Master Drainage Plan
Santa Barbara Airport

September 2001
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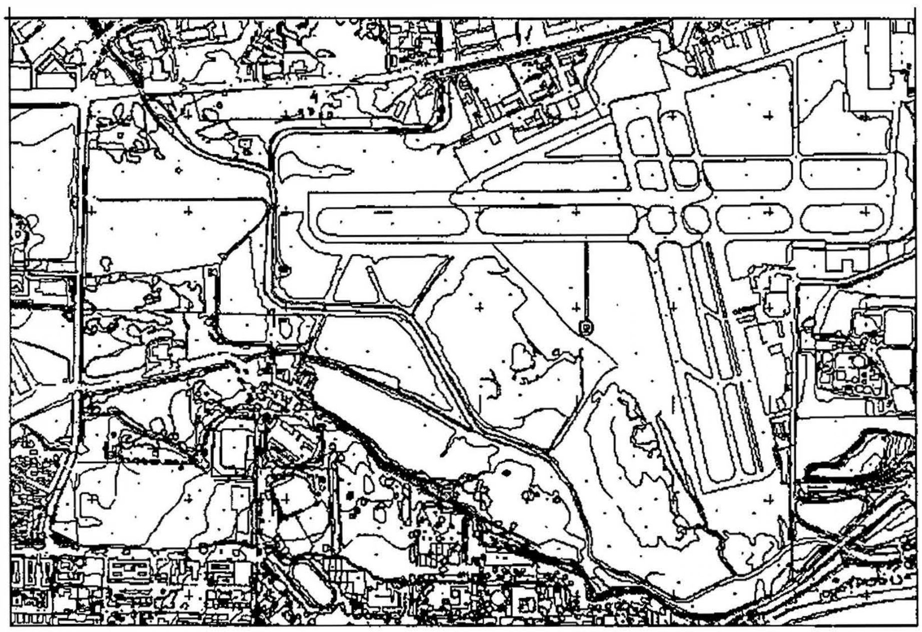

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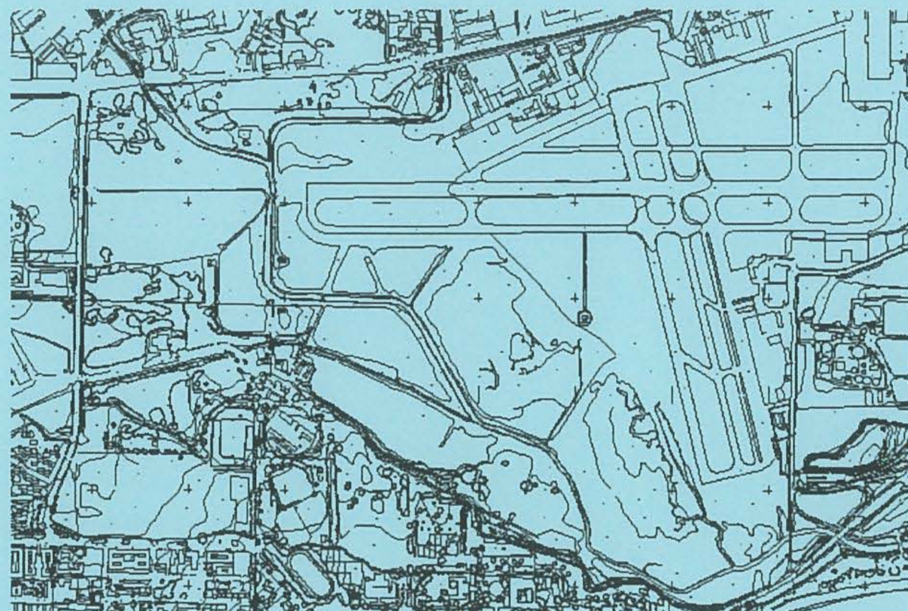
LIST OF CHAPTERS

EXECUTIVE SUMMARY
MASTER DRAINAGE PLAN



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EXECUTIVE SUMMARY-
MASTER DRAINAGE PLAN

Background Information

The Santa Barbara Airport (Airport) is owned and managed by the City of Santa Barbara. It is located in the South Coast region of Santa Barbara County, on the coastal plain between the Santa Ynez Mountains and the Pacific Ocean. In 1994, the City of Santa Barbara (City) initiated a comprehensive planning process for the Airport that included both an Industrial/Commercial Specific Plan and an Aviation Facilities Plan (AFP). The Specific Plan for the land north of Hollister Avenue was certified in 1998.

The AFP for the airfield areas south of Hollister Avenue was approved by City Council in December 2001. It consists of various improvements to increase public safety and enhance service at the Airport, while meeting both short-term and long-term aviation needs of the region. The AFP includes the following primary elements:

- ❖ Modify the airfield to meet standards of the Federal Aviation Administration (FAA) for Runway Safety Areas (RSAs)
- ❖ Expand the Airport terminal to meet current and future demands and to enhance service, including increased parking facilities
- ❖ Increase the number of "T" hangars for small commercial and general aviation airplanes

A Runway Safety Area (RSA) is the land surrounding a runway that must be smoothed and compacted such that damage to airplanes that overrun the paved surface would be minimized. The existing RSAs at the east and west ends of Runway 7-25, the primary commercial flight runway at the Airport, do not meet FAA standards. For Runway 7-25, the minimum RSA at each end is 1,000 feet long and 500 feet wide. The lengths of the current RSAs on the east and west ends are only 200 and 350 feet, respectively.

The Airport retained URS Corporation (URS) to assist in identifying RSA extension alternatives to meet the FAA's minimum standards. One of the primary issues associated with the extension of the RSA was the effect on local drainage at the Airport. In addition, the extension of the runway and RSA would require relocation of Tecolotito Creek which is situated at the west end of Runway 7-25.

Hence, the Airport retained URS to prepare a Master Drainage Plan for the Airport. The primary objectives of the plan and the chapter of the technical study addressing each objective are as follows:

- ❖ An assessment of overall drainage conditions for the Airport south of Hollister Avenue and recommendations for drainage improvements (Chapter 1)
- ❖ Assessment of the base flood elevation for the Airport terminal (Chapter 2)
- ❖ Assessment of creek modification alternatives for the RSA extension, including the use of a culvert versus a relocated creek at the west end of Runway 7-25 (Chapter 3)

- ❖ An evaluation of RSA extension alternatives, including alternative runway extensions and threshold modifications (Chapter 4)
- ❖ An evaluation of wetland impacts due to the RSA extension and description of a wetland mitigation plan (Chapter 5)

Drainage Improvement Plan (Chapter 1)

The Airport was constructed in Goleta Slough on fill material during the 1940s. The elevation of the Airport, and in particular the airfield, is very low, with an average ground elevation of about 8 to 10 feet (North American Vertical Datum of 1988 [NAVD 88] elevation datum). Significant portions of Goleta Slough and the lower ends of the creeks at the Airport are tidally influenced. Almost the entire Airport property is contained within the 100-year floodplain boundary. Two creeks traverse the airfield: Tecolotito and Carneros Creeks. Four other creeks are located on or near the eastern boundary of the Airport and influence surface water elevations in Goleta Slough: Las Vegas, San Pedro, San Jose, and Atascadero Creeks.

The Airport storm drain system includes catch basins, manholes, headwalls, drain pipes, pipe outlets, and other storm drain structures. Storm drains discharge directly to Tecolotito, Carneros, and San Pedro Creeks, and to the tidal channels in Goleta Slough.

A significant sediment load is carried from the mountains that is often deposited at the Airport because of the reduction in slope as flows reach the coastal plain. Extensive sediment deposition often occurs along San Pedro, Tecolotito, and Carneros Creeks below Hollister Avenue that reduces channel capacity and causes overbank flooding. The County Flood Control District maintains two sediment basins on Tecolotito and Carneros Creeks downstream of Hollister Avenue.

Drainage at the Airport is generally adequate during small storms, that is, less than a 10-year event. However, drainage is poor during larger storms, particularly coupled with high tides, due to the following constraints: (1) the Airport is located at a very low elevation relative to the receiving tidal waters in Goleta Slough, San Pedro Creek, and Tecolotito Creek; and (2) the Airport is relatively flat with very little slope, limiting hydraulic capacity. Portions of the airfield flood during storms that exceed 10- to 25-year events. Recent flooding of the airfield occurred in 1995, 1998, and 2001.

An assessment of the existing storm drain system was conducted to identify hydraulically inefficient areas in the conveyance system such as areas with undersized pipes and shallow pipe slopes. Poorly rated pipes are either undersized or have very shallow slopes. Poorly rated inlets are located at elevations that are too high for efficient operations. Seventeen pipe segments were rated as poor. The percentage of pipes in the system that are rated as poor ranges from 11 percent for the 2-year storm to 16 percent for the 25-year storm. Seven inlets were rated as poor. The percentage of storm drain inlets in the system that are rated as poor ranges from 2 percent for the 2-year storm to 7 percent for the 25-year storm.

Recommended storm drain system improvements include replacing pipe sections, setting new pipe slopes, replacing storm drain inlets, and redirecting stormwater runoff flows at identified locations. Not all of the storm drain system components that were identified as having poor performance need to be replaced in order to improve overall conveyance and reduce flooding. As such, many of the pipe segments that were rated poor are not recommended for replacement. An assessment of the storm drain system performance with the proposed improvements indicates that the proposed modifications would slightly reduce the number of poorly performing drain pipes and significantly reduce the number of poorly performing drain inlets. With the proposed improvements, all inlets would be expected to perform adequately up to a 10-year storm event. Under regional or basin-wide flooding conditions, modeling results for the improved system indicate a significant reduction in drainage performance with larger storm events, with more than 20 percent of the total number of storm drain inlets expected to be flooded during a 10-year storm event.

Other major drainage deficiencies include the following: (1) inadequate channel capacity under Verhelle Bridge along San Pedro Creek; (2) bank erosion along San Pedro Creek; (3) poor channel hydraulics and low capacity along Las Vegas Creek; (4) hydraulic constraints and low capacity along Firestone Channel; and (5) overbank flooding along Hollister Avenue near Carneros Way. The recommended improvements to address these drainage problems at the Airport south of Hollister Avenue are listed below.

1. Replace Verhelle Bridge on San Pedro Creek with a single-span bridge
2. Stabilize the banks along San Pedro Creek downstream of Hollister Avenue
3. Improve Las Vegas Creek, including bank stabilization and a new golf course bridge
4. Modify Firestone Channel and the outlet to Carneros Creek
5. Replace the steel pipe culvert at Carneros Creek and improve associated drainage channels near Hollister Avenue

Additional information about the scope and costs of these improvements are provided in Sections 6 and 7, respectively, of Chapter 1.

<u>Base Flood Elevation at the Airport Terminal (Chapter 2)</u>

The base flood elevation (BFE) refers to the predicted water surface elevation within the floodplain of a creek corresponding to a flood event with a 1% chance of occurrence in any year (the 100-year flood event). In 1973, the Federal Emergency Management Agency (FEMA) estimated the BFE in the vicinity of the Airport terminal to be at elevation 11 feet National Geodetic Vertical Datum of 1929 (NGVD 29), which is equivalent to 13.5 feet using the NAVD 88 vertical datum (which is the vertical datum used in the Master Drainage Plan and current topographic maps of the Airport).

A new analysis was conducted to assess the reasonableness of the original BFEs developed by FEMA more than 30 years ago. Two computer models developed by the U.S. Army Corps of Engineers (USACE) and approved by FEMA for detailed flood insurance studies (the HEC-RAS and RMA-2 models) were used in the analysis. The results were compared to the FEMA published values to assess the effect of using different models to estimate the base flood elevation at the Airport. The base flood elevation at the Airport terminal was estimated to be approximately elevation 13 feet (NAVD 88) using the RMA-2 model and approximately elevation 13 feet to 14.5 feet using the HEC-RAS model with different creek flow assumptions, thus confirming the general accuracy of the FEMA base elevation. The "depressional storage" in the watershed above

Highway 101 was considered in the RMA-2 modeling analysis, but did not have a significant influence on the results. These findings are summarized from Section 3.1 of Chapter 2.

Creek Relocation Plan (Chapter 3)

An analysis of alternatives to modify Tecolotito and Carneros Creeks in the airfield to accommodate the proposed new Runway Safety Area (RSA) at the end of Runway 7-25 was conducted. The hydraulic performance of two alternatives were studied: (1) place the combined Tecolotito and Carneros Creeks into a concrete culvert under the extended runway and safety area; and (2) relocate Tecolotito and Carneros Creeks around the new safety area. The study also included an analysis of the feasibility of placing San Pedro Creek in a culvert to allow the extension of Runway 7-25 to the east, over the creek. The key conclusions of the study are summarized below from Section 7.3 of Chapter 3:

1. Relocating Tecolotito and Carneros Creeks is a feasible and preferable option for the runway and RSA extension project at the west end of Runway 7-25. The realigned open channel would provide the same capacity as current channels, and may provide a minor reduction in flood hazard because the new channel would be located farther from the paved runway. It would not cause a significant increase in sediment deposition near the RSA, nor would it increase sediment deposition in Goleta Slough.

2. The use of a culvert along Tecolotito Creek at the end of Runway 7-25 is not recommended because of the reasonably foreseeable risk that the culvert would become plugged by sediment during 10-year or greater flood events. Plugging of the culvert would result in increased frequency of flooding of the airfield, as well as increase culvert maintenance requirements. On-going maintenance to remove the sediments from the culvert is not considered a feasible operation.

3. The use of a culvert along San Pedro Creek at the eastern end of Runway 7-25 also is not recommended because of the potential to increase the risk of flooding on the runway due to sediment deposition in the culvert and the infeasible maintenance operations to remove sediments from the culvert. In addition, increased flooding at this location would also affect non-Airport property and Fairview Avenue.

Runway and RSA Alternatives (Chapter 4)

A range of alternatives to establish the required RSAs at the east and west ends of Runway 7-25 was analyzed in an aviation planning study. Six major alternatives were evaluated, as follows: (1) establish RSAs by extending the runway to the west and use a culvert along Tecolotito Creek; (2) establish RSAs by extending the runway to the west and relocating Tecolotito Creek, using either a displaced or relocated threshold; (3) establish RSAs by extending the runway to the west and placing Tecolotito and San Pedro Creeks into culverts, and displacing thresholds; (4) establish RSAs by extending the runway to the west, relocating Tecolotito Creek, placing San Pedro Creek into a culvert, and displacing thresholds; (5) same as Alternative 3, with slight reduction in length of runway extension; and (6) same as Alternative 4, with slight reduction in length of runway extension.

The following criteria were used to compare the various runway and RSA alternatives: safety, usability by aircraft, construction costs, easement costs, flooding impacts, wetland impacts, and bird strike hazards. All alternatives would meet the project objectives – establishment of a required RSA at both ends of the runway. However, only Alternative 2 (relocating the creek and extending the runway to the west) was determined to be desirable after considering all comparison criteria and other factors. The basis for this conclusion is presented in Section 6 of Chapter 4.

Mitigation Plan (Chapter 5)

A study was conducted to identify wetland restoration opportunities to mitigate for the unavoidable losses of wetlands associated with the proposed AFP, primarily due to the extended runway relocation of portions of Tecolotito and Carneros Creeks. A total of 13.3 acres of wetlands will be permanently removed or converted due to the proposed project. They include three wetland types: seasonal vegetated wetlands, unvegetated salt flats, and tidal open water and mudflat wetlands.

To compensate for the permanent loss of wetlands due to the proposed project, the Airport proposes to create and/or restore seasonal wetlands and open water habitat similar to those affected by the project (e.g., "in-kind replacement"). The proposed wetland mitigation will result in a greater acreage of wetlands with more functions than under current conditions. The mitigation package consists of the following elements, summarized from Section 6 of Chapter 5.

- New Creek Habitat. The relocation of Tecolotito and Carneros Creeks will create 9.3 acres of channel containing open water and mudflat wetlands. The relocated creeks will have the same width and depth as the existing creek channels. The banks will be stabilized with native shrubs to prevent erosion. Plants to be used for stabilization include saltbush, alkali heath, and pickleweed. The new creek lengths will have annual grassland buffer, identical to the current creeks, except the relocated creeks will be farther from the runway.

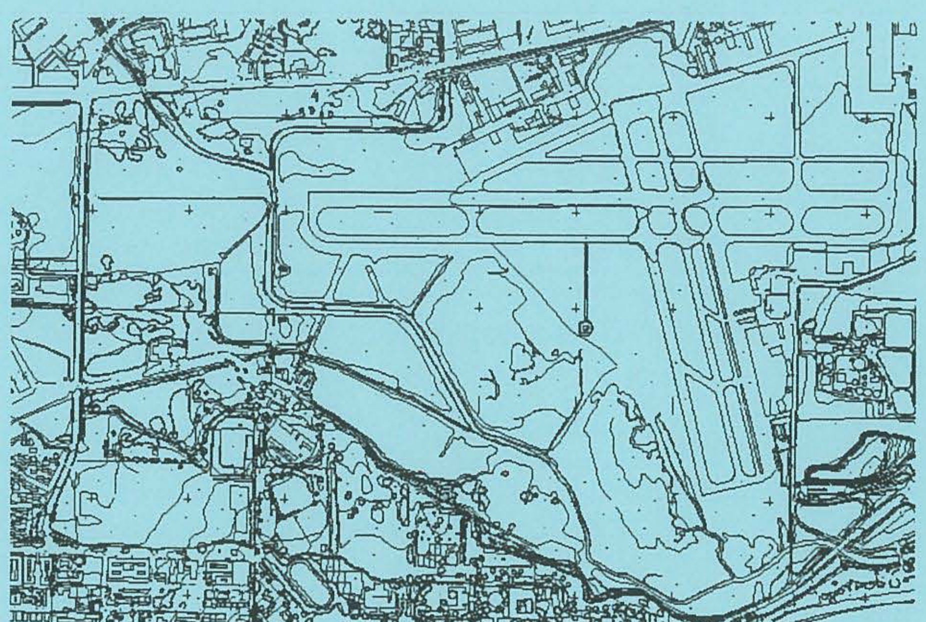
- Restored Berm Habitat. Berms occur on both sides of Tecolotito Creek in the middle of Goleta Slough. Dense monoculture stands of mustard occur along the tops and sides of the berms. Other exotic species include tree tobacco, Italian thistle, and poison hemlock. These non-native species (and their seed bank in the soil) will be removed from the tops and sides of the berms through a two-year series of "grow-kill" herbicide treatments. In the winter following the last treatment, the berms will be revegetated to create seasonal wet grassland using species such as alkali weed, saltgrass, alkali mallow, creeping rye-grass, meadow barley, western ragweed, alkali heath and saltbush. Approximately 7,600 linear feet of berms will be restored, encompassing 12.7 acres.

- Wetland Area I. New seasonal wetlands will be created in upland portions of "Area I," which is a 25-acre site owned by the Airport located between the UC Santa Barbara bluffs and Tecolotito Creek. Wet grassland and other seasonal wetlands would be created at the site in the following manner: (1) around the northern perimeter of the site in the location of the old salt marsh; and (2) in a mosaic pattern in the center of the site. The northern perimeter of the site will be lowered to an elevation of 5 to 6 feet with an uneven terrain and small depressions. Native seasonal wetland species will be planted, such as pickleweed, alkali heath, alkali weed, sand spurrey, meadow barley, and saltgrass. Nine acres of new seasonal wetlands will be created and 2.2 acres of existing seasonal wetlands will be enhanced, for a total of 11.2 acres of wetlands in the 25-acre site.

- Wetland Area R-2. This area represents a small man-made basin adjacent to Tecolotito Creek and south of the existing Runway 7-25. It contains non-tidal seasonal wetlands. The portion of Tecolotito Creek adjacent to this area will be filled as part of the proposed project. The berm along the creek and the filled creek bed will be graded to match the elevation of Area R-2, which supports non-tidal wet grassland. These areas will then be planted with pickleweed, alkali heath, alkali weed, sand spurrey, meadow barley, and saltgrass to create 2.2 acres of new seasonal wetlands.

CHAPTER 1

DRAINAGE IMPROVEMENT PLAN



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EXECUTIVE SUMMARY – DRAINAGE IMPROVEMENT PLAN

The City of Santa Barbara retained URS Corporation, Oakland office, to assess the drainage conditions at the Santa Barbara Municipal Airport (Airport) south of Hollister Avenue, identify deficiencies in the storm drain system and engineered channels, and provide recommendations on drainage improvements to be pursued in the future as funding becomes available.

The Airport was constructed in Goleta Slough on fill material during the 1940s. The elevation of the Airport, and in particular the airfield, is very low, with an average ground elevation at about elevation 8 to 10 feet North American Vertical Datum of 1988 (NAVD 88). Significant portions of Goleta Slough and the lower reaches of the creeks at the Airport are tidally influenced. Almost the entire Airport property is within the 100-year floodplain boundary. Two creeks traverse the airfield: Tecolotito and Carneros Creeks. Four other creeks are located on or near the eastern boundary of the Airport and influence surface water elevations in Goleta Slough: Las Vegas, San Pedro, San Jose, and Atascadero Creeks.

The Airport storm drain system includes catch basins, manholes, headwalls, drain pipes, pipe outlets, and other storm drain structures. Storm drains discharge directly to Tecolotito, Carneros, and San Pedro Creeks, and to the tidal channels in Goleta Slough.

A significant sediment load is carried from the mountains that is often deposited at the Airport because of the reduction in slope as flows reach the coastal plain. Extensive sediment deposition often occurs along San Pedro, Tecolotito, and Carneros Creeks downstream of Hollister Avenue, reducing channel capacity and causing overbank flooding along the creeks. The Santa Barbara County Flood Control District maintains two sediment basins on Tecolotito and Carneros Creeks downstream of Hollister Avenue.

Drainage at the Airport is generally adequate during small storms, that is, less than a 10-year event. However, drainage is poor during larger storms, particularly coupled with high tides, due to the following constraints: (1) the Airport is located at a very low elevation relative to the receiving tidal waters in Goleta Slough, San Pedro Creek, and Tecolotito Creek; and (2) the Airport is relatively flat with very little slope, limiting hydraulic capacity. Portions of the airfield flood during storms that exceed 10- to 25-year events. Recent flooding of the airfield occurred in 1995, 1998, and 2001.

An assessment of the existing storm drain system was conducted to identify hydraulically inefficient areas in the conveyance system such as areas with undersized pipes and inadequate pipe slopes. Poorly rated pipes are either undersized or have very shallow slopes. Poorly rated inlets are located at elevations that are too high for efficient operations. Seventeen pipe segments were rated as poor. The percentage of pipes in the system that are rated as poor ranges from 11 percent for the 2-year storm to 16 percent for the 25-year storm. Seven inlets were rated as poor. The percentage of storm drain inlets in the system that are rated as poor ranges from 2 percent for the 2-year storm to 7 percent for the 25-year storm. Recommended storm drain system improvements include replacing pipe sections, setting new pipe slopes, replacing storm drain inlets, and redirecting stormwater runoff flows at identified locations. Not all of the storm drain system components that were identified as having poor performance need to be replaced in order to improve overall conveyance and reduce flooding. As such, many of the pipe segments that were rated poor are not recommended for replacement. An assessment of the storm drain system performance with the proposed improvements indicates that the proposed modifications would slightly reduce the number of poorly performing drain pipes and significantly reduce the number of poorly performing drain inlets. With the proposed improvements, all inlets would be expected to perform adequately up to a 10-year storm event. Under regional or basin-wide flooding conditions, modeling results for the improved system indicate a significant reduction in drainage performance with larger storm events, with more than 20 percent of the total number of storm drain inlets expected to be flooded during a 10-year storm event.

Other major drainage deficiencies include the following: (1) inadequate channel capacity under Verhelle Bridge along San Pedro Creek; (2) bank erosion along San Pedro Creek; (3) poor channel hydraulics and low capacity along Las Vegas Creek; (4) hydraulic constraints and low capacity along Firestone Channel; and (5) overbank flooding of Carneros Creek along Hollister Avenue near Carneros Way. The recommended improvements to address these drainage problems at the Airport south of Hollister Avenue are listed below:

1. Replace Verhelle Bridge on San Pedro Creek with a single-span bridge
2. Stabilize the banks along San Pedro Creek downstream of Hollister Avenue
3. Improve Las Vegas Creek, including bank stabilization and a new golf course bridge
4. Modify Firestone Channel and the outlet to Carneros Creek
5. Replace the steel pipe culvert at Carneros Creek and improve associated drainage channels near Hollister Avenue

1.0 INTRODUCTION

The Santa Barbara Airport (Airport) is owned and managed by the City of Santa Barbara. It is located in the South Coast region of Santa Barbara County, on the coastal plain between the Santa Ynez Mountains and the Pacific Ocean. The airfield is located south of Hollister Avenue, adjacent to Goleta Slough. The Airport property also includes industrial/commercial property north of Hollister Avenue. Figure 1 provides an overview of the Airport and surrounding areas.

The City of Santa Barbara (City) initiated a comprehensive planning process for the Airport in 1994 that included both an Industrial/Commercial Specific Plan and an Aviation Facilities Plan (AFP). The Specific Plan for the land north of Hollister Avenue was certified in 1998. The AFP was approved by City Council in December 2001. It consists of various improvements to increase public safety and enhance service at the Airport, while meeting both short-term and long-term aviation needs of the region. The AFP includes shifting Runway 7-25 to the west and creating a new Runway Safety Area at the end of the runway, and relocating Tecolotito Creek around the new safety area, among other airfield safety improvements.

The Airport retained URS Corporation (URS) to provide various hydraulic, environmental, and engineering services during the development of the AFP. These services included preparation of a Master Drainage Plan that broadly addressed the key drainage issues associated with the AFP. Two of the primary elements of the Master Drainage Plan were an assessment of overall drainage conditions at the Airport independent of the AFP, and the development of recommendations for drainage improvements. The focus of this assessment was on storm drain facilities and engineered channels south of Hollister Avenue. The results of this study are presented in this report.

The scope of the work for the drainage improvement study included the following specific tasks:

1. Collect basic hydrologic data including rainfall data, tide data, topographic maps and storm water drainage data for the local Airport area.

2. Develop a hydrodynamic model for Goleta Slough and its associated drainage creeks and wetlands to analyze flooding conditions in the airfield area for peak design flood discharges (2-year, 5-year, 10-year, 25-year, and 100-year).

3. Develop a hydraulic model for the Airport storm water drainage system to assess the existing system capacities for peak design flood discharges (2-year, 5-year, 10-year, and 25-year) and to provide improvements to the drainage systems.

4. Provide recommendations on drainage system improvements, including a prioritization of individual projects with planning level costs.

2.0 OVERVIEW OF AIRPORT DRAINAGES

Hydrologic data for this study were developed by Penfield & Smith Engineers (2000, Appendix A). These hydrologic data include rainfall and runoff, rainfall-frequency-duration curves, design rainfall hyetographs, watershed physical characteristics (drainage areas, soil types, vegetation cover, channel slopes, etc.), and design flood hydrographs. A summary of the data developed by Penfield & Smith (2000) is provided below.

2.1 WATERSHEDS AND DRAINAGES

The Airport is located in the Goleta Slough watershed (Figure 2). The watershed has a total drainage area of about 30,880 acres (48 square miles). The watershed is bisected by Ward Memorial Boulevard (Highway 217), forming two sub-watershed areas as follows:

- West of Ward Memorial Boulevard (17,770 acres). The creeks located in this sub-basin are Tecolotito (3,470 acres), Carneros (2,740 acres), San Pedro/Las Vegas (4,400 acres), San Jose (5,330 acres), and Goleta Slough (1,830 acres). Drainage in this sub-basin directly influences the Airport. Three creeks in this sub-basin are located in and immediately adjacent to the Airport: Tecolotito, Carneros, and San Pedro Creeks (Figure 2).

- East of Ward Memorial Boulevard (13,110 acres). The creeks located in this sub-basin are Upper Atascadero (4,770 acres), Lower Atascadero (620 acres), and Maria Ygnacio/San Antonio (7,720 acres). These creeks merge with the creeks listed above near the mouth of Goleta Slough. Drainage in this sub-watershed indirectly influences the Airport by affecting the outflow from the Goleta Slough where these creeks converge with flows from Goleta Slough and from San Pedro Creek.

Characteristics of individual sub-watersheds are summarized in Table 1.

TABLE 1
WATERSHED CHARACTERISTICS

Watershed	Area (acres)	Length (ft)	Elevation Difference (ft)	Average Slope (%)
Tecolotito Creek	3,470	31,000	3,016	9.73%
Carneros Creek	2,740	28,000	2,891	10.33%
San Pedro/Las Vegas Creek	4,400	28,000	2,826	10.09%
San Jose Creek	5,330	43,000	2990	6.95%
Maria Ygnacio/San Antonio	7,720	33,000	3273	9.92%
Upper Atascadero Creek	4,770	26,000	973	3.74%
Lower Atascadero Creek	620	6,400	27	0.42%
Goleta Slough	1,830	7,400	4	0.05%
Total=	30,880			

Source: Penfield & Smith (2000).

2.2 AIRPORT TOPOGRAPHY AND ELEVATION DATUM

In 2000, the Airport acquired new topographic maps of the Airport and Goleta Slough using the NAVD 88 vertical datum, which was also used by Santa Barbara Flood Control District in their 1995 topographic maps of the South Coast, including the Airport. Prior to 1995, topographic maps of the Airport and surrounding lands were based on NGVD 29, which is about 2.6 feet lower than the NAVD 88. All of the ground and water surface elevations presented in the Master Drainage Plan are based on NAVD 88 vertical datum, unless otherwise noted.

The Airport was constructed on fill material during the 1940s. The elevation of the Airport, and in particular, the airfield, is very low, with an average ground elevation of about 8 to 10 feet (NAVD 88) as shown on Figure 3. Significant portions of Goleta Slough and the lower ends of the creeks at the Airport are tidally influenced (below 6 feet elevation). Tecolotito Creek and Carneros Creek are tidally influenced downstream of Hollister Avenue. San Pedro Creek is tidally influenced downstream of Fowler Road.

2.3 RAINFALL

The rainfall in the South Coast Santa Barbara area varies significantly with elevation. The average annual rainfall at the coast is on the order of 16 inches, while the average annual rainfall at the top of the Santa Ynez Mountains (3,000 feet) is about 30 inches (Penfield & Smith, 2000). Santa Barbara County maintains a network of rain gauging stations on the South Coast. Rainfall gauging stations with automatic short-duration recording apparatus are sparsely distributed in and around the project watersheds. Table 2 summarizes the gauging locations and the period of available records.

TABLE 2
RAIN GAUGING LOCATIONS AND DATA SUMMARY

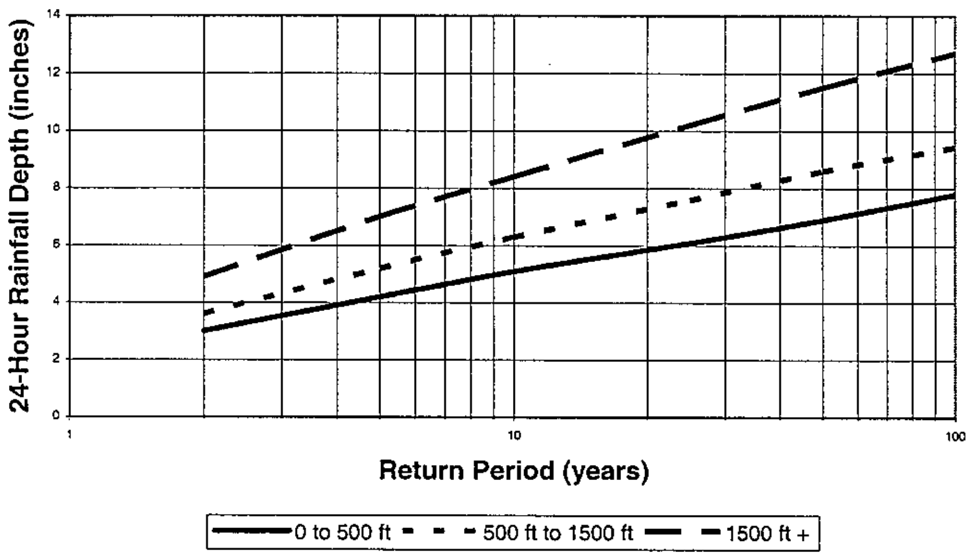
Station Number	Station Name	Elevation (feet)	Begin Water Year	End Water Year	No. of Years
199	Wood Residence	450	1985	1999	15
211	Santa Barbara County Road Yard	220	1962	1999	38
228	Stanwood Fire Station	700	1954	1999	46
308	Dos Pueblos Ranch	160	1947	1999	53
340	Doulton Tunnel	1,775	1926	1999	74
341	Santa Barbara - Downtown	100	1963	2000	38
390	San Marcos Pass	2,200	1955	2000	46
395	Trout Club	1,200	1951	1999	49

Source: Penfield & Smith (2000).

Rainfall in the project area varies temporally, geographically, and by elevation. Temporal distribution of the estimated rainfall depths was developed by using the Santa Barbara County unit hydrograph distribution that is typically applied in the Santa Barbara Urban Hydrograph (SBUH) Program. Geographic and elevational distributions were analyzed to estimate rainfall amounts in the

Airport watersheds for various return periods. Based on the analysis of the data, it was determined that rainfall depth is directly proportional to the ground elevation. These data are summarized in Chart 1.

CHART 1
RAINFALL AMOUNTS ALONG ELEVATIONAL GRADIENTS



Source: Penfield & Smith (2000).

Average annual rainfall recorded at the Airport is about 14 inches, compared with 18 inches recorded in the City of Santa Barbara, as shown in Table 3.

TABLE 3
SUMMARY OF RAINFALL DATA

Summary of Rainfall Data	Airport (NOAA Station 723925)*	City of Santa Barbara (NOAA Station 047902)
Period of Record	1941 - 2001	1927-2001
Annual Average (inches)	14.11	18.28
Annual Median (inches)	14.66	15.39
Highest Yearly Total	40.74 (1983)	41.48 (1941)
2nd Highest	35.11 (1978)	39.18 (1995)
3rd Highest	27.28 (1952)	37.96 (1998)
Highest Monthly Total	NA	24.2 (Jan '95)
2nd Highest Monthly Total	NA	21.76 (Feb '98)
3rd Highest Monthly Total	NA	17.33 (Feb '62)

Source: Penfield & Smith (2000). * (data from 1996-2001 incomplete)
NA = not available

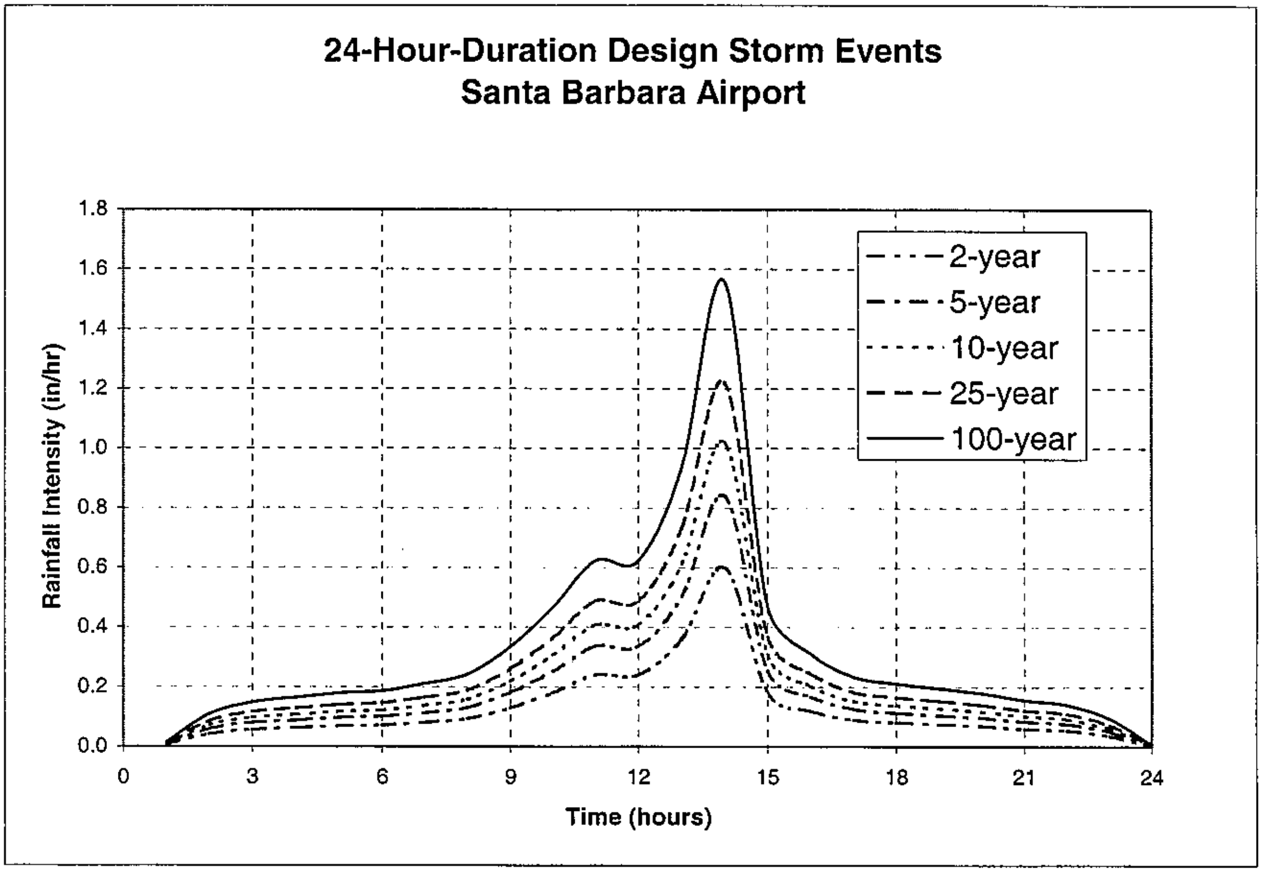
Rainfall data from gauging stations in the Goleta Slough watershed were compiled and analyzed to obtain the return period associated with specific 24-hour rainfall depths for three elevation ranges. The 24-hour duration rainfall hyetographs were then derived for selected design storm events at the Airport. Predicted hourly rainfall intensities for 2-year, 5-year, 10-year, 25-year, and 100-year return period storms are provided below in Table 4 and shown in Chart 2.

TABLE 4
PREDICTED 24-HOUR RAINFALL INTENSITY AT THE AIRPORT

Time (hours)	Rainfall Intensity (inches/hours)				
	2-year	5-year	10-year	25-year	100-year
1	0.006	0.008	0.01	0.012	0.016
2	0.042	0.059	0.071	0.085	0.109
3	0.057	0.08	0.097	0.116	0.148
4	0.063	0.088	0.107	0.128	0.164
5	0.069	0.097	0.117	0.14	0.179
6	0.072	0.101	0.122	0.146	0.187
7	0.081	0.113	0.138	0.165	0.211
8	0.093	0.13	0.158	0.189	0.242
9	0.129	0.181	0.219	0.262	0.335
10	0.18	0.252	0.306	0.366	0.468
11	0.24	0.336	0.408	0.488	0.624
12	0.24	0.336	0.408	0.488	0.624
13	0.36	0.504	0.612	0.732	0.936
14	0.6	0.84	1.02	1.22	1.56
15	0.18	0.252	0.306	0.366	0.468
16	0.12	0.168	0.204	0.244	0.312
17	0.09	0.126	0.153	0.183	0.234
18	0.081	0.113	0.138	0.165	0.211
19	0.075	0.105	0.128	0.153	0.195
20	0.069	0.097	0.117	0.14	0.179
21	0.06	0.084	0.102	0.122	0.156
22	0.054	0.076	0.092	0.11	0.14
23	0.036	0.05	0.061	0.073	0.094
24	0.003	0.004	0.005	0.006	0.008
Total	3.0	4.2	5.1	6.1	7.8

Source: Penfield & Smith (2000).

CHART 2
24-HOUR RAINFALL DESIGN STORM EVENTS AT THE AIRPORT



Source: Penfield & Smith (2000).

2.4 STREAMFLOW GAUGE DATA

A number of streamflow gauging stations have been established by the United States Geological Survey (USGS) in the Goleta Slough watershed. The number of years of record and reliability of these gauging stations vary significantly. The quality of the gauging data, due to poor channel cross section, tends to be fair to poor. A summary of the stream gauge records at and near the Airport is provided in Table 5. Years with maximum peak measured flows varied among stations, and included 1969, 1978, 1980, 1992, and 1995.

TABLE 5
STREAMFLOW GAUGE RECORDS IN THE WATERSHED

Station Name (location)	USGS Station No.	Drainage Area (square miles)	Period of Record	Flow (cfs)			
				Monthly Mean	Highest Peak[(1)]	2nd Highest Peak[(1)]	3rd Highest Peak[(1)]
Tecolotito Creek near Goleta, CA	11120530	4.42	1970-1991 (1970, 1971, 1972, 1980, 1981, 1982, 1987, 1988, 1989, 1990, 1991)	0.95	1,610 (Feb '80)	1,310 (Mar '91)	850 (Mar '81)
San Jose Creek near Goleta, CA (upstream of Patterson Avenue)	11120500	5.51	1941-1999	2.85	2,000 (Jan '69)	1,960 (Apr '41)	1,780 (Jan '73)
San Jose Creek at Goleta, CA (Below Hollister Avenue)	11120510	9.42	1970-1999	3.31	2,330 (Mar '78)	2,050 (Feb '92)	1,950 (Jan '73)
Maria Ygnacio Creek at University Drive near Goleta, CA	11119940	6.40	1970-1999	2.23	2,500 (Feb '92)	1,650 (Jan '78)	1,470 (Jan '73)
Atascadero Creek near Goleta, CA (below confluence with Maria Ygnacio)	11120000	18.9	1941-1999	5.86	10,200 (Mar '95)	5,380 (Jan '73)	5,380 (Feb '92)

(1) Peak flows represent highest, 2nd highest, and 3rd highest annual peak flows recorded.
Source: Penfield & Smith (2000) and United States Geological Survey (http://nwis.waterdata.usgs.gov)
cfs = cubic feet per second

2.5 DEPRESSIONAL STORAGE

Natural depressions with large detention storage or ponding volumes located within a watershed can significantly influence the flooding conditions in a watershed. Accumulation of surface runoff in these natural depressions can reduce peak flow rates and increase sediment deposition during storm events.

Penfield & Smith (2000) identified several depression storage areas located within the Goleta Slough watershed with significant volumes of detention (or ponding) capacities. Ponding of significant quantities of water during storm events may reduce peak flow rates and increase deposition of sediment. Table 6 lists the locations where volumes of depression storage were taken into consideration in the analyses for this plan. The table also includes the volume of runoff for the 2-year, 24-hour through 100-year, 24-hour storm events for comparison. The table shows that Goleta Slough has 3,000 acre-feet of storage capacity, which exceeds the runoff volumes resulting from storms up to 5-year storm events. The volume is equal to about 79% and 28% of storm runoff volumes of the 10-year and 100-year storm events, respectively. To the extent runoff has access to the storage, this storage or ponding can significantly reduce peak flow rates at the downstream end of Tecolotito Creek within Goleta Slough.

There is considerable depressional storage along Carneros Creek upstream of Highway 101, which reduces peak flows for Carneros Creek at the Airport, as shown in Table 6. In contrast, there is only a small amount of depressional storage along Las Vegas and San Pedro Creeks upstream of Highway 101, which provides very little reduction in peak flows for these creeks at the Airport (Penfield & Smith, 2000).

Table 6
Volume of Depression Storage Compared to Volume of 24-Hour Storm Events

Location	Volume of Depression Storage (acre-feet)	Total 24-hour Storm Volume (acre-feet)					
		2-Year Event	5-Year Event	10-Year Event	25-Year Event	50-Year Event	100-Year Event
Goleta Slough[1]	3,000	1,457	2,868	3,781	5,615	9,509	10,864
Percentage of 24-hour storm		100%	100%	79%	53%	32%	28%
Upstream of U.S. 101 at Carneros Creek[2]	148	206	430	578	858	1,446	1,650
Percentage of 24-hour storm		72%	34%	26%	17%	10%	9%
Upstream of U.S. 101 at Las Vegas Creek[3]	18	380	740	977	1,422	2,321	2,647
Percentage of 24-hour storm		5%	2%	2%	1%	1%	1%

[1]Location of depression storage is at Goleta Slough. It includes the various tidal and non-tidal basins and provides up to 3,000 ac-ft of storage. Storm volume includes flow from Tecolotito, Carneros, San Pedro/Las Vegas, and San Jose Creek watersheds.
[2]Location of depression storage is upstream of US 101 at Carneros Creek.
[3]Location of storage is upstream of US 101 at Las Vegas Creek. Storm volume includes runoff volume from San Pedro and Las Vegas Creeks below their confluence.
Source: Penfield & Smith (2000).

2.6 SEDIMENT BASINS

The Santa Barbara County Flood Control District (FCD) maintains two sediment basins on Tecolotito and Carneros Creeks downstream of Hollister Avenue. The storage capacities of the basins are about 10,000 cubic yards for the sediment basin on Tecolotito Creek and 6,000 cubic yards for the basin on Carneros Creek, respectively. The past experience with maintenance/dredging activities has shown that these basins have sufficient storage capacities to hold sediment materials generated during smaller, frequent flood events. However, they are too small to accommodate sediment materials generated during major flood events. On the average, the basins require de-silting about every other year. A review of sediment data collected from Tecolotito and Carneros Creeks indicates that the basins primarily capture fine to medium-size sand particles. The materials smaller than fine sand are expected to be transported downstream and deposited in the Goleta Slough or transported to the ocean.

2.7 ESTIMATED DISCHARGES FOR STREAMS NEAR THE AIRPORT

Penfield & Smith Engineers (2000) developed peak flow rates of creeks in the vicinity of the Airport by using the U.S. Army Corps of Engineers, Hydrologic Engineering Center's HEC-1-Flood Hydrograph Package model for the 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year, 24-hour storm events. A Clark synthetic hydrograph model was used to convert rainfall to runoff. Initial infiltration losses were adjusted to match final discharge estimates with recorded streamflow data. The Muskingum-Cunge method was used to route channel flows. Since Goleta Slough provides a large volume of storage, reservoir routing was applied at Goleta Slough to account for this storage. Peak flow rates at different locations near the Airport are presented in Table 7. Predicted hydrographs for the three major drainages at the Airport (Tecolotito, Carneros, and San Pedro Creeks) and for nearby San Jose Creek are presented in Charts 3a-f.

TABLE 7
SUMMARY OF ESTIMATED PEAK FLOOD DISCHARGES

Drainage Basin and Location	Peak Discharge (cfs)					
	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
Tecolotito Creek at Hollister Avenue	300	1,000	1,500	2,500	3,900	4,400
Carneros Creek at Hollister Avenue	300	900	1,300	2,100	3,100	3,600
San Pedro Creek at Hollister Avenue	600	1,500	2,200	3,400	5,000	5,700
San Jose Creek at Hollister Avenue	1,100	2,200	2,800	4,400	6,400	7,200
Inflow to Goleta Slough(3)	2,200	5,700	7,800	12,800	19,200	21,800
Outflow from Goleta Slough (d/s of Ward Memorial)(1)	1,700	3,800	4,300	5,900	9,100	10,000
Outflow to Pacific Ocean (2)	2,600	6,300	7,800	11,300	18,200	22,700

(1) Includes depressional storage effect of Goleta Slough.
(2) Includes runoff from Atascadero Creek.
(3) Please note that the combined flows at Goleta Slough from various creeks do not necessarily represent a simple sum of peak flows on individual creeks due to differences in the timing of peak flows in each creek.
Source: Penfield & Smith (2000). Data on Atascadero Creek were not provided in the report.

CHARTS 3a-f
DESIGN STORM HYDROGRAPHS

Chart 3a Hydrographs for 2-Year Return Period Storm Event

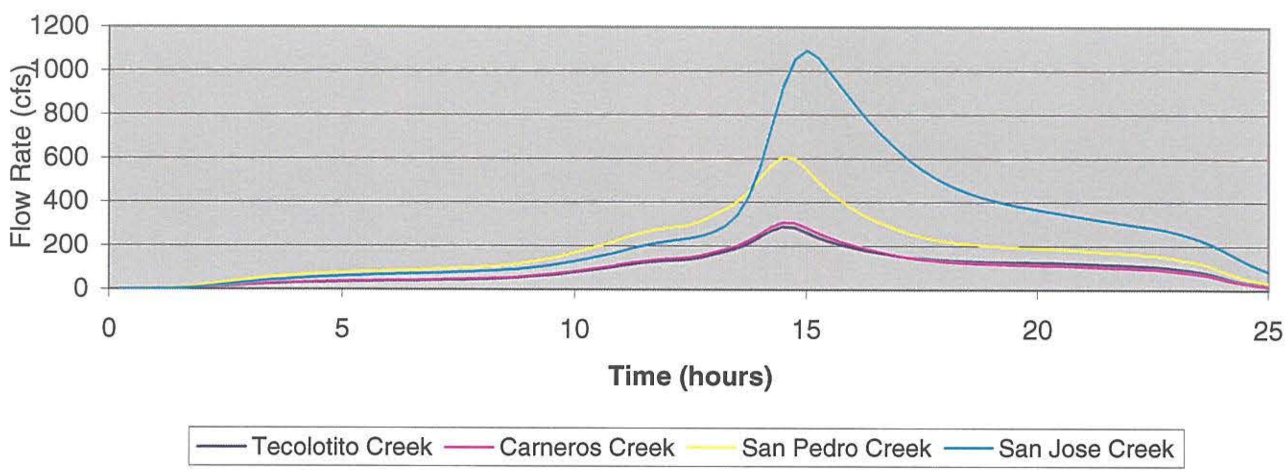


Chart 3b Hydrographs for 5-Year Return Period Storm Event

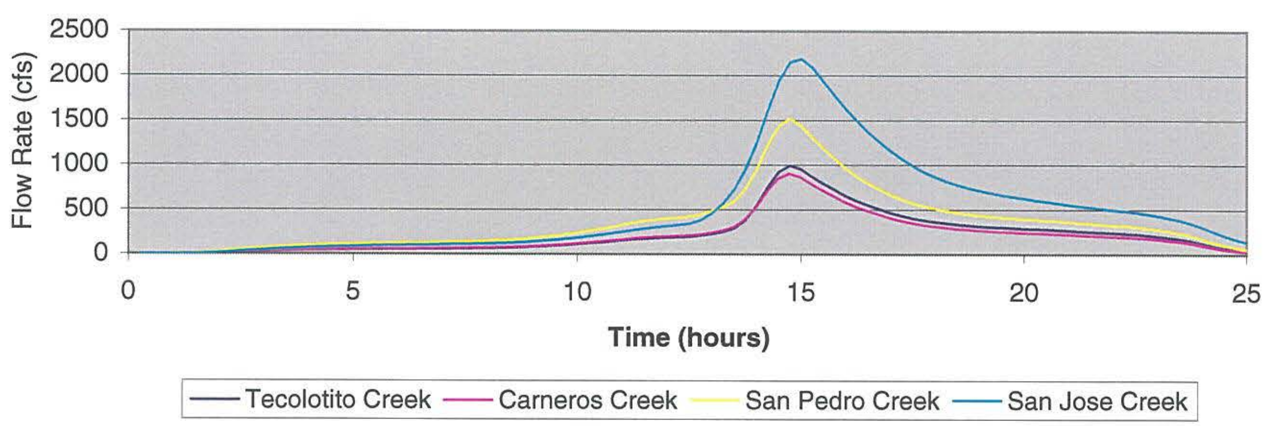
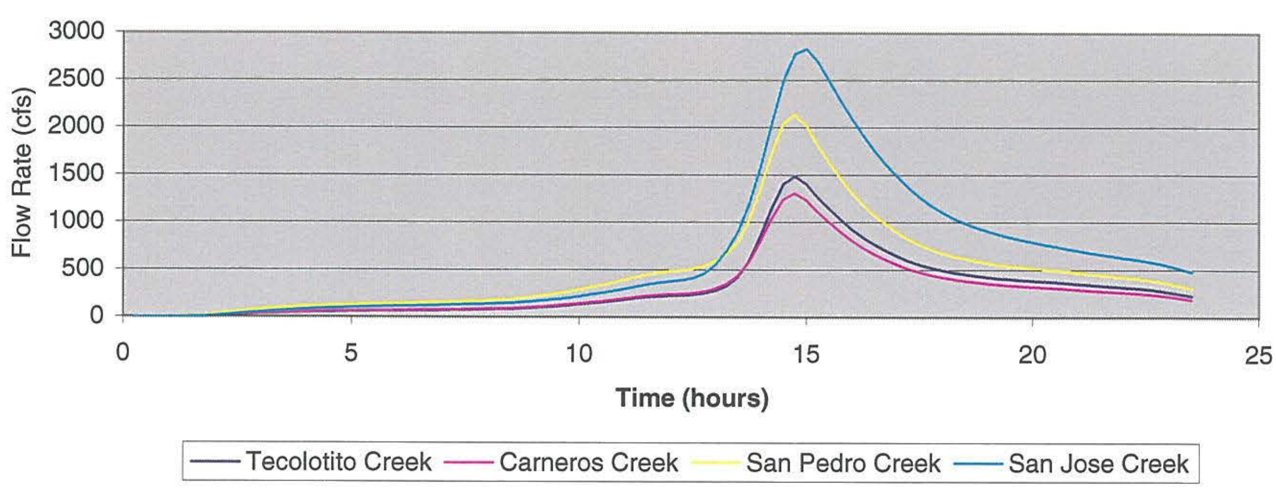
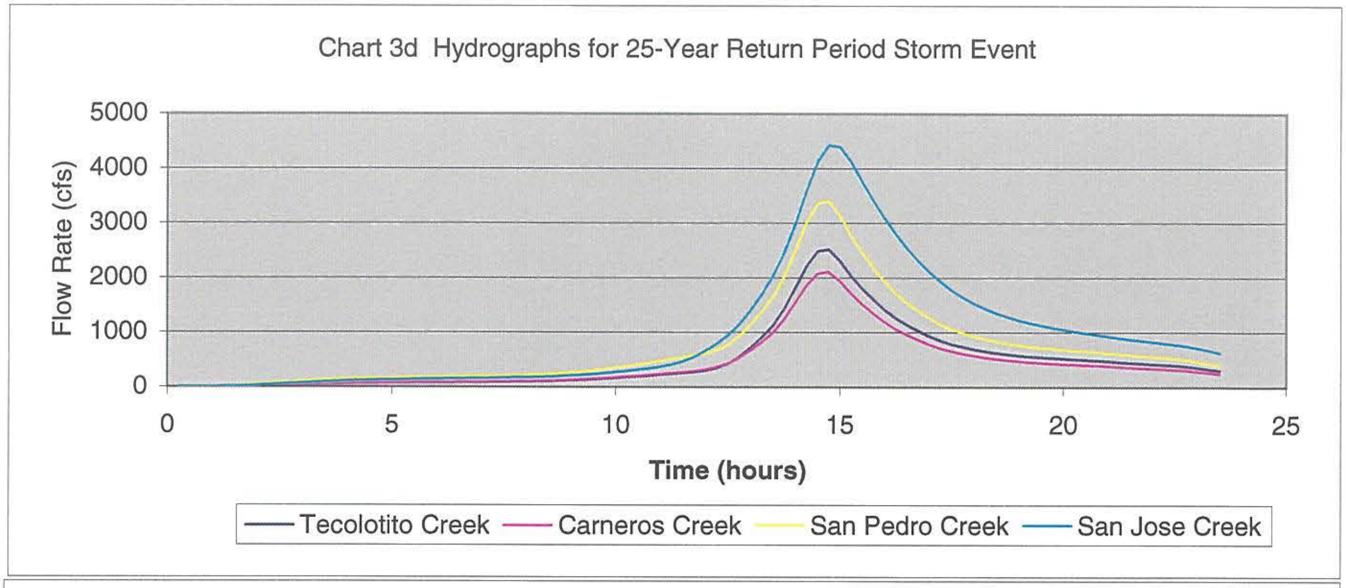


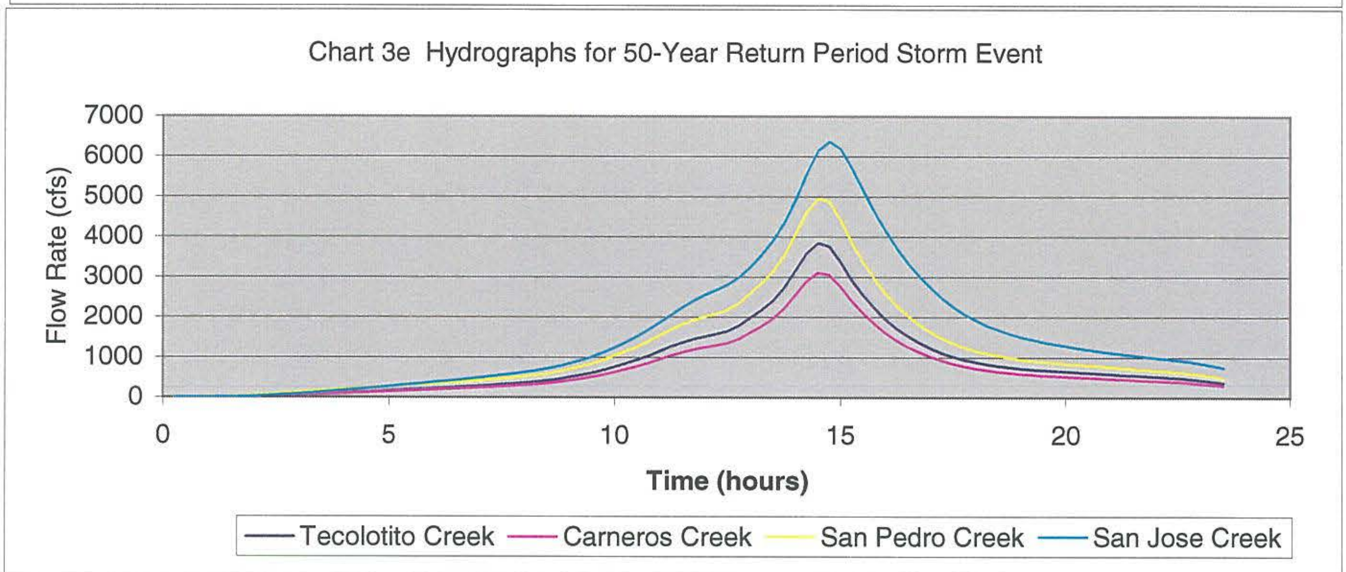
Chart 3c Hydrographs for 10-Year Return Period Storm Event

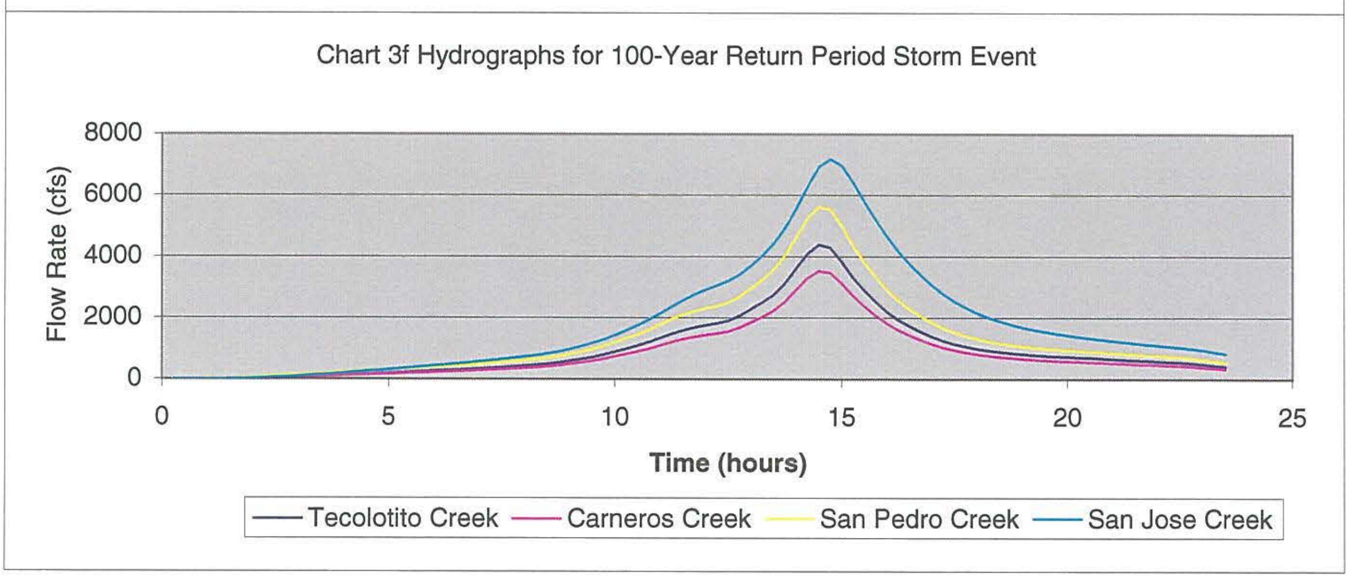


Source: Penfield Smith, 2000

CHARTS 3a-f
DESIGN STORM HYDROGRAPHS







Source: Penfield Smith, 2000

The estimated peak flow rates shown on Table 7 for the various creek locations were compared to recorded streamflow data and to peak flow rate estimates developed for the Federal Emergency Management Agency (FEMA). In most cases, modeled peak flow rates were within 20% of the statistical results based on recorded streamflow data. This accuracy is typical for hydrology studies where data are insufficient to accurately determine actual flow rates for low frequency events. Differences could be due to difficulties in gauging higher flows (most gauges are not rated for high flow rates), deficiencies in the length of the gauged record (most gauges do not have sufficient data to accurately estimate low frequency events (25-, 50- and 100-year), or features in the watershed that may not have been modeled in sufficient detail. The reduction in peak flow rates downstream of Ward Memorial is due to storage effects in Goleta Slough.

2.8 FLOODPLAIN AND FLOODWAY BOUNDARIES

Most of the Airport property is within the 100-year floodplain boundary as shown on Figure 4. The boundaries of the 100-year floodplain, as determined by FEMA, are described in the City of Santa Barbara Flood Insurance Study (dated 12/3/1991) and the Flood Insurance Study for Santa Barbara County, Unincorporated Areas (Revised July 7, 1999). These reports are updates of previous reports completed in 1973 to incorporate channel improvements on several creeks located in Santa Barbara County and City. However, floodplain boundaries for Tecolotito Creek near the Airport are based on the 1973 analysis. The County study provides floodplain boundaries from the mouth to 3.8 miles upstream. The City study covers the area from the mouth to Hollister Avenue.

The floodway is contained within the floodplain. It is the portion of the floodplain that can convey the entire 100-year flood flow without an increase in water surface elevation of more than one foot if the entire floodplain were developed. In other words, if the entire floodplain (outside the floodway) were completely obstructed, the water surface elevation in the floodway would not increase by more than one foot at any location. Three floodways occur at the Airport: along San Pedro/Las Vegas Creeks, Tecolotito Creek, and Carneros Creek (see Figure 4).

The predicted water surface elevations for the 100-year flood event, as estimated by FEMA, are as follows. The water surface elevation for the 100-year flood along Tecolotito Creek is about elevation 13.5 feet NAVD 88 throughout the entire floodplain near the Airport, increasing to about elevation 14.6 feet at Hollister Avenue. Along San Pedro Creek the water surface elevation is also about elevation 13.5 feet near the Airport terminal, increasing to greater than elevation 17.6 feet at Hollister Avenue.

2.9 CREEK CONDITIONS

The physical conditions of the creeks that occur on Airport property are described below.

2.9.1 Tecolotito Creek

Tecolotito Creek enters the Airport through a concrete culvert under Hollister Avenue (Figure 1). The creek traverses Goleta Slough through man-made channels for the first two-thirds of its length, then through a natural channel. It leaves Airport property at the bike path footbridge at the end of Moffett Place. The creek passes under Ward Memorial Drive and joins San Pedro, San Jose, and Atascadero Creeks before discharging to the ocean at Goleta Beach. The total length of the creek on Airport property is about 9,700 feet.

The creek is tidally influenced downstream of Hollister Avenue. Water is generally present year-round in the creek due to: (1) winter runoff; (2) tidal inflows; (3) ponded water in the Tecolotito Creek Sediment Basin (described below); and (3) nuisance flows from upstream urban uses.

The width of Tecolotito Creek ranges from 75 to 150 feet with a depth of 7 to 12 feet between Hollister Avenue and the confluence with Carneros Creek. The first 560 feet of the creek downstream of Hollister Avenue contains a sediment basin maintained by Santa Barbara County Flood Control District (FCD). The basin is an 80-foot-wide depression in the center of the channel that is maintained to a depth of 6 to 8 feet from the typical channel invert. The basin can store up to 10,000 cubic feet of sediments. The County FCD removes sediments from the basin on an as-needed basis, which occurs approximately every two years. Sediments are removed using a crane with a dragline operating from either side of the creek. Sediments are placed in adjacent stockpile sites (see below) about 30 to 100 feet from the banks for dewatering and eventual off-site disposal.

The County FCD has built up a 25- to 50-foot wide aggregate base road along the north side of Tecolotito Creek from Hollister Avenue to its confluence with Carneros Creek to facilitate the use of heavy equipment and trucks. An 800-foot by 100-foot sediment dewatering site is located adjacent to the access road on the top of the bank. A similar access road is present on the west side of the creek, along with a smaller sediment dewatering site. Sediment removal is conducted less frequently from the west side of the creek.

The northern banks of the creek between Hollister Avenue and its confluence with Carneros Creek are very steep and devoid of vegetation due to desilting operations. They are in varying stages of erosion. The southern and eastern banks are also very steep, but are covered with vegetation, which is preventing bank erosion. The channel bottom contains a mixture of sands and clays from the watershed. Water is present year round in the basin.

Downstream of the confluence with Carneros Creek, the creek consists of a uniform semi-trapezoidal shaped channel with non-engineered berms on both sides. The banks are very steep (up to 1.5:1 [horizontal:vertical]). Erosion from the oversteepened banks is present along most of this length, particularly along the base of the banks where there is continual tidal action. The channel is about 50 feet wide and 6 to 8 feet deep. The substrate is a mixture of sand and clay sediments deposited during storm events. Water is present year-round in the channel. Tidal fluctuations range up to 5 feet in height. The channel can only contain flows from a 5- to 10-year storm event.

The man-made levees on both sides of Tecolotito Creek within Goleta Slough end in the center of Goleta Slough. Downstream of this point, the creek is a natural channel that meanders through the salt marsh. The channel is about 30 to 40 feet wide, and 5 feet deep. The banks appear to be stable and are fully vegetated. The channel bottom is a mixture of fine and coarse sediments. Water is present year-round, including during most low tides.

2.9.2 Carneros Creek

Carneros Creek enters Airport property through a culvert under Hollister Avenue. It then passes under a bridge along Firestone Road. The creek also receives flows from the Firestone Ditch, which drains portions of the Airport property north of Hollister Avenue. The ditch terminates between Hollister Avenue and Firestone Road, and discharges to Carneros Creek through four culverts under

Firestone Road. In addition, a small surface drainage ditch along the south side of Firestone Road discharges to Carneros Creek along its west bank, immediately downstream of Firestone Road. Carneros Creek is tidally influenced up to Hollister Avenue.

The reach of Carneros Creek on the Airport is 2,500 feet long. It is a man-made channel about 50 to 60 feet wide and 6 to 10 feet deep. The first 600 feet of the creek (i.e., the north-south trending reach) is a sediment basin maintained by County FCD. The basin consists of a depression in the center of the channel that is excavated as much as 6 feet below the typical channel invert elevation. The basin can store up to about 6,000 cubic feet of sediments. The County FCD removes sediments from the basin on an as-needed basis, approximately every two years. Sediments are removed using a crane with a dragline operating from the east bank of the creek. Sediments are placed on the other side of the access road along the east bank for dewatering and eventual off-site disposal.

The County FCD has built up a 30-foot-wide aggregate base road along the east and south sides of Carneros Creek for the first 600 feet to facilitate the use of heavy equipment and trucks. A similar access road has also been constructed along the north side of Carneros Creek from the Airport maintenance yard to its confluence with Tecolotito Creek. Although this reach is not a routine sediment basin, it has been used for emergency sediment removal in 1995 and 1998. A 400-foot by 100-foot sediment dewatering site is located adjacent to the access road on the west side of the creek.

The banks on the east side of the creek at the sediment basin site are devoid of vegetation and highly eroded, although they have a gentle slope (about 2:1). The northern banks of the creek from the Airport maintenance yard to the confluence with Tecolotito Creek are very steep, devoid of vegetation, and eroding. The southern bank is also very steep, but is covered with vegetation, which is preventing bank erosion. The channel bottom contains a mixture of sands and clays from the watershed. Water is present year-round in the basin. The channel can only contain flows from a 5- to 10-year storm event within its banks.

2.9.3 San Pedro Creek

San Pedro Creek has two main tributaries: San Pedro Creek and Las Vegas Creek. It has the largest watershed of the creeks at the Airport. The two tributaries join immediately upstream of the Hollister Avenue bridge, then the creek extends along Fairview Avenue to its confluence with San Jose Creek, then with Tecolotito and Atascadero Creeks, and finally to the ocean at Goleta Beach. On Airport property, San Pedro and Las Vegas Creeks consist of maintained man-made channels. San Pedro Creek is tidally influenced up to Matthews Road, about 1,500 feet upstream of the Fowler Road bridge. Water is only present within this creek above this point during winter runoff conditions.

San Pedro Creek upstream of Hollister Avenue is a man-made earthen channel about 40 to 50 feet wide and 5 feet deep. The substrate of the channel is loose silt and sand sediments. The banks of San Pedro Creek are varied – portions contain concrete bank protection, while other areas are devoid of vegetation and eroding. Downstream of Hollister Avenue, San Pedro Creek consists of a uniform earthen trapezoidal channel with concrete bank protection along limited reaches. The average channel width is about 50 to 60 feet, with a depth of 8 to 10 feet. The bed consists of loose silt and sand sediments. The channel bed is actively cleared of vegetation by County FCD. San Pedro Creek along Fairview Avenue can convey runoff from a 10- to 25-year storm event. County FCD maintains a sediment basin along San Pedro Creek downstream of the Fowler Road bridge.

3.0 DRAINAGE FACILITIES AT THE AIRPORT

The storm drain facilities and engineered channels south of Hollister Avenue are described below.

3.1 SURFACE WATER AND STORM DRAIN SYSTEMS

The Airport storm drainage system includes catch basins, manholes, headwalls, drain pipes, pipe outlets, and other storm drainage structures. Figure 5 shows the general layout of the Airport storm drainage system and general surface drainage patterns in and adjacent to the airfield area. Sage Consultants, Inc. field surveyed all drainage facilities owned and/or served by the Airport, including catch basins, manholes, drain inlets, headwalls, pipe outlets, etc. All the visible drainage features were surveyed and subsurface conduits were drawn schematically from record drawings. Field measurement of facility attributes such as depth, size, construction type, etc. was cataloged and provided in Microsoft Access 97 database format. The general surface drainage pattern in the airfield area was identified based on the recent topographic map of the Airport by Sage Consultants Inc (January 2001).

The Airport storm drainage system south of Hollister Avenue was grouped into eight separate storm drainage networks, each with its own drainage outlet into an adjacent creek or wetland in Goleta Slough. A detailed map of the storm drain facilities in each network is shown on Figure 5. The drainage features for each network are shown on Figure 6. A summary of the networks is also presented in Table 8.

TABLE 8
SUMMARY OF AIRPORT STORM DRAIN NETWORKS SOUTH OF HOLLISTER AVE

Network	Primary Drainage Basin	Outlet
1, 3, 4, 6	Airfield	Goleta Slough
2	North ramp area	Tecolotito Creek upstream of Goleta Slough
5	Ramps along Runway 15/33 and airfield	Goleta Slough
7	Airfield, fuel farm. Garrett Aviation hangar	San Pedro Creek
8	Airfield, terminal ramps	San Pedro Creek

* See Figures 5 and 6 for locations of networks.

The invert elevations of drain inlets, surrounding ground elevations, and drainage area of each drain inlet are presented in Tables B-1 to B-8 in Appendix B for each of the eight storm drainage networks. Paved and unpaved drainage areas were identified and measured based on digital aerial photographic maps provided by Sage Consultants, Inc. The surveyed elevations and drain inlet sizes were obtained from the storm drainage system database provided by Sage Consultants, Inc.

Data on the types of stormdrain pipes and the open channel sections for each of the eight stormdrain networks are provided in Tables B-9 to B-16 in Appendix B. The tables summarize the drain pipe details including pipe types (e.g., reinforced concrete pipe (RCP)), diameters, lengths, etc. These data were obtained from the storm drain system database provided by Sage Consultants, Inc.

The storm drain outfall diameters and invert elevations are summarized in Table 9. Outfall locations are shown on Figure 5. Tide elevations (for tidal heights) that block the outfall and prevent drainage are shown in Table 9. Discharges from the outfalls will continue at these elevations, which are based on the lowest inlet elevation in the network, because there would be positive pressure in the drain pipe. However, tides above these elevations would prevent drainage into the inlet and cause upstream flooding.

TABLE 9
OUTFALL DIAMETERS AND INVERT ELEVATIONS FOR DISCHARGES FROM AIRPORT STORM DRAINAGE SYSTEM

Outfall Number (See Figure 5)	Network (See Figs 5 or 6)	Outfall Diameter (inches)	Outlet Invert Elevation (feet, NAVD 88)	Tidal Height That Blocks Outfall[(1)]	Comments
Discharges to Goleta Slough					
P-X07-009	1	24	4.36	8.00	
P-W07-034	2	24	3.96	7.30	
P-X07-097	4	46	2.62	8.69	
P-X07-029	3	24	4.54	8.04	
P-Y-08-085	6	18	4.22	8.04	
P-Y08-059	5	30	4.42	7.94	
P-Y08-088		24	4.01	9.18	
P-Y07-156		24	5.47	8.97	
Discharges to Carneros Creek					
P-X07-170		36	6.20	9.66	Drains area south of Hollister
P-X07-108		12	8.24	9.81	Drains maintenance yard (12" PVC)
P-X06-252		12	9.02	11.16	Drains maintenance yard (12" PVC)
P-X06-242		24	8.04	ND	Drains facilities south of Firestone Road
P-X06-244		36	7.91	ND	Drains Firestone Channel
P-X06-245		36	7.93	ND	Drains Firestone Channel
P-X06-246		36	7.84	ND	Drains Firestone Channel
P-X06-247		36	5.79	ND	Drains Firestone Channel
Discharges to San Pedro Creek					
P-Z07-201	7	30	2.64	8.86	
P-Z07-263	8	30	4.91	8.24	
P-Z06-189		12	ND	13.81	Drains parking lot across Verhelle Bridge
P-Z06-196		12	7.56	15.51	Drains parking lot across Verhelle Bridge
P-Z06-200		12	6.74	13.90	Drains parking lot across Verhelle Bridge
Discharges to wetlands southeast of Terminal (no tides assumed)					
P-Z07-125		20	ND		Drains terminal parking
P-Y07-251		18	6.16		Drains terminal parking
P-Y07-181		14	5.51		Drains terminal parking
P-Y08-158,159		12	7.18		Drains terminal parking

(1) Tidal Height is the tidal elevation that prevents drainage without causing flooding. The analysis of controlling tide height is based on the lowest structure in the network. Tide heights differ slightly from ground elevations commonly used for surveying. The Airport topographic maps are based on the NAVD 88 vertical datum, which is about 0.2 foot less than the tide datum. As such, ground elevations based on NAVD 88 datum can be used interchangeably with tide height when precision is not required.

PVC = polyvinyl chloride

ND = not determined

3.2 FIRESTONE CHANNEL

Firestone Channel is an earthen drainage channel located between Hollister Avenue and Firestone Road (Figure 7). It extends about 2,500 feet from Hartley Place to its confluence with Carneros Creek. The channel receives storm runoff from eight sub-areas located just north of Hollister Avenue with a total area of 221 acres (see Figure 7 for location of sub-areas). There are five concrete box culverts that convey runoff under Hollister Avenue to the channel. Table 10 lists the sub-areas and individual acreage. The land use is primarily light industrial uses, parking lots, and streets, with a small amount of undeveloped land. Sub-areas H and G, north of Highway 101, are currently open space. Peak 25-year design discharges from these sub-areas calculated by Flowers & Associates (November 1997) is provided in Table 10.

TABLE 10
CHARACTERISTICS OF FIRESTONE CHANNEL DRAINAGE AREAS

Sub-Area ID	Drainage Area (acres)	Land Use	25-year Design Discharge Q_{25} (cfs)
A	30.8	Light Industrial	68
B	22.9	Light Industrial	51
C	24.4	Light Industrial	54
D	0.6	Street, parking lot	1
E	31.9	Light Industrial	70
F	37.3	Light Industrial, open	82
G	8.3	Open space	18
H	64.8	Open space	120
Total	221.0		464

*See Figure 7 for locations of drainage sub-areas. Data from Flowers & Associates, Nov. 1997.

URS reviewed the predicted storm runoff and design discharges developed by Flowers and Associates (November 1997). The estimated discharges for the individual sub-areas shown on Table 10 were computed based on the 25-year design storm (2.9 in/hr) using a time of concentration of 12 minutes. The total discharge in Firestone Channel was then estimated by a simple sum of the individual peak discharges for the sub-areas. This approach of adding peak discharges provides a very conservative estimate of the total peak runoff of the creek for design purposes.

4.0 DRAINAGE PROBLEMS AT THE AIRPORT

4.1 GENERAL DRAINAGE CONSTRAINTS AND FLOODING PROBLEMS

Drainage at the Airport is generally adequate during small storms. However, drainage is poor during large storms, particularly coupled with high tides, due to the following constraints: (1) the Airport is located at a very low elevation relative to the receiving tidal waters in Goleta Slough, San Pedro Creek, and Tecolotito Creek; and (2) the Airport is relatively flat with very little slope, limiting hydraulic capacity.

Portions of the airfield flood during large storms, such as those experienced in 1995, 1998, and 2001. For example, in the January and March 1995 storms, flooding and sediment deposition occurred on Runway 7-25, Runway 15R-33L, Runway 15R-33R, and Taxiways A, B, C, D, H, and J. The flooding was due to a combination of backwater flooding from the storm drain system in the infield that was overwhelmed by the high flood flows and tides in Goleta Slough that prevented drainage; the high amount of direct precipitation and local runoff on the airfield; flooding from Tecolotito and Carneros Creeks at the west end of the airfield; and flooding from San Pedro Creek in the northwest corner of the Airport.

A significant sediment load is carried from the mountain portions of the Airport watershed that is often deposited at the Airport because of the reduction in slope as flows reach the coastal plain. Extensive sediment deposition often occurs along San Pedro, Tecolotito and Carneros Creeks below Hollister Avenue (see Figure 8) that reduces channel capacity and causes overbank flooding.

4.2 VERHELLE BRIDGE

A wood trestle bridge is located along San Pedro Creek about 700 feet south of Hollister Avenue (Figure 9). Supports for the bridge are located in the creek channel and therefore obstruct the flow, especially during high flow events. Debris also can be trapped by the trestle, further reducing the capacity of the creek to convey flow under the bridge. A hydraulic analysis of the bridge was conducted to assess the impact of the trestle and supports on the flow capacity of San Pedro Creek under the bridge. The analysis was conducted using the U.S. Army Corps of Engineers, Hydrologic Engineering Center's River Analysis System (HEC-RAS) model developed for San Pedro Creek for the channel modification alternatives study.

The bridge supports were assumed to consist of five 1.5-foot-wide piers on 18-foot centers. The analyses included three scenarios of debris accumulation: (1) no debris, (2) moderate amount of debris, and (3) high level of debris. Debris accumulation under the bridge was represented by debris width and depth. It was assumed that the area between the banks and the first row of piers would be blocked and would not be able to carry flow. Results of the analyses are summarized in Table 11. A high level of debris accumulation would increase the water surface elevation in San Pedro Creek upstream of the bridge by about 0.7 feet for the 10-year flood event and about 1.3 feet for the 25-year flood event.

TABLE 11
INCREASE IN WATER SURFACE ELEVATION DUE TO TRESTLE BRIDGE ON SAN PEDRO CREEK

Modeling Scenario No.	Debris Width (feet)	Debris Depth (feet)	Water Surface Elevation for Specified Flood Event[1] (feet, NAVD 88)			
			10-yr	25-yr	50-yr	100-yr
1 – no debris	0	0	12.18	14.31	16.43	17.05
2 – moderate debris	6	3	12.26	15.04	16.98	17.53
3 – high debris	10	5	12.86	15.58	17.29	17.79

(1) Based on an assumption of a clear span. Modeling results from URS Corporation.

4.3 SAN PEDRO CREEK BANK EROSION

San Pedro Creek downstream of Hollister Avenue is experiencing various stages of bank failures (Figure 8). These bank failures are due to a combination of bank sloughing during and after major storm events that fill the channel; and incidental erosion following maintenance dredging of the creek after major storms. Over time, the toes of the creek banks have been reduced during the dredging operations, creating overly steep banks devoid of vegetation and causing increased bank erosion. Flood flows continue to erode the creek banks, resulting in bank erosion at the end of the safety area for Runway 7-25.

4.4 LAS VEGAS CREEK PROBLEMS

Las Vegas Creek flows through the Twin Lakes Golf Course before discharging into San Pedro Creek (Figure 9). The creek experiences several drainage problems:

- The abutments on the wooden footbridge associated with the golf course are exposed and need to be repaired.
- The concrete-lined channel between the golf course bridge and Hollister Avenue has experienced channel degradation and bank erosion during flood events.
- Portions of the concrete lining upstream of the golf course bridge are being undermined.
- The channel has very limited capacity and overbank flooding occurs during high flows, depositing sediment throughout the golf course. This material must be collected and hauled off.

It should be noted that there are severe capacity problems along Las Vegas and San Pedro Creeks between Calle Real and the Airport property. The culverts under Calle Real and Highway 101, and the Union Pacific railroad bridges for these creeks convey less than the 10-year storm event, causing flooding upstream of Highway 101 during larger storm events. Penfield & Smith (2000) recommended enlargement of these culverts and bridges to improve conveyance under Highway 101 and the railroad. These improvements would occur outside Airport property by other government agencies. If these improvements are implemented, there would be a greater need to address the channel problems along Las Vegas Creek and the conveyance limitation of the Hollister Avenue Bridge on San Pedro Creek.

4.5 FIRESTONE CHANNEL CAPACITY

Firestone Ditch is an earthen channel located between Hollister Avenue and Firestone Road at the Santa Barbara Airport (Figure 7). It extends about 2,500 feet from Hartley Place to its confluence with the Carneros Creek sediment basin. The channel conveys stormwater runoff from the industrial areas north of Hollister Avenue to Carneros Creek, which in turn discharges to Goleta Slough. Five concrete box and pipe culverts convey runoff under Hollister Avenue to the channel. Firestone Channel discharges to the Carneros Creek sediment basin through four pipe culverts.

The existing hydraulic capacity of the Firestone Channel is 200 cubic feet per second (cfs) (Flowers & Associates, 1997), which is less than the runoff from a 5-year storm event. This discharge exceeds the channel capacity at the western portions of Firestone Channel and at the four culverts discharging into Carneros Creek. As such, the Firestone Channel is prone to overbank flooding, which creates a public safety hazard along Hollister Avenue and Firestone Road, and can adversely affect operations at the Airport.

4.6 FLOODING ALONG HOLLISTER AVENUE

The area just south of Hollister Avenue and between Tecolotito and Carneros Creeks is undeveloped and floods periodically (Figure 10). The low-lying portion of this area is at an elevation of 9 to 10 feet. The elevation of Hollister Avenue between Aero Camino and Los Carneros Way ranges from 11.5 to 15.8 feet and the surrounding areas are at elevations of 10 to 11 feet. Runoff from the undeveloped land north of Hollister Avenue is directed to an 8-foot by 2-foot concrete box culvert under Hollister Avenue. It discharges to a poorly defined earthen channel, about two feet deep and 5 to 8 feet wide. The channel extends to a 36-inch-diameter culvert that discharges to Carneros Creek. The invert of the box culvert under Hollister Avenue is about elevation 9.5 feet, while the invert elevation of the pipe culvert at Carneros Creek is about elevation 9.7 feet.

A 24-inch-diameter concrete pipe culvert is located under Hollister Avenue, west of the box culvert (Figure 10). It conveys runoff from the parking lot of the industrial area, and from the westbound lanes of Hollister Avenue. It discharges to a small swale south of Hollister Avenue that carries runoff to the above-mentioned steel pipe culvert. The invert elevation of the drainage channel and swale that extend from Hollister Avenue to the steel pipe culvert (Figure 10) is about elevation 9 feet.

The low-lying areas south of Hollister Avenue on Airport property flood every year because these areas are not drained. This flooding does not represent a problem for Airport operations. However, Hollister Avenue frequently floods during high rainfall events near this low-lying area for the following reasons:

- The channel that extends from Hollister Avenue to the steel pipe culvert at Carneros Creek is densely vegetated with cattails and giant reed, and as such, has limited conveyance.

- The invert elevation of the steel pipe culvert at Carneros Creek is too high to drain the area near Hollister Avenue.
- The size of the steel pipe culvert (36 inches) at Carneros Creek is insufficient to convey runoff from the area.

5.0 HYDRAULIC ASSESSMENT

5.1 HYDRAULIC MODELING OF EXISTING STORM DRAINAGE SYSTEM

The hydraulic conveyance capacities of the storm drainage networks were assessed to identify critical drainage areas (such as areas with surcharging and flooding) in the system that need to be improved under the proposed Runway Safety Area Extension Project. For this purpose, a comprehensive storm water drainage model, which can simulate both rainfall-runoff processes and dynamic flow conditions in pipe drainage systems, was selected.

The United States Environmental Protection Agency's (USEPA's) Storm Water Management Model (SWMM) was used to assess hydraulic capabilities of the Airport storm drainage system in order to identify areas with surcharging and localized flooding. The SWMM Version 4.3 (1993) is a comprehensive computer model for analysis of quantity and quality problems associated with urban runoff.

The SWMM consists of several sub-models or blocks, including three principal computational blocks: Runoff Block, Transport Block, and Extran Block used for hydrologic and hydraulic analyses of drainage conveyance systems. A few of the model capabilities are listed below:

- Performs both single-event and continuous simulations on catchments having storm sewers, or combined sewers and natural drainage, for prediction of flows, stages and pollutant concentrations.

- Used in both planning and design levels. In the planning level, the model is used for overall assessment of existing and proposed storm drainage systems. In design level, an event simulation mode can be used with detailed catchment schematization and shorter time steps for precipitation input.

- Simulates all aspects of the urban hydrologic and quality cycles, including rainfall, surface and subsurface runoff, flow routing through drainage network, storage and treatment.

- Runoff Block generates runoff hydrographs from rainfall hyetograph and physical characteristics of drainage areas. Simulated runoff hydrographs are routed overland using the non-linear reservoir cascade routing method.

- Transport Block simulates free surface flow of runoff through a drainage conveyance system of pipes and channels. The hydraulic flow routing though the conveyance system is performed using kinematic wave method.

- Extran Block solves complete dynamic flow routing equations (St. Venant equations) for accurate simulation of backwater, looped connections, surcharging, and pressure flow conditions. The Extran Block has proven especially valuable for sophisticated hydraulic analysis of urban storm drainage systems, such as the one at the Airport.

The Runoff Block sub-model was used to calculate inflow runoff hydrographs at sub-catchment manhole inlets for various design storm events. The selected 24-hour duration design storm events for 2-year, 5-year, 10-year, and 25-year return periods are given in Appendix A. The sub-catchment physical characteristics, including amount of paved and unpaved drainage areas, elevations, etc., given in Tables B-1 to B-8 in Appendix B were used as input data to develop the Runoff Block sub-models for the storm drainage Networks 1 to 8, respectively.

The Runoff Block sub-model parameters including Manning's roughness coefficients, depression storages, and infiltration rates for paved and unpaved sub-catchment areas were obtained from the SWMM User Manual (USEPA, 1993) for typical conditions observed at the Airport area. Since no storm water flow-monitoring programs were conducted to calibrate the model parameters, the use of typical values that represent the site conditions can generally be considered as sufficient for this drainage assessment study.

The Extran Block sub-model was used to calculate hydraulic flow conditions, including water surface elevations in the storm drain system, by routing the sub-catchment runoff hydrographs derived earlier, using the Runoff Block sub-model. These simulated hydraulic flow conditions were then used to identify critical areas in the system (such as areas with surcharging and flooding conditions).

The storm drainage system data, including pipe invert elevations, diameters, and lengths and system connectivity data given in Tables B-9 to B-16 in Appendix B were used as input data to develop the Extran Block sub-models for the storm drainage Networks 1 to 8, respectively. The Extran Block sub-model parameters including Manning's roughness coefficient values for various pipe types were obtained from the SWMM User Manual (USEPA, 1993).

5.2 ASSESSMENT OF EXISTING STORM DRAIN SYSTEM

A drainage assessment for the existing storm drain system was conducted to identify "hydraulically inefficient" areas in the conveyance system (such as areas with undersized pipes and inadequate pipe slopes) and to provide improvements to such areas in the system. A traditional approach to drainage design is to select a design storm and design all the components of the drainage system to that standard. However, replacing a few components of an existing storm drain system that are below a specified design standard may not be economically justified if the system generally functions satisfactorily. An alternative approach is to assess the system as a whole and only replace those components that cause the system to not meet the design standard.

This approach involves comparing the storm drainage system response to different return frequency storm events. The design standard is to have a high reliability for high frequency events with decreasing reliability for low frequency events. Two hydraulic factors were used to assess the overall hydraulic conditions in the storm drain system as defined below (Yue and Hodgson, 1992):

- Theoretical Load Factor (TLF) measures trunk discharge capacities of system storm drain pipes. A TLF greater than 1 means that the capacity of the system to convey water is insufficient without surcharging the system. The greater the TLF, the more frequently the storm flows exceed the system capacity.

- Hydraulic Gradeline Rating (HGR) measures flooding conditions at system inlets. HGR is similar to a factor of safety. A high HGR value implies little danger of flooding. Small values imply that flooding near inlets is likely.

Table 12 provides the hydraulic rating criteria used to assess the hydraulic flow conditions in the Airport storm drainage system.

TABLE 12
HYDRAULIC RATING CRITERIA FOR THE AIRPORT STORM DRAIN SYSTEM

Hydraulic Rating Class	Theoretical Load Factor (TLF) ($Q_{Peak}/Q_{Capacity}$)	Hydraulic Gradeline Rating (HGR) (below nearest paved surface, feet)
Excellent	0.0 to 0.75	> 3.0
Above Average	0.75 to 1.25	2.0 to 3.0
Average	1.25 to 1.75	1.0 to 2.0
Below Average	1.75 to 2.25	0.5 to 1.0
Poor	> 2.25	<0.5

Hydraulic flow conditions in the existing storm drain system were evaluated based on TLF and HGR ratings. These ratings were calculated for the "local" design storm events of 2-year, 5-year, 10-year, and 25-year return frequencies using the SWMM model described above. "Local" design storm events assume that the storm drain system is able to drain freely to the receiving waters. That is, there is no obstruction to draining to the Airport creeks or Goleta Slough due to high tides. During large storm events, such as the 10- and 25-year events, the storm drain system may not be able to drain due to high water or flooding from the creeks and water will pond on the Airport property. However, the TLF and HGR ratings for a local storm provide the first indication of the performance of the storm drain system. The calculated TLF and HGR values are given in Tables 13 and 14, respectively, for storm drainage Networks 1 to 8.

Table 13 shows the pipes that are rated as poor (in terms of TLF). The pipes rated as poor are either undersized or have very shallow slopes. A total of 17 pipe segments were rated as poor in all eight networks. Examples include: (1) the last segments of Networks 1, 2, and 3 (these were rated poor because the slopes of these pipes are too small); (2) the first pipe in Network 7 (the pipe is too small with a 6-inch diameter); and (3) other pipes in Networks 2, 4, 6, and 7, which generally have slopes that are too shallow.

TABLE 13
THEORETICAL LOAD FACTORS (TLF) FOR EXISTING STORM DRAIN SYSTEM

Storm Drainage Network	Pipe No.	Pipe Slope (feet/feet)	Pipe Diameter (feet)	Theoretical Load Factor (TLF) = [$Q_{Peak}/Q_{Capacity}$]			
				2-yr	5-yr	10-yr	25-yr
1							
	101	0.00267	1.25	0.14	0.29	0.53	0.85
	102	0.00143	1.25	0.46	1.02	2.04	**3.35**
	103	0.00300	1.25	0.07	0.16	0.30	0.53
	104	0.00204	2	0.08	0.18	0.37	0.67
	105	-0.00024	2	**2.92**	**6.45**	**12.7**	**22.3**
2							
	106	0.00280	1.25	0.15	0.24	0.24	0.24
	107	0.00142	1.25	0.19	0.38	0.69	1.19
	108	0.00170	1.5	0.37	0.61	0.66	0.71
	109	0.00134	1.5	0.71	1.00	1.00	1.00
	110	0.00044	1.5	**2.50**	**2.53**	**2.56**	**2.62**
	111	0.01980	2	0.01	0.01	0.01	0.01
3							
	112	0.00170	1.25	0.09	0.20	0.41	0.45
	113	0.00517	1.25	0.12	0.26	0.53	0.59
	114	0.00477	1.25	0.03	0.06	0.12	0.20
	115	0.00002	2	**29.5**	**65.6**	**135.5**	**159.5**
	116	0.00018	2	**4.16**	**9.36**	**19.8**	**25.9**
4							
	117	0.00240	1.5	0.01	0.03	0.03	0.03
	118	0.00171	1.5	0.03	0.15	0.18	0.14
	119	0.00127	1.5	0.06	0.26	0.61	0.94
	120	0.00087	2	0.02	0.02	0.03	0.03
	121	0.00120	2	0.03	0.03	0.04	0.07
	122	0.00332	1.25	0.07	0.15	0.21	0.21
	123	0.00072	2.5	0.10	0.16	0.22	0.28
	124	0.00857	1	0.00	0.00	0.01	0.05
	125	0.00257	1.5	0.13	0.26	0.41	0.66
	126	0.00500	2	0.12	0.23	0.29	0.38
	127	0.01160	1.5	0.06	0.12	0.19	0.30
	128	0.00133	2	0.88	0.88	0.88	0.88
	129	0.00140	2	0.31	0.32	0.31	0.31
	130	0.00005	2.5	2.02	**2.40**	**2.66**	**2.89**
	131	0.00055	2.5	0.46	0.53	0.71	0.86
	132	0.00003	2.5	**3.39**	**5.48**	**15.1**	**24.9**
	133	0.00048	3	0.14	0.14	0.14	0.14
	134	0.00070	3	0.12	0.12	0.12	0.12
	135	0.00660	1.5	0.10	0.21	0.32	0.36
	136	0.00510	1.5	0.16	0.32	0.52	0.56
	137	0.00086	3	0.14	0.14	0.14	0.14
	138	0.00065	2	1.96	2.04	2.13	**2.25**
	139	0.01022	3.83	0.00	0.00	0.00	0.00
	190	0.00462	2	0.12	0.22	0.27	0.31
	191	0.00679	1.5	0.88	1.66	1.85	1.99
	192	0.00488	1.5	0.25	0.53	0.76	0.76
	193	0.00209	1.5	0.31	0.66	1.00	1.00
	194	0.00256	1.5	0.04	0.09	0.16	0.26
5							
	140	0.00437	1.25	0.05	0.12	0.22	0.37
	141	0.00124	1.25	0.41	0.88	1.56	**2.69**
	142	0.02384	1.25	0.00	0.00	0.00	0.01
	143	0.00128	1.25	0.79	1.37	1.37	1.37
	144	0.00424	1.25	0.00	0.01	0.01	0.02
	145	0.01520	0.83	0.20	0.42	0.76	0.86
	146	0.00020	1.5	**4.62**	**4.54**	**4.62**	**4.58**

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TABLE 13
THEORETICAL LOAD FACTORS (TLF) FOR EXISTING STORM DRAIN SYSTEM

Storm Drainage Network	Pipe No.	Pipe Slope (feet/feet)	Pipe Diameter (feet)	Theoretical Load Factor (TLF) = $[Q_{Peak}/Q_{Capacity}]$			
				2-yr	5-yr	10-yr	25-yr
	147	0.00424	1.25	0.02	0.04	0.06	0.07
	148	0.00029	2	1.21	1.49	1.59	1.69
	149	0.00328	1.25	0.01	0.02	0.04	0.07
	150	0.00023	2	2.10	**2.89**	**3.42**	**3.57**
	151	0.00472	1.25	0.01	0.01	0.03	0.05
	152	0.00134	2	0.49	0.72	0.92	0.94
	153	0.02854	0.67	0.01	0.02	0.03	0.04
	154	0.00320	1.25	0.01	0.02	0.04	0.07
	155	0.00097	2.5	0.28	0.44	0.58	0.64
	156	0.03292	0.67	0.02	0.05	0.07	0.10
	157	0.00352	1.25	0.02	0.04	0.07	0.12
	158	0.00120	2.5	0.32	0.53	0.74	0.88
6							
	159	0.00198	1.25	0.16	0.34	0.45	0.44
	160	0.00197	1.25	0.31	0.69	1.00	1.14
	161	0.00258	1	0.79	0.79	0.79	0.79
	162	0.00040	1	**6.15**	**6.10**	**6.15**	**6.10**
	163	0.00082	1.5	0.22	0.22	0.20	0.20
	164	0.00255	1.5	0.79	0.79	0.81	0.81
7							
	165	0.00706	0.5	**2.28**	**2.28**	**2.28**	**2.28**
	166	0.00161	1.5	0.24	0.42	0.59	0.83
	167	0.00432	1.5	0.12	0.23	0.32	0.34
	168	0.00031	1.5	**3.31**	**6.50**	**8.76**	**9.12**
	169	0.00231	2.5	0.04	0.08	0.12	0.12
	170	0.00000	2.5	**16.7**	**34.0**	**50.8**	**56.9**
	171	0.00283	2.5	0.19	0.40	0.61	0.72
	172	0.00191	2.5	0.30	0.62	1.00	1.23
	173	0.00004	2.5	**17.2**	**35.5**	**57.0**	**72.8**
	174	0.02308	2.5	0.07	0.12	0.18	0.23
	175	0.00124	1.5	0.08	0.11	0.11	0.11
	176	0.00160	1.75	0.01	0.01	0.04	0.09
	177	0.00126	2	0.10	0.12	0.12	0.13
	178	0.00044	2	0.55	0.66	0.67	0.66
	179	0.00310	2	0.49	0.61	0.64	0.64
	180	0.00343	2	0.59	0.81	0.96	1.08
8							
	181	0.00474	1.25	0.05	0.10	0.16	0.22
	182	0.00291	1.5	0.56	1.12	1.51	1.51
	183	0.00195	1.5	0.76	0.77	0.72	0.71
	184	0.00060	1.75	1.51	1.51	1.51	1.51
	185	0.00127	1.5	0.01	0.02	0.03	0.05
	186	0.00113	1.75	1.23	1.37	1.42	1.42
	187	0.00087	1.75	1.90	2.22	**2.43**	**2.56**
	188	0.00060	2.5	0.52	0.66	0.79	0.92
	189	0.00187	2.5	0.21	0.28	0.36	0.45
	Colored cells indicate a poorly performing pipe						

TABLE 14
HYDRAULIC GRADELINE RATINGS (HGR) FOR EXISTING STORM DRAIN SYSTEM

Storm Drainage Network	Pipe Inlet No.	Ground[1] Surface Elevation (feet)	Paved[2] Area Elevation (feet)	Maximum Water Depth Below Ground Level (feet)				Cumulative Flood Volume At Storm Drain Inlet ($feet^3$)				Maximum Water Depth Below Lowest Paved Area[3] (feet)			
				2-yr	5-yr	10-yr	25-yr	2-yr	5-yr	10-yr	25-yr	2-yr	5-yr	10-yr	25-yr
1															
	1	8.48	10.45	1.83	1.70	1.17	0.00				64				1.97
	2	8.13		2.04	1.79	1.21	0.27								
	3	8.10		2.46	2.27	2.00	1.69								
	4	8.00		1.76	1.65	1.54	1.15								
	5	9.23		3.84	3.62	3.39	3.14								
	6	7.66		2.62	2.47	2.31	2.15								
2															
	7	9.93		1.48	0.50	0.67	0.35								
	8	8.90		0.48	0.00	0.00	0.00		844	3780	8050		3.13	3.05	2.94
	9	9.11		0.76	0.22	0.24	0.21								
	10	8.19		0.20	0.00	0.00	0.00		1120	2710	4970		3.35	3.34	3.32
	11	7.52		0.00	0.00	0.00	0.00	200	3160	4990	8640	3.53	3.50	3.49	3.45
	12	7.30		1.89	1.89	1.88	1.87								
	13	6.76		2.35	2.35	2.34	2.33								
3															
	14	8.88	12.35	1.83	1.65	0.28	0.00				2340				3.42
	15	8.92		2.34	1.84	0.53	0.08								
	16	8.97		2.79	2.26	1.39	0.79								
	17	8.45	11.75	2.06	1.64	0.69	0.00				445				3.29
	18	8.55		2.77	2.49	2.10	1.81								
	19	8.04		2.86	2.71	2.54	2.47								
4															
	20	9.54		0.78	0.68	0.63	0.39								
	21	9.22		0.47	0.32	0.26	0.17								
	22	8.69	11.25	0.00	0.00	0.00	0.00	5570	13500	27500	43600	2.48	2.36	2.14	1.90
	23	9.39		0.68	0.56	0.49	0.35								
	24	9.02	11.55	0.31	0.24	0.12	0.00				82				2.53
	25	9.11	12.65	0.31	0.12	0.00	0.00			630	3550			3.53	3.47
	26	9.15		0.45	0.38	0.26	0.13								
	27	9.27		0.60	0.55	0.46	0.31								
	28	13.5		1.90	1.80	1.69	1.35								
	29	10.53		0.88	0.74	0.60	0.01								
	30	10.51		1.17	1.06	0.93	0.49								
	31	9.23	12.55	0.00	0.00	0.00	0.00	676	9820	17700	30200	3.29	2.89	2.54	1.99
	32	10.93		1.58	1.45	1.37	1.12								
	33	8.88	12.65	0.00	0.00	0.00	0.00	9880	18900	37800	56400	3.64	3.53	3.29	3.05
	34	8.86		0.10	0.08	0.05	0.01								
	35	8.92		0.18	0.16	0.14	0.08								
	36	8.66	12.15	0.00	0.00	0.00	0.00	48900	119000	174000	240000	2.68	1.52	0.62	**0.0**
	37	9.08		0.42	0.36	0.26	0.11								
	38	9.78	12.35	0.85	0.51	0.09	0.00				1960				2.37
	39	9.69		0.87	0.63	0.32	0.17								
	40	9.02		0.36	0.30	0.20	0.04								
	41	8.94		0.32	0.26	0.16	0.01								
	42	9.55		4.90	4.88	4.87	4.82								
	43	6.45		3.19	3.17	3.16	3.11								
	981	13.28		3.60	3.41	3.28	2.93								
	982	12.24	14.25	0.92	0.00	0.00	0.00		461	3810	4930		1.99	1.88	1.85
	983	13.18	14.55	1.25	0.29	0.00	0.00			392	1860			1.34	1.23
	984	14.09	14.65	1.17	0.65	0.00	0.00			255	3820			0.55	**0.38**
	985	14.77		1.29	1.19	0.54	0.19								
5															
	44	10.03		1.34	0.88	0.60	0.08								
	45	11.07		2.58	2.08	1.90	1.61								
	46	10.94		1.10	1.06	1.02	0.98								
	47	8.76	11.55	0.41	0.00	0.00	0.00		735	4430	9040		2.53	1.23	**0.0**
	48	9.13	9.85	0.00	0.00	0.00	0.00	610	5520	8890	13000	**0.0**	**0.0**	**0.0**	**0.0**
	49	8.30		0.38	0.19	0.04	0.00				740				1.56
	50	7.93		1.71	1.41	1.33	1.20								
	51	8.63		0.99	0.79	0.59	0.57								
	52	8.06	10.55	0.41	0.20	0.00	0.00			104	3780			2.49	2.33
	53	8.83		1.34	1.13	0.93	0.85								
	54	8.19		0.70	0.48	0.27	0.18								
	55	8.96		1.72	1.49	1.28	1.17								
	56	7.90		0.66	0.42	0.20	0.08								
	57	9.95		0.61	0.59	0.57	0.55								
	58	8.89		2.01	1.78	1.58	1.47								
	59	7.99		1.11	0.87	0.67	0.54								
	60	10.13		0.47	0.44	0.42	0.39								
	61	8.90		2.21	1.98	1.79	1.66								
	62	7.94		1.24	1.00	0.79	0.65								
	63	8.97		3.56	3.43	3.32	3.27								
6															
	64	10.16	12.75	0.60	0.23	0.00	0.00			548	2970			2.58	2.51
	65	10.53		1.11	0.88	0.70	0.61								
	66	9.24	11.45	0.00	0.00	0.00	0.00	1230	4670	8750	16700	2.19	2.12	2.04	1.88
	67	8.33	11.05	0.00	0.00	0.00	0.00	8280	19000	27400	38300	2.53	2.28	2.08	1.83
	68	8.98		1.00	0.97	0.95	0.94								
	69	8.04	11.45	0.00	0.00	0.00	0.00	1800	6100	11100	23500	3.40	3.37	3.33	3.24
	70	7.72		2.90	2.89	2.89	2.89								

TABLE 14
HYDRAULIC GRADELINE RATINGS (HGR) FOR EXISTING STORM DRAIN SYSTEM

Storm Drainage Network	Pipe Inlet No.	Ground[1] Surface Elevation (feet)	Paved[2] Area Elevation (feet)	Maximum Water Depth Below Ground Level (feet)				Cumulative Flood Volume At Storm Drain Inlet (feet³)				Maximum Water Depth Below Lowest Paved Area[3] (feet)			
				2-yr	5-yr	10-yr	25-yr	2-yr	5-yr	10-yr	25-yr	2-yr	5-yr	10-yr	25-yr
7															
	71	13.15	14.55	0.00	0.00	0.00	0.00	9980	17700	25900	34700	**0.0**	**0.0**	**0.0**	**0.0**
	72	11.88		1.14	1.01	0.53	0.47								
	73	11.19	13.55	0.89	0.76	0.00	0.00			789	4680			2.35	2.32
	74	10.81	13.55	1.49	0.95	0.03	0.00				3990				2.36
	75	11.40		2.63	2.24	1.48	0.90								
	76	11.01		2.30	1.92	1.17	0.57								
	77	11.01		2.89	2.56	1.65	1.14								
	78	9.54		2.00	1.44	0.69	0.34								
	79	9.47		2.15	1.70	1.24	1.03								
	80	11.51		5.22	4.99	4.74	4.59								
	82	8.94	11.55	0.20	0.00	0.00	0.00		700	2230	4410		2.60	2.58	2.54
	83	8.94		0.24	0.04	0.03	0.01								
	84	8.88	11.25	0.18	0.00	0.00	0.00		3650	8730	14900		2.31	2.22	2.12
	85	8.86	11.05	0.23	0.03	0.00	0.00			122	3130			2.19	2.14
	86	8.91		0.39	0.19	0.14	0.10								
	87	9.9		2.06	1.92	1.91	1.86								
	81	5.14		1.63	1.48	1.36	1.28								
8															
	89	10.09	10.55	1.11	0.48	0.05	0.00				150				**0.44**
	90	9.91	11.05	0.97	0.38	0.00	0.00			583	4820			**0.0**	**0.0**
	91	8.45	10.45	0.00	0.00	0.00	0.00	3000	12100	28200	39700	1.94	1.75	1.41	1.17
	92	8.27	10.45	0.27	0.07	0.00	0.00			1050	5470			2.16	2.07
	93	9.06		0.00	1.15	0.99	0.89								
	94	8.33		0.66	0.43	0.27	0.18								
	95	8.24		1.00	0.80	0.65	0.52								
	96	8.43		1.68	1.57	1.47	1.38								
	97	8.69		2.28	2.18	2.09	2.00								
	98	10.00		4.10	4.02	3.95	3.89								

Note:
1. Ground surface elevation is equal to the top elevation of the rim of the manhole.
2. Lowest elevation at the nearest paved area to the manhole inlet
3. Maximum water depth (below the lowest paved area elevation) is used to assess the flooding condition at the inlet.

