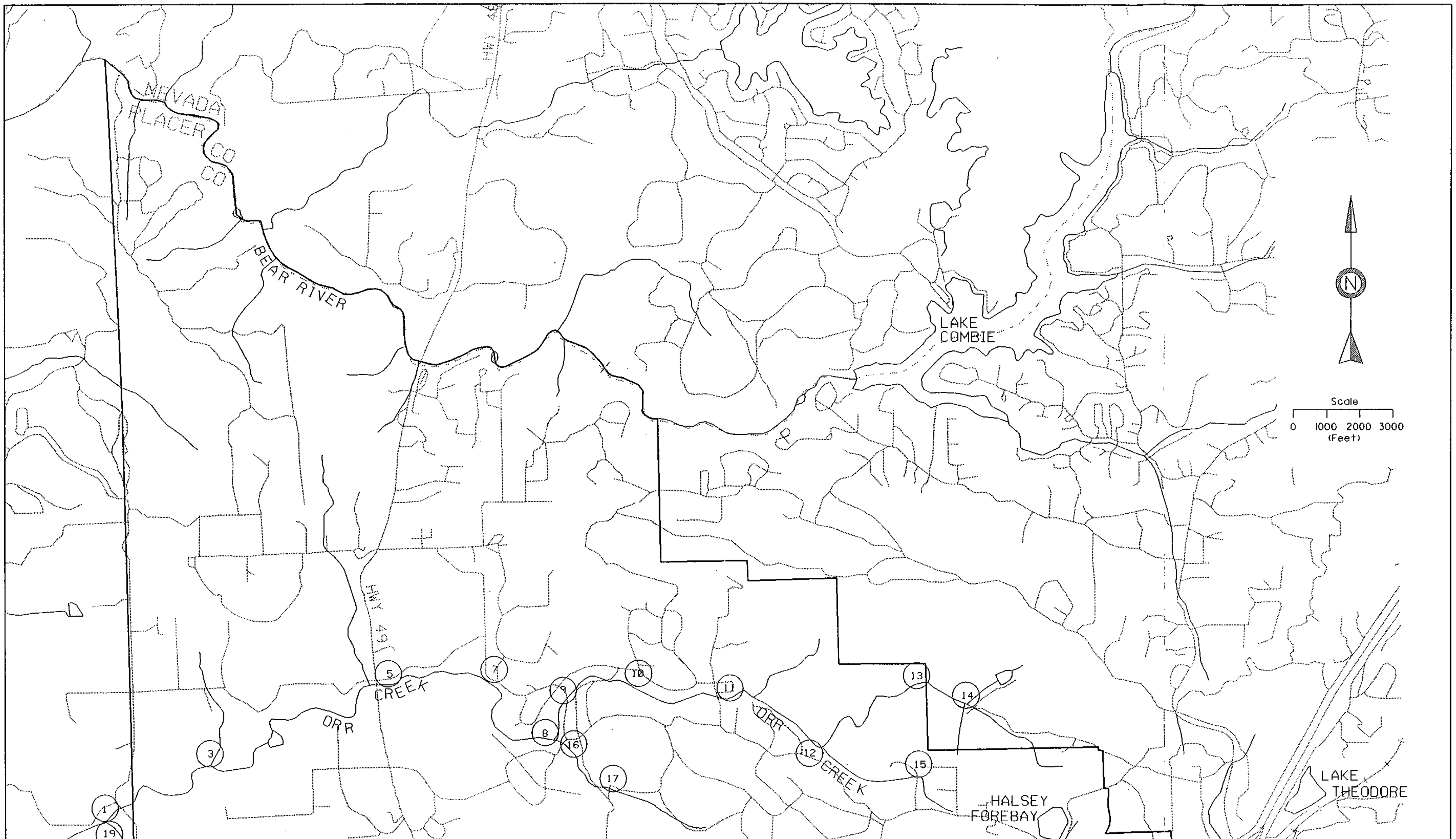

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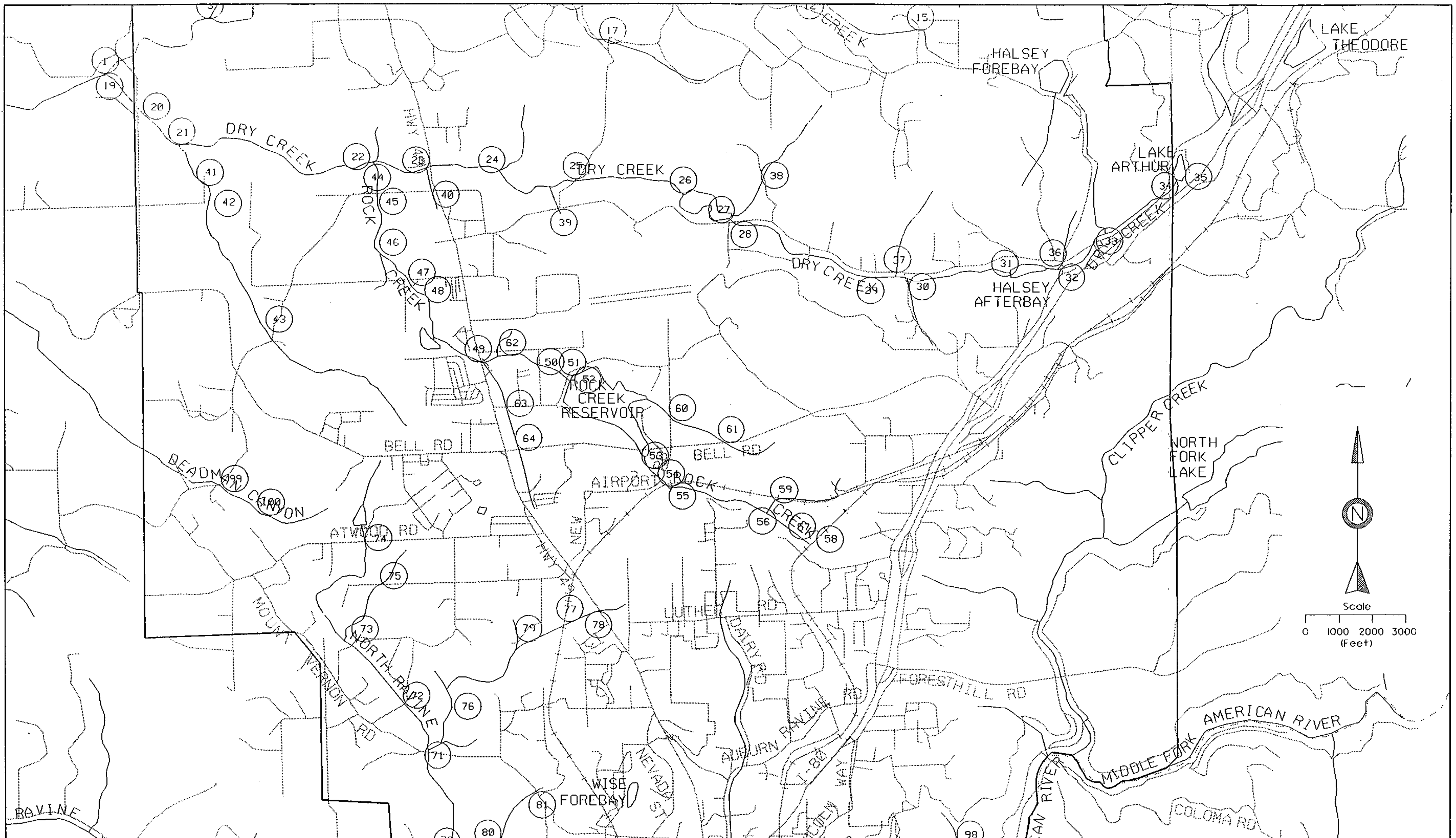
FIGURE I-6A



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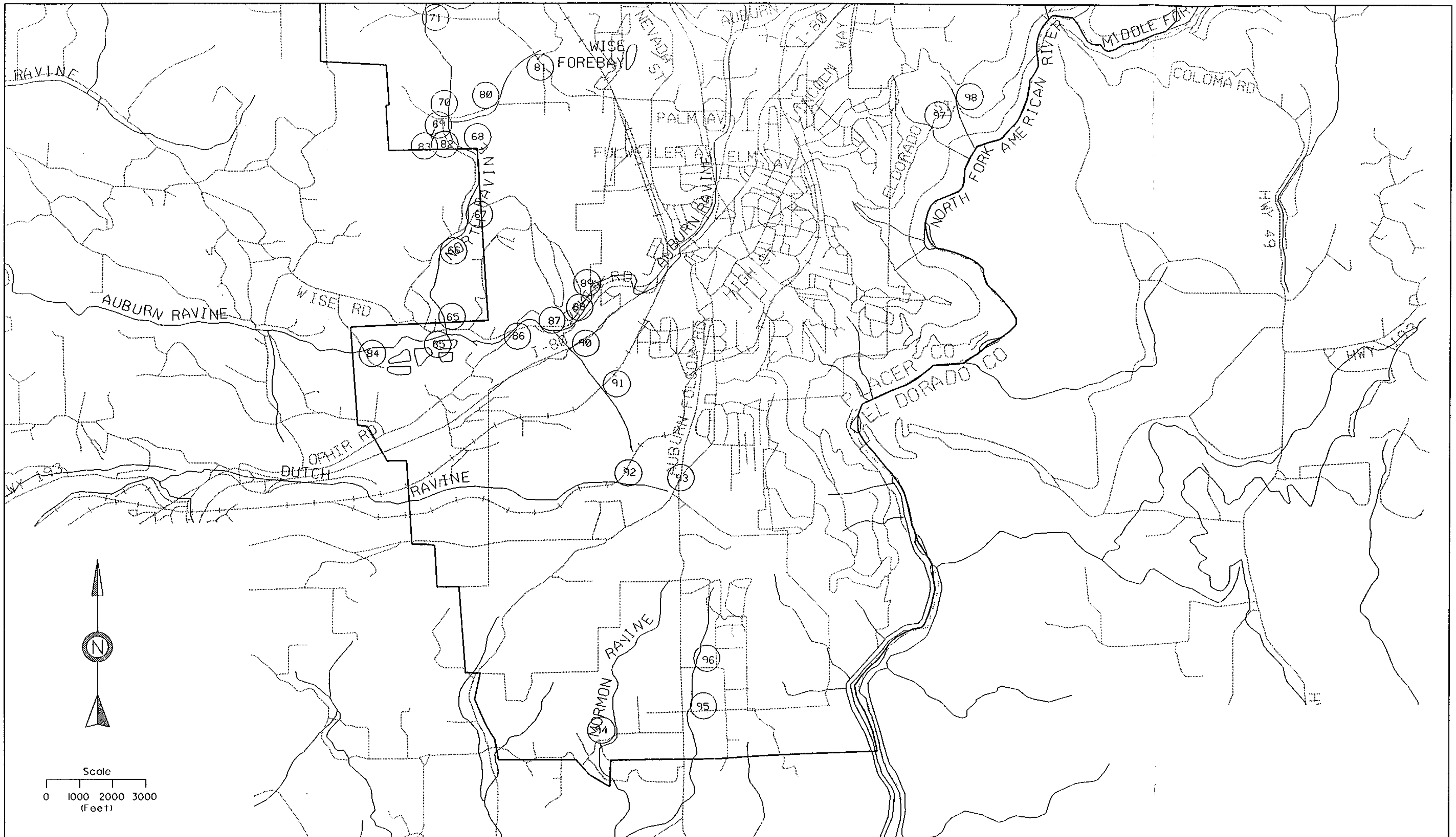
AUBURN/BOWMAN WATERSHED
STREAM CROSSINGS AND
POINTS OF INTEREST
MAP B

FIGURE I-6B



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AUBURN/BOWMAN WATERSHED
STREAM CROSSINGS AND
POINTS OF INTEREST
MAP C

FIGURE I-6C

SECTION 2
HYDROLOGIC ANALYSIS

The hydrologic analysis for the Auburn/Bowman Drainage Study is based on parameters and techniques specified in the Placer County Flood Control and Water Conservation District "Stormwater Management Manual." The purpose of the hydrologic analysis portion of this study is to determine how the watershed reacts to various levels of precipitation. This is accomplished through the use of a computer model that mathematically represents the physical processes of rainfall and the resulting runoff.

DESCRIPTION OF MODELS

A major portion of this study entailed the development and calibration of the hydrologic model HEC-1 of the watersheds in the study area. This model simulates the runoff in the watersheds in response to precipitation and is a tool that is used to predict the amounts and timing of runoff from a wide variety of simulated rainfall events.

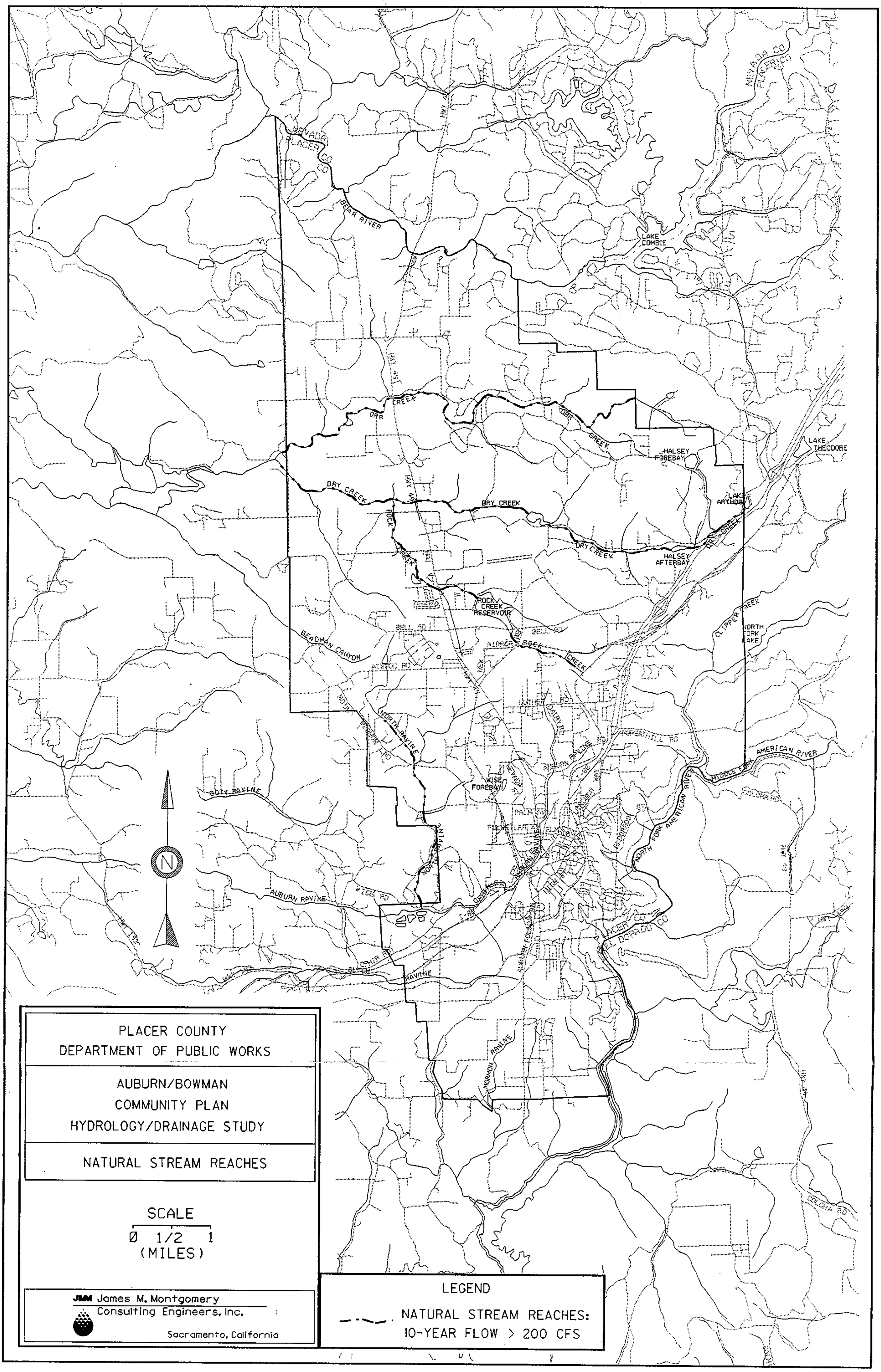
A hydraulic model (HEC-2) was also developed to model the hydraulics of streams with 10-year flows exceeding 200 cfs. This hydraulic model aided in the determination of the water surface elevations associated with various streamflows within the stream channels as well as at hydraulic structures such as bridges and culverts.

HEC-1 Model

The HEC-1 model is designed to simulate the surface runoff response of a watershed to precipitation. This is accomplished by representing the watershed as an interconnected system of hydrologic and hydraulic components. Each model component represents a specific aspect of the rainfall-runoff processes occurring in a portion of the watershed. A component may represent the runoff occurring in a subbasin, the routing of flows down a stream channel, or the routing of flows through a reservoir. Description of the components of a model requires estimation of a set of parameters that describes the hydrologic and hydraulic characteristics of the components. Parameters describing the various components of the model are based on land use, soils, vegetation, and topography. For example, the land use in a subbasin will determine the percent of that subbasin that is impervious and the average condition of the drainage channels. The end result of the modeling process is the computation of streamflow hydrographs (including peak flows) at specified locations throughout the watershed.

HEC-2 Model

The HEC-2 hydraulics model was developed for stream reaches with 10-year flows exceeding 200 cfs. These stream reaches are designated as natural streams and are to remain in their natural conditions as much as possible. Figure 2-1 shows the stream reaches in the Auburn/Bowman Community Plan area in which the 10-year flows exceed 200 cfs. As apart of this study, a field survey was performed for the natural stream reaches in which stream cross sections and elevations



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DEPARTMENT OF PUBLIC WORKS

AUBURN/BOWMAN
COMMUNITY PLAN
HYDROLOGY/DRAINAGE STUDY

NATURAL STREAM REACHES

SCALE
0 1/2 1
(MILES)

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LEGEND

NATURAL STREAM REACHES:
10-YEAR FLOW > 200 CFS

FIGURE 2-1

were surveyed at 1000 foot intervals for the 24 miles of designated natural streams in the study area. These stream reaches included portions of Orr Creek, Rock Creek, Dry Creek and North Ravine.

The HEC-2 model is used to compute the water surface profiles of one-dimensional, steady, gradually varied flow in streams. The program uses and solves energy and energy loss equations between adjacent flow cross sections. Output from HEC-2 is in the form of steady-state water surface profiles for the modeled stream reaches. It is also possible to obtain the storage in a reach based on a given flow rate. This capability of HEC-2 was used, where possible, to develop Modified Puls routing parameters for use in HEC-1 routing.

HEC-1 Model Development

This section of the report describes the assumptions and criteria that were used in developing the HEC-1 model of the watersheds in the Auburn/Bowman Community.

Model Overview

Whenever the use of a model is considered, or when the results of a model are interpreted, it is very important to understand the limitations that apply to the use of the model. Probably the most crucial limitation is that any model can only approximate the real world hydrologic and hydraulic processes. The HEC-1 model uses a number of simple mathematical and empirical methods to represent the complex physical processes that produce runoff from precipitation and route that runoff through a watershed. Although these methods are among the best currently available, they are still only mathematical or empirical simplifications of complex physical processes.

One of the important goals of the modeling effort for the study area was to set up the model using standard, accepted, consistent, and logical rules that could be applied to all areas in the in the study area with consistent and reliable results. This took the form of a spreadsheet database containing all of the parameters describing each subbasin and routing reach. The parameters were combined with formulas in the spreadsheet to develop the input data needed for the HEC-1 model. For example, subbasin 'n' values, lengths, and slopes are combined in the spreadsheet to produce T_p, the basin lag time for the Snyder unit hydrograph method. Subbasin infiltration coefficients and percent impervious are obtained in a similar manner.

By its very nature, the HEC-1 model does not give a complete and detailed representation of any of the subbasins or of the watersheds as a whole. Drainage subbasins used in the HEC-1 computer model of the study area cover more than 64 acres as a minimum, with the average size of a subbasin being 300 acres or slightly less than half of a square mile. Using subbasins of this size requires simplifying the representation of the subbasin. All of the methods used to simplify the subbasin representation revolve around that basic assumption that the subbasin is homogeneous, or if it is not, that the subbasin parameters can be averaged to model the subbasin as if it were homogeneous.

Because of the large number of subbasins involved, it is not possible to assure that every subbasin is represented in the highest level of detail. There may be features in any watershed that, upon more detailed investigation, may be found to affect streamflows. However, on the average, it is expected that the streamflows obtained from the model will be accurate for the watershed as a whole.

It was necessary to obtain peak flow results at many locations that were not represented explicitly in the model. Peak flow estimates from locations specified in the model were used to interpolate peak flows at other locations of interest, such as areas where historic flooding has occurred or a location where a stream crosses a road. This interpolation had to take into account not only the peak flow produced by a particular subbasin or group of subbasins, but also the routing of the flow to the location in question and the timing of the peaks of the subbasin runoff and the routed runoff.

Model Assumptions and Criteria

This section of the report details the assumptions and criteria that were used in developing and calibrating the HEC-1 model of the watersheds in the study area. Many of the assumptions were made in order to provide consistency and ease of use of the model as described above.

Unit Hydrograph Parameters. As suggested in the Stormwater Management Manual, the Snyder unit hydrograph method was chosen to represent the rainfall/runoff process occurring in each basin. This method requires two input parameters, standard lag (T_p) in hours and a peaking coefficient (C_p). Standard lag, or lag time, is described as the time that the rise in runoff lags the rainfall causing the rise.

The equation used to compute the T_p was taken from the USBR's "Flood Hydrology Manual" (1989) and is given below.

$$T_p = 26 * n\left(\frac{LL_c}{S^{0.5}}\right)^{0.33}$$

where
- Tp = lag time in hours
- L = length of the longest watercourse in the subbasin, in miles
- Lc = length along the longest watercourse from the point of concentration to a point opposite the centroid of the subbasin, in miles
- S = overall slope of the channel in ft/mile
- n = a physical parameter related to the hydraulic roughness characteristics of the watershed

Loss Rates. Loss rates represent the infiltration of rainfall into the ground. The initial and uniform loss rate option in HEC-1 (LU card) was used to describe the loss rates in the study area. In order to account for the variability of the soil and land use characteristics at the various subbasins, a weighted infiltration coefficient was developed for each subbasin. Table 5-4 in the Placer County Stormwater Management Manual defines soil loss rates for each soil group and vegetative cover. For the purposes of estimating soil loss rates for this study, the vegetative cover in developed areas was assumed to be urban landscaping, and the cover in undeveloped areas was assumed to be annual grasses. The weighting formula for determining subbasin loss rate is given below.

$$\frac{1}{A}\sum_{i=1\rightarrow A}\left[(A_i)_{dev}*(L_i)_{ls}+(A_i)_{und}*(L_i)_{ag}\right]$$

where

- Ai = Area in i-type soil group within the subbasin
- Li = Loss rate in inches/hr for i-type soil group
- dev = developed areas
- und = undeveloped areas
- ls = landscaped cover
- ag = annual grass cover

The constant (uniform) loss rate for each subbasin was not changed for each of the design storm events under study because it represents the loss rate of saturated soil. However, the initial loss rates were changed for each of the design storms as shown below:

Design Storm Return Period	Initial Loss (inches)
2-year	0.40
10-year	0.20
25-year	0.15
100-year	0.10

Initial losses for the 100-year design storm were determined from the model calibration to the February 1986 flood event. Initial losses for the 2-year, 10-year, and 25-year were obtained from work previously completed in the Dry Creek watershed in Placer and Sacramento Counties (Draft Dry Creek Watershed Flood Control Plan, 1991).

Initial Conditions. Initial conditions describe the streamflows at the beginning of the storm that is being modeled. If the storm is an historical one, initial conditions can be determined from stream gage records, if they are available. The HEC-1 model uses the Base Flow variable (BF card) to quantify the streamflow at the beginning of the simulation. This parameter is intended to describe the flows that can be attributed to groundwater recession flows. The definition attributed to the BF variable in HEC-1 was changed for the Auburn/Bowman model to describe the streamflow at the beginning of the simulation, independent of the source. This change in definition and use of the BF variable allows the model to simulate antecedent conditions that can play a major role in the overall streamflow and potential flooding in a watershed. The values of the BF variable, in cfs flow per square mile, for the various design storms were obtained from the

Dry Creek Watershed Flood Control Plan and are presented below. The recession coefficient controls the rate at which the base flow decreases during the simulation, and is defined as the ratio of the base flow occurring at the present time to the base flow that will occur in one hour. The recession coefficient is set to 1.05 for all watersheds.

Design Storm Return Period	BF - Initial Conditions (cfs/sq.mi.)
2-year	2.0
10-year	5.0
25-year	6.0
100-year	23.0

Precipitation. Design storm precipitation for the HEC-1 model of the Auburn/Bowman study area was derived from tables given in the Placer County Stormwater Management Manual. Depth-Duration-Frequency data was used to construct synthetic design storms of 6-hour duration (with five-minute time steps) for cloudburst events. Precipitation was adjusted for average basin elevation for each duration and the average subbasin elevations were classified into three categories for this purpose: 500 - 1000 feet, 1000 - 1500 feet and 1500 - 2000 feet mean sea level. Cloudburst storm centering resulted in additional adjustments to the 1-hour maximum intensity values depending on the location of the storm template isohyets. As an example, Figure 2-2 is a map of the Orr Creek watershed with the 100-year cloudburst template superimposed. Maximum runoff from each individual subbasin was developed using a storm centered over that subbasin, but different storm centers were used to develop the maximum runoff at each combination point in the study area. Table 2-1 indicates the location (subbasin) and inclination of the storm center used to determine 100-year flows at each of the combination points in the study area. Table 2-2 lists the location and names of each of the combination points used in the models.

The use of cloudburst storm data requires that the cloudburst be centered over different locations in the watershed depending on the point at which the peak flow is wanted. From previous studies in Placer and Sacramento Counties, it was determined that the highest flows for any given point in a watershed occur when the cloudburst is centered slightly downstream of the centroid of the area upstream of the point of interest. For this study, storm centering was developed for the 2-, 10-, 25-, and 100-year storms at each of the 100 stream crossings and points of interest. However, it should be noted that in many cases the same storm centering was used for different crossing points when they are in close proximity to each other.

