FLOOD INSURANCE STUDY

SAN DIEGO COUNTY, CALIFORNIA

AND INCORPORATED AREAS

VOLUME 1 OF 7

COMMUNITY NAME	COMMUNITY NUMBER
CARLSBAD, CITY OF	060285
CHULA VISTA, CITY OF	065021
CORONADO, CITY OF	060287
DEL MAR, CITY OF	060288
EL CAJON, CITY OF	060289
ENCINITAS, CITY OF	060726
ESCONDIDO, CITY OF	060290
IMPERIAL BEACH, CITY OF	060291
LEMON GROVE, CITY OF	060723
NATIONAL CITY, CITY OF	060293
OCEANSIDE, CITY OF	060294
POWAY, CITY OF	060702
SAN DIEGO, CITY OF	060295
SAN DIEGO COUNTY, UNINCORPORATED AREAS	060284
SAN MARCOS, CITY OF	060296
SANTEE, CITY OF	060703
SOLANA BEACH, CITY OF	060725
VISTA, CITY OF	060297

COMMUNITY NAME	COMMUNITY NUMBER
*LA MESA, CITY OF	060292

*NON-FLOODPRONE COMMUNITY

REVISED: JUNE 16, 1999

Federal Emergency Management Agency

NOTICE TO
FLOOD INSURANCE STUDY USERS

Communities participating in the National Flood Insurance Program have established repositories of flood hazard data for floodplain management and flood insurance purposes. This Flood Insurance Study may not contain all data available within the repository. It is advisable to contact the community repository for any additional data.

This publication incorporates revisions to the original Flood Insurance Study. These revisions are presented in Section 10.0.

Initial Countywide Flood Insurance Study Effective Date: June 19, 1997

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Volume 7

FLOOD INSURANCE STUDY
SAN DIEGO COUNTY, CALIFORNIA AND INCORPORATED AREAS

1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study revises and updates information on the existence and severity of flood hazards in the geographic area of San Diego County, California, including the Cities of Carlsbad, Chula Vista, Coronado, Del Mar, El Cajon, Encinitas, Escondido, Imperial Beach, Lemon Grove, National City, Oceanside, Poway, San Diego, San Marcos, Santee, Solana Beach and Vista, and the unincorporated areas of San Diego County (referred to collectively herein as San Diego County), and aids in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

San Diego County also includes the City of La Mesa, which does not contain any identified Special Flood Hazard Areas.

In some states or communities, floodplain management criteria or regulations may exist that are more restrictive or comprehensive than the minimum Federal requirements. In such cases, the more restrictive criteria take precedence and the State (or other jurisdictional agency) will be able to explain them.

1.2 Authority and Acknowledgments

The sources of authority for this Flood Insurance Study are the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

San Diego County, Unincorporated Areas

The hydrologic and hydraulic analyses for South Las Chollas Creek and Las Puleta Creek in the initial study were performed by the City of San Diego for the Federal Emergency Management Agency (FEMA), and were completed in September 1979.

The hydrologic and hydraulic analyses in the initial study for Broadway Creek and Sweetwater River (near National City) were performed by the U.S. Army Corps of Engineers (USACE), Los Angeles District, for FEMA under Interagency Agreement No. H-19-74, Project Order No. 13 and Interagency Agreement No. H-16-75, Project Order No. 22. This work was completed in June and September 1976, respectively.

Hydrologic and hydraulic analyses in the initial study for Agua Hedionda Creek, Buena Creek, Escondido Creek, Hatfield Creek, Kit Carson Park Creek downstream of its confluence with Kit Carson Park Creek Tributary, Kit Carson Park Creek Tributary, Los Coches Creek, North Tributary to Santa Maria Creek, the Otay River, Reidy Creek, Santa Maria Creek (Santa Maria Valley Area), South Tributary to Santa Maria Creek, a portion of the Sweetwater River, Telegraph Canyon Creek, South Tributary to Santa Maria Creek, and hydrologic and preliminary hydraulic analyses in the initial study for Carroll Canyon Creek, Casa de Oro Creek, Descanso Creek, Kit Carson Park Creek, Samagutuma Creek, the San Diego River, San Vicente Creek, Spring Valley Creek, and Sweetwater River (Descanso area) were performed by the California Department of Water Resources for FEMA under Contract No. H-3947. Final hydraulic analyses for Carroll Canyon Creek, Casa de Oro Creek, Descanso Creek, Harbison Canyon Creek, Kit Carson Park Creek, Samagutuma Creek, the San Diego River, San Vicente Creek, Spring Valley Creek, and the Sweetwater River (Descanso area) were performed by Dames & Moore under Contract No. C-0542. Hydrologic and hydraulic analyses for the Pacific Ocean were performed by Tetra Tech, Inc., under Contract No. H-4543. This work was completed in December 1981.

The updated hydraulic analysis for Harbison Canyon Creek was performed by the San Diego County Department of Public Works. This work was completed in May 1986.

The initial hydrologic analyses for San Luis Rey River, Moosa Canyon Creek, and South Fork Moosa Canyon Creek were performed by the California Department of Water Resources under Contract No. H-3947.

Hydraulic analyses for Alpine Creek, Moosa Canyon Creek, South Fork Moosa Canyon Creek, the San Luis Rey River, Santa Maria Creek (San Pasqual Valley area), Santa Ysabel Creek, and the Sweetwater River were performed by Nolte and Associates under Contract No. EMW-83-6-1163. This work was completed in August 1986.

Revisions to the flood delineations along Los Coches Creek resulted from the construction of a concrete-lined channel from its confluence with San Diego River west of Winter Garden Boulevard to Ha-Hana Road. Technical data to support the revision were prepared by the USACE, Los Angeles District. This work was completed in February 1987.

Floodplain and floodway boundary delineation revisions along South Fork Moosa Canyon Creek from a point approximately 2,400 feet downstream of Champagne Boulevard to Champagne Boulevard were based on information prepared by Civil Design Group, Ltd. These revisions were the result of channel improvements through the Welk Park North subdivision. This work was completed in November 1987.

Floodplain and floodway boundary delineations along the San Diego River from the City of Santee, California, to the confluence of San Vicente Creek were prepared by the San Diego County Department of Public Works. This work, completed in March 1988, and the work completed in 1987, 1986, 1981, 1979, and 1976, accounted for all significant flooding sources affecting the unincorporated areas of San Diego County.

City of Carlsbad

The original study was prepared by Dames & Moore, for FEMA under Contract No. C-0542. This work was based on the hydrologic and hydraulic analyses performed by Tetra Tech, Inc., and the California Department of Water Resources for FEMA. This work, which was completed in December 1981, covered all significant flooding sources affecting Carlsbad.

This study has been revised based on a revised hydraulic analysis for a portion of Buena Vista Creek that was performed by George S. Nolte and Associates and submitted to FEMA in June 1986.

For this revised study the hydrologic analyses of the coastal areas were performed by Dames & Moore, for FEMA, under Contract No. CMW-C-0970.

City of Chula Vista

The hydrologic and hydraulic analyses were performed by Tetra Tech, Inc., for San Diego Bay, under Contract No. H-4543; the California Department of Water Resources, for Telegraph Canyon Creek and Otay River, under Contract No. H-3947; and the USACE, Los Angeles District, for part of Sweetwater River, under Inter-Agency Agreement No. IAA-H-16-75, Project Order No. 22. This work was completed in December 1981. The hydrologic and hydraulic analyses for Poggi Canyon Creek, Rice Canyon Creek, part of Sweetwater River and Telegraph Canyon Creek Overflow were performed by George S. Nolte and Associates, for FEMA, under Contract No. EMW-823-C-1163. This work was completed in December 1984.

City of Coronado

The hydrologic and hydraulic analyses for this study were performed by Dames & Moore, for FEMA, under Contract No. C-0970. This study was completed in June 1986.

City of Del Mar

The hydrologic and hydraulic analyses for the Pacific Ocean were performed by Tetra Tech, Inc., under Contract No. H-4543. A regression analysis was used to supersede the approximate coastal analysis and to update the coastal analysis done by Tetra Tech. This regression analysis was performed by Dames & Moore under Contract No. C-0970.

The hydrologic and hydraulic analyses for Soledad Canyon were performed by the California Department of Water Resources, under Contract No. C-0452. The hydraulic analysis of the San Dieguito River was performed by George S. Nolte and Associates for FEMA under Contract No. EMW-83-C-1163. This work, which was completed in February 1985, covered all significant flooding sources affecting the City of Del Mar.

City of El Cajon

The hydrologic and hydraulic analyses for this study were performed by the USACE, Los Angeles District, for the Federal Insurance Administration under Interagency Agreement No. IAA-H-19-74, Project Order No. 13. This work, which was completed in June 1976, covered all flooding sources affecting the City of El Cajon. Additional analysis for downstream portions of Forester Creek was provided by the San Diego County Department of Sanitation and Flood Control.

City of Encinitas

The hydrologic and hydraulic analyses for this study were performed by the California Department of Water Resources and by Tetra Tech, Inc., and under FEMA Contracts H-3947 and H-4543, respectively.

City of Escondido

Additional hydrologic and hydraulic analyses for this study were performed by George S. Nolte and Associates, for FEMA, under Contract EMW-83-6-1163. This study was completed in February 1985.

City of Imperial Beach

The hydrologic and hydraulic analyses for the Tijuana River for the revised study were performed by George S. Nolte and Associates for the City of San Diego, California. This work was completed in July 1985.

In coastal areas, the hydrologic analyses for this study were performed by Dames & Moore, for FEMA, under Contract No. C-0970. This work was completed in June 1986.

Hydrologic and hydraulic analyses of the Otay River were performed by the USACE, Los Angeles District, for FEMA, under Interagency Agreement No. IAA-H-16-75, Project Order No. 17. This work was completed in November 1976. However, this work was superseded by the coastal analyses completed in 1986.

City of Lemon Grove

The hydrologic and hydraulic analyses for this study were performed by George S. Nolte and Associates, the study contractor, for FEMA, under Contract No. EMW-83-6-1163.

City of National City

The original hydrologic and hydraulic analyses for this community were performed by the USACE, Los Angeles District, for FEMA, under Interagency Agreement No. IAA-H-16-75, Project Order No. 22. That work was completed in September 1976.

The hydrologic and hydraulic analyses for La Paleta Creek were performed by the City of San Diego and were completed in 1979.

For the revised study, the hydraulic analysis for Sweetwater River upstream of a point approximately 0.6 mile upstream of Interstate 805 was performed by George S. Nolte & Associates, for FEMA, under Contract No. EMW-83-C-1163. This work was completed in December 1984.

For the revised study, the hydrologic analyses of coastal areas were performed by Dames & Moore, for FEMA, under Contract No. C-0970.

City of Oceanside

The original study report was prepared by Dames & Moore for FEMA, under Contract No. C-0542. This work was based on hydrologic and hydraulic analyses for Buena Vista Creek and hydrologic and preliminary hydraulic analyses for Loma Alta Creek performed by the California Department of Water Resources, under Contract No. H-3947, and hydrologic and hydraulic analyses for the Pacific Ocean performed by Tetra Tech, Inc., under Contract No. H-4543. The original study was completed in December 1981.

The hydrologic and hydraulic analyses for the revised study, except the hydrologic analyses for the coastal areas, were performed by George S. Nolte & Associates, for FEMA, under Contract No. EMW-83-C-1163. This work was completed in July 1985.

For the revised study, the hydrologic analyses of the coastal areas were performed by Dames & Moore, for FEMA, under Contract No. C-0970.

A revised hydraulic analysis for a portion of Buena Vista Creek was performed by George S. Nolte and Associates in June 1986.

City of Poway

The hydrologic and hydraulic analyses for this study were performed by the San Diego County Department of Public Works, for FEMA, under Contract No. C-0970. This study was completed in January 1983.

City of San Diego

The hydrologic and hydraulic analyses for Las Chollas Creek; Wabash Branch; Home Avenue Branch; South Las Chollas Creek; Encanto Branch; Switzer Creek; Florida Drive Branch; Las Puleta Creek; Nestor Creek; Sunrise Overflow; Wabash Tributary; Chollas Reservoir Branch; Radio Drive Tributary; Jamacha Branch; Cadman Street Tributary; Logan Avenue Branch; Goat Canyon Creek; Paradise Creek - North Branch, North Branch Tributary, and Valley Road Branch; Curlew Creek; Maple Street Canyon Tributary; Arroyo Drive Tributary; Reynard Way Tributary; and the hydrologic analysis for the Tijuana River were performed by the City of San Diego and were completed in 1979.

Hydrologic and hydraulic analyses for Murray Canyon Creek, Otay River, Rose Canyon Creek, San Clemente Canyon Creek, San Diego River, Tecolote Creek, and Telegraph Creek, and hydrologic and preliminary hydraulic analyses for Carmel Valley Creek, Carroll Canyon Creek, Kit Carson Park Creek, Los Penasquitos Creek, and Soledad Canyon were performed by the California Department of Water Resources for FEMA, under Contract No. H-3947. Final hydraulic analyses for Carroll Canyon Creek, Kit Carson Park Creek, Los Penasquitos Creek, and Soledad Canyon were performed by Dames & Moore under Contract No. H-4834. Hydrologic and hydraulic analyses for the Pacific Ocean, Mission Bay, and San Diego Bay were performed by Tetra Tech, Inc., for FEMA, under Contract No. H-4543. This work was completed in December 1981.

The upstream portion of Los Penasquitos Creek commencing at the dam just upstream of the confluence with Chicarita Creek has been revised by Rick Engineering in July 1985. Final hydrologic and hydraulic analyses for Carmel Valley Creek were performed by Leedshill Herkenhoff, Inc., in December 1985.

Hydraulic analyses for Murphy Canyon Creek, San Diego River upstream of Friars Road, Santa Ysabel Creek, Santa Maria Creek, the Tijuana River, and Alvarado Canyon Creek were performed by George S. Nolte and Associates, for FEMA, under Contract No. EMW-83-6-1163. The 1985 restudy which was completed in July 1985, along with the work completed in 1979 and 1981, covered all significant flooding sources affecting the City of San Diego.

City of San Marcos

The hydrologic and hydraulic analyses for the original study were performed by the USACE, Los Angeles District, for FEMA, under Interagency Agreement No. IAA-H-15-72, Project Order No. 14. That study was completed in March 1975.

In December 1986, FEMA authorized a restudy of the City of San Marcos to include areas annexed by the city since the publication for the previous Flood Insurance Study. No new or revised hydrologic or hydraulic analyses were performed for this restudy. Approximate floodplain boundaries along San Marcos Creek and Lake San Marcos were added within the annexed portions of the city, downstream of Discovery Street (Reference 1).

The hydrologic and hydraulic analyses for a restudy of the City of San Marcos were prepared by Nolte and Associates. New analyses were performed for San Marcos Creek and its tributaries. The restudy was completed in December 1989.

The restudy incorporates analyses performed by Boyle Engineering Corporation for the Woodland Parkway culvert at the upstream limits of San Marcos Creek, and analyses performed by JBF and Associates, and Dudek and Associates for the Las Posas Road Drainage System. In addition, analyses performed by Landmark Engineering and Stevenson, Porto & Pierce, Inc., were used in delineating the floodway boundaries along short reaches of San Marcos Creek and the Highway 78 Split Flow.

In December 1992, FEMA received the final information required to modify the 100-year flood elevations, floodplain boundary delineations, and floodway boundary delineations along Twin Oaks Valley Creek from approximately 2,950 feet upstream of Mission Road to approximately 5,750 feet upstream of La Cienega Road. These modifications were made based on analyses performed by Hunsaker & Associates, Irvine, Inc.

<u>City of Santee</u>

The hydrologic and hydraulic analyses for this study were performed by the San Diego County Department of Public Works.

<u>City of Solana Beach</u>

The hydrologic and hydraulic analyses for the coastal analysis were performed by Tetra Tech, Inc., under Contract No. H-4543. This work was completed in December 1981.

The hydraulic analyses of the San Dieguito River were performed by George S. Nolte and Associates under Contract No. EMW-83-C-1163. This work was completed in February 1985.

<u>City of Vista</u>

The hydrologic and hydraulic analyses for Agua Hedionda Creek, Buena Creek, and the southwestern portion of Buena Vista Creek were performed by the California Department of Water Resources, under Contract No. H-3947. This work was completed in December 1981.

Additional hydrologic and hydraulic analyses for the northwestern portion of Buena Vista Creek, were performed by George S. Nolte and Associates, for FEMA, under Contract No. EMW-83-C-1163. This work was completed in January 1985.

1.3 Coordination

The following entities were contacted for information pertinent to the individual Flood Insurance Studies:

Boyle Engineering Corporation
California American Water Company
California Coastal Commission
California Department of Transportation
California Department of Water Resources
CH2M HILL, Inc.
City of Carlsbad, California
City of Chula Vista, California
City of Coronado, California
City of Del Mar, California
City of Imperial Beach, California

City of National City, California
City of Oceanside, California
City of San Diego, California
City of Vista, California
Comprehensive Planning Organization of the San Diego Region
Federal Highway Administration
International Boundary and Water Commission, U.S. Section
Leedshill-Herkenhoff, Inc.
National Oceanic and Atmospheric Administration, Eastern Pacific Hurricane Center
National Oceanic and Atmospheric Administration, National Climatic Center
National Oceanic and Atmospheric Administration, Tide Predictions Branch
National Weather Service, Los Angeles, California
San Diego Coast Regional Commission
San Diego County
San Diego County Department of Sanitation and Flood Control
San Diego Public Library
Scripps Institute of Oceanography
Security Pacific Bank
U.S. Army Corps of Engineers, Coastal Engineering Research Center
U.S. Army Corps of Engineers, Los Angeles District
U.S. Army Corps of Engineers, Waterways Experiment Station
U.S. Department of Defense, Fleet Numerical Weather Center
U.S. Geological Survey

During the preparation of the initial Flood Insurance Studies for the individual communities, FEMA representatives held coordination meetings with community officials, representatives of the study contractor for each study, and other interested agencies and citizens. The meetings, referred to as the initial, intermediate, and final Consultation Coordination Officer meetings, were held at specified intervals during the preparation of the studies. The comments and issues raised at those meetings were addressed in the Flood Insurance Study for each community. The dates that the meetings were held for each community are provided in Table 1.

2.0 AREA STUDIED

2.1 Scope of Study

This Flood Insurance Study covers the geographic area of San Diego County, California, including the incorporated communities listed in Section 1.1. The streams that were studied by detailed methods are listed in Table 2.

Approximate analyses were used to study those areas having a low development potential or minimal flood hazards. The scope and methods of study were proposed to, and agreed upon by, FEMA and the individual communities.

Table 1. Community Coordination Officer (CCO) Meetings

Community Name	Final CCO Meeting
San Diego County, Unincorporated Areas	July 31, 1986
Carlsbad, City of	November 23, 1982
Chula Vista, City of	November 23, 1982 (Otay River) November 9, 1984
Coronado, City of	
Del Mar, City of	November 8, 1984
El Cajon, City of	March 11, 1976
Encinitas, City of	July 17, 1987
Escondido, City of	November 23, 1982 (Reidy Creek) November 8, 1984
Imperial Beach, City of	May 24, 1977 August 1, 1986
Lemon Grove, City of	February 5, 1987
National City, City of	May 29, 1977
Oceanside, City of	November 22, 1982 May 31, 1985 (Garrison Creek and San Luis Rey River)
Poway, City of	
San Diego, City of	November 23, 1982 May 31, 1985
San Marcos, City of	June 28, 1977
Santee, City of	November 15, 1983
Solana Beach, City of	March 18, 1987
Vista, City of	November 23, 1982 November 7, 1984

Table 2. Streams Studied by Detailed Methods

Agua Hedionda Creek (At City of Carlsbad)	Pomerado Creek
Agua Hedionda Creek (At City of Vista)	Poway Creek
Beaver Hollow Creek	Rainbow Creek (Main Branch)
Beeler Creek	Rainbow Creek (West Branch)
Broadway Creek	Rattlesnake Creek
Buena Creek	Rattlesnake Creek Split Flow at Heritage Hills
Buena Vista Creek	Rattlesnake Creek Split Flow at Midland Road
Buena Vista Creek Tributary 1	Reidy Creek
Calavera Creek	Rice Canyon Creek
Calavera Creek Overbank Split Flow	Rose Canyon Creek
Carmel Valley Creek	Samagutuma Creek
Carroll Canyon Creek	San Clemente Canyon Creek
Coleman Creek	San Diego River
County Ditch Creek	San Dieguito River
Deer Springs Creek	San Elijo Creek
Descanso Creek	San Luis Rey River (At Oceanside)
Encanto Branch	San Marcos Creek
Escondido Creek	San Marcos Creek Highway 78 Split Flow
Escondido Creek (Above Lake Wohlford)	San Vicente Creek
Escondido Creek (Left Reach)	Santa Maria Creek (San Pasqual Valley Area)
Eucalyptus Hills (East Branch)	Santa Maria Creek (Santa Maria Valley Area)
Eucalyptus Hills (West Branch)	Santa Ysabel Creek
Florida Drive Branch	Slaughterhouse Creek
Forester Creek	Soledad Canyon
Forester Creek-Carlton Hills Boulevard Overflow	South Branch Poway Creek
Garrison Creek	South Fork Moosa Canyon Creek
Gopher Canyon Creek	South Las Chollas Creek
Green Valley Creek	South Tributary to Santa Maria Creek
Green Valley Creek Tributary	Spring Valley Creek
Harbison Canyon Creek	Steele Canyon Creek
Hatfield Creek	Stevenson Creek
Home Avenue Branch	Sunrise Overflow
Johnson Canyon Creek	Sweetwater River (Above Reservoir)
Kit Carson Park Creek	Sweetwater River (At National City)
Las Chollas Creek	Sweetwater River (Descanso Area)
Las Posas Creek (Upper)	Switzer Creek
Las Puleta Creek	Tecolote Creek
Lawson Valley Creek	Telegraph Canyon Creek
Loma Alta Creek	Tijuana River
Los Penasquitos Creek	Tributary of South Tributary to Santa Maria Creek
Lusardi Creek	Tributary to Forester Creek
Mexican Canyon Creek	Tributary to Forester Creek (South Branch)
Moosa Creek (North Branch)	Tributary to Sweetwater River
Moosa Creek (South Branch)	Twin Oaks Valley Creek
Murphy Canyon Creek	Wabash Branch
Murray Canyon Creek	Witch Creek
Nestor Creek	
North Branch Poway Creek	
North Tributary to Santa Maria Creek	
Olive Creek	
Otay River	
Pala Mesa Creek	
Paradise Creek	
Pilgrim Creek	
Poggi Canyon Creek	

The creeks located in eastern San Diego County in the desert area, namely Box Canyon, Coyote Canyon, Unnamed Canyon, El Vado Canyon, Henderson Canyon, Borrego Palm Canyon, Fire Canyon, Hellhole Canyon, Dry Canyon, and Tubb-Culp Canyon, were studied by the alluvial fan method. All of the above creeks in the desert area were studied from the apex of the alluvial fan down toward the Borrego Sink area.

Flooding caused by the Pacific Ocean (which also affects San Diego Bay and Oneonta Slough) was studied by detailed methods.

Detailed analyses were performed to evaluate flood hazards from shallow flooding in three areas throughout the City of Escondido, designated as "West," "North," and "South." The West areas comprised flooding for Country Club Creek, from the intersection of Gary Lane with Nutmeg Street, downstream to El Norte Parkway (corporate limits). The West areas also included analyses of flooding from the Unnamed Tributary at the intersection of Golden Circle Drive and Country Club Lane, downstream to Country Club Creek. Shallow flooding in the South areas was studied along Citrus Wash from Falconer Road to Ash Street, and along South Midway Wash from Oak Hill Memorial Park Cemetery to its confluence with Citrus Wash. North area shallow flooding included analysis of Maywood Wash and Midway Wash. Maywood Wash was studied from La Honda Drive, 2,200 feet north of El Norte Parkway, downstream to Escondido Creek. Midway Wash was studied from El Norte Parkway downstream to Escondido Creek.

The following flooding sources were studied by approximate methods: Alpine Creek, Casa de Oro Creek, Kit Carson Park Creek Tributary, La Orillia Road Tributary, Las Puleta Creek, Los Coches Creek, Moosa Canyon Creek, Murphy Creek, Rice Canyon, a portion of San Diego River, San Dieguito River and Spring Valley Creek.

Kit Carson Park Creek and overflow of Dixon Reservoir from the dam to Escondido Creek were studied by approximate methods.

Approximate methods were used to study the flooding that exists along Federal Boulevard within the corporate limits of the City of Lemon Grove.

Approximate flooding on an unnamed tributary along Avenida Magnifica to Carrol Canyon Creek was deleted due to construction of a large concrete-lined channel which is designed to carry the 100-year flood.

Curlew Creek, and its tributaries, Maple Street Canyon and Arroyo Drive, were studied by approximate methods, as were Wabash Tributary and Chollas Reservoir Branch of Las Chollas Creek; Radio Drive Tributary and Cadman Street Tributary of South Las Chollas Creek; Paradise Creek - Valley Road Branch, North Branch, and North Branch Tributary; Logan Avenue Branch of Las Puleta Creek; a portion of Switzer Creek; a portion of Las Puleta Creek; Jamacha

Branch of South Las Chollas Creek; Goat Canyon Creek; Reynard Way Tributary; and Alvarado Canyon Creek.

2.2 Community Description

San Diego County is located in the southwest corner of California. It is bounded on the west by the Pacific Ocean, on the north by Riverside County, on the east by Imperial County, and on the south by Mexico.