	Colored cells indicate a drain inlet susceptible to flooding

Table 14 shows the calculated maximum water depths below the ground level at the inlet for all the inlets in the storm drain system. The table also presents the estimated cumulative flood volumes and maximum water depths below the lowest adjacent paved area for only the inlets that are subjected to flooding. To provide a conservative estimate of the maximum ponded depth of water, only one-half of the available unpaved area was assumed available for storage. Storm drain inlets considered poor (i.e., HGR< 0.5) are listed in Table 14. Seven inlets were rated as poor for the 25-year design storm event. Four of the inlets are located near the Airport terminal ramp (Inlets 47, 48, 89, and 90).

Table 15 summarizes the overall hydraulic conditions of the existing storm drain system at the Airport in terms of pipe capacities (TLF) and flooding conditions (HGR). The percentage of conduits in the system that are rated as poor ranges from 11 percent for the 2-year storm to 16 percent for the 25-year storm. The percentage of drain inlets in the system that are rated as poor ranges from 2 percent for the 2-year storm to 7 percent for the 25-year storm.

TABLE 15
SUMMARY OF EXISTING STORM DRAIN SYSTEM PERFORMANCE

Hydraulic Criteria	Percentage of Pipe and Inlets with Poor Rating for Different Design Storm Events*			
	2-year	5-year	10-year	25-year
Poor pipe conveyance (TLF > 2.25)	11%	13%	15%	16%
Poor inlet performance (HGR < 0.5)	2%	2%	3%	7%

* Based on results shown in Tables 13 and 14. TLF = Theoretical load factor. HGR = hydraulic gradeline rating. Based on local storm analysis.

A listing of pipes and inlets rated as poor is provided in Table 16.

TABLE 16
SUMMARY OF DRAINAGE FACILITIES WITH POOR PERFORMANCE

Facilities Rated as Poor	Pipe and Inlet Identification Numbers (See Figure 5 for locations)
Pipes	102, 105, 110, 115, 116, 130, 132, 138, 141, 146, 150, 162, 165, 168, 170, 173, 187
Inlets	36, 47, 48, 71, 89, 90, 984

6.0 RECOMMENDED IMPROVEMENTS

The recommended improvements to address drainage problems at the Airport are listed below and described in the following subsections:

1. Improve storm drain system in Networks 1, 2, 4, 5, 7, and 8 (replace pipes, set new slopes for pipes, and replace drain inlets)
2. Replace Verhelle Bridge on San Pedro Creek with a single-span bridge
3. Improve Las Vegas Creek, including bank stabilization and new golf course bridge
4. Modify Firestone Channel and outlet to Carneros Creek
5. Replace steel pipe culvert at Carneros Creek and improve associated drainage channels
6. Stabilize the banks of San Pedro Creek downstream of Hollister Avenue

6.1 STORM DRAIN SYSTEM IMPROVEMENTS

6.1.1 Proposed Improvements

Not all of the Airport storm drainage system components that are rated as poor need to be replaced in order improve conveyance conditions in the storm drainage system to reduce flooding. Components that need upgrading were selected based on their TLF and HGR ratings, their location in the drainage network, and the consequences of not upgrading the components. The following selection criteria were adopted to identify improvements to the existing storm drainage system:

- Only components with poor TLF and HGR ratings were considered.
- Pipes with a poor rating and a slope less than about 0.10% were considered low priority. With such a shallow slope, increasing the pipe size results in only a marginal improvement. To increase the capacity of the system, the network would need to be re-graded. For segments near the end of the network, re-grading may be a reasonable alternative. For segments near the head of the drainage or in the middle, only a few segments may need re-grading.
- If a particular segment has a poor rating but does not seem to result in flooding based on the modeling, then it was considered a low priority. This situation can occur when a pipe is undersized and surcharges during design storm events but the surcharging is not sufficient to flood upstream inlets.

Using the above criteria, a number of storm drain system improvement projects were identified to reduce the surcharge and flooding conditions at drain inlets based on their TLF and HGR ratings given in Tables 13 and 14. These improvements to the storm drain system are described below.

Pipe Projects (see Figure 5 in Appendix D for locations)

- Pipe 105: The existing pipe segment 105 in Network 1 has a negative slope. The outlet is along the perimeter of Goleta Slough near the Adams Road berm. The outlet invert should be lowered from elevation 4.36 feet to 4.20 feet.

- Pipe 165: This segment in Network 7 drains the storm runoff from the "T Hangars" area. The diameter of the existing pipe is too small to adequately drain the storm runoff from the catchment area. The diameter of this pipe segment should be increased from 6 inches to 18 inches.

Inlet Projects (see Figure 5 in Appendix D for locations)

- Inlet 36: The basin storage volume at drainage inlet 36 in Network 4 should be increased, if feasible, to accommodate flood volumes up to 25-year storm events. The ground surface elevation of the drainage basin (unpaved grass area) should be lowered by about 0.6 feet. This inlet captures runoff from Taxiways C and H.

- The ground surface at the following inlets should be lowered to create additional storage: Inlet 47, 48, 71, 89, and 90.

- Inlet 984: This drain inlet in Network 4 behind the Airport Administration building could cause flooding during storm events larger than the 25-year design event. Drainage could be improved by increasing the size of the drainage inlet and/or reducing the contributing drainage area by diverting a part of the flood flows to nearby drainage inlets (i.e., 193 or 194).

Other General Improvements (see Figure 5 in Appendix D for locations)

- The storm runoff volume in Network 5, which includes runoff from the terminal ramp, air cargo ramp, and T-hangars, should be reduced. A portion of runoff could be diverted north and east to drainage Network 8 for discharge to San Pedro Creek. This could be accomplished by diverting storm runoff at Node 44 in Network 5 to Node 91 in Network 8. A new storm drain between Node 44 and Node 91 would be constructed and would consist of an 18-inch-diameter, 400-foot-long reinforced concrete pipe. There may be an opportunity to address this drainage deficiency with the terminal expansion project.

- The surface drainage and storm drain pipes in the northern portion of Network 5 (terminal and air cargo ramps, rental car parking) should be re-configured to improve overall drainage performance. The under-sized storm pipe segments 141, 143, 145, and 146 in drainage Network 5 should be replaced with larger-diameter reinforced concrete pipes (see Table 17). Also, pipe segments 143, 146, 147, 148, 149, 150, and 151 should be re-graded. There may be an opportunity to address these drainage deficiencies with the terminal expansion project.

TABLE 17
RECOMMENDED IMPROVEMENTS IN DRAINAGE NETWORK 5

Pipe No.	Recommended Diameter (inches)	Recommended Upstream Invert Elevation (feet, NAVD 88)	Recommended Downstream Invert Elevation (feet, NAVD 88)
141	18	6.97	6.71
143	18	6.71	6.10
145	12	8.00	6.10
146	24	6.10	6.00

Storm water outflow from Network 2 should be redirected northward into Carneros Creek to accommodate the channel re-alignment proposed under the new runway extension project. A new 24-inch-diameter, 400-foot-long reinforced concrete pipe could be installed to re-direct the outflow.

6.1.2 Hydraulic Benefits of Improvements

The effects of the above recommended drainage improvements were analyzed with the SWMM model. Hydraulic flow conditions in the storm drain system with the proposed improvements were calculated for the "local" design storm events (2-year, 5-year, 10-year, and 25-year). Results are presented in Tables 18 and 19 for pipe conveyance hydraulics (i.e., TLF) and inlet performance (i.e., HGR), respectively.

TABLE 18
THEORECTICAL LOAD FACTORS (TLF) FOR MODIFIED STORM DRAIN SYSTEM

Storm Drainage Network	Pipe No.	Pipe Slope (feet/feet)	Pipe Diameter (feet)	Theoretical Load Factor (TLF) = [$Q_{Peak}/Q_{Capacity}$]			
				2-yr	5-yr	10-yr	25-yr
1							
	101	0.00267	1.25	0.14	0.29	0.53	0.86
	102	0.00143	1.25	0.46	1.02	2.04	**3.50**
	103	0.00300	1.25	0.07	0.16	0.30	0.52
	104	0.00204	2	0.08	0.18	0.35	0.64
	105	0.00110	2	0.22	0.50	0.98	1.74
2							
	106	0.00280	1.25	0.15	0.28	0.34	0.24
	107	0.00142	1.25	0.18	0.38	0.69	1.19
	108	0.00170	1.5	0.36	0.61	0.66	0.71
	109	0.00134	1.5	0.71	1.19	1.19	1.17
	110	0.00044	1.5	**2.82**	**5.06**	**5.52**	**5.71**
	111	0.00250	2	0.11	0.19	0.22	0.25
3							
	112	0.00170	1.25	0.09	0.20	0.41	0.45
	113	0.00517	1.25	0.12	0.26	0.53	0.59
	114	0.00477	1.25	0.03	0.06	0.12	0.20
	115	0.00002	2	**29.5**	**65.6**	**135.5**	**159.5**
	116	0.00018	2	**4.16**	**9.36**	**19.8**	**25.9**
4							
	117	0.00240	1.5	0.01	0.03	0.03	0.03
	118	0.00171	1.5	0.03	0.15	0.18	0.14
	119	0.00127	1.5	0.06	0.26	0.61	0.94
	120	0.00087	2	0.02	0.02	0.03	0.03
	121	0.00120	2	0.03	0.03	0.04	0.07
	122	0.00332	1.25	0.07	0.15	0.21	0.21
	123	0.00072	2.5	0.10	0.16	0.22	0.28
	124	0.00857	1	0.00	0.00	0.01	0.05
	125	0.00257	1.5	0.13	0.26	0.41	0.66
	126	0.00500	2	0.12	0.23	0.29	0.38
	127	0.01160	1.5	0.06	0.12	0.19	0.30
	128	0.00133	2	0.88	0.88	0.88	0.88
	129	0.00140	2	0.31	0.32	0.31	0.31
	130	0.00005	2.5	2.02	**2.40**	**2.66**	**2.89**
	131	0.00055	2.5	0.46	0.53	0.71	0.86
	132	0.00003	2.5	**3.39**	**5.48**	**15.1**	**24.9**
	133	0.00048	3	0.14	0.14	0.14	0.14
	134	0.00070	3	0.12	0.12	0.12	0.12
	135	0.00660	1.5	0.10	0.21	0.32	0.36
	136	0.00510	1.5	0.16	0.32	0.52	0.56
	137	0.00086	3	0.14	0.14	0.14	0.14
	138	0.00065	2	1.96	2.04	2.13	**2.25**
	139	0.01022	3.83	0.00	0.00	0.00	0.00
	190	0.00462	2	0.12	0.22	0.27	0.31
	191	0.00679	1.5	0.88	1.66	1.85	1.99
	192	0.00488	1.5	0.25	0.53	0.76	0.76
	193	0.00209	1.5	0.31	0.66	1.00	1.00
	194	0.00256	1.5	0.04	0.09	0.16	0.26
5							
	140	1.25	0.23	0.12	0.22	0.37	
	141	0.00124	1.5	0.01	0.04	0.07	0.11
	142	0.02384	1.25	0.00	0.00	0.00	0.01
	143	0.00153	1.5	0.07	0.15	0.28	0.46
	144	0.00424	1.25	0.02	0.04	0.13	0.31
	145	0.01520	1	0.02	0.04	0.06	0.08
	146	0.00029	2	0.41	0.79	0.81	0.81

TABLE 18
THEORECTICAL LOAD FACTORS (TLF) FOR MODIFIED STORM DRAIN SYSTEM

Storm Drainage Network	Pipe No.	Pipe Slope (feet/feet)	Pipe Diameter (feet)	Theoretical Load Factor (TLF) = $[Q_{Peak}/Q_{Capacity}]$			
				2-yr	5-yr	10-yr	25-yr
	147	0.00528	1.25	0.01	0.03	0.06	0.06
	148	0.00054	2	0.48	0.92	0.94	0.96
	149	0.00504	1.25	0.01	0.01	0.03	0.05
	150	0.00050	2	0.77	1.51	1.61	1.72
	151	0.00712	1.25	0.00	0.01	0.02	0.04
	152	0.00049	2	1.12	2.22	**2.37**	**2.53**
	153	0.02854	0.67	0.01	0.02	0.03	0.04
	154	0.00320	1.25	0.01	0.02	0.04	0.07
	155	0.00097	2.5	0.23	0.48	0.53	0.61
	156	0.03292	0.67	0.02	0.05	0.07	0.10
	157	0.00352	1.25	0.02	0.04	0.07	0.12
	158	0.00120	2.5	0.28	0.58	0.71	0.86
6							
	159	0.00198	1.25	0.16	0.34	0.45	0.44
	160	0.00197	1.25	0.31	0.69	1.00	1.14
	161	0.00258	1	0.79	0.79	0.79	0.79
	162	0.00040	1	**6.15**	**6.10**	**6.15**	**6.10**
	163	0.00082	1.5	0.22	0.22	0.20	0.20
	164	0.00255	1.5	0.79	0.79	0.81	0.81
7							
	165	0.00706	**1.5**	0.12	0.25	0.37	0.53
	166	0.00161	1.5	0.64	1.30	1.90	**2.37**
	167	0.00432	1.5	0.27	0.48	0.48	0.49
	168	0.00031	1.5	**6.15**	**10.8**	**11.0**	**11.2**
	169	0.00231	2.5	0.07	0.13	0.13	0.13
	170	0.00000	2.5	**21.6**	**40.6**	**50.8**	**56.9**
	171	0.00283	2.5	0.24	0.46	0.61	0.72
	172	0.00191	2.5	0.38	0.74	1.00	1.23
	173	0.00004	2.5	**21.3**	**41.2**	**57.0**	**72.8**
	174	0.02308	2.5	0.08	0.14	0.18	0.23
	175	0.00124	1.5	0.08	0.11	0.11	0.11
	176	0.00160	1.75	0.01	0.01	0.04	0.09
	177	0.00126	2	0.10	0.12	0.12	0.13
	178	0.00044	2	0.55	0.66	0.67	0.67
	179	0.00310	2	0.49	0.62	0.64	0.64
	180	0.00343	2	0.59	0.83	0.96	1.08
8							
	140	0.00420	1.5	0.00	0.00	0.00	0.00
	181	0.00474	1.25	0.00	0.00	0.00	0.01
	182	0.00291	1.5	0.20	0.41	0.61	0.86
	183	0.00195	1.5	0.64	0.64	0.66	0.66
	184	0.00060	1.75	1.49	1.49	1.49	1.49
	185	0.00127	1.5	0.03	0.03	0.03	0.05
	186	0.00113	1.75	1.23	1.37	1.42	1.42
	187	0.00087	1.75	1.90	2.22	**2.43**	**2.56**
	188	0.00060	2.5	0.52	0.66	0.79	0.92
	189	0.00187	2.5	0.21	0.28	0.36	0.45

	Colored cells indicate a poorly performing pipe (without any modifications)
123	**Red lettering indicates modified pipe, per recommendations in this report.**

TABLE 19
HYDRAULIC GRADELINE RATINGS FOR MODIFIED STORM DRAIN SYSTEM

Storm Drainage Network	Pipe Inlet No.	Ground[1] Surface Elevation (feet)	Paved[2] Area Elevation (feet)	Maximum Water Depth Below Ground Level (feet)				Cumulative Flood Volume At Storm Drain Inlet ($feet^3$)				Maximum Water Depth Below Lowest Paved Area[3] (feet)			
				2-yr	5-yr	10-yr	25-yr	2-yr	5-yr	10-yr	25-yr	2-yr	5-yr	10-yr	25-yr
1															
	1	8.48	10.45	1.83	1.70	1.17	0.00				64				1.97
	2	8.13		2.04	1.79	1.21	0.27								
	3	8.10		2.46	2.27	2.00	1.69								
	4	8.00		1.76	1.65	1.54	1.15								
	5	9.23		3.84	3.62	3.39	3.14								
	6	7.66		2.62	2.47	2.31	2.15								
2															
	7	9.93		1.93	0.58	0.52	0.35								
	8	8.90		1.01	0.00	0.00	0.00		844	3780	8050		3.13	3.05	2.94
	9	9.11		1.39	0.23	0.22	0.21								
	10	8.19		0.92	0.00	0.00	0.00		1120	2710	4970		3.85	3.84	3.82
	11	7.52		0.68	0.12	0.03	0.00				8640				4.45
	12	7.30		1.48	1.32	1.28	1.25								
	13	6.76		2.14	2.02	1.99	1.97								
3															
	14	8.88	12.35	1.83	1.65	0.28	0.00				2340				3.42
	15	8.92		2.34	1.84	0.53	0.08								
	16	8.97		2.79	2.26	1.39	0.79								
	17	8.45	11.75	2.06	1.64	0.69	0.00				445				3.29
	18	8.55		2.77	2.49	2.10	1.81								
	19	8.04		2.86	2.71	2.54	2.47								
4															
	20	9.54		0.78	0.68	0.63	0.39								
	21	9.22		0.47	0.32	0.26	0.17								
	22	8.69	11.25	0.00	0.00	0.00	0.00	5570	13500	27500	43600	2.48	2.36	2.14	1.90
	23	9.39		0.68	0.56	0.49	0.35								
	24	9.02	11.55	0.31	0.24	0.12	0.00				82				2.53
	25	9.11	12.65	0.31	0.12	0.00	0.00			630	3550			3.53	3.47
	26	9.15		0.45	0.38	0.26	0.13								
	27	9.27		0.60	0.55	0.46	0.31								
	28	13.5		1.90	1.80	1.69	1.35								
	29	10.53		0.88	0.74	0.60	0.01								
	30	10.51		1.17	1.06	0.93	0.49								
	31	9.23	12.55	0.00	0.00	0.00	0.00	676	9820	17700	30200	3.29	2.89	2.54	1.99
	32	10.93		1.58	1.45	1.37	1.12								
	33	8.88	12.65	0.00	0.00	0.00	0.00	9880	18900	37800	56400	3.64	3.53	3.29	3.05
	34	8.86		0.10	0.08	0.05	0.01								
	35	8.92		0.18	0.16	0.14	0.08								
	36	8.66	12.15	0.00	0.00	0.00	0.00	48900	119000	174000	240000	2.68	1.52	0.62	0.0
	37	9.08		0.42	0.36	0.26	0.11								
	38	9.78	12.35	0.85	0.51	0.09	0.00				1960				2.37
	39	9.69		0.87	0.63	0.32	0.17								
	40	9.02		0.36	0.30	0.20	0.04								
	41	8.94		0.32	0.26	0.16	0.01								
	42	9.55		4.90	4.88	4.87	4.82								
	43	6.45		3.19	3.17	3.16	3.11								
	981	13.28		3.60	3.41	3.28	2.93								
	982	12.24	14.25	0.92	0.00	0.00	0.00		461	3810	4930		1.99	1.88	1.85
	983	13.18	14.55	1.25	0.29	0.00	0.00			392	1860			1.34	1.23
	984	14.09	14.65	1.17	0.65	0.00	0.00			255	3820			0.55	0.38
	985	14.77		1.29	1.19	0.54	0.19								
5															
	44	10.03		1.75	1.75	1.75	1.63								
	45	11.07		3.56	3.05	2.91	2.67								
	46	10.94		1.10	1.06	1.02	0.98								
	47	8.76		1.27	0.75	0.61	0.38								
	48	9.13	11.05	0.48	0.00	0.00	0.00		247	5590	11200		3.10	2.76	2.41
	49	8.30		0.86	0.38	0.30	0.20								
	50	7.93		0.88	0.83	0.79	0.76								
	51	8.63		1.25	0.77	0.66	0.57								
	52	8.06	10.55	0.67	0.18	0.05	0.00				2470			2.49	2.38
	53	8.83		1.57	1.11	0.98	0.86								
	54	8.19		0.92	0.46	0.33	0.19								
	55	8.96		1.85	1.44	1.32	1.18								
	56	7.90		0.79	0.37	0.24	0.09								
	57	9.95		0.61	0.59	0.57	0.55								
	58	8.89		2.08	1.74	1.63	1.49								
	59	7.99		1.17	0.83	0.71	0.56								
	60	10.13		0.47	0.44	0.42	0.39								
	61	8.90		2.27	1.94	1.82	1.68								
	62	7.94		1.30	0.96	0.83	0.67								
	63	8.97		3.60	3.41	3.34	3.28								
6															
	64	10.16	12.75	0.60	0.23	0.00	0.00			548	2970			2.58	2.51
	65	10.53		1.11	0.88	0.70	0.61								
	66	9.24	11.45	0.00	0.00	0.00	0.00	1230	4670	8750	16700	2.19	2.12	2.04	1.88
	67	8.33	11.05	0.00	0.00	0.00	0.00	8280	19000	27400	38300	2.53	2.28	2.08	1.83
	68	8.98		1.00	0.97	0.95	0.94								
	69	8.04	11.45	0.00	0.00	0.00	0.00	1800	6100	11100	23500	3.40	3.37	3.33	3.24
	70	7.72		2.90	2.89	2.89	2.89								

TABLE 19
HYDRAULIC GRADELINE RATINGS FOR MODIFIED STORM DRAIN SYSTEM

Storm Drainage Network	Pipe Inlet No.	Ground[1] Surface Elevation (feet)	Paved[2] Area Elevation (feet)	Maximum Water Depth Below Ground Level (feet)				Cumulative Flood Volume At Storm Drain Inlet ($feet^3$)				Maximum Water Depth Below Lowest Paved Area[3] (feet)			
				2-yr	5-yr	10-yr	25-yr	2-yr	5-yr	10-yr	25-yr	2-yr	5-yr	10-yr	25-yr
7															
	71	13.15		1.29	1.12	0.88	0.63								
	72	11.88		0.89	0.32	0.13	0.01								
	73	11.19	13.55	0.73	0.40	0.00	0.00			789	4680			2.35	2.32
	74	10.81	13.55	1.03	0.35	0.03	0.00				3990				2.36
	75	11.40		2.48	2.05	1.48	0.90								
	76	11.01		2.18	1.75	1.17	0.57								
	77	11.01		2.81	2.29	1.65	1.14								
	78	9.54		1.84	1.17	0.69	0.34								
	79	9.47		2.01	1.52	1.24	1.03								
	80	11.51		5.19	4.92	4.74	4.59								
	82	8.94	11.55	0.20	0.00	0.00	0.00		700	2230	4410		2.60	2.58	2.54
	83	8.94		0.24	0.04	0.04	0.01								
	84	8.88	11.25	0.19	0.00	0.00	0.00		3650	8730	14900		2.31	2.22	2.12
	85	8.86	11.05	0.23	0.03	0.00	0.00			122	3130			2.19	2.14
	86	8.91		0.39	0.19	0.14	0.10								
	87	9.9		2.07	1.94	1.94	1.86								
	81	5.14		1.60	1.45	1.36	1.28								
8															
	44	10.03		1.54	1.53	1.52	1.51								
	89	10.09	10.55	1.44	1.28	1.10	0.80								
	90	9.91	11.05	1.27	1.10	0.93	0.63								
	91	8.45	10.45	0.00	0.00	0.00	0.00	2400	11900	22900	35300	1.95	1.75	1.52	1.26
	92	8.27	10.45	0.27	0.07	0.00	0.00			1050	5470			2.16	2.07
	93	9.06		1.20	1.15	1.00	0.89								
	94	8.33		0.66	0.43	0.27	0.18								
	95	8.24		1.00	0.80	0.65	0.52								
	96	8.43		1.68	1.57	1.47	1.38								
	97	8.69		2.28	2.18	2.09	2.00								
	98	10.00		4.10	4.02	3.95	3.89								

Note:
1. Ground surface elevation is equal to the top elevation of the rim of the manhole.
2. Lowest elevation at the nearest paved area to the manhole inlet
3. Maximum water depth (below the lowest paved area elevation) is used to assess the flooding condition at the inlet.

Colored cells indicate a drain inlet susceptible to flooding

Table 20 summarizes the overall hydraulic conditions of the storm drain system, in terms of pipe capacities (TLF) and inlet flooding conditions (HGR) due to the proposed modifications. This table presents the percentages of total pipes and drain inlets in the system that are rated as poor, based on the rating criteria defined in Table 12. The proposed modifications would slightly reduce the number of poor drain pipes and significantly reduce the poorly performing drain inlets.

TABLE 20
SUMMARY OF STORM DRAIN SYSTEM PERFORMANCE WITH PROPOSED IMPROVEMENTS – LOCAL STORM ANALYSIS

Hydraulic Criteria	Percentage of Pipes and Inlets with "Poor" Rating for Different Design Storm Events*			
	2-year	5-year	10-year	25-year
Poor pipe conveyance (TLF > 2.25)	8%	9%	11%	13%
Poor inlet performance (HGR < 0.5)	0%	0%	0%	2%

* Based on results shown in Tables 18 and 19. TLF = Theoretical load factor. HGR = hydraulic gradeline rating.

6.1.3 Effects of Regional Storms

The hydraulic performance of the modified storm drain system was also evaluated under regional or basin-wide flooding conditions. During a regional storm event, the storm drainage outlets are expected to be flooded at receiving waters (either Goleta Slough or San Pedro Creek), depending on the frequency of the storm event. The estimated flood water levels at the outlets of the storm drain system are given in Table 21 for various design storm events. These flood water levels were calculated using the HEC-RAS hydraulic model.

TABLE 21
FLOOD WATER LEVELS AT STORM DRAIN OUTLETS DURING REGIONAL STORM EVENTS

Storm Drain Inlet			Water Surface Elevation(1) at Storm Drain Outlet			
Node Number	Invert Elevation[1]	Crown Elevation[1]	2-Year	5-Year	10-Year	25-Year
6	4.36	6.36	7.67	10.07	10.68	11.51
13	3.96	5.96	8.39	10.63	11.29	12.07
19	4.54	6.54	7.50	10.03	10.66	11.48
43	2.62	6.45	7.59	10.10	10.72	11.53
63	4.42	6.92	2.96	6.29	7.12	8.94
70	4.22	5.72	6.61	9.31	9.80	10.59
81	2.64	5.14	8.61	11.43	12.98	15.01
98	2.41	4.91	7.99	10.56	12.05	14.13

(1) All elevations are in feet with reference to NAVD 1988 Datum.

The hydraulic rating parameters (TLF and HGR) for the modified storm drain system were estimated using the SWMM model with regional storm conditions. The hydraulic performance of the modified storm drain system is summarized in Table 22 for two regional flood events, the 2-year and the 10-year events. The results indicate a significant reduction in drainage performance with larger storm events. Due to the low elevation of the Airport relative to the creeks, there are no feasible drainage improvements to improve stormdrain performance during storm events.

TABLE 22
SUMMARY OF DRAINAGE PERFORMANCE WITH PROPOSED IMPROVEMENTS - REGIONAL STORM ANALYSIS

Hydraulic Criteria	Percentage of Inlets and Pipes Rated as Poor for Different Design Storm Events	
	2-year	10-year
TLF > 2.25	16%	22%
HGR < 0.5	4%	21%

The analysis shows that about 4% of the total storm drain inlets in the drainage system would be flooded during the 2-year regional storm event and most of these are located close to the drainage outlets where tidal effluence is most pronounced. During the 10-year regional storm event, more than 20% of the total storm drain inlets in the drainage system would be flooded.

6.2 VERHELLE BRIDGE

The existing Verhelle Bridge is a wood trestle bridge across San Pedro Creek that should be replaced with a free span bridge to provide additional flow capacity and reduce risk of flooding along this reach of the creek.

6.3 LAS VEGAS CREEK RESTORATION

The existing golf course footbridge across Las Vegas Creek should either be repaired to stabilize the abutments, or replaced. The concrete-lined section of the creek downstream of the bridge should be repaired to prevent further undermining of side panels, and channel downcutting. If concrete lining is not acceptable to permitting agencies, alternative bank stabilization materials should be used that are suitable for peak flow velocities. The concrete lining upstream of the bridge should be removed. The entire channel upstream of the bridge should be widened and stabilized with geotextiles and vegetation. Permanent golf cart bridges should be installed upstream of the footbridge at the clubhouse, replacing the removable wooden bridges.

6.4 FIRESTONE CHANNEL

Firestone Channel should be modified to increase flow capacity consistent with the combined capacities of the culverts discharging into the channel from north of Hollister Avenue. There are two major alternative approaches: increase channel capacity and/or reduce upstream runoff.

Options to Increase Channel Capacity

1. Replace Firestone Channel with a natural swale for the upper 2,000 feet. Replace the lower 800 feet with a concrete channel as described in Flowers & Associates (1997). Install a 4-foot by 28-foot concrete box culvert under Firestone Road at the confluence with Carneros Creek.

2. Replace the entire length of Firestone Channel with a natural swale with a maximum width of approximately 25 feet. Install a 4-foot by 10-foot box culvert under Firestone Road at the confluence with Carneros Creek. Construct a high flow bypass for the last 800 feet of the channel. The bypass would require three 48-inch-diameter pipes discharging to Carneros Creek about 100 feet downstream from the Hollister Avenue over-crossing. The large size and number of by-pass drainage pipes are required to achieve the required flow capacity under very shallow slopes.

3. Replace the entire length of Firestone Channel with a natural swale channel ranging in width from 25 feet at the upstream end to 50 feet at the downstream end. This channel would be able to convey the 25-year design flow; however, the culverts at the confluence with Carneros Creek would need to be replaced. Install a 4-foot by 28-foot box culvert under Firestone Road at the confluence with Carneros Creek (as designed by Flowers & Associates).

4. Construct 50-foot-wide natural channel, similar to the third alternative. However, instead of passing the flow through a box culvert at the confluence with Carneros Creek, remove the existing culverts and Firestone Road bridge. Install a new bridge across Firestone Channel across from Robin Hill Road to provide access to Firestone Road. This option eliminates the need for culverts and associated maintenance for culvert cleaning. The swale could discharge directly to Carneros Creek as an open channel, in the same way that a tributary discharges to a creek.

5. Replace the entire length of Firestone Channel with concrete channel and box culvert, as designed by Flowers & Associates (1997). This is the most hydraulically efficient option for stormwater runoff conveyance and is the more traditional approach.

Options to Reduce Runoff

Under this approach, runoff from the areas north of Hollister Avenue would be reduced to alleviate the conveyance limitations of Firestone Channel. Runoff from the developed property would be reduced by increasing the amount of pervious surfaces (e.g., porous pavements and infiltration devices) throughout the property and/or building detention basins.

The objective of infiltration is to *infiltrate* a portion of the stormwater volume, thus reducing the amount that runs off to Firestone Channel. The objective of a detention basin is to *hold* the stormwater volume back in a pond and release it at a slower, regulated rate. Porous pavements and infiltration facilities could be constructed around parking lots and even accept runoff from rooftops. Infiltration facilities could be installed around the perimeter of the parking areas or as a single infiltration basin. A single infiltration basin could be designed as a combination detention/infiltration basin. Perimeter infiltration trenches can more easily be incorporated into the development than basins, which require more land area. However, since the Airport does not own much of the land area that drains to Firestone Channel, this option may have limited opportunity for implementation.

6.5 FLOODING ALONG HOLLISTER AVENUE

To reduce flooding along Hollister Avenue, the following improvements should be implemented:

- Create a well-defined earthen channel that extends from the 8-foot by 2-foot box culverts under Hollister Avenue to Carneros Creek. Keep the channel free of obstructive vegetation through an ongoing channel maintenance program.
- Create a well-defined earthen channel about 3 feet wide (at bottom) and 1 to 2 feet below existing grade that extends from the 24-inch-diameter concrete pipe culvert under Hollister Avenue to Carneros Creek. Keep the channel free of obstructive vegetation through an ongoing channel maintenance program.
- Replace the existing 36-inch-diameter steel pipe culvert at Carneros Creek with a 48-inch pipe and lower the pipe invert to elevation 8 feet (NAVD 88) to ensure adequate drainage.

6.6 SAN PEDRO CREEK BANK STABILIZATION

The physical nature of San Pedro Creek makes it difficult to eliminate bank failures and improve habitat, while allowing for efficient channel maintenance. Because of the bank steepness, revegetation alone will not likely be successful at reducing erosion. However, there are bio-technical bank stabilization measures that have a potential to be successful. The primary objective would be to re-build the toes of the creek banks by planting vegetation in the creek bed along the toe. This will cause sand to settle out and be deposited along the bank. Over time the plants will grow and more sand will settle out, thereby increasing the height of the bank toe. Future maintenance of the creek (dredging) must be limited to the center and allow the vegetation along the banks to grow over time. Once the toe can be stabilized, the upper bank can be re-graded (where possible) and planted with natural riparian vegetation to improve habitat quality.

As an alternative to the above approach to bank stabilization, San Pedro Creek banks could also be stabilized using Geolayers. Geolayering is essentially a gravity retaining wall structure, constructed of successive layers of soil draped in a geotextile. It is a reinforced earth structure and provides immediate protection from scour, subsidence, and bank failures from saturated soils. A geotextile fabric is used for strength and a coir fabric is used outside for aesthetics. The fabrics are laid horizontally, filled with soil, and then the fabric is wrapped back over the top of the soil to create a layer. Successive layers are constructed and the face of the layers becomes the armored face of the riverbank. Vegetation, such as willows, can be planted between layers (brush layers) or directly through the face of each layer (pole cuttings).

Geolayers can be easily formed to curves and allow a steeper slope face than can otherwise be achieved by the soil itself. The fabrics provide structural reinforcement that supports the weight of the soil. As the plant roots grow, they add strength to the bank. The added roughness of the vegetation and the fabrics prevent surface erosion. A footing would have to be constructed that extends down below the expected scour depth of the riverbed.

7.0 ESTIMATED COSTS

This section of the report presents the estimated costs for each of the projects identified in the Drainage Improvement Plan. Table 23 presents the total estimated cost for each proposed improvement. The total cost for each project includes an additional 30% (of the estimated cost) for contingencies, an additional 15% (of the estimated cost plus contingencies) for design costs, and an additional 10% (of the estimated cost plus contingencies) for construction management.

Additional cost information is presented in Tables C-1 to C-16 in Appendix C.

TABLE 23
SUMMARY OF ESTIMATED PROJECT COSTS

Proposed Improvements	Estimated Costs*
Storm Drain System Improvements:	
Storm Drain Network 1	$ 25,300
Storm Drain Network 2	$ 49,000
Storm Drain Network 8	$ 59,400
Storm Drain Network 5	$ 297,200
Storm Drain Network 7	$ 68,200
Storm Drain Network 4	$ 63,900
Subtotal=	$ 563,000
Las Vegas Creek improvements, including bank stabilization and new G.C. bridge	$ 687,000
Firestone Channel Improvements (Alternatives):	
Alternative 1 - (natural swale + concrete channel, 4' x 28' box culvert)	$ 586,300
Alternative 2 - (natural swale + high flow bypass, 4' x 10' box culvert)	$ 722,700
Alternative 3 – (natural swale, 4' x 28' box culvert)	$ 344,500
Alternative 4 - (natural swale, bridge replacement)	$ 609,600
Alternative 5 - (concrete channel, 4' x 28' box culvert)	$ 1,396,400
Replace steel pipe culvert at Carneros Creek, improve drainage channels	$ 106,700
Replace Verhelle Bridge	**$ 287,200**

* Includes design, permitting, and construction costs (see Appendix C)

8.0 REFERENCES

City of Santa Barbara, 1997. Construction of Airport Improvements at Santa Barbara Municipal Airport, Airport Project No. 3-06-0235-11.

Flowers & Associates Inc., 1997. Santa Barbara Municipal Airport, Airport Infrastructure Plan for the Area North of Hollister Avenue, Final Hydraulic and Hydrology Report.

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United States Environmental Protection Agency (USEPA), 1993. Storm Water Management Model (SWMM) User Manual.

URS Corporation, November 2000. Master Drainage Plan Santa Barbara Municipal Airport, Channel Modification Alternatives for the Runway Safety Area Extension Project (Volume III).

Yue, A. Kwan. D. and J. Hodgson, 1992. New Techniques for Modeling the Management of Stormwater Quality Impacts, Application of SWMM4 Model for Real Time Control of a Storm Trunk Sewer.

APPENDIX A

HYDROLOGY FOR THE SANTA BARBARA AIRPORT

BY
PENFIELD & SMITH
NOVEMBER 2000

HYDROLOGY
FOR THE
SANTA BARBARA MUNICIPAL AIRPORT

Santa Barbara, California

November 20, 2000

CLIENT: URS

PREPARED BY: Penfield & Smith
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WORK ORDER NO.: 13594.01

PROJECT MANAGER: Craig A. Steward, P.E.

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1. PURPOSE OF REPORT

The purpose of this report is to provide storm flow hydrographs for the channel systems through the Santa Barbara Municipal Airport. Hydrographs for the 2-year, 5-year, 10-year, 25-year, 50-year and 100-year design storm events are presented. The flow results generated were compared to available flow information for validation. It is intended that the hydrograph information will be used by URS to provide storm water elevation data for the Goleta Slough and environs.

2. LOCATION

The Santa Barbara Municipal Airport is situated on the south coastal plain of Santa Barbara County. (See Figure 1.) It is located about 9 miles west of the center of the City of Santa Barbara in an area known as Goleta. It has been constructed on the coastal plan over a portion of the Goleta Slough. The Goleta Slough is tributary to Glen Annie Creek (also known as Tecolotito Creek), Carneros Creek, San Pedro Creek, Las Vegas Creek, San Jose Creek, Atascadero Creek, and Maria Ygnacio Creek. See Figure 2.

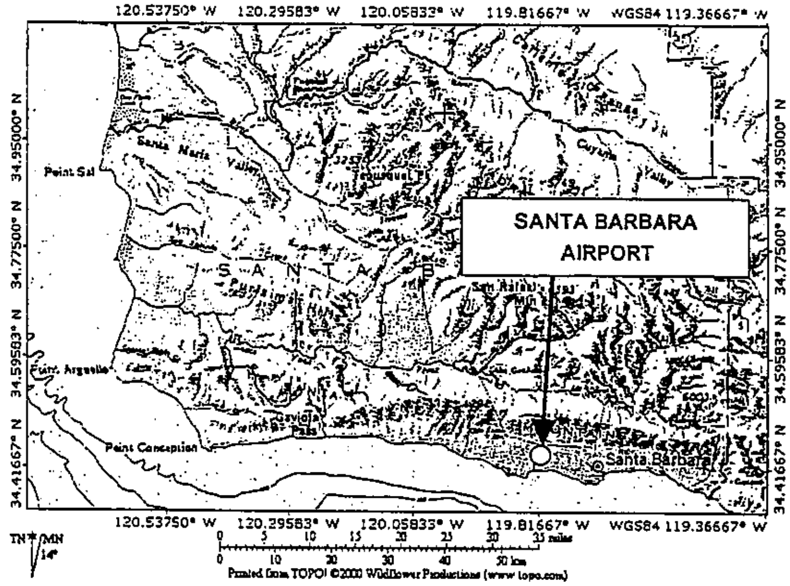


Figure 1 - Area Map

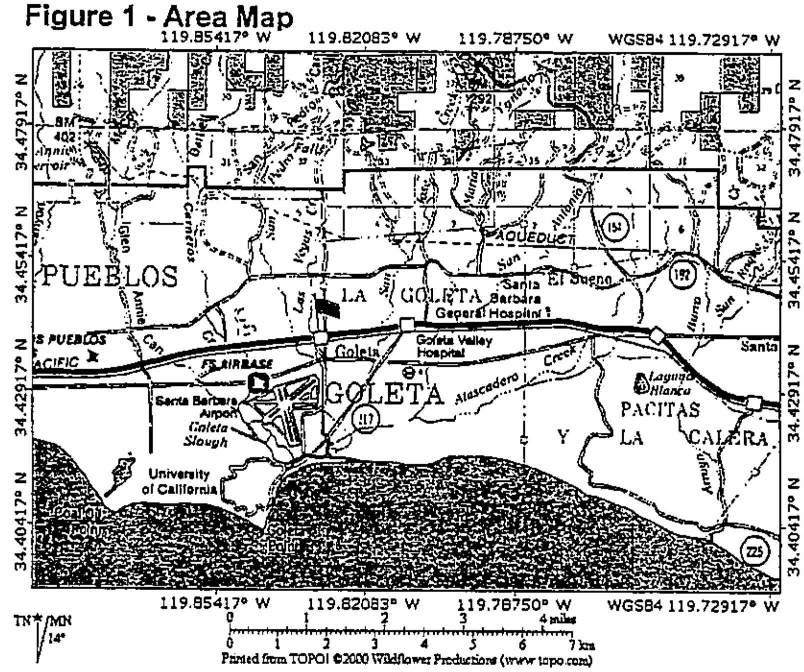


Figure 2 - Vicinity Map

The area tributary to the Goleta Slough is comprised of approximately 30,880 acres (48 square miles). However, the slough itself is divided by State Route 217 (also known as Ward Memorial Boulevard). Ward Memorial Boulevard forms a barrier, restricting discharge from several of the creeks. The Santa Barbara Municipal Airport is located west and upstream of this barrier. The affected creeks are:

- Tecolotito Creek;
- Carneros Creek;
- San Pedro Creek;
- Las Vegas Creek; and
- San Jose Creek

Atascadero Creek and Maria Ygnacio Creek are located east and downstream of Ward Memorial Boulevard. As such, they influence the outlet conditions of the other streams at the bridges under Ward Memorial Boulevard. All the creeks tributary to the Goleta Slough discharge to the Pacific Ocean near Goleta Beach. Watershed drainage areas are summarized in Table 1.

Table 1 - Watershed Names and Tributary Areas

Watershed Names	Drainage Area (acres)
West of Ward Memorial	
Tecolotito Creek	3,470
Carneros Creek	2,740
San Pedro/Las Vegas Creeks	4,400
San Jose Creek	5,330
Goleta Slough	1,830
East of Ward Memorial	
Upper Atascadero Creek	4,770
Maria Ygnacio/San Antonio Creeks	7,720
Lower Atascadero Creek	620

3. METHOD OF ANALYSIS

3.1 Field Investigation and Research

The lower watershed and critical drainage features were reviewed by site visit. Available plans and topographic data were referenced to verify drainage paths and watershed boundaries. Design plans, reports, rain and flow gauging data, and historical accounts were reviewed. A list of the sources of information is contained in Attachment A.

3.2 Compilation and Analysis of Data

3.2.1 Watersheds

The watersheds were delineated using USGS 7-1/4 minute quadrangle maps. Exhibit 1 shows the watershed boundaries as defined for this project. The project required flow estimates at the upstream side of the Santa Barbara Municipal Airport and at several downstream points. In addition, some watersheds were defined based on the need to verify gauging data. Table 2 summarizes the watershed areas.

Table 2 - Watershed Characteristics

Watershed Name	Area (acres)	Length (ft)	Elevation Difference (ft)	Average Slope (%)
Tecolotito Creek	3,470	31,000	3,016	9.73%
Carneros Creek	2,740	28,000	2,891	10.33%
San Pedro/Las Vegas	4,400	28,000	2,826	10.09%
San Jose	5,330	43,000	2990	6.95%
Maria Ygnacio/San Antonio	7,720	33,000	3273	9.92%
Upper Atascadero	4,770	26,000	973	3.74%
Lower Atascadero	620	6,400	27	0.42%
Goleta Slough	1,830	7,400	4	0.05%
Total	30,880			

3.2.2 Streamflow Gauging

A number of streamflow gauging stations have been established by the U.S.G.S. within the project study area. The number of years of record and reliability of these gauging stations vary significantly. The quality of the gauging data, due to poor channel cross section, tends to be fair to poor.

It is generally accepted that statistical data, such as supplied by stream gauges, can only be extrapolated to a return period equal to 2.5 times the period of record (ie to extrapolate to a 100-year flow, there would need to be at least 40 years of record. Table 3 summarizes the streamflow gauging locations and the period of available records.

The peak annual flow rates were analyzed using methods outlined in government Bulletin #17B[1]. A record of these results is found in Attachment A.

Table 3 - Streamflow Gauging Locations and Data Summary

Stream Name (location)	Station No.	Period of Record	Number of Years
Tecolotito Creek	USGS 11120530 (Nr Goleta CA)	1971 - 1990	9
San Jose (upstream of Patterson Avenue)	USGS 11120500 (Nr Goleta CA)	1941 - 1998	58
San Jose (below Hollister Ave.)	USGS 11120510 (At Goleta)	1971 - 1992	22
Maria Ygnacio	USGS 11119940 (at University Dr Nr Goleta CA)	1971 - 1999	28
Atascadero (below confluence with Maria Ygnacio)	USGS 11120000 (Nr Goleta CA)	1942 - 1999	58

3.2.3 Rainfall

The rainfall in the South Coast Santa Barbara area varies significantly with elevation. At the coast the average annual rainfall is 16 inches while at the mountain ridge (3,000 feet msl) the average annual rainfall is about 30 inches. Santa Barbara County maintains a network of rain gauging stations. Rainfall gauging stations with automatic short-duration recording apparatus are sparsely distributed in and around the project watersheds. Exhibit 2 shows the locations of these gauges. Table 4 summarizes the gauging locations and the period of available records.

[1] Hydrology Subcommittee Guidelines for Determining Flood Flow Frequency, Bulletin #17B, Revised September 1981, Editorial Corrections March 1982; Interagency Advisory Committee on Water Data; U.S. Department of Interior, Geological Survey Office of Water Data Coordination.

Table 4 - Rain Gauging Locations and Data Summary

Station Number	Station Name	Elevation (ft msl)	Begin Water Year	End Water Year	No. of Years
199	Wood Residence	450	1985	1999	15
211	Santa Barbara County Road Yard	220	1962	1999	38
228	Stanwood Fire Station	700	1954	1999	46
308	Dos Pueblos Ranch	160	1947	1999	53
340	Doulton Tunnel	1,775	1926	1999	74
341	Santa Barbara - Downtown FCD Office	100	1963	2000	38
390	San Marcos Pass	2,200	1955	2000	46
395	Trout Club	1,200	1951	1999	49

Rainfall in the project area varies temporally, geographically, and by elevation. Temporal distribution of the estimated rainfall depths was provided by using the Santa Barbara County unit distribution that is typically applied in the Santa Barbara Urban Hydrograph (SBUH) Program. Geographic and elevational distributions were analyzed. Within the study area, it was determined that rainfall depth is directly proportional to the ground elevation. Analysis of the available rainfall gauging data

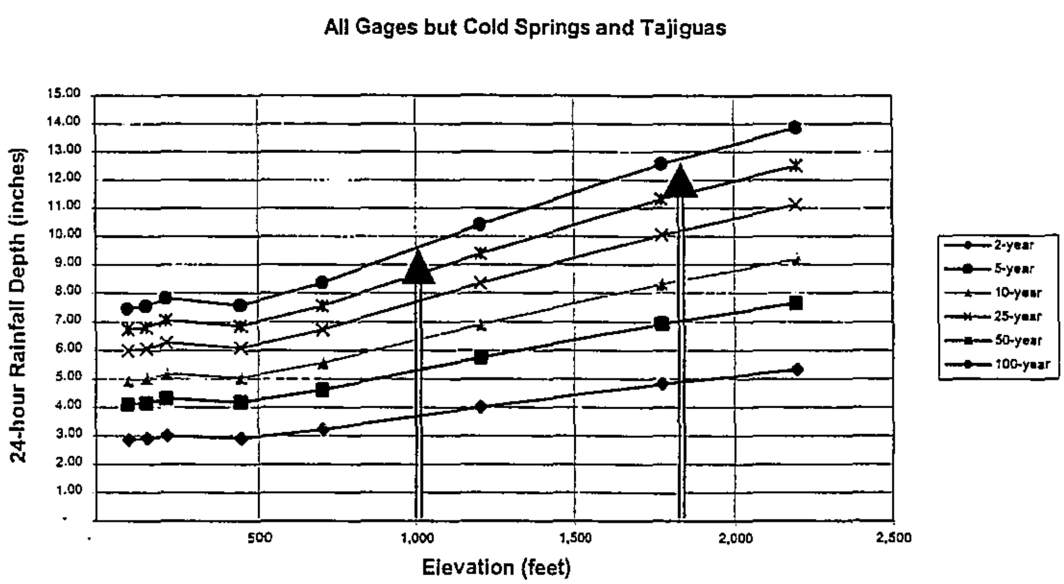


Figure 3 - Rainfall by Elevation Summary

yielded the relationships shown in Figure 3. Rainfall depths for each watershed were calculated for elevation ranges from 0 – 500 feet msl, 500 – 1,500 feet msl, and greater than 1,500 feet msl. Average values were selected as indicated by the arrows in Figure 3and shown in Figure 4. A more complete analysis is found in Attachment C.

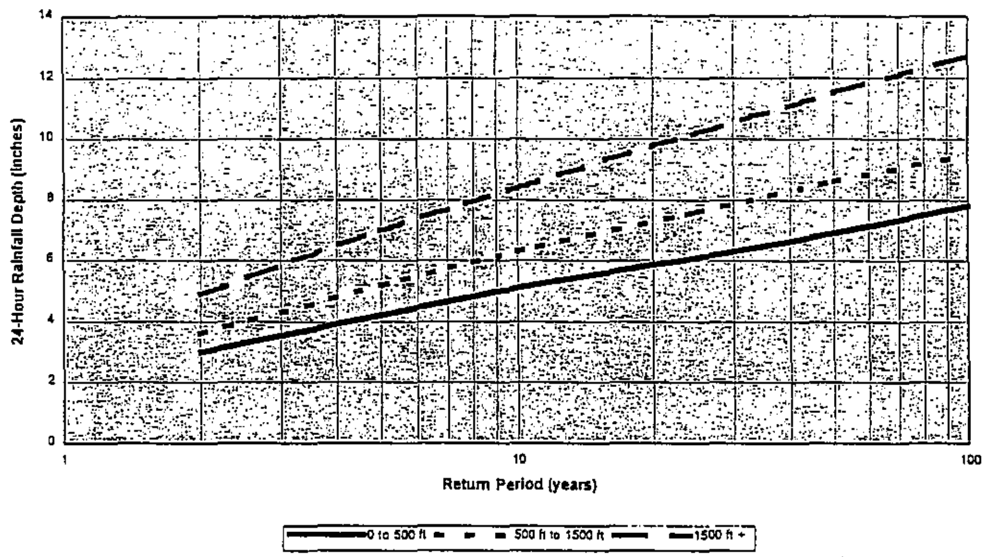


Figure 4 - Rainfall Depth vs Return Period (for selected elevations)

3.2.4 Soil Types

Soil types were determined from the NRCS (formerly SCS) soil maps. The soils were classified as to hydrologic soils group A, B, C, and D. Type A soils (typically sands) are the most permeable and free draining ranging to Type D soils (typically clays) being the most impermeable, yielding rapid runoff of storm water. A summary of soil type distribution by watershed is shown in Table 5.

Table 5 - Soil Type Distribution by Watershed

Watershed	Soil Type (%)			
	A	B	C	D
Tecolotito	0.0	9	9	82
Cameros	0.0	8	7	85
San Pedro	0.0	21	2	77
San Jose	0.0	13	0.0	87
Maria Ygnacio	0.5	9	0.0	90.5
Upper Atascadero	0.2	16	8	75.8
Lower Atascadero	11	30	50	9
Goleta Slough	21	12	48	19

3.2.5 Watershed Cover

Watershed cover was grossly determined by review of development trends as shown on the USGS topographic maps and personal knowledge of the consultant. SCS curve numbers[2] were applied as shown in Table 6 for a representative weighted curve number over the entire watershed.

Table 6 - SCS Curve Numbers (CN)

Cover Description	Soil Types (CN)			
	A	B	C	D
Commercial	88	91	93	95
Residential 1 Acre Lots	50	67	78	84
Residential 1/4 Acre Lot	60	74	82	87
Chaparral	N/A	52	62	75
Grasslands	46	61	68	76

3.2.6 Depression Storage

Natural depressions within the watershed can offer detention storage or ponding capabilities. There are several locations within the Goleta Slough watershed where significant volumes of detention or ponding storage can occur. These detention storage areas are given in Table 7.

[2] Runoff Curve Numbers (Table 2.1 – Undeveloped, Native Vegetation, Antecedent Moisture Condition II, Table 2.2 – Urban Land Use, Antecedent Moisture Condition II); Ventura County Public Works Agency; Stormwater Detention Seminar and Workshop #2; November 22, 1988.

Table 7 – Depression Storage Locations

Location	Volume (acre-feet)	Depth (feet)
Goleta Slough	3,000+	10
Upstream of U.S. 101 at Carneros Creek	148	17
Upstream of U.S. 101 at Las Vegas Creek	18	3

In addition, Santa Barbara County Flood Control maintains smaller sediment basins downstream of Hollister Avenue at Tecolotito Creek and Carneros Creek. These basins tend to take the form of long linear basins.

Ponding of significant quantities of water during storm events allows for a reduction in peak flow rates and deposition of sediment. The deposition of sediment can either have a positive or negative impact depending on where the sediment is deposited. In the case of Las Vegas Creek, significant quantities of sediment have been deposited in residential neighborhoods and several homes have been damaged by inundation. Overflow from Carneros Creek into the depression storage areas occurred during the 1995 storms. After the 1995 storms, significant amounts of sediment were found to have been deposited at this location that would otherwise have been deposited in the Goleta Slough. The Goleta Slough provides significant detention Storage capabilities, reducing larger flow rates by more than fifty percent.

3.2.7 Initial Loss Rates

Initial surface soil conditions typically allow infiltration of a portion of rainfall prior to initiating direct runoff of excess water. The project watersheds will satisfy the initial losses at different times depending on the amount of rainfall received during a given rainfall event. No detailed study has been made to quantify the loss rates of these watersheds and therefore, the initial loss rates are generally based on engineering judgment. This being the case, for the project hydrologic analysis, the initial loss rate was varied to match the final discharge estimates to the recorded streamflow data.

3.2.8 Hydrologic Routing

Hydrologic routing is used to adjust flows as they travel from one watershed collection point to the next collection point. It is also used for simulating flow through reservoirs.

To simulate translation of flows down a stream channel, the Muskingum-Cunge method was applied. Due to relatively short reaches, the impact of routing was insignificant. Reservoir routing was applied to areas thought to have significant storage volume. Only one location (the Goleta Slough) was studied. Outflow was estimated by developing a rating curve based on the Corps of Engineers HEC-2 model. Storage volume was calculated by contour slice method using contours from the Goleta Valley topographic mapping.

3.2.9 Rainfall-Runoff Model.

A Clark synthetic hydrograph model was used to convert rainfall into runoff. Since little information has been developed for the study area regarding the hydrologic parameters used in the model, typical values were assigned to the model . The parameters of time of concentration (Tc) and a storage coefficient (R) are used to determine the shape of the hydrograph. The Tc was detemined using standard methods developed for the TR-55 hydrologic program. Then a factor of R/(Tc+R) that approximates the study watershed was selected. Typical values range from 0.3 (rapid runoff) to 0.7 (slow runoff). An average factor of 0.5 was used. Hydrographs at each of the collection points are calculated and given in Attachment D.

3.3 Verification of Results

The model-estimated peak flow rates were compared to the recorded streamflow data and peak flow rate estimates developed for the Federal Emergency Management Agency for use in preparing the Flood Insurance Rate Maps. The estimated peak flow rates at the watershed collection points, between the gauging stations and the watershed collection points, were adjusted proportional to the watershed areas for comparison.

Table 8 - Verification of Results Summary

Location	Estimated Peak Flow Rates as a Percent of Gauging Data							
	2-yr	5-yr	10-yr		50-yr		100-yr	
	Computed Probability	Computed Probability	Computed Probability	FEMA	Computed Probability	FEMA	Computed Probability	FEMA
Tecolotito Creek	98%	120%	106%	106%	111%	113%	92%	95%
San Jose Creek*	109%	102%	90%	166%	108%	155%	98%	136%
Maria Ygnacio Creek*	92%	107%	125%	98%	157%	101%	181%	111%
Atascadero Creek (below confluence w/ Maria Ygnacio)	105%	101%	88%	80%	103%	95%	104%	100%

* Indicates interpolated results.

Due to variations in watershed characteristics, antecedent moisture conditions, changes in landuse development, debris generation, and storage volume, a precise match to statistical data is not generally found. In most cases, peak flow rates were adjusted to be within about 20 percent of the recorded streamflow gauging data. No attempt was made to assess runoff volumes. The verification of peak flow estimates is summarized in Table 8. Results within 20 percent represent reasonable results. Some values outside this range, particularly for gauging data, are present for Maria Ygnacio Creek. This may represent difficulty in gauging higher flows, a deficiency in the length of gauging record, or features in the watershed that may not be modeled in sufficient detail.

Since the flow rates were estimated at gauging stations where recorded flow data are monitored, a fair degree of confidence can be placed in the flow estimates. In addition, interviews of the City personnel were conducted to ascertain the general impact of known flooding events such as the 1995 storms and the 1998 storms.

4. CONCLUSION

The estimated peak flow rates are summarized in Table 9. Peak flow rates are rounded off to the nearest 100 cfs.

Table 9 – Estimated Peak Flow Rates for Selected Design Events

Location	Peak Runoff (cfs)					
	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
Tecolotito Creek at Hollister Avenue	300	1,000	1,500	2,500	3,900	4,400
Carneros Creek at Hollister Avenue	300	900	1,300	2,100	3,100	3,600
San Pedro Creek at Hollister Avenue	600	1,500	2,200	3,400	5,000	5,700
San Jose Creek at Hollister Avenue	1,100	2,200	2,800	4,400	6,400	7,200
Outflow from West Goleta Slough (upstream of Ward Memorial)	2,200	5,700	7,800	12,800	19,200	21,800
Outflow from West Goleta Slough (downstream of Ward Memorial)	1,700	3,800	4,300	5,900	9,100	10,000

EXHIBITS AND ATTACHMENTS

Exhibits

1 – Watershed Areas
2 – Gauging Station Locations
3 – Isohyets

Attachments

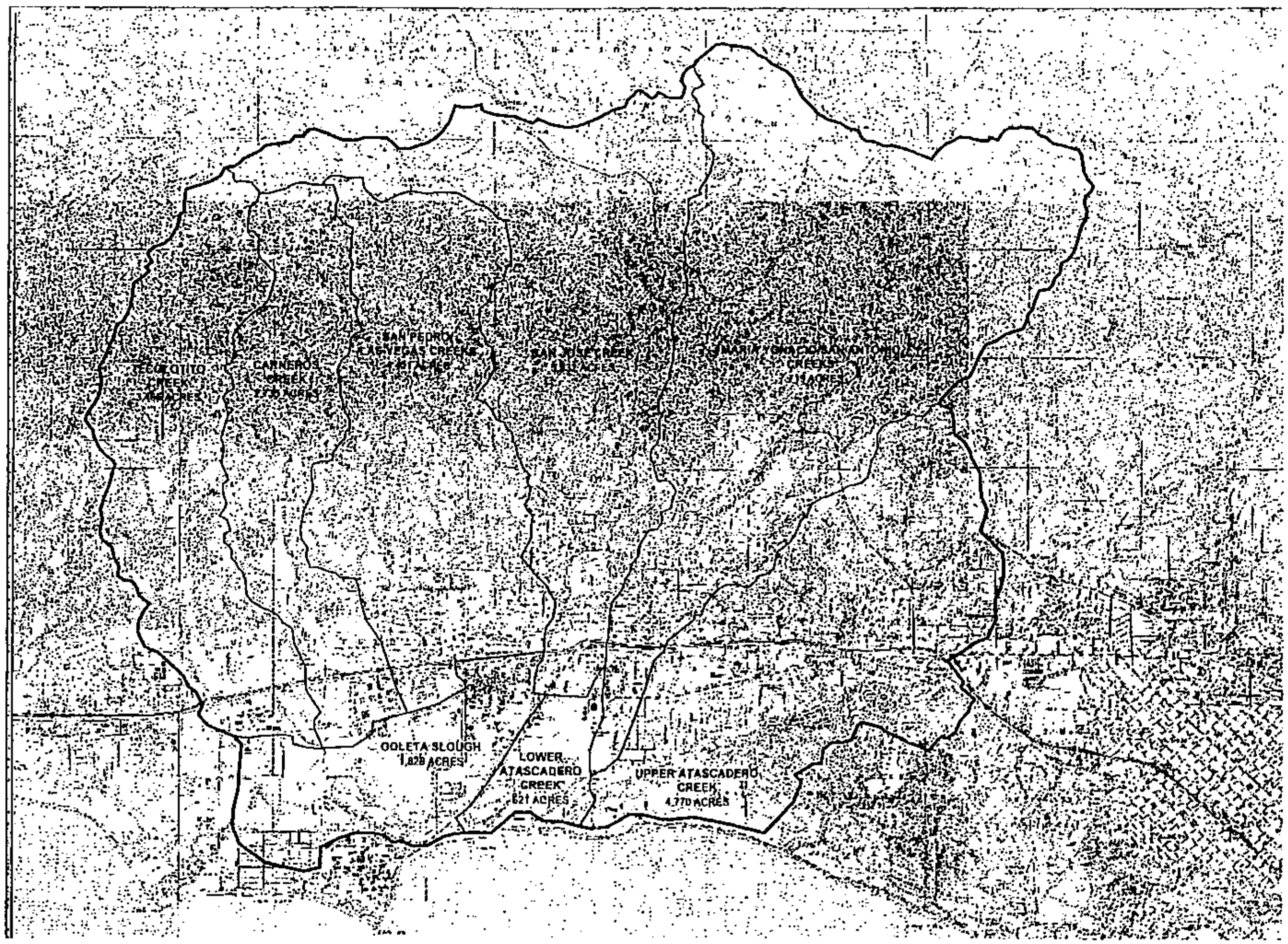
Attachment A - Statistical Analysis of Flow Gauging

Attachment B - List of Sources

Attachment C - Calculations

Attachment D - Hydrographs

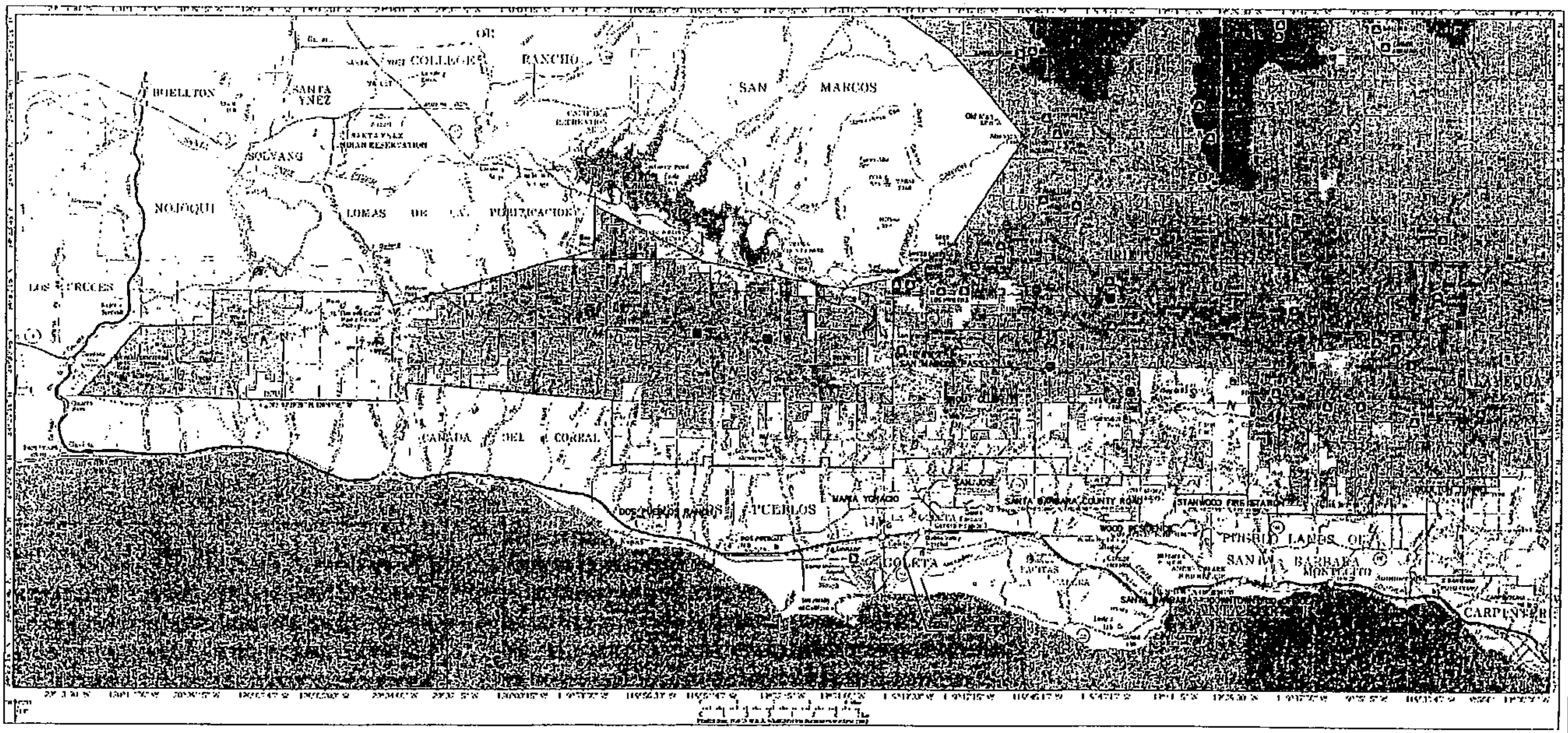
Attachment E - HEC-1 Summary Output



Penfield & Smith
ENGINEERS & SURVEYORS

COUNTY OF SANTA BARBARA, CALIFORNIA

WATERSHED AREAS
MASTERPLAN



LEGEND

WOOD RESIDENCE
○ 211, 34 11' 00" N, 119 48' 00" W — LOCATION OF PRECIPITATION STATION

SAN JOSE — LOCATION OF STREAM FLOW GAUGING STATION

REFERENCES:	
PROGRAM FILE:	
DATA FILE:	
PROJECT FILE:	PrecipStations
DRAWING FILE:	

NO.	DATE	REVISIONS	APPR.

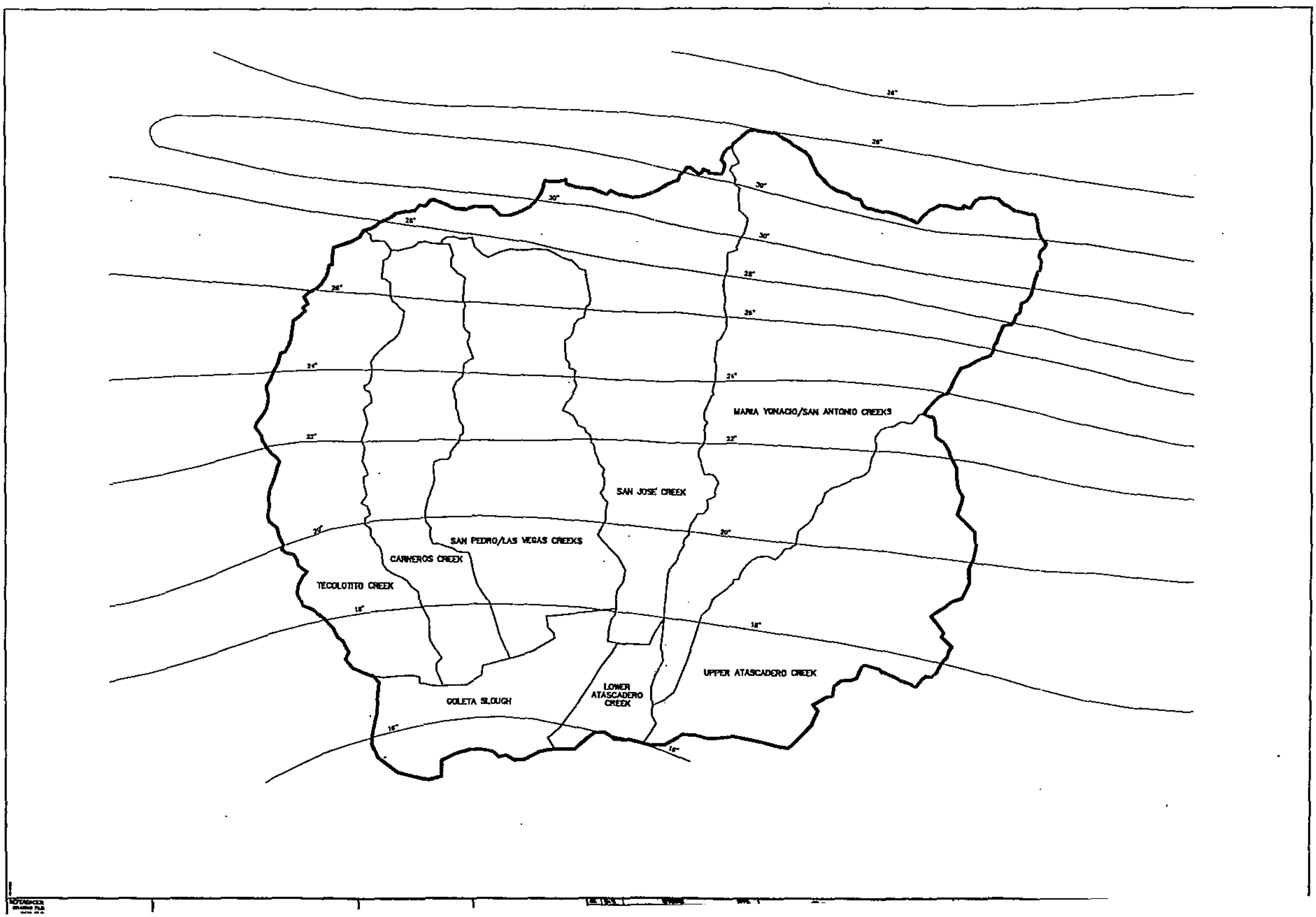
Penfield & Smith
ENGINEERS • SURVEYORS

DESIGN: CAS CHECKED: ______

CITY OF SANTA BARBARA, CALIFORNIA
REVIEWED BY:

GAUGING STATION LOCATIONS
AIRPORT MASTERPLAN

WORK ORDER 13594.01
SHEET


MARIA YGNACIO/SAN ANTONIO CREEKS
SAN JOSE CREEK
SAN PEDRO/LAS VEGAS CREEKS
CARNEROS CREEK
TECOLOTITO CREEK
GOLETA SLOUGH
LOWER ATASCADERO CREEK
UPPER ATASCADERO CREEK
26"
28"
30"
30"
28"
26"
24"
22"
20"
18"
16"

ATTACHMENT A

Statistical Analysis of Flow Gauging

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*************************************        **************************************
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*    PROGRAM DATE:  MAY 1992        *        * THE HYDROLOGIC ENGINEERING CENTER *
*        VERSION:  3.0              *        *         609 SECOND STREET          *
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*       01 SEP 00    16:42:28       *        *          (916) 756-1104            *
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TT    ATASCADERO CR NR GOLETA CA
TT    FITTING THE LOG-PEARSON TYPE III DISTRIBUTION

**STATION IDENTIFICATION**
ID    USGS STATION 11120000

**GENERALIZED SKEW**
     ISTN    GGMSE     SKEW
GS  20000     .000     -.20

**SYSTEMATIC EVENTS**
     58 EVENTS TO BE ANALYZED

**END OF INPUT DATA**
ED +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
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□□□□□□□□□□□□□□□□□□□□□□□PRELIMINARY RESULTS □□□□□□□□□□□□□□□□□□□□□□□


-SKEW WEIGHTING -
□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□
BASED ON  58 EVENTS, MEAN-SQUARE ERROR OF STATION SKEW =    .260
DEFAULT OR INPUT MEAN-SQUARE ERROR OF GENERALIZED SKEW =    .302
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 PRELIMINARY RESULTS

-FREQUENCY CURVE-  USGS STATION 11120000
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□ COMPUTED    EXPECTED    □  PERCENT   □   CONFIDENCE LIMITS   □
□   CURVE   PROBABILITY   □   CHANCE   □    .05          .95   □
□      FLOW IN CFS        □ EXCEEDANCE □      FLOW IN CFS      □
□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□
□   14200.      15300.    □         .2 □   26400.       8820.  □
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8660.	9060.	2.0	14900.	5640.
6320.	6530.	5.0	10400.	4230.
4570.	4680.	10.0	7210.	3140.
2910.	2950.	20.0	4360.	2070.
1020.	1020.	50.0	1410.	743.
270.	264.	80.0	379.	183.
120.	114.	90.0	179.	74.
58.	53.	95.0	92.	32.
13.	10.	99.0	24.	5.

SYSTEMATIC STATISTICS

LOG TRANSFORM: FLOW, CFS		NUMBER OF EVENTS	
MEAN	2.9240	HISTORIC EVENTS	0
STANDARD DEV	.6312	HIGH OUTLIERS	0
COMPUTED SKEW	-1.3104	LOW OUTLIERS	0
REGIONAL SKEW	-.2000	ZERO OR MISSING	0
ADOPTED SKEW	-.8000	SYSTEMATIC EVENTS	58

FINAL RESULTS

-PLOTTING POSITIONS- USGS STATION 11120000

EVENTS ANALYZED				ORDERED EVENTS			
MON	DAY	YEAR	FLOW CFS	RANK	WATER YEAR	FLOW CFS	WEIBULL PLOT POS
4	14	1942	118.	1	1995	10200.	1.69
1	22	1943	1900.	2	1973	5380.	3.39
2	22	1944	1050.	3	1992	5380.	5.08
2	2	1945	1050.	4	1969	5230.	6.78
12	22	1946	265.	5	1967	5000.	8.47
11	20	1947	920.	6	1980	4600.	10.17
3	24	1948	60.	7	1952	4500.	11.86
3	4	1949	84.	8	1978	4310.	13.56
2	6	1950	180.	9	1967	4020.	15.25
3	1	1951	2.	10	1998	3450.	16.95
1	15	1952	4500.	11	1983	3390.	18.64
12	30	1953	232.	12	1993	2990.	20.34
1	24	1954	235.	13	1972	2500.	22.03
1	18	1955	102.	14	1973	2470.	23.73
1	26	1956	1090.	15	1976	2380.	25.42
1	13	1957	408.	16	1991	2360.	27.12
4	3	1958	1600.	17	1962	1950.	28.81
2	16	1959	182.	18	1943	1900.	30.51
2	1	1960	128.	19	1958	1600.	32.20
11	5	1961	331.	20	1966	1530.	33.90
2	9	1962	1950.	21	1985	1470.	35.59
2	9	1963	732.	22	1976	1380.	37.29
3	22	1964	529.	23	1979	1260.	38.98
11	9	1965	1530.	24	1974	1140.	40.68
11	16	1966	4020.	25	1956	1090.	42.37
1	24	1967	5000.	26	1990	1090.	44.07
3	7	1968	460.	27	1994	1090.	45.76
1	25	1969	5230.	28	1945	1050.	47.46
3	4	1970	956.	29	1944	1050.	49.15

11	29	1971	2500.	30	1981	1010.	50.85
12	27	1972	2470.	31	1986	979.	52.54
1	18	1973	5380.	32	1977	960.	54.24
1	7	1974	1140.	33	1970	956.	55.93
12	3	1975	2380.	34	1948	920.	57.63
2	9	1976	1380.	35	1990	888.	59.32
1	2	1977	960.	36	1986	828.	61.02
1	16	1978	4310.	37	1963	732.	62.71
3	27	1979	1260.	38	1964	529.	64.41
2	16	1980	4600.	39	1996	528.	66.10
3	1	1981	1010.	40	1968	460.	67.80
4	1	1982	457.	41	1982	457.	69.49
1	27	1983	3390.	42	1989	457.	71.19
12	25	1984	1470.	43	1998	438.	72.88
12	19	1985	828.	44	1957	408.	74.58
2	14	1986	979.	45	1962	331.	76.27
3	5	1987	189.	46	1999	311.	77.97
12	4	1988	457.	47	1947	265.	79.66
12	17	1989	888.	48	1954	235.	81.36
2	17	1990	1090.	49	1954	232.	83.05
3	18	1991	2360.	50	1987	189.	84.75
2	12	1992	5380.	51	1959	182.	86.44
3	25	1993	2990.	52	1950	180.	88.14
2	20	1994	1090.	53	1960	128.	89.83
3	10	1995	10200.	54	1942	118.	91.53
2	20	1996	528.	55	1955	102.	93.22
12	10	1997	438.	56	1949	84.	94.92
2	7	1998	3450.	57	1948	60.	96.61
3	25	1999	311.	58	1951	2.	98.31

-OUTLIER TESTS -

LOW OUTLIER TEST

BASED ON 58 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.824

1 LOW OUTLIER(S) IDENTIFIED BELOW TEST VALUE OF 13.8

STATISTICS AND FREQUENCY CURVE ADJUSTED FOR 1 LOW OUTLIER(S)

HIGH OUTLIER TEST

BASED ON 57 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.818

0 HIGH OUTLIER(S) IDENTIFIED ABOVE TEST VALUE OF 29013.

-SKEW WEIGHTING -

BASED ON 58 EVENTS, MEAN-SQUARE ERROR OF STATION SKEW = .106
DEFAULT OR INPUT MEAN-SQUARE ERROR OF GENERALIZED SKEW = .302

FINAL RESULTS

-FREQUENCY CURVE- USGS STATION 11120000

COMPUTED CURVE FLOW IN CFS	EXPECTED PROBABILITY FLOW IN CFS	PERCENT CHANCE EXCEEDANCE	CONFIDENCE LIMITS .05 FLOW IN CFS	CONFIDENCE LIMITS .95 FLOW IN CFS
22500.	26000.	.2	43000.	13700.
16600.	18600.	.5	30300.	10500.
12900.	14100.	1.0	22500.	8380.
9710.	10400.	2.0	16200.	6500.
6280.	6560.	5.0	9850.	4390.
4210.	4340.	10.0	6260.	3060.
2570.	2610.	20.0	3590.	1930.
951.	951.	50.0	1240.	730.
333.	327.	80.0	443.	239.
188.	182.	90.0	261.	126.
116.	110.	95.0	168.	72.
45.	40.	99.0	73.	25.

SYNTHETIC STATISTICS

LOG TRANSFORM: FLOW, CFS		NUMBER OF EVENTS	
MEAN	2.9608	HISTORIC EVENTS	0
STANDARD DEV	.5276	HIGH OUTLIERS	0
COMPUTED SKEW	-.2548	LOW OUTLIERS	1
REGIONAL SKEW	-.2000	ZERO OR MISSING	0
ADOPTED SKEW	-.2000	SYSTEMATIC EVENTS	58

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+ END OF RUN            +
+ NORMAL STOP IN FFA    +
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*     PROGRAM DATE:  MAY 1992       *       * THE HYDROLOGIC ENGINEERING CENTER   *
*          VERSION:  3.0            *       *         609 SECOND STREET           *
*     RUN  DATE   AND   TIME:       *       *      DAVIS, CALIFORNIA 95616        *
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TT    MARIA YGNACIO C AT UNIV DR NR GOLETA CA
TT    FITTING THE LOG-PEARSON TYPE III DISTRIBUTION

**STATION IDENTIFICATION**
ID    USGS STATION 11119940

**GENERALIZED SKEW**
     ISTN    GGMSE    SKEW
GS  19900     .000    -.20

**SYSTEMATIC EVENTS**
     28 EVENTS TO BE ANALYZED

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FINAL RESULTS

-PLOTTING POSITIONS- USGS STATION 11119940

EVENTS ANALYZED				ORDERED EVENTS			
MON	DAY	YEAR	FLOW CFS	RANK	WATER YEAR	FLOW CFS	WEIBULL PLOT POS
11	29	1971	255.	1	1992	2500.	3.45
12	27	1972	240.	2	1978	1650.	6.90
1	18	1973	1470.	3	1973	1470.	10.34
1	7	1974	340.	4	1998	1460.	13.79
12	3	1975	867.	5	1983	1230.	17.24
2	9	1976	118.	6	1991	1180.	20.69
1	2	1977	148.	7	1993	1020.	24.14
1	16	1978	1650.	8	1976	867.	27.59
3	27	1979	301.	9	1986	830.	31.03
2	16	1980	765.	10	1980	765.	34.48
3	1	1981	731.	11	1981	731.	37.93
4	1	1982	320.	12	1985	648.	41.38

1	27	1983	1230.	13	1998	468.	44.83
12	25	1984	648.	14	1996	409.	48.28
12	19	1985	273.	15	1974	340.	51.72
2	14	1986	830.	16	1982	320.	55.17
3	6	1987	45.	17	1994	312.	58.62
2	29	1988	226.	18	1979	301.	62.07
12	20	1989	50.	19	1986	273.	65.52
2	17	1990	84.	20	1972	255.	68.97
3	18	1991	1180.	21	1973	240.	72.41
2	15	1992	2500.	22	1988	226.	75.86
3	25	1993	1020.	23	1977	148.	79.31
2	20	1994	312.	24	1976	118.	82.76
2	19	1996	409.	25	1990	84.	86.21
12	26	1997	468.	26	1999	56.	89.66
2	7	1998	1460.	27	1990	50.	93.10
3	25	1999	56.	28	1987	45.	96.55

-OUTLIER TESTS -

LOW OUTLIER TEST

BASED ON 28 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.534

0 LOW OUTLIER(S) IDENTIFIED BELOW TEST VALUE OF 23.7

HIGH OUTLIER TEST

BASED ON 28 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.534

0 HIGH OUTLIER(S) IDENTIFIED ABOVE TEST VALUE OF 6553.

-SKEW WEIGHTING -

BASED ON 28 EVENTS, MEAN-SQUARE ERROR OF STATION SKEW = .214
DEFAULT OR INPUT MEAN-SQUARE ERROR OF GENERALIZED SKEW = .302

FINAL RESULTS

-FREQUENCY CURVE- USGS STATION 11119940

COMPUTED CURVE FLOW IN CFS	EXPECTED PROBABILITY FLOW IN CFS	PERCENT CHANCE EXCEEDANCE	CONFIDENCE LIMITS .05 FLOW IN CFS	CONFIDENCE LIMITS .95 FLOW IN CFS
6430.	8300.	.2	15700.	3530.
5020.	6130.	.5	11500.	2860.
4070.	4780.	1.0	8850.	2390.
3210.	3630.	2.0	6570.	1950.
2210.	2400.	5.0	4150.	1410.
1570.	1650.	10.0	2730.	1040.

1010.	1040.	20.0	1620.	702.
416.	416.	50.0	595.	293.
158.	152.	80.0	228.	99.
92.	86.	90.0	140.	52.
58.	52.	95.0	93.	30.
23.	18.	99.0	43.	9.

SYSTEMATIC STATISTICS

LOG TRANSFORM: FLOW, CFS		NUMBER OF EVENTS	
MEAN	2.5953	HISTORIC EVENTS	0
STANDARD DEV	.4819	HIGH OUTLIERS	0
COMPUTED SKEW	-.4162	LOW OUTLIERS	0
REGIONAL SKEW	-.2000	ZERO OR MISSING	0
ADOPTED SKEW	-.3000	SYSTEMATIC EVENTS	28

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+++++++++++++++++++++++++
+ END OF RUN            +
+ NORMAL STOP IN FFA    +
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*************************************        *************************************
*              FFA                  *        *                                   *
*     FLOOD FREQUENCY ANALYSIS      *        *   U.S. ARMY CORPS OF ENGINEERS    *
*     PROGRAM DATE:  MAY 1992       *        * THE HYDROLOGIC ENGINEERING CENTER *
*         VERSION:  3.0             *        *        609 SECOND STREET          *
*     RUN  DATE   AND   TIME:       *        *     DAVIS, CALIFORNIA 95616       *
*        01 SEP 00    16:45:04      *        *         (916) 756-1104            *
*                                   *        *                                   *
*************************************        *************************************


 INPUT FILE NAME: SANJOSE.DAT
OUTPUT FILE NAME: SANJOSE.OUT
   DSS FILE NAME: SANJOSE.DSS


   -----DSS---ZOPEN:  Existing File Opened,  File: SANJOSE.DSS
                      Unit:  71;  DSS Version: 6-GX

**TITLE RECORD(S)**
TT    FLOOD FLOW FREQUENCY ANALYSIS
TT    SAN JOSE C NR GOLETA CA
TT    FITTING THE LOG-PEARSON TYPE III DISTRIBUTION

**STATION IDENTIFICATION**
ID    USGS STATION 11120500

**GENERALIZED SKEW**
     ISTN   GGMSE    SKEW
GS  20500    .000    -.20

**SYSTEMATIC EVENTS**
     58 EVENTS TO BE ANALYZED

**END OF INPUT DATA**
ED ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++


□□□□□□□□□□□□□□□□□□□□□□PRELIMINARY RESULTS □□□□□□□□□□□□□□□□□□□□□□


-SKEW WEIGHTING -
□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□
BASED ON  58 EVENTS, MEAN-SQUARE ERROR OF STATION SKEW =     .153
DEFAULT OR INPUT MEAN-SQUARE ERROR OF GENERALIZED SKEW =     .302
□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□