Routing. One of the most critical components in the development of the HEC-1 model is the specification of routing of flows from one subbasin to another. For this study, the Modified Puls, Muskingum-Cunge and Muskingum routing techniques were utilized. The HEC-2 backwater computer program allowed the use of the Modified Puls storage routing in reaches covered by

TABLE 2-1
100-YEAR STORM CENTER LOCATIONS

COMBINATION POINT	LOCATION (subbasin)	INCLINATION (degrees)
OCC1	OC2	60
OCC2	OC15	60
OCC4	OC2	60
OCC5	OC20	60
OCC6	OC10	60
OCC9	OC10	60
OCC11	OC62	60
OCC13	OC25	60
OCC16	OC30	60
OCC19	OC62	60
OCC20	OC62	60
DCC1	DC5	60
DCC3	DC15	60
DCC4	DC10	60
DCC6	DC15	60
DCC9	DC15	60
DCC10	DC35	60
DCC11	DC35	60
DCC13	DC35	60
DCC14	DC55	60
DCC15	DC55	60
DCC16	DC45	60
DCC19	DC60	60
DCC20	DC60	60
RCC1	RC5	60
RCC3	RC10	60
RCC4	RC20	60
RCC7	RC20	60
RCC8	RC25	60
RCC9	RC25	60
RCC10	RC40	60
CCC1	DC65	60
ARC1	AR10	0
ARC3	AR10	10
ARC4	AR10	10
ARC5	AR10	10
ARC6	AR35	10
ARC8	AR50	10
ARC10	AR45	0
ARC12	AR40	10
ARC13	AR45	10
ARC14	AR45	10
ARC15	AR70	10
ARC16	AR70	10

TABLE 2-2
HEC-1 COMBINATION POINTS

COMBINATION POINT		COMBINATION POINT	
NA ME	LOCATION	NAME	LOCATION
ORR CREEK		**ROCK CREEK**	
OCC1	OC2,OC15	RCC1	RC5,RC10
OCC2	OC5	RCC2	RC15
OCC3	OC10	RCC3	RC15,RC20
OCC4	OC10,OC20	RCC4	RC25
OCC5	OC25	RCC5	RC30
OCC6	OC30	RCC6	RC40
OCC7	OC35	RCC7	RC30,RC40
OCC8	OC45	RCC8	RC45
OCC9	OC35,OC40	RCC9	RC50
OCC10	OC50	RCC10	RC55
OCC11	OC55	**CLIPPER CREEK**	
OCC12	OC60	CLC1	CL10
OCC13	OC50,OC60	CLC2	AM5
OCC14	OC65	**DEADMAN CANYON**	
OCC15	OC75	DMC1	DM10
OCC16	OC65,OC75	**AUBURN RAVINE**	
OCC17	OC80	ARC1	AR10
OCC18	OC90	ARC2	AR15
OCC19	OC80,OC90	ARC3	AR15,AR20
OCC20	OC95	ARC4	AR25
CCC1	OC95,DC105	ARC5	AR30
DRY CREEK		ARC6	AR40
DCC1	DC10	ARC7	AR45
DCC2	DC20	ARC8	AR50,AR55
DCC3	DC15,DC20	ARC9	AR60
DCC4	DC25	ARC10	AR45,AR60,AR62
DCC5	DC30	ARC11	AR65
DCC5A	DC40	ARC12	AR65,AR70
DCC6	DC30,DC35,DC40	ARC13	AR75
DCC7	DC45	ARC14	AR80
DCC8	DC55	ARC15	AR30,AR80
DCC9	DC45,DC55	ARC16	AR85
DCC10	DC60	**MORMON RAVINE**	
DCC11	DC65	MRC1	MR10
DCC12	DC70	MRC2	
DCC13	DC70,DC75	MRC3	MR20
DCC14	DC80	MRC4	MR25
DCC15	DC85	MRC5	
DCC16	DC85,RC55		
DCC17	DC90		
DCC18	DC100		
DCC19	DC90,DC100		
DCC20	DC105		

these models. The Modified Puls routing is a more accurate routing technique in that it takes into account the in-channel and overbank storage available in a reach. In addition, routing through the various reservoirs in the study area was also modeled with the Modified Puls method by developing storage-outflow rating curves for each reservoir. These curves were developed based on spillway design and depth-volume-area relationships for each reservoir.

The Muskingum-Cunge routing technique was utilized in areas in stream reaches not modeled by the HEC-2 models. This included the upper reaches of Orr Creek, Dry Creek, Rock Creek, and North Ravine as well as all of the tributaries to these streams. In addition Muskingum-Cunge routing was used for all stream reaches in the Bear River, American River, Mormon Ravine, Dutch Ravine and Deadman Canyon watersheds. For this routing method, the HEC-1 model requires the following input data: channel length, channel slope, roughness (Manning's 'n') and cross-section. Channel length and slopes were obtained from USGS 1:24,000 scale topographic maps and channel cross-sections were obtained from field surveys that were performed as part of this study. In stream reaches where surveys were not done, cross-sections from other streams with similar drainage areas and slopes were utilized. A Manning's 'n' value of 0.15 was used for the main stream channels and a value of 0.07 was used for the overbanks. The higher value in the main channel was used to take into account the blackberries and other vegetation that occurs in most of the stream channels.

As mentioned in Section 1, the City of Auburn did not participate in this study. However, flows from this area contribute to a section of Auburn Ravine which is located in the study area. CH2M-Hill had previously developed a HEC-1 model of western Placer County which included these sections of Auburn Ravine. Hence, the portion of the CH2M Hill model that covers the city limits was incorporated into the model which includes the Muskingum routing technique. In addition, since Auburn Ravine was not surveyed as part of this study, the Muskingum routing used in the CH2M Hill model for Auburn Ravine located in the study area was also incorporated into the model.

Subbasin Descriptions

The study area was subdivided into 105 subbasins to provide the necessary detail for the purpose of this study. This subdivision is made on the basis of hydrologic characteristics of the watershed with the goal of providing HEC-1 model output at stream junctions, major bridges and crossings, problem areas, and downstream boundaries. Subbasin hydrologic divisions were based on topography from the USGS 1:24,000 scale topographic maps. The subbasin areas range from 0.10 square miles (64 acres) to over two square miles (1300 acres). Figure 2-2 shows all the study subbasins in the study area. Table 2-5 presents most of the pertinent data and parameters for each subbasin in the watershed for the Base Conditions. The method of obtaining the data and parameters is described in the following sections.

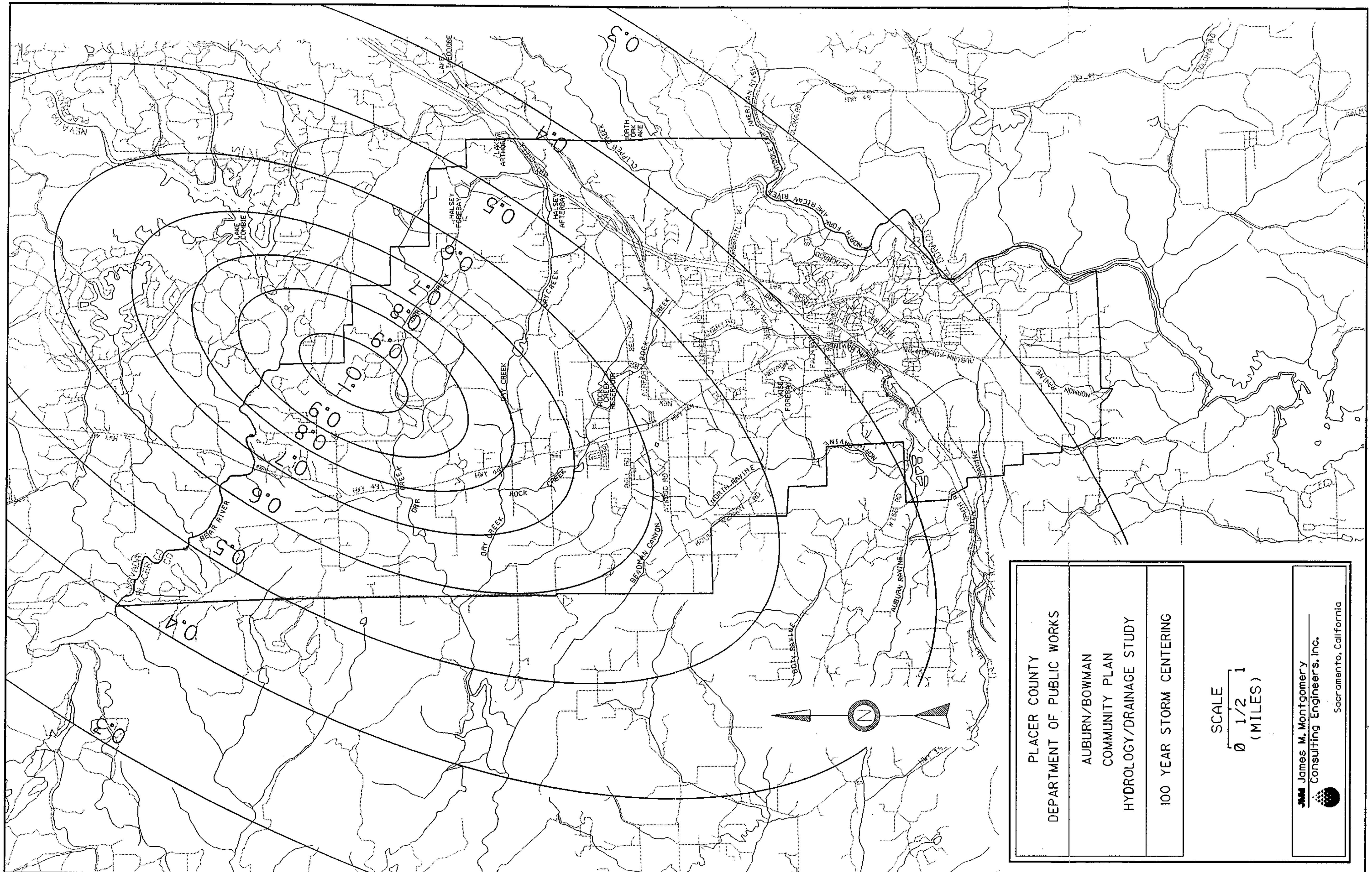

PLACER COUNTY
DEPARTMENT OF PUBLIC WORKS
AUBURN/BOWMAN
COMMUNITY PLAN
HYDROLOGY/DRAINAGE STUDY
100 YEAR STORM CENTERING
SCALE
0 1/2 1
(MILES)
James M. Montgomery
Consulting Engineers, Inc.
Sacramento, California

FIGURE 2-2

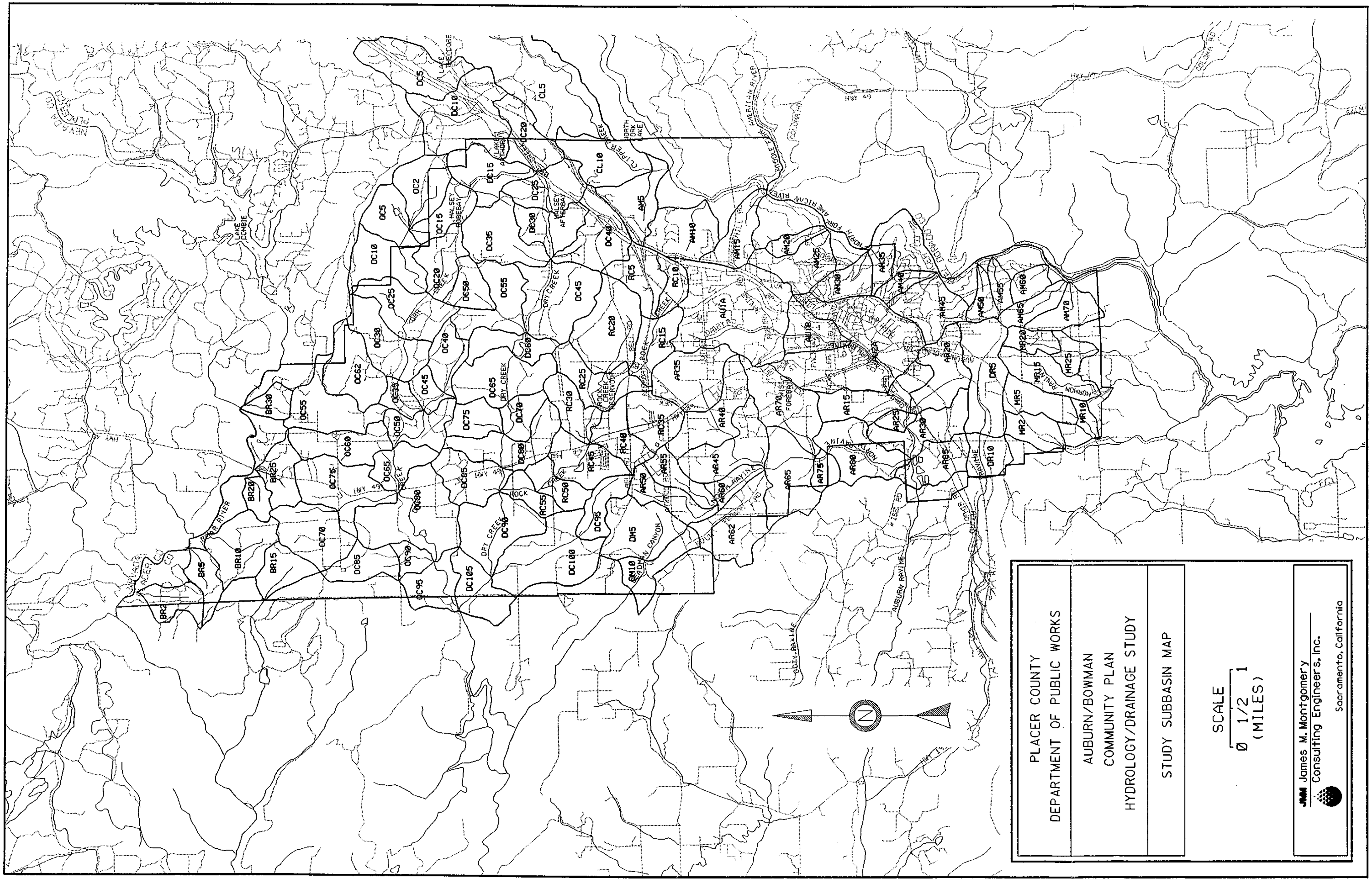

PLACER COUNTY
DEPARTMENT OF PUBLIC WORKS
AUBURN/BOWMAN
COMMUNITY PLAN
HYDROLOGY/DRAINAGE STUDY
STUDY SUBBASIN MAP
SCALE
0 1/2 1
(MILES)
JMM James M. Montgomery
Consulting Engineers, Inc.
Sacramento, California

FIGURE 2-3

Unit Hydrograph Parameters. Each subbasin in the watershed was described hydrologically using the parameters listed in the following paragraphs.

Basin Area. The subbasin areas for input into the model were taken from digitized USGS 1:24,000 scale topographic maps using Intergraph computer software.

Lengths. The lengths along the longest watercourse and along the main channel within each subbasin were measured using a map wheel on the same maps used for basin area determination. The centroid of each subbasin was estimated based on subbasin shape.

Slopes. The slope of the subbasin and of the main channel in the subbasin are dependent on the lengths of both the longest watercourse and of the main channel, as described above, and the elevation of the upstream and downstream ends of the longest watercourse and the main channel. The elevations at the upstream and downstream end of the main channel and the longest watercourse in each subbasin were read off the USGS topographic maps.

Loss Rates. Soil maps from the Soil Conservation Service (SCS) were used to determine the hydrologic soil types in the watershed. A list of most of the soils in the United States with the hydrologic soil group classification for each soil is provided in the SCS manual TR-55. This list was used to color code the SCS soil maps covering the Dry Creek watershed by hydrologic soil type. Subbasin outlines were placed over the soil maps and the approximate percentage of each soil group in each subbasin was determined and entered into the spreadsheet. Loss rates for each soil group, based on the soil infiltration rate and the assumed ground cover for each land use in the subbasin, is calculated as described previously. A weighted loss rate for each of the subbasins is calculated in the spreadsheet and put into the model. The loss rates used for the urban landscaping assumed for the developed areas are 0.48, 0.25, 0.16, and 0.12 inches per hour for soil types A, B, C, and D respectively. The corresponding loss rates used for annual grasses in undeveloped areas are 0.31, 0.16, 0.09, and 0.07.

Effective Impervious Area. The effective impervious area for a subbasin is defined as the percent of the area that is impervious and which does not drain across a neighboring pervious area. The effective impervious area for each subbasin is based on averages for a given land use description, and was determined by estimating the percent of the subbasin contained in each type of land use discussed in Section 1. Current land use was estimated from land use maps provided by Placer County Planning Department with overlays of the subbasin boundaries. Future land use was determined from the general plan maps. In order to go from land use to effective impervious area, an imperviousness factor had to be assumed for each land use as shown in Table 2-3.

Basin 'n'. Basin 'n' values for the subbasins range from a low of around 0.018, in subbasins with a high percentage of commercial development and well developed channels, to a high of around 0.130 in subbasins with very low density development and/or open space combined with dense vegetation in the channels and floodplains. The 'n' values for the study subbasins were determined using Table 2-3. In this table, the subbasin 'n' value is chosen by selecting the row in the table that has land use matching the subbasin weighted land use. This weighted land use was determined in the spreadsheet by weighting the effective impervious area for each of the land use types in the basin and then using that effective impervious area to determine which line of Table 2-3 to use. The subbasin 'n' is then selected from one of four columns of 'n' values based on the condition of the channels and floodplains in the subbasin. Determination of the channel/floodplain type was based on examination of normal aerial photography and actual visits to the watershed.

TABLE 2-3
SUBBASIN 'N', C_p, AND EFFECTIVE IMPERVIOUS

Basin 'n' by Type Channel/Floodplain Description				Snyder		Effective Impervious	
1 Pipe/ Conc.	2 Grass/ Earth	3 Open Woods	4 Dense Veg.	C_p	Basin Land Use	Low	High
0.015	0.023	0.032	0.040	0.85	Commercial/Highways/Parking Lots	0.80	0.99
0.016	0.024	0.033	0.042	0.80	Apartments/Offices/Mobile Homes	0.70	0.90
0.018	0.026	0.035	0.044	0.75	Condominiums/Schools/Industrial	0.50	0.70
0.020	0.028	0.037	0.046	0.70	Residential 8-10 Houses per Acre	0.45	0.60
0.022	0.030	0.039	0.048	0.65	Residential 6-8 Houses per Acre	0.35	0.50
0.024	0.032	0.041	0.050	0.60	Residential 4-6 Houses per Acre	0.30	0.40
0.026	0.034	0.044	0.055	0.60	Residential 3-4 Houses per Acre	0.20	0.30
0.028	0.037	0.048	0.060	0.60	Residential 2-3 Houses per Acre	0.15	0.25
0.030	0.040	0.052	0.065	0.60	Residential 1-2 Houses per Acre	0.10	0.20
0.032	0.045	0.058	0.075	0.60	Residential 1-2 Acres per House	0.07	0.15
0.035	0.050	0.070	0.090	0.60	Residential 2-5 Acres per House	0.05	0.10
0.040	0.060	0.090	0.120	0.60	Rural Residential/Rural Estates	0.02	0.05
0.050	0.080	0.110	0.150	0.60	Open Space (undeveloped)	0.01	0.02

Notes:

1. Low effective impervious is appropriate for 2-year and less recurrence interval events. High effective impervious is appropriate for 10-year and greater recurrence interval events.
2. If suitable land use description cannot be found in table, basin 'n' is a weighted average, by length of a typical flow path, using Manning's 'n' for expected depths for overland flow, gutters, storm drains, channels, and floodplains.
3. System constraints due to undersized inlets and storm drains cause temporary flooding in streets and will increase basin lag time and should be taken into account when determining basin 'n'.

Canals. As discussed in Section 1, the majority of the canals within the study area are not encased and hence, the canals have the capabilities of intercepting sheet runoff from areas directly upstream of the canals. In addition during storm events, the canals also have the potential to spill excess water into streams at various spill locations located along the canals. Therefore, it may be possible for a canal to intercept storm runoff in one watershed and transport the water to another watershed where it may be spilled to a stream.

All canals with capacities greater than 10 cfs were incorporated in the HEC-1 model by utilizing the diversion options in the model. In effect, the canals were simulated by diverting water from subbasins where canals cross through and then adding the diversion to the subbasins where the spills are located.

The following assumptions were made in the development of canals into the HEC-1 model:

- The canals were assumed to be at design capacity at the start of the storm event.
- The maximum canal capacity is 25% above the design capacity.
- Canals can only intercept the difference between maximum capacity and design capacity
- Canals spill at spill locations with maximum spill no greater than the difference between maximum capacity and design capacity
- Amount of flow intercepted by a canal in any given subbasin is proportional to the area of the subbasin upstream of the canal.

Data on canal locations and capacities as well as spill locations and capacities were obtained from PG&E, PCWA and NID. Table 2-4 lists the canals that were incorporated into the model along with the associated canal capacities and subbasins where diversions and spills take place. In addition, spill locations are also presented in the map of canal systems in the study area (Figures 1-5a to 1-5c).

Calibration of Model

Calibration of a model is the process used to insure that the model predicts actual system behavior as closely as possible. In model calibration, known input data for a historical event is entered into the model and the output from the model is compared with the known flood conditions. Parameters in the model are then adjusted until the model output matches historic data for the event.

The HEC-1 model of the Auburn/Bowman Community Plan area was calibrated to observed flows and high water marks for flood events occurring in February 1986. Peak flows in the February 18-19, 1986 event had recurrence intervals for most of the study area of approximately 100 years.

The precipitation used for calibration of the HEC-1 model was based on actual rain gage data collected during the calibration event (February 1986 storm). The precipitation station used for calibration of the HEC-1 model is located in Auburn, however, in order to take into account elevation effects, subbasins in higher elevations than Auburn were given a 10-20% higher total rainfall.

TABLE 2-4
CANALS INCORPORATED INTO HEC-1 MODEL

CANAL	CANAL NORMAL CAPACITY* (CFS)	CANAL MAXIMUM CAPACITY** (CFS)	MAXIMUM SUBBASIN DIVERSION*** (CFS)	SUBBASIN	NO. OF SPILL LOCATIONS	DIVERSIONS: % SUBBASIN DIVERTED TO CANAL	DIVERSIONS: DIVERSION NAME	ADDITIONS: DIVERSIONS ADDED TO SUBBASIN	ADDITIONS: ADDED DIVERSION NAME
LONE STAR	20	25	5	BR30	0	15	LNE1	---	
	20	25	5	BR25	2	5	LNE2		
	20	25	5	OC75	0	10	LNE3	---	
	20	25	5	OC70	2	0	LNE4	OC75	LNE1
									LNE2
									LNE3
	20	25	5	OC75	0	5	LNE5	---	
	20	25	5	OC80	2	<5	---	OC75	LNE5
	20	25	5	OC90	0	10	LNE6	---	
	20	25	5	OC85	0	5	LNE7	---	
GOLD HILL	20	25	5	OC55	0	0	---	---	
	20	25	5	OC60	0	0	---	---	
	20	25	5	OC65	0	0	---	---	
	20	25	5	OC80	0	5	GLD1	---	
	20	25	5	OC95	0	<5	---	---	
	20	25	5	DC105	1	5	GLD2	OC95	GLD1
	20	25	5	DC90	0	40	GLD3	---	
	20	25	5	DC100	4	10	GLD4	DC105	GLD2
							---	DC90	GLD3
	20	25	5	DC105	0	10	GLD5	---	
COMBIE - OPHIR	40	50	10	BR30	1	0	---	---	
	40	50	10	OC55	0	35	CMB1	---	
	40	50	10	OC62	2	0	---	OC55	CMB1
	40	50	10	OC35	0	0	---	---	
	40	50	10	OC45	0	15	CMB2	---	
	40	50	10	OC40	1	0	---	OC45	CMB2
	40	50	10	DC65	1	0	---	---	
	40	50	10	DC70	0	7	CMB3	---	
	40	50	10	DC80	0	7	CMB4	---	
	40	50	10	RC45	0	0	---	---	
	40	50	10	DC95	0	<5	---	---	
	40	50	10	AR50	0	<5	---	---	
	40	50	10	DM5	1	<5	---	DC70	CMB3
								DC80	CMB4
	40	50	10	AR50a	1	<5	---	---	
	40	50	10	AR62	1	<5	---	---	
	40	50	10	AR65	1	<5	---	---	
WISE CANAL	510	638	128	DC30	0	40	WIS1	---	
	510	638	128	DC40	0	10	WIS2	---	
	510	638	128	DC45	0	40	WIS3	---	
	510	638	128	RC25	0	---	---	---	
	510	638	128	RC20	0	---	---	---	
	510	638	128	RC25	0	---	---	DC30	WIS1
								DC40	WIS2
								DC45	WIS3
	510	638		RC35			WIS4		
	510	638		AR35			WIS5		
	510	638		AR40			WIS6		
	510	638		AR70			WIS7		

* From data provided by operating agencies
** Assumed to be 25% greater than normal capacity
*** 25% of normal capacity

TABLE 2-4 (continued)

CANAL	CANAL NORMAL CAPACITY* (CFS)	CANAL MAXIMUM CAPACITY** (CFS)	MAXIMUM SUBBASIN DIVERSION*** (CFS)	SUBBASIN	NO. OF SPILL LOCATIONS	DIVERSIONS: % SUBBASIN DIVERTED TO CANAL	DIVERSIONS: DIVERSION NAME	ADDITIONS: DIVERSIONS ADDED TO SUBBASIN	ADDITIONS: ADDED DIVERSION NAME
FIDDLER GREEN	40	50	10	RC25	0	5	FG1	---	
	40	50	10	RC40	0	<5	---	---	
	40	50	10	RC35	0	10	FG2	---	
	40	50	10	AR35	2	15	FG3	RC25	FG1
								RC35	FG2
	40	50	10	AR40	0	10	FG4	---	
	40	50	10	AR70	1	5	FG5	AR35	FG3
								AR40	FG4
	40	50	10	AR15	0	<5	---	---	
	40	50	10	AR80	0	<5	---	---	
	40	50	10	AR15	0	5	FG6	---	
	40	50	10	AR25	0	0	---	---	
	40	50	10	AR30	0	35	FG7	---	
	40	50	10	AR85	0	<5	---	---	
	40	50	10	DR10	0	<5	---	---	
BOWMAN	6	8	2	DC10	1	7	BOW1	---	
	6	8	2	DC15	1	8	BOW2	DC10	BOW1
	15	19	4	OC15	0	8	BOW3	---	
	15	19	4	DC35	0	8	BOW4	---	
	15	19	4	DC25	1	0	---	DC15	BOW2
								OC15	BOW3
								DC35	BOW4
SHIRLAND	10	13	3	AM45	1	0	---	---	
	10	13	3	AM50	0	50	SHR1	---	
	10	13	3	AM55	0	25	SHR2	---	
	10	13	3	AM60	1	<5	---	AM50	SHR1
								AM55	SHR2
	10	13	3	AM65	2	0	---	---	
	10	13	3	AM70	0	<5	---	---	
	10	13	3	MR20	0	50	SHR3	---	
	10	13	3	MR15	0	10	SHR4	---	
	10	13	3	MR5	2	0	---	MR20	SHR3
								MR15	SHR4
BOARDMAN	30	38	8	DC10	0	5	BRD1	---	
	30	38	8	DC20	0	35	BRD2	---	
	30	38	8	DC25	0	7	BRD3	---	
	30	38	8	DC40	0	<5	---	---	
	30	38	8	AM5	1	10	BRD4	DC10	BRD1
								DC20	BRD2
								DC25	BRD3
	30	38	8	AM10	1	0	---	AM5	BRD4
	30	38	8	AR5	1	10	BRD5	---	
	30	38	8	AR10	2	<5	---	AR5	BRD5
	30	38	8	AM30	0	0	---	---	
	30	38	8	AM35	0	0	---	---	
	30	38	8	AM40	0	0	---	---	
	30	38	8	AM45	0	7	BRD6	---	
	30	38	8	AR20	0	10	BRD7	---	
	30	38	8	DR5	3	5	BRD8	AM45	BRD6
								AR20	BRD7
	30	38	8	DR10	0	10	BRD9	---	

* From data provided by operating agencies
** Assumed to be 25% greater than normal capacity
*** 25% of normal capacity

Unfortunately, no stream gages are located within the study area and hence, very limited information was available on flows resulting from the February 1986 storm. However, through interviews with County officials, flooding problem areas were identified. These areas are discussed in greater detail in Section 3.