San Diego County has a total area of 4,314 square miles, 459 square miles of which are incorporated areas encompassing 13 cities. The population of San Diego County is relatively low, approximately 1,520,000 people, of which approximately one-half live in the City of San Diego, leaving the unincorporated areas of San Diego County with a population density of approximately 200 persons per square mile.

San Diego County has approximately 76 miles of coastline. Much of the coastal plain is elevated and not subject to coastal flooding. Most of the low-lying and densely populated coastal areas lie in and around the City of San Diego.

The climate of the San Diego area is classified as subtropical Mediterranean. Annual rainfall averages 9 to 10 inches a year. The majority of precipitation occurs from December to March. In the summer, rainless periods may extend for as long as 4 months. Temperatures range from an average summer temperature of 75°F to an average winter temperature of 65°F.

Agua Hedionda and Buena Creeks are located in the northern part of San Diego County approximately 45 miles from downtown San Diego. Major economic interests adjacent to these creeks consist of chicken ranches and other commercial areas. There are several residential structures located along both streams. Eighty percent of the stream length is under the jurisdiction of San Diego County, while the remainder is within the City of Vista. The drainage area for Agua Hedionda Creek is approximately 6 square miles.

Most of Broadway Creek flows through the City of El Cajon and drains an area of approximately 4.5 square miles. The floodplain of Broadway Creek is ill-defined, and development generally extends to the channel banks in the developed areas.

Carroll Canyon Creek flows westerly through the northern portion of the City of San Diego. Development in the floodplain is sparse. Carroll Canyon drains an area of approximately 18 square miles.

Casa de Oro Creek, a tributary of Spring Valley Creek, flows southwesterly in the Spring Valley area and has a drainage area of approximately 3 square miles. The area is composed of a foothill terrain with a long, narrow valley running generally in a north-south direction. Rocks in the immediate Spring Valley Creek area are primarily pre-cenozoic metamorphic rocks, designated as

Santiago Peak Volcanics; Black Mountain Volcanics; Bedford Canyon formation; undifferentiated metamorphic rocks; and Quarternary Residuum. The remnants of native vegetation, previously disturbed areas containing successional vegetative growth, and areas of introduced vegetation still provide habitats for numerous species of wildlife.

Descanso Creek flows south-southwesterly to Sweetwater River (near Descanso) and has a drainage area of approximately 6 square miles.

Escondido Creek flows southwest through the west central portion of the county. The basin drains approximately 89 square miles, with topography varying from rugged to gently rolling hills. Escondido Creek flows down a narrow canyon to the City of Escondido corporate limits, where it is contained within a concrete flood-control channel.

Harbison Canyon Creek is a tributary to Sweetwater River. The drainage basin is located between Loveland Reservoir and the City of El Cajon. It drains an area of approximately 10 square miles.

Hatfield Creek lies in the Santa Maria Valley, located approximately 30 miles northeast of the City of San Diego. The central portion of the valley consists of approximately 25 square miles of relative flatland that gives way to rugged foothills on all sides. The valley is bisected by the bed of Santa Maria Creek, which flows only at periods of high runoff during the winter months. The central portion of the valley contains the unincorporated Town of Ramona. Hatfield Creek drains an area of approximately 30 square miles.

Kit Carson Park Creek originates east of the City of Escondido in the foothills and flows southerly into Lake Hodges, in the northeast corner of San Diego County. This stream has a drainage area of approximately 7 square miles.

Mexican Canyon Creek originates north of Jamul and flows westerly along Jamul Drive. Draining 4.7 square miles, Mexican Canyon Creek discharges to the Sweetwater River in Cottonwood Country Club.

North Tributary to Santa Maria Creek is located in the Santa Maria Valley and drains an area of approximately 33 square miles.

Most of the Otay River Valley is located in the unincorporated areas of southern San Diego County. Portions of the floodplain near the mouth are within the corporate limits of the City of San Diego.

The Otay River basin is situated between the Telegraph Canyon and Sweetwater River basins to the north and the Tijuana River basin to the south. The basin has a drainage area of approximately 140 square miles. The upper 99 square miles of area are controlled by Savage Dam, which forms Lower Otay Reservoir, and a smaller dam in Proctor Valley which forms Upper Otay Reservoir.

The Otay River basin is somewhat pearshaped, with a maximum eastwest length of approximately 25 miles and a maximum width of approximately 10 miles. Elevations range from approximately 3,300 feet at White Mountain to sea level where Otay River flows into the southern end of San Diego Bay. Stream slopes in the area above the reservoirs range from 200 to 300 feet per mile; below Savage Dam, the subbasins have stream slopes ranging from 100 to 400 feet per mile (Reference 1).

The geology of the area is one of eroded upland surfaces, with numerous short streams, broad mature valleys, and a coastal plain on which marine terraces (locally called mesas) are prominently visible. The higher portions of the basins are underlain by igneous and metamorphic rocks of Pre-Cretaceous age. In the western portion, marine sedimentation of younger ages is encountered. The most recent deposits, mainly sands, silts, and calcarious clays, form a thin cover over uplifted marine terraces and can also be found in the floodplain of many of the streams (Reference 1).

Soils in the upper reaches of the basin are rocky, silty loam. They are shallow and poorly developed with high runoff potential. In the stream bottoms and lower portion of Otay Valley, the soils are well-developed sandy loam that can sustain agricultural cultivation. The U.S. Department of Agriculture, Soil Conservation Service (SCS) has classified this soil as having moderate runoff potential (Reference 1).

Development of the Otay floodplain downstream of the Interstate Highway 805 bridge is not extensive; however, it does increase. Manufacturing, commercial, and residential encroachment into the floodplain is not extensive at this time with the exception of numerous sand and gravel operations just east of Beyer Way to Hollister Street to the west. Developments in the floodplain downstream of Hollister Street include farms, a mobile home park, and a sewage treatment plant. At the mouth of the Otay River, numerous dikes have been constructed in San Diego Bay to form salt evaporators which are leased by the Western Salt Company.

Although development in the Otay floodplain is light at present, the lower reaches of the study area are under intense pressure for development. These pressures will undoubtedly increase for the entire Otay Valley area as population growth and urban expansion continue to increase.

Reidy Creek originates in the foothills north of the City of Escondido and has a drainage area of approximately 15 square miles before joining with Escondido Creek east of the intersection of Tulip Street and Hale Avenue.

Rice Canyon Creek flows through the eastern section of the City of Chula Vista and discharges into the Sweetwater River near Interstate Highway 805. The flow collects in a natural basin near the eastern study limit and is carried in a large culvert under residential and developing residential areas.

Samagutuma Creek flows westerly to Sweetwater River (Near Descanso) and has a drainage area of approximately 6 square miles.

Santa Maria Creek originates in the mountains above Valley de Los Amigos. The creek flows westerly through the Santa Maria Valley to Bandy Canyon, through which it continues in a northwesterly direction into the San Pasqual Valley where it flows in a dredged channel to its confluence with Santa Ysabel Creek. Elevations range from 380 feet at the confluence to 1,294 feet at the stream gage at the upstream end of Bandy Canyon to 3,279 feet at Witch Creek Mountain. The drainage basin of Santa Maria Creek occupies approximately 57 square miles and is roughly rectangular in shape, being 15 miles long and 4 miles wide within the Santa Maria Valley. The valley is located approximately 30 miles northeast of San Diego and 25 miles inland. The central portion of the valley consists of approximately 25 square miles of relatively flat land that gives way to rugged foothills on all sides. The valley is bisected by the bed of Santa Maria Creek, which flows only at periods of high runoff during the winter months. The central portion of the valley contains the unincorporated Town of Ramona. While the valley is primarily residential and agricultural in nature, there are a number of commercial and industrial activities in Ramona. The general pattern of zoning as established by San Diego County is for agricultural use outside the central area of Ramona and for residential use around that central area. The area immediately to the southeast and southwest of Ramona is zoned for residential use of the type likely to encourage the construction of individual homes. A large portion of the area west of Ramona is zoned for eight 1-acre home sites which, in effect, holds the land open for future changes in land use.

The San Diego River flows westerly through the central portion of the county. The river drains 433 square miles at its mouth in Mission Bay. Sand and gravel operations exist at several locations within the floodplain. The land along the river is used for cultivation, dairy farming, and ranching.

San Vicente Creek flows south from San Vicente Reservoir to San Diego River in the south central portion of the county. The drainage area is approximately 83 square miles.

South Fork Moosa Canyon Creek is located in the northern portion of San Diego County and flows generally north to its confluence with Moosa Canyon Creek. A major development straddling the creek is Lawrence Welk's Country Club Village, Mobile Home Park, and Golf Course.

Floodplain development on South Las Chollas Creek is composed of industrial and commercial development downstream of Interstate Highway 805, residential areas upstream of Interstate Highway 5 on the south bank and upstream of Euclid Avenue, and a mobile home park upstream of 47th Street on the north bank in the City of San Diego. The drainage area is approximately 11 square miles.

South Tributary to Santa Maria Creek and Tributary of South Tributary to Santa Maria Creek are located in the Santa Maria Valley. The drainage area for South Tributary to Santa Maria Creek is approximately 9 square miles.

Spring Valley Creek originates in the La Mesa area east of San Diego and flows southward to join the Sweetwater River below Sweetwater Reservoir. The basin runs in a north-south direction, with a drainage area of approximately 12 square miles. It has a length of approximately 8 miles and an average width of 2 to 3 miles. The highest elevation is 1,373 feet above sea level at Mount Helix, a resistant hillock of the old San Diego Mesa erosion surface. The lowest elevation in the basin is approximately 140 feet at the mouth. The average slope along the longest watercourse is approximately 130 feet per mile.

Exposed soils in the upper reaches of the basin are rocky, coarse, sandy loam, which become finer as one travels to a lower elevation. Soils in the lower areas, where not altered by urbanization, are fine sandy loam.

In Spring Valley, a rapid transformation of rural space into urban space is occurring. Much of the undeveloped upland soil cover is composed of orchards, coastal scrub, and annual grasses. Within the floodplain, residential and commercial development has displaced or significantly modified the natural communities. Numerous trees, (California pepper trees, avocado trees, and olive trees), shrubs, and grasses have been introduced into the floodplain for agricultural and landscaping purposes.

The Sweetwater River drainage area comprises approximately 219 square miles and is elongated in shape. Elevations range from sea level at the mouth of Sweetwater River to approximately 6,500 feet at Cayamaca Peak. The gradient of Sweetwater River ranges from 6 feet per mile near the mouth to approximately 850 feet per mile at the headwaters.

The San Luis Rey River is located in the northern portion of San Diego County and runs generally east to west in a well-defined river bed. The major economic interest in and adjacent to the river is agriculture. Other interests are three golf courses (two major and one minor), an airport, sand and gravel operations, and a dairy. Major concentrations of homes occur around the golf courses. The Pauma Valley Country Club Estates was designed so the houses would be located on either side of the floodplain, which contains a golf course. Other small business and private homes are widely scattered along the river.

A high growth rate is projected for the northern portion of San Diego County. The freeway system currently being constructed will improve access and accelerate growth. Several major developments are proposed that include areas within the 100-year floodplain.

Buena Vista Creek originates in the San Marcos Mountains and flows westerly along the northern corporate limits of the City of Carlsbad into Buena Vista Lagoon, which empties into the Pacific Ocean. The entire watershed lies within San Diego County and includes parts of the Cities of Vista, Carlsbad, and Oceanside.

The Buena Vista Creek watershed is long and narrow. State Highway 78 abuts the creek for almost the entire study reach. It connects with Interstate Highway 5 on the west and U.S. Highway 395 on the east, facilitating quick transportation and communication between Carlsbad and Oceanside, Vista, San Marcos, Escondido, and communities outside the immediate area. Several highway interchanges have been constructed that traverse the floodplain, such as the one at Jefferson Street and College Boulevard in Carlsbad. These excellent transportation facilities will contribute to increased residential, commercial, and industrial development in the area.

The Poggi Canyon Creek drainage area comprises approximately 4.6 square miles. The creek flows in a steep, well-defined channel through the southeastern section of the City of Chula Vista and discharges into Otay River south of the city. A concrete trapezoidal channel carries the flow through the residential area from Oleander Avenue to a point above Otay Valley Road. In the less developed upper and lower areas, the creek flows in a natural channel.

The Telegraph Canyon Creek drainage area comprises 7.5 square miles and is an elongated area with a length approximately 9 miles and an average width approximately 0.8 mile. The creek originates at an elevation approximately 800 feet and flows generally in a westerly direction through the southern section of the City of Chula Vista to San Diego Bay.

In the upper basin of Telegraph Canyon Creek, open space and agricultural land uses predominate. The lower one-third of the basin is highly urbanized; encroachments and developments have highly modified and limited the creek and floodplain vegetative community. Approximately 82 percent of the drainage area is developed, and 57 percent of this developed area is in residential use. Annual and perennial herbs, grasses, and trees and shrubs characterize the vegetation through the urbanized areas.

The topography of the City of Coronado is generally low, with elevations ranging from sea level to approximately 20 feet National Geodetic Vertical Datum of 1929 (NGVD). The elevation of Highway 75 on the strand is approximately 10 feet. A few areas within the Naval Air Station on the northwestern part of the island reach an elevation of 30 feet. The northern part of the island is sheltered from open ocean waves by the rugged headland of Point Loma, whose elevations reach 300 feet. Serious erosion of beaches, especially of the beaches in the south, is occurring on the island. Actual measured beach erosion rates in Coronado over a 100-year period are estimated to average about 20 feet per year (Reference 2).

San Diego Bay ranges in depth from 30 to 70 feet in the northern part, 10 to 15 feet in the central bay (except for a 30-foot deep channel and some berthing areas along the eastern margin), and 0 to 8 feet in the south bay (except for several 8- to 20-foot channels) (Reference 3). The narrow entrance to San Diego Bay significantly reduces the action of ocean seas and swells upon the enclosed bay waters.

San Dieguito River flows westerly through the northern half of the City of Del Mar just south of the Del Mar racetrack. The river is controlled 9.5 miles upstream by Lake Hodges Dam. Upstream of the dam, the Santa Ysabel River contributes to the San Dieguito drainage. The Santa Ysabel River is controlled 39 miles upstream of Del Mar by the Sutherland Dam. The San Dieguito watershed is comprised of 347 square miles. The average slope for the approximately 1 mile of river flowing through Del Mar is 3 feet per mile. Soledad Canyon flows westerly just south of the city.

The Forester Creek basin, which includes the City of El Cajon, is characterized by a relatively flat, substantially developed valley floor surrounded by steep undeveloped hillsides. The valley floor generally extends from 350 feet to 550 feet NGVD, while the hillsides vary from 550 feet NGVD to a high elevation of over 1,750 feet NGVD at the ridge. Forester Creek, the main watercourse in the basin, varies in slope from 42 feet per mile in the valley portion to over 300 feet per mile within its steep headwaters above Greenfield Drive.

Forester Creek drains northwest to join the San Diego River near the City of Santee. Notable tributaries to Forester Creek, within the city, are County Ditch Creek, Washington Creek, and Broadway Creek. Floodplains along all streams are ill-defined, and development generally extends to channel banks in the developed portions of the city.

In the City of Escondido, Country Club Creek and its tributary drain a 2.1 square mile watershed on the southwest side of the Merriam Mountains. Development in flood-prone areas consists mostly of single-family homes built around a golf course and country club. Midway and Maywood Washes drain approximately 2 square miles through established residential areas to the north of Escondido Creek. Upstream of their confluence, Citrus and South Midway Wash each drain almost 1 square mile. Established development consists of a mix of single- and multi-family residential home, schools, and commercial buildings. Downstream from their confluence, flood-prone areas are predominantly commercial.

Paradise Creek, a tributary to the Sweetwater River, flows southwesterly through the City of National City. The major portion of National City is in the 5-square mile drainage area of Paradise

Creek. The highest elevation in the area is 460 feet NGVD. The gradient of Paradise Creek is approximately 2.5 feet per mile from the mouth to Harbison Avenue and approximately 105 feet per mile from Harbison Avenue to its headwaters. Paradise Creek passes through highly developed areas, and the natural course of the stream has been altered significantly by diversion works designed to convey floodwater away from the center of the city. However, these diversion works lack the capacity to divert major flows.

In addition to the Sweetwater River and Paradise Creek, Creeks A and B flow westerly through the northern part of the City of National City. Creek A flows along the northern corporate limits into the 7th Street Channel. Total drainage area of Creek A is approximately 3 square miles, including the drainage area, approximately 1 square mile, of Creek B. Creek B flows from the eastern corporate limits to its confluence with Creek A near Highland Avenue. Creek A has a gradient of approximately 80 feet per mile. The major obstruction of Creek B is the Interstate Highway 805 crossing, which causes ponding at El Toyon Park. There are some flooding areas related to Creek A, but they are not in National City. The 7th Street Channel is within the San Diego Naval Reservation, which was not studied.

Loma Alta Creek flows westerly through the central part of the City of Oceanside and drains 9.1 square miles.

Garrison Creek flows west-southwesterly through the central part of the City of Oceanside. Small businesses and homes are located adjacent to the creek.

In the City of Poway, a number of residential tracts have already been developed in Poway Valley, particularly along the upper end of Poway Creek after it emerges from the mountainous canyons to the east. Extensive mobile home developments are also located along Poway Creek and on high ground east of Rattlesnake Creek. Where tracts and mobile home parks were developed in the floodplains, the developers were required to provide flood protection. Generally, the creeks in these developments have been confined in moderately sized concrete or earthen channels, and the old stream beds have been graded over for building lots. The result is that approximately one-third of the streams in Poway have been channelized, and the other two-thirds of the valley streams remain in their natural condition.

Large rural-residential areas are located along the central and lower portions of Poway Creek, the central and upper portions of Rattlesnake Creek, and in the hills between Poway and Rattlesnake Creeks. Upper Beeler Creek is relatively undeveloped and will probably remain undeveloped as it forms the boundary of the Camp Elliot Naval Reservation. Substantial agricultural acreage remains in the upper reaches of Poway and Rattlesnake Creeks.

The Green Valley drainage basin is located to the north of the Poway Creek Complex (Poway Creek, Rattlesnake Creek, and Beeler

Creek) and just east of the community of Rancho Bernardo. Composed primarily of rural residential development, the basin is approximately 2.3 miles long and 1.9 miles wide, and covers approximately 4.4 square miles.

Green Valley Creek originates in the low rolling hills east of Espola Road near the Poway Reservoir and flows northwest in an unimproved, natural channel to Martincoit Road. The creek continues east in the City of Poway until it enters a concrete trapezoidal channel at the City of San Diego corporate limits. Two small tributaries enter from the northern side at Martincoit Road and Valle Verde Road.

San Marcos Creek flows through the City of San Marcos for a distance of approximately 4 miles. It originates in the coastal range of mountains north and east of the city and eventually empties into Batiquitos Lagoon.

Las Chollas Creek, South Las Chollas Creek, Switzer Creek, Las Puleta Creek, and their tributaries flow through the central portion of the City of San Diego.

The topography of the Las Chollas area consists of a low, relatively flat coastal belt which rises in elevation toward the western foothills of the Laguna Mountains. Localized, steep-sided, meandering canyons with grades in excess of 5 percent are prominent topographic features within the regional drainage basins. The general pattern of drainage flow originates with initial rainfall accumulation in the tributary canyons, where elevations reach 800 feet NGVD. Substantial flows are conveyed to the major flood-control channels, which eventually flow into San Diego Bay.

Development in the floodplain of Las Chollas Creek the City of San Diego consists of industrial development downstream of National Avenue on the east bank, residential development downstream of Market Street on the west bank and upstream of Euclid Avenue on the east bank, and a mobile home park upstream of Fairmont Avenue on the east bank. Medium-density residential development, subject to 100-year shallow flooding, exists upstream of Euclid Avenue on Home Avenue Branch.

Wabash Avenue Branch of Las Chollas Creek floodplain includes a commercial area immediately upstream of the State Highway 94 crossing. Upstream of this area, no development has occurred.

Floodplain development on South Las Chollas Creek is composed of industrial and commercial development downstream of Interstate Highway 805, residential areas upstream of Interstate Highway 5 on the south bank and upstream of Euclid Avenue, and a mobile home park upstream of 47th Street on the north bank. An industrial and commercial development upstream of Federal Boulevard is subject to 100-year shallow flooding due to inadequate channel improvements upstream of the corporate limits. A residential area upstream of

Merlin Drive on the north bank of Encanto Branch is also subject to 100-year shallow flooding conditions.

The floodplain of Encanto Branch of South Las Chollas Creek subjects both commercial and low-density residential areas to shallow flooding.

Switzer Creek flows through the fully developed center city business district. It has been improved by the construction of a 10-foot-diameter reinforced concrete pipe. Flow not contained by this pipe will create shallow flooding conditions in the business district.

The floodplain of Florida Drive Branch of Switzer Creek is currently maintained as an open-space area and, as such, contains no development.

Development within the floodplain of Las Puleta Creek consists of residential areas upstream of Interstate Highway 5 and downstream of Interstate Highway 805.

Tijuana River begins at the confluence of Cottonwood Creek and Rio de las Palmas near the City of Tijuana, Mexico. From its origin, it flows northwesterly for approximately 11 miles, passing through the City of Tijuana, to the point where it crosses the international boundary and enters the City of San Diego. North of the boundary, the river turns westerly and flows approximately 6 miles to the ocean.

The Tijuana River drainage basin is roughly triangular in shape and ranges in width from approximately 2 miles near the Pacific Ocean to approximately 50 miles near its eastern boundary. The basin comprises approximately 1700 square miles; approximately 455 square miles are in the United States and approximately 1245 square miles are in Mexico.

Runoff in the Tijuana River watershed is controlled in the United States by the Barrett Dam (built in 1922) and the Morena Dam (built in 1912), and in Mexico by the Rodriguez Dam (built in 1934). The reservoirs were designed as water-conservation facilities and do not have storage capacity for flood-control purposes. The dams are located approximately 33 stream miles, 41 stream miles, and 17 stream miles above the Pacific Ocean, respectively.

The Tijuana River valley is sparsely developed. Most of the valley is utilized for agricultural purposes or as open space in the form of abandoned agricultural lands. Residential and commercial development in the valley is in the eastern half, directly adjacent to Interstate Highway 5. Additionally, sand and gravel mines are being operated at several locations within the floodplain.

Goat Canyon, a tributary to the Tijuana River, has a drainage basin of approximately 4.7 square miles. Approximately 10 percent of the drainage area is within the United States and the remainder is within Mexico. The confluence of Goat Canyon and the Tijuana River is located approximately 1 mile inland from the Pacific Ocean, along the southern bluff.

Land use in Goat Canyon is similar to the unurbanized areas of the Tijuana River valley. One single-family residential dwelling unit exists near the confluence of Goat Canyon with the Tijuana River.

Considerable residential development has recently occurred in the Sunrise Overflow area.

Nestor Creek is a tributary to Otay River. The confluence of Nestor Creek and Otay River is approximately 1 mile above San Diego Bay. The contributing drainage area of Nestor Creek is approximately 3 square miles. The drainage basin is located entirely within the United States.

The Nestor Creek area is highly urbanized. Current land uses include residential, commercial, and industrial development. Recent development trends have been toward high-density apartment and condominium units. Land use in the low-lying areas, which are subject to frequent flooding, remain primarily agricultural. The agricultural lands are slowly being replaced by urban development.

Los Penasquitos Creek and Carroll Canyon Creek flow westerly through the northern portion of the City of San Diego, forming Soledad Canyon. Carmel Valley Creek is formed by the confluence of drainages from McGonigle and Deer Canyons. It flows westerly, joining Soledad Canyon near its outlet to the Pacific Ocean, just south of the City of Del Mar. Soledad Canyon and its tributaries drain approximately 96 square miles. These floodplains are sparsely developed, although some commercial development exists in Soledad Canyon near its confluence with Los Penasquitos Creek.

Murray Canyon Creek flows south along Interstate Highway 805 to its confluence with San Diego River. The reach above Interstate Highway 805 is a deep canyon. Downstream of the canyon area the floodplain gradually widens.

Rose Canyon Creek flows westerly in the upper reaches before turning south above the State Highway 52 crossing. The creek continues along Interstate Highway 5 to its mouth at Mission Bay. Upstream of State Highway 52, the floodplain is relatively narrow and consists almost entirely of undeveloped land (Reference 4). The lower reaches of Rose Canyon Creek consist of residential areas from the mouth to Interstate Highway 5, and commercial development upstream of Interstate Highway 5.

The studied reach of San Clemente Canyon extends upstream from its confluence with Rose Canyon Creek to Miramar Naval Air Station. San Clemente Canyon Creek flows westerly through San Clemente Canyon Park. State Highway 52 parallels the creek from the Interstate Highway 805 interchange downstream to the confluence with Rose Canyon Creek. The floodplain has an average width of

500 feet (Reference 4) and, except for San Clemente Canyon Park, is undeveloped.

Tecolote Creek flows southerly through the central portion of the city, draining approximately 9 square miles at its mouth in Mission Bay. A concrete channel begins at Cross Street and terminates downstream of the Atchison, Topeka and Sante Fe Railway bridge. The banks of this channel are elevated by 2 to 4 feet of compacted earth, which provides extra carrying capacity in this channel. A concrete ditch also exists upstream of Diane Avenue.

Murphy Canyon Creek flows southerly parallel to Interstate Highway 15 in the northern portion of the city and enters the San Diego River near the San Diego-Jack Murphy Stadium. Upstream of the corporate limits of San Diego, Murphy Canyon Creek flows through the Miramar Naval Air Station. Existing land use in Murphy Canyon consists of light industrial development on the canyon floor, with residential development on the mesas. Murphy Canyon is currently undergoing extensive development. The Murphy Canyon Creek watershed is comprised of 12.1 square miles. The average slope for the approximately 1.9 miles of creek flowing through the city is 68 feet per mile. Shepherd Canyon flows into Murphy Canyon Creek at Tierra Santa Boulevard.

