San Juan Creek Watershed Management Study
Orange County, California

Feasibility Phase

F-5 Report

August 2002

U.S. Army Corps of Engineers
Los Angeles District
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EXECUTIVE SUMMARY

This report presents the findings of the Corps of Engineers San Juan Creek Watershed Management Study. This southern California watershed is primarily located within Orange County with some portions extending into northern San Diego County. The Los Angeles District of the U.S. Army Corps of Engineers (Corps) teamed with the County of Orange (Sponsor) to co-sponsor this feasibility study. In addition, various other stakeholders within the watershed provided financial support, data, and feedback and direction during the preparation of this study. These interests include several water districts, municipalities, other governmental agencies, and private organizations and individuals. A complete list of watershed study partners is provided in Table 1 of Section 1 of this report.

GOALS AND PURPOSE

A primary goal of this study is to provide analytical tools and data, and strategies and practices that can assist interested parties in making better decisions on the current and future management of the watershed and its land and water resources. Another goal is to identify alternative plans that look at an array of management measures developed to address watershed problems and needs in order to shift the negative impacts associated with water resources degradation and enhance positive trends in maintaining a healthy watershed.

This report addresses problems and opportunities and a summary baseline of existing and future without- and with-project conditions in the watershed. It also develops and discusses potential solutions and recommendations for a watershed management strategy, both as a guide to potential Federal and non-Federal involvement in projects and as a resource to assist in the decision-making of local government and others. Although study topics address conditions from the headwaters to the ocean, the primary area of focus for this study has been on the lower portion of the watershed that has or that will experience the most change due to development and other land use changes.

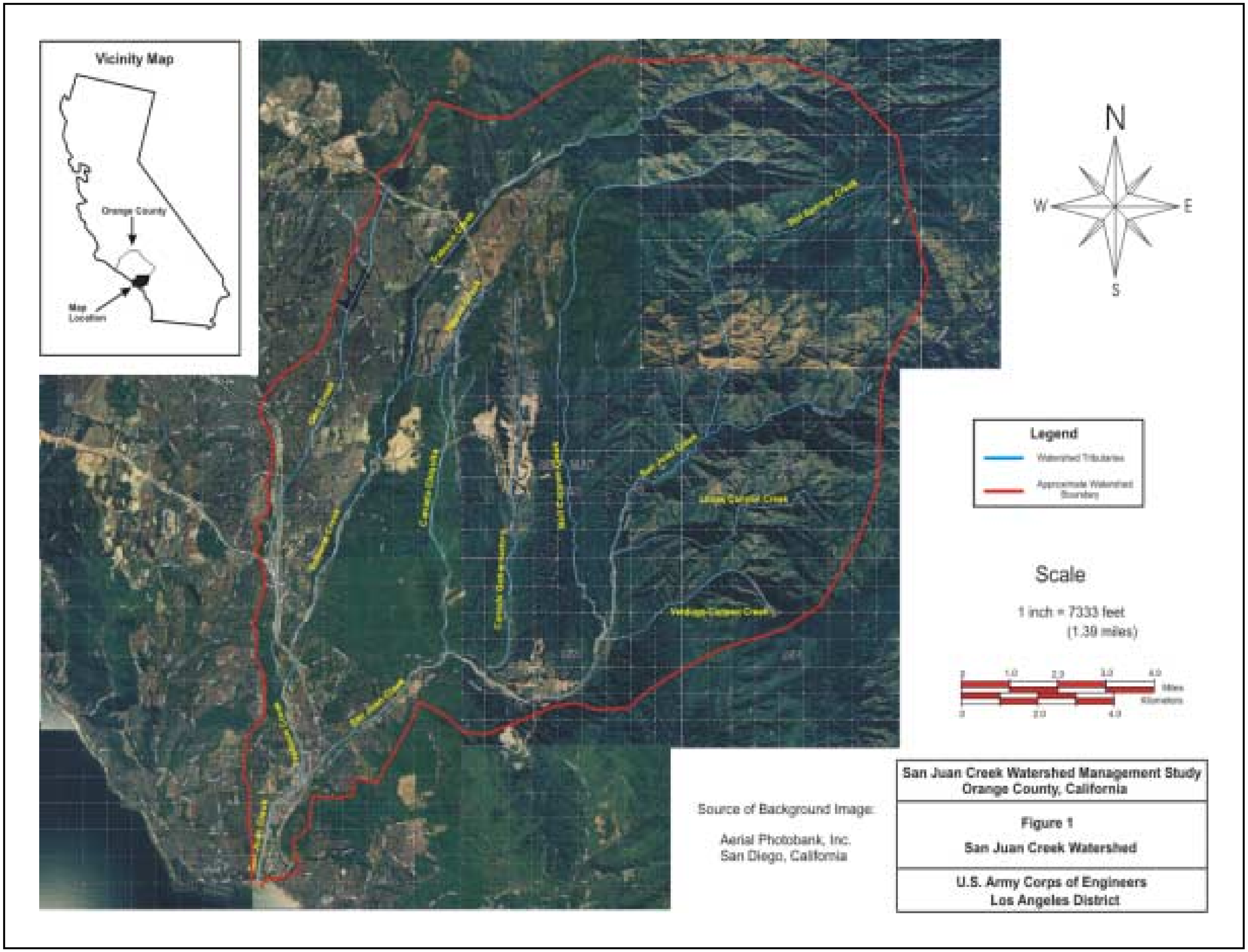
GENERAL DESCRIPTION OF STUDY AREA

The San Juan Creek watershed is a diverse mix of open space and urban development, exhibiting tremendous physical differences, ranging from mountainous chaparral-covered headwaters, to rolling hills covered with sage scrub to a coastal plain that ends at the Pacific Ocean. The watershed is approximately 456 square kilometers (176 sq. miles) extending from the Cleveland National Forest in the Santa Ana Mountains to the Pacific Ocean at Doheny State Beach near Dana Point Harbor (see Figure 1). The watershed basin is comprised of 23 canyons with three primary watercourses addressed in this study: San Juan Creek, Trabuco Creek and Oso Creek. Elevations range from about 1,733 meters (5,700 feet) on Santiago Peak to sea level at the mouth of San Juan Creek. Stream gradients range from 19 percent in Holy Jim Canyon to less than 0.4 percent near the San Juan Creek ocean outlet.

The Cleveland National Forest extends throughout the northeastern portion of the watershed. Large wilderness parks and conservancy lands are located adjacent to the national forest along the western boundary. The western boundary of the watershed is highly urbanized, as is the lower portion of the watershed where the cities of San Juan Capistrano and Dana Point are located. The Rancho Mission Viejo Company owns much of remaining portions of undeveloped open space.

WATERSHED PROBLEMS AND OPPORTUNITIES

The Sponsor, stakeholders and the study team identified problems and opportunities primarily during the earlier reconnaissance study phase, the initial public workshop, and subsequent stakeholder meetings. These problems are the result of a wide variety of naturally occurring and human-induced changes. They include the potential for flooding along the last several miles of San Juan and Trabuco Creeks, channel instability and associated impacts to environmental resources and infrastructure along San Juan, Trabuco and Oso Creeks, general degradation of environmental resources and habitat, poor surface and groundwater quality, declining water supplies, potential loss of sand sources for coastal sand replenishment, and impacts to cultural resources. A more complete list of perceived watershed problems is provided in Section 1.8 of this report.


Vicinity Map
Orange County
Map Location
N
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Legend
Watershed Tributaries
Approximate Watershed Boundary
Scale
1 inch = 7333 feet
(1.39 miles)
Miles
Kilometers
Source of Background Image:
Aerial Photobank, Inc.
San Diego, California
San Juan Creek Watershed Management Study
Orange County, California
Figure 1
San Juan Creek Watershed
U.S. Army Corps of Engineers
Los Angeles District

Opportunities are often times similar to problems, but they focus more on positive and future conditions, where something can be made better. Opportunities that were used for this watershed study include the use of concurrent studies and programs. Examples include the introduction of new public education programs for stormdrains, water quality studies performed by the County of Orange, and environmental studies and technical tools related to the development of a Special Area Management Plan (SAMP) by the Corps Regulatory Branch of the Los Angeles District. The opportunity exists in the San Juan Creek watershed to address flooding problems, ecosystem degradation, water quality problems, fish passage problems, and a host of other issues, through implementation of a comprehensive treatment presented in the Watershed Management Plan. A detailed discussion of the problems and opportunities is included in Section 7.2.4, Watershed Problems and Potential Measures.

CONSTRAINTS

A constraint is a restriction that limits the extent of the planning process, and can be categorized as a resource or planning constraint. Examples of resource constraints are limitations of knowledge, data, money and time. Planning constraints can be divided into universal and study-specific constraints. Examples of universal constraints include compliance with Federal, State and local government laws and regulations. For example, alternative measures would not be formulated to intentionally adversely affect threatened or endangered species. Study-specific planning constraints are statements that alternative plans should avoid. Examples for the development of alternative measures include no decrease in the current level of flood protection along San Juan Creek and tributaries, no loss of fish passage and no net increase of exotic, non-native species for restoration measures. A more detailed description of study constraints is presented in Section 7.2.3 of this report.

WATERSHED STUDY PROCESS

The Corps watershed planning process began in a 1997 reconnaissance study for the San Juan and Aliso Creek watersheds. The reconnaissance study provided the framework for more detailed studies conducted during this feasibility phase, which began in 1998. The feasibility study was prepared using an iterative six-step planning process. This process includes specifying problems and opportunities; describing the existing and future conditions (baseline, or without-project); formulating, evaluating, and comparing alternative plans; and selecting a recommended plan for the watershed. The recommended plan is defined by all of the proposed actions addressed in the watershed management plan. It is assumed that the watershed management plan will be used as a guide for current and future planning activities within this watershed, and therefore, should be considered a living document subject to change. A summary of the watershed management plan is included in the current documentation, but a separate draft plan will be issued after public review of this draft report.

In conducting this feasibility study, a wide range of technical issues were analyzed with the goal of developing an accurate description of historic, existing, and future without-project conditions in the San Juan Creek watershed, and developing a “recommended plan”, or group of solutions to the problems felt to be reasonably addressed under this study process. The assessment presented in this report serves to identify, confirm, and refine watershed problems and opportunities, planning objectives and constraints, and to guide the formulation of alternative plans that result in the development of the recommended plan. Federally-supported flood control, ecosystem restoration, channel stabilization, and incidental recreation alternatives must be pursued in a more detailed ‘site-specific’ feasibility study (“spin-off” study) for project implementation that focuses on detailed design, cost estimating, environmental mitigation requirements, and pursuit of plans and specifications for construction.

To obtain public and interagency input regarding problems, opportunities, solutions, constraints, and impacts, an active public involvement and coordination program was implemented for the watershed study. A discussion of the public involvement and coordination program is also provided in Section 2.

Available information was initially collected about existing studies, project and research programs that could assist in the preparation of the inventory of existing and forecast of future without project conditions, to characterize the baseline conditions for the watershed. The major technical areas of focus for the study include hydrologic, hydraulic, and limited sediment (H&H) studies, environmental studies related to biological resources, cultural resources and recreation and economic analyses of proposed alternative measures. Products that have been developed include aerial photography, analytical tools such as topographic mapping and hydrologic and hydraulic numerical models (HEC-HMS and HEC-RAS, respectively), and environmental surveys. Some environmental data was provided as products of the SAMP process.

Because the vast majority of potential damages are concentrated within the middle and lower reaches of San Juan Creek and the lower reaches of Trabuco and Oso Creeks, newly-generated topographic mapping and hydraulic modeling were developed only for the lower 14 kilometers (approximately 9 miles) of San Juan Creek, and lower Oso and Trabuco Creeks to characterize the critical flooding and erosive areas within the watershed. The upper portions of these watercourses are not subject to significant flood damage, channel destabilization, or ecosystem degradation and were not mapped or hydraulically modeled in detail. Development of alternatives for flood control, ecosystem restoration, and channel stabilization, therefore, focused primarily on these lower reaches. Those existing site-specific issues, such as small erosion problems, currently evident in the upper reaches of the watershed do not require the large monetary and time expenditures required to perform this work. Detailed documentation of these technical studies is included in the Technical Appendices.

The final watershed feasibility report documentation will ultimately include several documents: a main report demonstrating Federal interest in further phases including construction, a watershed management plan to guide activities all over the watershed, and supporting technical appendices. The watershed management plan will specifically address recommended management actions that could be pursued within the watershed, including Federal and non-Federal projects, Best Management Practices (BMPs), watershed education, programs, a water quality monitoring plan, and an exotic species eradication program. The products that have been developed for this feasibility phase of study are not decision documents for project implementation requiring compliance with the National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA). As mentioned earlier, implementation of proposed projects with Federal interest would require additional site-specific 'spin-off' investigations beyond the scope of this study.

BASELINE CONDITION ASSUMPTIONS AND CONCLUSIONS

Several baseline assumptions were made for this study in order to refine the planning process and develop alternative measures. It is assumed that development will occur on Rancho Mission Viejo lands and other private properties for the future "without-project" condition analyses of the watershed. Details of the type and specific locations of development are not known at this time, but this study assumes that all new development will have to comply with California Regional Water Quality Control Board (RWQCB) standards of no net increase in discharges to receiving waters, including San Juan Creek and tributaries. Therefore, the future condition base flows and storm flows for San Juan Creek and tributaries are assumed to be within 10 percent of those under existing conditions. More information on the H&H studies is presented in Section 3 and land use is shown in Section 2.4 of this report.

Some problems that were identified early in the planning process were not analyzed in detail due to lack of available information, conflicting political interests and time and funding constraints. For example, water supply studies for surface water storage or groundwater recharge were not investigated in detail, although several measures address the potential for the inclusion of water supply measures, and the preliminary pros and cons of implementation of these actions. Orange County is in the midst of preparing updated water quality information for this watershed. Although some information may be included in this report, water quality impacts related to future implementation of alternative measures have not been fully addressed. Loss of sand sources to the coast has also not been addressed in any detail. A detailed scour and sediment transport analysis has not been prepared for this study.

As mentioned, the development of alternative measures focused on the lower reaches of the watershed since there are few flooding, channel degradation or ecosystem degradation problems in the upper reaches. Different levee and bridge failure scenarios were investigated to address flooding and channel degradation problems in the downstream reaches, including the undermining of levees and the overtopping of levees. Scour along the channel bottom (invert) has exposed some of the footings of the concrete slope protection (panels) in these downstream reaches. Panel failures have occurred in recent high flow events, including the 1998 flood, estimated as a 4% exceedance (approximately 25-year) event. A preliminary scour analysis indicated areas where panel failure could occur. Panel failure, in turn may result in a breach in the levees and flooding of nearby structures within the floodplain. The scour of the channel leading to potential panel failure is the baseline conditions assumption for flooding within the lower reaches of the watershed. The channel may also be exceeded by overtopping of the levee system, currently estimated to occur at a 2% exceedance (approximately 50-year) event.

Estimates of economic damages related to flooding, and emergency and clean-up costs begin when the non-damaging discharge event has been exceeded. The non-damaging discharge before undermining of the channel begins is assumed to be slightly less than the 4% exceedance (approximately 25-year event), with a discharge rate of approximately 451 cms (15,900 cfs) on San Juan Creek downstream of Interstate 5, 640 cms (22,600 cfs) at the ocean, and approximately 244 cms (8,600 cfs) on Trabuco Creek upstream of the San Juan confluence. If the channel were to resist undermining (for instance, if channel stabilization measures were in place), overtopping would begin to occur at an approximate 2% exceedance event (approximately 50-year). Above the 2% exceedance flood event, it is assumed that flows will break out of the levee system, and flow out to an extent and depth depending on the ultimate size remaining portions of the existing levees will also be overtopped increasing the potential for flood damages. Damage estimates include impacts to structures and contents, emergency clean up costs, and the potential for bridge failure. Bridge failure is possible due to the scour exposing bridge footings leading to undermining and collapse of the structure. The bridges that are at risk from undermining/scour of piers and abutments include Stonehill Drive, Camino Capistrano, Interstate 5 (although this bridge may now be protected by a invert stabilizer immediately downstream), La Novia, and Lower Ortega Highway bridges on San Juan Creek, and Del Obispo Street bridge on Trabuco Creek. Exceedance of design safety criteria may occur in as little as a 20% exceedance (approximately 5-year) event to a 4% exceedance (25-year) event, based on currently invert elevations compared to toe-down of piers. New floodplain mapping for specific flood events, including the 1% exceedance and 0.2% exceedance (approximately 100-year and 500-year, respectively) events was prepared for this study to support the analyses, but should not be used to replace existing FEMA floodplain mapping (see Figure 6 to Figure 15).

Approximately 2,439 residential, 1,144 manufactured (pre-assembled residential), and 536 non-residential structures occupy the floodplain. The damages by flood event frequency, which again includes emergency and clean-up costs, are approximately $886,000, $47,969,000, $149,129,000, and $349,237,000 for the 4% exceedance, 2% exceedance, 1% exceedance, and 0.2% exceedance flood events, respectively.

Ecosystem degradation is evident almost everywhere within the lower reaches of the watershed. The problems relate to the impacts of development within this area. Seasonal watercourses within this watershed now have perennial flow due to higher base flows during the dry seasons. This has altered the habitat base, impacting dominant species types and diversification. Exotic and invasive plant species such as *Arundo Donax*, the Giant Reed, have overwhelmed the system further degrading the value of the remaining habitat. Channel erosion is clearly evident in the downstream reaches of Oso Creek and Trabuco Creek, affecting not only the habitat within the watercourses, but surrounding overbank areas that rely on the water table for growth and sustainability. The lower reaches of San Juan mainstem are barren of any significant amounts of vegetation that assist in improving water quality, reducing water temperatures, and providing forage areas for migratory fish and birds. To characterize and quantify the existing habitat and compare that to potential restoration measures, a non-monetary analysis was performed. A modified hydrogeomorphic method (HGM) analysis was used for this study. Results are presented in Functional Capacity Units (FCUs). Opportunities for ecosystem restoration measures were confined to existing channel and overbank areas, where connectivity to existing healthy habitat areas was possible, and where lands were still open space. More discussion of the environmental studies and results are presented in Section 4 of this report.

ALTERNATIVE MEASURES

Alternative measures were prepared to address the list of more refined problems and opportunities identified subsequent to the preparation of the baseline conditions analysis (See Section 7). Preliminary measures addressed such categories as ecosystem restoration, flood control, channel stabilization, public education, management practices, and water quality. Each category had multiple components. For example, ecosystem restoration measures included stream lengthening, fish passage, revegetation, public awareness and education plans, and exotic species eradication. The measures could be addressed in multiple ways, through future Federal involvement in an implementation project, by local governments, volunteer groups, schools, or private citizens. A screening process was used to refine the list of alternative measures based on economic, environmental, engineering, societal, cultural, infrastructure, and public acceptability, as well as on other criteria. A "trade-off" analysis was used, and is presented herein, to narrow down a field of potential solutions to the most cost-effective, least environmentally impacting, locally acceptable, and technically soundest solutions possible.

Combinations of these measures formed the alternative plans that are addressed in Section 7 and are analyzed in comparison with one another to determine that alternative plan (package of recommendations) being recommended for potential implementation as both Federal and local projects. The primary focus of the Federally cost-shared implementation projects are ecosystem restoration, flood control and channel stabilization, with some "incidental" water quality, water supply and recreation benefits. Other recommendations for which there is no Corps of Engineers authority to pursue (as cost-shared projects) include water quality improvement measures, public education, and pursuit of exotic species eradication measures. These may, however, be pursued using funding from other sources, including state and regulatory permit fee funding.

The goal of these recommendations is to establish a framework where negative trends may be reversed, projects may be implemented, and wise stewardship of the resource may be encouraged. It is recognized that many of the recommendations may be controversial in nature for one reason or another. Further screening of alternatives will likely occur following public input received on this draft report. Alternative measures, the screening process and the selection of alternative plans are addressed in Section 7.

DRAFT RECOMMENDATIONS FOR THE WATERSHED MANAGEMENT PLAN

- Establish a "watershed keeper" (steward) committee funded jointly and administered by the County and cities that will coordinate, integrate and leverage programs and projects by cities, county, schools, universities, utility districts, public and private entities. This will guide implementation of the local action items (evaluating BMPs, conducting water quality monitoring, identifying grants and corporate sponsors for special projects, organizing volunteer efforts, etc.), and provide the means by which planning and implementation will occur once this initial study effort is complete.

- Fully implement a watershed-wide monitoring program as part of the watershed stewardship program. Monitor continuing problem areas; monitor project performance, monitor efficacy of established programs for Water Quality, Exotic Species, 404 permits, Channel degradation trends, wildlife surveys conducted each year, completed and proposed projects in the watershed, and annual flooding and/or erosion damages. An annual or bi-annual "State of the Watershed" report could be issued, possibly on an Internet website, and also by attachment to utility bills or other existing dissemination programs.

- Strengthen the existing Water Quality Monitoring Program, building on existing testing activities by the County and others. Expand the testing program to include testing sites based on results of prior testing. For example, upstream extension of test sites should occur by first testing immediate upstream tributaries or drainage systems, not by random coverage based on downstream results. To do this will require both time and funding on a long-term basis. A "shotgun" approach will not make best use of the limited resources currently available. It is important to conduct regular testing, to thoroughly evaluate results, to determine appropriate actions based on that evaluation, and adjust the approach as needed.

- Implement Best Management Practices and other water quality treatment alternatives at the local and regional level. There remains a great deal of uncertainty regarding the sources and locations of bacterial contamination in the watershed and ocean nearshore zone. It is strongly recommended that remaining studies on water quality issues first focus on identifying both sources and locations of bacterial contamination before any large-scale projects are considered. Once site-specific information can be developed which indicates particular "hot spots", treatment wetlands or directed water quality improvement measures should be implemented. Initial follow-on efforts should be focused on the implementation of on-site biofiltration/infiltration treatment, landscape controls aimed at reduction of water runoff, reduction of pesticide and fertilizer application, and enforcement of ordinances aimed at pet waste control. The study team should then seek out and obtain grants to aid in these costly efforts from the Environmental Protection Agency, the State of California, and from other granting bodies. Further, the study team also recommends that the long-term effort must include evaluation of the effectiveness of implemented BMPs and adjust as needed.

- Utilizing Exotic Species Eradication guidelines, establish a program for elimination of exotic species in the watershed. Critical in this program is the need to conduct initial eradication efforts in an upstream-to-downstream approach. It is recommended that a "pool" of funding be established, involving Corps of Engineers Regulatory Branch, State of California Department of Fish and Game, and other resource agencies, to address this program in a systematic manner. Random eradication efforts have shown themselves to be ineffective, as upstream stands of exotics may re-infest areas cleared in prior efforts. A plan and schedule of activities should be established in coordination with all of the relevant agencies that is broadly distributed by both hard and electronic media. A long-term monitoring plan should be included in the coordination.

- Develop a Watershed Education Program. Establish objectives, goals, curricula, schools involved, teaching requirements, funding sources, and a teaching plan. Develop and distribute the non-point source public awareness plan.

- Create and distribute a short "Refrigerator List" of things that can be done by individuals to improve watershed health. Examples include supplying phone numbers, points of contact, and recommendations regarding fertilizer and pesticide application, pet waste clean-up, recycling, wise water use, and other actions that can be done by everyone in the watershed. The tone of the list should be friendly and informative, with features designed to catch the interest of individuals so that it does not become an additional piece of trash but is displayed prominently in the home. It is the hope of the study team that more residents and visitors to the watershed might be encouraged to become involved. The first step is to catch their interest and convince them that they can contribute to the solutions.

- Support local interest and the Federal interest in a recommended plan for a combination of channel stabilization, flood damage reduction and ecosystem restoration. The plan may be revised during this phase of the study based on feedback from the Sponsor and the stakeholders. If there were local support for the final recommended plan, a cost-shared "spin-off" study would be initiated for project implementation at the end of the watershed study. Detailed investigations would be required to optimize the plan to determine the best method and spacing of channel grade stabilization, and location and sizing of flood control features, to further examine the long-term sustainability of the ecosystem restoration measures, and to consider other objectives such as water quality improvements, beach nourishment, water supply and recreation. The "spin-off" study would require preparation of a NEPA/CEQA document. More details of the plan are presented in the following section.

- Under the Corps of Engineers Continuing Authorities Program (CAP), utilize Section 14 Emergency Streambank Erosion Control study authority to investigate and prioritize treatment of erosion sites that would not be covered by implementation of the larger flood control and channel stabilization project.

THE PRELIMINARY RECOMMENDED PLAN FOR FEDERAL (CORPS OF ENGINEERS) PURSUIT

A combination of measures is necessary to address the flood damage, channel stability, and ecosystem restoration problems. Channel stabilization is required to ensure that the existing levees do not fail due to existing channel scour and subsequent channel lining/levee failure potential. Stabilization is also required to address the potential for bridge failure due to scour and subsequent failure. However, if channel stabilization were in place, overtopping of the levee system would still be possible. The additional structural inclusion of floodwalls is required to contain the less frequent, but larger storm events above 2% exceedance (50-year) that will continue to overtop the levee system.

Ecosystem degradation problems similarly require a group of measures spaced along San Juan Creek that will provide restoration of riparian and upland habitats, buffer zones, revegetation of several habitat types, and spaced "resting" points along the channel to ensure some likelihood of aquatic species habitation.

This study recommends pursuit of a multi-purpose flood damage reduction, channel stabilization and ecosystem restoration alternative. The flood damage reduction portion of this plan (Alternative FC-7) concentrates on the lower reaches of San Juan (SJ-5 and SJ-6) and Trabuco Creeks (TR-7) that contain the highest potential for flood damage. The recommended plan components for flood control and channel stabilization possess a preliminary Benefit-Cost ratio of 8.3 to 1, and yield a net benefit of $10,073,000 annually. The ecosystem restoration components of this alternative (Alternatives ER-2 through ER-7, and ER-9) possess the highest potential for improvement of degraded environmental resources on San Juan Creek, with the greatest cost-effectiveness of all measures examined. The costs of this restoration range from $151,000 to $281,000 per habitat unit, which compares favorably to other restoration projects in this region of the country. While the ecosystem restoration alternatives may be implemented individually and are highly productive environmentally on their own, these measures were developed and integrated with the flood damage reduction/channel stabilization portion, and are therefore recommended for implementation based on their maximization of both environmental and economic benefits.