In addition, PG&E did record the high water mark at the spill of Rock Creek Reservoir as a result of the storm. From this information PG&E estimated the peak spill to Rock Creek to be approximately 1100 cfs (with an additional release of 350 cfs from Rock Creek Reservoir to Wise Canal). PG&E also estimated the peak flow from Halsey Afterbay to Dry Creek to approximately 1400 cfs. A comparison of these estimated flows to model simulated flows is presented in Table 2-5.

Base Condition (1990) Model

The Base Condition Model was developed utilizing the land use survey by Placer County Planning Department (1990) and is taken to represent the present condition of the study area. Channel and floodplain descriptions for determining subbasin 'n' type were based on the aerial photography and personal visits to each of the locations where streams cross roadways in the watershed. Table 2-6 contains the hydrologic data for the Base Condition Model.

Future Condition (General Plan) Model

A Future Conditions HEC-1 model was developed by modifying the base model for the General Plan Future condition. This mainly involved incorporating the changes in land use from the base condition to the Future condition. Land use values were changed in the spreadsheet to match the land use from the Alternative 2 General Plan. Where the change in land use was extensive enough to warrant a change in the channel and floodplain description used to determine basin 'n', that parameter was also modified in the spreadsheet. The changes in land use and channel/floodplain description affected the unit hydrograph parameters of subbasin 'n', lag time (T_p), and peaking coefficient (C_p); the effective impervious area of the subbasin; and the constant loss rates because of the change in cover type that occurs with development. Table 2-7 contains the Future Condition hydrologic data for each of the subbasins.

TABLE 2-5
HEC-1 MODEL CALIBRATION RESULTS

	PG&E estimated	HEC-1 Model
Rock Creek Lake Spill	1121 cfs	958 cfs
Halsey Afterbay Spill (Dry Creek)	1400 cfs	1455 cfs

TABLE 2-6
1990 BASE CONDITION SUBBASIN HYDROLOGIC DATA

BASIN ID	BASIN DESCRIPTION	Basin Area (Sq Mi)	Chan DElev (ft)	Basin UElev (ft)	Basin Length (ft)	Basin Centrd (ft)	Basin Slope (ft/mi)	Basin Type	Basin 'n'	Basin Ct	Basin Lag (hr)	Basin Cp	Imp Area (%)	1990 LAND USE CONDITIONS Comm 0.90	HDR 0.60	MDR 0.30	LDR 0.20 (%)	RLDR 0.15	RR 0.10	RE 0.10	Ag 0.10	Open 0.02	Loss Rates (in/hr)	SCS Soil Classification A:.48 A:.31	B:.25 B:.16	C:.16 C:.09	D:.12 D:.07
BR2	Bear River	0.30	940	1355	3390	2368	646	4	0.15	3.90	0.89	0.60	2.0								50	50	0.084		15		85
BR5	Bear River	0.26	1080	1380	3025	2349	524	4	0.15	3.90	0.88	0.60	2.0								40	60	0.075		5		95
BR10	Bear River	0.57	1100	1460	4446	2794	428	4	0.15	3.90	1.10	0.60	2.0								10	90	0.07		0.5		99.5
BR15	Bear River	0.31	1200	1360	1913	2348	442	4	0.15	3.90	0.78	0.60	2.0								10	90	0.07				100
BR20	Bear River	0.15	1250	1480	3000	1801	405	4	0.15	3.90	0.84	0.60	2.0								65	35	0.072		2		98
BR25	Bear River	0.33	1250	1415	3400	1662	256	3	0.15	3.90	0.92	0.60	2.0								75	25	0.072		2	0.5	97.5
BR30	Bear River	0.19	1310	1430	3000	2100	211	4	0.15	3.90	0.99	0.60	2.0								100		0.118		43	44	13
CL1	Clipper Creek	2.17	1760	1980	8100	3960	143	4	0.15	3.90	1.80	0.60	2.0									100	0.118		43	44	13
CL2	Clipper Creek	1.46	1560	1760	4270	4270	247	4	0.15	3.90	1.37	0.60	2.0									100	0.118		43	44	13
CL5	Clipper Creek	1.48	1230	1560	13400	8300	130	4	0.15	3.90	2.76	0.60	2.0									100	0.118		43	44	13
CL10	Clipper Creek	0.55	700	1230	4387	3256	638	4	0.15	3.90	1.08	0.60	2.8							10	90		0.09		20	8	72
AM5	American River	0.45	575	1570	3530	2618	1488	4	0.15	3.90	0.81	0.60	3.2						5	10		85	0.116		48	15	37
AM10	American River	0.54	600	1480	4166	2958	1115	4	0.14	3.64	0.87	0.60	8.6	5			10		5		50	30	0.094		13	18	69
AM15	American River	0.37	580	1560	4800	3400	1078	3.5	0.11	2.86	0.76	0.60	17.4	15			10		5		30	40	0.088		5		95
AM20	American River	0.14	530	1320	3800	2386	1098	4	0.15	3.90	0.85	0.60	2.9				5				30	65	0.109		40		60
AM25	American River	0.46	530	1500	6000	2850	854	3.5	0.08	2.08	0.58	0.60	13.7			5	40	5	30			20	0.114		20		80
AM30	American River	0.30	600	1380	4400	2576	936	3.5	0.09	2.34	0.56	0.60	14.9	5		15	15			20		45	0.114		25		75
AM35	American River	0.15	540	1355	2100	1325	2049	4	0.12	3.12	0.41	0.60	10.4			30					30	40	0.144		57	3	40
AM40	American River	0.15	500	1280	4000	2502	1030	4	0.08	2.08	0.47	0.60	24.4			80					20		0.123		10	1	89
AM45	American River	0.49	500	1320	3800	2049	1139	3.5	0.11	2.86	0.59	0.60	6.2			15					85		0.089		12		88
AM50	American River	0.17	560	1220	3600	2550	968	3.5	0.13	3.38	0.75	0.60	2.0									100	0.121	1	54		45
AM55	American River	0.14	500	1360	3400	2000	1336	3.5	0.13	3.38	0.65	0.60	2.0									100	0.113	1	45		54
AM60	American River	0.17	500	1120	2800	1610	1169	4	0.15	3.90	0.67	0.60	2.0									100	0.083		14		86
AM65	American River	0.24	490	1240	4095	2966	967	3.5	0.13	3.38	0.83	0.60	2.0								40	60	0.084		16		84
AM70	American River	0.32	480	1200	4400	1927	864	4	0.14	3.64	0.81	0.60	2.7					5			90	5	0.077		8		92
OC2	Bear River Canal	0.46	1695	1800	3730	3260	149	3.5	0.13	3.38	1.13	0.60	2.8							10		90	0.132		63	25	12
OC5	Irrig. Reservoir	0.37	1660	1880	4400	2600	264	3	0.11	2.86	0.85	0.60	2.8							10		90	0.097		10	90	
OC10	Sugar Pine Mtn.	0.53	1560	1660	4163	3603	127	4	0.15	3.90	1.43	0.60	2.8							10		90	0.09			100	
OC15	Halsey Forebay	0.32	1695	1765	4400	3800	84	3.5	0.13	3.38	1.37	0.60	2.8							10		90	0.115		35	65	
OC20	Christian Valley R.	0.39	1545	1680	4904	2582	145	3.5	0.11	2.86	0.97	0.60	7.6						10	60		30	0.095		7	93	
OC25	Christian Valley R	0.59	1475	1640	4200	1870	207	4	0.11	2.86	0.78	0.60	5.6						40	5		55	0.104		20	80	
OC30	Stanley Drive	0.59	1400	1475	2907	2007	136	3.5	0.11	2.86	0.76	0.60	6.4						40	15	25	20	0.096		15	60	25
OC35	Shirley Lane	0.17	1340	1400	3388	1489	94	3.5	0.11	2.86	0.77	0.60	5.2						40		25	35	0.097		30		70
OC40	Sunshine Mdw. Dr.	0.31	1495	1640	3583	2250	214	3.5	0.11	2.86	0.78	0.60	9.6							95		5	0.073			14	86
OC45	Kimo Way	0.17	1340	1495	1954	1054	419	3	0.09	2.34	0.37	0.60	9.6						10	85		5	0.07				100

TABLE 2-6 (continued)

BASIN ID	BASIN DESCRIPTION	Basin Area (Sq Mi)	Chan DElev (ft)	Basin UElev (ft)	Basin Length (ft)	Basin Centrd (ft)	Basin Slope (ft/mi)	Basin Type	Basin 'n'	Basin Ct	Basin Lag (hr)	Basin Cp	Imp Area (%)	1990 LAND USE CONDITIONS (%) Comm 0.90	HDR 0.60	MDR 0.30	LDR 0.20	RLDR 0.15	RR 0.10	RE 0.10	Ag 0.10	Open 0.02	Loss Rates (in/hr)	SCS Soil Classification A:.48 A:.31	B:.25 B:.16	C:.16 C:.09	D:.12 D:.07
OC50	Stanley Drive	0.38	1300	1340	4252	2663	50	4	0.10	2.60	1.01	0.60	9.6						80	15		5	0.106		40		60
OC55	Gold Hill Canal	0.60	1340	1435	5280	3256	95	3.5	0.13	3.38	1.36	0.60	2.4							5	95		0.094		12	68	20
OC60	Lake Valley Drive	0.49	1300	1400	5200	3600	102	3.5	0.12	3.12	1.28	0.60	3.6							20	80		0.081		5	30	65
OC62	McElroy Drive	0.44	1320	2121	4200	2800	1007	3.5	0.12	3.12	0.75	0.60	8.4							80		20	0.081		5	30	65
OC65	Hwy 49 Bridge	0.32	1285	1300	2348	1978	34	3.5	0.13	3.38	1.05	0.60	2.0								95	5	0.084		15		85
OC70	Lone Star School	0.61	1320	1410	3038	1953	156	3	0.11	2.86	0.75	0.60	2.0								75	25	0.081		12		88
OC75	Hwy 49	0.70	1285	1360	6400	4200	62	3	0.11	2.86	1.43	0.60	2.0								97	3	0.084		7	40	53
OC80	Hwy 49	1.01	1160	1285	6617	4059	100	3.5	0.13	3.38	1.56	0.60	2.2							2	90	8	0.075		5		95
OC85	Lone Star Canal	0.33	1285	1460	4800	2300	193	3.5	0.13	3.38	1.05	0.60	2.0								100		0.071		1		99
OC90	Lone Star Spill	0.15	1160	1285	2300	1295	287	3.5	0.13	3.38	0.64	0.60	2.0								100		0.07				100
OC95	Lone Star Cmty	0.38	1050	1120	4211	2074	88	4	0.15	3.90	1.27	0.60	2.0								95	5	0.07				100
DC5	Hwy 80	0.68	1740	1970	6000	3512	202	4	0.13	3.38	1.28	0.60	4.6							33	33	34	0.087		0.5	84.5	15
DC10	Hwy 80	0.98	1600	1860	7335	3966	187	3.5	0.12	3.12	1.33	0.60	4.6							33	33	34	0.087			86	14
DC15	Christian Valley R.	0.48	1540	1820	4833	3469	306	4	0.14	3.64	1.20	0.60	4.4							30		70	0.096		12	75	13
DC20	Hwy 80	0.44	1540	1600	2776	2148	114	4	0.14	3.64	1.00	0.60	4.6							33	33	34	0.094		10	75	15
DC25	Dry Creek Road	0.47	1500	1600	3242	1587	163	3.5	0.13	3.38	0.84	0.60	8.2	7							30	63	0.133		60	20	20
DC30	Dry Creek Road	0.41	1420	1580	4200	2000	201	3.5	0.12	3.12	0.88	0.60	6.4	3						22		75	0.142		70	30	
DC35	Bowman Canal	0.62	1415	1700	5600	3950	269	4	0.15	3.90	1.44	0.60	3.2						8	7		85	0.135		67	25	8
DC40	Bell Road	0.57	1420	1600	5000	3800	190	4	0.14	3.64	1.35	0.60	9.4	5		2				30	25	38	0.121		45	25	30
DC45	Dry Creek Road	0.83	1335	1420	5620	3335	80	3.5	0.12	3.12	1.33	0.60	5.2							40		60	0.095		25	10	65
DC50	Gregg Way	0.27	1400	1645	3400	2138	380	3	0.10	2.60	0.63	0.60	8.4						40	40	15	5	0.139		70	30	
DC55	Black Oak Road	0.55	1335	1760	5200	2400	432	3.5	0.12	3.12	0.88	0.60	5.6							45	45	10	0.12		55		45
DC60	Dry Creek Road	0.32	1305	1490	4300	1300	227	3	0.09	2.34	0.56	0.60	8.0							75		25	0.074		4	2	94
DC65	Dry Creek Road	0.68	1260	1305	3301	1700	72	3.5	0.12	3.12	0.91	0.60	4.8							35		65	0.078		7	8	85
DC70	Dry Creek Road	0.24	1225	1470	3800	1653	340	3.5	0.11	2.86	0.67	0.60	6.8						40	20		40	0.071		1		99
DC75	Moss Rock Drive	0.28	1235	1360	3600	2188	183	3.5	0.11	2.86	0.80	0.60	10.0						5	95			0.07		0.5		99.5
DC80	Hwy 49	0.56	1200	1430	5200	950	234	3.5	0.08	2.08	0.48	0.60	14.7	5			15		30	40		10	0.08		0.5		99.5
DC85	Hwy 49	0.47	1180	1340	3600	2400	235	3.5	0.10	2.60	0.72	0.60	6.0						5	45	50		0.07				100
DC90	Joeger Road	0.69	1080	1180	6180	3472	85	3.5	0.10	2.60	1.14	0.60	5.6						5	40	50	5	0.07				100
DC95	Meadowbrook Dr.	0.29	1270	1410	5212	2777	142	3.5	0.13	3.38	1.20	0.60	2.0								100		0.07				100
DC100	Bell Road	0.94	1080	1270	5587	3365	180	3.5	0.11	2.86	1.07	0.60	7.6							70	25	5	0.07				100
DC105	Bell Road	0.44	1040	1080	3102	1618	68	3.5	0.13	3.38	0.96	0.60	2.0								100		0.084	6			94
RC5	S.P.R.R.	0.40	1500	1620	5400	2880	117	3.5	0.09	2.34	0.88	0.60	11.5	5				30		15		50	0.096		20	25	55
RC10	S.P.R.R.	0.21	1500	1600	4000	2800	132	3.5	0.11	2.86	0.95	0.60	11.9	3			7			75		15	0.115	1	39	5	55
RC15	S.P.R.R.	0.37	1450	1500	4629	2761	57	3.5	0.12	3.12	1.24	0.60	8.8	3			15	10		2		70	0.083		4	2	94
RC20	Bell Road	0.77	1450	1620	7000	2949	128	3	0.10	2.60	1.06	0.60	4.4	2						8	10	80	0.08		8	7	85

TABLE 2-6 (continued)

BASIN ID	BASIN DESCRIPTION	Basin Area (Sq Mi)	Chan DElev (ft)	Basin UElev (ft)	Basin Length (ft)	Basin Centrd (ft)	Basin Slope (ft/mi)	Basin Type	Basin 'n'	Basin Ct	Basin Lag (hr)	Basin Cp	Imp Area (%)	1990 LAND USE CONDITIONS Comm 0.90	HDR 0.60	MDR 0.30	LDR 0.20 (%)	RLDR 0.15	RR 0.10	RE 0.10	Ag 0.10	Open 0.02	Loss Rates (in/hr)	SCS Soil Classification A:.48 A:.31	B:.25 B:.16	C:.16 C:.09	D:.12 D:.07
RC25	Rock Creek Lake	0.47	1420	1485	3085	1360	111	2	0.07	1.82	0.45	0.60	25.2		40						5	55	0.091			5	95
RC30	Rock Creek Road	0.35	1330	1470	4550	2757	162	2	0.05	1.30	0.43	0.60	36.7	15	35				15			35	0.107		6	18	76
RC35	Hwy 49	0.41	1355	1390	3200	1800	58	2	0.04	1.04	0.32	0.66	52.3	45	12	5		18				20	0.101				100
RC40	Hwy 49	0.35	1330	1355	2823	2055	47	2	0.06	1.56	0.49	0.60	29.2	30						10		60	0.085				100
RC45	Hwy 49	0.47	1265	1330	3601	1599	95	3	0.08	2.08	0.58	0.60	17.0	8		25		7				60	0.087				100
RC50	Dry Creek Road	0.28	1215	1345	2800	1260	245	3.5	0.10	2.60	0.53	0.60	7.8					20		40		40	0.07				100
RC55	Joeger Road	0.21	1180	1215	2437	1854	76	3.5	0.08	2.08	0.56	0.60	6.9					10	20	25	40	5	0.07				100
DM5	Deadman Canyon	0.63	1245	1360	3702	2403	164	3.5	0.11	2.86	0.85	0.60	8.1				5		5	60	25	5	0.073				100
DM10	Deadman Canyon	0.36	1060	1245	2300	1874	425	4	0.14	3.64	0.72	0.60	3.6							20	70	10	0.093		25		75
AR1A	Auburn (CH2M)	1.57			8000	3400	174		0.04		0.34	0.75	24.0										0.15				
AR1B	Auburn (CH2M)	0.29			5000	2600	153		0.02		0.22	0.80	38.0										0.15				
AR2A	Auburn (CH2M)	1.66			6200	2200	121		0.03		0.28	0.75	29.0										0.15				
AR15	Stonehouse Road	0.54	940	1180	5800	2800	218	4	0.13	3.38	1.16	0.60	13.8	10			10		5	10		65	0.1		20		80
AR20	Highway 80	0.52	940	1295	5200	3295	360	4	0.13	3.38	1.09	0.60	12.0	5		20						75	0.119		35	5	60
AR25	Ophir Road	0.10	930	940	1161	503	45	3.5	0.11	2.86	0.43	0.60	10.0							100			0.084		15		85
AR30	Highway 80	0.49	835	1190	5600	2000	335	3.5	0.12	3.12	0.88	0.60	9.6	5						40		55	0.089		18		82
AR35	Highway 80	0.64	1350	1500	3800	2400	208	2	0.04	1.04	0.30	0.60	36.3	25	10		25	15			5	20	0.1				100
AR40	S.P.R.R.	0.56	1240	1380	3700	1300	200	3	0.07	1.82	0.43	0.60	25.0	12	12	12	12				45	7	0.094				100
AR45	Bean Road	0.60	1100	1340	5400	2300	235	3.5	0.11	2.86	0.89	0.60	6.8						30	30	30	10	0.07				100
AR50	Atwood Road	0.35	1215	1415	6866	4378	154	3	0.08	2.08	0.93	0.60	22.2	20		3				22	40	15	0.082				100
AR55	Atwood Road	0.27	1215	1420	5400	3562	200	3.5	0.09	2.34	0.86	0.60	31.0	30		5				15	20	30	0.088				100
AR60	Hidden Oaks Rd.	0.18	1100	1215	3984	2294	152	3.5	0.11	2.86	0.86	0.60	9.2							90	10		0.07				100
AR62	Mt . Vernon Rd.	0.64	1100	1240	5900	4000	125	3.5	0.11	2.86	1.22	0.60	9.2							90		10	0.07				100
AR65	Vada Ranch Rd.	0.63	1030	1100	3595	1657	103	3.5	0.12	3.12	0.87	0.60	7.2							65	35		0.078		7	8	85
AR70	Mt. Vernon Rd.	0.65	1040	1300	6300	3698	218	3.5	0.09	2.34	0.91	0.60	14.6	7					25	55	10	3	0.085		12		88
AR75	Bar Ranch Road	0.14	1020	1190	2800	1800	321	4	0.12	3.12	0.68	0.60	10.0							100			0.07		0.5		99.5
AR80	Millertown Road	0.59	835	1020	6571	4086	149	4	0.12	3.12	1.35	0.60	10.0							100			0.072		2		98
AR85	Highway 80	0.40	800	1080	4400	2800	336	3.5	0.12	3.12	0.91	0.60	6.0							50	50		0.071		1		99
DR5	Dutch Ravine	0.74	1100	1280	5137	3995	185	3.5	0.13	3.38	1.29	0.60	2.4							5	10	85	0.111		45		55
DR10	Dutch Ravine	0.27	980	1100	3085	1544	205	3.5	0.12	3.12	0.72	0.60	6.4						10	45	45		0.106		40		60
MR2	Mormon Ravine	0.10	895	1240	4400	2050	414	3.5	0.13	3.38	0.86	0.60	2.4							5	30	65	0.072		2		98
MR5	Mormon Ravine	0.35	920	1240	5398	3055	313	3.5	0.13	3.43	1.12	0.60	2.6							8		92	0.074			20	80
MR10	Mormon Ravine	0.10	835	920	2144	1439	209	3.5	0.11	2.86	0.57	0.60	10.0							100			0.077		3	20	77
MR15	Mormon Ravine	0.44	1005	1220	6548	4695	173	3.5	0.12	3.12	1.38	0.60	4.6							33	33	34	0.07			2	98
MR20	Mormon Ravine	0.19	1125	1240	2536	2083	239	3	0.10	2.60	0.61	0.60	5.3					25			65	10	0.081		12		88
MR25	Mormon Ravine	0.19	1040	1125	2660	1923	169	3	0.11	2.86	0.70	0.60	2.7					5			95		0.077			35	65

TABLE 2-7
FUTURE CONDITION SUBBASIN HYDROLOGIC DATA

BASIN ID	BASIN DESCRIPTION	Basin Area (Sq Mi)	Chan DElev (ft)	Basin UElev (ft)	Basin Length (ft)	Basin Centrd (ft)	Basin Slope (ft/mi)	Basin Type	Basin 'n'	Basin Ct	Basin Lag (hr)	Basin Cp	Imp Area (%)	Community Plan Land Use Conditions (%) Comm 0.90	HDR 0.60	MDR 0.30	LDR 0.20	RLDR 0.15	RR 0.10	RE 0.10	Ag 0.10	Open 0.02	Loss Rates (In/hr)	SCS Soil Classification A:.48 A:.31	B:.25 B:.16	C:.16 C:.09	D:.12 D:.07
BR2	Bear River	0.30	940	1355	3390	2368	646.37	4	0.15	3.9	0.89	0.60	2.0								100		0.084		15		85
BR5	Bear River	0.26	1080	1380	3025	2349	523.64	4	0.15	3.9	0.88	0.60	2.0								100		0.075		5		95
BR10	Bear River	0.57	1100	1460	4446	2794	427.53	4	0.15	3.9	1.10	0.60	2.0								100		0.07		0.5		99.5
BR15	Bear River	0.31	1200	1360	1913	2348	441.61	4	0.15	3.9	0.78	0.60	2.0								100		0.07				100
BR20	Bear River	0.15	1250	1480	3000	1801	404.8	4	0.15	3.9	0.84	0.60	2.0								100		0.072		2		98
BR25	Bear River	0.33	1250	1415	3400	1662	256.24	3	0.15	3.9	0.92	0.60	2.0								100		0.072		2	0.5	97.5
BR30	Bear River	0.19	1310	1430	3000	2100	211.2	4	0.15	3.9	0.99	0.60	2.0								100		0.118		43	44	13
CL1	Clipper Creek	2.17	1760	1980	8100	3960	143.41	4	0.15	3.9	1.80	0.60	2.0									100	0.118		43	44	13
CL2	Clipper Creek	1.46	1560	1760	4270	4270	247.31	4	0.15	3.9	1.37	0.60	2.0									100	0.118		43	44	13
CL5	Clipper Creek	1.48	1230	1560	13400	8300	130.03	4	0.15	3.9	2.76	0.60	2.0									100	0.118		43	44	13
CL10	Clipper Creek	0.55	700	1230	4387	3256	637.88	4	0.15	3.9	1.08	0.60	2.8							10	90		0.09		20	8	72
AM5	American River	0.45	575	1570	3530	2618	1488.3	4	0.15	3.9	0.81	0.60	12.8	10						25	10	55	0.123		48	15	37
AM10	American River	0.54	600	1480	4166	2958	1115.3	4	0.14	3.64	0.87	0.60	5.0				10		5	10	55	20	0.091		13	18	69
AM15	American River	0.37	580	1560	4800	3400	1078	3.5	0.11	2.86	0.76	0.60	23.6	15		10	20		25			30	0.098		5		95
AM20	American River	0.14	530	1320	3800	2386	1097.7	3.5	0.11	2.86	0.62	0.60	7.0				10		40			50	0.113		40		60
AM25	American River	0.46	530	1500	6000	2850	853.6	3.5	0.08	2.08	0.58	0.60	13.7			5	40	5	30			20	0.114		20		80
AM30	American River	0.30	600	1380	4400	2576	936	3.5	0.09	2.34	0.56	0.60	14.9	5		15	15			20		45	0.114		25		75
AM35	American River	0.15	540	1355	2100	1325	2049.1	4	0.12	3.12	0.41	0.60	10.4			30					30	40	0.144		57	3	40
AM40	American River	0.15	500	1280	4000	2502	1029.6	4	0.08	2.08	0.47	0.60	24.4			80					20		0.123		10	1	89
AM45	American River	0.49	500	1320	3800	2049	1139.4	3.5	0.11	2.86	0.59	0.60	6.2			15					85		0.089		12		88
AM50	American River	0.17	560	1220	3600	2550	968	3.5	0.13	3.38	0.75	0.60	2.0									100	0.121	1	54		45
AM55	American River	0.14	500	1360	3400	2000	1335.5	3.5	0.13	3.38	0.65	0.60	2.0									100	0.113	1	45		54
AM60	American River	0.17	500	1120	2800	1610	1169.1	4	0.15	3.9	0.67	0.60	2.0									100	0.083		14		86
AM65	American River	0.24	490	1240	4095	2966	967.03	3.5	0.13	3.38	0.83	0.60	2.0								40	60	0.084		16		84
AM70	American River	0.32	480	1200	4400	1927	864	4	0.14	3.64	0.81	0.60	2.7					5			90	5	0.077		8		92
OC2	Bear River Canal	0.46	1695	1800	3730	3260	148.63	3.5	0.13	3.38	1.13	0.60	2.8							10		90	0.132		63	25	12
OC5	Irrig. Reservoir	0.37	1660	1880	4400	2600	264	3	0.11	2.86	0.85	0.60	2.8							10		90	0.097		10	90	
OC10	Sugar Pine Mtn.	0.53	1560	1660	4163	3603	126.83	4	0.15	3.9	1.43	0.60	2.8							10		90	0.09			100	
OC15	Halsey Forebay	0.32	1695	1765	4400	3800	84	3.5	0.11	2.86	1.16	0.60	8.4							80		20	0.115		35	65	
OC20	Christian Valley R.	0.39	1545	1680	4904	2582	145.35	3.5	0.1	2.6	0.88	0.60	9.6						10	85		5	0.095		7	93	
OC25	Christian Valley R	0.59	1475	1640	4200	1870	207.43	3.5	0.09	2.34	0.64	0.60	8.8						40	45	10	5	0.104		20	80	
OC30	Stanley Drive	0.59	1400	1475	2907	2007	136.22	3.5	0.11	2.86	0.76	0.60	7.2						45	20	30	5	0.096		15	60	25
OC35	Shirley Lane	0.17	1340	1400	3388	1489	93.506	3.5	0.11	2.86	0.77	0.60	6.0						45	5	20	30	0.097		30		70
OC40	Sunshine Mdw. Dr.	0.31	1495	1640	3583	2250	213.68	3.5	0.11	2.86	0.78	0.60	9.6							95		5	0.073			14	86
OC45	Kimo Way	0.17	1340	1495	1954	1054	418.83	3	0.09	2.34	0.37	0.60	9.2						15	75		10	0.07				100

