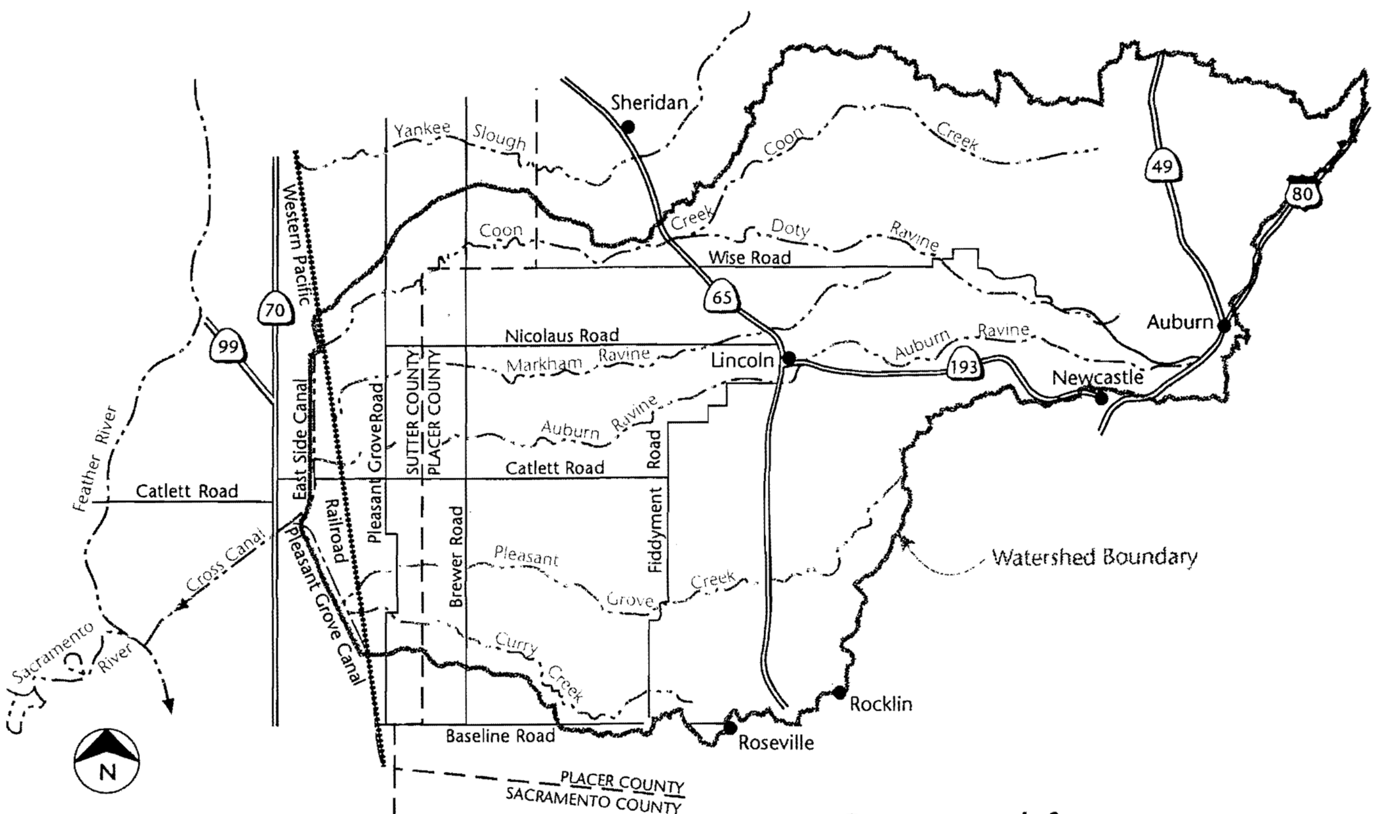
Auburn Ravine, Coon, and Pleasant Grove Creeks Flood Mitigation

Volume 1



Prepared for

Placer County Flood Control and Water Conservation District

CH2M HILL

June 1993

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Study Goal

The goal of this study is to determine funding needs required to mitigate increases in storm runoff from a developing portion of western Placer County.

Introduction

The Placer County Flood Control and Water Conservation District sponsored this study for the area drained by Auburn Ravine, Coon, and Pleasant Grove Creeks (see Figure ES-1). These creeks and their tributaries drain approximately 292 square miles of northwestern Placer County and southeastern Sutter County. The Natomas Cross Canal, at the western end of the study area, carries the combined flow of the creeks to the Sacramento River.

The study was prepared to respond to concerns over potential increases in flooding in the lower portion of the watershed. Portions of the study area within Placer County have planned land uses that allow for significant industrial, commercial, and residential development. The increase in land coverage by buildings and pavement with such development would normally increase flood flows and volumes. An extensive area upstream of the Cross Canal, in eastern Sutter County and western Placer County, has periodically flooded and could be adversely affected by additional stormwater runoff from development in Placer County.

The report provides an overview of the potential drainage problems and presents conceptual facilities to mitigate the increase in flood flows. A financing plan is proposed to provide for collecting the fees required to construct and maintain the facilities. More detailed feasibility studies and designs will be required before finalizing the concepts and constructing the mitigation facilities.

Major Assumptions

Major assumptions developed by the Technical Advisory Committee include:

- The proposed plan will not attempt to reduce the degree or frequency of existing flooding conditions.
- Only impacts from future development will be mitigated. Future development will pay the cost of the major improvements required for mitigation.

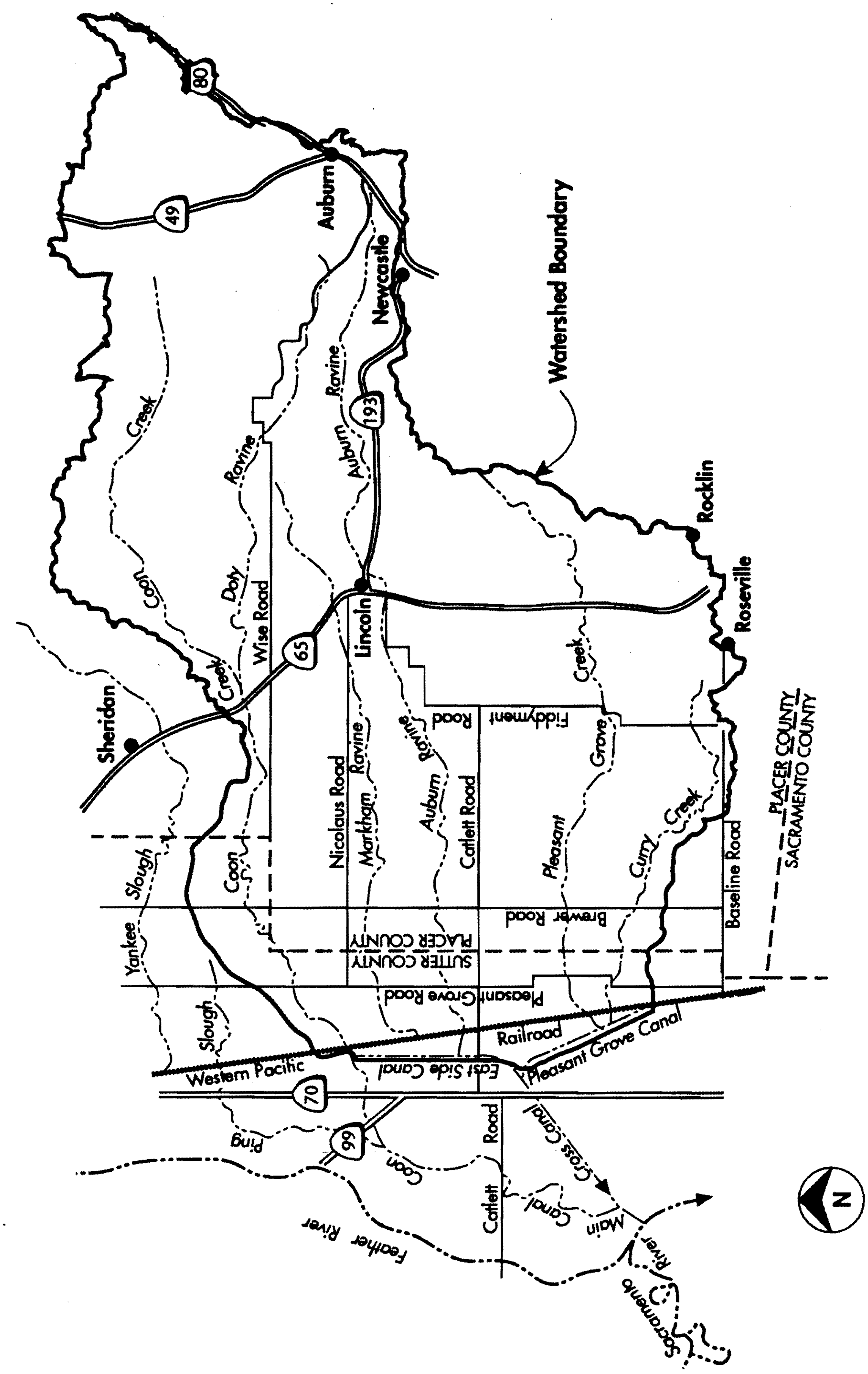

Figure ES-1
Cross Canal Watershed

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- Each jurisdiction will provide improvements, such as detention basins, within its boundaries to mitigate local drainage problems.

- All stormwater mitigation/improvements will be carried out within Placer County so eminent domain authority need not be exercised within downstream Sutter County.

- The following mitigation alternatives were considered:

  - Regional stormwater retention basins near Sutter County
  - Local detention basins near upstream development
  - Purchase of flood easements
  - Channelization and levees
  - Flood proofing and localized improvements
  - Participation in the Corps of Engineers' American River Study
  - Flood warning systems

Findings

Study findings are summarized below:

1. Major flooding in the watershed occurs as ponding and overland flow over many square miles of land east of the Natomas Cross Canal. Flooding also occurs adjacent to tributary streams where channel capacities are exceeded.

2. Inadequately sized road crossings, land leveling, and channelization within the lower portion of the watershed have likely contributed to the frequency and degree of flooding.

3. Without mitigation, flooding depths over approximately 30,000 acres will increase from future development in Placer County. These increases will be generally less than 0.3 foot along the tributary streams and approximately 0.1 foot in the ponding area upstream of the Cross Canal. These increases will inundate an additional several hundred acres of land during a major flood. The future development will also result in flooding on a more frequent basis. For example, a level of flooding that may occur with existing conditions once every 10 years will occur approximately once in 9 years with the developed condition; flooding that occurs with existing conditions every 25 years will occur approximately once every 20 years with the developed condition.

4. The flood depth increases in the lower regions of the watershed can be mitigated by regional storage basins. Peak flow impacts immediately downstream from development can be mitigated with local detention basins.

5. Levees, channel improvements, and flood proofing did not lend themselves to mitigation of increased runoff because Placer County has no flood control authority within Sutter County. Also, these improvements do not provide complete mitigation. However, these improvements may be a viable means of reducing existing flooding conditions.

6. The purchase of flood easements (primarily in Sutter County) was not considered a feasible alternative for a number of reasons:

   - History of resistance from affected landowners.

   - Difficult implementation because Placer County does not want to exercise eminent domain authority within Sutter County.

   - Difficulty in defining affected area due to the flat terrain and small increases in flood level. Topography information is not available in enough detail to accurately define the inundated area. Each frequency of flood will have an associated affected area. Therefore, all areas inundated during the largest flood will have increased flooding because of increased development in the watershed. This affected area appears to be at least 10,000 acres immediately upstream of the Cross Canal, but may be up to 30,000 acres including the tributary streams.

   - No damages when only land is flooded. Any easements would need to include restrictions on development within the easement.

7. Participation in the Corps of Engineers' American River Study may have merit as an alternative to the regional retention basins. Discussions on cooperatively funding a flood control project are underway between Placer County, Sutter County, and the Sacramento Area Flood Control Agency (SAFCA).

8. Regional storage basins would control approximately 3,600 acre-feet of storm runoff. This could be achieved with three basins: one on Pleasant Grove Creek, one on Auburn Ravine, and one on Coon Creek. Capital costs for the project are estimated to be approximately $32 million. Operation and maintenance costs are estimated to be approximately $140,000 annually.

9. The debt service on the total project cost would be prohibitive with each alternative because it is unlikely development keeps pace with repayment needs. Therefore, phasing construction of regional storage basins will be required to provide for realistic project repayment.

10. The District has limited authority to collect fees. However, the legislation forming the District does not specifically define the services.

Recommendations

1. If flooding impacts are determined to be significant, a combination of regional and local storage basins may be the best method for eliminating increases in flood depth due to watershed development. The regional facilities would be designed and built by the District. The plan provides for construction of three regional storage basins upstream of the Sutter/Placer County line. The basins would be located on Auburn Ravine, Coon Creek, and Pleasant Grove Creeks. Local facilities could be built by either developers or local jurisdictions.

2. A flood warning system is recommended for the watershed to help manage local response to flooding events. The system would also be valuable to acquire more specific information on the watershed flood characteristics, provide a historical record of flooding events, and provide a function of mitigation monitoring.

3. The District should continue to explore alternative cooperative plans with the SAFCA and Sutter County. Regional flood management involving the combined interests of these jurisdictions may provide for a more cost-effective plan for flood-prone areas. Given the high cost of the retention basins, alternatives that may be more cost-effective should be cooperatively explored.

4. Adoption of a floodplain management plan, grading ordinances, and policies are needed to control development in the floodplain and to preserve channel capacity in the lower watershed (Placer and Sutter Counties).

5. If flooding impacts are determined to be significant, the District should implement development impact fees as soon as possible.

   Because impact fees will be collected only as development occurs, the total funds required for retention basin construction will not be immediately available. Several years will be required for completion of permitting and design of the regional retention basins. The collection of impact fees during this period would likely result in only a portion of the required funds being available when the first basin is ready for construction. At that time, the District would have the option of issuing debt to finance the first phase of construction or possibly waiting until adequate funds are available for construction.

6. Annual costs of approximately $140,000 for operations and maintenance of the regional storage basins and the flood warning system need to be collected by the District. These costs could be collected by contributions from the jurisdictions within the District. However, the District has other ongoing annual funding needs not related to mitigating impacts of future development. These include District administration and engineering staff, channel clearing and maintenance work, additional studies and designs, and floodplain management and water

quality programs. Annual costs associated with mitigation could also include system operation and maintenance, flood warning system, monitoring, selective capital improvements, right-of-way purchase, and contingency fund.

7. The District should determine the level of service it will provide on an annual basis and proceed with implementation of a drainage utility. Implementation of an ongoing drainage user charge may be an appropriate method to fund a reasonable level of service from the District. The need for service has been estimated to be approximately $1 million annually for the watershed.

   These annual costs would be paid by all developed properties in the watershed. Implementation of the fund would include significant administrative work necessary to identify the property owners and assign annual fees.

   With the drainage utility in place, debt financing for this project would be easier to issue because the fund would be a secondary source of revenue, in case actual development (and associated impact fees) did not keep pace with repayment needs.

Chapter 1
Introduction

Purpose of Study

This study investigates ways to mitigate the effects of increases in storm runoff from proposed development in northwestern Placer County. Planned future land uses allow for significant industrial, commercial, and residential development. The increase in land coverage by buildings and pavement with such development increases flood flows and volumes.

Existing flooding problems in the lower (western) portion of the watershed have long been a concern to property owners in the area. Although flooding impacts in other portions of the watershed are also considered, the study focuses primarily on mitigating flooding impacts in the western portion of the watershed.

The Placer County Flood Control and Water Conservation District sponsored this study so land development could continue without increasing storm drainage into southeastern Sutter County. The study does not investigate measures to correct existing flooding problems. The study provides an overview of the potential drainage problems and recommends conceptual facilities to mitigate the increase in flood flows due to land development. A financing plan provides for collecting the fees required to construct and maintain the facilities. More detailed feasibility studies and designs will be required before finalizing the concepts and constructing the mitigation facilities.

Study Area

The study area is the watershed drained by Auburn Ravine, Coon Creek, Pleasant Grove Creek, Markham Ravine, and Curry Creek (see Figure 1-1). These creeks and their tributaries drain approximately 292 square miles of northwestern Placer County and southeastern Sutter County (88 percent in Placer County and 12 percent in Sutter County). The Natomas Cross Canal, at the western end of the study area, carries the combined flow of the creeks to the Sacramento River. An extensive area upstream of the Cross Canal, in eastern Sutter County and western Placer County, has periodically flooded and could be adversely affected by additional stormwater runoff from development in Placer County.

Currently, the watershed is primarily undeveloped. The western portion of the watershed is primarily agricultural, and the eastern portion is primarily woodland. The City of Lincoln and portions of the Cities of Auburn, Rocklin, and Roseville are located within the watershed. Approximately 2 percent of the watershed is covered with buildings and pavement. Land use projections based on existing General and Specific Plans show this area developing in the future to approximately 10 percent impervious.