The preliminary recommended plan maximizes both monetary and non-monetary benefits. It is also known as the "National Economic Development/ National Ecosystem Restoration (NED/NER) Plan" using Federal planning guidance language. The NED/NER Plan is economically justified, environmentally beneficial, and is sound from an engineering standpoint.

The total cost of the NED/NER plan is $43,522,755, and would be cost-shared on a 65% Federal/35% Non-Federal basis, based on current guidance for Federal flood damage reduction/ecosystem restoration projects funded by Congress through the Corps of Engineers. The potential Non-Federal share is anticipated to be approximately $15,233,000. While a combined NED/NER plan has been identified, it is recognized that the local sponsor and residents of the watershed may not support the floodwall plan as designed. No Locally Preferred Plan (LPP) has been identified to date. Therefore, a "spin-off" phase will serve to both optimize the NED/NER plan, as well as fully develop the Locally Preferred Plan, if different. Because of the inseparability of the solutions for flood inundation reduction and channel stabilization, and the necessity of including the ecosystem restoration alternatives in the planning and design process for proper integration, any follow-on phase consisting of a "spin-off" study, should be authorized for the joint purposes of addressing flood damage reduction, channel stability, ecosystem restoration, and incidental recreation.

SAN JUAN CREEK WATERSHED MANAGEMENT STUDY
ORANGE COUNTY, CALIFORNIA

SAN JUAN CREEK WATERSHED MANAGEMENT REPORT
F5 MILESTONE

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Section One
WATERSHED STUDY OVERVIEW

The San Juan Creek Watershed Management Feasibility Study (watershed study) is a team effort of local and Federal agencies to identify solutions to water and related land resource problems in the San Juan Creek watershed. The primary focus of the study is the problems and solutions related to impacts associated with existing flooding, environmental degradation, water quality, and water supply and recreation. This report presents the findings from the watershed study's assessment of existing and future "without-project" conditions, as well as those associated with a range of preliminary watershed solutions known as "with-project" conditions.

The future without-project condition represents the longer-term planning horizon that is reasonably expected to exist without a Federal project. This condition is a projection of how the existing conditions are expected to change over the period of analysis (i.e., 50 years) to form the basis against which alternatives could be developed, evaluated, and compared. With-project condition describes the most likely condition expected to exist in the future with the implementation of a particular Federal project.

This section presents a discussion of the study authority the feasibility phase of study, watershed study goals, local sponsors and roles of the study partners, previous studies, the public involvement and coordination program, and an initial list of watershed problems and opportunities.

1.1 Study Authority

The authority for the Corps participation in the reconnaissance and feasibility phases of the watershed study is provided by a resolution of the Committee on Public Works, House of Representatives, which was adopted on May 8, 1964, for the Santa Ana River Basin and Area Streams. Federal funding for the studies has been provided by the 1996 and 1998 Energy and Water Development Appropriation Acts.

1.2 Feasibility Study

Because of the public, political, and media interest in the problems of the San Juan Watershed, the process used to accomplish this study was considered carefully. At the inception of the reconnaissance study in 1996, it was recognized that the Corps " business as usual" approach was not appropriate. Instead, a new approach emphasizing the entire watershed was used to successfully manage and accomplish a system-wide study that addresses all of the water resource problems and opportunities. This approach was continued in the feasibility phase of the study.

The feasibility study was initiated in 1998. This phase of the watershed study builds upon the findings of the reconnaissance phase and develops detailed technical data across a range of study categories in order to evaluate the feasibility of various solution alternatives accurately. Accomplishment of this feasibility watershed study was primarily the responsibility of the Corps of Engineers, Los Angeles District, and the non-Federal cost sharing partner, Orange County, California. The Study Team consisted of an interdisciplinary/interagency professional staff drawn from the technical disciplines necessary to accomplish the study. Areas of detailed study in the feasibility phase include survey and mapping, hydrology and hydraulics, preliminary study of water quality issues, geomorphology and sedimentation, social and economic issues, flooding and erosion damage, recreation analysis, environmental and cultural resources, geotechnical considerations, and regulatory considerations. The results of these analyses are the subject of this report and support the conclusions and recommendations presented in Sections 11 and 12, respectively.

1.3 Watershed Study Goals

The goal of the watershed study is to identify feasible management options to address watershed problems in a variety of categories outlined by the sponsor agencies and by the local constituents, as well as to reestablish a stable, healthy, and sustainable watershed environment. In pursuit of these goals, a baseline assessment was conducted to examine watershed problems and identify potential solutions. Problem area studies in this assessment included environmental degradation and economic damages from flooding and erosion. These studies provide the basis of support for developing watershed management plans aimed at improving watershed conditions. Additional studies identified water quality, water supply, and other water resource and land-related problems. These problems were evaluated, a range of potential solutions was developed, these solution alternatives were compared and contrasted, and a package of recommendations was issued.

1.4 Local Sponsors

The feasibility phase of the watershed study is cost shared between the Corps of Engineers Los Angeles District and the primary local sponsor, Orange County, California. Orange County's share of study responsibilities is divided among several municipalities and utility districts. All feasibility study cost sharing sponsors are identified in Table 1.

Table 1 San Juan Creek Study Partners

Study Partners	
♦ County of Orange Flood Control District	♦ California Department of Parks and Recreation
♦ Orange County Transportation Authority	♦ South Coast Water District
♦ City of Dana Point	♦ Moulton-Niguel Water District
♦ City of Laguna Hills	♦ San Juan Basin Authority
♦ City of Laguna Niguel	♦ Santa Margarita Water District
♦ City of Mission Viejo	♦ South Orange County Water Authority
♦ City of San Juan Capistrano	♦ Municipal Water District of Orange County
♦ Transportation Corridors Agency	♦ Rancho Mission Viejo Company
Additional Study Participants	
♦ Orange County Harbors, Beaches, and Parks	♦ California Water Resources Control Board
♦ Orange County Planning and Development Services	♦ U.S. Forest Service
♦ City of San Clemente	♦ U.S. Fish and Wildlife Services
♦ California Regional Water Quality Control Board	♦ Resource Conservation Service
♦ California Coastal Commission	♦ Clean Water Now! Coalition
♦ Surfrider Foundation	♦ Dana Point Harbor Water Quality Commission
♦ California Department of Fish and Game	

All study partners contributed funding to meet the local sponsor cost-sharing requirements for the feasibility study. In addition to study funding, the County of Orange also contributed technical services. The Orange County Public Facilities and Resources Department (PFRD) was responsible for technical studies related to water supply and demand, recreation, and cultural resources.

Other technical responsibilities of the local cost-sharing partners included assistance in study tasks related to public involvement, environmental resources, real estate studies, and study management. In addition to their responsibilities as defined in the project study plan, all study partners provided valuable input and assisted with collection for nearly all of the watershed study tasks.

1.5 Previous Studies

The Corps of Engineers, Los Angeles District completed a reconnaissance phase study of the San Juan watershed in February 1997, resulting in the *San Juan and Aliso Creeks Watershed Management Study, Orange County, California, Reconnaissance Report*. As indicated in the report's title, the study looked at both the San Juan Creek watershed and its neighbor to the north, the Aliso Creek watershed. The reconnaissance study concluded that a Federal interest existed in completing cost-shared, detailed feasibility studies of both watersheds with local interests. For the feasibility phase of the study, the two watersheds were separated into two distinct studies.

The reconnaissance study reviewed and assessed past and current activities and conditions in the two watersheds to identify management opportunities from a basin-wide perspective. Issues addressed in the reconnaissance study included geomorphology, geology and soils, land use, environmental resources, hydrology, hydraulics, sedimentation, groundwater, water quality, and economics. The findings from these study areas supported the identification and refinement of watershed problems and opportunities, watershed study planning objectives and constraints, key stakeholders, and conceptual watershed solutions. The feasibility level assessment, which is the subject of this report, builds upon the work completed for the reconnaissance study.

Numerous water-related studies have been conducted for the San Juan Creek watershed and vicinity. These studies, as presented in Table 2, range from watershed-scale resource studies to more narrow technical study areas such as archaeological sites and area hydrology. Relevant information contained in these studies was incorporated into this watershed study.

Table 2 Previous Studies on San Juan Creek Watershed and Vicinity

Study	Subject
Newport Coast Archeological Project, Coastal Community Builders, 1994	Cultural
Reevaluation of the Prehistoric Archaeological Sites within the Pendleton Coast District, California Department of Parks and Recreation, 1991	Cultural
Cultural Tradition and Ecological Adaptation on Southern California Coast, Warren Claude, 1961	Cultural
Orange County Flood Insurance Study, FEMA, 1993	Economics/ Hydrology/ Hydraulics
Natural Diversity Database Rare Find, California Department of Fish and Game, 1998	Environmental
Status and Distribution of Freshwater Fishes of Southern California, C.C. Swift, 1993	Environmental
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1.6 Public Involvement and Coordination

The public involvement and coordination plan for the watershed study included a range of activities aimed at (1) promoting understanding of processes at work in the watershed; (2) obtaining public input regarding problems, opportunities, constraints, alternatives, outputs, impacts, and costs; and (3) coordination of the watershed planning effort with related efforts of other Federal, state, and local agencies. Public involvement activities included public meetings, workshops, hearings, and briefings as well as the preparation and distribution of fact sheets and information papers to interested parties and local news agencies. During the conduct of the study effort, over 30 stakeholder meetings were held, hosted by Orange County and attended by an average of over 25 agency representatives and interested individuals. Public involvement activities for the watershed studies were conducted jointly by the Corps and the local sponsors.

An initial public meeting was held on March 26, 1998, at the Del Obispo Community Center in the City of Dana Point. The public meeting served to introduce the study to interested parties and solicit public input on issues, concerns, and opportunities. Over 60 interested citizens and representatives from various resource agencies and special interest groups attended. The workshop was conducted in two phases. The first phase consisted of a presentation by the Corps describing the work conducted during the reconnaissance phase of the study, the findings of the reconnaissance phase, and the work to be completed during the feasibility phase of the study. During this presentation, the workshop participants were provided a list of questions to which the participants were permitted to provide written responses. These responses were later compiled and written up in a "Public Workshop Summary" and mailed to all persons listed on the San Juan Creek Watershed Study mailing list. A summary of these responses is provided in Table 3. The second phase of the workshop consisted of an open public forum where the workshop participants were allowed to make oral comments concerning important issues that needed to be addressed in the feasibility study. The problems discussed in this meeting, and later stakeholder meetings, are the reason for conducting this study. Although some of the problems are beyond the scope of what the study team might accomplish, they are still viewed as the primary driving force behind this effort.

Table 3 San Juan Creek Initial Public Workshop Questionnaire Responses

Question #1: What do you believe are the most important resources in the San Juan Creek Watershed?

- Healthy natural habitat for wildlife and plants.
- Increased vegetation along the creek bed.
- Improved groundwater supplies and quality.
- Clean water.
- Flow of sand down the creeks to supply the beaches.
- Flood control improvements to prevent property erosion and other damages.
- Water recreation.
- Improved fishing.
- Preservation of upper watershed lands.
- Diversity of habitats.
- Community education concerning the watershed.
- Riparian habitat fishery and plants.
- Quality of life.
- Agriculture.
- Beneficial uses which support economic viability of the region.

Question #2: What are the major problems and opportunities in the San Juan Creek Watershed?

Problems:

- Lack of a source of water to replenish groundwater for keeping high water quality.
- Large amounts of streets and channel lining in San Juan Creek which reduce groundwater recharge.
- Poor water quality.
- Degraded ecosystem.
- Lack of concern by agencies and companies for the quality of water in the creek. They pollute it on a daily basis.
- Human waste flowing into the creek.
- Loss of habitat.
- Loss of soft stream.
- Pollution causing impediment to humans and wildlife.
- Erosion.
- Loss of habitat due to city development and not protecting trees, plants, and wetlands.
- Development has occurred up to the edges of the creek.
- Invasive plant species.
- Sewage plant spills and failures to have polluted the creek and the coast for too many years.

Opportunities:

- Implementation of the Doheny Longboarders Association restoration plan.
- Many resources are currently available for use and improvement.
- Limit development along creek and return as much as possible back to its natural state.
- Higher agency should put restriction on development.
- City/County employees should be held accountable or fined for excess development.
- Development of a “trash-collection” site in upstream areas.
- Opportunity to improve flood control.

Question #3: How would you judge the success of a project constructed for San Juan Creek?

- Less pollution in the final outflow so that water is fishable and swimmable.
- Free flowing sand for beach replenishment.
- A healthy watershed.
- Steelhead trout restoration.
- Lots of vegetation, wildlife, and open spaces.
- Decrease in the number of people getting sick after swimming in the ocean.
- Increased amount of sea life in the ocean.
- Increased amount of trails for walking and horses.
- Restoration of San Juan Creek to a more natural state.
- An aesthetically pleasing San Juan Creek.
- Increased recreational opportunities in the watershed.
- Improvement of flood protection.
- Development of cooperative agreements between agencies.
- Development of educational opportunities for schools.
- Migrating fish and increased spawning.
- No warnings about contaminated water.
- Increased water storage.
- Increased water flow to prevent backing up of water at the beach.
- Elimination of raw sewage inputs into the creek.
- Improved watershed management.
- Initiation of a water quality monitoring program.
- Increase in riparian habitat with the appropriate animals, especially rare and endangered species.
- Removal of paving and buildings.
- Increased diversity of native habitat and wildlife.
- Improved geomorphological stability.
- Preservation of as much ecosystem as possible.
- No beach closures.
- A safe environment for all to use and enjoy.
- Decreased erosion.
- Initiation of a locally defined plan that respects property and provides effective planning.

The numerous stakeholder meetings have served an additional purpose. They have served as a means to disseminate information, find out about the activities of various entities in the watershed, work out problems in an open forum, hear complaints and suggestions, make decisions regarding the conduct of the study effort in future phases, reformulate alternatives as needed, and devise strategies to obtain funding for additional studies and project implementation. Furthermore, it is the intent of this feasibility study to address public concerns and incorporate public ideas into an integrated watershed management plan for the San Juan Creek watershed. Such considerations are imperative to the Corps' goal to address the public's needs for watershed management within the scope of NED/NER plan requirements.

Two major public involvement activities are scheduled in the remaining portion of the feasibility study. These activities include the release of a draft version of the watershed management report for public review and comment, with a final public meeting during the comment period. The final public meeting will provide a forum to present the findings of the draft watershed management report. At this meeting, public comments will be obtained for incorporation into the final watershed management report.

1.7 Preliminary Identification of Watershed Problems and Opportunities

As mentioned in the previous section, problems and opportunities for watershed improvement were the outcome of public meetings, stakeholder meetings, research and literature search performed during the reconnaissance phase, and feedback from stakeholders in a variety of forms.

The first step in actually developing solutions to the water resource problems encountered in the San Juan Creek watershed began with clearly identifying the issues affecting the watershed. To this end, the public meetings, work sessions, and formal stakeholders meetings have been held through the course of the study to identify concerns and problems related to water resources, to gather comments and insight from as many people as possible in identifying all the problems and opportunities affecting the resource health and livability of the watershed, and most importantly, to discuss the implications of the results of the many technical studies conducted during the course of this effort to determine how to best solve the problems at hand.

Individuals, homeowner's associations, public and private agencies, cities, the County, and resource agencies charged with monitoring this watershed were all asked to name as many issues as they could identify. Following this, a number of field visits were held to allow interested parties to witness the actual focus of the problem and to allow experts from each technical field provide input in defining the extent and depth of the problem and its potential causes. These public sessions and field visits were extremely productive and allowed the study team to develop a comprehensive list of problems affecting the watershed, as detailed in Table 3 of Section 2.

The next step was to identify the opportunities to solve the problems and create the widest range of potential solutions possible to ensure a complete and comprehensive evaluation in developing solutions that would best meet the many needs of the stakeholders and environment. No constraints were placed on identifying opportunities and potential solutions at this point, so that as much creative input as possible would be received. Input on opportunities and potential solutions were received from homeowners, students at area schools, representatives of resource agencies, water districts, County agencies, City Managers, land and park managers, and many others. The final step in developing solutions was to construct a list of preliminary alternatives.

1.8 Watershed Problems

The San Juan Creek watershed is currently suffering from a variety of water resource and related land resource problems. Most of these are related to widespread changes in the watershed, including changes in the hydrologic regime, channel instability, habitat loss, ecosystem degradation, declines in water quality, threats to recreational resources, and others. While change is part of the evolution of any landscape, dramatic change from a balanced historic state often results in undesirable consequences. The San Juan Creek watershed has suffered several recent dramatic changes that are currently negatively impacting watershed resources. For example, channel downcutting, which is occurring as a result of both human and non-human influences, is negatively impacting infrastructure in the floodplain and riparian habitats, as well as other natural resources.

As part of this comprehensive watershed management effort, every opportunity was taken to solicit input from all individuals, parties, and agencies involved in the watershed to ensure a complete list of the problems impacting human beings, wildlife, and physical and intangible resources. Several public meetings, numerous stakeholder meetings, and many field trips resulted in the (unranked) list of observed problems shown in Table 4.

Table 4 List of Observed Problems

- Flood Inundation Damage to Structures
- Flood-Related Costs for Emergency Services, Clean-Up, and Floodfighting
- Land Loss due to Erosion
- Channel Instability and its Effects on Resources
- Infrastructure Destruction by Surface Water Flow
- Water Quality Problems in the Ocean Nearshore Environment
- Surface Water Quality Problems in San Juan Creek Mainstem and Tributaries
- Water Quality Problems in Groundwater Aquifer(s)
- Loss of Floodplain Habitat
- Loss of Riparian Habitat
- Loss of Recreation Opportunities
- Decline in Floodplain Moisture
- Geotechnical Instability
- Decline in Water Supply
- Depletion of Sand Sources for Coastal Sand Replenishment
- Higher Flood Peak Discharges for a Given Storm Frequency
- Decrease or Disappearance of Aquatic Species
- Decrease or Disappearance of Riparian (non-Aquatic) Species
- Decrease or Disappearance of Floodplain (non-Aquatic) Species
- Invasive Species
- Declining Local Aesthetic Quality
- Piecemeal Treatment of Problems and its Consequences
- Excess Litigation Due to Watershed-Related Problems
- Excessive Regulatory Actions
- Degradation of Cultural Resources
- Degradation of Habitat for Endangered and Threatened Species
- Degradation of Surface Water/Groundwater Interface

Following development of this large list of problems, the watershed stakeholders group and other groups of interested participants convened to discuss how these problems might be addressed, particularly in light of the multiple goals of the many stakeholders. Potential means and methods were also discussed as to how the larger issues in the watershed relate to where these problems originate and how they might be dealt with in an overlapping manner. Using this approach, input from stakeholders and the public indicated that the most severe problems in the watershed could be grouped as:

a. General ecosystem degradation, including channel and floodplain instability
b. Poor water quality, both in surface waters and the ocean nearshore zone
c. Loss of habitat and associated wildlife loss
d. Flooding and erosion damages

1.8.1 Flooding problems

Flooding in the watershed may occur from either of two mechanisms: that of overtopping of the channel, or by undermining and failure of the levee system. To date, floodwater breakout has occurred only from the former mechanism. However, during the floods of 1996, were it not for emergency levee reinforcement during the flood conducted by the County with assistance from the Corps of Engineers, levee failure may have well occurred. This flood undermined portions of the levee lining on both San Juan and Trabuco Creeks, causing collapse of the concrete lining, with subsequent erosion of the levee core. Dumped stone, placed during the height of the flood event, saved the levee from further erosion and potential failure. Were the levee to have failed, subsequent floodplain inundation would have occurred. This flood event, estimated as an approximately 4% exceedance (approximate 25-year) event, became the basis for the failure frequency used later in his study effort to estimate potential flood damages resulting from a variety of flood events. Later hydrologic and hydraulic studies conducted during this feasibility study, estimated the overtopping failure frequency at an approximate 2% exceedance (approximate 50-year) event, which is rarer than that estimated for the channel failure event. This lesser failure frequency may be partly due to the increased channel capacity, which has resulted from channel downcutting and subsequent capacity increases that subsequently occurred. In its "as-built" configuration, the channel system would be considerably more resistant to failure by undermining, although it would also possess a lesser degree of protection from flooding due to channel overtopping.

1.8.2 General Ecosystem Degradation

General ecosystem degradation has resulted from a number of factors. Development has replaced natural habitats with structures, roads, and other infrastructure. Natural channels have been replaced by drains, culverts, and engineered channels. Paved surfaces allow less infiltration and create greater runoff within remaining natural channels. Large rainfall events produce larger runoff volumes, delivered with higher velocities, resulting in higher rates of erosion. Less benign climatic conditions have also produced larger flood events in recent years than in past decades. In turn, this has produced widespread negative trends in the immediate area of the channel. These trends include channel degradation (incision of the invert or channel bed); damage to nearby infrastructure; a decline in floodplain moisture resulting from drainage of the alluvium (soils in and below the floodplain), and hence, loss of riparian, floodplain, and aquatic habitat and associated wildlife; increased water temperatures from a loss of shading; an expansion of the extent of exotic species; damage to utilities, roads, trails, and other infrastructure; undermining of bridge foundations; and a devalued recreational experience.

1.8.3 Poor Water Quality

Poor water quality in the watershed is not completely understood and may be related to numerous factors, but is most objectionable in the form of bacteria and the exceedance of human health standards. Additional concerns include the presence of herbicides and pesticides, metals, and other contaminants. High water temperatures (due to a loss of shaded riparian habitat and destruction of “riffles” in the channel), low dissolved oxygen content, and high sediment load (turbidity) are also water quality problems. Causes of contamination may include human occupancy, pets, native wildlife populations, leaking pipes, fertilizer application, sewage spills, leaking dumpsters, and many other factors. Lack of riffles or rocky “falls” in the creek reduces oxygenation. Lack of tree shading raises water temperatures. The outcome of these factors has been the listing of the final 1.5 miles of San Juan Creek as an “impaired” water body for human contact, and closure of downstream beaches to swimming during extended periods of each year due to high bacteria counts. The effect of poor water quality on environmental resources includes exceedance of the parameters that would allow survival of native aquatic species, and of course, the wildlife dependent on them.

1.8.4 Loss of Habitat

Habitat loss is related to the problems discussed above, as well as to the high degree of development in the watershed. The conversion of natural plant communities to first agriculture and then urbanized landscapes has eliminated many native plants and their dependent wildlife. Channel instability and associated floodplain drainage has impacted the hydrologic connection on which the habitat was dependent. Outside of the riparian zone, residential and commercial development has eliminated the upland area habitats that provided a complete range of habitat types within the watershed. Those few areas left in a somewhat “original” state have been dramatically affected by surrounding development. The wildlife dependent on these areas has largely disappeared. Elements of the water quality problem have severely constrained the survival of wildlife in the riparian zone and elsewhere. Unlike many watersheds in nearby areas, however, the San Juan Creek watershed still retains a significant amount of acreage within the floodplain and headwaters that is not developed and retains some environmental value.

1.8.5 Flooding and Erosion Damages

Flooding has always been a natural process in the watershed, but has caused negative impacts to those properties in the floodplain and infrastructure in close proximity to the channel. While the floods themselves cause inundation damage to the flood-prone properties in the floodplain, they also cause associated problems of sediment deposition, erosion, and induced damage to nearby facilities that add to the pollution problem.

1.9 Watershed Opportunities

There is a substantial amount of undeveloped land in the headwaters and surrounding areas within the San Juan Creek watershed, as well as some remaining undeveloped land along San Juan Creek. There are also reaches of San Juan Creek and some of its tributaries that remain unmodified. The opportunity exists to use these areas to develop long-range solutions to many of the problems discussed above. The flooding issue may be addressed by application of non-structural methods, such as floodplain regulation and flood insurance, or by structural means, such as upgrading of the existing flood control system or installing floodwater detention. Opportunities exist to provide on-site detention in many areas subject to future development that will offset any increases in peak discharges or volumes that might accompany modification of the landscape.

The opportunity also exists to identify areas suitable for ecosystem restoration and to implement measures that might result in an increase in the acreage or quality of degraded habitats. Because many locations would benefit from ecosystem restoration, and are capable of achieving sizable increases in habitat value, treatment of these problems has high public support. The opportunity exists to restore connection between the headwaters area of San Juan Creek and the Pacific Ocean through modification of the existing system. Installation of restored areas along the channel, and structures that create eddies and resting places for migratory fish will provide the means for this connection.

There are numerous opportunities to address water quality problems within the watershed. Application of Best Management Practices, ecosystem management, spot treatment of "hotspots", development and implementation of educational campaigns, retrofitting of existing structures, and other innovative solutions have the potential to reduce many of the problems now evident in the watershed.

There are also many opportunities to enhance groundwater recharge, recreational opportunities, and deal with "quality of life" issues that impact the watershed. Many of these opportunities exist in conjunction with measures mentioned above, as multi-purpose plans and projects. All of these will be explored in detail during plan development.

Restoration of ecosystems in the riparian area, reduction of flooding damages, treatment of water quality problems, and provision of recreation amenities associated with the above were identified as potentially having a Federal interest. Many solutions commonly associated with "Best

Management Practices" were recognized as beneficial, although not likely to warrant participation using Federal funding. The opportunity exists to identify solutions for Federal, state, and/or local participation are identified in this document. Opportunities for participation from groups outside of the County or Corps were also identified as sources for potential implementation.

The local sponsor, the County of Orange, and the stakeholder group, which includes all of the cities and water districts in the watershed, cannot on their own fund a comprehensive plan to deal with all of the problems identified. The opportunity exists to obtain Federal participation in the implementation of solutions to the problems of flood inundation, ecosystem degradation, and recreation loss. For flood inundation damage reduction and ecosystem restoration, the Federal share of construction costs may amount to 65 percent of the total costs, depending on the extent of real estate and other costs. The Federal requirement for participation is completion of a decision-making document for Congressional use, of which this study process is a part, and identification of a local sponsor that will cost-share in study and construction. The County of Orange and some of the stakeholders have expressed their support for this effort and have identified programs that they would conceivably participate in as cost-sharing partners. The opportunity exists to develop multi-partner participation in a comprehensive package of treatments to the group of problems discussed above. A refined set of problems and opportunities is discussed in the section on plan formulation.