TABLE 2-7 (continued)

BASIN ID	BASIN DESCRIPTION	Basin Area (Sq Mi)	Chan DElev (ft)	Basin UElev (ft)	Basin Length (ft)	Basin Centrd (ft)	Basin Slope (ft/mi)	Basin Type	Basin 'n'	Basin Ct	Basin Lag (hr)	Basin Cp	Imp Area (%)	Community Plan Land Use Conditions (%): Comm 0.90	HDR 0.60	MDR 0.30	LDR 0.20	RLDR 0.15	RR 0.10	RE 0.10	Ag 0.10	Open 0.02	Loss Rates (in/hr)	SCS Soil Classification: A:.48 A:.31	B:.25 B:.16	C:.16 C:.09	D:.12 D:.07
OC50	Stanley Drive	0.38	1300	1340	4252	2663	49.671	4	0.1	2.6	1.01	0.60	9.2						80	10	5	5	0.106		40		60
OC55	Gold Hill Canal	0.60	1340	1435	5280	3256	95	3.5	0.13	3.38	1.36	0.60	2.4							5	95		0.094		12	68	20
OC60	Lake Valley Drive	0.49	1300	1400	5200	3600	101.54	3.5	0.12	3.12	1.28	0.60	4.4							30	70		0.081		5	30	65
OC62	McElroy Drive	0.44	1320	2121	4200	2800	1007	3.5	0.12	3.12	0.75	0.60	8.4							80		20	0.081		5	30	65
OC65	Hwy 49 Bridge	0.32	1285	1300	2348	1978	33.731	3.5	0.13	3.38	1.05	0.60	2.0								95	5	0.084		15		85
OC70	Lone Star School	0.61	1320	1410	3038	1953	156.42	3	0.11	2.86	0.75	0.60	2.0								95	5	0.081		12		88
OC75	Hwy 49	0.70	1285	1360	6400	4200	61.875	3	0.11	2.86	1.43	0.60	2.0								95	5	0.084		7	40	53
OC80	Hwy 49	1.01	1160	1285	6617	4059	99.743	3.5	0.13	3.38	1.56	0.60	2.0								95	5	0.075		5		95
OC85	Lone Star Canal	0.33	1285	1460	4800	2300	192.5	3.5	0.13	3.38	1.05	0.60	2.0								100		0.071		1		99
OC90	Lone Star Spill	0.15	1160	1285	2300	1295	286.96	3.5	0.13	3.38	0.64	0.60	2.0								100		0.07				100
OC95	Lone Star Cmty	0.38	1050	1120	4211	2074	87.77	4	0.15	3.9	1.27	0.60	2.0								95	5	0.07				100
DC5	Hwy 80	0.68	1740	1970	6000	3512	202.4	4	0.13	3.38	1.28	0.60	4.6							33	33	34	0.087		0.5	84.5	15
DC10	Hwy 80	0.98	1600	1860	7335	3966	187.16	3.5	0.12	3.12	1.33	0.60	4.6							33	33	34	0.087			86	14
DC15	Christian Valley R.	0.48	1540	1820	4833	3469	305.9	4	0.14	3.64	1.20	0.60	4.4							30		70	0.096		12	75	13
DC20	Hwy 80	0.44	1540	1600	2776	2148	114.12	4	0.14	3.64	1.00	0.60	4.6							33	33	34	0.094		10	75	15
DC25	Dry Creek Road	0.47	1500	1600	3242	1587	162.86	3.5	0.12	3.12	0.77	0.60	5.2							40		60	0.128		60	20	20
DC30	Dry Creek Road	0.41	1420	1580	4200	2000	201.14	3.5	0.11	2.86	0.80	0.60	6.8							60		40	0.139		70	30	
DC35	Bowman Canal	0.62	1415	1700	5600	3950	268.71	3.5	0.1	2.6	0.96	0.60	9.6						8	87		5	0.135		67	25	8
DC40	Bell Road	0.57	1420	1600	5000	3800	190.08	3.5	0.11	2.86	1.06	0.60	12.4	5						75		20	0.119		45	25	30
DC45	Dry Creek Road	0.83	1335	1420	5620	3335	79.858	3.5	0.12	3.12	1.33	0.60	6.4							55		45	0.095		25	10	65
DC50	Gregg Way	0.27	1400	1645	3400	2138	380.47	3	0.1	2.6	0.63	0.60	10.0						50	50			0.139		70	30	
DC55	Black Oak Road	0.55	1335	1760	5200	2400	431.54	3.5	0.11	2.86	0.81	0.60	9.2							90		10	0.12		55		45
DC60	Dry Creek Road	0.32	1305	1490	4300	1300	227.16	3	0.09	2.34	0.56	0.60	9.2							90		10	0.074		4	2	94
DC65	Dry Creek Road	0.68	1260	1305	3301	1700	71.978	3.5	0.11	2.86	0.83	0.60	9.6							95		5	0.078		7	8	85
DC70	Dry Creek Road	0.24	1225	1470	3800	1653	340.42	3	0.07	1.82	0.43	0.60	18.6	10			10		40	35		5	0.081		1		99
DC75	Moss Rock Drive	0.28	1235	1360	3600	2188	183.33	3.5	0.11	2.86	0.80	0.60	10.0						5	95			0.07		0.5		99.5
DC80	Hwy 49	0.56	1200	1430	5200	950	233.54	3	0.07	1.82	0.42	0.60	23.1	15			15		30	35		5	0.086		0.5		99.5
DC85	Hwy 49	0.47	1180	1340	3600	2400	234.67	3.5	0.1	2.6	0.72	0.60	5.6							45	55		0.07				100
DC90	Joeger Road	0.69	1080	1180	6180	3472	85.437	3.5	0.1	2.6	1.14	0.60	5.6						5	40	50	5	0.07				100
DC95	Meadowbrook Dr.	0.29	1270	1410	5212	2777	141.83	3	0.06	1.56	0.55	0.60	16.1			20		50	25			5	0.08				100
DC100	Bell Road	0.94	1080	1270	5587	3365	179.56	3.5	0.11	2.86	1.07	0.60	9.6							95		5	0.07				100
DC105	Bell Road	0.44	1040	1080	3102	1618	68.085	3.5	0.13	3.38	0.96	0.60	2.0								100		0.084	6			94
RC5	S.P.R.R.	0.40	1500	1620	5400	2880	117.33	3	0.07	1.82	0.68	0.60	24.6	15			30			50		5	0.121		20	25	55
RC10	S.P.R.R.	0.21	1500	1600	4000	2800	132	3.5	0.11	2.86	0.95	0.60	19.7	10	2		15			63		10	0.127	1	39	5	55
RC15	S.P.R.R.	0.37	1450	1500	4629	2761	57.032	3	0.06	1.56	0.62	0.60	34.7	25			55			10		10	0.116		4	2	94
RC20	Bell Road	0.77	1450	1620	7000	2949	128.23	3	0.09	2.34	0.95	0.60	13.6	10						35		55	0.084		8	7	85

TABLE 2-7 (continued)

BASIN ID	BASIN DESCRIPTION	Basin Area (Sq Mi)	Chan DElev (ft)	Basin UElev (ft)	Basin Length (ft)	Basin Centrd (ft)	Basin Slope (ft/mi)	Basin Type	Basin 'n'	Basin Ct	Basin Lag (hr)	Basin Cp	Imp Area (%)	Community Plan Land Use Conditions (%): Comm 0.90	HDR 0.60	MDR 0.30	LDR 0.20	RLDR 0.15	RR 0.10	RE 0.10	Ag 0.10	Open 0.02	Loss Rates (in/hr)	SCS Soil Classification: A:.48 A:.31	B:.25 B:.16	C:.16 C:.09	D:.12 D:.07
RC25	Rock Creek Lake	0.47	1420	1485	3085	1360	111.25	1.5	0.06	1.56	0.38	0.60	32.9	10	35		10					45	0.099			5	95
RC30	Rock Creek Road	0.35	1330	1470	4550	2757	162.46	1	0.03	0.78	0.26	0.71	61.8	35	50							15	0.127		6	18	76
RC35	Hwy 49	0.41	1355	1390	3200	1800	57.75	1.5	0.02	0.52	0.16	0.77	73.5	65	20		15						0.12				100
RC40	Hwy 49	0.35	1330	1355	2823	2055	46.759	1	0.02	0.52	0.16	0.81	81.1	85	5	5						5	0.118				100
RC45	Hwy 49	0.47	1265	1330	3601	1599	95.307	2	0.04	1.04	0.29	0.60	40.2	20	15	40		5				20	0.108				100
RC50	Dry Creek Road	0.28	1215	1345	2800	1260	245.14	3	0.07	1.82	0.37	0.60	18.9	5	5		5	45	35			5	0.078				100
RC55	Joeger Road	0.21	1180	1215	2437	1854	75.831	3	0.07	1.82	0.49	0.60	10.1					10	85			5	0.07				100
DM5	Deadman's Gulch	0.63	1245	1360	3702	2403	164.02	3	0.08	2.08	0.62	0.60	10.4				5	5	45	40		5	0.073				100
DM10	Deadman's Gulch	0.36	1060	1245	2300	1874	424.7	3.5	0.11	2.86	0.57	0.60	9.6							95		5	0.093		25		75
AU1A	Auburn (CH2M)	1.57			8000	3400	174.2		0.035		0.30	0.75	37.0										0.15				
AU1B	Auburn (CH2M)	0.29			5000	2600	153.1		0.024		0.20	0.80	80.0										0.15				
AU2A	Auburn (CH2M)	1.66			6200	2200	121.4		0.028		0.20	0.75	65.0										0.15				
AR15	Stonehouse Road	0.54	940	1180	5800	2800	218.48	4	0.13	3.38	1.16	0.60	13.8	10			10		5	10		65	0.1		20		80
AR20	Highway 80	0.52	940	1295	5200	3295	360.46	4	0.13	3.38	1.09	0.60	12.0	5		20						75	0.119		35	5	60
AR25	Ophir Road	0.10	930	940	1161	503	45.478	3.5	0.11	2.86	0.43	0.60	10.0							100			0.084		15		85
AR30	Highway 80	0.49	835	1190	5600	2000	334.71	3.5	0.12	3.12	0.88	0.60	10.0							100			0.086		18		82
AR35	Highway 80	0.64	1350	1500	3800	2400	208.42	1.5	0.03	0.78	0.22	0.68	56.5	35	30		35						0.12				100
AR40	S.P.R.R.	0.56	1240	1380	3700	1300	199.78	2	0.04	1.04	0.24	0.60	34.1	12	13	35	10		30				0.105				100
AR45	Bean Road	0.60	1100	1340	5400	2300	234.67	2.5	0.08	2.08	0.65	0.60	11.5			5	5		40	50			0.075				100
AR50	Atwood Road	0.35	1215	1415	6866	4378	153.8	2	0.05	1.3	0.58	0.60	33.2	20	10	15			45			10	0.093				100
AR55	Atwood Road	0.27	1215	1420	5400	3562	200.44	2	0.04	1.04	0.38	0.60	22.1	10	5	25			15	10		5	0.069				100
AR60	Hidden Oaks Rd.	0.18	1100	1215	3984	2294	152.41	3.5	0.11	2.86	0.86	0.60	8.4							80		20	0.07				100
AR62	Mt . Vernon Rd.	0.64	1100	1240	5900	4000	125.29	3.5	0.11	2.86	1.22	0.60	9.2							90		10	0.07				100
AR65	Vada Ranch Rd.	0.63	1030	1100	3595	1657	102.81	3.5	0.11	2.86	0.80	0.60	9.6							95		5	0.078		7	8	85
AR70	Mt. Vernon Rd.	0.65	1040	1300	6300	3698	217.9	3	0.08	2.08	0.81	0.60	18.3	10				5	30	55			0.086		12		88
AR75	Bar Ranch Road	0.14	1020	1190	2800	1800	320.57	4	0.12	3.12	0.68	0.60	10.0							100			0.07		0.5		99.5
AR80	Millertown Road	0.59	835	1020	6571	4086	148.65	4	0.12	3.12	1.35	0.60	10.0							100			0.072		2		98
AR85	Highway 80	0.40	800	1080	4400	2800	336	2.5	0.06	1.56	0.46	0.60	40.5	35	5					60			0.091		1		99
DR5	Dutch Ravine	0.74	1100	1280	5137	3995	185.01	3.5	0.13	3.38	1.29	0.60	8.0						10	70			0.088		45		55
DR10	Dutch Ravine	0.27	980	1100	3085	1544	205.38	3.5	0.11	2.86	0.66	0.60	8.4						10	70		20	0.106		40		60
MR2	Mormon Ravine	0.10	895	1240	4400	2050	414	3.5	0.13	3.38	0.86	0.60	2.4							5	30	65	0.072		2		98
MR5	Mormon Ravine	0.35	920	1240	5398	3055	313	3.5	0.132	3.432	1.12	0.60	2.6							8		92	0.074			20	80
MR10	Mormon Ravine	0.10	835	920	2144	1439	209.33	3.5	0.11	2.86	0.57	0.60	10.0							100			0.077		3	20	77
MR15	Mormon Ravine	0.44	1005	1220	6548	4695	173.37	3.5	0.12	3.12	1.38	0.60	4.6							33	33	34	0.07			2	98
MR20	Mormon Ravine	0.19	1125	1240	2536	2083	239.43	3	0.1	2.6	0.61	0.60	5.3					25			65	10	0.081		12		88
MR25	Mormon Ravine	0.19	1040	1125	2660	1923	168.72	3	0.09	2.34	0.57	0.60	10.3					5		95			0.077			35	65

MODEL RESULTS

The model setups described above were used to make HEC-1 model runs for the major points of interest in the watershed, such as culverts, bridges, problem areas, and tributary confluences. The 2-, 10-, 25-, and 100-year peak flows for Present and Future conditions at each of these locations are listed in Table 2-8. Figures 1-6a to 1-6c indicate the locations for the peak flows listed in Table 2-8.

USE OF MODEL

The HEC-1 model input for the Auburn/Bowman Community has been set up with the goal of providing a tool for use in the future. Because of the storm centering method that was used to determine the precipitation for input into the HEC-1 model, there are a large number of input data files. Each of these input files represents the storm centering for a particular HEC-1 flow combination point. When runoff based on changed hydrologic parameters is wanted at a particular combination point in the watershed, it is necessary to modify the input file for that combination point and then run HEC-1 using the input file. Output from the HEC-1 model is then used as input to the FIXFORM program to change the formatting to be more easily readable.

Several FORTRAN programs were utilized as a part of this study to automate the modification of large numbers of input files, and to extract the wanted peak flows from the HEC-1 output files. The input modification program called MODSUB takes data from the hydrologic spreadsheet and inserts it into specified HEC-1 input files. CROSFLOW takes the output from specified HEC-1 output files and combines and interpolates it into flow output tables like Table 2-8. This combination and interpolation of flows, at points between combination points in the model, takes into account not only the magnitude of flows at each of the locations, but also the timing of the flood peaks being combined.

TABLE 2-8
PEAK FLOWS

CROSSING NUMBER	STREAM	CROSSING	DRAINAGE AREA (SQ. MI.)	2-YEAR		10-YEAR		25-YEAR		100-YEAR	
				PRESENT (CFS)	FUTURE (CFS)	PRESENT (CFS)	FUTURE (CFS)	PRESENT (CFS)	FUTURE (CFS)	PRESENT (CFS)	FUTURE (CFS)
1	ORR CREEK	INFLOW TO COON CR.	9.31	674	689	2180	2213	2931	2978	4176	4238
2		BELL RD.	9.29	673	688	2176	2209	2926	2972	4168	4230
3		TRIB. CONFLUENCE	8.93	643	658	2123	2157	2868	2915	4047	4112
4		TRIB. CONFLUENCE	7.44	571	582	1901	1936	2459	2504	3517	3578
5		HWY 49 (State)	6.13	477	488	1589	1623	2100	2141	2881	2936
6		TRIB. CONFLUENCE	5.81	511	522	1517	1550	2019	2060	2845	2902
7		W. STANLEY DR.	4.26	353	364	1092	1120	1464	1497	2031	2075
8		TRIB. CONFLUENCE	3.9	362	368	1063	1085	1410	1439	1916	1955
9		E. STANLEY DR.	3.36	306	310	917	935	1222	1247	1662	1692
10		COMBIE-OPHIR SIPHON	3.25	307	311	916	933	1194	1218	1631	1660
11		CHRISTIAN VALLEY RD.	2.66	265	271	823	838	1058	1077	1414	1435
12		TRIB. CONFLUENCE	2.07	254	267	646	667	835	862	1111	1144
13		STUDY BOUNDARY	1.15	151	161	368	387	469	492	624	653
14		TRIB. CONFLUENCE	0.78	114	124	248	264	316	335	420	444
15	ORR CK TRIB #1	LITTLE CREEK RD. (Private)	0.12	23	25	46	49	58	61	76	80
16	ORR CK TRIB #2	VIRGINIA WAY	0.48	69	69	194	194	250	250	334	334
17		KENNETH WY. (Private)	0.31	72	72	141	141	175	175	228	228
17	ORR CK TRIB #3	LONE STAR RD.	0.75	146	146	301	301	375	375	495	495
19	DRY CREEK	INFLOW TO COON CR	15.5	860	945	2787	2877	3844	3944	5575	5706
20		BELL RD.	15.32	848	932	2758	2847	3810	3908	5511	5638
21		TRIB. CONFLUENCE	15.06	831	915	2707	2800	3749	3832	5447	5555
22		ROCK CK. CONFLUENCE	13.14	660	729	2405	2464	3305	3355	4589	4675
23		HWY 49 (State)	8.38	431	461	1562	1630	2104	2195	2960	3100
24		TRIB. CONFLUENCE	7.82	399	428	1488	1550	1988	2082	2819	2938
25		BLUE GRASS RD.	7.3	368	391	1418	1476	1934	2012	2655	2759
26		BELOW DAM	6.62	392	411	1324	1366	1761	1814	2408	2483
27		INFLOW TO RES.	6.3	371	385	1291	1327	1704	1750	2323	2380
28		DRY CK. ROAD	5.48	334	343	1133	1151	1468	1485	1993	2017

TABLE 2-8 (continued)

CROSSING NUMBER	STREAM	CROSSING	DRAINAGE AREA (SQ. MI.)	2-YEAR		10-YEAR		25-YEAR		100-YEAR	
				PRESENT (CFS)	FUTURE (CFS)	PRESENT (CFS)	FUTURE (CFS)	PRESENT (CFS)	FUTURE (CFS)	PRESENT (CFS)	FUTURE (CFS)
29		TWIN PINES TR. (Private)	4.69	369	371	1056	1062	1379	1384	1877	1876
30		HAINES RD.	4.03	324	324	894	891	1171	1165	1589	1580
31		HALSEY AFTBAY OUTFLOW	3.05	298	298	750	748	955	951	1279	1275
32		BOWMAN RD.	2.82	288	289	702	702	898	898	1196	1195
33		LAKE ARTHUR RD.	2.58	262	264	649	652	831	834	1101	1104
34		LAKE ARTHUR RD.	1.81	178	178	407	407	525	525	695	696
35		BELOW LAKE ARTHUR	1.66	156	156	360	359	465	465	616	616
36	DRY CK TRIB #1	DRY CREEK RD.	0.1	19	20	38	40	48	51	64	67
37	DRY CK TRIB #2	DRY CREEK RD.	0.62	81	111	177	230	228	292	304	386
38	DRY CK TRIB #3	BLACK OAK RD.	0.35	100	104	203	208	256	261	338	344
39	DRY CK TRIB #4	DRY CREEK RD	0.1	22	30	44	56	55	70	72	92
40	DRY CK TRIB #5	JOEGER RD.	0.25	72	78	139	148	173	185	228	243
41	DRY CK TRIB #6	HOWE RD. (Private)	1.14	238	282	479	557	600	690	789	901
42		HUBBARD RD. (Private)	1.04	223	265	447	523	560	648	737	846
43		JOEGER RD.	0.29	46	77	96	149	120	186	158	244
44	ROCK CREEK	INFLOW TO DRY CREEK	4.29	386	457	1006	1229	1342	1711	1912	2424
45		JOEGER RD.	4.25	383	453	997	1217	1325	1688	1883	2387
46		SHERWOOD WY.	4.08	433	535	1019	1287	1312	1696	1773	2260
47		DRY CREEK RD.	3.8	381	478	922	1149	1195	1566	1596	2088
48		RICHARDSON RD.	3.78	381	478	922	1149	1195	1566	1596	2088
49		HWY 49 (State)	3.33	384	509	834	1045	1062	1380	1390	1861
50		ROCK CREEK RD.	2.24	394	396	466	499	603	641	772	812
51		ROCK CK LAKE OUTFLOW	2.22	400	400	464	497	601	641	769	809
52		ROCK CK LAKE INFLOW	2.22	370	421	898	1000	1104	1231	1435	1591
53		BELL RD.	0.98	134	159	284	322	359	404	472	532
54		NEW AIRPORT RD.	0.91	133	155	277	311	349	390	459	513
55		CRYSTAL SPRINGS RD.	0.85	131	152	271	302	342	379	449	498

TABLE 2-8 (continued)

CROSSING NUMBER	STREAM	CROSSING	DRAINAGE AREA (SQ. MI.)	2-YEAR		10-YEAR		25-YEAR		100-YEAR	
				PRESENT (CFS)	FUTURE (CFS)	PRESENT (CFS)	FUTURE (CFS)	PRESENT (CFS)	FUTURE (CFS)	PRESENT (CFS)	FUTURE (CFS)
56		TRIB. CONFLUENCE	0.61	123	136	247	265	309	332	406	435
57		CREEKVIEW CT.	0.19	36	37	73	74	92	93	122	122
58		RAILROAD	0.15	28	29	57	57	71	72	95	95
59	**ROCK CK TRIB #1**	RAILROAD	0.38	79	94	158	181	197	225	257	295
60	**ROCK CK TRIB #2**	NEW AIRPORT RD.	0.58	107	120	219	236	274	295	358	383
61		BELL RD.	0.31	57	64	117	126	146	157	191	204
62	**ROCK CK TRIB #3**	LOCKSLEY LN.	0.26	82	122	153	221	191	274	251	361
63	**ROCK CK TRIB #4**	ROCK CREEK RD.	0.66	174	246	385	527	499	708	669	976
64		BELL RD.	0.41	166	256	300	461	373	576	489	759
65	**NORTH RAVINE**	WISE RD.	5.25	591	646	1739	1862	2281	2459	3012	3241
66		WARREN WY. (Private)	5.1	578	632	1698	1823	2228	2408	2943	3176
67		CALNICK RD. (Private)	4.83	646	715	1701	1861	2207	2419	2908	3203
68		BELOW MILLERTOWN RD.	4.66	641	713	1674	1849	2176	2404	2863	3186
69		TRIB. CONFLUENCE	4.52	661	739	1654	1828	2126	2365	2792	3110
70		MILLERTOWN RD.	3.87	534	599	1395	1553	1805	2028	2373	2671
71		MT. VERNON RD.	3.24	523	600	1264	1473	1606	1928	2122	2549
72		HARRIS RD. (Private)	0.8	87	104	238	281	299	357	397	476
73		VISTA ROBLE RD. (Private)	0.62	126	177	247	333	306	413	401	541
74		ATWOOD RD.	0.35	32	42	62	80	77	99	100	129
75	**N.RAV. TRIB #1**	KEMPER RD. (Private)	0.23	46	61	89	115	110	142	144	187
76	**N.RAV. TRIB #2**	HIDDEN OAKS LN. (Private)	1.56	326	376	783	927	1017	1256	1372	1705
77		RAILROAD	0.64	203	259	375	478	470	618	648	842
78		HWY 49 (State)	0.35	112	142	206	263	259	340	356	463
79		PEAR RD. (Private)	0.28	87	119	164	219	204	273	268	360
80	**N.RAV. TRIB #3**	MILLERTOWN RD.	0.6	113	122	228	241	284	301	373	395
81		MT. VERNON RD.	0.36	69	75	139	147	173	184	228	241

TABLE 2-8 (continued)

CROSSING NUMBER	STREAM	CROSSING	DRAINAGE AREA (SQ. MI.)	2-YEAR		10-YEAR		25-YEAR		100-YEAR	
				PRESENT (CFS)	FUTURE (CFS)	PRESENT (CFS)	FUTURE (CFS)	PRESENT (CFS)	FUTURE (CFS)	PRESENT (CFS)	FUTURE (CFS)
82	N.RAV. TRIB #4	MILLERTOWN RD.	0.06	13	13	26	26	32	32	42	42
83		BAR RANCH RD. (Private)	0.04	10	10	20	20	24	24	32	32
84	AUBURN RAVINE	AUBURN RAVINE OUTFLOW	10.82	884	1047	3160	3406	4270	4589	6047	6411
85		N. RAVINE CONFLUENCE	10.42	856	1017	3042	3281	4060	4384	5835	6050
86		WISE RD.	4.68	968	1111	2366	2539	2993	3185	4300	4429
87		OPHIR RD.	4.58	948	1079	2326	2511	3033	3208	4217	4349
88		OPHIR RD.	4.23	934	1067	2233	2430	2901	3092	4034	4189
89		FORGOTTEN RD. (Abandoned)	3.54	1019	1192	2236	2440	2811	3038	3916	4088
90	AUBURN R. TRIB	I-80 (State)	0.49	75	75	161	161	202	202	271	271
91		RAILROAD	0.34	51	51	110	110	138	138	185	185
92	DUTCH RAVINE	RAILROAD	0.41	56	61	122	128	154	160	205	211
93		AUBURN-FOLSOM RD.	0.22	31	33	66	70	84	87	112	115
94	MORMON RAVINE	SHIRLAND RD.	0.04	6	6	14	14	17	17	22	22
95	MORMON R. TRIB	NO NAME RD	0.29	66	70	138	145	174	182	228	240
96		ANDREGG RD.	0.19	42	48	85	95	106	118	139	155
97	AMER.R.TRIB #1	HWY 49 (State)	0.32	78	78	155	155	194	194	257	257
98	AMER.R.TRIB #2	HWY 49 (State)	0.04	28	28	56	56	69	69	92	92
99	DEADMAN CANYON	JOEGER RD.	0.63	127	157	256	306	318	380	417	498
100		OAK CREEK CT.	0.19	38	47	77	92	95	114	125	149

SECTION 3
PROBLEM IDENTIFICATION

As discussed in Section 1, the watersheds in the study area are characterized by relatively steep slopes with moderate relief. Hence, flooding of structures (i.e. houses, buildings) in floodplains is much less severe in this area than in low-lying areas of western Placer County. However, most of the problems due to flooding in the Auburn/Bowman Community Plan area are associated with inadequate bridges and culverts which may be subject to damage by overtopping. Overtopping of these structures may also result in roads being damaged or closed, thus impeding traffic and restricting emergency access to an area. In addition, overtopping of bridges and culverts may result in potentially hazardous situations to traffic along roadways as vehicles may become stalled and swept downstream if severe overtopping occurs.