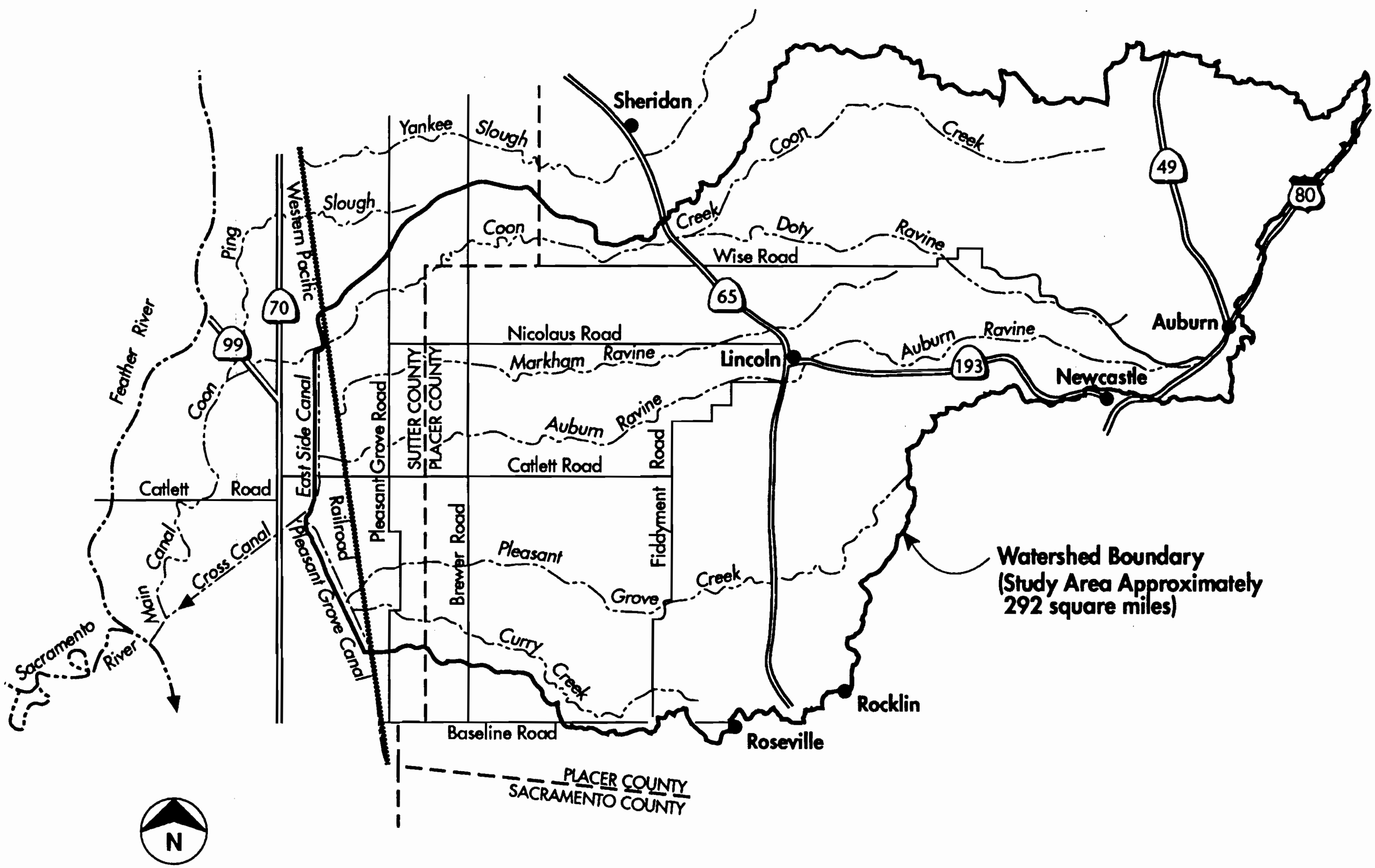

Figure 1-1
Study Area

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Previous Studies

There have been many drainage studies for various portions of the watershed. Most of these have been for specific development projects less than a few square miles in area. Two studies have been conducted for the entire watershed:

1. Coon Creek-Auburn Ravine Watershed Study, October 1967, by Kendall-Landis & Associates and Robert Beamish Consulting Engineers. The study addressed flood control, irrigation water, recreational facilities, and wildlife enhancement. Flood control was included as part of multipurpose projects.

2. Sutter-Placer Watershed Area Study, April 1982, by U.S. Soil Conservation Service. The study primarily addressed flood control but also included irrigation, drainage, and other watershed problems. A wide range of flood control projects was investigated, but most projects were not economical. The study recommended selective clearing for Curry Creek, King Slough, and Auburn Ravine and landowner-constructed dikes along King Slough and Markham Ravine.

Study Organization

CH2M HILL was authorized to prepare the flood mitigation plan by the May 21, 1990, Agreement with the Placer County Flood Control and Water Conservation District.

The District formed a Technical Advisory Committee (TAC) to contribute to and monitor the progress of the study. The TAC, which regularly reviewed study goals and methodologies, included staff members from Placer and Sutter Counties and the Cities of Auburn, Roseville, Lincoln, and Rocklin. The District's Policy Advisory Committee supplemented the work of the TAC with political and executive members of the same jurisdictions.

Public input on the study process was obtained through public meetings in Lincoln and Pleasant Grove.

Acknowledgements

We thank the members of the Technical Advisory Committee and the Policy Advisory Committee for their valuable guidance during the study. Special thanks goes to Dennis Huff, District Engineer, for the day-to-day coordination and assistance.

Chapter 2
Flooding Characteristics

Basin Characteristics

Climate

The climate of the area is often described as "Mediterranean," typified by dry, hot summers and wet, cool winters. Average annual precipitation ranges from approximately 15 inches in the western portion of the watershed to approximately 35 inches in the eastern portion. More than 88 percent of the precipitation normally occurs between November and April. Less than 2 percent of the annual precipitation occurs between June and August. Summer temperatures often exceed 100 degrees Fahrenheit, and winter temperatures are seldom lower than 20 degrees.

Topography

The watershed slopes from east to west with elevations ranging from 2,500 feet to 25 feet. The eastern portion of the watershed is located in the foothills of the Sierra Nevada. Stream channels in this area have slopes of several hundred feet per mile. The eastern portion of the watershed is typified by the much flatter land of the Central Valley. Stream channels in this area have slopes of a few feet per mile.

Soils

Figure 2-1 shows the generalized hydrologic soil groups in the watershed. The nearly level western portion of the watershed consists of somewhat poorly to poorly drained soils of moderately fine to fine textured alluvium. The nearly level to rolling terraces, with elevations ranging from 50 to 250 feet, consist of a sandy loam or loam surface layer and an underlying claypan or hardpan at 24 to 60 inches. The lower and middle foothill area of the eastern portion of the watershed consists of well-drained, gravelly coarse sandy loams to silt loams.

Natural and Manmade Features

The 292-square-mile watershed is drained by five major streams (see Figure 1-1). From south to north they are:

- Curry Creek—Drains approximately 17 square miles between Roseville and the western limit of the watershed. This area is primarily agricultural and open land less than 250 feet in elevation.

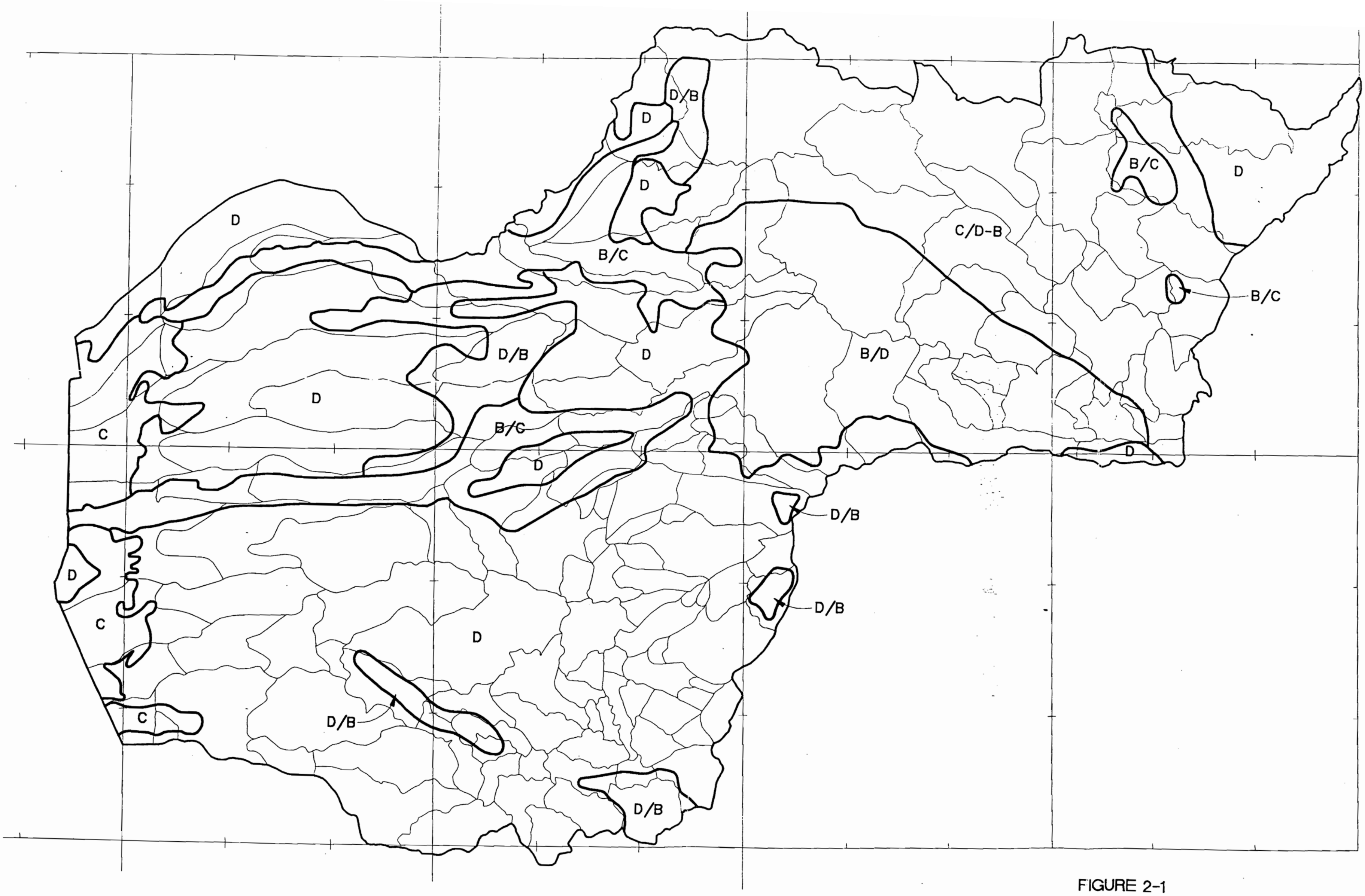

FIGURE 2-1
GENERALIZED SOILS

- Pleasant Grove Creek—Drains approximately 47 square miles between Rocklin and the western limit of the watershed. The Pleasant Grove Creek subbasin will be one of the most developed in the future because of growth in Rocklin and Roseville. The Howsley Tributaries drain approximately 6 square miles of agricultural land north of Pleasant Grove Creek.

- Auburn Ravine—Drains approximately 79 square miles and includes the Cities of Auburn and Lincoln. Planned growth of these cities will produce development similar to that which will occur in the Pleasant Grove subbasin. King Slough drains a small portion of agricultural land south of Auburn Ravine.

- Markham Ravine—Drains approximately 32 square miles of land between Lincoln and the western limit of the watershed. Planned growth in this drainage will primarily be limited to the upper portion, near Lincoln.

- Coon Creek—Drains approximately 112 square miles of mostly open land. Although this is the largest subbasin of the five, it will likely remain the most rural. Bunkham Slough drains an area of agricultural land between Markham Ravine and Coon Creek.

The creeks historically drained along their natural courses to the Feather and Sacramento Rivers. Reclamation District 1001 was formed in 1911 and constructed a canal/levee system to reclaim lands east of the Feather River from flooding. The East Side Canal intercepts Coon Creek, Bunkham Slough, Markham Ravine, Auburn Ravine, and King Slough. The Pleasant Grove Creek Canal intercepts the Howsley Tributaries, Pleasant Grove Creek, and Curry Creek. The two canals join to form the Natomas Cross Canal, which carries the flow from all the creeks to the Sacramento River. The Natomas Cross Canal forms the common boundary between Reclamation District 1001 to the north and Reclamation District 1000 to the south.

In addition to this canal/levee system, many low dikes have been constructed in the western portion of the watershed along the creeks by the adjacent landowners. Extensive land leveling and rechannelization have altered many of the natural stream channels east of the canal/levee system.

Existing Records

Stream Flow

There are no long-term continuous stream gaging records for any of the creeks within the watershed. A series of gages were operated intermittently from 1949 to 1966 (Table 2-1).

The City of Roseville is currently collecting records from a tributary to Pleasant Grove Creek. The lack of long-term continuous record at these stations limits their value for this study. They do not include data from major floods that could be used for calibration of the flood models.

Table 2-1
Stream Recording Stations

California Department of Water Resources (DWR) Station	DWR No.	Period of Record
Auburn Ravine near Auburn	A0-0920	1939
Auburn Ravine at Lincoln	A0-0060	1947-1962
Coon Creek at Highway 99E	A0-0080	1947-1962
Coon Watershed A near Lincoln	A0-0085	1956-1965
Coon Watershed B near Lincoln	A0-0086	1956-1965
Coon Watershed C near Lincoln	A0-0087	1957-1965
Natomas Cross Canal near Roseville	A0-2920	1949-1966
Pleasant Grove Creek at Lincoln Road	A0-0050	1950

Precipitation

Precipitation records were collected at numerous stations within and adjacent to the watershed. The earliest records are in 1869 at a Rocklin station. Few of the stations have long-term continuous record. Station records reviewed for this study are shown in Table 2-2.

Table 2-2
Precipitation Stations

Station	Period of Record	Station	Period of Record
Newcastle-Fowler	1942-58, 1962-88	Auburn-KAHI	1962-70, 1978-84
Loomis 3 ENE	1963-70, 1975-88	Roseville	1926-53, 1959-66
Loomis	1953-59, 1962-88	Roseville 6W	1965-66, 1968-69
Loomis No. 2	1966-88	Roseville City Hall	1982-83
Loomis 2NW	1947-54, 1962-64	Rocklin	1869-72
Cool	1958-86	Rocklin	1897-1939,1959-72
Coon Creek	1955-65	Rocklin 1SE	1954-64
Pines Ranch	1953-61	Rocklin Igarashi	1958-61
McClellan AFB	1953-88		

Sacramento River Stage

Flows have been recorded for the Sacramento River at Verona since water year 1930. The gage is located at the confluence of the Sacramento River and the Natomas Cross Canal. Figure 2-2 shows the maximum flow of the Sacramento River at Verona for each year of record. The three highest flows recorded at the gage have occurred since 1980, and six of the eight highest recorded flows have occurred since 1970.

The stage of the Sacramento River affects the severity of flooding within the western portion of the watershed. High flows in the Sacramento River result in higher stages in the Cross Canal. The capacity of the Cross Canal was estimated for various stages in the Sacramento River with the Corps of Engineers' HEC-2 computer program. The cross sections used in the modeling were obtained by the Corps of Engineers as part of its ongoing study of the American River. Figure 2-3 shows the Cross Canal rating used during the study.

Identified Existing Flood Problems

Flooding problems within the watershed range from local nuisance ponding to major flooding in the western portion of the watershed. Due to the large watershed size, local flooding problems were not reviewed in detail. This study does not attempt to resolve these existing flooding problems.

The Sutter-Placer Watershed Area Study by the Soil Conservation Service estimated approximately 31,000 acres of the watershed would be inundated during a 100-year frequency flood event (see Figure 2-4). Approximately 95 percent of this area is west of Highway 65, in the flatter portion of the watershed.

As described above, the watershed is drained by five major streams that join at the Cross Canal. During major flooding, inundation along the individual streams combines upstream of the Cross Canal to form a continuous body of water approximately 10 miles by 3 miles. Several roads in the western portion of the watershed flood once or more each year on the average. Sutter County normally places flood warning barriers along the roads at the beginning of winter. The County often closes roads several times during the winter when the channels overflow. These road closures inhibit public travel and movement emergency services.

The following elements contribute to this major flooding within the lower portion of the basin.