Section Two

WATERSHED DESCRIPTION

This section contains a discussion on the “baseline”, or existing conditions in the watershed. The understanding of baseline conditions is important in the understanding of what, precisely, exists in the watershed, so that everyone can grasp the nature of the problems facing the watershed and that goals and objectives might be correctly formulated. Without a good understanding of the existing condition, one cannot understand what constitutes an improvement from a degraded condition. The baseline condition is compared to, and contrasted with, the historic condition of the watershed, which might be vastly different. In fact, conditions in the San Juan Creek watershed are vastly different from even 20 years ago. Development has drastically changed the look and behavior of the floodplain. Infiltration of rainfall into the groundwater table has decreased due to paving of soil surfaces. Sand delivery to channels has also declined with paving and removal of those sources from erosion by rainfall. Riparian habitat has greatly diminished, with an attendant loss in wildlife numbers and diversity. As development has progressed, the “connection” between upstream and downstream segments of the channel system has been impaired or severed from historic conditions. Migratory fish which formerly accessed upstream portions of the watershed no longer can migrate due to insurmountable blocks to passage. Floods have been greatly reduced from their destructive capacity of decades ago. But that protection comes at the cost of the loss of riparian vegetation which formerly lined the channel and much of the resource value that San Juan Creek formerly possessed.

This discussion of baseline conditions addresses not only an inventory of historic and existing conditions, but also a forecast of future “without-project” conditions. The without-project condition is that expected to exist in the watershed in the absence of measures set in place to prevent damages that might result from the continuation of an undesirable condition. Future without-project conditions are based on the County’s “General Plan” for development in the watershed, and as such, may be subject to future revision should the General Plan undergo modification. In general, the conditions assumed in the future without-project condition include full development of all remaining land in the watershed not currently slated under the plan for “open space” or park/national forest designation.

The information presented under baseline conditions is used to formulate alternative measures that address the watershed problems and opportunities discussed earlier in this report. This section begins with a brief discussion of the historical condition of the watershed, plan formulation assumptions for existing and future without project conditions, evaluation tools used for the baseline condition analysis, an inventory of existing conditions and a forecast of future conditions. General features within the watershed are described first. Later, the watershed is broken down into reaches to better focus on areas within the watershed that exhibit the most significant problems or opportunities and for the identification of appropriate alternative measures to address those problems and opportunities.

2.1 Watershed History

The San Juan Creek watershed has a long history of human occupancy. Approximately 250 years ago, just prior to European entry into the region, the San Juan Creek watershed was occupied by a rather substantial (for the time) group of residents. These early occupants lived in small villages, gathered fruits, acorns, and wild grains, hunted, manipulated and harvested limited crops from natural sources, and moved their habitations when necessary. They had little dramatic effect on the landscape, although research indicates that they commonly burned the understory in areas occupied by oaks to enhance acorn harvests. They also harvested substantial amounts of shellfish, as formerly extensive shell middens indicated. According to historical references, migratory fish and birds visited the watershed in large numbers. Steelhead migrated to the upper reaches of the watershed to breed, before making their way once again to the ocean.

During this period, floods occurred, fire occasionally swept parts of the landscape, but humans had little permanent effect on the environmental resources and functions of the watershed. The beginnings of the dramatic physical change in the San Juan Creek watershed began with the coming of the Spanish in 1769. With them came concentration of local population, cultivation of fields, building of permanent structures, and grazing herds of livestock. Groves of trees were cut down for firewood, shipbuilding, and structures. Much of the floodplain was cleared for farming and grazing. Irrigation channels were constructed and natural flow paths altered. During this period, non-native species of grasses and other types of vegetation were introduced causing significant changes in the look of the land (USACE, 1997).

In 1776, following the establishment of the Mission San Juan Capistrano, many of the earlier occupants of the watershed were forced onto the Mission grounds to work for the Mission fathers. This resulted in abandonment of many outlying villages and concentration of several thousand residents in one small part of the San Juan Creek watershed. This affected both resource viability and distribution. According to some Orange County historians, much of the original large tree canopy disappeared during this period for use in the construction of the new mission and associated outbuildings, as a fuel source, and in the construction of other products such as boats and furniture. In addition, much of the San Juan Creek watershed was divided into several large grants that were used for cattle grazing. The collapse of the local cattle grazing industry in the 1860s due to an extended drought caused a shift towards sheep ranching and agriculture. During the 1800s, agriculture became the primary change evident in land use in the watershed. Attendant with large numbers of grazing animals came gradual reduction of the numbers and diversity of floodplain and riparian zone wildlife and plants. Only the steepest slopes were immune to the depredations of cattle and later, sheep.

Despite the early impacts, evidence of erosion, and the general reduction of resource values in some areas, the San Juan Creek watershed remained fairly stable until well into the 20^{th} Century. It is not until the large-scale urbanization of the watersheds that the drastic loss of watershed stability and the lack of recovery of riparian and floodplain resources became more evident. The sustainability of the resource, and its connection with the larger ecosystem, became increasingly impaired. While grazing and other early uses negatively impacted the environment, the resource was still capable of “bouncing back” by regeneration. Movement of large numbers of permanent “modern” residents into the watershed forever changed that. Development in the early 1960s continued to convert agricultural lands to residential uses, a trend accelerated by completion of Interstate 5 (I-5). Burgeoning population created pressures for continued residential development throughout Orange County.

During the past 35 years, rapid urban development has occurred in this area. These developments are primarily residential with a density range from 1 to 30 units per acre. They are centered in the (1) cities of San Juan Capistrano, Mission Viejo, Laguna Hills, Laguna Niguel and Dana Point, and (2) county-planned communities and specific plan developments within the watershed including Rancho Trabuco, Rancho Santa Margarita, Las Flores, Ladera, Robinson Ranch, Dove Canyon, Coto De Caza, and Foothill/Trabuco. There has also been commercial and some light industrial development mainly along the I-5 Freeway.

Approximately 3 percent of the total watershed was urban in 1964. By 1974 and 1988, urbanization had grown to 9 and 18 percent, respectively. By 1990, approximately 32 percent of the total watershed was urbanized. By 2000, the urbanized area has increased to approximately 35 percent. By year 2050, the expected level development would reach up to 48 percent

(OCEMA, 1982). The Oso and Trabuco watersheds were developed largely in the 80's and 90's. Those areas remaining in the San Juan sub-watershed that are not in public hands are expected to largely be developed by 2010. Substantial portions of the San Juan Creek watershed will remain undeveloped, as National Forest and County park lands. This provides both a resource of incomparable value to residents, but also an issue of disconnection, as much of the public land is in headwaters areas and is not easily accessed from the ocean.

A significant portion of the remaining undeveloped lands in the watershed are owned by the Rancho Mission Viejo Company. The Company has, and continues to develop portions of its land in response to demand for residential and commercial housing. A number of solutions to watershed problems may impact lands owned by the Company, and thus makes close coordination with the Company very important to assure than multiple needs might be met. The Company is currently working to develop, in conjunction with the Corps of Engineer's Regulatory branch, a "Special Area Management Plan" to comprehensively deal with the many requirements and interactions that may arise as development proceeds on these lands. The functional assessment of resources developed during this process is used in this study effort to better define areas suitable for restoration, and to ensure that the study team views the resource in a way similar to that of the regulatory function. Assessment of future conditions assumes development on Company land as outlined in the County's General Plan. As many modifications to this may occur over time, there will be impacts to some study results. However, understanding this issue resulting in some agreement about the potential changes, and these are accommodated in the following studies.

2.2 Plan Formulation Assumptions

A number of assumptions were made regarding future conditions that play an important role in the plan formulation process.

Based on analysis of the County's General Plan, it is assumed that minimal change in peak discharge or volume of floodwaters should be expected in the future. This is based both on the small amount of remaining land suitable for development (and hence, change in permeability), but also the assumption that future development will be accompanied by measures that hold any increase in discharge on-site, and that no substantial change in either peak or volume will be evident downstream. The effects of future development on hydrology are illustrated in the Hydrology Appendix.

It is assumed that the existing flood problem in the watershed will continue into the future, but that little additional development will be threatened. Floodplain regulation will continue to minimize any potential impacts relating to floodplain usage. It is also assumed that water quality problems will continue to plague waters both in the watershed, but also offshore. Bacteria will remain the contaminant of most concern, as the sources and causes of this problem are so numerous and widespread throughout the watershed.

Ecosystem degradation will continue as remaining lands are fully developed. In the absence of measures formulated to deal with this issue, connectivity, sustainability, and extent of habitat will remain as increasingly problematic issues. These issues are discussed in more detail in the Alternatives Analysis Report.

Recreational opportunities are assumed to decrease in the future as some of the remaining open space is either developed or taken out of the public realm. Recreation will continue to be at odds in some areas with changing land use and competing interests. Use of existing open space for equestrian uses will decline with increasing resource management.

2.3 Evaluation Tools for Baseline Conditions

This section contains a brief description of the types of evaluation tools that were developed for use in this study effort. These include mapping and Geographic Information Systems (GIS) development, hydrologic and hydraulic modeling of the watershed, development of habitat evaluation methods and species surveys for ecosystem resource evaluation, preliminary design and cost estimation for comparison of alternative measures, and economic evaluation utilizing the Corps' Flood Damage Assessment model.

2.3.1 Mapping and GIS

One initial product of the watershed study process was the development of updated mapping. Mapping tasks for the watershed study included the collection and compilation of existing aerial photographs, and topographic and geographic information system (GIS) mapping for use by the study team in defining existing conditions in the watershed, for hydrologic and hydraulic (H&H) modeling needs, and for environmental baseline surveys. GIS mapping was reviewed and updated with new technical data generated during the study. These products were extremely important in the accurate assessment of existing conditions, particularly for flood damage reduction and environmental studies.

To complement the update and evaluation of historically-generated mapping, new aerial topographic mapping was completed at a scale of one to one thousand (1:1000) with a one-meter contour interval. The new mapping covered the main San Juan Creek channel from its outlet to the Pacific Ocean at Doheny State Beach to approximately 17 kilometers (10 miles) upstream. Included in the mapping were the Trabuco Creek, Oso Creek, and Cañada Gobernadora tributaries. The mapping was developed from 1:10,000-scale aerial photography flown in April 1998. More recently updated digital aerial photography was also used for the preparation of figures including verification of land use information and other uses. Up-to-date topographic and aerial mapping was considered vital in the determination of topography for the delineation of floodflow breakout under different flood conditions, in the determination of first-floor elevation for flood damage surveys, and in the determination of ecosystem resource locations, densities, and condition, for establishing existing conditions all over the watershed.

2.3.2 Hydrologic and Hydraulic Models

Hydrologic and hydraulic modeling of the watershed was performed using the Corps' HEC-1 and HEC-RAS models. HEC-1 is a rainfall-runoff model that simulates the distribution of rainfall, its behavior as runoff traveling through the watershed, the peak discharges to be expected at concentration points such as where two channels join together, and ultimately how much water should be expected under different frequencies of flood events at different places in the watershed. Hydrologic modeling was used to determine the frequency and volume of runoff during low flow conditions, which is vital in determining whether an area might sustain vegetation and wildlife in ecosystem restoration studies.

HEC-RAS is a hydraulic model that takes the hydrologic and topographic information generated, and uses it to determine where, and to what depth, floodwater may be expected to go under different flood event conditions. It establishes the performance of existing bridges and channels under a variety of flood conditions. It can also be used to determine the depth to which floodwater may inundate structures within the floodplain.

It is extremely important to note that the watershed study's hydrologic/hydraulic (H&H) models and analyses were aimed at developing watershed-wide, without-project rainfall-runoff models that can be used as planning tools to determine the hydrologic effects of the proposed watershed management alternatives. The hydrologic analyses, which include characterization of low flows and sediment/debris yields, are detailed and specific enough to allow for evaluation of detention basins or stream restoration alternatives at particular points in the watershed. If spin-off studies are justified and initiated, the analyses conducted to date will be directly applicable to, or can be readily adapted for, design level work. The complete presentation of the hydrological analysis is included in the Hydrology Appendix. These models are NOT intended for use other than in this study effort, and should not be used for other purposes. In particular, the models, including those resulting "floodplain" maps, are not comparable to existing Federal Emergency Management Agency (FEMA) maps, which serve an expressly different purpose of a regulatory nature.

The without-project hydraulic models and plotted floodplains serve as baseline for comparison of the effects of the watershed management alternatives. In addition, the hydraulics results are used to quantify potential flood damages at bridge and culvert crossings, and bank protection. The hydraulics results are also used as input to the watershed study's sediment models. The Hydraulic Appendix includes detailed information from the hydraulic analyses, including sediment transport.

A geormorphic analysis was conducted to assess the characteristics and general stability of San Juan, Trabuco, and Oso Creeks. Changes in the profile of these creeks over time were investigated in light of changes in development and flood history. No geomorphic analysis was performed on for Oso Creek and Cañada Gobernadora since no historical data is available. Detailed results and discussion of the geomorphic analysis are also provided in the Hydraulic Appendix.

The watershed was divided into a number of subreaches (21 in San Juan Creek, 15 in Trabuco Creek, 6 in Oso Creek, and 6 in Cañada Gobernadora) for the sedimentation analyses. The reaches were broken down based on a comparison of hydraulic parameters (i.e., top width and velocity), existing hydraulic controls (e.g., bridges and drop structures), and cross-sectional geometry. Comparison of the total event yield indicates the potential of each reach to be either aggradational or degradational. The without-project sedimentation models will serve as a baseline for comparison of the effects of the watershed management alternatives. The goal of project alternatives will be to achieve equilibrium in potential transport capacity from reach to reach. Detailed results and discussion of the sedimentation analyses are provided in the Hydraulic Appendix.

Hydrologic/hydraulic modeling, sediment modeling, and geomorphic analyses were used to evaluate the performance of existing structures under a variety of conditions. They were also used to evaluate performance under a future "without-project" condition, as well as with new potential projects in place, as part of the analysis of alternative measures conducted later in the study process. This type of modeling is vital to determine the best alternatives, technically, environmentally, and economically.

2.3.3 Habitat Evaluation Tools and Species Surveys

In order to accurately assess the existing (and potentially historic) condition of the watershed ecosystem, the study team utilized aerial photography, site visitation, and application of a landscape-level application of the Hydro-Geomorphic Methodology (a.k.a. "HGM") of functional assessment of ecosystem functions throughout the watershed. Species surveys added greatly to the understanding of where and in what numbers various species reside in the watershed. The establishment of existing, or baseline conditions in the watershed is critical to the understanding of what exists currently, what has been lost historically, and what might be expected to exist in the future if nothing is done to ameliorate existing problems.

The natural historic and future "without-project" conditions of the potential restoration areas were also assessed prior to developing conceptual restoration plans. In addition to restoring a degraded ecosystem's functions and values, the restoration approach also recognizes that existing and planned infrastructure is a legitimate feature of the human environment and should co-exist compatibly with the natural features of ecosystems in which they are placed. Therefore, existing land use constraints and opportunities were considered during the development of the conceptual restoration alternatives.

2.3.4 Preliminary Design and Cost Estimating

Preliminary design as conducted using Micro-Station computer-aided drafting and design tools, at a feasibility level of detail. This was then used in the development of cost estimates for alternative measures developed in problem solving. This is discussed in greater detail in following sections of the report and in the Engineering Design Appendix.

2.3.5 Economic Evaluations

The economics of the watershed were evaluated using the Corps' "Flood Damage Assessment" (FDA) methodology. This tool evaluates existing values of structures and contents in the watershed, potential emergency expenditures, disruptions in transportation costs, and other flood-related costs. Use of this tool was important to understand the extent of the flood problem, and where and how to direct measures that might significantly reduce future expenditures directed at this issue.

2.4 Watershed Land Use

Historically, land uses within the San Juan Creek watershed were primarily agricultural or livestock-oriented. Agriculture was conducted along the floodplains of San Juan and lower Trabuco Creek. Upland areas were used for grazing. During the past 35 years, rapid urban development with the associated infrastructure (e.g., roads, underground conduits, etc.) has occurred. These developments, primarily residential, centered in the communities of Mission Viejo, Leisure World, Laguna Hills, Rancho Santa Margarita, Laguna Niguel, Aliso Viejo, Lake Forest, and areas along San Juan Creek and I-5. Figure 1 shows a map of land use as it currently exists.

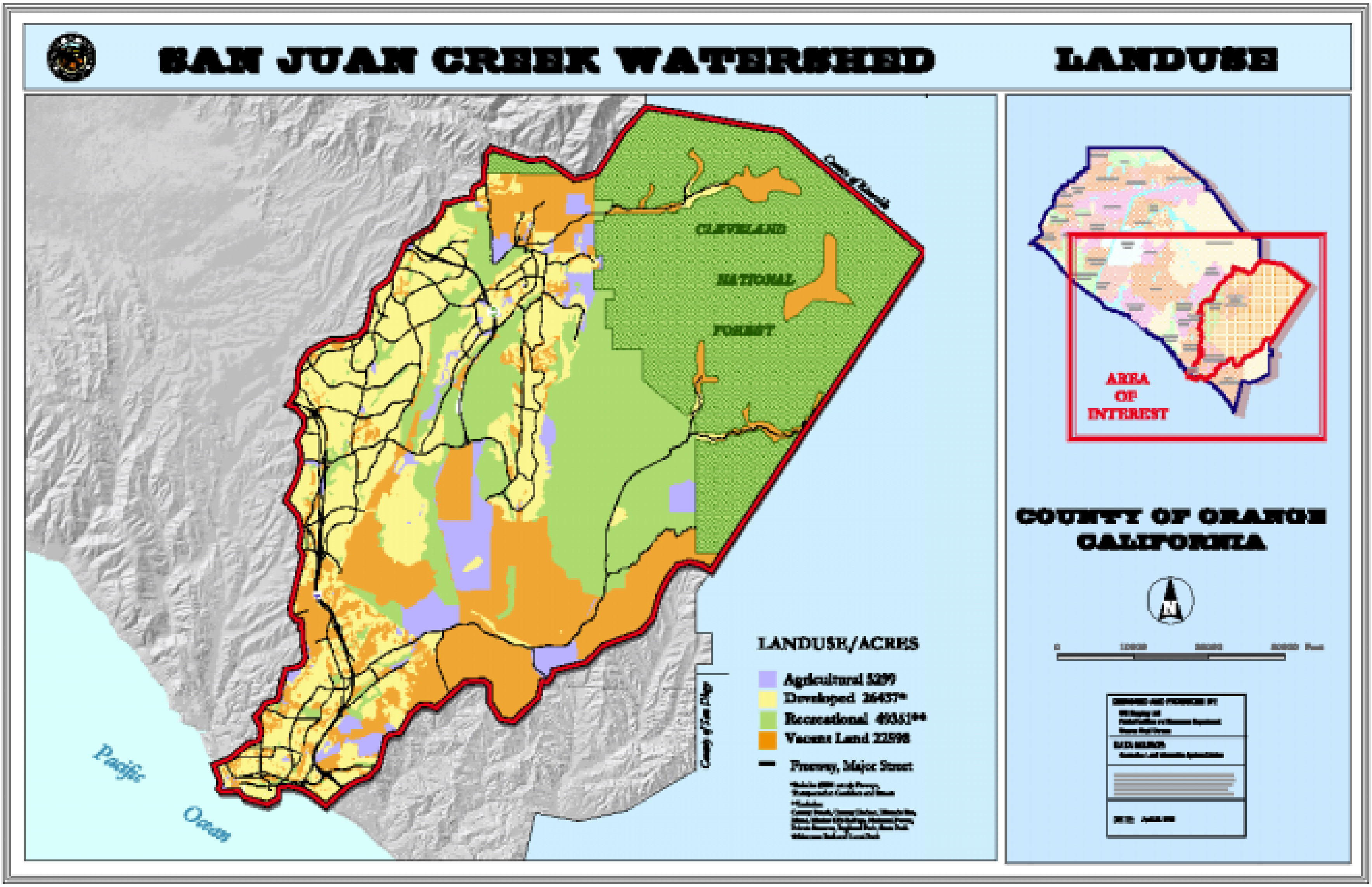
As shown in Figure 1, downstream land uses are primarily urban. This portion of the watershed contains single- and multiple-family dwelling, as well as, commercial and industrial uses such as shopping centers and business parks. In the northwestern portion of the watershed, suburban communities dominate the landscape. Land use rapidly changes further east in the unincorporated areas of the county, the majority of which is open space. However, pockets of other land uses exist within this area, including rural and suburban residential communities to the north, mineral extraction, recreation, agriculture, and business parks. Examples of common land uses present within the San Juan Creek watershed are presented in Table 5.

Table 5 Land Use Categories – San Juan Creek Watershed

Category	Typical Uses
Residential	Single or multi-family homes; Low-density estates; Attached dwelling units (e.g., townhouses, condominiums, and clustered arrangements)
Community Commercial	A wide range of facilities for convenience goods and retail trade (e.g., supermarkets, restaurants, movie theaters, and banks)
Public Facilities	Include civic buildings, junior colleges, military installations, hospitals, solid waste facilities, water facilities, and sewer facilities
Open Space	Major parks, beaches, forests, harbors, agricultural lands, and reserve areas
Urban Activity	Identifies locations intended for high-intensity mixed-use development including residential, commercial, office, industrial park, materials recovery/recycling facility, civic, cultural, educational facilities, and childcare facilities

Source: Orange County General Plan, as amended

Figure 1. San Juan Creek Watershed Land Use – Present Condition



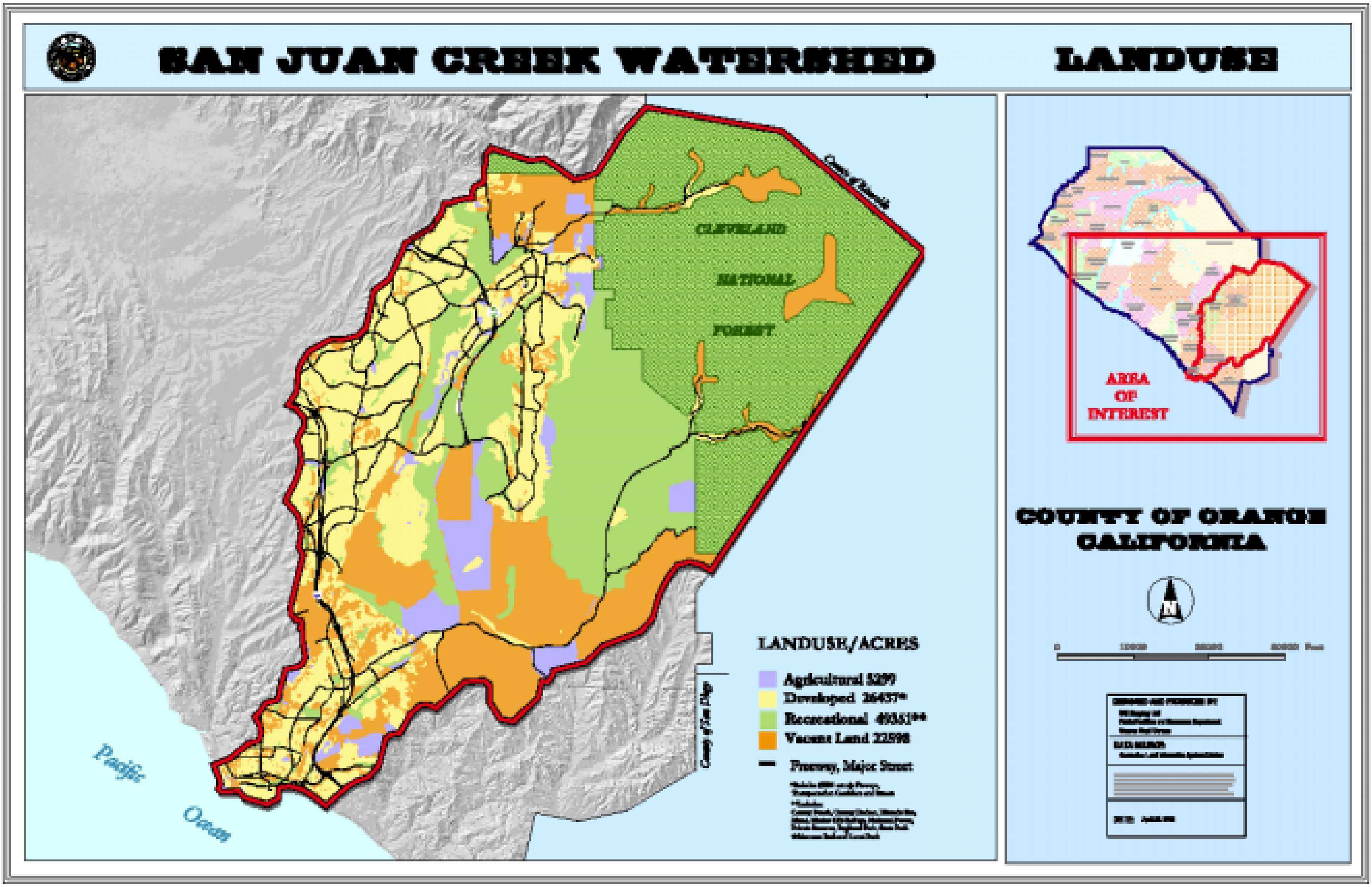
Future land use within the San Juan Creek watershed, shown in Figure 2, will generally be consistent with existing patterns, with the most intensive residential and commercial uses occurring in the downstream portions of the watershed. Construction of new roadways within the watershed will accompany development of the remaining privately-held portions of the watershed. As the County continues to grow, the pressure on local resources will increase. Urbanization affects agriculture, parkland, wildlife habitat, and natural vegetation most directly, since these resources often compete with development of the same land.

Currently, local, state, and Federal agencies, in cooperation with local landowners, are engaged in a coordinated land and natural resource conservation planning effort to address future development within a 91,000-acre portion of southern Orange County. The three planning processes underway are as follows: (1) an amendment to the County's General Plan and zone change; (2) development of a Special Area Management Plan/Master Streambed Alteration Agreement (SAMP/MSAA); and (3) development of a Natural Community Conservation Plan/Habitat Conservation Plan (NCCP/HCP). As shown in Figure 2, the NCCP reserve system currently encompasses approximately 114 hectares (281 acres) of the San Juan Creek watershed. Approximately 2,062 hectares (5,095 acres) are proposed to be included as designated NCCP/SAMP reserve system.

While change in the extent and distribution of development from the County's current General Plan may be expected, little change in the overall impacts of development on either peak discharges or baseflow are anticipated. This is partly due to the limited amount of land remaining in the watershed that is suitable for intensive development, but more importantly due to the County requirement for on-site detention of stormwater. These requirements state that all development of open space must result in no significant increase in either the peak discharge or volume of floodwater released to downstream channels. It is expected that re-development of property in the watershed will be subject to similar regulation.