SUMMARY OF 1986 FLOODING PROBLEMS

The flood of February 1986 caused the most severe flooding damage to date in the Auburn/Bowman Community Plan area. As mentioned above, most of the flooding problems were due to inadequate bridges and culverts which resulted in overtopping of these structures. However at several locations in the study area flooding of structures did occur in the floodplains.

In order to identify the locations where flooding or overtopping has occurred, various departments were contacted within Placer County and interviews of staff members were conducted. The following is a list of departments contacted:

- Placer County Public Works Department
- Placer County Planning Department
- Placer County Office of Emergency Services

The following is a summary of the known existing problem areas due to flooding. It should be noted that this list may not be conclusive and does not include areas of local flooding not attributed to stream flow. It is also possible that more bridges and culverts were overtopped than are included in this list but do not pose a hazard or cause damage to the structure, and have not been reported to the County.

<u>Dry Creek Watershed</u>

Bowman Road Bridge at Dry Creek
Dry Creek Road adjacent to Dry Creek
Dry Creek Road and Haines Road at Dry Creek
Bell Road Bridge at Dry Creek
Blue Grass Road at Dry Creek
Twin Pines Trail at Dry Creek
Howe Road at Dry Creek Tributary
Hubbard Road at Dry Creek Tributary

Rock Creek Watershed

Sherwood Way at Rock Creek
Highway 49 Bridge at Rock Creek
Joeger Road at Rock Creek
Richardson Road at Rock Creek
Rock Creek Road at Rock Creek
New Airport Road at Rock Creek
New Airport Road at Rock Creek Tributary

Orr Creek Watershed

Christian Valley Road at Orr Creek
West Stanley Drive at Orr Creek
Lone Star Road at Orr Creek Tributary

North Ravine Watershed

Vada Ranch Road at North Ravine
Calnick Lane at North Ravine
Warren Way at North Ravine
Millertown Road at North Ravine
Mt. Vernon Road at North Ravine
Harris Road at North Ravine
Vista Roble Road at North Ravine
Kemper Road at North Ravine
Millertown Road at North Ravine Tributary
Mt. Vernon Road at North Ravine Tributary
Bar Ranch Road at North Ravine Tributary

Auburn Ravine Watershed

Stonehouse Road and Forgotten Road at Auburn Ravine

SUMMARY OF 100-YEAR STORM PROBLEMS

The following sections summarize the problems that were identified in the watershed based on HEC-1 and HEC-2 model runs using both the Base (present) and the Future Condition land use as described in Section 2.

For the purposes of this study, overtopping of culverts and bridges were determined using two methods.

1. Where HEC-2 model input data were available, the HEC-2 model and its associated bridge and culvert routines were used to determine the flow at which a bridge or culvert overtopped.
2. In stream reaches where the HEC-2 model was not developed, the Federal Highway Administration (FHWA) standard culvert formulas and nomographs were used to

determine the capacity of the bridge or culvert. Due to the relatively steep slopes throughout the study area, the structures were analyzed as inlet control structures.

After the bridge and culvert capacities were determined, they were compared against the 2-Year, 10-Year, 25-Year and 100-year flood flows (present and future conditions) at the same locations, given in Table 2-7. The capacity of the bridge or culvert was next subtracted from the flood flow and any remaining flow was entered in Table 3-1. It is important to note, however, that overtopping alone does not necessarily mean that damage will occur to the road surface or structure itself. It does mean that traffic on the roadway, and in particular emergency traffic, may be severely impeded and a serious safety hazard may exist.

The extent of the upstream floodplain that is affected by backwater from undersized culverts and bridges is hard to determine without detailed survey information indicating the elevation of the floodplain and dwellings and other buildings that may be in the floodplain. This detailed type of information was not collected as a part of this study and hence, was not possible to review in detail.

Existing Problems, Based on 1990 Land Use

Flooding problems that would occur in the watershed with the present base land use conditions and the 100-year design storm are classified as existing problems.

Bridges and Culverts - Overtopping and Backwater. Table 3-1 contains a listing of all bridges and culverts, with an indication next to those that have insufficient capacity to pass the design storms without going over the top of the roadway. The numbers in the table indicate the magnitude, in cfs, of the peak flow over the roadway at that location. A blank in the table indicates that the culvert or bridge has sufficient capacity to pass the flood.

The table indicates that over 70 percent of the bridges and culverts in the watershed are inadequate to pass the 100 year flood without overtopping under present land use conditions. Over 60 percent of the stream crossings are inadequate for even the 25-year flood.

Floodplain. The 100-year floodplains for Orr Creek, Rock Creek, Dry Creek and North Ravine were delineated on USGS 1:24,000 topographic maps based on flows developed from HEC-1 utilizing the 100-year design storm (with present land use conditions). The HEC-2 hydraulics model was then used in conjunction with the HEC-1 model to develop the water surface profiles and the associated floodplain for the 100-year flood. The water surface profiles for Orr Creek, Dry Creek, Rock Creek, and North Ravine are presented in Figures 3-1 to 3-4 respectively. The corresponding floodplains are delineated on Figures 3-5a to 3-5c. As shown on the figures, the floodplain for each of the streams is relatively narrow (average 200 to 300 feet wide) and the 100-year flood would probably impact few structures. However, the actual number of structures in the floodplain has not been identified.

TABLE 3-1
BRIDGE AND CULVERT OVERTOPPING TABLE

CROSSING NUMBER	STREAM	CROSSING	CROSSING CAPACITY (CFS)	2-YEAR PRESENT (CFS)	2-YEAR FUTURE (CFS)	10-YEAR PRESENT (CFS)	10-YEAR FUTURE (CFS)	25-YEAR PRESENT (CFS)	25-YEAR FUTURE (CFS)	100-YEAR PRESENT (CFS)	100-YEAR FUTURE (CFS)
2	**ORR CREEK**	BELL RD.	5291								
5		HWY 49 (State)	3107								
7		W. STANLEY DR.	1800							231	275
9		E. STANLEY DR.	1800								
11		CHRISTIAN VALLEY RD.	210	55	61	613	628	848	867	1204	1225
15	**ORR CK TRIB #1**	LITTLE CREEK RD. (Private)	45			1	4	13	16	31	35
16	**ORR CK TRIB #2**	VIRGINIA WAY	110			84	84	140	140	224	224
17		KENNETH WY. (Private)	210							18	18
18	**ORR CK TRIB #3**	LONE STAR RD.	35	111	111	266	266	340	340	460	460
20	**DRY CREEK**	BELL RD.	2917					893	991	2594	2721
23		HWY 49 (State)	8125								
25		BLUE GRASS RD.	1800					134	212	855	959
28		DRY CK. ROAD	2312								
29		TWIN PINES TR. (Private)	200	169	171	856	862	1179	1184	1677	1676
30		HAINES RD.	1100					71	65	489	480
32		BOWMAN RD.	600			102	102	298	298	596	595
33		LAKE ARTHUR RD.	1040							61	64
34		LAKE ARTHUR RD.	1100								
36	**DRY CK TRIB #1**	DRY CREEK RD.	15	4	5	23	25	33	36	49	52
37	**DRY CK TRIB #2**	DRY CREEK RD.	220				10	8	72	84	166
38	**DRY CK TRIB #3**	BLACK OAK RD.	110			93	98	146	151	228	234
39	**DRY CK TRIB #4**	DRY CREEK RD	100								

TABLE 3-1 (continue)

CROSSING NUMBER	STREAM	CROSSING	CROSSING CAPACITY (CFS)	2-YEAR		10-YEAR		25-YEAR		100-YEAR	
				PRESENT (CFS)	FUTURE (CFS)	PRESENT (CFS)	FUTURE (CFS)	PRESENT (CFS)	FUTURE (CFS)	PRESENT (CFS)	FUTURE (CFS)
40	DRY CK TRIB #5	JOEGER RD.	2625								
41	DRY CK TRIB #6	HOWE RD. (Private)	100	138	182	379	457	500	590	689	801
42		HUBBARD RD. (Private)	700							37	146
43		JOEGER RD.	45	1	32	51	104	75	141	113	199
45	ROCK CREEK	JOEGER RD.	3860								
46		SHERWOOD WY.	977			42	310	335	719	796	1283
47		DRY CREEK RD.	2387								
48		RICHARDSON RD.	696			226	453	499	870	900	1392
49		HWY 49 (State)	1368						12	22	493
50		ROCK CREEK RD.	290	104	106	176	209	313	351	482	522
53		BELL RD.	1346								
54		NEW AIRPORT RD.	405							54	108
55		CRYSTAL SPRINGS RD.	602								
57		CREEKVIEW CT.	450								
60	ROCK CK TRIB #2	NEW AIRPORT RD.	25	82	95	194	211	249	270	333	358
61		BELL RD.	185							6	19
62	ROCK CK TRIB #3	LOCKSLEY LN.	30	52	92	123	191	161	244	221	331
63	ROCK CK TRIB #4	ROCK CREEK RD.	105	69	141	280	422	394	603	564	871
64		BELL RD.									
65	NORTH RAVINE	WISE RD.	3730								
66		WARREN WY. (Private)	2327						81	616	849
67		CALNICK RD. (Private)	1800				61	407	619	1108	1403
70		MILLERTOWN RD.	1172			223	381	633	856	1201	1499
71		MT. VERNON RD.	2169								380
72		HARRIS RD. (Private)	90		14	148	191	209	267	307	386
73		VISTA ROBLE RD. (Private)	228			19	105	78	185	173	313
74		ATWOOD RD.	135								

TABLE 3-1 (continue)

CROSSING NUMBER	STREAM	CROSSING	CROSSING CAPACITY (CFS)	2-YEAR PRESENT (CFS)	2-YEAR FUTURE (CFS)	10-YEAR PRESENT (CFS)	10-YEAR FUTURE (CFS)	25-YEAR PRESENT (CFS)	25-YEAR FUTURE (CFS)	100-YEAR PRESENT (CFS)	100-YEAR FUTURE (CFS)
75	**N.RAV. TRIB #1**	KEMPER RD. (Private)	8	38	53	81	107	102	134	136	179
76	**N.RAV. TRIB #2**	HIDDEN OAKS LN. (Private)									
78		HWY 49 (State)	144			62	119	115	196	212	319
79		PEAR RD. (Private)	2	85	117	162	217	202	271	266	358
80	**N.RAV. TRIB #3**	MILLERTOWN RD.	60	53	62	168	181	224	241	313	335
81		MT. VERNON RD.	100			39	47	73	84	128	141
82	**N.RAV. TRIB #4**	MILLERTOWN RD.	7	6	6	19	19	25	25	35	35
83		BAR RANCH RD. (Private)	5	5	5	15	15	19	19	27	27
85	**AUBURN RAVINE**	N. RAVINE CONFLUENCE									
86		WISE RD.	2400				139	593	785	1900	2029
87		OPHIR RD.	3600							617	749
88		OPHIR RD.	6000								
89		FORGOTTEN RD. (Abandoned)	1000	19	192	1236	1440	1811	2038	2916	3088
93	**DUTCH RAVINE**	AUBURN-FOLSOM RD.	175								
94	**MORMON RAVINE**	SHIRLAND RD.	65								
95	**MORMON R. TRIB**	NO NAME RD	18	48	52	120	127	156	164	210	222
96		ANDREGG RD.	35	7	13	50	60	71	83	104	120
97	**AMER.R.TRIB #1**	HWY 49 (State)	120			35	35	74	74	137	137
98	**AMER.R.TRIB #2**	HWY 49 (State)	25	3	3	31	31	44	44	67	67
99	**DEADMAN CANYON**	JOEGER RD.	270				36	48	110	147	228
100		OAK CREEK CT.	300								

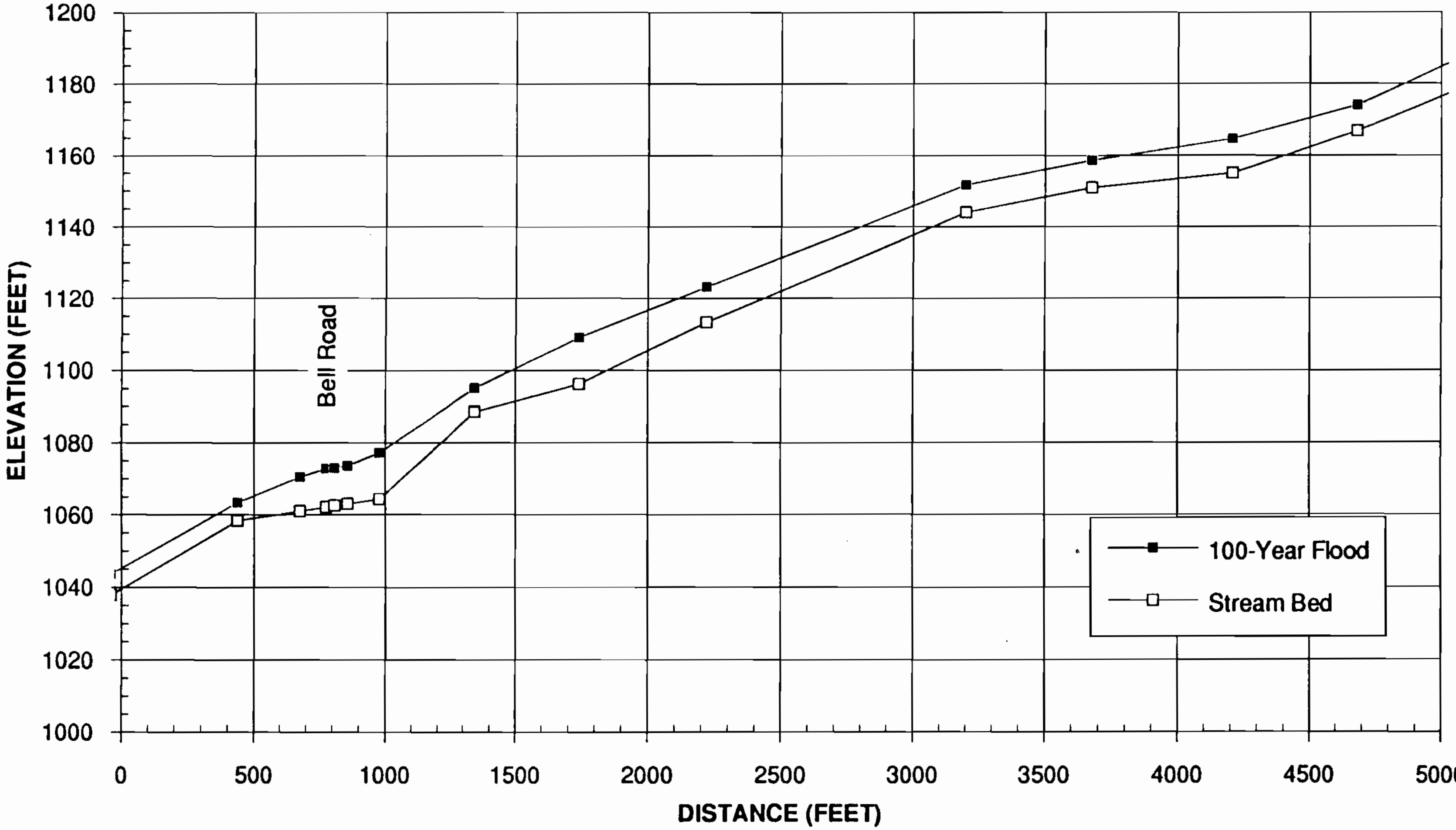


FIGURE 3-1
ORR CREEK 100-YEAR FLOOD PROFILE

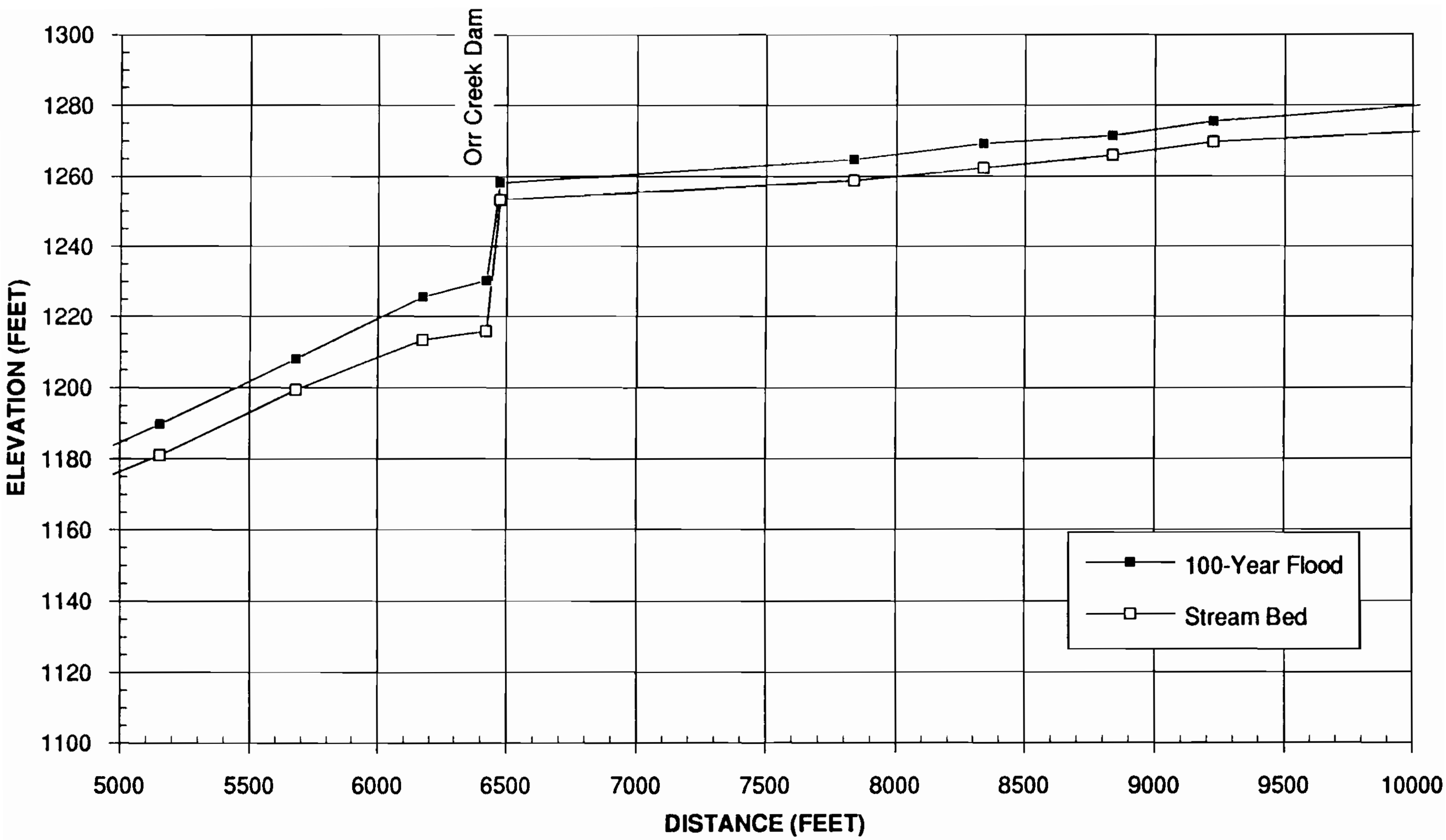


FIGURE 3-1 (continued)

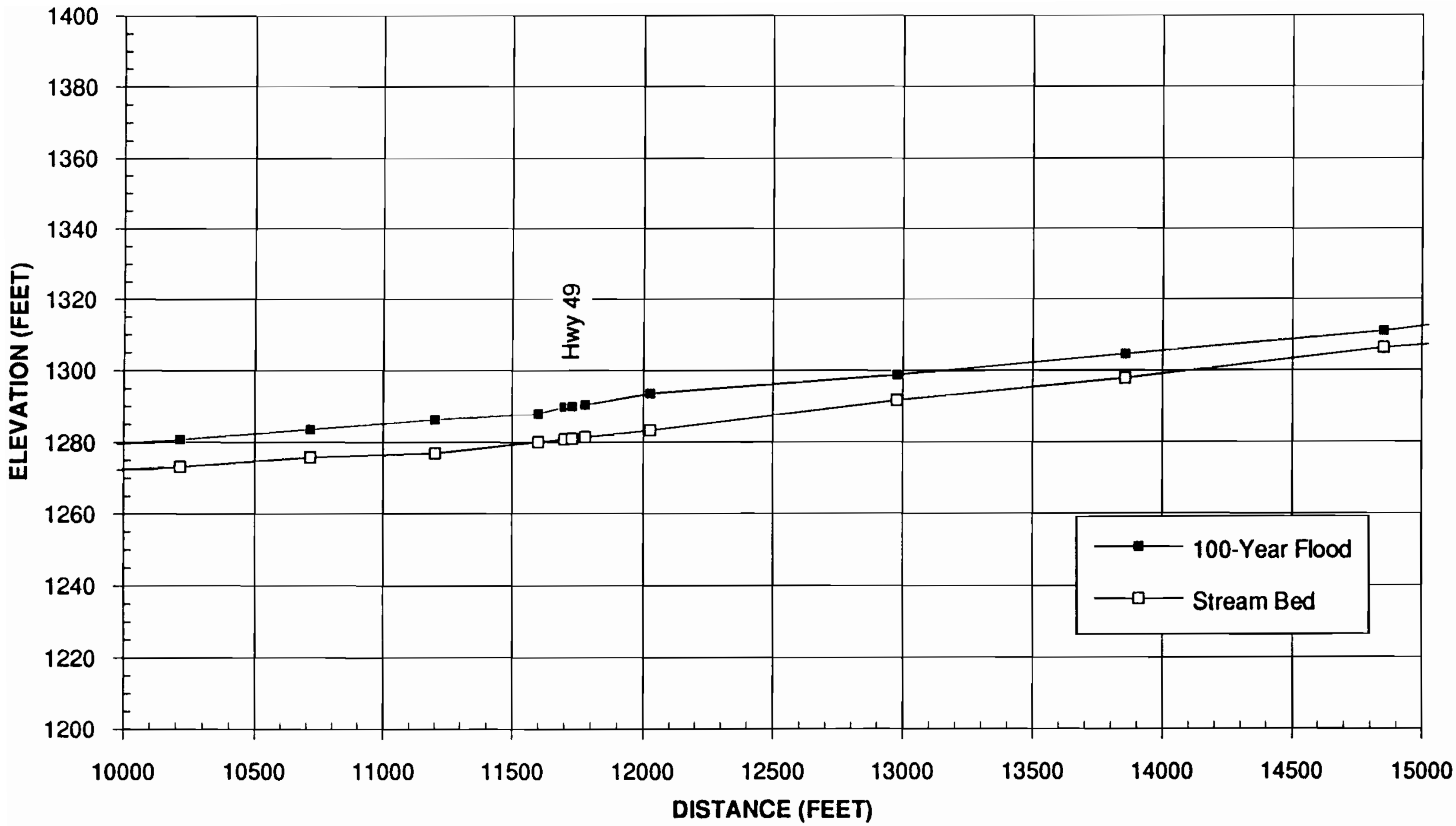


FIGURE 3-1 (continued)