WATER YEAR MAXIMUM FLOWS

SACRAMENTO RIVER AT VERONA

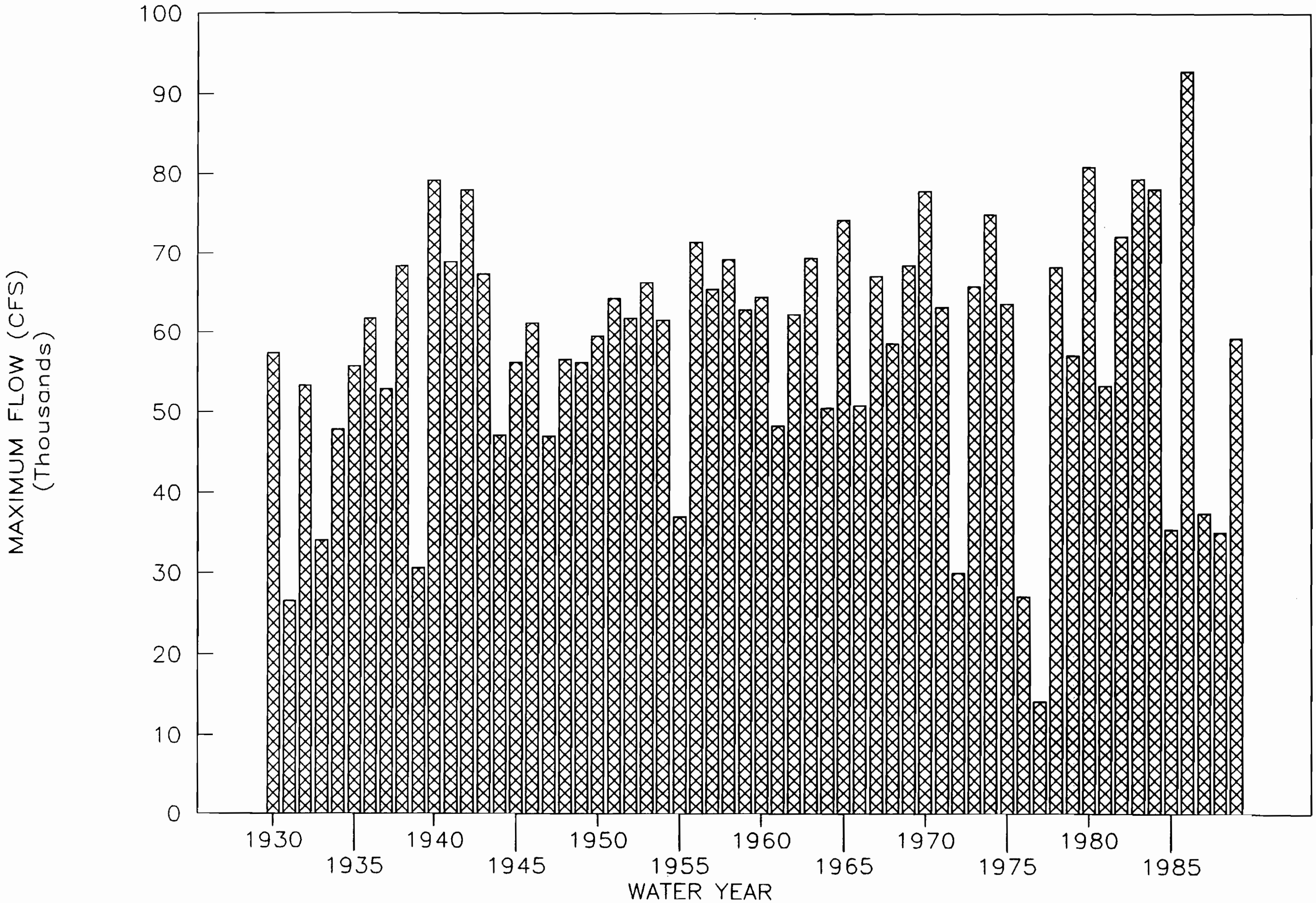

FIGURE 2-2

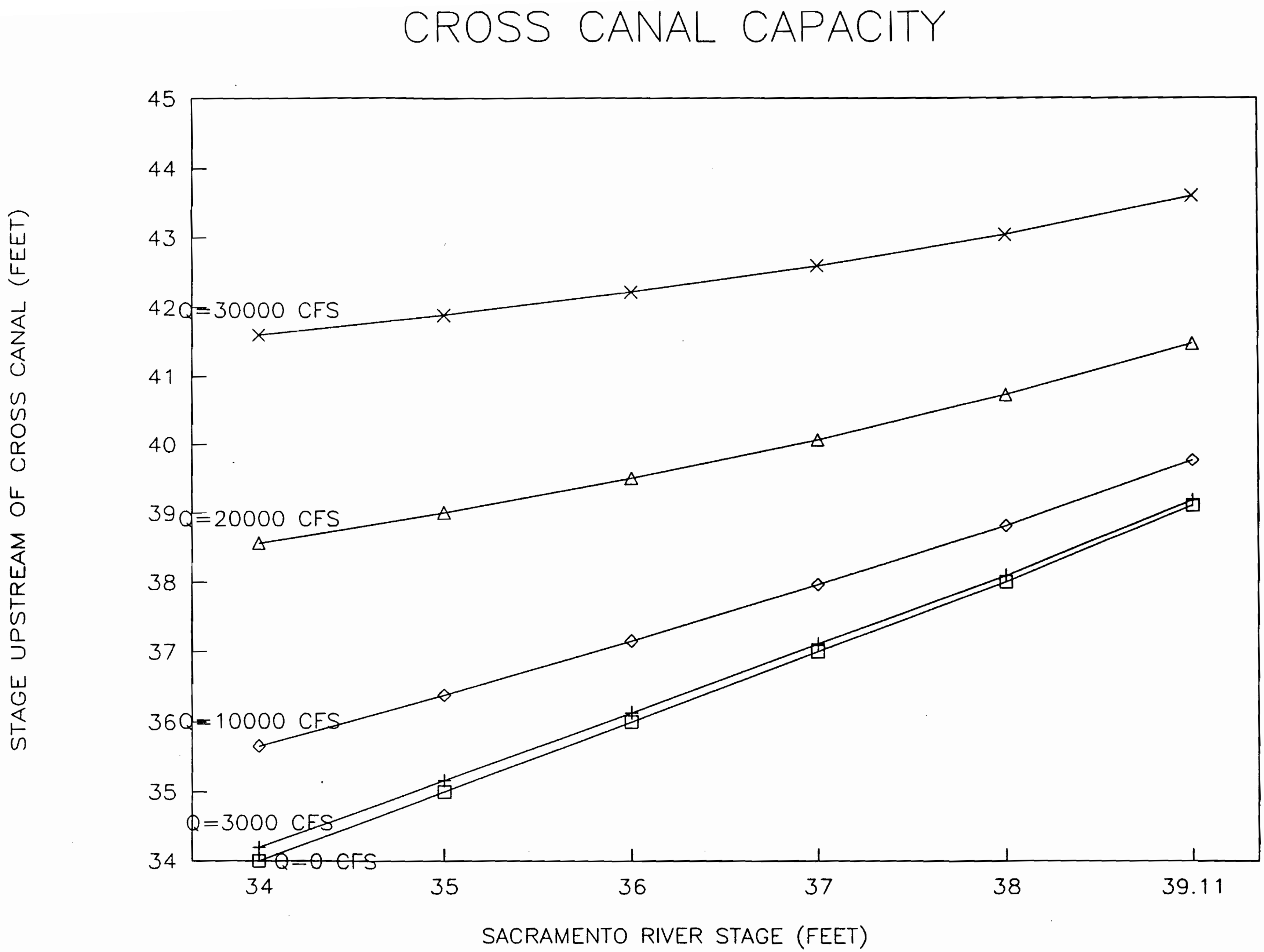
CROSS CANAL CAPACITY
STAGE UPSTREAM OF CROSS CANAL (FEET)
SACRAMENTO RIVER STAGE (FEET)
45
44
43
42
41
40
39
38
37
36
35
34
34
35
36
37
38
39.11
Q=30000 CFS
Q=20000 CFS
Q=10000 CFS
Q=3000 CFS
Q=0 CFS

FIGURE 2-3

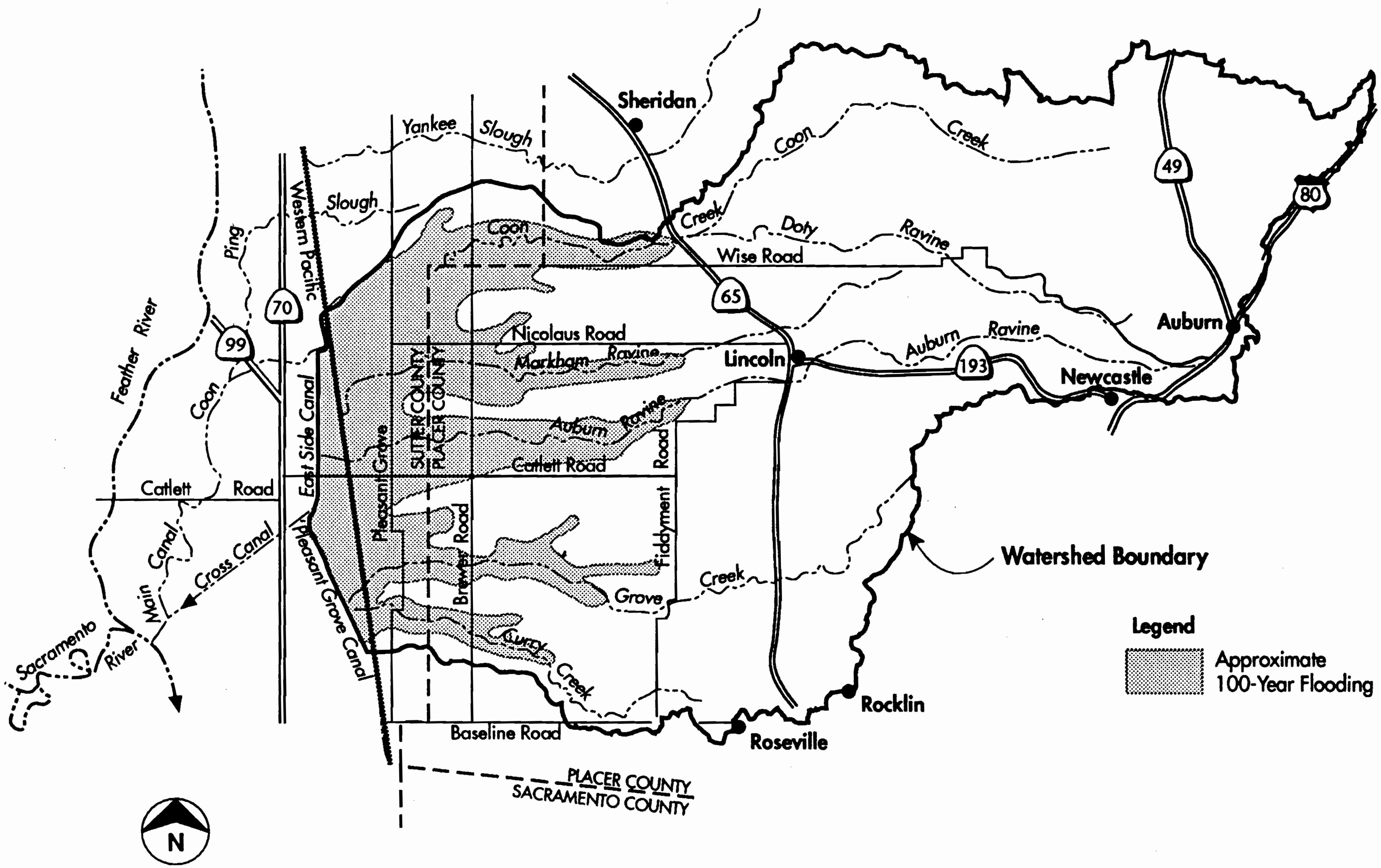

Figure 2-4
Approximate Flood Inundation
100-Year Frequency Flood

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Channel Capacity

Limited channel capacity contributes to flooding along each of the stream channels. Overgrowth and debris limit the capacity of most channels, but channel cross sections are generally small compared with even the frequent flood flows. For example, the 10-year flood flows are several times the limiting capacities of each of the streams. Because the area upstream of the Natomas Cross Canal is flat, most streams have small channels with extensive overbanks. Many of the channels have been further restricted by encroachment from agricultural development of the area. Flows exceeding the channel capacity spread across the broad overbank areas.

Bridges and Culverts

Like the stream channels, most bridges and culverts in the western portion of the watershed area are undersized. Due to the extensive overbank flooding, the majority of flows pass over the roads rather than through the bridge openings. Most roads are at grades similar to the adjoining land so they result in little resistance to flow. The exception to this is the Western Pacific Railroad grade which crosses the watershed approximately 1 mile upstream of the Cross Canal. The railroad is constructed on an embankment several feet higher than the surrounding ground. Floodwaters not passing through the bridges pond upstream of the railroad grade. Ponding continues until the railroad is overtopped.

River Stage

High stages in the Sacramento River result in higher stages upstream of the Cross Canal during flooding. As the Sacramento River rises, floodwaters in and upstream of the Cross Canal must rise to a higher elevation to flow to the river.

Flooding upstream of the Cross Canal does not necessarily depend on high stages in the Sacramento River. However, the river forms a downstream control where flood levels upstream of the Cross Canal cannot be lower than the river elevation. A high river stage coincident with high-flood Cross Canal flows would result in more flooding area upstream of the Cross Canal than with a low river stage.

During the February 1986 flood in the area upstream of the Cross Canal, the Sacramento River was also at a historically high stage. The river reached a stage of 39.11 feet NGVD (National Geodetic Vertical Datum, formerly Mean Sea Level). This historically high stage, together with the extreme flood flows from the watershed, resulted in the most severe flooding on record in the area upstream of the Cross Canal.

Land Leveling and Channel Modifications

The western portion of the watershed is primarily agricultural land. Extensive areas in Sutter County and the western portion of Placer County have been leveled for use as rice fields and other agriculture. As a result, many of the natural stream channels have been modified to conform to field boundaries. In many cases, this has decreased the natural storage and increased flow velocities. In some cases, berms surrounding the fields may redirect floodwaters and flood other areas.

The land leveling and channel modifications may have a greater impact on the more frequent floods than on a flood of 100-year return frequency.

Upstream Development

Development in this section is the residential, industrial, and commercial land development. An increase in impervious area from watershed development results in less water soaking into the ground during a storm. Development also increases flow velocities due to channel improvements. While major development can have large impacts on peak flood flows and volumes, the study watershed is largely undeveloped. Based on review of aerial photographs, approximately 2 percent of the watershed is covered with buildings and pavement. This development has resulted in small increases in flooding in the watershed (see Chapter 4). Existing flooding problems in the western portion of the watershed would not be significantly reduced even if all existing development could be removed from the watershed.

Recent Weather

Although recent weather cannot be classified as a flooding problem for the watershed, it likely contributes to perceptions that the frequency and severity of flooding has increased over the years. As mentioned above, the three highest recorded flows in the Sacramento River at Verona have occurred since 1980 and six of the highest eight flows have occurred since 1970. In addition, the February 1986 flood was the flood of record for the western portion of the watershed. The recent weather in combination with the other above problems make the recent flooding the most significant in memory.

Chapter 3
Hydrologic Modeling Methodology

Limitations

The scope of work provided for the study is a simplified overview of the existing drainage problems that are due to development within the watershed and presents a conceptual solution to these problems. The hydrologic modeling was prepared to estimate the changes in runoff due to land use changes over the watershed. Therefore, the model was necessarily simplified to include the drainage features of this very large watershed. The model is intended to be sufficient for general planning and will require refinement when more detailed drainage master plans are prepared. Following are model limitations:

- General in nature; used to evaluate an array of conditions.
- Simplified; no detailed field surveys were conducted.
- All channel lengths are based on drainage patterns shown on the USGS topographic maps. Extensive land leveling in the western portion of the watershed has changed local drainage patterns and channel configurations. The effects of these changes will be evaluated in future studies.
- Intended to evaluate drainage impacts over the large drainage area; model flows from small areas are likely underestimated. (However, the model can be used to model flows from small areas by inputing the appropriate precipitation for the area of interest.)
- Future land use was based on existing Community General and Specific Plans within the watershed. Areas identified as planning reserves were assumed to retain their existing land use throughout the model runs. The planning reserves were assumed not to develop for this study because the timing of development and repayment for mitigation facilities were less certain than for the areas covered by the General and Specific Plans. The Technical Advisory Committee decided that the planning reserves would be included in future mitigation planning at the time the Specific Plans are prepared.

However, the model was developed to be flexible for a number of uses. The above limitations can easily be eliminated in future studies by providing the detailed information needed for the specific area of interest.

Computer Program

The Corps of Engineers' HEC-1 computer program was used to model the hydrology of the watershed. The model was prepared to operate on an IBM-compatible PC with at least 2mb of expanded memory. The input file for the model was constructed within a Lotus 123 spreadsheet to allow for changes between runs. The spreadsheet consists of a data file and a HEC-1 file. Changes in the data file are automatically made in the HEC-1 file, which allows changes in routing coefficients, precipitation, land use condition, or other basin parameters.

Major Modeling Assumptions

Detailed information on all parameters needed for the model was not available due to the large watershed size. However, because the model was used primarily to evaluate the incremental impact between land use conditions and storm frequency, detailed information for many of the parameters is not necessary.

The following sections describe the major modeling assumptions.

Subbasins

The watershed was divided into 147 subbasins for modeling flood flows. The subbasins were selected so hydrographs could be determined at major stream junctions and road crossings and so each would represent a reasonably uniform future land use condition. Figure 3-1 shows the arrangement of subbasins in the watershed. The subbasins for each USGS topographic quadrangle are shown in detail in Appendix A.

Base Flow

Base flow for the model was estimated from the records of the Natomas Cross Canal (California Department of Water Resources Station No. A0-2920). The Cross Canal carries the flow from the study watershed, approximately 292 square miles. The records indicate that flows occasionally exceed 2,000 cfs, but flows ranging from 200 cfs to 1,000 cfs are common in the canal during the winter. Therefore, base flows ranging from approximately 1 to 3 cfs per square mile were considered reasonable for the model. Because base flow proved to be a relatively small component of the modeled flood flows, a base flow of 3 cfs per square mile was used for all evaluations.

Unit Hydrographs

The Placer County Stormwater Management Manual lists the kinematic wave method as the preferred method to compute runoff response from a watershed. The kinematic wave method is particularly useful in small developing areas because the model directly uses the physical geometry and lengths of flow channels. However, due to large watershed size and its primarily undeveloped nature, a unit hydrograph procedure was considered more appropriate.