Similarly, baseflow is not expected to change significantly from existing conditions. Although landscape irrigation is expected to increase slightly in extent from existing conditions, this is expected to be offset to some extent by a decrease in the magnitude of irrigation in other previously developed areas due to a gradual change to more efficient watering techniques and a general public awareness of water conservation needs in a changing environment.

Figure 2. San Juan Creek Watershed Land Use – Future Condition



2.4.1 Recreation

The size and natural diversity of the landscape in the San Juan Creek watershed produces numerous opportunities for public recreation, education, and environmental awareness. Recreational facilities available throughout the watershed include bird watching, fishing, hiking, jogging, surfing, golfing, and mountain bike riding, among others.

Regionally, the watershed contains a variety of recreational facilities managed by Federal, state, and local agencies, as well as some private institutions. Recreational opportunities are found throughout the watershed from the rugged foothills of the Santa Ana Mountains to the shores of the Pacific Ocean at Dana Point and Capistrano Beach. The significant recreational facilities adjacent to or near major tributaries of the San Juan Creek watershed are listed in Table 6. Other recreational facilities including parks, tennis facilities, walking/hiking trails, bicycling trails/paths, swimming pools, senior centers, and team sport facilities including baseball, football, soccer, and volleyball are located within the watershed, but are too numerous to list here. Brief descriptions of the more prominent recreational facilities in the watershed follow the next paragraph.

Little future expansion of existing park areas is anticipated. As open space greatly diminishes, and what remaining open land in private hands is converted to development, there will be little opportunity for linkage amongst these disparate areas. Much of the parkland in the watershed resides in its upper reaches, and is therefore disconnected from downstream portions of the watershed and the ocean. County parks currently serve an important function in providing connection between the upper reaches contained in the National Forest, with lower reaches of the watershed. Despite the existence of these significant upper lands that will remain removed from development pressure, the best that can probably be expected in the future is to establish spaced refuges between the ocean, dispersed lower park areas, the large park areas in the upper reaches of the watershed. Unfortunately impacts to park areas must be expected to increase, as population pressure increases in nearby developed areas. Avoidance of unacceptable impacts, perhaps by limiting access and numbers, may be a reality of future park management activities. Limited wildlife corridor preservation may still be possible along San Juan Creek upstream of the lined channel segment, as a product of the various habitat conservation plans in development. This concept may be no longer possible for certain tributaries, in particular Oso Creek. In addition, any expectation of large-scale ecosystem preservation in privately held lands is probably not economically possible, due to the value of remaining open space in the watershed. However, habitat protection of lands that contain threatened and/or endangered species is another matter. Much of this land is riparian, and may be expected to be preserved in one form or another. The realities of conflicting expectations in the San Juan watershed strongly constrain plan formulation in later phases of this study. This is discussed in more detail in the plan formulation section of the report.

2.4.1.1 Cleveland National Forest

The Cleveland National Forest is a large wilderness area that extends from just north of the U.S. Mexican Border to the City of Corona. It contains several mountain ranges including the Santa Ana Mountains, the Palomar Mountains, the Laguna Mountains, and others. It is divided into three separate and distinct districts: the Trabuco District, the Palomar District, and the Descanso District. The only district that overlaps onto the San Juan Creek watershed is the Trabuco District. The other two districts are located solely within the boundaries of San Diego County.

Recreational opportunities within the Cleveland National Forest in the San Juan Creek watershed include camping, picnicking, hiking, backpacking, mountain bike riding, and wildlife observation. There are several facilities within the watershed that accommodate these activities. All these facilities are located either adjacent to Highway 74, or near Highway 74 along a small side road. Brief descriptions of the recreational facilities provided for those operated by the U.S. Forest Service are shown in Table 7. Ortega Oaks Campground is an additional facility located along Highway 74 within the Cleveland National Forest, but it is privately owned and operated.

Table 6 Parks and Recreational Facilities Linked to San Juan Creek and Tributaries

Facility	Location	Management	Recreational Opportunities	Tributary
Cleveland National Forest	Southeastern Orange County.	United States National Forest Service.	Camping, hiking, wildlife viewing, bicycling, photography.	San Juan, Trabuco, Bell Canyon
O'Neill Regional Park	Along Trabuco Creek from Live Oak Road/Trabuco Canyon Road to just south of Oso Parkway.	County of Orange, Dept. of Harbors, Beaches and Parks.	Camping, hiking, wildlife viewing, bicycling, photography.	Trabuco
Ronald W. Caspers Regional Park	Along Ortega Highway and San Juan Creek from the Cleveland National Forest to Cañada Gobernadora.	County of Orange, Dept. of Harbors, Beaches and Parks.	Camping, hiking, wildlife viewing, bicycling, photography.	San Juan, Bell Canyon
Thomas S. Riley Wilderness Park	At eastern end of Oso Parkway between Cañada Gobernadora and Canada Chiquita Creeks.	County of Orange, Dept. of Harbors, Beaches and Parks	Hiking, wildlife viewing, bicycling, photography	Between Chiquita and Cañada Gobernadora
Doheny State Beach	City of Dana Point at San Juan Creek ocean outfall.	State of California, Department of Parks and Recreation.	Camping, surfing, swimming, walking, sunbathing, picnicking, volleyball.	San Juan
Audubon Starr Ranch Sanctuary	Bell Canyon near Dove Canyon.	National Audubon Society	Research, guided tours, workshops	Bell Canyon
Descanso Park	Paseo Adelanto at Trabuco Creek confluence with San Juan Creek	City of San Juan Capistrano	Walking, picnicking, children recreational area.	San Juan, Trabuco
Oso Viejo Community Park/Jeronimo Open Space	Between Jeronimo Road and La Paz Roads near Marguerite Parkway.	City of Mission Viejo	Hiking, picnicking, bicycling, various sports activities (site of the World Cup Soccer Center).	Oso
Cook Park	Calle Arroyo & La Novia Ave. along San Juan Creek.	City of San Juan Capistrano	Walking, picnicking, wildlife viewing.	San Juan
Cook Park Cordova	Calle Arroyo & Via Estenaga	City of San Juan Capistrano	Walking, picnicking, wildlife viewing.	San Juan
Lake Mission Viejo	Between Alicia Parkway, Marguerite Parkway, and Olympiad Road.	City of Mission Viejo	Walking, paddle boating, bicycling.	Oso
San Juan Hills Golf Course	San Juan Creek Road in the City of San Juan Capistrano	Private	Golfing	San Juan
Mission Viejo Golf Course	Oso Parkway in the City of Mission Viejo.	Private	Golfing	Oso
Casta Del Sol Golf Course	Marguerite Parkway in the City of Mission Viejo.	Private	Golfing	Oso
Tijeras Creek Golf Club	Along Tijeras Creek and Antonio Parkway in Rancho Santa Margarita.	Private	Golfing	Trabuco, Tijeras
Coto De Caza Golf Course and Country Club	Along Cañada Gobernadora Creek in Coto De Caza.	Private	Golfing, Tennis	Oso

Table 7 Recreational Facilities within the Cleveland National Forest

Facility	Elevation (ft)	Camp Units	Group Camp Units	Picnic Sites	Year-long (Y) or Seasonal (S) Use
Blue Jay	3400	55	0	0	Y
El Cariso North	2600	24	0	4	Y
Falcon	3300	0	3	0	Y
Upper San Juan	1800	18	0	0	Y
Lower San Juan	1800	0	0	8	Y

2.4.1.2 O'Neill Regional Park/Arroyo Trabuco

O'Neill Regional Park is a 3,100-acre wilderness area situated along Trabuco and Live Oak Creeks in the northeastern portion of the City of Mission Viejo. Arroyo Trabuco is an addition to O'Neill Regional Park and consists of 935 acres of relatively pristine land, which is currently maintained as a wilderness preserve. The Arroyo Trabuco Park is located immediately adjacent to O'Neill Park on the downstream end of Trabuco Creek. Overall, the two parks extend from just downstream of Oso Parkway Bridge up to Live Oak Canyon Road and Trabuco Canyon Road. The total size of the two parks is over 4,000 acres, most of which is situated within the area known as Plano Trabuco. The park is heavily wooded with coastal live oak and sycamore trees. Hillsides surrounding the park are filled with cactus, wild buckwheat, sagebrush, and chaparral of scrub oak, buckthorn, and mountain mahogany. Trabuco Creek and several smaller tributaries meander through the park, flowing in winter and early spring, but are usually dry during summer and fall.

O'Neill Park serves both as an overnight camping facility and has day/picnic use. These facilities are located in the northernmost portion of the park near the confluence of Trabuco and Live Oak Creeks. The picnic area provides for single and group uses and contains picnic tables, barbecues, a large turf area, horseshoe pits, and playground equipment. The park facilities also offer other recreational opportunities including an equestrian campground, an arena, and 32 kilometers (20 miles) of equestrian trails.

2.4.1.3 Ronald W. Caspers Wilderness Park

Caspers Wilderness Park is a 7,600-acre, protected wilderness preserve nestled among the river terraces and sandstone canyons of the western coastal Santa Ana Mountains. The park is located about 13 kilometers (8 miles) inland from Interstate 5 along Highway 74. The park extends on both sides of Highway 74 between the confluences of San Juan Creek with Bell Canyon and Hot

Springs Creeks. The park's many fertile valleys are overtly complemented by specimen groves of native Coastal Live Oak and magnificent strands of California Sycamore. These areas are further accentuated by seasonal wildflower displays and running streams. Wildlife is abundant and can be readily viewed from any of the parks numerous trails.

Caspers Wilderness Park affords the visitor numerous opportunities for primitive forms of recreation such as camping, picnicking, hiking, horseback riding, mountain biking, photography, nature study, and astronomy. The park has campgrounds, restrooms and showers, picnic areas, an equestrian campground, and hiking and equestrian trails. The park has 82 individual camp sites and two group sites. The Visitor Center offers the park user an insight into the park's history, wildlife, and plant life.

2.4.1.4 Thomas F. Riley Wilderness Park

Thomas F. Riley Wilderness Park is a 475-acre wilderness park that is popular with hikers, equestrians, and mountain bikers. The park is a designated wildlife and plant sanctuary. The terrain is large, open, grassy slopes; deep Oak/Sycamore groves (home to at least 16 Heritage Oaks); and a small seasonal pond, which is surrounded by Coastal Sage habitat. Two seasonal creeks are present within the park.

Recreational use of the park is restricted to day use only with parking available for 60 vehicles, including horse trailer rigs. For the equestrians, there are four pipe corrals and a watering fountain. The park offers seven interlinking trails, totaling over 8 kilometers (5 miles). Trails range from single track to wide multipurpose dirt roads, which were once used by ranch wagons during the 1800s. Also available are amenities for picnicking, portable restrooms, and drinking fountains. To preserve its viable ecosystem, no dogs are permitted in the park, assuring that the resident wildlife population will not be stressed by their presence.

The park office houses a visitors center and a volunteer operated gift shop. There are also opportunities for Scout patch and badge programs, Eagle Scout projects, community service projects, Junior Ranger programs (6 weeks long), classroom outreach, and outdoor education for all school levels.

2.4.1.5 Doheny State Beach

Doheny State Beach is a 62-acre park operated by the California State Parks. It is located at the ocean outfall of San Juan Creek on both the north and south sides of the creek in the City of

Dana Point. The park is divided into three parts. The portion of the park on the north side of San Juan Creek is reserved for day use only with a sandy beach, grassy areas, numerous trees, 170 picnic tables, 99 barbecue grills, and 5 fire rings. This area is adjacent to Dana Point Harbor. Just south of San Juan Creek is a campground with 122 single unit campsites, full service restrooms, and a sandy beach. The third area, just south of the campground, is another day use area with a long stretch of sandy beach, volleyball courts, and 33 fire rings.

2.4.1.6 Audubon-Starr Ranch Sanctuary

The Starr Ranch is operated as a 4,000-acre wildlife preserve by the National Audubon Society. It is located adjacent to the Dove Canyon development along Bell Creek in the upper portion of the Bell Creek watershed. Access to the park is via Plano Trabuco Road and Bell Canyon Road.

The Starr Ranch Sanctuary encompasses the unique mosaics of Mediterranean climate habitats that were once, before the spread of urbanization, typical of Southern Californian landscapes, including coastal sage scrub, grasslands (perennial bunchgrass and annual), oak woodland, chaparral, and riparian woodland. In addition to acting as a wildlife preserve, the sanctuary is used as a fully operational field station for the study of native flora and fauna. Currently, there are 12 active research projects at Starr Ranch by 10 different universities and public agencies.

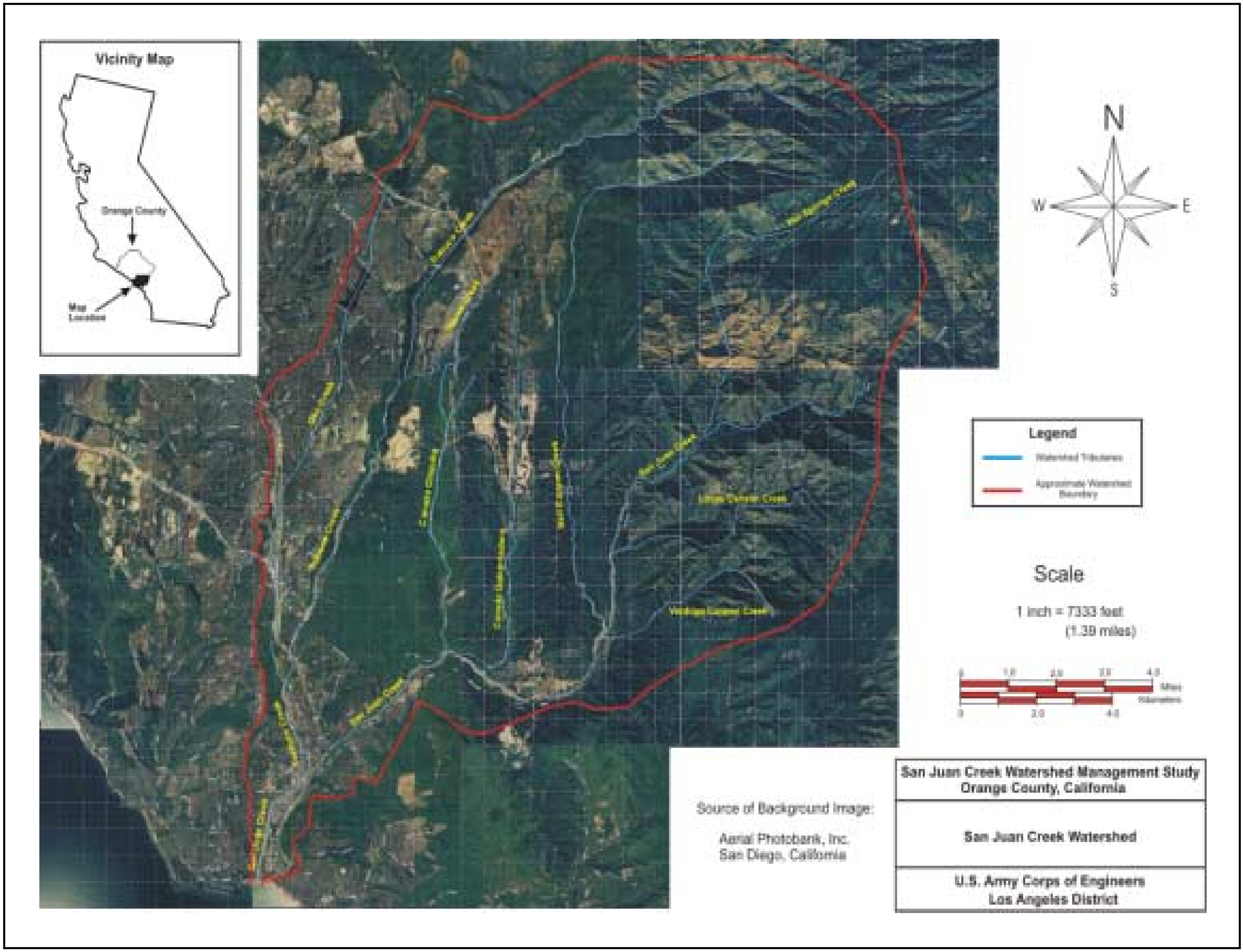
Although Starr Ranch is closed to the general public, the sanctuary offers several public outreach programs including volunteer-docent-led nature walks, video screenings, workshops, adult and children summer programs, and university classes.

2.5 Watershed Geology

2.5.1 Regional Topography

The San Juan Creek watershed (Figure 3) is located in southern Orange County, California. The watershed encompasses a drainage area of approximately 456 square kilometers (176 square miles) extending from the Cleveland National Forest in the Santa Ana Mountains to the Pacific Ocean at Doheny State Beach near Dana Point Harbor. The upstream tributaries of the watershed flow out of steep narrow canyons. As the streams flow, they coalesce and widen out into several alluvial floodplains. Overall, the basin is comprised of 23 canyons, which include Trampas, Verdugo, Lucas, Bear, Morrell, Decker, Long, Lion, Hot Springs, Cold Spring, Dove, Bell, Crow, Gobernadora, Chiquita, Horno, Trabuco, Tijeras, Holy Jim, Falls, Hickey, Live Oak, and Oso Canyons.

Figure 3. San Juan Creek Watershed Map



Elevations range from 1,733 meters (5,687 feet) on Santiago Peak to sea level at the mouth of San Juan Creek. Stream gradients range from approximately 19 percent (189 meters per kilometer / 1,000 feet per mile) in Holy Jim Canyon to less than 0.4 percent (3.79 meters per kilometer / 20 feet per mile) near the San Juan Creek ocean outfall. The San Juan Creek watershed is bounded on the north by the Aliso Creek and Salt Creek watersheds, and on the south by the San Mateo Creek watershed (with additional small drainages within residential neighborhoods of San Clemente which drain directly to the ocean). The Lake Elsinore watershed, which is a tributary of the Santa Ana River watershed, is adjacent to the eastern edge of the San Juan Creek watershed.

2.5.2 Regional Geology

The San Juan Creek watershed lies on the western slopes of the Santa Ana Mountains and the *Lomas de Santiago*, or Santiago Hills. This range is part of the Peninsular Ranges which extend from the tip of Baja California northward to the Palos Verdes peninsula and Santa Catalina Island. The geology of the San Juan Creek watershed region is complex and has been dominated by alternating periods of depression and uplift, mass wasting and sediment deposition. The portion of the Santa Ana Mountains in which San Juan Creek and its tributaries rise is composed of igneous and sedimentary rocks of Jurassic age and younger. The exposed rocks in the mountains are slightly metamorphosed volcanics, which have been intruded by granites, gabbros, and tonalites of Cretaceous age. Overlying these rocks are several thousand stratigraphic feet of sandstones, siltstones, and conglomerates of Upper Cretaceous age.

Sedimentary rocks of Tertiary age are found between the Santa Ana Mountains, their foothills, and the Pacific Ocean. The rocks are at least 6,100 meters (20,000 feet) thick and are described as marine and non-marine sandstones, limestones, siltstones, shales, and conglomerates, overlain by Quaternary stream terrace deposits, Holocene stream channel and landslide material. The geologic structures of San Juan Creek and the various tributaries are discussed below.

2.5.2.1 San Juan Creek, Upstream of Bell Canyon

San Juan Creek rises at an elevation of 1,554 meters (5,100 feet) on the southwest edge of the Santa Ana Mountains. The stream flows through bedded sedimentary rocks, intrusive igneous rock, volcanics, streambed alluvium, and terrace deposits ranging in age from Jurassic to Tertiary. The Aliso fault which trends northwest-southeast, crosses the creek about a mile below where the stream originates. The Mission Viejo fault crosses San Juan Creek about three miles upstream of the confluence with Bell Canyon. This fault separates the Cretaceous sediments (upstream) from the Tertiary sediments (downstream). The sedimentary rocks of Cretaceous age are from the Williams Formation, the Bedford Canyon Formation, and the Trabuco Formation, described as interbedded siltstone and conglomerates, slaty siltstones, and graywackes and massive sandy/silty conglomerates. The sedimentary rocks of Tertiary age are from the Santiago Formation, described as sandstone with interbedded siltstones. The intrusive igneous rocks are described as granites, tonalites, gabbros, and granodiorites also of Cretaceous age. The volcanics are known as the Santiago Peak Volcanics of Jurassic age and contain a mixture of various types of extrusive rocks, described as tuffs, flow breccias, and andesites, some of which have been slightly metamorphosed. San Juan Creek flows through an alluvial valley, varying in width from 457 to 914 meters (1,500 to 3,000 feet), which contains Holocene alluvium and Pleistocene terrace deposits for two miles upstream and one mile downstream of Lucas Canyon.

2.5.2.2 San Juan Creek, Downstream of Bell Canyon

Downstream of the confluence with Bell Canyon, for an approximate seven-mile reach to San Juan Capistrano, the stream flows through bedded sedimentary rocks. The sedimentary rocks are from the Silverado and Santiago formation of Tertiary age and are described as conglomerates, fanglomerates, and cross-bedded sandstones. The average width of the San Juan Creek floodplain in this reach is 1,220 meters (4,000 feet). In San Juan Capistrano and vicinity, San Juan Creek flows through an alluvial valley approximately 2,590 meters (8,500 feet) wide before flowing through the breached San Joaquin Hills into the Pacific Ocean at Doheny State Beach. The alluvial valley contains Holocene alluvium, landslide deposits, and Pleistocene terrace deposits. The San Joaquin Hills contain sedimentary rocks, described as sandstones, siltstones, conglomerates, and shales from the Capistrano Formation and the Santiago Formation of Tertiary age. These rocks are often mantled or covered with terrace deposits and landslide deposits, described as silts, sands, and gravels of Pleistocene and Holocene age. The length of the stream below Bell Canyon is about 16.1 kilometers (10 miles).

2.5.2.3 Trabuco Creek

Trabuco Creek rises in the Santa Ana Mountains at an elevation of 1,314 meters (4,310 feet), at the base of Trabuco Peak, and flows south-southwest through igneous and sedimentary rock of Jurassic age and younger. The exposed rocks in the mountains are slightly metamorphosed volcanics from the Santiago Peak Volcanics, which have been intruded by granites, gabbros, and tonalites of Cretaceous age. Overlying these rocks are several thousand feet of sandstones, siltstones, and conglomerates of Upper Cretaceous age. The contract between the Cretaceous and the Tertiary sediments lies about 1.6 kilometers (1 mile) downstream of where the creek originates. The creek flows out of these mountains through a narrow canyon for about 1.6 kilometers (1 mile) into the "Plano Trabuco," an alluvial terrace about 6.5 to 8 kilometers (4 to 5 miles long), and about 1.6 kilometers (1 mile) wide. The foothills on each side of this valley are composed of sedimentary rocks described as sandstone, silty sandstone, and conglomeratic sandstone of Tertiary age. Downstream of the "Plano Trabuco," the stream narrows as it flows through more resistant beds of sedimentary rock, until about 3.2 kilometers (2 miles) upstream of downtown San Juan Capistrano where Oso Creek meets and flows into Trabuco Creek. Trabuco Creek then flows south for another 3.2 kilometers (2 miles) to the confluence with San Juan Creek, which then flows on to the Pacific Ocean. The total stream length of Trabuco Creek is about 40 kilometers (25 miles) from the headwaters to the confluence with San Juan Creek.

2.5.2.4 Oso Creek

Oso Creek rises about 11.3 kilometers (7 miles) upstream of Mission Viejo in the foothills of the Santa Ana Mountains at an elevation of 491 meters (1,610 feet). The stream flows almost south-southeast until the confluence with Trabuco Creek, about 3.2 kilometers (2 miles) upstream of downtown San Juan Capistrano. For its entire length, the Oso Creek floodplain is generally less than 610 meters (2,000 feet) wide. It is bordered on each side by sedimentary rocks, described as sandstones, arkosic sandstone, mudstones, siltstones, siliceous shales, breccias, and conglomerates of the Capistrano, Vaqueros, Monterey, Sespe, Topanga, and Niguel Formations of Tertiary age. The total stream length of Oso Creek is about 21.7 kilometers (13.5 miles), from the headwaters to the confluence with Trabuco Creek.

2.5.2.5 Lucas Canyon Creek

Lucas Canyon Creek rises at an elevation of 872 meters (2,680 feet) on the slopes of Sitton Peak in Riverside County. The stream flows 3.2 to 4.8 kilometers (2 to 3 miles) west in Orange County, then flows southwest for 6.4 kilometers (4 miles) to the confluence with San Juan Creek, about 11.3 kilometers (7 miles) north and east of San Juan Capistrano. For the first few kilometers, the stream flows through narrow rock canyons. The streambed widens for the last 3.2 kilometers (2 miles) to about 122 to 152 meters (400 to 500 feet) in width until the confluence. The creek flows through the Santiago Peak Volcanics of Jurassic age, which are composed of metamorphosed volcanic flows, dikes, pyroclastic rocks, and interbedded sediments and the Trabuco Formation of Late Cretaceous age, which is composed of non-marine conglomerates.

The Lucas Canyon Creek floodplain contains Holocene alluvium, landslide deposits, and occasional Pleistocene terrace deposits.

2.5.2.6 Bell Canyon Creek

Bell Canyon Creek rises in the Santa Ana Mountains at an elevation of about 1,220 meters (4,000 feet) at the western slopes of Los Pinos Peak, elevation 1,375 meters (4,510 feet). The stream flows west for about 8 kilometers (5 miles) and south for about 16 kilometers (10 miles) before joining San Juan Creek about 12 kilometers (7.5 miles) upstream and east of San Juan Capistrano. The creek rises and flows through a narrow canyon for the first few thousand feet, widens to about 152 meters (500 feet) until the confluence with Dove Creek, then widens again to an alluvial valley of about 305 meters (1,000 feet) for the next 11.3 kilometers (7 miles) until the confluence with San Juan Creek. Bell Canyon Creek rises and flows for the first few miles through the Bedford Canyon Formation of Jurassic age, composed of slightly metamorphosed sedimentary rocks described as slaty siltstone and graywacke. The creek crosses the Aliso Fault, which lies about 8 kilometers (5 miles) south of the headwaters of the creek and separates the Jurassic rocks from the Cretaceous rocks. The Cretaceous rocks are from the Williams and Ladd Formation and are described as sandstones and conglomerates. The creek flows over the Mission Viejo fault 4.8 kilometers (3 miles) further downstream. This fault separate the rocks of Cretaceous age from those of Tertiary age. The Tertiary rocks are from the Silverado and Santiago Formation and are described as sandstones with interbedded claystones, arkosic sandstones, and conglomerates. The wide alluvial valley contains Holocene alluvium, landslide deposits and Pleistocene terrace deposits.