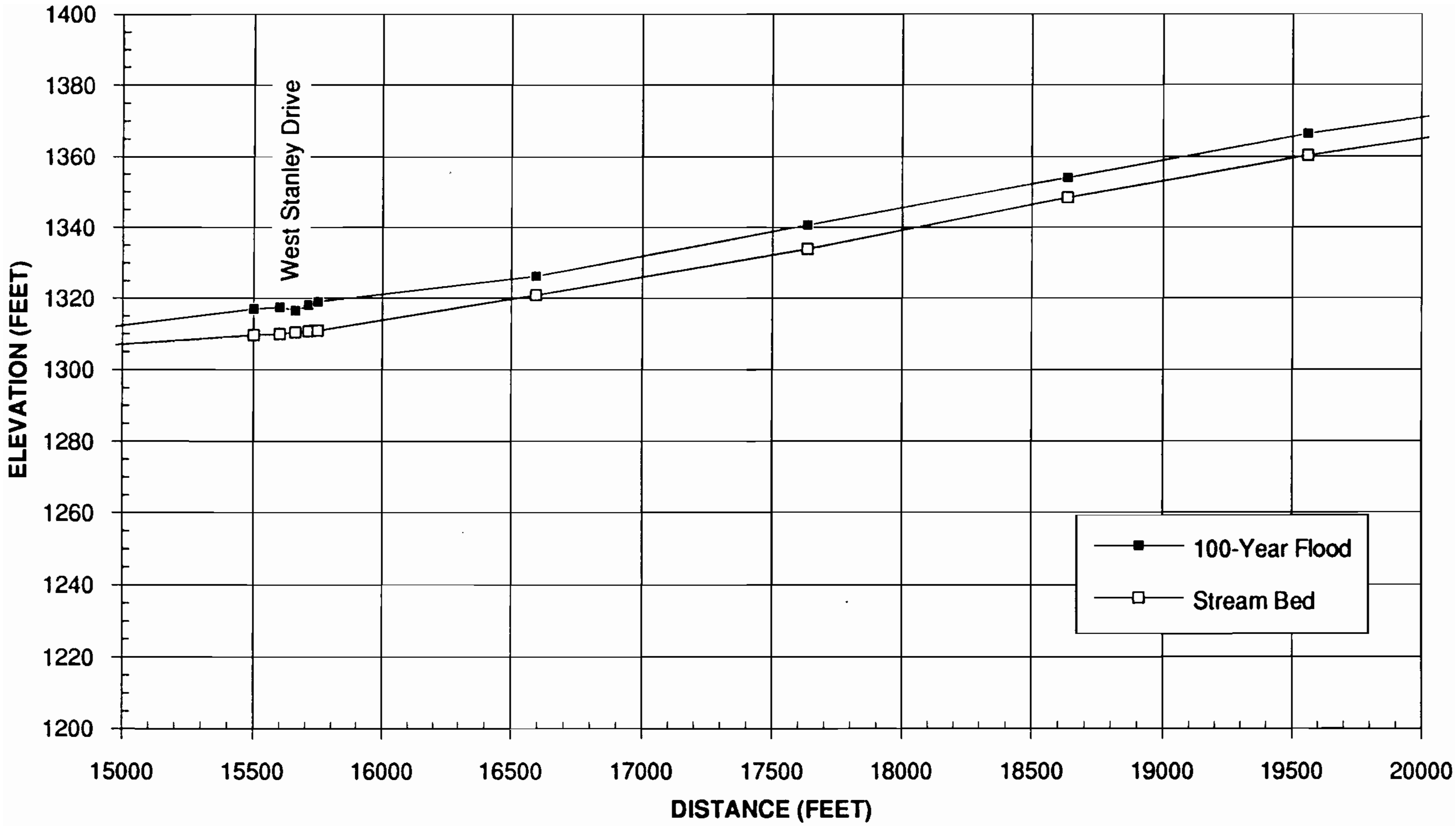
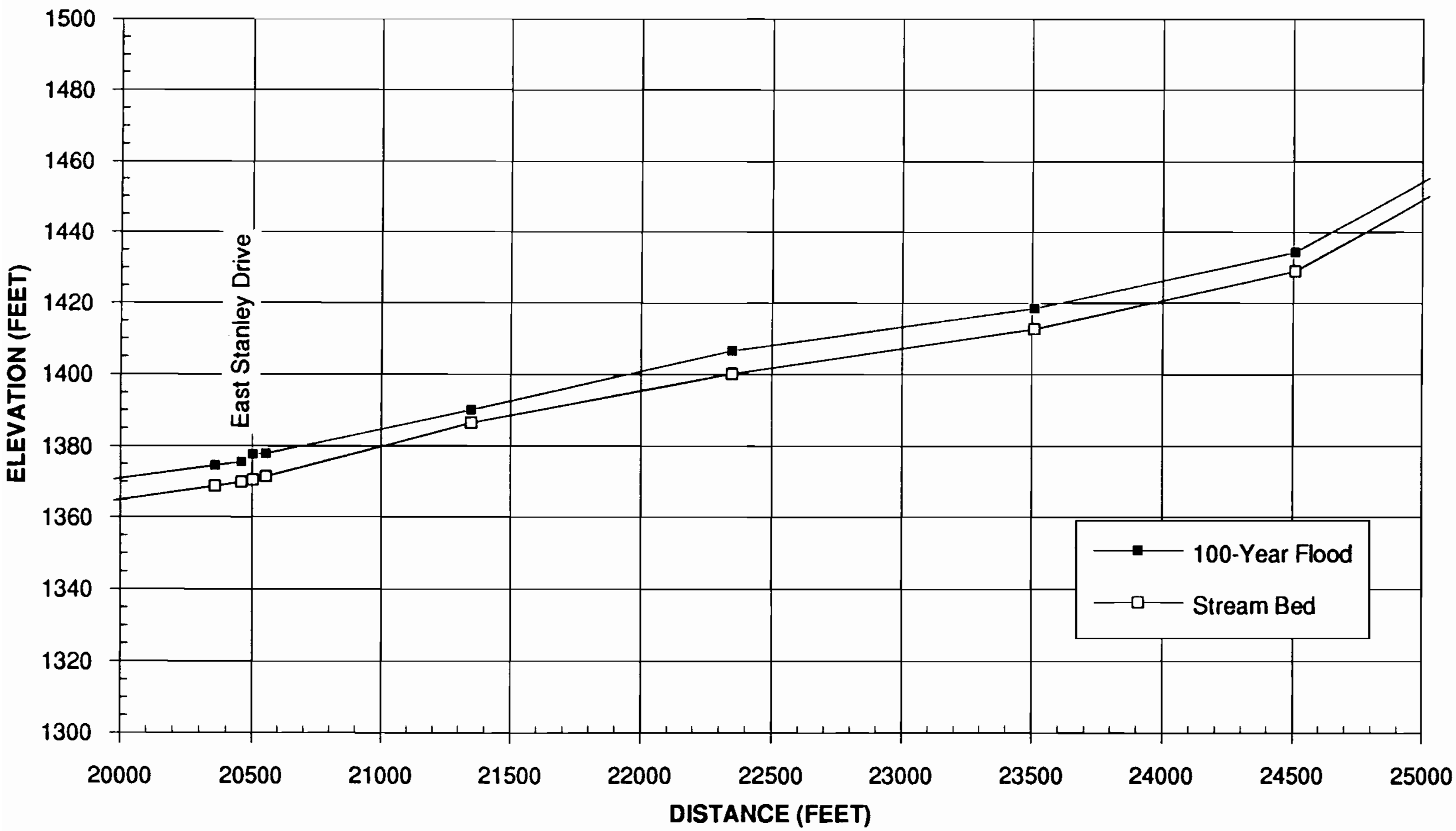


FIGURE 3-1 (continued)



1500
1480
1460
1440
1420
1400
1380
1360
1340
1320
1300
ELEVATION (FEET)
East Stanley Drive
100-Year Flood
Stream Bed
20000
20500
21000
21500
22000
22500
23000
23500
24000
24500
25000
DISTANCE (FEET)

FIGURE 3-1

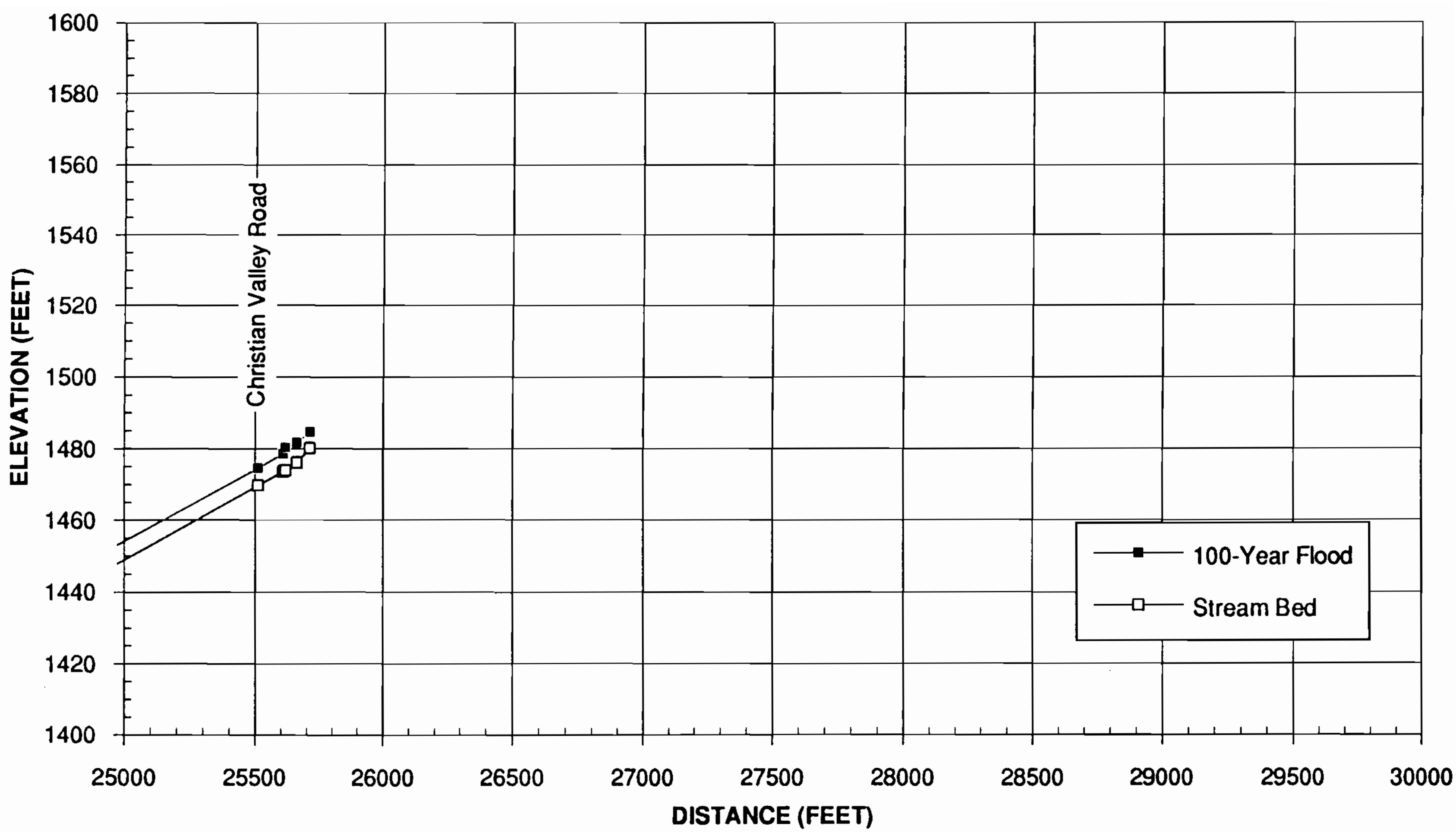


FIGURE 3-1 (continued)

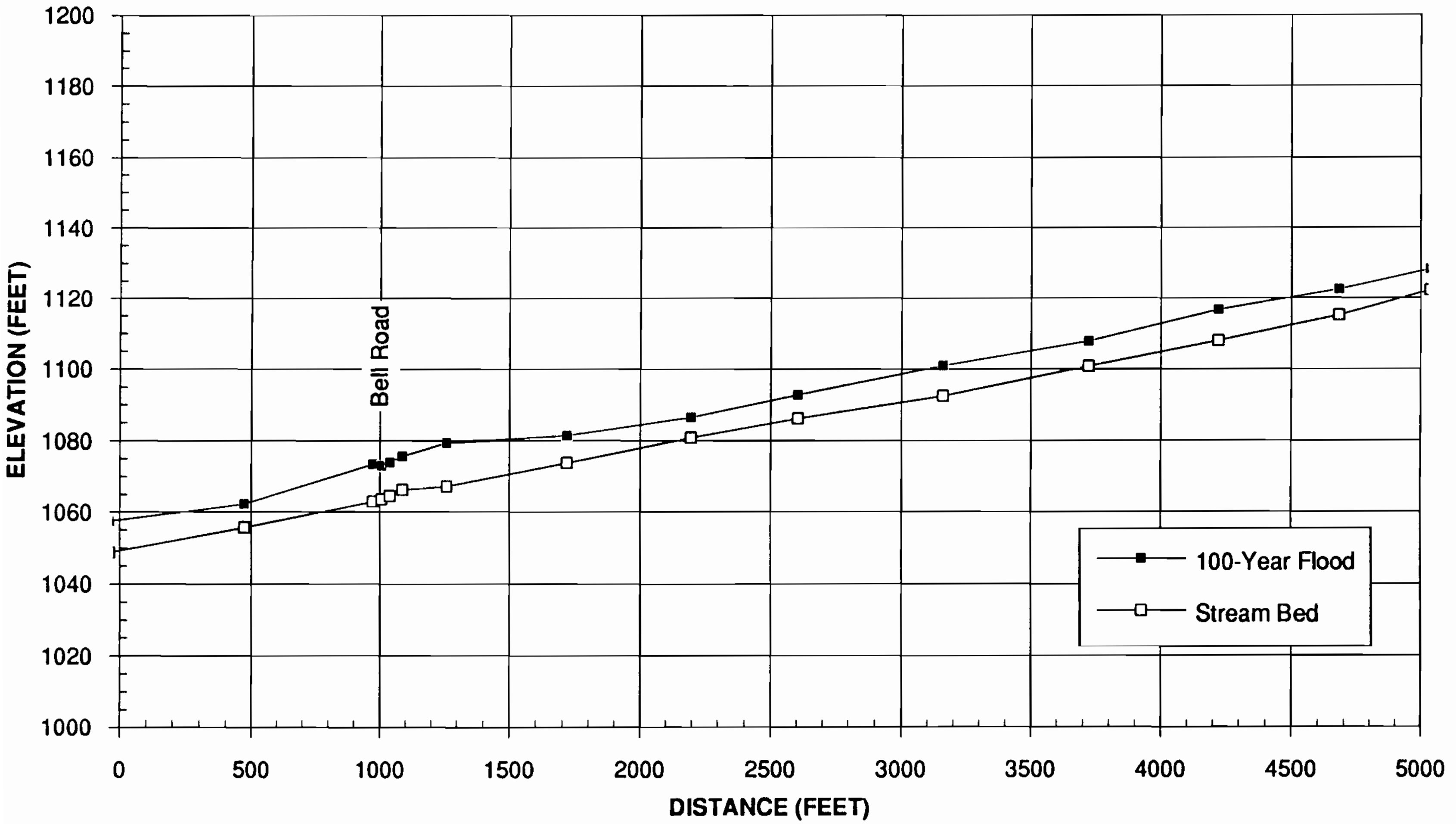


FIGURE 3-2
DRY CREEK 100-YEAR FLOOD PROFILE

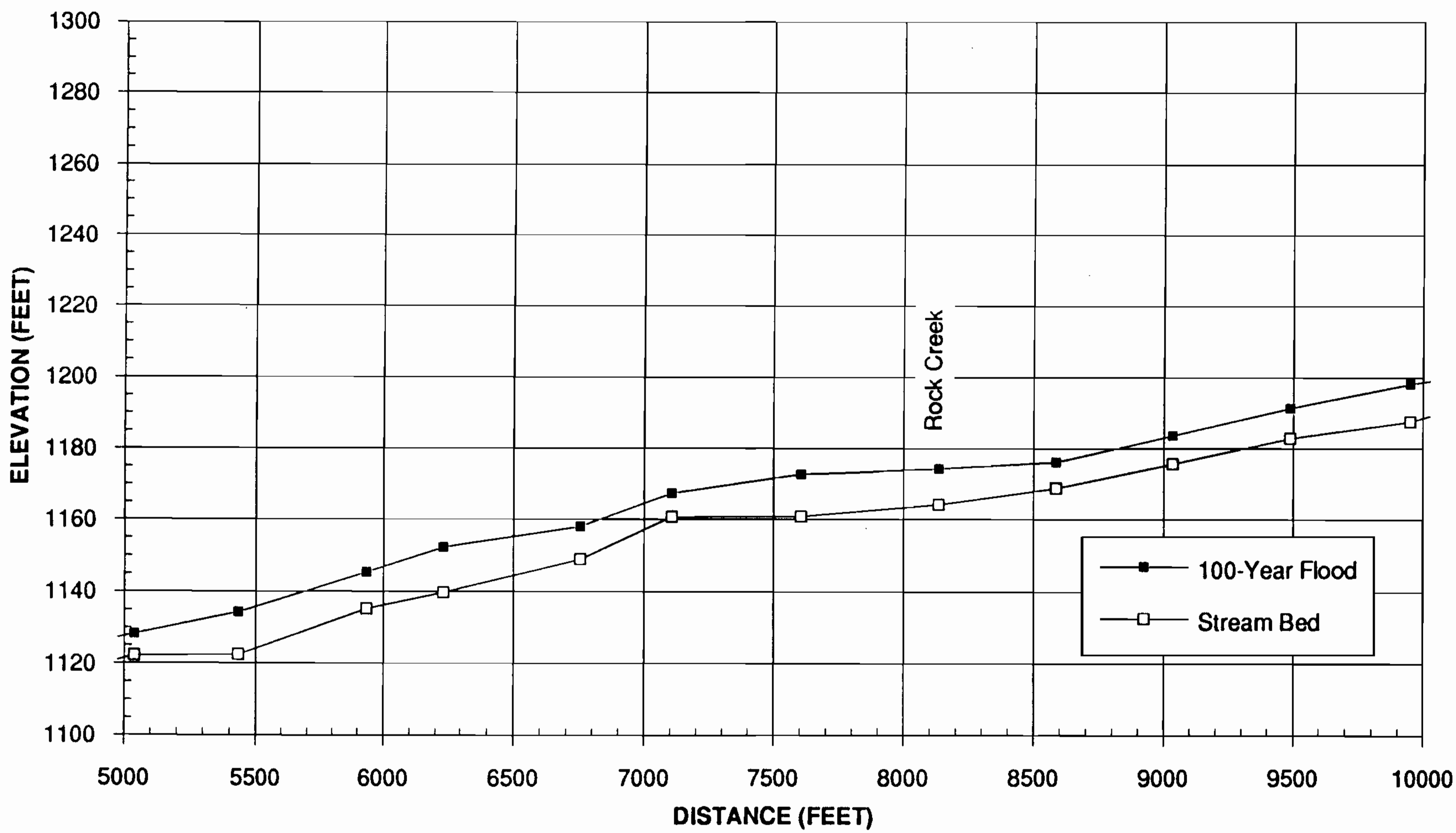


FIGURE 3-2 (continued)

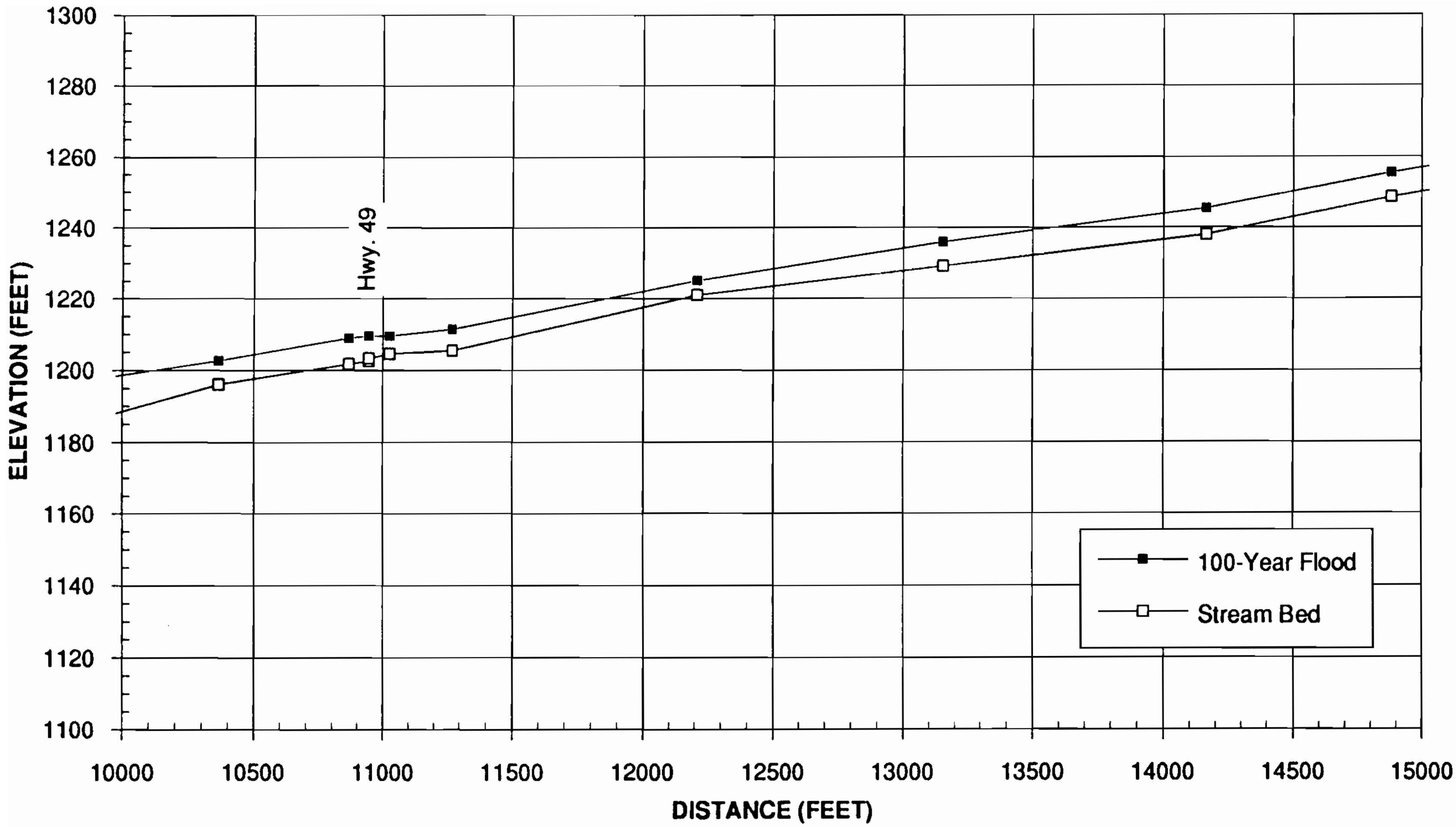


FIGURE 3-2 (continued)

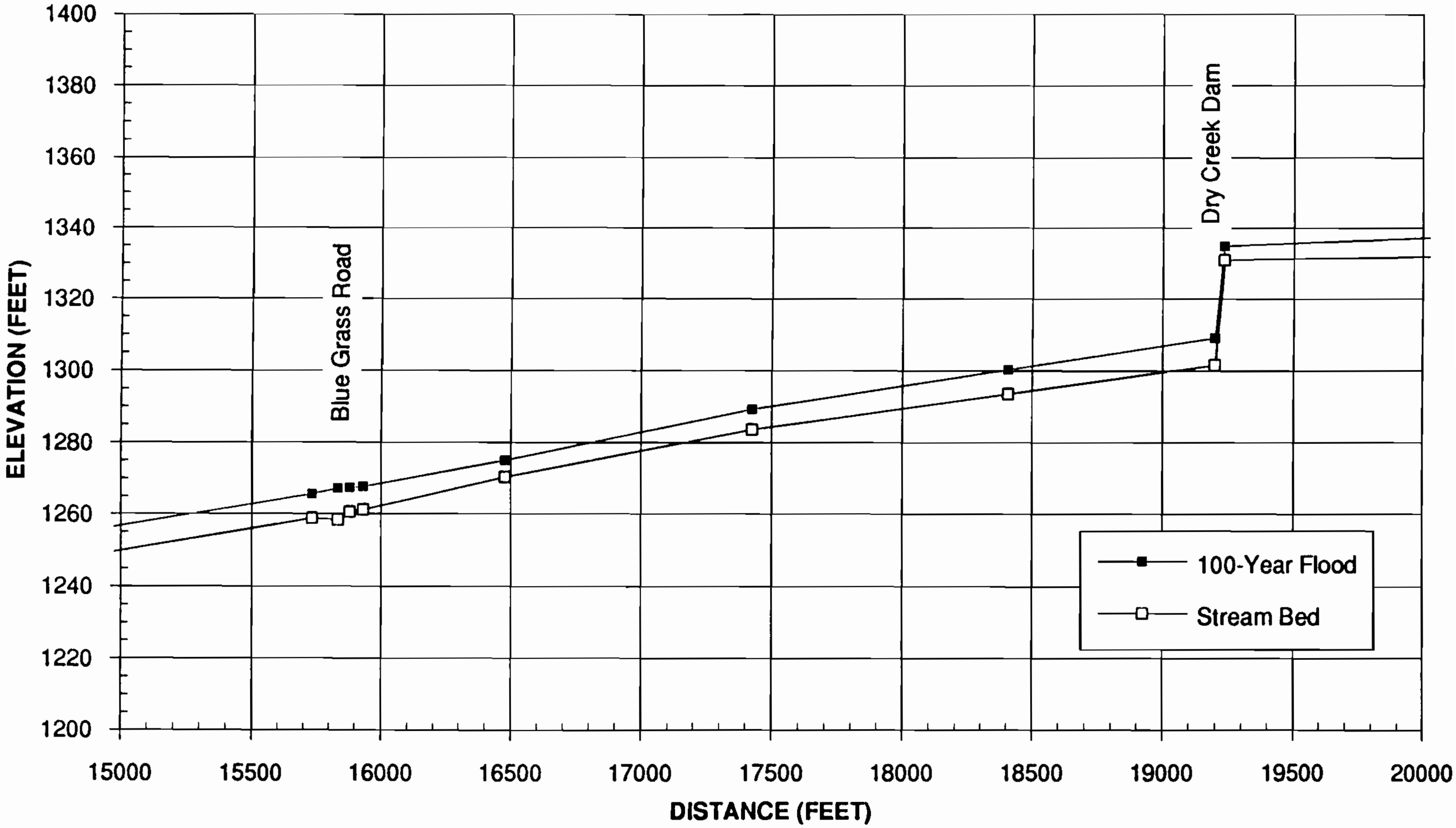


FIGURE 3-2 (continued)