 PRELIMINARY RESULTS

-FREQUENCY CURVE-  USGS STATION 11120500
□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□
□  COMPUTED    EXPECTED   □   PERCENT   □    CONFIDENCE LIMITS   □
□    CURVE    PROBABILITY □    CHANCE   □      .05         .95   □
□      FLOW IN CFS        □  EXCEEDANCE □       FLOW IN CFS      □
□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□
□     4910.       5330.   □        .2   □      8580.      3190.  □
□     4070.       4360.   □        .5   □      6920.      2700.  □
```

3450.	3660.	1.0	5720.	2330.
2840.	2980.	2.0	4570.	1950.
2060.	2130.	5.0	3170.	1460.
1510.	1540.	10.0	2220.	1100.
992.	1010.	20.0	1390.	744.
394.	394.	50.0	516.	303.
132.	129.	80.0	175.	95.
69.	66.	90.0	96.	46.
39.	37.	95.0	57.	24.
12.	10.	99.0	20.	6.

SYSTEMATIC STATISTICS

LOG TRANSFORM: FLOW, CFS		NUMBER OF EVENTS	
MEAN	2.5432	HISTORIC EVENTS	0
STANDARD DEV	.5291	HIGH OUTLIERS	0
COMPUTED SKEW	-.8310	LOW OUTLIERS	0
REGIONAL SKEW	-.2000	ZERO OR MISSING	0
ADOPTED SKEW	-.6000	SYSTEMATIC EVENTS	58

FINAL RESULTS

-PLOTTING POSITIONS- USGS STATION 11120500

EVENTS ANALYZED				ORDERED EVENTS			
MON	DAY	YEAR	FLOW CFS	RANK	WATER YEAR	FLOW CFS	WEIBULL PLOT POS
4	4	1941	1960.	1	1969	2000.	1.69
4	14	1942	210.	2	1941	1960.	3.39
1	21	1943	1780.	3	1943	1780.	5.08
2	22	1944	200.	4	1978	1770.	6.78
2	2	1945	500.	5	1967	1700.	8.47
3	29	1946	390.	6	1967	1620.	10.17
11	20	1947	500.	7	1998	1540.	11.86
3	24	1948	23.	8	1992	1480.	13.56
3	4	1949	150.	9	1995	1470.	15.25
2	6	1950	230.	10	1983	1440.	16.95
1	11	1951	5.	11	1980	1370.	18.64
1	15	1952	1340.	12	1952	1340.	20.34
12	20	1953	120.	13	1973	1220.	22.03
1	24	1954	162.	14	1962	1150.	23.73
1	18	1955	119.	15	1957	978.	25.42
12	24	1956	978.	16	1976	902.	27.12
4	17	1957	286.	17	1991	830.	28.81
4	3	1958	790.	18	1958	790.	30.51
1	5	1959	254.	19	1985	698.	32.20
4	27	1960	51.	20	1986	570.	33.90
11	12	1961	102.	21	1993	531.	35.59
2	9	1962	1150.	22	1945	500.	37.29
2	9	1963	258.	23	1948	500.	38.98
11	20	1964	148.	24	1973	428.	40.68
4	9	1965	360.	25	1997	400.	42.37
11	16	1966	1700.	26	1946	390.	44.07
1	24	1967	1620.	27	1996	368.	45.76
3	8	1968	121.	28	1965	360.	47.46
1	25	1969	2000.	29	1970	340.	49.15

2	28	1970	340.		30	1957	286.	50.85
11	29	1971	257.		31	1977	285.	52.54
12	27	1972	428.		32	1994	277.	54.24
1	18	1973	1220.		33	1981	267.	55.93
1	6	1974	243.		34	1982	267.	57.63
12	3	1975	902.		35	1963	258.	59.32
2	9	1976	192.		36	1972	257.	61.02
1	2	1977	285.		37	1959	254.	62.71
1	16	1978	1770.		38	1974	243.	64.41
3	27	1979	163.		39	1950	230.	66.10
2	16	1980	1370.		40	1990	212.	67.80
3	1	1981	267.		41	1942	210.	69.49
4	1	1982	267.		42	1944	200.	71.19
1	24	1983	1440.		43	1976	192.	72.88
10	1	1984	698.		44	1979	163.	74.58
12	19	1985	146.		45	1954	162.	76.27
2	14	1986	570.		46	1988	159.	77.97
3	6	1987	87.		47	1949	150.	79.66
2	29	1988	159.		48	1965	148.	81.36
2	9	1989	26.		49	1986	146.	83.05
2	17	1990	212.		50	1968	121.	84.75
3	18	1991	830.		51	1954	120.	86.44
2	12	1992	1480.		52	1955	119.	88.14
3	25	1993	531.		53	1962	102.	89.83
2	20	1994	277.		54	1987	87.	91.53
1	10	1995	1470.		55	1960	51.	93.22
2	4	1996	368.		56	1989	26.	94.92
1	26	1997	400.		57	1948	23.	96.61
2	3	1998	1540.		58	1951	5.	98.31

-OUTLIER TESTS -

LOW OUTLIER TEST

BASED ON 58 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.824

1 LOW OUTLIER(S) IDENTIFIED BELOW TEST VALUE OF 11.2

STATISTICS AND FREQUENCY CURVE ADJUSTED FOR 1 LOW OUTLIER(S)

HIGH OUTLIER TEST

BASED ON 57 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.818

0 HIGH OUTLIER(S) IDENTIFIED ABOVE TEST VALUE OF 8066.

-SKEW WEIGHTING -

BASED ON 58 EVENTS, MEAN-SQUARE ERROR OF STATION SKEW = .107
DEFAULT OR INPUT MEAN-SQUARE ERROR OF GENERALIZED SKEW = .302

FINAL RESULTS

-FREQUENCY CURVE- USGS STATION 11120500

COMPUTED CURVE FLOW IN CFS	EXPECTED PROBABILITY FLOW IN CFS	PERCENT CHANCE EXCEEDANCE	CONFIDENCE LIMITS .05 FLOW IN CFS	CONFIDENCE LIMITS .95 FLOW IN CFS
5650.	6340.	.2	9870.	3690.
4440.	4850.	.5	7450.	2980.
3610.	3880.	1.0	5870.	2480.
2860.	3030.	2.0	4490.	2010.
1990.	2070.	5.0	2960.	1450.
1420.	1460.	10.0	2020.	1070.
930.	943.	20.0	1260.	721.
390.	390.	50.0	495.	308.
151.	149.	80.0	195.	112.
89.	87.	90.0	120.	62.
57.	54.	95.0	79.	37.
23.	21.	99.0	36.	13.

SYNTHETIC STATISTICS

LOG TRANSFORM: FLOW, CFS		NUMBER OF EVENTS	
MEAN	2.5673	HISTORIC EVENTS	0
STANDARD DEV	.4707	HIGH OUTLIERS	0
COMPUTED SKEW	-.2744	LOW OUTLIERS	1
REGIONAL SKEW	-.2000	ZERO OR MISSING	0
ADOPTED SKEW	-.3000	SYSTEMATIC EVENTS	58

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*************************************        *************************************
*              FFA                  *        *                                   *
*     FLOOD FREQUENCY ANALYSIS      *        *   U.S. ARMY CORPS OF ENGINEERS    *
*     PROGRAM DATE:  MAY 1992       *        * THE HYDROLOGIC ENGINEERING CENTER *
*         VERSION:  3.0             *        *         609 SECOND STREET         *
*     RUN  DATE   AND   TIME:       *        *     DAVIS, CALIFORNIA 95616       *
*        01 SEP 00    16:45:04      *        *         (916) 756-1104            *
*                                   *        *                                   *
*************************************        *************************************


 INPUT FILE NAME: SANJOSE.DAT
OUTPUT FILE NAME: SANJOSE.OUT
   DSS FILE NAME: SANJOSE.DSS


**TITLE RECORD(S)**
TT    FLOOD FLOW FREQUENCY ANALYSIS
TT    SAN JOSE CREEK AT GOLETA, CALIF
TT    FITTING THE LOG-PEARSON TYPE III DISTRIBUTION

**STATION IDENTIFICATION**
ID    USGS STATION 11120510

**GENERALIZED SKEW**
     ISTN    GGMSE     SKEW
GS  20510     .000     -.20

**SYSTEMATIC EVENTS**
     22 EVENTS TO BE ANALYZED

**END OF INPUT DATA**
ED +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
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FINAL RESULTS

-PLOTTING POSITIONS- USGS STATION 11120510

EVENTS ANALYZED				ORDERED EVENTS			
MON	DAY	YEAR	FLOW CFS	RANK	WATER YEAR	FLOW CFS	WEIBULL PLOT POS
11	29	1971	300.	1	1978	2330.	4.35
12	27	1972	516.	2	1992	2050.	8.70
1	18	1973	1950.	3	1973	1950.	13.04
1	4	1974	542.	4	1976	1830.	17.39
12	3	1975	1830.	5	1985	1610.	21.74
2	9	1976	239.	6	1983	1420.	26.09
1	2	1977	523.	7	1980	1330.	30.43
3	4	1978	2330.	8	1981	854.	34.78
3	27	1979	487.	9	1991	810.	39.13
2	16	1980	1330.	10	1986	774.	43.48
3	1	1981	854.	11	1986	660.	47.83
4	1	1982	373.	12	1974	542.	52.17
1	27	1983	1420.	13	1977	523.	56.52

10	1	1984	1610.	14	1973	516.	60.87
12	19	1985	660.	15	1979	487.	65.22
2	14	1986	774.	16	1982	373.	69.57
3	5	1987	112.	17	1972	300.	73.91
12	4	1988	220.	18	1976	239.	78.26
12	20	1989	134.	19	1989	220.	82.61
2	17	1990	166.	20	1990	166.	86.96
3	18	1991	810.	21	1990	134.	91.30
2	15	1992	2050.	22	1987	112.	95.65

-OUTLIER TESTS -

LOW OUTLIER TEST

BASED ON 22 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.429

0 LOW OUTLIER(S) IDENTIFIED BELOW TEST VALUE OF 64.5

HIGH OUTLIER TEST

BASED ON 22 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.429

0 HIGH OUTLIER(S) IDENTIFIED ABOVE TEST VALUE OF 5778.

-SKEW WEIGHTING -

BASED ON 22 EVENTS, MEAN-SQUARE ERROR OF STATION SKEW = .246
DEFAULT OR INPUT MEAN-SQUARE ERROR OF GENERALIZED SKEW = .302

FINAL RESULTS

-FREQUENCY CURVE- USGS STATION 11120510

COMPUTED CURVE FLOW IN CFS	EXPECTED PROBABILITY FLOW IN CFS	PERCENT CHANCE EXCEEDANCE	CONFIDENCE LIMITS .05 FLOW IN CFS	CONFIDENCE LIMITS .95 FLOW IN CFS
7000.	9600.	.2	17400.	3940.
5560.	7090.	.5	12900.	3260.
4580.	5560.	1.0	10000.	2770.
3690.	4270.	2.0	7560.	2310.
2650.	2910.	5.0	4930.	1740.
1960.	2080.	10.0	3360.	1340.
1340.	1380.	20.0	2110.	950.
629.	629.	50.0	882.	451.
283.	273.	80.0	398.	181.
183.	170.	90.0	269.	105.
127.	112.	95.0	195.	66.
62.	47.	99.0	107.	26.

SYSTEMATIC STATISTICS			
LOG TRANSFORM: FLOW, CFS		NUMBER OF EVENTS	
MEAN	2.7855	HISTORIC EVENTS	0
STANDARD DEV	.4019	HIGH OUTLIERS	0
COMPUTED SKEW	-.2519	LOW OUTLIERS	0
REGIONAL SKEW	-.2000	ZERO OR MISSING	0
ADOPTED SKEW	-.2000	SYSTEMATIC EVENTS	22

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+ END OF RUN            +
+ NORMAL STOP IN FFA    +
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*************************************          *************************************
*               FFA                 *          *                                   *
*     FLOOD FREQUENCY ANALYSIS      *          *   U.S. ARMY CORPS OF ENGINEERS    *
*     PROGRAM DATE:  MAY 1992       *          * THE HYDROLOGIC ENGINEERING CENTER *
*          VERSION:  3.0            *          *         609 SECOND STREET         *
*     RUN  DATE   AND   TIME:       *          *     DAVIS, CALIFORNIA 95616       *
*        01 SEP 00    15:31:15      *          *         (916) 756-1104            *
*                                   *          *                                   *
*************************************          *************************************


 INPUT FILE NAME: TECTIT.DAT
OUTPUT FILE NAME: TECTIT.OUT
   DSS FILE NAME: TECTIT.DSS


   -----DSS---ZOPEN:  New File Opened,  File: TECTIT.DSS
                      Unit:  71;  DSS Version: 6-GX

**TITLE RECORD(S)**
TT    FLOOD FLOW FREQUENCY ANALYSIS
TT    TECOLOTITO CR NR GOLETA CA
TT    FITTING THE LOG-PEARSON TYPE III DISTRIBUTION

**STATION IDENTIFICATION**
ID    USGS STATION 11120530

**GENERALIZED SKEW**
     ISTN   GGMSE    SKEW
GS  20530    .000    -.20

**SYSTEMATIC EVENTS**
      9 EVENTS TO BE ANALYZED

**END OF INPUT DATA**
ED ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
* * * * WARNING - LESS THAN TEN EVENTS FOR ANALYSIS
            BULLETIN 17-B PROCEDURES NOT APPLICABLE.


                        FINAL RESULTS

-PLOTTING POSITIONS-  USGS STATION 11120530
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EVENTS ANALYZED				ORDERED EVENTS			
MON	DAY	YEAR	FLOW CFS	RANK	WATER YEAR	FLOW CFS	WEIBULL PLOT POS
12	21	1971	80.	1	1980	1610.	10.00
12	27	1972	397.	2	1991	1310.	20.00
2	16	1980	1610.	3	1981	850.	30.00
3	1	1981	850.	4	1973	397.	40.00
4	11	1982	208.	5	1988	232.	50.00
4	19	1988	232.	6	1982	208.	60.00
12	20	1989	95.	7	1990	95.	70.00
2	16	1990	53.	8	1972	80.	80.00
3	18	1991	1310.	9	1990	53.	90.00

-OUTLIER TESTS -

LOW OUTLIER TEST

BASED ON 9 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 1.977

0 LOW OUTLIER(S) IDENTIFIED BELOW TEST VALUE OF 24.6

HIGH OUTLIER TEST

BASED ON 9 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 1.977

0 HIGH OUTLIER(S) IDENTIFIED ABOVE TEST VALUE OF 3388.

-SKEW WEIGHTING -

BASED ON 9 EVENTS, MEAN-SQUARE ERROR OF STATION SKEW = .526
DEFAULT OR INPUT MEAN-SQUARE ERROR OF GENERALIZED SKEW = .302

FINAL RESULTS

-FREQUENCY CURVE- USGS STATION 11120530

COMPUTED CURVE FLOW IN CFS	EXPECTED PROBABILITY FLOW IN CFS	PERCENT CHANCE EXCEEDANCE	CONFIDENCE LIMITS .05 FLOW IN CFS	CONFIDENCE LIMITS .95 FLOW IN CFS
8950.	39000.	.2	115000.	2810.
6350.	18600.	.5	65500.	2170.
4780.	10900.	1.0	41000.	1740.
3480.	6400.	2.0	24500.	1370.
2160.	3130.	5.0	11300.	935.
1400.	1760.	10.0	5730.	656.
828.	928.	20.0	2560.	412.
295.	295.	50.0	626.	140.
102.	90.	80.0	204.	33.
58.	45.	90.0	124.	14.
36.	24.	95.0	84.	7.
15.	5.	99.0	42.	2.

SYSTEMATIC STATISTICS

LOG TRANSFORM: FLOW, CFS		NUMBER OF EVENTS	
MEAN	2.4601	HISTORIC EVENTS	0
STANDARD DEV	.5411	HIGH OUTLIERS	0
COMPUTED SKEW	.1207	LOW OUTLIERS	0
REGIONAL SKEW	-.2000	ZERO OR MISSING	0
ADOPTED SKEW	-.1000	SYSTEMATIC EVENTS	9

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+ END OF RUN           +
+ NORMAL STOP IN FFA   +
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REPORT LOG

W.O. No.	Date	Title
3772	Dec-74	Santa Barbara Municipal Airport Taxiway Improvements ADAP Project No. 8-06-0235-04 Drainage System, Study and Design
4830	Apr-78	Santa Barbara Municipal Airport ADAP Project No. 6-06-0235-05 Drainage System, Study and Design
5392	Dec-79	Engineer's Report Santa Barbara Municipal Airport FAA ADAP Project No. 6-06-0235-06 For the Installation of Drainage Facilities
10930.01	11/21/95	Santa Barbara Airport Masterplan Flooding Impacts and Mitigation Measures Technical Report
	Jun-68	Goleta Watershed Report
	Apr-90	General Reevaluation Report and Environmental Assessment, Including Technical Report US Corps of Engineers
	6/20/68	Interim Report on Survey for Flood Control, Goleta California and Vicinity US Corps of Engineers
	5/9/69	1969 Floods S.B. County Flood Control and Water Conservation District
		1995 Floods S.B. County Flood Control and Water Conservation District
		1998 Floods S.B. County Flood Control and Water Conservation District
		1990 Precipitation Report

S.B. County Flood Control and Water Conservation District

Stubchaer Residence	3
Stubchaer Residence	8
Cater Treatment Plant	21

1996 Precipitation Report
S.B. County Flood Control and Water Conservation District

Wood Residence	13
Santa Barbara Road Yard	23
Santa Barbara Flood Control Office	32
San Marcos Trout Club	26

Annual Discharge Series for the following Stations:	years
Atascadero Creek at Puente	8
Maria Ygnacio Creek at University Drive	25
Atascadero Creek at Patterson ?	55
San Jose Creek	56
San Jose Creek	22
San Pedro Creek	2
Tecolotito Creek	9

Precipitation (15 minute, 1 hr)

San Marco Pass	27
Santa Barbara	27

PLAN LOG

Work Order Number	Date	No. Sheets	Material (ie paper, vellum, mylar)	Description (ie Taxiway J Drainage)
	2/14/67	1	mylar	Runway extensions topo 1"=100' (Mark Hurd)
	5/1/67	1	paper	Cameros Creek relocation plan & profile & sections
	5/1/67	1	paper	Runway extension grading & drainage plan
	5/1/67	1	paper	Runway extension plan & profile & sections
2508		1	paper	Tecolotito Creek Channel plan & profile & sections (Corps of Eng)
4830	12/29/78	1	mylar	Grading & drainage plan as-built
4830	12/29/78	1	mylar	Storm drain structures as-built
4830	12/29/78	3	mylar	Runway 7-25 plan & profile as-built
4830	12/29/78	1	vellum	Runway 7-25 sections & details as-built
4830	12/29/78	1	mylar	Terminal Apron plan & details as-built
4830	12/29/78	1	mylar	Terminal Apron sections & details as-built
4830	12/29/78	1	mylar	Terminal Road plan & profile as-built
4830	12/29/78	1	vellum	Terminal Road sections & details as-built
4830	12/29/78	1	vellum	Terminal Road miscellaneous details as-built
4830	12/29/78	1	mylar	Soil borings & logs as-built
5390	4/1/79	1	mylar	Project sketch for pre-app. for ADAP funds
5391	10/7/79	1	mylar	Storm drain topo 1" = 50'
5393	6/26/80	1	mylar	Topo 1" = 50'
	2/27/81	1	paper	Airport layout plan
5392	4/28/82	4	mylar	Grading & drainage plan as-built
5392	4/28/82	1	mylar	Storm drain "D" & "D-1" as-built
5392	4/28/82	1	mylar	Storm drain "D" structures as-built
5392	4/28/82	1	mylar	Storm drain structures & miscellaneous details as-built
5392	4/28/82	1	vellum	Storm drain "D" as-built
5392	4/28/82	1	vellum	Storm drain "D" & "F" as-built
5645		1	mylar	Runway 33-L topo 1"=50'
5645		1	mylar	Airport topo
6409	10/8/82	2	paper	Taxiway "B" storm drain
6409	10/8/82	2	paper	Taxiway "B" grading plan
6409	10/8/82	2	paper	Taxiway "B" plan & profile
6409	10/8/82	1	paper	Soil borings
6638		1	sepia	Topo
6638	8/16/83	1	paper	Taxiway "H" storm drain "A"
6638	8/16/83	1	paper	Taxiway "H' storm drain "A" & "B"
6638	8/16/83	4	paper	Taxiway "H" grading plan
6638	8/16/83	1	paper	Taxiway "J" & Exit Taxiway grading plan
6638	8/16/83	4	paper	Taxiway "H" plan & profile
6638	8/16/83	1	paper	Taxiway "J" & Exit Taxiway plan & profile
6638	8/16/83	1	paper	Taxiway "J" plan & profile
6638	8/16/83	2	paper	Taxiway "H" & "J" & Exit Taxiway soil borings
7123	7/25/84	8	mylar	Topo?
7123	9/14/84	3	mylar	David Love Place plan & profile
7123	9/14/84	1	mylar	Botello Place plan & profile
7123	9/14/84	1	mylar	Lopez Road & water line "B" plan & profile
7123	9/14/84	1	mylar	12" water line "C" plan & profile
7123	9/14/84	2	mylar	12" water line "A" & storm drain plan & profile
7123	9/14/84	1	mylar	12" water line "A" plan & profile
7123	9/14/84	1	mylar	Storm drain plan & profile
7123	9/14/84	2	mylar	La Patera Lane plan & profile

ATTACHMENT C

Calculations

South Coast Watershed Map

Cieneguitas Ck Name	Area acres	Atascadero Ck Name	Area acres	Hospital Ck Name	Area acres	San Antonio Ck Name	Area acres	Maria Ygnacio Ck Name	Area acres
CI-1	473	AT-1	459	HO-1	165	SA-1	3,040	MY-1	2,617
CI-2	181	AT-2	184	HO-2	178	SA-2	190	MY-2	1,122
CI-3	186	AT-3	186	HO-3	174			MY-3	320
CI-4	500	AT-4	1,161	HO-4	83			MY-4	180
		AT-5	214	HO-5	300				
		AT-6	296						
		AT-7	702						
Total	1,340		3,202		900		3,230		4,239

San Jose Ck Name	Area acres	Las Vegas Ck Name	Area acres	San Pedro Ck Name	Area acres	Carneros Ck Name	Area acres	Glen Annie (Tecolotito) Ck Name	Area acres
SJ-1	3,568	LV-1	652	SP-1	2,505	CA-1	2,031	GA-1	2,651
SJ-2	625	LV-2	196	SP-2	225	CA-2	152	GA-2	619
SJ-3	276	LV-3	358			CA-3	230	GA-3	588
SJ-4	138	LV-4	156			CA-4	26	GA-4	1,256
SJ-5	108	LV-5	211			CA-5	228		
SJ-6	422	LV-6	252						
SJ-7	366								
	5,503		1,825		2,730		2,667		5,114

Total East of Ward Memorial = 12,911 acres
Total West of Ward Memorial = 17,839 acres

Total to Ocean = 30,750 acres = 48.05 square miles

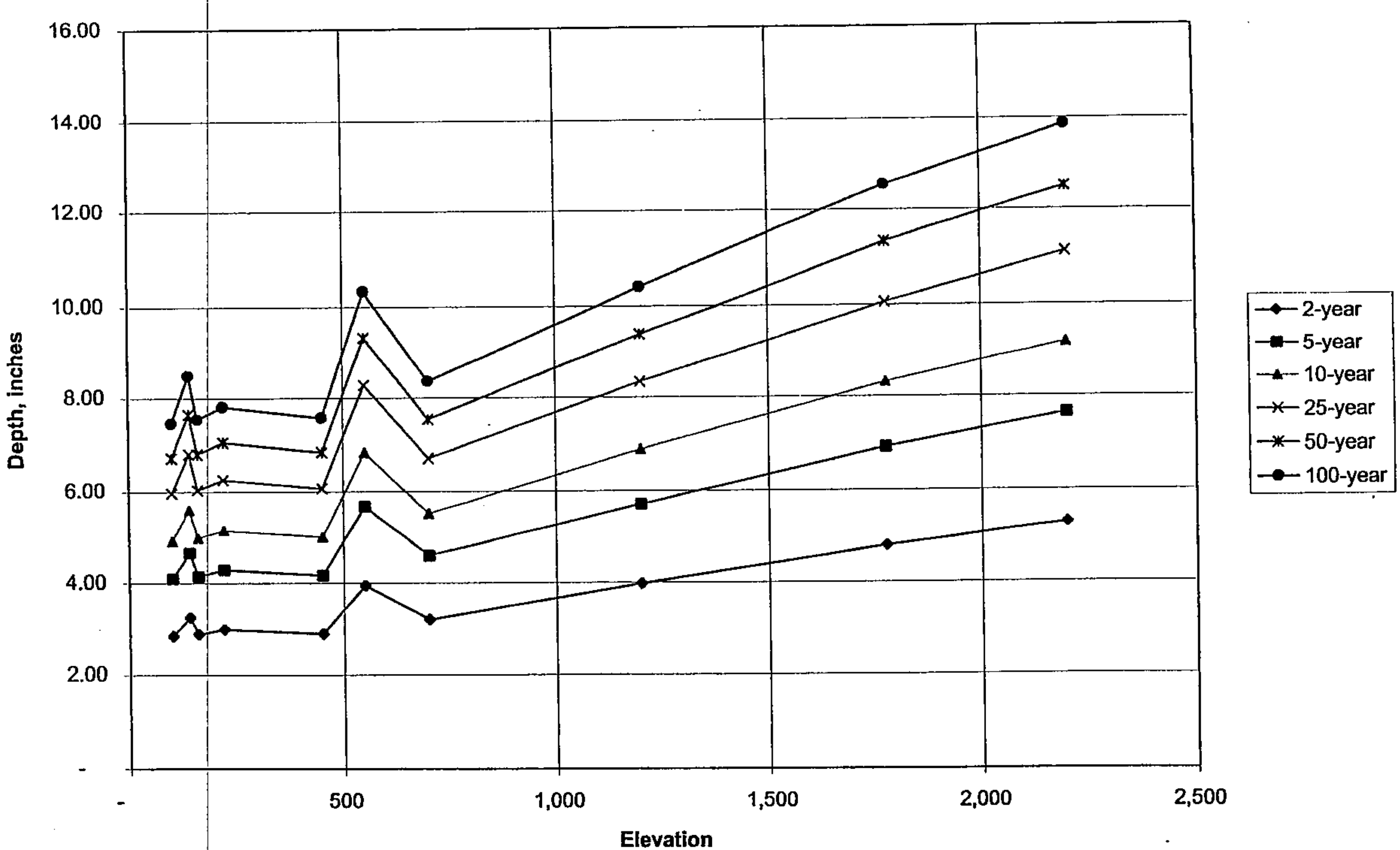
WATERSHED SUMMARY

Watershed Designation	Area		Length		Elevation Range		Elevation Difference	Average Slope	
	acres	sm	ft	Miles	High ft	Low ft	ft	percent	ft/mi
Tecolotito Creek	3,470	5.42	31,000	5.87	3,025	9	3,016	9.73%	514
Carneros Creek	2,740	4.28	28,000	5.30	2,900	9	2,891	10.33%	545
San Pedro/Las Vegas	4,400	6.88	28,000	5.30	2,840	14	2,826	10.09%	533
San Jose	5,330	8.33	43,000	8.14	3,025	35	2,990	6.95%	367
Maria Ygnacio/San Antonio	7,720	12.06	33,000	6.25	3,300	27	3,273	9.92%	524
Upper Atascadero	4,770	7.45	26,000	4.92	1,000	27	973	3.74%	198
Lower Atascadero	620	0.97	6400	1.21	27	0	27	0.42%	22
Goleta Slough	1,830	2.86	7400	1.40	9	5	4	0.05%	3
Total	30,880								

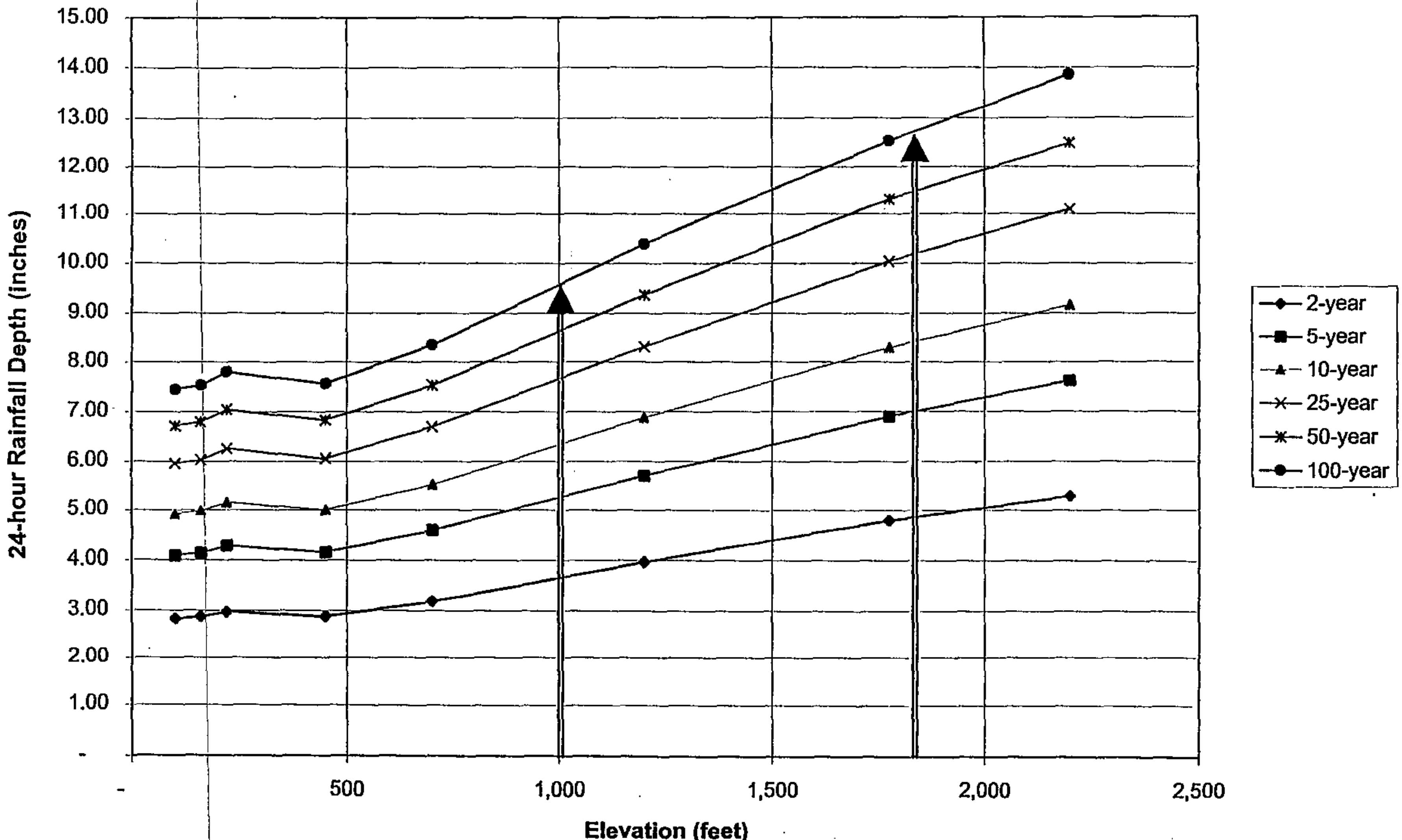
PRECIPITATION STATIONS

Station Number	Station Name	Elevation	Begin Water Year	End Water Year	No. of Years
199	Wood Residence	450	1985	1999	15
200	UCSB		1998	1999	2
210	Cold Springs Basin	550	1965	1999	35
211	Santa Barbara County Road Yard	220	1962	1999	38
228	Stanwood Fire Station	700	1954	1999	46
262	Tajiguas Landfill	140	1974	1999	26
308	Dos Pueblos Ranch	160	1947	1999	53
340	Doulton Tunnel	1,775	1926	1999	74
341	Santa Barbara - Downtown FCD Office	100	1963	2000	38
390	San Marcos Pass	2,200	1955	2000	46
395	Trout Club	1,200	1951	1999	49

Review of all Rain Gages



All Gages but Cold Springs and Tajiguas



Station Analysis

Return Period	199	210	211	228	262	308	340	341	390	395
	24-hour Depth									
2	2.89	3.94	2.98	3.19	3.24	2.88	4.79	2.84	5.29	3.97
5	4.16	5.67	4.29	4.59	4.66	4.14	6.90	4.09	7.62	5.71
10	5.01	6.83	5.16	5.53	5.61	4.99	8.30	4.92	9.17	6.88
25	6.06	8.26	6.25	6.69	6.79	6.03	10.04	5.96	11.09	8.32
50	6.83	9.31	7.04	7.53	7.64	6.79	11.31	6.71	12.49	9.37
100	7.56	10.31	7.80	8.35	8.47	7.53	12.54	7.44	13.85	10.39
Elevation	450	550	220	700	140	160	1775	100	2200	1200
Years	15	35	38	46	26	53	74	38	46	49
Within Watershed?	no	no	yes	no	no	no	no	no	yes	yes
Placement within Watershed?	lower	middle	lower/middle	middle	lower/middle	lower/middle	upper	lower	upper	middle/upper

Correlation with Elevation

Station	Elevation	2	5	10	25	50	100
341	100	2.84	4.09	4.92	5.96	6.71	7.44
262	140	3.24	4.66	5.61	6.79	7.64	8.47
308	160	2.88	4.14	4.99	6.03	6.79	7.53
211	220	2.98	4.29	5.16	6.25	7.04	7.80
199	450	2.89	4.16	5.01	6.06	6.83	7.56
210	550	3.94	5.67	6.83	8.26	9.31	10.31
228	700	3.19	4.59	5.53	6.69	7.53	8.35
395	1,200	3.97	5.71	6.88	8.32	9.37	10.39
340	1,775	4.79	6.90	8.30	10.04	11.31	12.54
390	2,200	5.29	7.62	9.17	11.09	12.49	13.85

Leave out Stations 210 and 262

Station	Elevation	2	5	10	25	50	100
341	100	2.84	4.09	4.92	5.96	6.71	7.44
308	160	2.88	4.14	4.99	6.03	6.79	7.53
211	220	2.98	4.29	5.16	6.25	7.04	7.80
199	450	2.89	4.16	5.01	6.06	6.83	7.56
228	700	3.19	4.59	5.53	6.69	7.53	8.35
395	1,200	3.97	5.71	6.88	8.32	9.37	10.39
340	1,775	4.79	6.90	8.30	10.04	11.31	12.54
390	2,200	5.29	7.62	9.17	11.09	12.49	13.85

Good Correlation when Stations 210 and 262 are left out

Watershed/Elevation Relationships

Elevation Range	Watershed															
	Tecolotito		Carneros		San Pedro		San Jose		Maria Ygnacio		Upper Atascadero		Lower Atascadero		Goleta Slough	
	Area	Percent	Area	Percent	Area	Percent	Area	Percent	Area	Percent	Area	Percent	Area	Percent	Area	Percent
0-500	2,159	62%	1,603	59%	2,766	63%	1,806	34%	1,880	24%	4,398	92%	621	100%	1,828	100%
500-1500	755	22%	571	21%	841	19%	1,208	23%	2,200	29%	372	8%	-	0%	-	0%
1500+	550	16%	561	20%	794	18%	2,318	43%	3,638	47%	-	0%	-	0%	-	0%
Total	3,465		2,735		4,401		5,332		7,719		4,769		621		1,828	

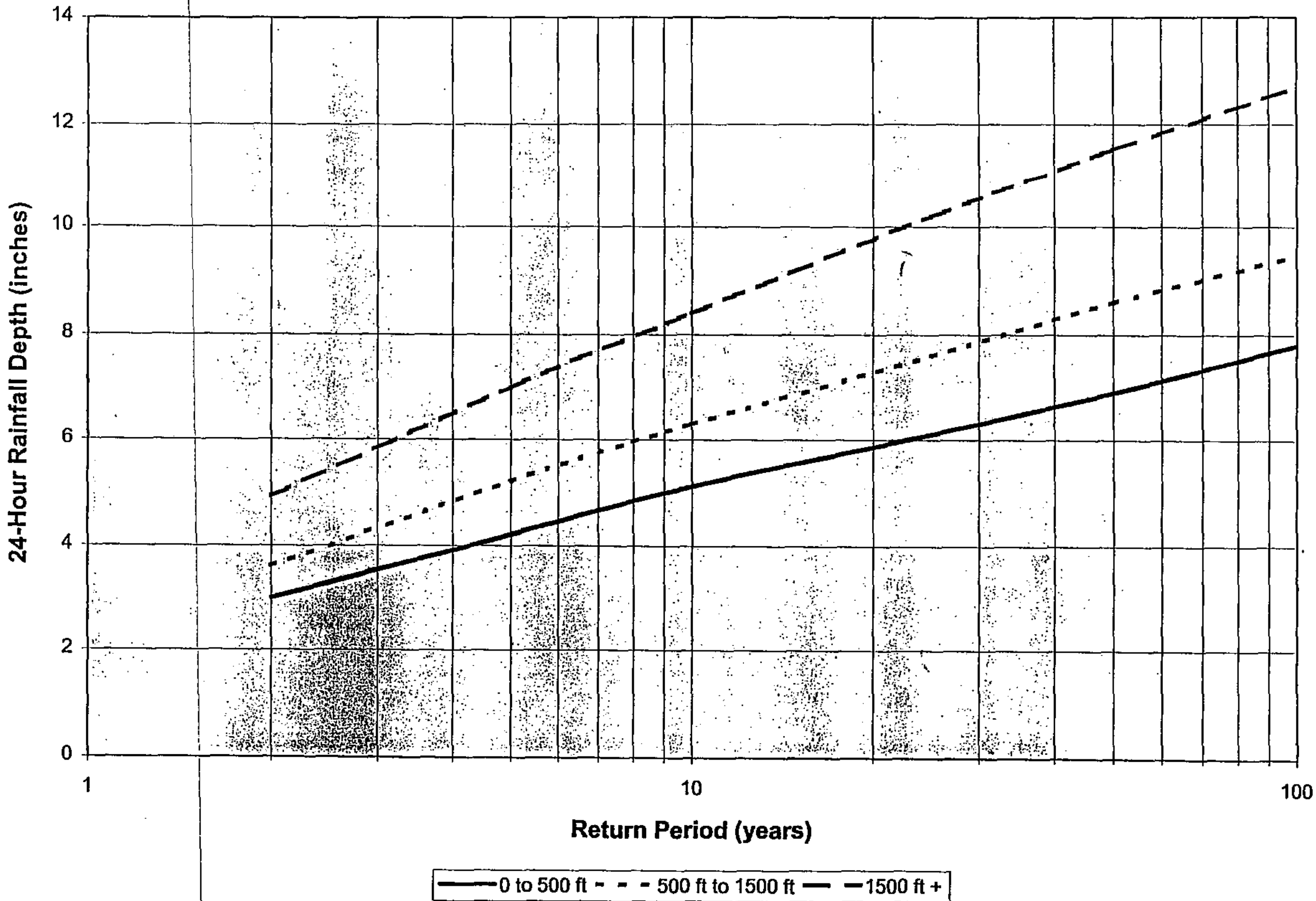
24-Hour Precipitation Factored for Elevation

Watershed	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
Tecolotito	3.43	4.86	5.89	7.08	8.00	8.94
Carneros	3.51	4.98	6.03	7.25	8.20	9.15
San Pedro	3.46	4.90	5.92	7.13	8.06	9.00
San Jose	3.96	5.64	6.81	8.22	9.28	10.30
Maria Ygnacio	4.07	5.80	7.00	8.46	9.55	10.58
Upper Atascadero	3.05	4.28	5.19	6.22	7.03	7.93
Lower Atascadero	3.00	4.20	5.10	6.10	6.90	7.80
Goleta Slough	3.00	4.20	5.10	6.10	6.90	7.80

Return Period		**Elevation**	
years	**0-500**	**500-1500**	**1500-**
2	3.0	3.6	4.9
5	4.2	5.2	7.0
10	5.1	6.3	8.4
25	6.1	7.6	10.2
50	6.9	8.6	11.5
100	7.8	9.5	12.7

RAINFALL DISTRIBUTION BY ELEVATION

Return Period years	Elevation 0-500	500-1500	1500-
2	3	3.6	4.9
5	4.2	5.2	7
10	5.1	6.3	8.4
25	6.1	7.6	10.2
50	6.9	8.6	11.5
100	7.8	9.45	12.7


14
12
10
8
6
4
2
0
24-Hour Rainfall Depth (inches)
1
10
100
Return Period (years)
0 to 500 ft
500 ft to 1500 ft
1500 ft +

Percentage of Different Soil Types in Each Watershed

Watershed	%A	%B	%C	%D
Tecolotito	0	8.81	8.89	82.29
Carneros	0	8.28	6.89	84.83
San Pedro	0	21.17	2.24	76.59
San Jose	0	13.53	0	87.13
Maria Ygnacio	0.37	8.93	0	91.07
Upper Atascadero	0.2	15.94	7.92	76.14
Lower Atascadero	11.45	29.55	49.91	9.09
Goleta Slough	20.69	12.37	48.34	19.12

Land Development

Curve Numbers and Soil Types with Respect to Watersheds

Tecolotito	Soil Types									
Land Use	Type A		Type B		Type C		Type D		Total Area	CN x Area
	Area	CN	Area	CN	Area	CN	Area	CN		
Commercial	-	88	59	91	7	93	76	95	141	13,177
Residential 1 Acre Lots	-	50	-	67	-	78	-	84	-	-
Residential 1/4 Acre Lot	-	60	76	74	28	82	404	87	507	42,998
Chaparral	-	0	6	52	-	62	1,512	75	1,517	113,649
Grasslands	-	46	166	61	99	68	797	76	1,062	77,468
Total Area	-		306		134		2,789		3,228	247,291
Wt'd Curve Number										77

Carneros	Soil Types									
Land Use	Type A		Type B		Type C		Type D		Total Area	CN x Area
	Area	CN	Area	CN	Area	CN	Area	CN		
Commercial	-	88	11	91	72	93	85	95	168	15,772
Residential 1 Acre Lots	-	50	-	67	-	78	-	84	-	-
Residential 1/4 Acre Lot	-	60	66	74	54	82	319	87	440	37,111
Chaparral	-	0	52	52	-	62	1,380	75	1,432	106,192
Grasslands	-	46	99	61	63	68	535	76	697	51,004
Total Area	-		228		189		2,320		2,737	210,077
Wt'd Curve Number										77

San Pedro	Soil Types									
Land Use	Type A		Type B		Type C		Type D		Total Area	CN x Area
	Area	CN	Area	CN	Area	CN	Area	CN		
Commercial	-	88	159	91	87	93	23	95	270	24,798
Residential 1 Acre Lots	-	50	32	67	-	78	404	84	436	36,052
Residential 1/4 Acre Lot	-	60	502	74	10	82	346	87	858	68,109
Chaparral	-	0	82	52	-	62	1,945	75	2,027	150,165
Grasslands	-	46	120	61	4	68	668	76	792	58,336
Total Area	-		895		101		3,386		4,383	337,460
Wt'd Curve Number										77

San Jose	Soil Types									
Land Use	Type A		Type B		Type C		Type D		Total Area	CN x Area
	Area	CN	Area	CN	Area	CN	Area	CN		
Commercial	-	88	-	91	-	93	71	95	71	6,710
Residential 1 Acre Lots	-	50	-	67	-	78	-	84	-	-
Residential 1/4 Acre Lot	-	60	533	74	-	82	273	87	806	63,202
Chaparral	-	0	41	52	-	62	4,034	75	4,076	304,725
Grasslands	-	46	7	61	-	68	372	76	379	28,724
Total Area	-		581		-		4,751		5,332	403,361
Wt'd Curve Number										76

Maria Ygnacio	Soil Types									
Land Use	Type A		Type B		Type C		Type D		Total Area	CN x Area
	Area	CN	Area	CN	Area	CN	Area	CN		
Commercial	-	88	62	91	-	93	-	95	62	5,617
Residential 1 Acre Lots	25	50	116	67	4	78	758	84	902	72,947
Residential 1/4 Acre Lot	-	60	456	74	-	82	195	87	651	50,741
Chaparral	-	0	19	52	-	62	5,785	75	5,804	434,870
Grasslands	-	46	8	61	-	68	189	76	197	14,875
Total Area	25		661		4		6,927		7,617	579,049
Wt'd Curve Number										76

Upper Atascadero	Soil Types									
Land Use	**Type A**		**Type B**		**Type C**		**Type D**		**Total Area**	**CN x Area**
	Area	**CN**	**Area**	**CN**	**Area**	**CN**	**Area**	**CN**		
Commercial	-	88	-	91	-	93	-	95	-	-
Residential 1 Acre Lots	97	50	85	67	99	78	72	84	352	24,253
Residential 1/4 Acre Lot	-	60	676	74	279	82	-	87	955	72,929
Chaparral	-	0	-	52	-	62	-	75	-	-
Grasslands	-	46	22	61	-	68	-	76	22	1,342
Total Area	97		783		378		72		1,330	98,523
Wt'd Curve Number										74

Lower Atascadero	Soil Types									
Land Use	**Type A**		**Type B**		**Type C**		**Type D**		**Total Area**	**CN x Area**
	Area	**CN**	**Area**	**CN**	**Area**	**CN**	**Area**	**CN**		
Commercial	-	88	15	91	-	93	-	95	15	1,348
Residential 1 Acre Lots	68	50	169	67	297	78	72	84	606	43,936
Residential 1/4 Acre Lot	-	60	-	74	-	82	-	87	-	-
Chaparral	-	0	-	52	-	62	-	75	-	-
Grasslands	-	46	-	61	-	68	-	76	-	-
Total Area	68		184		297		72		621	45,284
Wt'd Curve Number										73

Goleta Slough	Soil Types									
Land Use	Type A		Type B		Type C		Type D		Total Area	CN x Area
	Area	CN	Area	CN	Area	CN	Area	CN		
Commercial	27	88	201	91	557	93	19	95	804	74,232
Residential 1 Acre Lots	272	50	1	67	182	78	131	84	587	38,908
Residential 1/4 Acre Lot	59	60	27	74	127	82	225	87	438	35,531
Chaparral	-	0	-	52	-	62	-	75	-	-
Grasslands	-	46	-	61	-	68	-	76	-	-
Total Area	358		230		866		375		1,828	148,672
Wt'd Curve Number										81

ESTIMATED TIME OF CONCENTRATIONS FOR SUB AREAS BASED ON SCS TR-55 METHOD

PROJECT NO.: 11024.01
DESCRIPTION: HYDROLOGY CALCULATIONS
CLIENT: CITY OF SANTA MARIA
WATERSHED: BETTERAVIA
PREPARED BY: CAS DATE: 20-Nov-00
FILE NAME: TCR.WQ2

PENFIELD & SMITH
P.O.BOX 98
SANTA BARBARA, CA 93102
(805) 963-9532

R/(Tc+R) = 0.5

SUBAREA NAME	SHEET FLOW					SHALLOW CONCENTRATED FLOW				CHANNEL FLOW								Total	
	MANS. N TABLE 3-1	FLOW LENGTH FT	P 2YR/24HR IN	LAND SLOPE FT/FT	TRAV. TIME HRS	FLOW LENGTH FT	WTRCOURSE SLOPE FT/FT	Vavg FIG 3-1 FPS	TRAV. TIME HRS	ESTIM'D Q CFS	BASE WIDTH FT	AVERAGE SIDE SLOPE HORIZ/VERT	CHANNEL SLOPE FT/FT	MANS. N	NORMAL VELOCITY FPS	FLOW LENGTH FT	TRAV. TIME HRS	TRAV. TIME HRS	R HRS
Tecolotito	0.15	300	3.50	0.150	0.17	1,500	0.200	7.2	0.06	1,000			0.096		12.00	27,000	0.63	0.85	0.85
Cameros	0.15	300	3.50	0.150	0.17	4,000	0.200	7.2	0.15	1,000			0.091		12.00	24,000	0.56	0.88	0.88
San Pedro	0.15	300	3.50	0.150	0.17	4,000	0.200	7.2	0.15	1,000			0.063		12.00	24,000	0.56	0.88	0.88
San Jose	0.15	300	3.50	0.150	0.17	2,000	0.170	6.7	0.08	1,500			0.074		12.00	38,000	0.88	1.13	1.13
Maria Ygnacio	0.15	300	3.50	0.150	0.17	2,500	0.300	8.8	0.08	1,000			0.038		10.00	36,000	1.00	1.25	1.25
Upper Atascadero	0.15	300	3.50	0.080	0.22	2,500	0.125	5.7	0.12	1,000			0.023		8.50	24,000	0.78	1.12	1.12
Lower Atascadero	0.15	300	3.50	0.010	0.50	5,000	0.015	2.0	0.70	2,500			0.010		4.50	5,000	0.31	1.51	1.51
Goleta Slough	0.15	300	3.50	0.005	0.65	2,000	0.010	2.0	0.27	3,000			0.003		3.00	8,000	0.74	1.67	1.67

ESTIMATE VOLUME

Project: Santa Barbara Airport Masterplan
Location: Goleta Slough

W.O. No.: 13594.01
Date: 7/5/00
Calc'd by: CAS

Method: Contour Slice using Average End Area

Earthwork or Water (E or W): w

Elevation	Difference	Area	Average Area	Volume	Volume	Cummulative Volume
	ft	sf	sf	cf	ac-ft	ac-ft
0		-				0
	5		3,652,908	18,264,538	419	
5		7,305,815				419
	5		22,090,561	110,452,805	2,536	
10		36,875,307				2,955
	5		45,119,140	225,595,700	5,179	
15		53,362,973				8,134

Project: Santa Barbara Airport Masterplan
Location: Carneros Creek at US101

W.O. No.: 13594.01
Date: 7/5/00
Calc'd by: CAS

Method: Contour Slice using Average End Area

Earthwork or Water (E or W): w

Elevation	Difference	Area	Average Area	Volume	Volume	Cummulative Volume
	ft	sf	sf	cf	ac-ft	ac-ft
18		-				0
	2		73,019	146,037	3	
20		146,037				3
	5		184,580	922,898	21	
25		223,122				25
	5		362,437	1,812,183	42	
30		501,751				66
	5		716,015	3,580,073	82	
35		930,278				148

Project: Santa Barbara Airport Masterplan
Location: Las Vegas @ US101

W.O. No.: 13594.01
Date: 7/5/00
Calc'd by: CAS

Method: Contour Slice using Average End Area

Earthwork or Water (E or W): w

Elevation	Difference	Area	Average Area	Volume	Volume	Cummulative Volume
	ft	sf	sf	cf	ac-ft	ac-ft
25.7		-				0
	3.3		233,394	770,202	18	
29		466,789				18

DISCHARGE CHECK

Return Period: 100 year

Watershed	Gaging Data Computed	Gaging Data Expected	Area, acres At Gage	Area, acres At CP	Adjusted Gaging Data Computed	Adjusted Gaging Data Expected	FEMA cfs	Loss Rate in	Impervious %	Peak Flow cfs
Tecolotito	4,780	10,900					4,600	0.1	15	4,392
Carneros							3,600	0.1	20	3,541
San Pedro							6,100	0.1	25	5,634
San Jose, upper	3,610	3,880								
San Jose, lower	4,580	5,560	3,844	5,332	7,306	8,869	5,300	0.1	15	7,190
Maria Ygnacio	4,070	4,780	4,059	4,239	4,888	5,741	8,000	2.5	5	8,841
Upper Atascadero							4,900	0.1	20	4,691
Lower Atascadero	12,900	14,100					13,500	0.1	15	13,464
Goleta Slough (out)										9,777
Goleta Slough (in)								0.1	20	21,804
To Ocean							23,000			22,657

Return Period: 50 year

Watershed	Gaging Data Computed	Gaging Data Expected	Area, acres At Gage	Area, acres At CP	Adjusted Gaging Data Computed	Adjusted Gaging Data Expected	FEMA cfs	Loss Rate in	Impervious %	Peak Flow cfs
Tecolotito	3,480	6,400					3,400	0.1	15	3,853
Carneros							2,800	0.1	20	3,117
San Pedro							4,700	0.1	25	4,961
San Jose, upper	2,860	3,030								
San Jose, lower	3,690	4,270	3,844	5,332	5,886	6,811	4,100	0.1	15	6,367
Maria Ygnacio	3,210	3,630	4,059	4,239	3,855	4,360	6,000	3.7	5	6,069
Upper Atascadero							3,800	0.1	20	4,049
Lower Atascadero	9,710	10,400					10,500	0.1	15	10,002
Goleta Slough (out)										9,080
Goleta Slough (in)								0.1	20	19,168
To Ocean							18,000			18,271

Return Period: 25 year

Watershed	Gaging Data Computed	Gaging Data Expected	Area, acres At Gage	Area, acres At CP	Adjusted Gaging Data Computed	Adjusted Gaging Data Expected	FEMA cfs	Loss Rate in	Impervious %	Peak Flow cfs
Tecolotito										
Carneros							2,400	2.5	15	2,518
San Pedro							2,000	2.5	20	2,114
San Jose, upper							3,500	2.5	25	3,399
San Jose, lower			3,844	5,332	-	-				
Maria Ygnacio			4,059	4,239	-	-	4,100	2.5	15	4,419
Upper Atascadero							4,300	3.7	5	3,953
Lower Atascadero							4,800	2.5	20	2,307
Goleta Slough (out)							7,700	2.5	15	6,219
Goleta Slough (in)										5,845
To Ocean								2.5	20	12,750
							13,000			11,344

Return Period: 10 year

Watershed	Gaging Data Computed	Gaging Data Expected	Area, acres At Gage	Area, acres At CP	Adjusted Gaging Data Computed	Adjusted Gaging Data Expected	FEMA cfs	Loss Rate in	Impervious %	Peak Flow cfs
Tecolotito	1,400	1,760								
Carneros							1,400	2.8	15	1,489
San Pedro							900	2.8	20	1,311
San Jose, upper	1,420	1,460					2,200	2.8	25	2,139
San Jose, lower	1,960	2,080	3,844	5,332	3,127	3,318				
Maria Ygnacio	1,570	1,650	4,059	4,239	1,886	1,982	1,700	2.8	15	2,828
Upper Atascadero							2,400	3.7	5	2,363
Lower Atascadero	4,210	4,340					3,100	2.5	20	1,372
Goleta Slough (out)							4,600	2.5	15	3,689
Goleta Slough (in)										4,297
To Ocean								2.8	20	7,814
							7,700			7,777

Return Period: 5 year

Watershed	Gaging Data Computed	Gaging Data Expected	Area, acres At Gage	Area, acres At CP	Adjusted Gaging Data Computed	Adjusted Gaging Data Expected	FEMA cfs	Loss Rate in	Impervious %	Peak Flow cfs
Tecolotito	828	928						2.5	15	995
Carneros								2.5	20	909
San Pedro								2.5	25	1,518
San Jose, upper	930	943								
San Jose, lower	1,340	1,380	3,844	5,332	2,138	2,201		2.3	15	2,189
Maria Ygnacio	1,010	1,040	4,059	4,239	1,213	1,249		3.4	5	1,299
Upper Atascadero								1.7	20	1,391
Lower Atascadero	2,570	2,610						1.7	15	2,594
Goleta Slough (out)										3,797
Goleta Slough (in)								2.5	20	5,720
To Ocean										6,319

Return Period: 2 year

Watershed	Gaging Data Computed	Gaging Data Expected	Area, acres At Gage	Area, acres At CP	Adjusted Gaging Data Computed	Adjusted Gaging Data Expected	FEMA cfs	Loss Rate in	Impervious %	Peak Flow cfs
Tecolotito	295	295						2.5	15	288
Carneros								2.5	20	309
San Pedro								2.5	25	608
San Jose, upper	390	390								
San Jose, lower	629	629	3,844	5,332	1,003	1,003		1.9	15	1,093
Maria Ygnacio	416	416	4,059	4,239	500	500		2.7	5	460
Upper Atascadero								1.7	20	601
Lower Atascadero	951	951						1.7	15	997
Goleta Slough (out)										1,649
Goleta Slough (in)								2.5	20	2,322
To Ocean										2,602

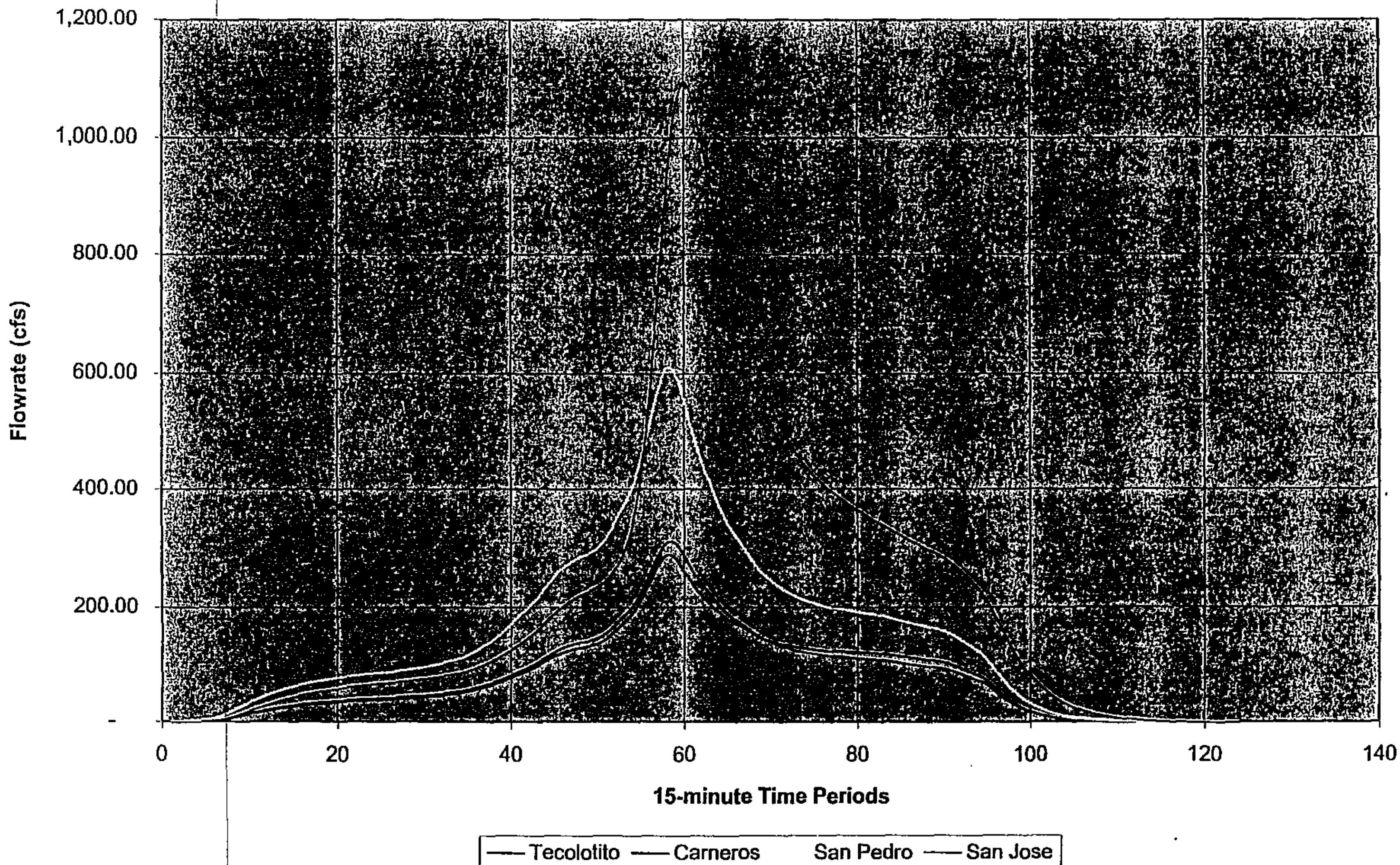
VERIFICATION TABLE

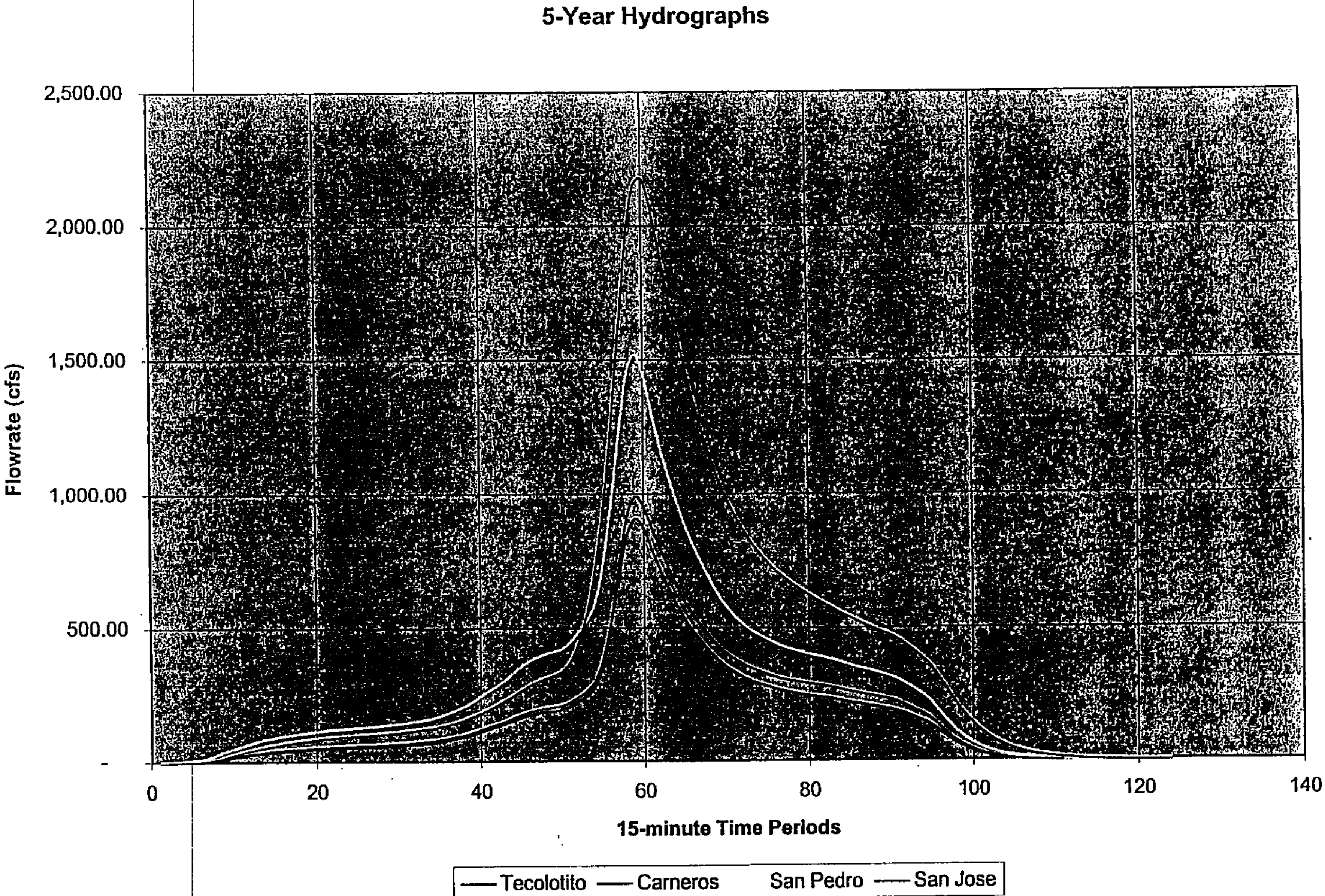
Location	Estimated Peak Flow Rates as a Percent of Gauging Data							
	2-yr	5-yr	10-yr		50-yr		100-yr	
	Computed Probability	Computed Probability	Computed Probability	FEMA	Computed Probability	FEMA	Computed Probability	FEMA
Tecolotito Creek	98%	120%	106%	106%	111%	113%	92%	95%
San Jose Creek*	109%	102%	90%	166%	108%	155%	98%	136%
Maria Ygnacio*	92%	107%	125%	98%	157%	101%	181%	111%
Atascadero (below confluence w/ Maria Ygnacio)	105%	101%	88%	80%	103%	95%	104%	100%

ATTACHMENT D

Hydrographs

2-Year Hydrographs





5-Year Hydrographs
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2,000.00
1,500.00
1,000.00
500.00
-
Flowrate (cfs)
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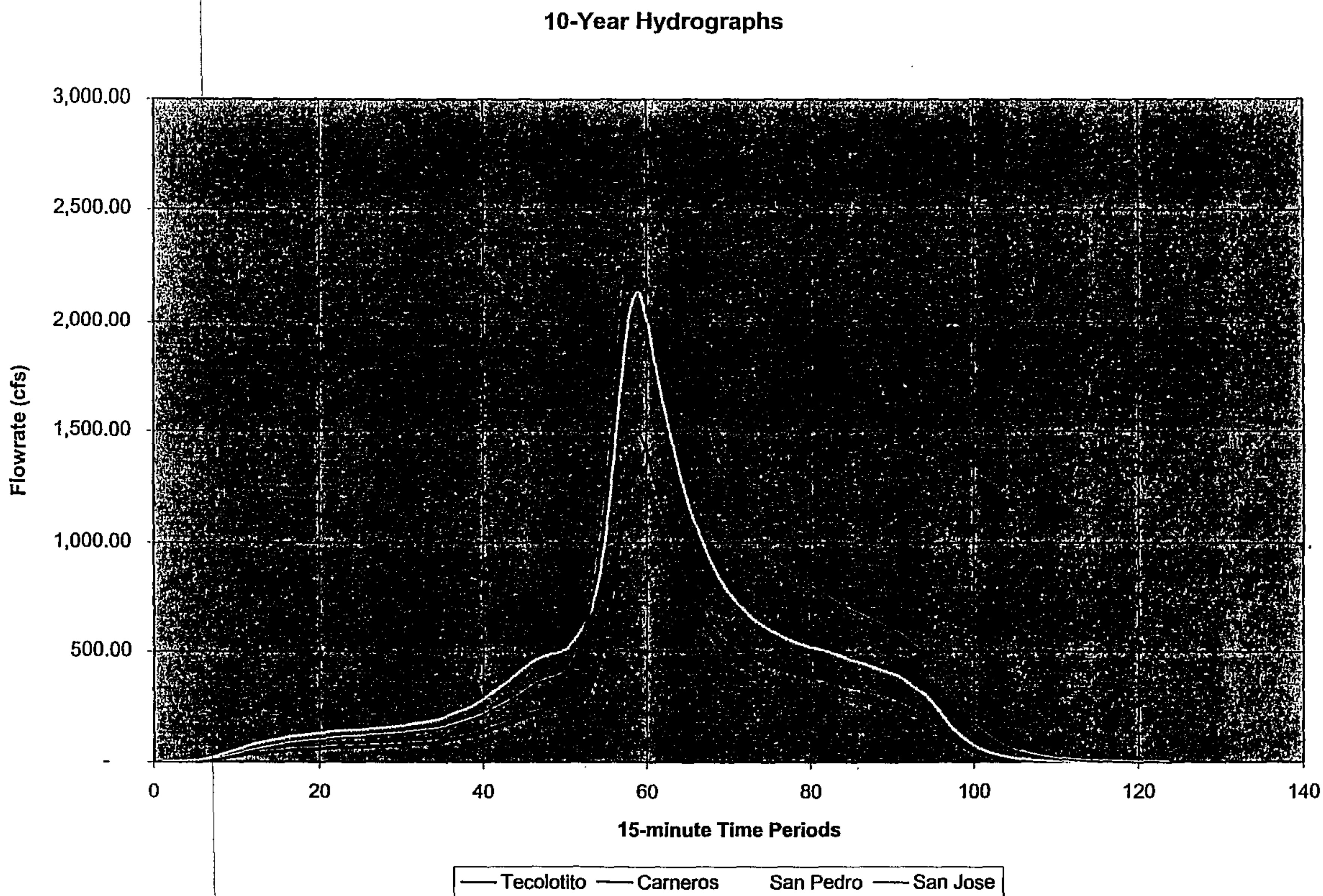
20
40
60
80
100
120
140
15-minute Time Periods
Tecolotito
Carneros
San Pedro
San Jose


10-Year Hydrographs
Flowrate (cfs)
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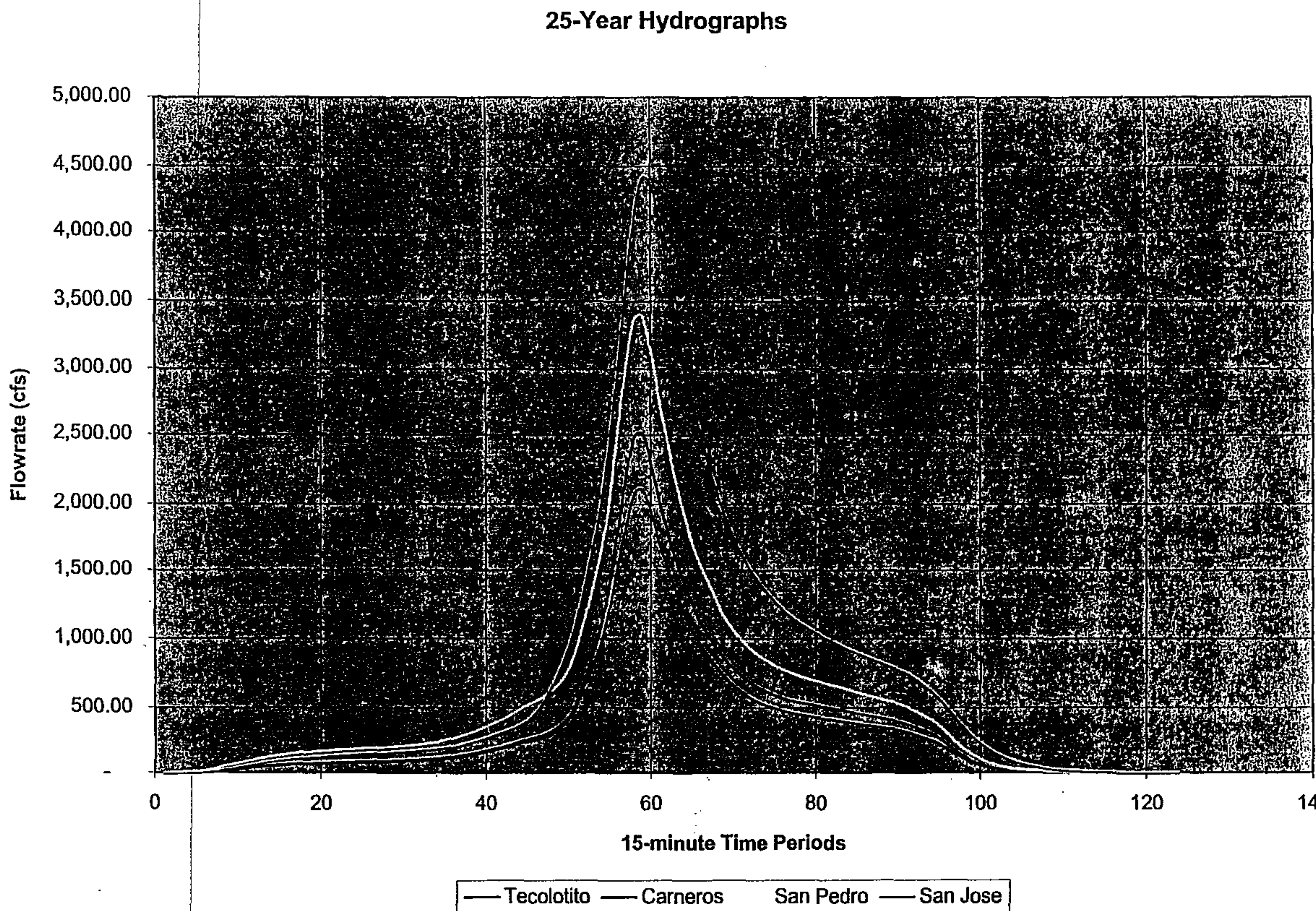
1,000.00
500.00
-
0
20
40
60
80
100
120
140
15-minute Time Periods
Tecolotito
Carneros
San Pedro
San Jose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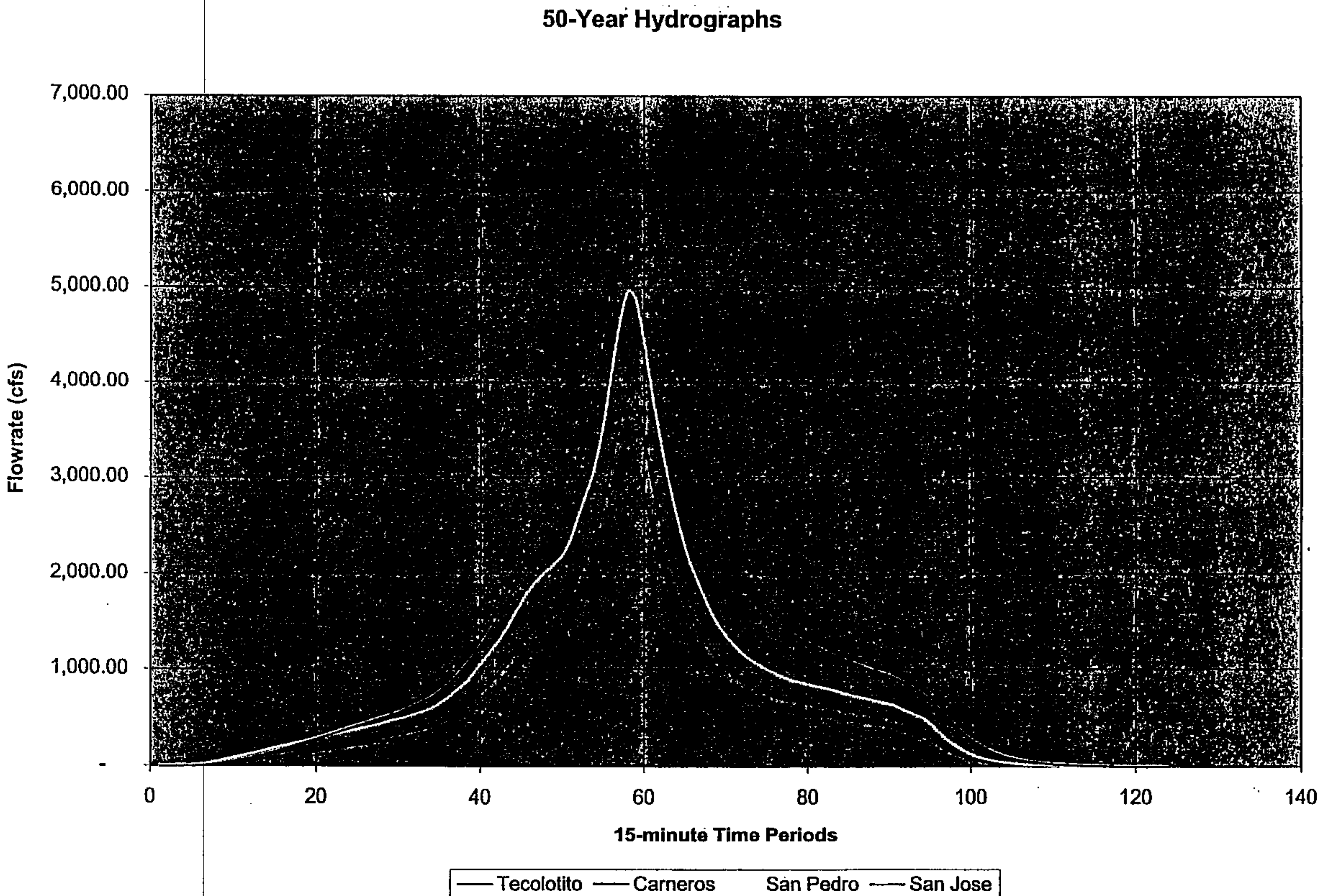
1,500.00
1,000.00
500.00
0
20
40
60
80
100
120
140
15-minute Time Periods
Tecolotito
Carneros
San Pedro
San Jose


50-Year Hydrographs
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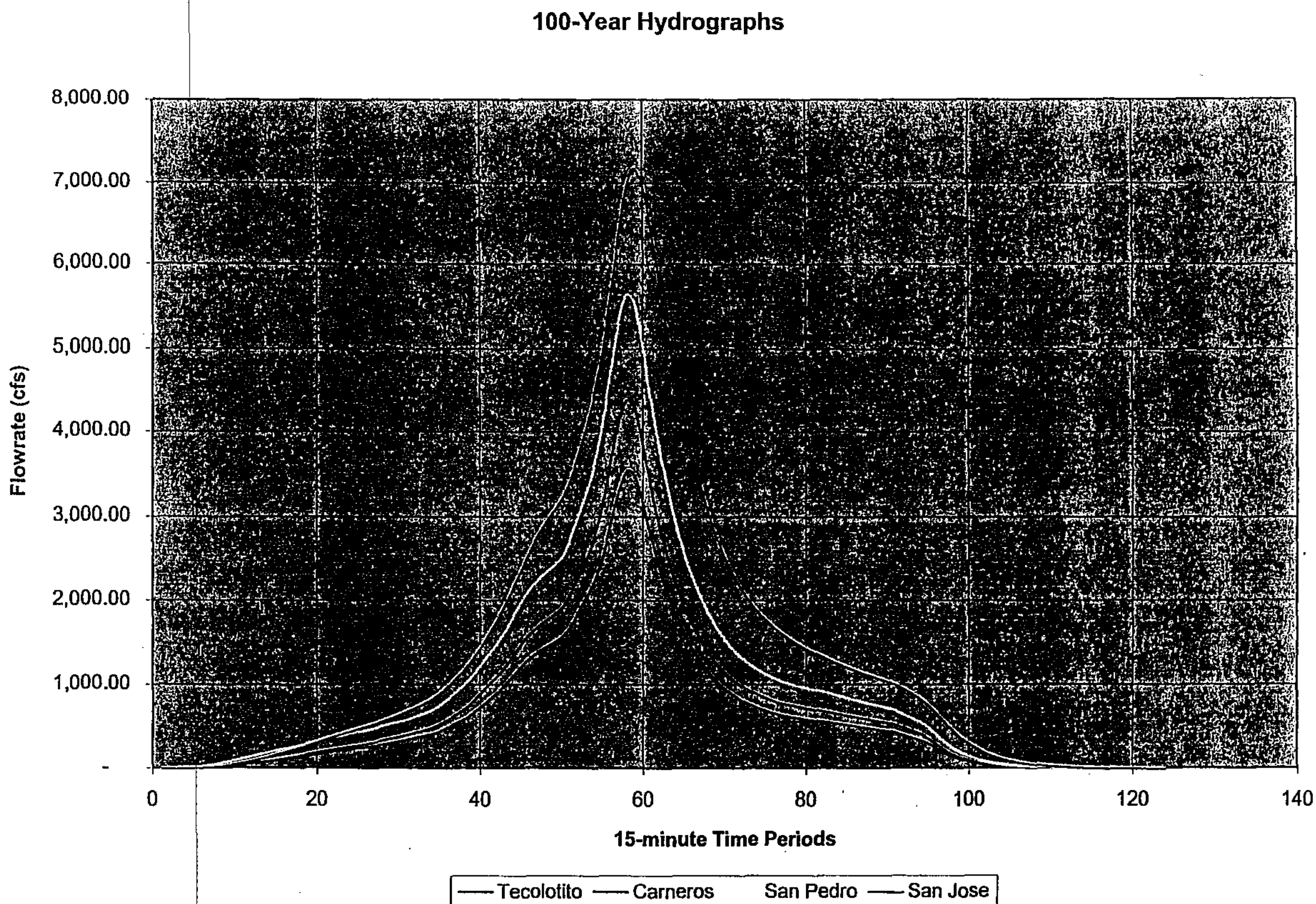
6,000.00
5,000.00
4,000.00
3,000.00
2,000.00
1,000.00
-
Flowrate (cfs)
0
20
40
60
80
100
120
140
15-minute Time Periods
Tecolotito
Carneros
San Pedro
San Jose


100-Year Hydrographs
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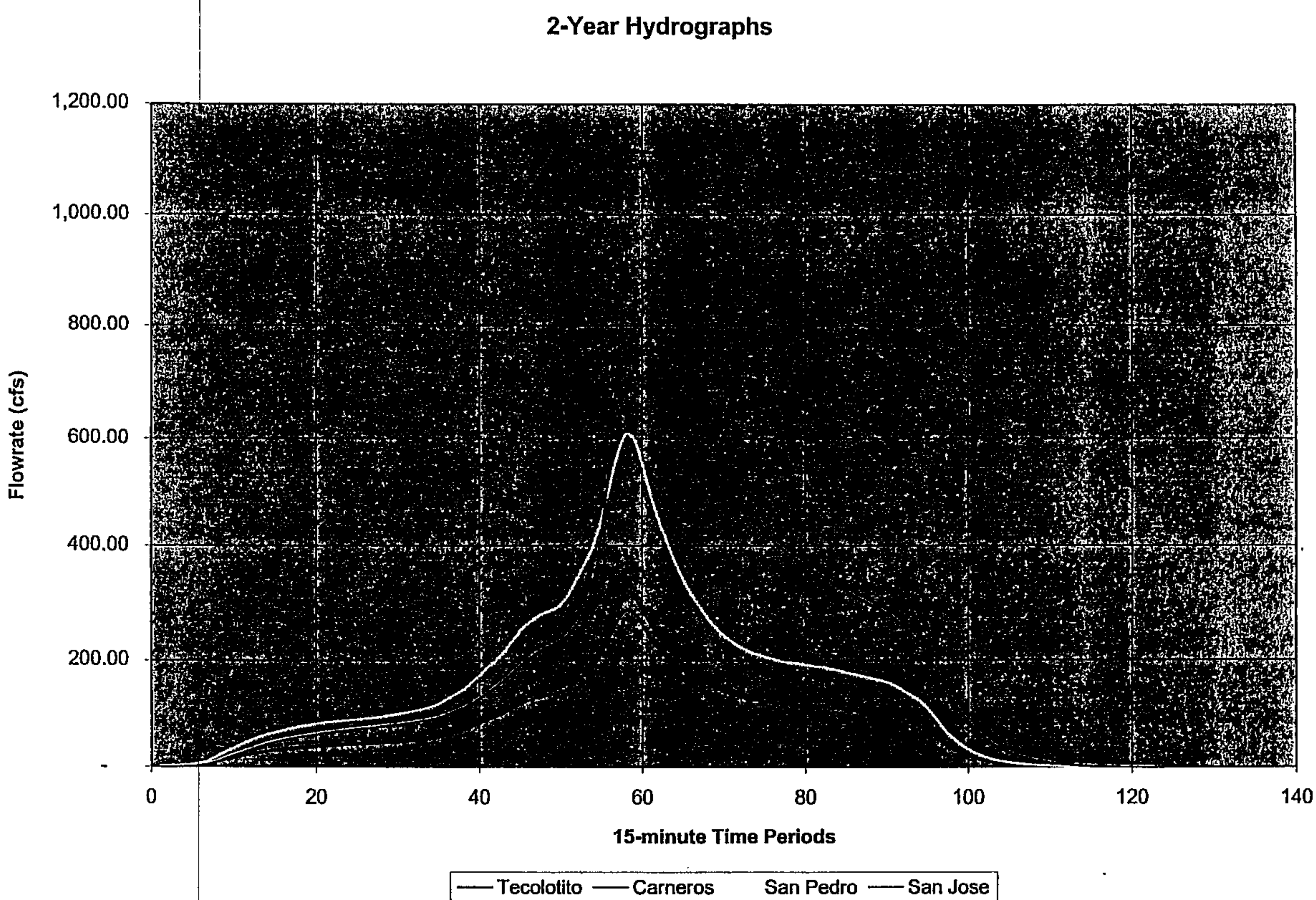
7,000.00
6,000.00
5,000.00
4,000.00
3,000.00
2,000.00
1,000.00
-
Flowrate (cfs)
0
20
40
60
80
100
120
140
15-minute Time Periods
Tecolotito
Carneros
San Pedro
San Jose


2-Year Hydrographs
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200.00
Flowrate (cfs)
0
20
40
60
80
100
120
140
15-minute Time Periods
Tecolotito
Carneros
San Pedro
San Jose

APPENDIX B

SWMM MODEL INPUT DATA

<u>Tables B-1 through B-8</u>
Catch Basin Inlet/Manhole Date for Storm Drainage, Networks 1-8

<u>Tables B-9 through B-16</u>
Drain Pipe Connectivity Data for Storm Drainage, Networks 1-8

Table B-1. Catch Basin Inlet/Manholes Data for Storm Drainage Network 1

Basin Inlet/ Manhole No	Ground Elevation(1) (feet)	Invert Elevation(1) (feet)	Drainage Area (acres)	
			Paved	Unpaved
1	8.48	6.13	2.20	3.91
2	8.13	5.33	0.80	2.08
3	8.10	4.90	0.60	1.95
4	8.00	5.80	1.73	1.87
5	9.23	4.43	0.94	0.94
6	7.66	4.36	0	0

1. All elevations are in feet with reference to 1988 NAVD Datum.

Table B-2. Catch Basin Inlet/Manholes Data for Storm Drainage Network 2

Basin Inlet/ Manhole No	Ground Elevation(1) (feet)	Invert Elevation(1) (feet)	Drainage Area (acres)	
			Paved	Unpaved
7	9.93	7.43	1.74	3.12
8	8.90	7.35	2.23	1.79
9	9.11	6.86	0.37	1.72
10	8.19	5.84	1.04	5.39
11	7.52	5.17	0.83	5.11
12	7.30	4.95	0.00	0.73
13	6.76	3.96	0	0

1. All elevations are in feet with reference to 1988 NAVD Datum.

Table B-3. Catch Basin Inlet/Manholes Data for Storm Drainage Network 3

Basin Inlet/ Manhole No	Ground Elevation(1) (feet)	Invert Elevation(1) (feet)	Drainage Area (acres)	
			Paved	Unpaved
14	8.88	6.58	1.45	2.30
15	8.92	6.07	1.45	2.30
16	8.97	4.57	0.74	1.97
17	8.45	6.05	1.30	1.78
18	8.55	4.56	0.65	3.62
19	8.04	4.54	0	0

1. All elevations are in feet with reference to 1988 NAVD Datum.

Table B-4. Catch Basin Inlet/Manholes Data for Storm Drainage Network 4

Basin Inlet/ Manhole No	Ground Elevation[1] (feet)	Invert Elevation[1] (feet)	Drainage Area (acres)	
			Paved	Unpaved
20	9.54	8.04	0.18	3.12
21	9.22	7.32	0.20	2.05
22	8.69	6.74	0.62	3.03
23	9.39	6.39	2.11	2.94
24	9.02	6.02	1.79	1.79
25	9.11	7.01	1.79	2.34
26	9.15	5.60	1.88	1.70
27	9.27	5.27	0.66	2.16
28	13.5	11.6	0.00	2.57
29	10.48	9.03	3.21	0.00
30	10.51	8.31	1.41	0.39
31	9.23	6.28	0.00	1.04
32	10.93	7.38	0.46	2.16
33	8.88	5.88	0.07	3.61
34	8.86	5.46	0.89	8.26
35	8.92	5.45	3.57	1.36
36	8.66	5.28	1.65	2.78
37	9.08	5.13	0.83	2.07
38	9.78	6.98	5.05	0.46
39	9.69	5.99	0.44	0.51
40	9.02	4.92	1.08	1.88
41	8.94	4.59	2.00	2.36
42	9.55	4.00	2.24	2.73
43	6.42	2.62	0	0
981	13.28	8.88	1.28	1.28
982	12.24	9.94	0.74	1.39
983	13.18	11.18	1.79	0.60
984	14.09	12.09	2.89	0.96
985	14.77	13.02	1.94	1.29

1. All elevations are in feet with reference to 1988 NAVD Datum.

Table B-5. Catch Basin Inlet/Manholes Data for Storm Drainage Network 5

Basin Inlet/ Manhole No	Ground Elevation[1] (feet)	Invert Elevation[1] (feet)	Drainage Area (acres)	
			Paved	Unpaved
44	10.03	8.28	1.79	1.65
45	11.07	6.97	0.83	0.55
46	10.94	9.69	0.56	0.82
47	8.76	6.71	0.53	0.13
48	7.93	6.63	0.52	0.72
49	8.30	6.20	0.39	0.18
50	9.13	8.29	1.18	0.00
51	8.63	6.13	3.67	0.14
52	8.06	6.66	1.01	1.06
53	8.83	6.03	2.75	0.14
54	8.19	6.44	0.64	0.73
55	8.96	5.96	2.75	0.15
56	7.90	6.55	0.64	0.78
57	9.95	9.20	1.10	0.05
58	8.89	5.49	0.70	0.16
59	7.99	5.89	0.62	0.85
60	10.13	9.48	0.73	0.05
61	8.90	5.20	0.99	0.18
62	7.94	5.64	0.91	0.87
63	8.97	4.42	0	0

1. All elevations are in feet with reference to 1988 NAVD Datum.

Table B-6. Catch Basin Inlet/Manholes Data for Storm Drainage Network 6

Basin Inlet/ Manhole No	Ground Elevation[1] (feet)	Invert Elevation[1] (feet)	Drainage Area (acres)	
			Paved	Unpaved
64	10.16	8.66	2.06	1.78
65	10.53	7.83	0.83	1.85
66	9.24	7.24	0.79	2.33
67	8.33	6.08	0.72	1.97
68	8.98	5.88	1.24	2.20
69	8.04	6.29	3.32	6.41
70	7.72	4.22	0	0

1. All elevations are in feet with reference to 1988 NAVD Datum.

Table B-7. Catch Basin Inlet/Manholes Data for Storm Drainage Network 7

Basin Inlet/ Manhole No	Ground Elevation(1) (feet)	Invert Elevation(1) (feet)	Drainage Area (acres)	
			Paved	Unpaved
71	13.15	11.25	2.86	0.00
72	11.88	9.98	2.90	0.00
73	10.94	9.69	0.90	4.96
74	10.81	7.96	1.80	0.48
75	11.40	7.85	1.23	1.62
76	11.01	6.96	8.93	7.78
77	11.01	6.96	1.08	5.05
78	9.54	6.04	0.68	3.31
79	9.47	5.42	1.54	2.23
80	11.51	5.41	0.55	0.62
81	5.14	2.64	0	0
82	8.94	6.54	1.84	3.04
83	8.94	6.54	0.90	6.43
84	8.88	5.98	1.84	2.75
85	8.86	5.31	1.82	2.96
86	8.91	5.11	1.56	2.93
87	9.90	6.35	1.29	1.12

1. All elevations are in feet with reference to 1988 NAVD Datum.

Table B-8. Catch Basin Inlet/Manholes Data for Storm Drainage Network 8

Basin Inlet/ Manhole No	Ground Elevation(1) (feet)	Invert Elevation(1) (feet)	Drainage Area (acres)	
			Paved	Unpaved
89	10.09	8.39	0.44	0.09
90	9.91	7.56	4.18	0.00
91	8.45	6.6	1.78	2.20
92	8.27	5.82	1.97	2.20
93	9.06	5.91	0.62	0.29
94	8.33	5.58	1.79	1.17
95	8.24	5.24	0.85	1.86
96	8.43	4.98	1.46	1.68
97	8.69	5.19	1.59	1.11
98	0.00	4.91	0	0

1. All elevations are in feet with reference to 1988 NAVD Datum.

Table B-9. Drain Pipe Connectivity Data for Storm Drainage Network 1

Pipe No	Pipe Inlet / Manhole No.		Diameter (inches)	Length (feet)	Pipe Type
	Upstream	Downstream			
101	1	2	15	300	ACP
102	2	3	15	300	ACP
103	4	3	15	300	ACP
104	3	5	24	260	ACP
105	5	6	24	125	ACP

Table B-10. Drain Pipe Connectivity Data for Storm Drainage Network 2

Pipe No	Pipe Inlet / Manhole No.		Diameter (inches)	Length (feet)	Pipe Type
	Upstream	Downstream			
106	8	9	15	175	RCP
107	7	9	15	400	RCP
108	9	10	18	600	RCP
109	10	11	18	500	RCP
110	11	12	18	500	RCP
111	12	13	24	50	RCP

Table B-11. Drain Pipe Connectivity Data for Storm Drainage Network 3

Pipe No	Pipe Inlet / Manhole No.		Diameter (inches)	Length (feet)	Pipe Type
	Upstream	Downstream			
112	14	15	15	300	ACP
113	15	16	15	290	ACP
114	17	16	15	310	ACP
115	16	18	24	450	CMP
116	18	19	24	116	CMP

Table B-12. Drain Pipe Connectivity Data for Storm Drainage Network 4

Pipe No	Pipe Inlet / Manhole No.		Diameter (inches)	Length (feet)	Pipe Type
	Upstream	Downstream			
117	20	21	18	300	RCP
118	21	22	18	340	RCP
119	22	23	18	275	RCP
120	23	24	24	425	RCP
121	24	26	24	350	ACP
122	25	26	15	425	ACP
123	26	27	30	460	ACP
124	28	29	12	300	CMP
125	29	30	18	280	RCP
126	32	31	24	220	RCP
127	30	31	18	175	RCP
128	31	33	24	300	RCP
129	33	34	24	300	RCP
130	34	35	30	200	ACP
131	35	36	30	310	ACP
132	36	27	30	380	ACP
133	27	37	36	290	ACP
134	37	40	36	300	RCP
135	38	39	18	150	ACP
136	39	40	18	210	ACP
137	40	41	36	385	RCP
138	41	42	24	910	RCP
139	42	43	46	135	ACP
190	981	32	24	325	RCP
191	982	981	18	156	CMP
192	983	982	18	254	SCSP
193	984	983	18	435	SCSP
194	985	984	18	363	SCSP

Table B-13. Drain Pipe Connectivity Data for Storm Drainage Network 5

Pipe No	Pipe Inlet / Manhole No.		Diameter (inches)	Length (feet)	Pipe Type
	Upstream	Downstream			
140	44	45	15	300	ACP
141	45	47	15	210	ACP
142	46	47	15	125	ACP
143	47	49	15	400	ACP
144	50	49	15	125	ACP
145	48	49	15	125	ACP
146	49	51	18	350	ACP
147	52	51	15	125	ACP
148	51	53	24	350	ACP
149	54	53	15	125	ACP
150	53	55	24	300	ACP
151	56	55	15	125	ACP
152	55	58	24	350	ACP
153	57	58	8	130	ACP
154	59	58	15	125	ACP
155	58	61	30	300	ACP
156	60	61	8	130	ACP
157	62	61	15	125	ACP
158	61	**63**	30	650	ACP

Table B-14. Drain Pipe Connectivity Data for Storm Drainage Network 6

Pipe No	Pipe Inlet / Manhole No.		Diameter (inches)	Length (feet)	Pipe Type
	Upstream	Downstream			
159	64	65	15	420	ACP
160	65	66	15	300	ACP
161	66	67	12	450	ACP
162	67	68	12	500	CMP
163	69	68	18	500	ACP
164	68	**70**	18	650	CMP

Table B-15. Drain Pipe Connectivity Data for Storm Drainage Network 7

Pipe No	Pipe Inlet / Manhole No.		Diameter (inches)	Length (feet)	Pipe Type
	Upstream	Downstream			
165	71	72	15	180	CMP
166	72	73	18	180	RCP
167	73	74	18	400	ACP
168	74	75	18	350	ACP
169	75	76	30	385	ACP
170	76	77	30	350	ACP
171	77	78	30	325	ACP
172	78	79	30	325	ACP
173	79	80	30	250	ACP
174	80	81	30	120	ACP
175	82	84	18	450	ACP
176	83	84	21	350	ACP
177	84	85	24	530	ACP
178	85	86	24	450	ACP
179	86	87	24	400	CMP
180	87	80	24	274	CMP

Table B-16. Drain Pipe Connectivity Data for Storm Drainage Network 8

Pipe No	Pipe Inlet / Manhole No.		Diameter (inches)	Length (feet)	Pipe Type
	Upstream	Downstream			
181	89	90	15	175	ACP
182	90	91	18	330	ACP
183	91	92	18	400	ACP
184	92	94	21	400	ACP
185	93	94	18	260	ACP
186	94	95	21	300	ACP
187	95	96	21	300	ACP
188	96	97	30	350	ACP
189	97	98	30	150	ACP

APPENDIX C

PRELIMINARY COST ESTIMATES FOR DRAINAGE IMPROVEMENTS

SEPTEMBER 2001

PRELIMINARY COST ESTIMATE
TABLE C-1
Firestone Channel Alternative 1
Santa Barbara Municipal Airport

Location: Santa Barbara Municipal Airport
Prepared By: AD

Item No	Description	Est Qty	Unit	Unit Price	Est Amt
1	Asphalt Pavement Saw Cutting - Assume 3" Thick	100	LF	$ 1.30	$ 130
2	Pavement Handling and Disposal - 30 mi rt	23	Tons	$ 117.00	$ 2,633
3	Subgrade Preparation	23	SY	$ 3.30	$ 74
4	Aggregate Base - 9" Compacted	23	SY	$ 9.00	$ 203
5	Asphalt Concrete Paving - Assume 3" Thick	23	SY	$ 40.00	$ 900
6	Channel Excavation	6,950	CY	$ 3.30	$ 22,934
7	Hauling - 30 mi rt	8,340	CY	$ 14.90	$ 124,259
8	Road Closure Signage	1	LS	$ 5,000.00	$ 5,000
9	Box Culvert - 4' by 28' - Precast	50	LF	$ 753.00	$ 37,650
10	CC Channel	607	CY	$ 269.00	$ 163,393
11	CC Channel Bedding - Compacted	400	SY	$ 9.00	$ 3,600

SUBTOTAL	$ 360,775
CONTINGENCIES - 30%	$ 108,232
DESIGN - 15%	$ 70,351
CONSTRUCTION MANAGEMENT - 10%	$ 46,901
ESTIMATED COST	**$ 586,300**

Assumptions/Notes:
1 No sheeting or dewatering will be required for the excavations.
2 Design and construction costs are based on "large scale" jobs. Bidding of individual small projects included in this estimate may result in higher costs.
3 Soil disposal costs are not included. It is assumed the soil will be placed in a stockpile, for use by others.

PRELIMINARY COST ESTIMATE
TABLE C-2
<u>Firestone Channel Alternative 2</u>
Santa Barbara Municipal Airport

Location: Santa Barbara Municipal Airport
Prepared By: AD

Item No	Description	Est Qty	Unit	Unit Price	Est Amt
1	Asphalt Pavement Saw Cutting - Assume 3" Thick	100	LF	$ 1.30	$ 130
2	Pavement Handling and Disposal - 30 mi rt	23	Tons	$ 117.00	$ 2,633
3	Subgrade Preparation	23	SY	$ 3.30	$ 74
4	Aggregate Base - 9" Compacted	23	SY	$ 9.00	$ 203
5	Asphalt Concrete Paving - Assume 3" Thick	23	SY	$ 40.00	$ 900
6	Temporary Road Closure Signage	1	LS	$ 5,000.00	$ 5,000
7	Box Culvert - 4' by 10' - Precast	50	LF	$ 462.00	$ 23,100
8	Bypass - 3 - 48 in RCP	1,800	LF	$ 124.00	$ 223,200
9	Bypass Excavation - No Dewatering	2,000	CY	$ 3.30	$ 6,600
10	Bypass Material Handling	2,400	CY	$ 3.40	$ 8,160
11	Bypass Backfill	2,000	CY	$ 2.00	$ 4,000
12	Bypass Bedding & Compaction	167	CY	$ 32.00	$ 5,333
13	Channel Excavation	7,809	CY	$ 3.30	$ 25,769
14	Hauling - 30 mi rt	9,371	CY	$ 14.90	$ 139,623

SUBTOTAL	$ 444,725
CONTINGENCIES - 30%	$ 133,417
DESIGN - 15%	$ 86,721
CONSTRUCTION MANAGEMENT - 10%	$ 57,814
ESTIMATED COST	**$ 722,700**

Assumptions/Notes:

1 No sheeting or dewatering will be required for the excavations.
2 Design and construction costs are based on "large scale" jobs. Bidding of individual small projects included in this estimate may result in higher costs.
3 Soil disposal costs are not included. It is assumed the soil will be placed in a stockpile, for use by others.

PRELIMINARY COST ESTIMATE
TABLE C-3
Firestone Channel Alternative 3
Santa Barbara Municipal Airport

Location: Santa Barbara Municipal Airport
Prepared By: AD

Item No	Description	Est Qty	Unit	Unit Price	Est Amt
1	Asphalt Pavement Saw Cutting - Assume 3" Thick	100	LF	$ 1.30	$ 130
2	Pavement Handling and Disposal - 30 mi rt	23	Tons	$ 117.00	$ 2,633
3	Subgrade Preparation	23	SY	$ 3.30	$ 74
4	Aggregate Base - 9" Compacted	23	SY	$ 9.00	$ 203
5	Asphalt Concrete Paving - Assume 3" Thick	23	SY	$ 40.00	$ 900
6	Temporary Road Closure Signage	1	LS	$ 5,000.00	$ 5,000
7	Box Culvert - 4' by 28' - Precast	50	LF	$ 753.00	$ 37,650
8	Channel Excavation	7,809	CY	$ 3.30	$ 25,769
9	Hauling - 30 mi rt	9,371	CY	$ 14.90	$ 139,623

SUBTOTAL	$ 211,982
CONTINGENCIES - 30%	$ 63,594
DESIGN - 15%	$ 41,336
CONSTRUCTION MANAGEMENT - 10%	$ 27,558
ESTIMATED COST	**$ 344,500**

Assumptions/Notes:

1 No sheeting or dewatering will be required for the excavations.
2 Design and construction costs are based on "large scale" jobs. Bidding of individual small projects included in this estimate may result in higher costs.
3 Soil disposal costs are not included. It is assumed the soil will be placed in a stockpile, for use by others.

PRELIMINARY COST ESTIMATE
TABLE C-4
Firestone Channel Alternative 4
Santa Barbara Municipal Airport

Location: Santa Barbara Municipal Airport
Prepared By: AD

Item No	Description	Est Qty	Unit	Unit Price	Est Amt
1	Asphalt Pavement Saw Cutting - Assume 3" Thick	100	LF	$ 1.30	$ 130
2	Pavement Handling and Disposal - 30 mi rt	23	Tons	$ 117.00	$ 2,633
3	Bridge Excavation	600	CY	$ 3.30	$ 1,980
4	Hauling - 2mi rt - onsite disposal	720	CY	$ 3.40	$ 2,448
5	Road Closure Signage	1	LS	$ 10,000.00	$ 10,000
6	Bridge	1,750	SF	$ 110.00	$ 192,500
7	Channel Excavation	7,809	CY	$ 3.30	$ 25,769
8	Hauling - 30 mi rt	9,371	CY	$ 14.90	$ 139,623

SUBTOTAL	$ 375,083
CONTINGENCIES - 30%	$ 112,525
DESIGN - 15%	$ 73,141
CONSTRUCTION MANAGEMENT - 10%	$ 48,761
ESTIMATED COST	**$ 609,600**

Assumptions/Notes:

1. No sheeting or dewatering will be required for the excavations.
2. Design and construction costs are based on "large scale" jobs. Bidding of individual small projects included in this estimate may result in higher costs.
3. Soil disposal costs are not included. It is assumed the soil will be placed in a stockpile, for use by others.

PRELIMINARY COST ESTIMATE
TABLE C-5
Firestone Channel Alternative 5
Santa Barbara Municipal Airport

Location: Santa Barbara Municipal Airport
Prepared By: AD

Item No	Description	Est Qty	Unit	Unit Price	Est Amt
1	Asphalt Pavement Saw Cutting - Assume 3" Thick	100	LF	$ 1.30	$ 130
2	Pavement Handling and Disposal - 30 mi rt	23	Tons	$ 117.00	$ 2,633
3	Subgrade Preparation	23	SY	$ 3.30	$ 74
4	Aggregate Base - 9" Compacted	23	SY	$ 9.00	$ 203
5	Asphalt Concrete Paving - Assume 3" Thick	23	SY	$ 40.00	$ 900
6	Temporary Road Closure Signage	1	LS	$ 5,000.00	$ 5,000
7	Box Culvert - 4' by 28' - Precast	50	LF	$ 753.00	$ 37,650
8	Channel Excavation	11,366	CY	$ 3.30	$ 37,508
9	Hauling - 30 mi rt	13,639	CY	$ 14.90	$ 203,223
10	CC Channel	2,080	CY	$ 269.00	$ 559,620
11	CC Channel Bedding - Compacted	1,370	SY	$ 9.00	$ 12,330

SUBTOTAL	$ 859,269
CONTINGENCIES - 30%	$ 257,781
DESIGN - 15%	$ 167,557
CONSTRUCTION MANAGEMENT - 10%	$ 111,705
ESTIMATED COST	**$ 1,396,400**

Assumptions/Notes:

1 No sheeting or dewatering will be required for the excavations.
2 Design and construction costs are based on "large scale" jobs. Bidding of individual small projects included in this estimate may result in higher costs.
3 Soil disposal costs are not included. It is assumed the soil will be placed in a stockpile, for use by others.

PRELIMINARY COST ESTIMATE
TABLE C-6
Las Vegas Creek Planning and Conceptual Designs
Santa Barbara Municipal Airport

Location: Santa Barbara Municipal Airport
Prepared By: GP

Item No	Description	Est Amt
1	**Planning**	
2	Las Vegas Creek Restoration Planning, Designs, Spec's	$ 105,000
3	San Pedro Creek Bank Rehabilitation Designs	$ 20,000
4	Bridge Plans and Spec's	$ 100,000
5	Prepare Environmental Doc's / Permit Applications	
	Construction	
6	Las Vegas Creek Restoration	$ 60,000
7	San Pedro Creek Bank Rehabilitation	$ 50,000
8	Pro Shop Bridge Replacement (Golf Course)	$ 60,000
9	Foot Bridges (2) within Golf Course	$ 100,000
10	Maintenance Vehicle Bridge (Golf Course)	$ 60,000

PREPARE ENVIRON. & CONSTRUCTION DOCUMENTS	$ 225,000
TOTAL CONSTRUCTION COSTS	$ 330,000
CONTINGENCIES ON CONSTRUCTION - 30%	$ 99,000
CONSTRUCTION MANAGEMENT - 10%	$ 33,000
ESTIMATED COST	**$ 687,000**

Assumptions/Notes:

1 Costs based on past projects with similar work requirements
2 Only gross costs estimated, not individual task details
3 Construction and management cost estimates are not based on specific designs.

PRELIMINARY COST ESTIMATE
TABLE C-7
Storm Drain Network 1
Santa Barbara Municipal Airport

Location: Santa Barbara Municipal Airport
Prepared By: AD

Item No	Description	Est Qty	Unit	Unit Price	Est Amt
1	Waste Handling and Disposal - 30 mi rt	20	TON	$ 117.00	$ 2,340
2	Pipe Removal 24"	125	LF	$ 10.00	$ 1,250
3	24" Storm Drain - RCP	125	LF	$ 39.00	$ 4,875
4	Excavation	70	CY	$ 5.00	$ 350
5	Hauling - 30 mi rt	28	CY	$ 14.90	$ 413
6	Trench Backfill	47	CY	$ 7.00	$ 328
7	Bedding	23	CY	$ 30.00	$ 693
8	Compaction - Trench Bedding and Backfill	70	CY	$ 4.30	$ 301
9	Plug and Grout Pipe #111 - 50lf, 24" RCP	1	LS	$ 2,500.00	$ 2,500
10	New Headwall - 24" Pipe	1	Ea.	$ 2,467.00	$ 2,467

SUBTOTAL	$ 15,517
CONTINGENCIES - 30%	$ 4,655
DESIGN - 15%	$ 3,026
CONSTRUCTION MANAGEMENT - 10%	$ 2,017
ESTIMATED COST	**$ 25,300**

Assumptions/Notes:

1. No sheeting or dewatering will be required for the excavations.
2. Excavated material will be stockpiled within the construction area Special hauling will not be required.
3. Design and construction costs are based on "large scale" jobs. Bidding of individual small projects included in this estimate may result in higher costs.
4. Soil disposal costs are not included. It is assumed the soil will be placed in a stockpile, for use by others.

PRELIMINARY COST ESTIMATE
TABLE C-8
<u>Storm Drain Network 2</u>
Santa Barbara Municipal Airport

Location: Santa Barbara Municipal Airport
Prepared By: AD

Item No	Description	Est Qty	Unit	Unit Price	Est Amt
1	Waste Handling and Disposal - 30 mi rt	10	TON	$ 117.00	$ 1,170
2	24" Storm Drain - RCP	400	LF	$ 39.00	$ 15,600
3	Excavation	230	CY	$ 5.00	$ 1,150
4	Hauling - 30 mi rt	185	CY	$ 14.90	$ 2,755
5	Trench Backfill	76	CY	$ 7.00	$ 531
6	Bedding	154	CY	$ 30.00	$ 4,623
7	Compaction - Trench Bedding and Backfill	230	CY	$ 4.30	$ 989
8	Remove Headwall	3	CY	$ 269.00	$ 807
9	New Headwall - 24" Pipe	1	Ea.	$ 2,467.00	$ 2,467

SUBTOTAL	$ 30,093
CONTINGENCIES - 30%	$ 9,028
DESIGN - 15%	$ 5,868
CONSTRUCTION MANAGEMENT - 10%	$ 3,912

ESTIMATED COST	**$ 49,000**

Assumptions/Notes:

1. No sheeting or dewatering will be required for the excavations.
2. Excavated material will be stockpiled within the construction area Special hauling will not be required.
3. Design and construction costs are based on "large scale" jobs. Bidding of individual small projects included in this estimate may result in higher costs.
4. Soil disposal costs are not included. It is assumed the soil will be placed in a stockpile, for use by others.

PRELIMINARY COST ESTIMATE
TABLE C-9
Storm Drain Network 8
Santa Barbara Municipal Airport

Location: Santa Barbara Municipal Airport
Prepared By: AD

Item No	Description	Est Qty	Unit	Unit Price	Est Amt
1	Waste Handling and Disposal - 30 mi rt	40	TON	$ 117.00	$ 4,680
2	Concrete Pavement Saw Cutting - Assume 12" Thick	120	LF	$ 12.00	$ 1,440
3	Drop Inlet Removal	2	No.	$ 2,000.00	$ 4,000
4	Pipe Removal 15" to 18"	400	LF	$ 8.00	$ 3,200
5	P-209 Crushed Aggregate Base	9	TON	$ 25.00	$ 225
6	P-304 Cement Treated Base (18")	28	SY	$ 25.00	$ 700
7	P-401 Bit. Concrete Pavement	18	TON	$ 60.00	$ 1,080
8	18" Storm Drain - RCP	400	LF	$ 28.00	$ 11,200
9	Excavation	120	CY	$ 5.00	$ 600
10	Hauling - 30 mi rt	48	CY	$ 14.90	$ 708
11	Trench Backfill	80	CY	$ 7.00	$ 563
12	Bedding	40	CY	$ 30.00	$ 1,188
13	Compaction - Trench Bedding and Backfill	120	CY	$ 4.30	$ 516
14	Drop Inlets	2	Ea.	$ 3,225.00	$ 6,450

SUBTOTAL	$ 36,550
CONTINGENCIES - 30%	$ 10,965
DESIGN - 15%	$ 7,127
CONSTRUCTION MANAGEMENT - 10%	$ 4,751
ESTIMATED COST	**$ 59,400**

Assumptions/Notes:

1. No sheeting or dewatering will be required for the excavations.
2. Special Conditions for ACP Handling and Disposal Not Included
3. Excavated material will be stockpiled within the construction area Special hauling will not be required.
4. Design and construction costs are based on "large scale" jobs. Bidding of individual small projects included in this estimate may result in higher costs.
5. Soil disposal costs are not included. It is assumed the soil will be placed in a stockpile, for use by others.

PRELIMINARY COST ESTIMATE
TABLE C-10
<u>Storm Drain Network 5</u>
Santa Barbara Municipal Airport

Location: Santa Barbara Municipal Airport
Prepared By: AD

Item No	Description	Est Qty	Unit	Unit Price	Est Amt
1	Waste Handling and Disposal - 30 mi rt	200	TON	$ 117.00	$ 23,400
2	Concrete Pavement Saw Cutting - Assume 12" Thick	680	LF	$ 12.00	$ 8,160
3	Drop Inlet Removal	9	No.	$ 2,000.00	$ 18,000
4	Pipe Removal 12" and Less	125	LF	$ 7.00	$ 875
5	Pipe Removal 15" to 18"	960	LF	$ 8.00	$ 7,680
6	Pipe Removal 24"	650	LF	$ 10.00	$ 6,500
7	P-209 Crushed Aggregate Base	50	TON	$ 25.00	$ 1,250
8	P-304 Cement Treated Base (18")	153	SY	$ 25.00	$ 3,825
9	P-401 Bit. Concrete Pavement	105	TON	$ 60.00	$ 6,300
10	12" Storm Drain - RCP	125	LF	$ 21.00	$ 2,625
11	18" Storm Drain - RCP	610	LF	$ 28.00	$ 17,080
12	24" Storm Drain - RCP	1,000	LF	$ 39.00	$ 39,000
13	Excavation	651	CY	$ 5.00	$ 3,255
14	Hauling - 30 mi rt	258	CY	$ 14.90	$ 3,841
15	Trench Backfill	436	CY	$ 7.00	$ 3,053
16	Bedding	215	CY	$ 30.00	$ 6,444
17	Compaction - Trench Bedding and Backfill	651	CY	$ 4.30	$ 2,799
18	Drop Inlets	8	Ea.	$ 3,225.00	$ 25,800
19	Plug and Grout Pipe #140 - 300lf, 15"ACP	1	LS	$ 3,000.00	$ 3,000

SUBTOTAL	$ 182,886
CONTINGENCIES - 30%	$ 54,866
DESIGN - 15%	$ 35,663
CONSTRUCTION MANAGEMENT - 10%	$ 23,775

ESTIMATED COST	**$ 297,200**

Assumptions/Notes:

1. No sheeting or dewatering will be required for the excavations.
2. Special Conditions for ACP Handling and Disposal Not Included
3. Excavated material will be stockpiled within the construction area Special hauling will not be required.
4. Design and construction costs are based on "large scale" jobs. Bidding of individual small projects included in this estimate may result in higher costs.
5. Soil disposal costs are not included. It is assumed the soil will be placed in a stockpile, for use by others.

PRELIMINARY COST ESTIMATE
TABLE C-11
<u>Storm Drain Network 7</u>
Santa Barbara Municipal Airport

Location: Santa Barbara Municipal Airport
Prepared By: AD

Item No	Description	Est Qty	Unit	Unit Price	Est Amt
1	Waste Handling and Disposal - 30 mi rt	85	TON	$ 117.00	$ 9,945
2	Concrete Pavement Saw Cutting - Assume 12" Thick	360	LF	$ 12.00	$ 4,320
3	Drop Inlet Removal	2	No.	$ 2,150.00	$ 4,300
4	Pipe Removal 12" and Less	180	LF	$ 7.00	$ 1,260
5	P-209 Crushed Aggregate Base	40	TON	$ 25.00	$ 1,000
6	P-304 Cement Treated Base (18")	120	SY	$ 25.00	$ 3,000
7	P-401 Bit. Concrete Pavement	81	TON	$ 60.00	$ 4,860
8	18" Storm Drain - RCP	180	LF	$ 28.00	$ 5,040
9	Excavation	60	CY	$ 5.00	$ 300
10	Hauling - 30 mi rt	24	CY	$ 14.90	$ 354
11	Trench Backfill	40	CY	$ 7.00	$ 281
12	Bedding	20	CY	$ 30.00	$ 594
13	Compaction - Trench Bedding and Backfill	60	CY	$ 4.30	$ 258
14	Drop Inlets	2	Ea.	$ 3,225.00	$ 6,450

SUBTOTAL	$ 41,962
CONTINGENCIES - 30%	$ 12,589
DESIGN - 15%	$ 8,183
CONSTRUCTION MANAGEMENT - 10%	$ 5,455
ESTIMATED COST	**$ 68,200**

Assumptions/Notes:

1. No sheeting or dewatering will be required for the excavations.
2. Excavated material will be stockpiled within the construction area Special hauling will not be required.
3. Design and construction costs are based on "large scale" jobs. Bidding of individual small projects included in this estimate may result in higher costs.
4. Soil disposal costs are not included. It is assumed the soil will be placed in a stockpile, for use by others.

PRELIMINARY COST ESTIMATE
TABLE C-12
<u>Storm Drain Network 4</u>
Santa Barbara Municipal Airport

Location: Santa Barbara Municipal Airport
Prepared By: AD

Item No	Description	Est Qty	Unit	Unit Price	Est Amt
1	Waste Handling and Disposal - 30 mi rt	5	TON	$ 117.00	$ 585
2	Hauling - 30 mi rt	1,600	CY	$ 14.90	$ 23,840
3	Excavation	1,333	CY	$ 3.30	$ 4,400
4	Drop Inlets	2	Ea.	$ 3,225.00	$ 6,450
5	Drop Inlet Removal	2	No.	$ 2,000.00	$ 4,000

SUBTOTAL	$ 39,275
CONTINGENCIES - 30%	$ 11,783
DESIGN - 15%	$ 7,659
CONSTRUCTION MANAGEMENT - 10%	$ 5,106
ESTIMATED COST	**$ 63,900**

Assumptions/Notes:

1 No sheeting or dewatering will be required for the excavations.
2 Excavated material will be stockpiled within the construction area
Special hauling will not be required.
3 Design and construction costs are based on "large scale" jobs. Bidding of individual small projects included in this estimate may result in higher costs.
4 Soil disposal costs are not included. It is assumed the soil will be placed in a stockpile, for use by others.

PRELIMINARY COST ESTIMATE
TABLE C-13
Force Main Removal and Replacement
Santa Barbara Municipal Airport

Location: Santa Barbara Municipal Airport
Prepared By: AD

Item No	Description	Est Qty	Unit	Unit Price	Est Amt
1	Waste Handling and Disposal - 30 mi rt	60	TON	$ 117.00	$ 7,020
2	Asphalt Pavement Saw Cutting - Assume 3" Thick	200	LF	$ 1.30	$ 260
3	Demolish Existing Pipe	3	Days	$ 1,774.00	$ 5,322
4	Subgrade Preparation	35	SY	$ 8.00	$ 280
5	Aggregate Base - Compacted	35	SY	$ 9.00	$ 315
6	Asphalt Concrete Paving - Assume 3" Thick	35	SY	$ 40.00	$ 1,400
7	10" Steel Force Main	200	LF	$ 47.00	$ 9,400
8	Pipe Excavation	50	CY	$ 5.00	$ 250
9	Hauling - 30 mi rt	20	CY	$ 14.90	$ 295
10	Trench Backfill	34	CY	$ 7.00	$ 235
11	Bedding	17	CY	$ 30.00	$ 495
12	Compaction - Trench Bedding and Backfill	50	CY	$ 4.30	$ 215
13	Bridge Abutment Modifications	3	Ea.	$ 1,500.00	$ 4,500
14	Plug and Grout Ex. Pipe In Place, 100lf, 18"	1	Ea.	$ 4,000.00	$ 4,000
15	Manholes	2	Ea.	$ 4,300.00	$ 8,600
16	Pipe Access Excavation	1,000	CY	$ 14.00	$ 14,000
17	Streambed Backfill	1,000	CY	$ 3.00	$ 3,000

SUBTOTAL	$ 59,587
CONTINGENCIES - 30%	$ 17,876
DESIGN - 15%	$ 11,619
CONSTRUCTION MANAGEMENT - 10%	$ 7,746
ESTIMATED COST	**$ 96,900**

Assumptions/Notes:

1. No sheeting or dewatering will be required for the excavations.
2. Excavated material will be stockpiled within the construction area Special hauling will not be required.
3. Total replacement length was assumed to be 200 lf. This includes demolition of 100 lf under the bridge and abandonment-in-place of 50 lf on both sides of the bridge (total 100 lf)
4. Design and construction costs are based on "large scale" jobs. Bidding of individual small projects included in this estimate may result in higher costs.
5. Soil disposal costs are not included. It is assumed the soil will be placed in a stockpile, for use by others.

PRELIMINARY COST ESTIMATE
TABLE C-14
Replacement Storm Drain Outfall
Santa Barbara Municipal Airport

Location: Santa Barbara Municipal Airport
Prepared By: AD

Item No	Description	Est Qty	Unit	Unit Price	Est Amt
1	Waste Handling and Disposal - 30 mi rt	150	TON	$ 117.00	$ 17,550
2	Manholes	1	Ea.	$ 4,300.00	$ 4,300
3	Pipe Removal 36"	450	LF	$ 13.00	$ 5,850
4	24" Storm Drain - RCP	450	LF	$ 39.00	$ 17,550
5	Excavation	250	CY	$ 5.00	$ 1,250
6	Hauling - 30 mi rt	99	CY	$ 14.90	$ 1,475
7	Trench Backfill	168	CY	$ 7.00	$ 1,173
8	Bedding	83	CY	$ 30.00	$ 2,475
9	Compaction - Trench Bedding and Backfill	250	CY	$ 4.30	$ 1,075
10	Remove Headwall	3	CY	$ 268.80	$ 806
11	New Headwall - 24" Pipe	1	Ea.	$ 2,467.10	$ 2,467
12	Transition Structure at Ex Culvert	1	LS	$ 3,225.00	$ 3,225
13	Drop Inlets	2	Ea.	$ 3,225.00	$ 6,450

SUBTOTAL	$ 65,646
CONTINGENCIES - 30%	$ 19,694
DESIGN - 15%	$ 12,801
CONSTRUCTION MANAGEMENT - 10%	$ 8,534
ESTIMATED COST	**$ 106,700**

Assumptions/Notes:

1. No sheeting or dewatering will be required for the excavations.
2. Special Conditions for ACP Handling and Disposal Not Included
3. Excavated material will be stockpiled within the construction area
   Special hauling will not be required.
4. Design and construction costs are based on "large scale" jobs. Bidding of individual small projects included in this estimate may result in higher costs.
5. Soil disposal costs are not included. It is assumed the soil will be placed in a stockpile, for use by others.

PRELIMINARY COST ESTIMATE
TABLE C-15
Replace Trestle Bridge on San Pedro Creek
Santa Barbara Municipal Airport

Location: Santa Barbara Municipal Airport
Prepared By: PM

Item No	Description	Est Qty	Unit	Unit Price	Est Amt
1	Bridge Excavation	600	CY	$ 3.30	$ 1,980
2	Hauling - 30 mi rt	720	CY	$ 14.90	$ 10,728
3	Bridge Demolition	1	EA	$ 10,000.00	$ 10,000
4	Bridge	1,400	SF	$ 110.00	$ 154,000
SUBTOTAL					$ 176,708
CONTINGENCIES - 30%					$ 53,012
DESIGN - 15%					$ 34,458
CONSTRUCTION MANAGEMENT - 10%					$ 22,972
ESTIMATED COST					**$ 287,200**

Assumptions/Notes:

1 No sheeting or dewatering will be required for the excavations.
2 Design and construction costs are based on "large scale" jobs. Bidding of individual small projects included in this estimate may result in higher costs.
3 Bridge assumed to be 2 12-foot lanes plus 1 four foot shoulder
4 Soil disposal costs are not included. It is assumed the soil will be placed in a stockpile, for use by others.

PRELIMINARY COST ESTIMATE
TABLE C-16
Realignment of Tecolotito Creek
Santa Barbara Municipal Airport

Location: Santa Barbara Municipal Airport
Prepared By: JH

Item No	Description	Est Qty	Unit	Unit Price	Est Amt
1	Unclassified Excavation & Loading	200,000	CY	$ 3.70	$ 740,000
2	Hauling - 30 mi rt	240,000	CY	$ 14.90	$ 3,576,000

SUBTOTAL	$ 4,316,000
CONTINGENCIES - 10%	$ 431,600
DESIGN - 5%	$ 237,380
CONSTRUCTION MANAGEMENT - 10%	$ 474,760
ESTIMATED COST	**$ 5,459,800**

Assumptions/Notes:

1 Design and construction costs are based on "large scale" jobs. Bidding of individual small projects included in this estimate may result in higher costs.
2 Excavation does not include 71,500 cy for runway, taxiway, and safety areas.
3 Soil disposal costs are not included. It is assumed the soil will be placed in a stockpile, for use by others.

APPENDIX D

FIGURES

Figure 1. Santa Barbara Airport

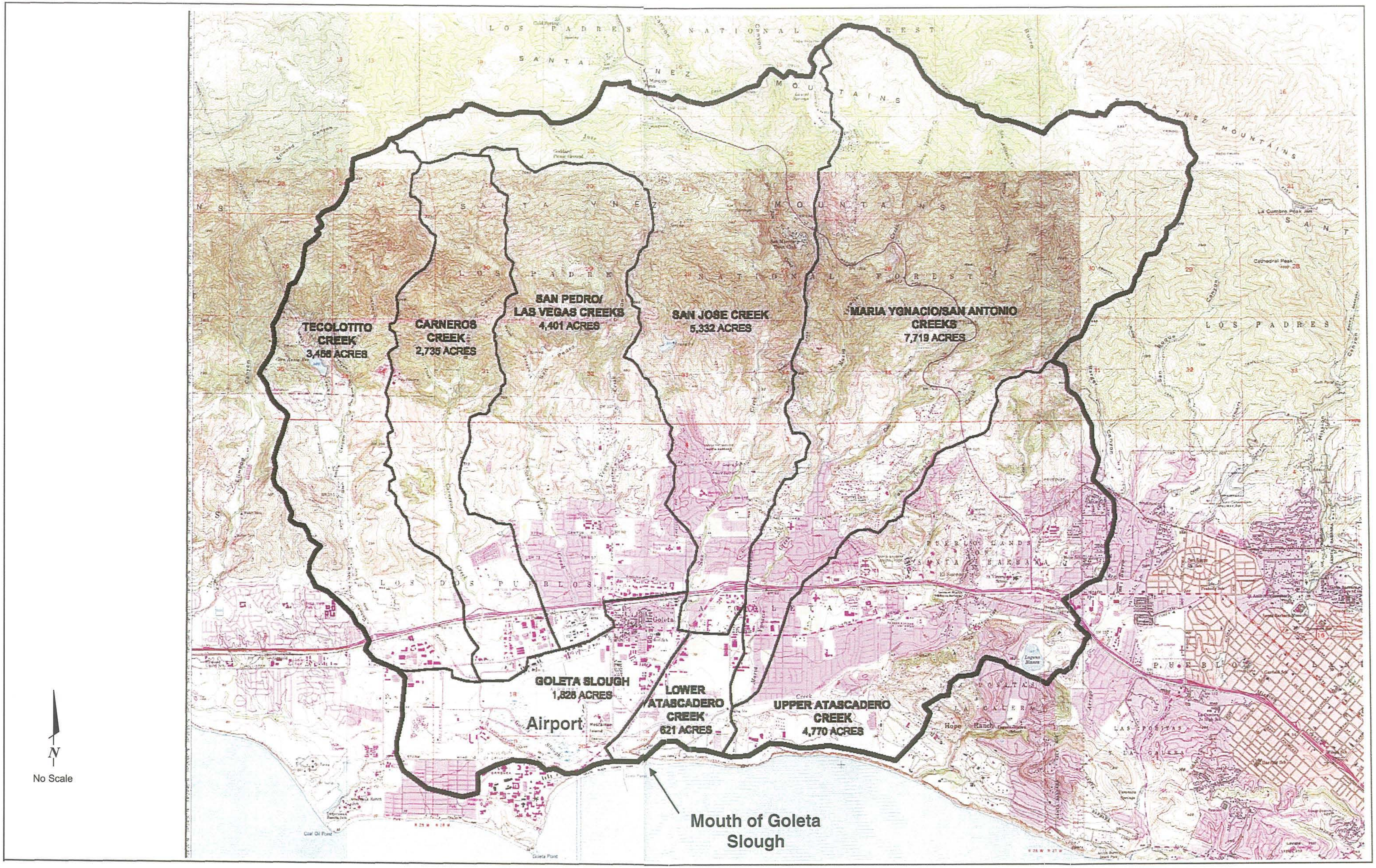
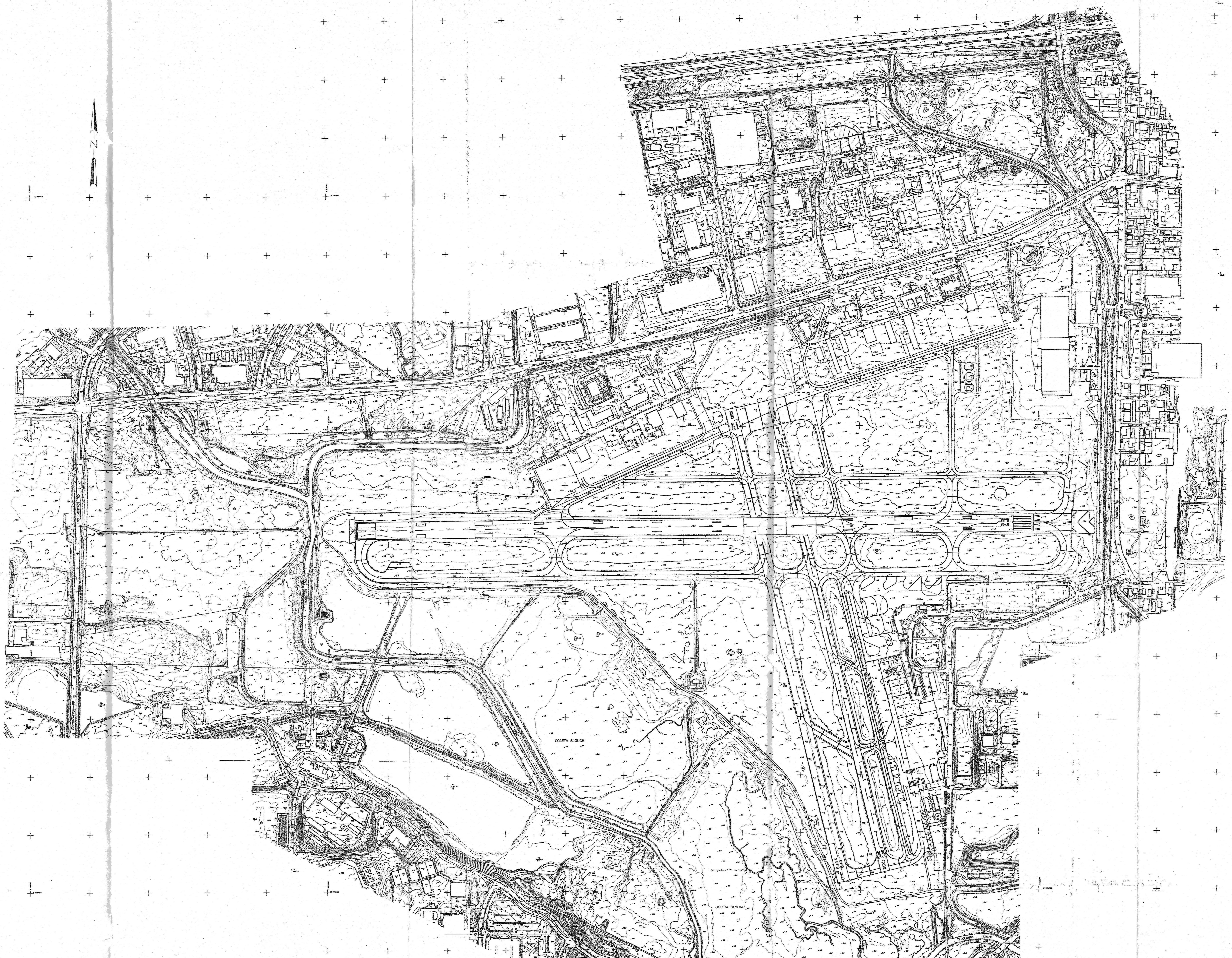


Figure 2. Watersheds above Santa Barbara Airport

9/09/04 vsa..\Santa Barbara Municipal Airport Phase 3\ Graphics\Fig 2.cdr



NOTE:
ALL ELEVATIONS ARE IN FEET NAVD 1988.

300' 0 300' 600'
SCALE 1"= 300'

Project No. 66-00000040.00	TOPOGRAPHIC DATA BY SAGE CONSULTANT INC.	SANTA BARBARA AIRPORT TOPOGRAPHIC MAP	FIGURE 3
URS Corporation			

J:\CADSHARED\SANTABARBARA\FIGURES\FIGURE2.DWG APRIL 18, 2001

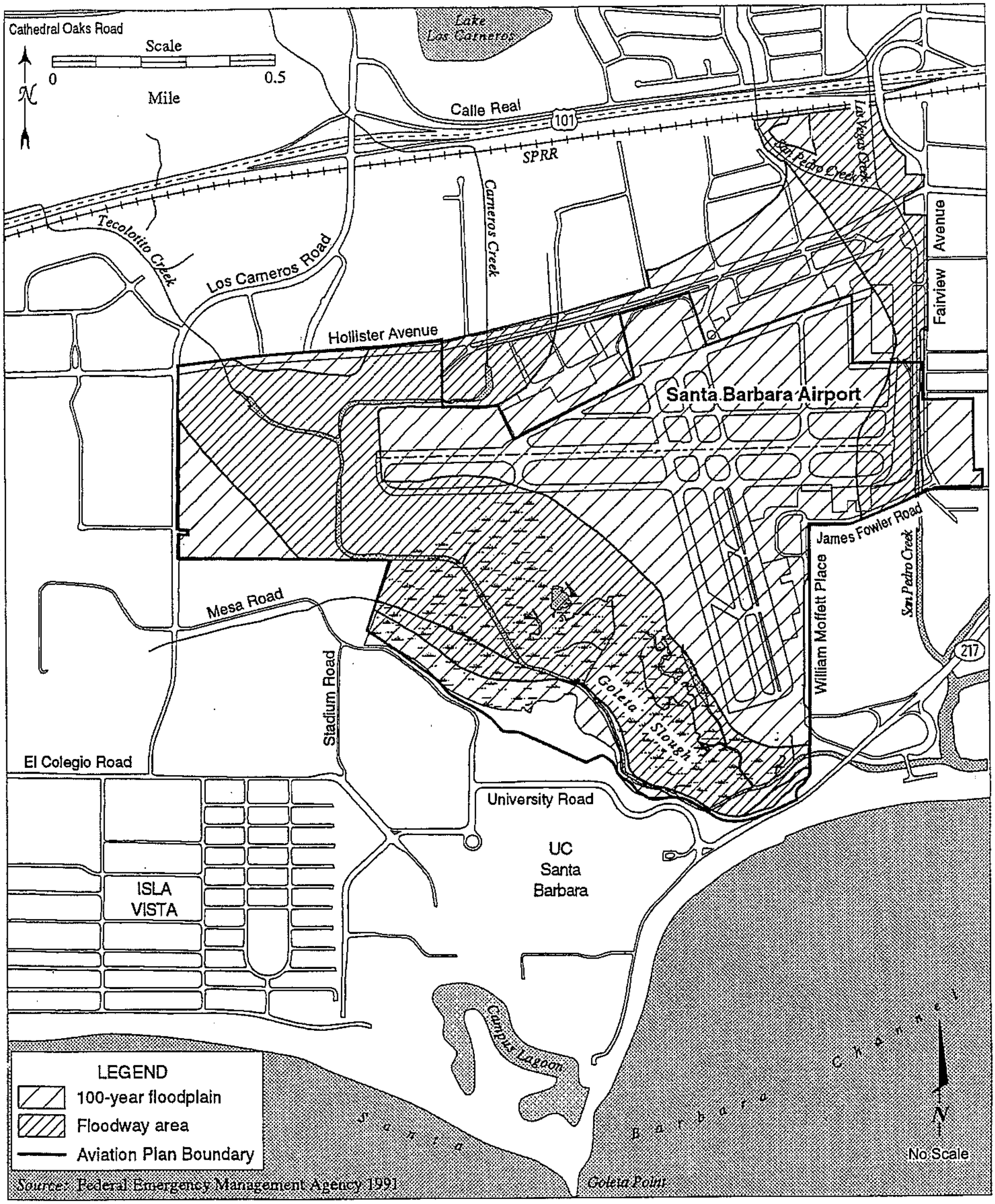
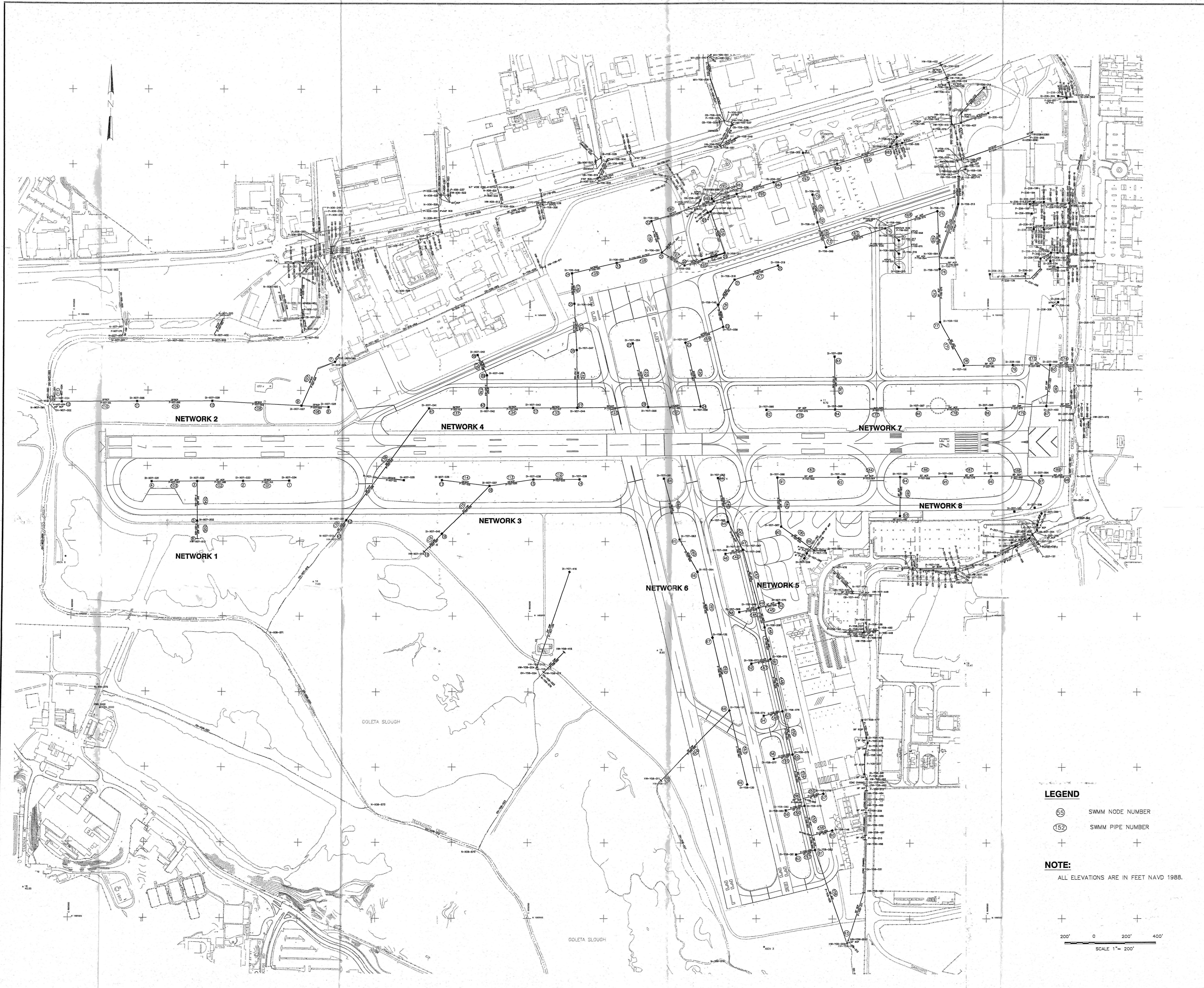


Figure 4. Floodplain and Floodway Boundaries at the Airport



Project No. 66-00000040.00	STORM DRAINAGE NETWORK DATA BY SAGE CONSULTANT INC.	SANTA BARBARA AIRPORT EXISTING STORM DRAINAGE NETWORK	FIGURE 5
URS Corporation			

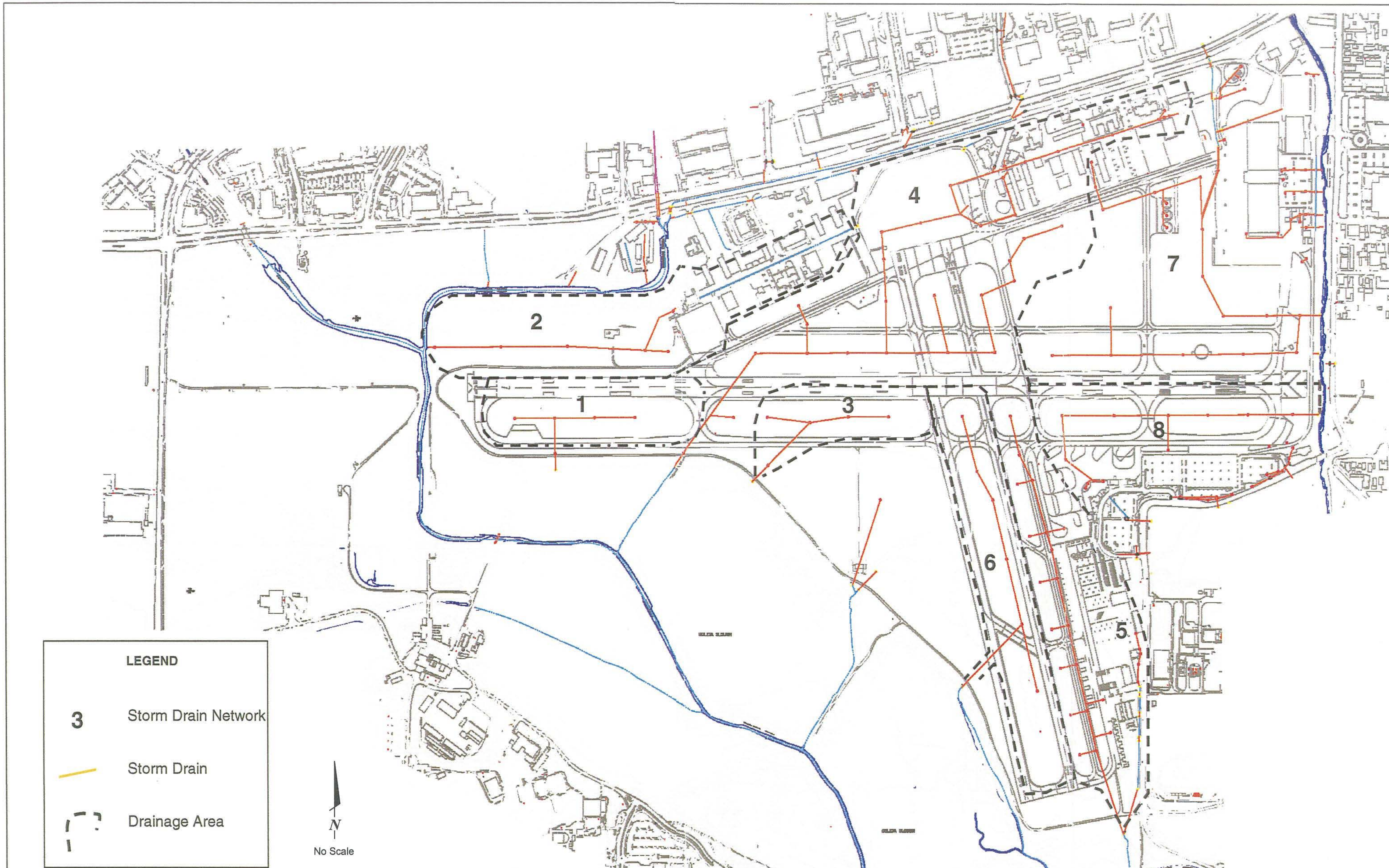
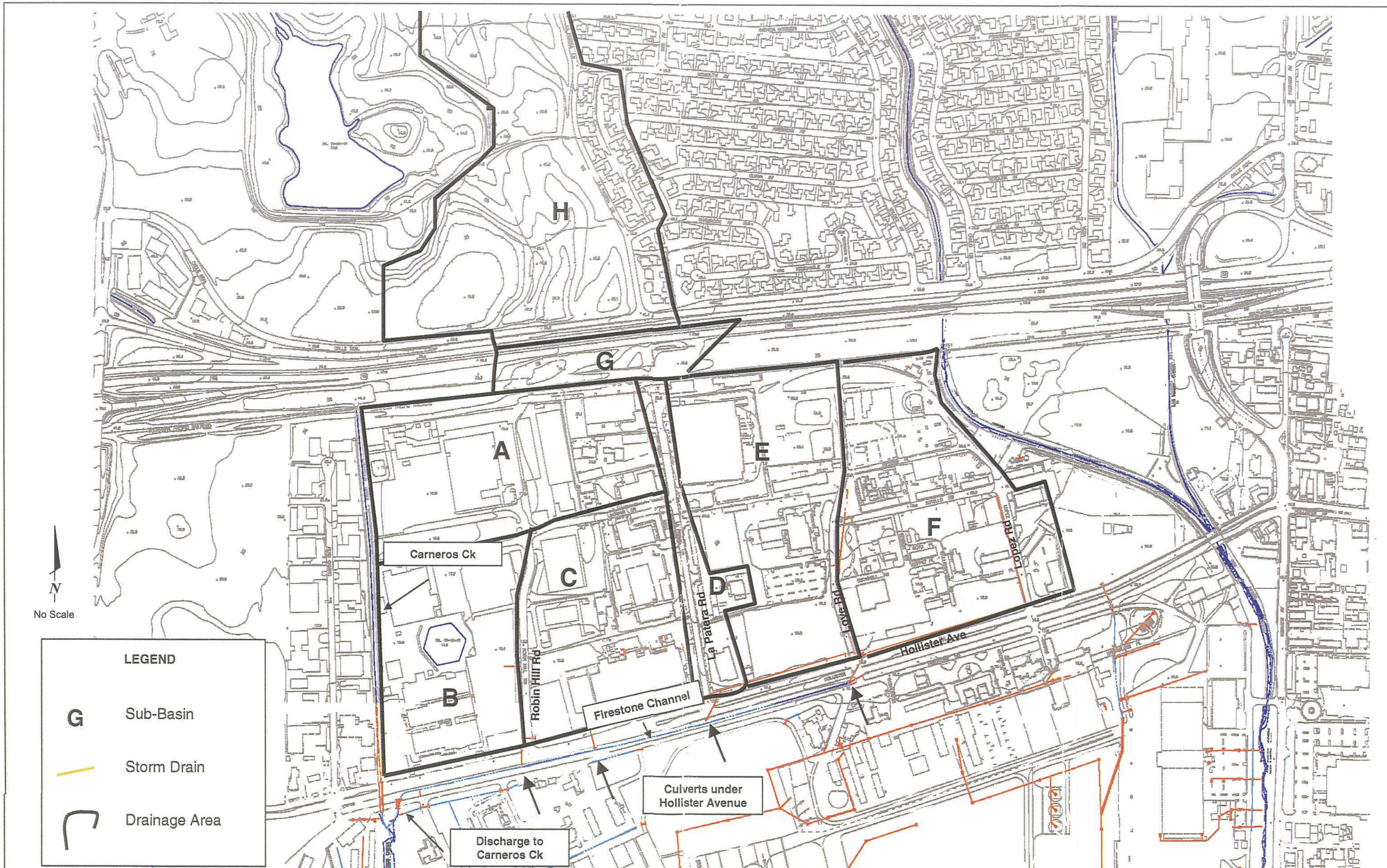


Figure 6. Overview of Storm Drain Networks at the Airport



9/09/04 vsa..\Santa Barbara Municipal Airport Phase 3\ Graphics\Fig 7.cdr

Figure 7. Firestone Channel and Drainage System

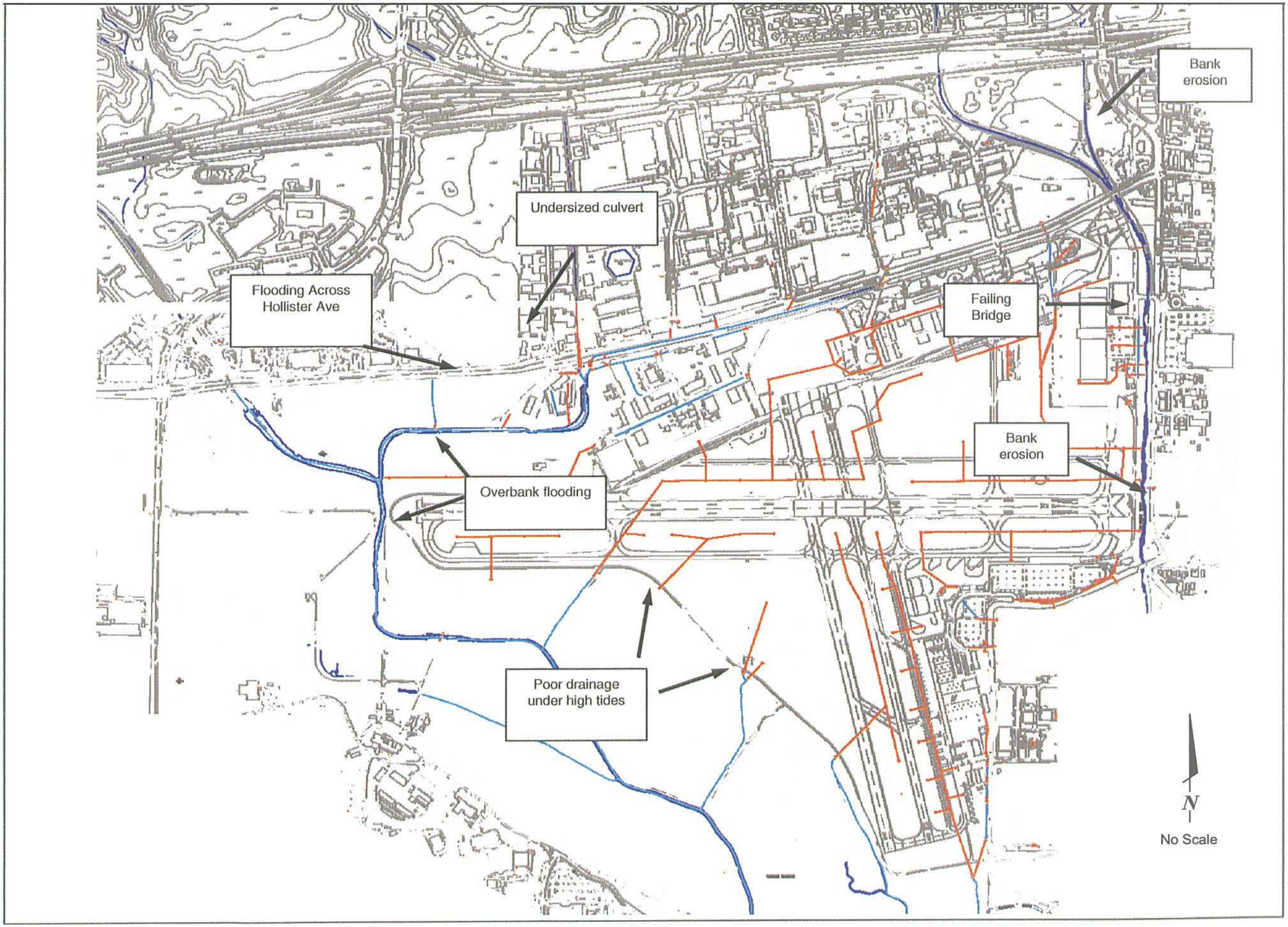


Figure 8. Location of Major Drainage Problems at the Airport

9/09/04 vsa..\Santa Barbara Municipal Airport Phase 3\ Graphics\Fig 8.cdr

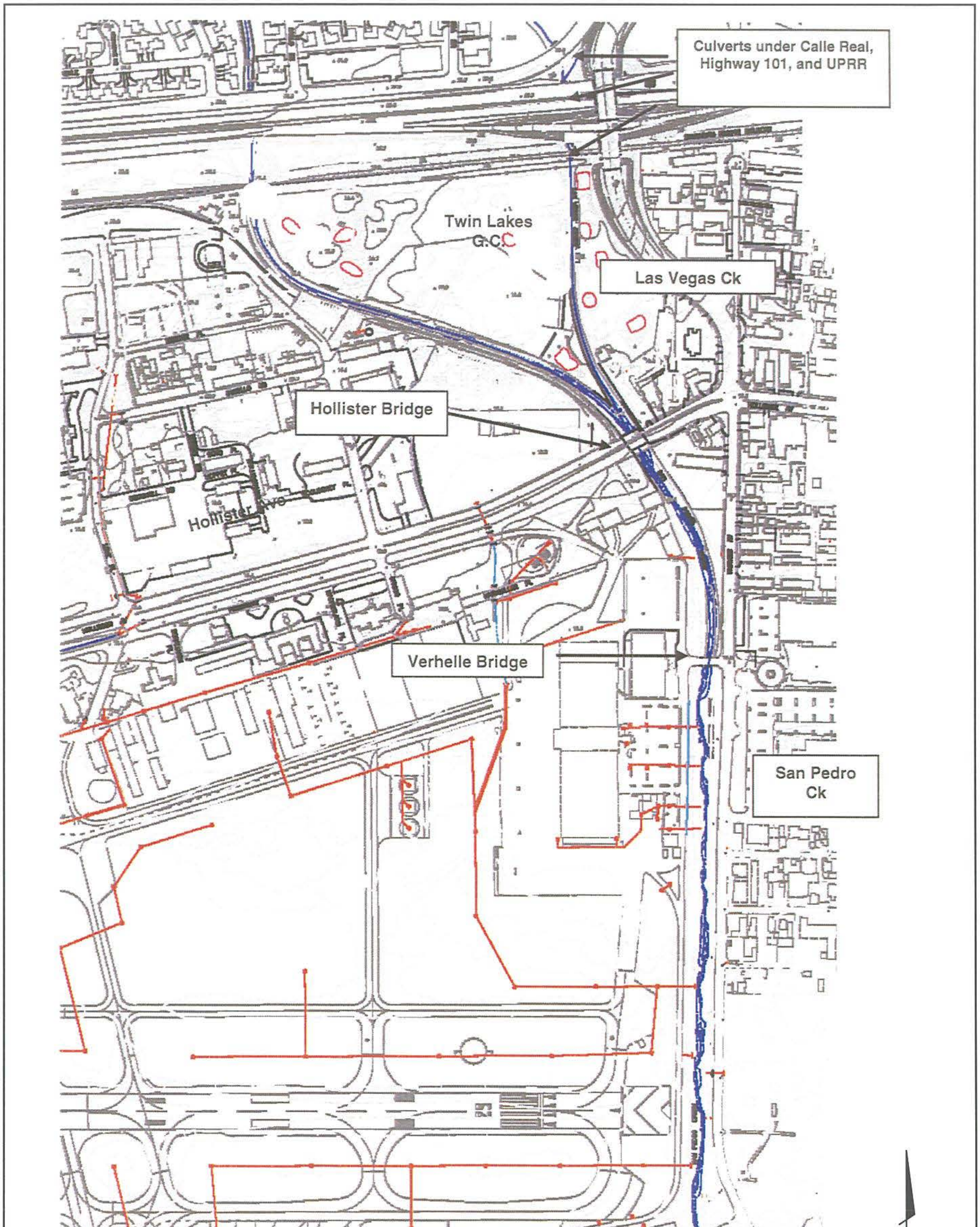


Figure 9. Las Vegas and San Pedro Creeks

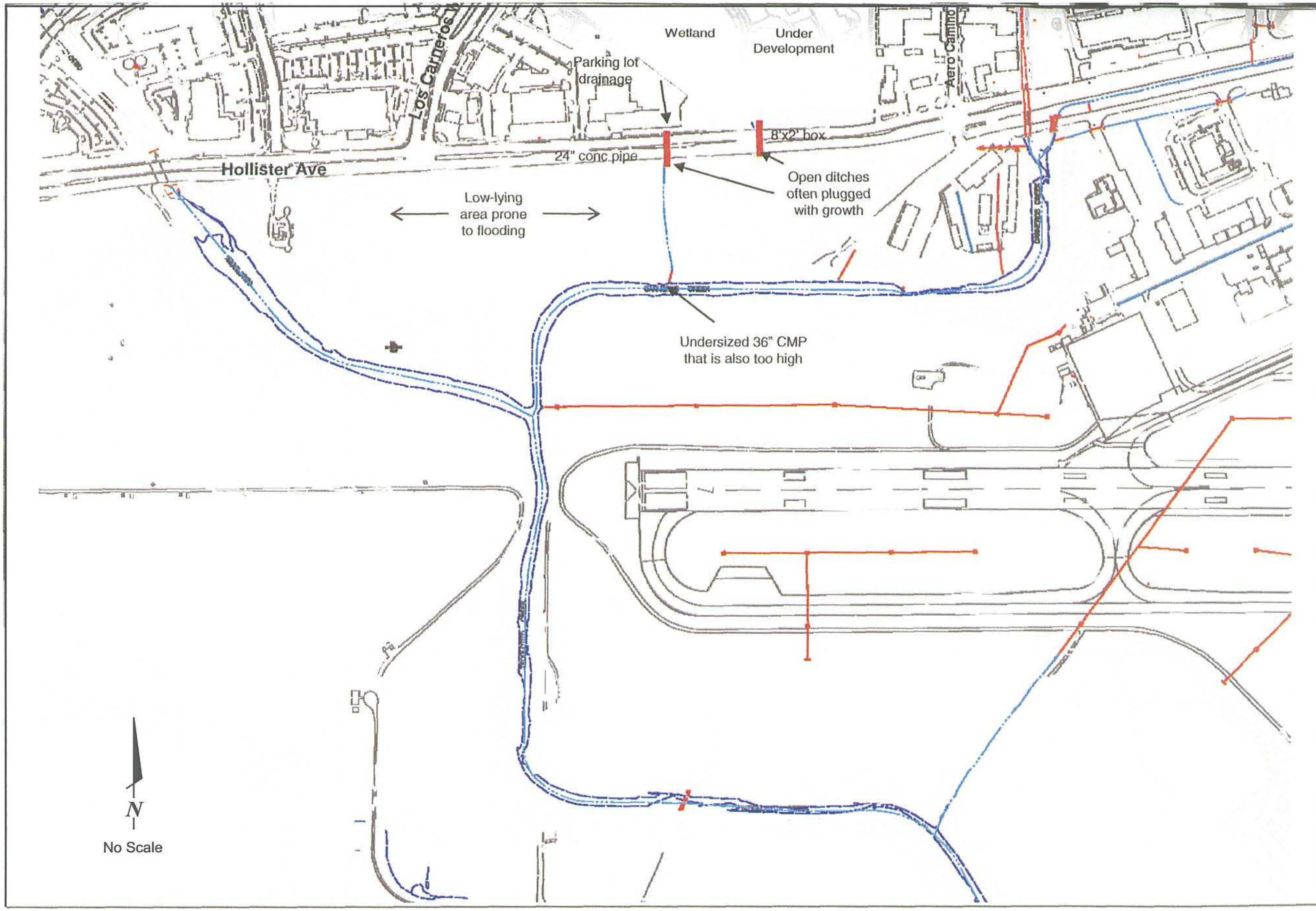
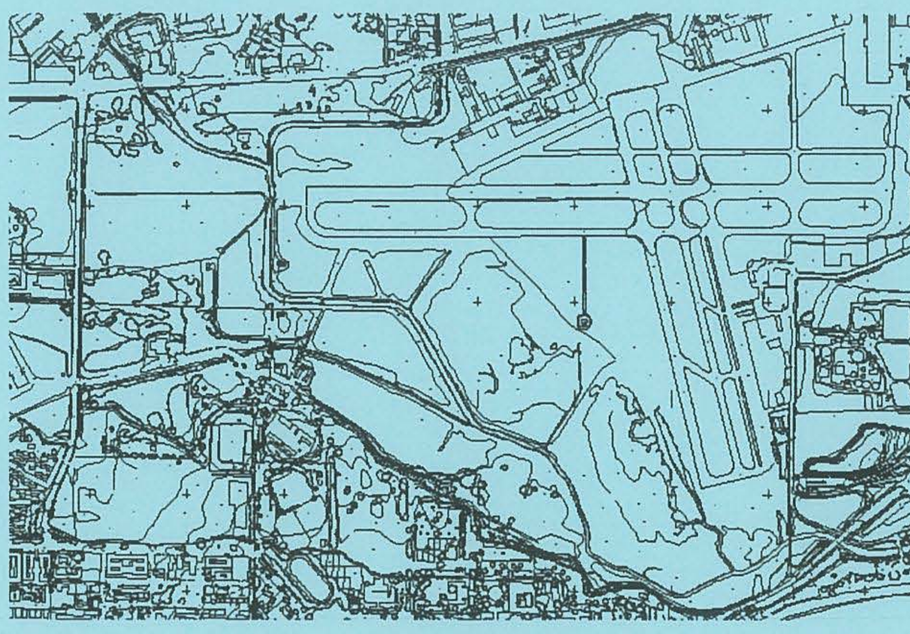


Figure 10. Drainage Channels and Culverts along Hollister Avenue near Los Carneros Way

9/09/04 vsa..\Santa Barbara Municipal Airport Phase 3\ Graphics\Fig 10.cdr

CHAPTER 2

BASE FLOOD ELEVATION ANALYSIS



Prepared by URS Corporation
September 2001
Phil Mineart

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1.0 INTRODUCTION

The Santa Barbara Municipal Airport (Airport), owned and managed by the City of Santa Barbara, is located in the South Coast region of Santa Barbara County, on the coastal plain between the Santa Ynez Mountains and the Pacific Ocean. There are three runways in the airfield, which encompasses about 725 acres south of Hollister Avenue. The Airport property also includes the industrial/ commercial area north of Hollister Avenue, as well as most of Goleta Slough and its associated wetlands and tidal channels.