2.5.2.7 Verdugo Canyon Creek

Verdugo Canyon Creek rises in the foothills of Sitton Peak in Riverside County at an elevation of about 2,400 feet and flows northwest for 1.6 kilometers (1 mile), then turns and flows southwest for 8 kilometers (5 miles) to the confluence with San Juan Creek, which is about 8.8 kilometers (5.5 miles) northeast of San Juan Capistrano. The floodplain for this stream is very narrow as it rises through rocky canyons, until the stream flows southwest when it widens to 152 meters (500 feet) until about 1.6 kilometers (1 mile) from the confluence, when the stream becomes approximately 305 meters (1,000 feet) wide. The creek rises and flows through the Trabuco, Ladd, and Williams formations, all of Upper and Late Cretaceous age. These sediments are composed of conglomerates, marine shales, conglomeratic limestone, bituminous sandstone, and sandstone with interbeds of siltstone and fossiliferous sandstone. The Verdugo Canyon Creek floodplain contains Holocene alluvium and occasional Pleistocene terrace deposits.

2.5.2.8 Cañada Gobernadora Creek

Cañada Gobernadora Creek rises near the base of the Santa Ana Mountains at an elevation of about 317 meters (1,040 feet). The stream flows south for about 13.7 kilometers (8.5 miles) before joining San Juan Creek about 6.4 kilometers (4 miles) upstream and northeast of San Juan Capistrano. The floodplain for this stream is generally less than 213 to 244 meters (700 to 800 feet) wide, with a maximum width of 366 meters (1,200 feet). For the first 6.4 kilometers (4 miles), the creek rises and flows through the Sespe Formation of Tertiary age, which is composed of non-marine conglomeratic coarse sandstone with thin interbeds of clayey and sandy siltstones. For the next 6.4 kilometers (4 miles), the creek flows through the Santiago Formation, also of Tertiary age, composed of interbedded marine sandstones, siltstones, and claystones. The Cañada Gobernadora Creek floodplain contains Holocene alluvium, landslide deposits, and Pleistocene terrace deposits.

2.5.2.9 Cañada Chiquita Creek

Cañada Chiquita Creek rises at an elevation of about 305 meters (1,000 feet), near the Plano Trabuco, and flows southwest for 1.6 kilometers (1 mile), then due south for about 9.7 kilometers (6 miles) to the confluence with San Juan Creek about 1.6 kilometers (1 mile) west of Cañada Gobernadora Creek. The floodplain for this stream is only a few hundred feet wide for the first 4 kilometers (2.5 miles) then widens to about 305 meters (1,000 feet) until the confluence with San Juan Creek. For the first four miles, the creek rises and flows through the Sespe Formation of Tertiary age, which is composed of non-marine conglomeratic coarse sandstone with thin interbeds of clayey and sandy siltstones. For the next two miles, the creek flows through the Santiago Formation, also of Tertiary age, composed of interbedded marine sandstones, siltstones, and claystones. The Cañada Chiquita Creek floodplain contains Holocene alluvium, landslide deposits, and occasional Pleistocene terrace deposits. The Cristianitos fault, which trends northwest-southeast, crosses San Juan Creek at the confluence with Cañada Chiquita Creek.

2.5.2.10 Tijeras Creek

Tijeras Canyon Creek rises on the Plano Trabuco, one mile south of the mouth of Trabuco Canyon in the foothills of the Santa Ana Mountains. The creek rises at an approximate elevation of 564 meters (1,850 feet) and flows southwest along the eastern edge of the Plano Trabuco for about 10.5 kilometers (6.5 miles) until the confluence with Arroyo Trabuco, approximately three miles east of Mission Viejo. (Arroyo Trabuco Creek continues to flow southwesterly for another 10.5 kilometers (6.5 miles) prior to meeting Oso Creek and flowing to San Juan Capistrano). Tijeras Canyon Creek flows through a floodplain varying in width from a rocky narrow canyon where it rises to one mile wide in the Plano Trabuco to 61 meters (200 feet) wide at the confluence with the Arroyo Trabuco. The creek rises in the Trabuco Formation of Upper Cretaceous age, which is composed of conglomerates, then flows through older alluvial deposits in the Plano Trabuco described as silts, sands, and gravels. Further downstream where the stream hugs the left bank of the Plano Trabuco, the stream flows through both Pleistocene terrace deposits, the Vaqueros Formation, and the Sespe Formation, both of Tertiary age. The Pleistocene terrace deposits consist of silt, sand, and gravel. The Vaqueros Formation consists of arkosic sandstone with thin interbeds of siltstone and shale, while the Sespe Formation consists of non-marine coarse sandstone with thin interbeds of clayey and silty sandstones. For the last few miles to the confluence, the stream flows through Holocene and older alluvial deposits, described as silts, sands, and gravels.

2.5.3 Soils

The evaluation of soils in the watershed is important in the understanding of how they might affect slope stability, channel stability, structure installation and stability, and also how they might impact ecosystem restoration options. Soils affect water retention, permeability for groundwater recharge purposes, and determine suitability for different types of vegetation in native vegetation re-establishment.

The U.S. Department of Agriculture divides Orange County for the purposes of soil classifications and surveys as follows: A narrow strip of beaches and tidal flats along the coast; an area of terraces and rolling foothills extending from the coast to the base of the Santa Ana Mountains and the alluvial floodplains (USDA, 1978).

Soils of the alluvial floodplain and fans are very deep and have smooth surfaces, extend on gradually decreasing gradients towards the ocean, and often terminate in tidal flats. The soils in the lower parts of the plains and in the basins are naturally poorly drained to somewhat poorly drained. The soils at higher elevations are well drained. These are the most productive agricultural soils in the area.

In their “General Soil Map,” the USDA Report (USDA, 1978) shows a general description of six different “soil associations” in the study area. The numbers given with the soil types are assigned by the USDA and indicate soils association. Numbers not shown are soils not found in the study area. The map describes the soils along the streambeds, the alluvial plains, the foothills, and the Santa Ana Mountains as:

Table 8 Soil Associations in the Study Area

SOMEWHAT EXCESSIVELY DRAINED TO POORLY DRAINED, NEARLY LEVEL TO MODERATELY SLOPING SOILS ON ALLUVIAL FANS AND FLOOD PLAINS AND IN BASINS OF THE COASTAL PLAINS. SA #3. Metz-San Emigdio association: Nearly level, somewhat excessively drained and well drained, calcareous loamy sands and find sandy loams on alluvial fans and flood plains. SA #4. Sorrento-Mocho association: Nearly level to moderately sloping, well drained sandy loams, loams, or clay loams on alluvial fans and flood plains.
MODERATELY WELL DRAINED, NEARLY LEVEL TO MODERATELY STEEP SOILS OF THE COASTAL TERRACES SA #5. Myford association: Nearly level to moderately steep, moderately well drained sandy loams that have a strongly developed subsoil on terraces.
SOMEWHAT EXCESSIVELY DRAINED AND WELL DRAINED, STRONGLY SLOPING TO VERY STEEP SOILS OR THE COASTAL FOOTHILLS SA #6. Alo-Bosanko association: Strongly sloping to steep, well drained clays on coastal foothills. SA #7. Cieneba-Anaheim-Soper association: Strongly sloping to very steep, somewhat excessively drained and well drained sandy loams, loams, clay loams, gravelly loams, and cobbly loams on coastal foothills.
SOMEWHAT EXCESSIVELY DRAINED AND WELL DRAINED, STRONGLY SLOPING TO VERY STEEP SOILS OF THE SANTA ANA MOUNTAINS. SA #8. Friant-Cieneba-Exchequer association: strongly sloping to very steep, somewhat excessively drained and well drained fine sandy loams, sandy loams, and gravelly silty loams on mountains.

2.5.4 Seismicity

2.5.4.1 Faults

The study of faults and seismicity is important chiefly for the siting of large structures, but also in the understanding of groundwater behavior. The location of faults may affect where dams or detention basins may be sited, and in design considerations.

There are several Quaternary faults in the study area. The most significant is the Newport-Inglewood-Rose Canyon fault, which is found about 9.7 kilometers (6 miles) offshore of the mouth of San Juan Creek. This fault, which parallels the coastline, extends from Beverly Hills in the Los Angeles Basin, through Long Beach and Newport Beach, southeast to Rose Canyon, Mission Bay, and San Diego, and is thought by some to extend to and beyond the Mexican Border. Two fault zones are located north and east of San Juan Capistrano. The Cristianitos fault and the Mission Viejo fault. The Cristianitos fault parallels Oso Creek in a northwest-southeast direction, crosses San Juan Creek about 6.4 kilometers (4 miles) east of San Juan Capistrano, and passes into the Pacific Ocean in San Clemente, about 11.3 kilometers (7 miles) down coast of the mouth of San Juan Creek. The Mission Viejo fault zone is parallel to the Cristianitos fault zone, crosses San Juan Creek about 14.5 kilometers (9 miles) east of San Juan Capistrano, then passes offshore into the Pacific Ocean below San Mateo Point in San Diego County. The Newport-Inglewood-Rose Canyon fault is known to be active; the Cristianitos fault is thought by some to be active.

2.5.4.2 Earthquakes

The earliest recorded event in the project area was an earthquake which occurred near San Juan Capistrano in 1812, and almost demolished the nearby mission. The approximate location of the epicenter is not known. The next severe event that occurred in the vicinity of the study area was the San Diego, Point Loma Earthquake of 1862, which was thought to have originated a few kilometers offshore of Point Loma. This event, with an intensity of VII in downtown San Diego and a calculated magnitude of 6.5, was located about 97 to 105 kilometers (60 to 65 miles) from the study area. The next strong event was the magnitude 6.3 Long Beach Earthquake of 1933. The epicenter of this event was about 1.6 kilometers (1 mile) offshore of the mouth of the Santa Ana River, between Huntington Beach and Newport Beach, about 32 kilometers (20 miles) west to northwest of the study area. A magnitude 5.5 event occurred about 32 kilometers (20 miles) northwest of San Juan Capistrano in Upper Trabuco Canyon near Santiago Peak in the Santa Ana Mountains in May of 1938.

A maximum credible event of 7.1 on the nearby Newport-Inglewood offshore portion of the Newport-Inglewood-Rose Canyon fault, located about 9.7 kilometers (6 miles) offshore, would produce a peak bedrock site acceleration of 0.39g at San Juan Capistrano.

2.5.4.3 Geologic Hazards

The hillsides on both sides of San Juan Creek and all of its major tributaries contain layered sedimentary bedrock, which is prone to landsliding. The geologic maps published by the State of California, Division of Mines and Geology, indicate that the potential for landslides is high to moderately high along San Juan Creek or any of its tributaries, particularly in reaches where the canyons are very narrow (Morton et al. 1976). Slides have occurred along all of the tributaries of San Juan Creek. Recently released seismic hazard maps of the adjacent Laguna Beach quadrangle suggest that the surficial sediments in San Juan Creek and its tributaries have a potential for liquefaction.

2.6 Water Resources

Water resources in the San Juan Creek watershed consist of numerous components, including surface flows in the creeks of the watershed, subsurface groundwater, and municipal and industrial water supplies. The following is a description of these water resources.

2.6.1 Municipal and Industrial Water Supplies

Five retail water districts provide for the water resource needs of those in the San Juan Creek watershed: Moulton Niguel Water District (MNWD), Santa Margarita Water District (SMWD), South Coast Water District (SCWD), Trabuco Canyon Water District (TCWD), and Capistrano Valley Water District (CVWD), a subsidiary district operated by the City of San Juan Capistrano. A short description of these retail water districts is provided below. These retail districts are provided potable water by the Metropolitan Water District of Southern California (MWD) through water wholesale agencies. These wholesale agencies include the Coastal Municipal Water District, the Municipal Water District of Orange County, and the Tri-Cities Municipal Water District. Non-potable water is obtained from groundwater or from use of treated sewage water. This water is used to provide irrigation for golf courses, greenbelts, parks, and school grounds. Wastewater treatment and disposal in the watershed is accomplished by the five individual water districts through their own facilities or by the South East Regional Reclamation Authority (SERRA), which operates a treatment plant in the City of Dana Point. All effluent waters from these treatment plants are directed into outfall pipelines, which deliver excess treated water to the Pacific Ocean. No treated water is directed into any of the tributaries of the San Juan Creek watershed.

2.6.1.1 Moulton Niguel Water District

The Moulton Niguel Water District (MNWD) serves about 24,500 acres with over 50,000 connections. MNWD provides water and wastewater services to portions of the cities of Dana Point, Laguna Niguel, Laguna Hills, and Mission Viejo. Residential housing, primarily single family, is the predominant land use in the service area. MNWD receives 95 percent of its domestic water from MWD and also operates a large recycled water system.

2.6.1.2 Santa Margarita Water District

The Santa Margarita Water District (SMWD) encompasses approximately 62,300 acres and serves about 39,000 retail customers and 4 wholesale customers. SMWD provides water and wastewater services to portions of the City of Mission Viejo and the City of Rancho Santa Margarita as well as the unincorporated foothill area communities of Coto de Caza, Las Flores, and Ladera Ranch. Due to extensive development planned in the near future within the areas served by SMWD, the number of retail customers is expected to increase to over 62,000 customers by the year 2020. SMWD receives virtually all of its domestic water from MWD which is derived from two sources: the Colorado River Project and the State Water Project. SMWD also operates an extensive water recycling system.

2.6.1.3 Capistrano Valley Water District

The Capistrano Valley Water District (CVWD) has recently become a subsidiary district to the City of San Juan Capistrano. CVWD has over 10,000 service connections within the city and a small portion of the City of Dana Point. The CVWD service area is primarily residential with some commercial uses.

2.6.1.4 South Coast Water District

The South Coast Water District (SCWD) serves portions of Dana Point, Laguna Beach, and San Clemente. The SCWD recently consolidated with the former Dana Point Sanitary District and Capistrano Beach Water District. SCWD receives 100 percent of its domestic water from MWD.

2.6.1.5 Trabuco Canyon Water District

The Trabuco Canyon Water District (TCWD) encompasses approximately 9,100 acres and connects with over 4,000 residential, agricultural, and forestland customers in unincorporated areas of southeastern Orange County. In addition, 441 acres of the Cleveland National Forest are within the TCWD service area. The developed areas within TCWD are primarily residential with some agricultural uses (mostly commercial nurseries). TCWD has some groundwater supply, but most of its domestic water is from MWD. TCWD also has a small recycled water system.

2.6.1.6 South Orange County Water Authority

The South Orange County Water Authority (SOCWA) is a joint powers authority formed in 1999 to provide regional wastewater collection, treatment, and disposal at a treatment plant in Dana Point. This plant has a treatment capacity of 2.25 million gallons per day. The member agencies of SOCWA are Moulton Niguel Water District, Santa Margarita Water District, South Coast Water District, the City of San Juan Capistrano, and the City of San Clemente.

2.6.2 Surface Water

Surface waters include water flowing within San Juan Creek and its tributaries, as well as waters in lakes and ponds (whether creek associated or creek independent). Historically, surface waters consisted primarily of the perennial creek flows in San Juan and Trabuco Creeks and the ephemeral flows in all of the smaller tributaries of the watershed. These flows derived from stormwater runoff during the rainy season and from springs and groundwater seepage into the creek during the dry season.

Due to extensive development in the Oso and Trabuco Creek watersheds, which has increased the impermeable surface area and decreased infiltration, ephemeral creek surface flows have become essentially perennial. Since no effluent flows from wastewater treatment plants are placed into any of the creeks in the watershed, the principal source of these added waters is runoff flows from urban activities such as lawn watering (e.g.. homes, golf courses, greenbelts, schools) and other forms of irrigation. While San Juan Creek itself was perennial historically, numerous smaller tributaries undoubtedly were not. It is not possible to know exactly which tributaries did or did not have year-round water. Increased water in the tributaries of San Juan Creek provides more opportunity for vegetation establishment that may not have formerly existed. It also provides a source of erosion as low flows continuously acts on the bed and banks of the channel system and associated infrastructure such as buried pipelines, bridge abutments, drop structures and channel linings. Perennial low flow carries contaminants that would normally remain in upper reaches down into lower reaches of the channel system, and into the ocean itself. Low flow must be accounted for in formulating solutions, as it will remain a problem in the future in the absence of measures such as xeriscaping on all landscaping that would tend to reduce the quantity of water entering the channel as through-flow.

2.6.3 Groundwater

Information pertaining to geohydrology has been obtained from the San Juan Basin Authority (SJBA) and the Metropolitan Water District of Southern California (MWD). San Juan basin groundwater information is described in detail in two reports prepared for the SJBA: “San Juan Basin Groundwater Management and Facility Plan” prepared by NBS Lowry, and the “Availability of Unappropriated Water San Juan Creek Basin” prepared by Stetson Engineers Inc., and Boyle Engineering.

Groundwater exists in a generally narrow, shallow alluvial valley fill that has been deposited in the San Juan Canyon area and its tributaries: Trabuco, Oso, and numerous other smaller canyons. Groundwater in these alluvial fill areas is unconfined. Groundwater studies indicate the alluvial fill ranges from reported depths of 61 meters (200 feet) at the coast to zero at the end of the small alluvial fingers tributary to the main canyons.

The main structural feature influencing groundwater movement is the Cristianitos Fault, which traverses the area in a north-south direction and crosses the San Juan Canyon at a narrows about 5.6 kilometers (3.5 miles) upstream from the confluence of San Juan and Trabuco Creeks.

This fault and narrows separate the groundwater alluvium into an upper and lower area. The three basins downstream of the Cristianitos Fault, the Lower Trabuco, Middle San Juan, and Lower San Juan, are referred to as the “lower basins.” The total calculated storage capacity of the San Juan Creek Groundwater Basin was estimated by the State Water Resources Control Board (SWRCB) in 1977 to be 90,000 acre-feet. Of this, about 10,500 acre-feet are surface water and about 450 acre-feet are subsurface water, which flows to the ocean each year. It is unknown at this point what effect these faults might have on groundwater recharge or subsurface flow, although it is clear tat they affect both to some degree.

Natural recharge is estimated to be greater than 10,500 acre-feet per year. Recharge consists of streambed percolation from the mainstem San Juan and Trabuco Creeks, rainfall infiltration and subsequent deep percolation to the water table, deep percolation of applied water from landscape and agricultural irrigation, and subsurface inflow from the tributary alluvial stream areas.

Of these sources, rainfall is the greatest recharge input component, averaging 160,000 acre-feet per year over the 111,000-acre basin. Applied water from landscape and irrigation currently averages 35,000 to 40,000 acre-feet per year and is growing steadily with increased urbanization in the watershed. Generally, the efficiency of irrigation (proportion of applied water used by the landscape) is in the range of 70 percent. The percentage of irrigation lost or "irrigation return flow" is approximately 30 percent of the water applied. A sizeable amount of this irrigation return flow ends up as non-storm streamflow in the tributary stream courses. This has resulted in historically intermittent streams now exhibiting year-round flow.

Discharge from the basin consists of well extractions, phreatophytes extractions, and subsurface outflow to the Pacific Ocean. Extractions of water from the lower reaches of the basin have been mostly eliminated since the early 1960s due to the water quality and the importation of water. In recent years, the Lower Basin has remained essentially full. It is estimated that historically, the San Juan Creek watershed was overdrafted by an average of 2,000 acre-feet per year. The issues of future water demand and long-term plans by many of the water districts for groundwater pumping in the watersheds remain tied to the overall picture of regional water supply. Additional information on the correlation between current groundwater levels and overdraft in the watershed is being pursued by local agencies and the SWRCB in reviewing pending water rights applications.

Historic sustained yield in the San Juan Basin has been estimated at about 5,200 acre-feet per year. Sustained yield will gradually increase in the future due to development of the tributary watershed areas that will see increased urbanization and landscape irrigation with imported water. Over the past several decades, many areas in the San Juan Creek watershed have undergone extensive development. These areas include the Plano Trabuco along Trabuco Creek and communities along the Oso Creek tributaries. This urbanization has resulted in an increase in impervious surfaces of the watershed, with land transitioning from vacant or agricultural uses to urban (residential and commercial or industrial) usage. Buildings, streets, parking lots, and other paved areas account for a large portion of any urbanized area; replacing native vegetation. The increase in impervious surfaces results in less infiltration of precipitation and results in greater runoff. Return flows from agricultural and urban landscape irrigation will also result in increased subsurface inflow to the main basin and increased stream surface baseflows which will partially percolate into the main basin. The sustained yield for the basin in 1993 was estimated to be 7,800 acre-feet. Ground water pumped out of the basin is used principally for agricultural or golf course irrigation, with a lesser amount for municipal purposes. Under ultimate buildout of the watershed, the sustained yield is estimated to be 9,000 acre-feet per year in the main San Juan Basin.

Historic water level records at various wells in the San Juan Creek Basin indicate that after drought periods, the groundwater levels recover within a period of only 3 to 4 months during the first wet season. The rapid recovery in groundwater levels following a drought suggests that the basin has a high maximum recharge rate. The recharge rate is a critical factor in determining the safe yield for pumping in the groundwater basin.

In 1987, groundwater levels were obtained from an area that extends from Oso Creek division to south of lower San Juan Creek and then to upper San Juan Creek division. Groundwater contour maps prepared in 1987 from measurements taken at certain monitoring stations during quarterly monitoring events indicate that general groundwater flows are in the southwesterly direction. Capistrano Valley Water District measures well levels on a regular basis. A recent localized investigation on geotechnical issues at the Antonio Parkway Crossing on the San Juan Creek (RM-6.0) revealed that groundwater levels within the lower San Juan Creek area are relatively close to the surface. Depths to groundwater near the bridge and the lower Ortega Highway Bridge were found to be less than 6 meters (20 feet).

There is limited management of the groundwater basin at the present time. Cleanup of this resource would need to be done for any domestic or environmental use due to problems with sulfate, chloride, magnesium, and total dissolved solids, which are considered to be too high for domestic use and problems with total dissolved solids, chloride, and boron, which are considered to be too high for irrigation use. Seawater intrusion could also be a potential problem in the coastal portions of the basin. However, there is currently little groundwater recharge being performed. It is believed that much of the salt content in the groundwater comes from the marine sediments which underlie much of the basin. These issues are being investigated in greater detail by the water districts in the watershed to answer questions as to the best use of this resource and future management of the watershed.

2.6.3.1 Groundwater Quality

The groundwater in the San Juan Creek watershed has typically high dissolved solids and salts. The preference of local water agencies is to use imported water where available for domestic needs, with pumped groundwater as the supplemental source. There are only two agencies within the San Juan Basin Authority actively pumping groundwater for domestic use. The

Capistrano Valley Water District obtains approximately 30 percent of its needs from groundwater, and the Trabuco Canyon Water District obtains approximately 15 percent of their current supply from groundwater. The remainder of local water is received from the MWD.

Groundwater quality information data was obtained from the San Juan Basin Authority and Capistrano Valley Water District. Table 9 provides a general groundwater quality data for 1987.

Table 9 San Juan Basin 1987 Water Quality Data (mg/l)

Subbasin	TDS	SO_3	Iron	Mn
Lower San Juan	1500-2000	500-750	>2.0	0.5-1.5
Lower Trabuco	1000-1500	250-500	0-0.3	0-0.05
Middle San Juan	500-1000	250-500	0.3-2.0	0.5-1.5
Upper San Juan	0-500	0-250	0-0.3	0-0.05

2.7 Watershed Infrastructure

Due to the extensive development that has occurred in the San Juan Creek watershed, particularly along almost the entire length of Oso Creek and the downstream reaches of Trabuco and San Juan Creeks, placement of both private and public infrastructure has occurred close to the creeks. Such infrastructure that has influenced, or is influenced by, the major tributaries of the San Juan Creek watershed is described below. Infrastructure includes transportation (roads and bridges), water and sewer utility lines, flood control facilities, and recreational features.

2.7.1 Transportation

The transportation network within the San Juan Creek watershed is extensive and highly important to the plan formulation process. Roads affect drainage patterns, and are themselves threatened by surface flow. There are a number of bridges that cross channels in the watershed that are being slowly undermined by both low flows and stormflow. Bridges are most threatened by large flows resulting from flood events. Their very nature as connections between one side of a creek and the other makes them at risk from floods. If these bridges were to be severed, they would cause measurable economic impact. Severance of transportation during (and after) floods is an important issue in plan formulation, as some measures may have no positive impact on bridge or road protection, and others will have a strong protection aspect that creates benefits for a project, particularly in regards to Federal interest. This issue is discussed and quantified in the section on plan formulation.

Since the early 1960s, the San Juan Creek watershed has experienced a period of continuous and rapid growth. This growth has resulted in the development of transportation infrastructure to support resident populations as well as local and regional commercial and industrial economies. There are numerous transportation arteries within the watershed including several freeways, several highways, and numerous high capacity parkways and roads. More roads and parkways either are currently being constructed or are in planning stages in this rapidly growing area.

There are currently six major north-south corridors and four east-west corridors that provide access to a variety of landscapes in the San Juan Creek watershed. In general, the north-south thoroughfares tend to be larger and carry higher traffic volumes. The east-west corridors are generally oriented perpendicular to watershed drainage in the Trabuco and Oso Creek tributary watersheds and parallel to watershed drainage in the San Juan Creek watershed. The reverse is true for the north-south oriented corridors. Ten of the major transportation routes that cross major tributaries of the watershed are briefly described below. (See Figure 4)

2.7.1.1 San Diego Freeway (Interstate 5)

The San Diego Freeway is a ten- to twelve-lane, divided highway, which is the major north-south connector route between the metropolitan areas of San Diego and Los Angeles and beyond. This freeway crosses San Juan Creek in the City of San Juan Capistrano.