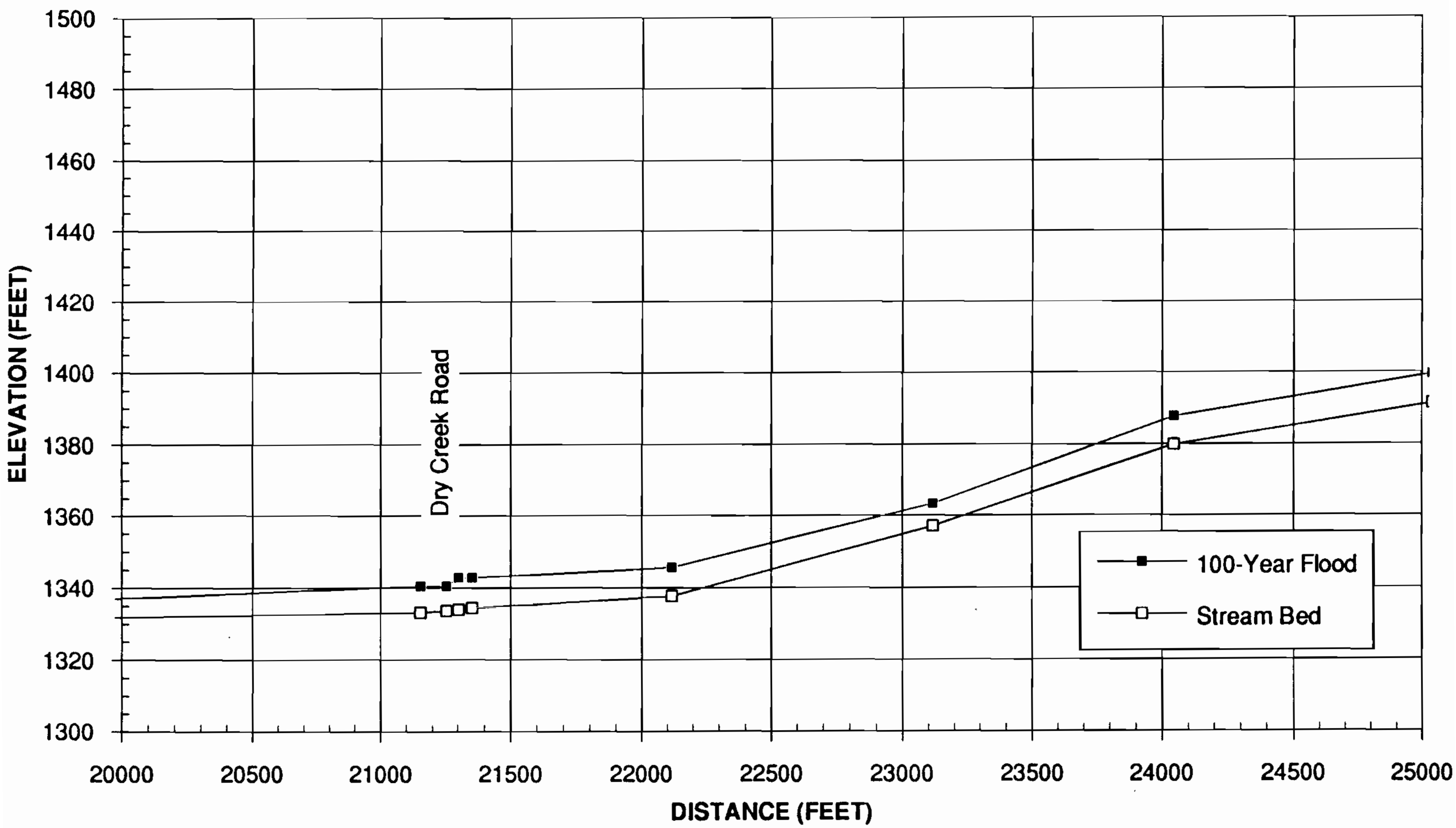


FIGURE 3-2 (continued)

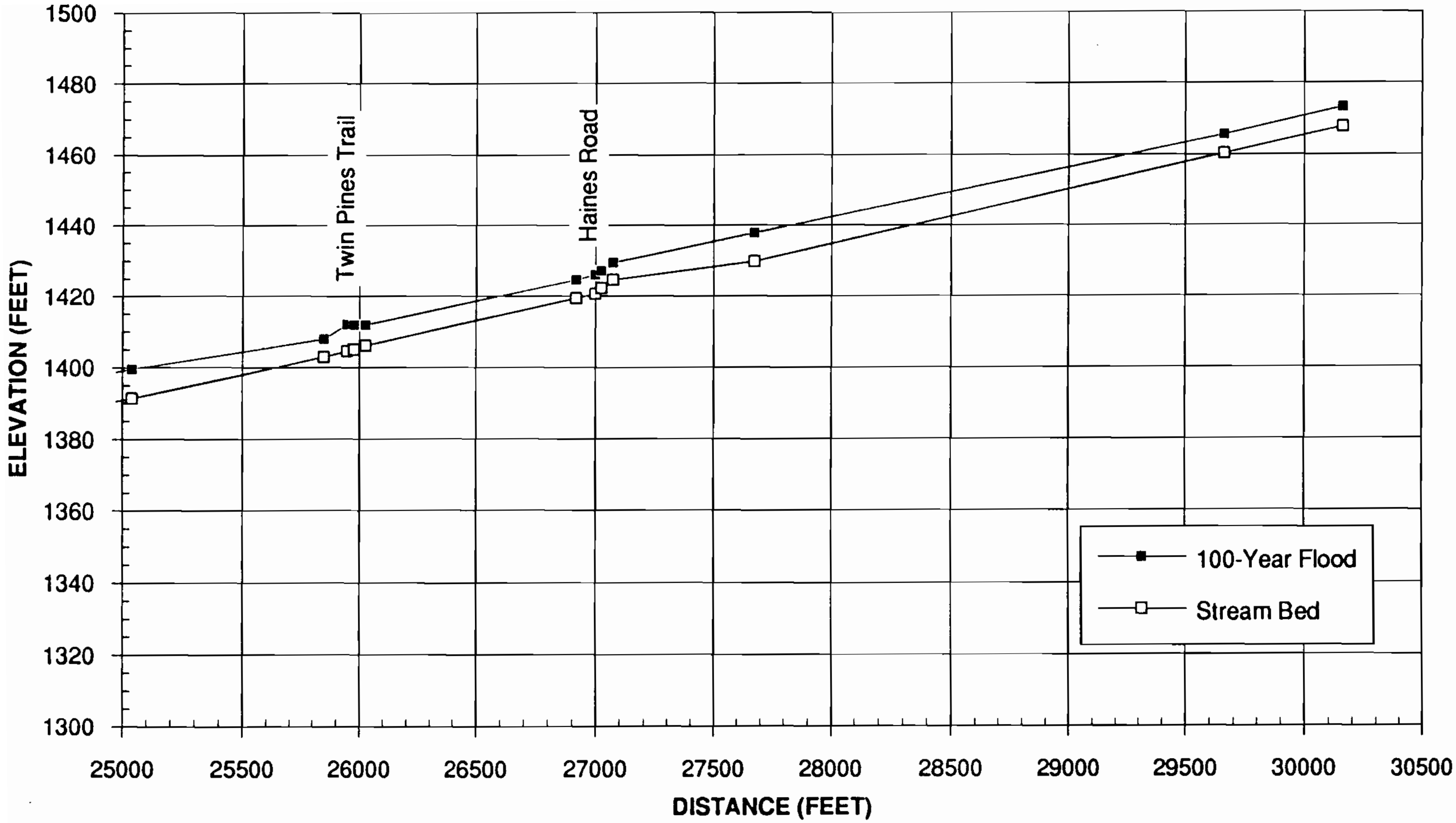


FIGURE 3-2 (continued)

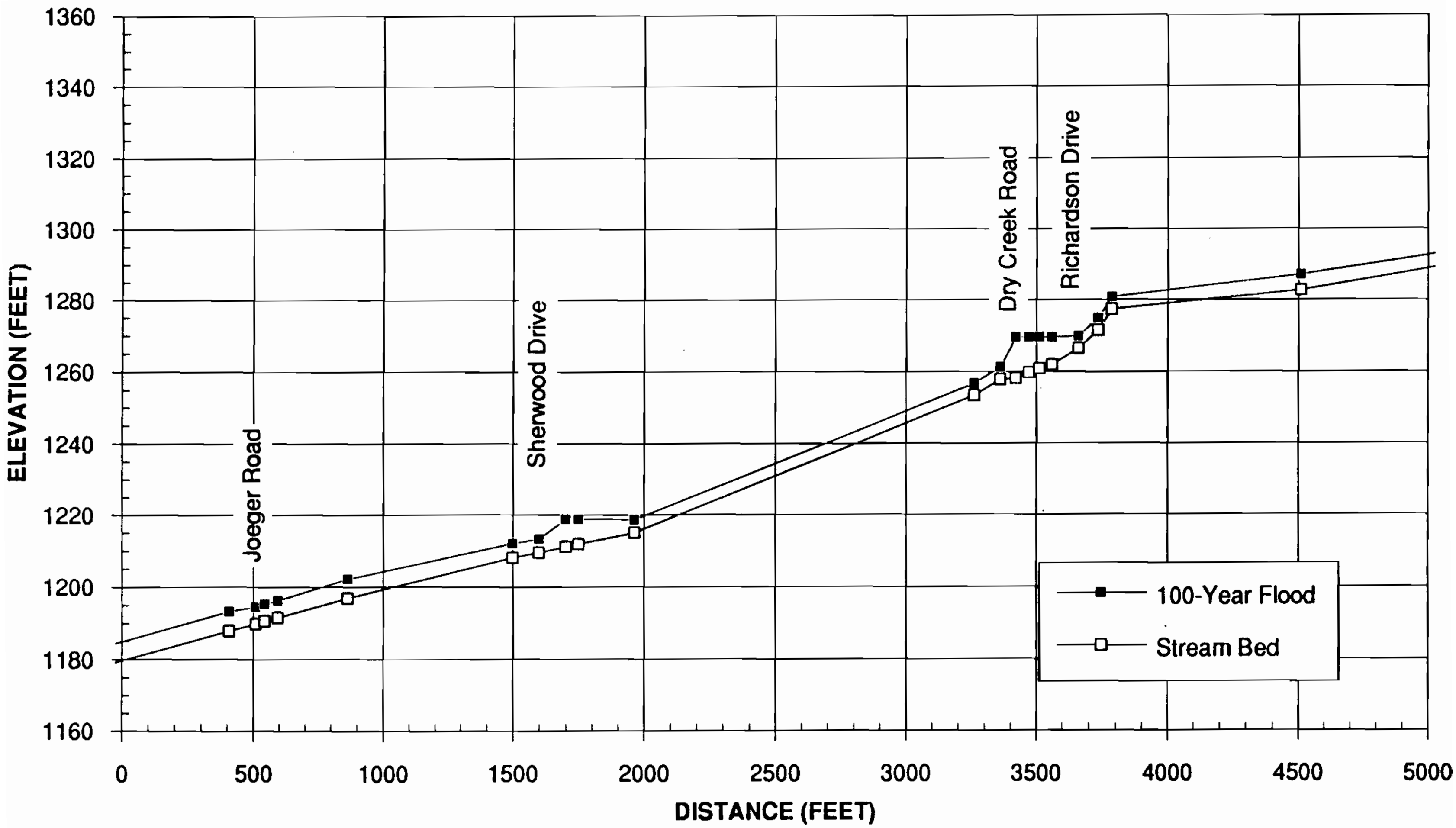


FIGURE 3-3
ROCK CREEK 100-YEAR FLOOD PROFILE

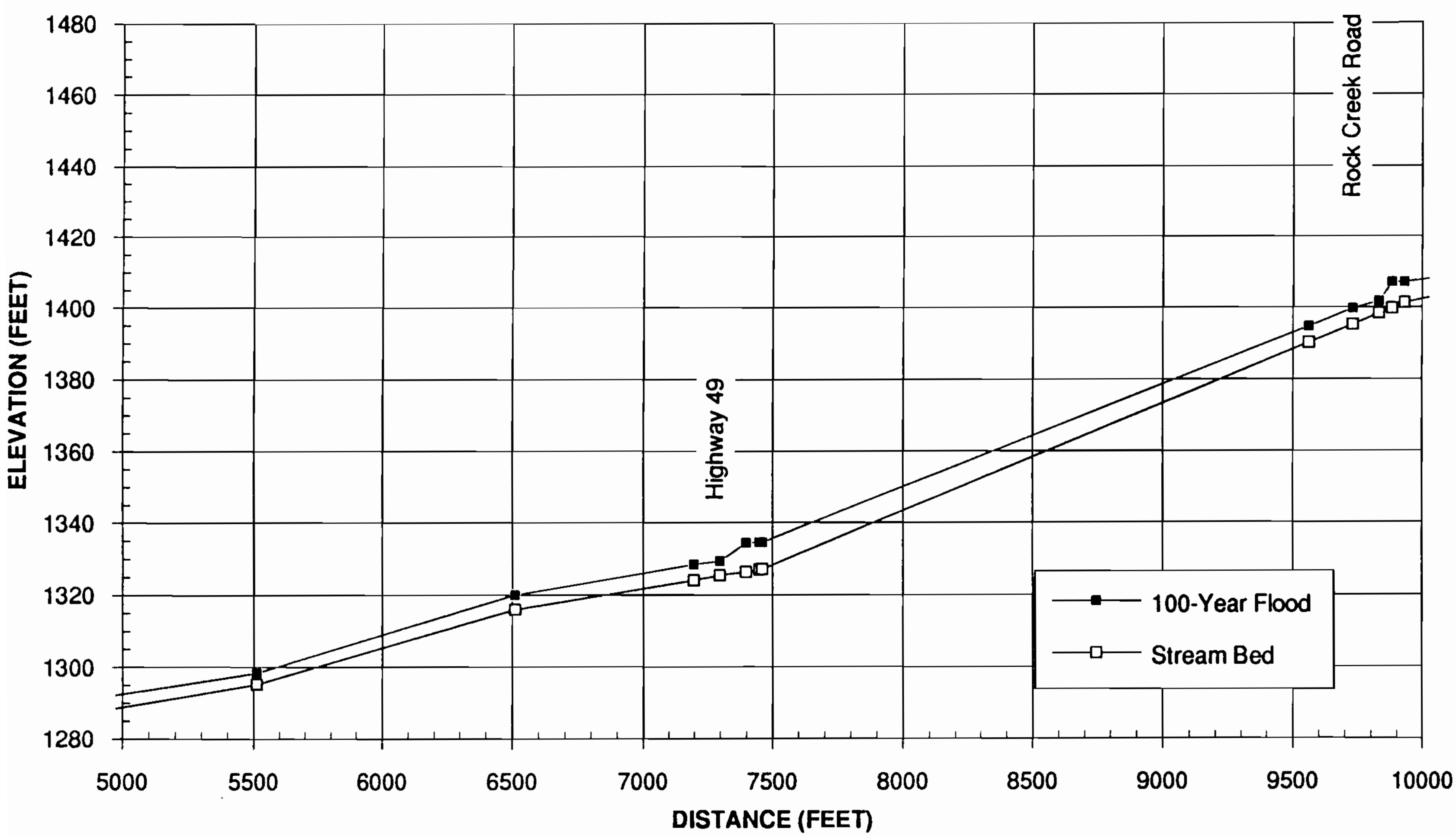


FIGURE 3-3 (continued)

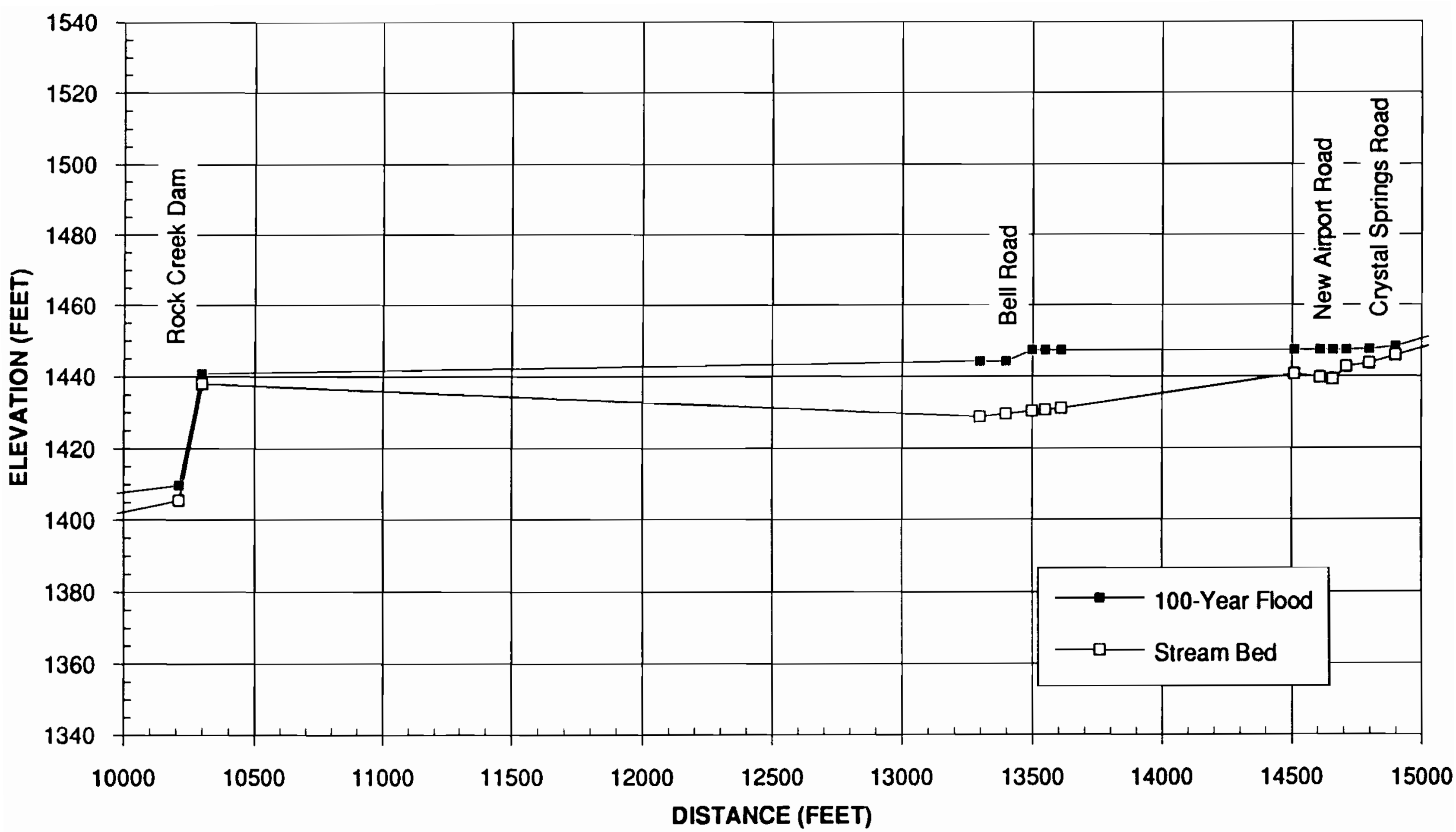
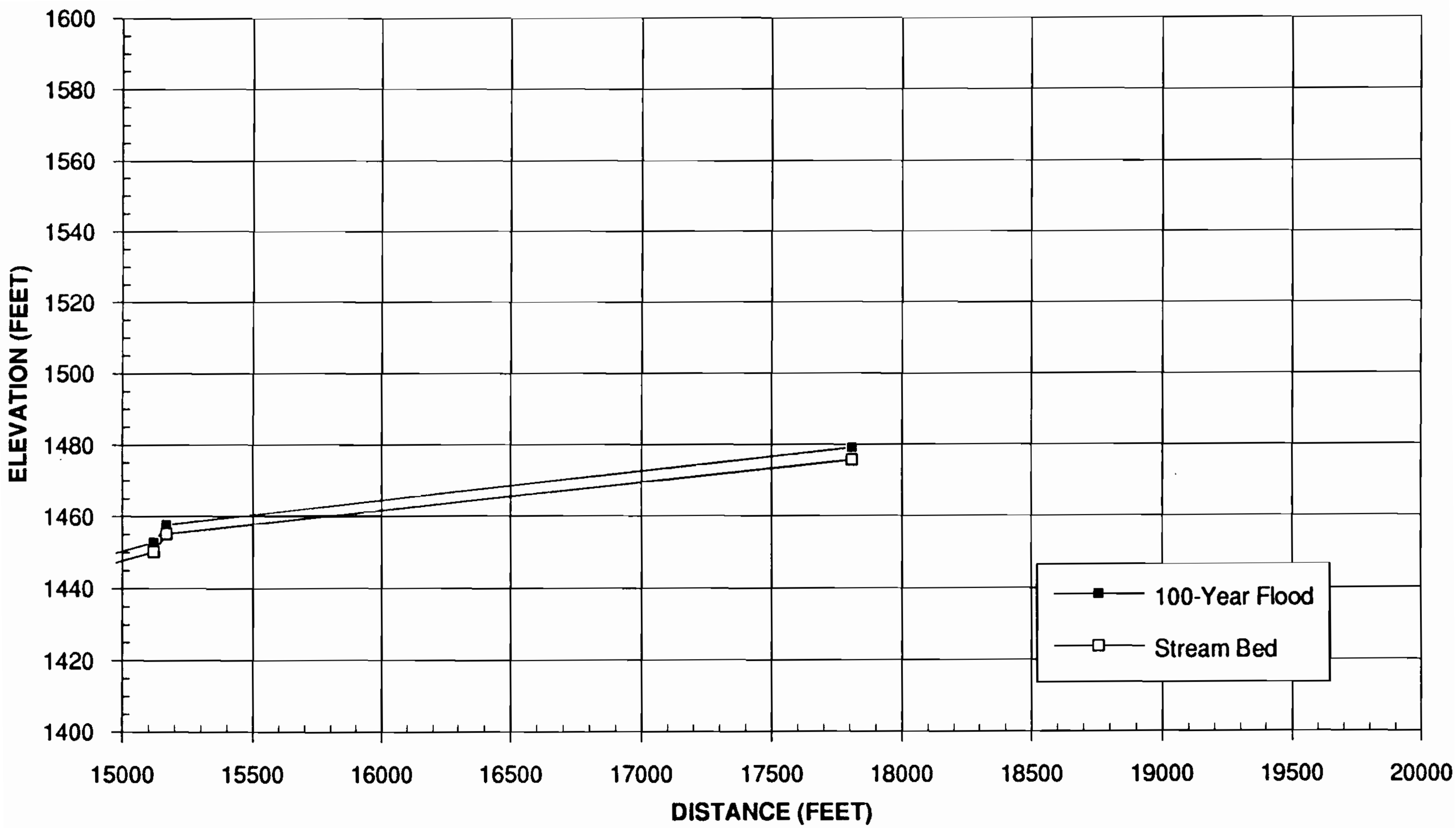


FIGURE 3-3 (continued)



1600
1580
1560
1540
1520
1500
1480
1460
1440
1420
1400
ELEVATION (FEET)
15000
15500
16000
16500
17000
17500
18000
18500
19000
19500
20000
DISTANCE (FEET)
100-Year Flood
Stream Bed