2.3 Principal Flood Problems

The southern California coastline is exposed to waves generated by winter and summer storms originating in the Pacific Ocean. It is not uncommon for these storms to cause 15-foot breakers. The occurrence of such a storm event, in combination with high astronomical tides and strong winds, can cause a significant wave runup and allow storm waves to effect higher-than-normal elevations along the coastline. When this occurs, shoreline erosion and coastal flooding frequently result in damage to inadequately protected structures and facilities located along low-lying portions of the shoreline.

Brief descriptions of several significant storm events are presented to provide historic information on coastal and riverine flood hazards and to compare projected flood depths (References 5, 6, 7, 8, and 9).

September 24, 1939

A tropical cyclone, due west of the City of San Diego and moving up the coast towards the City of Los Angeles, caused much damage in San Diego County. Winds ranged from 30 to 60 miles per hour in the coastal communities, and considerable wind damage occurred. Point Loma and Mission Beach were hit particularly hard.

A 20-foot fishing boat went ashore near Cardiff and was battered to pieces. At the City of Oceanside, the fishing pier which is normally 27 feet above the waterline, was closed after the waves began smashing over the structure. Six pleasure crafts were washed ashore at the San Diego Yacht Club in the yacht harbor at Roseville.

December 26, 1940

Mission Beach, Ocean Beach, and Oceanside were the target of a series of high waves riding a high 7.1-foot spring tide on the 26th of December.

The forerunner of the storm was observed from the research ship E.W. Scripps off Baja, California before December 23. Swells from that distant storm were 50 feet high. More than 3.5 inches of rain fell in the City of San Diego on both December 23 and 24. Unusually large breakers began appearing at Oceanside and at Ocean Beach on December 25. On December 26, 20-foot high waves smashed over the beach at Ocean Beach, and imperiled five houses at the foot of Saratoga Avenue. Damage to structures at the foot of Cape May Avenue was also reported. One thousand sandbags were stacked to prevent the surf from undermining foundations of houses. Five hundred tons of rock were placed south of the Mission Beach seawall to break the force of the waves, which sent water surging across Mission Boulevard and into Mission Bay. At Oceanside, high waves were observed breaking over the end of the pier. Erosion at the Wisconsin Street ramp was observed. Sandbags were used to protect El Sereno Court.

Despite the higher tide (7.3 feet) on December 27, the waves had subsided to such an extent that they no longer surged over the Mission Bay seawall.

February 1957

High tides (5.7 feet to 6.9 feet), coupled with storms and winds, undermined homes at nearby Imperial Beach, Mission Beach, and Oceanside.

December 1962

15-foot waves were observed at La Jolla and Coronado.

September 9-10, 1976

Eastern San Diego County was hit hard by tropical storm Kathleen on September 9 and 10, 1976. Rainfall totals for the storm ranged from 1.5 inches on the Pacific Coast, up to 10 inches at Laguna Mountain, and 2.5 to 4.5 inches in the San Diego County desert areas. Intense rainfalls occurred on the eastern slopes of the mountains.

Storm frequency for the county ranged from less than a 2-year return period on the coast to more than 100-year frequency in the southeast corner of the county.

About $2 million in damage was reported in San Diego County because of tropical storm Kathleen. From Borrego Valley to the Mexican border, extensive sedimentation and erosion occurred in parks, airports, private homes, ranches, and businesses. Roads were severely damaged. Airports were closed at Ocotillo Wells, Agua Caliente, and Jacumba (Reference 10).

August 15-17, 1977

Severe thunderstorms occurred west of Borrego Valley on August 15, 1977, followed by tropical storm Doreen on August 16 and 17, approximately 60 miles west of the City of San Diego. Rainfall totals were approximately 1.5 to 2 inches along the coast, 3 to 4 inches in mountain areas, and 4 to 5 inches in the desert areas.

Storm frequency for the county ranged from less than a 2-year return period on the coast to more than 100-year frequency in the desert areas, particularly near Borrego Valley. More than $1.5 million worth of storm damage, mainly in the homes surrounding DeAnza Desert Country Club in Borrego Valley, was reported in San Diego County due to tropical storm Doreen. About 100 homes were damaged with mud flow up to five feet deep.

The most severe flooding occurred on Montezuma Road, where water from Henderson Canyon emerges onto an alluvial fan and the stream patterns are continually shifting down the fan. For many years, the flow has been primarily to the east, with perhaps 10 percent flowing south toward Montezuma Road. This flood changed the main course of the flow toward the south and, therefore, caused heavy flooding in the Montezuma Road area (Reference 11).

Winter 1977-1978

The entire coastline in San Diego County was hit hard by high storm waves. Damage occurred to private homes as well as to state, city, and county facilities. Private residences located along coastal bluffs between La Jolla and Oceanside were threatened or damaged by wave action. In Oceanside, 10-foot breakers flooded the first floor of an apartment building and caused $500,000 in damages. Stairs, bulkheads, and rock protection belonging to private residents in Carlsbad were destroyed or damaged by wave action. As much as four vertical feet of beach sand was washed away in some areas. The south jetty in Oceanside lost 30 feet off its end and the entire length was weakened by waves. Total damage was estimated at between $280,000 and $375,000. Approximately 300 feet of the seaward end of the Oceanside Municipal Pier was destroyed, amounting to $450,000 worth of damage. Other smaller amounts of damage caused by wave action occurred at various points along the coastline.

The winter of 1977-1978 drew attention to the fact that severe storms, coupled with intensified rainfall and large waves, may cause more erosion along the coastline in a shorter period of time than erosion during years of normal weathering.

January-February 1980

In the 1980 storms, approximately 15 to 20 inches of precipitation accumulated over approximately six weeks, followed immediately by the storm of February 20-21. During this climax, most county reservoirs peaked and local streams reached maximum levels. Considerable evacuation was necessary, particularly in Lakeside and San Diego-Mission Valley. The Del Mar area was hit hard by the massive spillover from Lake Hodges and 20 beach-front homes had to be evacuated. At Imperial Beach, raw sewage poured at the rate of 10 million gallons a day from a broken pipe in the Tijuana River Valley.

This storm was the most severe since the great storms of 1916 and 1927 for most county areas. A comparison of county rain charts shows that the January 1916 rainfall was almost double the February 1980 rainfall and slightly less than the combined totals for January and February 1980. The rain chart for February 1927 is comparable to the February 1980 chart, although the record rainfall of 12.8 inches at Cuyamaca on February 16, 1927, was not approached.

Three types of storms produce precipitation in the area: general winter storms, general summer storms, and thunderstorms. The storm selected as critical for the watershed, one producing the largest peak discharge, is a high-intensity, three-hour thunderstorm. Runoff from such cloudbursts is characterized by high-peak flows, short-duration flows, and relatively small volumes.

Snow is not considered an important contributory factor to runoff in the area. Also, climatic and drainage area characteristics are not conducive to continuous flow. Consequently, little streamflow occurs, except during and immediately following rains. Runoff increases rapidly in response to rainfall excess.

No major flood problems exist on Agua Hedionda Creek and Buena Creek in the unincorporated areas of San Diego County.

Overbank floodflows on Casa de Oro Creek are caused by debris collected by driveways upstream of Olive Drive and the restricted capacity of culverts located at Troy Street and Olive Drive, as well as limited channel capacity downstream of Mac Lane, at Kenwood Drive, and upstream of Andreen Lane.

The concrete-lined channel for Escondido Creek, from approximately 1,300 feet upstream of Rose Street to 1,300 feet upstream of Harmony Grove Road, does not contain 500-year floodflows and results in shallow flooding. Downstream of the channel improvement, floodwaters from the 100-year flood inundate the sewage treatment plant.

There are no major flooding problems on Otay River. Some areas downstream of Broadway Avenue will be inundated by the 100-year flood. A large flood on the Otay River will divide in such a way that the greater portion of the water will flow almost uniformly over the Southern Pacific Railroad embankment, travel 150 feet, and then flow over the perimeter dike into the salt evaporation ponds at the southern end of San Diego Bay. Once the floodwaters pass over the perimeter dike and encounter the asymmetrical maze of interior dikes, weir flow will occur in several directions simultaneously before ultimately flowing back over the dike and into the bay. The smaller portion of the floodwaters will be conveyed the last 2 miles to the San Diego Bay by a partially improved, limited-capacity, soft-bottom channel.

There are no major flooding problems on Reidy Creek.

Shallow flooding for the 500-year event results from limited channel capacity on Reidy Creek downstream of Lincoln Avenue in the City of Escondido.

In the City of Escondido, flooding in the west shallow flooding area is primarily the result of sheet runoff from upland areas. During the 100-year event, drainage swales and natural channels are filled beyond capacity. Combined channel overflow and sheet runoff cause ponding at El Norte Parkway.

Flooding in the north and south shallow flooding areas is caused by 100-year sheet runoff that has greater volumes and flow rates than existing storm drains can handle. Excess flows, not conveyed in the storm-drain system, spill down streets and across developed and undeveloped property, and ultimately pond against Escondido Creek channel banks on both the north and south sides of the creek.

Santa Maria Creek flows intermittently; only during periods of heavy rainfall is there any substantial flow. During heavy storms, the creek and its several tributaries are subject to overflow, inundating adjoining properties. As the community of Ramona continues to grow, the overflows will result in greater losses of property. The most serious flood problem in Ramona is caused by a shallow swale, which carries runoff from the low hills at the east end of the town through the central residential section to a southeasterly tributary of Santa Maria Creek. A moderately heavy storm will inundate the streets and homes in the vicinity of this swale. In the San Pasqual Valley, Santa Maria Creek would inundate at least one Fenton Ranch structure in a 100-year storm.

There are no records of historical flooding along Carroll Canyon Creek, Descanso Creek, Harbison Canyon Creek, Hatfield Creek, Kit Carson Park Creek, North Tributary to Santa Maria Tributary, Samagutuma Creek, San Vicente Creek, South Tributary to Santa Maria Creek, Sweetwater River (near Descanso), Tributary of South Tributary to Santa Maria Creek, Soledad Canyon, Los Penasquitos Creek, Carmel Valley Creek, Rose Canyon Creek, San Clemente Canyon Creek, Switzer Creek, Florida Drive Branch, Las Puleta Creek, and Murphy Canyon Creek.

Limited culvert capacity on Spring Valley Creek exists at Quarry Road, Sweetwater Road near Jamacha Boulevard, and at Jamacha Road north of Spring Valley Estates. The channel between Lamar Street and Sweetwater Road does not convey the 100-year flood. Between Spring Place and Bancroft Drive, the channel is rock-lined and crossed by many bridges that reduce the flow area of the channel by more than 50 percent.

The major cause of flooding along Sweetwater River is long-duration, high-intensity storms. Large floods occurred in the Sweetwater River drainage area in 1825, 1862, 1884, 1916, 1927, and 1937. According to the inhabitants of the area, the flood of 1862 was said to have been the most severe. The 1916 flood caused the wing dike on the right abutment of Sweetwater Dam, which was built in 1888, to fail. The flood of 1927 was almost as large as the 1916 flood.

During the 1977-1978 winter season, several floods occurred on the San Luis Rey River. Erosion and sedimentation occurred in many places, washing out or silting many areas and closing dip section road crossings. The Pauma Valley Country Club experienced major disruptions as a result of water and silt problems. Approximately 40,000 cubic yards of sediment was deposited in the golf course area and expenditures of approximately $30,000 were required because of the flooding problems.

The embankment where Monument Road crosses the San Pasqual Valley, 6.3 miles upstream of the Interstate 15 bridges, washes out in small (less than 10-year) floods at the crossing of both Santa Ysabel and Santa Maria Creeks.

The peak flow passing the San Pasqual gage on Santa Ysabel Creek upstream of the San Pasqual Valley was 12,500 cubic feet per second (cfs), a flow with a 0.04 exceedance frequency, corresponding to a 25-year event. Flow in the San Pasqual Valley was augmented by the overtopping and failure of an earthen dam in Bandy Canyon on Santa Maria Creek. The resulting flow washed out the bridge carrying Bandy Canyon Road across Santa Maria Creek and extensively flooded the valley downstream.

The major watercourses within the Las Chollas study area are Las Chollas Creek and South Las Chollas Creek. Their combined drainage basins encompass approximately 27 square miles. There are few available historical records for Las Chollas Creek and South Las Chollas Creek. Major floods occurred in other San Diego County river basins in 1862, 1884, 1916, 1927, and 1937. Medium-to-small floods occurred in 1889, 1891, 1895, 1906, 1921, 1938, 1941, and 1943. The 1862 flood was probably the largest of record in the county, but the 1916 flood was the most destructive. The 1916 flood caused damage to many important highway and railroad bridges and washed out miles of track and roadbeds. The greatest damage occurred to farmland improvements. Much of the agricultural land was severely damaged. The 1927 flood caused extensive damage to buildings, roads, bridges, utilities, land, and crops in San Diego County.

From available data concerning San Diego River, it is estimated that approximately a 100-year frequency flood occurred in 1916 and approximately a 50-year frequency flood occurred in 1927. Although no historical records are available for Las Chollas Creek and South Chollas Creek for this period, it is likely that they experienced major floods during these two years.

The 1969 floods caused extensive damage to seven southern California counties adjoining the Los Angeles area. Fortunately for San Diego, only the fringes of the storm passed through the county; most of the damage from these floods occurred in the northern part of the county. Damage occurred on South Las Chollas Creek in the lower reaches when the channel banks collapsed in the vicinity of Oceanview Boulevard crossing. No homes were damaged. The Jackie Robinson YMCA on South Las Chollas Creek suffered damage to its playfield and pool when the flow exceeded the natural channel capacity, which is estimated to be less than the 10-year flood. The flow was estimated to be approximately the 10-year flood. Flooding also occurred in 1978 and 1979, resulting in extensive flood damage.

Many of the flooding problems in the developed areas are caused by the flow breaking out of the channel at road crossings due to inadequate conveyance structures and debris buildup on the pier walls. Debris accumulation is a particular problem in the upstream reaches of Las Chollas Creek and South Las Chollas Creek, and Paradise Creek, where open brush is the predominant ground cover.

Historically, the Tijuana River valley has been subjected to many severe floods. A storm in 1825 caused severe flooding, and a flood in 1862 was reported to have been the largest flood in the memory of inhabitants at that time. No quantitative records are available for floods prior to 1877. Medium-to-large floods occurred in the drainage area in 1889, 1891, 1895, 1906, 1916, 1921, 1937, 1938, 1941, 1944, and 1980. The greatest rate of runoff in the lower valley measured by gages was 33,500 cfs, which occurred during the February 1980 flood. The most severe flood occurred in 1916, when the flow was estimated at 75,000 cfs. Floodflow rates of 17,000 cfs and 75,000 cfs correspond to 10- and 100-year floodflows, respectively.

Due to a protracted drought and the water storage by the dams, surface flows in the lower Tijuana River valley were minimal from 1945 until 1980. The estimated average runoff was approximately 30,000 acre-feet per year for the period 1937-1960. Since 1960, runoff in the lower valley has decreased substantially. From 1960 to 1979, the yearly flow averaged 6,500 acre-feet.

The USACE estimates the in-bank capacity of the natural channel in the Tijuana River valley to be approximately 1,500 cfs. Comparison of this estimated channel capacity with the magnitude of the

10-year flood of 17,000 cfs indicates that substantial flooding and damages can be expected frequently in the valley. Damage will include physical damage to structures and improvements, business losses, and interruption of homelife and other normal community activities. The February 21, 1980, flood had a discharge of 33,500 cfs, a 25-year event. It washed out bridges at 19th Street and Dairy Mart Road and changed the river alignment.

Nestor Creek flows through a highly urbanized area. The majority of the less-frequent floodflows are conveyed in the overbank areas, causing considerable inundation of the development within the floodplain. Floodflows on Nestor Creek are significantly restricted at two locations by embankments. One restriction, located 1.7 stream miles above the confluence of Nestor Creek with Otay River, is Interstate Highway 5. The other restriction, located 2.1 stream miles above the confluence, is the San Diego and Arizona Eastern Railroad. Neither of these embankments was designed as a floodwater-retarding structure, but they function as such due to low-capacity culverts.

All runoff from the drainage basin above the freeway enters a retarding pool above the freeway embankment. Water leaves the pool in three directions: (1) through culverts under the freeway; (2) over the center barrier wall of the freeway; and (3) along the freeway alignment. Water crossing over the center barrier wall and under the freeway through the culverts remains within the Nestor Creek drainage basin and continues downstream in Nestor Creek. Flow along the alignment of the freeway is diverted from the Nestor Creek drainage basin northerly to Otay River.

The restriction at the railroad also causes a pool to develop upstream. The storage volume of the pool is adequate to contain the 10-, 50-, and 100-year floods. Overtopping of the railroad occurs during the 500-year flood.

The low-lying lands adjacent to Hollister Street are subject to flooding from both the Tijuana River and Nestor Creek. Flooding is experienced in the area when water-surface elevations in Nestor Creek or the Tijuana River exceed certain elevations. This overflow area diverts water from the Tijuana River into the Nestor Creek during the less-frequent floods, and diverts water from Nestor Creek into the Tijuana River during the more-frequent floods. The overflow area is referred to as Sunrise Overflow, and is described as follows.

Diversion of water from Nestor Creek to Tijuana River occurs during the 10-, 50-, and 100-year events. The direction of flow in the overflow area is southerly during these floods. The quantity diverted is a significant portion of the Nestor Creek runoff, and peak flow rates downstream of the overflow area are reduced accordingly.

Diversion of floodwaters from the Tijuana River to Nestor Creek occurs during the 500-year event. The direction of flow in the overflow area is northerly during this frequency flood. The quantity of water diverted is insignificant in comparison to the magnitude of the Tijuana River, but it significantly increases the peak flow rate downstream of the overflow area in Nestor Creek.

The 1978 completion of the Sunrise residential development, at the confluence of the overflow area and Tijuana River, has significantly affected floodflow characteristics in the overflow area. The grading that has taken place elevates the development above the 100-year flood elevation for Tijuana River, partially blocking the path of flow entering the overflow area. Consequently, this development has reduced the potential for flooding on Nestor Creek due to floodwater diverted from the Tijuana River by the overflow area.

Documentation of historical flooding problems on Nestor Creek downstream of the overflow area from the Tijuana River is based on the conditions that existed prior to completion of the Sunrise development. Historically, the flooding problems have been attributed to floodwaters that overflowed from the Tijuana River.

Historical flood-damage estimates for Nestor Creek downstream of the overflow area are available for the floods of 1916 and 1938. Although the damage estimates for these floods do not represent the damages that would result under present conditions, they do provide indications of the severity of the historical problem. The 1916 flood destroyed most of the improvements in Nestor Creek. Large areas of fertile croplands were covered with debris. Direct losses were estimated by local residents to have exceeded $200,000. In 1938, a flood with a floodflow rate of 6,670 cfs caused damages estimated at $64,000.

Flooding problems along the reach of Nestor Creek, upstream of the overflow area, are caused by runoff from the Nestor Creek drainage basin only. Flooding of a condominium development upstream of the freeway occurs frequently. Floodflows washed out the Union Pacific Railroad bridge over Nestor Creek in 1937. The present embankment was constructed as a replacement for the washed-out railroad bridge.

There are no historical records of flooding along Telegraph Canyon Creek; however, in 1968, the Harbor Side-Castle Park area in the City of Chula Vista experienced considerable flooding. A serious flood problem exists along the lower one-third of Telegraph Canyon Creek, where residential, commercial, and industrial development would be inundated. Approximately 82 percent of the floodplain along the lower one-third of the creek is presently developed for urban uses, with residential usage occupying more than half of the urban area. In the vicinity of Mission Valley Shopping Center, approximately 30 percent (12,000 cfs) of the 100-year discharge on San Diego River breaks out of the channel and causes shallow flooding at the shopping center. Shallow flooding also occurs at the Town and Country Hotel area downstream of Fashion Valley Road.

The 500-year flood on Rose Canyon Creek breaks out of the channel at two locations. The first breakout occurs upstream of the Interstate Highway 5 bridge; the second breakout occurs at the Mission Bay Drive bridge. Approximately 12,000 cfs breaks out at both locations and flows southerly from the Mission Bay Drive bridge through urbanized areas and into Mission Bay.

Both overbanks along the concrete channel on Tecolote Creek are subject to 100-year flooding because high-flow velocities in the channel may cause erosion to the unprotected earthen banks. Additional flood problems are caused by water ponding upstream of Weeks Avenue and Morena Boulevard.

The concrete ditch upstream of Diane Avenue can convey low flows. During major floods, the culverts at Verley Court and Derrick Drive cannot pass the floodwaters, which results in a breakout along Chateau Drive.

Flooding problems along Murray Canyon Creek are relatively minor. The 100-year floodwaters pond behind Friars Road to a depth of 15 feet. Floodwaters back up behind Frazee Road bridge at a depth of 8 feet for the 100-year flood.

Major floods have occurred along Buena Vista Creek, as well as in adjacent basins during both the winter and summer, although most of the precipitation occurs between December and March. Rainless periods of several months are common during the summer.

Damaging floods occurred in the region that includes the Buena Vista Creek basin in 1862, 1884, 1895, 1916, 1927, 1932, 1938, and 1942. Little information is available, but indications are that significant inundation occurred in the basin, blocking roads and flooding out farmhouses and crops. Flood damage from such floods has been relatively light because virtually no high-value developments existed on the floodplain during those floods.

Prior to extensive development and improvement of its natural intermittent streams, the City of El Cajon was subject to heavy inundation during large storms. One resident described the use of rowboats for traveling along Main Street during the 1916 flooding in El Cajon. However, due to some protective measures, flooding has been limited to deep water in streets and water seeping into garages, with only minor damage being reported.

The construction of Interstate 8 through the City of El Cajon has created a major hindrance to large flows on County Ditch Creek and Washington Creek. The combined 500-year flood from these streams will pond to as much as 7 feet deep upstream from the freeway and overtop it in the vicinity of Washington Creek.

Forester Creek's 500-year flood would also be hindered from entering the channel, and the excess will flow west along the south side of the freeway from Main Street to the ponding area of

Washington Creek as it crosses the freeway to join Forester Creek west of Magnolia Avenue.

Forester Creek will also be hindered in crossing Highway 67, causing backup to the north for the 500-year flood. This flow will travel north along the Highway 67 embankment, turning west under the highway at the Fletcher Parkway undercrossing.

In several cases, there is extensive street flooding in El Cajon due to storm flows exceeding the capacity of storm sewers.

In the downstream reach near San Elijo Lagoon in the City of Encinitas, Encinitas Boulevard and El Camino Del Norte dip sections are subject to overtopping and damage due to flooding from low-return period events similar to the 5- to 10-year flood of January 17, 1978 (Reference 12).

The City of Lemon Grove is affected by flood hazards along Spring Valley Creek. In addition, flooding occurs on Federal Boulevard when there is extended heavy rain.

There is no major flood problem from Paradise Creek itself in the City of National City. Minor floods are expected at River Mile 3.6 on Paradise Creek when floods of 100-year or greater recurrence intervals occur. The excess water is expected to flow north along the Old Paradise Creek course and rejoin the main flow at River Mile 2.47. Major flooding problems along Paradise Creek occur, however, when the floodwater from the Sweetwater River flows into Paradise Creek. This can occur in two ways: one is by backing up through the Interstate Highway 5 culvert along Paradise Creek, the other is by backing up from the ditch along the Southern Pacific Railroad near West 30th Street. During periods of major flows, the capacity of the Paradise Creek diversion channel will be exceeded. This will result in an area of shallow sheetflow in the vicinity of Las Palmas Park.

Between Interstate Highway 5 and the confluence with the Sweetwater River, there is a swampy area that the City of National City has no intention of developing.

Most of the floodprone areas identified in the City of Poway are a result of inadequate drainage facilities through floodplain developments and at road crossings. The blockage of culverts by sediment and debris, in addition to restricted carrying capacities, would cause backups and overbank flows in several developed areas. Areas that have been identified as those where damage to structures is most probable during a 100-year flood event are shown in Table 3.

Estimated flood elevations along Las Chollas Creek and Las Puleta Creek in the City of San Diego are shown in Figures 1 through 4.

Table 3. Areas of Probable Damage to Structures in the City of Poway

Location	Area of Probable Damage
Poway Creek	
At confluence of Poway and Pomerado Creeks	The areas south of Oak Knoll Road north and northwest of the confluence will be inundated by the 100-year flood.
At Pomerado Road Bridge	Although the computed water surface at Pomerado Road was lower than the minimum road elevation on Pomerado Road, the water-surface elevation 75 feet upstream was 2.4 feet higher. It was assumed that the momentum of the 100-year flow in the south overbank (approximately 1,800 cfs at 3 feet per second based on the flow distribution) should carry it over the south approach road in a stream separate from the flow under the bridge. Also, the areas west of Casa Real Unit 4 and north of Tustin Hill Unit 1 lie within the 100-year floodplain.
At Community Road	The south overbank areas immediately downstream of Community Road are subject to sheetflow by the 100-year natural flood.
At Gate Drive	A 100-year flood exceeds the capacity of the culvert at Gate Drive, the approach channel, and the natural channel upstream of it. Overflows are conveyed through the subdivision by Woodgate Place, Gate Drive, and Fairgate Drive. Some houses of low ground elevations will be flooded by the 100-year storm.