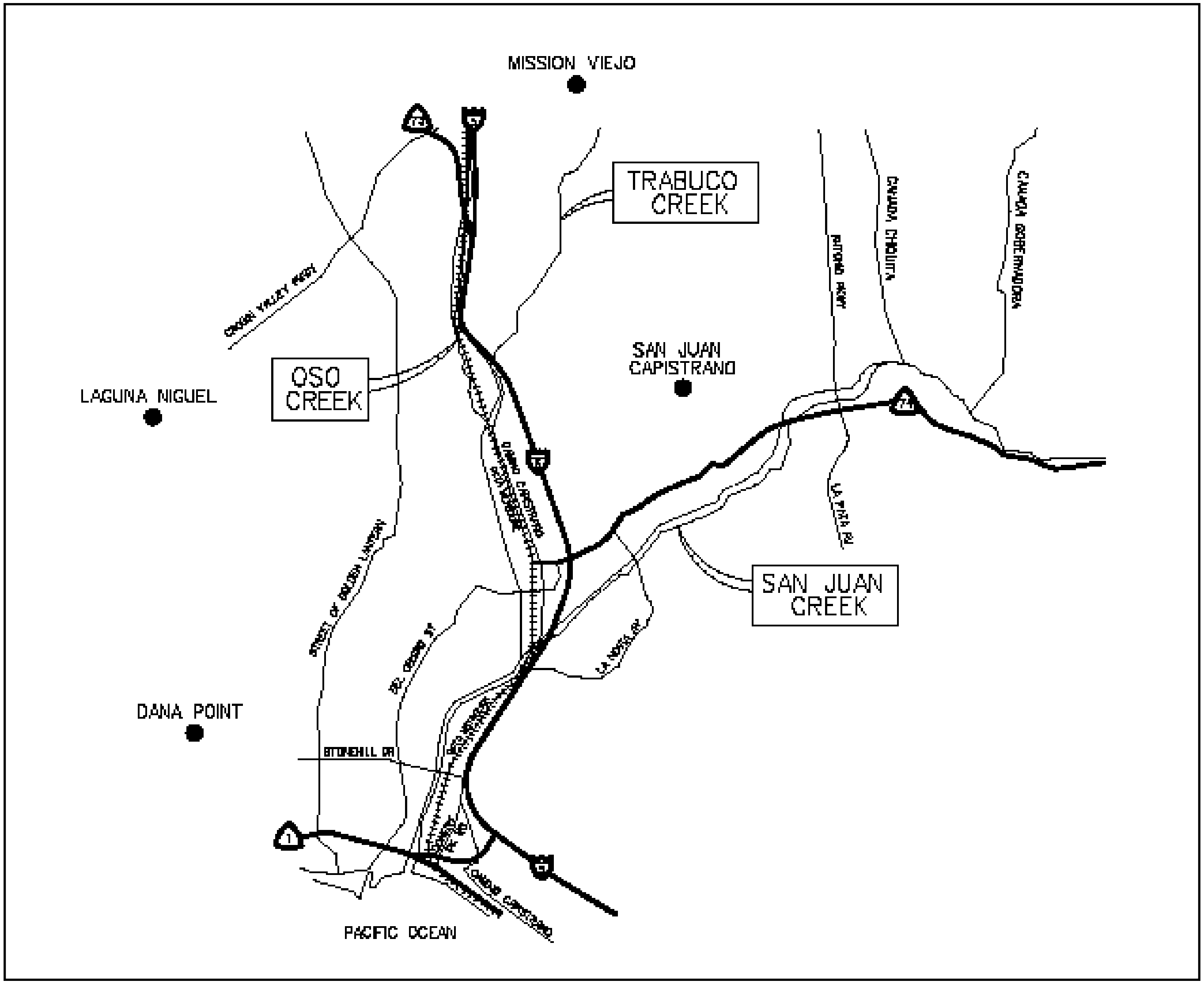
2.7.1.2 Pacific Coast Highway (State Highway 1)

Pacific Coast Highway is a four-lane divided California State Highway that runs along the Pacific Ocean coastline through the downstream most portion of the project area. This highway serves as a major connector route between the beach communities of Laguna Beach, Dana Point, Capistrano Beach, and San Clemente. Between Del Obispo Street and San Juan Creek, Pacific Coast Highway junctions with Camino Las Ramblas, which provides access from Dana Point to the northernmost region of the City of San Clemente.

2.7.1.3 San Joaquin Hills Transportation Corridor (State Highway 73)

The San Joaquin Hills Transportation Corridor is a newly completed toll highway linking the 405 Freeway in Costa Mesa on the northern end with I-5 in San Juan Capistrano on the south. This highway, completed in 1997, crosses Oso Creek in the City of Laguna Niguel near Camino Capistrano. The bridge has a high platform and does not cause direct impacts to the flows in Oso Creek.

Figure 4. Major Transportation Routes in San Juan Creek Watershed



2.7.1.4 Ortega Highway (State Highway 74)

Ortega Highway is a heavily traveled two- to four-lane highway that runs along San Juan Creek from Camino Capistrano in the City of San Juan Capistrano to the Lake Elsinore area. This major east-west highway essentially parallels San Juan Creek through its entire course. Ortega Highway crosses San Juan Creek at several locations including just east of the San Juan Capistrano city limits (Lower Ortega Highway Bridge), within Caspers Regional Park just upstream from the Lucas Creek confluence (Upper Ortega Highway Bridge), and just upstream of the San Juan Ranger Station near San Juan Hot Springs (within Reach SJ-1).

2.7.1.5 Foothill Transportation Corridor (State Highway 241)

The Foothill Transportation Corridor (FTC), like the San Joaquin Hills Transportation Corridor, is a north-south highway designed to provide a six- to ten-lane, high-speed, high-capacity transportation route with limited access. This corridor connects the Riverside Freeway (State Highway 91) south of the City of Corona with the San Diego Freeway (I-5) in northern San Diego County. Currently, the completed portion extends from west of the El Toro Air Station to Antonio Parkway in Rancho Santa Margarita. Environmental studies for the potential southerly expansion of the FTC (FTC South) is currently being completed. The FTC South is scheduled for completion in 2003 (PDSD, 1999).

2.7.1.6 Marguerite Parkway

Marguerite Parkway is a highly used surface street extending from El Toro Road on the north to Avery Parkway on the south. This four-lane road is a major north-south route, which essentially parallels Oso Creek throughout its upper reaches. Marguerite Parkway crosses Oso Creek between Oso Parkway and La Paz Road.

2.7.1.7 Oso Parkway

Oso Parkway is a highly used east-west surface street that extends from I-5 (where it becomes Pacific Parkway and extends into Laguna Niguel) to the Thomas F. Riley Wilderness Park in the Coto de Caza area. This four- to six-lane road crosses several tributaries of the San Juan Watershed. It crosses Oso Creek at the Mission Viejo Golf Course just east of I-5. The crossing is a small bridge due to the limited flows that are expected to pass even during larger events. Oso Parkway crosses Trabuco Creek just west of Antonio Parkway at the downstream end of

Plano Trabuco in Reach TR-3. Oso Parkway crosses Cañada Chiquita just west of the Riley Wilderness Park.

2.7.1.8 Santa Margarita Parkway

Santa Margarita Parkway is a major east-west surface street that extends from El Toro Road (where it becomes Portola Parkway as it travels further to the west) to Plano Trabuco Road. It is a four-lane, partially divided road crossing Trabuco Creek just east of the intersection of the Santa Margarita Parkway/Alicia Parkway intersection. The bridge has a high platform with two large piers located within the Plano Trabuco adjacent to the creek.

2.7.1.9 Crown Valley Parkway

Crown Valley Parkway is a major east-west surface street that currently extends from Marguerite Parkway on the east to the Pacific Coast Highway on the west. Only the small portion of this road near its eastern most end currently resides within the San Juan Creek Watershed.

2.7.1.10 Camino Capistrano

Camino Capistrano is a north-south surface street extending from the Pacific Coast Highway to Oso Parkway. (Note: Camino Capistrano does not actually connect with Oso Parkway, but instead dead-ends just before connecting). This road is heavily traveled in the downtown San Juan Capistrano area with lesser amounts of traffic on the northernmost and southernmost ends. This road parallels San Juan Creek through Reach SJ-6, parallels Trabuco Creek through Reaches TR-6 and TR-7, and parallels Oso Creek through Reaches OS-3 and OS-4. Camino Capistrano crosses San Juan Creek adjacent to and just downstream of the I-5 Bridge and crosses Oso Creek just upstream of the Galivan Detention Basin. The stretch of Camino Capistrano from Junipero Serra to near Avery Parkway has been closed several times over the past 10 years due to slumping of the hillside adjacent to Oso Creek.

2.7.2 Bridges

Due to the extensive development in various portions of the San Juan Creek watershed, numerous road bridges have been constructed as part of the extensive infrastructure of the area. Table 10 identifies these bridges, specifies their location, and provides a brief description of the bridges.

Table 10 Bridges Spanning Major Tributaries of the San Juan Creek Watershed

Name	Location	Description
SAN JUAN CREEK		
Pacific Coast Highway	City of Dana Point	· 2-lane road · Low platform · 8 long piers in creek bed · K-rail on bridge used as lane divider · Bicycle trail underneath on west side of creek
Camino Las Ramblas	City of Dana Point	· 4-lane divided highway · High platform bridge · 4 long piers in creek bed · Bicycle trail underneath on west side of creek
Stonehill Drive	City of Dana Point	· 4-lane road · 1 long pier in creek bed · Bicycle trail underneath on north side of creek.
Metrolink Railroad Bridge	City of San Juan Capistrano	· Railroad bridge (Metrolink) · Low platform bridge · 2 long piers in creek bed
Camino Capistrano	City of San Juan Capistrano	· 5-lane road · 1 long pier in creek bed · Low platform bridge
Interstate-5	City of San Juan Capistrano	· 10-lane highway · 2 long piers in creek bed · Low platform bridge
La Novia Avenue	City of San Juan Capistrano	· 2-lane road · 2 long piers in creek bed · Low platform bridge
Lower Ortega Highway	County of Orange Just east of San Juan Capistrano city boundary.	· 2-lane road · 1 cylindrical pier in creek bed · Low platform bridge
Antonio Parkway	County of Orange just upstream from Lower Ortega Highway bridge	· 4-lane road · 3 pairs of cylindrical bridge piers in creek bed · High platform bridge
Nursery Road	County of Orange just downstream of Caspers Park	· 4-lane road · 5 6-foot cylindrical corrugated steel pipes to convey creek flow underneath · Low platform bridge
Middle Ortega Highway	Caspers Regional Park	· 2-lane road · 2 long piers in creek bed · Low platform bridge
Upper Ortega Highway	Cleveland National Forest	· 2-lane road · No piers in creek bed · High platform bridge
TRABUCO CREEK		
Pedestrian/Bicycle Bridge at Descanso Park	City of San Juan Capistrano	· Bicycle/Pedestrian bridge · No piers in creek bed · High platform bridge
Del Obispo Street	City of San Juan Capistrano	· 4-lane road · 2 long piers in creek bed · Low platform bridge
Camino Capistrano	City of San Juan Capistrano	· 2-lane road · 1 pier in creek bed

Table 10 Bridges Spanning Major Tributaries of the San Juan Creek Watershed

Name	Location	Description
		· Creek contained within large rectangular box channel under bridge
Interstate-5	City of San Juan Capistrano	· 10-lane highway · 2 long piers in creek bed · Creek contained within large rectangular box channel under bridge
Rancho Viejo Road	City of San Juan Capistrano	· 2-lane road · 1 pier in creek bed · Creek contained within large rectangular box channel under bridge
Crown Valley Parkway (proposed)	City of Mission Viejo	· No information available
Oso Parkway	City of Mission Viejo over lower O'Neill Regional Park lands	· 6-lane road · 4 pairs of cylindrical piers in creek bed · High platform bridge
Santa Margarita Parkway	City of Mission Viejo over upper O'Neill Regional Park lands	· 6-lane road · 6 cylindrical piers in creek bed · High platform bridge
Foothill Transportation Corridor	City of Mission Viejo over upper O'Neill Regional Park lands	· Two separate bridges · 2 lane highway each bridge · 7 cylindrical piers in creek bed · High platform bridge
Trabuco Canyon Road	Trabuco Canyon at northeastern most edge of O'Neill Regional Park	· 2-lane road · 5 long piers in creek bed · Low platform bridge
OSO CREEK		
San Joaquin Hills Corridor	City of San Juan Capistrano	· 6-lane highway · No piers in creek bed · High platform bridge
Paseo De Colinas	City of Laguna Niguel	· 4-lane road · No piers in creek bed · High platform bridge
Crown Valley Parkway	City of Laguna Niguel	· 6-lane road · No piers in creek bed · High platform bridge
Metrolink Railroad	City of Laguna Niguel	· Railroad bridge · 20+ wooden post piers in creek bed · Low platform bridge
Camino Capistrano	City of Laguna Niguel	· 2-lane road · 1 pier in creek bed · Low platform bridge

2.7.3 Hydraulic Structures

A number of hydraulic structures have been constructed along the course of San Juan Creek and its tributaries. Detention basins have been constructed for the primary purpose of flood control. Drop structures have been constructed to provide grade control, primarily to protect transportation infrastructure (bridges, roads, and utilities). Additionally, segments of the creek have been converted to concrete channel for bank protection and flood conveyance. Major watershed hydraulic modifications are listed in Table 11.

Table 11 Major Hydraulic Structures in San Juan Creek Watershed

Water Course	Description	Location
DETENTION STRUCTURES		
Oso Creek	Galivan Detention Basin Off-line detention basin	Along Cabot Road just north of Crown Valley Parkway.
DROP STRUCTURES		
San Juan Creek	Grade control structure to protect access road.	Caspers Park at access road near main entrance.
San Juan Creek	Grade control structure to stabilize stream bed.	Approximately 500 feet downstream of Caspers Park access road.
Trabuco Creek	Grade control structure to protect Rancho Viejo, Interstate 5, Camino Capistrano Bridges.	Just downstream of rectangular box channel at Camino Capistrano.
Trabuco Creek	Grade control structure to protect Metrolink railroad bridge	Near Camino Capistrano just upstream of the Oso/Trabuco confluence.
Trabuco Creek	Series of small (1-3 feet) drop structures for grade control	From San Juan Creek confluence to upstream of Del Obispo Road.
Oso Creek	Rip-rap energy dissipator	At terminus of rectangular concrete box channel.
CHANNEL MODIFICATIONS		
San Juan Creek	Trapezoidal soft-bottomed channel with concrete side slopes.	From ocean outfall to Interstate 5.
San Juan Creek	Gabion sideslope protection	Within Caspers Regional Park.
Trabuco Creek	Rectangular concrete box channel	Beneath Rancho Viejo, Interstate 5, Camino Capistrano creek crossings.
Trabuco Creek	Trapezoidal soft-bottomed channel with concrete side slopes	From San Juan Creek confluence to just upstream of Del Obispo Road.
Oso Creek	Trapezoidal soft-bottomed channel with rip-rap sideslopes	From just upstream of the Camino Capistrano Road crossing to just upstream of Crown Valley Parkway.
Oso Creek	Rectangular concrete box channel	From just upstream of Crown Valley Parkway to just downstream of Rancho Capistrano property.

A number of hydraulic structures along San Juan Creek and its tributaries are regarded by the resource agencies as impediments to fish passage and breaks in habitat connectivity between upstream and downstream reaches. This is primarily related to their height and steepness. While they serve a critical purpose in the protection of structures and infrastructure crossing the creek, migratory fish species cannot surmount them in an upstream direction. In addition, these structures tend to prevent interaction between aquatic species in upstream and downstream reaches. Their modification or replacement by passable structures will be an important part of future phases of study.

2.8 Watershed Study Reaches

San Juan Creek and its major tributaries, for purposes of discussion and analysis of problems, has been divided into a series of specific "reaches," or smaller channel segments. Division of the creek into reaches was based upon identifying segments of the creek with similar riverine characteristics. Table 6 identifies the boundaries of each study reach within the watershed that will be specifically addressed in this study. Figure 5 graphically shows the boundaries of each reach identified in Table 12. The following is a detailed description of these reaches.

2.8.1 San Juan Creek

San Juan Creek, and many of its tributary runoff channels, originates at an elevation of approximately 1,554 meters (5,100 feet) in the Santa Ana Mountains of the Cleveland National Forest. The creeks then travel in a southwesterly direction to its ultimate outlet at the Pacific Ocean at Doheny State Beach (just downcoast of the City of Dana Point). The terrain in the watershed ranges from extremely rugged mountains in the headwaters to very level floodplain lands along the downstream reaches of the channel. The headwater areas maintain a cover of sparse chaparral, with underlying rocky soils and bedrock outcrops. On lesser slopes, there is a cover of coastal sage scrub. The channels in this area are very steep and almost devoid of vegetation. Further downstream, there are steep-walled canyons, the bottoms of which are choked with dense riparian habitat. In the canyon environment, there is perennial flow in many places, fed by groundwater draining from water-bearing sandstones within the mountain mass.

A number of tributaries enter the San Juan Creek channel along the canyon reach, including Hot Springs and Cold Springs Creeks. Much of this part of the watershed is within the Cleveland National Forest and Caspers Regional Park. This portion of the creek is relatively unaffected by anthropogenic or natural factors evident elsewhere in the watershed.

Upon leaving the canyons, the creek becomes braided and flows back and forth over steep alluvial fill. Surface water is in little evidence, but underground flows are present in the sandy alluvial deposits underlying the channel. Several large tributaries (including Bell Canyon and Cañada Gobernadora Creeks) and several smaller tributaries (including Lucas and Verdugo Creeks) flow into the main San Juan Creek channel in this area. In several places, alluvial fill is being mined for sand and gravel extraction. This area represents a transition zone with regard to the surrounding terrain. Hillsides become less steep and lose their cover of natural chaparral and sage for non-native grasses and scrub. This part of the watershed supports livestock, materials extraction, agriculture, nursery operations, and other uses. In these channel reaches and floodplain areas, there is a rapid change from the dense riparian corridor found further upstream to a patchwork of native, non-native, and denuded areas. This area exhibits the first evidence of channel degradation and other systemic problems.

Further downstream, the channel passes through an area of increasing development. The natural environment is fragmented. Floodplains contain a variety of land uses and introduced vegetation types. Hillsides change from native cover to a mix of non-native grasses and, in other areas, cut-and-fill topography with residential development. The riparian corridor ranges from channelized segments with little vegetation to highly impacted natural environments to segments in which little change is evident. Both riparian and floodplain environments, and frequently the hillside environment, are impacted by a number of problems.

In its downstream-most segment (from Interstate 5 to the ocean), San Juan Creek is channelized within sloped concrete banks and is devoid of any significant vegetation. The floodplain is a patchwork of degraded open space, commercial and residential development, golf courses, and other uses. Hillsides are largely covered by homes and non-native vegetation. The environmental resources of this reach are minimal, although it still serves a function as a potential (and badly needed) conduit from the ocean to high quality habitats upstream, and as a water resource to birds and other small animals. Because of a combination of natural flow and return flows from landscape irrigation, structure and vehicle washing, and golf course irrigation, a good amount of water is evident within the channel. There are few aquatic species evident within the channel. In this lower reach, Trabuco Creek enters San Juan Creek.

Figure 5. Study Reaches

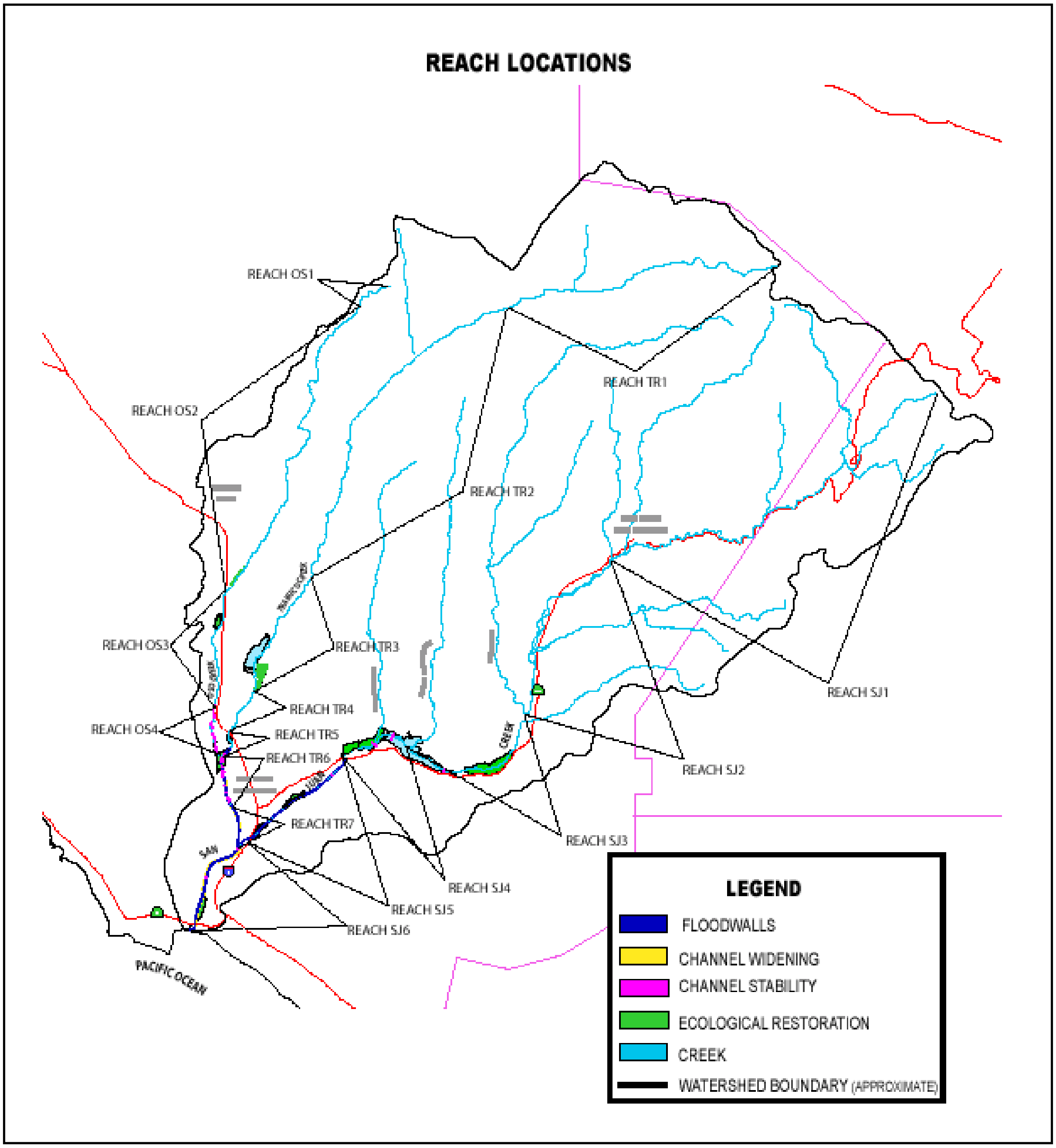


Table 12 San Juan Creek Watershed Study Reaches

STUDY REACH	FROM	TO
San Juan Creek		
Reach SJ-1	RM-27 (upper headwaters)	RM-15.6 (Cold Springs Creek confluence)
Reach SJ-2	RM-15.6 (Cold Springs Creek confluence)	RM-11.2 (Bell Canyon Creek confluence)
Reach SJ-3	RM-11.2 (Bell Canyon Creek confluence)	RM-7.5 (Cañada Gobernadora confluence)
Reach SJ-4	RM-7.5 (Cañada Gobernadora confluence)	RM-5.5 (Lower Ortega Highway Bridge)
Reach SJ-5	RM-5.5 (Lower Ortega Highway Bridge)	RM-2.7 (the beginning of concrete sideslope channel banks)
Reach SJ-6	RM-2.7 (the beginning of concrete sideslope channel banks)	RM-0 (Pacific Ocean outlet)
Trabuco Creek		
Reach TR-1	RM-25 (upper headwaters)	RM-15.3 (Upper Plano Trabuco)
Reach TR-2	RM-15.3 (Upper Plano Trabuco)	RM-7.9 (Tijeras Creek confluence)
Reach TR-3	RM-7.9 (Tijeras Creek confluence)	RM-3.9 (Above sand and gravel mining operation)
Reach TR-4	RM-3.9 (Above sand and gravel mining operation)	RM-2.7 (Rancho Viejo Road)
Reach TR-5	RM-2.7 (Rancho Viejo Road)	RM-2.1 (Oso Creek confluence)
Reach TR-6	RM-2.1 (Oso Creek confluence)	RM-1.0 (the beginning of concrete sideslope channel banks)
Reach TR-7	RM-1.0 (the beginning of concrete sideslope channel banks)	RM-0.0 (San Juan Creek confluence)
Oso Creek		
Reach OS-1	RM-13.5 (upper headwaters)	RM-11.6 (Upper Oso Reservoir)
Reach OS-2	RM-11.6 (Upper Oso Reservoir)	RM-3.8 (Interstate-5 undercrossing)
Reach OS-3	RM-3.8 (Interstate-5 undercrossing)	RM-1.25 (Terminus of concrete channel)
Reach OS-4	RM-1.25 (Terminus of concrete channel)	RM-0.0 (Trabuco Creek confluence)
Cañada Gobernadora		
Reach CG-1	RM-8.5 (upper headwaters)	RM-5.7 (Terminus of Coto De Caza golf course)
Reach CG-2	RM-5.7 (Terminus of Cota De Caza golf course)	RM-4.5 (Terminus of agricultural development)
Reach CG-3	RM-4.5 (Terminus of agricultural development)	RM-0.0 (San Juan Creek confluence)

Specific descriptions of each reach are provided below:

2.8.1.1 Reach SJ-1: RM-27 to RM-15.6

The uppermost reach of the San Juan Creek mainstem extends from the upper headwaters in the San Juan Hot Springs area to the confluence with Cold Springs Creek. This portion of San Juan Creek and its tributaries are almost entirely contained within the boundaries of the Cleveland National Forest and are characterized by the rugged, mountainous terrain of the Santa Ana

Mountains. Hot Springs Creek enters San Juan Creek approximately 610 meters (2,000 feet) upstream of the Cold Spring Creek confluence.

The channel in this reach is confined within bedrock at the base of steep, rocky hillsides. Channel depths and widths range from shallow depressions with widths less than 0.3 meters (one foot) to a channel approximately 2 meters (6 feet) deep and 100 meters (330 feet) wide in its downstream-most segment. Channel slopes range from over one foot-per-foot (rise over run) to 0.042 m/m. The channel itself is a typical mountain stream characterized by boulders, large cobbles, and occasional pools and riffles. Flow velocities are high and turbulent. There is no appreciable development adjacent to this channel and, therefore, little human interference with natural processes in this part of the watershed. Tributary channels within this reach are generally similar in nature to the main channel, but with steeper slopes.