FIGURE 3-3

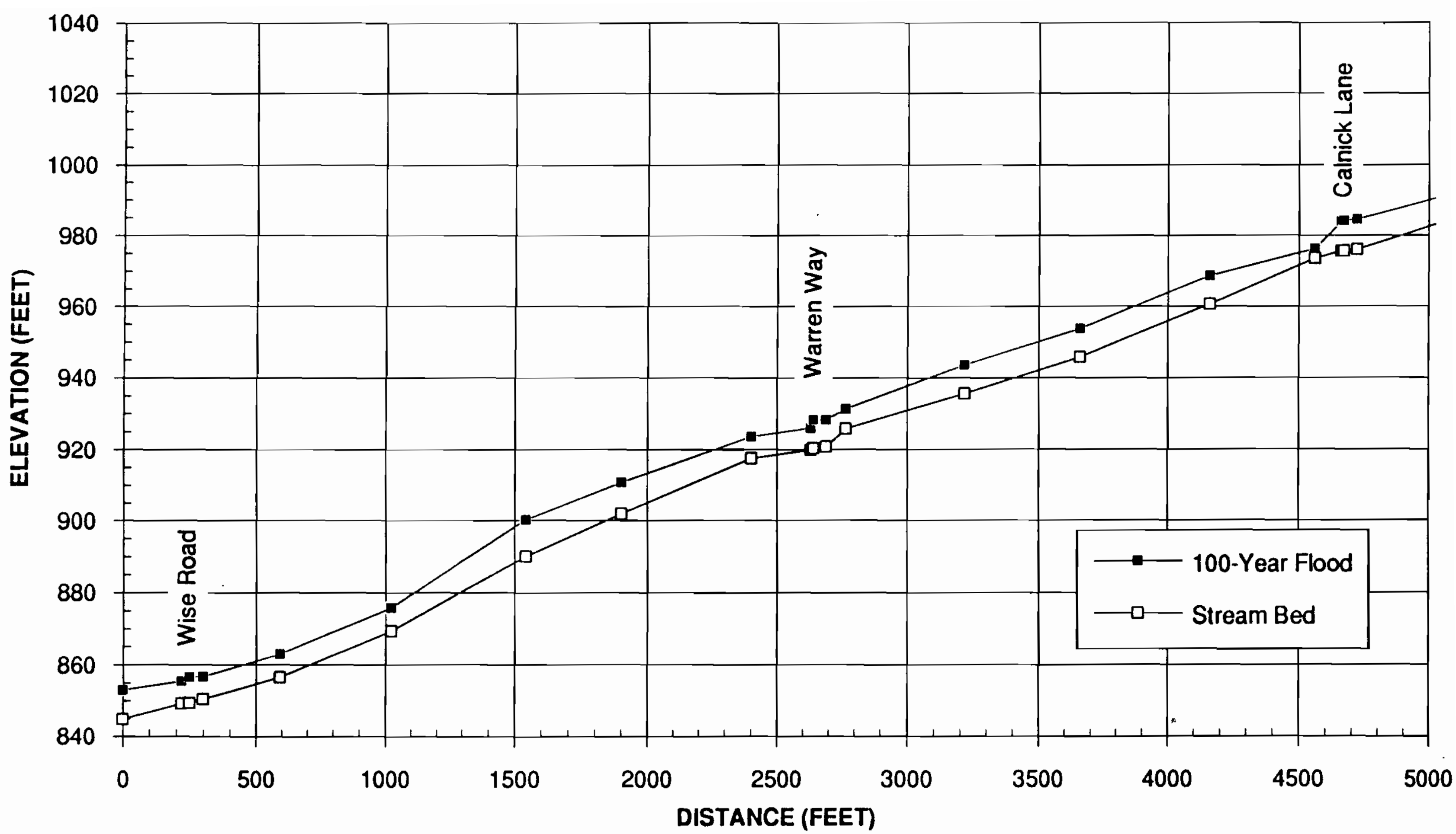


FIGURE 3-4
NORTH RAVINE 100-YEAR FLOOD PROFILE

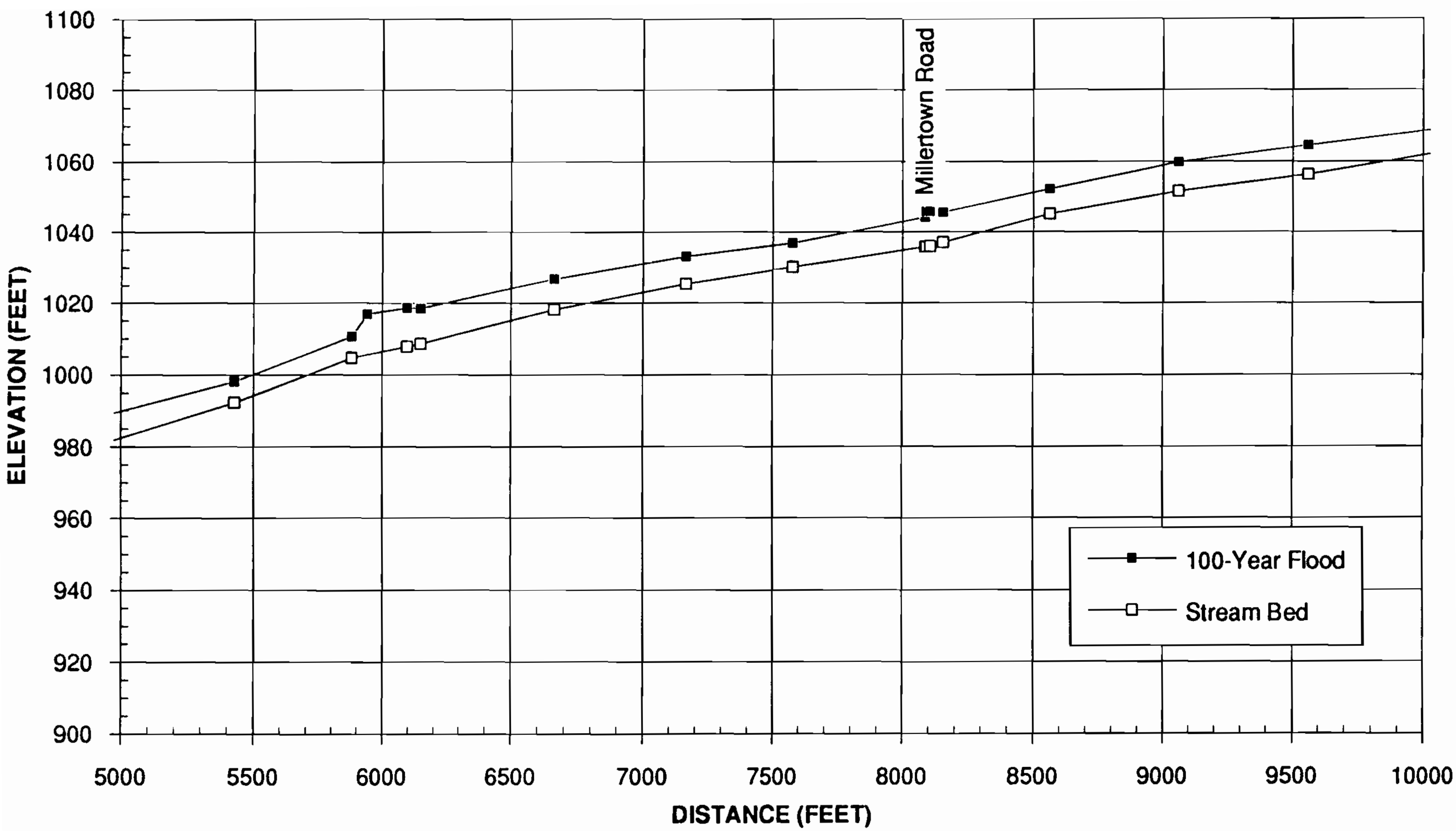


FIGURE 3-4 (continued)

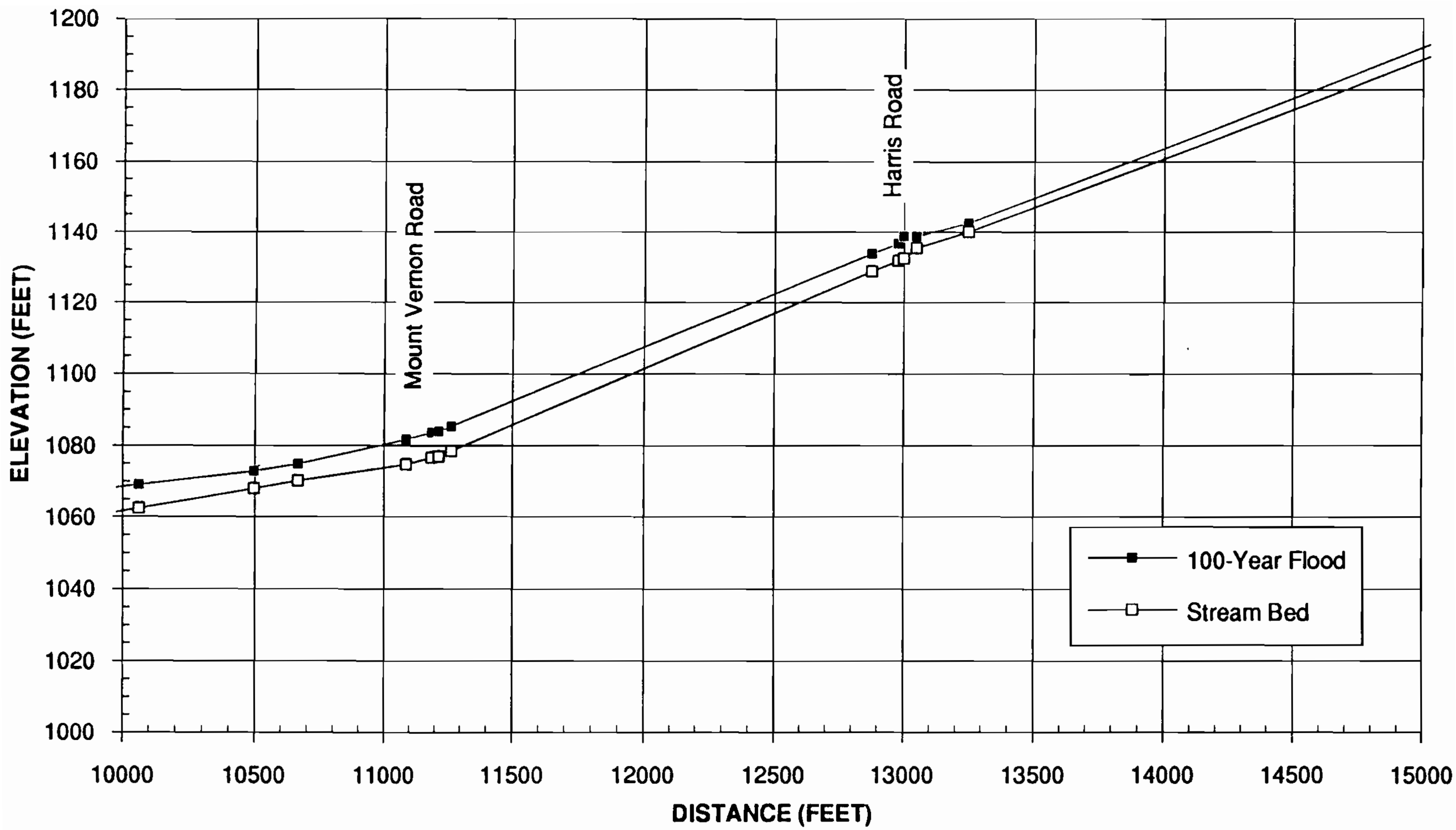


FIGURE 3-4 (continued)

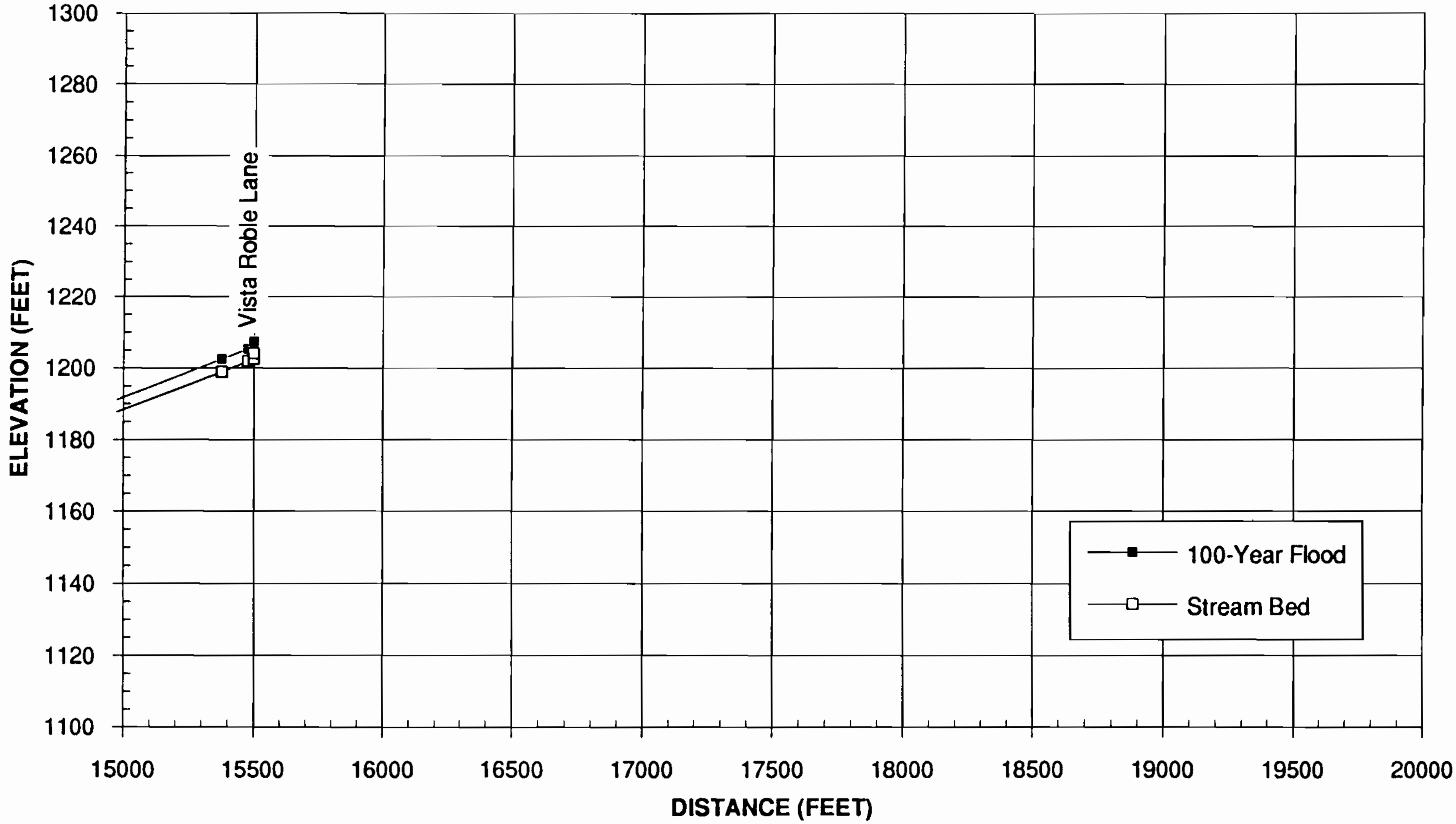
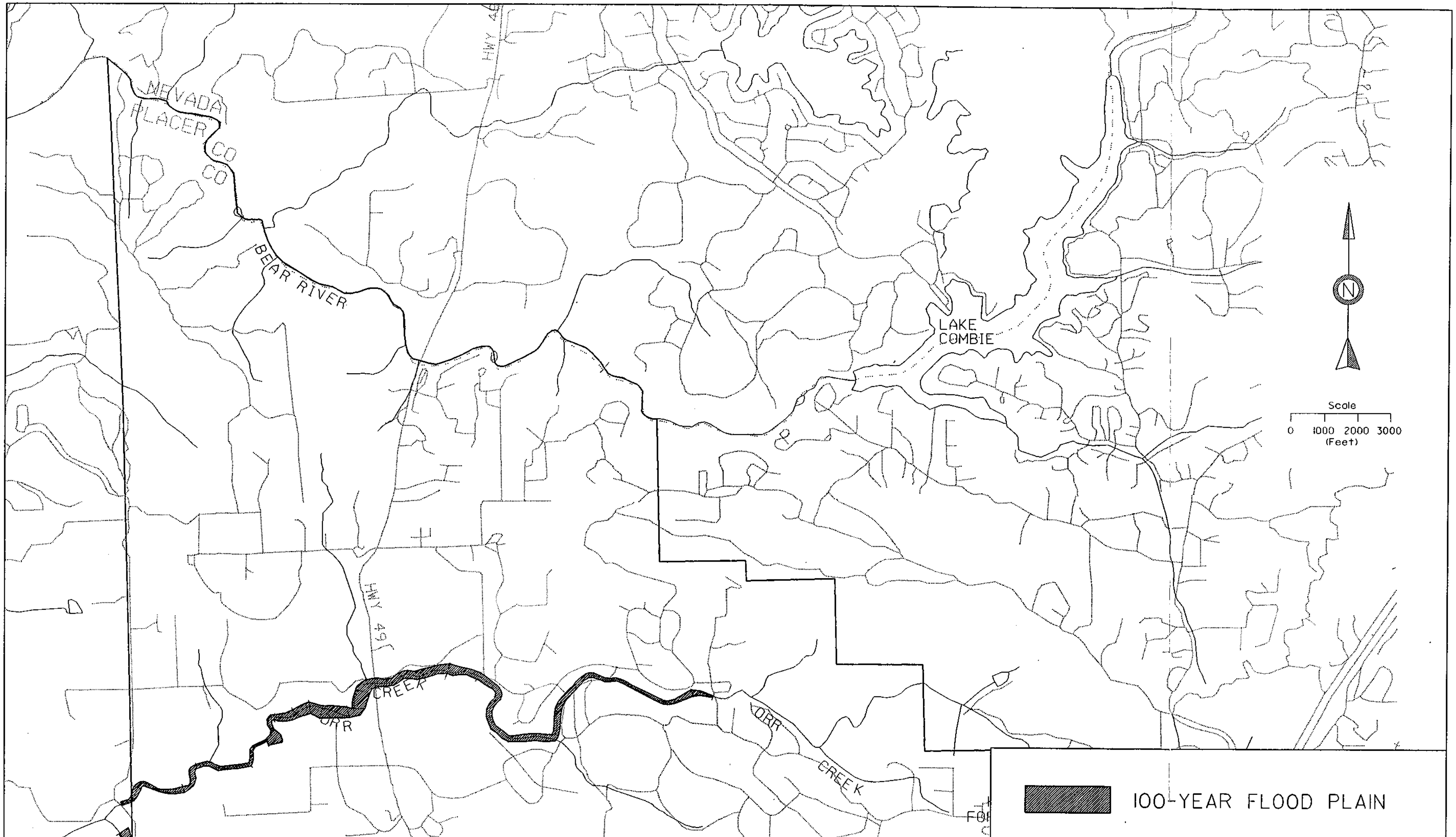


FIGURE 3-4 (continued)



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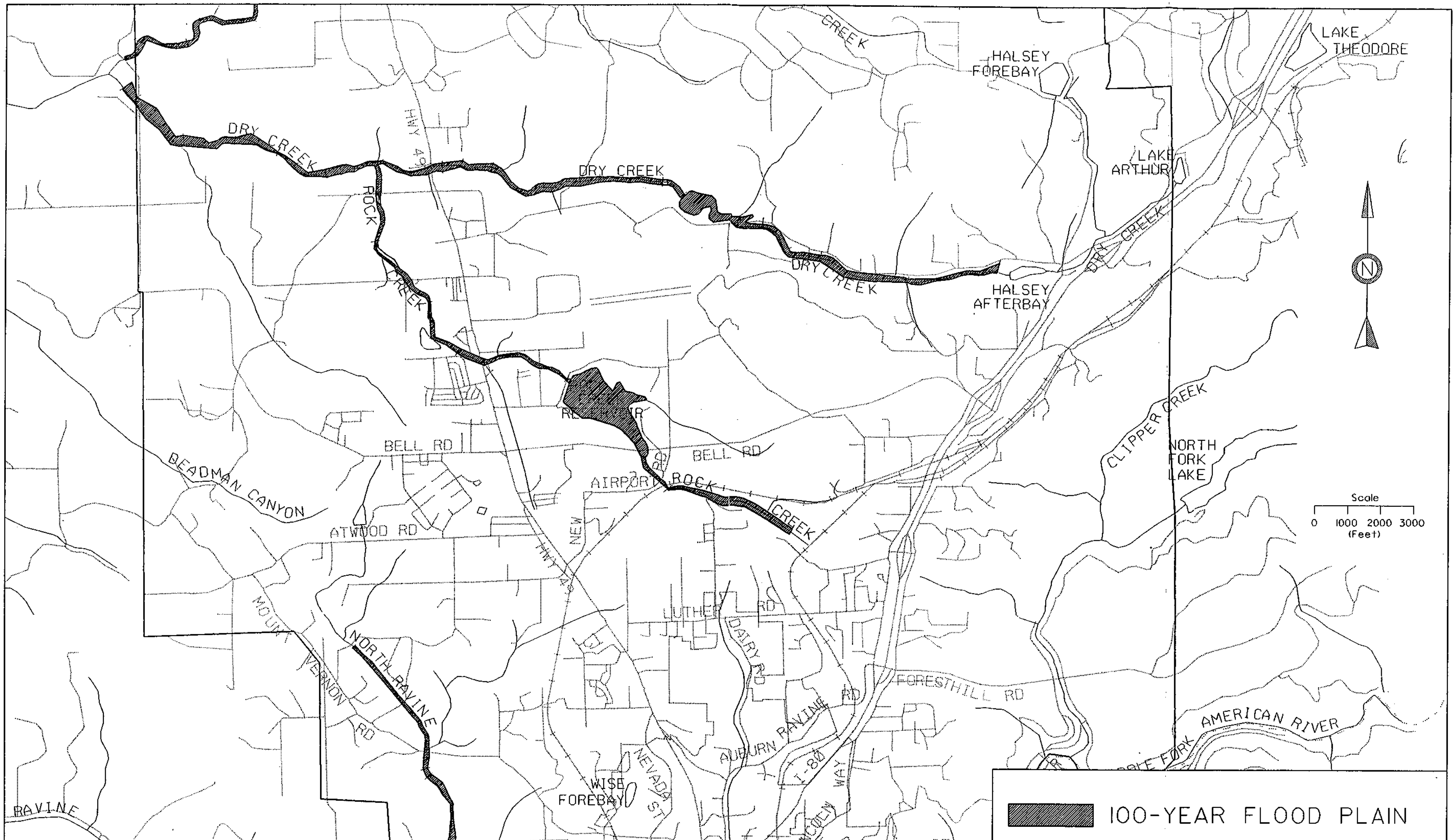
PLACER COUNTY
DEPARTMENT OF PUBLIC WORKS

AUBURN/BOWMAN WATERSHED
100-YEAR FLOOD PLAIN
MAP A

FIGURE 3-5A



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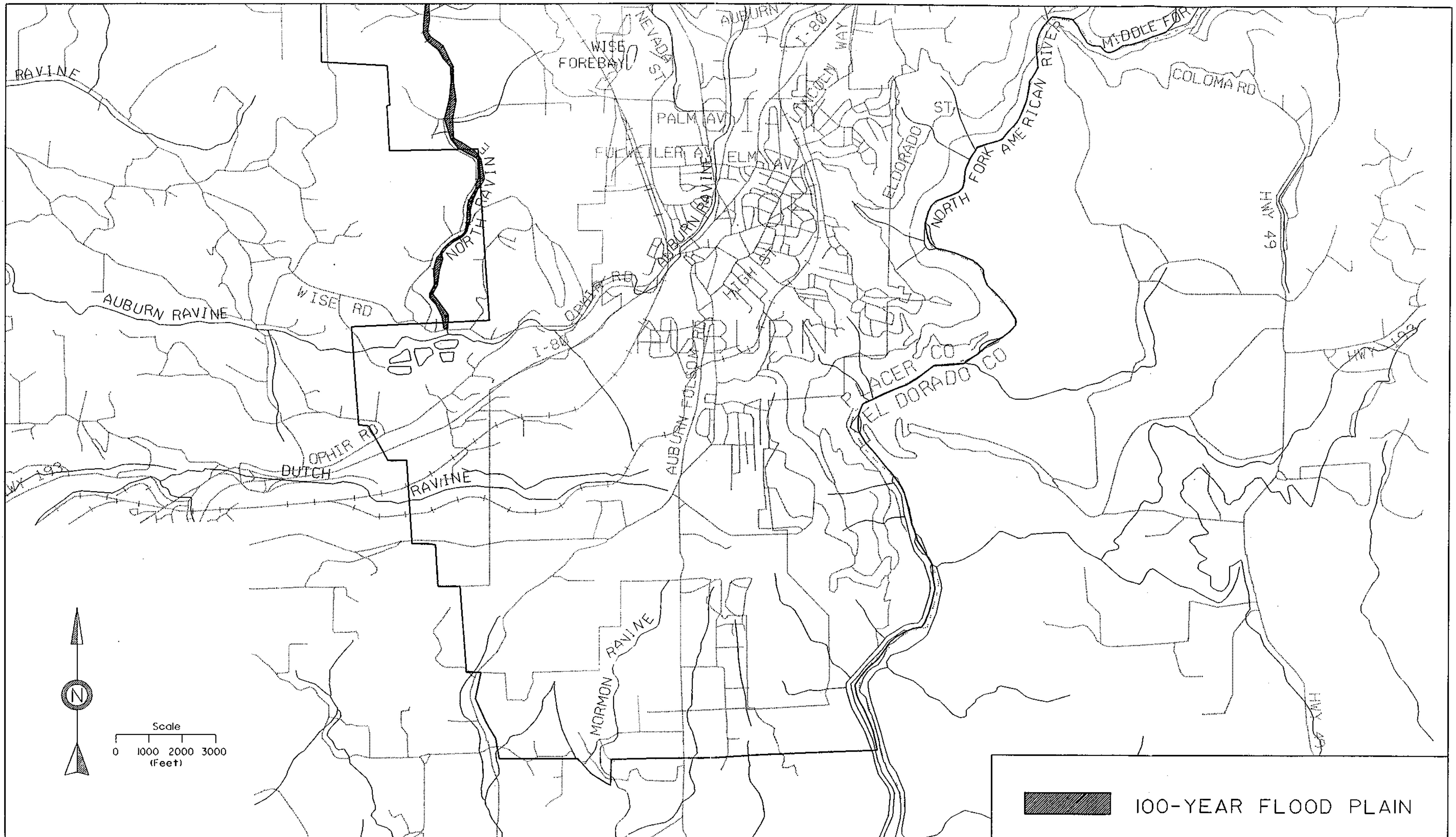
AUBURN/BOWMAN WATERSHED
100-YEAR FLOOD PLAIN
MAP B

FIGURE 3-5B



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DEPARTMENT OF PUBLIC WORKS

AUBURN/BOWMAN WATERSHED
100-YEAR FLOOD PLAIN
MAP C

FIGURE 3-5C

Future Problems, Based on General Plan Land Use

Land use changes in the watershed from the 1990 base conditions to the Future Conditions cause a five percent overall increase in the impervious area, from around 9 percent of the watershed in 1990 to about 14 percent for Future Conditions. This increase in impervious area, combined with the other changes described in Section 2, accounts for an average overall increase in all the tributaries of around six percent in the 100-year peak flows. The range in flow increases for each individual watershed, however, is from 2 percent to 22 percent, depending on the size of the watershed, and the amount of development that is projected to take place in that watershed. The net result of this peak flow increase is that the problems in areas with existing problems are made worse, and there are some areas without existing problems that may experience problems based on the Future Conditions' flows.

Bridges and Culverts - Overtopping and Backwater. Table 3-1 also contains a listing of the locations and magnitude of culvert and bridge overtopping in the watershed under Future land use conditions. As indicated in Table 3-1 over 70 percent of the bridges and culverts will overtop during the 100-year flood under Future land use conditions and over 60 percent will overtop during the 25-year flood. Backwater from overtopping bridges and culverts will increase slightly due to the increase in flood flows due to Future Conditions. The backwater increase will probably not be directly proportional to the increased flood flows because the length of the overflow section usually increases with increasing depth of flow over the roadway.

Floodplain. The areas where the increase in flood flows from Base to Future land use conditions causes additional problems do not change significantly from those already impacted by the 100-year flood with present land use conditions. Additional structures may be impacted, but they will most probably be located near those that are already at risk with present land use conditions.

Erosion Potential

Except where roadway embankments were eroded by flood waters flowing over the roads during the February 1986 flood, the streams in the Auburn/Bowman Community have not shown a serious erosion potential in the past. Dense vegetation, in and along the majority of the channels and floodplains in the watershed, reduces flow velocities and erosion potential significantly. This slowing in flow velocity, in addition to the fact that flood flows are normally of fairly short duration, would seem to indicate that erosion of stream banks should not be a serious problem.

Erosion protection may be required, however, in areas where channel improvements are constructed because of the higher velocities that are incident with those improvements. Erosion protection will also be required in the stilling basin area downstream of the outlets from local detention basins. This erosion protection can take many forms but will usually be rock riprap, gabions, grassing, or some other type of channel lining.