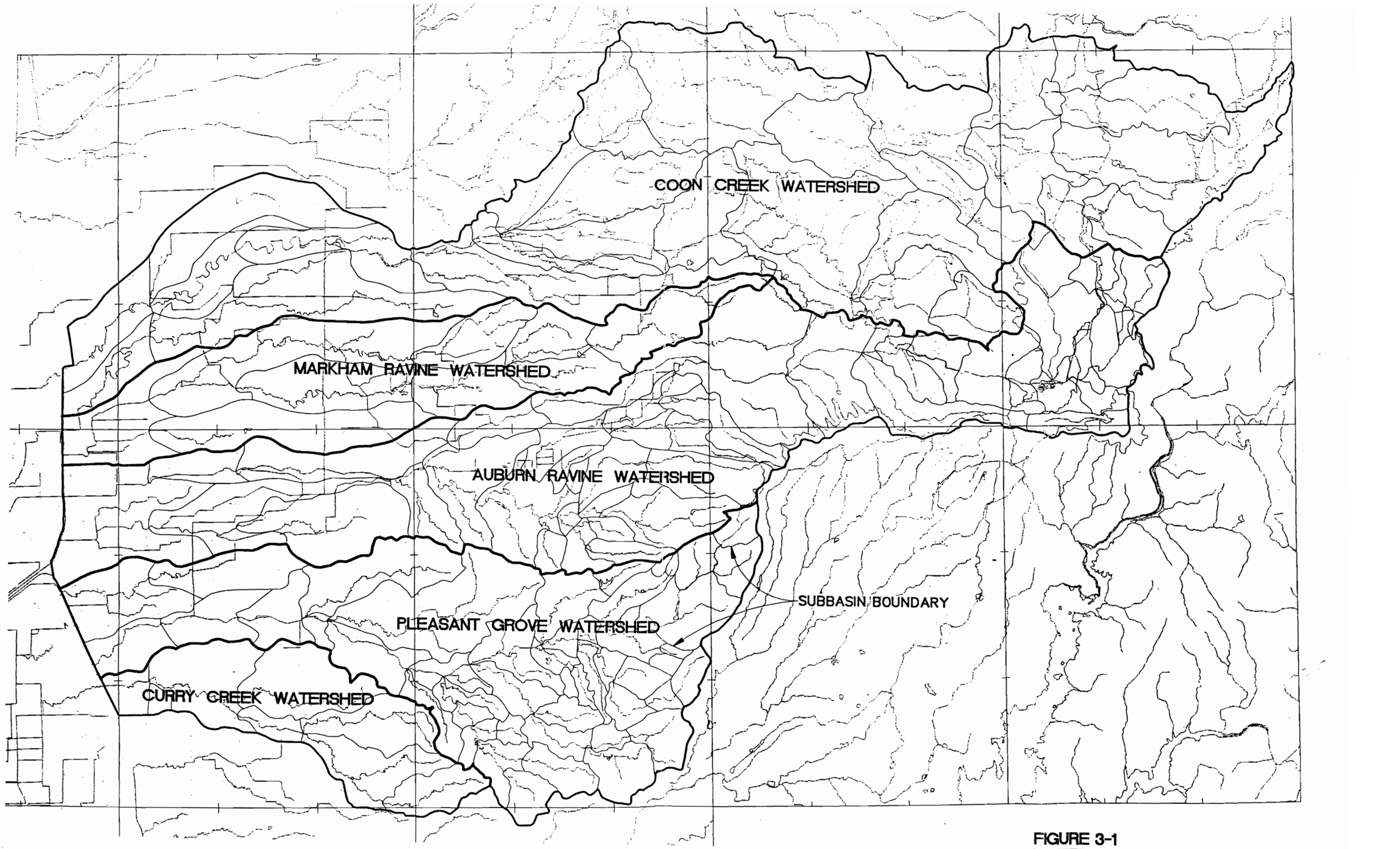

FIGURE 3-1
WATERSHED SUBBASINS

Three unit hydrograph procedures were screened in the initial model development:

- Soil Conservation Service dimensionless unit hydrograph
- Snyder unit hydrograph procedure
- S-graph procedure using the Los Angeles Valley S-graph from the Corps of Engineers

All three procedures were used to model flood flows with existing and future land use scenarios. Although the incremental flooding impacts were similar with each procedure, the Snyder unit hydrograph procedure was selected because it allowed for more flexibility in changing the unit hydrograph shape. The methodology is also consistent with that used for Placer County's drainage master plan for the Dry Creek Watershed to the south.

The lag for each subbasin was determined from the following formula:

$$Lag = 26 * "n" * (L * L_c / S^{.5})^{0.38}$$

where

Lag	=	Lag time in hours
"n"	=	Manning's "n" roughness for the subbasin
L	=	Length of longest flow path of subbasin in miles
L_c	=	Length along flow path to basin centroid in miles
S	=	Slope of flow path in feet/mile. The slope is between two points 10 and 85 percent of the length measured from the subbasin outlet.

In addition to the lag, the Snyder unit hydrograph procedure requires an estimate of a peaking coefficient (Cp) to adjust the hydrograph shape for each subbasin. Table 3-1 provides "n", Cp, and percent impervious for various land use types.

Table 3-1 Subbasin Parameters			
Subbasin Type	**Basin "n"**	**Cp**	**% Impervious**
Commercial	0.015	0.75	90
Business/Apartments	0.017	0.70	80
Industrial/Condominium	0.019	0.65	70
Residential (8 to 10 houses/acre)	0.021	0.60	60
Residential (6 to 8 houses/acre)	0.023	0.60	50
Residential (4 to 6 houses/acre)	0.025	0.60	40
Residential (3 to 4 houses/acre)	0.030	0.60	30
Residential (2 to 3 houses/acre)	0.035	0.60	25
Residential (1 to 2 houses/acre)	0.040	0.60	20
Rural Residential (1 to 2 acres minimum)	0.050	0.60	12
Rural (2 to 5 acres minimum)	0.080	0.60	3
Low Density/Open	0.08-0.12	0.60	2

Losses

Hydrologic analyses were conducted using a constant infiltration rate throughout the storms. However, the model was developed so the Holtan loss rate formula can be used in the future. The formula computes the loss rate, varying with time, based on the infiltration capacity of the soil. The formula is:

$$f = GIA * SA^{BEXP} + FC$$

where

f = Infiltration capacity in inches per hour

GI = "Growth index" representing the relative maturity of the ground cover

A = Infiltration capacity in inches per hour (inch $^{1.4}$ of available storage)

SA = Equivalent depth in inches of pore space in the surface layer of soil which is available for storage of infiltrated water

FC = Constant rate of percolation of water through the soil profile below the surface layer

BEXP = Empirical exponent, typically equal to 1.4

The use of this formula for estimating variable loss rates normally requires detailed soil information. The detail of available information varies widely over this large watershed; the more detailed soil information is in areas that have recently been developed. The model was run with estimates of the above parameters to check the sensitivity of using the variable loss rate or only the constant loss rate. Due to the variability of available data and the large watershed size, only the constant loss portion of the formula was used in the flood impact evaluations. The model will easily accept the more detailed information if needed for future studies.

Information from Table 5-4 of the Stormwater Management Manual (September 1990), developed by the Placer County Flood Control and Water Conservation District, was used to estimate infiltration rates. The manual points out that soils in the region are generally shallow, relatively impervious, and readily saturated and that the resulting infiltration rates are relatively low and can be assumed to be constant. The constant infiltration rates (FC) used in the modeling varied with the hydrologic soil type:

- Type A = 0.20 to 0.40
- Type B = 0.09 to 0.20
- Type C = 0.06 to 0.12
- Type D = 0.04 to 0.08

Land Use

The basis of this plan is the need to mitigate the difference in runoff between existing and future land use conditions. Development in place during mid-1990 was selected as the existing land use condition. The future land use condition was selected from the General and Specific Plans within the watershed.

Existing Land Use

Existing land use within the watershed was estimated from aerial photographs taken by Cartright Aerial Survey in 1989. This information was extended from field reconnaissance to include development present in mid-1990. A representation of existing land use is shown in Figure 3-2.

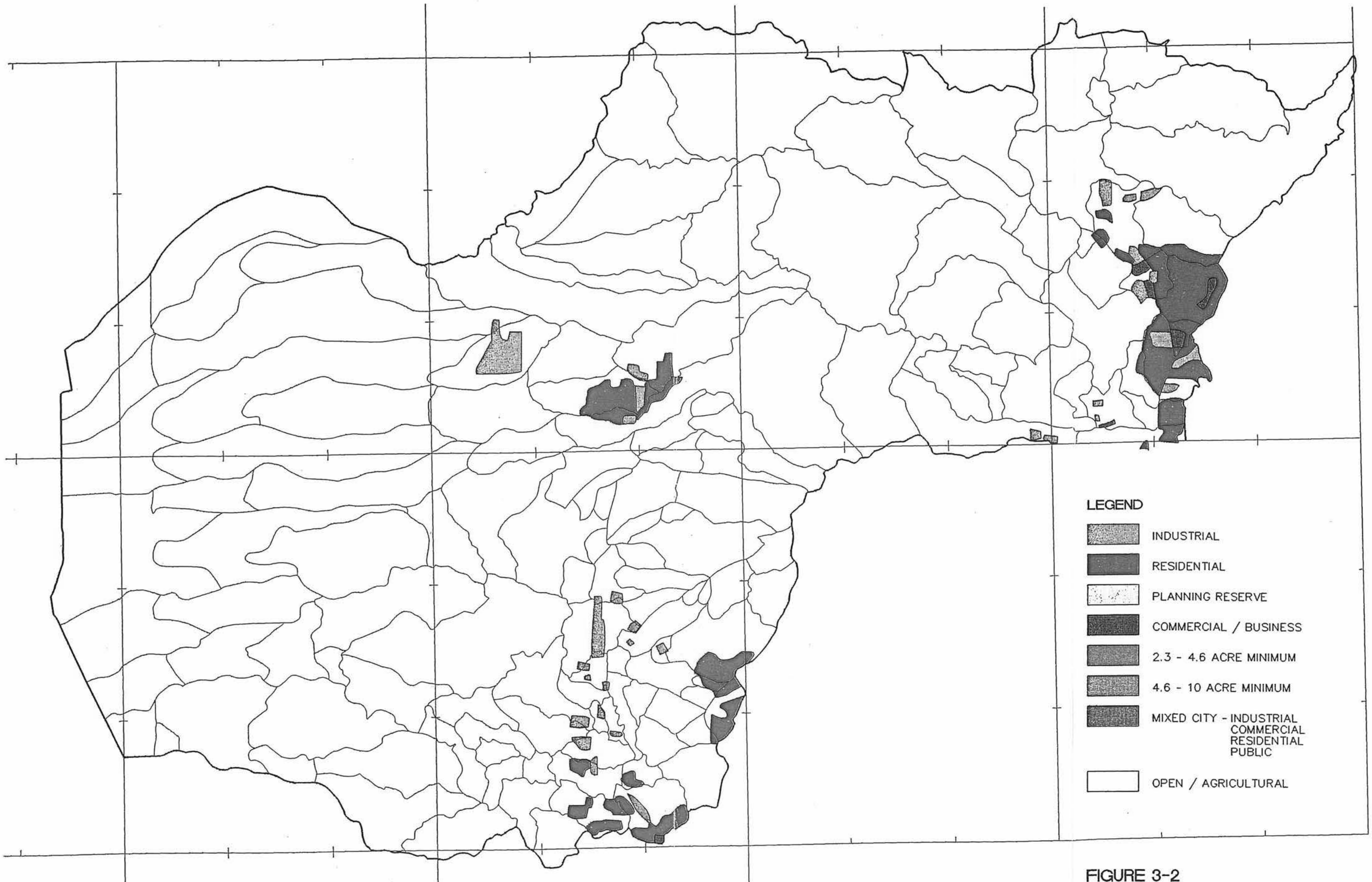

FIGURE 3-2
GENERALIZED EXISTING LAND USE

Future Land Use

There currently is no single plan for future buildout land use within the watershed. The Technical Advisory Committee decided that the General and Specific Plans within the watershed would form the basis of the future land use conditions for this study. The plans were prepared at different times by various jurisdictions but provide the best collective estimate of the future land use conditions. The plans used in this study are:

- Ophir General Plan and Environmental Impact Report, June 1983, by Placer County (planning year 2000)
- Sunset General Plan, 1980, by Placer County (planning year 2000)
- Auburn General Plan, 1978-1979, by City of Auburn (planning year 1995)
- Lincoln General Plan, September 1988, by Sacramento Area Council of Governments (planning year 2010)
- Bowman General Plan, May 1979, by Placer County (planning year 1995)
- Placer County General Plan, December 1967, by Placer County (planning year 2060)
- City of Rocklin, Stanford Ranch General Plan Amendment, January 1987
- North Central Roseville Specific Plan
- Northwestern Roseville Specific Plan, May 1989

A composite land use map (Figure 3-3) was prepared from these plans for the future land use condition for this study. The Placer County General Plan was used only for areas not covered by the other plans. The future land use conditions for each USGS topographic quadrangle are shown in detail in Appendix C.

Historical Land Use

The logic of mitigating only differences in runoff between the existing and future land use conditions was questioned during the public meetings and by some Technical Advisory Committee members. Their reasoning was that a base year of 1980, 1960, or earlier would be more reasonable because development has already increased runoff.

A consensus on an appropriate base year earlier than 1990 could not be obtained. Therefore, a hypothetical year was used to represent a condition prior to any buildings or pavement in the watershed. This land use assumes that there is no impervious area in the watershed but that the hydraulic conditions associated with the Cross Canal are in place. This would relate to approximately 1911.

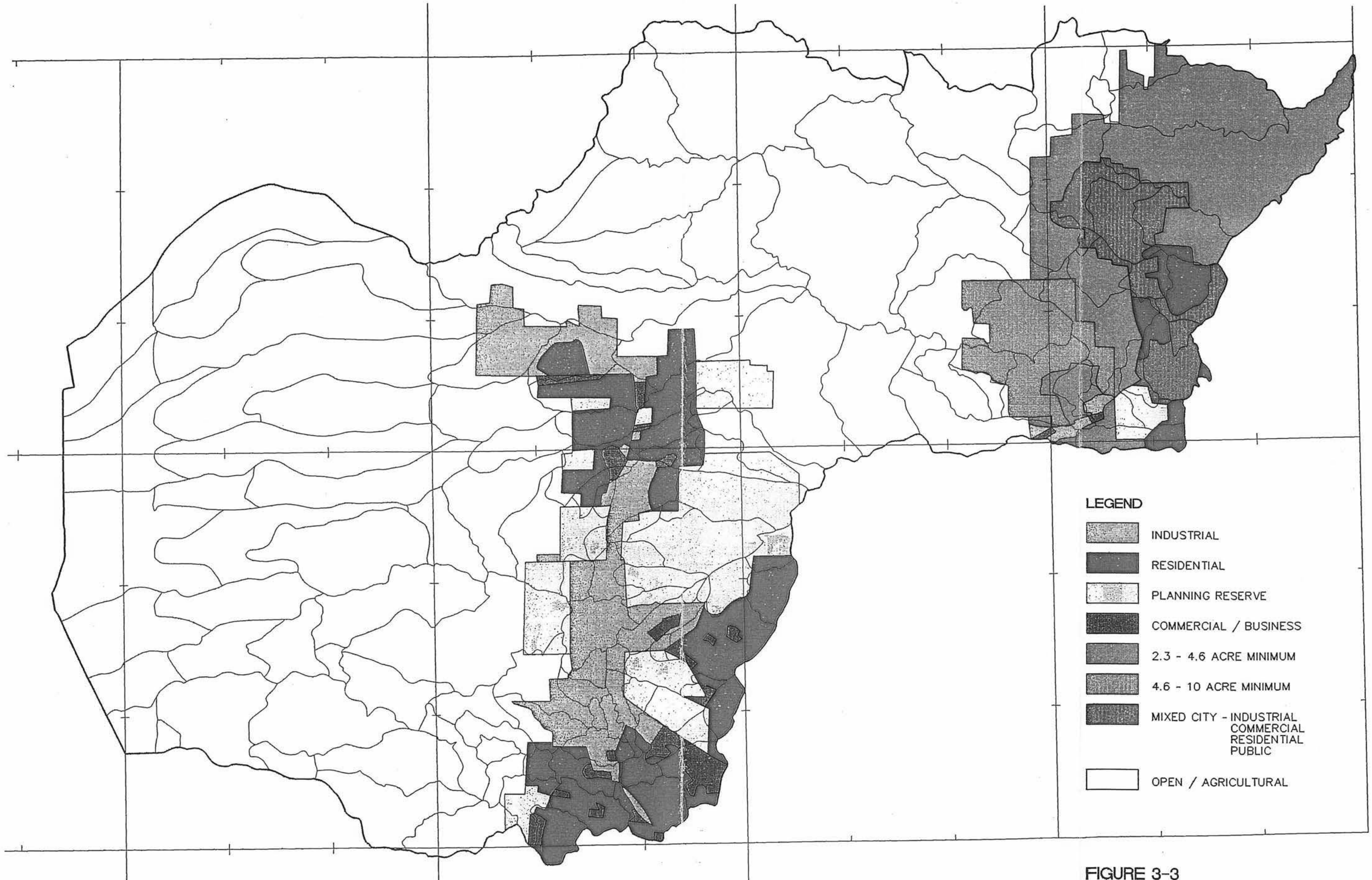

FIGURE 3-3
GENERALIZED FUTURE LAND USE

The flooding conditions for this hypothetical historical land use, when compared with the flooding conditions for existing land use, provides an estimate of the flooding impact resulting from the existing development.

Precipitation

Five storms were used to evaluate the flooding impacts:

- 2-year storm frequency of 24-hour duration
- 10-year storm frequency of 24-hour duration
- 25-year storm frequency of 24-hour duration
- 100-year storm frequency of 24-hour duration
- 100-year storm frequency of 8-day duration

The 24-hour duration storms were developed from the NOAA Atlas II for California. The watershed average storms used in the model are shown in Table 3-2. These storms include the areal reduction factors for the 292-square-mile basin. The hydrologic model was developed so each subbasin could accept different precipitation to account for precipitation changes with location. The mean annual precipitation for each subbasin was estimated from Figure 3-4 and used as an index to adjust the watershed average storms in Table 3-2 to each subbasin. The following relationship was developed to approximate the NOAA Atlas II precipitation changes:

Storm Precipitation at Subbasin = FACTOR*(Total from Table 3-2)

where

FACTOR = 0.047*(Mean Annual Precipitation for Subbasin)-0.065

The model spreadsheet uses this relationship to adjust the Table 3-2 incremental precipitation for each subbasin.