Infrastructure within this reach is minimal and consists of a few homes and structures in the village of San Juan Hot Springs, several campgrounds, and Ortega Highway, which parallels San Juan Creek throughout its length within this reach. Upper Ortega Highway Bridge crosses the creek just upstream of the Hot Springs Creek confluence. Due to this limited use and marginal impacts, the environment has changed little historically and may be expected to change little in the future. Therefore, this reach was not studied in any additional detail. No measures, aside from monitoring, are proposed for this reach.

2.8.1.2 Reach SJ-2: RM-15.6 to RM-11.2

This reach extends from the confluence with Cold Springs Creek to the confluence of Bell Canyon Creek. This reach is entirely contained within the boundaries of Ronald W. Caspers Regional Park. Lucas Canyon Creek enters San Juan Creek within Reach SJ-2 at RM-12.8.

As the creek leaves the upstream canyon environment of Reach SJ-1, a large, braided channel is formed. This braided region results from the creek, whose waters carry a high sediment load, exits the controls imposed by steep canyon walls, and enters a wider channel reach where the creek is allowed to meander somewhat freely across the valley fill surface. This change causes the turbulent energy in the waters to decrease, thereby allowing sediment deposition that causes the creek to establish a braided characteristic. This sudden widening of the valley is believed to be due to a change in the underlying rock formation from relatively resistant volcanics and intrusives to less resistant sedimentary rocks.

Channel widths in this reach vary considerably from over 213 meters (700 feet) in some locations to approximately 30 meters (100 feet) at the Upper Ortega Highway Bridge (RM 14.0). The channel is extremely braided in the wider sections, with sparse vegetation occupying a significant percentage of the channel bed area. Thalweg slopes range from 0.009 to 0.013 feet/foot.

Two significant channel features exist within Reach SJ-2. The first is the Middle Ortega Highway Bridge, a multi-span, reinforced concrete bridge, which imposes a major constriction to high flows. Average channel widths upstream and downstream of the bridge vary from 122 to 183 meters (400 to 600 feet). The bridge opening is about 30 meters (100 feet) wide. The second significant channel feature is the channel modifications just upstream of the Bell Canyon confluence. Modifications at this site includes gabion bank protection, both in the main channel and in Bell Canyon, and a low-flow park access road crossing about 305 meters (1,000 feet) upstream of the Bell Canyon confluence. The gabion protection, from channel invert to the top of the bank has been in place since 1979. The gabion bank protection has been installed in the downstream end of the park to control bank erosion that was caused by severe channel degradation that in turn was caused by past floods. The more recently constructed park access road that crosses San Juan Creek permits passage of low flows via six 36-inch CMP culverts.

Two grade control sections (i.e. channel cross-sections that prevent bed degradation from traveling farther upstream or downstream) are located at the downstream end of Reach SJ-2. One is located at the low-flow park access crossing near the main entrance to Caspers Park. However, at high flows, this constructed rock and concrete road embankment will probably wash out and thus no longer function as a control section. The other control section is approximately 152 meters (500 feet) downstream of the road crossing. A natural sandstone outcropping is exposed along the right half of the channel. It appears that the outcrop is localized and dips off rapidly to the left side of the channel. Because of this, the outcropping is unlikely to prevent channel degradation and erosion in the direction of the right bank.

Although there are problems related to bank erosion in this reach, these problems were not determined to be significant enough at this time to warrant further study or planning of management measures. The bank erosion is a natural response to meander expansion and contraction and not a result of an induced problem. The reach is protected from development, but should be subject to monitoring to ensure that park resources are not threatened.

2.8.1.3 Reach SJ-3: RM-11.2 to RM-7.5

This reach extends from the Bell Canyon confluence to the confluence with Cañada Gobernadora. The confluence of Trampas Creek occurs within this reach at RM 8.8.

The principal feature of Reach SJ-3 is the sand and gravel mining operations occurring between RM-8.0 and RM-10.3. These mining operations have been carried out within the main channel of this reach since the early 1960s. A significant quantity of material has been removed since then. Pits 91 to 122 meters (300 to 400 feet) wide and about 18 meters (60 feet) deep have been excavated at various locations throughout the reach. Two large excavation pits and a siltation pond exist within the main channel. Throughout the remainder of the reach, the channel is unnaturally wide with no well-defined low-flow channel due to significant regrading by the mining activities. Existing channel thalweg slopes are approximately 0.008 to 0.009 feet per foot and are somewhat flatter than the natural slopes because of channel invert lowering by sand and gravel removal. Depth of alluvium in this area is estimated to be approximately 18 to 24 meters (60 to 80 feet).

A major structural feature within Reach SJ-3 is the gravel mining access road that crosses the river near RM-8.7. This road was washed out during stormwater flows in February 1998 and was subsequently rebuilt.

Land uses adjacent to Reach SJ-3 consist mainly of agricultural activities. The lower part of the reach enters into the upper part of Capistrano Valley, where agricultural land uses are extensive. These land uses effect these reaches geomorphically in that larger amounts of surficial erosion, and hence sediment, are provided to the channel within this reach.

Sand and gravel mining activities within this reach have an impact on upstream and downstream reaches of the channel. The excavation of pits within the channel causes a lowering of the bed elevation, which then has tended to migrate upstream from the pit’s upstream edge. This has occurred to some extent, while being limited by bedrock controls. The excavation has had a more dramatic effect on downstream sediment transport. Removal of sediments and their replacement by an artificial sediment trap has resulted in sediment delivery reductions to downstream reaches. It is not known at this time as to whether this activity has had a significant effect on either channel behavior or beach nourishment.

This reach was modeled in detail for the hydrology and hydraulics analysis. Flows from upstream reaches (SJ-1 & SJ-2) provided input to the detailed modeling measures for both flood control and ecosystem restoration measures developed in this reach.

2.8.1.4 Reach SJ-4: RM-7.5 to RM-5.5

This reach extends from the Cañada Gobernadora confluence to the Lower Ortega Highway Bridge (located just outside the boundary of the City of San Juan Capistrano) and contains the confluence with Canada Chiquita Creek at RM-6.7. This reach is similar to upper reaches in that substantial stream braiding is evident in this portion of San Juan Creek. Main channel widths range from 91 meters (300 feet) to nearly 213 meters (700 feet) at channel bends. Thalweg slopes are about 0.008 feet/foot at RM-7.9 and decrease to about 0.007 at the Lower Ortega Highway Bridge. Vegetation in the main channel consists of small to moderately sized brush. Vegetative growth is dense along the low-flow channel and main channel banks. Bed material in this reach is primarily sand with significant quantities of gravel.

Land use adjacent to San Juan Creek in Reach SJ-4 consists primarily of open space in the upper portion with agricultural uses in the lower most portion.

Two main channel modifications within Reach SJ-4 are the bridges for Antonio Parkway (at RM-6.0) and Lower Ortega Highway (at RM-5.5). The Antonio Parkway Bridge is a five-span concrete bridge with a high deck, wide bridge opening. Lower Ortega Highway Bridge, however, has a low deck and narrows San Juan Creek to about 46 meters (150 feet).

Because of erosion problems in this reach, its suitability for detention storage, and its degradation in associated ecosystem resources, this reach is targeted for evaluation in regards to potential flood control, channel stabilization, and ecosystem restoration measures.

2.8.1.5 Reach SJ-5: RM-5.5 to RM-2.7

This reach extends from the Lower Ortega Highway Bridge to the beginning of the concrete-sided trapezoidal channel. This concrete side-slope channel begins just upstream of Camino Capistrano and just downstream of the Interstate 5 (I-5) Freeway bridge. The channel through this reach is relatively straight with a width of approximately (61 meters) 200 feet. This straight channel is a result of previous creek re-alignment due to development activities adjacent to the channel. This realignment consisted of constructing levees using local materials between Interstate 5 and several hundred feet upstream of La Novia Avenue Bridge (at RM-3.7). Creek widths in this upper portion of Reach SJ-5 range from 61 meters (200 feet) to 122 meters (400 feet).

From RM-4.5 upstream to the Lower Ortega Highway Bridge, the channel typifies the natural braiding tendencies found further upstream. Significant regrading (and removal of material) has taken place within the channel just downstream of the Lower Ortega Highway Bridge, causing progressive lowering of the channel bed. The channel is about 61 to 122 meters (200 to 400 feet) wide in the more braided sections and about 61 meters (200 feet) wide in the straighter downstream sections. Thalweg slopes in this reach range from 0.005 to 0.006 feet/foot. Some vegetation exists within the main channel with fairly dense vegetation along channel banks.

Two bridges, located at La Novia Avenue (RM3.7) and Interstate-5 ("San Diego Freeway" at RM-2.7) span San Juan Creek in Reach SJ-5. The La Novia Avenue crossing is a multi-span reinforced concrete bridge. Channel width beneath La Novia Avenue is approximately 61 meters (200 feet). The I-5 crossing is composed of a northbound and southbound bridge, each of which is a multi-span, reinforced concrete bridge. The two bridge decks are skewed in the direction of flow in the channel; however, bridge piers are aligned with the direction of creek flow. Total bridge opening across the channel, measured parallel to the bridge, is over (122 meters (400 feet).

Land adjacent to San Juan Creek in Reach SJ-5 is substantially developed at this time. Land uses along the banks of the creek are predominantly characterized by residential neighborhoods with scattered commercial and light industrial properties. A golf course parallels the creek on the southeastern side of the creek just upstream of the I-5 Bridge crossing.

Because of erosion and channel degradation problems, existing flood control issues, and degraded environmental resources, this reach is targeted for flood control, channel stabilization, and ecosystem restoration evaluation.

2.8.1.6 Reach SJ-6: RM-2.7 to RM-0.0

This reach extends from just north of Camino Capistrano Road to the outlet of San Juan Creek to the Pacific Ocean at Doheny State Beach. Trabuco Creek, the largest tributary of San Juan Creek, enters in this reach at RM-2.4). This reach is characterized by a trapezoidal channel with a soft, earthen bottom and concrete-lined banks. This concrete-lined, trapezoidal channel extends from just upstream of Camino Capistrano in the City of San Juan Capistrano to the Pacific Coast Highway Bridge in the City of Dana Point, which is the entire reach except for the 183-meter (600 feet) segment from Pacific Coast Highway to the Pacific Ocean. The channel has a bottom width of approximately 46 meters (150 feet) with an average height of about 4 meters (14 feet). Channel thalweg gradients range from approximately 0.0047 feet/foot at the upstream end of the channelization to 0.0038 feet/foot at the mouth of the channel. Bed material sizes are progressively finer from the upstream end of the reach to the river mouth. Cobbles up to three to five inches in size are still found in the bed material, although not as many as in the upstream reaches. Creek flow within the narrow channel bottom resembles a braided stream.

Five bridges span San Juan Creek in this reach. These include the Camino Capistrano (at RM-2.6), Metrolink Railroad (at RM-2.5), Stonehill Drive (at RM-0.6), and Camino Las Ramblas and Pacific Coast Highway bridges (at RM-0.2).

Lands adjacent to San Juan Creek in Reach SJ-6 are highly developed. Land uses are predominantly characterized by commercial and light industrial activities on the southeastern side of the creek and residential neighborhoods on the northwestern side. This development has occurred very close to the edges of the trapezoidal channel levees.

Because of erosion and channel degradation problems, existing flood control issues, and degraded environmental resources, this reach is targeted for flood control, channel stabilization, and ecosystem restoration evaluation.

2.8.2 Trabuco Creek

Trabuco Creek originates in the Santa Ana Mountains at an elevation of 1,310 meters (4,310 feet) above sea level and flows for a distance of 40 kilometers (25 miles) to enter San Juan Creek at San Juan Creek RM-2.4. The headwaters originate within the steep, mountainous terrain of the Santa Ana Mountains in the Cleveland National Forest. The mountains gradually give way to ridges and moderately steep hillsides as the canyons give way to a wider floodplain on an alluvial fill surface within O'Neill Regional Park. This area is called the "Plano Trabuco" area. Upon leaving O'Neill Regional Park, Trabuco Creek constricts to a narrow floodplain as it travels through steep rolling coastal range hills. This constricted floodplain continues until the creek crosses I-5 where a slightly wider floodplain exists. Oso Creek enters Trabuco Creek just downstream of the I-5 crossing (at RM-2.5). The lowermost 1.9 kilometers (1.2 miles) of

Trabuco Creek has been channelized with concrete trapezoidal sideslopes with a soft bottom to control flooding and erosion within the City of San Juan Capistrano.

Specific descriptions of each reach are provided below:

2.8.2.1 Reach TR-1: RM-25 to RM-15.3

Reach TR-1 extends from the upper headwaters of Trabuco Creek to the upper area of Plano Trabuco and is almost entirely contained within the boundaries of the Cleveland National Forest. This reach is characterized by steep canyon walls with a narrow channel and little floodplain or environmental degradation. This reach is similar to the upper reaches of San Juan Creek and its upper tributaries. The channel itself is a typical mountain stream characterized by boulders, large cobbles, and pools and riffles. Flow velocities are high and turbulent. There is no appreciable development adjacent to this channel. Tributary channels within this reach are generally similar in nature to the main channel, but with steeper slopes. This reach serves as a sediment supply for the lower reaches of the channel.

Because this reach suffers few channel problems, ecosystem degradation, or flood control issues, it is not subject to further detailed study. It should be subject to monitoring, however, to ensure preservation of park resources.

2.8.2.2 Reach TR-2: RM-15.3 to RM-7.9

Reach TR-2 extends across the area known as "Plano Trabuco." All of this reach except for the uppermost one-half mile is contained within the boundaries of O'Neill Regional Park. As Trabuco Creek leaves the narrow steep canyon confines, which characterize Reach TR-1, it passes into a flatter and wider floodplain with low rolling foothills south and west of the Santa Ana Mountains. Channel widths within the reach range from approximately 91 meters (300 feet) in the upper and lower portions of Plano Trabuco to 305 meters (1,000 feet) to 457 meters (1,500 feet) in the central portion. Thalweg gradients in this reach range from 0.0121 feet/foot to 0.0109 feet/foot.

Land use adjacent to the creek consists primarily of single-family residential communities with several golf course communities also present. However, these communities are set off from the creek a substantial distance and are located on the tops of the hills which parallel the creek just outside the boundaries of O'Neill Park. This "buffer zone" permits the creek to maintain its natural braided channel character with substantial vegetative communities providing a healthy riparian habitat zone.

As with Reach TR-1, this reach suffers few of the problems that plague Trabuco and San Juan Creeks further downstream. As such, it is not the focus of further detailed study. However, it is subject to monitoring to ensure that resources are not negatively impacted in the future.

2.8.2.3 Reach TR-3: RM-7.9 to RM-3.9

Reach TR-3 extends from the Tijeras Creek confluence to the uppermost edge of the Mission Viejo Materials sand and gravel mining operation. This reach, which contains the lowermost portion of O'Neill Park, flows through rolling hills with mild slopes. The channel in this reach, although significantly more narrow than the Plano Trabuco area, still exhibits a largely braided characteristic with channel widths varying from 91 to 213 meters (300 to 700 feet). The reach is relatively undisturbed as compared to lower reaches with vegetation consisting of large areas of dense vegetation distributed throughout the reach.

This reach is mostly undeveloped with Oso Parkway Bridge being the only major man-made feature. Oso Parkway Bridge has only recently been constructed and is located just downstream of the Tijeras Creek confluence at RM-7.3. The bridge has a high platform with no bridge piers within the channel and therefore does not cause a constriction of flows in Trabuco Creek.

Land use adjacent to Trabuco Creek in Reach TR-3 is similar to that of Reach TR-2. The reach consists of mostly single-family residential communities located on the western side of the creek. These communities are also set off from the creek providing a buffer. Currently, there is no development on the eastern side of the creek. Much of this land, however, is currently slated for construction of additional residential communities.

Although not currently subject to many of the problems in downstream reaches, due to the planned construction of large areas of development, this reach should be closely monitored in the future to ensure that channel stability and associated resources are not negatively affected.

2.8.2.4 Reach TR-4: RM-3.9 to RM-2.7

Reach TR-4 extends from the uppermost edge of the Mission Viejo Materials sand and gravel mining operation to Rancho Viejo Road. The creek in this reach is deeply incised with channel widths of approximately 15 meters (50 feet) and a thalweg slope of approximately 0.008 feet/foot. The channel bed and side slopes are heavily vegetated.

Bed material in this reach is very fine and more cohesive than evident in most channel segments elsewhere in the watershed. The reason for this characteristic is that channelization was constructed in the area sometime prior to construction of the Camino Capistrano Bridge. The existing channel was forced to the west side of the valley and has downcut through materials deposited outside the typical alluvial fill depositional environment. This reach is not typical of the remainder of the Trabuco Creek System.

Land use within this reach consists of high-density, single-family residences located upslope along the hills which parallel the creek on the western side of the creek. Limited development has occurred along the eastern side of the creek.

Reach TR-4 suffers from channel incision, but retains a high degree of vegetation. There are currently no identified flood control issues in this reach. Aside from continued monitoring, no further detailed study will be conducted on this reach.

2.8.2.5 Reach TR-5: RM-2.7 to RM-2.1

Reach TR-5 extends from the Rancho Viejo Road undercrossing to the Oso Creek confluence. Channel width in this reach varies from about 30 to 91 meters (100 to 300 feet) with a thalweg gradient of approximately 0.007 feet/foot. Limited downcutting is evident within the central portion of the reach. Vegetation in the channel is moderately dense in the central portion of the reach and sparse at either end. The sparseness of the vegetation is likely due to the fact that at each end of the reach are areas immediately downstream of large drop structures which cause scouring of the channel bed thereby limiting the growth of vegetation and the development of complex vegetative cover.

Two significant structures are present within this reach. The first structure is a 183-meter (600-foot), fully concrete-lined rectangular channel, 21 meters (70 feet) wide and 3.7 to 4.6 meters (12 to 15 feet) deep, which allows Trabuco Creek to pass beneath I-5, Rancho Viejo Road, and Camino Capistrano Road. A single, large bridge pier is located within the channel, which supports all three of the overpass roads. Low flows of Trabuco Creek are split and directed in two streams around this single, large bridge pier. At the terminus of this structure, a drop structure lowers the bed elevation approximately 5.5 meters (18 feet). This combined approach channel and drop structure serves as a grade control and has prevented degradation in the natural reach downstream from progressing further upstream through the upper reaches. The second structure is the Metrolink Railroad crossing at RM-2.24. The bridge is a steel structure with a single concrete pier at mid span. The opening under the bridge in the main channel is approximately 55 meters (180 feet) wide and does not cause a major constriction to flows under the bridge. A drop structure is located at the downstream end of the underpass, which is designed to protect the bridge pier and abutments from scour. However, the effectiveness of this drop structure is questionable as storm flows in 1997 resulted in significant scour and caused substantial damage to the structure to the point where the bridge abutments were in danger of being undermined. The structure was repaired in the spring and summer of 1997. Land use within this reach is mostly agricultural in nature with citrus groves scattered along both sides of the creek.

Reach TR-5 suffers from intense channel degradation, erosion to peripheral properties, and associated ecosystem degradation. There are currently no flood control issues in this reach. This reach is targeted for analysis for channel stabilization and ecosystem restoration.

2.8.2.6 Reach TR-6: RM-2.1 to RM-1.0

Reach TR-6 extends from the confluence with Oso Creek (at RM-2.2) to the upstream end of the channelization portion of Trabuco Creek (at RM-1.0). This reach is characterized by a natural section that has experienced significant erosion and degradation since the early 1960s, particularly in the upper portion of the reach. Channel width just downstream of the Oso Creek confluence is approximately 30 meters (100 feet) which widens to 11 to 122 meters (35 to 400 feet), and then narrows again to about 21 meters (70 feet) as the creek enters the channelized portion. Bed material in this reach consists primarily of medium to course sand with smaller quantities of gravel. This is considerably finer than that found further upstream.

Land use adjacent to the creek on the eastern side consists of a small citrus grove at the uppermost portion of the reach and a horse stable complex for the rest of the reach. The western side of the creek consists mostly of undeveloped land except for a new housing community at the lowermost portion of this reach. This housing community consists of 39 individual properties of one-half acre or more. Due to past erosional processes along this portion of the creek, the developers have placed heavy-duty crib walls along the creek to stabilize the slope supporting the housing development.

As with Reach TR-5, this reach suffers from intense channel degradation and ecosystem degradation. There are currently no flood control issues in this reach. This reach is targeted for analysis for both channel stabilization and ecosystem restoration.

2.8.2.7 Reach TR-7: RM-1.0 to RM-0.0 (San Juan Creek Confluence)

Reach TR-7 is the channelized portion of Trabuco Creek. It extends from RM-0.95 to the downstream confluence with San Juan Creek. The channelization is trapezoidal in shape with an earthen bottom and concrete-lined side slopes. The bottom width is about 21 meters (70 feet) with a depth of about 4.5 meters (15 feet). The thalweg slope varies from 0.006 to 0.008 feet/foot. Bed material characteristics in this reach are similar to those of Reach TR-4.

Several structures are located within Reach TR-7. The large bridge at Del Obispo Street (at RM-0.56) carries four traffic lanes. This bridge is approximately the same size as the channel with no bridge piers within the channel. A smaller pedestrian bridge, located just upstream of the San Juan Creek confluence, has a high platform and no bridge piers within the channel and therefore is also expected not to cause flow constriction. The channel in Reach TR-7 also contains several small drop structures. These drop structures are only one to two feet high.

Land use on the eastern side of the channel in Reach TR-7 consists of the commercial properties that comprise the downtown area of the city of San Juan Capistrano. Residential neighborhoods, consisting of single family residences, apartment complexes, and a trailer park, are located on the western side of the channel in Reach TR-7.

Reach TR-7 also suffers from intense channel degradation and associated ecosystem degradation. There are currently no flood control issues in this reach. Reach TR-7 is targeted for analysis for potential channel stabilization and ecosystem restoration measures.

2.8.3 Oso Creek

Oso Creek originates in the foothills of the Santa Ana Mountains at an elevation of 1,640 feet above sea level and flows for a distance of 22 kilometers (13.5 miles) to enter Trabuco Creek at Trabuco Creek RM-2.1. The entire channel flows through the low, rolling foothills west of the Santa Ana Mountains.

Specific descriptions of each reach are provided below:

2.8.3.1 Reach OS-1: RM-13.5 to RM-11.6

The uppermost reach of Oso Creek extends from the headwaters to the lowermost end of Upper Oso Reservoir (which begins at RM-12.6). This portion of the channel is fairly natural with little surrounding development. The portion of this reach above Upper Oso Reservoir is entirely contained within O'Neill Regional Park.

There are currently no identified flood control, ecosystem degradation, or channel stabilization issues in this reach. Aside from monitoring, no detailed study will be performed on Reach OS-1.

2.8.3.2 Reach OS-2: RM-11.6 to RM-3.8

This reach extends from the lowermost end of Upper Oso Reservoir to the Interstate-5 undercrossing. This area is highly developed with residential communities on either side of the creek. Lake Mission Viejo, which extends from RM-9.0 to RM-9.9, is classified as a recreational lake and is completely surrounded by townhomes. Several drop structures (at RM-4.9, RM-5.0, and RM-6.0) and numerous undercrossings beneath roads occurs in this reach. The channel itself is narrow in this reach, rarely exceeding 30 meters (100 feet) in width. Oso Creek passes through two golf courses - Casta Del Sol Golf Course and Mission Viejo Country Club.

There are currently no identified flood control, ecosystem degradation, or remaining channel stabilization issues in this reach. Aside from monitoring, no detailed study will be performed on Reach OS-2.

2.8.3.3 Reach OS-3: RM-3.8 to RM-1.25

This reach extends from the I-5 undercrossing to the terminus of the rectangular open concrete channel just downstream of Avery Parkway. Most of the channel segments within this reach have been enlarged to "interim" or "ultimate" design levels. Channel improvements within this reach include channel modifications, bank/bed protection, grade controls, various types of bridge crossing structures, and detention basins. The segment from I-5 to just above Avery Parkway consists of a soft-bottomed trapezoidal channel with grouted stone sideslopes. Below this trapezoidal channel, Oso Creek passes into an open rectangular, concrete box culvert with a width of 10 meters (34 feet) and a height of 3.4 to 4.6 meters (11 to 15 feet). At the terminus of this box culvert is a drop structure consisting of a boulder field designed to dissipate excess stream energy.

Through this reach, several bridge crossings exist including Camino Capistrano Road, the AT&SF railroad, Crown Valley Parkway, Paseo De Colinas, and the San Juan Hills Toll Road. This reach also includes the Galivan Detention Basin.

There are currently no identified flood control or channel stabilization issues in this reach. Because of its heavily channelized nature, there is no ecosystem value at all within this reach. It is essentially a storm drain. No ecosystem restoration opportunities exist in this reach. Aside from monitoring, no detailed study will be performed on Reach OS-3.

2.8.3.4 Reach OS-4: RM-1.25 to RM-0.0

Lower Oso Creek below the concrete box culvert is still in an unmodified condition. It is currently a wide, deep, meandering gully through mostly agricultural lands. This reach, as recently as 1969, was a shallow, well-vegetated channel with broadly sloped banks and few evident problems. Since then, the creek has downcut extensively up to 12 meters (40 feet) in some places. As a result of this downcutting, adjacent lands are sloughing off gradually and during larger storm events resulting in the loss of several acres of land per large storm event. In addition to the loss of lands, the downcutting has resulted in an undercutting of the support toe of a sideslope adjacent to the Metrolink Railroad tracks. This loss of toe support has resulted in a rotational slope failure beneath the tracks and Camino Capistrano. Metrolink has stabilized this rotational slump by installing soil “tiebacks”. These tiebacks will not affect the process of channel degradation, but are solely meant to address the issue of adjacent slope failure.

This reach suffers from incredible channel stabilization issues, as well as accompanying ecosystem degradation. With its greatly enlarged size, the reach has no flood control issues. Although the channel stabilization issue has been dealt with in the short portion adjacent to the Metrolink tracks, it remains a problem throughout the reach. This reach is targeted for potential channel stabilization and ecosystem restoration.