Three creeks are located in and adjacent to the airfield: Tecolotito, Carneros, and San Pedro Creeks. These creeks are tributaries to Goleta Slough, which empties to the ocean at Goleta Beach. The elevation of the airfield is very low, with an average ground elevation of about 8 to 10 feet above mean sea level. Significant portions of Goleta Slough and the lower ends of the creeks at the Airport are tidally influenced.

The boundaries of the 100-year floodplain, as determined by the Federal Emergency Management Agency (FEMA), are described in the City of Santa Barbara Flood Insurance Study (dated 12/3/1991) and the Flood Insurance Study for Santa Barbara County, Unincorporated Areas (Revised July 7, 1999). These reports are updates of previous reports completed in 1973 to incorporate channel improvements on several creeks located in Santa Barbara County and City. The floodplain boundaries for Tecolotito Creek near the airport are based on the 1973 analysis (i.e., not updated). The County Study provides floodplain boundaries from the mouth upstream 3.8 miles. The City Study covers the area from the mouth to Hollister Avenue. According to the County study most of the length of Tecolotito and Carneros Creeks upstream of the City of Santa Barbara corporate limits can contain the 100-year flow.

The entire airport property south of Hollister Avenue, west of Fairview and east of Los Carneros Road is contained within the 100-year floodplain boundary. Based on the FEMA analyses, the water surface elevation for the 100-year flood along Tecolotito Creek is about elevation 11 feet National Geodetic Vertical Datum of 1929 (NGVD 29) throughout the entire floodplain, increasing to about elevation 12 feet NGVD 29 at Hollister Avenue. Along San Pedro Creek the water surface elevation is also about elevation 11 feet NGVD 29 near the airport terminal, increasing to greater than elevation 15 feet at Hollister Avenue.

Since the FEMA floodplain boundaries and elevations are based on a study that is over 30 years old, an analysis was conducted to confirm whether the information in the FEMA studies was reasonable. The base flood elevation (BFE) refers to the predicted water surface elevation within the floodplain of a creek corresponding to a flood event with a 1% chance of occurrence in any year (the 100-year flood event). The BFE for the creeks and the wetland areas adjacent to the Airport were estimated using two hydraulic models developed by the U.S. Army Corps of Engineers (USACE): (1) the RMA-2 hydrodynamic numerical model, and (2) the River Analysis System, HEC-RAS hydraulic model. The RMA-2 model is a two-dimensional depth-averaged finite element hydrodynamic numerical model. It computes water surface elevations and horizontal velocity components for sub-critical and free-surface flow conditions in a two-dimensional flow-field. The HEC-RAS model is a one-dimensional hydraulic model. It calculates the steady-state water surface elevation. It replaces the USACE Hydrologic Engineering Center's "HEC-2, Water Surface Profiles" model ("HEC-2 model") that was used in the earlier studies to predict floodplain boundaries and base flood elevations.

The RMA-2 model has been extensively used by various agencies to simulate water levels, flow velocities, and circulation patterns in natural waterbodies such as rivers, lakes, wetlands, and estuaries and at man-made structures including bridge openings and channel reaches. A few of the model capabilities are listed as follows:

- Simulates both steady and transient state hydrodynamic problems and wetting and drying conditions.
- Accepts user-defined turbulent exchange and friction (Manning's) coefficients as calibration parameters throughout the model domain.
- Models up to five different types of one-dimensional flow control structures such as bridge openings, culverts, and channel reaches.
- Accepts a wide variety of boundary conditions, such as velocity components by node, water surface elevations by node/line, discharge by node/line/element, and tidal radiation by line.

The River Analysis System HEC-RAS (version 2.2) model developed by the USACE Hydrologic Engineering Center (HEC) is also used to predict the water surface elevations due to the 100-year flood. Its predecessor, HEC-2, was commonly used by FEMA for Flood Insurance Studies to estimate base flood elevations. HEC-2 is the model that FEMA used to calculate the base flood elevation at the Santa Barbara Airport. The HEC-RAS model performs one-dimensional steady-state gradually varied flow simulations for a network of channels using standard backwater computations. While FEMA still considers the HEC-2 model to be an acceptable model for detailed flood insurance studies, FEMA encourages the use of HEC-RAS, or other accepted models, when updating hydraulic analyses. While the HEC-RAS model was released in the late 1990s to replace the HEC-2 model, it is a completely different model that uses different hydraulic routines.

For the HEC-RAS model, the study area is subdivided into a series of cross sections. Each cross section is subdivided into the main channel area and the left and right overbank areas as designated by the user. The change in water surface elevation between two sections is determined by the energy losses, which include friction losses and expansion/contraction losses. Friction loss is evaluated using Manning's equation with the user-defined roughness coefficient.

Data required by the models include topographic, boundary condition and flow data. The boundary condition data includes tides and/or inflows at each model boundary for the RMA-2 model and maximum tidal elevation at the mouth of Goleta Slough for the HEC-RAS model. A brief description of each of these data sets is provided below.

2.0 DATA USED IN THE ANALYSIS

2.1 TOPOGRAPHIC DATA

Topographic data were obtained from the County topographic survey supplied by the Airport. The data were supplemented with topographic data obtained from Sage Consultants. Channel cross sections included the cross sections from the 1991 FEMA Flood Insurance Study and five cross sections surveyed for this project.

Since RMA-2 uses the finite element method as its numerical solution methodology, the topographic data input into the model does not have to be uniformly spaced. This allows detailed topographic data to be used to define features such as creek channels, depression storage and levees, and coarser data to be used where details are not needed, such as for airport runways. Where detailed data were needed, additional topography was input by interpolating between the existing data. More than 7,400 data points were used to represent the topography at the airport. Figure 1 shows a representation of the topography used in the model and Figure 2 shows the resulting finite-element model grid.

The HEC-RAS model only requires cross-section data. The cross -section data used in the model are the same as used in the 1991 FEMA study. A comparison between the cross-section data used in the 1991 FEMA study and the topography used in the RMA-2 study shows them to be qualitatively the same. In the HEC-RAS model, the cross sections with the wetland areas have been "filled in" since they are ineffective at transporting water (i.e., the bottom of the wetland has been raised to match the surrounding ground level).

2.2 BOUNDARY CONDITIONS

The RMA-2 model requires flow boundary conditions for Tecolotito, Carneros, San Pedro, San Jose and Atascadaro Creeks. A tide is required in the Santa Barbara Channel. The HEC-RAS model only requires a constant tidal elevation at the mouth of Goleta Slough and a constant flow rate.

Development of hydrographs for Tecolotito, Carneros, San Pedro and San Jose Creeks is described in other reports prepared for the Airport (e.g., Drainage Improvement Plan, URS, 2001 and Hydrology for the Santa Barbara Municipal Airport, Penfield & Smith, 2000). The hydrographs were based on precipitation, precipitation-frequency-duration data, and watershed physical characteristics (drainage areas, soil types, vegetation cover, channel slopes, etc.). The 100-year flood hydrographs were used in the RMA-2 analysis, while the peak flows along the creeks were used in the HEC-RAS analysis. The 100-year peak discharge for Tecolotito Creek at Hollister Avenue (i.e., upstream of the confluence with Carneros Creek) was estimated to be approximately 4,400 cubic feet per second (cfs) and downstream of the confluence with Carneros Creek, approximately 7,900 cfs.

In the original FEMA input file, the 100-year peak flow in Tecolotito Creek is 4,600 cfs upstream of the confluence with Carneros Creek and 7,400 cfs just downstream of the confluence, which are slightly different than the flows estimated from the recently developed hydrographs described above. However, approximately 2,000 feet downstream of the confluence with Carneros Creek, the flow is decreased to 6,500 cfs in the FEMA study. The Flood Insurance Studies (FIS) for Santa Barbara County and City (1991) do not provide any information on the reason for the decrease. The 1973 FIS reports may provide more information, but were not available for review.

A typical tide for Santa Barbara Channel obtained from the National Oceanographic and Atmospheric Administration (NOAA), National Ocean Survey Tide Station 9411340 was applied at the ocean boundary in the RMA-2 model. A water surface elevation of 7.49 feet from the 1991 FEMA study was used at the downstream boundary of the HEC-RAS model.

2.3 MODEL PARAMETERS

Manning's roughness coefficient is the main physical parameter used by both models. In addition, an eddy viscosity is required by the RMA-2 model. Eddy viscosity represents turbulent mixing, and for the RMA-2 model, is primarily used to maintain numerical stability. Manning's roughness values for the RMA-2 model were set equal to the values used in the FEMA flood study to allow for a comparison between the studies. In the FEMA analysis, a Manning's roughness value of 0.025 was used for the channel and 0.045 for the floodplain.

3.0 HYDRAULIC ANALYSIS RESULTS

3.1 DISCUSSION

A 100-year flood event on the existing Tecolotito Creek, Carneros Creek and San Pedro Creek results in a predicted water surface elevation using the RMA-2 model at the Airport terminal of about elevation 10.4 feet NGVD 29 and about elevation 10.7 to 11.9 feet NGVD 29 using the HEC-RAS model, as compared to the FEMA predicted elevation of 11 feet. The difference between the FEMA results and the RMA-2 and HEC-RAS results could be due to a number of factors, because the HEC-2 model used by FEMA is very different from both the RMA-2 and HEC-RAS models. The RMA-2 model showed that the flood levels were still rising when the peak flow in the river occurred; therefore, steady-state flood levels had not been reached. This may explain why RMA-2 predicts lower water levels than HEC-RAS.

Location on Tecolotito Creek	Miles upstream of confluence with Atascadero Creek	Water Surface Elevation (feet, NGVD 29) [1]			
		HEC-RAS Run 1	HEC-RAS Run 2	HEC-RAS Run 3	Maximum RMA-2
Just downstream of Carneros Creek	1.758	11.0	11.8	12.0	10.8
Middle of Goleta Slough (Terminal for RMA-2)	0.881	10.7	11.6	11.9	10.4
Upstream of Ward Memorial Bridge	0.383	10.5	11.5	11.7	10.1

(1) To convert NGVD 29 elevations to NAVD 88 elevations, add 2.5 feet.

Description of HEC-RAS Runs
Run 1: No modifications of imported HEC-2 file (4,600 cfs upstream of Carneros Creek confluence, 7,400 cfs for next 2,000 feet, 6,500 cfs for remainder of Goleta Slough)
Run 2: No decrease in flow downstream of Carneros Creek confluence (4,600 cfs upstream of Carneros Creek confluence, 7,400 cfs for remainder)
Run 3: No decrease in flow downstream of Carneros Creek confluence, increase of peak flow downstream of confluence to match flows in this study (4,600 cfs upstream of Carneros Creek, 7,900 cfs for remainder)

The water surface is relatively flat throughout the Airport property, resulting in the same base flood elevation over the entire Airport. Water surface elevations in Carneros and Tecolotito Creeks near Hollister Avenue were predicted to be almost 14 feet NGVD 29, which is higher than the elevation predicted by FEMA. In San Pedro Creek near Hollister Avenue, the FEMA predicted water surface elevation was about elevation 15 feet NGVD 29, which is similar to the elevation predicted by the RMA-2 model. Modeling results indicate that flooding of the airport is primarily from Tecolotito Creek.

Figure 3 shows the start of flooding from Tecolotito Creek, about 8 hours into the storm event. At this time the flow in the creeks is equivalent to about a 2- to 5-year flood event. Figure 4 shows flooding 14 hours into the storm event. At this time flooding is occurring along both sides of the runway. Figure 5 shows flooding 16 hours into the storm event at the peak water surface elevations. At this time, the water surface elevation at the airport terminal is predicted to be elevation 10.4 feet. Arrows on the figure indicate the direction and magnitude of the major flood flows. At peak flood stage, floodwaters cover the entire Airport.

3.2 MODEL LIMITATIONS

Because of the large flat area of the model domain and the large flood flows, the RMA-2 model exhibited numerical stability problems related to wetting and drying. The problems were related to the model's difficulty in determining where the wetting front was at any given time. The wetting front moved across the airport quickly, requiring the model to add a large number of new elements in a short time. To increase model stability, areas of shallow flooding were not resolved in the model. The effect of this assumption is that the airport may flood at a faster rate than predicted by the model. The RMA-2 model has a user-defined parameter for determining when an area becomes dry or wet. For most time steps, an area was considered flooded when the water depth equaled or exceeded 0.6 foot. Therefore, in Figures 3 through 5, areas adjacent to the areas shown as flooded may also be flooded at a depth of less than 0.6 foot. This assumption does not significantly impact the predicted water surface elevations of areas with deeper flooding, which includes most of the airport.

4.0 CONCLUSIONS

Estimates of the base flood elevation at the Airport using the RMA-2 and HEC-RAS models compare reasonably well to the FEMA predicted base flood elevation at the Airport given that the models are very different from each other and from the original FEMA study. In order to revise FIS published base flood elevations, detailed hydraulic modeling and preparation of a Letter of Map Revision (LOMR) would be required. However, the information in this study indicates that the base flood elevations would not be significantly different than reported in the existing FIS. Therefore, the FEMA published elevation should be used as the base flood elevation for the Airport.

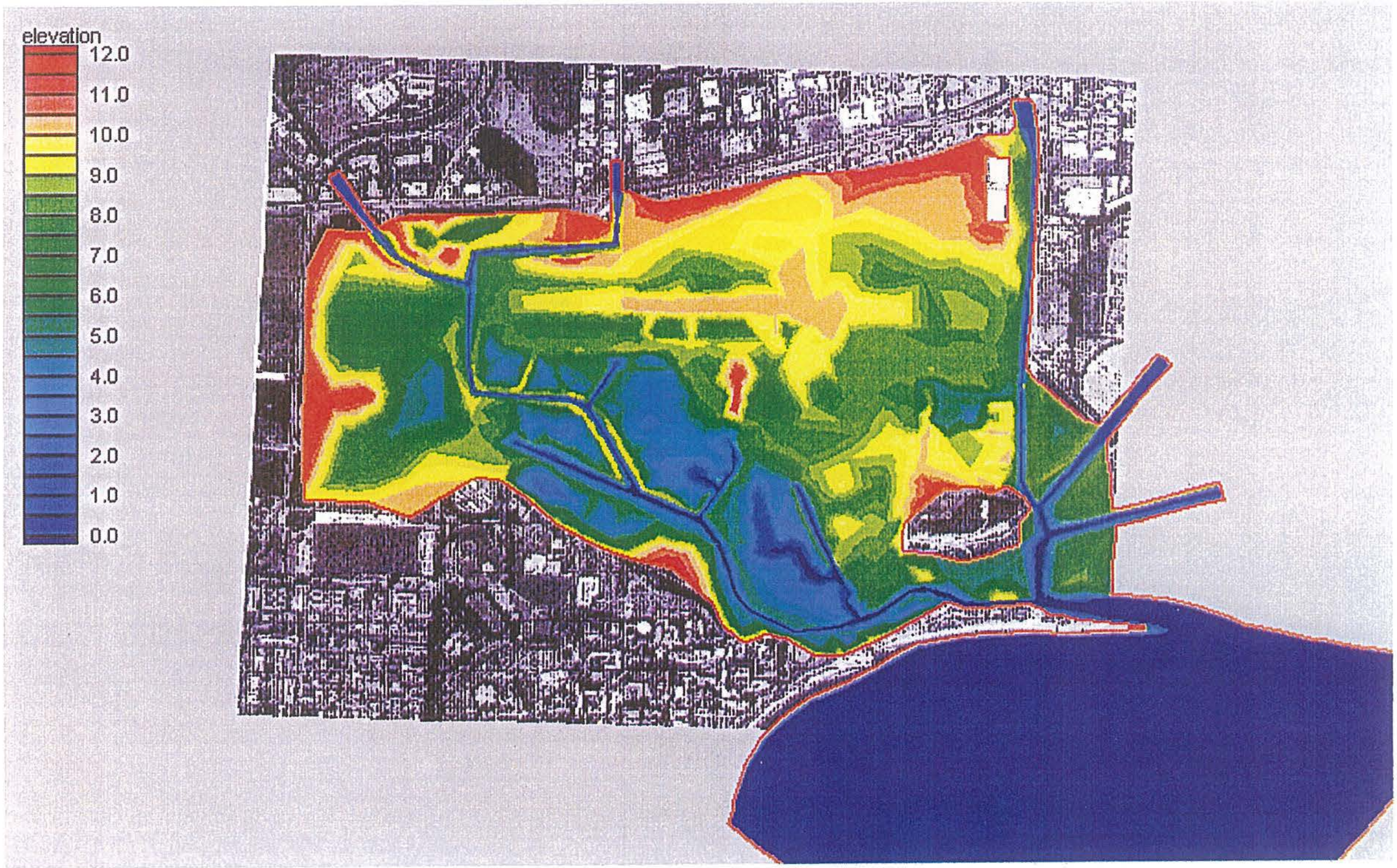


Figure 1. Topography Used in RMA-2 Model

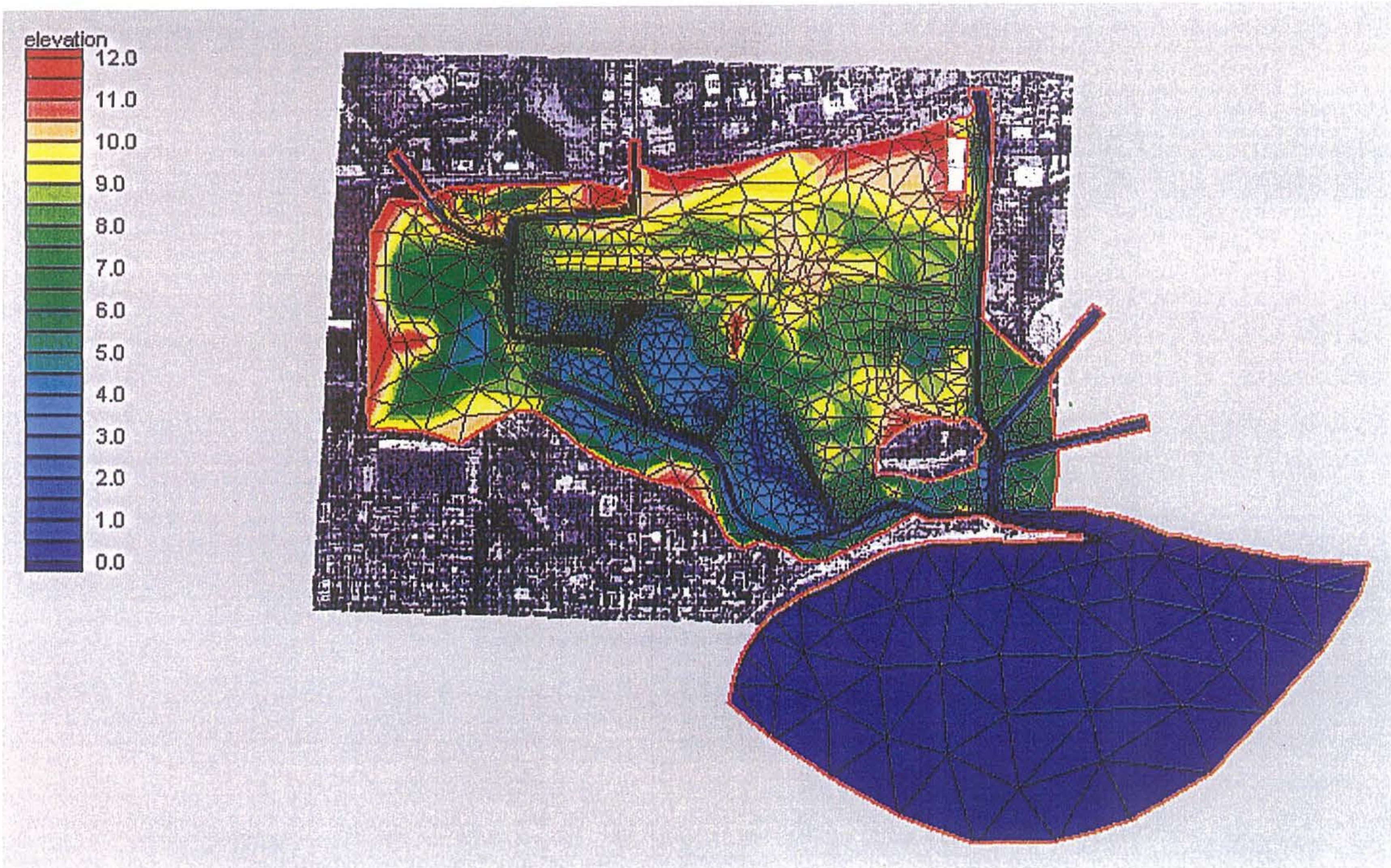


Figure 2. Finite-Element Grid Used in RMA-2 Model

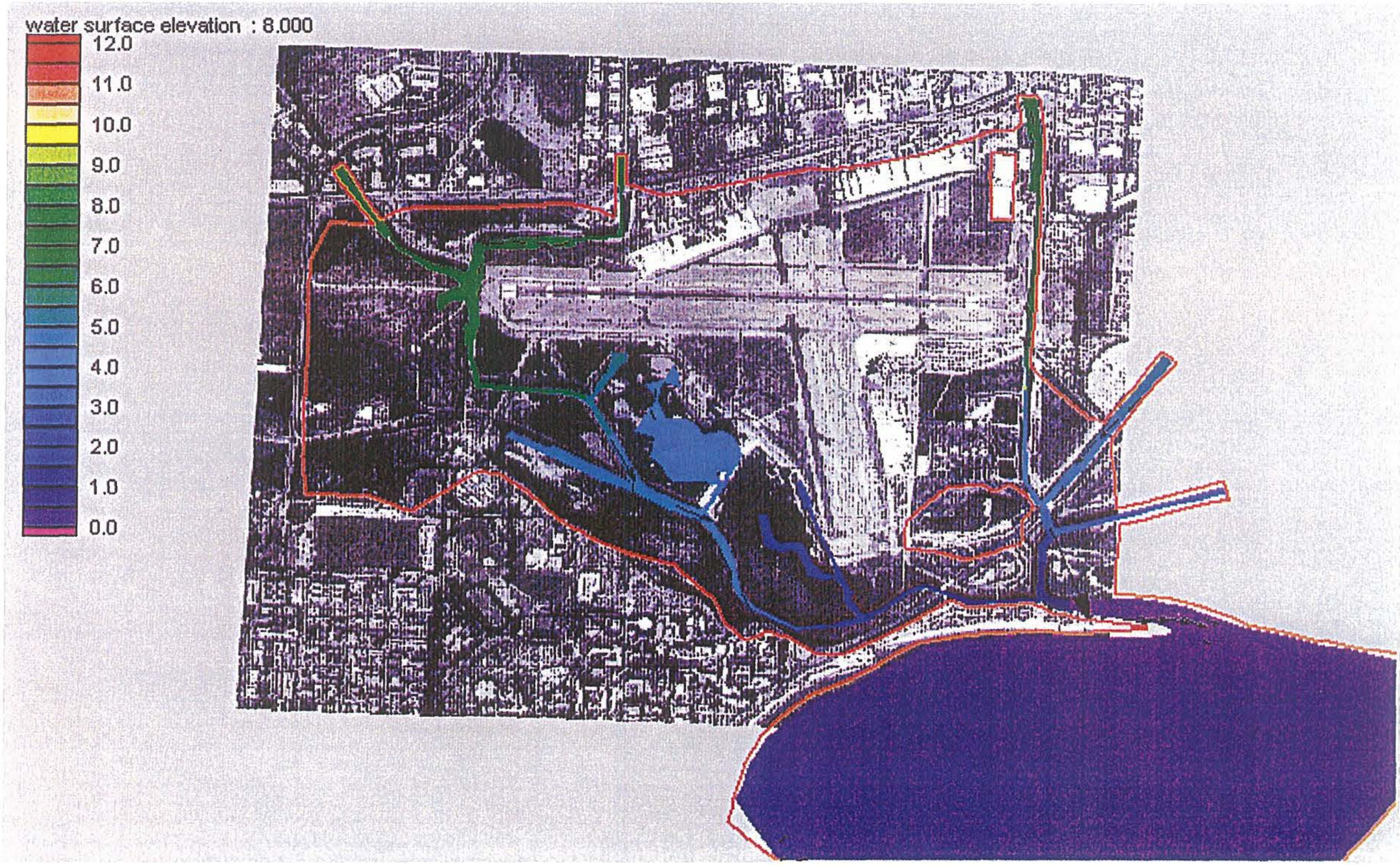


Figure 3. Flooding at the Santa Barbara Airport Predicted by the RMA-2 Model 8 Hours after the Start of the 100yr **Storm and at the Start of Flooding.**

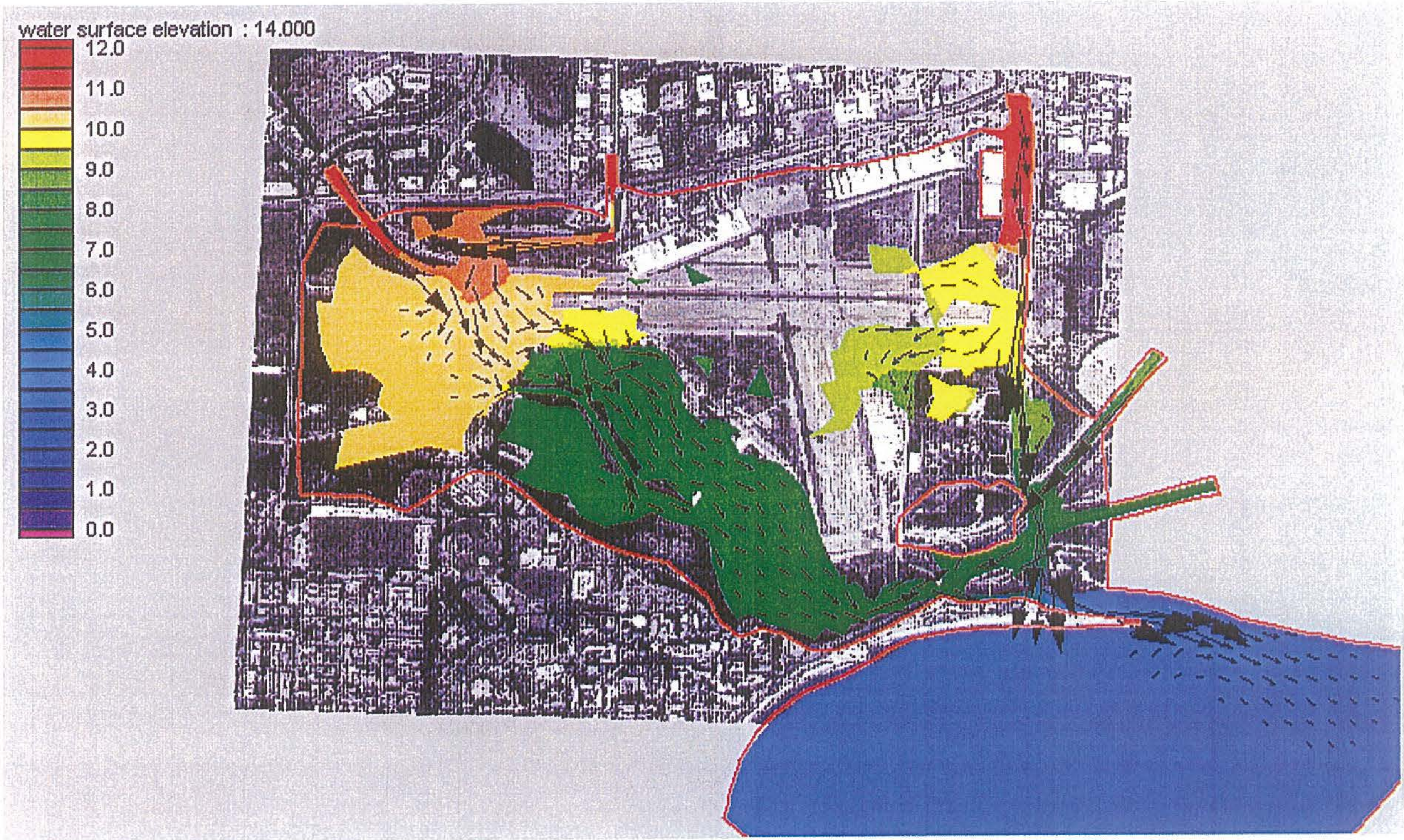


Figure 4. Flooding at the Santa Barbara Airport Predicted by the RMA-2 Model 14 Hours after the Start of the Storm and 6 Hours after the Start of Flooding. Water Surface Elevation 9.1 feet at Terminal.

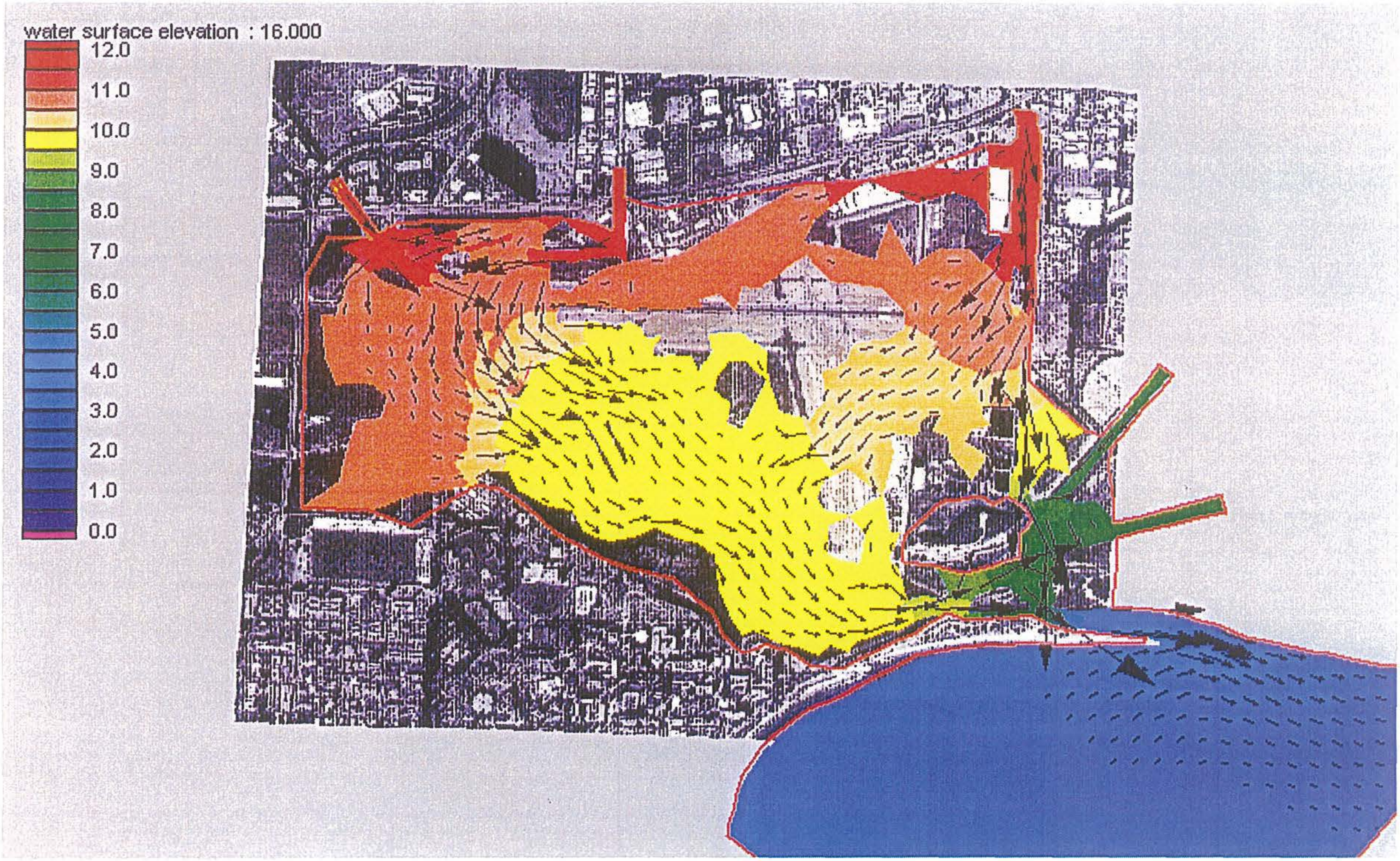
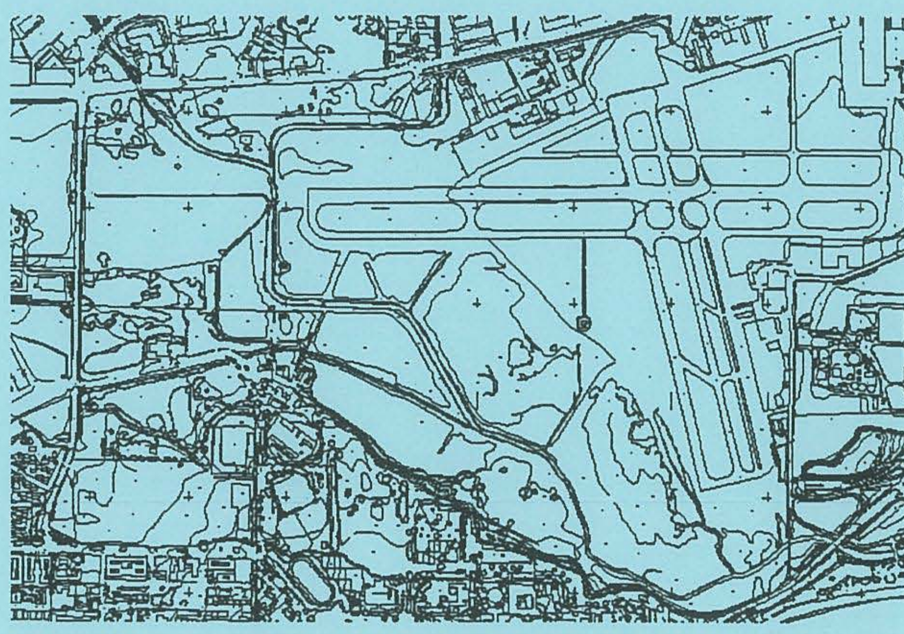


Figure 5. Flooding at the Santa Barbara Airport Predicted by the RMA-2 Model 16 Hours after the Start of the Storm and 8 Hours after the Start of Flooding. Water Surface Elevation 10.4 feet at Terminal.

CHAPTER 3

CHANNEL MODIFICATION ALTERNATIVES FOR THE RSA EXTENSION PROJECT (HYDROLOGY STUDY)



Prepared by URS Corporation
November 2000

CHANNEL MODIFICATION ALTERNATIVES FOR THE RUNWAY SAFETY AREA EXTENSION PROJECT

Master Drainage Plan
Santa Barbara Municipal Airport

November 2000

Prepared for:

Santa Barbara Municipal Airport
City of Santa Barbara
601 Firestone Road
Santa Barbara, California 93117

Prepared by:

URS Corporation
130 Robin Hill Road, Suite 100
Santa Barbara, California 93117

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1.0 INTRODUCTION

The Santa Barbara Municipal Airport (Airport) is owned and managed by the City of Santa Barbara. It is located on the South Coast region of Santa Barbara County, the coastal plain between the Santa Ynez Mountains and the Pacific Ocean. There are three runways in the airfield, which encompasses about 725-acres south of Hollister Avenue (Figure 1, see Appendix A). The Airport property also includes the industrial/commercial area north of Hollister Avenue, as well as most of Goleta Slough and its associated wetlands and tidal channels.

Three creeks are located in and adjacent to the airfield: Tecolotito, Carneros, and San Pedro creeks (Figure 1). These creeks are tributaries to Goleta Slough which empties to the ocean at Goleta Beach. The elevation of the airfield is very low, with an average ground elevation of about 8 to 10 feet above mean sea level. Significant portions of Goleta Slough and the lower ends of the creeks at the Airport are tidally influenced.

The City of Santa Barbara (City) initiated a comprehensive planning process for the Airport in 1994 that included both an Industrial/Commercial Specific Plan and an Aviation Facilities Plan (AFP). The Specific Plan for the land north of Hollister Avenue was approved in 1999. The AFP is currently under development. It consists of various improvements to increase public safety and enhance service at the Airport, while meeting both short-term and log-term aviation needs of the region. The AFP includes the following primary elements:

- Expand the Airport terminal to meet current and future demands and to enhance service, including increased parking facilities
- Increase the number of "T" hangers for small commercial and general aviation airplanes
- Acquire property or easements on non-Airport property at the end of runways to provide the required Runway Protection Zone (RPZ)
- Modify the airfield to meet requirements of the Federal Aviation Administration (FAA) for Runway Safety Areas (RSAs)

A Runway Safety Area (RSA) is the land surrounding a runway that must be smoothed and compacted such that damage to airplanes that overrun the paved surface would be minimized. The existing RSAs at the east and west ends of Runway 7-25, the primary commercial flight runway at the Airport, do not meet FAA requirements. For Runway 7-25, the minimum RSA at each end is 1,000 feet long and 500 feet wide. The lengths of the current RSAs on the east and west ends are only 200 and 350 feet, respectively.

The Airport retained URS Corporation (URS) to assist in identifying RSA extension alternatives to meet the FAA's minimum requirements. One of the primary issues associated with the extension of the RSA was the effect on local drainage at the Airport. Hence, URS was retained to prepare a Master Drainage Plan for the Airport, which included the following independent, but related studies:

- Aviation facilities study to identify RSA extension alternatives
- Wetland impact, wetland mitigation, and bird strike hazard study on the RSA alternatives
- Hydraulic study of the channel modifications associated with the RSA alternatives
- Drainage assessment and improvement plan for the entire Airport

This study addresses the hydraulic impacts associated with the RSA extension alternatives identified in the companion report by URS Corporation – *Runway Safety Area Extension Alternatives, Master Drainage Plan, November 2000.* The scope of the work for this study are listed below:

- Collect basic data including topographic maps, watershed characteristics, rainfall data, tide data, channel cross-section data, and sediment data need for hydrologic, hydraulic and sediment transport analyses.

- Develop a rainfall-runoff model for watersheds that contribute flows into or impact flooding conditions in the airfield area and derive peak design flood flows (2-year, 5-year, 10-year, 25-year, 50-year, and 100-year).

- Develop channel modification scenarios (conceptual level) to accommodate the proposed runway extension project and select the best scenario(s) based on hydraulic and sediment transport performance characteristics.

The study consists of three elements. First, a hydrology study was completed by Penfield & Smith Engineers for the watersheds draining to the Airport to provide design hydrographs for the subsequent analyses. The results of this analysis are presented in Appendix B. A hydraulic analysis was then conducted for the channel modifications associated with the RSA extension alternatives, which included either culverts under the RSA extension or relocated channels. Lastly, a sediment transport analysis was conducted to determine sediment deposition in culverts and relocated channels.

2.0 RSA EXTENSION ALTERNATIVES

Six RSA extension alternatives were identified in the companion report by URS Corporation, *Runway Safety Area Extension Alternatives, Master Drainage Plan, November 2000*, and are listed below. Each alternative involves the establishment of a 1,000-foot long RSA at both ends of Runway 7-25 through a combination of the physical extension of the paved runway and associated RSA, and relocation of the landing threshold (a "mark" on the runway) farther from the end of the paved runway.

TABLE 1
SUMMARY OF ALTERNATIVES

No.	Alternative	Channel Modification at West End	Channel Modification At East End	Fairview Ave Modification
1	West culvert	Culvert		
2	West realignment	Realignment		
3	Fairview realignment/ West culvert	Culvert	Culvert	Realignment
4	Fairview realignment/ West creek realignment	Realignment	Culvert	Realignment
5	Fairview tunnel/ West culvert	Culvert	Culvert	Tunnel
6	Fairview tunnel/ West creek realignment	Realignment	Culvert	Tunnel

The alternatives involve extension of the runway and RSA at the east and west ends of Runway 7-25, either at one end or at both ends. San Pedro Creek and Tecolotito Creek are located at the east and west ends of the runway, respectively. Extension at the west end will require either realigning Tecolotito Creek around the new RSA, or placing the creek in a culvert under the new runway and RSA extension. RSA extensions at the east end will require placement of San Pedro Creek into a culvert under the new RSA. and realigning Fairview Avenue. Relocating San Pedro Creek is not feasible due to insufficient Airport property to accommodate a relocated creek. These channel modification result in three basic hydraulic scenarios:

1. Construction of a culvert to pass flows in Tecolotito Creek under the proposed runway extension. This scenario is required for the Alternatives 1, 3 and 5.
2. Realignment of Tecolotito Creek below the confluence with Carneros Creek to accommodate the proposed runway extension. This scenario is required for the Alternatives 2, 4, and 6.
3. Construction of a culvert to pass flows in San Pedro Creek under the proposed runway extension. This scenario is required for the Alternatives 3 through 6.

The flow and sediment transport capacities under the three channel modification scenarios were analyzed in order to compare their relative hydraulic performance and flooding hazards. Two variations of scenarios were considered for the realignment of Tecolotito Creek (Scenarios 2A and 2B). The channel modification scenarios are briefly described below:

- Scenario 1- Culvert on Tecolotito Creek: Route the combined flows from Carneros and Tecolotito creeks through a 750-foot long and 80 foot wide culvert under the proposed runway extension.

- Scenario 2A - Tecolotito Creek Realignment: Divert the combine flows from Carneros and Tecolotito creeks around the western end of the proposed RSA extension in a new alignment with the same channel dimensions. The realigned channel will stay within the existing Airport property.

- Scenario 2B - Tecolotito Creek Realignment (outside Airport): Divert the combined flows from Carneros and Tecolotito creeks around the western end of the proposed RSA extension. The realigned drainage channel will cross into the adjacent property located to southwest end of the Airport property. This alignment is similar to Scenario 2A but follows a more direct route.

- Scenario 3 - Culvert on San Pedro Creek: Route the flow from San Pedro Creek through a 500-foot long and 60 foot wide culvert under the eastern end of the proposed runway extension.

An overview of the four channel modification scenarios are shown on Figures 2 through 5.

3.0 DATA SOURCES

3.1 HYDROLOGIC DATA

Hydrologic data for this study were developed by Penfield & Smith Engineers, including precipitation and runoff, precipitation-frequency-duration data, and watershed physical characteristics (drainage areas, soil types, vegetation cover, channel slopes, etc.). These data, and the hydrologic analysis conducted to determine peak design flood flows for the project area, are provided in Appendix B (Penfield & Smith, 2000).

3.2 CROSS SECTION DATA

Channel cross-section data used in the most recent Federal Emergency Management Agency (FEMA) Flood Insurance Study were obtained from Penfield & Smith. The exact locations of the cross-sections were not available but their approximate locations could be determined and are shown on Figure 6. In addition to the FEMA cross-sections, five cross-sections were surveyed for this project. These five cross-sections correspond to the locations of tide gages installed for the project. The cross-section locations surveyed are also shown on Figure 6. Two cross-sections were surveyed in the Goleta Slough (Station Nos. 4 and 5), one in San Pedro Creek (Station No. 3) and two in the Goleta Beach inlet channel (Station Nos. 1 and 2).

Figures 7 through 11 show the measured cross-sections. For Station Nos. 1, 4 and 5, FEMA cross-sections were available nearby and are also shown on these figures. The FEMA cross-sections cover the entire floodplain, however, only the channel portion of the cross-section is shown on Figures 7, 10 and 11. At Station #4 the FEMA and newly measured cross-sections are about the same. Station No. 5 is located between FEMA section Nos. 26 and 27. FEMA section No. 26, located downstream, is about 20 feet wider than the measured section. FEMA section No. 27 located upstream has about the same width but is shallower. The differences are most likely due to different measurement locations and time of measurement and the fact that the creek does not have uniform cross-sections along its length. However, the results indicate that the FEMA sections provide a reasonable estimate of channel cross-sections along the stream length.

3.3 SEDIMENT DATA

Streambed sediment were sampled from both Tecolotito and Carneros Creeks and analyzed to determine the particle size. The sediment sampling locations are shown on Figure 6. The particle size distribution curves for the collected sediment samples are shown on Figure 12. The Goleta Slough sample consisted of fine sand, silt, and clay (sample at Station No. 4). Other samples consisted of fine to medium sand with little or no silt and clay. Table 2 summarizes the D_{50} and D_{90} values of the collected sediment samples.

TABLE 2
SUMMARY OF SEDIMENT PARTICLE SIZE ANALYSIS

Sediment Sampling Location	Particle Size (mm)	
	D_{50}	D_{90}
Carneros Creek at d/s of Hollister Ave.	0.30	0.70
Tecolotito Creek at d/s of Hollister Ave.	0.42	2.80
Tecolotito Creek at Station #5	0.22	0.30
Tecolotito Creek at Station #4	0.05	0.19

Table 2 shows that the particle sizes (D_{50}) of sediment samples collected from Tecolotito and Carneros creeks are 0.42 mm and 0.32 mm, respectively. The sediment materials smaller than fine sand are expected to be transported downstream and deposited in the Goleta Slough or transported to the ocean. For example, the D_{50} value is 0.05 mm at Station No. 4 located in the center of Goleta Slough, indicating that mostly fine materials are deposited here.

4.0 EXISTING CONDITIONS

4.1 DRAINAGE BASINS

The Goleta Slough watershed has a total drainage area of about 30,880 acres (48 square miles). The watershed is bisected by Ward Memorial Boulevard forming two watershed areas as follows:

- Watershed area (17,770 acres) located to the west of Ward Memorial Boulevard directly influences the flooding at the airfield area. The creeks located in this area are Tecolotito (3,470 acres), Carneros (2,740 acres), San Pedro/Las Vegas (4,400 acres), San Jose (5,330 acres), and Goleta Slough (1,830 acres).

- Watershed area (13,110 acres) located to the east of Ward Memorial Boulevard influences the outflow from the Goleta Slough at the bridge under Ward Memorial Boulevard. The creeks located in this area are Upper Atascadero (4, 770 acres), Lower Atascadero (620 acres), and Maria Ygnacio/San Antonio (7,720 acres).

4.2 DISCHARGE DATA

The hydrologic characteristics including the estimated peak flood discharges for these basins are provided in detail in Appendix B. Table 3 summarizes the peak design flood discharges estimated at the selected drainage locations of the airfield area.

TABLE 3
SUMMARY OF ESTIMATED PEAK DESIGN FLOOD DISCHARGES

Drainage Basin and Location	Peak Discharge (cfs)					
	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
Tecolotito Creek at Hollister Avenue	300	1,000	1,500	2,500	3,900	4,400
Carneros Creek at Hollister Avenue	300	900	1,300	2,100	3,100	3,600
San Pedro Creek at Hollister Avenue	600	1,500	2,200	3,400	5,000	5,700
San Jose Creek at Hollister Avenue	1,100	2,200	2,800	4,400	6,400	7,200
Outflow from Goleta Slough (u/s of Ward Memorial)	2,200	5,700	7,800	12,800	19,200	21,800
Outflow from Goleta Slough (d/s of Ward Memorial)	1,700	3,800	4,300	5,900	9,100	10,000

4.3 CREEK CONDITIONS

4.3.1 Tecolotito Creek

Tecolotito Creek enters the Airport through a concrete culvert under Hollister Avenue (Figure 1). The creek traverses Goleta Slough through man-made channels for the first two-thirds of its length, then through a natural channel. It leaves Airport property at the bike path footbridge at the end of Moffet Place. The creek goes under Ward Memorial Drive and joins San Pedro, San Jose, and Atascadero creeks before discharging to the ocean at Goleta Beach. The total length of the creek on Airport property is about 9,700 feet.

The creek has tidal influence up to Hollister Avenue. Water is generally present year-round in the creek due to: (1) winter runoff; (2) tidal inflows; (3) ponded water in the Tecolotito Creek Sediment Basin (described below); and (3) nuisance flows from upstream urban uses.

The width of Tecolotito Creek ranges from 75 -150 feet with a depth of 10 to 12 feet between Hollister Avenue and the confluence with Carneros Creek. The first 560 feet of the creek is a sediment basin (see Figure 1) maintained by Santa Barbara County Flood Control District (FCD). It is about 80 feet wide and 8 feet deep, can store up to 10,000 cubic feet of sediments. and is located in the center of the creek. The County FCD removes sediments from the basin on an as-needed basis, which occurs approximately every two years. Sediments are removed using a crane with a dragline operating from either side of the creek. Sediments are placed in adjacent stockpile sites (see below) about 30 to 100 feet from the banks for dewatering and eventual off-site disposal. Dragline operations clear vegetation and reshape the entire width of the channel, which is about 150 feet wide.

The County FCD has built up a 50-foot wide aggregate base road along the north side of Tecolotito Creek from Hollister Avenue to its confluence with Carneros Creek to facilitate the use of heavy equipment and trucks. An 800 by 100 foot sediment dewatering site is located adjacent to the access road on the top of the bank. A similar access road is present on the west side of the creek, along with a smaller sediment dewatering site. Sediment removal is conducted less frequently from the west side of the creek.

The northern banks of the creek between Hollister Avenue and its confluence with Carneros Creek are very steep and devoid of vegetation due to desilting operations. They are in varying stages of erosion. The southern and eastern banks are also very steep, but are covered with vegetation. which is preventing bank erosion. The channel bottom contains a mixture of sands and clays from the watershed. Water is present year round in the basin.

Downstream of the confluence with Carneros Creek, the creek consists of a uniform trapezoidal earthen channel with levees on both sides. The banks are very steep. Erosion from oversteepened banks is present along most of this length, particularly along the base of the banks where there is continual tidal action. The channel is about 50 feet wide and 8 to 10 feet deep. The substrate is a mixture of sand and clay sediments deposited during storm events. Water is present year-round in the channel. Tidal fluctuations range up to 5 feet in height. During significant winter storm events, the channel is filled to the top of the levees.

The man-made levees on both sides of Tecolotito Creek within Goleta Slough end in the center of Goleta Slough. Downstream of this point, the creek is a natural channel that meanders through the salt marsh. The channel is about 30 to 40 feet wide, and five feet deep. The banks are stable and fully vegetated. The channel bottom is a mixture of fine and coarse sediments. Water is present year round.

4.3.2 Carneros Creek

Carneros Creek enters Airport property through a culvert under Hollister Avenue. It then passes under a bridge along Firestone Road. The creek also receives flows from the Firestone Ditch, which drains portions of the Airport property north of Hollister Avenue. The ditch terminates between Hollister Avenue and Firestone Road, and discharges to Carneros Creek through four culverts under Firestone Road. In addition, small surface drainage ditch along the south side of Firestone Road discharges to Carneros Creek along its west bank, immediately downstream of Firestone Road. Carneros Creek is tidally influenced to the Airport maintenance yard.

The reach of Carneros Creek on the Airport is only 2,500 feet long. It is a man-made channel about 50 to 60 feet wide and 10 to 12 feet deep. The first 600 feet of the creek (i.e., the north-south trending reach) is a sediment basin maintained by County FCD (see Figure 1). It is about 60 feet wide and 6 feet deep and can store up to about 6,000 cubic feet of sediments. The County FCD removes sediments from the basin on an as-needed basis, approximately every two years. Sediments are removed using a crane with a dragline operating from the east bank of the creek. Sediments are placed on the other side of the access road along the east bank for dewatering and eventual off-site disposal.

The County FCD has built up a 50-foot wide aggregate base road along the east and south sides of Carneros Creek for the first 900 feet to facilitate the use of heavy equipment and trucks. A similar access road has also been constructed along the north side of Carneros Creek from the Airport maintenance yard to it confluence with Tecolotito Creek. Although this reach is not a routine sediment basin, it has been used for emergency sediment removal in 1995 and 1998. A 400 by 100 foot sediment dewatering site is located adjacent to the access road on the west side of the creek.

The banks on the east side of the creek at the sediment basin site are devoid of vegetation and highly eroded, although they have a gentle slope (about 2:1). The northern banks of the creek from the Airport maintenance yard to the confluence with Carneros Creek are very steep, devoid of vegetation, and eroding. The southern bank is also very steep, but is covered with vegetation, which is preventing bank erosion. The channel bottom contains a mixture of sands and clays from the watershed. Water is present year round in the basin.

4.3.3 San Pedro Creek

San Pedro Creek has two main tributaries: San Pedro Creek and Las Vegas Creek. It has the largest watershed of the creeks at the Airport. The two tributaries join immediately upstream of the Hollister Avenue bridge, then the creek extends along Fairview Avenue to its confluence with San Jose Creek, then with Tecolotito and Atascadero Creek, and finally to the ocean at Goleta Beach. The entire lengths of San Pedro and Las Vegas creeks on Airport property consists of maintained man-made channels. San Pedro Creek is tidally influenced up to Matthews Road, about 1,500 feet upstream of the Fowler Road bridge. Water is only present above this point during winter runoff.

San Pedro Creek upstream of Hollister Avenue is a man-made earthen channel about 40 to 50 feet wide and five feet deep. The substrate of the channel is loose silt and sand sediments. The banks of San Pedro Creek are varied – portions contain concrete bank protection, while other areas are devoid of vegetation and eroding. Downstream of Hollister Avenue, San Pedro Creek consists of a uniform earthen trapezoidal channel with concrete bank protection along limited reaches. The average channel width is about 50 to 60 feet, with a depth of 8 to 10 feet. The bed consists of loose silt and sand sediments. The channel bed is actively cleared of vegetation by County FCD. During significant winter runoff events, the channel of San Pedro Creek along Fairview Avenue is often filled to the top of the channel. County FCD maintains a sediment basin downstream of the Fowler Road bridge.

4.4 FLOODPLAIN

The entire airfield area is located within a special flood hazard area (floodplain) inundated by 100-year flood event according to Flood Insurance Rate Map (Community Panel Number 060335 0003D) prepared by FEMA. There are two distinct floodway areas that lie within the airfield floodplain. The one is located along Tecolotito Creek between Hollister Avenue and Goleta Slough and the other is located along San Pedro Creek between Highway 101 and Fowler Road.

The 100-year floodplain elevation on the airfield varies from 11 to 16 feet above mean sea level. The runway elevation is approximately 10.0 feet, while the taxiway elevation is approximately 7.5 feet. This indicates that the surfaces of the runway and taxiway are located one and 2.5 feet below the floodplain elevation, respectively.

4.5 DEPRESSION STORAGE

Depression storage areas with large detention storage volumes located within a watershed can significantly influence the flooding conditions in a watershed. Accumulation of surface runoff in these areas can reduce peak flow rates and increase sediment deposition volumes in storage basins during storm events.

There are few natural depression storage areas located within the Goleta Slough watershed. The major natural storage basin is the Goleta Slough wetlands, which have a storage capacity of about 4.8 million-yards^3. The natural storage basins that are located upstream of Highway 101 on Carneros and Las Vegas creeks have storage capacities of about 239,000 and 29,000 yards^3, respectively.

4.6 STORAGE IN SEDIMENT BASINS

As described above, the County FCD maintains two sediment basins on Tecolotito and Carneros creeks downstream of Hollister Avenue. The storage capacities of the basins are about 10,000 $yards^3$ on Tecolotito Creek and 6,000 $yards^3$ on Carneros Creek, respectively. The past experience with maintenance/dredging activities has shown that these basins have sufficient storage capacities to hold sediment materials generated during smaller, frequent flood events. However, they are too small to accommodate sediment materials generated during major flood events. On the average, they require de-silting about every other year. A review of sediment data collected from Tecolotito and Carneros creeks (see Figure 12) indicates that the basins primarily capture fine to medium size sand particles. The materials smaller than fine sand are expected to be transported downstream and deposited in the Goleta Slough or transported to the ocean.

4.7 OBSERVED FLOODING HAZARDS

Three major flood events have occurred in 1995 and 1998 that have resulted in major flooding and extensive sediment deposition in the airfield area. The affected areas and events are summarized below:

- Extensive sediment deposition occurred in Carneros Creek south of Firestone Road that resulted in blocking upstream ditches and culverts. The blocked drainage caused flooding of Airport tenant business south of Firestone Road, and adjacent airfield.

- Extensive sediment deposition occurred in Tecolotito and Carneros creeks below Hollister Avenue that resulted in an overall decrease in channel capacity on the Airport property. This caused a breakout along Tecolotito Creek immediately downstream of the confluence, and a breakout along Carneros Creek immediately upstream of the confluence. Flood waters reached the runway and safety area at the west end of Runway 7-25.

- Flooding and sediment deposition occurred on Runway 7-25, Runway 15R-33L, Runway 15R-33R, and Taxiways A, B, C, D, H, and J. The flooding was due to a combination of backwater flooding from storm drain system in the infield that was overwhelmed by the high flood flows and tides in Goleta Slough that prevented drainage; high amount of direct precipitation and local runoff on the airfield; flooding from Tecolotito and Carneros creeks at the west end of the airfield; and flooding from San Pedro Creek in the northwest corner of the Airport.

- The banks of San Pedro Creek were eroded during flood flows near the easterly end of Runway 7-25 safety area.

5.0 STUDY METHODS AND ASSUMPTIONS

The four channel modification scenarios described in Section 2 were analyzed to evaluate channel flow and sediment transport capacities. The methodologies used to estimate flow and sediment transport capacities for the existing conditions and the channel modification scenarios are described in Sections 5.2 and 5.3, respectively. For each scenario, the proposed channel and culvert sizes were selected to maintain the existing flow capacity of the system and to minimize the impact flooding at the airfield area. The NGVD 1929 datum was used as the referenced datum for elevation data and the results presented in this report.

5.1 METHODOLOGY FOR HYDRAULIC FLOW MODELING

The Army Corps of Engineer's HEC-RAS model was used to analyze hydraulic flow conditions for the four selected scenarios. Each scenario was evaluated for the 2-year, 5-year, 10-year, and 100-year peak flood events. The existing conditions were also modeled for Tecolotito and San Pedro creeks in order to provide a basis for comparison.

5.1.1 Cross Sections

Cross sections used in the FEMA Flood Insurance Study were used for the geometry of Tecolotito Creek. However, the east bank of FEMA section No. 27 was raised from 5.0 to 7.4 feet, based on recent Airport improvement plans (City of Santa Barbara, 1997). Since no cross section data were available for Carneros Creek, estimated geometries were developed. The bottom elevation of Carneros Creek above the confluence with the existing Tecolotito Creek was estimated to be at the same elevation as FEMA section No. 28 (see Figure 6). The channel slope was estimated at approximately 0.0002 ft/ft. Channel geometry outside of the channel was estimated from the county topographic map. Carneros Creek was estimated to be 45 feet wide.

The channel geometry for San Pedro Creek on the western end of the runway, as well as upstream. was based on the San Pedro Creek cross-section surveyed by URS (Station No. 3), and the slope was estimated to be approximately 0.0002 ft/ft. The channel geometry downstream of the runway was estimated from both the County topographic map and the cross-section measured by URS on Atascadero Creek (Station No. 2). The slope of the channel between the two surveyed cross-sections was approximately 0.0003 ft/ft. The channel geometry between the surveyed section on Atascadero Creek and FEMA section No. 1 was interpolated.

The tidal elevation at section No. 1 from the FEMA Flood Insurance Study (see Figure 6) was used as a downstream boundary condition for each the scenario.

5.1.2 Channel and Culvert Dimensions

Scenario 1 - Culvert on Tecolotito Creek

The culvert under the western end of the runway (just downstream of FEMA section No. 27) was assumed to be 750 feet long and 80 feet wide, as shown on Figure 13. The culvert invert was assumed to be at elevation of 2.1 feet to match the existing channel bed elevation. The runway surface at the culvert was assumed to be at about elevation 10.3 feet based on the proposed runway profile. The culvert soffit was assumed to be two feet below the runway surface. This would result in a maximum culvert opening height of 6.2 feet (with runway surface at elevation 10.3 feet).

Scenario 2A - Tecolotito Creek Realignment

The realignment of Carneros and Tecolotito creeks is shown on Figure 14. This alignment was chosen to reduce hydraulic constraints, and most importantly, to locate the open channel as far from the end of the runway as possible in order to reduce bird strike hazards. The new channels would have the same or slightly greater width than the existing channels, with slightly steeper and more uniform banks. The new channels would have a 40 to 45-foot wide bottom and a 60-foot wide top width, and side slopes that range from 1:1 to 1.25:1 (H:V). The slope of the realigned Tecolotito Creek was assumed to be constant at 0.0002 ft/ft.

The 400-foot long channel between Hollister Avenue and the new confluence with Carneros Creek was assumed to be 150 feet, and the 375 feet downstream of the confluence was assumed to be 80 feet wide. This 775-foot long section would replace the existing 560-foot-long sediment basin on Tecolotito Creek (Figure 14). Sediment could be removed from both sides of the creek in the same manner currently used by the County FCD.

Scenario 2B - Tecolotito Creek Realignment (Outside Airport)

Under this scenario, Carneros and Tecolotito creeks would be realigned in a similar manner as under Scenario 2A, except that the lower end of the realigned Tecolotito Creek would be connected to a tidal channel in Goleta Slough, south of the existing channel (see Figure 4). The objective of this scenario is to create a straight alignment to reduce sediment deposition in the relocated creek reach, to the extent feasible. This scenario would require purchase of property outside the Airport, and would likely require widening of the downstream channel within Goleta Slough. The slope of the new channel was assumed to be constant at 0.0005 ft/ft between FEMA section Nos. 31 and 19 (Figures 4 and 8).

Scenario 3 - Culvert on San Pedro Creek

The culvert under the eastern end of the runway was assumed to be 500 feet long and 60 feet wide, as shown on Figure 15. The culvert invert was assumed to be at about elevation of 0.6 feet (to match the existing channel bed elevation), with the soffit two feet below the runway surface. The existing elevation at the eastern end of the runway was assumed to be about 9.0 feet. This would result in a maximum culvert opening height of 6.4 feet (without raising the exiting runway surface elevation). Under this scenario, Fairview Avenue would either be realigned or placed into a tunnel.

5.2 METHODOLOGY FOR SEDIMENT TRANSPORT MODELING

5.2.1 Sediment Transport Model

An in-house sediment transport model was developed to determine bed-load sediment transport capacities of Carneros and Tecolotito creeks. The creek cross-section and sediment sample data reported in Sections 3.2 and 3.3 were used as input data to the sediment transport model. The flow data required for these models include slope of the water surface, water depth and velocity.

The sediment transport capacity for a stream reach was estimated using the relationship:

$$Q_s = aQ_f^b$$

where:

Q_s = sediment transport rate (tons/sec)
Q_f = water discharge (feet/sec)
a,b = empirical coefficients

The sediment transport model included nine different bed-load sediment transport equations and they are used to estimate the coefficients a and b. Development of these equations was based on experimental sediment data with different particle size distributions. Therefore, each sediment transport equation is usually recommended only for the range of particle sizes that was used in its development. The sediment transport equations included in the model are given Table 4.

TABLE 4
SEDIMENT TRANSPORT EQUATIONS INCLUDED IN THE MODEL

Sediment Transport Equation	Recommended Range of D_{50} (mm)
DuBoys	0.05 to 5.0
Meyer-Peter	3.0 to 30.0
Meyer-Peter Muller	0.40 to 30.0
Engelund-Hansen	0.20 to 1.0
Einstein-Brown	0.30 to 7.0
Inglis-Lacey	0.01 to 1.0
Schoklitsch	0.30 to 5.0
Laursen	0.01 to 4.0
Shields	1.7 to 2.5

In general, most of these bed-load sediment transport equations are formulated based on critical bed shear stress approach. The sediment transport capacity is a function of the bed shear stress induced by the flow rate as depth of water in the channel and the critical shear stress associated with sediment particle size. When the bed shear stress is smaller than the critical shear stress, there is no bed-load sediment transport capacity.

When there is no sediment transport capacity (to transport bed-load sediment), the only sediment carried by the water will be the particles that can remain in suspension. The suspended sediment will settle according to the settling velocity of the particle. For different particle sizes, settling velocities can be obtained from Simons and Senturk (1992). It is assumed that a sediment particle will settle in a channel reach according the following relationship:

$$D^* V/L < V_S$$

where:

D = depth of flow
V = velocity of flow
L = length of channel reach
V_s = settling velocity

This relationship says that that time for a particle to settle to the bottom is less then the time for the particle to be advected through the reach.

Under existing conditions, the sediment sample data collected from the Goleta Slough indicates that most suspended sediment materials are transported past the Airport to the ocean.

Table 6. Sediment Transport Characteristics of Carneros Creek - Existing Conditions

Carneros Creek (at u/s reach of Hollister Avenue)

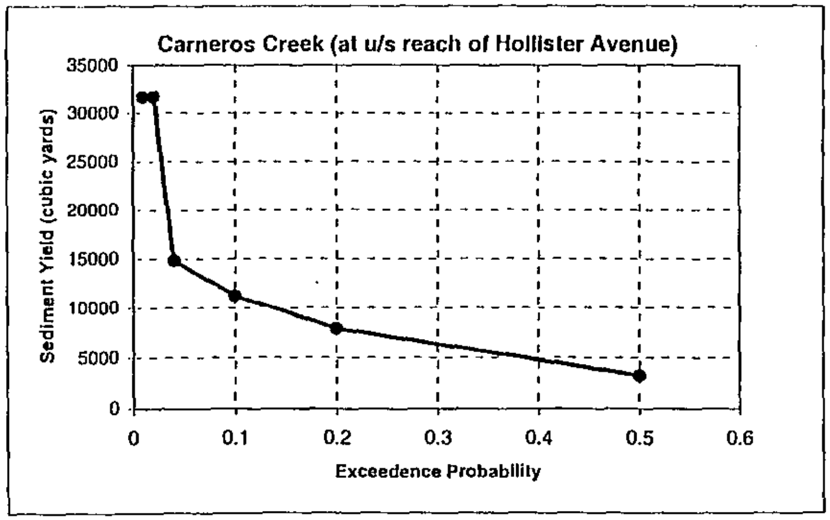
Return Period	Exceedence Probability	Peak Channel Discharge (cfs)	Total Sediment Yield (yards^3)	Incremental Sediment Yield (yards^3)
2	0.5	300	3202	
5	0.2	900	7899	1665
10	0.1	1300	11217	956
25	0.04	2100	14782	780
50	0.02	2900	31667	464
100	0.01	2900	31667	317

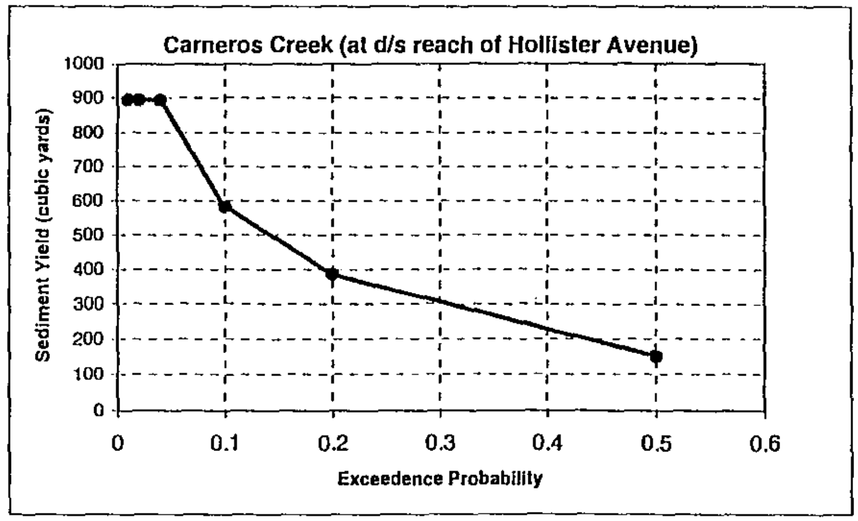
Average Annual Sediment Inflow (cubic yards) => 4182

Carneros Creek (at d/s reach of Hollister Avenue)

Return Period	Exceedence Probability	Peak Channel Discharge (cfs)	Total Sediment Yield (yards^3)	Incremental Sediment Yield (yards^3)
2	0.5	300	151	
5	0.2	550	385	80
10	0.1	850	583	48
25	0.04	1100	894	44
50	0.02	1100	894	18
100	0.01	1100	894	9

Average Annual Sediment outflow (cubic yards) => 200





Results:	
Average Annual Sediment Inflow (cubic yards) =>	4182
Average Annual Sediment Outflow (cubic yards) =>	200
Average Annual Sediment Deposition (cubic yards) =>	3982

Table 7. Sediment Transport Characteristics for Channel Modification Scenarios Analyzed

Scenario	Channel Reach[1]	Mean Annual Sediment Volume (yards^3) Inflow	Outflow	Deposition
Existing Condition	Channel Reach A-B: Tecolotito Creek (reach between Hollister Ave. and confluence with Carneros Creek)	6786	183	6603[2]
	Channel Reach C-D: Carneros Creek (reach between Hollister Ave. and confluence with Tecolotito Creek)	4182	200	3982[3]
	Channel Reach E-F: Tecolotito Creek (reach between the confluence with Carneros Creek and the sharp bend to the east)	383	734	-351[4]
Scenario 2A (Tecolotito Creek Realignment)	Channel Reach H-I-F-G:			
	Reach H-I:	383	209	175
	Reach I-F	209	214	-6
	Reach F-G	214	734	-520[4]
Scenario 2B (Tecolotito Creek Realignment)	Channel Reach H-I-J-G:			
	Reach H-I	383	354	29
	Reach I-J	354	312	43
	Reach J-G	312	388	-76[4]
Scenario 1 (Culvert on Tecolotito Creek)	Tecolotito Creek	n/a[5]	n/a[5]	n/a[5]
Scenario 3 (Culvert on San Pedro Creek)	San Pedro	n/a[6]	n/a[6]	n/a[6]

Note:

1. Refer the attached figure for channel reach locations (Figures 2 to 5).
2. Most of this sediment is expected to deposit in the Tecolotito Creek sediment basin, which is located at the u/s section of this reach.
3. Most of this sediment is expected to deposit in the Carneros Creek sediment basin, which is located at the u/s section of this reach.
4. No sediment is expected to deposit in this reach.
5. During a 1:5-year storm event, the inlet to the culvert starts to plug (after filling the two u/s sediment basins).
6. A flood event larger than the mean annual flow is expected to plug the inlet to the culvert.

The peak flood events larger than the 10-year event will result in flooding of the Airport property from Tecolotito and San Pedro creeks because the flows almost exceed the existing channel capacities. Therefore, the scenarios for the RSA extension alternatives were only analyzed for the flood events up to the 10-year flood event. For larger flood events, flooding in the airfield area would be the same as the existing conditions under all scenarios.

6.1.2 Scenario 1 – Culvert on Tecolotito Creek

Figure 18 shows the water surface elevation in Tecolotito Creek for various sized culverts under the western end of the runway. In order to pass the 10-year flood on Tecolotito Creek, a 750-foot long culvert under the western end of the runway would need to be approximately 80 feet wide (the modeling assumed five 16-foot wide barrels). In addition, Runway 7-25 would need to be raised from 9.0 to 10.3 feet to provide sufficient height in the culvert. The minimum soffit for the runway is two feet. The invert of the culvert would be 2.1 feet. Hence, the height of the culvert would be 6.2 feet.

Figure 19 shows the resulting water surface profile assuming a culvert with a total width of 80 feet and height of 6.2 feet. Table 10 summarizes the estimated hydraulic flow conditions including channel flow velocities, depths, and water surface elevations at the upstream end of the 80-foot wide culvert on Tecolotito Creek.

TABLE 10
HYDRAULIC FLOW CONDITIONS ON TECOLOTITO CREEK AT CULVERT INLET

Design Event	Peak Flow (cfs)	Velocity (feet/sec)	Flow Depth (feet)	W.S.E (feet)
2-year	600	3.8	3.6	5.7
5-year	1,900	0.9	6.4	8.5
10-year	2,800	0.8	8.0	10.1(1)

(1) Proposed elevation at the western end of the runway is 10.3 feet (see Section 5.2.2).

The water surface elevation at the upstream end of the 80-foot wide culvert would be 10.1 feet for the 10-year flood event in Tecolotito Creek. This elevation is about 0.2 foot lower than the proposed extended runway elevation of 10.3 feet (at western end). However, if the culvert were constructed to match the main channel width of 50 feet, the water surface elevation would rise to 10.5 feet for the 10-year flood event.

TABLE 12
HYDRAULIC FLOW CONDITIONS ON SAN PEDRO CREEK AT CULVERT INLET

Design Event	Peak Flow (cfs)	Velocity (feet/sec)	Flow Depth (feet)	W.S.E (feet)
2-year	600	3.7	4.9	5.5
5-year	1,500	5.1	7.7	8.3
10-year	2,200	5.7	9.4	10.0

6.2 SEDIMENT TRANSPORT RESULTS

6.2.1 Existing Conditions

The two existing sediment basins that are located in Tecolotito and Carneros creeks have sediment holding capacities of about 10,000 yards^3 and 6,000 yards^3, respectively. The results shown in Table 7 showed that the two existing sediment basins have sufficient storage capacity to intercept estimated sediment volumes transported through Tecolotito (6,786 yards^3) and Carneros (4,182 yards^3) creeks on mean annual basis.

Table 13 summarizes the estimated sediment transport volumes at the upstream reach of Tecolotito and Carneros creeks for design storm events of 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year.

TABLE 13
ESTIMATED SEDIMENT TRANSPORT VOLUMES UPSTREAM OF HOLLISTER AVENUE

Return Period (years)	Sediment Volume (yard^3)	
	Tecolotito Creek	Carneros Creek
2	2.548	3,202
5	12,385	7,899
10	18.259	11.217
25	30,859	14,782
50	59,116	31.667
100	69,039	31,667
Mean Annual	6,786	4,182

The results show that, when both sediment basins are empty, they have sufficient capacities to hold sediment volumes generated during a 2-year design storm event. However, during a 5-year design storm event, both basins are expected to fill completely with sediment (12,385 yards^3 in Tecolotito Creek and 7,899 yards^3 in Carneros Creek). The remaining sediment materials that overflow the two sediment basins (4284 yards^3) are expected to deposit in Tecolotito Creek below the confluence with Carneros Creek.

6.2.2 Scenarios 2A and 2B – Tecolotito Creek Realignments

The sediment transport characteristics of Tecolotito and Carneros creeks (above the confluence) will remain the same for the existing and the proposed channel modification scenarios. However, the channel reaches downstream from the confluence will have slightly different sediment transport characteristics between the existing and the proposed channel modification scenarios (see Table 7).

For example, no sediment deposition is expected within the channel at the end of Runway 7-25 (i.e., Reach E-F; see Figure 2) under existing conditions. However, some sediment deposition is expected for Scenarios 2A and 2B along the new channel alignment, downstream of the end of the runway (Scenario 2A: 171 $yards^3$ in channel reach H-I-F) and (Scenario 2B: 72 $yards^3$ in channel reach H-I-J). The increased sediment deposition downstream of the County FCD's sediment basins would be due to the decreased in channel slope along the new alignment relative to existing conditions. However, the increase in deposition would be less than 3 percent of the deposition in the Tecolotito Creek basin, and would not result in increased deposition in the center of Goleta Slough (see Table 7).

In summary, the effectiveness and rate of accrual in the two County FCD sediment basins would not be affected by the realigned channels, nor would the new channels significantly affect the sediment transport characteristics of Tecolotito Creek at the end of the runway and in the center of Goleta Slough. As such, it does not appear that substantial and regular channel desilting would be required along the new channel, except where it has been designated for County FCD.

6.2.3 Scenarios 1 and 3 – Culvert Options

The culvert options are proposed to pass flows in Tecolotito and San Pedro creeks under the proposed runway extension for Scenarios 1 and 3, respectively. During major flood events (5-year or larger), the culverts along both creeks would fill and cause a backwater effect upstream, which in turn, would reduce upstream flow velocities and water surface slopes.

The backwater effect (created by major flood events) would reduce the bed shear stress to less than the critical shear stress value, reducing the sediment transport capacity to near zero. This would result in bed-load sediment materials to settle in the approach channel to the culverts along both Tecolotito and San Pedro creeks (Scenarios 1 and 3). This deposition would occur upstream of the proposed RSA extension and increase the potential for flooding of the runway and RSA compared to existing conditions and Scenario 2 with an open channel.

For example, the bed shear stress at the upstream reach of a culvert on Tecolotito Creek was estimated to be as 0.0037 lbs/ft^2 for the 5-year flood event. This estimated bed stress is less that the critical bed stress of 0.018 lbs/ft^2 for D_{50} of 0.22 mm (see Table 2). Therefore, the bed-load sediment materials carried into this reach are expected to settle in the approach channel to the culvert. This would continue until the capacity of the approach channel to hold the sediment materials is exhausted. The sediment materials would then start to move into the culvert and result in plugging the culvert.

The setting velocity of suspended sediment under Scenarios 1 and 3 would not be large enough to cause the suspended sediment materials to settle in the approach channel. Therefore the suspended sediment materials would continue to be transport downstream of the culverts to the Goleta Slough, as under current conditions and under Scenario 2.

6.3 MAINTENANCE REQUIREMENTS

6.3.1 Scenarios 1 and 3 – Culvert Options

As noted above, base-load sediments during major flood events (5-year or larger) would settle in the approach channel to the culverts, and eventually move into the culvert and plug it. This situation would caused an increase in flooding of the runways compared to existing conditions, and compared to Scenarios 2A and 2B. Under emergency conditions, the sediment could be removed from the approach channel and from the airfield runway. However, it would not be possible to remove sediment from the culvert during or soon after flood flows. Hence, options to relieve airfield flooding during emergencies would be limited.

Routine maintenance of the culverts would be problematic due to the confined space of the culverts. For example, the short height of the culverts would preclude standard earthmoving equipment used for sediment removal such as clamshells, draglines, or gradalls. Hence, customized equipment with small capacity buckets would be needed. In addition, there would be significant hazards involved in a mechanized removal of sediment from the culverts due to the potential for build up of noxious gasses from equipment exhaust and sediment emissions, potential for equipment become stuck in soft sediments, and limited ability for access in an emergency. At the very least, sediment removal from a 500 to 750 foot long culvert would be a very time consuming and labor intensive action, that may require restrictions on use of the runway. Finally, hydraulic dredging of the culvert is not considered a viable option for two reasons. One, there would be insufficient room and water depth to float a dredge. Two, there is insufficient room for dewatering a slurry from a hydraulic dredges along either Tecolotito Creek or San Pedro Creek. For these reasons, the culvert scenarios (Nos. 1 and 3) are not considered feasible options.

6.3.2 Scenarios 2A and 2B – Tecolotito Creek Realignment

As described above, the two County FCD sediment basins would not be affected by the realigned channels under these scenarios, nor would the new channels significantly affect the sediment transport characteristics of Tecolotito Creek at the end of the runway and in the center of Goleta Slough. As such, it does not appear that substantial and regular channel desilting would be required along the new channel, except where it has been designated for County FCD. There may be an occasional need to desilt portions of the realigned channel at and downstream of the extended RSA. However, this would likely occur on a very infrequent basis (e.g., every 5 to 10 years) and would not extend into Goleta Slough. Finally, sediment maintenance along the channel alignment under Scenario 2B would be slightly less than under Scenario 2A, although the difference is so small that it may not be measurable under real world conditions.

7. SUMMARY AND CONCLUSIONS

7.1 HYDRAULIC FLOW ANALYSIS

Existing Conditions

The existing bank-full flow capacity of Tecolotito Creek at the western end of the runway is approximately equivalent to the 10-year flood event of 2,800 cfs. The water surface elevation at the bank-full capacity is estimated to be 8.8 feet, which is about 0.2 feet below the existing runway elevation of 9.0 feet.

The existing bank-full flow capacity of San Pedro Creek at the eastern end of the runway is approximately between the 5- and 10-year flood event. For the 10-year flood event of 2,200 cfs on San Pedro Creek, the water surface elevation on the eastern side of the runway is estimated be at 10.0 feet, which is about 1.0 foot above the existing runway elevation of 9.0 feet.

The peak flood events larger than the 10-year event would result in flooding of the airport property from Tecolotito and San Pedro creeks, because the flows exceed the existing channel bank-full capacities.

Scenario 1 – Culvert on Tecolotito Creek

Based on the results of hydraulic analysis for Scenario 1, a 750-foot long, 80-foot wide, and 6.2-foot high box culvert would be needed on Tecolotito Creek to maintain the existing bank-full channel flow capacity, which is equivalent to the 10-year flood event. In addition, the runway and RSA would need to be raised about one foot.

Scenarios 2A and 2B – Tecolotito Creek Realignments

Scenario 2A would result in 0.2 foot decrease in water surface elevation over the existing water surface elevation of 8.8 feet on Tecolotito Creek in the area just west of the proposed runway extension for the 10-year flood event. As such, there would be a minor decrease in flooding hazard. Scenario 2B would not change the water surface elevation over the existing conditions. and as such, does not improve hydraulic conditions or reduce flooding hazards compared to Scenario 2A. The runway and RSA would need to be raised under these scenarios. This would require offsetting the increase in elevation of the floodway to maintain the current 100-year flood elevation, which may not be feasible in the airfield.

Scenario 3 – Culvert on San Pedro Creek

There is an insufficient elevation difference between the channel bottom and the existing runway elevation to construct a culvert with a 10-year flow capacity. The existing runway need to be raised at least up to an elevation of 10.0 feet to pass the 10-year flood event with a 60 feet wide and 7.4 feet high box culvert. Therefore, installing a culvert on San Pedro Creek would result in an increase flooding of the airfield unless Runway 7-25 were raised. Raising the runway would require offsetting the increase in elevation of the floodway to maintain the current 100-year flood elevation.

7.2 SEDIMENT TRANSPORT ANALYSIS

Existing Condition