Table 3-2
24-Hour Storms

	Inches/Hour			
Hour	**2-Year**	**10-Year**	**25-Year**	**100-Year**
1	.05	.07	.09	.11
2	.05	.08	.09	.11
3	.05	.09	.10	.12
4	.06	.09	.10	.12\
5	.06	.09	.10	.12
6	.07	.10	.11	.14
7	.07	.11	.11	.14
8	.07	.11	.12	.15
9	.08	.13	.14	.18
10	.09	.13	.15	.18
11	.10	.15	.16	.21
12	.12	.18	.21	.24
13	.19	.26	.30	.37
14	.41	.55	.65	.79
15	.14	.21	.23	.29
16	.11	.15	.18	.22
17	.08	.12	.14	.16
18	.08	.10	.13	.16
19	.07	.10	.12	.14
20	.06	.09	.10	.13
21	.06	.09	.10	.12
22	.05	.08	.09	.11
23	.06	.08	.09	.11
24	.05	.08	.08	.10
Total	2.23	3.24	3.69	4.52

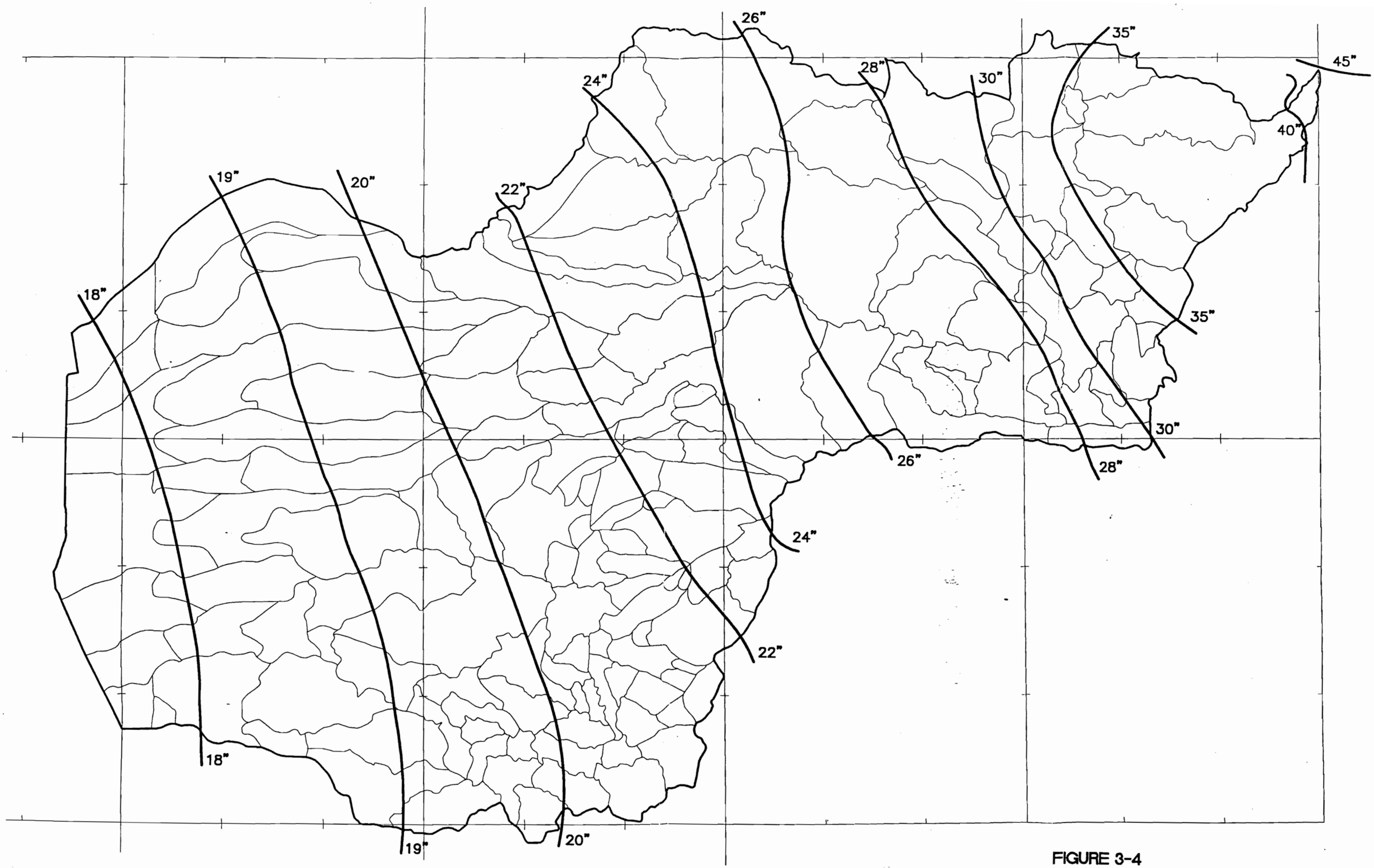

FIGURE 3-4
MEAN ANNUAL PRECIPITATION

The 8-day 100-year storm was selected as the longest duration storm that is reasonably possible. This long storm provides a much larger volume than the 24-hour storms. The 8-day 100-year storm was patterned after the February 1986 storm that created significant flooding in the lower portion of the watershed. The 8-day precipitation depth for the 1986 storm was checked at precipitation stations from Rocklin to Cool to estimate how the storm varied over the basin. The precipitation did show some increase with elevation, but not nearly as much as would be determined from the above relationship for the 24-hour storms. Therefore, the precipitation pattern recorded at the Rocklin station was used to pattern the 8-day 100-year precipitation depth of 10.67 inches. Because the precipitation recorded in the 1986 storm did not vary widely with location, no areal reduction was used.

Table 3-3 shows the watershed average 8-day storm used by the model.

Routing

Routing of flows through channel reaches was modeled using the normal-depth modified Puls relationship in HEC-1. The cross sections used in the routing were estimated by observations at 99 road crossings of the channels within the watershed. The channel cross sections, including overbank and roughness, were estimated during the field reconnaissance. The flow length through each subbasin was used as the routing reach for upstream flows passing through the subbasin.

Due to the extensive ponding upstream of the Cross Canal during major flooding, the area was modeled as a reservoir. An area-capacity relationship was developed from the USGS topographic maps. The inflow to the reservoir was the combined flow of the creeks entering this area. The outflow was determined from the rating of the Cross Canal capacity (Figure 2-3). The model runs were conducted for stages of the Sacramento River varying from elevation 34 to 39.11 feet and the corresponding ratings of the Cross Canal.

Validation

The lack of long-term stream gaging information in the watershed prevented direct validation of the model. However, flows estimated by Magnitude and Frequencies of Floods in California by the U.S. Geological Survey were compared with the flows generated by the model. The modeled flows at many locations in the watershed were on the same order of magnitude as those estimated from the publication.

Table 3-3
8-Day 100-Year Storm
Hourly Precipitation Pattern

Hour	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8
1	0.00	0.00	0.00	0.01	0.00	0.07	0.00	0.05
2	0.05	0.01	0.00	0.12	0.00	0.05	0.00	0.01
3	0.10	0.02	0.00	0.50	0.00	0.01	0.01	0.00
4	0.07	0.02	0.00	0.01	0.05	0.02	0.02	0.00
5	0.02	0.00	0.05	0.00	0.03	0.03	0.00	0.00
6	0.01	0.00	0.04	0.07	0.02	0.02	0.00	0.00
7	0.02	0.00	0.01	0.04	0.04	0.10	0.00	0.01
8	0.01	0.00	0.00	0.03	0.02	0.19	0.00	0.01
9	0.00	0.00	0.05	0.15	0.00	0.11	0.01	0.00
10	0.00	0.00	0.02	0.02	0.00	0.04	0.01	0.01
11	0.00	0.00	0.03	0.03	0.00	0.26	0.01	0.00
12	0.02	0.00	0.02	0.01	0.03	0.20	0.01	0.01
13	0.06	0.00	0.15	0.06	0.03	0.04	0.08	
14	0.04	0.00	0.03	0.02	0.10	0.01	0.01	
15	0.13	0.00	0.00	0.02	0.08	0.00	0.00	
16	0.05	0.00	0.01	0.02	0.09	0.10	0.00	
17	0.06	0.00	0.00	0.02	0.08	0.07	1.15	
18	0.08	0.00	0.00	0.00	0.25	0.11	0.15	
19	0.06	0.02	0.01	0.02	0.20	0.12	0.15	
20	0.20	0.12	0.02	0.04	0.08	0.15	0.25	
21	0.02	0.03	0.01	0.01	0.06	0.10	0.80	
22	0.03	0.03	0.01	0.01	0.05	0.25	1.00	
23	0.02	0.00	0.01	0.00	0.05	0.01	0.20	
24	0.02	0.00	0.02	0.00	0.01	0.04	0.13	

Note: Adjusted to 10.67 inches total in model.

Use of Model

The HEC-1 model was developed within a Lotus 123 spreadsheet so the input files for alternative runs could easily be produced. Physical data pertaining to each subbasin are contained in tabular form at the beginning of the spreadsheet. The tabular data are followed by the HEC-1 input file. Physical data can be changed to represent different land use conditions or other scenarios. The changes are directly computed by the spreadsheet and inserted into the appropriate location in the input file.

Appendix B provides more detail on use of the model.

Chapter 4

Flooding Impact Comparisons

Before flood mitigation alternatives were evaluated, various hydrologic conditions were tested to provide information on changes in flooding impact. It is important to understand the magnitude of these impacts because elimination of these impacts is the goal for the mitigation alternatives in this plan. Elimination of 2 feet of flooding depth impact or elimination of a quarter-inch of flooding depth impact would likely be viewed differently by most people. Policy makers and the public need to understand what the mitigation facilities will achieve.

Flood stage changes between the model runs are the primary measures of flooding impact used in this study. Due to the lack of detailed survey information, especially in the lower portion of the watershed, the absolute values of flood elevations are not known. However, the incremental change in flood stage is more important for this evaluation than are actual flood elevations. Because the model is used to evaluate the general change in flooding over a very large area, the actual flooding impacts at a specific location may be more or less than modeled.

Appendix C contains tables showing flow for the various flooding scenarios:

- 8-day, 100-year storm with historical land use
- 8-day, 100-year storm with existing land use
- 8-day, 100-year storm with future land use
- 24-hour, 100-year storm with future land use

Summary tables in Appendix C also show approximate stage change due to land use changing from historical to existing and from existing to future conditions.

Storm Duration

The flooding impacts during a 24-hour 100-year frequency storm were compared with the flooding impacts during an 8-day 100-year frequency storm to test the sensitivity of storm duration over the watershed. The two storm durations were used because sizing of some mitigation alternatives will be more sensitive to the larger 8-day storm volume. The computed maximum stages for the 8-day duration storm were higher than those for the 24-hour duration storm for each routing reach of the model. The stages for the 8-day duration storm average 1.1 feet higher than the 24-hour duration storm and depending on location within the basin are from 0.23 to 3.88 feet higher.

Although this represents a significant difference between the two storms, the two storms show similar impacts for changes in land use. For example, the change in watershed land use from existing conditions to future conditions would result in approximately a 0.12-foot increase in flood stage upstream of the Cross Canal during the 24-hour storm. The corresponding stage increase for the 8-day storm would be approximately 0.08 foot. Table 4-1 shows the impacts for other locations in the watershed.

Table 4-1
Storm Duration Impact For 100-Year Storms

Creek	Location	Stage Change (ft) Existing to Future Land Use Change	Stage Change (ft) Existing to Future Land Use Change
		24-Hour Duration	8-Day Duration
Curry Creek	Brewer Road	0.01	0.00
Pleasant Grove Creek	Highway 65	0.01	0.00
	South Branch at Highway 65	0.29	0.28
	Fiddyment Road	0.30	0.22
	Pettigrew Road	0.14	0.11
	Brewer Road	0.15	0.16
Auburn Ravine	Highway 49	0.10	0.11
	Ophir	0.17	0.16
	Highway 65	0.09	0.04
	Brewer Road	0.06	0.04
Markham Ravine	Highway 65	0.62	0.71
	Brewer Road	0.08	0.05
Coon Creek	Dry Creek at Highway 49	0.27	0.16
	Dry Creek/Orr Creek Confluence	0.32	0.27
	Highway 65	0.10	0.07
	Brewer Road	0.06	0.03
Cross Canal	U/S Ponding Area	0.12	0.08

Note: Does not represent 100-year flood at the specific locations because storms were patterned to cover entire 292-square-mile watershed.

Land Use Changes With No Mitigation

Existing land use conditions were used as the base case for estimating the impacts of future development. This change in development is measurable in terms of the growth anticipated by the General and Specific Plans in the watershed. The future development is also a source of revenue to pay for the needed mitigation.

During the initial stage of the study, there were several suggestions that an earlier base year be used to account for development that has occurred in recent years. However, there was no consensus on which year would be appropriate. Unlike mitigating for the future development, there is not an acceptable way to collect mitigation fees from existing development. Because the current level of development is relatively low, a hypothetical year prior to development within the basin was used as an estimate of the amount of existing impact. For this condition, the basin was modeled as a natural basin, prior to buildings and pavement.

The watershed developing to existing conditions has the most impact directly adjacent to the development. In the lower reaches of the watershed, the impact is much less. The hydrologic modeling indicated that the impact in the area upstream of the Cross Canal may be in the neighborhood of 0.05 foot. The impact from the land use changing from "existing" to "future" would be approximately 0.12 foot in the same area. Flood hydrographs for Pleasant Grove Creek, Auburn Ravine, and Coon Creek are shown in Figures 4-1, 4-2, and 4-3. Each figure shows hydrographs for the three land use conditions.

Storm Frequency

Storms of 2-, 10-, 25-, and 100-year frequency were evaluated for their respective impacts on flooding stage. Each storm was evaluated with the three land use scenarios. Table 4-2 shows estimated flooding stage impacts for land use changes from "historical" to "existing" conditions. Table 4-3 shows estimated flooding stage impacts for land use changes from "existing" to "future" conditions. Tables in Appendix C show estimated impacts for land use changes for each subbasin.

Effect of Sacramento River Stage

The stage in the Sacramento River has a direct impact on the degree of flooding upstream of the Cross Canal during high flows from the watershed. The Cross Canal flow relationships in Figure 2-3 were used to model the outflow from the watershed. Because the flow relationships change with the river stage, the effect of various river stages can be evaluated by comparing the flooding impacts with the various Cross Canal flow relationships. River stages from elevation 34 to 39.11 feet were used in the analyses. The comparisons showed that the river stage did not have a significant effect on the flooding stage change due to development.