Table 3. Areas of Probable Damage to Structures in the City of Poway (Cont'd)

Location	Area of Probable Damage
At Garden City and Park Poway	Some areas in the Garden City and Park Poway Subdivisions are inside the 100-year flood boundary. These areas are ponded or with low velocity backwater. At the northeast corner of Park Poway Subdivision, minor amounts of flow from North Branch Poway Creek that do not enter the north-south channel at the eastern boundary may flow west on Garden Road, south on Acton Avenue, west on Biddeford and Saco Streets, and finally rejoin the main flow.
	Floodwaters from North Branch Poway Creek in the north-south channel east of Park Poway will exceed the channel capacity, overflowing the west bank and flow between the houses on the east side of Acton Street. These flows into Acton Street will continue to Saco and Kittery Streets.
Rattlesnake Creek	
At Heritage Hills	Backwater at the entrance to the concrete-lined channel on the north side of Heritage Hills Unit 4 Subdivision causes 100-year floodflow to split and travel down the east overbank through open fields, and over parking lots, streets, earth fill (at time of study) storage yards, and grass-covered lots. The culvert at Poway Road is not capable of carrying the 100-year floodflow. This contributes to overbank flow upstream and downstream of Poway Road.
At Midland Road	Between Community Road and Midland Road and immediately upstream, many buildings lie within the 100-year floodplain.

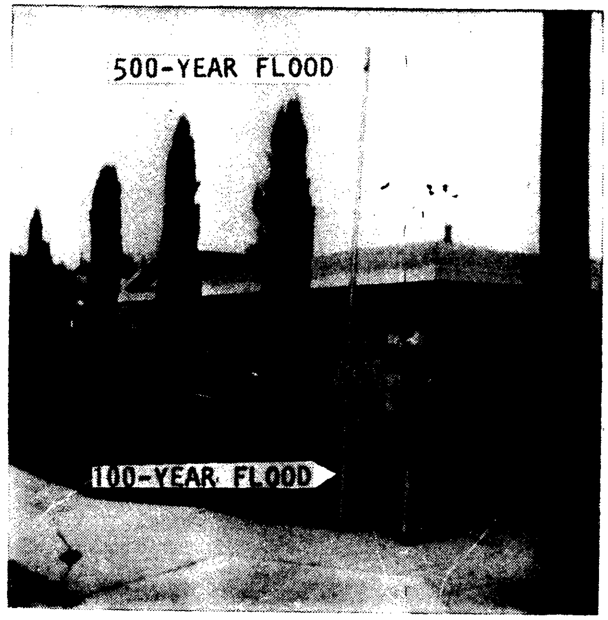


Figure 3. 100-and 500-Year Flood Elevations for Las Puleta Creek at the Intersection of Cottonwood Avenue and Osborne Street

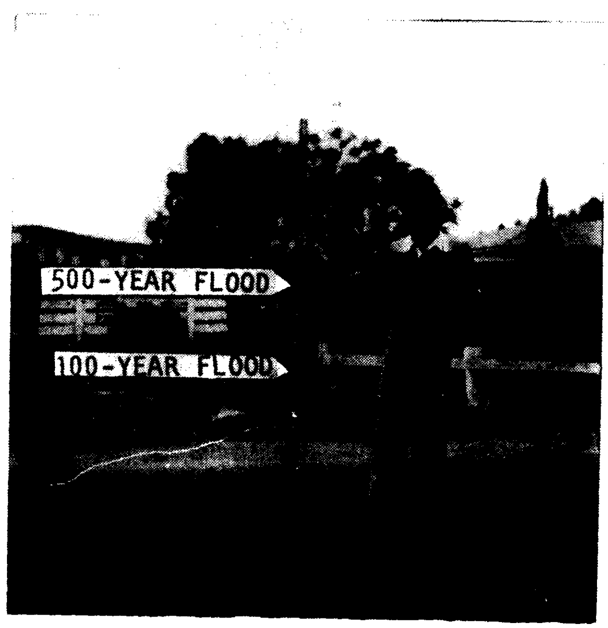


Figure 4. 100- and 500-Year Flood Elevations for Las Puleta Creek at the Delta Street Crossing

2.4 Flood Protection Measures

San Diego County, Unincorporated Areas

A reinforced concrete trapezoidal channel has been constructed on Broadway Creek from just west of Victor Street to Oro Street.

An improved flood control channel for Escondido Creek was constructed from 1,300 feet upstream of Rose Street to 1,300 feet upstream of Harmony Grove Road. This channel has the capacity to contain a 100-year flood.

For floodplain management purposes, the county has identified the floodplain for the lower 4 miles of Moosa Canyon Creek as an erosion/sedimentation hazard area, and may require that special studies be performed before development is allowed in that area.

There are no flood protection works on Otay River. Lower Otay Dam (Savage Dam) does provide incidental flood protection, although its main purpose is to provide water storage.

An improved channel for Reidy Creek downstream of Lincoln Avenue contains the 100-year flood. No other flood-protection measures are known to exist within the county.

There are two privately owned water conservation reservoirs on Sweetwater River. The Sweetwater Reservoir was completed in 1888. This reservoir was breached by the 1916 flood and was rebuilt shortly thereafter. The Loveland Reservoir was completed in 1945.

The only major flood-protection work along San Luis Rey River is approximately 2,000 feet of channel with an unlined bottom and riprap bank protection constructed by the California Department of Transportation as part of the Interstate Highway 15 bridge crossing.

There are no known engineering projects installed or planned specifically for protection against coastal flooding. However, within the county, breakwaters and seawalls exist at many places along the shore that are designed to absorb the impact of wave forces. These structures provide protection against excessive beach and berm erosion and function as protection for small craft in harbors. In some instances (e.g., the wall along Strand Way on Mission Beach and the off-shore submerged breakwater under construction at Imperial Beach), structures may also serve as flood-protection measures.

City of Carlsbad

No known engineering projects have been installed or are planned specifically for protection from coastal flooding; however, within the county, breakwaters and seawalls exist at many places along the coast that are designed to absorb the impact of wave forces. These structures provide protection from excessive beach and berm erosion, and function as protection for small craft in harbors. In some instances (e.g., the wall along Strand Way on Mission Beach and the offshore submerged breakwater under construction at Imperial Beach), they may also serve as flood-protection measures.

A section of Buena Vista Creek flows in a concrete-lined channel extending approximately 0.2 mile upstream from Thunder Drive; however, this channel does not have the capacity to carry the 100-year flood.

City of Chula Vista

There are no flood-protection works on Otay River. Lower Otay Dam (Savage Dam) does provide incidental flood protection, although its main purpose is to provide water storage.

No Federal flood control facilities exist on Poggi Canyon Creek, Rice Canyon Creek, or Telegraph Canyon Creek; however, local interests have conducted improvement projects that have reduced flood damage. Improvements have consisted of a concrete-lined channel on a reach of Poggi Canyon Creek and a long culvert on a reach of Rice Canyon Creek.

The USACE designed and constructed a project on Lower Telegraph Canyon Creek that extends from the San Diego Bay to east of 4th Avenue. That project is described in Section 10.0 under a Letter of Map Revision issued December 10, 1991, to the City of Chula Vista.

There are two privately owned water-conservation reservoirs on Sweetwater River. The Sweetwater Reservoir was completed in 1888. This reservoir was breached by the 1916 flood and was rebuilt shortly thereafter. The Loveland Reservoir was completed in 1945.

There are no known engineering projects installed or planned specifically for protection against coastal flooding. However, within the county, breakwaters and seawalls exist at many places along the shore, which are designed to absorb wave forces. These provide protection against excessive beach and berm erosion and function as protection for small craft in harbors. In some instances, the wall along Strand Way on Mission Beach and the off-shore submerged breakwater under construction at Imperial Beach may also serve as flood protection measures.

City of Coronado

On the ocean side of the peninsula, a submerged jetty extending south from Zuniga Point on North Island and two Hotel del Coronado jetties were built about 1900. A seawall was constructed in 1905 to protect the shore in front of the Hotel del Coronado from storm surge and wave erosion. That same year, the city constructed the massive rock seawall which extends about one mile along Ocean Avenue. The Coronado Shores area is protected by a rock seawall constructed in 1970. On the bay side, the Coronado Cays residential development on the Silver Strand is protected by more than five miles of bulkhead at an elevation of eight feet above mean higher high water (MHHW), and the residential areas on the head of the peninsula are protected by various types of privately constructed shore-protection structures (Reference 13).

Nonstructural flood-protection measures in San Diego County consist of development regulations as required by the California Coastal Act of 1976. The City of Coronado also has a flood-damage-prevention ordinance.

The City of Coronado entered the Regular Phase of the National Flood Insurance Program on June 1, 1982. At that time, no Special Flood Hazard Areas were identified within the community.

City of Del Mar

There are no known engineering projects installed or planned specifically for protection against coastal flooding in the City of Del Mar; however, in the coastal zone within the county, breakwaters and seawalls exist along the shore that are designed to absorb the impact of wave forces. These structures provide protection for small craft in harbors. In some instances, the wall along Strand Way on Mission Beach and the off-shore submerged breakwater under construction at Imperial Beach may also serve as flood-protection measures.

In the riverine zone, Lake Hodges on the San Dieguito River and Sutherland Reservoir on the Santa Isabel River provide incidental flood protection, although their main purpose is to provide water storage.

City of El Cajon

In addition to many culverts under roadways, the city has improved much of its major storm channel system with concrete channel linings and box conduits.

Forester Creek has been improved as a reinforced concrete box conduit from Fletcher Parkway to the extension of Petree Street, and from Arnelle Avenue to Johnson Avenue. A reinforced concrete trapezoidal channel extends from Bradley Avenue to Fletcher Parkway and from Johnson Street to the upstream corporate limits.

County Ditch Creek extends from its underground confluence with Forester Creek to the upstream side of Interstate 8 as a reinforced concrete box conduit. A reinforced concrete trapezoidal channel has been constructed from the freeway to east of Johnson Avenue and from Main Street to Washington Avenue.

Open reinforced concrete channels have been constructed on Washington Creek from its confluence with Forester Creek to Jamacha Road, except for sections of reinforced concrete box conduits from

Wisconsin Avenue to Cypress Avenue and from Julian Avenue to Claydelle Avenue.

A reinforced concrete trapezoidal channel has been constructed on Broadway Creek from just west of Victor Street to the study limit at Oro Street.

The city has also constructed various underground collector drain systems. These systems include those existing or now under construction along the streams in the westerly portion of the city that were studied by approximate methods.

City of Encinitas

There are no known engineering projects installed or planned specifically for protection from coastal flooding; however, within the community, breakwaters and seawalls designed to absorb the impact of wave forces exist at many places along the shore. These structures provide protection from excessive beach and berm erosion.

City of Escondido

An improved flood-control channel for Escondido Creek within the corporate limits of Escondido was constructed from El Norte Parkway to a point 1,300 feet upstream of Harmony Grove Road; this channel has the capacity to contain a 100-year flood. An improved channel for Reidy Creek downstream of Lincoln Avenue contains the 100-year flood. No other flood-protection measures are known to exist within the city.

City of Imperial Beach

Flood-control structures on the Tijuana River consist of approximately 0.5 mile of trapezoidal concrete channel, an energy dissipator, and 2 miles of levees. This is a continuation of a 2.7-mile-long channel constructed in Mexico through the City of Tijuana. These improvements will reduce the floodwater velocity entering the United States at San Ysidro, but will do nothing to alleviate the potential for riverine flooding within the City of Imperial Beach.

The natural source of beach sand that the Tijuana River had historically supplied to the Imperial Beach shoreline has been greatly reduced since 1937, when the Mexican government constructed Rodriguez Dam approximately 14.5 miles southeast of Imperial Beach. It has been estimated that approximately 70 percent of the natural source of sand transported down the river has been cut off as a result of the dam's trapping effect. This situation has caused a serious attrition problem along the city's beachfront, as the river cannot supply a sufficient quantity of sand to offset that lost to the ocean. For an 8-year period (1946-1954), approximately 2.5 million cubic yards of sand were lost offshore. Shoreline erosion left both public and private property in danger of periodic damage from wave action.

Concern over this problem prompted a shore-protection study by the USACE (Reference 14). The immediate result of this study has been the initiation of a sand-replenishment construction contract, which allows for the transportation of sandy material from dredging operations in San Diego Bay to the beachfronts of Coronado and Imperial Beach. Dredging commenced on July 30, 1975, and restoration, as indicated on the topographic maps for the City of San Diego and Imperial Beach (Reference 5), is reflected on the Flood Insurance Rate Map. However, the USACE study pointed out that this beach-restoration operation provides only a short-term (5- to 10-year) solution to the problem, unless a series of stabilizing rock groins or underwater offshore breakers are also constructed to complement the new, wider beach. An offshore submerged breakwater is under construction.

<u>City of Lemon Grove</u>

Presently, the City of Lemon Grove benefits from a system of storm drains.

<u>City of National City</u>

The City of National City has passed and adopted Resolution No. 11976, dated February 17, 1976 (Reference 15), which provides that when floods occur on the Sweetwater River, sandbags will be placed to prevent flows from entering Paradise Creek from the ditch paralleling the Southern Pacific Railway. The sandbags will be placed perpendicular to Interstate Highway 5, the ditch, and the Southern Pacific Railway, and will be placed to an elevation of 16 feet. The sandbagging is intended to divert the floodwaters west across Interstate Highway 5 and then back into the Sweetwater River.

The maps presented in this study were prepared assuming that the Paradise Creek basin is protected from the 100-year floodwater surface level by a sandbag dike. However, any breakdown in this operation (e.g., lack of manpower, lack of mobility, failure of dike control, or any unforeseen circumstance), will cause serious damage to the basin. After the flood threat, the dikes will be removed by the city; therefore, it is considered a temporary flood-protection measure. This emergency flood-protection measure is prepared and ready to implement until the Sweetwater River Flood Control Channel (Reference 16) is constructed.

There are two privately owned water conservation reservoirs on the Sweetwater River. The Sweetwater Reservoir, at River Mile 9, was completed in 1888. This reservoir was breached by the 1916 flood and was rebuilt shortly thereafter. The Loveland Reservoir, at River Mile 28, was completed in 1945.

The USACE is constructing a flood-control channel (Reference 16) along the Sweetwater River that will include the entire reach of the river within the corporate limits. The channel is designed to handle the 500-year flood. This proposed channel was not considered in this report, but, when completed, will change the Sweetwater River overflow considerably.

The Bonita Plaza (Reference 17) is considered in this study. The project includes a proposed rock-lined channel from Bonita Mesa Road to Interstate Highway 805. The channel will tie to the proposed USACE Sweetwater River flood control channel, and will have all of the design dimensions except depth of invert. Thus, the 100-year flood will overtop the channel and inundate the parking lot of the plaza. When the USACE project is constructed, the channel will be deepened and the 500-year flood will be contained within the channel banks.

City of Oceanside

There are no known engineering projects installed or planned specifically for protection against coastal flooding; however, within the county, breakwaters and seawalls exist at many places along the coast that are designed to absorb the impact of wave forces. These structures provide protection against excessive beach and berm erosion and function as protection for small craft in harbors. In some instances (e.g., the wall along Strand Way on Mission Beach and the off-shore submerged breakwater under construction at Imperial Beach), such structures may also serve as flood-protection measures.

Buena Vista Creek has a concrete-lined channel extending approximately 0.2 mile upstream from Thunder Drive; however, this channel does not have the capacity to carry the 100-year flood.

Several flood-protection measures have been taken on the San Luis Rey River. At the mouth, a 2,000-foot-long stone groin and rock revetment runs from the beach into the ocean. The rock revetment extends along the northern riverbank from the beach to approximately 500 feet upstream of a railroad bridge. The southern riverbank is protected with rock revetment from the railroad bridge to the Pacific Ocean. In the vicinity of the Oceanside Airport, levees were constructed along the northern and southern banks. Both levees are approximately 4,000 feet long. Bank protection measures have been taken upstream of the Douglas Drive Bridge and the Murray Road Bridge. Stone revetments have been placed along the northern riverbank upstream of the Douglas Drive Bridge, while along the southern bank upstream of the Murray Road Bridge rock has been used to provide 100-year flood protection for the surrounding areas.

City of Poway

On Poway Creek, there are manmade drainage channels through Ridgedale, Tustin Hills, and Casa Real Poway upstream of Pomerado

Road. The drainage channels in Westgate, Garden City, and Park Poway are not sufficient to carry 100-year discharges.

On Rattlesnake Creek, the drainage channel east of Russ Estates is not adequate to contain the 100-year discharge. The concrete channel through Heritage is capable of conveying the 100-year flow, but not the triple concrete box culvert just downstream under Poway Road. The flow tends to divide before it enters this concrete channel, with overbank flow occurring through the open field to the east.

City of San Diego

The City of San Diego has adopted a zoning ordinance that limits development in flood hazard zones. The city utilizes the floodway (see Section 4.2) and the 500-year flood as defined by FEMA to delineate the flood zones.

Floodplain management regulations have been adopted by the City of San Diego to regulate development in flood hazard areas. These regulations will aid in the prevention of future flood damages. One objective of the regulations is to elevate the first flood of residential structures above the 100-year water-surface elevation.

There are several graded, trapezoidal, concrete-lined channel banks, culverts, and pipelines along portions of each stream studied in the Las Chollas Valley area. Several of these structures have been constructed to contain the 100-year and sometimes the 500-year flood. However, shallow flooding may occur as a result.

The USACE constructed a flood-control project for the Tijuana River. This project consists of approximately 0.5 mile of trapezoidal concrete channel, an energy dissipator, and 2 miles of levees. It is a continuation of a 2.7-mile-long channel constructed in Mexico through the community of Tijuana. The levee system, which was constructed in 1978 as part of an international agreement between the United States and Mexico, was designed to handle a flow of 135,000 cfs with 2.5 to 3 feet of freeboard. The 100-year flow for the Tijuana River is estimated at 75,000 cfs.

The International Boundary and Water Commission (IBWC), United States Section is responsible for the operations and maintenance of the project.

An industrial park exists within the Nestor Creek floodplain immediately downstream of Beyer Way. A 10- by 5-foot reinforced concrete box culvert, constructed within the park, decreases the extent of flooding in the vicinity of the park from the flows on Nestor Creek. The culvert will fully contain the 10- and 50-year floodflows, and will contain a significant portion of the 100- and 500-year floodflows.

Channel improvements for Carmel Valley Creek are in progress or are planned starting at Shaw Valley Road and extending upstream approximately 1 mile. Additional improvements have been proposed for Carmel Valley Creek from downstream of Interstate Highway 5 upstream to Shaw Valley Road.

Chambers Dam is located on Los Penasquitos Creek upstream of Interstate Highway 5. This structure does not affect the magnitude of 100- or 500-year flood discharges.

There are no flood-protection works on the Otay River. Lower Otay Dam (Savage Dam) provides incidental flood protection, although its main purpose is to provide water storage.

Existing flood-control facilities on Rose Canyon Creek consist of approximately 700 feet of trapezoidal concrete channel under the Interstate Highway 5-State Highway 52 interchange and approximately 1,500 feet of trapezoidal concrete channel between mile 3.78 and mile 4.06. These two concrete channels were constructed and are being maintained by CALTRAN. In addition, there is approximately 500 feet of rock slope protection for the channel at the crossing of Interstate Highway 805.

The City of San Diego has constructed and maintains 250 feet of rock-revetted channel immediately downstream from the Genesee Avenue crossing. A similar channel improvement is at the Regents Road crossing (Reference 4).

On Murphy Canyon Creek, just upstream of Friars Road, there is an approximately 300-foot long concrete-lined trapezoidal channel downstream of a 1,900-foot long double, 8- by 14-foot reinforced concrete box culvert. Upstream of the double box culvert, there is an additional 600 feet of concrete-lined trapezoidal channel. This lined channel/box culvert structure will fully contain the 10- and 50-year floodflows and will contain a major portion of the 100- and 500-year floodflows. In addition to this structure, CALTRAN, in conjunction with the USACE, has installed a large corrugated metal pipe culvert at the Interstate Highway 15-Murphy Canyon Creek crossing. This corrugated metal pipe culvert restricts the floodflow, thereby causing the upstream valley to act as a detention pond. This detention pond greatly reduces the peak floodflows downstream, and is wholly contained within the Miramar Naval Air Station.

Sutherland Reservoir provides incidental flood protection for Santa Ysabel Creek, although its main purpose is water storage. The City of San Diego is adopting an extensive program of channel widening and maintenance in the San Pasqual Valley on both Santa Ysabel and Santa Maria Creeks by allowing sand and gravel mining in the channels following engineered guidelines (References 18 and 19). The designed improvements consist of excavation of trapezoidal channels of widths from 50 to 400 feet and depths from 5 to 8 feet. A 300- by 8-foot channel begins 4.0 miles upstream of the Interstate 15 bridge on Santa Ysabel Creek and ends 400 feet downstream of Monument Road, where a 400-foot wide channel with armored sides continues to the road, a total distance of 2.3 miles. The upper 2.1 miles of this improved channel will contain the 10-year flood. Beginning 1,200 feet upstream of Monument Road, 0.8 mile of a 300- by 5-foot channel is designed to contain the 10-year flood. None of the improved sections will contain the 50-year or larger floods.

On Santa Maria Creek, the 0.7 mile of channel from the confluence with Santa Ysabel Creek up to Monument road is designed as a 250- by 8-foot trapezoidal channel, with armored sides on the 300-foot-long reach immediately downstream of the road. The channel will contain the 10-year flood.

There are no known engineering projects installed or planned specifically for protection from coastal flooding. However, within the county, breakwaters and seawalls exist at many places along the coast that are designed to absorb the impact of wave forces. These structures provide protection from excessive beach and berm erosion and function as protection for small craft in harbors. In some instances, for example, the wall along Stand Way on Mission Beach and the off-shore submerged breakwater under construction at Imperial Beach may also serve as flood-protection measures.

City of San Marcos

At the time of the initial study, an improved earthen channel had been constructed near the southwestern corporate limits of the city to control the flow of San Marcos Creek. In addition, the city planned to build a flood control dam near the confluence of San Marcos Creek and the East Branch of San Marcos Creek. That plan has since been abandoned. A citywide master plan of drainage was adopted in 1990.

The Woodland Parkway culvert, which is located at the upstream limits of San Marcos Creek and is approximately 3,485 feet in length, contains the entire 100-year flood discharge.

Las Posas Creek is an improved channel from its confluence with San Marcos Creek to approximately 600 feet downstream of Linda Vista Drive. A reinforced concrete box culvert extends from approximately 600 feet downstream of Linda Vista Drive to Grand Avenue. A siltation basin was completed in 1989 at the intersection of Las Posas Road and Avenida Azul. This facility has an insignificant effect on the peak flow rates. Upstream of the siltation basin, Las Posas Creek consists of an underground storm drain system in series with an improved channel.

Twin Oaks Valley Creek has been modified from approximately 2,950 feet upstream of Mission Road to approximately 5,750 feet upstream of La Cienega Road. As a result of these modifications, which include the construction of eight drop structures along the creek, the 100-year floodplain is confined within the Twin Oaks Valley Ranch Golf Course.

City of Santee

The Mission Creek channelization project has been completed on the San Diego River. The project is documented in Section 10.3 as a Letter of Map Revision issued to the City of Santee on January 29, 1992.

The flood-protection facilities along Forester Creek consist of the 10-year design-channel reaches extending over most of the City of Santee.

City of Solana Beach

There are no known engineering projects installed or planned specifically for protection against coastal flooding. However, within the City of Solana Beach, breakwaters and seawalls, which are designed to absorb the impact of wave forces, exist at many places along the shore. These structures provide protection against excessive beach and berm erosion.

City of Vista

An improved trapezoidal channel is located approximately 500 feet downstream of State Highway 78 on Buena Creek, and extends for a distance of approximately 600 feet. This portion of the channel has the capacity to carry the 100-year flood.

A concrete-lined SCS trapezoidal channel is located 400 feet upstream of State Highway 78, on Buena Vista Creek, and extends approximately 5,400 upstream. Generally, this channel does not have the capacity to contain the 100-year floodflows.