The existing sediment basins located on Tecolotito and Carneros creeks have enough capacity to intercept sediment materials transported through the creeks on mean annual basis. However, the peak flood flows larger the 5-year event are expected to fill both basins completely. The remaining sediment materials that overflow the two basins are expected to deposit in Tecolotito Creek below the confluence with Carneros Creek.

Scenarios 1 and 3 – Culvert Options

Base-load sediments during major flood events (5-year or larger) would settle in the approach channel to the culverts. This would continue until the capacity of the approach channel to hold the sediment materials is exhausted. The sediment materials would then start to move into the culvert, plugging it and causing backwater flooding and overtopping of the culvert. This situation would cause an increase in flooding of the runways compared to existing conditions, and compared to Scenarios 2A and 2B. These scenarios require raising the ends of the runway.

Scenarios 2A and 2B – Tecolotito Creek Realignments

The realigned channel would not affect the operations or effectiveness of the existing County FCD sediment basins. There would be a slight increase in sediment deposition below the confluence of Tecolotito and Carneros creeks due to the decreased slope of the modified channel relative to the existing conditions. However, the increase would be negligible and would not likely cause a need for regular or substantial channel maintenance. Scenario 2B provides only a negligible increase in sediment transport compared to Scenario 2A.

7.3 CONCLUSIONS

1. Scenario 2A is the preferred hydraulic solution for the runway RSA extension project at the west end of Runway 7-25. The realigned open channel would provide a minor improvement in channel capacity and concomitant reduction in flood hazard due to a slightly larger dimension, and because the channel would be located farther from the paved runway. It would not cause a significant increase in sediment deposition near the RSA, nor would it increase sediment deposition in Goleta Slough. As such, future maintenance requirements along the new channel would be expected to be negligible to minor.

2. The use of a culvert along Tecolotito Creek at the end of Runway 7-25 is not recommended because of the reasonably foreseeable risk that the culvert would be plugged during 10-year or more flood events. Plugging of the culvert would result in increased frequency of flooding of the airfield, as well as increase culvert maintenance requirements. Removal of the sediments from the culvert is not considered a feasible operation. Finally, use of a culvert would require raising the runway.

3. The use of a culvert along San Pedro Creek at the eastern end of Runway 7-25 is also not recommended because of the increased risk of flooding the runway due to sediment deposition in the culvert and the infeasible maintenance operations. In addition, increased flooding at this location would also affect non-Airport property and Fairview Avenue. The use of a culvert would require raising the runway.

The above conclusions are consistent with the results of an earlier study by Penfield & Smith (1995) on the use of a culvert along Tecolotito Creek at the west end of Runway 7-25.

8.0 REFERENCES

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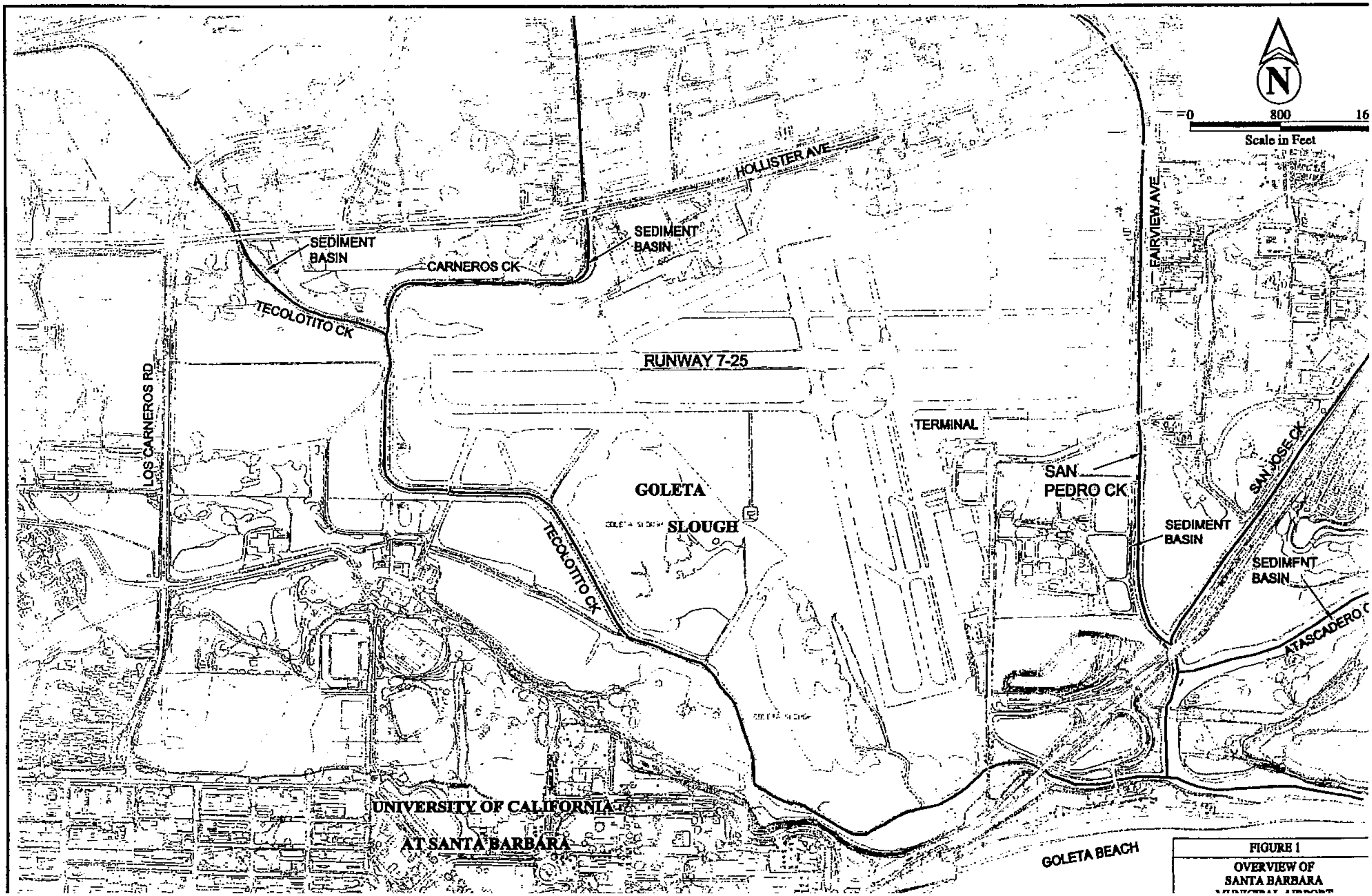
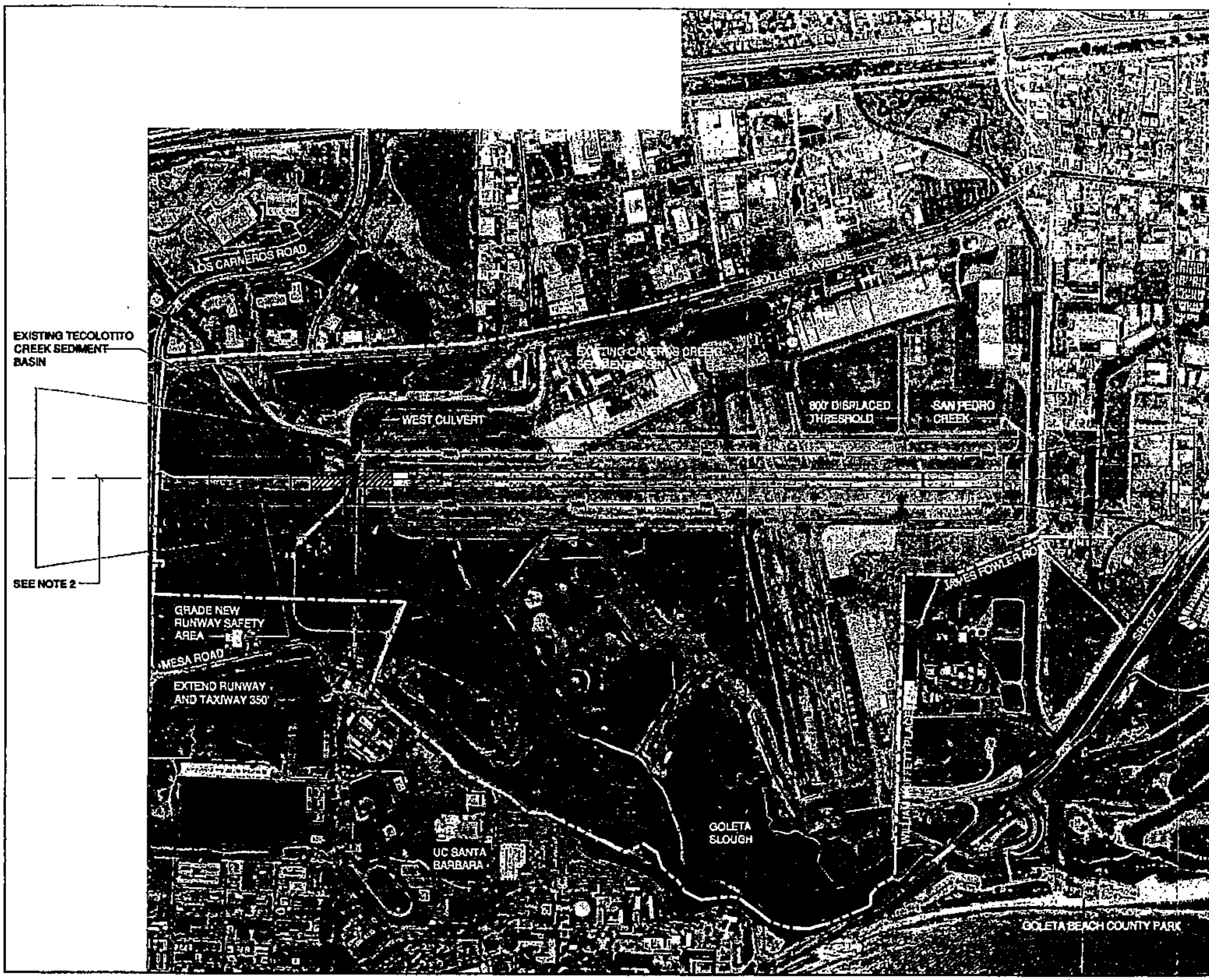


FIGURE 1

OVERVIEW OF SANTA BARBARA



LEGEND

- APPROACH PROFILE
- CLEARWAY
- APPROACH RUNWAY PROTECTION ZONES
- RUNWAY SAFETY AREA
- OBJECT FREE AREA
- AIRPORT PROPERTY LINE
- RUNWAY / TAXIWAY CONSTRUCTION

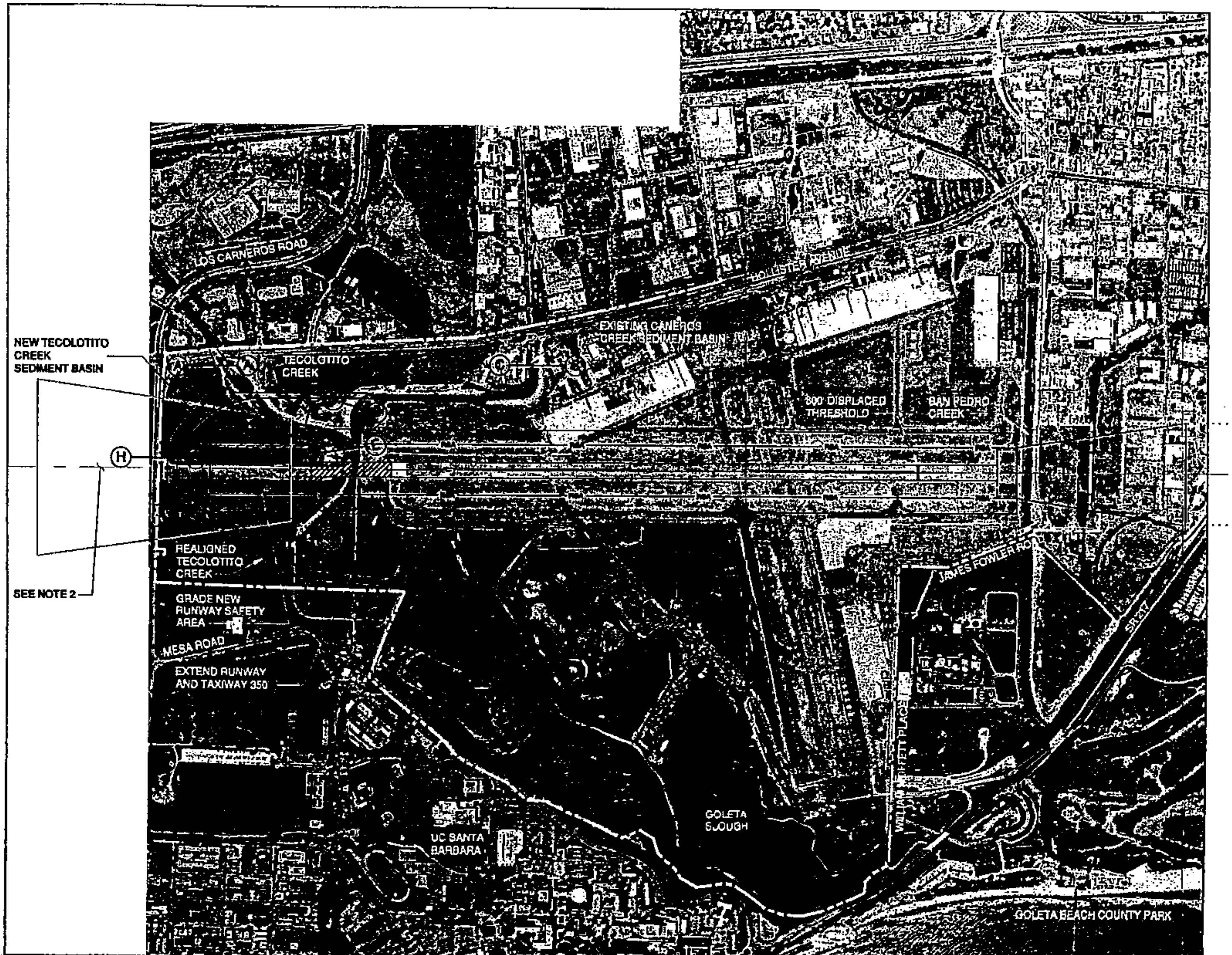
DEVELOPMENT

- 800' RW CONSTRUCTION WEST
- 1000' RSA EXTENSION WEST
- REALIGN TECOLOTITO CREEK
- 800' RW 25 THRESHOLD DISPLACEMENT WEST
- 1000' AND 200' CLEARWAYS

NOTES: 1) CULVERTS, TUNNEL, AND ROADWAY AND CREEK REALIGNMENT LOCATIONS ARE APPROXIMATE FOR ALL ALTERNATIVES
2) ACQUIRE EASEMENTS, RELOCATE LIGHTING, MIDDLE MARKER

500 0 500 1000
SCALE IN FEET

FIGURE 2
SCENARIO 1
CULVERT ON TECOLOTITO CREEK



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2) ACQUIRE EASEMENTS, RELOCATE LIGHTING, MIDDLE MARKER

Ⓒ—Ⓒ STUDY RESEARCH

500 0 500 1000

SCALE IN FEET

FIGURE 3
SCENARIO 2A
TECOLOTITO CREEK REALIGNMENT

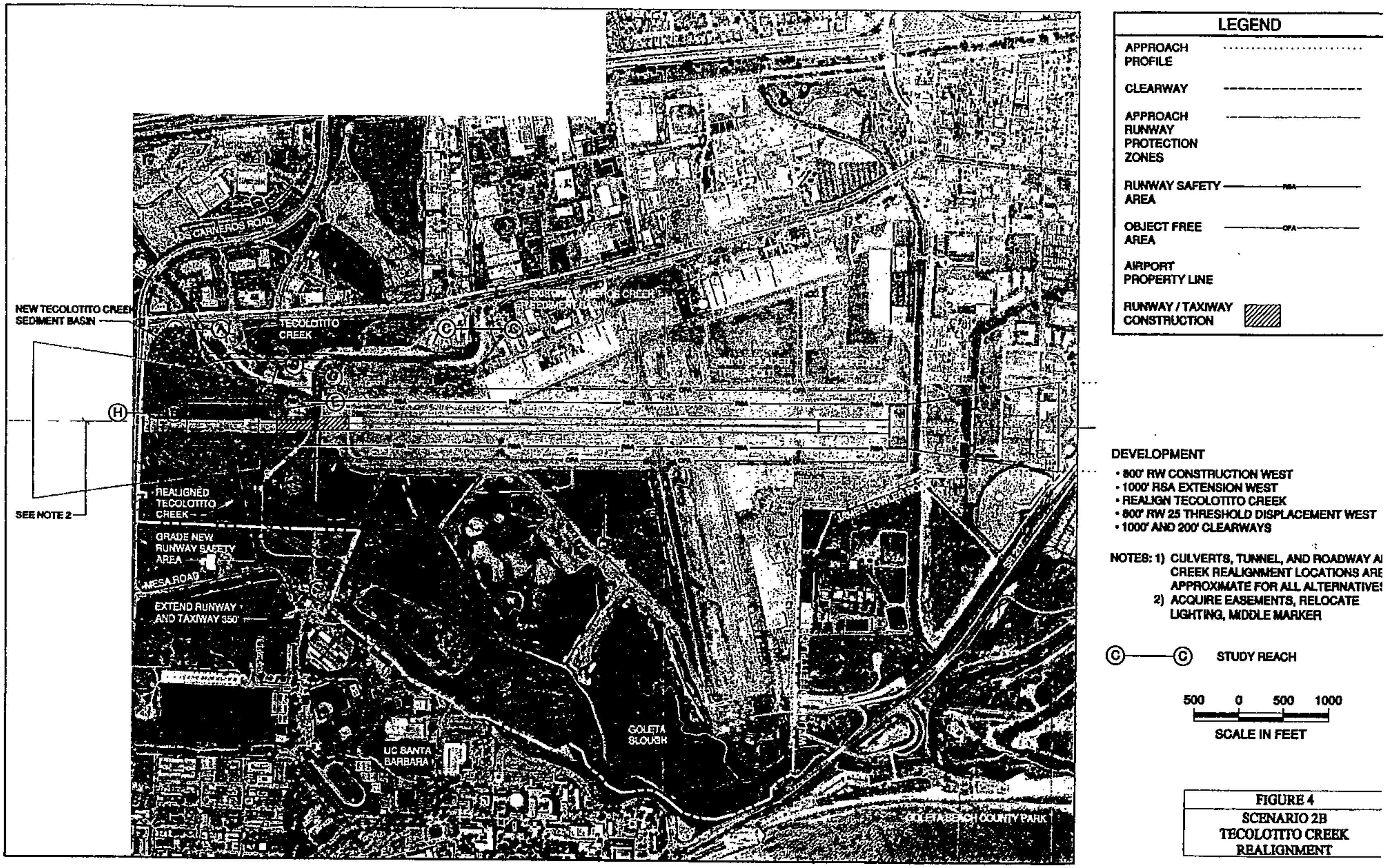
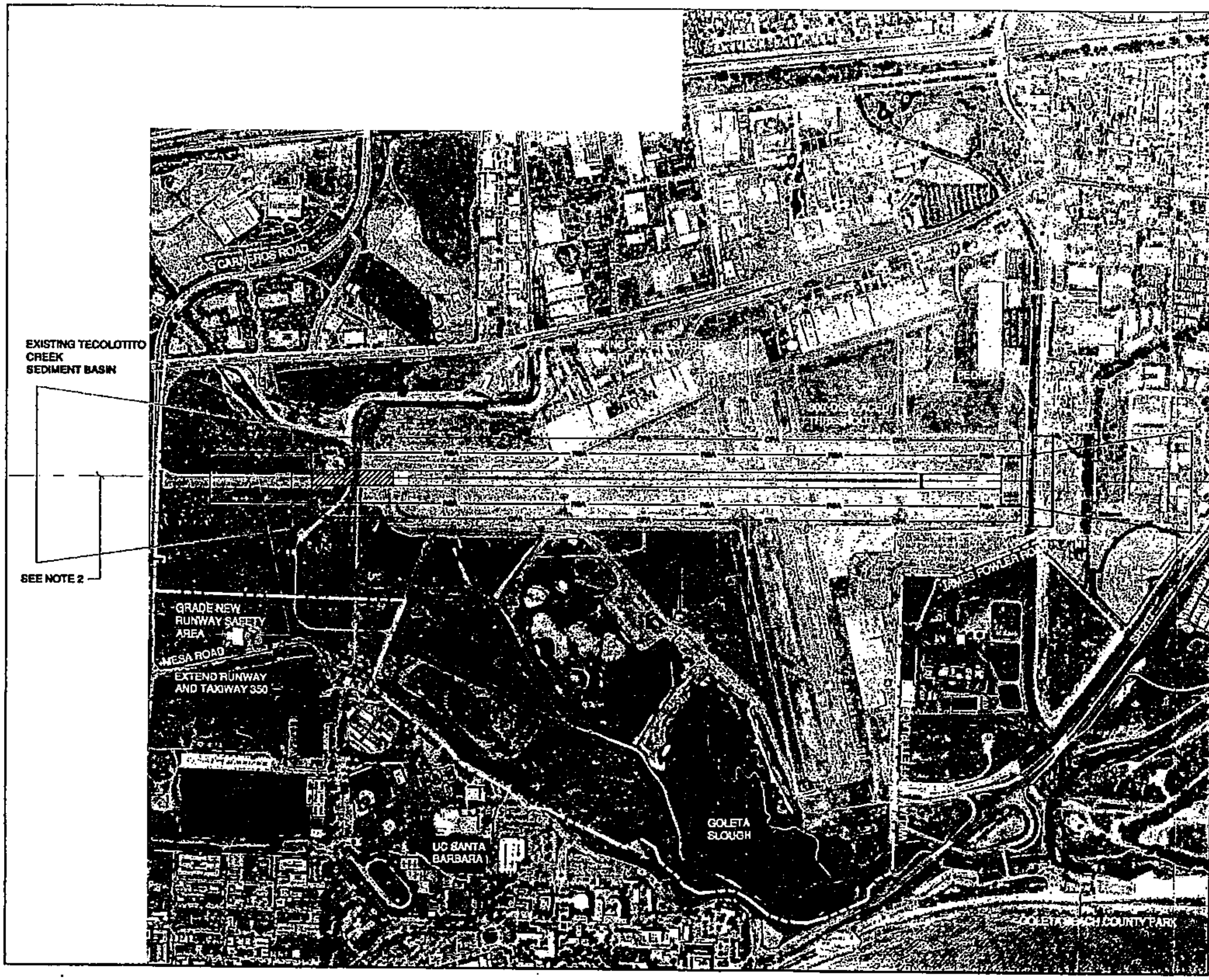


FIGURE 4
SCENARIO 2B
TECOLOTITO CREEK
REALIGNMENT



LEGEND

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- 1000' AND 200' CLEARWAYS

NOTES: 1) CULVERTS, TUNNEL, AND ROADWAY A
CREEK REALIGNMENT LOCATIONS AR
APPROXIMATE FOR ALL ALTERNATIVE
2) ACQUIRE EASEMENTS, RELOCATE
LIGHTING, MIDDLE MARKER

500 0 500 1000
SCALE IN FEET

FIGURE 5
SCENARIO 3
CULVERT ON
SAN PEDRO CREEK

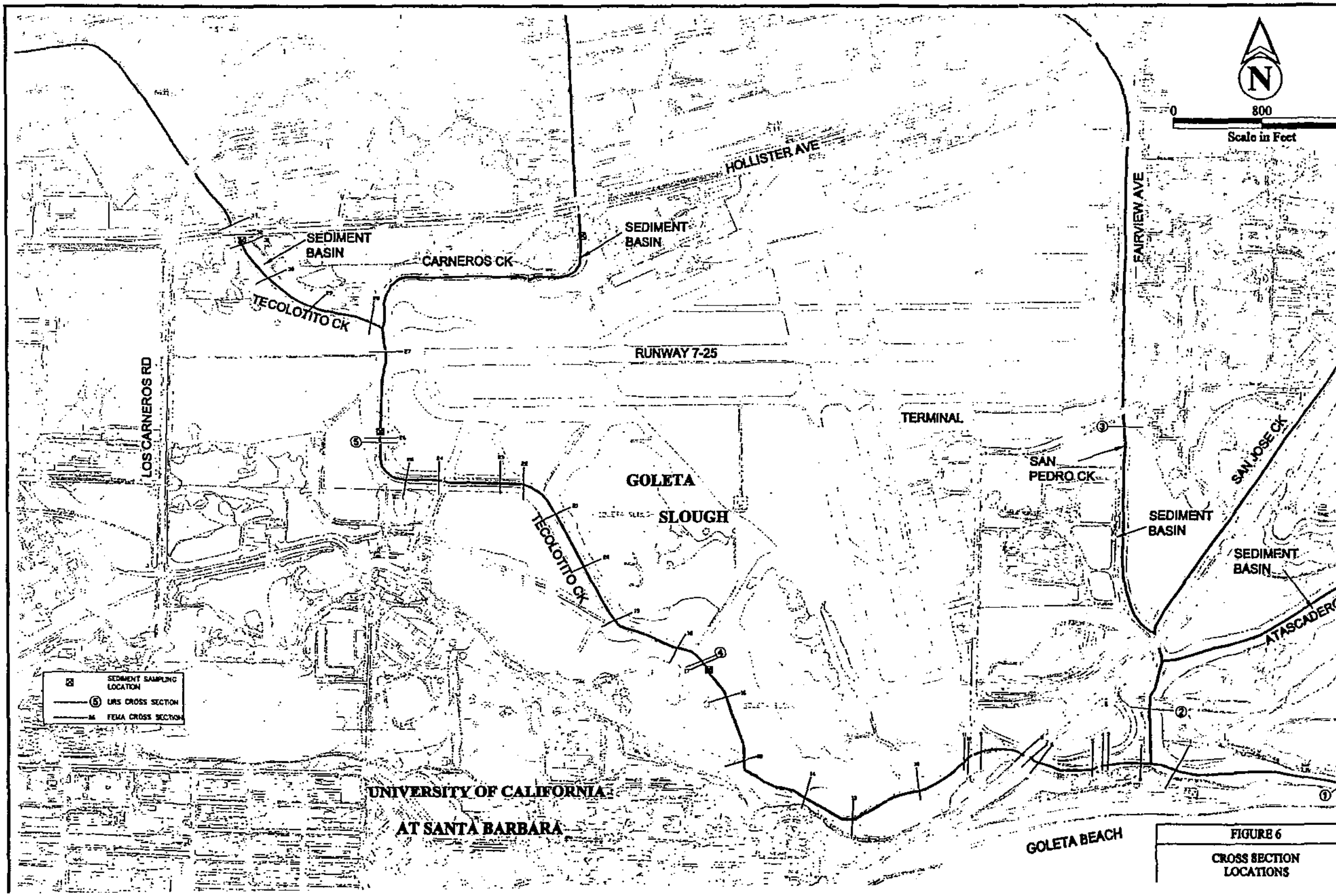


FIGURE 6

CROSS SECTION LOCATIONS

FIGURE 7
Measured Cross-section at Station 1

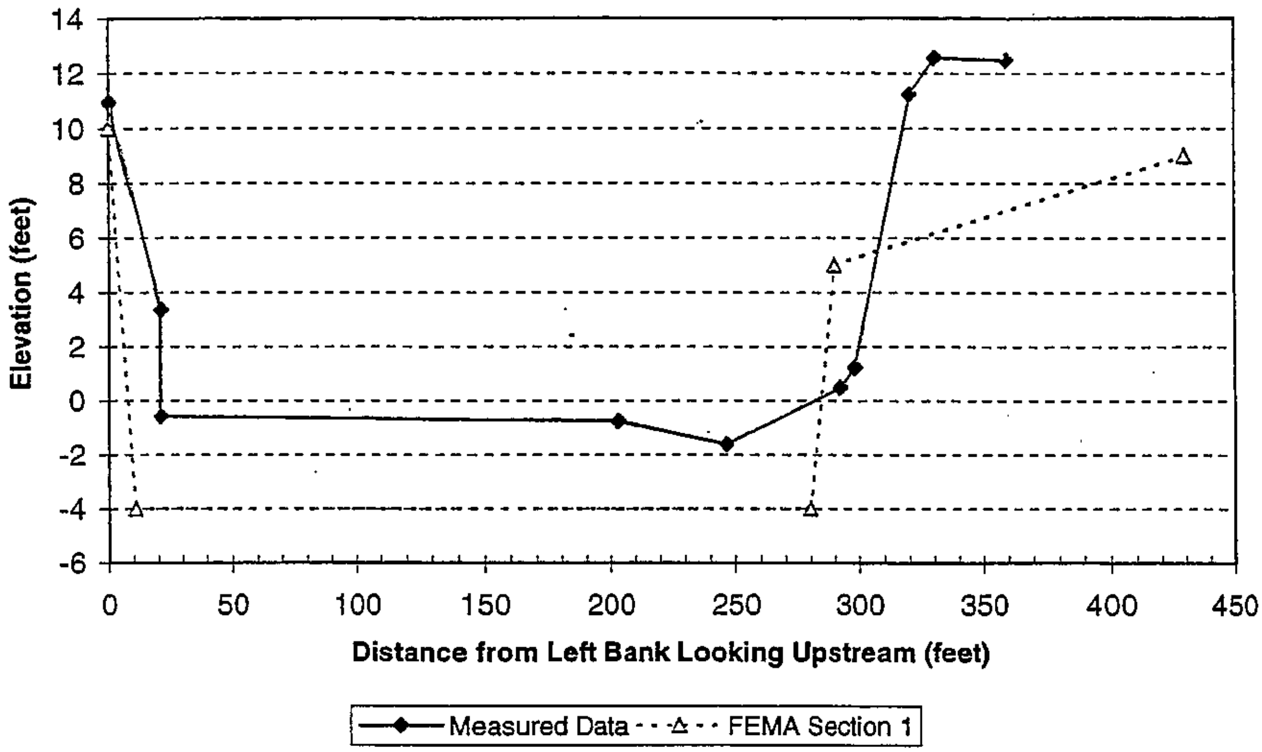


FIGURE 8
Measured Cross-section at Station 2

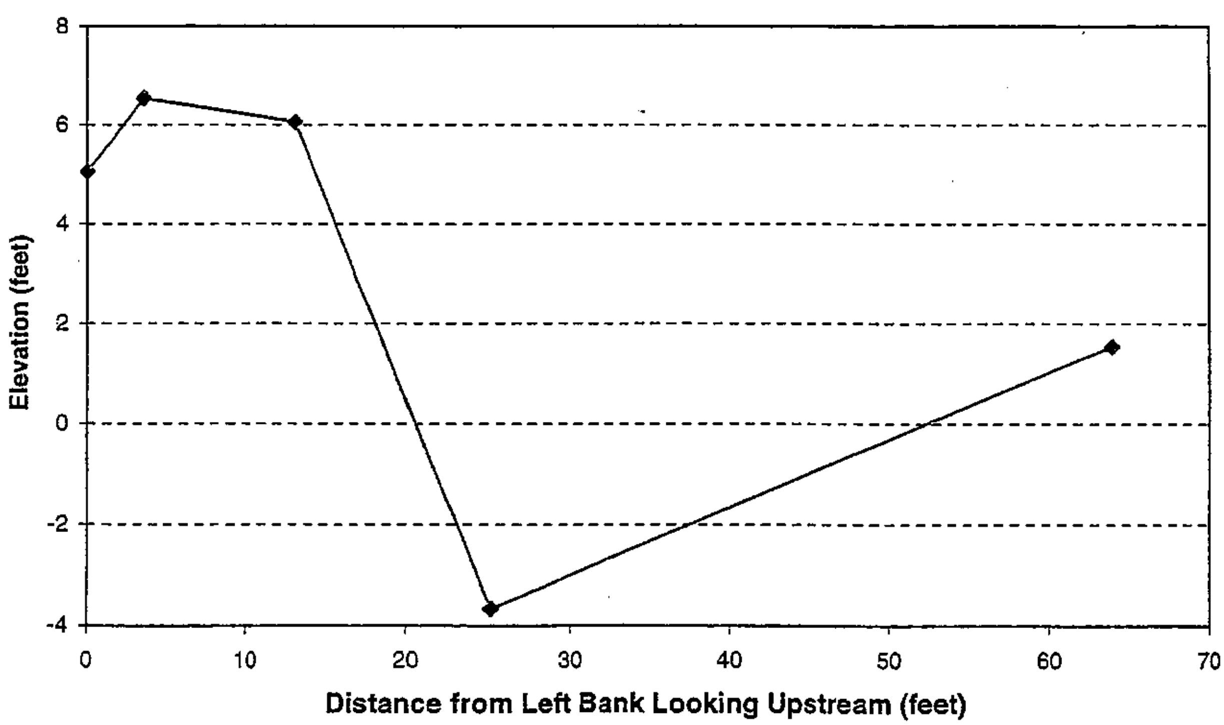


FIGURE 9
Measured Cross-section at Station 3

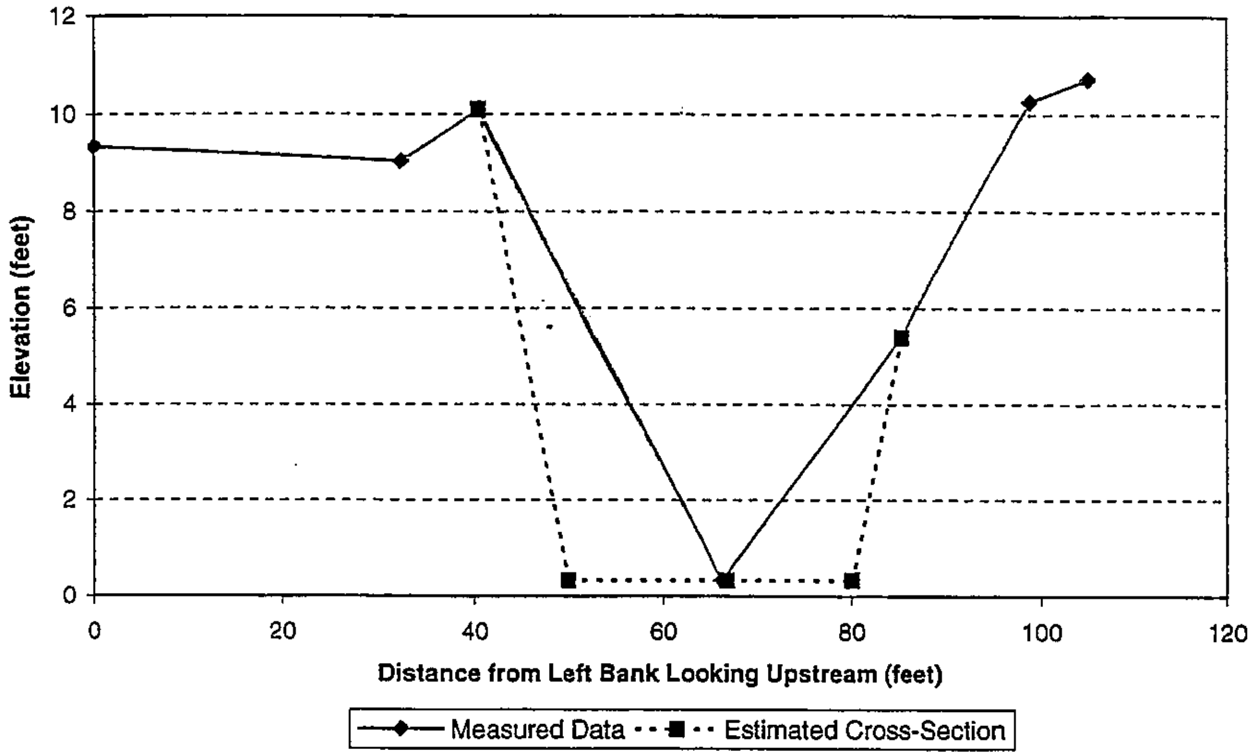


FIGURE 10
Measured Cross-section at Station 4

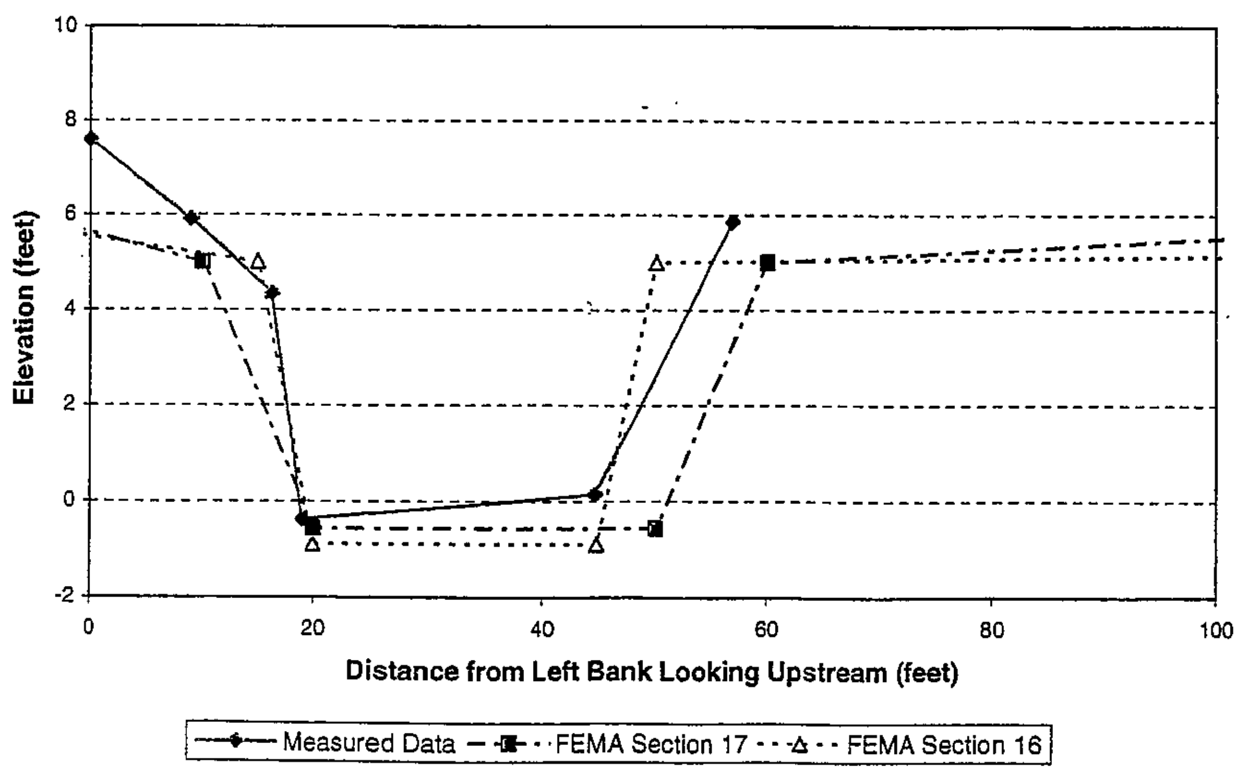
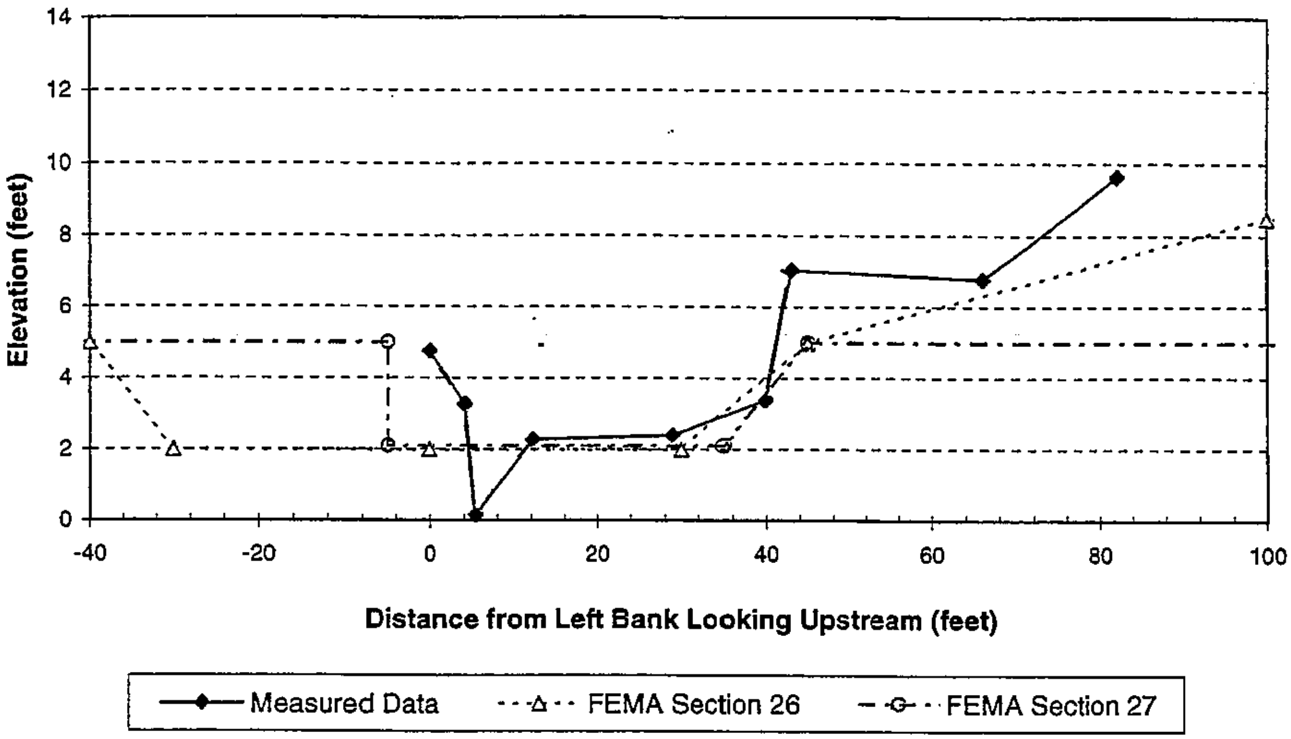
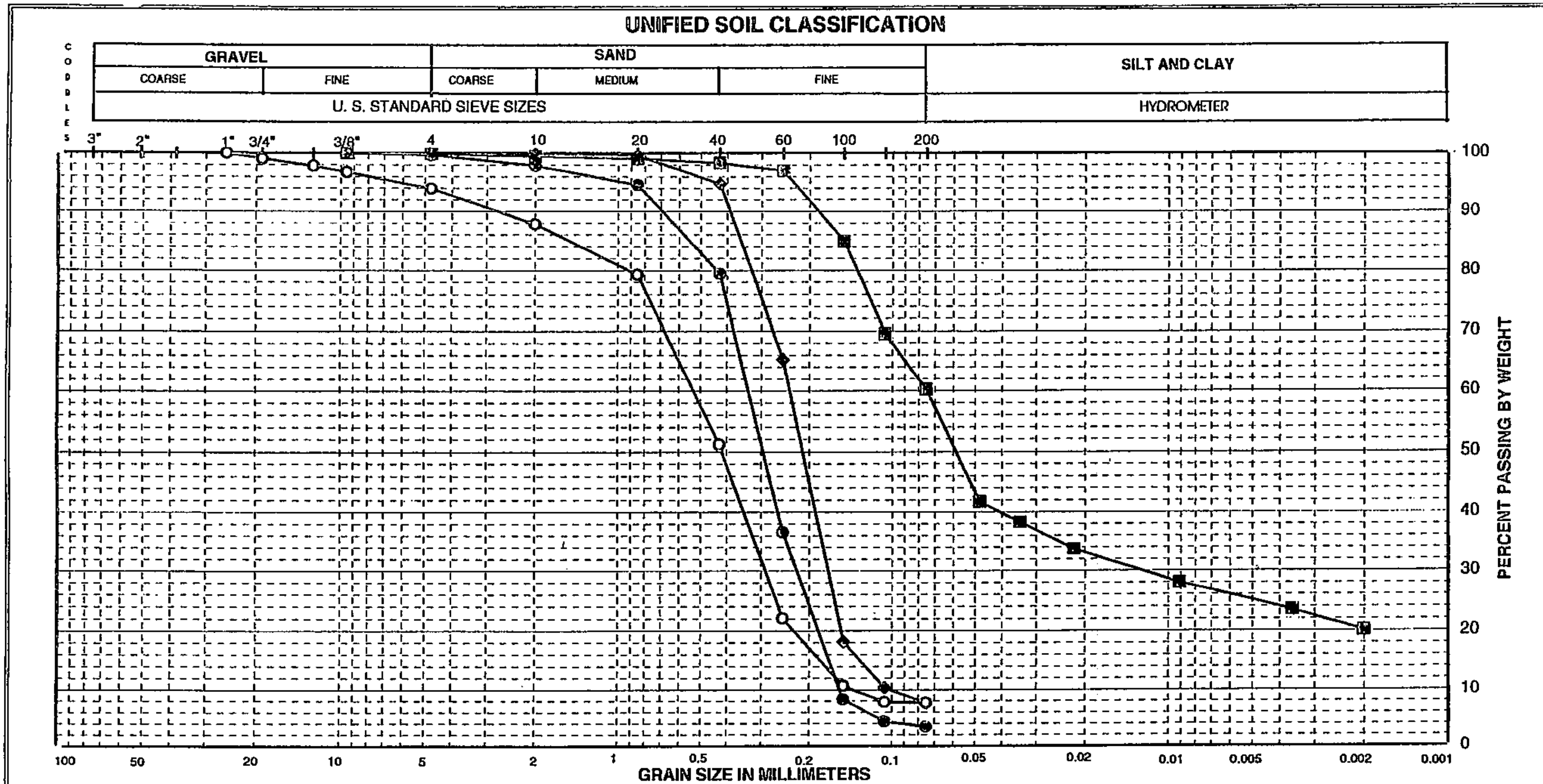


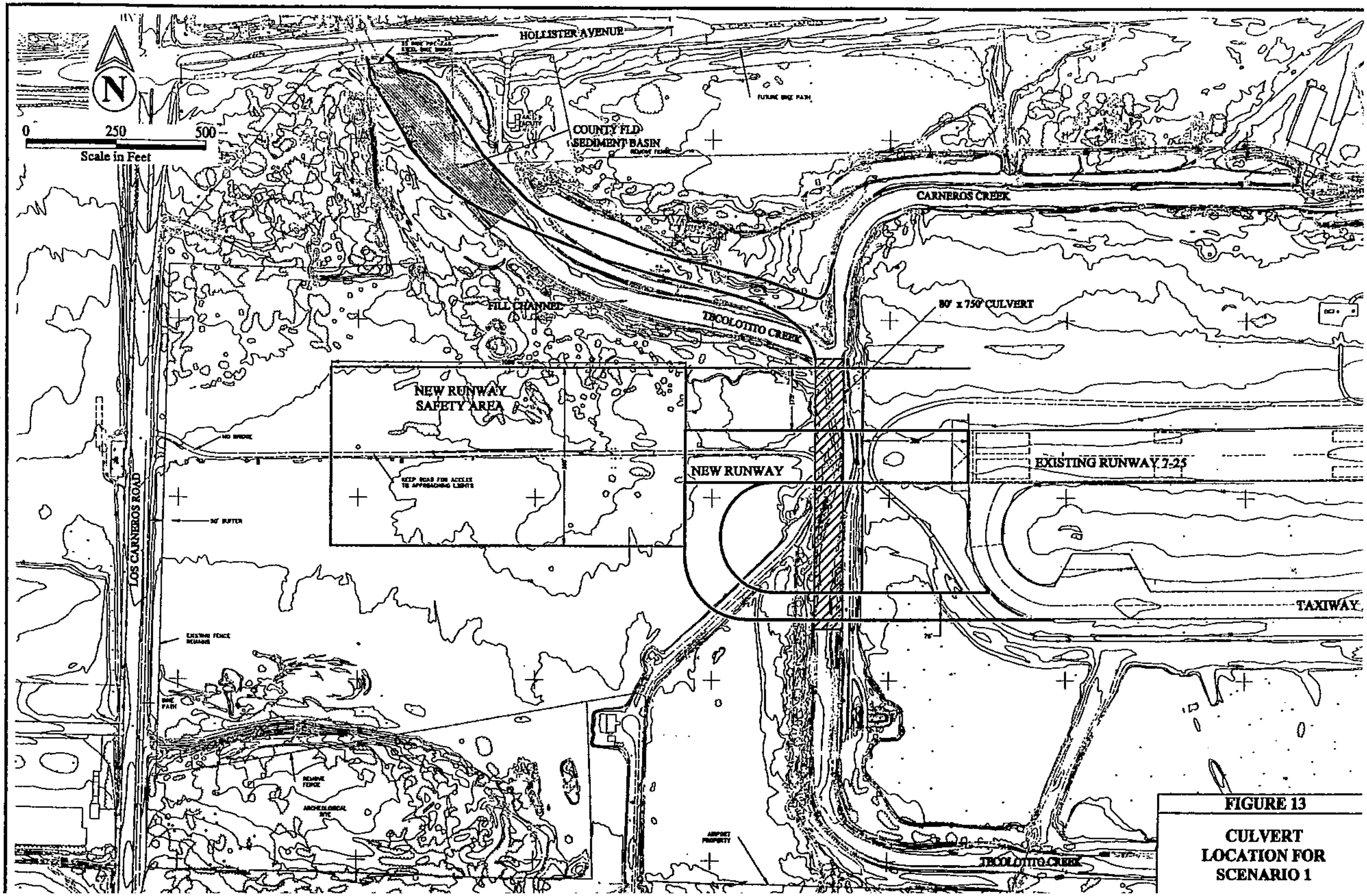
FIGURE 11
Measured Cross-section at Station 5





Exploration.	Location	Depth (ft)	SYMBOL	Wn (%)	LL	PI	% Clay	Description and Classification	D_{60}	D_{30}	D_{10}	C_u	C_c
Carneros Crk	d/s Holl. Ave		⊙					**Dark gray poorly graded Sand (SP)**	0.34	0.22	1.6	0.2	0.1
Tecolotito Ck	Station 5		◈					**Black to very dark gray poorly graded Sand with silt (SP-SM)**	0.24	0.17	0.1	2.4	1.2
Goleta Slough	Station 4		▣				20	**Olive gray sandy Clay (CL)**					
Tecolotito Ck	d/s Holl. Ave		○					**Brown poorly graded Sand with silt (SP-SM)**	0.53	0.29	0.14	3.8	1.1

FIGURE 12. PARTICLE SIZE DISTRIBUTION CURVES


HOLLISTER AVENUE
N
0
250
500
Scale in Feet
COUNTY FLD
SEDIMENT BASIN
CARNEROS CREEK
80' x 750' CULVERT
FILL CHANNEL
TECOLOTITO CREEK
NEW RUNWAY
SAFETY AREA
NEW RUNWAY
EXISTING RUNWAY 7-25
TAXIWAY
LOS CARNEROS ROAD
TECOLOTITO CREEK
FIGURE 13
CULVERT
LOCATION FOR
SCENARIO 1

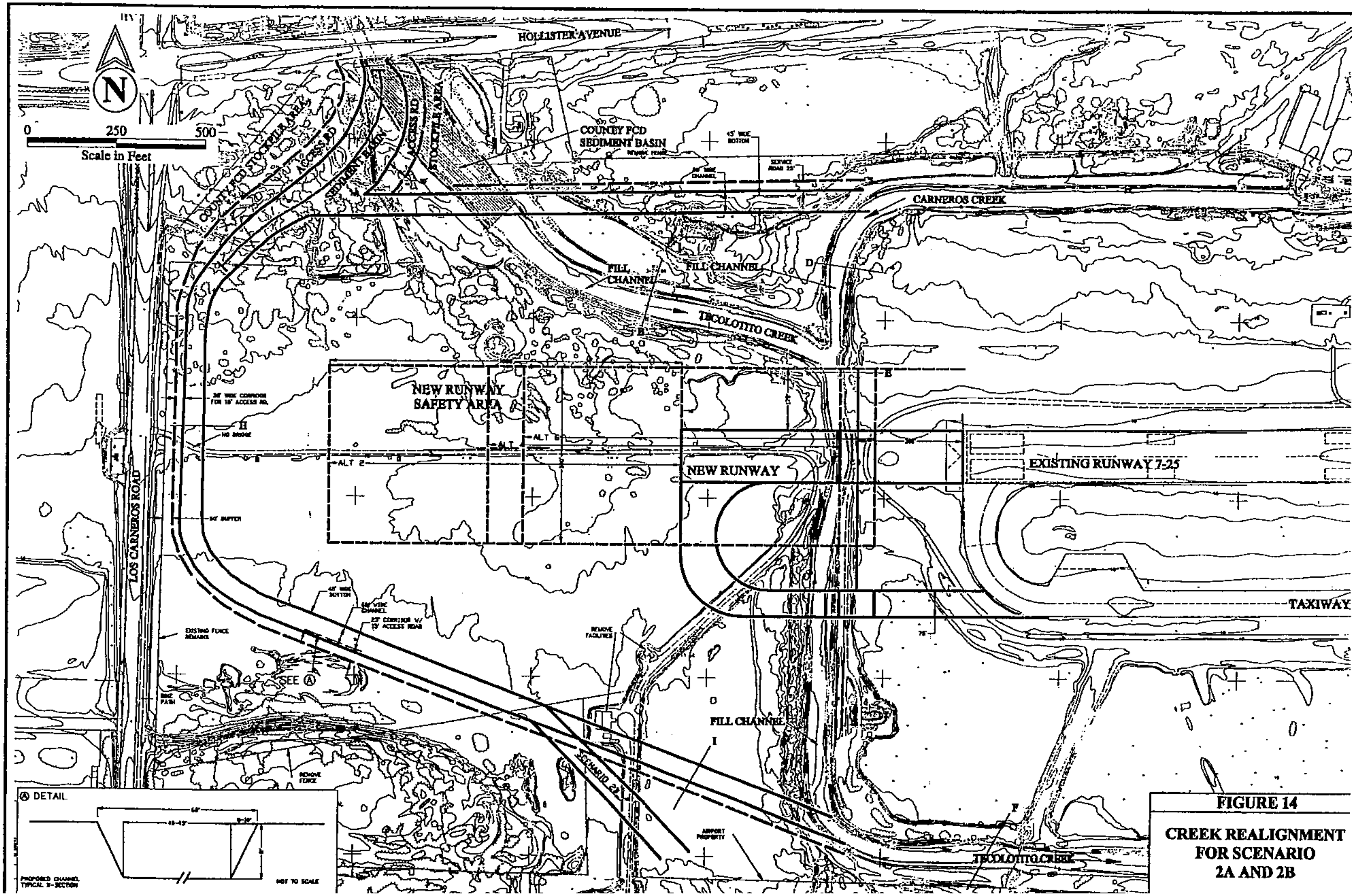


FIGURE 14

CREEK REALIGNMENT FOR SCENARIO 2A AND 2B

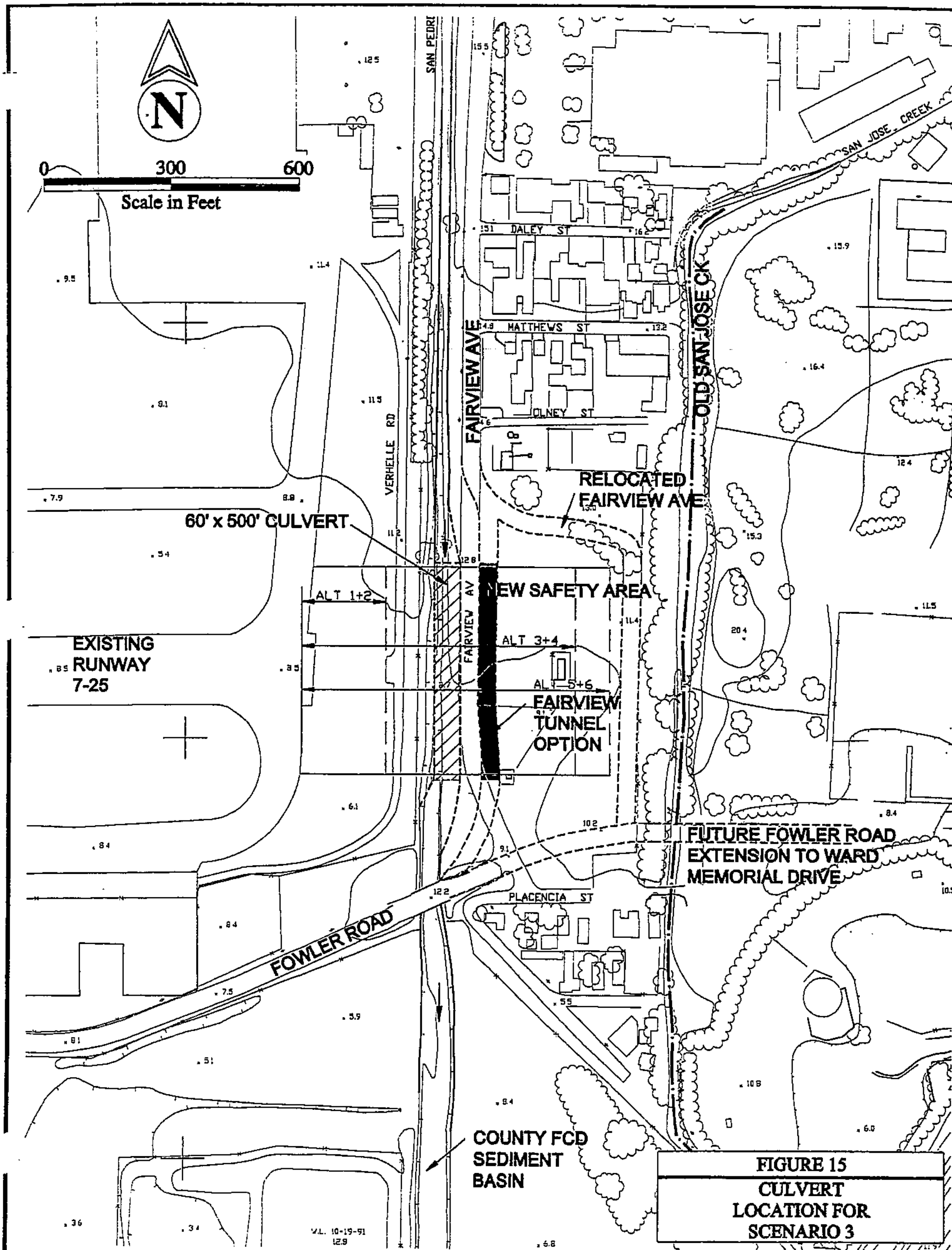


FIGURE 15
CULVERT LOCATION FOR SCENARIO 3

s:\curran\sbairport\112800-03.dwg 12/1/00 14:00

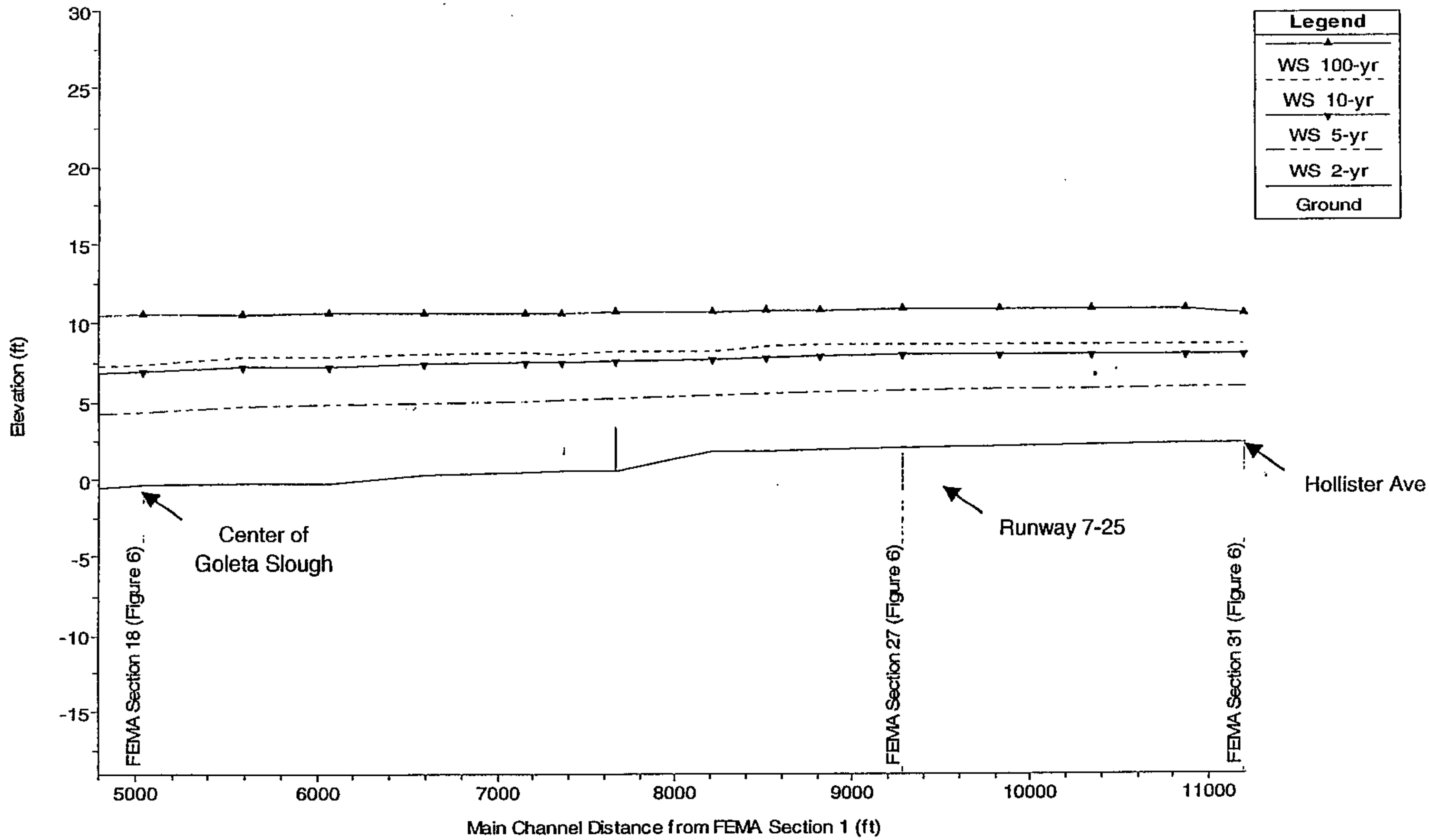


Figure 16. Profile of Tecolotito Creek with Existing Conditions

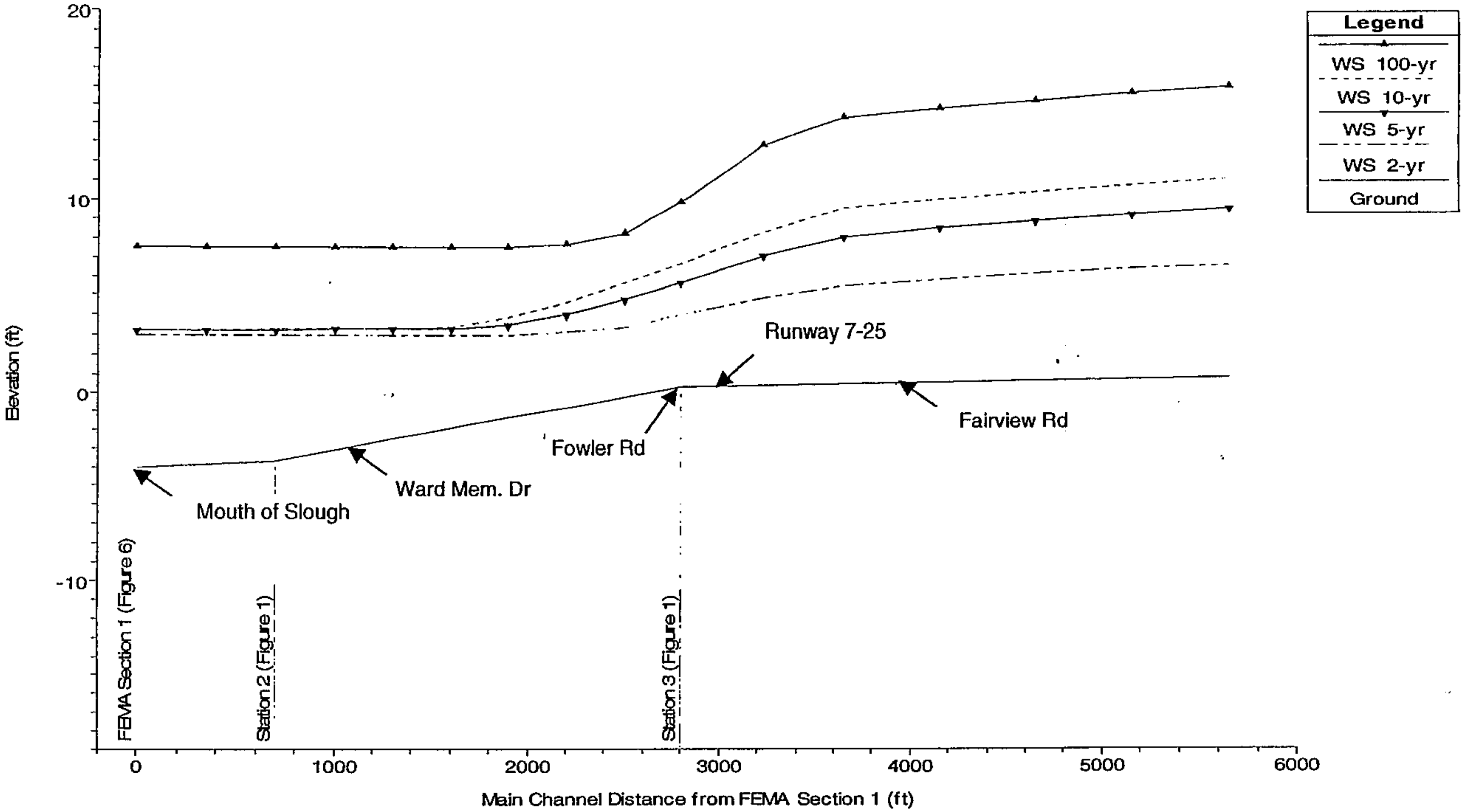
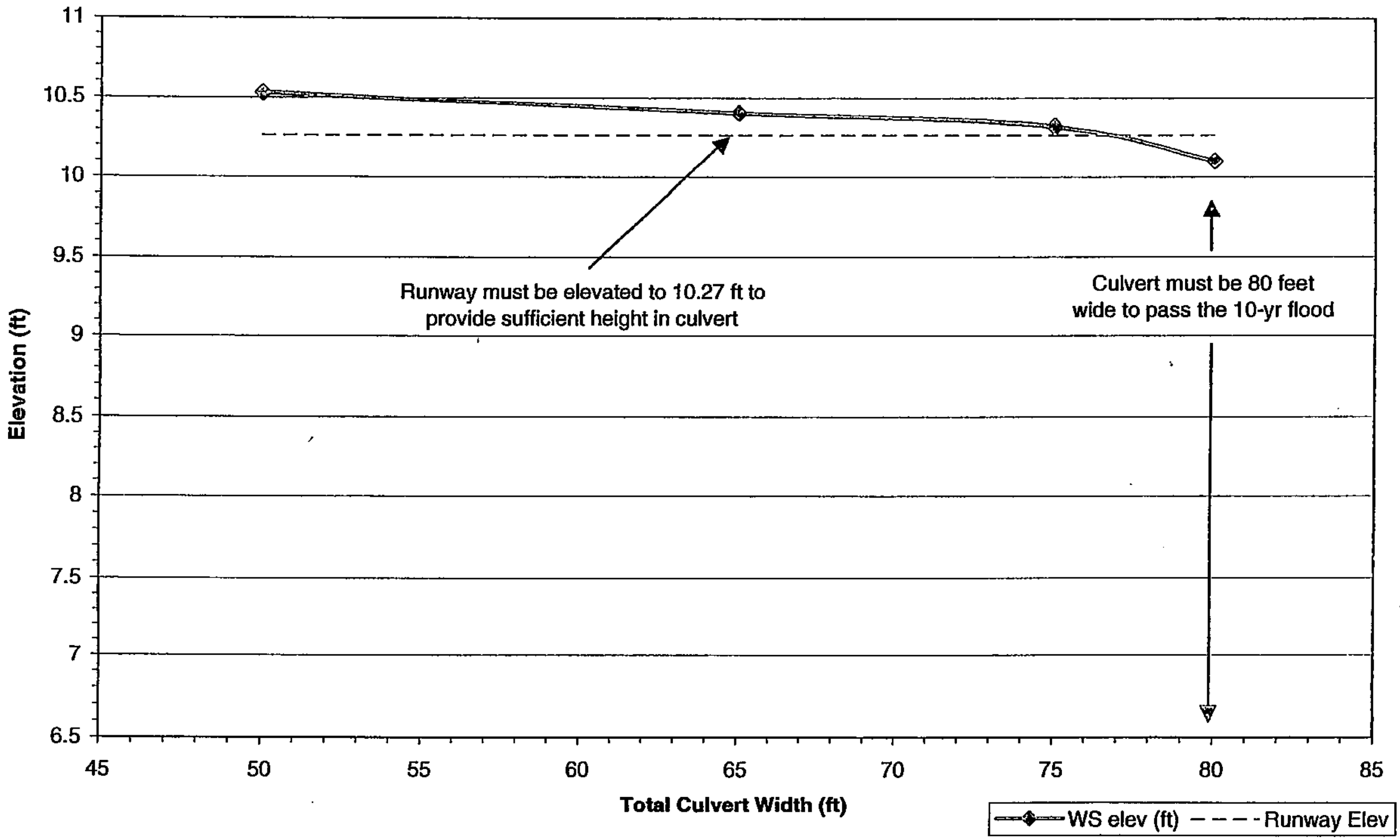


Figure 17. Profile of San Pedro Creek with Existing Conditions

FIGURE 18

Water Surface Elevation Upstream of Culvert with 10-year Flood Flow on Tecolotito Creek (5 Barrels with 1-foot Spacing, Runway Raised to Elevation 10.27 feet)



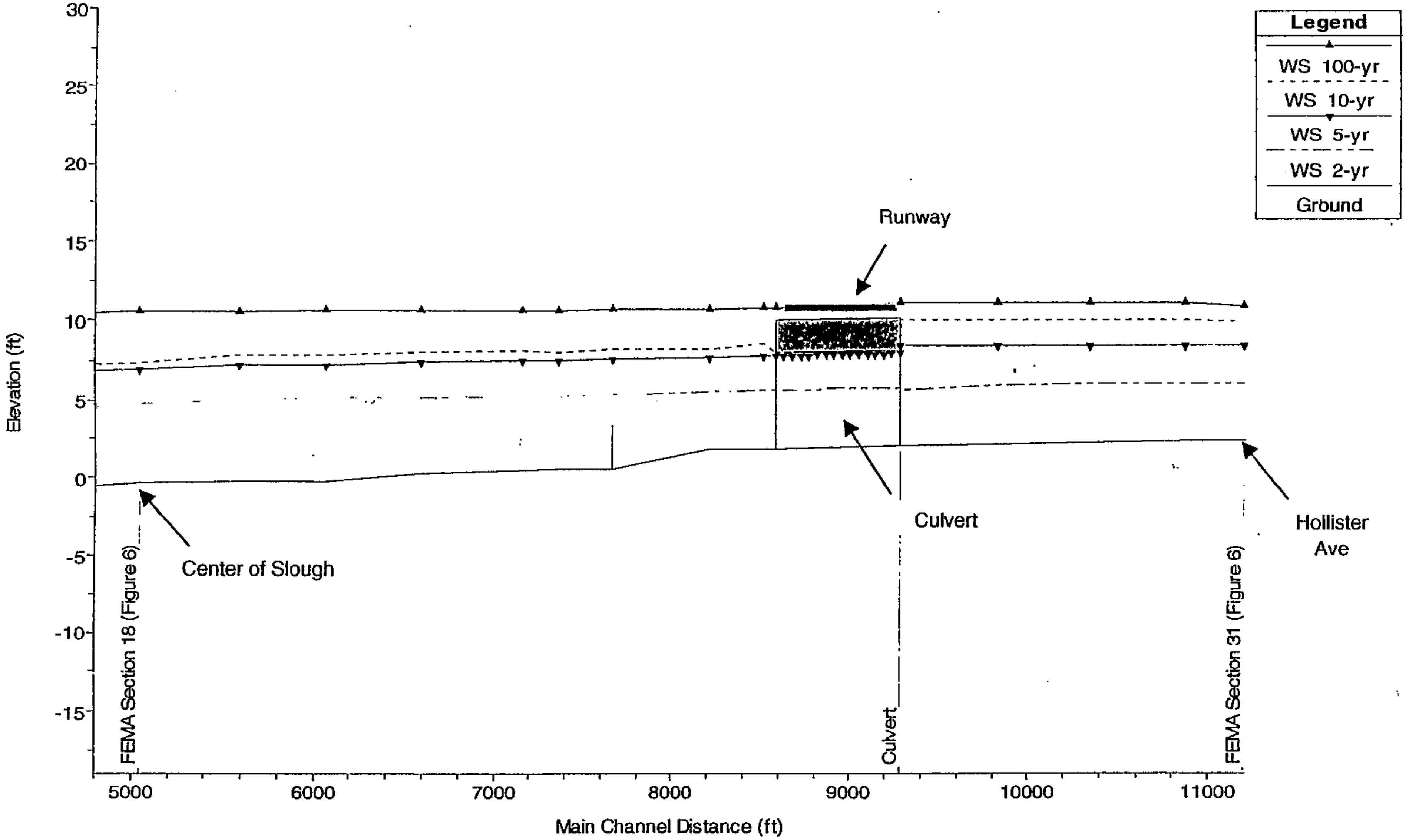


Figure 19. Profile of 80-foot wide Culvert Option on Tecolotito Creek with Runway Raised to Elevation 10.27 feet

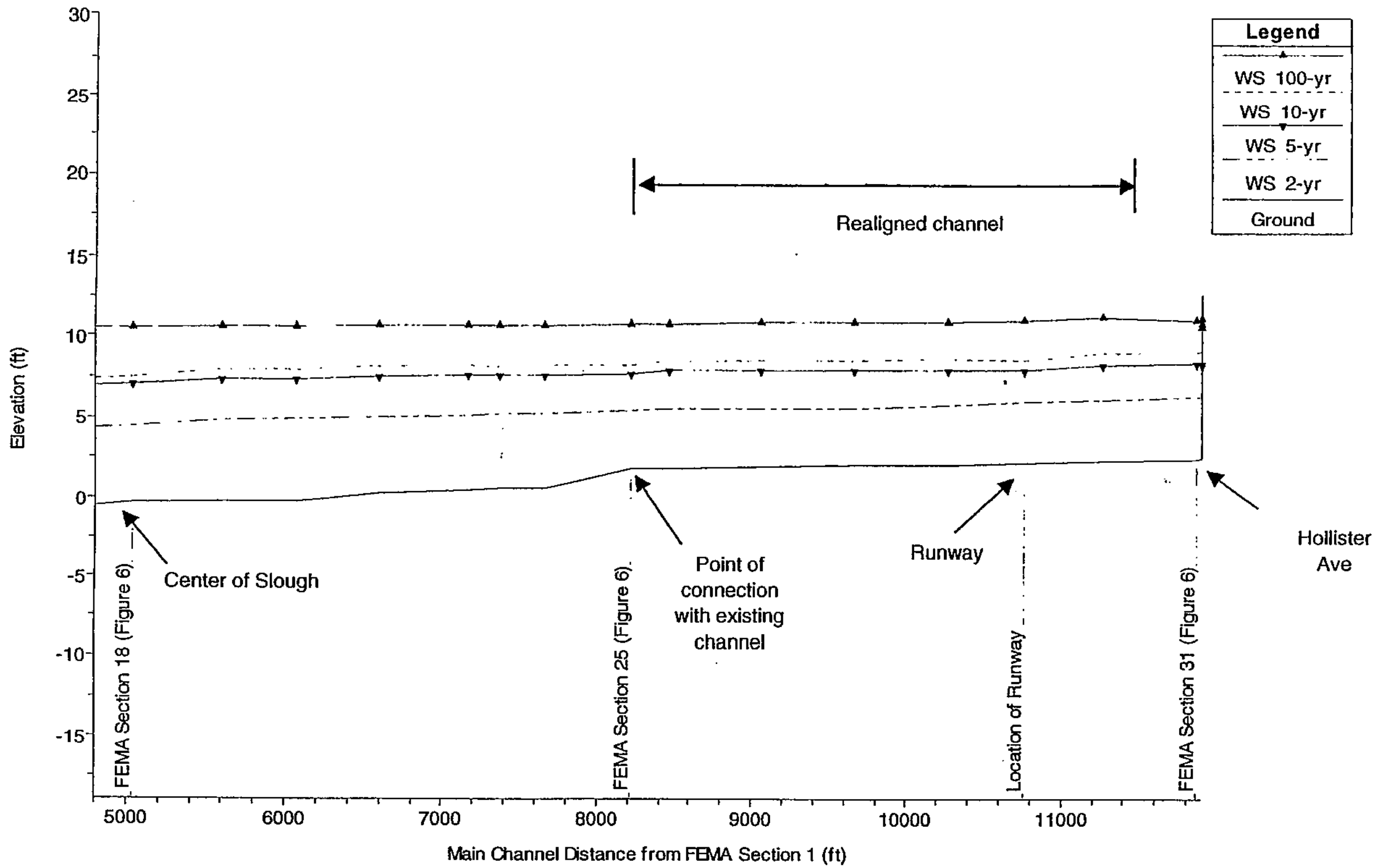


Figure 20. Water Surface Profile for Scenario 2A on Tecolotito Creek

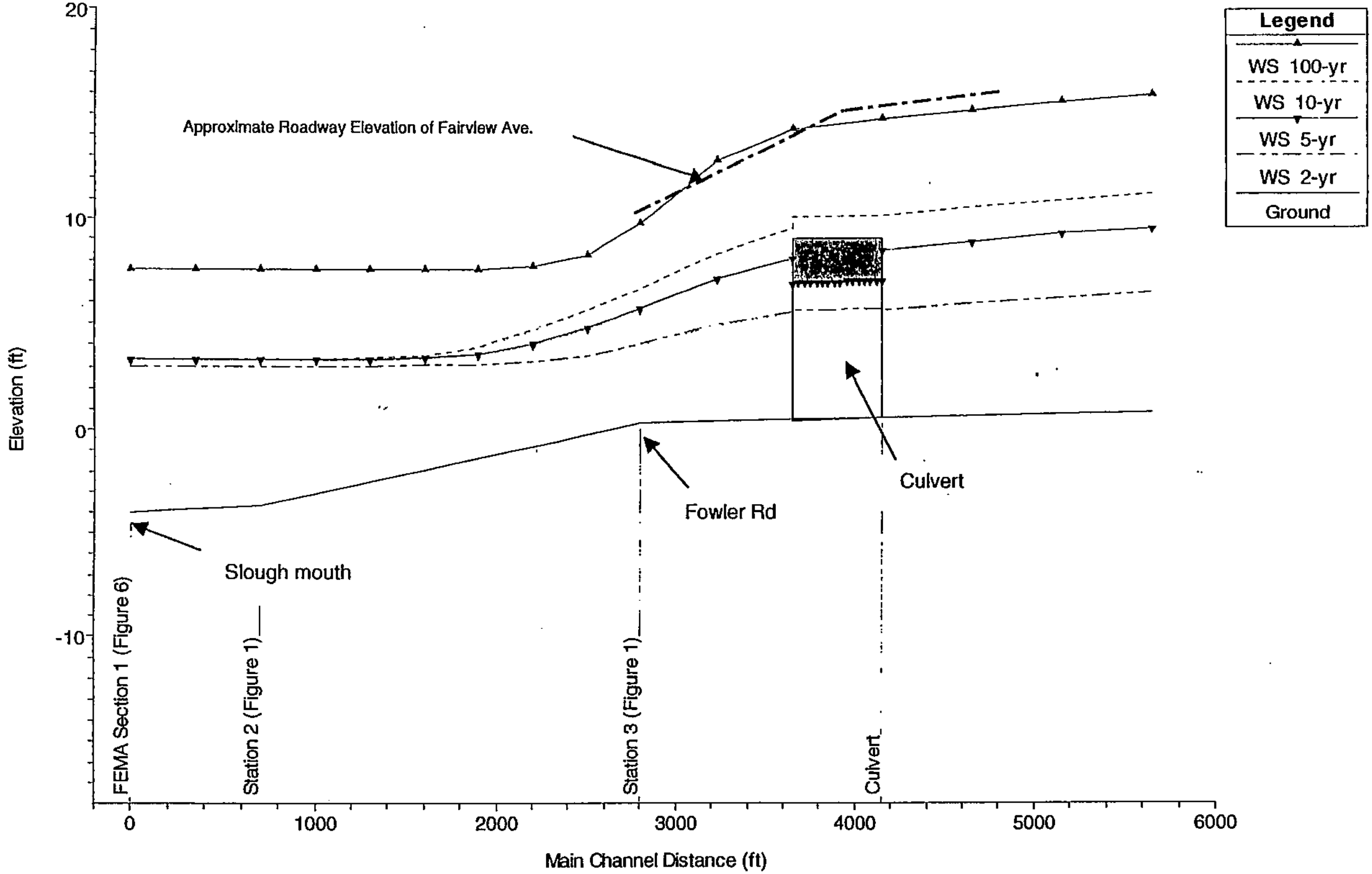
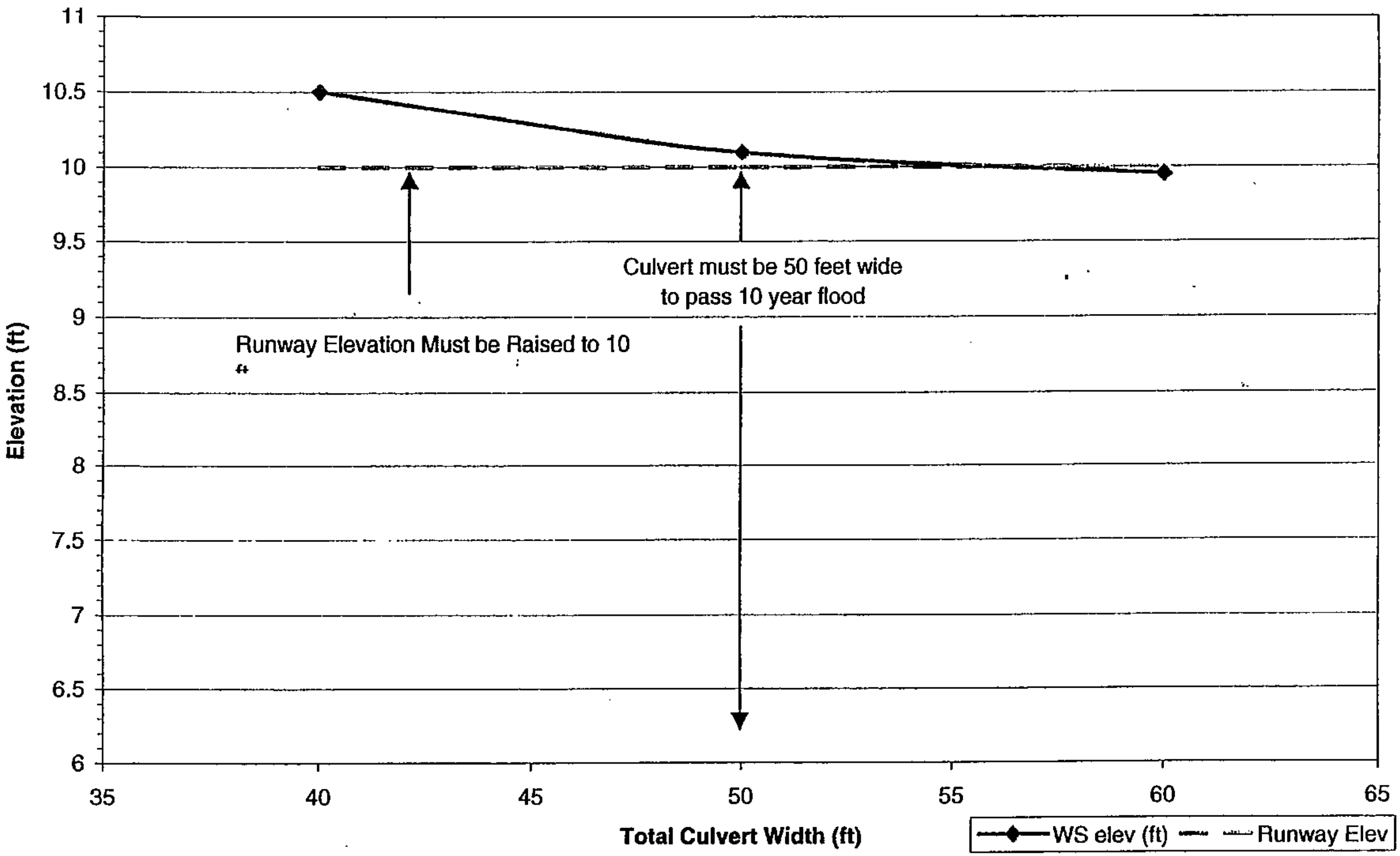


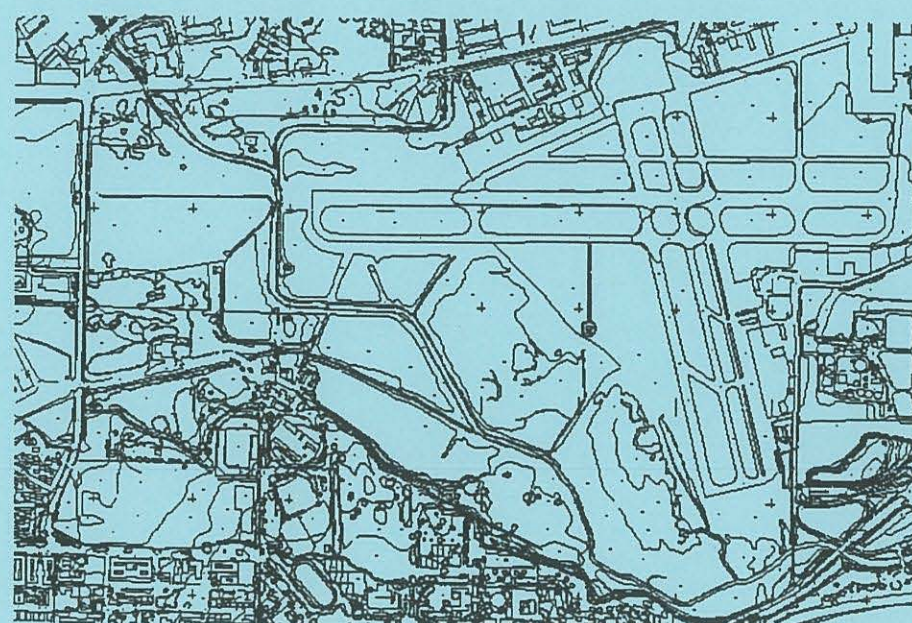
Figure 21. Profile of 50-foot Culvert on San Pedro Creek with Runway at Elevation 9.0 feet

FIGURE 22
Water Surface Elevation Upstream of Culvert with 10-year Flood Flow on San Pedro Creek and Runway Raised to Elevation 10 feet



CHAPTER 4

ALTERNATIVES STUDY FOR THE RUNWAY SAFETY AREA EXTENSION PROJECT



Prepared by URS Corporation
May 2001

ALTERNATIVES STUDY FOR THE RUNWAY SAFETY AREA EXTENSION PROJECT

Master Drainage Plan
Santa Barbara Municipal Airport

May 2001

Prepared for:

Santa Barbara Municipal Airport
City of Santa Barbara
601 Firestone Road
Santa Barbara, California 93117

Prepared by:

URS Corporation
130 Robin Hill Road, Suite 100
Santa Barbara, California 93117

TABLE OF CONTENTS

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LIST OF FIGURES (see Appendix A)

1.0 INTRODUCTION

1.0 BACKGROUND INFORMATION

The Santa Barbara Municipal Airport (Airport) is owned and managed by the City of Santa Barbara. There are three runways in the airfield, which encompasses about 725 acres south of Hollister Avenue (Figure 1, see Appendix A). The Airport property also includes the industrial/commercial area north of Hollister Avenue, as well as most of Goleta Slough and its associated wetlands and tidal channels.

The City of Santa Barbara (City) initiated a comprehensive planning process for the Airport in 1994 that included both an Industrial/Commercial Specific Plan and an Aviation Facilities Plan (AFP). The Specific Plan for the land north of Hollister Avenue was approved in 1999. The AFP is currently under development. It consists of various improvements to increase public safety and enhance service at the Airport, while meeting both short-term and log-term aviation needs of the region. A primary element of the AFP is to modify the airfield to meet requirements of the Federal Aviation Administration (FAA) for Runway Safety Areas (RSAs).

A Runway Safety Area (RSA) is the land surrounding a runway that must be smoothed and compacted such that damage to airplanes that overrun the paved surface would be minimized. The existing RSAs at the east and west ends of Runway 7-25, the primary commercial flight runway at the Airport, do not meet FAA requirements. For Runway 7-25, the minimum RSA at each end is 1,000 feet long and 500 feet wide. The lengths of the current RSAs on the east and west ends are only 200 and 350 feet, respectively. Runway 7-25 is the only runway equipped with instrumentation providing precision approach guidance (Runway 7) to the Airport. The runway functions under a deviation from standard as per design guidance, for non-standard RSA length at both ends (Advisory Circular 150/5300-13, Airport Design, Change 6).

The overall objective of this investigation was to identify and evaluate alternatives to establish a minimum RSA on Runway 7-25. The scope of the analyses included: (1) review the previous study on RSA alternatives by Hodges and Shutt (1995), and identify feasible alternatives to be considered further; (2) develop preliminary construction cost estimates for these alternatives; (3) compare these alternatives relative to key performance, cost, and environmental factors; and (4) recommend a set of RSA alternatives to be studied in an environmental review process by the Airport and FAA.

Technical analyses about hydrologic and environmental issues associated with the RSA extension were addressed in companion reports by URS Corporation listed below:

- *Channel Modification Alternatives for the Runway Safety Area Extension Project, Master Drainage Plan, November 2000.*
- *Wetland and Bird Strike Hazard Issues Associated with the Runway Safety Area Extension Project, Master Drainage Plan, December 2000.*

Key results from these studies are incorporated into this report. The key hydraulic issue is the disposition of Tecolotito Creek at the end of Runway 7-25 with an extended RSA – it must either be rerouted around the new RSA, or placed in a culvert under the extended runway. A similar issue is present at the east end of Runway 7-25 where San Pedro Creek must be placed under an extended RSA. The key environmental issues involved are mitigating for impacts to wetlands at the end of Runway 7-25 and minimizing bird strike hazards at the end of the new RSAs.

1.2 SUMMARY OF 1995 RUNWAY SAFETY AREA STUDY

The study on RSA alternatives by Hodges and Shutt (1995) sought solutions to the non-standard safety area issue that would satisfy "two interrelated aeronautical objectives." The first involved increasing safety margins by bringing the RSAs into compliance with FAA criteria. The second involved providing "a runway length which minimizes the circumstance under which current and future airline aircraft flights are constrained (typically by limitations on the number of passengers that can be carried)." The objective of the 1995 study was to identify alternatives that provide additional runway length to accommodate demand that might be placed on the runway by a changing aircraft fleet serving SBA. To be minimally acceptable, the alternatives "must at least maintain the existing runway length presently considered usable for both takeoff and landing calculation purposes." There must be no net loss of usable runway length.

Alternatives identified by Hodges and Shutt (1995) employed some or all of the development techniques listed below to achieve the objectives:

- Creek realignments – could be applied to Tecolotito, San Pedro, and/or Old San Jose creeks
- Bridge or culvert of creeks – could be applied to Tecolotito, San Pedro, and/or Old San Jose Creek
- Road realignment or tunnel – could be applied to Fairview Avenue
- FAA Declared Distance Concept (DDC) – use of this technique along with clearways and stopways to optimize available runway length

Seventeen separate runway end alternative solutions were presented and analyzed in the 1995 report; eight of these were for the west end of the runway; nine were for the east end. The study took into consideration the "environmental cost implications" of each alternative and, "eliminated those alternatives deemed impractical because probable significant environmental impacts and/or high construction costs outweighing aeronautical benefits." A description of all alternatives included in the Hodges and Shutt (1995) study is provided in Table 1. The results of the analyses are summarized in Table 2.

In the first round of evaluation, six of the nine east end alternatives were eliminated due to high impact – either for perceived high construction costs and/or perceived significant environmental impact. These alternatives involved a bridge or culvert of San Pedro Creek located east of Runway 25 threshold, and the tunneling or realigning of Fairview Avenue.

In contrast, all eight alternatives at the west end of Runway 7-25 were determined to be practicable after the first evaluation round. In the final evaluation, the number of acceptable alternatives were reduced to three alternatives based on construction costs and/or significant environmental impacts. The alternatives that Hodges and Shutt (1995) recommended to be studied during a future environmental review are listed below:

- Alternative A. Status quo. No change.

- Alternative D2. Extend the runway and taxiway 800 feet west, extend RSA 1,000 feet beyond west end of new runway 7 threshold, and employ the FAA Declared Distance Concept by displacing Runway 25 threshold 800 feet to meet the required 1,000-foot RSA and Object Free Area (OFA) lengths at this end of the runway

- Alternative I .Extend the runway and taxiway 400 feet west, extend RSA 1,000 feet beyond west end of new Runway 7 threshold, realign Fairview Avenue around the OFA and RSA on airport property, and employ the FAA Declared Distance Concept by retaining Runway 25 displaced threshold at 314 feet to meet the required 1,000-foot RSA and Object Free Area (OFA) lengths.

Alternatives A, D2 and I are carried forward (in concept and with small modifications) for analysis in this report , and are subject to more detailed analyses of costs and environmental constraints. The correspondence between the 1995 and current alternatives is as follows:

Hodges and Shutt (1995) Alternatives	URS Alternatives (variants are related to hydraulic options for Tecolotito Ck only)
W6b, E2 (Alternative D2)	Alternatives 1 and 2a
W5b, E3b (Alternative I)	Alternatives 3 and 4

Although Hodges and Shutt (1995) eliminated the RSA alternatives at the east end due to high costs, we have included a several variations of these alternatives (Alternatives 3 – 6 in this report) to verify the previous conclusions.

TABLE 1 – 1995 STUDY ALTERNATIVES

Alternative	Description
West End Alternatives:	
W1 – Status Quo	Maintain existing pavement end and threshold location
W2 – Use Displaced Threshold and Declared Distance to meet Standard	Maintain existing pavements end location; grade area between runway end and Tecolotito Creek to RSA standards; displace threshold approximately 700 ft to meet RSA standards; establish 1,000-foot clearway.
W3 – Add Full RSA to Existing Runway End	Maintain existing pavement end and threshold location; bridge Tecolotito Creek to allow construction of full 1,000-foot RSA*; establish 1,000-foot clearway at runway end (optional). (*Relocate rather than bridge Tecolotito Creek.)
W4 – Extend Runway Approximately 300 ft and Displace Threshold to Meet Standards	Extend runway as far as possible without requiring modification of Tecolotito Creek; displace threshold 1,000 ft from new runway end to meet RSA standards; establish 1,000-foot clearway at runway end. This alternative was examined in the revised (1992) draft Master Plan.
W5a – Extend Runway 400 ft with Full RSA and Existing Threshold Location	Construct bridge over Tecolotito Creek*; extend runway and safety area, leave landing threshold in current location (resulting in a 400-foot threshold displacement). This is the west-end configuration proposed in the original draft Master Plan. (Variation: keep existing RPZ location.) (Variation: limit extension to 300 ft to reduce length of creek covered.)
W5b – Extend Runway 400 ft with Full RSA and Threshold at Runway End	Same as Alternative W5a, except landing threshold located at new end of runway.* (Variation: limit extension to 300 ft to reduce length of creek to be covered.)
W6a – Extend Runway 800 ft with Full RSA and Existing Threshold Location	Same as Alternative W5a, except extension length is 800 ft. This configuration is intended to complement Alternative E2. (Variation: keep existing RPZ location.)
W6b – Extend Runway 800 ft with Full RSA and Threshold at Runway End	Same as Alternative W6a, except landing threshold located at new end of runway. (Variation: relocate rather than bridge Tecolotito Creek.)
East End Alternatives	
E1 – Status Quo	Maintain existing pavement end and threshold location
E2 – Use Displaced Threshold and Declared Distance to meet Standard	Maintain existing pavement end location; displace threshold approximately 800 ft (500 ft more than existing displacement) to meet RSA length standards.
E3a – Add Full RSA to Existing Runway End	Maintain existing pavement end and displaced threshold location; bridge San Pedro and San Jose Creeks and Fairview Avenue to allow construction of full 1,000-foot RSA. This is the east-end configuration proposed in the original draft Master Plan. (Variation: eliminate displaced threshold.)
E3b – Create Full RSA Measure from Existing Displaced Threshold	This variation of Alternative E3a keeps the existing 314-fot displaced threshold in place, thus requiring only 686 feet of RSA beyond the existing end of runway pavement. Bridging across San Jose Creek is consequently avoided. Also, Fairview Avenue would be rerouted around the end of the RSA rather than placed in a tunnel.
E4a – Extend runway 500 ft with Full RSA and Existing Threshold Location	Extend runway and taxiway across San Pedro Creek and Fairview Avenue; continue safety area across San Jose Creek nearly to buildings on east. Configuration is the maximum eastward extension of the runway attainable with a full RSA
E4b – Extend runway 500 ft with Full RSA and Threshold at Runway End	Same as Alternative 4a, except landing threshold located at new end of runway.
E5 – Extend Runway Approximately 800 ft and Displace Threshold to Meet Standards	Extend runway as far as possible without requiring modification of San Jose Creek; Bridge San Pedro Creek and Fairview Avenue; displace threshold 1,000 feet from new runway end to meet RSA standards.
E6a – Extend Runway 1,100 ft with Partial RSA and Existing Threshold Location	Extend runway and taxiway enough to both increase runway length and allow full RSA at west end without crossing Tecolotito Creek; bridge San Pedro and Old San Jose creeks and Fairview Avenue; extend RSA nearly to buildings on east. The alternative was examined in the original (1990) draft Master Plan (as Alternative 3).
E6b – Extend Runway 1,100 ft with Partial RSA, Threshold Displacement of 1,000 ft	Same as Alternative E6a, except landing threshold located approximately 400 feet closer to new end of runway.

Source: Information compiled by URS Corporation from H Hodges & Shutt, 1995, *Santa Barbara Municipal Airport – Runway 7-25 Alternatives*, Santa Rosa, California

TABLE 2 – 1995 STUDY ALTERNATIVES DISPOSITION

Alternative	Disposition
West End Alternatives:	
W1 – Status Quo	Carried forward in this new evaluation.
W2 – Use Displaced Threshold and Declared Distance to meet Standard	Not carried forward in this evaluation due to reduced runway performance lengths.
W3 – Add Full RSA to Existing Runway End	Not carried forward in this evaluation due to reduced runway performance lengths.
W4 – Extend Runway Approximately 300 ft, Displace Threshold to Meet Standards	Not carried forward in this evaluation due to reduced runway performance lengths.
W5a – Extend Runway 400 ft with Full RSA and Existing Threshold Location	Concept of bridging (culverting) Tecolotito Creek carried forward in this evaluation, except that runway is extended 800 ft.
W5b – Extend Runway 400 ft with Full RSA and Threshold at Runway End	Concept of bridging (culverting) Tecolotito Creek carried forward in this evaluation, except that runway is extended 800 ft. (Similar concept to W5a.)
W6a – Extend Runway 800 ft with Full RSA and Existing Threshold Location	Fundamental concept is valid but this specific alternative is not carried forward due to reduced landing length to the east.
W6b – Extend Runway 800 ft with Full RSA and Threshold at Runway End	Carried forward as alternatives 1 and 2, in the new alternatives development section that follows.
East End Alternatives	
E1 – Status Quo	Carried forward for evaluation in this new evaluation.
E2 – Use Displaced Threshold and Declared Distance to meet Standard	Carried forward for evaluation in this new evaluation.
E3a – Add Full RSA to Existing Runway End	The concepts of bridging (culverting) San Pedro Creek and tunneling Fairview Avenue are carried forward in this evaluation. However, the alternative is not carried forward due to cost of bridging (culverting) an additional creek, Old San Jose Creek, and the required land acquisition east of Old San Jose Creek.
E3b – Create Full RSA Measure from Existing Displaced Threshold	Fundamental concept of bridging (culverting) San Pedro Creek and rerouting Fairview Avenue is valid but this specific alternative is not carried forward due to reduced runway performance lengths from west to east.
E4a – Extend runway 500 ft with Full RSA and Existing Threshold Location	Not carried forward. Same determination as E3a.
E4b – Extend runway 500 ft with Full RSA and Threshold at Runway End	Not carried forward. Same determination as E3a.
E5 – Extend Runway Approximately 800 ft and Displace Threshold to Meet Standards	Fundamental concepts of bridging (culverting) San Pedro Creek and tunneling Fairview Avenue are valid. However, this specific alternative is not carried forward due to location of new runway end within 100-foot environmental buffer of Old San Jose Creek, and significant land and easement acquisition east of this creek.
E6a – Extend Runway 1,100 ft with Partial RSA and Existing Threshold Location	The concepts of bridging (culverting) San Pedro Creek and tunneling Fairview Avenue are carried forward in this evaluation. However, this specific alternative is not carried forward due to cost of bridging (culverting) an additional creek, Old San Jose Creek, significant land and easement acquisition east of Old San Jose Creek, and only partial provision of a RSA at the east end of the runway.
E6b – Extend Runway 1,100 ft with Partial RSA, Threshold Displacement 1,000 ft	Same as E6a.

Source: Information compiled by URS Corporation

2.0 PROJECT OBJECTIVES & ASSUMPTIONS

The primary objectives and assumptions presented in the Hodges and Shutt (1995) report were used in this study, as listed below:

Objectives:

- Safety – Modify the existing configuration of each end of the runway to meet Federal Aviation Administration RSA length criteria.
- Usability – Provide a runway length that minimizes the circumstances under which current and future airline aircraft flights are constrained. Each alternative must at least maintain the existing runway length presently considered usable for both takeoff and landing calculation purposes.

Assumptions

- Utilize the Boeing 737 series and McDonald Douglas MD-80 series aircraft noted in the 1995 Runway 7-25 Alternatives report as the critical aircraft for design criteria. (Reference the 1995 report, Page 5.) Accordingly, the airport will continue to be planned and designed to Airport Reference Code (ARC) C-III.
- Utilize the city-pair stage length analysis, and the Boeing 737 series and McDonald Douglas MD-80 series aircraft analysis contained in the 1995 Runway 7-25 Alternatives report for aircraft operational performance and runway length requirements. (Reference the 1995 Runway 7-25 Alternatives report, Page 8.) Accordingly, the existing runway length of 6,052 feet is adequate to serve the current and anticipated aircraft fleet. A length of at least 6,850 feet would be required to provide any appreciable increase in stage length and/or payload improvement.

The Airport has expressed several preferences for the RSA extension project that influence the development of alternatives. For example, alternatives to be considered further should avoid or greatly minimize construction requirements and/or land purchases outside Airport property. Solutions that include off-Airport construction will involve other agencies and organizations whose objectives, schedules, and requirements that could render an alternative infeasible, or adversely affect the Airport's schedule for the project.

The FAA has suggested that the Airport endeavor to provide full RSAs while not employing the Declared Distance Concept (DDC) to meet design criteria, if possible. The FAA's policy is to avoid the use of the DDC if the project objectives can be achieved without the use of the DDC. The FAA's preference is noted; however, this reevaluation does not preclude analyzing solutions that could balance runway safety area recommendations while lessening project impacts and project cost, which could occur under application of this design technique. Therefore, the FAA DDC technique is included in several of the new alternatives presented in this analysis.

3.0 DESCRIPTION OF ALTERNATIVES

Seven alternatives were developed based on the objectives and assumptions discussed in Section 2.0. There are three primary RSA extension alternatives, each with two variations, in addition to a status quo alternative (totaling seven alternatives). One variation is to realign Tecolotito Creek west around the west end of Runway 7-25 and Taxiway A. The other would place Tecolotito Creek in a culvert under the runway and taxiway. The culvert would extend the full width of the runway and parallel taxiway safety areas (about 750 feet), and would approximate the existing alignment of the creek. The defining differences between the variations (Tecolotito Creek realignment vs. culvert), are demonstrated in construction costs, hydraulic characteristics, and environmental impacts.

A description of each alternative is presented below. Key features and runway length performance information are presented in Table 3. The runway performance length information is included because it is the result of applying the FAA's Declared Distance Concept to the design aspects, i.e., displaced thresholds, relocated thresholds, clearways, stopways, that may be included in the alternatives. Alternatives are shown on Figures 2 through 8. Existing conditions are shown on Figure 1.

Alternative 1 – West Culvert

This alternative consists of the following: an 800-foot runway extension west and placement of Runway 7 threshold at this new end location; a new 1,000-foot long RSA extending west; a culvert along Tecolotito Creek; an 800-foot long displacement of Runway 25 threshold to the west, and; a 1,000-foot long Clearway at the west runway end.

Alternative 2a – West Creek Realignment – Displaced Threshold

This alternative consists of the following: an 800-foot runway extension west and placement of Runway 7 threshold at this new end location; a 1,000-foot long RSA extending west; realignment of Tecolotito Creek to the west; an 800-foot long displacement of Runway 25 threshold west, and; a 1,000-foot long Clearway at the west runway end.

The specific focus of Alternatives 1 and 2 is to avoid significant construction at the east end of the runway. Each of these alternatives employs the FAA Declared Distance Concept to gain additional aircraft performance runway length which could be useful to the airport for westbound aircraft departures. These alternatives are similar to *Alternative D2* in the 1995 Hodges and Shutt study.

Alternative 2b – West Creek Realignment – Relocated Threshold

This alternative is the same as 2a, except the Declared Distance Concept is not employed, and thus the published runway length remains at 6052 feet.

Alternative 3

This alternative consists of the following: a 350-foot runway extension west and placement of Runway 7 threshold at this new end location; a 1,000-foot long RSA extending west; a culvert along Tecolotito Creek; a 350-foot long displacement of Runway 25 threshold to the west; culverting of San Pedro Creek; realigning the length of Fairview Avenue that is on Airport property to the outside of the RSA, OFA, and a 100-foot wide creek buffer.

Alternative 4

This alternative consists of the following: a 350-foot runway extension west and placement of Runway 7 threshold at this new end location; a 1,000-foot long RSA extending west; realignment of Tecolotito Creek to the west; a 350-foot long displacement of Runway 25 threshold to the west; culverting of San Pedro Creek; realigning the length of Fairview Avenue that is on Airport property to the outside of the RSA, OFA, and a 100-foot wide creek buffer.

Alternatives 3 and 4 endeavor to duplicate one of the objectives of Alternatives 1 and 2 but with reduced construction costs. They achieve this goal by displacing Runway 25 threshold 350 feet and extending the runway at the west end the same distance. This provides enough space at the east end to realign Fairview Avenue on Airport property while maintaining an environmental buffer of 100 feet further east on the west side of Old San Jose Creek. The runway performance measure for Accelerate-Stop Distance is marginally improved but it may be beneficial to aircraft departures to the west. These alternatives are similar to *Alternative 1* in the 1995 Hodges and Shutt study.

Alternative 5

This alternative consists of the following: a 265-foot runway extension west and placement of Runway 7 threshold at this new end location; a 1,000-foot long RSA extending west; culvert along Tecolotito Creek; a 265-foot long relocation of Runway 25 threshold to the west; culverting of San Pedro Creek; routing Fairview Avenue in a tunnel under the RSA and OFA of the runway.

Alternative 6

This alternative consists of the following: a 265-foot runway extension west and placement of Runway 7 threshold at this new end location; a 1,000-foot long RSA extending west; realignment of Tecolotito Creek; a 265-foot long relocation of Runway 25 threshold to the west; culverting of San Pedro Creek; routing Fairview Avenue in a tunnel under the RSA and OFA of the runway.

Alternatives 5 and 6 endeavor to reduce the impact at the west end of the runway through moderate length repositioning of the thresholds west by approximately 265 feet (i.e., minor runway extension west of 265 feet and shifting of the runway thresholds by the same distance). Runway lengthening opportunity gained by the culverting of San Pedro Creek and tunneling of Fairview Avenue at the east end compensate for the limited west end runway extension of 265 feet. As a result, costs and environmental impacts at the west end are reduced but with significantly increased costs at the east end associated with the tunneling of Fairview Avenue, when compared with Alternatives 1 through 4. Each of the alternatives described above meet or exceed the objectives of safety and usability for the Airport (i.e., maintaining runway length).

TABLE 3
RUNWAY PERFORMANCE LENGTH ANALYSIS

Item	Runway End	Alternatives 1 [1] (ft)	2a [1] (ft)	2b (ft)	3 [2] (ft)	4 [2] (ft)	5 (ft)	6 (ft)	Status Quo (ft)
Runway 7-25 Combined									
Additional Pavement	West	800	800	800	350	350	265	265	None
	East	None	None	None	None	None	None	None	None
Safety Area Length Behind Runway End	West	1,000	1,000	1,000	1,000	1,000	1,000	1,000	300
	East	200	200	1,000	650	650	1,000	1,000	200
Displaced Threshold	West	None	None	None	None	None	None	None	None
	East	800	800	None	350	350	None	None	314
Clearway	West	0	0	0	0	0	0	0	None
	East	0	0	0	0	0	0	0	None
Stopway	West	None	None	None	None	None	None	None	None
	East	800	800	None	None	None	None	None	None
Runway 7									
Takeoff Run Available		6,852	6,852	6,052	6,402	6,402	6,052	6,052	6,052
Takeoff Distance Available		6,852	6,852	6,052	6,402	6,402	6,052	6,052	6,052
Accelerate-stop Distance Available		6,052	6,052	6,052	6,052	6,052	6,052	6,052	6,052
Landing Distance Available		6,052	6,052	6,052	6,052	6,052	6,052	6,052	6,052
Runway 25									
Takeoff Run Available		6,852	6,852	6,052	6,402	6,402	6,052	6,052	6,052
Takeoff Distance Available		6,852	6,852	6,052	6,402	6,402	6,052	6,052	6,052
Accelerate-stop Distance Available		6,852	6,852	6,052	6,402	6,402	6,052	6,052	6,052
Landing Distance Available		6,052	6,052	6,052	6,052	6,052	6,052	6,052	5,738

Source: Information compiled by URS Corporation

[1] Similar to *Alternative D2* in the 1995 Hodges & Shutt study, except this alternative provides a nominal 200-foot Clearway and 800-foot Stopway at the east runway end. The resulting performance runway lengths are similar.

[2] Similar to *Alternative I* in the 1995 Hodges & Shutt study, except this alternative provides a 100-foot buffer between Old San Jose Creek and realigned Fairview Avenue. The resulting performance runway lengths are similar.

Alternative 1 – West Culvert
Alternative 2 – West Realignment
Alternative 3 – Fairview Realignment / West Creek Culvert
Alternative 4 – Fairview Realignment / West Creek Realignment
Alternative 5 – Fairview Tunnel / West Creek Culvert
Alternative 6 – Fairview Tunnel / W. Creek Realign
Alternative 7 – Status Quo

4.0 CONSTRUCTION COSTS

General planning costs were prepared to facilitate comparison of the alternatives. A summary of total construction costs is provided in Table 4. Detailed costs are presented in Appendix C. These costs are for planning purposes related to this study only. More detailed costs should be prepared as part of preliminary and final design analyses prior to project implementation of the preferred alternative. Costs for each of the six alternatives are in year 2000 dollars, and are based on unit costs from actual projects undertaken at the Airport in 2000. The unit costs also take into consideration the standard unit cost measures available through Caltrans.

Runway and taxiway design employs the design guidelines of the FAA. Soils data are provided by the City from recent soil analysis conducted for the Airport. The pavement section design for the runway and associated taxiways uses the MD-83 and Boeing 727 as the design aircraft. The design accommodates aircraft with dual tandem gear up to 245,000 pounds, and single gear up to 75,000 pounds. Annual departures of 15,000 are used as the level of operational activity. These data represent a conservative approach to pavement section design for the Airport. Additionally, the consultant prepared runway and taxiway plans and profiles to bring a higher level of accuracy to the cost estimates. A plan and profile was also prepared for the relocation of Runway 7 MALSR. These incorporated existing buildings and obstruction in the approach area, as shown on the NOAA Airport Obstruction Chart dated August 1995.

The box culverts employed for channeling Tecolotito Creek (Alternatives 1, 3, and 5) consist of five reinforced concrete culverts, each 14 feet wide and eight and one half feet high. A 10-year event is used to design this culvert system capacity. A higher event level was not employed since the capacity of the existing natural channel can only accommodate a 10-year event. The culverts used for San Pedro Creek (Alternatives 3, 4, 5, and 6) consist of four boxes, 15 feet wide each, and 10 feet high. The cost estimate prepared for the realignment of Fairview Avenue is based on a preliminary design conducted by the consultant. The roadway section design is based on that existing for the road.

The following is a summary of total costs for each of the alternatives. Following this are detailed cost breakdowns for each of the alternatives. Cost considerations specific to each alternative are included in the Notes section of each table.

As can be seen in the table below, alternatives involving the culverting of Tecolotito Creek or the tunneling of Fairview Avenue are the most expensive. Alternative 2 is the least expensive because it involves construction only at the west end of the runway, and realigns Tecolotito Creek rather than placing it in a 70-foot-wide culvert.

TABLE 4
COST COMPARISON SUMMARY

Alternative	Construction Cost ($)
Alternative 1 – West Culvert	11,127,350
Alternative 2a – West Realignment-Displaced Threshold *	5,019,625
Alternative 3 – Fairview Realignment / West Creek Culvert	16,466,580
Alternative 4 – Fairview Realignment / West Creek Realignment	10,654,280
Alternative 5 – Fairview Tunnel / West Creek Culvert	21,217,170
Alternative 6 – Fairview Tunnel / West Creek Realignment	17,406,870
Alternative 7 – Status Quo	N/A

Source: URS Corporation

* Alternative 2b – West Realignment – Relocated Threshold may be incrementally higher than Alternative 2a due to the possible need for additional access taxiways in the future.

5.0 ENVIRONMENTAL CONSIDERATIONS

5.1 SURFACE WATER HYDROLOGY

5.1.1 Hydraulic Scenarios Associated with Alternatives

The six alternatives involve extension of the runway and RSA at the east and west ends of Runway 7-25, either at one end or at both ends. San Pedro Creek and Tecolotito Creek are located at the east and west ends of the runway, respectively. Extension at the west end will require either realigning Tecolotito Creek around the new RSA, or placing the creek in a culvert under the new runway and RSA extension. RSA extensions at the east end will require placement of San Pedro Creek into a culvert under the new RSA, and realigning Fairview Avenue. Relocating San Pedro Creek is not feasible due to insufficient Airport property to accommodate a relocated creek. These channel modifications result in three basic hydraulic scenarios:

1. Construction of a 750-foot long and 80-foot wide culvert to pass flows in Tecolotito Creek under the proposed runway extension. This scenario is required for the Alternatives 1, 3 and 5.
2. Realignment of Tecolotito Creek below the confluence with Carneros Creek to accommodate the proposed runway extension. This scenario is required for the Alternatives 2, 4, and 6.
3. Construction of a 500-foot long and 60-foot wide culvert to pass flows in San Pedro Creek under the proposed runway extension. This scenario is required for the Alternatives 3 through 6.

The flow and sediment transport capacities under the three channel modification scenarios were analyzed in a separate study by URS Corporation order to compare their relative hydraulic performance and flooding hazards – *Channel Modification Alternatives for the Runway Safety Area Alternatives*. The results of the study are summarized below.

5.1.2 Hydraulic and Flooding Analyses

Existing Conditions. The existing bank-full flow capacity of Tecolotito Creek at the western end of the runway is approximately equivalent to the 10-year flood event. The water surface elevation at the bank-full capacity is estimated to be 8.8 feet, which is about 0.2 feet below the existing runway elevation of 9.0 feet. The existing bank-full flow capacity of San Pedro Creek at the eastern end of the runway is approximately between the 5- and 10-year flood event. For the 10-year flood event of 2,200 cfs on San Pedro Creek, the water surface elevation on the eastern side of the runway is estimated be at 10.0 feet, which is about 1.0 foot above the existing runway elevation of 9.0 feet. The peak flood events larger than the 10-year event would result in flooding of the airport property from Tecolotito and San Pedro creeks, because the flows exceed the existing channel bank-full capacities.

Scenario 1 – Culvert on Tecolotito Creek. Based on the results of hydraulic analyses, a 750-foot long, 80-foot wide, and 6.2-foot high box culvert would be needed on Tecolotito Creek to maintain the existing bank-full channel flow capacity, which is equivalent to the 10-year flood event. In addition, the runway and RSA would need to be raised about one foot.

Scenario 2 – Tecolotito Creek Realignment. A new channel alignment around the RSA extension would result in 0.2 foot decrease in water surface elevation over the existing water surface elevation of 8.8 feet on Tecolotito Creek in the area just west of the proposed runway extension for the 10-year flood event. As such, there would be a minor decrease in flooding hazard. The runway and RSA would need to be raised under this scenario.

Scenario 3 – Culvert on San Pedro Creek. There is an insufficient elevation difference between the channel bottom and the existing runway elevation to construct a culvert with a 10-year flow capacity. The existing runway need to be raised at least up to an elevation of 10.0 feet to pass the 10-year flood event with a 60 feet wide and 7.4 feet high box culvert. Therefore, installing a culvert on San Pedro Creek would result in an increase flooding of the airfield unless Runway 7-25 were raised.

5.1.3 Sediment Transport Analysis

Existing Conditions. Sediment basins are currently located on Tecolotito and Carneros creeks upstream of the airfield. These basins have enough capacity to intercept sediment materials transported through the creeks on mean annual basis. However, the peak flood flows larger the 5-year event are expected to fill both basins completely. The remaining sediment materials that overflow the two basins are expected to deposit in Tecolotito Creek below the confluence with Carneros Creek.

Scenarios 1 and 3 – Culvert Options. Base-load sediments during major flood events (5-year or larger) would settle in the approach channel to the culverts. This would continue until the capacity of the approach channel to hold the sediment materials is exhausted. The sediment materials would then start to move into the culvert, plugging it and causing backwater flooding and overtopping of the culvert. This situation would cause an increase in flooding of the runways compared to existing conditions, and compared to Scenario 2. These scenarios require raising the ends of the runway.

Scenario 2 – Tecolotito Creek Realignment. The realigned channel would not affect the operations or effectiveness of the existing sediment basins. There would be a slight increase in sediment deposition below the confluence of Tecolotito and Carneros creeks due to the decreased slope of the modified channel relative to the existing conditions. However, the increase would be negligible and would not likely cause a need for regular or substantial channel maintenance.

5.1.4 Conclusions

Scenario 2 is the preferred hydraulic solution for the runway RSA extension project at the west end of Runway 7-25. The realigned open channel would provide a minor improvement in channel capacity and concomitant reduction in flood hazard due to a slightly larger dimension, and because the channel would be located farther from the paved runway. It would not cause a significant increase in sediment deposition near the RSA, nor would it increase sediment deposition in Goleta Slough. As such, future maintenance requirements along the new channel would be expected to be negligible to minor.

The use of a culvert along Tecolotito Creek at the end of Runway 7-25 is not recommended because of the reasonably foreseeable risk that the culvert would be plugged during 10-year or more flood events. Plugging of the culvert would result in increased frequency of flooding of the airfield, as well as increase culvert maintenance requirements. Removal of the sediments from the culvert is not considered a feasible operation. Finally, use of a culvert would require raising the runway.

The use of a culvert along San Pedro Creek at the eastern end of Runway 7-25 is also not recommended because of the increased risk of flooding the runway due to sediment deposition in the culvert and the infeasible maintenance operations. In addition, increased flooding at this location would also affect non-Airport property and Fairview Avenue. The use of a culvert would require raising the runway.

5.2 WETLANDS

As noted above, extension of the RSA at the west end or Runway 7-25 will require either realigning Tecolotito Creek around the new RSA, or placing the creek in a culvert under the new runway and RSA extension. Extending the RSA at the east end will require placement of San Pedro Creek into a culvert under the new RSA, and realigning Fairview Avenue.

All six alternatives involve extension of the runway and RSA at the west end of Runway 7-25, involving either a culvert under the runway or realigning Tecolotito Creek. The length of the runway and RSA extension also varies amongst these alternatives. However, all these alternatives would affect existing wetland habitats along Tecolotito Creek and in the existing Runway Protection Zone (RPZ) on Airport property.

Extension of the runway RSA at the east end of the runway under Alternatives 3 through 6 would affect wetland habitats along San Pedro Creek. No wetlands are present east of the creek in the existing RPZ.

The impact of the six alternatives on native wetland habitats were analyzed in a separate study by URS Corporation -- *Wetland and Bird Strike Hazard Issues Associated with the Runway Safety Area Extension Project.* The study also included the development of a wetland mitigation plan. The results of the study are summarized below.

5.2.1 Occurrence of Wetlands

Wetlands along San Pedro Creek

San Pedro Creek within the RPZ contains very little native habitat. Most of the banks are barren, or dominated by weedy non-native species such as mustard and thistle. Willow trees are essentially absent, although there are small willow saplings at the base of the banks. No emergent wetlands or freshwater marsh are present along this reach. The bottom of the channel is scoured during the winter flows, precluding the establishment of woody perennial vegetation. In addition, the County Flood Control District clears the creek bottom each fall for maintenance purposes. As such, the only wetlands along this reach consists of scattered willow saplings along the lower banks.

Wetlands at the West End of Runway 7-25

Tecolotito and Carneros creeks adjacent to the airfield are man-made channels with steep near vertical banks. They supports a mixture of native and non-native plants. The upper banks include the native coyote bush and saltbush, as well as the following non-native species: mustard, thistle, tree tobacco, castor bean, poison hemlock, and ricegrass. The lower banks adjacent to the channels and brackish water include the native pickleweed, salt grass, and bulrush. There are several sandbars and mud flat areas along the margins of these reaches, particularly near Hollister Avenue that support freshwater marsh plants, including bulrush, willow, cattail, watercress, canary grass, and willow weed. The creeks contain water year-round; they are tidally influenced up to Hollister Avenue. In the center of Goleta Slough, Tecolotito Creek supports salt marsh vegetation consisting of pickleweed, alkali heath, and salt grass. However, the upper portions of the banks and tops of the levees are dominated by the non-native mustard plant, which forms dense impenetrable stands.

A variety of wetland habitats occur in the flat, open grassy area between the runway and Carneros Road. A detailed field assessment of wetland habitats in this area was conducted in 2000 in which two types of wetlands were identified and mapped:

- Wetlands are typically defined under the Coastal Act as vegetation types that are dominated by plant species that are considered hydrophytes, that is, plants that are found in wetland situations at least 50 percent or more of the time. This definition is very broad and encompassing of many vegetation types that are otherwise not considered wetlands. However, it was used in the assessment because the project is subject to permitting under the Coastal Act.

- Wetlands defined under the Clean Water Act must exhibit three characteristics: wetland hydrology (i.e., prolonged soil saturation or inundation), hydric soils, and hydrophytic plants. This definition was used in the assessment because the project is subject to the permitting requirements of the Corps of Engineers under Section 404 of the Clean Water Act.

Eighteen vegetation types (or series) were identified in the open area west of Runway 7-25, of which the following represent vegetation types dominated by hydrophytic plants. As such, these vegetation types are considered wetlands under the Coastal Act. If these wetlands also contain hydric soils and evidence of prolonged soil moisture, they would also be considered Corps wetlands. The following wetlands primarily consist of annual and perennial grasses and herbs that occur in areas where drainage is inhibited and/or in shallow depressions that retain water for several weeks after rainfall events. The area west of the runway is not subject to tidal influence. However, it is very flat and exhibits poor drainage. The wetlands are seasonal and contain with varying proportions of upland species.

- Alkali Weed Series
- Annual Grassland Series (wetland affinities)
- Arroyo Willow Series
- Bulrush Series
- Cocklebur Series
- Curly Dock Series
- Pickleweed Series
- Saltgrass Series
- Spikerush Series

5.2.2 Impacts to Wetlands

Wetlands would be permanently removed by the various alternatives due to the following project elements:

- Extension of the runway and RSA at the west end of Runway 7-25 that directly removes seasonal wetlands in the RPZ
- Construction of a culvert along Tecolotito and/or San Pedro creeks to accommodate runway and/or RSA extensions that would remove open water and wetland habitat along these creeks
- Realignment of Tecolotito Creek that will displace seasonal wetlands due to excavation of a new channel
- Construction of Taxiway M that would remove seasonal wetlands
- Relocation of approach lights to the property west of the Airport that would remove seasonal wetlands

A summary of the acreage of wetlands permanently removed by the above project elements is presented in Table 5.

TABLE 5
SUMMARY OF WETLAND AND CREEK IMPACTS (acres)

Alts.	RSA Extension on West End of Runway 7-25				Taxiway M (seasonal wetlands)	RSA Extension on East End of Runway 7-25 (San Pedro Ck impacts)	Total Net Impacts (seasonal wetland impacts only)
	Tecolotito Creek (change in amount of open water habitat)	Seasonal Wetlands in Existing RPZ on Airport Property (removal for RSA)	Seasonal Wetlands in Existing RPZ (removal for relocated creek)	Seasonal Wetlands on Adjacent Property (removal due to relocated approach lights)			
1	1.00	4.51	0	0.30	0.29	0	6.10 (5.10)
2a&b	+4.34	4.51	3.24	0.30	0.29	0	4.00 (8.34)
3	1.00	2.83	0	0.30	0.29	0.40	4.82 (3.42)
4	+4.34	2.83	3.24	0.30	0.29	0.40	2.72 (6.66)
5	1.00	2.55	0	0.25	0.29	0.40	4.49 (3.09)
6	+4.34	2.55	3.24	0.25	0.29	0.40	2.39 (6.33)

Alternative 1 – West Culvert
Alternative 2 – West Creek Realignment
Alternative 3 – Fairview Realignment/W. Creek Culvert
Alternative 4 – Fairview Realignment/W. Creek Realignment
Alternative 5 – Fairview Tunnel / West Creek Culvert
Alternative 6 – Fairview Tunnel / W. Creek Realign
Alternative 7 – Status Quo

5.2.3 Wetland Mitigation

Mitigation Requirements

The Airport proposes to replace the permanently removed seasonal wetlands on a 2:1 acreage replacement ratio. New seasonal, non-tidal wetlands with a similar structure and species composition to the wetlands affected would be created on Airport property using revegetation techniques and species that have been shown to be successful for the recent Safety Area Grading Project. The replacement acreage would vary depending upon which alternative is selected, as shown below in Table 6:

TABLE 6
SUMMARY OF WETLAND MITIGATION ACREAGE

Alternative	Seasonal Wetlands Removed	Wetlands to be Created as Mitigation
1 West Culvert	5.10	10.20
2a & 2b West Creek Realignment	8.34	16.68
3 Fairview Realignment/W. Creek Culvert	3.42	6.84
4 Fairview Realignment/W. Creek Realignment	6.66	13.32
5 Fairview Tunnel / West Creek Culvert	3.09	6.18
6 Fairview Tunnel / W. Creek Realign	6.33	12.66

Mitigation Approach

Mitigation would be achieved through the following two restoration efforts to be implemented concurrently:

- Mustard Removal and Wet Grassland Restoration. Dense monoculture stands of mustard would be removed from the tops of levees along Tecolotito Creek through several grow-kill herbicide treatments. Total length of levees available to be treated is about 6,200 feet. The width varies from 25 to 120 feet. The total area available for treatment is about 8 acres. The levees would not be lowered; only minor shaping would occur on the tops. Once weeds have been removed, the tops would be revegetated with wet grassland species such as Italian ryegrass, alkali weed, saltgrass, and alkali heath. This action would remove the single largest source of weed seeds in Goleta Slough and replace with habitat similar to that being affected by the AFP.

- Seasonal Wetland Restoration. New seasonal wetlands would be created in uplands in "Area I," which is a 20-acre site between the UCSB bluffs and Tecolotito Creek. This site was originally an upland that was lowered to construct the airfield. It is dominated by a complex mixture of annual grassland, coyote brush scrub, poison oak stands, scattered ornamental trees, scattered oak and willow trees, eucalyptus groves, and weedy patches (especially pampas grass). The area contains several small isolated wetlands. The site is an excellent candidate for wetland restoration because it is: highly disturbed by non-native vegetation, threatened by a conversion to a monoculture of coyote brush, poorly drained, remote from human influences, and connected to numerous other habitats (oak woodland on the bluffs, freshwater marsh to the west, and estuarine and salt marsh habitats to the north). Wet grassland and other seasonal wetlands could be created in a mosaic pattern in the center of the site and along the southern banks of Tecolotito Creek. Upland habitats would be retained in continuous patches along the margin of the site to retain wildlife habitat and movement corridors. The site would be graded to create low-lying areas to facilitate prolonged saturated soils. Up to 8 to 9 acres could be converted from disturbed uplands to wet grassland and seasonal wetlands.

5.2.4 Creek Mitigation

The relocation of Tecolotito and Carneros creeks would create 9.27 acres of new channel area. Approximately 4.93 acres of channel would be filled, resulting in a net increase of 4.34 acres of channel area with open water habitat. Hence, the project would provide mitigation through relocation and lengthening of the creek.

Impacts to Carneros Creek habitat (0.40 acres) would be mitigated by restoration actions along the creek, upstream of the new culvert. These actions would include removal of non-native trees and weeds, and replacement with would and cottonwood trees on the banks.

5.3 BIRD STRIKE HAZARD

The relative effect of the various alternatives on bird strike hazards at the Airport was evaluated in a separate study by URS Corporation –*Wetland and Bird Strike Hazard Issues Associated with the Runway Safety Area Extension Project*. The results are summarized below.

The existing level of bird strike hazard could be affected in a positive or negative manner by the following project elements:

- Removal of seasonal wetlands at the west end of the runway
- Placement of Tecolotito Creek in a culvert under the runway
- Relocation of Tecolotito Creek farther from the runway
- Lengthening of Tecolotito Creek in the RPZ
- Creation of new wetlands along the southern margins of the Airport for mitigation purposes

The effects of these actions on bird strike hazard are summarized below.

- <u>Culvert at the West End</u>. Under this alternative, 750 feet of Tecolotito Creek at the end of Runway 7-25 would be placed in a culvert. This action would remove an existing bird attractant that is very close to the runway. However, the creek would still be near the runway at the culvert inlet and outlet. The extended RSA would remove existing seasonal wetlands at the end of the runway, which would reduce bird strike hazards in the RPZ. Scrub vegetation in the margins of the RPZ which is used by passerines would also be reduced by an extended RSA. In addition, the new RSA would be mowed and compacted, reducing grassland use by raptors and passerines.

- Culvert at the East End. Under this alternative, 500 feet of San Pedro at the east end of Runway 7-25 would be placed in a culvert. This action would remove an existing bird attractant that is very close to the runway. However, it should be noted that San Pedro Creek does not represent a significant bird attractant because it is dry most of the year.

- Realignment of Tecolotito Creek. Tecolotito Creek would be realigned under this alternative. The creek would be 1,300 feet from the end of the runway, more than 1,000 further than under current conditions. This would remove an existing bird attractant near the runway, and to a greater degree than with a culvert because the creek would not pass under the runway. The extended RSA would remove existing seasonal wetlands at the end of the runway. The removal of these wetlands would reduce bird strike hazards in the RPZ. Scrub vegetation in the margins of the RPZ which is used by passerines would be reduced by an extended RSA. In addition, the new RSA would be mowed and compacted, reducing grassland use by raptors and passerines. The relocated creek would be designed with steeper slopes to reduce mud flat habitat for shorebirds/wading birds and adjacent cover on the banks for waterfowl nesting (i.e., reduce "edge effect"). However, there will be a net increase in open water near the airfield. There would be no change in the existing bird strike hazard at the east end of the runway.

- Wetland Mitigation. The proposed removal of weeds from levees along Tecolotito Creek in the center of Goleta Slough is expected to have a neutral effect on the existing bird strike hazard at the Airport. The existing dense mustard stands provide very little habitat for birds. The proposed sparse upland scrub to be established on the levees would not increase habitat for passerines, raptors, wading birds, waterfowl, and shorebirds.

  The wetland restoration site (Area I) is located 2,200 feet and 3,000 feet from the center of Runways 15/33 and 7-25, respectively. This site provides the greatest linear distance from the runways compared to all other potential wetland restoration sites on Airport property. The new habitats to be created at the mitigation site would reduce the amount of scrub and associated passerines, but would also increase the amount of seasonal wetlands that would be used by passerines and raptors. The extent of seasonal ponded water can be minimized by grading design so that there would be only a slight increase in seasonal wetland habitat for shorebirds. Potential use of the area by flocking passerines and by geese can be minimized by landscape design

- Wildlife Management Measures. The Airport has a Wildlife Management Program designed to reduce conflicts between wildlife and Airport operations, including bird strike hazards. All feasible wildlife management methods to reduce bird strike hazards would be incorporated into the project, as necessary, including any measures to reduce attractants, exclude habitat use, repel or harass birds, and remove birds.

A summary of the various effects on the existing bird strike hazard at the Airport is provided in Table 7. This comparison indicates that all alternatives would reduce the existing level of bird strike hazard at the Airport; however, elements of each alternative could create new bird attractants in the airfield that may or may not affect strike hazards.

TABLE 7
SUMMARY OF BIRD STRIKE HAZARD AMONGST THE ALTERNATIVES

Project Elements	Effect on Existing Bird Strike Hazard Conditions due to RSA Extension Alternatives "+" = improve bird strike hazard conditions "—" worsen bird strike hazard conditions						
	Alt. 1	Alt. 2a	Alt. 2b	Alt. 3	Alt. 4	Alt 5	Alt. 6
Placement of Tecolotito Ck into a culvert under runway	+			+		+	
Tecolotito Ck abuts against RSA on either side of runway	-			-		-	
Relocation of Tecolotito Ck farther from runway		+	+		+		+
Increase in open water near airfield due to relocated creek		-	-		-		-
Reduction in scrub (passerine cover) and raptor prey in new RSA	+	+	+	+	+	+	+
Reduction in seasonal wetlands in new RSA	+	+	+	+	+	+	+
Placement of San Pedro Ck into a culvert				+	+	+	+
Removal of weeds from levees as mitigation	0	0	0	0	0	0	0
Creation of new seasonal wetlands at remote site	0	0	0	0	0	0	0
Positive effects on existing hazard	3	3	2	4	4	4	4
Negative effects on existing hazard	1	1	1	1	1	1	1

Alternative 1 – West Culvert
Alternative 2 – West Creek Realignment
Alternative 3 – Fairview Realignment/W. Creek Culvert
Alternative 4 – Fairview Realignment/W. Creek Realignment
Alternative 5 – Fairview Tunnel / West Creek Culvert
Alternative 6 – Fairview Tunnel / W. Creek Realign
Alternative 7 – Status Quo

6.0 COMPARISON OF ALTERNATIVES

6.1 SUMMARY OF KEY FEATURES

A summary of the key attributes of the seven alternatives is provided in Table 8.

TABLE 8
ALTERNATIVES ATTRIBUTE SUMMARY

Feature	Alt. 1	Alt. 2a	Alt 2b	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7 Status Quo
West Runway Extension (ft)	800	800	800	350	350	265	265	
Declared Distance Concept	✓	✓		✓	✓			
West Runway Safety Area (ft)	1,000	1,000	1,000	1,000	1,000	1,000	1,000	300
West Runway Safety Area (ft)	1,000	1,000	1,000	1,000	1,000	1,000	1,000	200
Runway 25 Displacement (ft)	800	800		350	350			314
RW 25 Threshold Relocation (ft)			800			265	265	
West End Clearway (ft)	1,000	1,000	1,000	1,000	1,000	1,000	1,000	
East End Clearway (ft)	200	200	1,000	650	650	1,000	1,000	
Tecolotito Creek Culvert	✓			✓		✓		
Tecolotito Creek Realignment		✓	✓		✓		✓	
San Pedro Creek Culvert				✓	✓	✓	✓	
Fairview Avenue Tunnel						✓	✓	
Fairview Avenue Realignment				✓	✓			
Raise runway for culvert				✓	✓	✓	✓	
Infeasible culvert design and maintenance	✓			✓	✓	✓	✓	
Wetland impact (acres)	10.2	16.7	16.7	6.8	13.3	6.2	12.3	
Overall effect on bird strike hazard	+	+	+	+	+	+	+	
Estimated Construction Costs ($M) (does not include environmental mitigation costs)	11.13	5.02	5+	16.47	10.65	21.22	17.41	

Source: URS Corporation

Alternative 1 – West Culvert
Alternative 2 – West Creek Realignment
Alternative 3 – Fairview Realignment/W. Creek Culvert
Alternative 4 – Fairview Realignment/W. Creek Realignment
Alternative 5 – Fairview Tunnel / West Creek Culvert
Alternative 6 – Fairview Tunnel / W. Creek Realign
Alternative 7 – Status Quo

6.2 COMPARISON OF ALTERNATIVES

6.2.1 Evaluation Criteria

The following criteria were used to compare the alternatives. A relative ranking system was used to compare alternatives in which ratings were assigned to each alternative – High, Medium, and Low -- for each criterion.

Criteria for Meeting Project Objectives:

- Safety: length of Runway Safety Area, Clearway, and Stopway
- Usability: Length of Takeoff Run Available and Landing Distance Available

Criteria for Comparing Alternatives:

- Construction costs
- Costs purchasing property or easements at the west end of Runway 7-25 associated with an extended Runway Protection Zone (RPZ) and relocated approach lighting
- Impacts on flooding along Tecolotito Creek and San Pedro Creek due primarily to potential for channels to become filled with sediment, causing overbank flooding of the Airport and/or Fairview Avenue
- Wetland impacts (acreage) and the associated permitting effort and habitat mitigation costs
- Effect on existing bird strike hazards at the Airport due to new configuration of runway, RSA, and creeks; and the construction of a new seasonal wetland on Airport property

6.2.2 Meeting Project Objectives

A summary of how the various alternatives meet the project objectives is provided in Table 9. All alternatives would establish RSAs at each end of Runway 7-25 that would meet FAA requirements. Each alternative also provides additional incidental safety benefits by longer Stopways. Alternatives 5 and 6 provide the highest level of improved runway safety conditions.

The usability of the runway varies amongst the alternatives. Alternatives 1 and 2 provide the greatest level of usability, as determined by available takeoff and landing distances. It should be noted that all alternatives increase Landing Distance Available for Runway 25 compared to existing conditions. None of the alternatives increase Landing Distance Available for Runway 7. Alternatives 1 – 4 increase the Takeoff Run Available compared to existing conditions.

TABLE 9
RELATIVE RANKING OF ALTERNATIVES BASED ON PROJECT OBJECTIVES

Alternative	Safety		Usability (Runway Performance)			
	RSA	Stopway	Runway 7		Runway 25	