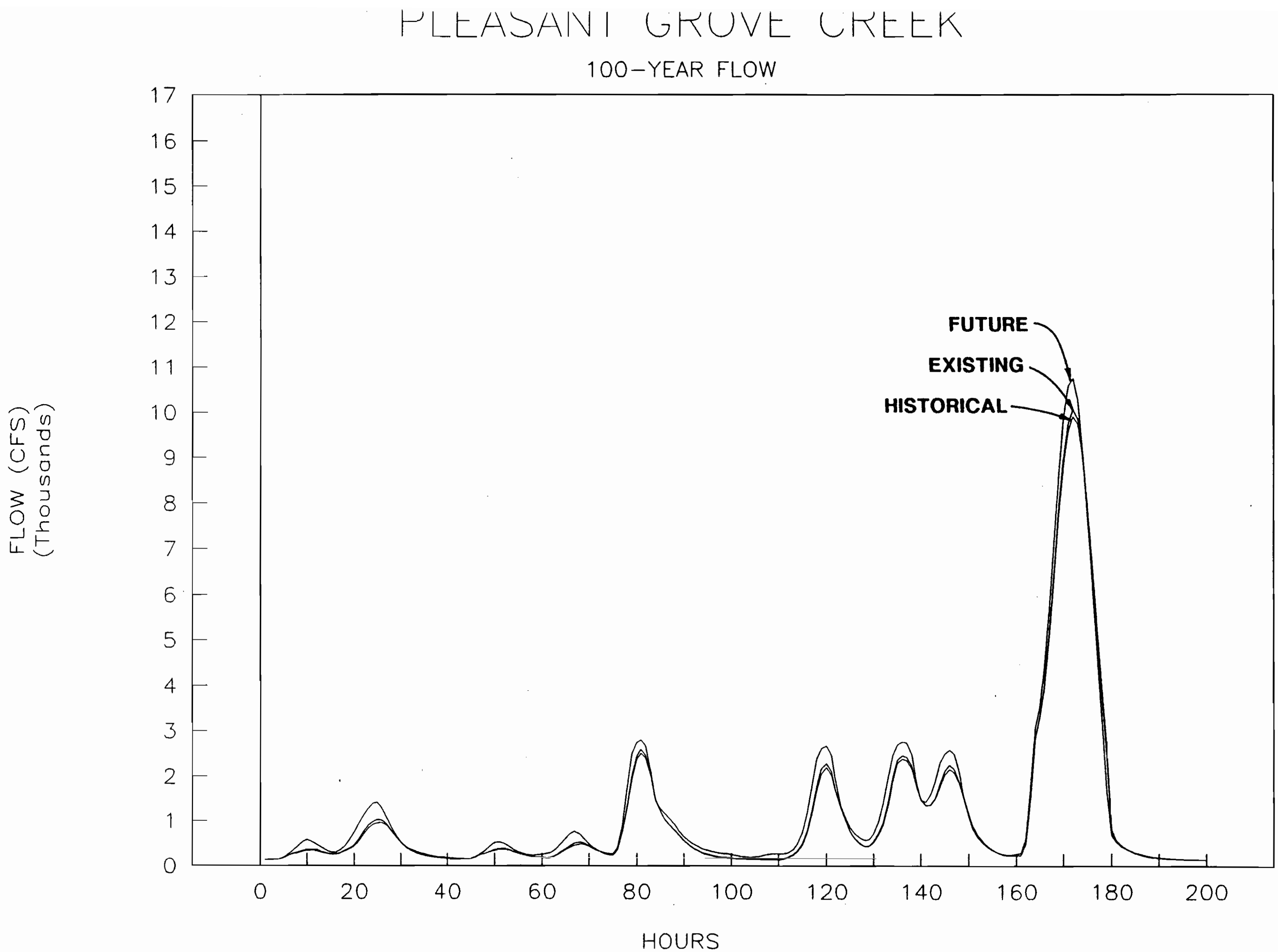

FIGURE 4-1
PLEASANT GROVE CREEK
100-YEAR FREQUENCY HYDROGRAPH

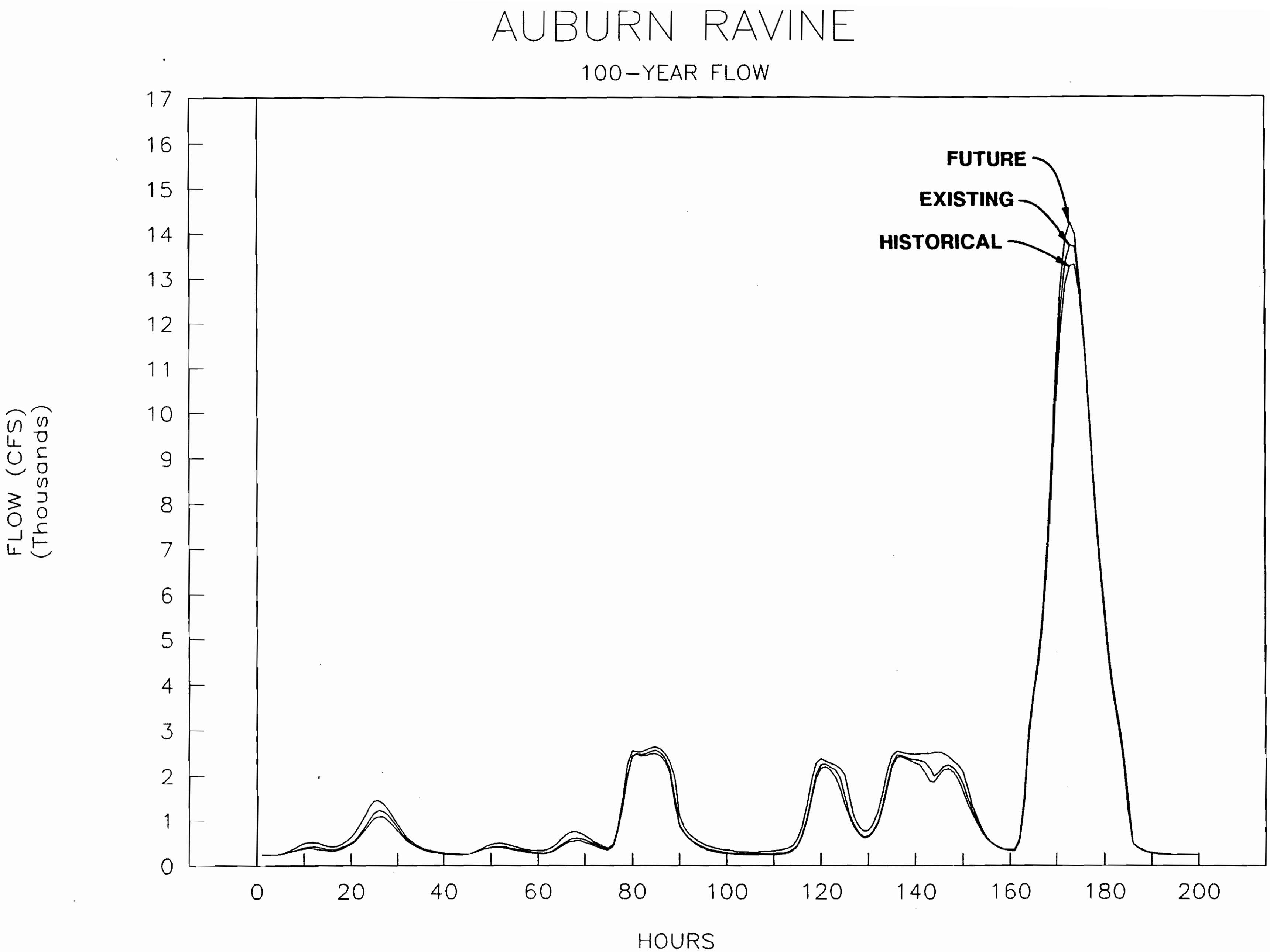

FIGURE 4-2
AUBURN RAVINE
100-YEAR FREQUENCY HYDROGRAPH

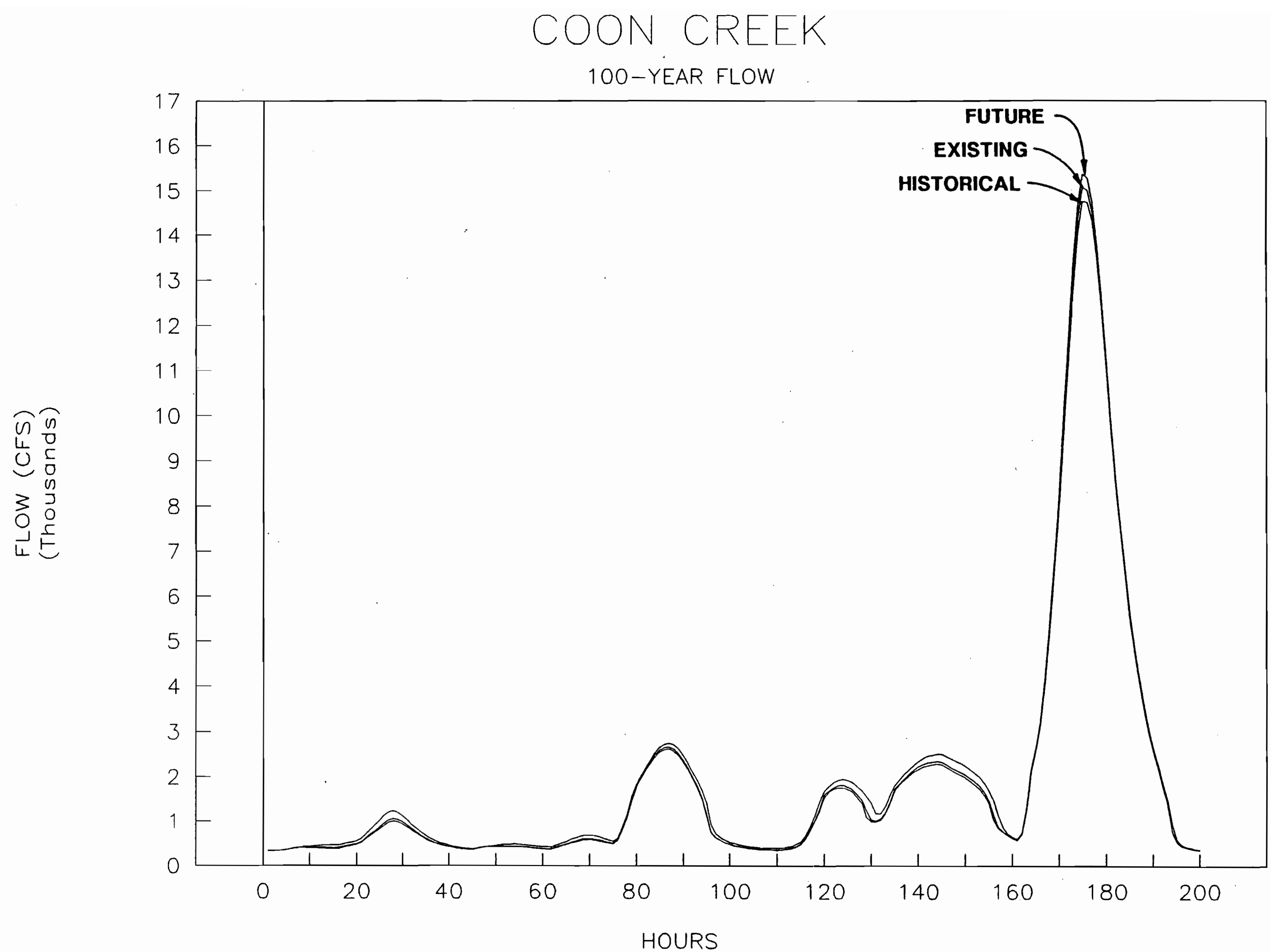

FIGURE 4-3
COON CREEK
100-YEAR FREQUENCY HYDROGRAPH

Table 4-2
Historical to Existing Land Use Impact

Creek	Location	Stage Change (ft) 2-Yr	Stage Change (ft) 10-Yr	Stage Change (ft) 25-Yr	Stage Change (ft) 100-Yr (24-Hr)	Stage Change (ft) 100-Yr (8-Day)
Curry Creek	Brewer Road	0.00	0.00	0.00	0.00	0.00
Pleasant Grove Creek	Highway 65	0.15	0.12	0.11	0.12	0.13
	South Branch at Highway 65	0.38	0.22	0.16	0.19	0.13
	Fiddyment Road	0.25	0.08	0.08	0.07	0.08
	Pettigrew Road	0.08	0.04	0.05	0.03	0.03
	Brewer Road	0.08	0.04	0.03	0.03	0.03
Auburn Ravine	Highway 49	0.26	0.30	0.31	0.36	0.78
	Ophir	1.18	0.93	1.03	0.88	0.57
	Highway 65	0.24	0.18	0.14	0.19	0.16
	Brewer Road	0.14	0.11	0.07	0.06	0.05
Markham Ravine	Highway 65	0.03	0.02	0.02	0.01	0.01
	Brewer Road	0.13	0.05	0.03	0.02	0.01
Coon Creek	Dry Creek at Highway 49	0.18	0.36	0.48	0.40	0.38
	Dry Creek/Orr Creek Conflu-ence	0.45	0.55	0.42	0.43	0.44
	Highway 65	0.11	0.10	0.09	0.09	0.08
	Brewer Road	0.06	0.04	0.02	0.04	0.03
Cross Canal	U/S Ponding Area	0.00	0.04	0.04	0.04	0.05

Note: Does not represent flood at the specific locations because storms were patterned to cover entire 292-square-mile watershed.

Table 4-3
Existing to Future Land Use Impact

Creek	Location	Stage Change (ft) 2-Yr	Stage Change (ft) 10-Yr	Stage Change (ft) 25-Yr	Stage Change (ft) 100-Yr (24-Hr)	Stage Change (ft) 100-Yr (8-Day)
Curry Creek	Brewer Road	0.01	0.01	0.00	0.01	0.00
Pleasant Grove Creek	Highway 65	0.01	0.01	0.01	0.01	0.00
	South Branch at Highway 65	0.73	0.59	0.45	0.29	0.28
	Fiddyment Road	0.74	0.52	0.40	0.30	0.22
	Pettigrew Road	0.34	0.20	0.14	0.14	0.11
	Brewer Road	0.35	0.21	0.13	0.15	0.16
Auburn Ravine	Highway 49	0.10	0.11	0.10	0.10	0.11
	Ophir	0.29	0.27	0.25	0.17	0.16
	Highway 65	0.16	0.12	0.09	0.09	0.04
	Brewer Road	0.11	0.09	0.09	0.06	0.04
Markham Ravine	Highway 65	0.51	0.53	0.58	0.62	0.71
	Brewer Road	0.34	0.18	0.10	0.08	0.05
Coon Creek	Dry Creek at Highway 49	0.39	0.46	0.48	0.27	0.16
	Dry Creek/Orr Creek Confluence	0.44	0.56	0.33	0.32	0.27
	Highway 65	0.34	0.13	0.11	0.10	0.07
	Brewer Road	0.12	0.09	0.06	0.06	0.03
Cross Canal	U/S Ponding Area	0.08	0.10	0.12	0.12	0.08

Note: Does not represent flood at the specific locations because storms were patterned to cover entire 292-square-mile watershed.

Chapter 5
Flood Mitigation

Alternatives

As discussed in Chapter 4, flooding impacts due to changes in land use are relatively small compared to flooding conditions already prevalent in the lower portion of the watershed. The question asked independently by Technical Advisory Committee members, Political Advisory Committee members, and others involved with the study was, "Are these significant impacts?" To date there has not been a consensus on the answer to this question, but most believe it was a policy question for Placer and Sutter Counties.

For this study, a flooding impact was considered "insignificant" if it could not be physically measured by typical water stage measuring devices. During a flooding event, it would be difficult to accurately measure a water surface closer than about 0.01 foot.

The following sections describe the mitigation alternatives considered in the evaluation.

Local Detention Basins

The largest impact in flood stage due to changes in land use normally occurs immediately downstream of development. Although the magnitude of the impact would diminish as the flow progresses downstream, the development can affect flood stages for many miles downstream. The modeling indicated that if local detention basins are not constructed, stages in the streams could increase by 1 to 4 feet at some locations for the 100-year flood. Although no information was available on the actual impacts of these stage changes, it was assumed that they would be unacceptable to the local jurisdictions.

Local detention basins were evaluated for mitigating these increases in stage in the stream channels due to increases in peak flow. Thirty to thirty-five detention basins (from 10 to 50 acre-feet) were included in the model to mitigate local impacts for the model runs. Because the detention basins need to be located near the development, they are less effective in controlling flooding at the western end of the watershed. If these detention basins are the only mitigation for future development, they would eliminate approximately 15 percent of the stage increase upstream of the Cross Canal. Therefore, local detention basins alone are not effective in mitigating all flood impacts in the watershed.

Regional Storage Facilities

Where the local detention basins control peak flows in the stream channels, the regional storage facilities would provide more control for the increased volume of runoff from development. Due to the large ponding area upstream of the Cross Canal, the area is affected even though the local detention basins can prevent peak flow from increasing. Since the regional storage facilities control increases in flood volume, they are much larger than the local basins. A series of large storage facilities (Figure 5-1) were considered throughout the watershed:

- Locations in the foothills upstream of Highway 65 were not effective in mitigating the development due to the small drainage areas and the amount of development downstream of the sites that would not be served by an upstream reservoir. Therefore, large basins upstream of Highway 65 were not evaluated in further detail.

- A single regional storage facility of approximately 3,600 acre-feet capacity could mitigate the stage impact in the flooding area upstream of the Cross Canal. Such a basin would store more water than required to mitigate the development within the Pleasant Grove drainage in trade for allowing Auburn Ravine and Coon Creek to flow uncontrolled.

- Regional storage facilities on Coon Creek, Auburn Ravine, and Pleasant Grove Creek would have a combined storage similar to the single basin but would provide additional benefit in that flows would be controlled on each creek rather than on just one.

The basins were sized by routing the floods through various sized basins with uncontrolled outlets. Existing flooding stages in Sutter County were used as the target stages for the future land use conditions with the basins in place. It was found that the three basins with a combined storage of approximately 3,600 acre-feet would provide this mitigation. The basins would each store approximately 1,200 acre-feet, but depending on final design locations, the storage could be divided differently with little change in the routing results. For example, the size of the basins could be unbalanced where one was as large as 1,500 acre-feet and another was as small as 900 acre-feet. Both on-channel and off-channel basins were considered and found to provide similar results.

The basins were sized to control both the 10- and 100-year floods. This resulted in larger basins than if only the 100-year flood was to be mitigated.

Participation in American River Watershed Project

The District is exploring the possibility of cooperative projects with Sutter County and Sacramento Area Flood Control Agency (SAFCA). The Corps of Engineers and SAFCA are proposing to raise the levees at the western end of the watershed to provide flood protection for the Natomas area to the west. Because this levee work could keep the levees from failing during a flood, the flood stage upstream of the Cross Canal would be higher. The Corps of Engineers estimates that the stage impact could be approximately 0.2 to 0.4 foot. To mitigate this impact, the Corps of Engineers considered purchase of flowage easements, lengthening the Fremont Weir on the Sacramento River to lower stages, and construction of storage near the Cross Canal.

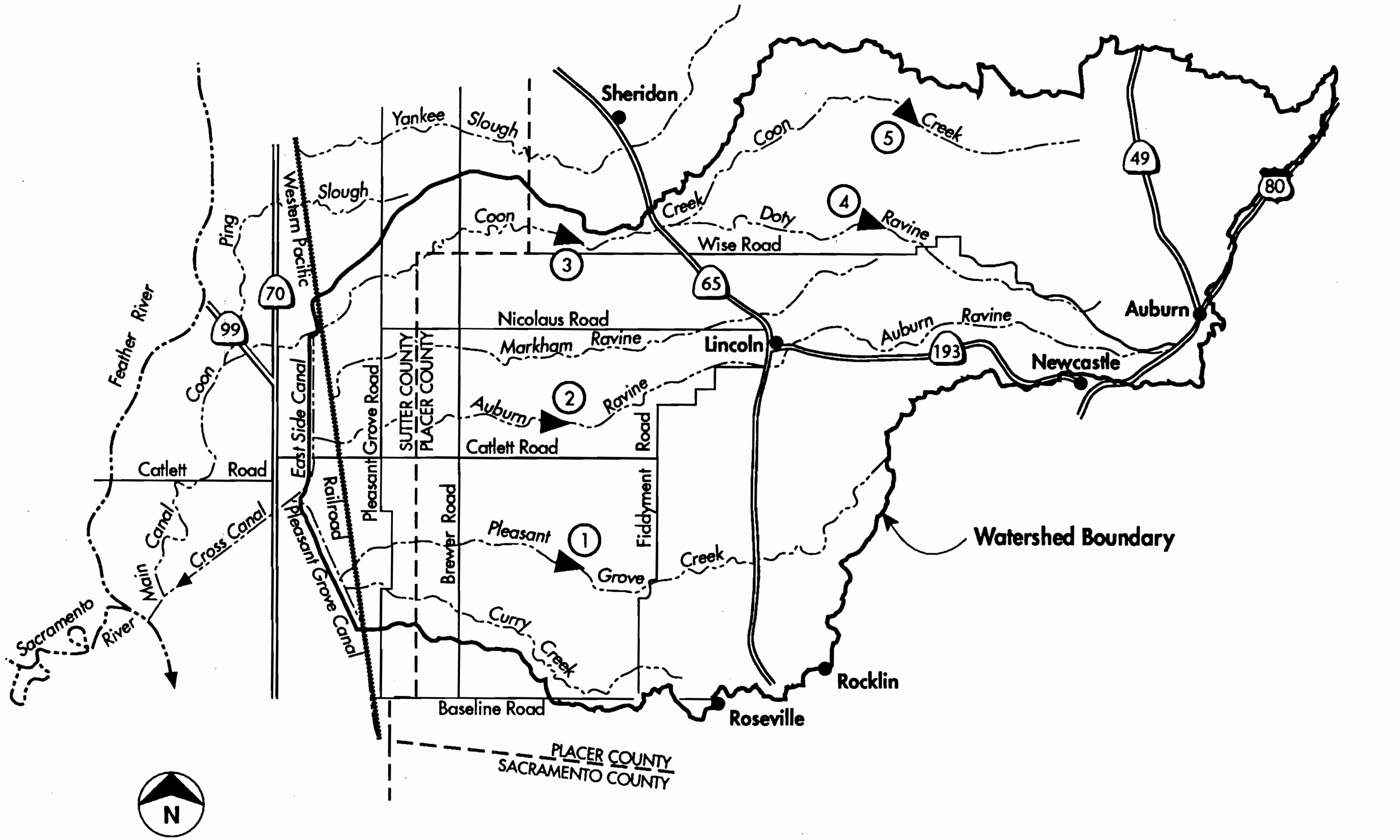

Figure 5-1
Alternative Regional Storage Sites

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The purchase of flowage easements met with opposition from the local landowners. The Fremont Weir mitigation was found to be ineffective due to hydraulic restrictions within the Yolo Bypass. The storage was planned to be effective during extreme floods. The mitigation for development in Placer County needs to be effective also for lesser frequency floods. However, as mentioned above, discussions are continuing with Sutter County and SAFCA to search for a possible joint project.