3.0 ENGINEERING METHODS

For the flooding sources studied by detailed methods in the community, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Flood events of a magnitude which are expected to be equaled or exceeded on the average of once during any 10-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for floodplain management and for flood insurance rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10, 2, 1 and 0.2 percent chance, respectively, of being equaled or exceeded during any year. Although the recurrence interval represents the long-term, average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. For example, the risk of having a flood that equals or exceeds the 100-year flood (1 percent chance of annual exceedence) in any 50-year period is approximately 40 percent (4 in 10); for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported herein reflect flooding potentials based on

Table 4. Summary of Discharges (Cont'd)

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (cfs) 10-Year	50-Year	100-Year	500-Year
Buena Vista Creek Tributary 1					
At Confluence with Buena Vista Creek	2.6	460	1,180	1,510	2,020
At Intersection of Monte Vista Drive and Santa Fe Avenue	1.7	320	800	1,010	1,350
At Intersection of Monte Vista and Valley Drives	1.0	210	510	630	840
Buena Vista Creek Tributary 2					
At Confluence with Buena Vista Creek	0.8	110	410	530	700
At Intersection of Eucalyptus Avenue and Tiger Tail Road	0.5	110	280	360	480
Buena Vista Creek Tributary 3					
At Confluence with Buena Vista Creek	1.5	350	760	950	1,240
Approximately 1,000 feet Upstream of North Santa Fe Avenue	0.5	130	280	350	460
Buena Vista Creek Tributary 4					
At Confluence with Buena Vista Creek	2.5	570	1,210	1,450	1,860
Calavera Creek					
Upstream of Rancho Carlsbad Mobile Home Park	4.5	--[1]	--[1]	1,350	--[1]
Confluence with Agua Hedionda Creek	5.9	--[1]	--[1]	1,740	--[1]
Carmel Valley Creek					
Above Confluence with Soledad Canyon	15.7	2,100	6,500	9,800	21,300
Below Confluence with Shaw Valley Creek	11.0	1,400	4,200	6,300	13,700
Carroll Canyon Creek					
At Atchison, Topeka & Santa Fe Railway	17.8	1,500	4,500	6,700	18,700
At Interstate Highway 805	15.0	1,300	3,800	5,600	15,700
At Carroll Canyon Road	12.0	1,000	3,000	4,500	12,500
Coleman Creek					
Approximately 1,800 Feet Downstream of Highway 78	8.1	--[1]	--[1]	8,750	--[1]

[1]Data Not Available

Table 4. Summary of Discharges (Cont'd)

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (cfs) 10-Year	50-Year	100-Year	500-Year
Coyote Creek					
At Apex of Alluvial Fan	132.0	5,200	16,000	24,000	35,200
Culp-Tubb Canyon					
At Apex of Alluvial Fan	13.0	2,400	6,000	8,500	12,500
Deer Springs Creek					
At Mouth	1.8	--[1]	--[1]	1,550	--[1]
Descanso Creek					
At Mouth	5.6	1,300	3,800	6,000	10,400
Dry Canyon					
At Apex of Alluvial Fan	1.9	450	1,150	1,700	2,650
Encanto Branch					
Above Confluence with South Las Chollas Creek	6.0	1,200	2,700	3,500	6,600
Above Confluence with Radio Drive Tributary	4.8	1,100	2,600	3,400	6,500
At 64th Street	4.2	950	2,300	3,000	6,100
Above Confluence with Jamacha Branch	2.4	640	1,400	1,700	3,200
Escondido Creek					
At Interstate Highway 5	77.7	3,400	15,500	22,000	41,000
Upstream of Lake Val Sereno	68.0	3,200	14,500	21,000	38,400
Upstream of Elfin Forest Lake	55.7	2,800	13,000	19,000	35,000
At Harmony Grove Road	48.3	2,600	12,000	18,000	32,000
Approximately 11,200 feet Upstream of Wohlford Dam	2.2	--[1]	--[1]	2,700	--[1]
Eucalyptus Hills East Branch					
At Riverside Drive	1.5	--[1]	--[1]	860	--[1]

[1]Data Not Available

Table 4. Summary of Discharges (Cont'd)

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (cfs) 10-Year	50-Year	100-Year	500-Year
Eucalyptus Hills West Branch					
At Riverside Drive	1.9	--[1]	--[1]	970	--[1]
Fire Canyon					
At Apex of Alluvial Fan	0.8	200	550	900	1,500
Florida Drive Branch					
Above Confluence with Switzer Creek	2.5	490	1,120	1,350	2,340
Forester Creek					
At Terra Lane	3.1	--[1]	--[1]	1,420	--[1]
Forester Creek - Carlton Hills Boulevard					
At Mission Gorge Road	--[1]	--[1]	2,400	3,900	10,000
Garrison Creek					
At Confluence with Loma Alta Creek	2.24	230	780	1,130	1,940
6,500 Feet Upstream of El Camino Real	0.97	110	340	570	970
Gopher Canyon Creek					
At Mouth	11.0	--[1]	--[1]	7,690	--[1]
Green Valley Creek					
At Corporate Limits with City of San Diego	3.2	950	2,050	2,700	4,700
At Orchard Bend Road	1.5	450	925	1,200	2,000
Green Valley Creek Tributary					
At Confluence with Green Valley Creek	0.3	80	200	300	600
Harbison Canyon Creek					
At Noakes Street Crossing	--[1]	500	--[1]	2,100	--[1]
At Warfield Way Crossing	--[1]	750	--[1]	3,000	--[1]
At Collier Way Crossing	--[1]	775	--[1]	3,200	--[1]
At Dehesa Road Crossing	--[1]	1,050	--[1]	4,700	--[1]

[1]Data Not Available

Table 4. Summary of Discharges (Cont'd)

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (cfs) 10-Year	50-Year	100-Year	500-Year
Hatfield Creek					
At Mouth	20.8	1,700	7,900	13,700	35,600
Hellhole Canyon					
At Apex of Alluvial Fan	7.6	1,900	4,250	6,450	9,200
Henderson Canyon					
At Apex of Alluvial Fan	4.8	750	2,100	3,500	5,650
Home Avenue Branch					
At Confluence with Las Chollas Creek	2.1	430	950	1,200	2,200
0.8 Mile Above Fairmont Avenue	1.3	260	580	730	1,340
At Euclid Avenue	1.1	220	500	630	1,200
At Auburn Drive	0.8	160	360	450	830
Kit Carson Park Creek					
At Mouth	6.8	1,000	2,900	4,400	9,600
At Bear Valley Parkway	3.5	600	1,900	2,800	6,100
Las Chollas Creek					
At Main Street	26.4	4,200	8,000	10,000	21,000
Above Confluence with South Las Chollas Creek	15.3	3,000	6,000	7,900	15,000
At Market Street	12.7	2,700	5,400	7,100	13,500
Above Confluence with Wabash Branch	8.7	1,900	3,800	4,700	7,700
Above Confluence with Home Avenue Branch	6.6	1,500	2,800	3,500	5,500
Above Confluence with Chollas Reservoir Branch	4.9	1,400	2,400	3,000	4,300
Las Posas Creek					
Upstream of Confluence with San Marcos Creek	--[1]	1,100	1,800	2,450	3,150
Upstream of Las Posas Culvert Entrance	--[1]	750	1,200	1,850	2,350

[1]Data Not Available

Table 4. Summary of Discharges (Cont'd)

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (cfs) 10-Year	50-Year	100-Year	500-Year
Las Puleta Creek					
At San Diego and Arizona Eastern Railroad	2.8	550	1,200	1,400	2,500
Downstream of Confluence with Logan Avenue Branch	1.5	300	730	870	1,690
At 47th Street	0.8	160	390	470	910
0.6 Mile Upstream of Cervantes Avenue	0.1	20	50	60	120
Lawson Valley Creek					
Approximately 7,200 Feet Upstream of Mouth	10.2	--[1]	--[1]	9,000	--[1]
Loma Alta Creek					
At Mouth	9.1	800	2,500	3,800	8,200
Downstream of El Camino Real	4.7	450	1,500	2,200	4,800
Upstream of El Camino Real	2.9	350	1,100	1,700	3,700
Los Penasquitos Creek					
Above Confluence with Soledad Canyon	58.3	3,700	11,300	16,800	37,600
At U.S. Highway 395	42.7	3,100	10,000	15,400	35,800
Upstream of Confluence with Chicarita Creek	33.6	2,500	8,700	14,000	34,000
Lusardi Creek					
At Mouth	8.6	--[1]	--[1]	5,680	--[1]
Mexican Canyon Creek					
At Confluence with Sweetwater River	4.7	360	1,480	2,250	3,300
At U.S. Highway 94, 9,600 Feet Upstream of Confluence	2.0	160	700	1,060	1,470

[1] Data Not Available

Table 4. Summary of Discharges (Cont'd)

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (cfs) 10-Year	50-Year	100-Year	500-Year
Moosa Canyon Creek					
Near Junction of Moosa Road and U.S. Highway 395	34.7	2,600[2]	9,000[2]	13,000[2]	29,000[2]
At U.S. Highway 395, Near River at Elevation 400 Feet	29.2	2,200[2]	7,500	11,550[2]	26,000[2]
Upstream of Confluence with South Fork Moosa Canyon Creek	21.4	1,400[2]	5,100[2]	7,800[2]	17,000[2]
At Old Castle Ranch	15.0	800[2]	3,330[2]	5,100[2]	11,000[2]
At Unnamed Road	3.0	--[1]	--[1]	3,120	--[1]
Murphy Canyon					
Upstream of Friars Road	12.1	1,500	2,700	3,500	5,500
Downstream of Aero Drive	10.1	1,100	2,000[3]	2,300[3]	3,800[3]
Upstream at Aero Drive	10.1	1,100	2,400	3,000	5,000
Downstream of Confluence with Shepard Canyon	9.2	850	2,000	2,400	4,200
Upstream of Confluence with Shepard Canyon	6.2	550	1,400	1,700	3,300
Downstream of Balboa Boulevard	5.9	550	1,400	1,700	3,300
Upstream of Balboa Boulevard	5.9	550	1,400	1,700	3,300
Downstream of Confluence with Unnamed Tributary	5.8	550	1,400	1,700	3,300
Downstream of Clairmont Mesa Boulevard	3.4	350	800[3]	1,000[3]	1,850[3]
Upstream of Clairmont Mesa Boulevard	3.4	350	950	1,400	2,800
Murray Canyon Creek					
At Mouth	3.93	1,200	2,400	3,100	4,800
Upstream of Unnamed Tributary	2.74	1,000	1,700	2,100	3,300
Downstream of Interstate Highway 805	1.76	800	1,200[4]	1,400[4]	1,800[4]
Upstream of Interstate Highway 805	1.76	800	1,600	2,100	3,400

[1]Data Not Available
[2]Flows Partially Controlled by Turner Dam
[3]Decreases Due to Ponding Upstream
[4]Decrease Due to Overbank Losses Upstream

Table 4. Summary of Discharges (Cont'd)

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (cfs) 10-Year	50-Year	100-Year	500-Year
Nestor Creek					
At Palm Avenue	2.75	--[1]	--[1]	1,093	--[1]
At 19th Street	--[1]	--[1]	--[1]	864[2]	--[1]
At Elm Avenue	2.45	--[1]	--[1]	796[2]	--[1]
At Coronado Avenue	2.33	--[1]	--[1]	698[2]	--[1]
At Hollister Street	1.99	--[1]	--[1]	496[2]	--[1]
At 25th Street/Interstate 5	1.71	--[1]	--[1]	456[2]	--[1]
At San Diego and Arizona Eastern Railroad	1.40	515	800	945	2,155
North Branch Poway Creek					
At Sycamore Canyon Road	4.5	650	2,000	3,000	7,200
North Tributary to Santa Maria Creek					
At Mouth	1.6	100	600	1,100	2,900
Olive Creek					
At Mouth	1.0	--[1]	--[1]	1,370	--[1]
Otay River					
At Otay Valley Road	122.7	1,200	12,000	22,000	50,000
Pala Mesa Creek					
Approximately 265 Feet Upstream of Interstate Highway 15	2.1	--[1]	--[1]	1,700	--[1]
Pauma Creek					
At Apex of Alluvial Fan	14.7	1,550	6,270	10,480	30,460
Pilgrim Creek					
Upstream End of Oceanside Golf Course	14.0	--[1]	--[1]	5,775	--[1]
Downstream End of Oceanside Golf Course	14.0	--[1]	--[1]	1,440	
Just Upstream of the Confluence with Windmill Creek	15.8	--[1]	--[1]	2,020	--[1]
At Mouth	19.0	--[1]	--[1]	2,810	--[1]
Poggi Canyon Creek					
At City of Chula Vista Corporate Limit	3.74	180	830	1,280	2,470
At Confluence with Otay River	4.63	220	930	1,400	2,630

[1]Data Not Available
[2]Decrease Due to Construction of "Lot 6 Detention Basin" Upstream of Railroad

Table 4. Summary of Discharges (Cont'd)

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (cfs) 10-Year	50-Year	100-Year	500-Year
Pomerado Creek					
At confluence with Poway Creek	4.3	--	--	2,900	--
At Tassel Road	3.9	--	--	2,840	--
At Vaughn Road	3.3	--	--	2,590	--
At Holland Road	2.9	--	--	2,300	--
Poway Creek					
USGS Gage at Cobblestone Creek Road	31.2	2,500	8,700	14,000	34,000
USGS Gage 1,000 feet Upstream of Standish Drive	7.9	1,100	3,700	5,600	14,000
Rainbow Creek					
At Interstate Highway 15	7.1	--[1]	--[1]	5,210	--[1]
Rattlesnake Creek					
USGS Gage 400 feet Upstream of Confluence with Poway Creek	8.1	750	2,500	3,900	9,700
Reidy Creek					
Above Confluence with Escondido Creek	15.1	1,300	5,000	7,700	14,000
At Rincon Avenue	10.5	1,100	5,000	7,100	14,000
Upstream of Jesmond Dene Avenue	4.5	600	2,600	4,000	7,300
Rice Canyon Creek					
4,780 Feet Upstream of H Street	2.64	140	780	1,200	1,710
At H Street	3.25	170	890	1,350	1,940
At Confluence with Sweetwater River	3.60	180	920	1,400	2,030
Rose Canyon Creek					
At Mouth	37.0	2,700	8,100	12,000	28,000
Downstream of Confluence with San Clemente Creek	32.1	2,500	7,600	11,000	26,500
Upstream of Confluence with San Clemente Creek	13.7	1,300	4,000	6,200	13,900
Upstream of State Highway 52	13.2	1,300	3,800	6,100	13,400
Downstream of Genesse Avenue	9.7	1,100	3,200	5,000	11,200
Downstream of Interstate Highway 805	6.9	900	2,700	4,100	9,400

[1]Data Not Available

Table 4. Summary of Discharges (Cont'd)

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (cfs) 10-Year	50-Year	100-Year	500-Year
Samagutuma Creek					
At Mouth	6.4	900	2,600	4,000	7,000
San Clemente Canyon Creek					
Upstream of Confluence with Rose Canyon Creek	18.4	1,400	4,200	6,900	16,000
Upstream of Genesee Avenue	15.3	1,200	3,600	5,600	12,000
Upstream of Interstate Highway 805	12.5	1,000	3,100	4,900	11,000
San Diego River					
At Confluence with Murphy Canyon Creek	420.0	3,100	17,000	36,000	112,000
Just Downstream of Confluence of San Vicente Creek	290.0	2,500	--[1]	31,000	--[1]
San Dieguito River					
Upstream of Camino Del Mar Bridge	--[1]	5,700	31,400	41,800	90,000
Upstream of Atchison, Topeka & Santa Fe Railway Bridge	--[1]	5,700	31,400	41,800	90,000
Upstream of Jimmy Durante Bridge	--[1]	5,800	32,100	42,400	90,000
Upstream of U.S. Interstate Highway 5 Bridge	--[1]	5,900	32,500	42,800	90,000
San Elijo Creek					
0.1 Mile Upstream of El Camino Road	5.4	500	1,600	2,100	5,500
San Luis Rey River					
At Mouth	560.0	6,600	31,000	51,000	120,000
Downstream of Confluence with Moosa Canyon	355.6	6,200	30,000	48,000	110,000
Downstream of Confluence with Keys Canyon	252.3	5,000	25,000	41,000	98,000
Upstream of Confluence with Keys Canyon	180.4	4,000[2]	20,000	33,000	85,000
Downstream of Palma	167.3	4,000[2]	18,000	30,000	78,000
Downstream of Confluence with Puma Creek	126.7	4,000[2]	16,800	28,000	72,800
Upstream of Confluence with Puma Creek	71.5	5,000	15,000	24,500	64,000

[1]Data Not Available
[2]Discharge Decreases With Increasing Area Due to Breakouts From the Low Flow Channel

Table 4. Summary of Discharges (Cont'd)

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (cfs) 10-Year	50-Year	100-Year	500-Year
San Marcos Creek					
Upstream of Discovery Street	--[1]	7,400	13,300	14,700	19,350
Upstream of Confluence with Las Posas Creek	--[1]	6,450	11,650	13,150	16,950
Upstream of Highway 78	--[1]	6,200	11,000	12,450	16,000
Upstream of Confluence with Twin Oaks Valley Creek	--[1]	2,600	4,550	5,150	6,600
Approximately 1,000 Feet Upstream of Confluence with Twin Oaks Valley Creek	--[1]	2,200	3,900	4,400	5,600
San Vicente Creek					
At Mouth	83.0	1,400	10,500	16,000	34,000
Santa Maria Creek (Santa Maria Valley Area)					
Below Confluence with North Tributary	33.1	1,900	9,200	15,600	42,000
Santa Maria Creek (San Pasqual Valley Area)					
At Confluence with Santa Ysabel Creek	60.0	3,200	14,700	19,000	30,000
Santa Ysabel Creek					
Lake Hodges at Hodges Dam	290	10,000	48,000	62,000	95,000
Below Confluence with Santa Maria Creek	221	9,000	42,500	55,000	85,000
Above Confluence with Santa Maria Creek	160	6,100	29,000	37,000	60,000
Approximately 15,500 Feet Upstream of Confluence With Witch Creek	23.8	--[1]	--[1]	20,750	--[1]
Shallow Flooding Area - South					
Citrus Wash at Escondido Creek, 500 Feet Downstream of the Rose Street Bridge	2.4	600	1,440	1,920	2,550
Citrus Wash at Reed Road, 600 Feet West of Falconer Road	0.3	100	230	290	380
South Midway Wash at Midway Drive, 400 Feet Northwest of Grand Avenue	2.0	490	1,180	1,570	2,070

[1]Data Not Available

Table 4. Summary of Discharges (Cont'd)

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (cfs) 10-Year	50-Year	100-Year	500-Year
Shallow Flooding Area - North					
Midway Wash at Midway Drive Crossing of Escondido Creek	2.0	350	1,060	1,520	2,020
Lincoln Avenue and Midway Drive	1.7	290	920	1,310	1,750
Maywood Wash at Intersection of East Lincoln Avenue and Nightingale Place	1.3	230	720	1,020	1,350
Shallow Flooding Area - West					
Country Club Creek at El Norte Parkway, 1,100 Feet Northwest of Bennett Avenue	2.1	540	1,330	1,700	2,220
Country Club Creek at Nutmeg Street, 1,200 Feet North of Golden Circle Drive	0.3	70	200	260	350
Unnamed Tributary at Intersection of Golden Circle Drive and Country Club Lane	0.9	240	590	770	990
Slaughterhouse Creek					
Approximately 1,800 Feet Upstream of Mouth	2.9	--[1]	--[1]	2,450	--[1]
Soledad Canyon					
At Mouth	95.5	5,000	15,400	23,000	51,500
Downstream of Confluence with Los Penasquitos Creek	76.1	4,200	13,100	19,000	43,700
South Branch Poway Creek					
Approximately 1,150 Feet Upstream of Sycamore Canyon Road	1.8	400	1,200	1,800	4,300
South Fork Moosa Canyon Creek					
0.3 Mile Above Mouth	7.1	1,200[2]	3,400	5,200[2]	10,400
At Oak Shadows Drive	4.3	700	2,100	3,200	6,500

[1]Data Not Available
[2]Flow Partially Controlled by Turner Dam

Table 4. Summary of Discharges (Cont'd)

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (cfs) 10-Year	50-Year	100-Year	500-Year
South Las Chollas Creek					
Above Confluence with Las Chollas Creek	10.9	2,000	3,900	5,300	9,500
Above Confluence with Encanto Branch	3.3	730	1,400	1,900	3,400
At Kelton Road	2.6	580	1,100	1,500	2,700
South Tributary to Santa Maria Creek					
At Mouth	9.3	700	3,400	5,800	15,000
Spring Valley Creek					
Below Confluence with Casa de Oro Creek	7.1	1,300	2,600	3,600	9,300
Steele Canyon Creek					
At Mouth	2.7	--[1]	--[1]	2,980	--[1]
Stevenson Creek					
At Mouth	1.2	--[1]	--[1]	900	--[1]
Sunrise Overflow					
At Hollister Street	--[2]	50	435	700	1,800
At Iris Avenue	--[2]	0	300	550	3,000
Sweetwater River (Above Reservoir)					
At Broadway	219.0	1,200	21,000	35,000	60,000
At Intersection of Sweetwater and Bonia Roads	197.0	1,200	21,000	35,000	60,000
Below Confluence with Spring Valley Creek	194.0	1,200	21,000	35,000	60,000
Above Sweetwater Reservoir	174.0	5,600	21,500	29,500	53,600
Below Confluence with Harbison Creek	138.0	5,500	21,000	29,000	53,000
Below Confluence North Fork	131.0	5,300	20,500	28,000	50,000

[1]Data Not Available
[2]This Area is Subject to Overflow Flooding and Therefore, Does Not Have a Defined Contributing Drainage Area

Table 4. Summary of Discharges (Cont'd)

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (cfs) 10-Year	50-Year	100-Year	500-Year
Sweetwater River (At National City)					
At Broadway	219.0	1,200	21,000	35,000	60,000
Sweetwater River (Near Descanso)					
At Japatul Valley Road Bridge	41.0	3,800	14,800	20,300	36,800
Above Confluence with Descanso Creek	25.2	2,900	11,000	15,100	27,200
Switzer Creek					
At Harbor Drive	4.3	830	2,200	2,600	5,000
Upstream of Russ Boulevard	3.5	675	1,540	1,870	3,220
Above Confluence with Florida Drive Branch	1.0	185	420	510	880
Tecolote Creek					
At Interstate Highway 5	9.29	2,100	3,800	4,900	9,300
Downstream of Confluence with Unnamed Tributary	7.28	2,000	3,700	4,700	8,900
Upstream of Confluence with Unnamed Tributary	4.04	1,100	1,900	2,400	4,500
Downstream of Balboa Avenue	2.54	750	1,300	1,600[1]	2,600[1]
Upstream of Balboa Avenue	2.54	750	1,300	1,700	3,100
Downstream of Genesee Avenue	1.64	640	1,100	1,400[2]	2,100[2]
Upstream of Genesee Avenue	1.64	640	1,100	1,500	3,000
Telegraph Canyon Creek					
At Interstate Highway 5	7.3	900	2,100	2,800	5,500
At Hilltop Drive	5.5	600	1,600	2,200	4,700
Telegraph Canyon Creek Overflow	--[3]	0	100	800	3,500

[1]Decrease Due to Culvert Restriction at Balboa Avenue
[2]Decrease Due to Culvert Restriction at Genessee Avenue
[3]Data Not Available

Table 4. Summary of Discharges (Cont'd)

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (cfs) 10-Year	50-Year	100-Year	500-Year
Tijuana River					
At Mouth	1,700.0	17,000	50,000	75,000	150,000
Tributary of the South Tributary to Santa Maria Creek					
At Mouth	5.8	400	2,100	3,600	9,400
Tributary to Sweetwater River					
At Arroyo Road	2.8	--[1]	--[1]	2,070	--[1]
Twin Oaks Valley Creek					
Upstream of Confluence with San Marcos Creek	--[1]	3,450	6,250	7,100	9,100
Approximately 1,700 feet Upstream of Windy Way	--[1]	3,250	5,900	6,700	8,700
At Olive Drive	6.7	3,200	5,250	6,500	8,400
Upstream of Buena Creek Road	--[1]	2,600	4,600	5,200	6,700
Unnamed Canyon					
At Apex of Alluvial Fan	4.6	650	1,900	2,900	5,100
Vado Canyon					
At Apex of Alluvial Fan	3.5	400	1,500	2,200	4,100
Wabash Branch					
Above Confluence with Las Chollas Creek	4.1	700	1,380	1,600	2,700
Above Confluence with Wabash Tributary	3.5	570	1,190	1,380	2,330
Witch Creek					
Approximately 7,700 Feet Upstream of Mouth	3.3	--[1]	--[1]	3,540	--[1]
Alvarado Creek					
At Lake Shore Drive	4.6	1,200	2,000	2,300	3,000
At Interstate 8, Near Trailer Park	5.3	1,300	2,200	2,500	3,200
At Interstate 8, Near Murray Boulevard	5.7	1,400	2,400	2,700	3,500
Upstream of Murray Creek	6.3	1,600	2,600	3,000	3,800
Downstream of Murray Creek	10.1	1,700	2,900	3,300	4,200
At Downstream Side of College Avenue	11.4	2,100	3,400	3,900	5,000
Upstream of Tributary Channel	12.1	2,300	3,700	4,300	5,400
Downstream of Tributary Channel	13.4	2,600	4,300	4,800	6,100
At San Diego River	14.0	2,700	4,500	5,100	6,500

[1]Data Not Available

locations beyond the continental shelf bordering the study area. The data span the period 1951 to 1974, and were computed by FNWC using input from ship observations, meteorological stations, and synoptic surface meteorological charts of the Pacific Ocean. For the study, the incoming swell provided by FNWC was classified into 12 direction sectors of 10 degrees band widths each. (Exposure of the study area to winter swells was confined to a 120-degree band, i.e., swell coming from directions 220°T to 340°T). Within each sector, 10 days of swell height and period values were selected from the 24 years of FNWC data to represent extreme flood-producing days. The selection criteria were guided by Hunts formula for runup. The 120 days at each of the three deepwater stations were merged to obtain a master list of 161 extreme runup-producing days. For each of 161 days, the input swell provided by FNWC was refracted across the continental shelf and converted to runup at selected locations in the study area. The techniques used and data required for this are described in Section 3.2. Of the 161 days, a number of groups of consecutive days could be identified.

Each such group of days is considered to represent only one event; the largest runup from each group of days was selected as the maximum runup for that event. As a result of refraction and island sheltering effects, a number of the input swells produced no significant runup at certain locations; therefore, the number of extreme runup events is less than 161. The average number of events in the study area is approximately 40. For each location in the study area, the runup for the extreme events were fitted to a Weibull distribution to obtain a probability distribution of runup from winter swell. The Weibull distribution was found to be best suited for representing runup statistics (Reference 20). Because extreme winter swell runup lasts for at least one day, the maximum runup must be considered to coexist with the maximum high tide.