			Takeoff	Landing	Takeoff	Landing
1	H	H	H	H	H	H
2a	H	H	H	H	H	H
2b	H	M	L	H	L	H
3	H	M	M	H	M	H
4	H	M	M	H	M	H
5	H	M	L	H	L	H
6	H	M	L	H	L	H

Relative ranking: H = highest, most favorable rating. M = middle rating. L = lowest, most unfavorable rating.

Alternative 1 – West Culvert
Alternative 2 – West Creek Realignment
Alternative 3 – Fairview Realignment/W. Creek Culvert
Alternative 4 – Fairview Realignment/W. Creek Realignment
Alternative 5 – Fairview Tunnel / West Creek Culvert
Alternative 6 – Fairview Tunnel / W. Creek Realign
Alternative 7 – Status Quo

6.2.3 Comparing Other Factors

The alternatives vary considerably relative to costs, logistics, and environmental considerations. The relative rankings of the alternatives using these criteria are presented in Table 10. Alternatives 3, 5, and 6 had the lowest relative costs. Alternatives 5 and 6 had the lowest requirements for off-site easements for the RPZ at the west end of Runway 7-25. Alternative 2 had the highest rating relative to flooding impacts because it includes an open channel where sediment can continue to be transported through the airfield as under existing conditions. All other alternatives include culverts on Tecolotito or Carneros creeks where sediment is expected to accumulate and cause flooding and maintenance difficulties. Alternatives 3 and 5 would have the lowest relative wetland impacts and mitigation costs because the RSA at the western end would not extend as far to the west into existing wetlands, and because a culvert would be used along Tecolotito Creek rather than relocating the creek into areas with existing wetlands. All alternatives would reduce the bird strike hazard conditions in the airfield to a similar degree. However, Alternative 2b would reduce bird strike hazards less than Alternative 2a.

TABLE 10
RELATIVE RANKING OF ALTERNATIVES BASED ON OTHER FACTORS

Alternative	Construction Costs, including raising runway (H = low costs)	Real Estate Costs and Easement Reqmts. (west end only; H = low cost)	Flooding and Sedimentation Impacts (H = low flooding and sedimentation impacts)	Wetland Impacts & Environ. Mitigation Costs (H= low impacts and costs)	Positive Effect on Bird Strike Hazard Conditions (H = reduction in hazard)
1	M	L	L	M	M
2a	H	L	H	L	M
2b	H	L	H	L	M
3	L	M	L	H	M
4	M	M	L	L	M
5	L	H	L	H	M
6	L	H	L	L	M

Relative ranking: H = highest, most favorable rating. M = middle rating. L = lowest, most unfavorable rating.

Alternative 1 – West Culvert
Alternative 2 – West Creek Realignment
Alternative 3 – Fairview Realignment/W. Creek Culvert
Alternative 4 – Fairview Realignment/W. Creek Realignment
Alternative 5 – Fairview Tunnel / West Creek Culvert
Alternative 6 – Fairview Tunnel / W. Creek Realign
Alternative 7 – Status Quo

6.3 CONCLUSION

Selection of the most favorable alternative must take into account many factors, and ultimately must balance conflicting factors and needs. All alternatives will meet the project safety objective – that is, establishment of FAA required Runway Safety Areas. All alternatives will also meet the broad usability objective of maintaining current runway lengths to keep options available for future operational needs. The incremental increases in safety by longer Stopways are not considered important criteria for selecting a preferred alternative for this project.

Construction costs, wetland impacts, and real estate requirements vary considerably amongst the alternatives. In contrast, bird strike hazard is not a determining factor in the comparison of alternatives. The flooding and sedimentation issues is the single-most important factor because construction of a culvert under either Tecolotito or Carneros creeks is considered impractical due to severe flooding risks and infeasible sediment management requirements. Hence, only Alternatives 2a and 2b (relocating Tecolotito Creek , extending Runway 7-25 800 feet, and establishing a new 1,000 foot long RSA) are considered a reasonable and feasible option to consider.

7.0 REFERENCES

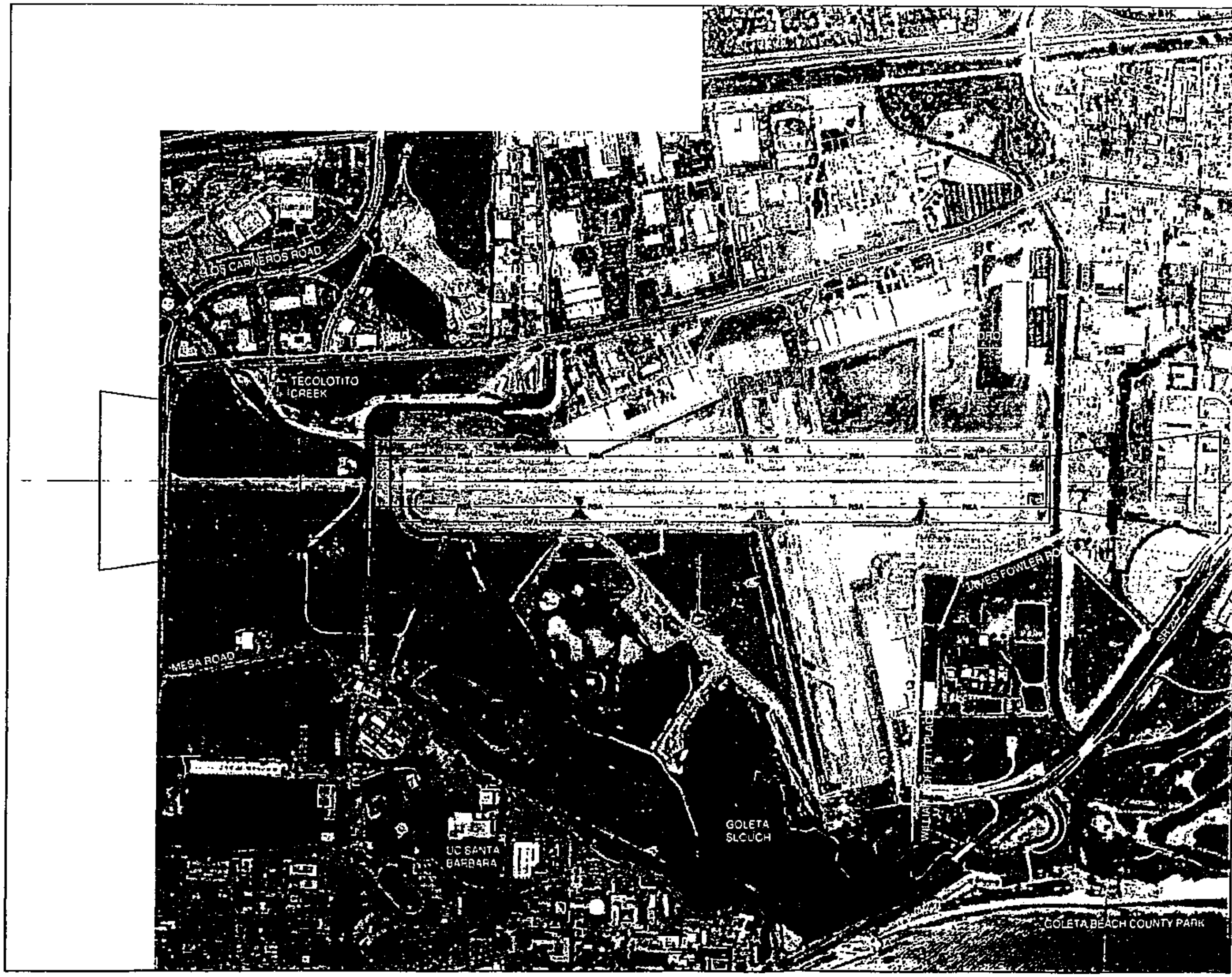
URS Corporation, 2000. Channel Modification Alternatives for the Runway Safety Area Extension Project, Master Drainage Plan, November 2000.

URS Corporation, 2000. Wetland and Bird Strike Hazard Issues Associated with the Runway Safety Area Extension Project, Master Drainage Plan, December 2000.

Hodges and Shutt, 1995. Runway 7-25 Alternatives. A discussion paper prepared for the Santa Barbara Municipal Airport, October 1995.

APPENDIX A

FIGURES



LEGEND

APPROACH RUNWAY PROTECTION ZONES

RUNWAY SAFETY AREA (RSA)

OBJECT FREE AREA (OFA)

AIRPORT PROPERTY LINE

200 0 200 400

SCALE IN FEET

Existing Conditions

URS

130 Robin Hill Road, Suite 100
Santa Barbara, CA 93117
(805) 964 6010

DESIGNED BY

DRAWN BY

CHECKED BY

DATE

FIGURE - 1

DECLARED DISTANCES (ft)		
ITEM	RUNWAY 7	RUNWAY 25
Take Off Run Available (TORA)	6,852	6,852
Take Off Distance Available (TODA)	7,052	7,852
Accelerate-Stop Distance Available (ASDA)	6,052	6,852
Landing Distance Available (LDA)	6,052	6,052

LEGEND

- APPROACH PROFILE
- CLEARWAY
- APPROACH RUNWAY PROTECTION ZONES
- RUNWAY SAFETY AREA
- OBJECT FREE AREA
- AIRPORT PROPERTY LINE
- RUNWAY / TAXIWAY CONSTRUCTION

ABBREVIATIONS

RW - RUNWAY
DT - DISPLACED THRESHOLD
RSA - RUNWAY SAFETY AREA
OFA - OBJECT FREE AREA

PROPOSED IMPROVEMENTS:

- 800' RW CONSTRUCTION WEST
- 1000' RSA EXTENSION WEST
- CULVERT TECOLOTITO CREEK
- 800' RW 25 THRESHOLD DISPLACEMENT WEST
- 1000' AND 200' CLEARWAYS

NOTE: 1) CULVERTS, TUNNEL, AND ROADWAY AND CREEK REALIGNMENT LOCATIONS ARE APPROXIMATE FOR ALL ALTERNATIVES
2) ACQUIRE EASEMENTS, RELOCATE LIGHTING, MALSR, MIDDLE MARKER

200 0 200 400
SCALE IN FEET

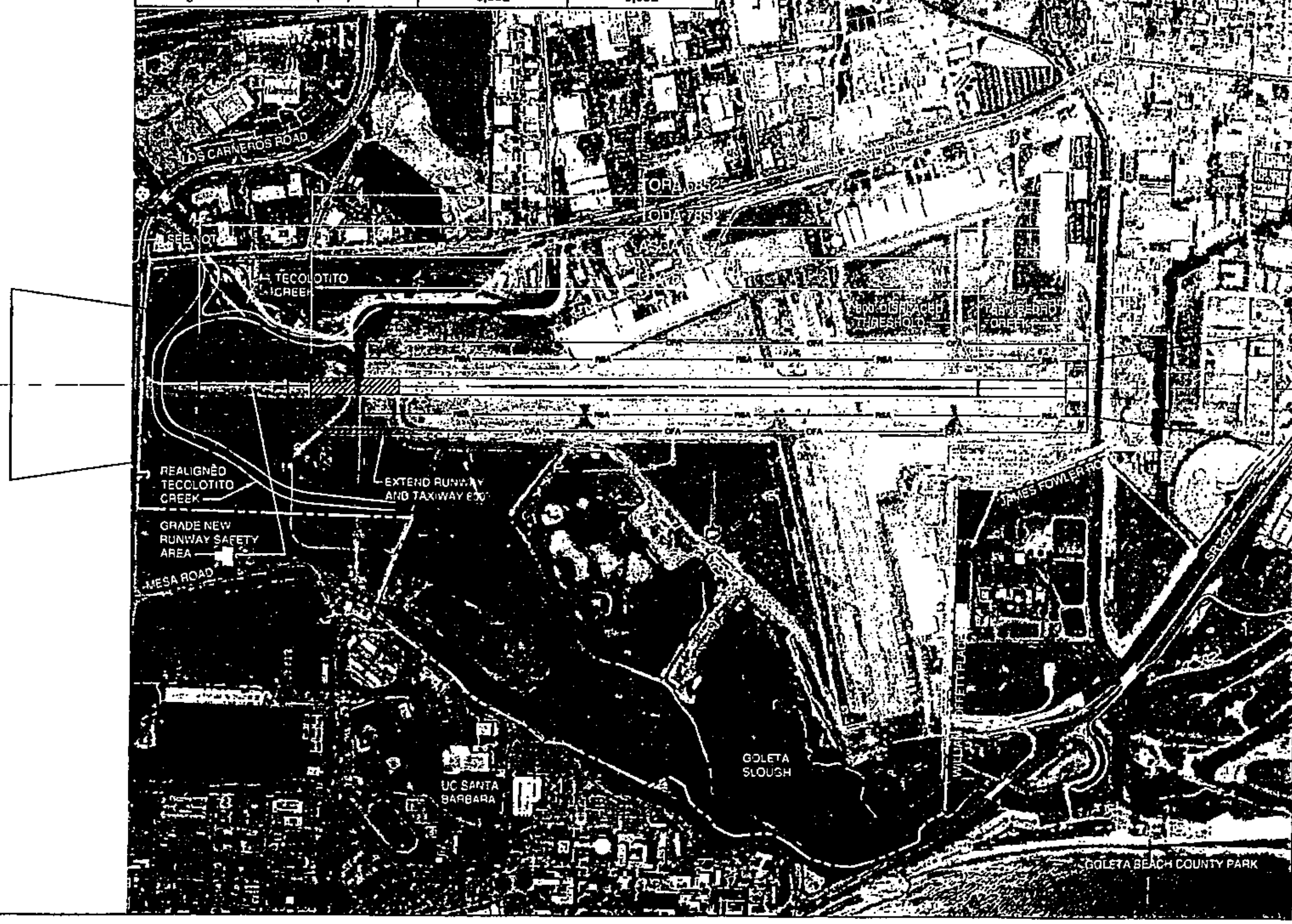
Alternative 1
West Culvert

URS
130 Robin Hill Road, Suite 100
Santa Barbara, CA 93117
(805) 964-6010

DESIGNED BY GCM
DRAWN BY BEB
CHECKED BY GFM
DATE 12/14/00

FIGURE - 2

DECLARED DISTANCES (ft)		
ITEM	RUNWAY 7	RUNWAY 25
Take Off Run Available (TORA)	6,852	6,852
Take Off Distance Available (TODA)	7,052	7,852
Accelerate-Stop Distance Available (ASDA)	6,052	6,852
Landing Distance Available (LDA)	6,052	6,052



LEGEND

- APPROACH PROFILE
- CLEARWAY
- APPROACH RUNWAY PROTECTION ZONES
- RUNWAY SAFETY AREA
- OBJECT FREE AREA
- AIRPORT PROPERTY LINE
- RUNWAY / TAXIWAY CONSTRUCTION

ABBREVIATIONS

RW - RUNWAY
DT - DISPLACED THRESHOLD
RSA - RUNWAY SAFETY AREA
OFA - OBJECT FREE AREA

PROPOSED IMPROVEMENTS:

- 800' RW CONSTRUCTION WEST
- 1000' RSA EXTENSION WEST
- REALIGN TECOLOTITO CREEK
- 800' RW 25 THRESHOLD DISPLACEMENT WEST
- 1000' AND 200' CLEARWAYS

NOTE: 1) CULVERTS, TUNNEL, AND ROADWAY AND CREEK REALIGNMENT LOCATIONS ARE APPROXIMATE FOR ALL ALTERNATIVES
2) ACQUIRE EASEMENTS, RELOCATE LIGHTING, MALSR, MIDDLE MARKER

200 0 200 400
SCALE IN FEET

Alternative 2a
West Creek Realignment
Displaced Threshold

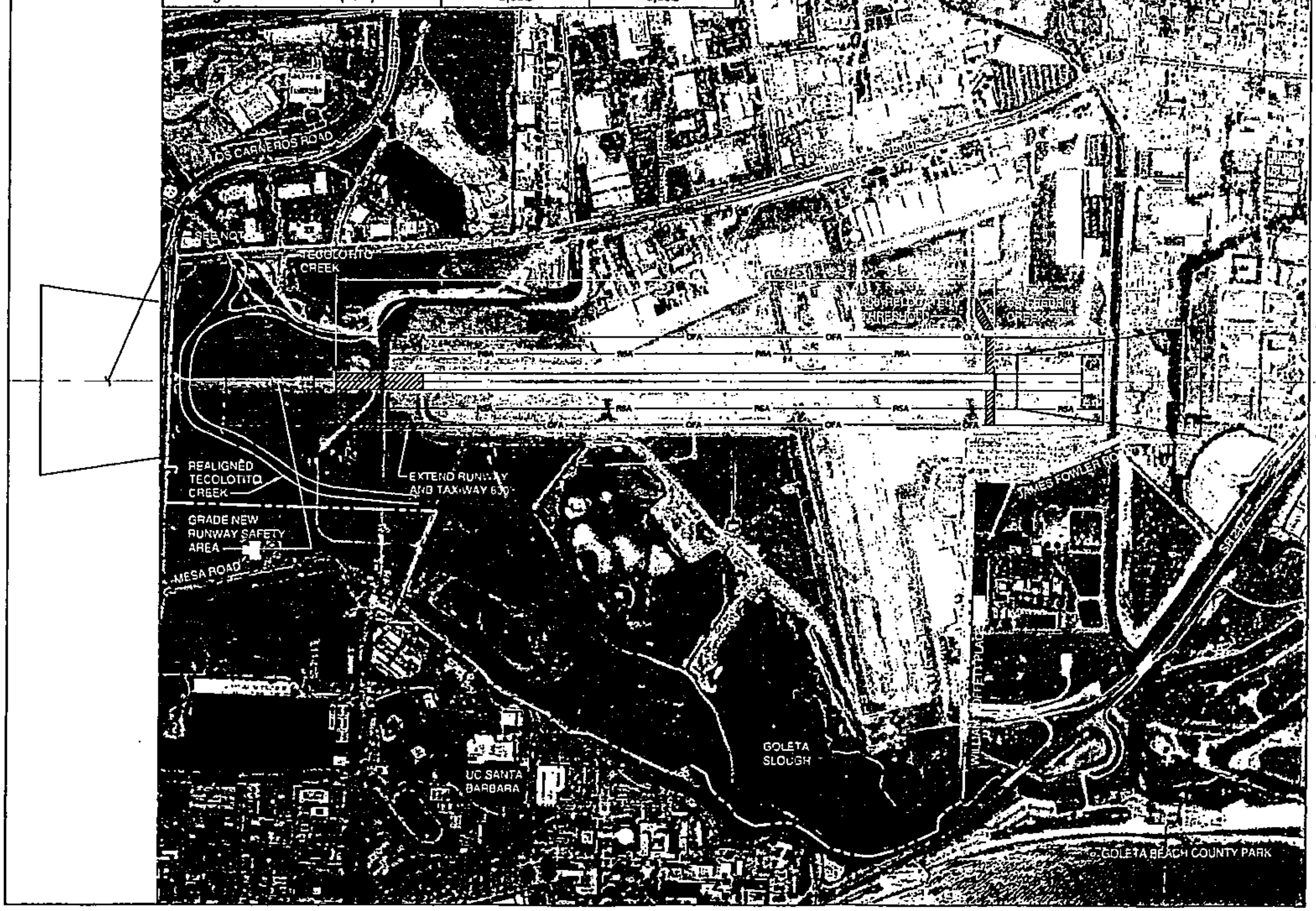
URS
130 Robin Hill Road, Suite 100
Santa Barbara, CA 93117
(805) 964 6010

DESIGNED BY OEM
DRAWN BY
CHECKED BY OEM
DATE 12/14/00

FIGURE - 3A

DECLARED DISTANCES (ft)

ITEM	RUNWAY 7	RUNWAY 25
Take Off Run Available (TORA)	6,052	6,052
Take Off Distance Available (TODA)	6,052	6,052
Accelerate-Stop Distance Available (ASDA)	6,052	6,052
Landing Distance Available (LDA)	6,052	6,052



LEGEND

- APPROACH PROFILE
- CLEARWAY
- APPROACH RUNWAY PROTECTION ZONES
- RUNWAY SAFETY AREA
- OBJECT FREE AREA
- AIRPORT PROPERTY LINE
- RUNWAY / TAXIWAY CONSTRUCTION

ABBREVIATIONS

RW - RUNWAY
DT - DISPLACED THRESHOLD
RSA - RUNWAY SAFETY AREA
OFA - OBJECT FREE AREA

PROPOSED IMPROVEMENTS:

- 600' RW CONSTRUCTION WEST
- 1000' RSA EXTENSION WEST
- REALIGN TECOLOTITO CREEK
- 600' RW 25 THRESHOLD RELOCATION WEST
- 1000' AND 200' CLEARWAYS

NOTE: 1) CULVERTS, TUNNEL, AND ROADWAY AND CREEK REALIGNMENT LOCATIONS ARE APPROXIMATE FOR ALL ALTERNATIVES
2) ACQUIRE EASEMENTS, RELOCATE LIGHTING, MALSR, MIDDLE MARKER

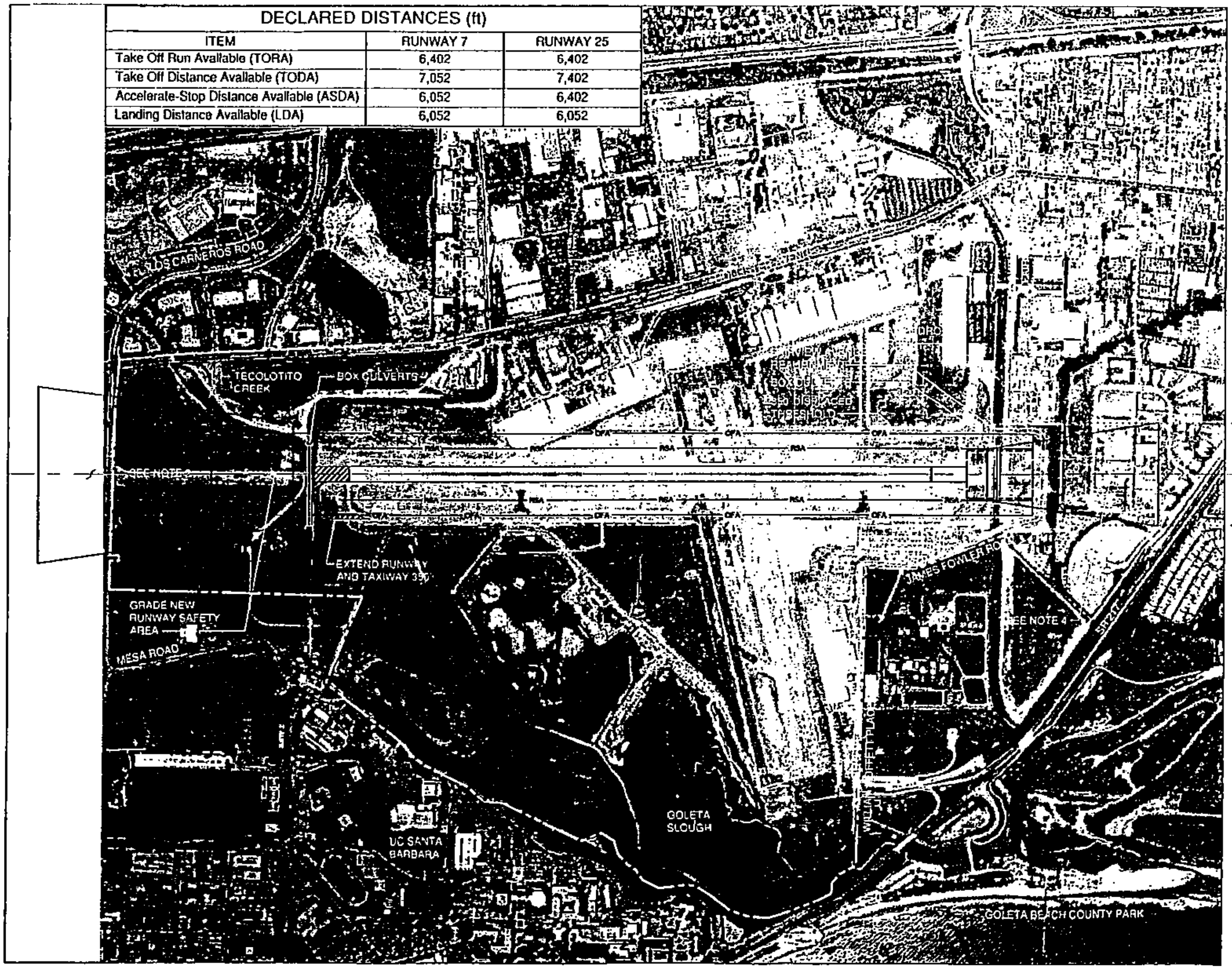
200 0 200 400
SCALE IN FEET

Alternative 2b
West Creek Realignment
Relocated Threshold

URS
130 Robin Hill Road, Suite 100
Santa Barbara, CA 93117
(805) 964-6010

DESIGNED BY GEM · DRAWN BY MEB · CHECKED BY GEM · DATE 12/14/00

FIGURE - 3B



DECLARED DISTANCES (ft)		
ITEM	RUNWAY 7	RUNWAY 25
Take Off Run Available (TORA)	6,402	6,402
Take Off Distance Available (TODA)	7,052	7,402
Accelerate-Stop Distance Available (ASDA)	6,052	6,402
Landing Distance Available (LDA)	6,052	6,052

LEGEND

- APPROACH PROFILE
- CLEARWAY
- APPROACH RUNWAY PROTECTION ZONES
- RUNWAY SAFETY AREA
- OBJECT FREE AREA
- AIRPORT PROPERTY LINE
- RUNWAY / TAXIWAY CONSTRUCTION

ABBREVIATIONS

RW - RUNWAY
DT - DISPLACED THRESHOLD
RSA - RUNWAY SAFETY AREA
OFA - OBJECT FREE AREA

PROPOSED IMPROVEMENTS:

- 350' RW CONSTRUCTION WEST
- 1000' RSA EXTENSION WEST
- CULVERT TECOLOTITO CREEK
- 350' RW 25 THRESHOLD DISPLACEMENT WEST
- 1000' AND 650' CLEARWAYS
- REALIGN FAIRVIEW AVENUE ALONG A/P PROPERTY

NOTES:
1) CULVERTS, TUNNEL, AND ROADWAY AND CREEK REALIGNMENT LOCATIONS ARE APPROXIMATE FOR ALL ALTERNATIVES
2) ACQUIRE EASEMENTS RELOCATE LIGHTING, MALSR, MIDDLE MARKER
3) DISPLACED THRESHOLD DISTANCE IS APPROXIMATE
4) ACQUIRE EASEMENTS

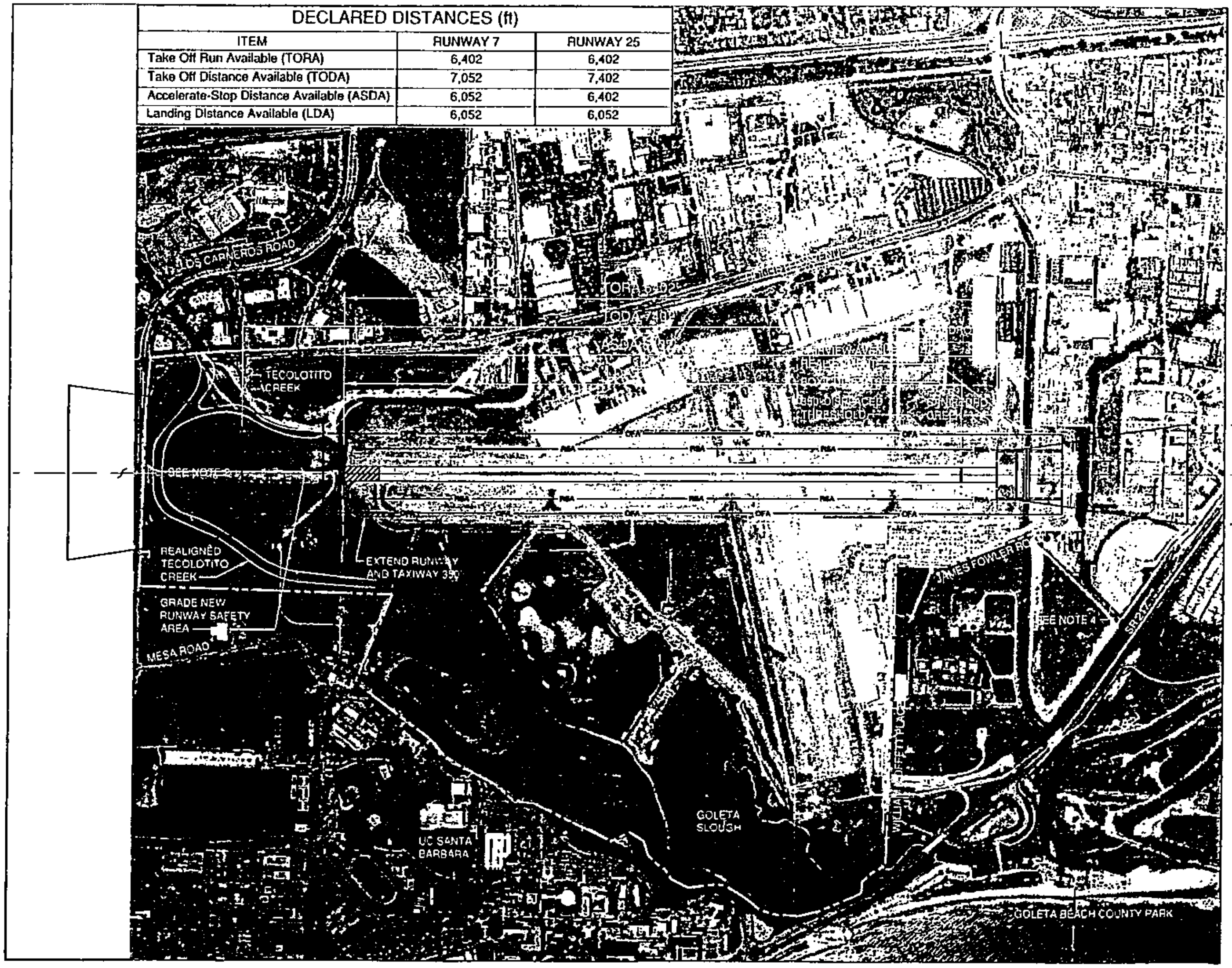
200 0 200 400
SCALE IN FEET

Alternative 3
Fairview Realignment/West Culvert

URS
130 Robin Hill Road, Suite 100
Santa Barbara, CA 93117
(805) 964-6010

DESIGNED BY	GEM	DATE	12/14/00
DRAWN BY	DEB	*FIGURE - 4*	
CHECKED BY	GLM		
PROJECT MANAGER	JW (Santa Barbara)		

DECLARED DISTANCES (ft)		
ITEM	RUNWAY 7	RUNWAY 25
Take Off Run Available (TORA)	6,402	6,402
Take Off Distance Available (TODA)	7,052	7,402
Accelerate-Stop Distance Available (ASDA)	6,052	6,402
Landing Distance Available (LDA)	6,052	6,052



LEGEND

- APPROACH PROFILE
- CLEARWAY
- APPROACH RUNWAY PROTECTION ZONES
- RUNWAY SAFETY AREA
- OBJECT FREE AREA
- AIRPORT PROPERTY LINE
- RUNWAY / TAXIWAY CONSTRUCTION

ABBREVIATIONS

RW - RUNWAY
DT - DISPLACED THRESHOLD
RSA - RUNWAY SAFETY AREA
OFA - OBJECT FREE AREA

PROPOSED IMPROVEMENTS:

- 350' RW CONSTRUCTION WEST
- 1000' RSA EXTENSION WEST
- CULVERT TECOLOTITO CREEK
- 350' RW 25 THRESHOLD DISPLACEMENT WEST
- 1000' AND 650' CLEARWAYS
- REALIGN FAIRVIEW AVENUE ALONG A/P PROPERTY

NOTES: 1) CULVERTS, TUNNEL, AND ROADWAY AND CREEK REALIGNMENT LOCATIONS ARE APPROXIMATE FOR ALL ALTERNATIVES
2) ACQUIRE EASEMENTS RELOCATE LIGHTING, MALSR, MIDDLE MARKER
3) DISPLACED THRESHOLD DISTANCE IS APPROXIMATE
4) ACQUIRE EASEMENTS

200 0 200 400
SCALE IN FEET

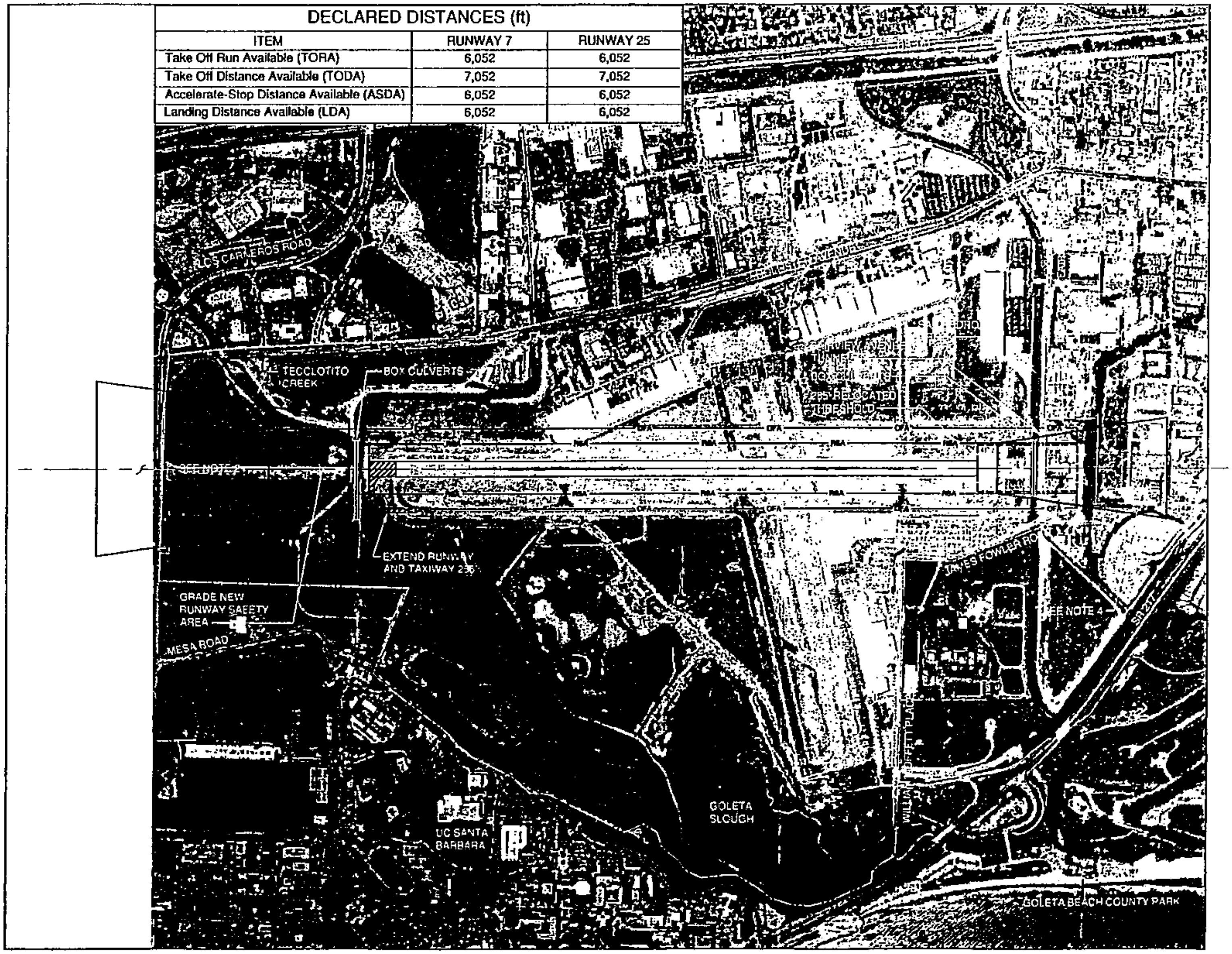
Alternative 4
Fairview Realignment/
West Creek Realignment

URS
130 Robin Hill Road, Suite 100
Santa Barbara, CA 93117
(805) 964-6010

DESIGNED BY	GEM	DATE	12/14/00
DRAWN BY	BEB		
CHECKED BY	GEM		

FIGURE - 5

DECLARED DISTANCES (ft)		
ITEM	RUNWAY 7	RUNWAY 25
Take Off Run Available (TORA)	6,052	6,052
Take Off Distance Available (TODA)	7,052	7,052
Accelerate-Stop Distance Available (ASDA)	6,052	6,052
Landing Distance Available (LDA)	6,052	6,052



LEGEND

- APPROACH PROFILE
- CLEARWAY
- APPROACH RUNWAY PROTECTION ZONES
- RUNWAY SAFETY AREA
- OBJECT FREE AREA
- AIRPORT PROPERTY LINE
- RUNWAY / TAXIWAY CONSTRUCTION

ABBREVIATIONS

RW - RUNWAY
DT - DISPLACED THRESHOLD
RSA - RUNWAY SAFETY AREA
OFA - OBJECT FREE AREA

PROPOSED IMPROVEMENTS:

- TUNNEL FAIRVIEW AVENUE
- 265' RW THRESHOLD RELOCATION WEST
- 1000' RSA EXTENSION WEST
- CULVERT TECOLOTITO CREEK
- 1000' CLEARWAYS

NOTES:
1) CULVERTS, TUNNEL, AND ROADWAY AND CREEK REALIGNMENT LOCATIONS ARE APPROXIMATE FOR ALL ALTERNATIVES
2) ACQUIRE EASEMENTS RELOCATE LIGHTING, MALSR, MIDDLE MARKER
3) RELOCATED THRESHOLD DISTANCE IS APPROXIMATE
4) ACQUIRE EASEMENTS

200 0 200 400
SCALE IN FEET

Alternative 6
Fairview Tunnel/West Creek Realignment

URS
130 Robin Hill Road, Suite 100
Santa Barbara, CA 93117
(805) 964-6010

DESIGNED BY SCM
DRAWN BY
CHECKED BY DEM
PROJECT MANAGER
DATE

FIGURE - 7

APPENDIX B

HODGES AND SHUTT (1995) STUDY

Santa Barbara Municipal Airport

Runway 7-25 Alternatives

October 1995

A Discussion Paper
Prepared for
City of Santa Barbara

by
Hodges & Shutt

INTRODUCTION

The purpose of this *Discussion Paper* is to review the design options available to the City of Santa Barbara for enhancement of the safety and utility of the Santa Barbara Municipal Airport's primary runway — Runway 7-25. The need for this type of improvement was initially outlined in the 1990 draft *Santa Barbara Municipal Airport Master Plan Update* (now called the *Airport Facilities Plan*). Several alternative runway configurations were presented and evaluated in that document and a specific concept was set forth. Subsequent planning efforts have refined the objectives of the project and consequently given rise to additional alternatives. The intended outcome of this paper is to reduce the wide range of possible alternatives to a list of those worthy of additional analysis as part of subsequent environmental impact studies.

As now defined, there are two interrelated aeronautical objectives to be accomplished by a runway improvement project:

- Safety — Modify the existing configuration of each end of the runway so as to meet Federal Aviation Administration runway safety area (RSA) length criteria — These criteria can be met either by providing a standard-length runway safety area or, if less than the standard length is provided, by declaring that only a specified amount of the runway length is considered usable for certain aircraft performance calculation purposes. The latter concept is referred to as *declared distances*. For the category of aircraft which use Runway 7-25, a standard configuration would have a 500-foot wide safety area (centered on the runway centerline) extending 1,000 feet beyond each end of the runway. At the present time, neither a standard RSA nor declared distances exist on this runway.

- Utility — Provide a runway length which minimizes the circumstances under which current and future airline aircraft flights are constrained (typically by limitations on the number of passengers that can be carried) — If determined to be of significant benefit, the existing operational length of the runway should be increased to both satisfy this objective and enhance the margin of safety for all aircraft operations. To be considered acceptable, an alternative must at least maintain the existing runway length presently considered usable for both takeoff and landing calculation purposes.

The following section of this paper defines a wide variety of alternative configurations for Runway 7-25. Some of these alternatives are drawn from previous studies, others are new here. The subsequent discussion then analyzes these alternatives with respect to the above project objectives. Two additional evaluation criteria — environmental impacts and construction costs — are briefly examined in the latter portion of the paper. A final section summarizes the findings and presents some conclusions.

RUNWAY 7–25 ALTERNATIVES

The process of defining and evaluating alternative configurations for Runway 7-25 was conducted in three steps:

- First, each end of the runway was examined independently to determine options for satisfying runway safety area criteria, either with a full 1,000-foot safety area length or with declared distances. A status quo alternative was also included for each runway end.

- Next, the runway end alternatives were evaluated and certain options were eliminated primarily on the basis of major, readily identifiable disadvantages compared to other alternatives.

- Thirdly, a set of combined alternatives was defined for further analysis. These full-runway alternatives were selected from among the many possible combinations as representing realistic, distinctly different runway configurations which meet the basic project objectives.

Runway End Alternatives

A total of eight alternatives were defined for the Runway 7 approach (west) end and nine for the Runway 25 approach (east) end. Several additional variations also were noted, but not considered to be sufficiently distinct from other configurations to be defined as separate alternatives. Table 1 lists and briefly describes each of the major runway end alternatives.

Alternatives for Approach (West) End of Runway 7

- **Alternative W1, Status Quo** — Maintain existing pavement end and threshold location.
- **Alternative W2, Use Displaced Threshold and Declared Distances to Meet Standards** — Maintain existing pavement end location; grade area between runway end and Tecolotito Creek to RSA standards; displace threshold approximately 700 feet to meet RSA standards; establish 1,000-foot clearway.
- **Alternative W3, Add Full RSA to Existing Runway End** — Maintain existing pavement end and threshold location; bridge Tecolotito Creek to allow construction of full 1,000-foot RSA*; establish 1,000-foot clearway at runway end (optional).
- **Alternative W4, Extend Runway Approximately 300 Feet and Displace Threshold to Meet Standards** — Extend runway as far as possible without requiring modification of Tecolotito Creek; displace threshold 1,000 feet from new runway end to meet RSA standards; establish 1,000-foot clearway at runway end. This alternative was examined in the revised (1992) draft *Master Plan*. (Variation: keep existing RPZ location.)

(* Variation: relocate rather than bridge Tecolotito Creek.)

- **Alternative W5a, Extend Runway 400 Feet with Full RSA and Existing Threshold Location** — Construct bridge over Tecolotito Creek*; extend runway and safety area, but leave landing threshold in current location (resulting in a 400-foot threshold displacement). This is the west-end configuration proposed in the original draft *Master Plan*. (Variation: keep existing RPZ location.) (Variation: limit extension to 300 feet to reduce length of creek to be covered.)
- **Alternative W5b, Extend Runway 400 Feet with Full RSA and Threshold at Runway End** — Same as Alternative W5a, except landing threshold located at new end of runway.* (Variation: limit extension to 300 feet to reduce length of creek to be covered.)
- **Alternative W6a, Extend Runway 800 Feet with Full RSA and Existing Threshold Location** — Same as Alternative W5a, except extension length is 800 feet. This configuration is intended to complement Alternative E2. (Variation: keep existing RPZ location.)
- **Alternative W6b, Extend Runway 800 Feet with Full RSA and Threshold at Runway End** — Same as Alternative W6a, except landing threshold located at new end of runway.*

Alternatives for Approach (East) End of Runway 25

- **Alternative E1, Status Quo** — Maintain existing pavement end and threshold location.
- **Alternative E2, Use Displaced Threshold and Declared Distances to Meet Standards** — Maintain existing pavement end location; displace threshold approximately 800 feet (500 feet more than existing displacement) to meet RSA length standards.
- **Alternative E3a, Add Full RSA to Existing Runway End** — Maintain existing pavement end and displaced threshold location; bridge San Pedro and San Jose Creeks and Fairview Avenue to allow construction of full 1,000-foot RSA. This is the east-end configuration proposed in the original draft *Master Plan*. (Variation: eliminate displaced threshold.)
- **Alternative E3b, Create Full RSA Measured from Existing Displaced Threshold** — This variation of Alternative E3a keeps the existing 314-foot displaced threshold in place, thus requiring only 686 feet of RSA beyond the existing end of runway pavement. Bridging across San Jose Creek is consequently avoided. Also, Fairview Avenue would be rerouted around the end of the RSA rather than placed in a tunnel.
- **Alternative E4a, Extend Runway 500 Feet with Full RSA and Existing Threshold Location** — Extend runway and taxiway across San Pedro Creek and Fairview Avenue; continue safety area across San Jose Creek nearly to buildings on east. This configuration is the maximum eastward extension of the runway attainable with a full RSA length.
- **Alternative E4b, Extend Runway 500 Feet with Full RSA and Threshold at Runway End** — Same as Alternative E4a, except landing threshold located at new end of runway.
- **Alternative E5, Extend Runway Approximately 800 Feet and Displace Threshold to Meet Standards** — Extend runway as far as possible without requiring modification of San Jose Creek; bridge San Pedro Creek and Fairview Avenue; displace threshold 1,000 feet from new runway end to meet RSA standards.
- **Alternative E6a, Extend Runway 1,100 Feet with Partial RSA and Existing Threshold Location** — Extend runway (and taxiway) enough to both increase runway length and allow full RSA at west end without crossing Tecolotito Creek; bridge San Pedro and San Jose Creeks and Fairview Avenue; extend RSA nearly to buildings on east. This alternative was examined in the original (1990) draft *Master Plan* (as Alternative 3).
- **Alternative E6b, Extend Runway 1,100 Feet with Partial RSA and Threshold Displaced 1,000 Feet** — Same as Alternative E6a, except landing threshold located approximately 400 feet closer to new end of runway.

Source: Hodges & Shutt (October 1995)

Table 1

Runway End Alternatives

All of the alternatives included in Table 1 either provide a full RSA length or would involve establishment of declared distances. Another concept which was examined for possible application at Santa Barbara Municipal Airport is a *soft ground arresting system*. This still experimental concept involves construction of an arrestor bed located just beyond the end of the runway and designed to safely decelerate an aircraft which overruns the runway. The Federal Aviation Administration has tested several types of arrestor bed materials, the latest (tested in June 1995) being constructed of pre-cast cellular concrete. The first scheduled installation of a soft ground arrestor bed is planned for John F. Kennedy International Airport in late 1995 or early 1996. Remaining unknown regarding this concept is whether it will allow a reduction in the standard 1,000-foot safety area length. At this time the FAA's Office of Airport Safety and Standards — the office which sets airport design standards — considers the concept too experimental to warrant any changes to the standards. Thus, while a soft ground arresting system may eventually be useful on Santa Barbara's Runway 7-25, the implications of the concept cannot yet be determined. For this reason, the concept is not further evaluated in this Discussion Paper.

The next step in the evaluation process was to identify significant advantages and disadvantages of each alternative. This analysis was general and non-quantified in scope, but did take into account the environmental and cost implications described later in this paper as well as airport design considerations. The primary purpose was to eliminate those alternatives deemed impractical because probable significant environmental impacts and/or high construction costs would outweigh aeronautical benefits.

At the runway's east end, six of the original nine alternatives were judged as failing this initial test. Five of these alternatives — E4a, E4b, E5, E6a, and E6b — each involves an eastward extension of the runway and parallel taxiway with a bridge across San Pedro Creek and placement of Fairview Avenue in a tunnel. Alternative E3a extends only the RSA eastward, but it too requires bridging the creek and tunneling the road. Preliminary hydrological studies indicate that constructing a tunnel for Fairview Avenue would involve major engineering complexities and would be prohibitively expensive. All alternatives except E3a and E5 additionally require bridging at least the runway safety area across San Jose Creek. Alternatives which would result in an eastward relocation of the Runway 25 runway protection zone (RPZ) also were ruled out because of land use impacts. Even a 200-foot eastward shift of the RPZ would encompass some 20 existing buildings. A 1,100-foot change (Alternatives E6a and E6b) would place at least 36 structures in the RPZ.

With these alternatives eliminated, the remaining choices are:

- Alternative E1, the status quo;
- Alternative E2, which displaces the Runway 25 landing threshold to provide a full 1,000 feet safety area length; and
- Alternative E3b, which relocates Fairview Avenue around an extended RSA and only bridges across San Pedro Creek.

By contrast, the initial review concluded that all eight of the west-end alternatives were potentially viable. Note that a variation on several of the west-end alternatives involves relocating Tecolotito

Creek rather than bridging across it for a runway/taxiway and/or safety area extension. From an airport safety and utility perspective, this variation is essentially the same as the bridging concept and therefore is not further addressed herein. However, assessment of the concept is anticipated as part of subsequent environmental studies.

Full-Runway Alternatives

Having completed this initial evaluation, the remaining runway end alternatives were then combined into various options representing complete runway configurations. Only by producing these paired alternatives was it possible to assess the operational length of the runway and its implications on aircraft operational capabilities. Also, although many of the environmental and cost factors can be addressed from a runway end perspective, the information is more meaningful when analyzed in terms of a full-runway configuration.

From the remaining runway end alternatives, a total of 11 full-runway alternatives were defined. These represent the following pairs of runway end alternatives:

		West End							
		W1	*W2*	*W3*	*W4*	*W5a*	*W5b*	*W6a*	*W6b*
East End	*E1*	A							
	E2			B		C1	C2	D1	D2
	E3b		E	F	G	H	I		

A diagram of each alternative (with the center portion of the runway omitted) is included at the back of this paper. Except for Alternative A (the status quo), all of the configurations involve extending the runway or RSA across at least one of the four runway boundary-defining features (the three creeks and Fairview Avenue).

AIRPORT DESIGN CRITERIA

The principal design criteria for airports are spelled out in the Federal Aviation Administration's *Airport Design* Advisory Circular. Most of these criteria take the form of standards, although a few are considered only as recommendations. Safety is the major objective of most of the design standards. Safety-related design standards include runway and taxiway widths, setback distances from a runway to adjacent objects and taxiways, requirements for displacing the location of landing thresholds because of obstacles in the runway approach, and requirements for smoothly graded areas adjacent to and at the end of the runway pavement. The latter features, known as *runway safety areas* (RSAs), are the principal concern with regard to Runway 7-25 at Santa Barbara Municipal Airport.

Runway Safety Areas

FAA standards for RSAs specify that they shall be:

- Cleared and graded and have no potentially hazardous ruts, humps or other surface variations;
- Drained by grading or storm sewers to prevent water accumulation;
- Capable, under dry conditions, of supporting snow removal equipment, aircraft rescue and firefighting equipment, and the occasional passage of aircraft without causing structural damage to the aircraft; and
- Free of objects, except for objects that need to be located in the runway safety area because of their function.

RSAs are centered on the runway centerline and extend beyond the ends of the runway. The dimensions vary depending upon the size of the aircraft using the runway and the type of instrument approach, if any, which the runway has. For Runway 7-25 at Santa Barbara Municipal Airport, the applicable dimensions are a width of 500 feet and a length of 1,000 feet beyond each end of the runway pavement. As previously mentioned, neither end of the runway presently meets the length standard.

Declared Distances

Ideally, all runways should have an RSA length which meets the current standards. On new runways, the FAA requires that the full-length standards be met. For many existing runways, however, attainment of this objective is not practical without costly or environmentally unacceptable construction. In such cases, a portion of the runway length may need to be declared unusable and/or unavailable for the purpose of assessing certain aircraft operational requirements. The resulting available runway lengths are indicated by means of *declared distances* noted on an airport layout plan and approved by the FAA. The purpose of this process is to provide a margin of safety equivalent to the standard runway safety area length.

As defined by Federal Aviation Regulations and further described in the *Airport Design* Advisory Circular, the four types of declared distances are:

- Takeoff Run Available (TORA) — TORA is the runway length declared available and suitable for the ground run of an airplane takeoff. From an airplane performance perspective, this is the distance required to accelerate from brake release to lift-off, plus safety factors. The safety factors typically are defined as the ability of the airplane to clear all obstacles along the flight path by 35 feet. In most circumstances, TORA equals the published length of the runway. TORA is less than the runway's published length only when the runway protection zone (RPZ) at the departure end of the runway is located other than in the normal position 200 feet beyond the pavement end (in effect, creating a displaced departure threshold). For the existing runway configuration and all defined alternatives at Santa Barbara Municipal Airport, TORA equals the published runway length. However, several alternatives have variations in which this would not be the case.

- Takeoff Distance Available (TODA) — TODA equals TORA plus the length of the clearway, if provided. A *clearway* is an area beyond the takeoff end of a runway which is under the control of airport authorities and within which terrain or fixed obstacles may not extend above specified limits. Operationally, takeoff distance is the distance to accelerate from brake release past lift-off to start of takeoff climb, plus safety factors. The usable TODA is controlled by obstacles present in the departure area, including beyond the end of the clearway, relative to aircraft performance. No clearways are currently established on Runway 7-25. Where feasible, however, clearways are included in most of the alternative configurations evaluated.

- Accelerate-Stop Distance Available (ASDA) — ASDA is the runway plus stopway length declared available and suitable for the acceleration and deceleration of an airplane aborting a takeoff. A *stopway* is an area beyond the takeoff end of a runway which is centered upon the extended centerline of the runway and no less wide than the runway and which is able to support an airplane during an aborted takeoff without causing structural damage to the airplane. This area must be designated by the airport authorities for use in decelerating an airplane during an aborted takeoff. In airplane performance terms, accelerate-stop distance is the distance to accelerate from brake release to takeoff decision speed (V_1) and then decelerate to a stop. For airport design purposes, any portion of the runway which extends into the required runway safety area length is regarded as not available or suitable for accelerate-stop distance. This situation applies to many of the alternative configurations for Runway 7-25 (none of the concepts include a stopway).

- Landing Distance Available (LDA) — LDA is defined as the length of runway which is declared available and suitable for the ground run of a landing airplane. Operationally, landing distance is the distance, measured from the landing threshold, needed to complete the approach and touchdown and to decelerate to a stop, plus safety factors. As with ASDA, airport design criteria dictate that a standard-length runway safety area must exist at the end of the available and suitable LDA. Also, the standard RSA length must be provided behind the landing threshold (i.e. toward the approach end of the runway). This latter criterion may necessitate displacement of the threshold farther down the runway than required for clearance over obstacles lying in the approach path. Such is the case for some of the alternatives examined here.

Many airports have runways with substandard RSA lengths, yet the operational lengths have not been reduced by application of declared distances. FAA policies currently allow these "grandfathered" runways to remain as is (the resulting implications on aircraft performance calculations are examined on page 11). At such time as improvements to these runways are constructed, the expectation is that the runways will be brought up to standard or declared distances will be established. Remaining vague with FAA policy — and thus consequently evaluated on a case-by-case basis — is what constitutes a runway improvement. Clearly, a runway extension qualifies, but a maintenance-related pavement overlay or replacement of edge lighting are less certain. Also, unknown is whether the FAA will at some future date require all runways — especially those used by airline aircraft — to either meet the standards or establish declared distances.

Evaluation

Except for the status quo configuration (Alternative A), all of the alternatives evaluated fully comply with airport design criteria. In each scenario, either the standard 1,000 feet of RSA length is provided at the end of the runway or the operational length of the runway is reduced by application of declared distances. The amount of additional pavement and/or RSA length which would be provided at each runway end under each full-runway alternative is indicated in Table 2. This table also lists the length of the declared distances for each runway configuration.

AIRCRAFT OPERATIONAL CAPABILITIES

The second aeronautical consideration in evaluating the runway configuration alternatives is the effect of the various layouts on aircraft operational capabilities. Of particular concern in this regard are the effects on aircraft which sometimes need a runway as long, or longer, than the existing 6,052-foot length of Runway 7-25.

In evaluating aircraft operational capabilities, it is important to note the distinction between usable runway length as defined above by airport design standards and declared distances and usable runway length as measured for the purpose of computing aircraft performance parameters. This issue is discussed in the evaluation which follows.

Determinants of Operational Capabilities

Many variables combine to determine the adequacy of a given runway length both in general and for an individual aircraft operation. Most significant of these variables are the aircraft itself, the length of flight, and the payload to be carried. The variables addressed here all concern aircraft takeoffs. Only rarely do conditions occur to make runway length limitations more significant for landings than for takeoffs (for example, an aircraft operating at near its maximum allowable landing weight on an icy or wet, poorly drained runway).

Critical Aircraft

Of the many aircraft types operating at Santa Barbara Municipal Airport, airline jets and, to a lesser extent, some business jets and fire attack aircraft are the types most demanding of runway length. The analysis in this report deals only with airline jets operating in scheduled service.

Among airline aircraft which have operated at Santa Barbara Municipal Airport or may do so in the future, the Boeing 737 series and the MD-80 series are considered to be the most demanding of runway length. The 737 currently operates at the airport; the MD-80 has operated there in the re-

Runway Configuration

Feature	*Runway End*	*A#*	*B*	*C1*	*C2*	*D1*	*D2*	*E*	*F*	*G*	*H*	*I*
Runway End Alternative	West (Rwy 7)	W1	W3	W5a	W5b	W6a	W6b	W2	W3	W4	W5a	W5b
	East (Rwy 25	E1	E2	E2	E2	E2	E2	E3b	E3b	E3b	E3b	E3b
Additional Pavement	West (Rwy 7)	0	0	400	400	800	800	0	0	300	400	400
	East (Rwy 25)	0	0	0	0	0	0	0	0	0	0	0
Safety Area Length behind Runway End	West (Rwy 7)	250	1,000	1,000	1,000	1,000	1,000	300	1,000	1,000	1,000	1,000
	East (Rwy 25)	200	200	200	200	200	200	686	686	686	686	686
Displaced Threshold	West (Rwy 7)	0	0	400	0	800	0	700	0	1,000	400	0
	East (Rwy 25)	314	800	800	800	800	800	314	314	314	314	314
Clearway Length	West (Rwy 7)	0	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
	East (Rwy 25)	0	0	0	0	0	0	686	686	686	686	686

Runway 7 Operations

Declared Distance	*A#*	*B*	*C1*	*C2*	*D1*	*D2*	*E*	*F*	*G*	*H*	*I*
Takeoff Run Available (TORA)	6,052	6,052	6,452	6,452	6,852	6,852	6,052	6,052	6,352	6,452	6,452
Takeoff Distance Available (TODA)	6,052	6,052	6,452	6,452	6,852	6,852	6,738	6,738	7,038	7,138	7,138
Accelerate-Stop Distance Available (ASDA)	6,052	5,252	5,652	5,652	6,052	6,052	5,738	5,738	6,038	6,138	6,138
Landing Distance Available (LDA)	6,052	5,252	5,252	5,652	5,252	6,052	5,038	5,738	5,038	5,738	6,138

Runway 25 Operations

Declared Distance	*A#*	*B*	*C1*	*C2*	*D1*	*D2*	*E*	*F*	*G*	*H*	*I*
Takeoff Run Available (TORA)	6,052	6,052	6,452 **	6,452	6,852 **	6,852	6,052	6,052	6,352 **	6,452 **	6,452
Takeoff Distance Available (TODA)	6,052	7,052	7,452	7,452	7,852	7,852	7,052	7,052	7,352	7,452	7,452
Accelerate-Stop Distance Available (ASDA)	6,052	6,052	6,452	6,452	6,852	6,852	5,352	6,052	5,352	6,452	6,452
Landing Distance Available (LDA)	5,738	5,252	5,652	5,652	6,052	6,052	5,038	5,738	5,038	6,138	6,138

Notes: All distances are in feet.
ASDA and LDA lengths which equal or exceed existing length shown in bold or underlined-bold, respectively.
\# Alternative A is Status Quo alternative.
* Runway 25 displaced threshold could be eliminated on these alternatives.
** Runway 25 TORA equals 6,052 feet for these alternatives if Runway 7 RPZ remains in current position.

Source: Data compiled by Hodges & Shutt (October 1995)

Table 2

Declared Distances
Alternative Runway Configurations

cent past and is a reasonable prospect for the future. The Boeing 727 is another aircraft which has operated at Santa Barbara in recent years. It is not considered likely to return, however; at least not on a regularly scheduled basis. Among somewhat larger airline aircraft which are conceivable for future use at Santa Barbara is the Boeing 757. This aircraft, though, has performance characteristics which are much less demanding of runway length than the 737 or MD-80.

The even larger DC-10 and Boeing 747 aircraft sometimes seen at the airport are brought in for maintenance purposes. They are lightly loaded — no passengers or cargo — and their flight times can be adjusted to avoid periods of high temperatures. Regularly scheduled flights by aircraft of this size are impractical at Santa Barbara Municipal Airport both for physical reasons — a substantially longer runway, greater pavement strength, and much larger terminal building would be required — and because the market area served by the airport does not support airplanes of this size. For these reasons, these aircraft are not considered critical with regard to runway length requirements.

Stage Length

Stage length — the non-stop flight distance — is a direct determinant of the amount of fuel an aircraft must carry on takeoff. If all other factors are held constant, the weight of the fuel in turn affects the runway length required for takeoff.

Historically, the longest stage lengths over which airline aircraft have operated from Santa Barbara on a scheduled basis have been Denver (about 800 nautical miles) and Dallas/Fort Worth (1,150 n.m.). The farthest location considered plausible as a non-stop destination from Santa Barbara is Chicago (1,580 n.m.). For the purposes of this analysis, these three cities were considered representative of potential future flight destinations. Other major cities encompassed within this range are Phoenix (400 n.m.), Salt Lake City (540 n.m.), and Portland (700 n.m.).

Payload

For airline aircraft, payload consists of passengers and their baggage, together with any additional cargo which can be carried. Ideally, airlines seek to operate without any restrictions on payload — that is, the payload is the maximum gross takeoff weight of the aircraft minus the aircraft empty weight and the weight of the fuel (plus reserves) required for the flight length. However, when runway length limitations or other factors prevent attainment of the maximum weight, payload — rather than flight stage length — is usually the variable that is reduced. Typically, cargo (not passengers' baggage) is limited first, then the number of passengers is reduced if necessary.

Restrictions on payload directly affect the profitability of a flight. This analysis consequently focuses on payload as the primary measure of aircraft operational capabilities.

Other Factors

Pilots also must take into account several other more technical variables when planning a particular flight. These include:

- Airport Elevation — Although this factor is constant for any given runway, it is an important variable from one airport to another. At high elevations, aircraft have less ability to climb. Consequently, they must reach a higher speed during their takeoff roll and, in turn, will need more runway length.

- Air Temperature — Of the remaining variables, air temperature is usually the most critical. High temperatures act like high elevations to reduce the climbing capabilities of aircraft. For aircraft such as business jets and charter airlines which often have more flexibility in departure time than do the scheduled airlines, one option sometimes used when runway length is limited is to plan the flight for a cool part of the day. Santa Barbara Municipal Airport has the advantage of being both at sea level elevation and generally having moderate high temperatures (the average high temperature of the hottest month in 74.6°F.).

- Wind Speed — Wind blowing toward the nose of an aircraft effectively increases the speed of the air over the wing and thus improves lift. Because aircraft normally avoid taking off with a tailwind, a worst-case condition of calm wind is assumed in most performance calculations.

- Runway Gradient — At airports where other conditions dictate that aircraft takeoff in an uphill direction, this factor must be taken into account. It is not a relevant factor at Santa Barbara Municipal Airport.

- Obstacles — Obstacles lying along an aircraft's climb-out path from a runway can sometimes be more of a restricting influence on allowable takeoff weight than the length of the runway. Federal regulations require that airline aircraft must be capable of clearing critical obstacles even if an engine should fail during climb out. The significance of any particular obstacle varies from one aircraft to another. As noted in the analysis below, several obstacles beyond the each end of Runway 7-25 come into play in determining the performance capabilities of aircraft operating at Santa Barbara Municipal Airport.

Evaluation

As noted earlier, the manner in which airlines evaluate runway and safety area lengths — and the existence of a stopway or clearway, if any — for the purpose of determining the allowable payload of a particular aircraft flight is not necessarily the same as the way these distances are evaluated for airport design purposes in accordance with the *Airport Design* Advisory Circular. The Federal Aviation Regulations (FARs) under which the airlines operate — FAR Part 121, in particular — require compliance with takeoff run, takeoff distance, accelerate-stop distance, and landing distance criteria applicable to the particular airplane, although no explicit reference is made to the term "declared distances." With regard to accelerate-stop distance, paragraph 121.189(c)(1) states that it must not exceed the length of the runway plus the length of any stopway. No mention is made of deducting for a safety area length that does not meet airport design standards. The potential need for pilots to recognize an ASDA which could be less than the published runway length is indicated only in general terms from such sources as the *Airman's Information Manual* reference to the ASDA length "declared available and suitable."

The apparent result of this ambiguity is that airlines interpret what is operationally required differently. When no takeoff declared distances have been published, the airlines rely upon the official length of the runway and individually evaluate the significance of any departure path obstacles relative to a particular airplane's performance. The greater difference in interpretation occurs when declared distances have been established. United Airlines, which provided the following evaluation of Boeing 737 performance and is currently the only scheduled operator of jet airline airplanes at Santa Barbara Municipal Airport, takes a conservative approach. They utilize official declared distances in their performance calculations, thus indirectly taking into account RSA design standards. However, Stewart Aviation, a consulting firm specializing in providing aircraft performance data for airlines, says that their computations do not deduct for RSA deficiencies. In other words, they may use an ASDA which is longer than one declared. The analysis of the MD-80 summarized herein was conducted by Stewart Aviation and consequently shows greater performance capabilities for some runway configuration alternatives than certain airlines might recognize.

These differences in aircraft performance calculation methodologies do not significantly change the conclusions regarding runway length requirements at Santa Barbara Municipal Airport, as documented below.

Boeing 737

Four different versions of the 737 were examined. The first three types are more common in the United Airlines fleet than the -200A model, but all are expected to remain in use for the foreseeable future. Several older, lower performance, models — including types which may still be operating at Santa Barbara Municipal Airport — are scheduled for retirement within the next few years.

Airplane Model	*Engine Type*	*Maximum Gross Takeoff Weight*	*Passenger Capacity*
737-300	-3B-2	130,000 lbs	126
737-300	-3-B1	130,000 lbs	126
737-500	-3-B1	122,500 lbs	108
737-200A	-17	117,000 lbs	109

All operational data provided by United was for an 80°F. day with zero wind. Also, for performance analysis purposes, United uses a concept referred to as *balanced field length*. Calculation of this distance for a specific airplane and runway is actually a complex process involving many variables. A simplified approach is to consider balance field length to be the shortest of the three declared takeoff distances. In most cases, including all of the alternatives (and all but two of the additional variations) analyzed for Santa Barbara Municipal Airport, the shortest declared distance is accelerate-stop (ASDA).

Significant findings extracted from the performance data include the following:

- Runway Direction — In some alternatives, differences in ASDA between the two directions of runway use result in substantial differences in operational capabilities. Also, for certain of the airplane types, the presence of close-in obstacles contributes to these operational differences.

  - *Runway 25* — Prevailing winds dictate that most operations are conducted in the Runway 25 direction; that is, toward the west. With the existing runway configuration, this direction is also favored because of fewer obstacles. (United and other airlines utilize *obstruction charts* published by the National Ocean Service for most major airports for information regarding obstacles in the airport vicinity. The most recent chart for Santa Barbara Municipal Airport includes several trees to the west of the runway which have since been removed, thus further improving the existing advantages of Runway 25 over Runway 7.)

  - *Runway 7* — Existing close-in obstacles (Fairview Avenue, the localizer antenna, etc.) adversely affect current operations toward the east. Some of the runway configuration alternatives eliminate these obstacles, others do not.

- Denver Flights — All of the above versions of the 737 can effectively fly non-stop to Denver from the existing length runway at Santa Barbara Municipal Airport on an 80°F. day. Certain of the runway alternatives which would reduce the ASDA would adversely affect this potential.

  - *Runway 25* — Using the existing-length Runway 25, all of the aircraft can carry a full load of passengers and baggage even with temperatures somewhat higher than 80°F.

  - *Runway 7* — On the present Runway 7, the 737-300/-3B-2 and 737-500 are capable of carrying a full payload on an 80°F. day. The 737-200A is restricted by only about four passengers, but the 737-300/-3-B1 loses as many as 20 passengers. The capabilities of all of the aircraft would be improved with elimination of the close-in obstacles, even without an increase in ASDA. Indeed, if the obstacles are not present, a slightly shorter ASDA would improve upon current operational capabilities for most of the aircraft variations. To the extent that significant obstacles east of the runway cannot be removed, a westward runway extension would provide operational benefits by increasing the distance between the start of takeoff roll and the obstacle location.

- Farther Destinations — Under present conditions, only the 737-300/-3B-2 could carry a full passenger load as far as Chicago on an 80°F. day and then only when using Runway 25. The other Boeing 737 models are significantly restricted on either runway except with cooler temperatures. No analysis was conducted of Santa Barbara to Dallas/Fort Worth flight capabilities. In any case, United Airlines indicates that Santa Barbara-Denver is about the maximum flight length for which they utilize 737s. Passengers do not like to fly farther in "narrow-body" airplanes.

MD-80

As with the Boeing 737, there are several aircraft type variations within the MD-80 series (the MD-81, MD-82, etc.). However, in the case of the MD-80 series, all versions are essentially identical operationally and no distinction among them has been made in the performance analysis. Each carries approximately 140 passengers.

Among the conclusions drawn from the MD-80 performance data are the following:

- Runway Direction — Because of different performance characteristics, specific obstacles at each end of the runway have different significance for the MD-80 than for the 737. Nevertheless, greater payloads are attainable for takeoffs on Runway 25 than for Runway 7 in all scenarios evaluated.

- Denver Flights — If obstacles were not a factor, the existing length runway would enable the MD-80 to use either runway direction for take off to Denver carrying a full passenger load, provided that the ambient temperature is no higher than 85°F. However, close-in obstacles east of the airport require aircraft using Runway 7 to limit their payload when the temperature exceeds 68°F. Under the assumptions used in the analysis, any of the alternative runway configurations which would increase the runway length would allow full passenger loads to be carried at higher temperatures. Elimination of the close-in obstacles to the east also would be beneficial.

- Dallas/Fort Worth Flights — The MD-80 cannot carry a full passenger load to Dallas/Forth Worth from the existing length runway. On an 80°F. day, the present Runways 25 and 7 permit only 101 and 91 passengers, respectively, to be carried. With obstacles not considered, the minimum runway length required for a full passenger load would be 6,600 feet at 60°F., 6,725 feet at 80°F., and 7,100 feet at 90°F. Among the runway configurations examined, Alternatives D1 and D2 (which each add 800 feet to the west end of the runway) would be most beneficial for MD-80 flights to Dallas/Fort Worth. The 6,852-foot ASDA provided on Runway 25 (with significant obstacles eliminated) would enable a full load to be carried with ambient temperatures as high as 86°F. These alternatives also would offer full-payload capabilities using Runway 7 with temperatures up to 66°F.

- Chicago Flights — Chicago flights would be even more restricted than ones to Dallas/Fort Worth. The maximum passenger loads for operations on Runways 25 and 7 would be only 79 and 69, respectively. To carry a full load to Chicago, the MD-80 would require at least 7,000 feet of runway even with a temperature of only 60°F.

Conclusions Regarding Runway Length

Conclusions suggested by the above analyses are as follows:

- The existing 6,052-foot operational length of Runway 7-25 is satisfactory for current and most foreseeable future airline flights from Santa Barbara to destinations such as Denver.

- A runway length increase on the order of 700 to 800 feet would be necessary to enable generally unrestricted flights to destinations as far as Dallas/Fort Worth with MD-80 type aircraft.

- A minor (300 to 400 feet) increase in operational length would provide useful benefits for some airline aircraft types, particularly on hot days.

- To the extent feasible, removal or relocation of remaining obstacles — trees, power lines, roads, the localizer antenna, etc. — would produce significant operational benefits. Although not necessarily reflected in the above aircraft performance data, all of the runway configuration alternatives assume that no major obstacles west of the runway will remain. East of the runway, the major obstacles are addressed differently by the various alternatives.

- A reduction in the operational length of the runway would adversely affect existing performance capabilities of the Boeing 737 and MD-80 types of airplanes, particularly for those airlines (e.g., United) which adhere to conservative performance calculation policies.

ENVIRONMENTAL IMPACTS

It is not the purpose of this paper to offer comprehensive assessment of the environmental impacts of the various runway configuration alternatives. Rather, the task is to narrow down the range of alternatives for which more detailed environmental analyses will be conducted. Nevertheless, general assessment of potential environmental impacts is an important part of the filtering process applied here.

Categories

The environmental impacts considered here fall into four broad categories:

- Creek Impacts — Tecolotito Creek on the west and San Pedro and San Jose Creeks on the east form boundaries to the existing runway. Any project to increase the safety area length or extend the runway would require crossing or realigning at least one of these three creeks. For the purposes of the analysis here, all of the creeks are regarded as environmentally equal. The impacts are measured in terms of the length of creek channel affected.

- Effects on Adjacent Roads — Fairview Avenue, adjacent to San Pedro Creek at the east end of the runway, is one of the major access routes from U.S. Highway 101 to the airport terminal area. Closure of the road to accommodate eastward extension of runway improvements is not practical. Realignment around or tunneling beneath the extension are possibilities. This impact category assesses the general extent to which the various airfield configurations would affect road traffic.

- Noise Impacts — Any changes to the location of runway ends and landing thresholds have the potential to affect the altitudes — and perhaps even the flight paths — which aircraft follow in flying over lands adjacent to the airport. The noise impacts generated thus could change as well. Depending upon the specific runway configuration, the noise levels could increase or decrease compared to the existing runway layout. For example, addition of pavement at the beginning of the runway would shift where aircraft start their takeoff roll. This configuration would tend to reduce noise beyond the departure end of the runway by allowing planes to be slightly higher over that area, but it also could increase the noise experienced by land uses behind the start end of the runway. For landing aircraft, adding pavement at the landing end of the runway would, if the landing threshold is moved to the new pavement end, place aircraft lower over lands along the approach path and therefore increase noise. On the other hand, displacement of the landing threshold farther down the runway (e.g., to meet safety area length standards) would place aircraft higher and would reduce noise. In any of these cases, the increase or decrease in single-event noise level would be small — less than 1.0 dB in most circumstances — and unlikely to be perceptible to people in the affected areas. (Few people can detect a 1.0 dB difference in noise levels even in a laboratory setting. Outside of a laboratory, 3.0 dB is considered the minimum detectible noise level difference, a 5.0 dB change is clearly noticeable, and a 10.0 dB increase (or decrease) is perceived as twice (or half) as loud.)

- Land Use Impacts — In addition to noise impact differences, the land uses at the runway ends could be affected by changes in the location of runway protection zones (RPZs) brought about by modification of the runway end designs. An airport should own all property within the RPZs or have sufficient property rights to control the underlying uses of the land (the FAA strongly encourages, but does not require, compliance with this criterion). Standard avigation easements are inadequate in this regard because they do not restrict how the land is used, provided that hazards to flight are not created (for example, an avigation easement would not preclude residential development in the RPZ as long as height limits are observed). Rather, *approach protection easements* are needed. Such easements combine standard avigation easements with acquisition of certain development rights to the underlying property. In all of the Runway 7-25 alternatives addressed here, including the status quo, Santa Barbara Municipal Airport should seek additional protection for the RPZs. Such measures are particularly appropriate where the land is currently undeveloped. For those alternatives in which the RPZs move outward from their current positions, additional property control — either in fee or in the form of approach protection easements — is essential.

An outward shift of the RPZ locations also suggests the need for corresponding shift in safety-related land use compatibility zones beyond the RPZ boundaries. Land use restrictions of this type are established by the Santa Barbara County Airport Land Use Commission. The commission would have the responsibility to decide what modifications, if any, it would wish to make to its safety (or noise) criteria. A significant point in this regard is as noted in the earlier discussion of how Takeoff Run Available (TORA) is calculated. Specifically, under current FAA guidelines, it is possible to extend a runway without changing the location of the RPZ at that end of the runway. In such cases, an argument can be made that safety concerns would not be appreciably changed either.

Evaluation

The extent to which each of the runway configuration alternatives would produce the above types of impacts is summarized in the Table 3. The results are described relative to the status quo (Alternative A).

CONSTRUCTION COSTS

Cost Factors

The fourth set of factors considered in this evaluation is construction costs. As with environmental factors, only qualitative judgments of the various alternatives have been made. The intent has simply been to estimate whether any particular configuration would likely cost more or less than other alternatives. Among the construction cost components taken into account are:

- Land acquisition.
- Runway/taxiway/safety area bridges across creeks.
- Creek impact mitigation.
- Road tunneling or realignment.
- Runway/taxiway pavement.
- Runway edge lighting and approach light system modifications.
- Localizer antenna relocation.

Evaluation

The cost of constructing bridges across creeks would be the dominant construction cost in most of the alternatives. A Fairview Avenue tunnel would be another major cost. Configurations involving a westward shift of the Runway 7 RPZ would have the added significant cost of additional property acquisition, as either fee title or easements. Although the various other costs could be substantial, they would be far outweighed by these categories. Because of the cost of bridge and tunnel construc-

Alternative	Minimum Length of Creek Crossings			Fairview Avenue[1]	Noise (Aircraft Altitude[1])		Land Use (RPZ Location[1])	
	Tecolotito	San Pedro	San Jose		West	East	West	East
A	None	None	None	No change	No change	No change	No change	No change
B	500 feet	None	None	No change	No change	Higher on landing	No change	No change
C1	755 feet[2]	None	None	No change	No change	Higher on takeoff	400-foot[3] shift to west	No change
C2	755 feet[2]	None	None	No change	Lower on landing	Higher on takeoff	400-foot shift to west	No change
D1	755 feet	None	None	No change	No change	Higher on takeoff	800-foot[3] shift to west	No change
D2	755 feet	None	None	No change	Lower on landing	Higher on takeoff	800-foot shift to west	No change
E	None	500 feet	None	Relocate	Higher on landing	No change	No change	No change
F	500 feet	500 feet	None	Relocate	No change	No change	No change	No change
G	None	500 feet	None	Relocate	Higher on landing	Higher on takeoff	300-foot[3] shift to west	No change
H	755 feet[2]	500 feet	None	Relocate	No change	No change	400-foot[3] shift to west	No change
I	755 feet[2]	500 feet	None	Relocate	Lower on landing	No change	400-foot shift to west	No change

[1] Relative to Status Quo (Alternative A).
[2] Length of creek crossing (width of bridge) could be reduced to 500 feet in these alternatives if extension length is limited to 300 feet (i.e., if extension remains east of creek and only RSA crosses creek).
[3] Alternatively, RPZ position could remain unchanged with result being limitation of Runway 25 TORA to 6,052 feet (i.e., existing runway length).

Source: Hodges & Shutt (October 1995)

Table 3

Environmental Impacts Summary

Alternative Runway Configurations

tion, a close correlation would likely exist in the various alternatives between the lengths of creek crossings and tunnels and the total costs.

SUMMARY AND CONCLUSIONS

Given the limited character of the preceding evaluation, especially with regard to environmental and cost factors, a comprehensive comparison among the runway configuration alternatives is not practical here. A detailed comparison is also not essential to this paper's primary purpose — that of assessing alternatives based primarily on airport safety and utility considerations.

The filtering process consequently focused on the project's twin objectives, enhancement of the safety and utility of Runway 7-25. Except for the status quo, all of the alternatives meet current FAA criteria with regard to the runway safety area (either with a full-length RSA or by applying declared distances). In terms of utility, the key question is whether the alternative has an accelerate-stop distance available (ASDA), for both Runway 7 and Runway 25, which is at least equal to that now computed as available (that is, at least equal to the current 6,052-foot runway length).

Environmental and cost factors were given minimal additional attention in this process of filtering out some of the full-runway alternatives. These factors were considerations in elimination of several of the runway end alternatives. Also, they will again be major factors in the analyses leading to selection of a proposed project design.

Three alternatives pass the test of equaling or exceeding the existing ASDA and LDA in both runway directions. These alternatives are recommended for additional review as part of the environmental impact study process. The following list represents a qualitative summary of observations about each:

- Alternative A (W1/E1) — Status Quo
  - Required by federal and state environmental impact analysis guidelines to be considered as a project alternative.
  - No significant environmental impacts or construction costs.
  - Satisfies most identifiable airline needs, but operationally limits certain aircraft on flights to destinations beyond the range of Denver.
  - Does not meet project objective of either providing full-length runway safety area in accordance with FAA design standards or, alternatively, establishing declared distances.
  - Leaves airport vulnerable to significant operational restrictions resulting from possible future mandatory FAA requirement to establish declared distances if full RSA standards are not met.

- Alternative D2 (W6b/E2) — Extend Runway 800 Feet West with Threshold at Runway End; 800-Foot Displaced Threshold on East
  - Provides full RSA on west; displaced threshold on east substitutes for full RSA.
  - Maintains existing accelerate-stop and landing distances available on Runway 7.

- Increases accelerate-stop and landing distances available on Runway 25.
- Allows fully loaded MD-80 to depart for Dallas/Forth Worth (on Runway 25) at ambient temperatures up to 83°F.
- Focuses construction-related environmental impacts on west end alone (primarily bridging Tecolotito Creek).
- Compared to status quo (Alternative A), minor (less than 1.0 dB in most cases) increase in single-event noise west of airport resulting from lower altitude of landing aircraft (about 40 feet for aircraft on the established 3.0° approach slope).
- Higher altitude over any given point for aircraft landing from east and potentially for aircraft departing to east.
- Westward shift of both the Runway 7 RPZ and landing threshold from current positions increases importance of additional RPZ property acquisition (in fee or as approach protection easements) and further restrictions on land uses beyond the end of the RPZ. Existing buildings would be within outer end of RPZ.

- Alternative I (W5b/E3b) — **Extend Runway 400 Feet West with No Displaced Threshold; Partial RSA and Realigned Road on East**
  - Provides full RSA on west; eastern RSA extends 1,000 feet from existing displaced threshold.