Channel Improvements

Channel improvements could include debris removal, removal of bottlenecks, and possibly realignment in places. Channel improvements could help mitigate the impact due to smaller floods but would do little for the 100-year flood in the western portion of the watershed. Due to the low ground in the area, channel improvements would need to include levee work. In addition, Placer County has no flood control authority within Sutter County.

Levees

An extensive levee system would be required to mitigate flooding impacts. A levee system could be built to solve existing flooding problems but would not be effective in mitigating only an incremental stage impact. A levee system would eliminate a large volume of flood storage that now occurs upstream of the Cross Canal and could significantly increase flows to the Sacramento River. Flows to the river could increase by more than 50 percent if the flood storage is not replaced elsewhere in the watershed. Also, as mentioned above, Placer County has no flood control authority within Sutter County.

Flood Proofing/Local Improvements

Flood proofing and local improvements could consist of ring levees around specific areas and raising individual structures. While this method could be effective for small areas, it does not mitigate the flood impact over tens of thousands of flooded acres.

Bridge/Culvert Improvements

Like channel improvements, bridge and culvert improvements may be effective for the most frequent floods. Due to the large expanse of overbank flooding upstream of the Cross Canal, these improvements would provide little benefit during the 100-year flood.

Flood Easements

Purchase of flood easements was not considered a feasible alternative during this study for a number of reasons:

- There is a history of resistance from affected landowners.

- Like other improvements within Sutter County, Placer County does not want to exercise eminent domain authority within Sutter County.

- Defining the affected area is nearly impossible with the existing information. The affected area would not necessarily be the change in flooded area during the 100-year flood. Each flood would be affected to some degree by development in Placer County. The 10-flood would have an affected area, the 15-year flood would have an affected area, etc. Therefore, all area inundated during the largest flood will have increased flooding due to increased development in the watershed. This area appears to be between 8,000 and 10,000 acres immediately upstream of the Cross Canal, but may be up to 30,000 acres including the tributary streams.

- No damages occur when only land is flooded. Any easements would need to include restrictions on development within the easement.

Floodplain Management

Floodplain management will not mitigate the increase in flood stage, but can be used as an effective planning tool to guard against existing flooding problems. A number of items are included in this category:

- Zoning to prevent new development in flood prone areas

- Regulation of land leveling to prevent further reduction of natural flood storage or redirecting flows

- Regulation of channel modifications to prevent restrictions to flow or increasing flow velocities

Flood Warning System

Like floodplain management, a flood warning system will not mitigate the increase in future flood stage but is a prudent way to limit impacts and public safety concerns from existing flooding conditions. The system will require a series of stage and precipitation recorders throughout the basin. Due to the relatively undeveloped nature of the basin, this system could begin with a few stations and could be expanded as development occurs. The initial elements would include:

- Precipitation station in Roseville

- Stage recorder on Pleasant Grove Creek at Fiddyment Road

- Precipitation station in Auburn

- Stage recorder on Auburn Ravine at Lincoln

- Precipitation station at Lincoln

- Stage recorder on Coon Creek at Highway 65

- Stage recorder at head of Cross Canal

- Tie-in with Sacramento River stage recorder at Verona

- Additional stage recorders distributed throughout the basin as needed by the District for overall monitoring.

These locations are shown in Figure 6-2 (Chapter 6).

Secondary Benefits

The retention and detention basins require substantial amounts of land as part of the facilities. Because the basins would be operational during major storm runoff, the basins could support alternative land uses during the remaining non-flooding period. The uses could include:

- Native vegetation and wildlife habitat
- Recreation areas
- Agricultural activities

Each of these alternative land uses is discussed in further detail.

Native Vegetation and Wildlife Habitat

There is potential for the area within the retention basins to be managed as open space for re-establishment of native vegetation and wildlife habitat. Depending on the hydrologic characteristics of each site, it may be possible for the development of a combination of vegetative communities including freshwater wetlands, freshwater riparian forest, and grassland. The amount and distribution of these vegetative communities within the basin areas would depend on the bottom configuration, seasonal availability of surface water, and soil/drainage characteristics. The design of the basin bottom could include relief that would provide a variety of vegetative conditions.

If large portions of the basins could be developed as wetlands or riparian forest, these lands may be used as future mitigation credits for other projects that would affect similar resources elsewhere in Placer County. Therefore, the basins could be used as a wetland mitigation bank.

Recreation Areas

If local demand warrants the development of additional recreational opportunities, the sites could be developed for such purposes. Playfields or other non-structural recreational activities could be promoted in the basin areas. The sites with the greatest potential for recreation use are the smaller local detention ponds that will be located closer to urban areas.

Agricultural Activities

The retention basins could also continue to be used for agricultural purposes depending on their size, access, and soil and drainage characteristics. It could be expected, however, that to continue agricultural productivity of the area, topsoil would have to be stored and re-distributed in the basin during construction.

Environmental Impacts

Existing land use in the area of the retention basins consists primarily of intensively irrigated agriculture. The stream channels appear to be relatively disturbed with agricultural activities abutting the stream margin. Based on the review of aerial photographs, there is no remnant vegetative cover along the stream courses. However, siting any of the basins will have environmental impacts that need to be addressed during design. The following discussion addresses those environmental issues that may likely influence the siting and design of the facilities.

Fish Populations

The operation of the retention basins has the potential of harming local fish populations by stranding of fish during the emptying of the retained floodwaters. It is expected that fish would enter the basin during flood events and remain in the pond until floodwaters are evacuated. Depending on the drawdown rate and slope of the basin sides and bottom, fish could be stranded. Specific designs with adequate channels within the basin bottom could minimize fish stranding.

Endangered Plant and Wildlife Species

Review of existing information indicates that no threatened or endangered plant species are known to exist in the immediate vicinity of the proposed basin sites. The lack of identified plant species population data may be due to the lack of site-specific field surveys performed in the area, or because ongoing agricultural practices have effectively disturbed most habitats in the area. It is likely that in areas where remnants of native vegetation are found, in local stream channels and lands adjacent to developed agricultural fields, that species designated as threatened or endangered may be present.

Those wildlife species designated as threatened or endangered that may inhabit lands within the vicinity of the proposed project sites are anticipated to be limited to raptor species that have relatively large habitat ranges. One species, Swainson's hawk, may either nest or hunt in the area near the proposed project sites. Other species, including the Burrowing Owl and Giant Garter Snake, may inhabit the area.

Cultural Resources

The proposed basin sites are anticipated to have a relatively higher probability to contain cultural materials than endangered plant and wildlife species. Although the surface features of these sites have been substantially disturbed by ongoing agricultural practices, materials located deeper in the substrate may be present. Appropriate monitoring of construction activities could adequately mitigate impacts to these sites.

Costs

Capital Costs

Based on the above evaluations, regional storage facilities were selected as the most appropriate alternative mitigation for the District to pursue. As mentioned previously, the local detention basins are assumed to be the responsibility of the local jurisdictions.

Order-of-magnitude estimates of project construction costs were made for the three regional storage facilities and include a flood warning system. All costs are expressed in 1991 dollars. These estimates were based on approximate quantities of major construction elements. Because of unknown factors at this time, a 25 percent contingency has been added as an allowance for undefined work. The estimate also includes an 18 percent allowance for engineering, legal, and administrative costs.

The capital cost of regional storage facilities is estimated to be approximately $32 million. The opinions of costs shown in Table 5-1 have been prepared for guidance in project evaluation and planning. The costs are based on the reconnaissance-level evaluations presented in this report. The final costs of the project will depend on the final designed projects, actual labor and material costs, competitive market (bidding) conditions, implementation schedule (escalation to time of construction), and other variable factors. As a result, the final project costs will vary from the opinions presented here.

Table 5-1 Capital Costs of Regional Basins			
Item	**Quantity**	**Unit Price ($)**	**Total Price ($1,000)**
Excavation, embankment, disposal	9,000,000 cy	1.80	16,200
Control Structures	LS		1,800
Access	40,000 lf	10.00	400
Misc	LS		240
Subtotal			18,640
Contingency (25%)			4,660
Engineering, Legal, and Administration (18%)			4,194
Subtotal			27,494
Land	900 acres	5,000	4,500
Total			32,000

Annual Costs

The cost of operation and maintenance of the three regional retention basins and the flood warning system is estimated to be approximately $140,000 annually in 1991 dollars. Since construction of the basins will be staged, the annual costs will vary with the number of basins that the District has in operation at a given time. Table 5-2 shows how the annual costs are estimated to change with the number of basins. The table shows a breakdown of the annual costs for conditions from existing (No Basins) to future buildout (three basins). The annual costs estimated for the No Basins condition is for the period prior to building the first basin. The costs in Table 5-2 should be escalated by the inflation rate for each year beyond 1991.

Activities/costs included in each item in Table 5-2 are:

- General Maintenance & Repairs—The annual activities required to keep the facilities in good working order. These include debris removal, vegetation control on the embankment, rodent control, rodent damage repair of embankment, maintaining embankment crest elevation, erosion repair of embankment and control structures, and periodic cleaning of the basin area.

Table 5-2
Annual Operation and Maintenance Costs

Item	Annual Costs ($)			
	No Basins	One Basin	Two Basins	Three Basins
General Maintenance & Repairs	0	21,000	42,000	63,000
Engineering Inspections & Reports	0	6,000	11,000	15,000
Periodic Site Visits and Surveillance During Floods	0	5,000	8,000	10,000
Operation of Flood Warning System	8,000	8,000	8,000	8,000
Mitigation Monitoring & Reporting	0	3,000	5,000	6,000
Agency Coordination	4,000	7,000	11,000	13,000
Administration	5,000	16,000	22,000	25,000
Total	17,000	66,000	107,000	140,000

- Engineering Inspections & Reports—The annual inspections of the embankments and control facilities. This includes $5,000 for each basin to cover the costs of the field inspections and reports to the California Division of Safety of Dams and reports for the District's records.

- Periodic Site Visits and Surveillance During Floods—Each of the three basins should be visited periodically (approximately once a month) to assess the general condition and to look for problems such as evidence of vandalism. Site visits will also be conducted during major flood events (approximately 5-year frequency events or larger) to ascertain if the basins are functioning properly and ensure that no problems are developing. The frequency of the periodic and major flood surveillance should not decrease until District experience with the facilities indicates that less frequent observations are appropriate.

- Operation of Flood Warning System—Compilation and analysis of data, and general maintenance and repairs of the system.

- Mitigation Monitoring & Reporting—Construction of the basins will result in environmental mitigation. Current law requires that the mitigation elements be monitored to ascertain that they are functioning as expected and to take corrective action if needed.

- Agency Coordination—Coordination with the various jurisdictions within the District and with the resources agencies. This assumes that since the basins are for regional benefit, there will need to be meetings and coordination for policy decisions relating to the continued operation and maintenance of the basins. Also, maintenance activities within the basins, such as sediment removal and vegetation control, will require coordination with the resources agencies.

- Administration—District's administration time associated with the basins, insurance, and legal costs.

Funding Alternatives

The District established some general guidelines for use in screening funding alternatives for needed facilities for the flood mitigation plan:

- Because the purpose of the plan was to mitigate the effects of flooding from future development within the Placer County portion of the watershed, the future development should pay the costs of the required facilities. Existing development should not have to pay for the facilities or the operation and maintenance of those facilities.

- Local funding authorities should be used when possible to collect fees.

- Any funding alternative that requires a vote for implementation is not viable; the District worked on implementation of a special assessment district but did not complete the work because a successful vote appeared extremely unlikely.

- The District's financial authority is contained in Senate Bill No. 1312, which created the Placer County Flood Control and Water Conservation District. Funding alternatives should fit within this authorization.

In selecting the appropriate financing plan for the District, sources for both project funding and repayment need to be considered. These sources, along with their repayment method, are described below and summarized in Table 5-3. Several borrowing options are potentially available.

A major difficulty with all the funding alternatives is that the area benefiting from the operation of the regional storage basins is extremely large. There are diverse political views within the local communities on the need for a regional solution to the drainage impacts from future development. The District will need to continue to solicit support before a workable funding method can be implemented.

Storm Drainage Funding Sources

Capital improvements can either be funded on a pay-as-you go method, where all construction costs are paid from the current revenues, or they can be funded through borrowing and repaid over a period of years. The cost allocation for the alternatives would be based on the proportional contribution of runoff by the type of land use being developed. The impervious percentages in Table 3-1 (Chapter 3) are used in the cost allocation.

Impact Fee

Under a pay-as-you-go approach, construction costs would be generated by an impact fee paid by new development. It would be part of the development permitting process and would be paid before the development begins construction. This method would collect fees only as development progresses; a business/building slowdown would delay collection of needed fees.

Construction of the regional basins could not start until adequate funds are generated. However, if the development was not occurring and generating funds, there would be little need for the basins. The size of the construction outlay would make pay-as-you-go impractical if all three of the regional storage basins were needed at the same time. Therefore, this method of payment would require staging of the basin construction.

The impact fee method is the most conservative of the funding alternatives because construction of the first basin would not begin until funds are available. However, there may be some opposition to this funding method because it does not provide for immediate mitigation of drainage impacts.

Special Assessments

A special assessment district could be formed to finance facilities that benefit a well-defined group of property owners. The assessment on an individual parcel must be directly related to an estimate of the benefit derived; benefit measures could include street frontage, lot size, building footage, and property value (though property value cannot be the sole criterion). Project facilities are financed with assessment bonds, which are secured and repaid by the special assessment. No election is required for a special assessment, but a protest hearing is required at which property owners may request justification of the assessment.

Table 5-3 Comparison of Funding Sources for Flood Control Facilities						
Funding Alternative	**Funding For**	**Repayment Source**	**Vote Required?**	**Implementation**	**Acceptability**	**Drawbacks**
Pay-As-You-Go	Capital	Impact fees	No	Easy	Yes	Requires Project Phasing
Improvement District Bonds	Capital	Assessments	Protest Hearing	Requires benefit spread	Unlikely	Existing development vs. new development issue
Mello-Roos Community Facilities District	Capital O&M	Assessments	2/3	Requires benefit spread	No	Existing development vs. new development issue
Loans from Cities	Capital	Impact Fees	No	Depends on repayment source	OK	None
Drainage Utility (Assumes Issues Revenue Bonds)	O&M Capital	Drainage charges & impact fees	No	Major effort to set up database, standby charge limitation if focused on new development	OK	Need to set up Drainage Utility

The District is empowered to levy benefit assessments for project construction and operating costs. This special district does require a majority vote to impose the assessment unless written consent of the majority of the voters is filed with the District. This assessment would be collected with the property tax bill. Because the three regional storage facilities are for the benefit of future development over a broad area, a single special assessment district for repayment would be the easiest to administer. However, smaller assessment districts coinciding with other political boundaries within the County generate more support from the local jurisdictions.

The advantage of this financing method is that it equitably distributes cost, is fairly easy to administer, and has favorable financing terms. The drawback is that an election is required. As mentioned above, the District decided not to form a special assessment district in 1988.

Mello-Roos Community Facilities District

The Mello-Roos Community Facilities Act authorizes cities, counties, and special districts to form "community facilities districts" to finance the construction, improvement, or purchase of public facilities that benefit a clearly defined service area. Assessment revenues can also be used to pay operation and maintenance costs of storm drainage systems. Two or more governmental agencies may form a joint community facilities district. All governmental agencies with jurisdiction in the proposed district boundary must agree to the formation of the district.

The community facilities district may issue bonds if approved by two-thirds of voters within the district. Bonds are repaid through special tax assessments. The assessment may not be strictly proportionate to property value. Unlike special assessment districts, the tax does not have to be based directly on benefit derived from the public facilities, although it may be so. Taxes have been based on acreage, street frontage, or square footage of buildings.

The Mello-Roos District has the same advantages of the special assessment districts, plus it can include annual operation and maintenance costs. The major disadvantage is that it requires a two-thirds positive vote for implementation. Due to the very large area, and the District's experience with the benefit assessment district, a positive vote is extremely unlikely.