Regarding the extreme runup values as a statistical sample only, the influence of the astronomical tides was included by convolving the probability distribution of runup with the probability distribution of daily high tides. The latter was obtained from standard tide-prediction procedures (Reference 21), using the harmonic constants at the nearest available tide gage for which such data exist (supplied by the National Oceanic and Atmospheric Administration (NOAA) Tidal Prediction Branch). At each location, the frequency of occurrence of extreme events is determined by the number of runup values used in the Weibull curve fit. The number of years over which these occur is 24. The product of the frequency of occurrence with the complement of cumulative probability distribution of the runup plus tide (convolved) distribution gives the exceedence frequency curve for flood elevations due to winter swell runup.

Tsunami

Elevation-frequency curves for tsunami flooding were obtained from information supplied by the USACE Waterways Experiment Station

(WES) (Reference 22). The results of the WES study were interpreted as directed by FEMA.

The statistics of tsunami elevations along the coastline were derived in the WES study by synthesizing data on tsunami source intensities, source dimensions, and frequencies of occurrence along the Aleutian-Alaskan and Peru-Chile trenches. As a result, 75 different tsunamis, each with a known frequency of occurrence, were generated and propagated across the Pacific using a numerical hydrodynamic model of tsunami. At a number of locations in the study area, these 75 tsunami time signatures were each added to the tidal time signature at the nearest tide gage location for which harmonic constants for tide computations are available. One year of tidal signature was generated from the harmonic constants. A given tsunami signature was then combined with the tide signature and the maximum tsunami, plus tide for the combination recorded. To simulate the occurrence of the tsunami at random phases of the tide, the tsunami signature was repeatedly combined with the tide signature starting at random phases over the entire year of tide signature. Each combination produces a maximum tsunami plus tide elevation with frequency of occurrence equal to the frequency of occurrence of the particular tsunami signature used, divided by the total number of such combinations for that particular tsunami. The process was repeated for all 75 tsunami, thus establishing the elevation frequency curve for tsunami flooding.

Wind Waves from Landfalling Storms

The source of data for wind waves is the same as that for winter swell, namely, the FNWC (1951-1974). The stations for which daily height, period, and direction data are available are also the same as for winter swells. The FNWC wind-wave data are directly correlated to local wind speeds. For obtaining runup statistics, the FNWC daily wave data were converted to daily runup data using the method outlined in Section 3.2 (Reference 20). The daily runup data were then fitted to a Weibull distribution and convolved with the tide in the same manner as for winter swells.

Tropical Cyclone Swell

Runup from swell generated by tropical cyclones off Baja, California, was computed using the techniques discussed in Section 3.2 (Reference 20). To establish the statistics of hurricane swell runup, the following procedure was used. Data concerning tropical cyclone tracks were obtained from the National Climatic Center (NCC). The data comprises 12-hourly positions of eastern North Pacific tropical cyclones from 1949 to 1974. This was supplemented by data on tropical cyclones tracks during the period 1975-1978 reported in various issues of the Monthly Weather Review (1976-1979).

Besides position data, storm intensities at each of 12-hourly positions are also given. The intensity classifications are based on estimated maximum wind speeds. The intensity categories are tropical depression (less than 35 knot winds), tropical storm (less than 65 knot winds), and hurricane (at least 65 knot winds). Storms with tropical depression status were considered to generate negligible swell and were omitted from this study. Data on actual maximum wind speeds were available from the NCC only from 1973 to 1977. These data were used as the basis for obtaining values to represent maximum wind speeds from each of the two intensity classifications associated with the track data. Data on storm radii were derived from North American Surface Weather Charts by analysis of pressure fields of tropical cyclones off Baja, California. These data were used to define the typical radius of maximum winds for each of two relevant intensity classes. For each tropical cyclone between 1949 and 1978, the hurricane wind waves were computed by using the mean radius and maximum wind speeds established for each intensity class, along with the track data. The swell and resultant runup were computed using the techniques described in Section 3.2 (Reference 20). For each tropical cyclone and each location of interest in the study area, a time history of swell runup was determined. These were added to time histories of the local astronomical tide in a procedure analogous to that used in determining tsunami-plus-tide effects. The exceedence frequencies of tropical cyclone swell runup were computed in a manner similar to that used for tsunami.

Landfalling Tropical Cyclones

The frequency of landfalling tropical cyclones in southern California is extremely low. During the years (1949 to 1974) covered by the NCC tape of eastern North Pacific tropical cyclones, no tropical cyclone hit southern California. A longer period of record was used to estimate the frequency of an event such as the Long Beach 1939 storm. A study by Pyke (Reference 23) was used to compile a list of landfalling tropical cyclones along the coast of southern California. The study was a result of extensive investigations of historical records, such as precipitation and other weather and meteorological data. The study spanned the period from 1889 to 1977 and showed only five or six identifiable landfalling tropical cyclones; the 1939 Long Beach event was the strongest and the only one in the tropical storm category. The others were all weak tropical depressions (with maximum winds of less than 35 knots). This low-frequency event (once in 105 years over approximately 360 miles of coastline, coupled with an impact diameter of approximately 60 miles) implies that, for any given location, the return period of a landfalling tropical cyclone is approximately 600 years. Therefore, landfalling tropical cyclones were not considered in this study.

At each location within the study area, the exceedence frequencies at a given elevation due to the various flood producing mechanisms were summed to give the total exceedence frequency at the flood elevation.

Elevations for floods of the selected recurrence intervals on the Pacific Ocean, Mission Bay, and San Diego Bay are shown in Table 5.

Table 5. Summary of Elevations

Flooding Source and Location	Elevation (Feet) 10-Year	50-Year	100-Year	500-Year
Pacific Ocean				
At La Jolla at Scripps Institute Pier	4.7	4.9	5.1	5.5
At La Jolla at Avienda De La Playa Extended	5.6	6.1	6.3	6.6
At Mission Beach at Crystal Pier	6.0	6.0	6.0	--[1]
At Mission Beach at Pacific Beach Drive Extended	5.9	6.5	6.8	7.4
At Ocean Beach at Saratoga Avenue Extended	5.5	6.2	6.5	6.9
From Northern Corporate Limits of City of Del Mar to Near Mouth of the San Dieguito River	8.50	--[1]	11.80	14.10
At Right Overbank of the Mouth of the San Dieguito River	7.40	--[1]	9.95	12.05
From Mouth of the San Dieguito River to 500 feet South of 18th Street	6.30	--[1]	8.10	10.00
From 500 feet South of 18th Street to the Intersection of Ocean Avenue and 15th Street	6.85	--[1]	8.90	10.99
At the Intersection of Ocean Avenue and 15th Street to 10th Street	7.30	--[1]	9.60	11.78
From Just North of 7th Street to 500 feet South of 4th Street	8.45	--[1]	11.64	13.90
From 500 feet South of 4th Street to Southern Corporate Limits of City of Del Mar	8.00	--[1]	10.62	12.80
Mission Bay				
At Mariners Point	4.0	4.0	4.1	6.5
San Diego Bay				
At Shelter Island	4.3	4.4	5.0	9.0
At City of Chula Vista	4.2	4.4	5.0	9.0
At City of National City	4.8	--[1]	5.8	7.8

[1]Data Not Available

For the areas that were not studied using the wave runup model, a regression analysis was developed (Reference 24). The regression analysis established wave runup and wave setup elevations at half-mile distances along the shoreline. Computed elevations for wave runup are shown in Table 6.

Flood hydrographs and peak discharges were based on rainfall-runoff hydrograph computations. The flood hydrograph and peak discharge analysis for the 10-, 50-, 100- and 500-year flood computations of the studied streams was performed by Nolte and Associates. The procedure used the basin area, unit hydrograph, soil type, ground cover, antecedent moisture condition, and a storm rainfall pattern to develop a runoff hydrograph. The basin characteristics were computed based on the procedures outlined in the San Diego County Hydrology Manual (Reference 25).

The Type B, 24-hour storm rainfall pattern (Figure II-B-1 of the San Diego County Hydrology Manual) (Reference 26) was used to develop runoff hydrographs for the western part of the county. The Type II, 24-hour storm rainfall pattern was used to develop rainfall hydrographs for the eastern part of the county, primarily the Borrego Valley area.

The 10-, 50-, and 100-year, 24-hour isopluvials from the San Diego County Hydrology Manual (Reference 25) and rainfall records from the California Department of Water Resources (Reference 26) were used to select rainfall amounts for hydrograph computations. The 500-year rainfall amounts were extrapolated using the 10-, 50-, and 100-year amounts.

Calibration of antecedent moisture conditions (AMC) in the western drainage watersheds was accomplished by analyzing annual peak flows at gaged streams with a log-Pearson Type III analysis (Reference 27) to obtain a best fit regarding gage statistics. The AMC values determined by the best-fit procedure were 1.5 for 10-year, 2.0 for 50-year, 2.5 for 100-year, and 3.0 for 500-year frequencies. These AMC values were also applied to the eastern watersheds. The 100-year flow rates at the Borrego Valley area resulting from this set of AMC values were very close to those reported by the county (Reference 25).

The hydrologic soil type and the percent and type of ground cover were determined based on information obtained from the soil survey performed for San Diego County (Reference 28).

Within major basins, the hydrographs from separate subbasins were combined and routed downstream using the Muskingum routing procedure.

Discharges for the 10- and 100-year floods on Agua Hedionda and Buena Creeks were taken from a 1976 study on Agua Hedionda Creek (Reference 29). Discharges for the 50- and 500-year floods were taken from a 1972 study on Buena Vista and Agua Hedionda Creeks (Reference 30).

Table 6. Summary of Pacific Ocean Wave Elevations

Location	Wave Runup Elevation (Feet)			Wave Setup Elevation (Feet)		
	10-Year	100-Year	500-Year	10-Year	100-Year	500-Year
At Mouth of Batiquitos Lagoon	9.5	13.3	15.8	4.8	5.4	6.5
Just South of Mouth of Batiquitos Lagoon	6.5	8.2	10.3			
Shoreline Adjacent to California Western University	13.8	20.9	24.0			
Shoreline Between the Intersections of Hill Street and Cordova Street to the Intersection of Point Loma Avenue and Sunset Cliffs Boulevard	12.0	17.8	20.6			
Shoreline Between the Intersection of Loma Point and Sunset Cliffs Boulevard to the Ocean Beach Park Municipal Pier	6.6	8.7	10.6			
Shoreline 1,000 feet South of False Point	9.47	13.47	15.9			
Shoreline North of False Point to the Intersection of Bird Rock Avenue and Dolphine Place	12.2	18.0	20.9			
Shoreline from the Intersection of Chelsea Avenue and Caminode La Coasta to a Point About 500 feet North of the Intersection of Caminode La Coasta and La Canada	8.6	12.0	14.3			
Shoreline from Palomar Avenue South Approximately 1,500 Feet	7.7	10.4	12.5			
Shoreline from Palomar Avenue to Fern Glen	7.1	9.4	11.5			
Shoreline from Fern Glen to Pearl Street	6.0	7.6	9.5			

Table 6. Summary of Pacific Ocean Wave Elevations (Cont'd)

Location	Wave Runup Elevation (Feet)			Wave Setup Elevation (Feet)		
	10-Year	100-Year	500-Year	10-Year	100-Year	500-Year
Shoreline from Whale View Point to Point La Jolla	7.7	10.4	12.6			
Shoreline from the Salk Institute to Torrey Pines State Park	6.8	8.8	10.8			
1,000 Feet North Along Shore from Pacific Avenue Extended	8.3	11.3	13.6			
500 Feet North Along Shore from Pacific Avenue Extended	7.0	8.8	11.1			
At Grand Avenue Extended	7.4	9.6	11.8			
At Cannon Road Extended	7.2	9.3	11.5			
At Cerezo Drive Extended	7.6	10.0	12.1			
400 Feet North Along Shore from Manzano Drive Extended	8.2	11.0	13.3			
200 Feet North Along Shore from Manzano Drive Extended	8.8	12.0	14.4			
Adjacent to Intersection of Carlsbad Boulevard and Palomar Airport Road	9.6	13.4	16.0			
Adjacent to Point on Carlsbad Boulevard 0.7 Mile South of Intersection with Palomar Airport Road	6.8	8.7	10.8			
At Poinsettia Lane Extended	9.6	13.3	15.8			

Table 6. Summary of Pacific Ocean Wave Elevations (Cont'd)

Location	Wave Runup Elevation (Feet)			Wave Setup Elevation (Feet)		
	10-Year	100-Year	500-Year	10-Year	100-Year	500-Year
At the Shoreline Along Ocean Boulevard	5.6	6.9	8.7			
At the Shoreline Along San Diego Bay				4.8	5.8	7.8
At Border State Park	5.9	7.3	9.2			
Tijuana River-Oneonta Slough Confluence				4.8	6.1	8.6
300 Feet West of Southern Extent of 1st Street	6.1	7.6	9.5			
200 Feet West of 1st Street, 1,400 Feet South of Encanto Avenue	6.9	8.9	11.0			
250 Feet West of 1st Street, 500 Feet South of Encanto Avenue	7.2	9.5	11.6			
At Encanto Avenue Extended	6.8	8.8	10.9			
At Cortez Avenue Extended	6.4	8.1	10.1			
At Evergreen Avenue Pier	5.9	7.3	9.2			
Along Otay River via San Diego Bay				4.8	5.8	7.8
At Oceanside Harbor				4.8	5.5	6.9
1,000 Feet Northwest of the Mouth of San Luis Rey River, Along Shoreline	6.9	8.8	10.9			
At Mouth of San Luis Rey River				4.8	5.5	6.9

Table 6. Summary of Pacific Ocean Wave Elevations (Cont'd)

Location	Wave Runup Elevation (Feet)			Wave Setup Elevation (Feet)		
	10-Year	100-Year	500-Year	10-Year	100-Year	500-Year
Shoreward of Intersection of 6th Street and The Strand	6.9	8.8	10.9			
1,000 Feet Southeast of Third Street Pier, Along Shoreline	7.6	9.9	12.2			
At Mouth of Loma Alta Creek	8.0	10.7	13.0			

Peak discharges for Broadway Creek were taken from a Hydrology for Survey Report (Reference 31).

Peak discharges for Casa de Oro Creek and Spring Valley Creek were taken from a 1973 hydrology report (Reference 32).

Peak discharges for Descanso Creek, Harbison Canyon Creek, Samagutuma Creek, the Sweetwater River, and the Sweetwater River (Near Descanso) were taken from a 1973 hydrology report (Reference 33).

Discharges for the 10-, 50-, 100-, and 500-year floods on Escondido and Reidy Creeks were taken from previous studies (References 34-36).

Peak discharges for Hatfield Creek, Kit Carson Park Creek, North Tributary to Santa Maria Creek, Santa Maria Creek (Santa Maria Valley Area), South Tributary to Santa Maria Creek, Tributary of South Tributary to Santa Maria Creek, Wabash Branch and Home Avenue Branch of Las Chollas Creek, South Las Chollas Creek and Encanto Branch, Switzer Creek, Florida Drive Branch, Las Puleta Creek, San Elijo Creek, Loma Alta Creek were computed based on the San Diego County Hydrology Manual (Reference 25). This method depends on precipitation, with direct runoff being a function of soil and ground-cover characteristics and also the antecedent moisture condition. Precipitation maps developed by the National Weather Service, along with soil and ground-cover maps established by the SCS, were used to obtain hydrologic information for these computations. Basin characteristics were confirmed by field reconnaissance. All peak discharges were computed based on existing conditions.

The peak discharges for Las Chollas Creek below Federal Boulevard reflect values obtained by the USACE (Reference 37) and agreed upon by representatives of San Diego County, the City of San Diego, and the USACE.

The 100-year discharge for Otay River was established in 1974 by the USACE and the City of San Diego (Reference 1). Discharges for the 10-, 50-, and 500-year floods were determined through coordination between the USACE, the City of San Diego, and San Diego County.

Peak discharges for the 10-, 50-, 100-, and 500-year floods on the downstream portions of San Diego River through the City of San Diego were taken from San Diego River Design Memorandum No. 1 (Reference 38). Peak discharges for the 10- and 100-year floods on the upstream reaches of San Diego River were taken from Upper San Diego River Flood Control Investigation (Reference 39).

Peak discharges for the 10-, 50-, and 100-year floods on Santa Maria Creek and Santa Ysabel Creek were taken from the Flood and Sediment Control Study for the San Pasqual Preliminary Report

(Reference 18). This study used the SCS methods contained in the computer program TR-20 (Reference 40). Input to the program was determined following the method given in the County of San Diego Hydrology Manual (Reference 25). The 500-year peak floods for these creeks were extrapolated graphically from the values given for smaller floods. In the 50-, 100-, and 500-year floods, significant spills occur from Santa Ysabel Creek into Santa Maria Creek near Monument Road, a short distance upstream of their confluence.

The 10- and 100-year discharges on San Vicente Creek were taken from a 1976 flood-control report (Reference 39). The 50-year discharges were computed using the same techniques as in the 1976 flood-control report. The 500-year discharge was computed based on the San Diego County Hydrology Manual (Reference 25).

The discharge-frequency data for the Sweetwater River (near National City) analyses were obtained from the Sweetwater River Flood Control Channel Report (Reference 16). Peak discharge-frequency relations for floods of the selected recurrence intervals on the Sweetwater River at its mouth were based on the current operating policies of the California American Water Company for Loveland and Sweetwater Reservoirs (Reference 16).

Peak discharges for Telegraph Canyon Creek were taken from a 1976 information brochure for flood control on Telegraph Canyon Creek (Reference 41). The flows for Telegraph Canyon Creek Overflow are from the flows in Telegraph Canyon Creek and the capacity of the culvert under Interstate Highway 5.

Peak discharges on San Luis Rey River were taken from a California Department of Water Resources report (Reference 42). The 10-year discharges between Pauma Creek and Keys Canyon decrease with increasing drainage area due to breakouts from the low flow channel.

Peak discharge-frequency relationships for the Tijuana River were established by the USACE (Reference 43). They were determined from U.S. Geological Survey (USGS) records and historical data on Tijuana River and other nearby streams (Reference 43). Discharges for Sunrise Overflow were determined in connection with the hydrologic analysis for the Tijuana River.

Peak discharge-frequency relationships for Nestor Creek were determined by utilizing rainfall runoff techniques developed by the SCS. The SCS computer program, TR-20, Project Formulation-Hydrology, was used in the analysis (References 40).

Peak discharges for the 10-, 50-, 100-, and 500-year floods on Soledad Canyon, Los Penasquitos Creek, Carmel Valley Creek, and Carroll Canyon Creek were taken from the 1976 Hydrology for Flood Insurance Studies, Soledad Canyon and Tributaries, San Diego County, California (Reference 44).

Peak discharges for Carmel Valley Creek restudy were modified to better account for changes in drainage area along the detailed study reach.

Peak discharges for the 10-, 50-, 100-, and 500-year floods on Murray Canyon Creek were taken from Hydrology for Flood Insurance Studies, Murray Canyon Creek, San Diego County, California Reference 45).

Discharges on Murray Canyon Creek decrease in a downstream direction due to two breakouts. Breakouts occur just upstream of the gravel pit area and at the Friars Road overpass.

Peak discharges for the 10-, 50-, 100-, and 500-year floods for Rose Canyon Creek and San Clemente Canyon Creek were taken from the 1972 Hydrology for Flood Plain Information Studies, Rose and San Clemente Canyons (Reference 46).

Discharges for the 10-, 50-, 100-, and 500-year floods on Tecolote Creek were taken from Hydrology for Flood Insurance Studies, Murphy, Murray, Alvarado, and Tecolote Canyons, San Diego County, California (Reference 47). Discharges decrease in a downstream direction at Genesee Avenue and Balboa Avenue due to culvert restrictions.

Peak discharges for the 10-, 50-, and 100-year floods on Murphy Canyon Creek were taken from Revised Murphy Canyon Peak Discharge Table (Reference 48). The 500-year flood peak was extrapolated graphically from the smaller peaks.

Discharges for the 10- and 100-year floods on Buena Vista Creek were taken from a 1976 San Diego County Department of Sanitation and Flood Control (DSFC) study on Buena Vista Creek (Reference 49).

Discharges for the 50- and 500-year floods were taken from discharge-frequency curves that were developed from frequency curves for similar gaged streams in the county (Reference 50). To draw the curve, the Standard Project Flood was calculated using Generalized Standard Project Rainflood Criteria for Southern California Coastal Streams (Reference 51), and routed by the Muskingum method. Discharges used in the hydrologic analysis for the portion of Buena Vista Creek between El Camino Real and Jefferson Street were taken from a 1976 DSFC hydrology report on Buena Vista Creek (Reference 49).

Flood hydrographs and peak discharges for the 10-, 50-, 100-, and 500-year flood events for Poggi Canyon Creek and Rice Canyon Creek were based on rainfall-runoff hydrograph computations. The procedure used the basin area, unit hydrograph, soil type, ground cover, antecedent moisture condition, and a storm rainfall pattern to develop a runoff hydrograph. The basin characteristics were computed based on the procedures outlined in the San Diego County Hydrology Manual (Reference 25).

The floodflows for the San Dieguito River were taken from a study by Leedshill-Herkenhoff, Inc., for the City of Del Mar (Reference 52). They routed the hydrographs developed by Boyle Engineering, Inc., for Santa Ysabel Creek through Lake Hodges Reservoir and down the San Dieguito River to Del Mar. Maximum storage conditions in the Lake Hodges Reservoir were assumed.

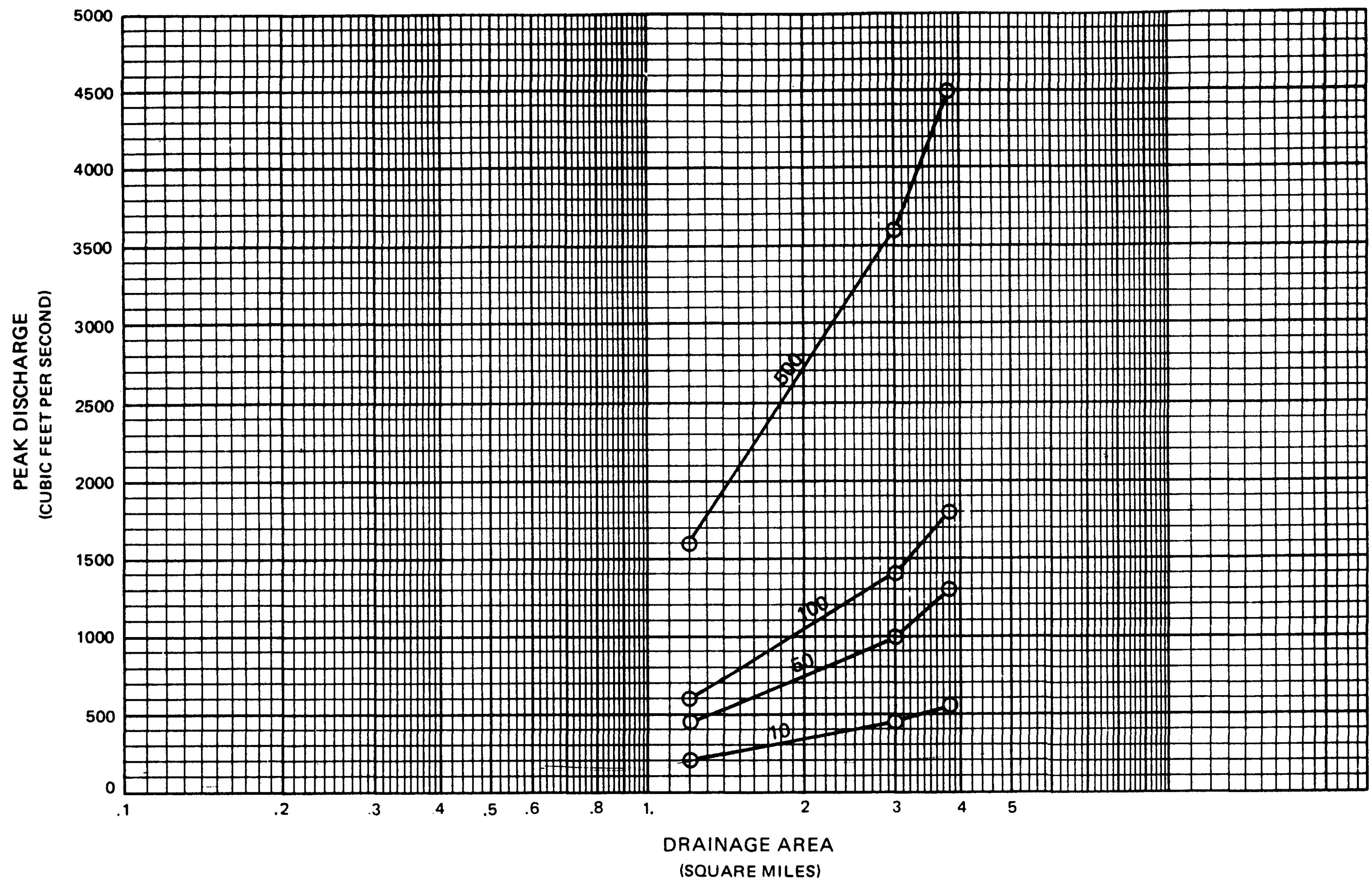
The only stream gage in the area is on Forester Creek at Cuyamaca Street and has only a 6-year record. Characteristics of the Forester Creek Drainage Basin were found to be similar to those of the nearby Spring Valley Basin for which frequency-discharge data had previously been published (Reference 31). The slope of the frequency-discharge curve for Spring Valley Creek was, thus, used as typical for the majority of the Forester Creek Basin. The exception is the steep, undeveloped headwaters of Forester Creek upstream from Greenfield Drive. Due to similarities of this area and the upper Murphy Canyon Basin for which frequency-discharge data had been published (Reference 47), the slope of the frequency curve for Murphy Canyon upstream from Clairmont Mesa was used for this area.