  - Additional 400 feet of accelerate-stop distance available on Runway 25 (compared to status quo) allows fully loaded MD-80 to depart for Dallas/Forth Worth at ambient temperatures up to 50°F.; at 80°F., about 88% of full payload could be carried.
  - Increases landing distance available on Runway 25 by 400 feet compared to status quo.
  - Increases existing takeoff and landing capabilities on Runway 7 by 86 feet compared to status quo.
  - Requires bridging (or relocation) of Tecolotito Creek on west end of runway. (Note that by limiting the runway extension to about 300 feet, the added pavement could be kept east of Tecolotito Creek and the minimum length of creek to be bridged could be reduced from 755 feet to 500 feet, the width of the RSA.)
  - Westward shift of RPZ remains on undeveloped property.
  - On east, requires bridging San Pedro Creek, but avoids crossing San Jose Creek.
  - Avoids need for Fairview Avenue tunnel on east; realigned road adds about 200 feet to travel distance from Highway 101 to airport terminal.
  - Aircraft landing on Runway 7 would be slightly lower over land uses to west than now occurs, but slightly higher than with Alternative D2.
  - No change in altitude of aircraft landing from east compared to status quo; aircraft departing to east potentially higher than under existing configuration.

The other alternatives and the rationale for their exclusion are:

- Alternative B (W3/E2) — **Full RSA on West; 800-Foot Displaced Threshold on East**
  - Substantial reduction (800 feet) in takeoff (ASDA) and landing (LDA) capabilities on Runway 7.

- Alternative C1 (W5a/E2) — Extend Runway 400 Feet West with Threshold as Is; 800-Foot Displaced Threshold on East
  - Reduces Runway 7 ASDA and LDA to less than currently available.
  - Otherwise environmentally similar in most respects to Alternative D1.

- Alternative C2 (W5b/E2) — Extend Runway 400 Feet West with Threshold at Runway End; 800-Foot Displaced Threshold on East
  - Reduces Runway 7 ASDA and LDA to less than currently available.
  - Environmentally similar to Alternative D2.

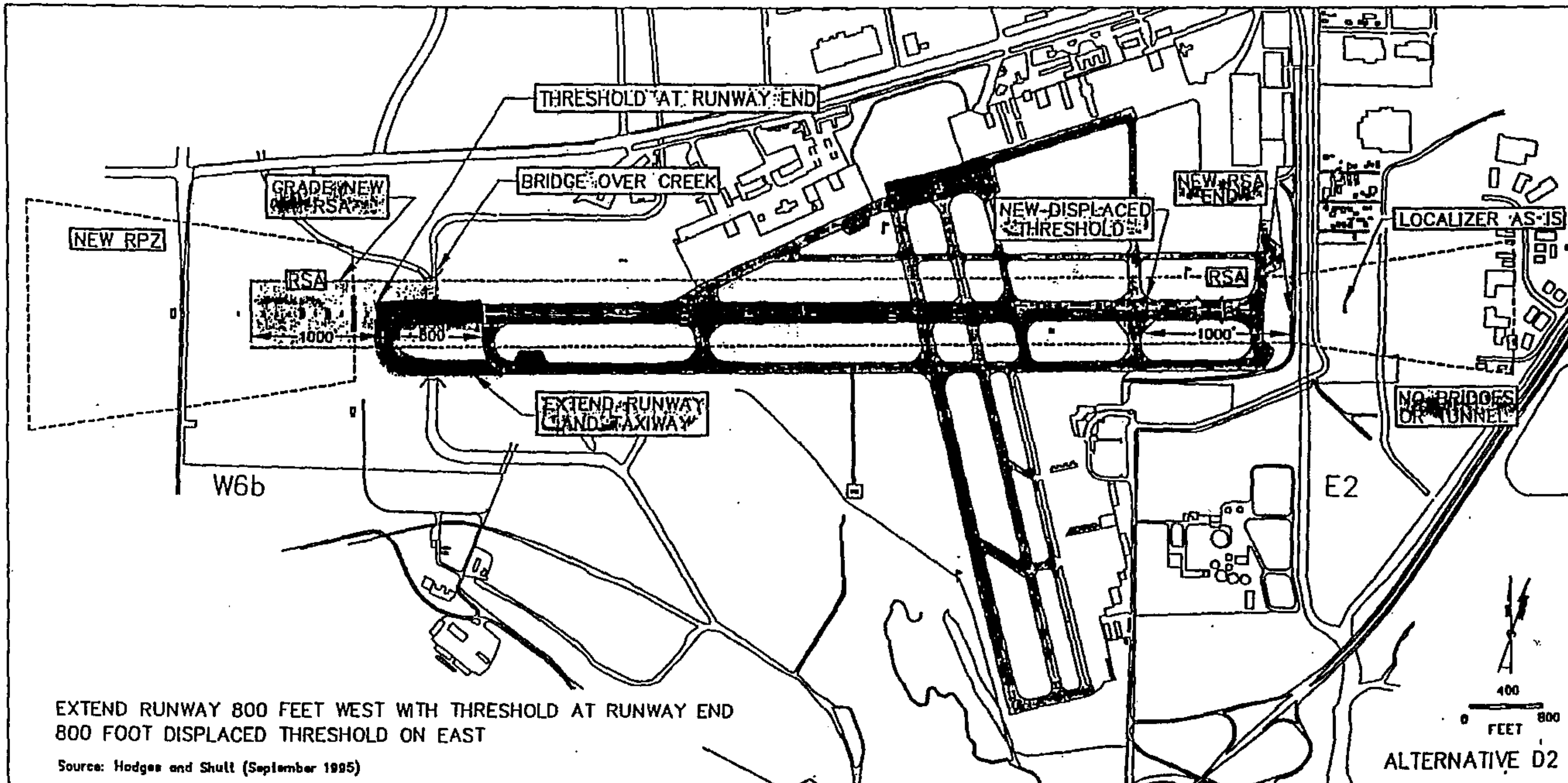
- Alternative D1 (W6a/E2) — Extend Runway 800 Feet West with Threshold as Is; 800-Foot Displaced Threshold on East
  - Displaced threshold on west end together with lack of full safety area at east end reduces official landing distance available for Runway 7 by 800 feet compared to existing use.

- Alternative E (W2/E3b) — 700-Foot Displaced Threshold on West; Partial RSA and Realigned Road on East
  - Reduces existing ASDA and LDA in both runway directions.

- Alternative F (W3/E3b) — Full RSA on West; Partial RSA and Realigned Road on East
  - Reduces existing Runway 7 ASDA and LDA by 314 feet.
  - No significant advantage over Alternative D2 except with regard to land acquisition on west.

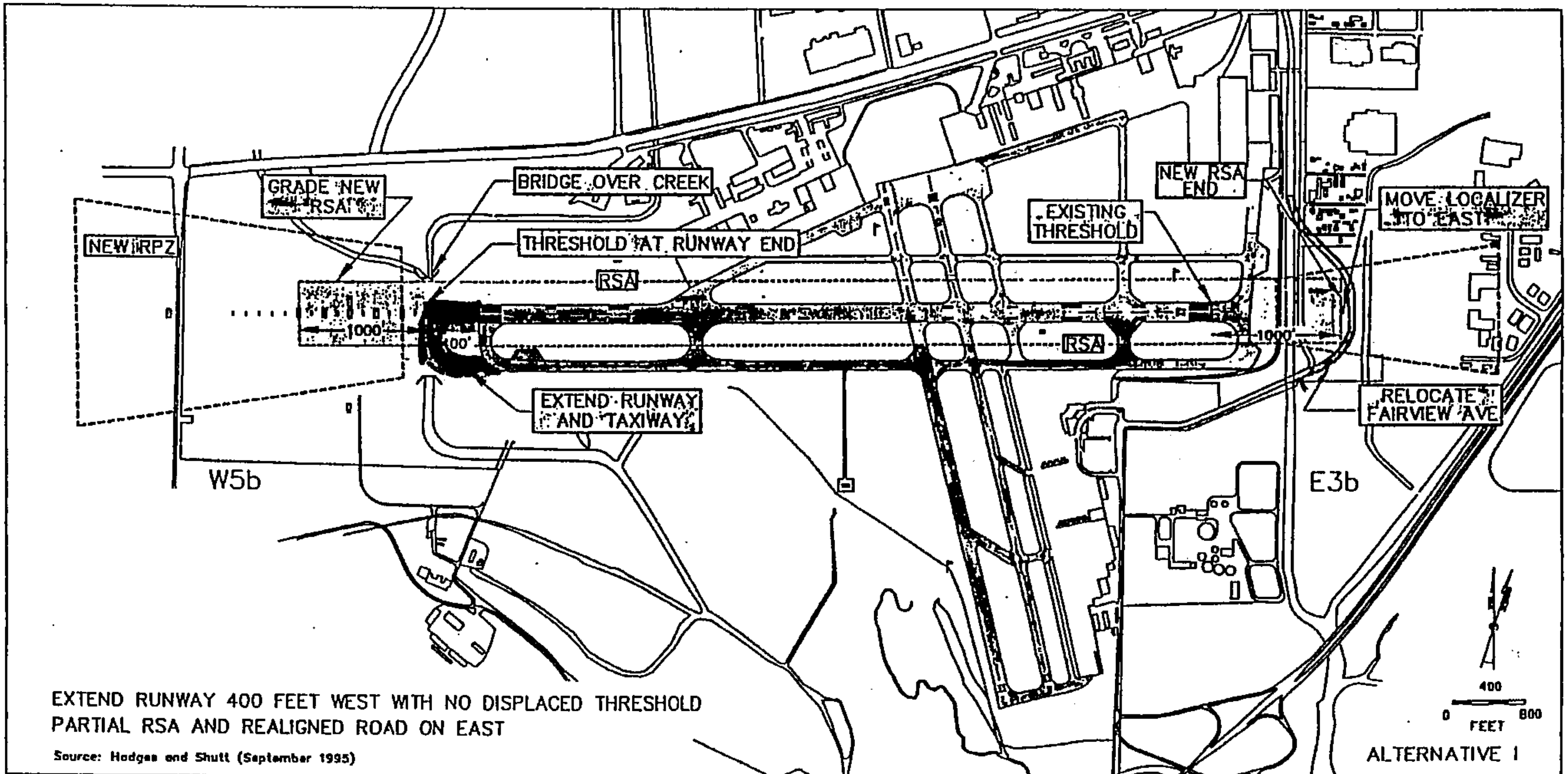
- Alternative G (W4/E3b) — Extend Runway 300 Feet West with 1,000-Foot Displaced Threshold; Partial RSA and Realigned Road on East
  - Significant reduction (700 feet) in Runway 25 ASDA and LDA.
  - Significant reduction (over 1,000 feet) in Runway 7 LDA.

- Alternative H (W5a/E3b) — Extend Runway 400 Feet West with Threshold As Is; Partial RSA and Realigned Road on East
  - Reduces existing Runway 7 LDA by 314 feet.



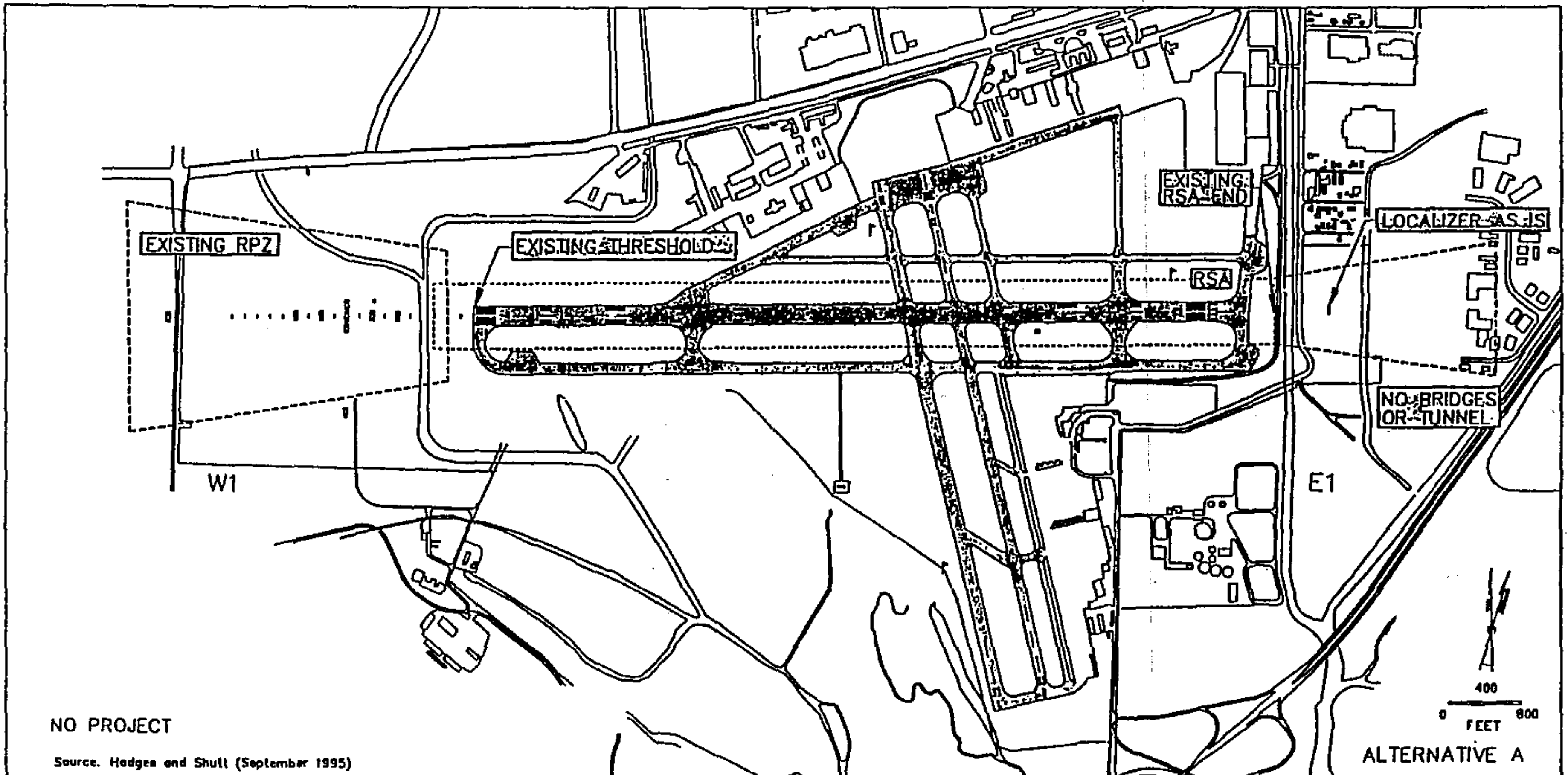
EXTEND RUNWAY 800 FEET WEST WITH THRESHOLD AT RUNWAY END
800 FOOT DISPLACED THRESHOLD ON EAST

Source: Hodges and Shult (September 1995)



EXTEND RUNWAY 400 FEET WEST WITH NO DISPLACED THRESHOLD
PARTIAL RSA AND REALIGNED ROAD ON EAST

Source: Hodges and Shutt (September 1995)



NO PROJECT

Source. Hodges and Shull (September 1995)

ALTERNATIVE A

APPENDIX C

CONSTRUCTION COSTS

Date: 10/30/00

PRELIMINARY COST ESTIMATE
TABLE 1
ALTERNATIVE 1 - West Culvert
SANTA BARBARA MUNICIPAL AIRPORT

PROJECT: RUNWAY 7 EXTENSION (800 LF TO THE WEST) , RELOCATED RW 25 THRESHOLD AND BOX CULVERTS AT TECOLOTITO CREEK.

CLIENT : SANTA BARBARA MUNICIPAL AIRPORT

PREPARED BY : LT

ITEM NO.	DESCRIPTION	APPROX. QUANTITY	UNIT	UNIT PRICE	EXTENDED AMOUNT
1	UNCLASSIFIED EXCAVATION	100,000	CY	5.00	500,000
2	BORROW FILL	37,400	CY	15.00	561,000
3	P-209 CRUSHED AGGREGATE BASE	5,050	TON	25.00	126,250
4	P-304 CEMENT TREATED BASE (18")	25,600	SY	25.00	640,000
5	P-401 BIT.CONCRETE PAVEMENT	17,600	TON	60.00	1,056,000
6	CONCRETE WING WALLS & APRON	125	CY	250.00	31,250
7	BOX CULVERTS (65'X8.5') @ TECOLOTITO CR.	800	LF	5,300.00	4,240,000
8	DEWATERING	1	LS	200,000.00	200,000
9	RELOCATE NAVAIDS	1	LS	1,000,000.00	1,000,000
10	LIGHTING, SIGNAGE & MARKING	1	LS	205,000.00	205,000
				SUBTOTAL	$8,559,500
				CONTINGENCIES (30%)	$2,567,850
				ESTIMATED TOTAL CONSTRUCTION COST	$11,127,350

Notes :

1. Runway 7 extension assumed to be 800' plus 1000' for RSA. Runway 25 threshold is relocated 800' west.
2. Box culverts are proposed for Tecololito Creek and the end of Runway 7 need to be raised and overlaid with P-401. See runway profile.
3. Unclassified excavation for runway, taxiway and safety areas is estimated at 100,000 cy.
4. Concrete wing walls and apron assumed between the creek and the box culverts.
5. Runway structural pavement is estimated to be 4" P-401 & 18" P-304 (Subgrade CBR assumed =6).
6. Borrow fill is estimated at 37,400 cy.
7. Costs for relocation of MALSR, Middle Marker, VASI and Glide Slope are included.

Date: 10/30/00

PRELIMINARY COST ESTIMATE

TABLE 3

ALTERNATIVE 3 - FAIRVIEW REALIGNMENT / WEST CULVERT

SANTA BARBARA MUNICIPAL AIRPORT

OJECT: 350' WEST RUNWAY EXTENSION, RELOCATED RW 25 THRESHOLD, TECOLOTITO & SAN PEDRO CREEK BOX CULVERTS AND REALIGN FAIRVIEW AVENUE.

ENT : SANTA BARBARA MUNICIPAL AIRPORT

EPARED BY : AY

EM O.	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT PRICE	EXTENDED AMOUNT
1	UNCLASSIFIED EXCAVATION	65,000	CY	$ 5.00	$ 325,000.00
2	BORROW FILL	32,500	CY	$ 15.00	$ 487,500.00
3	P-304 CEMENT TREATED BASE (18")	10,360	SY	$ 25.00	$ 259,000.00
4	P-401 BIT. CONCRETE PAVEMENT	41,750	TON	$ 60.00	$ 2,505,000.00
5	RELOCATE NAVAIDS	1	LS	$ 1,000,000.00	$ 1,000,000.00
6	LIGHTING, SIGNS, PAVEMENT MARKING	1	LS	$ 135,000.00	$ 135,000.00
7	BOX CULVERTS (65'X8.5') @ TECOLOTITO CR.	800	LF	$ 5,300.00	$ 4,240,000.00
8	BOX CULVERTS (50'X10') @ SAN PEDRO CR.	700	LF	$ 4,300.00	$ 3,010,000.00
9	CONCRETE WING WALLS & APRON	125	CY	$ 250.00	$ 31,250.00
1(	DEWATERING	1	LS	$ 400,000.00	$ 400,000.00
	ROADWAY EXCAVATION	5,305	CY	$ 10.00	$ 53,050.00
12	ASPHALT CONCRETE (CAL) @ FAIRVIEW AVE	2,190	TON	$ 40.00	$ 87,600.00
13	AGGREGATE BASE (CAL) @ FAIRVIEW AVE	6,660	TON	$ 20.00	$ 133,200.00
			TOTAL		$ 12,666,600.00
		CONTINGENCIES (30%)			$3,799,980.00
	ESTIMATED TOTAL CONSTRUCTION COST				$ 16,466,580.00

es :

1. The area of RSA extension is assumed to be unpaved.
2. Box culverts are proposed for San Pedro and Tecolotito Creeks.Both ends of Runways 7 and 25 need to be raised and overlaid with P-401. See runway profile.
3. Concrete quantities for wingwalls and apron are assumed based on the area bounded between San Pedro Creek and the proposed box culverts.
4. Unclassified excavation for runway, taxiway, and safety area is estimated to be 65,000 CY.
5. The quantity for borrow fill is estimated to be 32,500 CY.
6. Quantity for roadway excavation of Fairview Ave realignment is calculated based on the preliminary design of Fairview Avenue.
7. The thickness of the asphalt concrete and aggregate base for proposed Fairview Avenue is 4" and 12" respectively, and/or equivalent to the the existing roadway pavement thickness.
8. Cost estimates for relocation of MALSR, Middle Marker, VASI and Glide Slope are included.

Date: 10/30/00

PRELIMINARY COST ESTIMATE
TABLE 5
ALTERNATIVE 5 - FAIRVIEW TUNNEL / WEST CULVERT
SANTA BARBARA MUNICIPAL AIRPORT

PROJECT: 265' WEST RUNWAY EXTENSION, RELOCATED RW 25 THRESHOLD, SAN PEDRO & TECOLOTITO CREEK BOX CULVERTS AND FAIRVIEW AVE TUNNEL.
CLIENT : SANTA BARBARA MUNICIPAL AIRPORT
PREPARED BY : AY

ITEM NO.	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT PRICE	EXTENDED AMOUNT
1	UNCLASSIFIED EXCAVATION	48,500	CY	$ 5.00	$ 242,500.00
2	BORROW FILL	31,200	CY	$ 15.00	$ 468,000.00
3	P-304 CEMENT TREATED BASE (18")	13,450	SY	$ 25.00	$ 336,250.00
4	P-401 BIT. CONCRETE PAVEMENT	40,800	TON	$ 60.00	$ 2,448,000.00
5	LIGHTING, SIGNS, PAVEMENT MARKING	1	LS	$ 185,000.00	$ 185,000.00
6	BOX CULVERTS (65'X8.5') @ TECOLOTITO CR.	800	LF	$ 5,300.00	$ 4,240,000.00
7	BOX CULVERTS (50'X10') @ SAN PEDRO CR.	700	LF	$ 4,300.00	$ 3,010,000.00
8	CONCRETE WING WALLS & APRON	125	CY	$ 250.00	$ 31,250.00
9	DEWATERING	1	LS	$ 400,000.00	$ 400,000.00
10	ROADWAY EXCAVATION (TUNNEL)	47,000	CY	$ 5.00	$ 235,000.00
[illegible]	STRUCTURAL CONCRETE (TUNNEL)	500	LF	$ 7,000.00	$ 3,500,000.00
12	PUMP STATION (TUNNEL)	1	LS	$ 150,000.00	$ 150,000.00
13	ASPHALT CONCRETE (CAL) @ FAIRVIEW AVE	1,050	TON	$ 40.00	$ 42,000.00
14	AGGREGATE BASE (CAL) @ FAIRVIEW AVE	3,020	TON	$ 20.00	$ 60,400.00
15	RETAINING WALLS (TUNNEL)	10,000	SF	$ 60.00	$ 600,000.00
16	CONCRETE SLAB (TUNNEL)	990	CY	$ 250.00	$ 247,500.00
17	WATERSTOP (TUNNEL)	1,000	LF	$ 125.00	$ 125,000.00
				TOTAL	$ 16,320,900.00
				CONTINGENCIES (30%)	$4,896,270
				ESTIMATED TOTAL CONSTRUCTION COST	$ 21,217,170.00

Notes :

1. The area of RSA extension is assumed to be unpaved.
2. Box culverts are proposed for San Pedro and Tecolotito Creeks. Both ends of Runways 7 and 25 need to be raised and overlaid with P-401. See runway profile.
3. Concrete quantities for wingwalls and apron are assumed based on the area bounded between San Pedro Creek and the proposed box culverts.
4. Unclassified excavation for runway, taxiway, and safety area is estimated to be 48,500 CY.
5. The quantity for borrow fill is estimated to be 31,200 CY.
6. Quantity for Roadway excavation of Fairview Tunnel is calculated based on the preliminary design of Fairview Avenue.
7. The thickness of the asphalt concrete and aggregate base for proposed Fairview Avenue is 4" and 12" respectively, and/or equivalent to the the existing roadway pavement thickness.
8. Cost estimates for relocation of MALSR, Middle Marker, VASI and Glide Slope are included.
9. Quantity for Concrete Slab is estimated based on the area between the proposed Fairview Tunnel and proposed Fairview Avenue. The estimated thickness is 8".
10. Cost estimate of the retaining wall includes the cost of steel reinforcing bars.

APPENDIX D

ABBREVIATIONS AND DEFINITIONS

ABBREVIATIONS

AC	- Advisory Circular
ADF	- Automatic Direction Finder
ADPM	- Average Day of the Peak Month
AGL	- Above Ground Level
AIP	- Airport Improvement Program
ALP	- Airport Layout Plan
ALS	- Approach Lighting System
ALSF-1	- Approach Light System with Sequence Flasher Lights
ARC	- Airport Reference Code
ARFF	- Airport Rescue and Fire Fighting
ARP	- Airport Reference Point
ARTCC	- Air Route Traffic Control Center
ASDA	- Accelerate-Stop Distance Available
ASR	- Airport Surveillance Radar
ASV	- Annual Service Volume
ATC	- Air Traffic Control
ATCT	- Air Traffic Control Tower
AVGAS	- Aviation Gasoline
BRL	- Building Restriction Line
CIP	- Capital Improvement Program
CL	- Centerline
dBA	- A-weighted Decibels
DH	- Decision Height
DME	- Distance Measuring Equipment
DNL	- Day-Night Sound Levels
DOT	- Department of Transportation
EA	- Environmental Assessment
EIS	- Environmental Impact Statement
EP	- Enplaned Passenger
EPA	- The United States Environmental Protection Agency
FAA	- Federal Aviation Administration
FAR	- Federal Aviation Regulation
FBO	- Fixed Based Operator
FIS	- Federal Inspection Service
FSS	- Flight Service Station
GA	- General Aviation
GPS	- Global Positioning System
HIRL	- High Intensity Runway Lights
IFR	- Instrument Flight Rules
ILS	- Instrument Landing System
INM	- Integrated Noise Model
ISTEA	- Intermodal Surface Transportation Enhancement Act
LDA	- Landing Distance Available
LDN	- Day-Night Sound Levels (See DNL)
LIRL	- Low Intensity Runway Lights
MALS	- Medium Intensity Approach Light System
MALSF	- Medium Intensity Approach Light System with sequence flashing Lights

MALSR	- Medium-Intensity Approach Lighting System with Runway Alignment Indicators
MGW	- Maximum Gross Weight
MIRL	- Medium Intensity Runway Lights
MLS	- Microwave Landing System
MSL	- Mean Sea Level
NAVAID	- Air Navigation Facility/Aid
NDB	- Non-Directional Beacon
NPIAS	- National Plan of Integrated Airport Systems
OAG	- Official Airline Guide
OFA	- Object Free Area
OFZ	- Obstacle Free Zone
PAPI	- Precision Approach Path Indicator
PFC	- Passenger Facility Charge
PIR	- Precision Instrument Runway
PSC	- Tri-Cities Airport
RAIL	- Runway Alignment Indicator Lights
REIL	- Runway End Identifier Lights
RSA	- Runway Safety Area
RPZ	- Runway Protection Zone
RVR	- Runway Visual Range
TAF	- FAA Terminal Area Forecasts
TODA	- Take-Off Distance Available
TORA	- Take-Off Run Available
UHF	- Ultra High Frequency
VASI	- Visual Approach Slope Indicator
VFR	- Visual Flight Rules
VHF	- Very High Frequency
WAD	- Washington State Department of Transportation, Aeronautics Division
WSCASP	- Washington State Continuous Airport System Plan
WSDOT	- Washington State Department of Transportation

Definitions

Active Aircraft - Aircraft registered with the FAA and reported to have flown during the preceding calendar year.

Activity - Used in aviation to refer to any kind of movement, e.g., cargo flights, passenger flights, or passenger enplanements. Without clarification it has no particular meaning.

ADF - Automatic Direction Finder.

Advisory Circular (AC) - A series of Federal Aviation Administration (FAA) publications providing guidance and standards for the design, operation and performance of aircraft and airport facilities.

AGL - Above Ground Level.

Airport Improvement Program (AIP) - A congressionally mandated program through which the FAA provides funding assistance for the development and enhancement of airport facilities.

Air Cargo - Commercial freight, including express packages and mail, transported by passenger or all-cargo airlines.

Air Carrier - An airline providing scheduled air service for the commercial transport of passengers or cargo.

Air Navigation Facility (NAVAID) - Although generally referring to electronic radio wave transmitters (VOR, NDB, ILS), it also includes any structure or mechanism designed to guide or control aircraft involved in flight operations.

Air Route Traffic Control Center (ARTCC) - FAA-manned facility established to provide air traffic control services to aircraft operating in controlled airspace, en route between terminal areas. Although designed to handle aircraft operating under IFR conditions, some advisory services are provided to participating VFR aircraft when controller work loads permit.

Air Taxi - An air carrier certificated in accordance with FAR Part 135 and authorized to provide, on demand, public transportation of persons and property by aircraft. Air taxi operators generally operate small aircraft "for hire" for specific trips.

Air Traffic Hub - Air traffic hubs are not airports; they are cities and Metropolitan Statistical Areas requiring aviation services and may include more than one airport. Communities fall into four classes as determined by each community's percentage of the total enplaned passengers by scheduled air carriers in the 50 United States, the District of Columbia, and other U.S. areas designated by the Federal Aviation Administration. Hub designations are determined by the following criteria:

1. Large Hub: 1.00 percent
2. Medium Hub: 0.25 percent to 0.99 percent (cont.)
3. Small Hub: 0.05 percent to 0.249 percent
4. Nonhub: Less than 0.05 percent.

Aircraft Approach Category - A grouping of aircraft based on a speed of 1.3 times the stall speed in the landing configuration at maximum gross landing weight. The aircraft approach categories are:

Category A - Speed less than 91 knots;
Category B - Speed 91 knots or more but less than 121 knots;
Category C - Speed 121 knots or more but less than 141 knots;
Category D - Speed 141 knots or more but less than 166 knots; and,
Category E - Speed 166 knots or more.

Aircraft Gate Position - An aircraft operational stand close to the terminal building and related to a specific passenger loading gate.

Aircraft Mix - The classification of aircraft into groups, which are similar in size, noise, and operational characteristics.

Aircraft Operations - The airborne movement of aircraft. There are two types of operations: local and itinerant defined as follows:

1. Local Operations are performed by aircraft which:
   (a) operate in the local traffic pattern or within sight of the airport;
   (b) are known to be departing for or arriving from a local practice area.

2. Itinerant operations are all others.

Airfield - A defined area on land or water including any buildings, installations, and equipment intended to be used either wholly or in part for the arrival, departure or movement of aircraft.

Airplane Design Group - A grouping of airplanes based on wingspan. The groups are:

Group I:	Up to, but not including 49 feet
Group II:	49 feet up to, but not including 79 feet
Group III:	79 feet up to, but not including 118 feet
Group IV:	118 feet up to, but not including 171 feet
Group V:	171 feet up to, but not including 214 feet
Group VI:	214 feet up to, but not including 262 feet.

Airport Layout Plan (ALP) - A FAA required map of an airport depicting existing and proposed facilities and uses, with clearance and dimensional information showing compliance with applicable standards.

Airport Reference Code (ARC) - A coding system used to relate airport design criteria to the operational and physical characteristics of the airplanes intended to operate at the airport. It is a combination of the aircraft approach category and the airplane design group.

Airport Reference Point (ARP) - The location at which the designated latitude and longitude for an airport are measured.

Airport Service Area - The geographic area that generates demand for aviation services at an airport.

Airport Surveillance Radar (ASR) - Radar providing position of aircraft by azimuth and range data without elevation data. It is designed for a range of approximately 50 miles.

Airport Traffic Area - Unless otherwise specifically designated that airspace with a horizontal radius of five statute miles from the geographic center of any airport at which a control tower is operating, extending from the surface up to but not including 3,000 feet above the surface.

Airside - That portion of the airport facility where aircraft movements take place, airline operations areas, and areas that directly serve the aircraft (taxiway, runway, maintenance, and fueling areas). Also called the airport operations area.

Airspace - The area above the ground in which aircraft travel. It is divided into corridors, routes, and restricted zones for the control and safety of aircraft.

All-Cargo Carrier - An air carrier certificated in accordance with FAR Part 121 to provide scheduled air freight, express, and mail transportation over specific routes, as well as the conduct of nonscheduled operations that may include passengers.

Alternate Airport - An alternate destination airport if flight to the original destination cannot be completed.

Ambient Noise Level - Background noise level, exclusive of the contribution made by aircraft.

Annual Service Volume (ASV) - A reasonable estimate of an airport's annual capacity. It accounts for differences in runway use, aircraft mix, weather conditions, etc., that would be encountered over a year's time.

Approach End of Runway - The near end of the runway as viewed from the cockpit of a landing aircraft.

Approach Surface - An imaginary surface longitudinally centered on the extended runway centerline and extending outward and upward from each end of the primary surface. An approach surface is applied to each end of the runway based upon the planned approach. The inner edge of the approach surface is the same width as the primary surface and expands uniformly depending upon the planned approach.

Approved Instrument Approach - Instrument approach meeting the design requirements, equipment specifications, and accuracy, as determined by periodic FAA flight checks, and which are approved for general use and publication by the FAA.

Apron - A defined area where aircraft are maneuvered and parked and where activities associated with the handling of flights can be carried out.

ARFF - Aircraft Rescue and Fire Fighting.

ATC - Air Traffic Control

ATCT - Air Traffic Control Tower.

AVGAS - Aviation gasoline. Fuel used in reciprocating (piston) aircraft engines. Avgas is manufactured in the following grades; 80/87, 100LL, 100/130, and 115/145.

Avigation Easement - A form of limited property right purchase that establishes legal land-use control prohibiting incompatible development of areas required for airports or aviation related purposes.

Based Aircraft - Aircraft stationed at an airport on an annual basis.

BRL - Building Restriction Line.

Capacity - (Throughput capacity). A measure of the maximum number of aircraft operations that can be accommodated on the airport component in an hour.

Capital Improvement Program (CIP) - A scheduled of planned projects and costs, often prepared and adopted by public agencies.

CAT I (one) - Category I Instrument Landing System that provides for approach to a height above touchdown of not less than 200 feet and with Runway Visual Range of not less than 1,800 feet.

CAT II (two) - Category II ILS approach procedure which provides for approach to a height above touchdown of not less than 100 feet and a RVR of not less than 1,200 feet.

CAT III (three) - Category III ILS approach that provides for an approach with no decision height and a RVR of not less than 700 feet.

Ceiling - The height above the ground of the base of the lowest layer of clouds or obscuring phenomena aloft that is reported as broken or overcast and not classified as scattered, thin, or partial. Ceiling figures in aviation weather reports may be determined as measured, estimated, or indefinite.

Certificated Route Air Carrier - One of a class of air carriers holding certificates of public convenience and necessity. These carriers are authorized to perform scheduled air transportation over specified routes and a limited amount of nonscheduled activity.

Charter - A nonscheduled flight offered by either a supplemental or certificated air carrier.

Circling Approach - An instrument approach procedure in which an aircraft executes the published instrument approach to one runway, the maneuvers visually to land on a different runway. Circling approaches are also used at airports that have published instrument approaches with a final approach course that is not aligned within 30 degrees of any runway.

Clear Zone - See Runway Protection Zone

Clearway - A clearway is an area available for the continuation of the take-off operation, which is above a clearly defined area connected to and extending beyond the end of the runway. The area over which the clearway lies need not be suitable for stopping aircraft in the event of an aborted take-off. Clearways are applicable only in the take-off operations of turbine-engined aircraft.

Commercial Air Carriers - An air carrier certificated in accordance with FAR Parts 121 or 127 to conduct scheduled services on specified routes. These air carriers may also provide nonscheduled or charter services as a secondary operation. Four carrier groupings have been designated for statistical and financial data aggregation and analysis:

1. Majors:	Air carriers with annual operating revenues greater than $1 billion.
2. Nationals:	Air carriers with annual operating revenues of between $100 million and $1 billion.
3. Large Regionals:	Those carriers whose revenues are between $10 million and $99,999,999.
4. Medium Regionals:	Air carriers with annual revenues less than $10 million.

Commuter Air Carrier - An air carrier certificated in accordance with FAR Part 135 which operates aircraft with a maximum of 60 seats, and provides at least five scheduled round trips per week between two or more points, or carries mail.

Commuter/Air Taxi Operations - Those arrivals and departures performed by air carriers certificated in accordance with FAR Part 135.

Condemnation - Proceedings under which a property interest may be forcibly acquired: government may condemn land through the power of eminent domain: an individual may apply inverse condemnation to obtain just compensation for a property interest taken by the government without prior agreement.

Conical Surface - An imaginary surface extending outward and upward from the periphery of the horizontal surface at a slope of 20:1 for a horizontal distance of 4,000 feet.

Control Areas - These consist of the airspace designated as Federal Airways, additional Control Areas, and Control Area Extensions, but do not include the Continental Control Areas.
Control Tower - A central operations facility in the terminal air traffic control system consisting of a tower cab structure using air/ground communications and/or radar, visual signaling, and other devices to provide safe and expeditious movement of air traffic.

Control Zones - Areas of controlled airspace which extend upward from the surface and terminate at the base of the continental control area. Control zones that do not underlie the continental control area have no upper limit. A control zone may include one or more airports and is normally a circular area with a radius of five statute miles and any extensions necessary to include instrument departure and arrival paths.

Controlled Airspace - Airspace designated as continental control area, control area, control zone, or transition area within which some or all aircraft may be subject to air traffic control.

Critical Aircraft - The aircraft which controls one or more design items based on wingspan, approach speed and/or maximum certificated take off weight. The same aircraft may not be critical to all design items.

Crosswind - When used concerning wind conditions, the word means a wind not parallel to the runway or the path of an aircraft.

dBA - Decibels measured on the A-weighted scale to factor out anomalies.

Decibel (dB) - The standard unit of noise measurement relating to a logarithm scale in which 10 units represents a doubling of acoustic energy.

Decision Height (DH) - During a precision approach, the height (or altitude) at which a decision must be made to either continue the approach or execute a missed approach.

Declared Distances - The distances the airport owner declares available and suitable for satisfying an airplane's take-off distance, accelerated-stop distance, and landing distance requirements. The distances are:

Take-off run available (TORA) - The runway length declared available and suitable for the ground run of an airplane taking off.

Take-off distance available (TODA) - The TORA plus the length of any remaining runway and/or clearway (CWY) beyond the far end of the TORA.

Accelerate-stop distance available (ASDA) - The runway plus stopway (SWY) length declared available and suitable for the acceleration and deceleration of an airplane aborting take-off.

Landing distance available (LDA) - The runway length declared available and suitable for a landing airplane.

Design Hour - The design hour is an hour close to the peak but not the absolute peak, which is used for airport planning and design purposes. It is usually the peak hour of the average day of the peak month.

Displaced Threshold - Actual touchdown point on specific runways designated due to obstructions that make it impossible to use the actual physical runway end.

Distance Measuring Equipment (DME) - An airborne instrument that indicates the distance the aircraft is from a fixed point, usually a VOR station.

DOT - Department of Transportation.

Effective Runway Gradient - The maximum difference between runway centerline elevations divided by the runway length, expressed as a percentage.

Eminent Domain - Right of the government to take property from the owner, upon compensation, for public facilities or other purposes in the public interest.

Environmental Assessment (EA) - A report prepared under the National Environmental Policy Act (NEPA) analyzing the potential environmental impacts of a federally funded project.

Environmental Impact Statement (EIS) - A report prepared under NEPA fully analyzing the potential significant environmental impacts of a federally funded project.

EPA - The United States Environmental Protection Agency.

FAR Part 77 - Federal Aviation Regulations which establish standards for determining obstructions in navigable airspace.

Federal Aviation Administration (FAA) - A branch of the U.S. Department of Transportation responsible for the regulation of all civil aviation activities.

Fixed Base Operator (FBO) - An individual or company located at an airport providing commercial general aviation services.

Final Approach - The flight path of an aircraft which is inbound to the airport on an approved final instrument approach course, beginning at the point of interception of that course and extending to the airport or the point where circling for landing or missed approach is executed.

Fixed Wing - For the purposes of this report, any aircraft not considered rotorcraft.

Flight Plan - A description or outline of a planned flight which a pilot submits to the FAA, usually through a Flight Service Station.

Flight Service Station (FSS) - Air traffic facility operated by the FAA to provide flight service assistance such as pilot briefing, en route communications, search and rescue assistance and weather information.

General Aviation - All civil aviation operations other than scheduled air services and non-scheduled air transport operations for remuneration or hire.

Global Positioning System (GPS) - GPS uses a group of many satellites orbiting the earth to determine the position of users on or above the earth's surface. This system will provide at least non-precision approach capability to any airport having published instrument approach procedures.

HIRL - High Intensity Runway Lights.

Horizontal Surface - A horizontal plane 150 feet above the established airport elevation, the perimeter of which is constructed by swinging arcs with a radius of 5,000 feet for all runways designated as utility or general; and 10,000 feet for all other runways from the center of each end of the primary surface and connecting the adjacent arc by tangent lines.

Instrument Flight Rules (IFR) - These rules govern the procedures for conducting instrument flight. Pilots are required to follow these rules when operating in controlled airspace with visibility of less than three miles and/or ceiling lower than 1,000 feet.

Instrument Landing System (ILS) - ILS is designed to provide an exact approach path for alignment and descent of aircraft. Generally consists of a localizer, glide slope, outer marker, middle marker, and approach lights. This type of precision instrument system is being replaced by Microwave Landing Systems (MLS).

Instrument Runway - A runway equipped with electronic and visual navigation aids for which a precision or non-precision approach procedure having straight-in landing minimums has been approved.

Itinerant Operation - All aircraft operations at an airport other than local.

Landing Area - That part of the movement area intended for the landing and takeoff of aircraft.

LDN - Day-night sound levels; a method of measuring noise exposure.

Local Operation - Aircraft operation in the traffic pattern or within sight of the tower, or aircraft known to be departing or arriving from flight in local practice areas, or aircraft executing practice instrument approaches at the airport.

LIRL - Low Intensity Runway Lights.

Mean Sea Level (MSL) - Elevation above Mean Sea Level.

Medium-Intensity Approach Lighting (MALSR) -This system includes runway alignment indicator lights. An airport lighting facility which provides visual guidance to landing aircraft.

Microwave Landing System (MLS) - An instrument landing system operating in the microwave spectrum that provides lateral and vertical guidance to aircraft with compatible equipment.

Minimums - Weather condition requirements established for a particular operation or type of operation.

MIRL - Medium-Intensity Runway Lights.

Movement Area - The runways, taxiways and other areas of the airport used for taxiing, takeoff and landing of aircraft, exclusive of loading ramps and parking areas.

Navigational Aid (NAVAID) - Any visual or electronic device airborne or on the surface which provides point to point guidance information or position data to aircraft in flight.

Non-Directional Beacon (NDB) - Transmits a signal on which a pilot may "home" to using equipment installed in the aircraft.

Non-Precision Instrument Approach - An instrument approach procedure with only horizontal guidance or area-type navigational guidance for straight-in approaches.

Object Free Area (OFA) - A two-dimensional ground area surrounding runways, taxiways, and taxilanes which is clear of objects except those whose location is fixed by function.

Object Free Zone (OFZ) - The airspace defined by the runway OFZ and, as appropriate, the inner-approach OFZ and the inner-transitional OFZ, which is clear of object penetrations other than frangible NAVAIDS.

Runway OFZ - The airspace above a surface centered runway centerline.
Inner-approach OFZ - The airspace above a surface centered on the extended runway centerline. It applies to runways with an approach lighting system.
Inner-transitional OFZ - The airspace above the surfaces located on the outer edges of the runway OFZ and the inner-approach OFZ. It applies to precision instrument runways.

Obstruction - An object that penetrates an imaginary surface described in FAR Part 77.

Peak Factor - The factor applied to the annual operations to determine the peak hour activity.

PIR - Precision Instrument Runway.

Precision Approach Path Indicator (PAPI) - Provides visual approach slope guidance to aircraft during approach to landing by radiating a directional pattern of high intensity focused light beams.

Precision Instrument Approach - An instrument approach procedure in which electronic vertical and horizontal guidance is provided, e.g. ILS and MLS.

Primary Surface - A surface longitudinally centered on the runway, extending 200 feet beyond each end of the runway. The elevation of any point on the primary surface is the same as the elevation of the nearest point on the runway centerline.

Rotorcraft (e.g. Helicopter) - A heavier-than-air aircraft supported in flight by the reactions of the air on one or more power-driven rotors on substantially vertical axis.

Runway End Identifier Lights (REIL) - These lights aid in early identification of the approach end of the runway.

Runway Protection Zone (RPZ) - The ground area under the approach surface which extends from the primary surface to a point where the approach surface is fifty feet above the ground. This was formerly known as the clear zone.

Runway Safety Area (RSA) - A defined surface surrounding the runway prepared or suitable for reducing the risk of damage to airplanes in the event of an undershoot, overshoot, or excursion from the runway.

Segmented Circle - A system of visual indicators designed to provide traffic pattern information at airports without operating control towers.

Touch and Go Operation - Practice flight performed by a landing touch down and continuous take off without stopping or exiting the runway.

Transitional Surfaces - These surfaces extend outward and upward at right angles to the runway centerline and the extended runway centerline at a slope of 7:1 from the sides of the primary surface and from the sides of the approach surfaces. Transitional surfaces for those portions of a precision approach surface which project through and beyond the limits of the conical surface extend a distance of 5,000 feet measured horizontally from the edge of the approach surface and at right angles to the runway centerline.

Transport Airport - An airport designed, constructed and maintained to serve airplanes in aircraft approach category C and D.

Utility Airport - An airport designed, constructed and maintained to serve airplanes in aircraft approach category A and B.

VASI - Visual Approach Slope Indicator. See definition of PAPI.

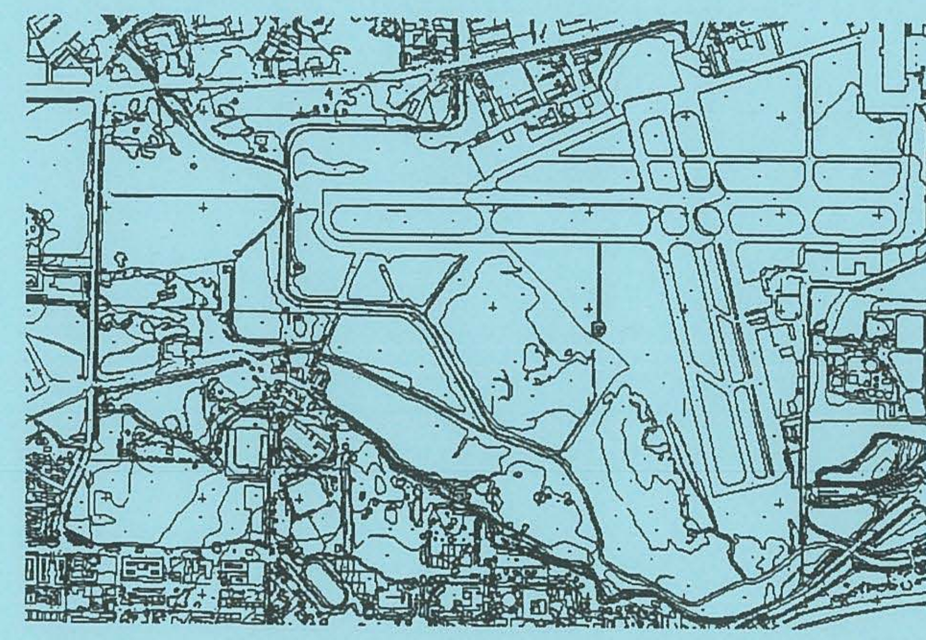
Visual Flight Rules (VFR) - Flight rules by which aircraft are operated by visual reference to the ground. Weather conditions for flying under these rules must include a ceiling greater than 1,000 feet, three miles visibility and standard cloud clearance.

Wind Coverage - Wind coverage is the percent of time for which aeronautical operations are considered safe due to acceptable crosswind components.

Wind Rose - A scaled graphical presentation of wind information.

CHAPTER 5

WETLAND MITIGATION PLAN FOR RUNWAY EXTENSION PROJECT (BIOLOGY STUDY)



Prepared by URS Corporation
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CONCEPTUAL WETLAND MITIGATION PLAN FOR THE AIRFIELD SAFETY PROJECTS

Santa Barbara Airport

October 2001

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1.0 INTRODUCTION

The Santa Barbara Airport (Airport) is owned and managed by the City of Santa Barbara. It is located in the South Coast region of Santa Barbara County, on the coastal plain between the Santa Ynez Mountains and the Pacific Ocean. There are three runways in the airfield, which encompasses about 725 acres south of Hollister Avenue (Figure 1, see Appendix A). The Airport property also includes the industrial/commercial area north of Hollister Avenue, as well as most of Goleta Slough and its associated wetlands and tidal channels.

Three creeks are located in and adjacent to the airfield: Tecolotito, Carneros, and San Pedro creeks (Figure 1). These creeks are tributaries to Goleta Slough, which empties to the ocean at Goleta Beach. The elevation of the airfield is very low, with an average ground elevation of about 8 to 10 feet above mean sea level. Significant portions of Goleta Slough and the lower ends of the creeks at the Airport are tidally influenced.

The City of Santa Barbara (City) initiated a comprehensive planning process for the Airport in 1994 that included both an Industrial/Commercial Specific Plan and an Aviation Facilities Plan (AFP). The Specific Plan for the land north of Hollister Avenue was certified by the California Coastal Commission in 1998. The AFP is currently under development. It consists of various improvements to increase public safety and enhance service at the Airport, while meeting both short-term and long-term aviation needs of the region. The AFP includes the following primary elements:

- Modify the airfield to meet requirements of the Federal Aviation Administration (FAA) for Runway Safety Areas (RSAs)
- Add a new Taxiway ("M") to improve airfield operations
- Expand the Airport terminal to meet current and future demands and to enhance service, including increased parking facilities
- Increase the number of "T" hangers for general aviation airplanes
- Acquire property or easements on non-Airport property at the end of runways to provide the required Runway Protection Zone (RPZ)

A Runway Safety Area (RSA) is the land surrounding a runway that must be smoothed and compacted such that injury to passengers and damage to aircraft that overrun the paved surface would be minimized. The existing RSAs at the east and west ends of Runway 7-25, the primary commercial flight runway at the Airport, do not meet FAA requirements. For Runway 7-25, the minimum RSA at each end is 1,000 feet long and 500 feet wide. The lengths of the current RSAs on the east and west ends are only 200 and 350 feet, respectively.

One of the primary issues associated with the extension of the RSA is the effect on wetlands at the end of Runway 7-25. URS Corporation was retained to develop a conceptual wetland mitigation plan for impacts to wetlands. The plan was developed based on the following tasks:

- Prepare an inventory of wetlands at the end of Runway 7-25, updating the 1995 Airport-wide wetland inventory prepared by Woodward-Clyde (1996a), now URS Corporation.

- Estimate the acreage of permanent wetland loss due to the extension of the RSA at the west end of Runway 7-25, and the relocations of Tecolotito and Carneros creeks.

- Review and examine candidate wetland restoration sites on Airport property identified in previous studies, including Woodward-Clyde (1996b), Goleta Slough Ecosystem Management Committee (1997), and Levine-Fricke-Recon (2000).

- Identify and develop a wetland restoration plan to compensate for the loss of wetlands due to the proposed runway safety area extension, as well as due to the approach light relocation and new Taxiway M

The overall objectives of the plan are to replace the functions of affected wetlands with similar wetlands (i.e., in-kind habitat replacement) on Airport property (i.e., on-site) that will be consistent with the overall restoration goals for Goleta Slough developed in the Goleta South Ecosystem Management Plan (Plan). The Goleta Slough Management Committee indicated that the proposed mitigation plan was consistent with the Plan in a letter to the Airport dated June 9, 2001 (Appendix C). The wetland restoration plan must not increase the bird strike hazards at the Airport. This plan was developed in consultation with the USDA Wildlife Services Division, which indicated that plan would not increase bird strike hazard in a letter to the Airport dated November 27, 2000 (Appendix C).

2.0 PROPOSED FACILITIES

2.1 RSA EXTENSION

Six Runway Safety Area (RSA) extension alternatives were identified in the companion report by URS Corporation, *Runway Safety Area Extension Alternatives, Master Drainage Plan, April 2001.* Each alternative involves the establishment of a 1,000-foot long RSA at both ends of Runway 7-25 through a combination of the physical extension of the paved runway and associated RSA, and relocation of the landing threshold (a "mark" on the runway) farther from the end of the paved runway.

The alternatives involve relocation of the runway and extension of the RSA at the east and west ends of Runway 7-25, either at one end or at both ends. San Pedro Creek and Tecolotito Creek are located at the east and west ends of the runway, respectively. Extension at the west end will require either realigning Tecolotito Creek around the new RSA, or placing the creek in a culvert under the new runway and RSA extension. RSA extensions at the east end will require placement of San Pedro Creek into a culvert under the new RSA, and realigning Fairview Avenue. Relocating San Pedro Creek is not feasible due to insufficient Airport property to accommodate a relocated creek.

Based on the alternatives study by URS (April 2001), the "West Creek Realignment" alternative was identified as the preferred project. Under this alternative, the RSA would be extended 1,000 feet to the west, and Tecolotito and Carneros creeks would be relocated around the new RSA (Figure 2).

The realignment of Carneros and Tecolotito creeks is shown on Figures 3 and 4. The new alignments were chosen to reduce hydraulic constraints, and most importantly, to locate the open channel as far from the end of the runway as possible in order to reduce bird strike hazards. The new channels would have the same or slightly greater width than the existing channels, with slightly steeper and more uniform banks. The new channels would have a 40 to 45-foot wide bottom and a 60-foot wide top width, and side slopes that range from 1:1 to 1.25:1 (H:V).

There is a 550-foot long sediment basin along Tecolotito Creek immediately downstream of Hollister Avenue. This basin will be slightly relocated and enlarged under the proposed project. The 400-foot long channel between Hollister Avenue and the new confluence with Carneros Creek was assumed to be 150 feet, and the 375 feet downstream of the confluence was assumed to be 80 feet wide. This 775-foot long section would replace the existing 560-foot-long sediment basin on Tecolotito Creek (Figure 3). Sediment could be removed from both sides of the creek in the same manner currently used by the County Flood Control District.

2.2 RELOCATED APPROACH LIGHTS

The existing approach lights at the west end of Runway 7-25 would be relocated to an Airport easement on the Sares-Regis property on the west side of Carneros Road due to the relocation of the runway (Figure 5). A 50-foot wide corridor with an easement to the Airport would be established that includes five new light standards and a middle marker (a small radar structure). The lights are tall, narrow metal structures with a small base (usually less than 10 by 10 feet). The lights would be individually fenced for security. A 12-foot wide access road (gravel or decomposed granite) would be placed north of the lights. The road would follow existing contours, but may require a minor culvert crossing if water accumulation in the low spot along the road prevents passage. Vegetation in the corridor would be maintained in a low stature (less than 3 feet high) to prevent interference with lighting and to facilitate inspection.

2.3 TAXIWAY M

A new 50-foot wide Taxiway M would be constructed parallel to, and west of, Runway 15R/33L, as shown on Figure 2. The taxiway will be extend north, crossing Taxiway A, Runway 7-25, Taxiway H, and terminating at Taxiway C and the northwest ramp. It would allow aircraft landing on the two parallel runways to access facilities on the north side of the Airport by only crossing the main runway once, rather than four times, as is now the case. A 34-foot wide mowed safety area would be established on each side of the new taxiway.

3.0 WETLANDS AT THE PROJECT SITE

A complete description of the biological resources at the Santa Barbara Airport, and at the locations of the Airfield Safety Projects is provided in the Draft Environmental Impact Report/Statement prepared for the proposed project by the City and FAA. Key background information and sections of the EIR/EIS include the following: upland and wetland habitats (Chapter 3.10); fish and wildlife resources (Chapter 3.10); sensitive plant, fish, and wildlife species (Chapter 3.11); and water quality (Chapter 3.7).

The occurrence of wetlands at the locations of the Airfield Safety Projects is described below based on ongoing investigations by URS Corporation for the Airport since 1996. This information was used by the City and FAA in preparation of the EIR/EIS, and is summarized below.

3.1 WETLANDS WEST OF RUNWAY 7-25

3.1.1 Wetland Inventory

In 1995, a comprehensive inventory of vegetation types over the entire Airport property was conducted by Woodward-Clyde (1996a). The Corps of Engineers officially accepted the delineation of Section 404 jurisdictional wetlands presented in the report. In addition, the City Community Development Department also accepted the boundaries of wetlands described in the report for use in permitting actions at the Airport under the Coastal Act and Local Coastal Plan. In July 2000, URS conducted field supplemental investigations at the west end of Runway 7-25 to update the data on vegetation due to recently observed changes in vegetation patterns at the project site. The results are presented in URS (2000) and summarized in this section.

Over the past five years, there has been higher than average rainfall, and two years with significantly higher than average rainfall (i.e., 1995 and 1998). The major changes observed at the project site over the past five years include the following:

- Increased number of isolated and scattered pickleweed (*Salicornia virginica*) and akali-heath (*Frankenia salina*), and an increase in the size and number of isolated willow trees along the south bank of Tecolotito Creek.

- Increase in the occurrence of spreading alkali-weed (*Cressa truxillensis* var. *truxillensis*) throughout the project site.

- Colonization of portions of the project site by the introduced Harding grass (*Phalaris aquatica*), and alkali mallow (*Malvella leprosa*).

URS biologists examined the entire project site in July and September 2000. Major vegetation types were identified based on dominant species and topographic features. Air photos of the project site were also used for reference. The minimum mapping unit was 25 by 25 feet. Twenty soil samples were taken to examine the soil profile, and to determine soil texture, soil salinity, and the presence of hydric soil characteristics.

3.1.2 Summary of Results

Wetland Vegetation

The native and naturalized vegetation types on the Airport property were classified and mapped based on dominant plant species. That is, areas dominated by one or two plant species and occupying a particular physical habitat (i.e., elevation, soil type, and topography), were described as a specific vegetation type or *"series."* The common name of one or more dominant plant species was used as the name of each series (example: Coyote Brush Series). Most series consist of several *associations* in which there are different co-dominant plant species (example: Coyote Brush – Mustard Association). Eighteen major vegetation types (or "series") were identified at the project site, as listed below and shown on Figure 6. Each vegetation series has been assigned a numeric code for mapping purposes. Vegetation types were assigned to one of the two functional categories: (1) hydrophytic or halophytic (salt tolerant) types; and (2) upland types (Table 1).

The occurrence of wetland vegetation at the project site based on the August 2000 field surveys is presented on Figure 6. The overall distribution of wetland vegetation in 2000 is generally similar to that observed in 1995; however, there is a slight increase in the total amount and in the variety of wetland types in 2000.

Wetland Hydrology

The entire project site is very flat with no distinct drainage channels or swales to remove runoff from the site. It appears that overall drainage is impeded at the project site due to the flat terrain and lack of drainage channels. This condition results in prolonged soil moisture and possibly standing water in selected portions of the site. The drainage in the northern and southern portions of the site (separated by the approach lighting road) is separated. The southwestern portion of the site collects runoff from the Sares-Regis property to the west from a culvert under Carneros Road. However, most of the site receives water only from direct precipitation. The overall drainage south of the approach lights is to the southeast towards the southern boundary of the Airport property.

TABLE 1
VEGETATION TYPES WEST OF RUNWAY 7-25

Map Code	Vegetation Types	Specific Associations*
Hydrophytic and/or/Halophytic Vegetation		
1	Pickleweed Series	1, 1H, 1HC, 1PL
3	Saltgrass Series	3, 3CF
4	Curly Dock Series	4C, 4FD, 4L, 4LM, 4P, 4PS, 4S, 4XC
5	Bulrush Series	5
7	Spikerush Series	7ER
8	Arroyo Willow Series	8
14	Cocklebur Series	14RC, 14RM, 14 RMC
11	Annual Grassland Series (wetland affinities)	11LC, 11LCF, 11CFR, 11LCR, 11LF, 11LFR, 11LFRD, 11LSC
22	Alkali Weed Series+	22, 22LR, 22LFRS, 22LFR, 22S, 22XR
24	Heliotrope Series+	24
Upland Vegetation		
9	Coyote Brush- Willow Series	9
10	Coyote Brush Series	10, 10B, 10F
12	Annual Grassland Series (upland affinities)	12B, 12BNF, 12LA, 12LC, 12LCB, 12LCBM, 12LCM, 12LCS, 12LCST, 12LCT, 12LMBC, 12LMBT, 12N, 12Y
13	Ruderal Series	13, 13A, 13B, 13H, 13I, 13BN, 13BIF, 13M, 13PC, 13SBL
17	Eucalyptus Series	17
18	Ornamental	18
23	Ragweed Series+	23
25	Saltbush Series+	25B
Other		
19	Bare Ground	19
20	Paved Area	20
* See Figure 6, Appendix A		
Series and associations based on classification system presented in Woodward-Clyde (1996)		
+ Indicates a new series not described in Woodward-Clyde (1996)		

Currently there is scattered evidence of wetland hydrology at the project site, including dried algal mats and cracked soils. The only clear topographic evidence of wetland hydrology at the project site is the round depression north of the runway lights, and several small salt flats in the southern portion of the site.

New and more precise topographic maps of the project site were acquired by the Airport in 2000. New boundaries of wetland hydrology were developed based on these topographic maps and field observations of hydrology, that latter consisting primarily of dried algal mats, cracked soils, and salt crusts. Two zones of wetland hydrology were identified in URS (2000). The primary zone appears to exhibit wetland hydrology during most years, as defined by the Corps of Engineers. A secondary zone of wetland hydrology includes areas that exhibit prolonged soil moisture during wet years.

Hydric Soils

Eighteen soil samples were examined at the project site in 2000. Five samples exhibited hydric soil characteristics consisting of infrequent and faint mottling at four sites, and oxidized root channels at one site. All but one of these sites supported wetland plants. Strong evidence of hydric soils characteristics were absent at these sites, such as bright and abundance mottling, a dark soil matrix, gleying, sulfuric odor, and more frequent oxidized rhizospheres. The evidence of hydric soils at the five locations was very weak compared to that observed elsewhere at the Airport.

The soils at the project site represent a highly disturbed combination of in-place soils from the delta of Tecolotito Creek, and fill soils imported to the site for the Airport. The soils at the project site appear to be too young to have developed strong hydric characteristics over the past 40 years. Hence, precise boundaries of hydric soils cannot be accurately determined at this time. A reasonable, conservative estimate of the extent of hydric soils would coincide with the boundaries of wetland hydrology shown in URS (2000).

Soils at the project site are fine grained and expected to have low permeability, which is likely to contribute to prolonged soil moisture in low-lying areas. Soil salinities were low to moderate. The soils with the highest salinities were located south of the approach lights, and mostly in the areas of wetland hydrology.

Presence of Wetlands

Figure 6 displays wetlands at the project site defined by the prevalence of hydrophytic vegetation (without reference to the presence of hydric soils or wetland hydrology). These areas represent wetland typically regulated under the Coastal Act.

Areas that exhibit three diagnostic characteristics (wetland plants, wetland hydrology, and hydric soils) are considered jurisdictional wetlands under Section 404 of the Clean Water Act. Areas with these three characteristics are shown in URS (2000), and encompass less area than shown on Figure 6.

3.2 WETLANDS ON SARES-REGIS PROPERTY

URS (1998) conducted an inventory of wetlands on the Sares-Regis property and identified wetlands that are typically regulated under the Coastal Act and by Santa Barbara County Planning & Development. The large open space on the property is dominated by non-native upland species including reed canary grass (*Phalaris canarensis)*, wild oat (*Avena barbata*), vetch, (*Vicia sativa*), Bermuda grass (*Cynodon dactylon)*, narrowleaf plantain (*Plantago lanceolata*), wild radish (*Raphanus sativa*), and Italian ryegrass (*Lolium multiflorum*).

The drainage in this area is very poor, creating prolonged soil moisture in several areas, which support wetland vegetation (see Figure 5). These seasonal wetlands include small areas with highly saline soils. A variety of native wetland plants are present, including alkali weed (*Cressa truxillensis* var. *truxillensis*), saltgrass (*Distichlis spicata*), saltmarsh sandspurry (*Spergularia marina*), Mediterranean barley (*Hordeum marinum* ssp. *gussoneanum*), rabbitsfoot grass (*Polypogon monspeliensis*), common toad rush (*Juncus bufonius*), umbrella-sedge (*Cyperus erythrorhizos*), curly dock (*Rumex crispus*), African brass-buttons, cocklebur (*Xanthium strumarium*), echinocloa (*Echinocloa crus-galli*), Italian ryegrass and common spikerush (*Eleocharis macrostachya*).

3.3 WETLANDS ALONG TAXIWAY M ROUTE

The route of Taxiway M mostly traverses annual grassland dominated by wild oats and Italian ryegrass. Portions of the route between existing taxiways and Runway 7-25 occur in the mowed safety area, which is dominated by upland grasses. South of Taxiway A, the route passes an annual grassland area with scattered and isolated seasonal wetlands. These wetlands developed in small undrained depressions created when the airfield was constructed. They are supported by rainfall and poor drainage and contain a mixture of upland grasses with scattered wetland plants, such as curly dock, Mediterranean barley, pickleweed, brass buttons, and spikerush.

4.0 WETLAND IMPACTS

In the following subsections, the impacts to wetlands associated with the proposed airfield safety projects are described. The following assessment addresses impacts to wetlands as defined under the Coastal Act - that is, wetlands identified based solely on the predominance of hydrophytic plants. Impacts to wetlands defined by the Corps of Engineers under Section 404 of the Clean Water Act are substantially less because Corps-defined wetlands encompass much less area at the Airport. By using the broader Coastal Act wetland definition, the proposed wetland restoration would provide more mitigation than required for impacts to Corps-defined wetlands.

Unless otherwise noted, wetlands discussed in this section refer specifically to Coastal Act wetlands. However, impacts to Corps wetlands are provided in Tables 3B and 4B for use by the Corps when considering a 404 permit for the project.

4.1 CREEK RELOCATION AND RSA EXTENSION

4.1.1 Impacts due to Filling Existing Creeks

Portions of Tecolotito and Carneros creeks would be filled due to the project, as shown on Figure 7a. The estimated loss of creek channel is 4.62 acres, as shown below:

TABLE 2
CREEK CHANNEL IMPACTS

Creek	Dimension	Acres
Creek Habitat Removed by Filling (includes bed and bank)		
Carneros Creek	375 linear feet, 60 ft width, top of bank	0.51
Tecolotito Creek	2700 linear feet, 60 to 120 ft width, top of bank	4.11
Total=		4.62

The creek channels affected by the project are tidal and currently support two primary wetland habitats: open water and mudflats. Hence, there would be a permanent loss of these wetland types, as shown in Table 3A.

4.1.2 Impacts from Relocating Creeks

New reaches of Tecolotito and Carneros creeks would be constructed around the new RSA, as shown on Figure 7a. Most of the routes of the new creeks would traverse upland habitats and disturbed areas. However, the construction of the new creek channels would permanently displace seasonal wetlands. The new reach of Carneros Creek would remove about 0.34 acres of salt flats, while the new reach of Tecolotito Creek would remove about 2.56 acres of various seasonal wetlands dominated by pickleweed, Mediterranean barley, curly dock, alkali weed, Italian ryegrass, alkali heath, and saltgrass (see Table 3A).

TABLE 3A
DETAILED IMPACTS TO COASTAL ACT WETLANDS

		Acres of permanent effect (removal due to paving or creek construction, or conversion to other habitat types)												
Map Code	Vegetation Series	Ex. Carneros Ck to be filled	Ex. Tec. Ck to be filled	New Carneros Ck channel	New Tec. Ck channel	Service Road along Tec. Ck. S. of Sed. Basin	New RSA (500x1000') at end of Runway	New Runway and Taxiway W. of Tec. Ck.	Other New RSA areas W. of Tec. Ck	New Runway and Taxiway E. of Tec. Ck.	New RSA areas E. of Tec. Ck.	New Approach Lights on Sares-Regis	Taxiway M	Total
Wetland Vegetation (dominated by hydrophytes)*														
1	Pickleweed				0.09	0.12				0.43	0.58		0.02	1.24
1H	Pickleweed-Mediterranean barley				0.22	0.01								0.23
1HB	Pickleweed-Mediterranean barley-brass buttons												0.11	0.11
1HC	Pickleweed-Mediterranean barley-alkali weed				0.40	0.08		0.06	0.06					0.60
3	Saltgrass						0.54							0.54
3CF	Saltgrass-alkali weed-alkali heath						0.25							0.25
4C	Curly dock-alkali weed						0.02		0.08					0.10
4FD	Curly dock-alkali heath-saltgrass					0.10		0.04	0.05					0.19
4P	Curly dock-bristly ox-tongue				0.02									0.02
7ER	Spikerush-curly dock												0.04	0.04
8	Arroyo willow				0.17		0.04							0.21
11	Italian ryegrass											0.10		0.10
11LC	Italian ryegrass-alkali weed				0.03	0.05								0.08
11LCF	Italian ryegrass-alkali weed-alkali heath					0.08								0.08
11LCT	Italian ryegrass-alkali weed-wild lettuce							0.03	0.03					0.06
11LCR	Italian ryegrass-alkali weed-curly dock							0.11	0.15					0.26
11LFR	Italian ryegrass-alkali weed-alkali heath-curly dock					0.07	0.14						0.12	0.33
11LFRD	Italian ryegrass-alkali heath-curly dock-pickleweed						0.08							0.08
11LSC	Italian ryegrass-pickleweed-alkali weed				0.20	0.21		0.11						0.52
14R	Cocklebur-curly dock							0.09	0.42					0.51
14RMC	Cocklebur-curly dock-alkali mallow-alkali weed								0.24					0.24
22LR	Alkali weed-Italian ryegrass-curly dock						0.17							0.17
22LFR	Alkali weed-Italian ryegrass-alkali heath-curly dock							0.14	0.24					0.38
22LFRS	Alkali weed-Italian ryegrass-alkali heath-curly dock-saltgrass				1.03	0.27	0.11							1.41
22S	Alkali weed-pickleweed				0.08									0.08
22XM	Alkali weed-cocklebur-alkali mallow								0.03					0.03
24	Heliotrope						0.15							0.15
Subtotal=		0	0	0.00	2.24	0.99	1.50	0.58	1.30	0.43	0.58	0.10	0.29	8.01
Non-vegetated Areas Seasonally Inundated or Saturated*														
19	Salt flats			0.34	0.32	0.01								0.67
Open Water and Mudflats in Tecolotito and Carneros Creeks*														
21	Open water - channels filled for RSA	0.51	4.11											4.62
Total Coastal Act Wetland Impacts=		0.51	4.11	0.34	2.56	1.00	1.50	0.58	1.30	0.43	0.58	0.10	0.29	13.30

**= Areas considered "wetlands" as defined in the Coastal Act, including non vegetated areas subject to periodic inundation and open water*

TABLE 3B
DETAILED IMPACTS TO CORPS OF ENGINEERS WETLANDS

				Acres of permanent effect (removal due to paving or creek construction, or conversion to other habitat types)										
Map Code	Vegetation Series	Ex. Carneros Ck to be filled	Ex. Tec. Ck to be filled	New Carneros Ck	New Tec. Ck	Service Road along Tec. Ck. S. of Sed. Basin	New RSA (500x1000') at end of Runway	New Runway and Taxiway W. of Tec. Ck.	Other New RSA areas W. of Tec. Ck	New Runway and Taxiway E. of Tec. Ck.	New RSA areas E. of Tec. Ck.	New Approach Lights on Sares-Regis	Taxiway M	Total
Corps of Engineers Jurisdictional Wetlands (presence of 3 requisite characteristics)														
1	Pickleweed				0.09	0.12				0.43	0.58			1.22
1H	Pickleweed-Mediterranean barley				0.22	0.01								0.23
1HC	Pickleweed-Mediterranean barley-alkali weed				0.40	0.08			0.06					0.54
4FD	Curly dock-alkali heath-saltgrass					0.10			0.05					0.15
4P	Curly dock-bristly ox-tongue				0.02									0.02
7ER	Spikerush-curly dock												0.04	0.04
8	Arroyo willow				0.17									0.17
11	Italian ryegrass											0.10		0.10
11LC	Italian ryegrass-alkali weed				0.03	0.05								0.08
11LCF	Italian ryegrass-alkali weed-alkali heath					0.08								0.08
11LFR	Italian ryegrass-alkali weed-alkali heath-curly dock					0.07								0.07
11LSC	Italian ryegrass-pickleweed-alkali weed				0.20	0.21		0.11						0.52
14R	Cocklebur-curly dock							0.09	0.42					0.51
14RMC	Cocklebur-curly dock-alkali mallow-alkali weed								0.24					0.24
22LFR	Alkali weed-Italian ryegrass-alkali heath-curly dock							0.14	0.24					0.38
22LFRS	Alkali weed-Italian ryegrass-alkali heath-curly dock-saltgrass				0.99	0.27								1.26
22S	Alkali weed-pickleweed				0.08									0.08
22XM	Alkali weed-cocklebur-alkali mallow								0.03					0.03
Subtotal=		0.00	0.00	0.00	2.20	0.99	0.00	0.34	1.04	0.43	0.58	0.10	0.04	5.72
Corps "Waters of the US" (Non-vegetated Areas Seasonally Inundated or Saturated)														
19	Salt flats			0.34	0.32	0.01								0.67
Corps "Waters of the US" (Open Water and Mudflats in Tecolotito and Carneros Creeks)														
21	Open water - channels filled for RSA	0.51	4.11											4.62
Total Corps Wetland and "Waters" Impacts=		0.51	4.11	0.34	2.52	1.00	0.00	0.34	1.04	0.43	0.58	0.10	0.04	11.01

4.1.3 RSA Extension Impacts

The construction of the 500 by 1,000-foot runway safety area at the west end of Runway 7-25 would involve filling in Tecolotito Creek and grading the area to a flat and compacted surface (Figure 3). Existing vegetation in the footprint of the new RSA would be graded and converted to low-growing upland native or naturalized grasses (see Figure 7a). The RSA would be graded to facilitate drainage and prevent the accumulation of surface water or prolonged soil saturation. Hence, all existing wetlands in the new RSA would be permanently removed. The existing Runway 7-25 and Taxiway A would be extended to the west, removing existing wetlands on both sides of Tecolotito Creek (see Figure 7a).

Wetlands that would be removed are shown on Figure 7a. A detailed accounting of all wetland types to be removed is provided in Table 3A. The primary wetlands that would be affected are low-growing seasonal wetlands that contain a mixture of annual upland grasses, with a high percentage of hydrophytic plants, such as pickleweed, Mediterranean barley, curly dock, alkali weed, Italian ryegrass, alkali heath, and saltgrass. These wetlands have developed in this area of artificial fill created when the Airport was constructed due to the flat terrain, poor drainage, and build-up of high soil salinity which favor hydrophytic plants.

4.2 APPROACH LIGHTS

Relocating the new approach lights to an Airport easement on the Sares-Regis property would affect about 2,000 square feet (rounded off to 0.1 acre in Table 3A) of existing seasonal wetlands at the eastern end of the corridor (Figure 4). This wetland area consists of a low lying grassy swale dominated Italian ryegrass that is periodically inundated by shallow water from rainfall and runoff.