Contributions or Loans From Affected Cities

In other flood control districts throughout the state, capital improvements have been financed by loans or contributions from cities within the service area. The flood control district would allocate the respective share of the capital costs to each benefiting city, with the city paying these costs from the General Fund. This was especially prevalent before Proposition 13 limited ad valorem taxes. These contributions currently make up the major portion of the District's operating budget. These contributions may be the best way to collect operation and maintenance costs for the regional storage basins. The operation and maintenance costs in the initial years before all basins are operating are relatively low compared with the other operating costs of the District.

Under current conditions, a city might be able to loan funds to the District at a zero or low-interest rate if the project were beneficial to its constituents.

Revenue Bonds

Revenue bonds are not a likely source of funds until a stable revenue source has been established by the District. Even if bonds could be sold, they would likely be at very unfavorable rates and conditions for the District. A stable revenue source could be established if the District can charge existing development their portion of the District's operating costs and capital costs.

Senate Bill No. 1312 allows the District's Board of Directors to "fix rates and charges for services provided by the district, reflecting the reasonable cost and value of providing the service." The bill does not provide a clear definition of what constitutes a service. One view would be that all functions of the District, including engineering, administration, insurance, maintenance, construction, monitoring, and studies, would constitute services. Communities across the United States are beginning to view drainage as a service or public utility like water supply and sewer disposal. Even though the bill allows the District to fix rates and charges for services, it also provides for benefit assessments for these expenditures. This results in some ambiguity in interpretation of the District's authority. The opinion of the County Counsel for Placer County is that the more specific wording in the bill on benefit assessments should be used and that the District would not be able to charge directly for the services.

If the District could charge for the services, by reinterpretation or legislative amendment of the bill, a regular revenue stream would be established. This would treat drainage as a required service to properties generating stormwater drainage. Fees for the service are collected, as are other utility services such as water, sewer, and garbage, through regular billings rather than through tax bills. With a revenue stream developed, revenue bonds could be issued. Repayment of the revenue bonds could be from a combination of impact fees or regular billings.

Federal Programs

Many federal programs were researched as possible funding alternatives. Most of the programs have no funds appropriated at this time.

Project Repayment

Capital Costs

Most of the above funding alternatives borrow money to pay for project construction. Repayment of the loans or bonds occurs over many years after construction. In the pay-as-you-go approach, funds are collected prior to construction. Following is a summary of the repayment with each of the above funding alternatives:

- **Impact Fee** is the pay-as-you-go approach where construction would not take place until sufficient funds are collected. The impact fee would be paid by new development as it occurs. Impact fees could also play a significant role if the District decides it can charge for drainage as a service. Impact fees could reduce the revenues required from billings.

- **Special Assessments** would sell assessment bonds for project construction. Repayment would be with the property tax bills of the benefited land during the term of the bonds. In this case, there would not need to be an impact fee for new development, as property would already be assessed. The required vote for implementation would likely eliminate this alternative.

- **Mello-Roos Community Facilities District** would sell bonds for project construction. Repayment would be through special tax assessments on the properties within the Mello-Roos District. The required vote for implementation would likely eliminate this alternative.

- **Contributions or Loans from Affected Cities** could take the form of a pay-as you-go approach. Each city could contribute money as needed, similar to the current method of funding District operations. Loans could also be made as needed. Repayment of these loans would likely be from the impact fees on development.

- **Revenue Bonds** could be sold by the Flood Control District. Unlike the bonds secured by the special assessment and the Mello-Roos Districts, these bonds would not have a stable repayment source. The repayment could be through the development impact fees, but this source would likely not be acceptable to lenders under favorable conditions and rates for the District.

- **Federal Programs**, most of which have no funds appropriated at this time.

Annual Costs

Annual costs will begin as a relatively small cost (Table 5-2) compared with other District operating costs. Even when all three basins are in place, the annual costs are relatively small. The alternatives for repayment of these operation and maintenance costs are limited:

- The Mello-Roos Community Facilities District provides for collecting annual costs. However, due to the required vote, the Mello-Roos District is not a likely method for this project.

- Contributions from the affected cities is the current method of funding the District's operation costs. Due to the lack of alternatives, this method will likely be the method to collect annual costs for the regional storage basins.

- Even though the scope of this study is directed solely at mitigating the impacts of future development in the watershed, the ongoing funding needs of the District extend well beyond the annual costs for the regional storage basins. The District currently operates on funds contributed from the jurisdictions within the District. In order for the District to be a viable flood control entity for the County, it must have adequate funding. These ongoing costs include administration, clerical and engineering staff, insurance, reserve account for emergency flood control costs, maintenance, studies and designs, construction programs, and monitoring. The needs for these services will only increase in the future. Water quality controls and more emphasis on local drainage problems will require increased work by the District.

The District studied implementation of a benefit assessment in 1988 to cover these ongoing costs. Although the assessment was never implemented, information prepared for that study indicates the funding needs for the watershed may be approximately $1 million annually. While confirmation of the District's ongoing funding needs are beyond the scope of this study, a stable funding source for the District would facilitate implementation of this plan. The District needs to decide the level of funding that it requires for its ongoing needs and to determine if it can charge for the services it provides.

As mentioned above, Senate Bill No. 1312 allows the District's Board of Directors to fix rates and charges for services provided. The ambiguity in this bill needs to be resolved so the District can establish a drainage utility to cover all services within this and other watersheds covered by the District.

Chapter 6
Mitigation Plan

The previous chapters have detailed the study methodology and the flooding impacts due to future development in the watershed. There has been considerable discussion throughout the study on the significance of these impacts. Not all jurisdictions within the District agree that mitigation is required. However, the purpose of this study was to develop a plan to mitigate these flooding impacts from future development.

The study addresses flooding impacts over a large regional area. The resulting flood control facilities are large in size and few in number. Therefore, compared to a comprehensive drainage plan for a watershed with numerous individual facility improvements, this mitigation plan is relatively straightforward.

The following mitigation plan includes potential for facilities, policies, funding, and additional studies. Implementation of the plan will depend on policy and funding decisions within the District.

Facilities

Three types of facilities could work together to mitigate flooding impacts from future development:

- Regional Storage Basins—Three regional storage basins would be constructed in the western portion of Placer County (see Figure 6-1). The first basin would be constructed to control flows from Pleasant Grove Creek, the second to control flows from Auburn Ravine, and the third to control flows from Coon Creek.

- Local Detention Basins—Determining the requirements for detention basins to address local flooding problems is beyond the scope of this plan. However, detention basins will be required to mitigate local flooding impacts in some areas. Therefore, detention basins were included in the modeling for this study in 30 to 35 locations within the major developing areas of the watershed. The need for detention basins associated with major development should be evaluated on a case-by-case basis.

- A flood warning system with precipitation and stream stage recording stations should be installed. This network would provide real time data on conditions that may lead to flooding to the District and County emergency services office. Figure 6-2 shows initial locations of the stations.

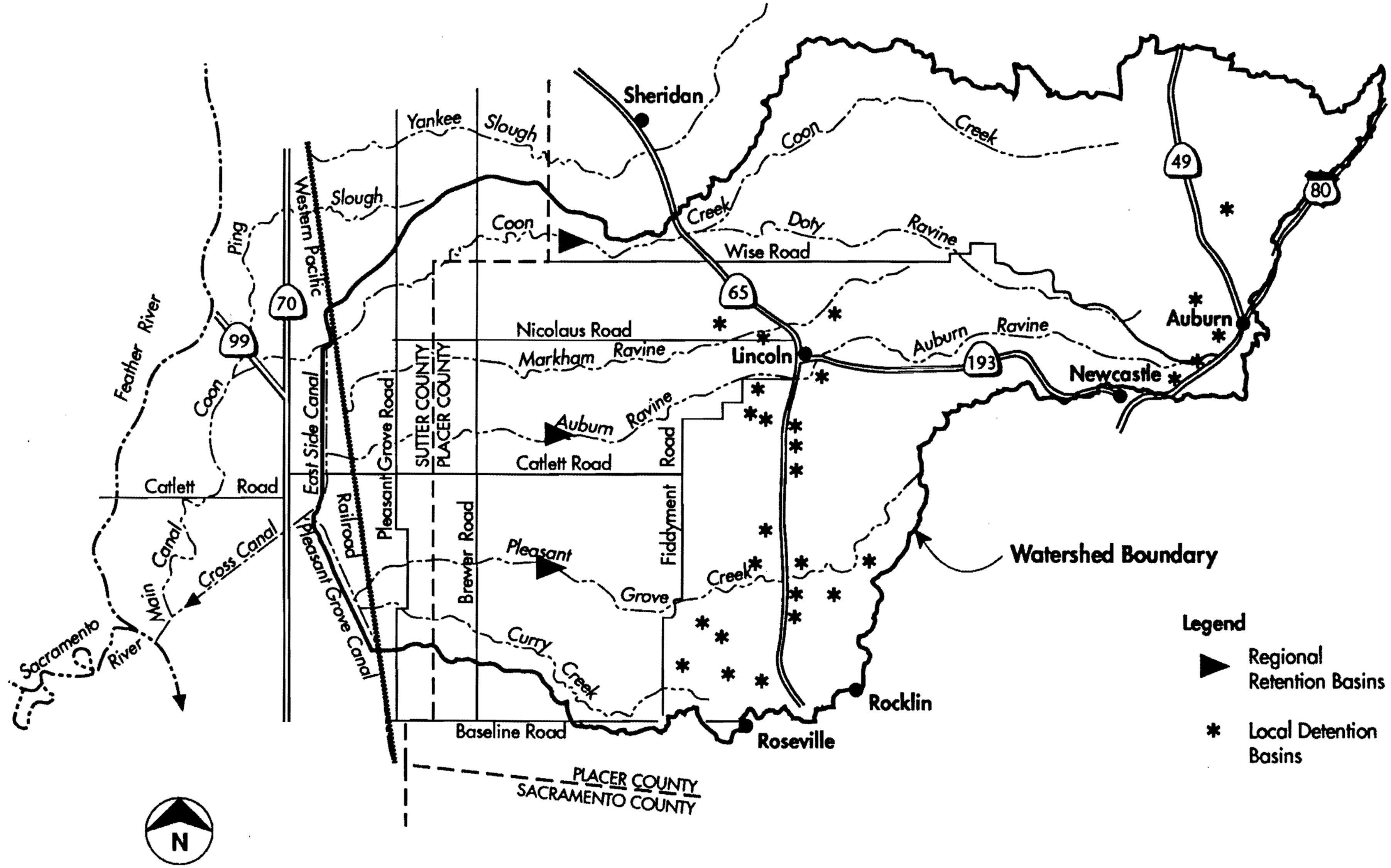

Figure 6-1
Retention and Detention Basins

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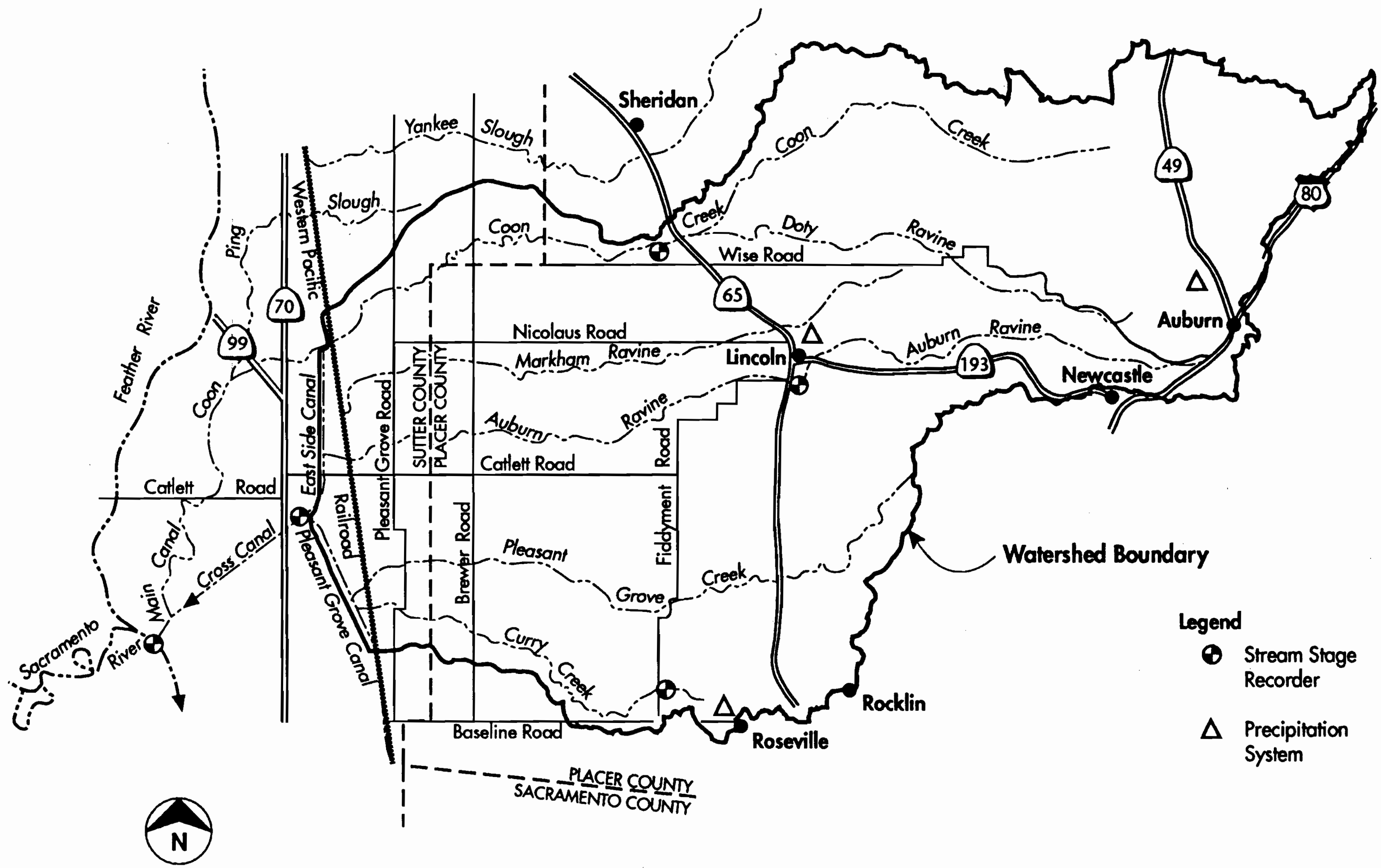

Figure 6-2
Flood Warning System

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Policies

This plan does not propose new policies for mitigating the flooding impacts from future development. The County currently has policies and regulations that are used to regulate development in and out of floodplains. However, for reference, the following ongoing policies are an important part of eliminating or minimizing flooding impacts in the watershed. As part of this plan, the District will be an active member of the County's staff in reviewing development plans.

- The County currently regulates development within floodplains through the Federal Emergency Management Agency (FEMA) Flood Insurance Program.

- Enforcement of the County grading ordinances are important to control reductions in the natural flood conveyance and routing capability of the stream channels and minimize sedimentation. This is especially important in the western portion of the County where extensive land leveling and stream channel modifications have contributed to flooding. The District should review all grading plans that are within the 100-year floodplains.

- The District should assist the local jurisdictions in reviewing the needs for local detention basins for specific developments.

- The District should continue to coordinate with Sutter County on floodplain management issues within eastern Sutter County.

- The District should continue to coordinate with Sutter County and SAFCA in looking for a cooperative project that may a viable alternative to the regional storage basins presented in this plan.

Funding

The funding plan consists of collection of development impact fees to cover the cost of the capital improvements and contributions from the affected cities to cover the annual operation and maintenance costs. These provide for a pay-as-you-go approach.

If flooding impacts are determined to be significant, the District should implement development impact fees as soon as possible. Based on the assumptions used in the study, these fees would be as shown in Table 6-1.

Table 6-1 Development Impact Fees	
Land Use Type	**Impact Fee ($/Acre)**
Commercial	2,430
Business/Apartments	2,160
Industrial/Condominium	1,890
Residential (8 to 10 houses/acre)	1,620
Residential (6 to 8 houses/acre)	1,350
Residential (4 to 6 houses/acre)	1,080
Residential (3 to 4 houses/acre)	810
Residential (2 to 3 houses/acre)	680
Residential (1 to 2 houses/acre)	540
Rural Residential (1 to 2 acres minimum)	330
Rural (2 to 5 acres minimum)	80

These fees are less than fees independently estimated by Roseville and Lincoln for their respective portions of the watershed. Each year, the fees should be escalated with the ENR construction cost index.

Several years of impact fees would be collected prior to completion of permitting and design of the regional storage basins. At that time, the District would have the option of issuing debt to finance construction of the regional storage basin for Pleasant Grove Creek or possibly waiting until adequate funds are available for construction. Impact fees would continue to be collected for construction of the basins for Auburn Ravine and Coon Creek.

Annual operation and maintenance cost should be collected from contributions from the affected cities, similar to existing District funding. Table 5-2 (Chapter 5) provides

Annual operation and maintenance cost should be collected from contributions from the affected cities, similar to existing District funding. Table 5-2 (Chapter 5) provides estimates of annual costs. However, because this is a pay-as-you-go approach, these contributions would depend on the actual expenditures for each year.

In addition to these annual mitigation costs, the District has other ongoing funding needs. A stable funding source for the District would help implement the plan. The District should determine the level of service it will provide on an annual basis and implement a drainage enterprise fund. Based on an estimated need of approximately $1 million annually for the watershed, the approximate drainage fees for developed land would be as shown in Table 6-2.

Table 6-2
Potential Annual Fees

Land Use Type	Annual Fee
Commercial	$270/acre
Business/Apartments	$240/acre
Industrial/Condominium	$210/acre
Single-Family Residence	$24/house

Implementation of the fund to charge for drainage services would include significant administrative work necessary to identify the property owners and assign annual fees.

With a stable funding source in place, debt financing for this project would be easier to issue because the fund would be a secondary source of revenue, in case actual development (and associated impact fees) did not keep pace with repayment needs.