Control points for the frequency-discharge curves were developed by calculating the equivalent of a 500-year flood. A high intensity, 3-hour thunderstorm was selected as critical for the area (Reference 51). Sub-area hydrographs were developed for the basin by means of the Clark Unit Hydrograph Method (Reference 53) and routed through the drainage system by the Muskingum Method (Reference 14), using the HEC-1 computer program (Reference 54). The Modified Puls Method (Reference 4) was used to account for heavy ponding upstream from Interstate 8 on County Ditch Creek and Washington Creek.

Drainage area-peak discharge curves for County Ditch Creek, Forester Creek, and Paradise Creek are shown in Figures 5 through 7.

The discharge-frequency analysis for Paradise Creek was based on the average mean discharge per square mile. This analysis was determined from three short-term stream gages in the immediate vicinity of Paradise Creek and five selected long-term stream gages in urbanized portions of southern California. The locations of lengths of record for the three short-term stream gages are: Las Chollas Creek at Wabash and Oceanview, 5 years; South Chollas Tributary (Encanto Branch) at Euclid and Market Street, 5 years; and, Spring Valley Creek at Goodland Acres Park, 9 years. The locations and lengths of record for the five long-term stream gages are: Alhambra Wash near Klingerman Street, 42 years; Rubic Wash at Glendon Way, 12 years; Compton Creek at 120th Street, 20 years; Compton Creek near Greenleaf Drive, 34 years; and, Santelle-Westwood Channel near Cuber Boulevard, 20 years. These gages are all located in the Los Angeles area.

The frequency-discharge curve for Paradise Creek was adjusted, as appropriate, to consider diversions at River Mile 3.0 and overflows



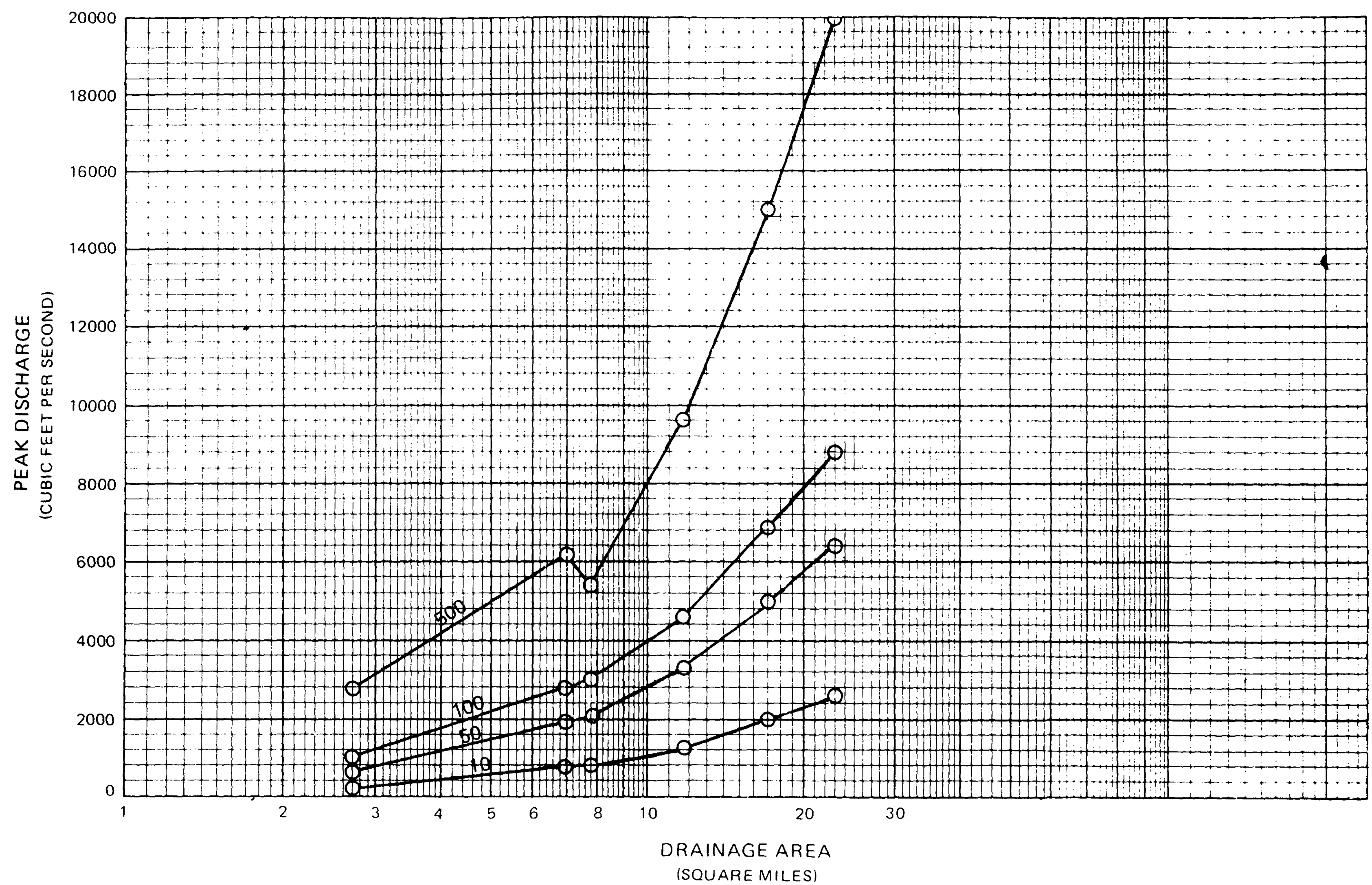
FEDERAL EMERGENCY MANAGEMENT AGENCY

SAN DIEGO COUNTY, CA AND INCORPORATED AREAS

FREQUENCY DISCHARGE, DRAINAGE AREA CURVES

COUNTY DITCH CREEK

FIGURE 5



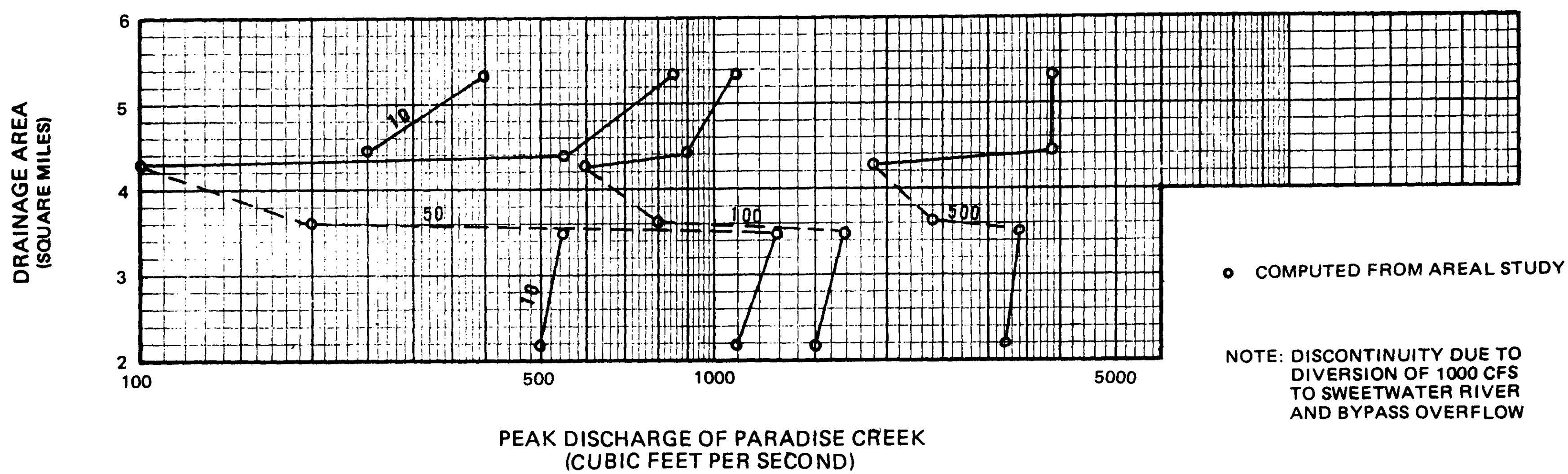
FEDERAL EMERGENCY MANAGEMENT AGENCY

SAN DIEGO COUNTY, CA AND INCORPORATED AREAS

FREQUENCY DISCHARGE, DRAINAGE AREA CURVES

FORESTER CREEK

FIGURE 6



FEDERAL EMERGENCY MANAGEMENT AGENCY

SAN DIEGO COUNTY, CA AND INCORPORATED AREAS

FREQUENCY–DISCHARGE DRAINAGE AREA CURVES

PARADISE CREEK

FIGURE 7

at River Mile 3.6 of the stream, which resulted in reductions of the peak discharges at downstream concentration points.

Flood hydrographs and peak discharges for the 10-, 50-, 100-, and 500-year flood events for Garrison Creek were based on rainfall-runoff hydrograph computations. The procedure used the basin area, unit hydrograph, soil type, ground cover, antecedent moisture condition, and storm rainfall pattern to develop a runoff hydrograph. The basin characteristics were computed based on the procedures outlined in a 1983 DSFC hydrology manual (Reference 25).

The Type I, 24-hour storm rainfall pattern (Figure II-B-1 of the 1983 hydrology manual) was used to develop runoff hydrographs.

The 10-, 50-, and 100-year, 24-hour isopluvials from the 1983 hydrology manual (Reference 25), and rainfall records from the California Department of Water Resources (Reference 26) were used to select design rainfall amounts for hydrograph computations. The 500-year rainfall amounts were extrapolated using the 10-, 50-, and 100-year amounts.

Peak discharges for 100-year floods on Beeler Creek, Poway Creek, North Branch Poway Creek, Rattlesnake Creek, and South Branch Poway Creek were taken from Hydrology Report for Poway Creek Complex (Reference 55). Discharges for 10-, 50-, and 500-year recurrence intervals were taken from Hydrology for Flood Insurance Studies, Soledad Canyon and Tributaries, San Diego County, California (Reference 44). These discharges were determined after extensive coordination among Poway community groups, the USACE, and San Diego County.

The 10- and 100-year peak discharges for Green Valley Creek and Green Valley Creek Tributary are based on computation methods explained in the San Diego County Hydrology Manual (Reference 25). The county computer programs CN and HYDRO2 were used to perform the numerical computations. The curve numbers (CN) computed by the county are based on the SCS Hydrologic Soil Group and Ground Cover maps 1969 Edition, and were updated to reflect 1990 land use projections. The 10-year and 100-year peak flows were obtained using the SCS Unit Hydrograph and precipitation values obtained from the National Weather Service Precipitation Maps (Reference 56). Field investigations were made to visually verify the 1969 maps, to update for current conditions, and to estimate the subbasin hydrologic conditions and basin factors. An overall fair hydrologic condition exists for the basin on the average.

Using the San Diego County lag definition, lag times and times to peak (Tp) were computed for each of the subbasins and the entire drainage basin. The basin drainage area, CN, infiltration rate, precipitation, and Tp were input into HYDRO2 and, using the SCS Unit Hydrograph, a hydrograph was developed for each concentration point resulting in peak discharges. By applying the ratio method to the peak discharges of different recurrence intervals, 50- and

500-year peak discharges for various concentration points were determined.

Four USGS stream gages are located within the City of Poway. Due to the short period of record, however, they were not utilized in hydrologic analyses.

The method used to develop the San Marcos Creek basin hydrology follows the procedures recommended in the San Diego County Hydrology Manual (Reference 25). The standard SCS unit hydrograph method was applied to Las Posas Creek, San Marcos Creek, and Twin Oaks Valley Creek.

Based on the watershed basin sizes and flowpaths of San Marcos and Twin Oaks Valley Creeks, the two creeks have virtually the same time of concentration. Therefore, the peak discharges from the two creeks are additive at their confluence, without significant lag times.

A siltation basin was constructed in the upper portion of the Las Posas Creek watershed at the intersection of Las Posas Road and Avenida Azul. This facility was not included in the hydrologic analyses because the routing effect from the reservoir is insignificant, compared to the overall peak flow rate for Las Posas Creek.

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of flooding from the sources studied were carried out to provide estimates of the elevations of floods of the selected recurrence intervals.

For areas of riverine flooding studied in detail, water-surface elevations for floods of the selected recurrence intervals were computed through use of the USACE HEC-2 computer program (Reference 57). Hand calculations were used in some places to augment the computer program.

Flood elevations on Murray Canyon Creek at Friars Road were determined from combined outlet control and weir flow computations, and were then inputed into the HEC-2 model (Reference 57).

Flood elevations on Tecolote Creek downstream of Morena Boulevard were developed from rating curves at each bridge and from normal-depth calculations. Water-surface elevations at Balboa and Genesee Avenues were determined from rating curves and then were imputed into the HEC-2 model (Reference 57).

Flood elevations for the 500-year breakouts on Rose Canyon Creek were determined from normal-depth calculations. Water-surface elevations at Genesee Avenue were developed from a rating curve for the three culverts and were entered as input into the HEC-2 model (Reference 57).

For those reaches not analyzed using the HEC-2 program, normal-depth calculations were used in conjunction with extensive field investigations and improvement plan research. Normal-depth calculations were used to establish water-surface elevations for reaches of Switzer Creek, Las Puleta Creek, Home Avenue Branch of Las Chollas Creek, and Murphy Canyon Creek where relatively long underground conduits were encountered.

Water-surface elevations for Telegraph Canyon Creek Overflow were determined by normal-depth calculations.

Cross sections for the backwater analysis were located at small intervals upstream and downstream from bridges and culverts and other hydraulically significant features to establish the backwater effect of such structures in areas presently urbanized or potentially subject to development. All bridges and culverts were field surveyed to obtain elevation data and structural geometry.

Cross section data for Agua Hedionda and Buena Creeks were digitized from aerial surveys (Reference 58). Additional cross section data were taken from grading plans and field surveys. All bridges and culverts were investigated to obtain elevation data and structural geometry.

Cross section data for the Carroll Canyon Creek, Otay River, and part of Telegraph Canyon Creek were digitized from aerial photographs (References 58 and 59). Additional cross section data were taken from grading plans and field surveys. All bridges and culverts were investigated to obtain elevation data and structural geometry.

Cross section data for Casa de Oro Creek and Spring Valley Creek were digitized from aerial photographs (Reference 60) and supplemented by grading plans and field investigations.

Cross section data for Descanso Creek, Harbison Canyon Creek, Samagutuma Creek, part of the Sweetwater River, and the Sweetwater River (near Descanso) were field surveyed.

Cross section data for Escondido Creek were taken from digitized aerial surveys and supplemented with as-built plans for the concrete portion of the channel. Cross section data for Reidy Creek were taken from digitized aerial survey sections provided by San Diego County. Cross section data for Kit Carson Park Creek were taken from aerial photographs (Reference 61).

Cross sections for Hatfield Creek, North Tributary to Santa Maria Creek, Santa Maria Creek (Santa Maria Valley area), South Tributary to Santa Maria Creek, and Tributary of South Tributary to Santa Maria Creek were digitized from aerial surveys (Reference 62) and supplemented by grading plans and field investigations.

Cross sections for San Vicente Creek were taken from a previous study (Reference 39).

Cross section data for Santa Maria Creek (San Pasqual Valley areas), South Fork Moosa Canyon Creek, and part of the Sweetwater River were digitized from aerial photogrammetric surveys and supplemented with existing plans, topographic mapping, and field survey data (References 58 and 63).

Cross section data for Las Chollas Creek, Wabash Branch, Home Avenue Branch, South Las Chollas Creek, Encanto Branch, Switzer Creek, Florida Drive Branch, Las Puleta Creek, Rose Canyon Creek, San Clemente Canyon Creek, and Tecolote Creek were taken from topographic maps (References 58 and 59).

Cross section data for Murray Canyon Creek were taken from topographic maps and map manuscripts (References 59 and 64).

Cross section data for the San Diego River were taken from topographic maps (Reference 65).

Cross section data for Carmel Valley Creek were developed from topographic maps (References 66 and 67) and from field surveys.

Cross section data for Nestor Creek, Tijuana River, Sunrise Overflow, Kit Carson Park Creek, Los Penasquitos Creek, Soledad Canyon, Otay River, Murphy Canyon Creek, Santa Ysabel Creek, Santa Maria Creek and San Diego River were digitized from aerial photographs (References 59, 60, 61, 68, and 69).

Cross section data for Buena Vista Creek were digitized from aerial surveys (Reference 12). Additional cross section data were taken from grading plans and field surveys. All bridges and culverts were investigated to obtain elevation data and structural geometry. Cross section data for the revised portion of Buena Vista Creek were digitized from aerial surveys (Reference 70).

Cross section data for Poggi Canyon Creek, Rice Canyon Creek, part of Sweetwater River, and Telegraph Canyon Creek Overflow were digitized by aerial photogrammetric surveys, supplemented with existing plans and topographic mapping, and field survey data (References 58 and 63). Cross sections for backwater analysis were located at small intervals upstream and downstream from bridges and culverts and other hydraulically significant features to establish the backwater effect of such structures in areas presently urbanized or potentially subject to development. Cross section data for Otay River and Telegraph Canyon Creek were digitized by aerial photogrammetric surveys (Reference 63). Additional cross sections on Telegraph Canyon Creek were taken from grading plans or field investigations.

Cross section data for a portion of the Sweetwater River were digitized by aerial photogrammetric surveys, supplemented with existing plans and topographic mapping, and field survey data (References 58, 59, 71, and 72).

Cross section data for Soledad Canyon were obtained from field surveys.

Cross section data for the San Dieguito River were obtained from digitized aerial surveys, field surveys, and local improvement plans (References 63 and 73).

Cross sections for the backwater analysis for Broadway Creek, County Ditch Creek, and Forester Creek were developed from available topographic maps (Reference 74), supplemented with as-built improvement plans (Reference 75) and field investigations.

Cross section data for San Elijo Creek and Escondido Creek were digitized by aerial photogrammetric surveys and supplemented with existing plans, topographic mapping, and field survey data (References 58 and 63).

Cross section data for the Tijuana River were digitized from aerial photographs (References 59, 63, 58, and 61).

Cross section data for Spring Valley Creek were digitized by aerial photogrammetric surveys and supplemented with existing plans, topographic mapping, and field survey data (References 63 and 76).

Cross section data for Paradise Creek were obtained from city orthophoto-topographic maps (Reference 71) and topographic maps (References 59 and 72). All bridges and culverts were surveyed to obtain elevation data and structural geometry.

Cross section data for the original study for the City of Oceanside were digitized from aerial surveys (Reference 77). Additional cross section data were taken from grading plans and field surveys. All bridges and culverts were investigated to obtain elevation data and structural geometry.

Cross section data for the revised study of Garrison Creek and the San Luis Rey River were also digitized from aerial surveys (References 58 and 63).

Cross sections for flooding sources through Poway were digitized from aerial surveys (Reference 78) and supplemented by field investigations.

Cross sections were digitized from aerial surveys (Reference 58) and supplemented by field investigations.

Cross section data for Buena Vista Creek Tributaries 1, 2, 3, and 4, and Buena Creek were digitized from aerial surveys (References 58 and 63). Additional cross section data were taken from grading plans and field surveys. All bridges and culverts were investigated to obtain elevation data and structural geometry.

Cross sections for the San Luis Rey River were digitized from aerial photographs taken in December 1973 (Reference 58).

Roughness coefficients (Manning's "n") used in the hydraulic computations (shown in Table 7) were chosen by engineering judgment, based on both aerial photographs and field observations of the channels and floodplain areas.

Starting water-surface elevations for Carroll Canyon Creek were determined from the flood profile for Soledad Canyon.

Starting water-surface elevations for Santa Maria Creek were determined from the flood profile for Santa Ysabel Creek, which itself was determined from the elevation in Lake Hodges when the peak flow arrives.

Starting water-surface elevations for Buena Vista Creek were calculated assuming critical depth. For the detailed study of Buena vista Creek Tributary 1, the starting water-surface elevation was derived from the downstream culvert analysis.

Starting water-surface elevations for Nestor Creek and Sunrise Overflow were computed using the slope-area methods.

Starting water-surface elevations for Carmel Valley Creek and Carroll Canyon Creek were taken from the flood profile for Soledad Canyon.

Starting water-surface elevations for Kit Carson Park Creek are based on the resulting Lake Hodges elevation when the spillway discharges 50,000 cfs.

Starting water-surface elevations for Rose Canyon Creek and Tecolote Creek were taken from Mission Bay. Starting water-surface elevations on San Clemente Creek were taken from the flood profile for Rose Canyon Creek. Starting water-surface elevations for Murray Canyon Creek were taken from flood profiles for San Diego River.

Starting water-surface elevation for the Tijuana River is the MHHW for the Pacific Ocean.

Starting water-surface elevations for Santa Ysabel Creek are based on elevations resulting from routing of flood hydrographs from San Dieguito River Flood Studies (Reference 52) through Lake Hodges.

Starting water-surface elevations for Santa Maria Creek were taken from the Santa Ysabel flood profiles, due to coincident flooding.

Starting water-surface elevations at the mouth of the San Diego River were computed assuming critical depth. Starting water-surface elevations for the San Diego River at Friars Road were taken from the flood profiles of the 1983 San Diego River Flood Insurance Study. Starting water-surface elevations for the upstream reach of the San Diego River were taken from a known 100-year flood elevation at Mission Dam.

Table 7. Summary of Manning's "n" Values

Stream	Manning's "n" Values Channel	Overbanks
Agua Hedionda Creek	0.014 - 0.040	0.020 - 0.040
Beaver Hollow Creek		
Beeler Creek	0.041 - 0.060	0.030 - 0.060
Broadway Creek	--[1]	--[1]
Buena Creek	0.020 - 0.050	0.015 - 0.050
Buena Vista Creek	0.015 - 0.045	0.024 - 0.050
Buena Vista Creek Tributary 1	0.015 - 0.045	0.024 - 0.050
Carmel Valley Creek	0.040 - 0.070	0.040 - 0.010
Carroll Canyon Creek	0.037 - 0.070	0.037 - 0.070
Coleman Creek		
County Ditch Creek	--[1]	--[1]
Deer Springs Creek		
Descanso Creek	0.027 - 0.050	0.030 - 0.050
Encanto Branch	0.015 - 0.045	0.025 - 0.080
Escondido Creek	0.016 - 0.025	0.040 - 0.050
Eucalyptus Hills (East Branch)		
Eucalyptus Hills (West Branch)		
Florida Drive Branch	0.015 - 0.045	0.040 - 0.070
Forester Creek	0.022	0.022
Forester Creek-Carlton Hills Boulevard Overflow	0.015 - 0.020	0.015 - 0.040
Garrison Creek	0.018 - 0.050	0.030 - 0.050
Gopher Creek		
Green Valley Creek	0.015 - 0.050	0.015 - 0.050
Green Valley Creek Tributary	0.015 - 0.035	0.015 - 0.035
Harbison Canyon Creek	--[1]	--[1]
Hatfield Creek	0.015 - 0.090	0.015 - 0.065
Home Avenue Branch	0.013 - 0.035	0.035 - 0.065
Kit Carson Park Creek	0.032 - 0.070	0.020 - 0.060
Las Chollas Creek	0.015 - 0.045	0.030 - 0.150
Las Posas Creek (Upper)	--[1]	
Las Puleta Creek	0.013 - 0.060	0.025 - 0.070
Lawson Valley Creek		--[1]
Loma Alta Creek	0.018 - 0.070	0.035 - 0.045
Las Penasquitos Creek	0.030 - 0.060	0.020 - 0.080
Lusardi Creek		
Mexican Canyon Creek	0.025 - 0.040	0.030 - 0.050
Moosa Creek (North Branch)		
Moosa Creek (South Branch)		
Murphy Canyon Creek	0.015 - 0.035	0.030 - 0.040
Murray Canyon Creek	0.020 - 0.050	0.080
Nestor Creek	0.030 - 0.045	0.030 - 0.100
North Branch Poway Creek	0.014 - 0.035	0.018 - 0.035
North Tributary to Santa Maria Creek	0.015 - 0.090	0.015 - 0.060

[1]Data Not Available

Table 7. Summary of Manning's "n" Values (Cont'd)

Stream	Manning's "n" Values Channel	Overbanks
Olive Creek		
Otay River	0.040	0.040
Pala Mesa Golf Course		
Paradise Creek	0.016 - 0.030	0.018
Poggi Canyon Creek	0.013 - 0.050	0.020 - 0.040
Poway Creek	0.014 - 0.050	0.018 - 0.040
Rainbow Creek (Main Branch)		
Rainbow Creek (West Branch)		
Rattlesnake Creek	0.014 - 0.040	0.010 - 0.060
Rattlesnake Creek Split Flow at Heritage Hills	0.014 - 0.040	0.010 - 0.060
Rattlesnake Creek Split Flow at Midland Road	0.014 - 0.040	0.010 - 0.060
Reidy Creek	0.014 - 0.040	0.025 - 0.060
Rice Canyon Creek	0.013	0.013
Rose Canyon Creek	0.040	0.035 - 0.040
Samagutuma Creek	0.035 - 0.040	0.030 - 0.040
San Clemente Canyon Creek	0.035 - 0.040	0.015 - 0.040
San Diego River	0.025 - 0.125	0.030 - 0.125
San Dieguito River	0.030 - 0.035	0.030 - 0.045
San Elijo Creek		
San Luis Rey River	0.025 - 0.120	0.030 - 0.120
San Marcos Creek		
San Marcos Creek Highway 78 Split Flow		
San Vicente Creek	0.045 - 0.050	0.042 - 0.050
Santa Maria Creek (San Pasqual Valley Area)	0.025 - 0.035	0.035 - 0.045
Santa Maria Creek (Santa Maria Valley Area)	0.015 - 0.090	0.015 - 0.090
Santa Ysabel Creek	0.025 - 0.035	0.035 - 0.040
Slaughterhouse Creek		
Soledad Canyon	0.020 - 0.070	0.035 - 0.150
South Branch Poway Creek	0.014 - 0.035	0.018 - 0.035
South Fork Moosa Canyon Creek	0.015 - 0.050	0.030 - 0.100
South Las Chollas Creek	0.015 - 0.045	0.025 - 0.080
South Tributary to Santa Maria Creek	0.015 - 0.090	0.015 - 0.060
Spring Valley Creek		
Steele Canyon		
Stevenson Creek		
Sunrise Overflow	0.025 - 0.040	0.025 - 0.040

Table 7. Summary of Manning's "n" Values (Cont'd)

Stream	Manning's "n" Values Channel	Overbanks
Sweetwater River (Above Reservoir)	0.015 - 0.060	0.030 - 0.070
Sweetwater River (At National City)	0.025 - 0.035	0.030 - 0.060
Sweetwater River (Descanso Area)	0.035 - 0.055	0.030 - 0.060
Switzer Creek	0.013 - 0.030	0.030
Tecolote Creek	0.014 - 0.050	0.035 - 0.050
Telegraph Canyon Creek	0.015 - 0.045	0.015 - 0.065
Tijuana River	0.040	0.040
Tributary of South Tributary to Santa Maria Creek	0.015 to 0.090	0.015 to 0.060
Tributary to Sweetwater River		
Twin Oaks Valley Creek		
Wabash Branch	0.013 - 0.035	0.065
Witch Creek		
Alvarado Creek	0.015 - 0.065	0.035 - 0.075

The starting water-surface elevation for Poggi Canyon Creek considered previously determined backwater conditions on Otay River. However, critical depth controls upstream of the confluence with Otay River. Starting water-surface elevations for Rice Canyon Creek were based on Sweetwater River flood elevations at the confluence. Sweetwater River starting water-surface elevations were determined by either the critical depth at the mouth or the tidal data in San Diego Bay, whichever is higher. Critical depth was used in the computation of the 50-, 100-, and 500-year floods, while the mean higher high tide of 2.9 feet was used for the 10-year flood. Starting water-surface elevations for Telegraph Canyon Creek were calculated assuming critical depth. Starting water-surface elevations for Telegraph Canyon Creek Overflow were derived from normal-depth calculations.