The existing large wetland area south of the approach light corridor (see Figure 4) would be avoided during construction of the new lights and service road. The property owner has proposed to develop other portions of this property, and to create a large wetland in the entire open space shown on Figure 4. The new wetland would encompasses the three isolated wetlands shown on Figure 4 into a continuous seasonal wetland with low-growing annual and perennial wetland plants. This area would be graded to create moist soil conditions and then weeded and planted. The areas in between the approach lights, and on both sides of the new access road, would be included in the new wetlands.

4.3 TAXIWAY M

The route of Taxiway M, south of Taxiway A, passes along the edges of three isolated, seasonal wetlands. The first wetland patch (0.8 acre) is dominated by curly dock, the second one (0.2 acre) by Mediterranean barley, pickleweed, and brass buttons, and the third one (0.3 acre) by spikerush and curly dock. The new taxiway would not traverses the center of these wetlands nor remove any of the depressions in their entirety. It would also not alter the hydrology in the area such that other existing wetlands would be dewatered. The total wetland area that would be permanently removed by the new taxiway is 0.29 acres (Table 3A).

4.4 SUMMARY OF WETLAND IMPACTS

4.4.1 Impact Acreage

A summary of impacts to major wetland types due to all Airfield Safety Projects is provided in Table 4A for Coastal Act wetlands. The proposed Airfield Safety Projects would result in the permanent loss of 13.3 acres of Coastal Act wetlands, which include vegetated wetlands, salt flats, open water, and mudflats. Of this total, eight acres represent vegetated wetlands comprised entirely of non-tidal seasonal herbaceous wetlands that are supported by short-term saturated soils or shallow inundation from direct rainfall and poor drainage.

The proposed projects would also result in the temporary disturbance of 1.77 acres of wetlands due to incidental disturbance by construction activities in adjacent wetland areas.

A summary of the wetland impacts and the types of wetland affected is provided in Table 5. The wetlands removed due to the filling of portions of Tecolotito and Carneros creeks are "estuarine." In contrast, all other wetlands are considered "palustrine" wetlands, based on the Cowardin et al (1977) wetland classification system, because they are non-tidal and supported by rainfall and runoff.

Section 30107.5 of the Coastal Act defines "Environmentally sensitive area" as *"... any area in which plant or animal life or their habitats are either rare or especially valuable because of their special nature or role in an ecosystem and which could be easily disturbed or degraded by human activities and developments."* Wetlands represent a special form of ESHA, with a generally higher sensitivity than other ESHAs. All wetlands affected by the project are considered ESHAs.

TABLE 4A
SUMMARY OF IMPACTS TO COASTAL ACT WETLANDS

Map Code	Wetland Type (Vegetated or Non-vegetated)	Permanent Effect* (acres)	Temporary Impacts (acres)
Coastal Act Wetlands (Vegetated wetlands) - RSA Extension and Creek Relocation Impacts			
1	Pickleweed Series	2.05	0.18
3	Saltgrass Series	0.79	0.06
4	Curly Dock Series	0.31	0.21
7	Spikerush Series	0.00	0.11
8	Arroyo Willow Series	0.21	0.00
11	Annual Grassland Series (wetland affinities)	1.29	0.73
14	Cocklebur Series	0.75	0.00
22	Alkali Weed Series	2.07	0.23
24	Heliotrope Series	0.15	0.00
Subtotal=		**7.62**	**1.52**
Coastal Act Wetlands (Unvegetated) - RSA Extension and Creek Relocation Impacts			
19	Salt flats (periodically inundated, no drainage)	0.67	0.00
Subtotal=		**0.67**	0.00
Coastal Act Wetlands (Unvegetated Open Water & Mudflats) - RSA Extn. & Ck Relocation			
21	Open water and mudflats (filling Carneros Creek for RSA)	0.51	0.03
21	Open water and mudflats (filling Tecolotito Creek for RSA)	4.11	0.03
Subtotal=		**4.62**	**0.06**
Coastal Act Wetlands (Vegetated) - Taxiway M			
1	Pickleweed Series	0.13	0.06
7	Spikerush Series	0.04	0.02
11	Annual Grassland (wet affinities)	0.12	0.06
Subtotal=		**0.29**	**0.14**
Coastal Act Wetlands (Vegetated) - Approach Light on Sares-Regis			
11	Annual Grassland (wet affinities)	0.10	0.05
Subtotal=		**0.10**	**0.05**
TOTAL COASTAL ACT WETLANDS=		13.30	1.77
TOTAL COASTAL ACT VEGETATED WETLANDS=		8.01	1.71

** Permanent effect = loss due to paving or creek construction, or conversion to another habitat type. Hence, some wetlands will be converted to upland habitat.*

TABLE 4B
SUMMARY OF IMPACTS TO CORPS WETLANDS

Map Code	Wetland Type (Vegetated or Non-vegetated)	Permanent Effect* (acres)	Temporary Impacts (acres)
Corps Wetlands (Vegetated) - RSA Extension and Creek Relocation Impacts			
1	Pickleweed Series	1.99	0.12
4	Curly Dock Series	0.17	0.21
8	Arroyo Willow Series	0.17	0.00
11	Annual Grassland Series (wetland affinities)	0.75	0.50
14	Cocklebur Series	0.75	0.00
22	Alkali Weed Series	1.75	0.20
Subtotal=		**5.58**	**1.03**
Corps "Waters of the US" (Unvegetated) - RSA Extension and Creek Relocation Impacts			
19	Salt flats (periodically inundated, no drainage)	0.67	0.00
Subtotal=		**0.67**	**0.00**
Corps "Waters of the US" (Unvegetated Open Water & Mudflats) - RSA Extn. & Ck Relocation			
21	Open water and mudflats (filling Carneros Creek for RSA)	0.51	0.03
21	Open water and mudflats (filling Tecolotito Creek for RSA)	4.11	0.03
Subtotal=		**4.62**	**0.06**
Corps Wetlands - Taxiway M			
7	Spikerush Series	0.04	0.02
Subtotal=		**0.04**	**0.02**
Corps Wetlands (Vegetated) - Approach Light on Sares-Regis			
11	Annual Grassland (wet affinities)	0.10	0.05
Subtotal=		**0.10**	**0.05**
TOTAL CORPS WETLANDS AND WATERS=		11.01	1.16
TOTAL CORPS VEGETATED WETLANDS=		5.68	1.08

** Permanent effect = loss due to paving or creek construction, or conversion to another habitat type. Hence, some wetlands will be converted to upland habitat.*

TABLE 5
SUMMARY OF WETLAND IMPACTS (acres)

Facility	Type of Wetland	Type of ESHA	Permanent Impact	Temporary Impact
New Runway Safety Area; extended paved runway and taxiway; RSA service road; and new Tecolotito Creek channel	Non-tidal seasonal wetlands dominated by annual grasses and herbs without impounded water. Palustrine persistent emergent wetlands.	Wetland	7.62	1.52
	Non-tidal unvegetated salt flats.	Wetland	0.67	0.00
Filling of portions of Carneros and Tecolotito creeks for the new RSA and runway extension	Tidal open water and mudflats. Estuarine intertidal aquatic bed and unconsolidated bottom.	Estuary	4.62	0.06
Construction of Taxiway M	Non-tidal seasonal wetlands dominated by annual grasses and herbs without impounded water. Palustrine persistent emergent wetlands.	Wetland	0.29	0.14
Relocated approach lights – service road	Non-tidal seasonal wet grassland without impounded water. Palustrine persistent emergent wetlands.	Wetland	0.10	0.05
Total =			13.30	1.77

4.4.2 Wetland Functions and Values

The functions of the three main wetland types (seasonal, saltflats, water/mudflats) affected by the proposed project are summarized in Table 6. The functions of the seasonal wetlands at the end of Runway 7-25 are very limited for the following reasons:

- The wetlands are not hydrologically connected to streams or tidal channels. As such, these wetlands have limited functions for movement and/or breeding of fish and wildlife. More importantly, the wetlands cannot transfer water, energy, organic matter, and nutrients – a condition that limits long-term productivity and viability.

- The wetlands do not convey or store stormwater runoff from developed areas. They are supported by direct precipitation, and hence, do not provide any water quality or flood retention benefits.

- The wetlands contain very little vegetative cover, primarily because they are mowed for safety conditions because they occur in the airfield. The amount of cover for wildlife is also variable and unpredictable. Hence, reliable breeding and rearing habitat for small mammals and birds is not present.

- The wetlands do not support sensitive species. No threatened or endangered plant or wildlife species occurs in the project site. The state listed Belding's savanna sparrow forages in low numbers in wetland vegetation along the lower banks of Tecolotito Creek. However, the population in Goleta Slough is mostly restricted to the tidal pickleweed marsh areas south of the airfield.

- The wetlands occur in areas where public access is prohibited. As such, the recreational values of the wetlands are very low.

The unvegetated salt flat wetlands have similar low functions as the seasonal wetlands described above. In contrast, the wetlands along Tecolotito and Carneros creeks exhibit more functions, as they capture sediments, convey flood flows, and provide habitat for sensitive water-associated bird species.

TABLE 6
FUNCTIONS OF AFFECTED WETLANDS

Typical Functions of Wetlands	Presence of Function		
	Seasonal wetlands dominated by annual grasses and herbs without impounded water	Unvegetated salt flats	Tidal open water and mudflats
Groundwater Recharge or Discharge	X	X	
Flood Flow Alteration or Reduction	X	X	X
Sediment Stabilization or Removal			X
Nutrient Removal or Transformation			
Biofiltration or Treatment			
Fish and Aquatic Species Habitat			X
Wildlife Habitat	X	X	X
Sensitive Species, including T&E Species			
Non-consumptive Recreation			
Hunting and Fishing			
Aesthetics & Quality of Life			

X = function is present. A blank box indicates that the function is absent.

5.0 ALTERNATIVE MITIGATION SITES

To compensate for the loss of wetlands due to the proposed AFP, the Airport proposes to create and/or restore wetlands similar to those affected on Airport property. Several key studies have been previously conducted that identified alternative mitigation approaches and sites, as summarized below.

- Woodward-Clyde (1996b) conducted a comprehensive analysis of alternative mitigation site and approaches for the Safety Area Grading Project. The study included field assessments of various potential wetland restoration sites at the Airport, as shown on Figure 8. Each site was examined relative to its potential for wetland restoration. Factors considered at each site included (among others): physical suitability for wetlands (e.g., soils, hydrology); proximity to other native habitat; difficulty in revegetation; and bird strike hazards. Based on the study, the Safety Area Grading Project mitigation site was identified as the most suitable area for wetland mitigation at the Airport. Other high-ranking mitigation sites included "Area AQ" and Area "AK" (Figure 8). The former includes a freshwater marsh along Hollister Avenue that could be expanded, while the latter includes a highly disturbed area next to UC Santa Barbara where new and enhanced wetlands could be created (also known as "Area I", the proposed mitigation site).

- The Goleta Slough Ecosystem Management Plan (1997) identifies wetland restoration priorities in the Goleta Slough watershed based on years of studies and coordination by the involved government agencies and non-government organizations comprising the Goleta Slough Ecosystem Management Committee. The Plan identifies future restoration actions in the watershed, including conversion of the above to areas to "Palustrine Wetland." The Committee identified various "habitat planning units" in and around the Airport in the Plan, as shown on Figure 9. These units include Area S (previously called Area AQ, Figure 8), and Area I (previously called Area AK, Figure 8).

- Levine-Fricke-Recon (2000) conducted a wetland mitigation feasibility and bird strike hazard study for the proposed AFP. They identified three primary wetland mitigation approaches in which the wetland losses would be compensated by new and restored wetlands: (1) in-kind habitat replacement; (2) out-of-kind habitat replacement; and (3) combination of the two approaches. The out-of-kind habitat replacement would involve restoring tidal circulation to closed basins in the Goleta Slough to increase the amount of tidal habitat in the slough. Levine-Fricke-Recon (2000) recommended a combination of in-kind and out-of-kind habitat replacement. The recommended in-kind wetland mitigation site was Area S (Figure 9).

The Federal Aviation Administration (FAA) and USDA Wildlife Services recommended that increasing tidal circulation as wetland mitigation be deferred until further studies are conducted by the Airport on the effect of increased tidal water on bird strike hazards at the Airport. The Airport has initiated a study and field experiments to address this issue. Due to the concerns about bird strike hazards from out-of-kind wetland mitigation, this mitigation option was not considered at this time.

URS evaluated the use of Area S for wetland restoration for the proposed AFP, but rejected it due to the potential to increase attractants for birds adjacent to the runway. By potentially creating more plant cover and seasonal surface water, it is possible that more birds would be attracted to the site. Movement to the site would entail travel across the runway, which may increase bird strike hazards. Hence, use of this site was rejected for the proposed AFP.

URS conducted a comprehensive field assessment of previously identified sites for wetland enhancement and restoration in August 2000. Several suitable mitigation sites and approaches were identified which are described in Section 6.0.

6.0 WETLAND MITIGATION PLAN

6.1 MITIGATION GOALS AND OBJECTIVES

To compensate for the permanent loss of wetlands due to the proposed project, the Airport proposes to create and/or restore seasonal wetlands and open water habitat similar to those affected by the project (e.g., "in-kind replacement"). The overall goal of the proposed wetland mitigation is to create more wetland acreage than would be affected by the project, with at least a 2:1 replacement ratio; and (2) create wetlands that exhibit more functions than the affected wetlands. The latter would be achieved by increasing the diversity of native plants in the new wetlands compared to existing wetlands; increasing plant productivity by providing better moisture conditions; strategically locating the new wetlands to increase their benefit to wildlife; ensuring the long term viability of the new wetlands through monitoring and maintenance; and protecting the new wetlands from future disturbances. The Airport would implement the wetland mitigation on Airport property in order to ensure maximum control and management flexibility, and to ensure economic feasibility of the mitigation by avoiding expensive land costs.

The specific objectives of the proposed mitigation plan is to create and enhance approximately 36 acres of various wetlands at three locations in Goleta Slough, initiating the restoration work concurrent with construction to ensure that at least half of the new wetlands would be established as young plants and seedlings before all of the wetland impacts have occurred. Restoration actions include clearing and grading, weed removal, seed and plant collection and cultivation, plant installation, monitoring, and maintenance. Four restoration sites would be utilized: Area I, Area R-2, Tecolotito Creek berms, and Tecolotito/Carneros sediment basins, as described in the following subsections. The Airport would be fully responsible for the development of final plans, construction management, and monitoring and maintenance.

The mitigation plan includes several different restoration and management actions, and several different restoration sites. The plan involves a complex suite of actions that would provide ecological benefits for the entire Goleta Slough ecosystem. The plan was developed in consideration of the restoration needs identified in the Goleta Slough Ecosystem Management Plan. For example, the plan for restoring seasonal wetlands is based not only on the objective of replacing affected with in-kind wetlands, but also because the Draft Goleta Slough Ecosystem Management Plan (1997) identified restoration of "palustrine transitional wetlands" as a priority in the Goleta Slough watershed due to its fragmented and degraded condition. The Plan identifies wetland restoration priorities in the Goleta Slough watershed based on years of studies and coordination by the involved government and non-government organizations comprising the Goleta Slough Management Committee.

Although this plan was specifically prepared to support the City's efforts to acquire necessary approvals from the CCC, it has also been designed to meet the requirements of the Corps of Engineers under Section 404 of the Clean Water Act.

Temporarily disturbed wetlands would be restored to pre-construction conditions immediately after construction, and as such, would not require compensatory mitigation.

6.2 OPEN WATER AND MUDFLAT WETLAND RESTORATION

The relocation of Tecolotito and Carneros creeks would create 9.27 acres of channel containing open water and mudflat wetlands, as shown on Figure 7c and summarized below in Table 7. The relocated creek channels would have the same width and depth as the existing ones, but would be longer.

TABLE 7
NEW CREEK CHANNEL

Creek	Dimension	Acres
New Creek Habitat Created by Relocation (includes bed and bank)		
Carneros Creek	1500 linear feet, 75 ft with, top of bank	2.58
Tecolotito Creek	3600 linear feet, 75 ft width, and 150 ft width (sediment basin)	6.69
Total=		9.27

The creation of 9.27 acres of new channel would offset the loss of 4.62 acres of creek bed (see Table 2), resulting in a net increase of 4.65 acres of channel area with open water and mudflat habitats. Hence, there would be no need to provide mitigation for creek relocation because the project would increase the amount of creek habitat compared to pre-project conditions.

The relocated creeks would have the same width and depth as the existing creek channels. The banks would be stabilized with native shrubs to prevent erosion. Plants to be used for stabilization include quail bush, alkali heath, and pickleweed. The channel bottom would be subject to daily tidal influence. The new reaches of the creek would have an annual grassland buffer on each side, identical to the current creeks. Views of current conditions along Tecolotito Creek are shown in Photograph Nos. 1 and 2 (Appendix B).

6.3 SEASONAL WETLAND RESTORATION

The loss of seasonal vegetated wetlands at the end of Runway 7-25, along the relocated approach lights, and along the route of Taxiway M would be mitigated by restoring in-kind habitats on Airport property using revegetation techniques and species that have been shown to be successful for the Safety Area Grading (SAG) Project approved by the CCC in 1998. The SAG mitigation encompasses about 30 acres of seasonal wetlands and was successfully completed in 2000. A conceptual wetland mitigation plan is presented below that involves three main elements: restoration along berms of Tecolotito Creek, at Area I, and at Area R-2 (see Figure 10).

6.3.1 Seasonal Wetland Restoration on Berms Adjacent to Tecolotito Creek

Berms occur on both sides of Tecolotito Creek in the middle of Goleta Slough (Figure 11). The berms direct flood flows to the mouth of the slough, and thereby protect the Slough from sedimentation that would raise the elevation the marsh and convert it to a non-tidal area. The berms are not engineered structures. They are earthen, constructed from on-site material that appears to be old sediment from the channel. The widths of the berms vary from 25 to 120 feet, with a relatively flat top. No bank protection is present on the berms. The berms are not maintained. Access to the berms is difficult due to the dense growth of weeds on the tops and sides of the berms. The tops of the berms are at about elevation 11 feet MSL.

Dense monoculture stands of mustard occur along the tops and sides of the berms, above the influence of the creek (inside slopes) and the salt marsh (outside slopes), at about elevation 6 feet MSL. Other exotic species include tree tobacco, Italian thistle, and poison hemlock. Typical berm conditions are shown on Figure 12. Conditions along the berms are shown in Photograph Nos. 3 through 10 (Appendix B).

The proposed wetland enhancement would be to remove non-native species (primarily mustard) from the tops and sides of the berms. Weed removal would be accomplished through several "grow-kill" herbicide treatments. The berms would first be mowed in the fall or early winter when plants are dormant and dead stems are present from the previous year's growth. Mowed vegetative debris would be collected from the berms to remove weed seeds, to reduce layer of organic matter that could fall into the adjacent creek or salt marsh, and to expose the soils to facilitate germination of new weeds. After the first several rains and new germination has occurred from seeds in the soil, Rodeo™ herbicide would be applied to the young plants. This treatment would be repeated to ensure that all emerging plants are killed. Weeds would be sprayed with herbicides as they germinate in the winter and early spring. In the summer when the berms are dry, water would be applied to the levees to stimulate further germination of weed seeds in the soil, followed by herbicide treatment.

It is anticipated that weed seeds in the soil would be killed after one year of repeated herbicide treatment. In the winter following the last treatment, the tops of the berms would be scarified, then seeded with native wetland and upland species that are typical of transitional seasonal wetlands in Goleta Slough (i.e., palustrine wetlands). These species include the following: (1) wet grassland species such as alkali weed, saltgrass, alkali mallow, creeping rye-grass, meadow barley, western ragweed, woolly sea-blight, and alkali heath; and (2) quail bush and coast goldenbush. Cross sections of the restoration treatment are provided on Figure 13.

Seven berms encompassing about 13 acres are suitable for restoration, as shown on Figure 11. The distance, width, and top acreage of these berms are listed below in Table 8.

TABLE 8
SUMMARY OF BERM RESTORATION SITES

Berm No. (see Figure 11)	Linear Distance (Feet)	Typical Width (feet)	Approx. Acreage
1	1,000	Varies	2
2	650	70	1
3	925	45	1
4	2,175	60	3
5	1,100	50	1.2
6	845	80	1.5
7	950	145	3
Total=	7,645		12.7

The proposed weed removal and restoration for the berms would remove the single largest source of weed seeds in Goleta Slough and replace it with habitat similar to that being affected by the proposed project. The new habitats would be compatible with the existing pickleweed marsh and the new wetlands created under the Safety Area Grading Project in 2000. The new habitats would indirectly benefit the adjacent tidal marsh habitat by creating native plant cover and food sources for use by wildlife, particularly the endangered Belding savannah sparrow that nests in the pickleweed marsh and forages in nearby native grassland/scrub areas.

6.3.2 Seasonal Wetland Restoration at Area I

New seasonal wetlands would be created in uplands in "Area I," which is a 25-acre site owned by the Airport and located between the UC Santa Barbara bluffs and Tecolotito Creek (Figure 14). It is dominated by a complex mixture of annual grassland, coyote brush scrub, poison oak stands, scattered ornamental trees, scattered oak and willow trees, eucalyptus groves, and weedy patches (especially pampas grass). The area contains several small isolated wetlands. Existing vegetation types are shown on Figure 16.

Much of the site was originally an upland that was lowered to construct the airfield during the 1960s. The original uplands and limits of excavation are shown on Figure 17. The site was lowered to its current elevation of about 10-14 feet MSL. The northern perimeter of the site was originally part of a wider Tecolotito Creek channel and a tidal salt marsh (Figure 15). It has been raised over the decades due to deposition sediments and the channelization of the creek. The site contains an abandoned brick incinerator (Figure 15)

A large storm drain empties into the site conveying runoff from UC Santa Barbara (Figure 15). Flow from this storm drain follows a small, poorly defined earthen channel (less than one foot deep) across the site, where it dissipates. A larger channel originates north of the incinerator, and conveys runoff directly to Tecolotito Creek. There are several isolated wetlands at the site (Figure 15), which represent low-lying remnants of the previous site conditions. The site is located within the airfield and therefore, public access is prohibited. A barbed wire fence is present on the southern perimeter, adjacent to a UCSB dirt service road and the UCSB North Bluffs.

The site is an excellent candidate for wetland restoration because it is: highly disturbed by non-native vegetation, threatened by a conversion to a monoculture of coyote brush, poorly drained, remote from human influences, and connected to numerous other habitats (oak woodland on the bluffs, freshwater marsh to the west, and estuarine and salt marsh habitats to the north). Wet grassland and other seasonal wetlands could be created: (1) around the northern perimeter of the site in the location of the old salt marsh; and (2) in a mosaic pattern in the center of the site. Upland habitats would be retained in continuous patches throughout the site to retain wildlife habitat and movement corridors. Specific restoration treatments are summarized below and shown on Figures 18 and 19:

1. Enhance existing transitional wetlands (wet meadow). This 0.7-acre portion of the site is located adjacent to the UCSB access road (Figure 18). It is low lying and receives runoff from the UCSB storm drain. It encompasses about one acre and is dominated by Italian ryegrass with scattered curly dock and spikerush. Occasional pickleweed and alkali heath plants are present. Non-native plants (e.g., curly dock, vetch, rabbitsfoot grass) would be removed from this area, and additional wetland plants would be installed such as spikerush, nut- sedge, toad rush, bulrush, and pickleweed.

2. Enhance existing transitional wetlands (wet grassland). This 1.9-acre low-lying area is located in the center of the mitigation site (Figure 18). It contains seasonally saturated soils. It consists of annual grassland dominated by Italian ryegrass, with scattered wetland depressions containing saltgrass, bulrush, curly dock, pickleweed, Mediterranean barley, and Bermuda grass. Non-native plants such as Bermuda grass and curly dock would be removed from this area, and additional wetland plants would be installed such as spikerush, nut- sedge, toad rush, meadow barley, and creeping rye-grass.

3. Grade and create new transitional wetlands. This area is located along the northern perimeter of the site (Figure 18). It would be lowered to 5 to 6 feet elevation with an uneven terrain and small depressions (less than 3 inches deep, similar to the contours at the Safety Area Grading Project mitigation site). This action would remove all non-native species, and would also convert uplands to wetlands. This area was originally part of Tecolotito Creek and contained open water and salt marsh. It encompasses about 6.6 acres. Native seasonal wetland species would be planted in the same manner as for the Safety Area Grading Project: pickleweed, alkali heath, alkali weed, sand spurrey, meadow barley, and saltgrass.

4. Remove exotic trees and weeds. The site contains abundant weeds and non-native ornamental trees. The former include mustard, vetch, iceplant, pampas grass, and Harding grass. Ornamental trees include myoporum, pine, and eucalyptus trees. Two very large clumps of eucalyptus trees would be removed along the access road (Figure 18). Specific high density weedy areas, encompassing about 0.7 acres, would be weeded as shown on Figure 18. These areas include several large pampas grass clumps near the incinerator. Weed infestations and

ornamental trees will also be removed from the entire 25-acre site, as needed. This treatment also includes removal of concrete and construction rubble and old dirt spoil piles from the entire site.

5. Remove poison oak. The site is being rapidly colonized by the native poison oak. Significant amounts of coyote brush are being overgrown by this native species. The removal of poison oak is recommended to prevent a hazard to restoration personnel at the site, and to allow other less-aggressive species (particularly wetland) to persist. About 0.5 acres of poison oak infestation could be treated in the northwestern portion of the site (Figure 18). The large concentration of poison oak plants overgrowing a coyote bush stand in the southeastern portion of the site will remain intact, per the recommendations of the Santa Barbara Audubon Society, because of its value for avian forage and shelter.

6. Remove incinerator. The old incinerator would be removed, along with the fill pad underlying the structure. Due to its previous use, the soils surrounding the structure would be tested for hazardous materials. USDA Wildlife Services Division has expressed an interest in removing this structure because it is used as a perch for birds, which could contribute to bird strike hazards on the airfield, in general.

7. Protect existing wetlands. The existing wetlands at the mitigation site would be protected and incorporated into the newly restored site.

Nine acres of new seasonal wetlands would be created and 2.2 acres of existing seasonal wetlands would be enhanced, for a total of 11.2 acres of wetlands in the 25-acre site. The entire site would be protected for habitat purposes. It is situated next to the U.C. Santa Barbara (UCSB) bluffs where an upland habitat restoration project was completed several years ago that includes an educational trail. The Airport would coordinate with UCSB about possible use of the new wetland areas for research and public education.

The order of work for the wetland restoration would be as follows:

1. Plant and seed collection from various locations in Goleta Slough would begin in the spring and summer prior to the winter when plants would be installed at the mitigation site. It is preferable that plant and seed collection (and the subsequent cultivation in a nursery) occur two years prior to installation in order to: (1) provide time to increase the number of plants by expanding them in the nursery; and (2) provide a second year of seed collection in the event that a dry winter inhibits seed production. For some species, there may not be sufficient plant material in Goleta Slough for use as a source. Hence, it may be necessary to order seeds and plants from a commercial source, which would acquire material from other locations along the South Coast. Commercial orders must be placed at least one year prior to delivery in the subsequent winter.

2. Weeding and tree removal would begin in the spring and early summer prior to the winter when plants would be installed and seeds would be applied. Weeding would be accomplished by the application of herbicides to the target areas at the mitigation site (Figure 18) wetland

restoration area, as well as the surrounding buffer zone to be planted with coastal sage scrub and oak savannah. Herbicides would be applied in March or April to kill all emerging weeds before they can produce seeds. A second application of herbicides would occur in May or June.

3. In June or July of the year that restoration is planned, the area where new wetlands would be created would be cleared and grubbed and rough graded to approximate final elevations. Several "grow and kill" treatments would be applied to the newly graded site to remove growing weeds and to reduce the seed bank of weeds in these areas. No later than September or October, the wetland restoration area would be graded to final contours and the surface "cat-tracked" to roughen the surface for seeding. Topsoil that is deemed suitable for use would be retained on site and spread in the planting and seeding areas. Topsoil that is undesirable would be removed from the site. If necessary, the planting and seeding areas may be pre-treated with salt water to discourage germination and growth of non-native weeds. After site preparation, container plants would be installed during the period December 15th through January 30th. Seeding would occur at the same time, using broadcast seeding methods. If any native wetland plants are present in the areas to be graded and planted, they would be salvaged to the extent feasible and practicable.

4. A temporary irrigation system would be installed at the same time that the plants are installed for use during the first several years. A temporary irrigation system with broadcast emitters would be installed for use during the first and second years to ensure successful germination and plant establishment. Individual drip emitters would be used for portions of the site or for certain plants, if it were determined to be more efficient and reliable. The landscaping contractor that installs the plants would determine the frequency and duration of irrigation. The irrigation system would be retained for additional years, if it were necessary to further support the establishment of plants by supplemental watering.

5. Seeding and the installation of container plants would occur after the irrigation system has been installed. Plants would be installed in non-uniform patterns at densities similar to those used in the Safety Area Grading Project mitigation site. Plants would be installed in small scattered groups amongst in the two wetland enhancement areas at the site where wetlands are already present. The objective of this planting is to increase the density, vigor, and area of wetlands in these areas, which already contain suitable hydrology.

6.3.3 Seasonal Wetland Restoration at Area R-2

Area R-2 represents a small man-made basin adjacent to Tecolotito Creek and south of the existing Runway 7-25 (Figure 10). It contains non-tidal seasonal wetlands. The portion of Tecolotito Creek adjacent to this area will be filled as part of the proposed project (Figure 7c). The berms along the creek contain uplands due to their high elevation. When the creek is filled and the berms removed, the disturbed areas will be graded to match the elevation of adjacent Area R-2, which supports non-tidal wet grassland. The newly lowered areas will then be planted with pickleweed, alkali heath, alkali weed, sand spurrey, meadow barley, and saltgrass to create 2.2 acres of new seasonal wetlands. Site preparation, seeding, and planting methods would be the same as for Area I.

6.4 ENLARGED SEDIMENT BASINS

The Airport would enlarge existing sediment basins along Tecolotito and Carneros creeks as part of the relocation work (Figure 20). The enlarged basins would substantially increase the amount of sediments captured upstream of the airfield and Goleta Slough. They have been designed to capture more than the amount of sediment that would be deposited along the additional length of Tecolotito Creek. As such, the proposed creek relocation and enlarged basins would cause a net decrease in the annual average sediment discharge to Goleta Slough. This action would reduce the amount of sediments that could be deposited in the tidal wetlands in Goleta Slough. Historic and ongoing sedimentation is a significant problem in the Slough, as it results in reduced tidal circulation and the conversion of wetlands to non-native uplands over time. Reducing sedimentation is one of the major restoration goals in the Draft Goleta Slough Ecosystem Management Plan (1997). Reducing sediment discharges would result in ecological benefits throughout the entire Slough.

The larger basins will reduce the frequency of dredging, which can temporarily affect water-associated birds and aquatic organisms in the creeks.

6.5 SUMMARY OF NEW AND ENHANCED WETLANDS

A summary of the new and enhanced wetlands is provided in Table 9. A total of 35.8 acres of new and enhanced wetlands would be created to compensate for the loss or conversion of 13.3 acres of Coastal Act wetlands.

In addition to the creation and enhancement of 35.8 acres of wetlands, two other actions would result in beneficial impacts to the tidal wetlands in Goleta Slough. The removal of the mustard stands along the Tecolotito Creek berms would remove the single largest source of non-native seeds from the Slough, thereby protecting existing wetlands and uplands in the ecosystem. The creation of native plant cover on the berms is expected to increase wildlife habitat use and productivity in the adjacent pickleweed marsh. This "buffer" effect would extend along the length of the restored berms. Using a 100-foot wide zone of ecological benefit, a total of 17.6 acres of tidal salt marsh would be beneficially affected by the wetland restoration.

TABLE 9
SUMMARY OF WETLAND MITIGATION

Restoration Action	Location	Type of Wetland	Acres
Direct Mitigation			
Create new seasonal wetlands	On berms next to Tecolotito Ck and tidal salt marsh	Non-tidal low-growing wetland herbs, grasses, & shrubs; palustrine persistent emergent wetlands	12.7
Create new seasonal wetlands	In Area I, amongst uplands and adjacent to tidal marsh	Non-tidal low-growing wetland herbs and grasses; palustrine persistent emergent wetlands	9.0
Create new seasonal wetlands	In Area R-2, amongst upland and wetland grassland mosaic	Non-tidal low-growing wetland herbs and grasses; palustrine persistent emergent wetlands.	2.2
Enhance existing seasonal wetlands	In Area I, in mosaic of uplands and wetlands	Non-tidal low-growing wetland herbs and grasses; palustrine persistent emergent wetlands.	2.6
Create new tidal open water and mudflat habitats	New channels for Tecolotito and Carneros Cks	Estuarine intertidal aquatic bed and unconsolidated bottom.	9.3
Subtotal =			35.8
Mitigation Ratio =			2.7 :1

Other Mitigation			
Indirect benefits on adjacent tidal salt marsh due to creating native wetlands on berms surrounding the tidal wetlands, and removing non-native mustard stands			17.6
Total direct and indirect habitat mitigation acreage =			53.4
Mitigation Ratio =			4:1

Indirect benefits on tidal salt marsh due to larger sediment basins on Tecolotito and Carneros Cks	100's

6.6 FUNCTIONS OF NEW WETLANDS

The anticipated key functions of the new and enhanced wetlands are summarized in Table 10 or conversion as part of the proposed project. In addition, several new wetland functions will be achieved with the new wetlands, including:

Area I wetlands would provide a flood reduction function by capturing and detaining more of the runoff from UCSB that empties into Goleta Slough. These wetlands would also provide a new nutrient removal and biofiltration function due to the longer detention time in this area and the contact with wetland plants. The use of this area for research and public education, in coordination with the UCSB oak woodland restoration project, would add a new function - non-consumptive recreation. Finally, the restoration in Area I would remove unsightly man-made rubble and an incinerator, enhancing the aesthetics of the landscape.

The wetland restoration on the berms of Tecolotito Creek would increase wildlife use of the berms and adjacent tidal marsh. The current mustard stands provide essentially no wildlife habitat functions.

TABLE 10
FUNCTIONS OF NEW AND ENHANCED WETLANDS

Typical Functions of Wetlands	Presence of Function			
	New or Enhanced Seasonal Wetlands (Area I)	New or Enhanced Seasonal Wetlands (Area R-2)	New or Enhanced Seasonal Wetlands (Berms)	New Tidal Open Water and Mudflats
Groundwater Recharge or Discharge	X	X		
Flood Flow Alteration or Reduction	XX	X		X
Sediment Stabilization or Removal				X
Nutrient Removal or Transformation	XX			
Biofiltration or Treatment	XX			
Fish and Aquatic Species Habitat				X
Wildlife Habitat	X	X	X	X
Sensitive Species, incl. T&E Species			XX	X
Non-consumptive Recreation	XX			
Hunting and Fishing				
Aesthetics & Quality of Life	XX		XX	

X= function of existing wetlands to be affected by the project
XX= new functions not associated with existing functions

7.0 PERFORMANCE CRITERIA

7.1 TARGET VEGETATION TYPES AND ACREAGES

The proposed target vegetation types to be created and enhanced are summarized in Table 11 for each restoration site. Key performance criteria include the following:

- All installed plants must achieve a 70 percent survival rate by the end of the first year, and an 80 percent survival rate of the remaining plants by the end of the second year.
- Non-native invasive weeds must remain below 15 percent of the total vegetative cover at all times. Non-native grasses are not included in this performance criterion.

TABLE 11
TARGET WETLAND VEGETATION GOALS AT YEAR 5

Restoration Site	Type of Wetland	Acres	Total Percent Cover after 5 years	Minimum Number of Native Wetland Plant Species Successfully Established	Maximum Cover of Non-native Weedy Species after 5 Years*
On berms next to Tecolotito Ck and tidal salt marsh	Non-tidal low-growing wetland herbs, grasses, & shrubs; palustrine persistent emergent wetlands	12.7	85	3	15
In Area I, amongst uplands and adjacent to tidal marsh	Non-tidal low-growing wetland herbs and grasses; palustrine persistent emergent wetlands	11.6	75	5	15
In Area R-2, amongst upland and wetland grassland mosaic	Non-tidal low-growing wetland herbs and grasses; palustrine persistent emergent wetlands.	2.2	75	4	15
New channels for Tecolotito and Carneros Cks	Estuarine intertidal aquatic bed and unconsolidated bottom.	9.3	10	2	15

* Does not include common naturalized species that are not aggressive, such as Italian ryegrass.

7.2 TARGET SOIL AND HYDROLOGY CONDITIONS

The soil and hydrologic objectives of the wetland restoration is to create conditions that would favor the establishment and maintenance of native wetland plants and reduce the amount of invasive weeds. To meet this objective, an appropriate soil salinity and moisture regime must be created by the following actions:

- Remove undesirable fill soils from the Areas I and R-2
- Remove rubble and old spoil piles at Area I
- Compact subsoils on Tecolotito Creek berms prior to planting in order to inhibit soil percolation and increase soil moisture
- Create shallow (3 to 4 inches deep) depressions throughout Areas I and R-2 and on the berms to collect surface water and create seasonal, short-term inundation (e.g., 1-2 days per year)
- Periodically use salt water to irrigate plants to reduce weed cover

7.3 TARGET FUNCTIONS AND VALUES

The key target functions and values to be established at the restoration sites are as follows:

- The berms along Tecolotito Creek would have a mixture of low-growing shrubs with dense, continuous cover that mimic the high marsh habitat that once occurred on the upper portions of the alluvial fans to Goleta Slough, that would also provide cover for native birds, in particularly, the Belding savannah sparrow.

- The new and enhanced seasonal wetlands in Areas I and R-2 would mimic the low and middle marsh transitional habitats that were once more common in Goleta Slough, exhibiting a diversity of plant species and irregular cover patterns. The wetlands would be seasonal in nature, supported by winter rainfall and dormant in the late summer and fall.

- The botanical diversity of the restored wetlands would reflect species that were once more common in Goleta Slough.

- The restored habitats at the restoration sites would provide a more natural complement of cover, shelter, and insect life to support the vertebrate species native to coastal wetlands.

- The restoration sites would no longer be dominated by noxious, introduced weeds that represent a continual weed seed source for other portions of the slough.

- The restoration sites would have a more natural appearance, without the dominance of weedy, introduced species and artificial berms.

- The new and enhanced wetlands in Area I would complement the adjacent upland habitats which exhibit high wildlife use.

8.0 IMPLEMENTATION SCHEDULE

The implementation schedule for the restoration plan is provided in Table 12. The Airport anticipates receipt of all agency approvals for the airfield safety projects by early 2002, and completion of project design plans by the end of 2003. Construction would begin in early 2004 and be completed within one year. Restoration actions would begin in 2002 with seed collection and development of detailed restoration plans and specifications. Carneros Creek sediment basin would be enlarged in 2002. Seed collection from Goleta Slough would occur during 2002 and 2003. The initial restoration actions would begin in 2003, one year prior to construction, and would be completed at the end of 2004, concurrent with the end of construction.

TABLE 12
SUMMARY OF IMPLEMENTATION SCHEDULE

Year	General Actions	Plant/Seed Stock Activities	Actions at Specific Restoration Sites			
			Berms	Areas I and R-2	New Channels	Sediment Basins
1 (estimated to be 2002)	Complete Detailed Site Inventory and Restoration Plans and Specifications	Collect seeds and plants for cultivation in nursery; order plants and seeds that cannot be collected locally		Assess hazardous waste at incinerator; map rubble and weeds		Enlarge Carneros Creek basin
2 (2003)	Retain contractor; begin restoration actions	Collect seeds and plants for cultivation in nursery	Grow-kill cycle to remove all weeds and weed seeds	Remove eucalyptus trees and pampas grass; remove incinerator		
3 (2004) This is the year project construction begins	Complete restoration activities	Continue collections, as necessary; use stock plants and seeds	Plant and seed berms	Site preparation, weeding, seeding, and planting	Constructed and revegetated	
4 (2005)	Begin 5-year maintenance and monitoring program					

9.0 MONITORING AND MAINTENANCE

Maintenance of the restoration sites along the Tecolotito Creek berms, at Areas I and R-2, and along the new reaches of Tecolotito and Carneros creeks would occur for two years following the planting of the sites. Monitoring and reporting of mitigation performance would be conducted for three years beginning immediately after the completion of 2-year maintenance period. The activities during these two periods are described below.

9.1 MAINTENANCE ACTIVITIES

The maintenance period would begin immediately after the contractor has completed the implementation of the wetland restoration. To receive final acceptance of the restoration, the mitigation site would be inspected and approved by the Airport and a qualified restoration specialist/biologist involved in the design and/or implementation of the wetland restoration plan.

During the 2-year maintenance period, the contractor would conduct routine activities to maintain the plantings and seeded areas in a healthy condition and control erosion of the site. The restoration sites would be inspected by the Airport and a qualified restoration specialist/biologist for necessary repair or remedial measures a minimum of 4 times a year during the 2-year period. Maintenance inspections would be conducted in early fall, mid-winter, spring and summer. Additional inspections may occur at any time of the year. Upon completion of the 2-year maintenance period, the Airport and the restoration specialist/biologist would conduct a final inspection. Any outstanding items would need to be completed before the Airport gives final approval and accepts the restoration from the contractor.

Maintenance activities during the 2-year period would involve routine watering, replanting or reseeding, repair of damaged areas, weeding, remedial erosion control, removal of excess sediment from areas if the sediment has clearly eroded from the restoration sites. Weeding would be performed to comply with the performance standards. Weeding would be performed primarily by hand methods, including hand-held weed whips. Herbicides approved for use in and near wetlands may be used for occasional spot treatment if applied by a licensed applicator and approved in advance by the Airport. No herbicides would be used to treat wetlands created on the banks and toe of slopes in the new reaches of Tecolotito and Carneros creeks.

In the fall of each of the two years, the germination rate of seeds and the survival rate of container plants would be determined by a sampling protocol to establish the requirement for replacement planting. The contractor would be required to re-seed and re-plant, as necessary, to ensure at least 80 percent of typical germination for each species by the end of Year 2, and at least 80 percent survival of all container plants by the end of Year 2. Replacement seeding and/or planting would be required if the 80 percent goal is not met or exceeded by the end of Year 2. Reseeding and replanting would occur prior to the next mid-winter inspection and the final replacement seeding and planting would occur before final acceptance by the Airport.

It is anticipated that winter rains would be sufficient to provide adequate soil moisture to germinate plants established by seeds or by container. However, in the event that the rains are insufficient or the need for supplemental water is determined, water would be supplied to the areas with container plants by a watering truck with a hand crew and/or a portable irrigation system. Irrigation would continue on an as-needed basis during the 2-year maintenance period following planting. Irrigation after that winter is not planned. The irrigation system would be continually maintained during the 2-year maintenance period.

The restoration sites would be graded and planted to minimize post-construction surface erosion. The primary restoration site treatment involves creating gentle gradients and shallow depressions to reduce soil loss from erosion and help maintain appropriate hydrology and soil conditions for wetland plants. At the end of construction, it may be necessary to maintain temporary erosion control devices until plant cover is sufficient to stabilize slopes. Near the base of slopes and at suitable locations in the mitigation site, particularly adjacent to the marsh, low silt fences, hay bales, or other similar erosion control structures may be used during after construction to help reduce transport of sediments into the marsh. These devices would be maintained during the 2-year maintenance period.

9.2 MONITORING METHODS, FREQUENCY, AND DOCUMENTATION

Bi-monthly site visits would be conducted during a 2-year maintenance period to inspect the plantings, record their survival, and remove invasive weeds. Quarterly surveys would be conducted during the following 3-year monitoring period. The number of container plants and liners that have died would be recorded during site visits. The percent survival of these species would be calculated during each visit to determine if the survival performance criteria are being met, or likely to be met, at the three year evaluation time. Typical plant vegetation sampling methods would be used. For example, plant species composition and percent would likely be determined for the entire mitigation site by placing transects with sampling plots throughout the site and recording relevant data, such as the following examples:

- Species occurring within the plot, the species wetland indicator status, and whether the species is native or introduced
- Percent absolute plant cover, and cover of native versus non native species
- Depth of water or depth to saturated soil
- Soil salinity at surface and at 12-15 inches (measured by EC)
- Soil pH at surface and at 12-15 inches

Qualitative information about the weather conditions and restoration site conditions (e.g., wildlife use, vegetation establishment trends, weed invasion, evidence and extent of erosion, and the need for corrective actions) would also be collected during the monitoring activities.

Permanent photo-documentation points would be established at the restoration sites. They would be marked with T-bar fence posts that would be removed after completion of the 3-year monitoring period. Color photographs would be taken each year at the time of monitoring to qualitatively document plant establishment, hydrologic conditions, and other site conditions. The photographs would be included in the annual monitoring report to allow comparison between monitoring years.

Bird surveys would be conducted at the restoration sites beginning at the end of Year 2. Four seasonal census surveys would be conducted along the Tecolotito Creek berms, at Areas I and R-2, and along the new reaches of Tecolotito and Carneros creeks. Point counts would be made at pre-established locations.

9.3 MEASUREMENT OF PERFORMANCE

The first measure of performance would occur during the 2-year maintenance period when the contractor must determine if seeding and plant survival was 70 percent at the end of the first year, and 80 percent (of the remaining plants) at the end of the second year. If these goals were not met, replanting and re-seeding would occur. During the 3-year monitoring period, the performance goals for plant cover and species diversity shown in Table 11 would apply. If these goals are not met, the Airport would reseed or replant as necessary.

9.4 WEEDING

Weeding of the restoration sites would be conducted regularly by the contractor during the 2-year maintenance period. Additional weeding would occur during the 3-year monitoring period if necessary to meet the performance goals for plant cover and species diversity. Weeds would be removed by hand or by selective spraying with Round-up™ . Weeding would occur at least six times per year, or more frequently, if necessary. Non-native invasive weeds must remain below 15 percent of the total vegetative cover at all times. Non-native grasses are not included in this performance criterion.

9.5 REPORTING AND SCHEDULE

The Airport would prepare a report on the condition of the restoration sites at the end of the 2-year maintenance period. During the 3-year monitoring period, annual reports describing the results of the mitigation monitoring would be prepared by the end of each November. The annual monitoring period would be from January through September. The monitoring period would begin after completion of the 2-year contractor maintenance period.

Reports would contain a quantitative analysis of attainment of annual performance standards and progress toward meeting final performance standards. The reports would provide a list of names, titles, and affiliations of persons conducting the monitoring and preparing the report; photographs taken at photodocumentation points; and relevant maps. Summary results of the previous years' monitoring would also be included in the reports.

9.6 COMPLETION OF MITIGATION

The wetland mitigation plan is anticipated to be completed within 5 years of the initial planting. Completion of the plan would occur when the final vegetative cover, plant species diversity, and weed cover performance goals have been met. At that time, the Airport would no longer have any responsibilities for maintenance or monitoring of the mitigation site for wetland restoration purposes.

9.7 CONTINGENCY PLANS

Unforeseen circumstances may cause delays in the implementation of the wetland restoration, or may cause failure to meet performance goals in the proposed period of time for measuring success (i.e., 5 years after planting). Contingency actions for minor and major events are described below:

Insufficient Seeds and Plant Materials

Under this circumstance, the Airport would extend the revegetation schedule, as necessary, in order to acquire new plants and complete the full installation of all plants in accordance with the specifications in the final restoration plan. The mitigation monitoring period would be extended for any areas in which revegetation was delayed.

Erosion due to Excessive Rainfall

The Airport would monitor and maintain the erosion control devices installed in during the first winter after planting. In the event that excessive rainfall and runoff at the mitigation site jeopardize the integrity of the newly-planted mitigation site, the Airport would immediately repair erosion control devices and take other measures to ensure protection of the revegetated areas.

If the erosion causes significant damage to the mitigation site such that applicable performance goals are not met during the 2-year maintenance period or the 3-year monitoring period, the Airport would revegetate the affected areas. This replacement planting would only occur once if the damage is due to excessive rainfall.

Poor Plant Establishment or Growth

In the event that plant establishment and/or seed germination performance fails to meet half of the quantitative performance goals during the 2-year maintenance period, and/or the 3-year monitoring period, the Airport would reseed or replant as necessary. If the goals are not met for two consecutive years, the Airport would contact permitting agencies and present a contingency revegetation plan that identifies the causative factors and provides remedial action to increase plant establishment, seed germination, and/or vegetation growth in the affected areas.

Weed Infestation

In the event that weeds invade the restoration sites or portions of the sites such that revegetation is poor or significantly hampered despite the efforts of the Airport to remove weeds, the Airport would contact the involved agencies and present a contingency plan that involves the control and possible eradication of weeds from the affected areas, followed by a new revegetation effort. The second revegetation of the affected area would only occur once. There would be no obligation to control weeds at the restoration sites after 5 years.

Flooding

In the event that a major flood event destroys or significantly harms the restoration sites during the 5 year monitoring period, the Airport would regrade and revegetate the affected areas. This replacement would only occur once. There would be no obligation to replace flood damaged wetlands at the mitigation site after 5 years.

10.0 REFERENCES

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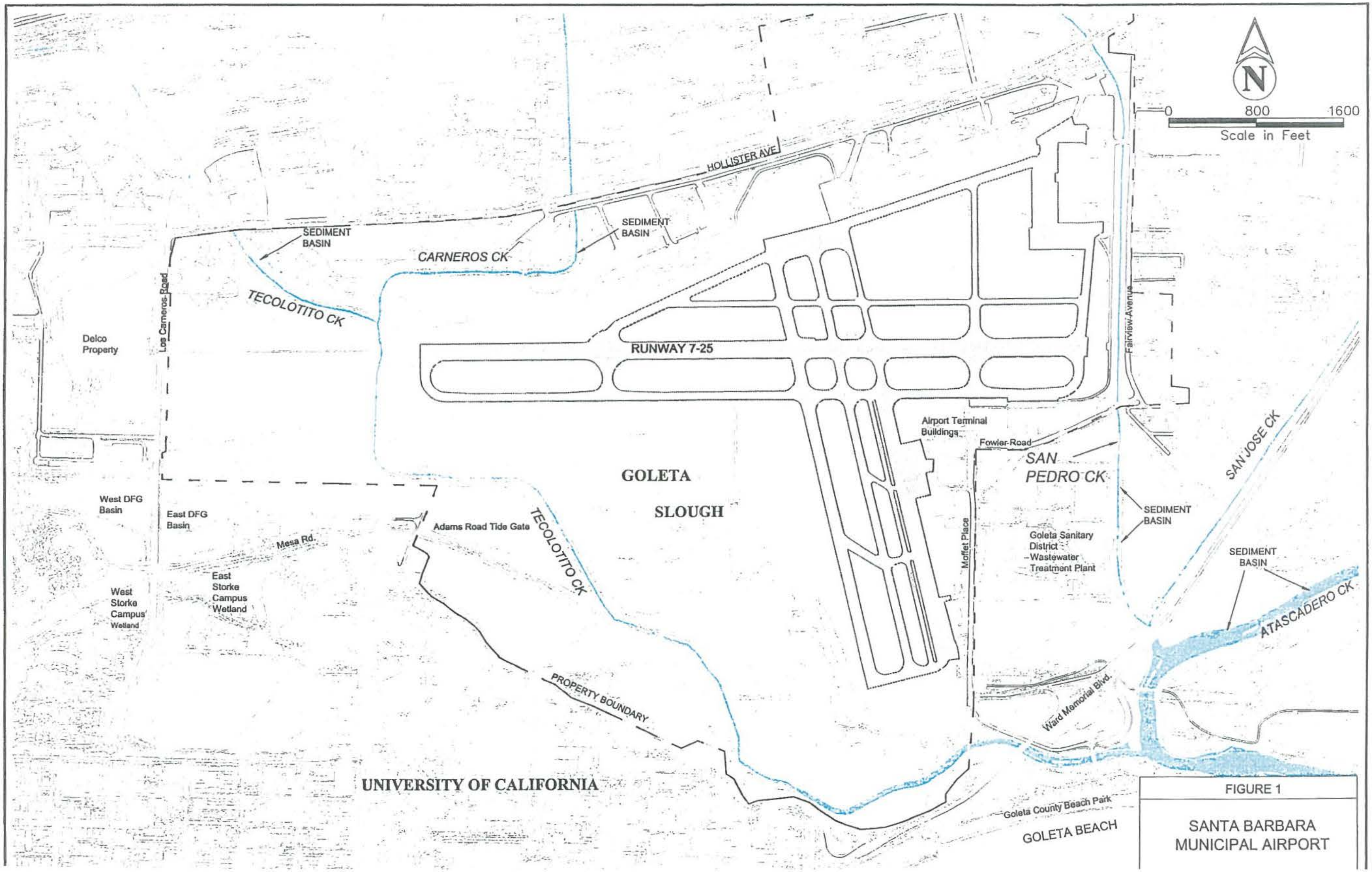
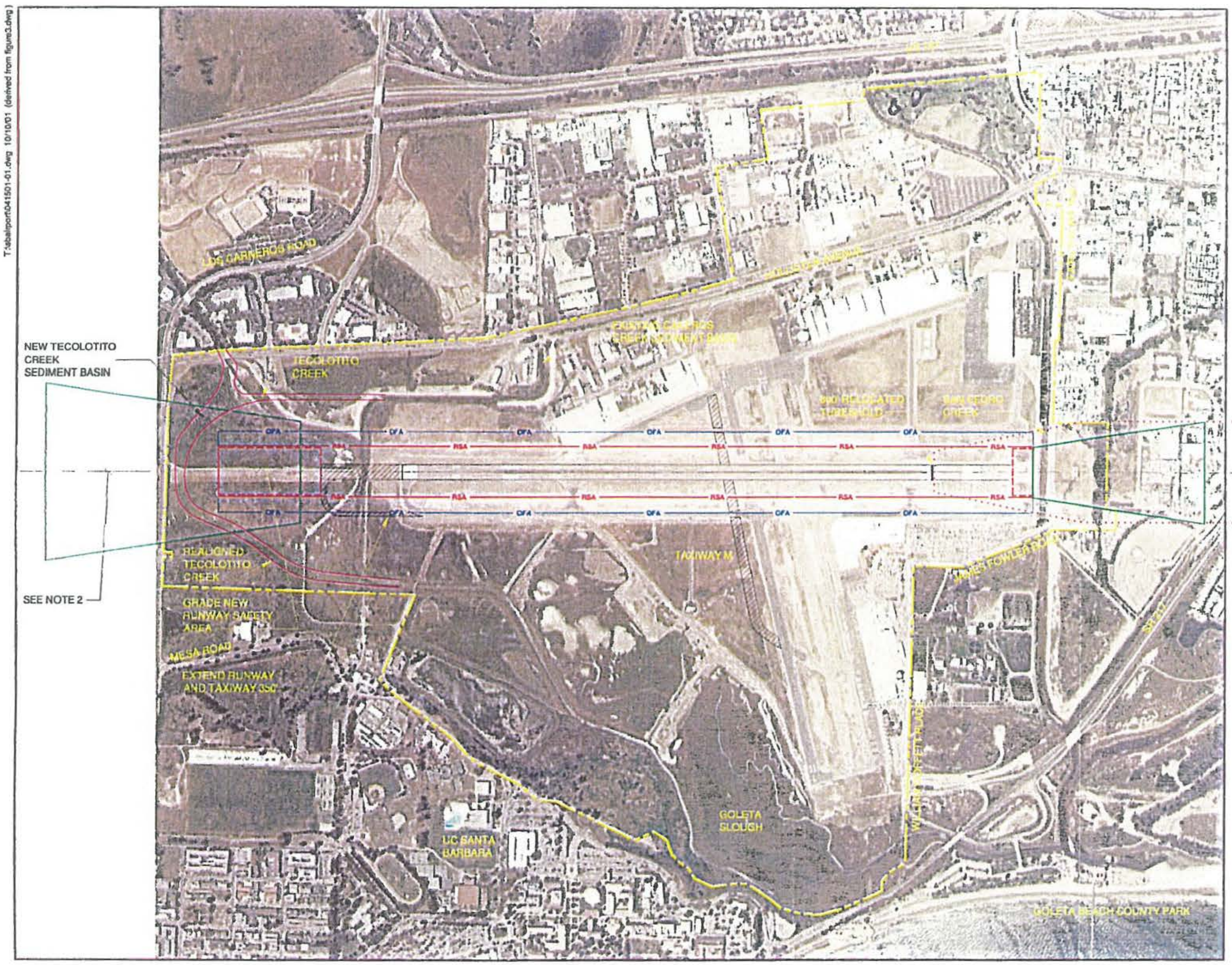


FIGURE 1

SANTA BARBARA MUNICIPAL AIRPORT



LEGEND

- APPROACH PROFILE
- CLEARWAY
- APPROACH RUNWAY PROTECTION ZONES
- RUNWAY SAFETY AREA (RSA)
- OBJECT FREE AREA (OFA)
- AIRPORT PROPERTY LINE
- RUNWAY / TAXIWAY CONSTRUCTION

DEVELOPMENT

- 800' RW CONSTRUCTION WEST
- 1000' RSA EXTENSION WEST
- REALIGN TECOLOTITO CREEK
- 800' RW 25 THRESHOLD RELOCATION WEST
- 1000' AND 200' CLEARWAYS

NOTES: 1) CULVERTS, TUNNEL, AND ROADWAY AND CREEK REALIGNMENT LOCATIONS ARE APPROXIMATE FOR ALL ALTERNATIVES

2) ACQUIRE EASEMENTS, RELOCATE LIGHTING, MIDDLE MARKER

500 0 500 1000

SCALE IN FEET

FIGURE 2

WEST CREEK REALIGNMENT ALTERNATIVE AND TAXIWAY M

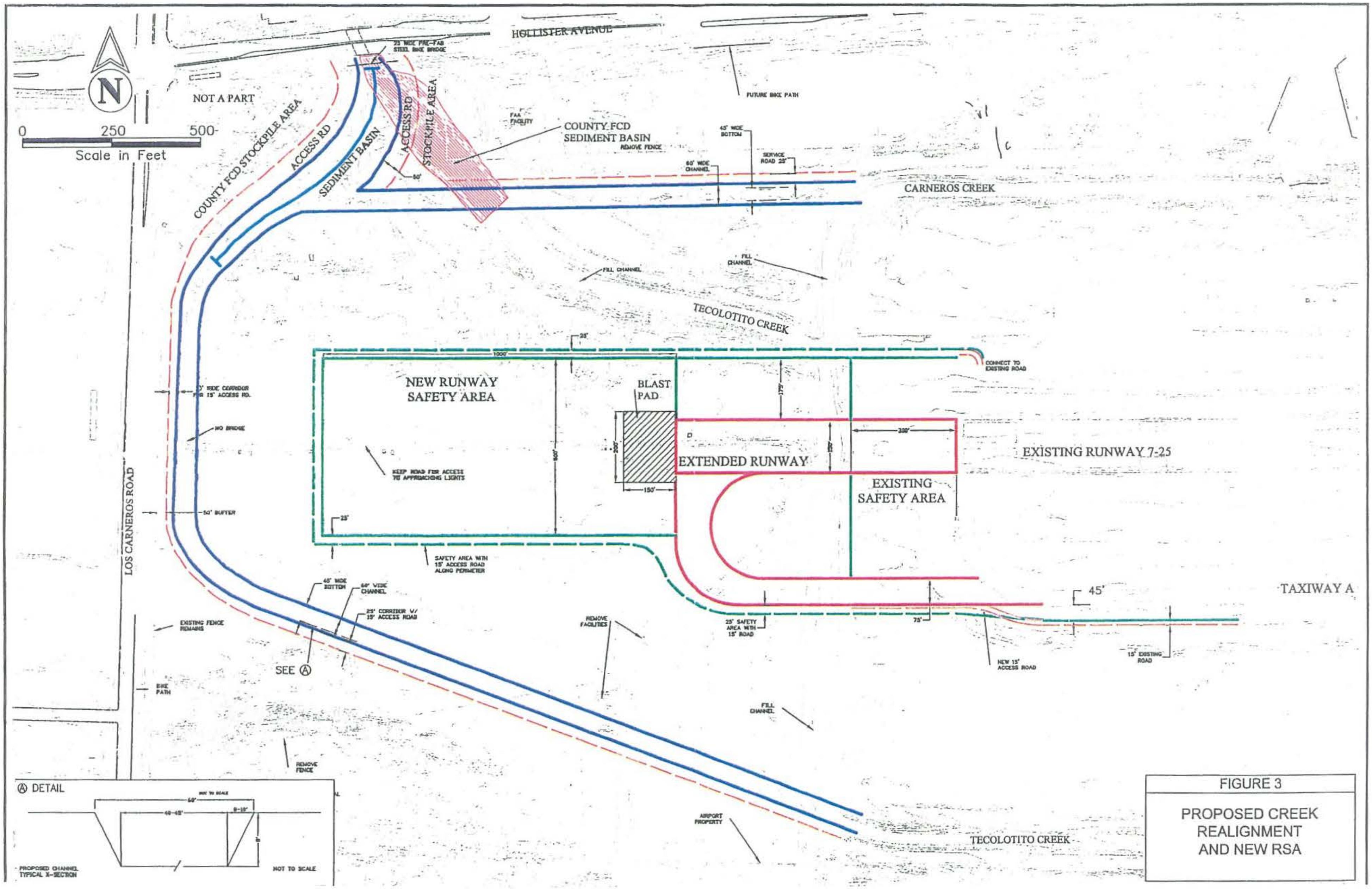


FIGURE 3

PROPOSED CREEK REALIGNMENT AND NEW RSA

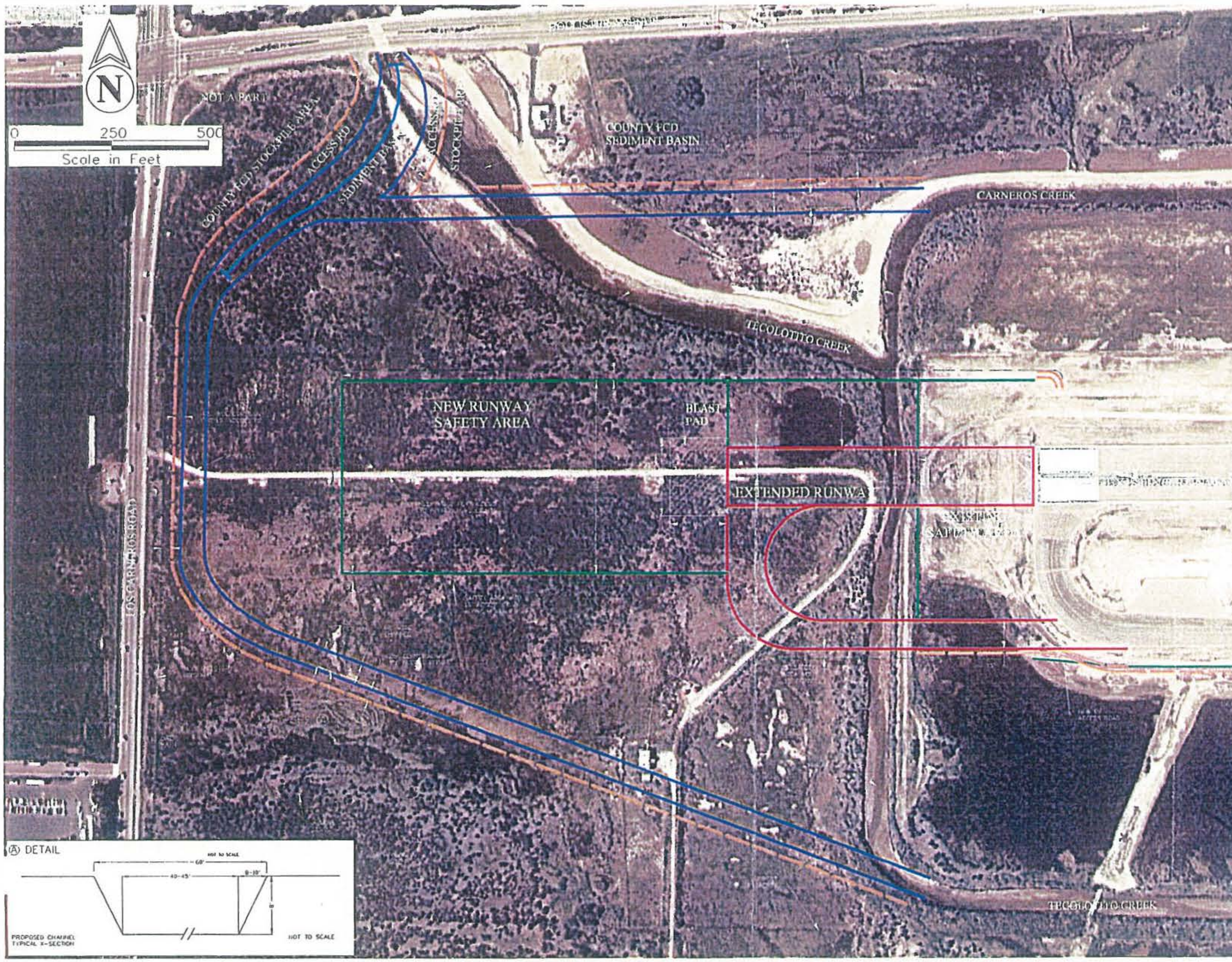


FIGURE 4

AERIAL PHOTOGRAPH OF
CREEK REALIGNMENT

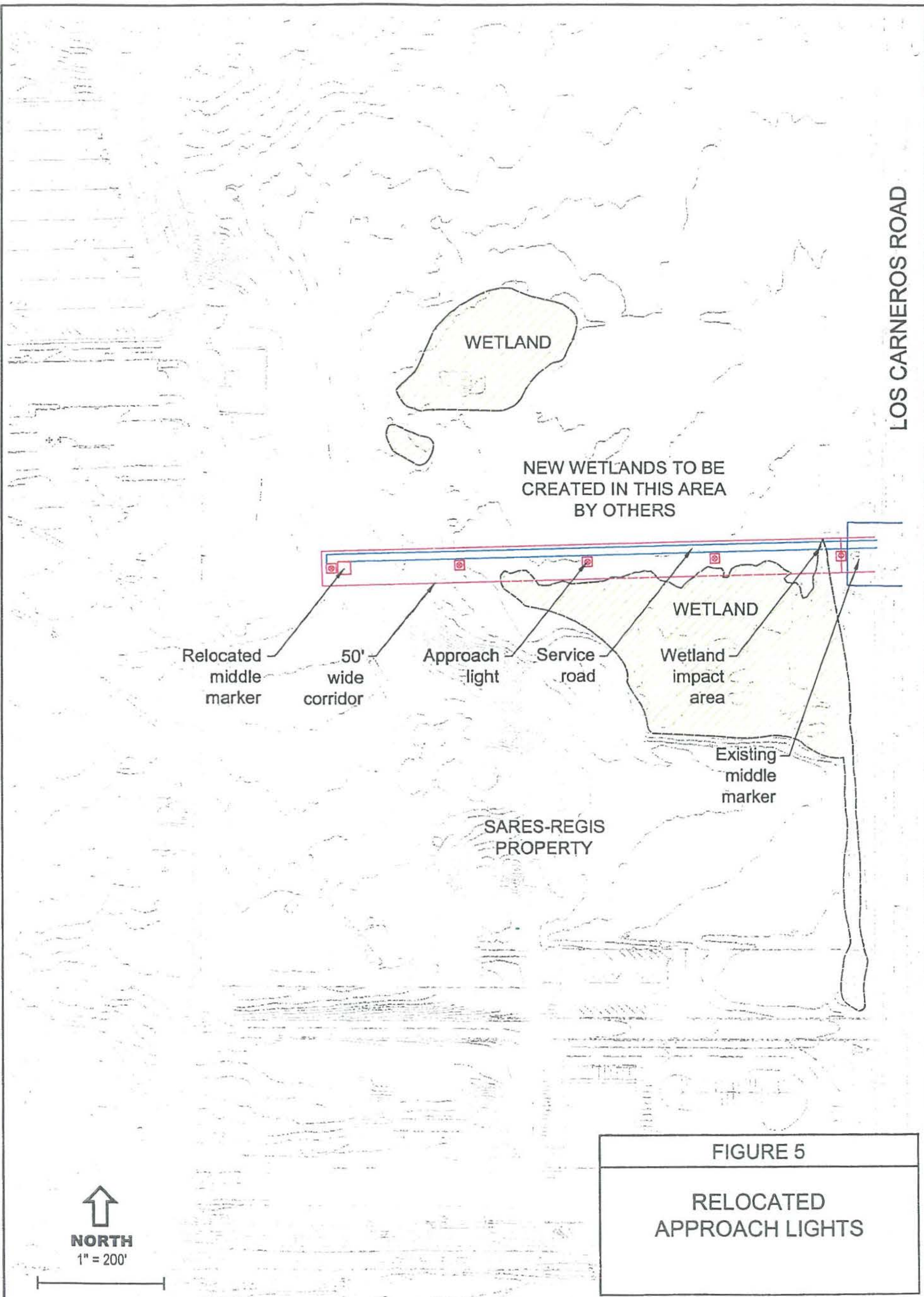
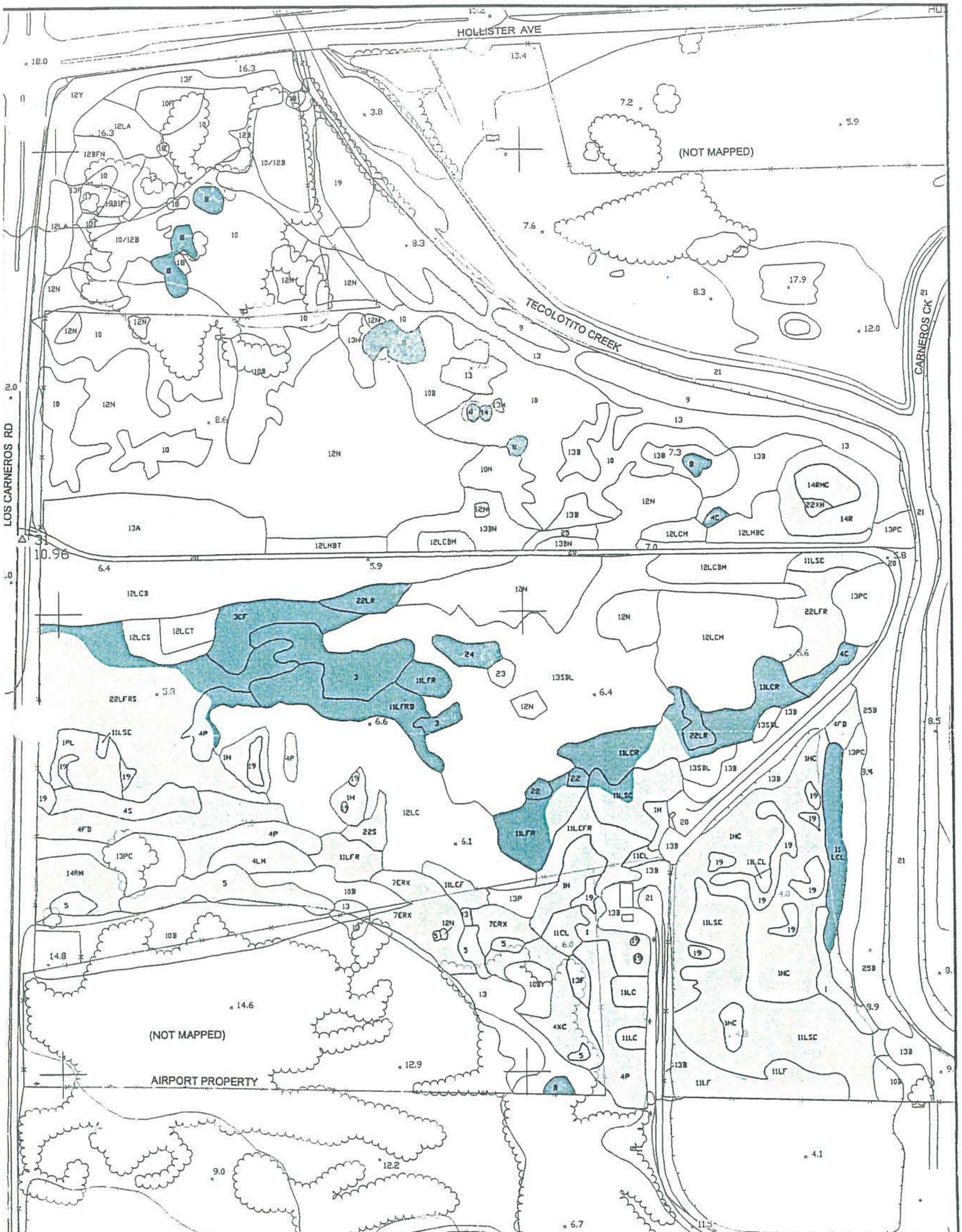


FIGURE 5

RELOCATED APPROACH LIGHTS



N

0 200 400
Scale in Feet

See attached legend for vegetation codes.
Mapping based on 1999 air photograph.

Legend

Corps & Coastal Act Wetlands

Coastal Act Wetlands

FIGURE 6

WETLAND VEGETATION
IN THE RSA
EXTENSION AREA

T:\sbairport\041501-04c.DWG 10/13/01 (derived from (110400-01.dwg)

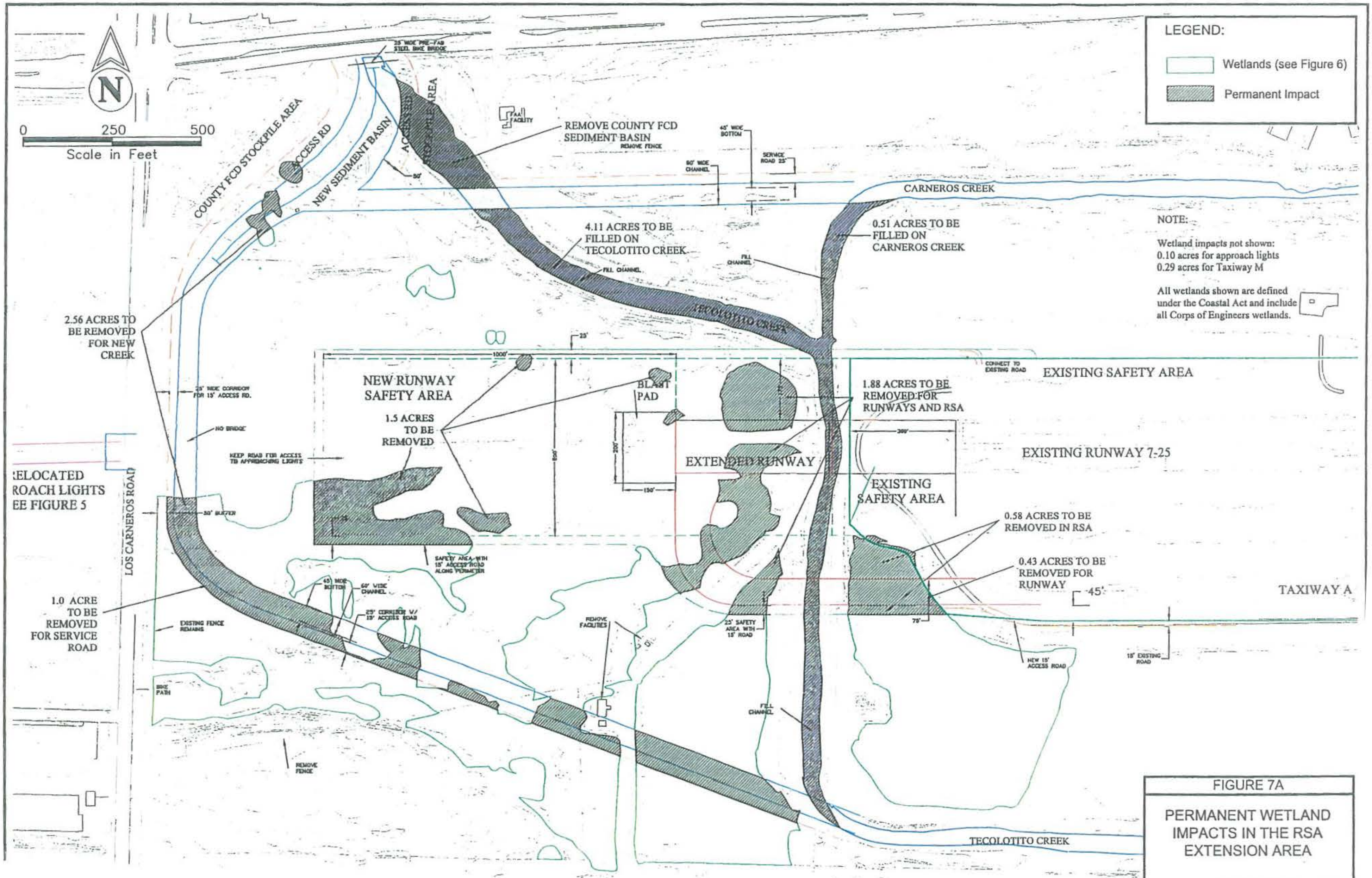


FIGURE 7A

PERMANENT WETLAND IMPACTS IN THE RSA EXTENSION AREA

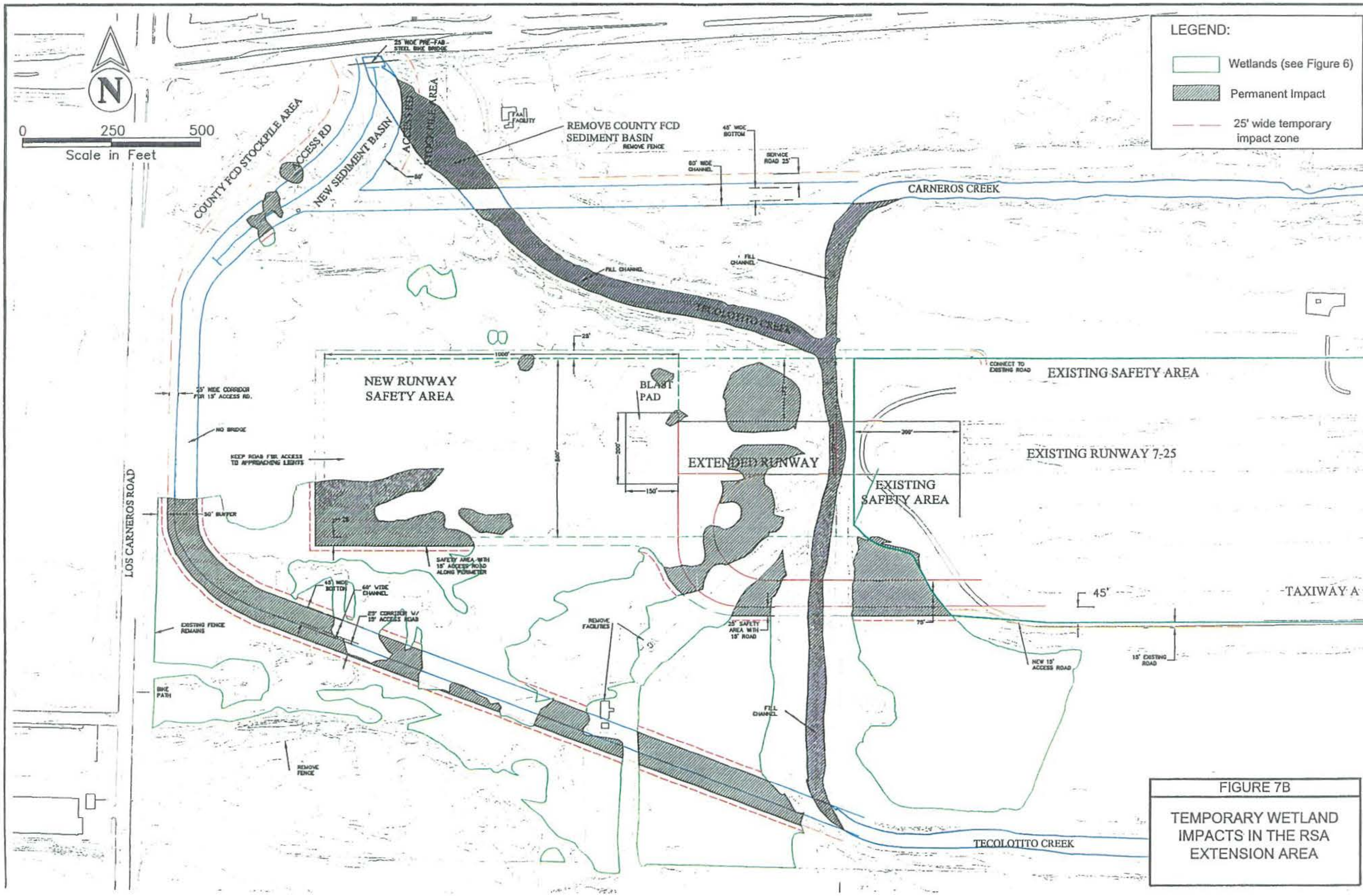


FIGURE 7B

TEMPORARY WETLAND IMPACTS IN THE RSA EXTENSION AREA

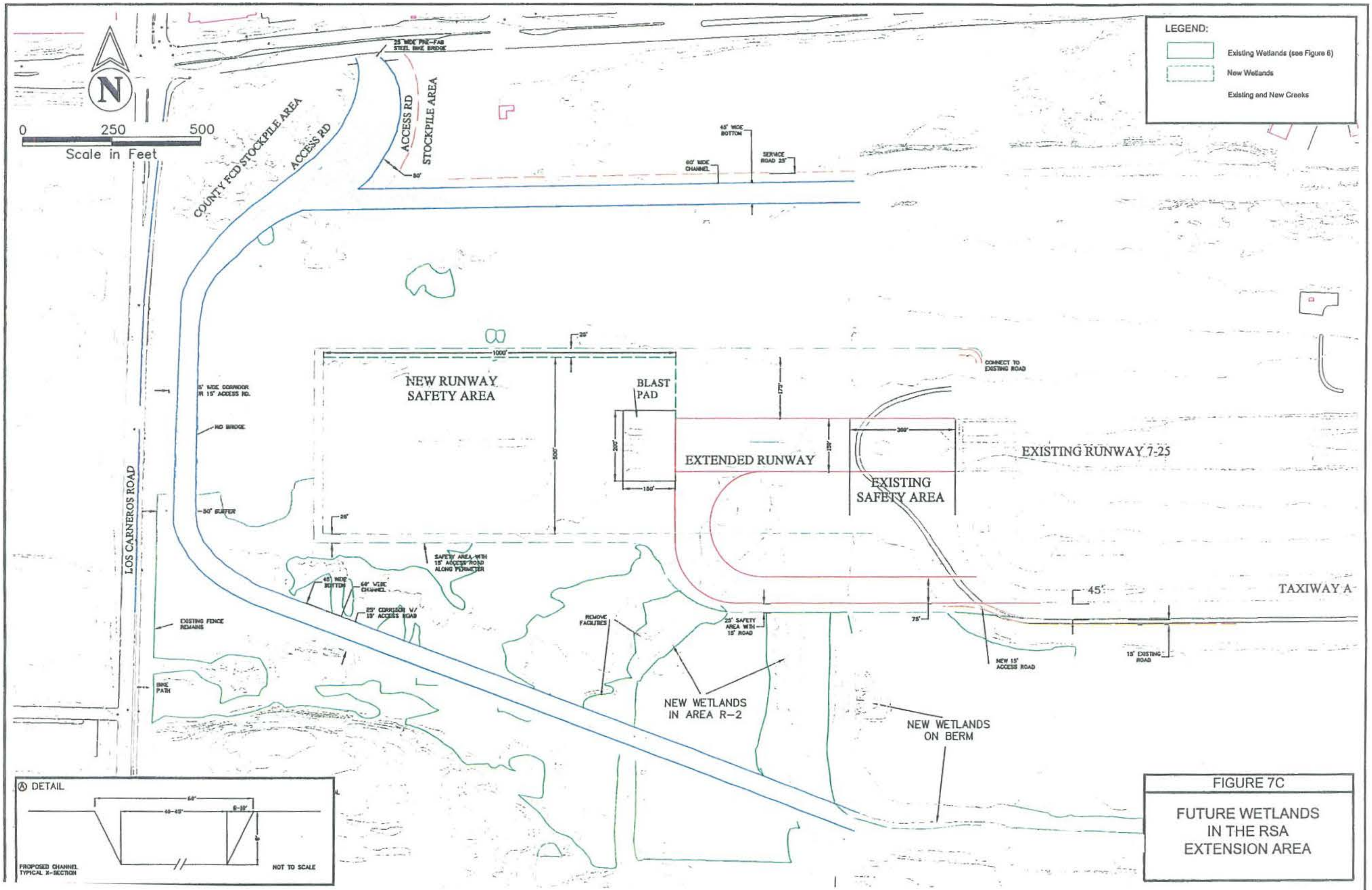


FIGURE 7C

FUTURE WETLANDS IN THE RSA EXTENSION AREA

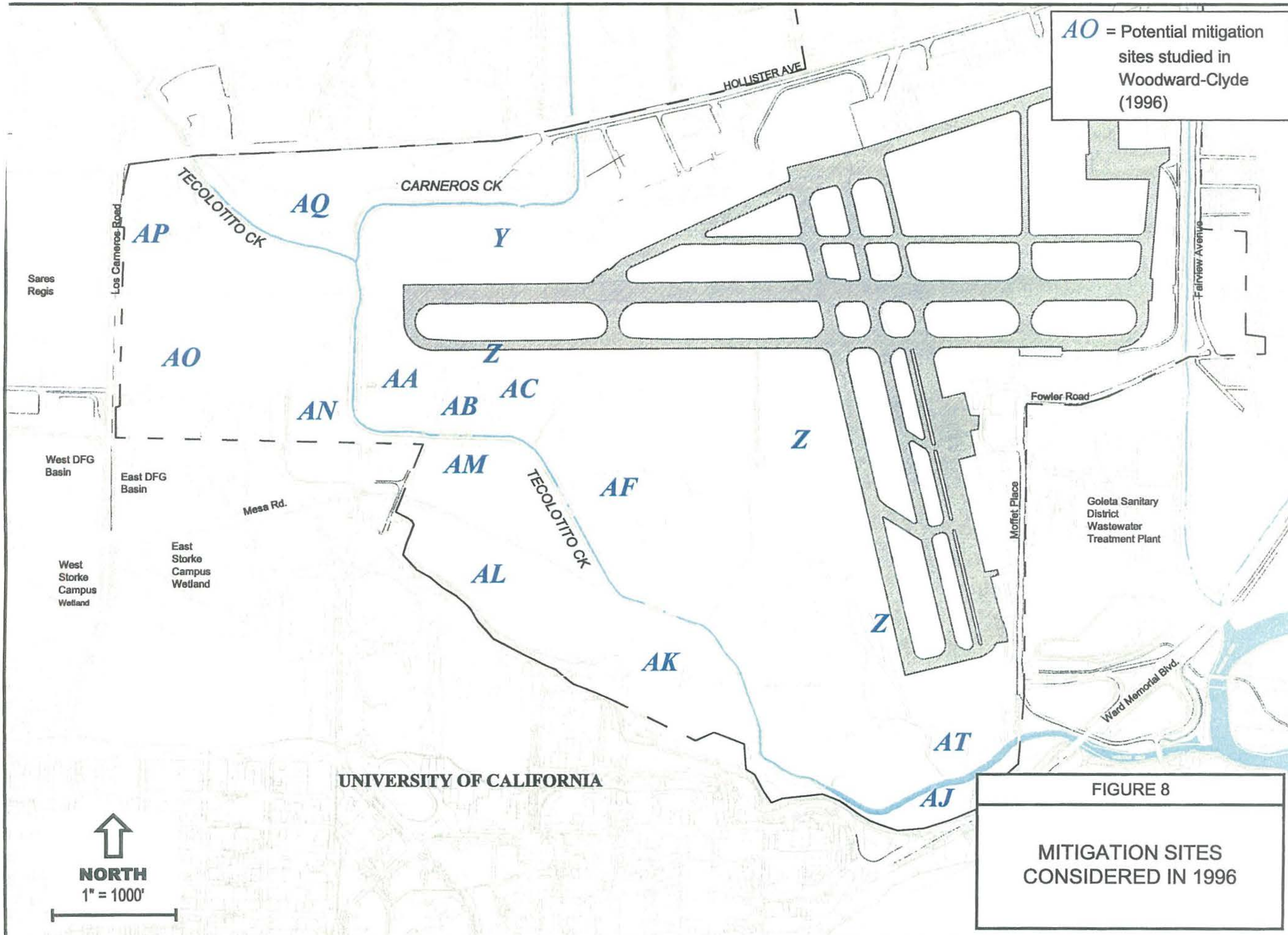


FIGURE 8

MITIGATION SITES CONSIDERED IN 1996

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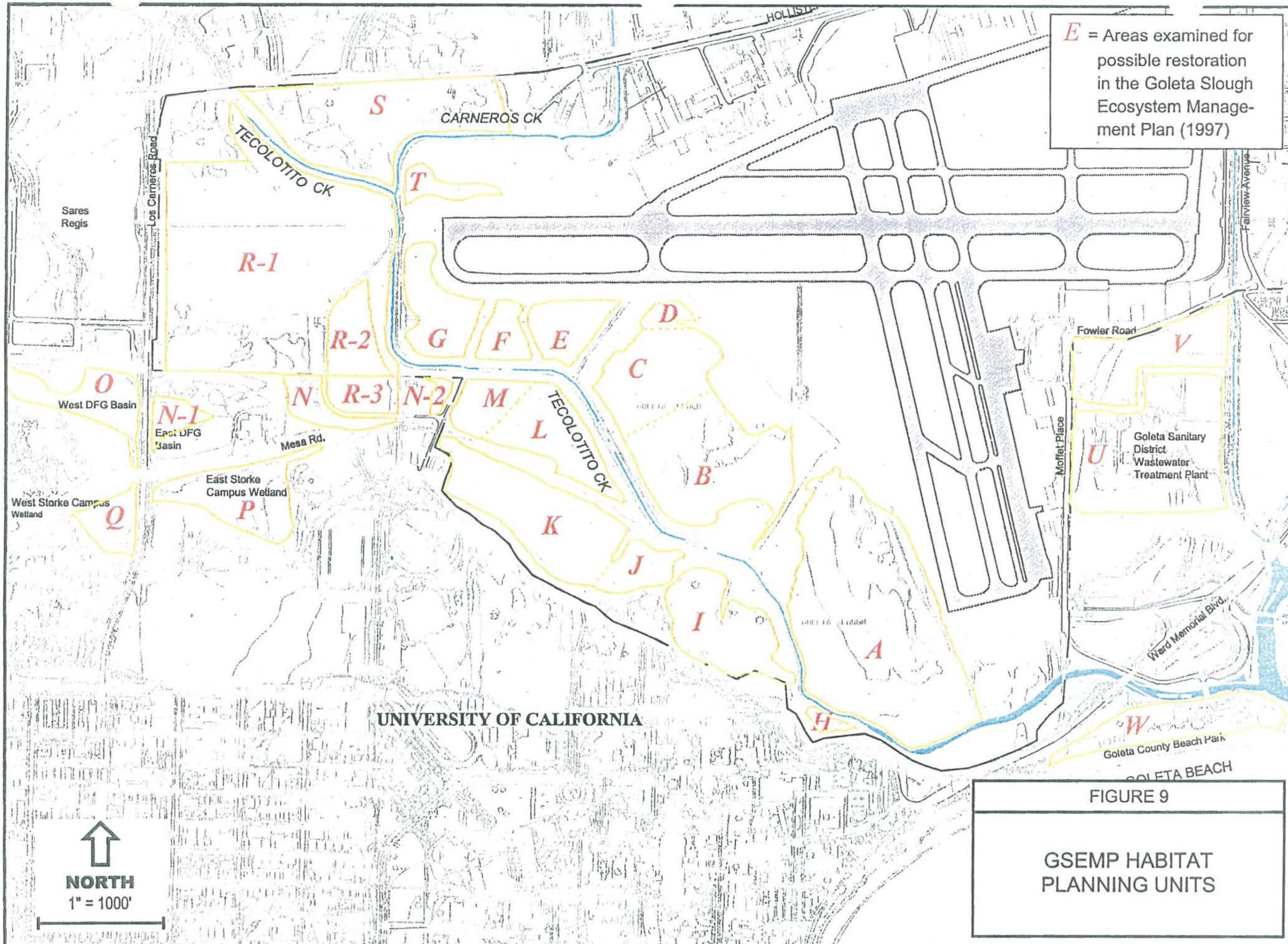

FIGURE 9

GSEMP HABITAT PLANNING UNITS

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FIGURE 10

AERIAL PHOTOGRAPH OF RESTORATION SITES

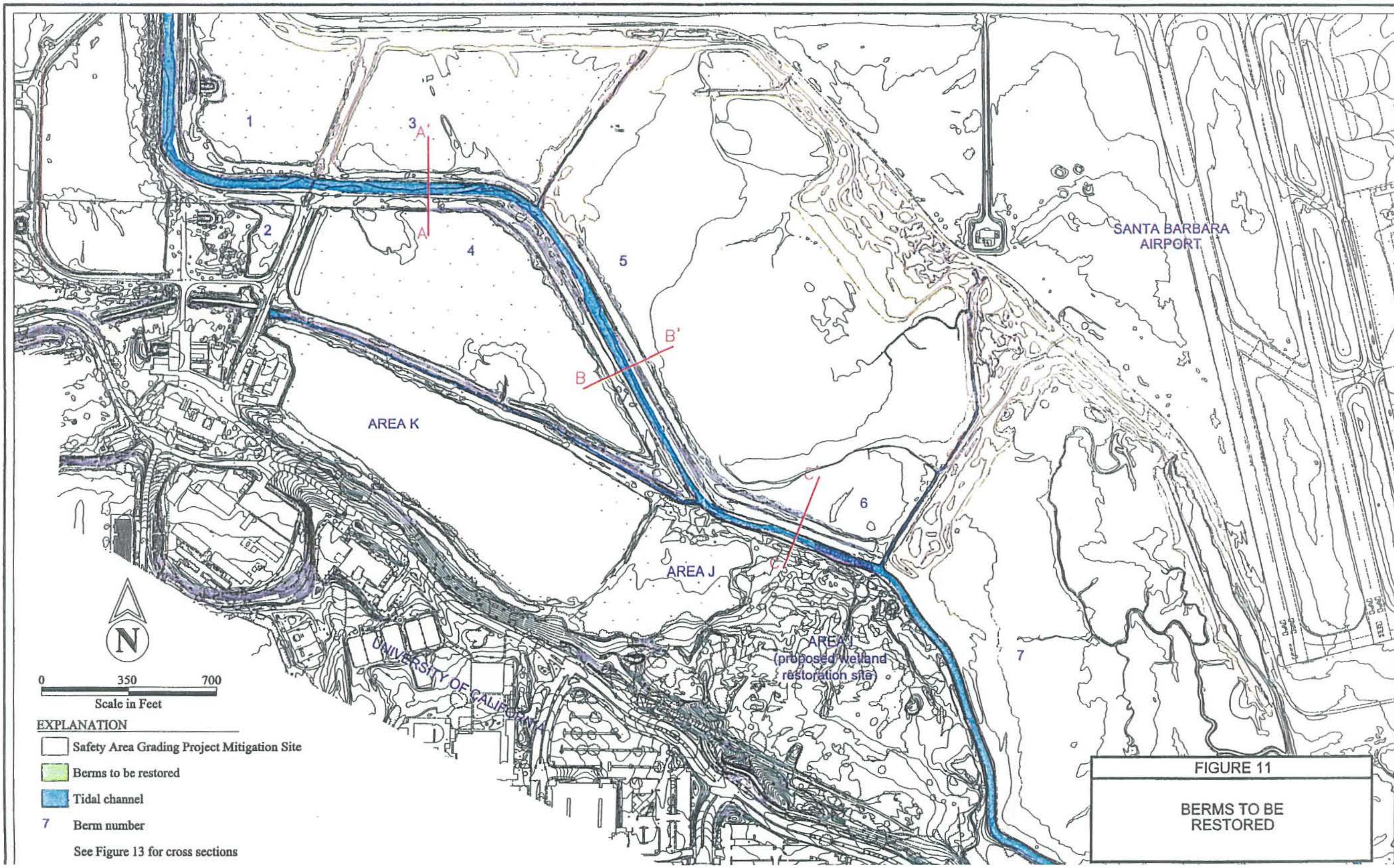
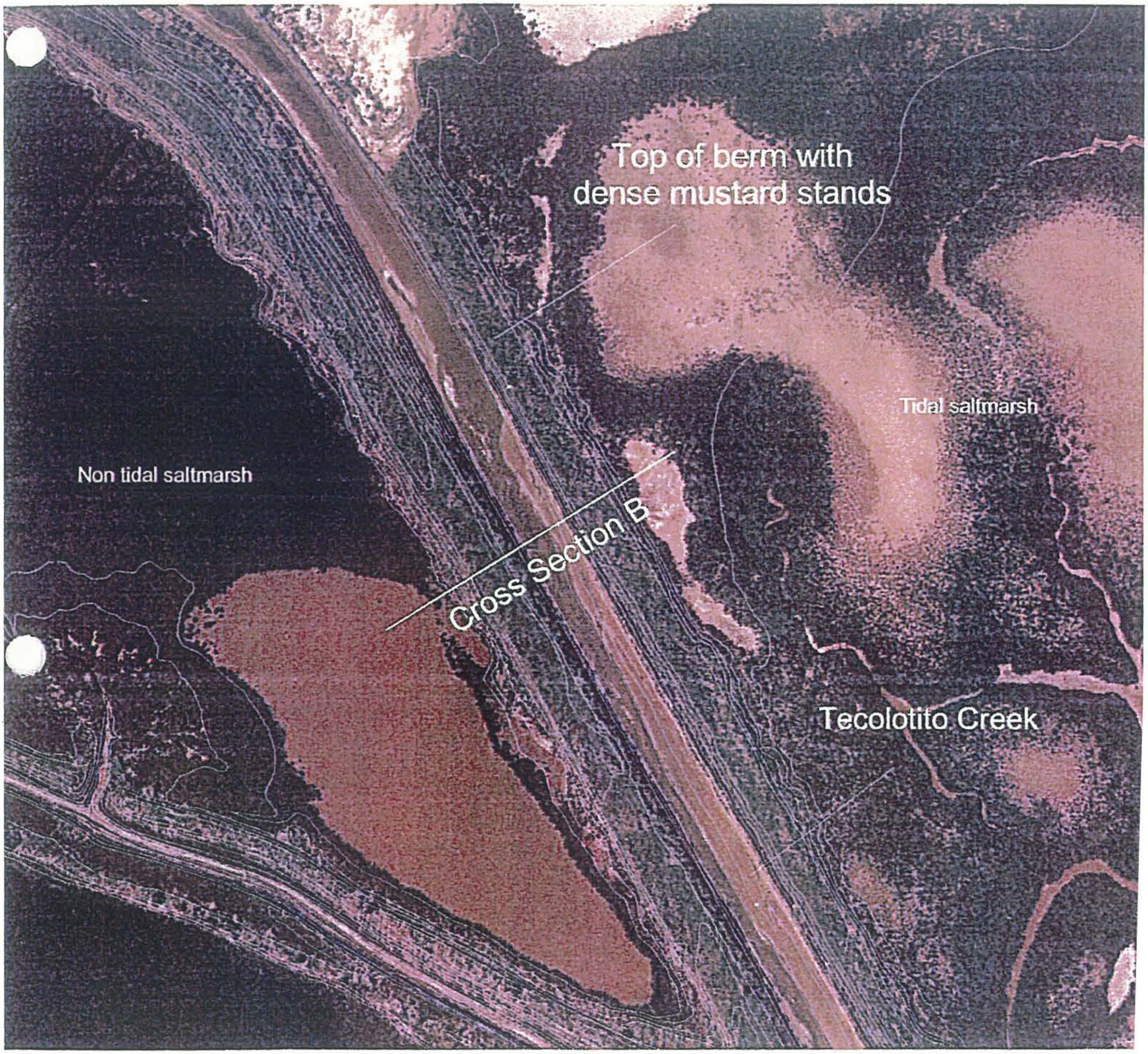


FIGURE 11

BERMS TO BE RESTORED



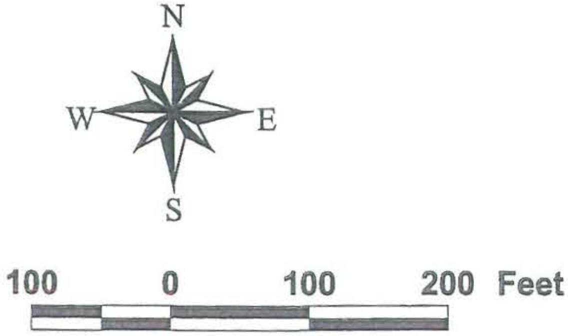
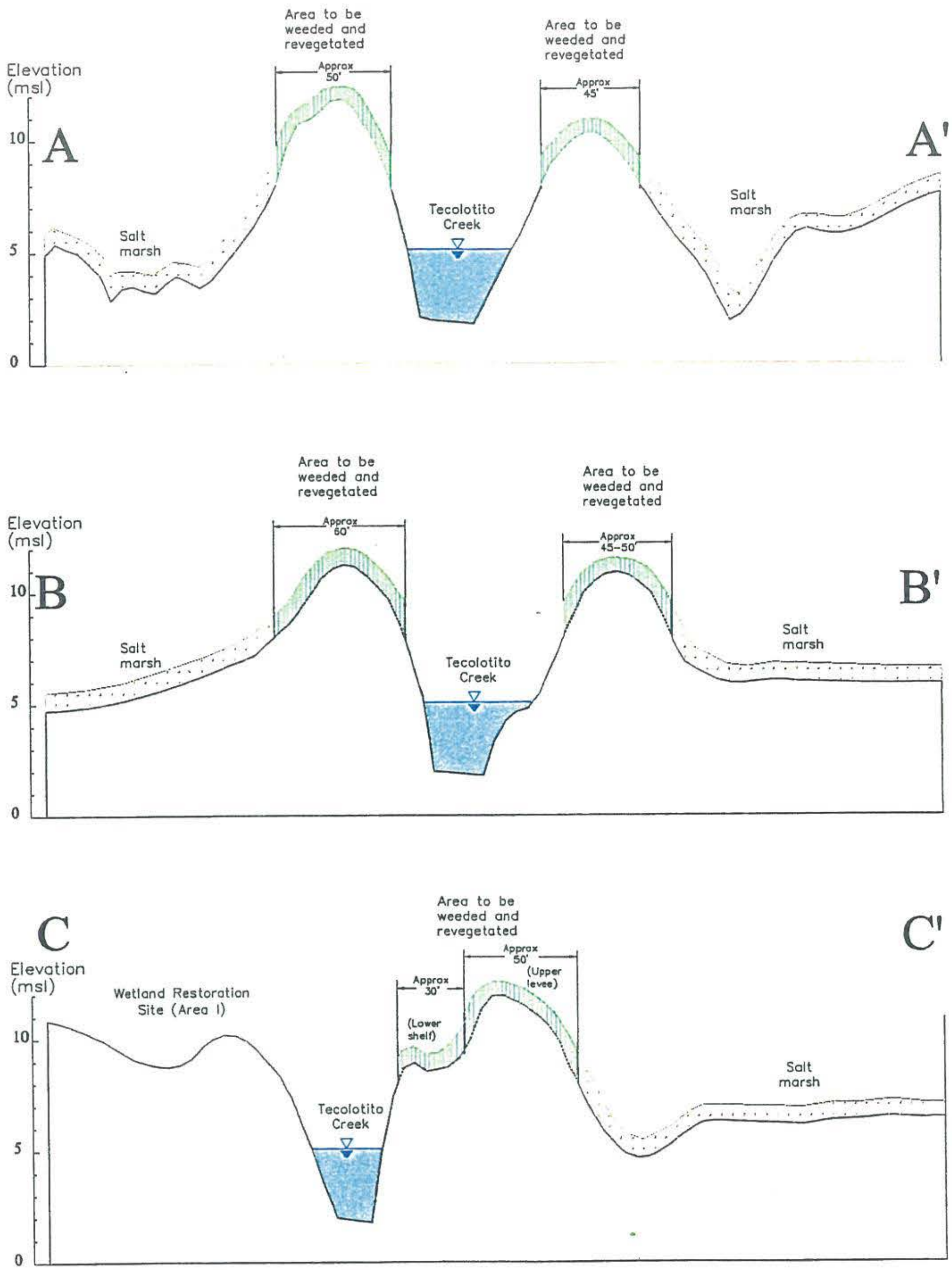


Figure 12
Aerial Photograph
of Existing Levee Habitat
Conditions



EXPLANATION

Dense, 6'-high mustard stands

Cross section locations shown on Figure 11

0 80 160

Horizontal Scale in Feet
Vertical exaggeration 10 times

FIGURE 13

CROSS SECTIONS OF BERM HABITAT RESTORATION

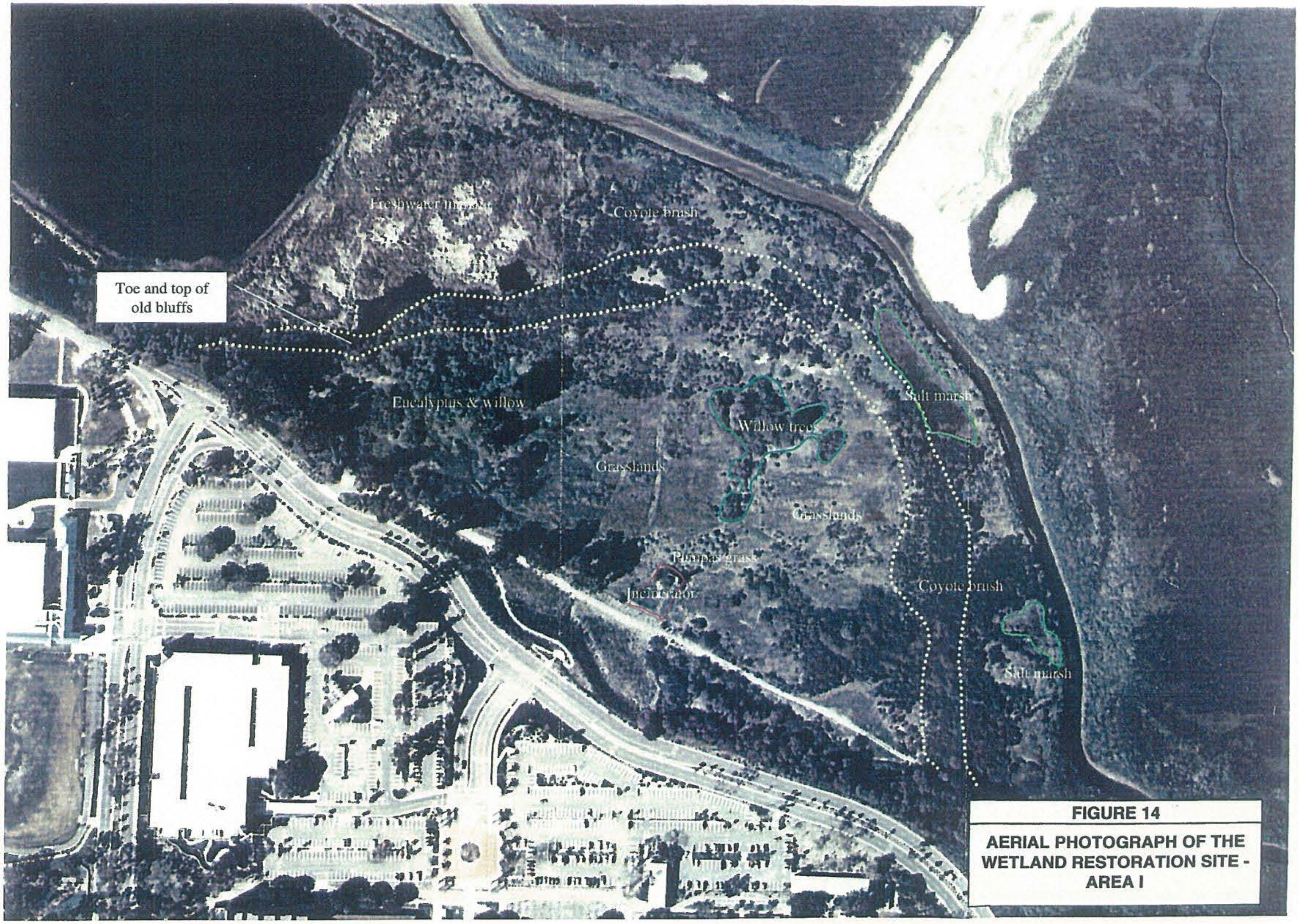


FIGURE 14

AERIAL PHOTOGRAPH OF THE WETLAND RESTORATION SITE - AREA I

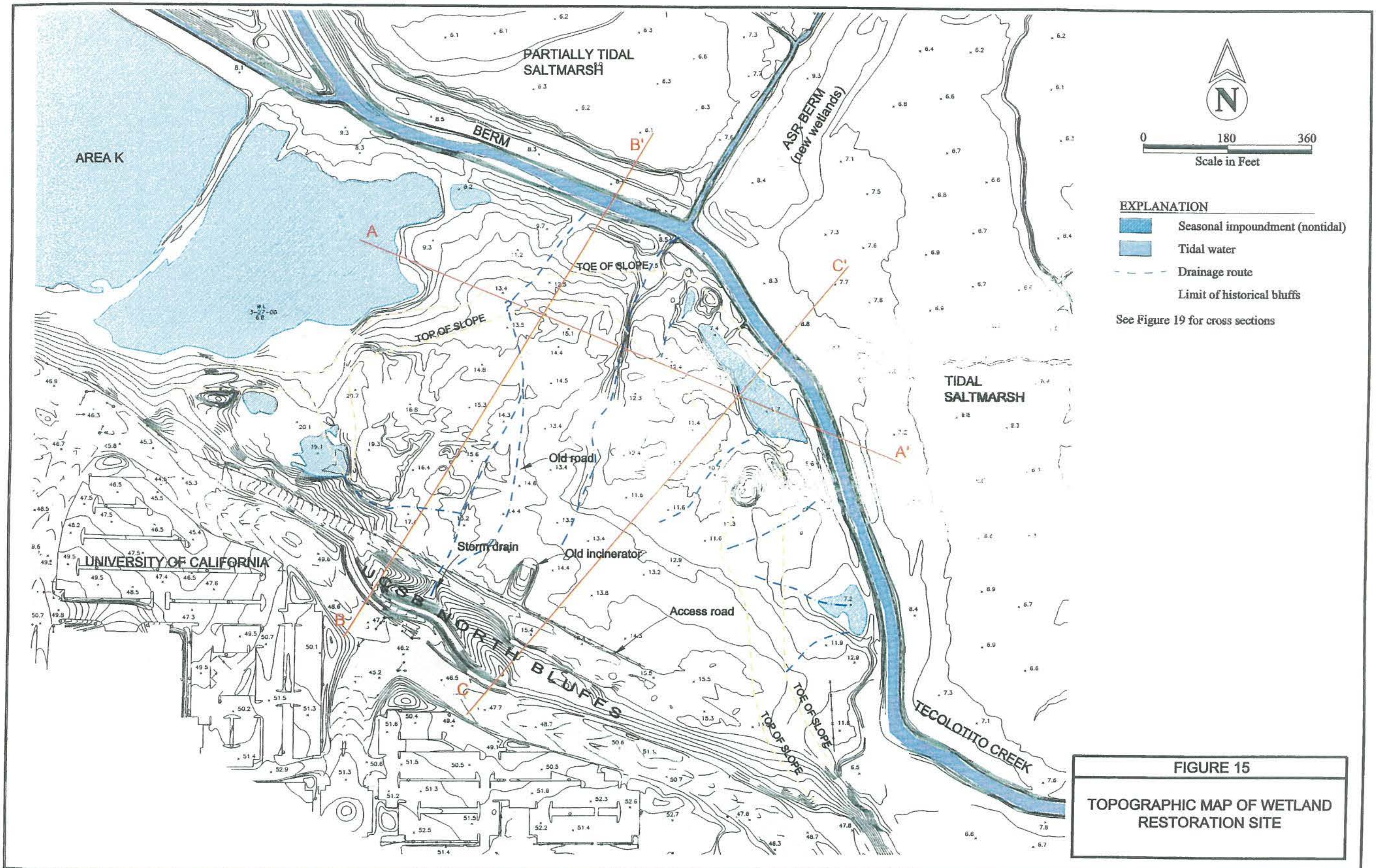


FIGURE 15

TOPOGRAPHIC MAP OF WETLAND RESTORATION SITE

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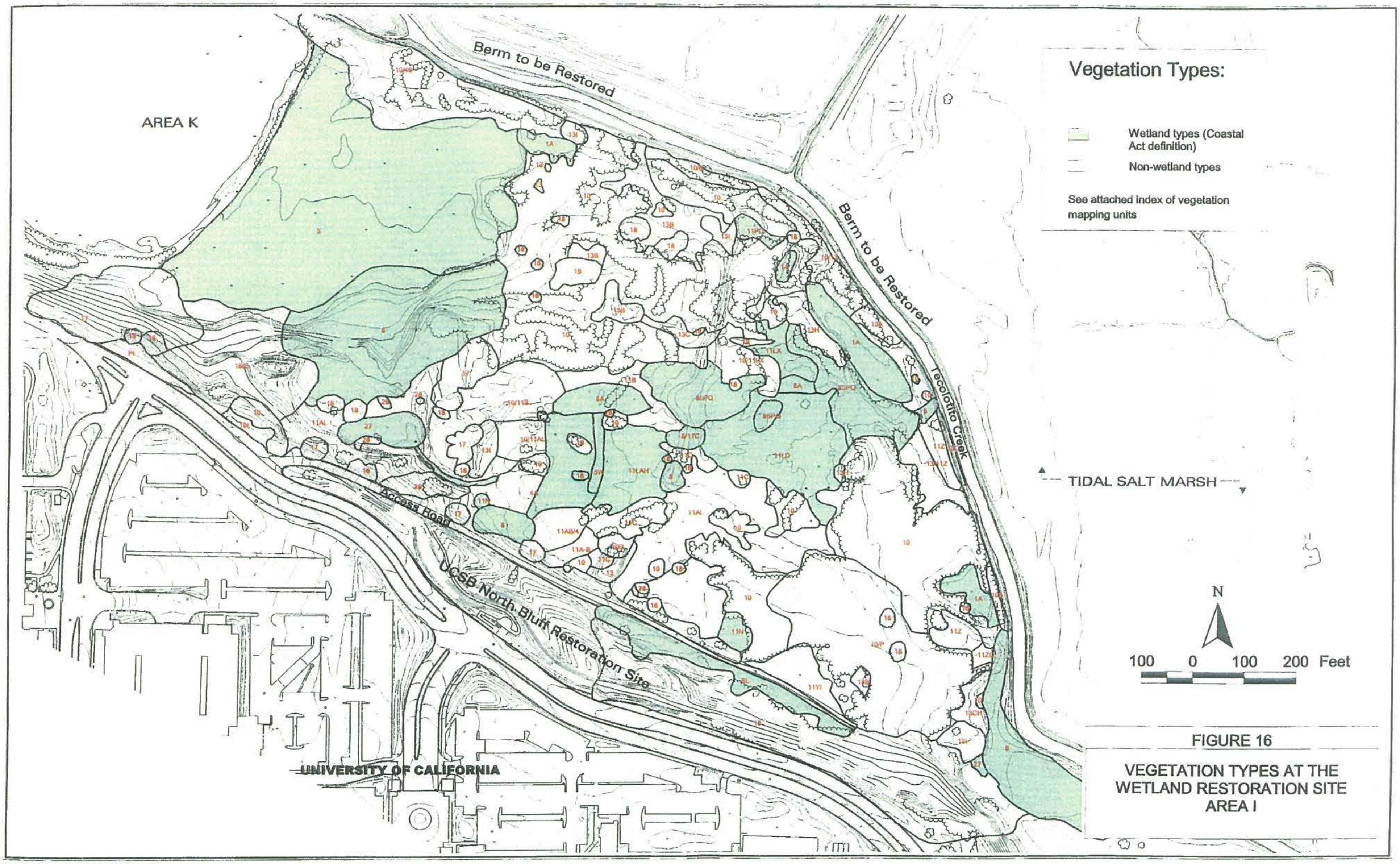

FIGURE 16

VEGETATION TYPES AT THE WETLAND RESTORATION SITE AREA I

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VEGETATION TYPES IN MITIGATION SITE

Code	Scientific Name	Common Name	Code	Scientific Name	Common Name
1A	*Salicornia virginica*	Virginia pickleweed	11AB	*Baccharis pilularis*	Coyote brush
	Atriplex lentiformis var. breweri	Brewer saltbush		*Ambrosia psilostachya*	Western ragweed
	Frankenia salina	Alkali heath		*Lolium multiflorum*	Italian ryegrass
	Picris echioides	Bristly ox-tongue		*Rumex crispus*	Curly dock
	Baccharis pilularis	*Coyote bush*		*Polypogon monspeliensis*	Rabbitsfoot grass
	Distichlis spicata	Saltgrass		*Cyperus eragrostis*	Umbrella-sedge
	Rumex crispus	Curly dock	10I	*Carpobrotus chilense*	Sea fig
	Salix lasiolepis	Arroyo willow		*Baccharis pilularis*	Coyote brush
	Eucalyptus sp.	Eucalyptus		*Ambrosia psilostachya*	Western ragweed
1X	*Salicornia virginica*	Virginia pickleweed	10B	*Baccharis pilularis*	Coyote brush
	Lolium multiflorum	Italian ryegrass		*Leymus condensatus*	Giant wildrye
	Polypogon monspeliensis	Rabbitsfoot grass		*Ambrosia psilostachya*	Western ragweed
	Rumex crispus	Curly dock		*Toxicodendron diverilobum*	Poison oak
	Ambrosia psilostachya	Western ragweed	10A	*Atriplex lentiformis var. breweri*	Brewer saltbush
	Hordeum marinum ssp. gussoneanum	Mediterranean barley		*Baccharis pilularis*	Coyote brush
5	*Scirpus californicus*	California bulrush		*Frankenia salina*	Alkali heath
5W	*Wet area*			*Carduus pycnocephalus*	Italian thistle
	Scirpus maritimus	Alkali bulrush		*Artemisia californica*	California sagebrush
	Rumex crispus	Curly dock	10I	*Isocoma menziesii*	Golden bush
	Lolium multiflorum	Italian ryegrass		*Ambrosia psilostachya*	Western ragweed
	Cynodon dactylon	Bermuda grass		*Baccharis pilularis*	Coyote brush
27	*Typha domingensis*	Southern cattail		*Salvia*	Purple sage
	Rumex crispus	Curly dock	11B	*Bromus hordeaceus*	Soft chess
8AJ	*Salix exigua*	Narrowleaf willow		*Toxicodendron diverilobum*	Poison oak
	Distichlis spicata	Saltgrass		*Lolium multiflorum*	Italian ryegrass
	Ambrosia psilostachya	Western ragweed		*Ambrosia psilostachya*	Western ragweed
	Cynodon dactylon	Bermuda grass		*Rumex crispus*	Curly dock
	Jaumea carnosa	Fleshy jaumea		*Carduus pycnocephalus*	Italian thistle
	Rubus ursinus	California blackberry	11C	*Cortedaria jubata*	Andean pampas grass
8SPQ	*Salix lasiolepis*	Arroyo willow		*Baccharis pilularis*	Coyote brush
	Baccharis salicifolia	Mule fat		*Ambrosia psilostachya*	Western ragweed
	Toxicodendron diverilobum	Poison oak		*Toxicodendron diverilobum*	Poison oak
	Baccharis pilularis	Coyote brush		*Bromus diandrus*	Ripgut grass
	Quercus agrifolia	Coast live oak	11ZC	*Leymus triticoides*	Creeping rye-grass
	Populus fremontii	Fremont cottonwood		*Carduus pycnocephalus*	Italian thistle
8A	*Salix exigua*	Narrowleaf willow	11Z	*Leymus triticoides*	Creeping rye-grass
	Ambrosia psilostachya	Western ragweed	11L	*Lolium multiflorum*	Italian ryegrass
	Cynodon dactylon	Bermuda grass		*Rumex crispus*	Curly dock
	Polypogon monspeliensis	Rabbitsfoot grass		*Polypogon monspeliensis*	Rabbitsfoot grass
	Baccharis pilularis	Coyote brush		*Cynodon dactylon*	Bermuda grass
	Hordeum marinum ssp. Gussoneanum	Mediterranean barley		*Typha domingensis*	Southern cattail
	Scirpus maritimus	Alkali bulrush		*Frankenia salina*	Alkali heath
4	*Rumex crispus*	Curly dock		*Picris echioides*	Bristly ox-tongue
	Lolium multiflorum	Italian ryegrass		*Piptatherum miliaceum*	Smilo grass
	Cynodon dactylon	Bermuda grass	11LX	*Lolium multiflorum*	Italian ryegrass
	Polypogon monspeliensis	Rabbitsfoot grass		*Cynodon dactylon*	Bermuda grass
4A	*Rumex crispus*	Curly dock		*Bromus hordeaceus*	Soft chess
	Lolium multiflorum	Italian ryegrass		*Rumex crispus*	Curly dock
	Baccharis pilularis	Coyote brush		*Polypogon monspeliensis*	Rabbitsfoot grass
	Baccharis pilularis	Coyote brush		*Hordeum marinum ssp. gussonea*	Mediterranean barley
5	*Scirpus californicus*	California bulrush	11LAH	*Lolium multiflorum*	Italian ryegrass
8L	*Salix lasiolepis*	Arroyo willow		*Ambrosia psilostachya*	Western ragweed
	Leymus triticoides	Creeping rye-grass		*Polypogon monspeliensis*	Rabbitsfoot grass
	Rosa californica	California rose		*Cynodon dactylon*	Bermuda grass
	Myoporum laetum	Myoporum		*Rumex crispus*	Curly dock
	Cynodon dactylon	Bermuda grass		*Bromus hordeaceus*	Soft chess
	Toxicodendron diverilobum	Poison oak		*Heliotropium curassavicum*	Alkali heliotrope
8	*Salix lasiolepis*	Arroyo willow		*Vicia sativa ssp sativa*	Sweet vetch

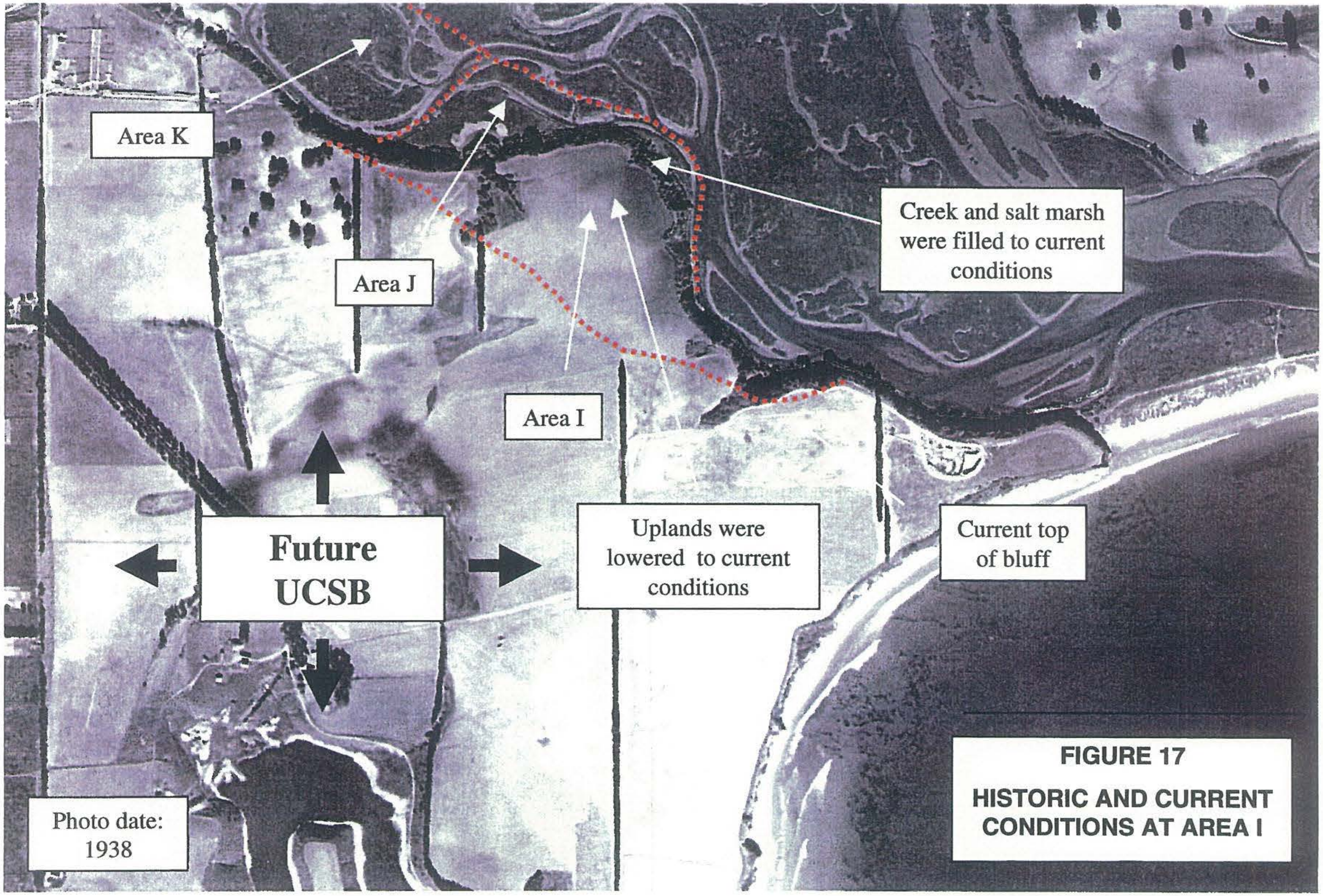

FIGURE 17

HISTORIC AND CURRENT CONDITIONS AT AREA I

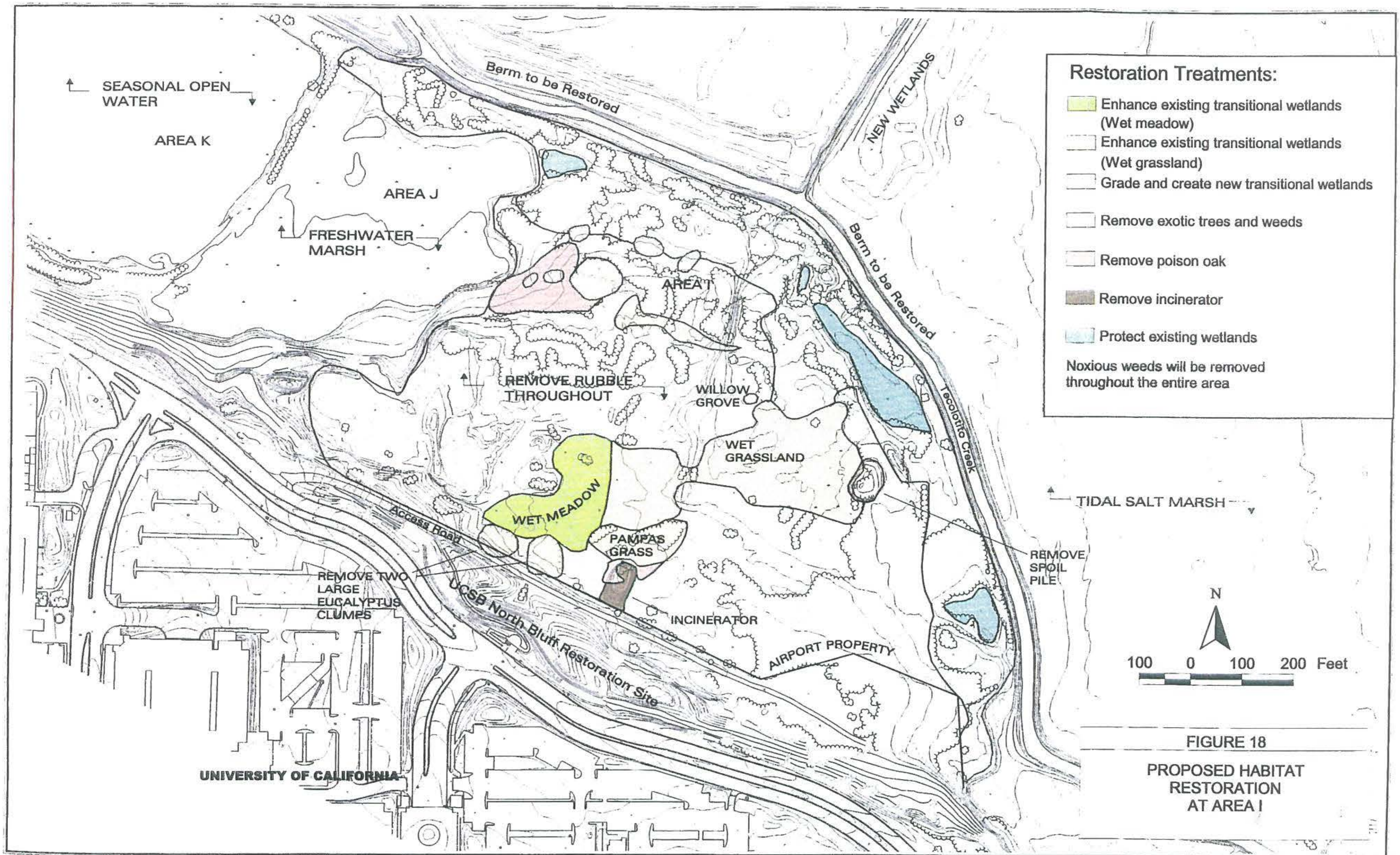

FIGURE 18

PROPOSED HABITAT RESTORATION AT AREA I

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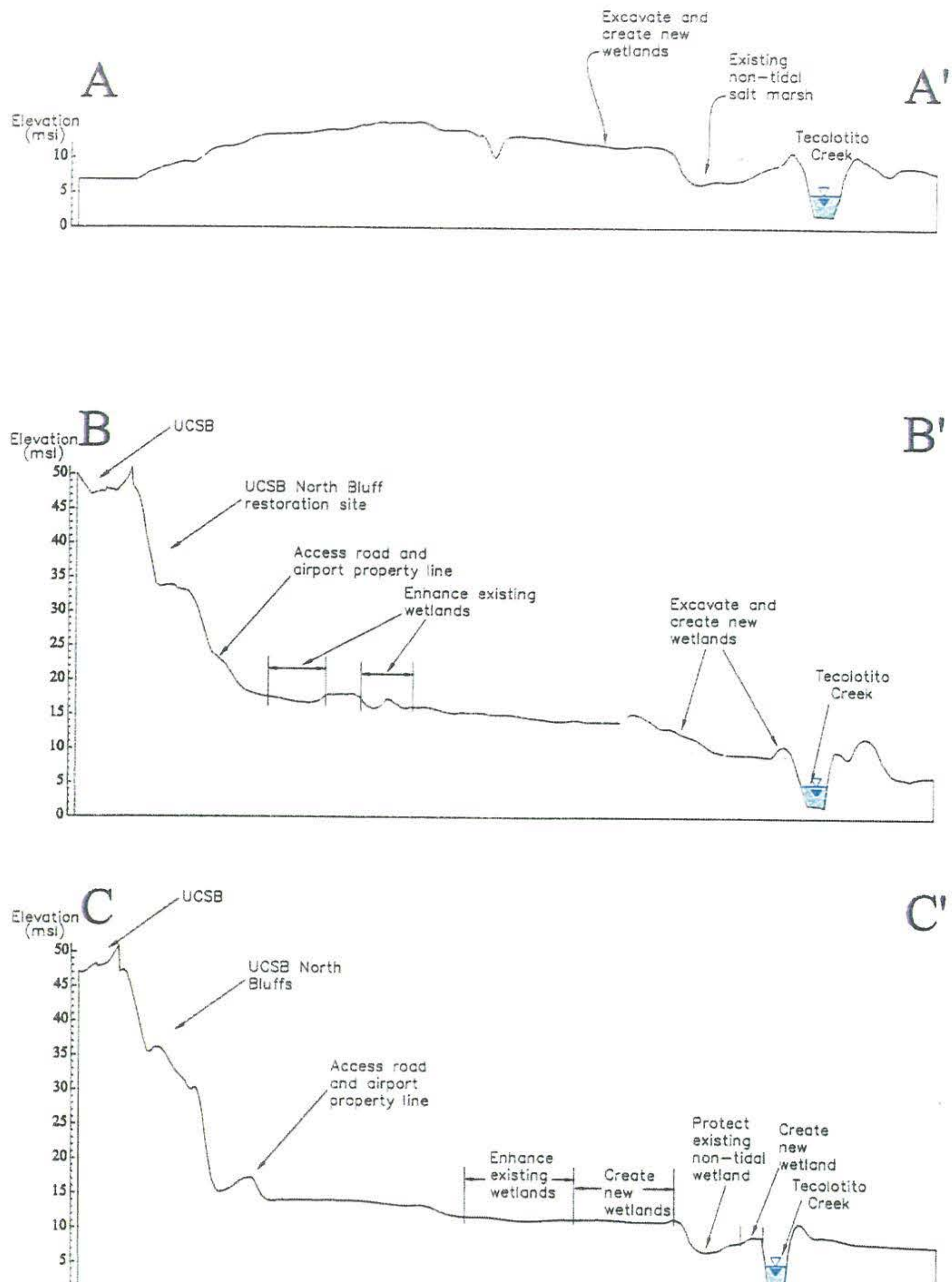

Cross section locations shown on Figure 15

0 250 500

Horizontal Scale in Feet
Vertical exaggeration 10 times

FIGURE 19

CROSS SECTIONS OF HABITAT RESTORATION

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9/09/04 vsa..\Santa Barbara Municipal Airport Phase 3\ Graphics\Fig 19.cdr

FIGURE 20

PROPOSED ENLARGED SEDIMENT BASINS