Starting water-surface elevations for the San Dieguito River were based on the MHHW for the Pacific Ocean.

Starting water-surface elevations for Escondido Creek were calculated by a reservoir-routing procedure at San Elijo Lagoon near the Pacific Ocean. Starting water-surface elevations for Reidy Creek were determined by calculating critical depth at Lincoln Avenue.

Starting water-surface elevations for the San Luis Rey River were calculated assuming critical depth and MHHW of the Pacific Ocean.

Starting water-surface elevations for Green Valley Creek were taken from a known 100-year flood elevation approximately 170 feet upstream of Pomerado Road in the community of Rancho Bernardo. Starting water-surface elevations for Green Valley Creek Tributary were taken from the main stem. Starting water-surface elevations for all other streams were determined by critical-depth calculations.

For Forester Creek, the initial water-surface elevation was determined by the slope-area method. For Forester Creek-Carlton Hills Boulevard Overflow, the initial water-surface was taken from a known water-surface elevation.

Starting water-surface elevations for the remaining streams studied by detailed methods were determined by either normal or critical depth calculations.

Flood profiles of the San Dieguito River are presented because of the areal extent and severity of flooding from this source. The hydraulic analyses for the study were based on unobstructed flow. The flood elevations shown on the profiles are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

Scouring of the riverbed at the mouth of the San Dieguito River was assumed to -4 feet. To simulate the 1980 flood, a discharge of 22,000 cfs was applied. The flooding results at the lower end of

San Dieguito River are in close agreement with the flood map provided by the City of Del Mar.

There is little significant flooding problem in the City of National City from the two unnamed intermittent creeks (designated as Creek A and Creek B). In the area of El Toyon Park by Creek B, however, a small-capacity culvert at Interstate Highway 805 would cause shallow ponding. Therefore, water-surface profiles for the unnamed creeks were eliminated in the study. For Las Puleta Creek, elevations above the long underground conduit downstream of Delta Street in the City of National City were determined by normal depth calculations, in conjunction with extensive field investigations and improvement plan research. The capacity of the conduit was determined to be approximately 70 percent of the 100-year discharge. This results in shallow flooding hazards with depths of approximately 1 foot in the residential area between Delta Street and 43rd Street.

Analysis indicated that the 100-year flood on Rattlesnake Creek would be divided at the Heritage Hills Unit 4 Subdivision and at Midland Road.

At Heritage Hills, the divergence from the main channel occurs downstream of Community Road on the northern side of the development. Backwater at the entrance to the concrete-lined trapezoidal open channel through the subdivision forces significant amounts of flow around the eastern boundary of the subdivision. Although the concrete channel follows a somewhat steeper slope, the confining flow conditions cause the backwater to occur and result in overbank flow to the east.

It was determined that under existing conditions the 100-year floodflow would be split, with 1,000 cfs entering the concrete channel through Heritage Hills and the remaining 2,900 cfs occurring as overflow through the vacant fields east of the subdivision. Flooding on Wanesta Drive is based on backwater computations of the east split flow area. Flow reentering the western channel from Wanesta Drive and between houses was judged to be minor. Along the downstream side of Poway Road, a discharge of 800 cfs flows across Westy's Store parking lot to rejoin the main stem of Rattlesnake Creek, which changes to an earth-lined trapezoidal channel at Poway Road. The remainder of the split flow (2,100 cfs) reenters the main channel of Rattlesnake Creek along the future western extension of Remlap Way through grass and brush cover.

At Midland Road another split flow on Rattlesnake Creek occurs. Midland Road serves as a "side-channel spillway" for the channel located on the east side of Midland Road. The east channel is higher than the west channel, resulting in an average water-surface elevation difference of 4 feet. Floodwaters from the east channel will have to flow laterally across the road into the west channel. Flow will, therefore, be continuously added to the west channel. A separate HEC-II step-backwater computer analysis was performed for the east and west channels. Flow rates for use in the computer analysis were established at each cross section by creating weir flow rating curves for Midland Road. Computations resulted in a flow configuration of 1,500 cfs through the Midland Road bridge and of 1,800 cfs proceeding along the east side of Midland Road to become weir flow. The split flow to the east gradually reenters the main channel and converges with Rattlesnake Creek just northwest of the intersection of Midland Road and Aubrey Street.

Downstream of the Midland Road split flow area, in the vicinity of York Avenue and Sycamore Avenue, a low flow channel, which lies outside the main 100-year floodplain, extends downstream of Edgemoor Street. This channel is capable of conveying only about 400 cfs; therefore, the main flow bypasses it and flows to the northwest of the area. This area was modified in the HEC-II computer analysis using encroachments to restrict flow to the course it will actually take.

A flood profile is not provided for Lower Las Posas Creek. The regulatory 100-year water-surface elevations in this area are based on the backwater effects of San Marcos Creek. The profile for San Marcos Creek should be used to determine the regulatory 100-year water-surface elevations in this area.

The pipes passing underneath Echo Lane, Twin Oaks Valley Road, and San Marcos Boulevard were determined to be negligible in capacity, in comparison with the 100-year flood discharge.

A detailed hydraulic analysis was performed by Boyle Engineering for the Woodland Parkway Culvert. This culvert contains the entire 100-year flood discharge.

The controlling element at the entrance to the box culvert along Las Posas Creek is the balance between the orifice and weir capacities at Grand Avenue. For the 100-year flood discharge of 1,850 cfs, approximately 1,300 cfs will flow into the culvert, with the remaining 550 cfs overtopping Grand Avenue.

Areas of shallow flooding were determined using the HEC-2 computer program (Reference 57), normal-depth calculations, rating curves for bridges and culverts, and engineering judgment.

Overtopping of the south channel bank of Descanso Creek occurs between Cross Sections O and S. The minimum channel capacity before the flow overtops the south channel bank is 1,100 cfs, which is less than the 10-year flood. Therefore, any flows in excess of 1,100 cfs will escape from Descanso Creek and spread out as sheetflow in the flatlands on the left overbank before being collected by Samagutuma Creek to the south.

The most serious flood problem in Ramona is caused by a shallow swale which carries runoff from the low hills at the east end of the town through the central residential section to a southeasterly tributary of Santa Maria Creek. Flows exceeding 500 cfs (a 10-year flood) will leave the channel and cause sheetflow downstream of Cross Section BU. These flows reenter the main channel near the intersection of Black Canyon Road and Pile Street.

The culvert under Fifth Avenue on Telegraph Canyon Creek can only pass the 800 cfs 10-year flood. From Fifth Avenue upstream to Cross Section K, the channel capacity is limited by low banks and cannot handle the 100-year flood. Restriction in flow capacity downstream of Cross Section K causes sheetflow to the south in the vicinity of the east side of Fifth Avenue. This sheetflow covers a wide area and is approximately 1 foot deep. These flows reenter the main channel in the vicinity of Woodlawn Avenue and Moss Street.

The long culvert for Telegraph Canyon Creek under Interstate Highway 5 will carry approximately 2,000 cfs under flood conditions. The 100-year discharge at the culvert for Telegraph Canyon Creek is 2,800 cfs. Some of the excess discharge backs up behind the culvert and creates a shallow flooding area between the San Diego and Arizona Eastern Railroad and Colorado Avenue. This excess discharge was labeled Telegraph Canyon Overflow for this report. The overflow flows north, across "L" Street, and into a natural ditch between the railroad and Colorado Avenue. The ditch flows directly into a rectangular concrete channel that terminates at a 4-foot-diameter corrugated metal pipe. The corrugated metal pipe carries the flow into the drainage system under Industrial Boulevard and Interstate Highway 5, eventually discharging into San Diego Bay.

On Sweetwater River, the 100- and 500-year floods overflow onto Bonita Road and proceed under Interstate Highway 805. The low area around Bonita Road west of Interstate Highway 805 is drained by two 42-inch diameter reinforced concrete pipes with flap gates. The drainage pipes cannot carry the full amount of the overflow, so ponding occurs west of Interstate Highway 805. Since the 10-year event does not overflow into this area, the zone designation is based on the difference between the 100-year ponding elevation and the average ground elevation within the ponded area.

During a 50-year, 100-year, and 500-year flood, 3,900 cfs from Forest Creek diverges and flows along the east side of Carlton Hills Boulevard into San Diego River.

Shallow 100-year flooding occurs in the southern overbank of the San Diego River between North Magnolia Avenue and Abraham Way. Generally, the flooding is less than 1 foot in depth.

Shallow flooding depths on Buena Creek just downstream of State Highway 78 and Buena Vista Creek and its tributaries in the City of Vista were determined by engineering judgment. Much of the shallow flooding in the City of Vista is contained in the streets.

Debris potential was considered in the analysis of the Las Chollas area in the City of San Diego. The current policies of several agencies with expertise in hydraulic analysis, including the USACE, were researched. Based on these data, the following criteria were adopted for consideration of the debris potential in the streams studied. The debris potential for each stream was classified as either high, medium, or low, based on historic flood data, an analysis of the characteristics of the drainage area, and a field investigation of the flooding source by hydraulic engineers. On streams with low debris potential, no provisions for debris were made in the hydraulic analysis. For stream reaches where debris potential was determined as medium, the bridge geometry was altered using the following criteria:

1. If the existing structure had no debris walls, the pier wall area was increased by 1.0 foot of width multiplied by the full depth of water.

2. If the existing structure had debris walls, the pier wall area was increased by 1.0 foot of width multiplied by 6.0 feet of depth.

The debris analysis of circular conduits involved a reduction in the effective flow area of up to 30 percent, based on field reconnaissance. A summary of the debris potential for some flooding sources studied in detail are as follows:

Stream	Debris Potential
Las Chollas Creek	Medium
Wabash Branch	Medium
Home Avenue Branch	Medium
South Las Chollas Creek	Medium
Encanto Branch	Low
Switzer Creek	Low
Florida Drive Branch	Medium
Las Puleta Creek	Medium

A brief discussion of some flooding sources follows.

Las Chollas Creek

The main branch of Las Chollas Creek was analyzed from its upstream limit of study approximately 0.3 mile upstream of 54th Street to the corporate limits of the City of San Diego downstream of the confluence with South Las Chollas Creek. The existing topography provided a strong basis for the use of the HEC-2 computer program (Reference 57). In the upstream segment, the 100-year discharge is conveyed by a well-defined, natural channel, with backwater effects occurring at 54th Street, Euclid Avenue, and Fairmont Avenue. At these crossings, the roads are overtopped due to inadequate culvert conveyance and topographic constraints. Most of the 100-year discharge enters a lined channel system just upstream of Interstate Highway 805 and is conveyed to State Highway 94. The flow breakout that occurs at the Interstate Highway 805 crossing is caused by the lack of upstream channel confinement. The flow enters a defined, natural channel just downstream of State Highway 94, and is confined by relatively steep channel banks until it reaches the Market Street crossing. At this point, a lined channel system begins, which conveys the flows to National Avenue, just upstream of the confluence with South Las Chollas Creek. 100-year flooding depths in excess of 5 feet exist in the right overbank of this reach and are caused by inadequate conveyance at the bridge crossings. The unlined channel reach from National Avenue to the corporate limits is subject to inundation from backwater effects at the confluence. Studies are underway to determine the economic feasibility of installing a lined channel system on this reach.

Wabash Branch

Flows collected north of State Highway 94 at Wabash Boulevard are conveyed to Las Chollas Creek through a wide, well-defined natural channel. The existing topography provided a strong basis for the use of the HEC-2 computer program. From State Highway 94 to the confluence of Las Chollas Creek, a series of underground conduits and lined channels was analyzed using normal-depth calculations. Backwater effects upstream of State Highway 94 create shallow flooding hazards with depths to 3 feet in the right overbank. Downstream of State Highway 94, the 100-year discharge breaks out over Wabash Boulevard due to inadequate culvert capacity.

Home Avenue Branch

Upstream of Auburn Drive, storm flows are conveyed by a natural channel. The 100-year discharge is not contained by the lined channel downstream of Auburn Drive due to inadequate culvert capacity at Auburn Drive caused by silting. Shallow flooding conditions with depths of approximately 1 foot exist in a residential area until the flow reenters the lined channel downstream of Euclid Avenue. This reach of lined channel was analyzed assuming a supercritical flow regime. The discharge is contained in a well-defined natural channel from 900 feet downstream of Euclid Avenue to 300 feet upstream of the Interstate Highway 805 crossing, with weir flow occurring at Fairmont Avenue where debris accumulation reduces culvert conveyance. Hand calculations were used to substantiate the 100-year flow capacity of the Interstate Highway 805 conduit. Downstream of Interstate Highway 805, the 100-year discharge is contained in a natural channel to Federal Boulevard. Debris accumulation at the Federal Boulevard culvert creates shallow flooding conditions in the east overbank. The flow then enters the main branch of Las Chollas Creek.

South Las Chollas Creek

The hydraulic analysis of South Las Chollas Creek was accomplished using the HEC-2 step-backwater computer program for three independent channel reaches. The upstream lined channel reach, beginning at the corporate limits and ending upstream at Federal Boulevard, was analyzed assuming supercritical flow. Shallow flooding conditions in the left overbank result from inadequate channel improvements upstream of the corporate limits. The 100-year discharge is then conveyed in a well-defined natural channel to the inlet of a lined channel system at Lenox Drive. This lined channel reach was also analyzed using the supercritical flow regime. The 100-year discharge creates shallow flooding conditions in the overbanks of this reach due to debris clogging the culverts. The subcritical flow regime was used to analyze the remaining portion of South Las Chollas Creek. Shallow flooding conditions within this reach are mainly due to backwater effects caused by inadequate culvert and bridge conveyance. Debris buildup at these structures reduces the effective flow areas of the conduits, resulting in weir flow conditions. A proposed 100-year design dike with slope paving is planned for the reach between Interstate Highway 805 and Imperial Avenue. This channel improvement was included in the analysis and mapping. From 40th Street to the confluence with Las Chollas Creek, the flow is conveyed in an improved channel with approximately 100-year capacity. Shallow flooding hazards are included in the lower reaches due to backwater effects at the confluence of the two creeks.

Encanto Branch

Encanto Branch of South Las Chollas Creek runs easterly from its confluence with the main channel west of Euclid Avenue. The channel reach upstream of Merlin Drive was analyzed using a combination of normal-depth calculations and the HEC-2 step-backwater computer program, assuming a supercritical flow regime. Shallow flooding conditions which exist in the overbank are created by inadequate culvert conveyance at the various crossings. Downstream of Merlin Drive, the flow is essentially contained by a well-defined natural channel to its confluence with South Las Chollas Creek. Debris and silting problems, particularly at 54th Street, are responsible for flooding hazards to an industrial area downstream of 54th Street. Also, backwater effects at the confluence create shallow flooding conditions downstream of Euclid Avenue.

Switzer Creek

The HEC-2 step-backwater computer program was used from the limit of detailed study at 26th Street to the inlet of the 10-foot-diameter underground conduit near Russ Boulevard (Reference 27). For this reach, the 100-year discharge is conveyed by a lined channel section to the inlet of the underground conduit. Normal-depth calculations were used to establish that approximately 60 percent of the 100-year discharge enters the underground conduit and is conveyed to San Diego Bay. The remaining 40 percent, or approximately 750 cfs, will produce shallow flooding hazards up to 1 foot deep through the eastern downtown business district.

Florida Drive Branch

The 100-year discharge breaks out at the Florida Place crossing due to heavy debris clogging the box culvert. Downstream of Florida Place, the flow is contained in a well-defined natural channel. A short reach of lined channel downstream of the Pershing Drive crossing conveys the 100-year discharge into the main channel of Switzer Creek.

Las Puleta Creek

Normal-depth calculations were used to supplement the HEC-2 step-backwater program throughout the study area. The capacity of the underground conduit downstream of Delta Street was determined to be approximately 70 percent of the 100-year discharge. This results in shallow flooding hazards with depths approximating 1 foot in the residential area between Delta Street and 43rd Street. The lined channel between 43rd Street and Interstate Highway 5 was found to have approximately 100-year capacity. The shallow flooding conditions which exist in the overbank in this reach are caused by inadequate conveyance at the bridge crossings.

Tijuana River - Nestor Creek - Sunrise Overflow

Diversion of water from Nestor Creek to the Tijuana River occurs during 10-, 50-, and 100-year events. A shallow flooding situation occurs as flow continues south toward the Sunrise Overflow area. Elevations in this area were determined using engineering judgment, field inspection of existing conditions, and historical information.

Murray Canyon Creek

Breakouts occur on Murray Canyon Creek for floods greater than a 50-year event at two locations. Breakouts occur both just upstream of a gravel pit and at Friars Road.

The breakout upstream of the gravel pit area was analyzed by assuming equal elevation of flow from the breakout section to the asphalt road weir. Weir calculations were used to plot rating curves for weir flow over road, weir flow back to the channel, and total weir flow. The HEC-2 computer program was used to compute the channel flow rating curve. The combined flow rating curve was formed by adding the total weir flow rating curve to the channel flow rating curve. Since equal elevation of flow was assumed, the rating curves were used to determine the amount of flow that leaves the main channel, reenters the main channel, and permanently leaves the main channel over the asphalt road.

The breakout at Friars Road was analyzed by assuming that all culvert flow remains in the channel and all weir flow over Friars Road permanently leaves the channel. Rating curves for culvert outlet control, weir flow, and combined weir and culvert outlet control flow were plotted on the same graph. Discharges entering the Friars Road overpass were added to the combined flow curve, and corresponding culvert flow and weir flow was read off the culvert flow rating curve and weir flow rating curve.

Rose Canyon Creek

The 500-year flood on Rose Canyon Creek breaks out of the channel at two locations. The first breakout occurs upstream of the Interstate Highway 5 bridge; the second breakout occurs at the Mission Bay Bridge. The depths of flooding due to the two breakouts were determined from normal-depth calculations.

San Diego River

Near Mission Valley Shopping Center, approximately 30 percent (12,000 cfs) of the 100-year discharge breaks out of the channel, resulting in shallow flooding at the shopping center. Floodwaters flow south along North Camino Del Rio Road, filling the underground parking facility to its ceiling. The depth of flooding along North Camino del Rio Road was determined from normal depth calculations. The analysis assumed the Conrock Low River Channel fill would not wash out during major floods. The City of San Diego agreed to this concept.

Tecolote Creek

Normal-depth calculations and rating curves for the bridges downstream of Cross Street were used to determine flood elevations in the channel and overbank areas.

Coastal flood hazard areas subject to inundation by the Pacific Ocean were determined on the basis of water-surface elevations established from regression relations defined by Thomas (Reference 24). These regression relations were defined as a practical method for establishing inundation elevations at any site along the southern California mainland coast. They were defined through analysis of water-surface elevations established for 125 locations in a complex and comprehensive model study by Tetra Tech, Inc. (Reference 79). The regression relations establish wave runup and wave setup elevations in Seal Beach for the 10-, 100-, and 500-year flood events.

Wave runup elevations were used to determine flood hazard areas for sites along the open coast that are subject to direct assault by deep-water waves. Runup elevations which range with locations and local beach slope were computed at 0.5-mile intervals, or more frequently in areas where the beach profile changes significantly over short distances. Areas with ground elevations 3.0 feet or more below the 100-year wave runup elevation are subject to velocity hazard.

Wave setup elevations determined from the regression equations on the basis of location along the coast were used to identify flood hazard areas along bays, coves, and areas sheltered from direct action of deep-water waves.

Coastal floodplain boundaries were delineated using the wave runup or wave setup elevations computed at each 0.5-mile interval. Between these points, the boundaries were interpolated using topographic maps and aerial photos (References 80 and 76). Structural modifications along the coast post-dating the above-mentioned maps were not considered in the coastal analysis.

Computed elevations for wave runup, wave setup, and other inundation hazard characteristics were shown earlier in Table 2.

Tidal elevations from the Pacific Ocean via San Diego Bay control flooding along the portion of the Otay River located in the southeast corner of Coronado.

To obtain runup values for the various flood-producing mechanisms, data on offshore bathymetry and beach profiles were obtained from U.S. Coast and Geodetic Survey and the NOAA bathymetric charts, USGS topographic maps, surveys of beach profiles, and from aerial photographs of the study area (References 81, 76, and 77, respectively).

The City of National City waterfront along San Diego Bay is owned or controlled by the U.S. Navy. Over the years, the entire reach has been bulkheaded and filled to an elevation of approximately 12 feet from 19th Street to the Sweetwater River, and varies from 8 feet at Division Street (the northern corporate limits) to 10 feet at 19th Street. In a previous study (Reference 82), the 100- and 500-year tidal elevations were found to be below the elevation of the bulkhead. Thus, for National City, there is no inland tidal flooding problem from either the 100- or 500-year tidal floods.

Elevations for areas studied by approximate methods were determined using the HEC-2 computer program, normal depth calculations, field investigation, and engineering judgment.

The base (100-year) flood elevations for the approximate study reach of Los Penasquitos Creek were determined by linear interpolation between the adjacent detailed study reaches.

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1). For stream segments for which a floodway was computed (Section 4.2), selected cross section locations are also shown on the Flood Insurance Rate Map (Exhibit 2).

The hydraulic analyses for this study were based on unobstructed flow. The flood elevations shown on the profiles are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

All elevations are referenced to the NGVD. Elevation reference marks and the descriptions of the marks used in this study are shown on the maps.

4.0 FLOODPLAIN MANAGEMENT APPLICATIONS

The NFIP encourages State and local governments to adopt sound floodplain management programs. Therefore, each Flood Insurance Study provides 100-year flood elevations and delineations of the 100- and 500-year floodplain boundaries and 100-year floodway to assist communities in developing floodplain management measures.

4.1 Floodplain Boundaries

To provide a national standard without regional discrimination, the 1 percent annual chance (100-year) flood has been adopted by FEMA as the base flood for floodplain management purposes. The 0.2 percent annual chance (500-year) flood is employed to indicate additional areas of flood risk in the community. For each stream studied by detailed methods, the 100- and 500-year floodplain boundaries have been delineated using the flood elevations determined at each cross section. Between cross sections, the boundaries were interpolated using topographic maps at a scale of 1:2,400, 1:1,200, and 1:24,000, with a contour interval of 2, 5, 10, and 20 feet (References 58, 59, 63, 65, 66, 70, 71, 74, 76, 80, 83, 84, and 85).

For coastal areas studied in detail, the boundaries of the 100- and 500-year floods have been delineated using topographic maps at a scale of 1:2,400, 1:4,800, and 1:24,000, with a contour interval of 2, 10, and 20 feet (References 58, 76, 80, and 81).

The 100- and 500-year floodplain boundaries are shown on the Flood Insurance Rate Map (Exhibit 2). On this map, the 100-year floodplain boundary corresponds to the boundary of the areas of special flood hazards (Zones A, AE, AH, AO, A99, V, and VE); and the 500-year floodplain boundary corresponds to the boundary of areas of moderate flood hazards. In cases where the 100- and 500-year floodplain boundaries are close together, only the 100-year floodplain boundary has been shown. Small areas within the floodplain boundaries may lie above the flood elevations but cannot be shown due to limitations of the map scale and/or lack of detailed topographic data.

It was determined that approximately 1,350 cfs of the 500-year flood along Forester Creek would be hindered from entering the channel from the south side of Interstate 8. This is due basically to the overloaded collector systems along the south side of the