2.8.4 Cañada Gobernadora

Cañada Gobernadora originates in the foothills of the Santa Ana Mountains in the Coto De Caza area at an elevation of 1,040 feet above sea level and flows southward for a distance of 14 kilometers (8.5 miles) to enter San Juan Creek at San Juan Creek RM-7.5. The upper reaches are moderately developed in the Coto De Caza area with residential communities and the Coto De Caza golf course. The middle reach of the creek passes through agricultural areas. The lowermost portion of the creek remains undeveloped.

Specific descriptions of each reach are provided below:

2.8.4.1 Reach CG-1: RM-8.5 to RM-5.7

The uppermost reach of Cañada Gobernadora extends from the headwaters to approximately one-half mile downstream of the Coto De Caza golf course. This portion of the creek is moderately developed with estate-type, single-family residences and the Coto De Caza golf course in the lower end. Vegetation in the creek is fairly dense, especially within the area of the golf course. The lowermost portion of the creek is currently being developed with large tracts of residential homes. The floodplain area surrounding the creek in the area of this development remains fairly wide at between 122 to 213 meters (400 to 700 feet).

This reach has no currently identified flood control, ecosystem degradation, or channel stabilization issues. Aside from recommended monitoring, no detailed study of these issues will be conducted on this reach.

2.8.4.2 Reach CG-2: RM-5.7 to RM-4.5

In this area, the creek narrows to a channel width of 30 meters (100 feet) or less. Fairly dense vegetation is present along this reach within the creek channel. Agricultural development is present on the east side of the creek within this reach with natural uplands present on the west side.

This reach has no currently identified flood control, ecosystem degradation, or channel stabilization issues. Aside from recommended monitoring, no detailed study of these issues will be conducted on this reach.

2.8.4.3 Reach CG-3: RM-4.5 to RM-0.0

The lowermost reach of Cañada Gobernadora extends from the lowermost end of the agricultural development to the confluence with San Juan Creek just below the sand and gravel mining operations. Within this reach, the creek channel widens with a floodplain area ranging from 122 meters (400 feet) to 213 meters (700 feet) in width. Vegetation within the channel in this reach is not as dense as in upstream areas. However, substantial riparian vegetation is present in the floodplain areas just outside the creek channel.

While this reach retains a good degree of habitat value, suffers from no identified flood control issues, and is not currently unstable, its location in respect to possible storage sites, and possible ecosystem restoration immediately downstream on San Juan Creek means it is targeted for analysis in the next phase of study.

Section Three

HYDROLOGIC, HYDRAULIC, AND SEDIMENT STUDIES

This section presents an overview of the tasks performed and methodologies used and summarize the results related to the watershed study's hydrology, hydraulics, and sedimentation analyses, collectively referred to as "H&H" studies. The methodologies employed in the development of hydrologic, hydraulic, and sedimentation models were designed to comply with U.S. Army Corps of Engineers policies and regulations for justification of Federal participation in the implementation of specific projects.

As mentioned earlier in the text, an understanding of the watershed's hydrology, hydraulics, and sediment behavior is critical in the development of solutions to many problems. Erosion, channel stabilization, ecosystem degradation, flood control, and even water quality problems are related to each of these studies. Study of these subjects indicates that the watershed suffers from higher peak discharges, greater low flow, and less sediment delivery than historically. The study of peak and low flows impacts the potential siting and sustainability of ecosystem restoration measures. The study of hydraulics allows the generation of floodplain maps that indicate the extent and depth of potential flooding. The study of sediment allows the determination of the adequacy of bridge pier depths, scour of the channel and associated habitat destruction, and potential beach nourishment problems. Theses all have an impact on plan formulation of measures to deal with the variety of problems presented in Sections 1 and 2.

3.1 Hydrologic Analysis

3.1.1 Precipitation and Streamflow Records

In general, the area has a mild climate characterized by warm, dry summers and cool, wet winters. Three types of storms produce precipitation in the area: general winter storms, general summer storms, and thunderstorms. Due to climatic and drainage area characteristics, little stream flow occurs except during and immediately following rains, and runoff increases rapidly in response to rainfall excess. The main flood season is from November to April. The storms occurring during these months can last for several days, are widespread, and produce the greater flood events in the watershed. However, local thunderstorms may occur at any time of the year. Rainless periods of several months during the summer are quite common. Snow occurs only in the most upstream part of the watershed and is not an important contributing factor to runoff.

The average annual precipitation is about 18 inches in the mountainous regions and 13 inches near the coast.

The National Weather Service, Orange County Public Facilities and Resources Department (PFRD), and other agencies and private citizens maintain precipitation records for 17 recording/non-recording precipitation stations within or adjacent to the San Juan Creek watershed. Of these 17, 6 are currently active while the other 11 are not. These precipitation gages provide records for as far back as 1929. A list of these precipitation gages, their location, elevations, operational periods, operators, and equipment types is provided in Section 3.1 of the Hydrology Appendix.

The United States Geological Survey (USGS) and Orange County PFRD currently maintain three stream gages within the San Juan Creek watershed. One is on San Juan Creek, currently located at the La Novia Bridge. Another gage is on Trabuco Creek at Camino Capistrano. (This gage was moved from a previous location downstream of its current location in 1981.) The third gage is on Oso Creek at Crown Valley Parkway. As a result, streamflow records are available on San Juan Creek from 1928 to present, on Trabuco Creek from 1932 to present, and on Oso Creek from 1969 to present. A description of these stream gages is provided in Section 3.2 of the Hydrology Appendix.

3.1.2 Peak Discharge-Frequency Analysis

A flood frequency analysis was carried out for stream gage records at La Novia Bridge (USGS. #11046530) on San Juan Creek and Camino Capistrano crossing (USGS #11467000) on Trabuco Creek. The resulting discharge-frequency relationships were used for rainfall-runoff calibrations.

An N-year rainfall-runoff model using LAPRE-1 and HEC-1 computer models was developed for the natural, present (Year 2000), and future (Year 2050) conditions on the San Juan Creek watershed. Future-year peak discharges were estimated in order to assess the potential impacts of future development in the San Juan Creek watershed. Development typically results in increased creek flows due to increases in the amount of impervious surfaces and the resulting decrease in the amount of runoff water that can infiltrate into the ground. This results in more water finding its way into the creeks. This can change the overall peak discharges by shortening the overall time during which storm flows travel through the creek system. The model was calibrated using discharge-frequency curves developed in the flood frequency analysis. The model results for 2-, 25-, 50-, 100-, 200-, and 500-year flood peak discharges for each concentration point are presented in Tables 13 and 14 using both Metric and English units (English units in parentheses). Because the risk and uncertainty studies require nine distinct frequency peak discharges, the 1-, 5-, and 10-year flood peak discharges for designated concentration points were graphically determined. Only the 5- and 10-year event flood peak discharges are included in these tables.

The results shown in Table 13 and Table 14 indicate a 100-year peak discharge of 1,510 cms (53,300 cfs) on San Juan Creek at its ocean outfall at Doheny State Beach. Of this discharge, approximately 530 cms (18,700 cfs), about 35 percent of the total flow, is contributed by Trabuco Creek and its upstream tributaries. Of this amount, 153 cms (5,400 cfs) is contributed by Oso Creek and its upstream tributaries. This amount represents approximately 10 percent of the total flow in San Juan Creek at the ocean outfall.

From a comparison of present versus future-year peak discharges, it is estimated that no significant increases in discharge are expected over the next 50 years. Flows anticipated in Year 2050 in San Juan Creek at the ocean outfall, Trabuco Creek entering San Juan Creek, and Oso Creek entering Trabuco Creek were calculated to be 1,533 cms (54,100 cfs), 547 cms (19,300 cfs), and 153 cms (5,400 cfs), respectively. This represents only a 1.5 percent increase in flows in San Juan Creek and a 3.1 percent increase in flows in Trabuco Creek. Oso Creek, which has been assumed to be essentially fully built out, was not estimated to experience any future increase in peak discharge flows. The reason for such a minimal increase in peak discharge between existing and future "without-project" conditions is the requirement in Orange County that all future development or re-development retain any water on-site that is above that calculated for existing conditions. This was assumed to occur for all flood events up to and including an 85% probability 100-year flood event, which also encompasses some portion of the volume and peak of events of even rarer occurrence. In addition, regulatory agency input into the development plans of any entities requesting permit processing will also tend to require this same condition.

Table 13 N-Year Model Peak Discharges Under Present Conditions[1]

Control Point	Location	2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	200-Yr	500-Yr
SAN JUAN CREEK									
CSJ1	@ Cold Spring Creek Confluence	10 (340)	--	--	204 (7,200)	366 (12,900)	530 (18,700)	765 (27,000)	1,173 (41,400)
CSJ2	Upstream of Bell & Verdugo Creek Confluences	10 (340)	--	--	252 (8,900)	431 (15,200)	635 (22,400)	907 (32,000)	1,383 (48,800)
CSJ2t	@ Bell Creek Confluence	13 (460)	--	--	366 (12,900)	572 (20,200)	853 (30,100)	1,210 (42,700)	1,808 (63,800)
CSJ3*	Upstream of Cañada Gobernadora Confluence	13 (460)	74 (2,600)	170 (6,000)	374 (13,200)	589 (20,800)	884 (31,200)	1,253 (44,200)	1,873 (66,100)
CSJ3t	@ Cañada Gobernadora Confluence	13 (460)	--	--	393 (13,900)	638 (22,500)	944 (33,300)	1,338 (47,200)	2,012 (71,100)
CSJ4*	@ Lower Ortega Hwy Bridge	14 (470)	85 (3,000)	190 (6,700)	422 (14,900)	683 (24,100)	1,006 (35,500)	1,425 (50,300)	2,120 (74,800)
CSJ5*	@ La Novia Bridge	14 (480)	85 (3,000)	193 (6,800)	428 (15,100)	691 (24,400)	1,023 (36,100)	1,454 (51,200)	2,148 (75,800)
CSJ6*	Downstream of I-5 Crossing	15 (520)	91 (3,200)	201 (7,100)	451 (15,900)	725 (25,500)	1,074 (37,800)	1,519 (53,600)	2,222 (78,400)
CSJ6t	@ Trabuco Creek Confluence	74 (2,600)	122 (4,300)	278 (9,800)	623 (22,000)	989 (34,900)	1,479 (52,200)	2,140 (75,500)	3,117 (110,000)
CSJ7*	@ Ocean Outfall	74 (2,600)	125 (4,400)	283 (10,000)	640 (22,600)	1,006 (35,500)	1,510 (53,300)	2,185 (77,100)	3,202 (113,000)
CAÑADA GOBERNADORA									
CCG1	Half distance to Wagon Wheel Confluence	5 (180)	--	--	40 (1,400)	65 (2,300)	88 (3,100)	119 (4,300)	170 (6,000)
CCG2	Upstream of Wagon Wheel Creek confluence	8 (280)	--	--	68 (2,400)	104 (3,700)	133 (4,700)	190 (6,700)	283 (10,000)
CCG2t	Wagon Wheel Creek confluence	9 (320)	--	--	77 (2,700)	125 (4,400)	164 (5,800)	238 (8,400)	346 (12,200)
CCG3*	Flow into San Juan Creek	9 (330)	23 (800)	45 (1,600)	94 (3,300)	147 (5,200)	196 (6,900)	278 (9,800)	385 (13,600)
TRABUCO CREEK									
CTB1	Trabuco Creek Rd crossing	12 (420)	--	--	147 (5,200)	241 (8,500)	360 (12,700)	544 (19,200)	791 (27,900)
CTB2	@ Tijeras Creek Golf Club	12	--	--	147	241	360	544	822

Table 13 N-Year Model Peak Discharges Under Present Conditions[1]

Control Point	Location	2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	200-Yr	500-Yr
		(420)			(5,200)	(8,500)	(12,700)	(19,200)	(29,000)
CTB3*	Upstream of Tijeras Creek confluence	12 (420)	31 (1,100)	60 (2,100)	147 (5,200)	241 (8,500)	360 (12,700)	544 (19,200)	833 (29,400)
CTB3t	@ Tijeras Creek confluence	14 (510)	31 (1,100)	60 (2,100)	147 (5,200)	266 (9,400)	408 (14,400)	621 (21,900)	930 (32,800)
CTB4	Upstream of Crown Valley Parkway crossing	15 (530)	--	--	156 (5,500)	272 (9,600)	411 (14,900)	646 (22,800)	981 (34,100)
CTB5*	Upstream of Oso Creek confluence	16 (550)	40 (1,400)	71 (2,500)	164 (5,800)	283 (10,000)	428 (15,400)	674 (23,800)	1,017 (35,900)
CTB5t	@ Oso Creek confluence	74 (2,600)	--	--	244 (8,600)	354 (12,500)	524 (18,500)	774 (27,300)	1,115 (40,600)
CTB6*	Flow into San Juan Creek	74 (2,600)	122 (4,300)	147 (5,200)	244 (8,600)	354 (12,500)	530 (18,700)	782 (27,600)	1,162 (41,100)
OSO CREEK									
COS1	Freeway 241 crossing	10 (340)	--	--	40 (1,300)	45 (1,500)	51 (1,700)	68 (2,300)	91 (3,200)
--	Outflow from Oso Reservoir	4 (150)	--	--	4 (150)	4 (150)	4 (150)	4 (150)	4 (150)
COS2a	Santa Margarita Parkway crossing	9 (300)	--	--	14 (500)	15 (540)	17 (600)	21 (750)	27 (940)
--	Outflow from Portola Basin	5 (161)	--	--	5 (167)	5 (168)	5 (170)	5 (174)	5 (179)
COS2b	Olympiad Road crossing	23 (800)	--	--	48 (1,700)	54 (1,900)	60 (2,100)	79 (2,800)	105 (3,700)
--	Outflow from O'Neill Basin	6 (196)	--	--	7 (230)	7 (234)	7 (241)	7 (263)	9 (319)
COS2c	Alicia Parkway crossing	22 (770)	--	--	45 (1,600)	51 (1,800)	57 (2,000)	77 (2,700)	99 (3,500)
COS3	Upstream of Oso Parkway crossing	48 (2,000)	--	--	139 (4,900)	164 (5,800)	190 (6,700)	264 (9,300)	349 (12,300)
COS4*	Downstream of I-5 crossing	57 (2,000)	85 (3,000)	105 (3,700)	142 (5,000)	167 (5,900)	193 (6,800)	269 (9,500)	351 (12,400)
COS4t*	La Paz Channel confluence	74 (2,600)	113 (4,000)	147 (5,200)	193 (6,700)	227 (8,000)	258 (9,100)	357 (12,600)	470 (16,600)
COS5a*	Downstream of Metrolink Railroad Crossing	74 (2,600)	113 (4,000)	147 (5,200)	193 (6,800)	227 (8,000)	258 (9,100)	360 (12,700)	473 (16,700)

Table 13 N-Year Model Peak Discharges Under Present Conditions[1]

Control Point	Location	2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	200-Yr	500-Yr
--	Outflow from Galivan Basin	74 (2,600)	105 (3,700)	108 (3,800)	113 (4,000)	116 (4,100)	122 (4,300)	224 (7,900)	337 (11,900)
COS5b *	Crown Valley Parkway crossing	74 (2,600)	116 (4,100)	119 (4,200)	125 (4,400)	133 (4,700)	139 (4,900)	221 (7,800)	337 (11,900)
COS6*	Flow into Trabuco Creek	74 (2,600)	122 (4,300)	125 (4,400)	130 (4,600)	139 (4,900)	153 (5,400)	221 (7,800)	337 (11,900)

[1] First unit represents SI units (metric) of cubic meters per second (cms). Second unit (in parenthesis) represents SAE units (English) of cubic feet per second (cfs).
* Indicates 5- and 10-Yr discharges were determined graphically.
t Indicates a control point at a creek confluence where total flow is estimated (e.g. CSJ2t is the combined flow of San Juan Creek and Bell Creek).

Table 14 N-Year Model Peak Discharges Under Future Conditions[1]

Control Point	Location	2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	200 Yr	500-Yr
SAN JUAN CREEK									
CSJ1	@ Cold Spring Creek Confluence	10 (340)	--	--	204 (7,200)	366 (12,900)	530 (18,700)	765 (27,000)	1,173 (41,400)
CSJ2	Upstream of Bell & Verdugo Creek Confluences	10 (340)	--	--	252 (8,900)	431 (15,200)	635 (22,400)	907 (32,000)	1,383 (48,800)
CSJ2t	@ Bell Creek Confluence	13 (460)	--	--	366 (12,900)	572 (20,200)	853 (30,100)	1,210 (42,700)	1,808 (63,800)
CSJ3*	Upstream of Cañada Gobernadora Confluence	13 (460)	74 (2,600)	170 (6,000)	374 (13,200)	589 (20,800)	884 (31,200)	1,253 (44,200)	1,873 (66,100)
CSJ3t	@ Cañada Gobernadora Confluence	15 (520)	--	--	397 (14,000)	640 (22,600)	944 (33,300)	1,338 (47,200)	2,012 (71,000)
CSJ4*	@ Lower Ortega Hwy Bridge	15 (540)	85 (3,000)	193 (6,800)	425 (15,000)	686 (24,200)	1,006 (35,500)	1,431 (50,500)	2,120 (74,800)
CSJ5*	@ La Novia Bridge	16 (564)	85 (3,000)	196 (6,900)	434 (15,300)	694 (24,500)	1,029 (36,300)	1,459 (51,500)	2,148 (75,800)
CSJ6*	Downstream of I-5 Crossing	18 (630)	94 (3,300)	204 (7,200)	459 (16,200)	734 (25,900)	1,080 (38,100)	1,536 (54,200)	2,227 (78,600)
CSJ6t	@ Trabuco Creek Confluence	74 (2,600)	122 (4,300)	278 (9,800)	649 (22,900)	1,015 (35,800)	1,502 (53,000)	2,176 (76,800)	3,146 (111,000)
CSJ7*	@ Ocean Outfall	74 (2,600)	130 (4,600)	295 (10,400)	666 (23,500)	1,029 (36,300)	1,533 (54,100)	2,227 (78,600)	3,231 (114,000)
CAÑADA GOBERNADORA									
CCG1	Half distance to Wagon Wheel Confluence	9 (300)	--	--	54 (1,900)	74 (2,600)	88 (3,100)	128 (4,500)	190 (6,700)
CCG2	Upstream of Wagon Wheel Creek confluence	12 (430)	--	--	79 (2,800)	111 (3,900)	139 (4,900)	207 (7,300)	292 (10,300)
CCG2t	Wagon Wheel Creek confluence	15 (530)	--	--	94 (3,300)	136 (4,800)	179 (6,200)	258 (9,100)	349 (12,300)
CCG3*	Flow into San Juan Creek	16 (550)	24 (862)	54 (1,900)	113 (4,000)	159 (5,600)	204 (7,200)	292 (10,300)	391 (13,800)
TRABUCO CREEK									
CTB1	Trabuco Creek Rd crossing	20 (700)	--	--	153 (5,400)	272 (9,600)	366 (12,900)	575 (20,300)	867 (30,600)
CTB2	@ Tijeras Creek Golf Club	20 (700)	--	--	153 (5,400)	272 (9,600)	371 (13,100)	575 (20,300)	867 (30,600)

Table 14 N-Year Model Peak Discharges Under Future Conditions[1]

Control Point	Location	2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	200 Yr	500-Yr
CTB3*	Upstream of Tijeras Creek confluence	20 (700)	34 (1,200)	62 (2,200)	153 (5,400)	272 (9,600)	380 (13,400)	575 (20,300)	867 (30,600)
CTB3t	@ Tijeras Creek confluence	23 (800)	34 (1,200)	62 (2,200)	173 (6,100)	289 (10,200)	434 (15,300)	646 (22,800)	958 (33,800)
CTB4	Upstream of Crown Valley Parkway crossing	24 (830)	--	--	179 (6,300)	295 (10,400)	445 (15,700)	672 (23,700)	995 (35,100)
CTB5*	Upstream of Oso Creek confluence	26 (900)	45 (1,600)	82 (2,900)	187 (6,600)	303 (10,700)	456 (16,100)	691 (24,400)	1,034 (36,500)
CTB5t	@ Oso Creek confluence	74 (2,600)	--	--	258 (9,100)	374 (13,200)	544 (19,200)	802 (28,300)	1,165 (41,100)
CTB6*	Flow into San Juan Creek	74 (2,600)	128 (4,500)	159 (5,600)	261 (9,200)	374 (13,200)	547 (19,300)	810 (28,600)	1,182 (41,700)
OSO CREEK									
COS1	Freeway 241 crossing	10 (340)	--	--	40 (1,300)	45 (1,500)	51 (1,700)	68 (2,300)	91 (3,200)
--	Outflow from Oso Reservoir	4 (150)	--	--	4 (150)	4 (150)	4 (150)	4 (150)	4 (150)
COS2a	Santa Margarita Parkway crossing	9 (300)	--	--	14 (500)	15 (540)	17 (600)	21 (750)	27 (940)
--	Outflow from Portola Basin	5 (161)	--	--	5 (167)	5 (168)	5 (170)	5 (174)	5 (179)
COS2b	Olympiad Road crossing	23 (800)	--	--	48 (1,700)	54 (1,900)	60 (2,100)	79 (2,800)	105 (3,700)
--	Outflow from O'Neill Basin	6 (196)	--	--	7 (230)	7 (234)	7 (241)	7 (263)	9 (319)
COS2c	Alicia Parkway crossing	22 (770)	--	--	45 (1,600)	51 (1,800)	57 (2,000)	77 (2,700)	99 (3,500)
COS3	Upstream of Oso Parkway crossing	48 (2,000)	--	--	139 (4,900)	164 (5,800)	190 (6,700)	264 (9,300)	349 (12,300)
COS4*	Downstream of I-5 crossing	57 (2,000)	85 (3,000)	105 (3,700)	142 (5,000)	167 (5,900)	193 (6,800)	269 (9,500)	351 (12,400)
COS4t*	La Paz Channel confluence	74 (2,600)	113 (4,000)	147 (5,200)	193 (6,700)	227 (8,000)	258 (9,100)	357 (12,600)	470 (16,600)
COS5a*	Downstream of Metrolink Railroad Crossing	74 (2,600)	113 (4,000)	147 (5,200)	193 (6,800)	227 (8,000)	258 (9,100)	360 (12,700)	473 (16,700)
--	Outflow from Galivan Basin	74	105	108	113	116	122	224	337

Table 14 N-Year Model Peak Discharges Under Future Conditions[1]

Control Point	Location	2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	200 Yr	500-Yr
		(2,600)	(3,700)	(3,800)	(4,000)	(4,100)	(4,300)	(7,900)	(11,900)
COS5b*	Crown Valley Parkway crossing	74 (2,600)	116 (4,100)	119 (4,200)	125 (4,400)	133 (4,700)	139 (4,900)	221 (7,800)	337 (11,900)
COS6*	Flow into Trabuco Creek	74 (2,600)	122 (4,300)	125 (4,400)	130 (4,600)	139 (4,900)	153 (5,400)	221 (7,800)	337 (11,900)

[1] First unit represents SI units (metric) of cubic meters per second (cms). Second unit (in parenthesis) represents SAE units (English) of cubic feet per second (cfs).
* Indicates 5- and 10-Yr discharges were determined graphically.
t Indicates a control point at a creek confluence where total flow is estimated (e.g. CSJ2t is the combined flow of San Juan Creek and Bell Creek).

3.1.3 Low Flow Analysis

A low flow analysis was performed using the stream gage data at La Novia Bridge on San Juan Creek, at the Camino Capistrano crossing on Trabuco Creek, and at the Crown Valley Parkway crossing on Oso Creek. The analysis characterized low flows in terms of average number of days, average number of consecutive days, and maximum number of consecutive days in which creek flows did not exceed a specified discharge each year. This analysis was also performed on a month-by-month basis in order to provide seasonal information. The results of this low-flow analysis are provided in Table 15 through Table 17.

The data presented in these tables indicate that only Oso Creek possesses perennial flows. Average daily flow in Oso Creek exceeds 0.03 cms (1 cfs) year round. Average daily flows of at least 0.28 cms (10 cfs) were observed to occur at least 50 percent of the time throughout the year. The maximum number of days in which at least 0.03 cms (1 cfs) of flow was not reached was 3 days during the entire period of 1980 to 1997.

The data also indicates that segments of both San Juan Creek and Trabuco Creek are ephemeral creeks with consistent flows occurring only during the winter and spring. For San Juan Creek, average daily flows of at least 0.03 cms (1 cfs) were present in the creek more than half the time only from December through June. For Trabuco Creek, average daily flows of at least 0.03 cms (1 cfs) occurred more than half the time only from December through May.

The significance of this information is that for ecosystem restoration alternatives that require sustained low flow for survival, there are certain segments of each creek that will not have sufficient year-round flow. There are native vegetation types, however, that are adapted to this type of situation. Many of the native tree species are traditionally located on floodplain surfaces that do not have access to year-round flow. However, as seedlings they may require irrigation for establishment. These considerations enter into the formulation of alternative plans for ecosystem restoration, and are incorporated into the planning of these measures.

Table 15 Daily Low Flow Analyses for San Juan Creek at La Novia Bridge (1980-1997)

Flows Not Excess of (cfs)	(cms)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Percent
Average Number of Days with Average Daily Flow NOT Exceeding the Specified Flow Rate															
No Flow		2	1	0	2	6	7	15	17	16	15	10	5	96	26.2
0.1	0.003	2	1	0	2	6	7	15	17	16	15	10	5	96	26.2
0.5	0.014	2	1	1	5	8	10	19	23	20	17	13	6	125	34.2
1	0.03	3	2	5	6	10	13	22	24	22	23	17	8	155	42.3
5	0.14	17	11	12	14	20	24	26	31	30	30	27	23	265	72.4
10	0.28	20	16	16	19	24	25	30	31	30	31	28	27	297	81.1
50	1.42	27	22	22	24	30	30	31	31	30	31	30	30	338	92.3
100	2.83	28	24	25	28	31	30	31	31	30	31	30	30	349	95.4
500	14.17	30	27	29	30	31	30	31	31	30	31	30	31	361	98.6
1000	28.34	31	27	30	30	31	30	31	31	30	31	30	31	363	99.2
Average Number of Consecutive Days with Average Daily Flow NOT Exceeding the Specified Flow Rate															
No Flow		1	1	0	1	6	7	14	17	16	14	9	5	91	24.9
0.1	0.003	1	1	0	1	6	7	14	17	16	14	9	5	91	24.9
0.5	0.014	1	1	1	4	7	9	18	22	19	16	11	6	115	31.4
1	0.03	2	2	4	5	10	12	21	24	20	21	15	7	143	39.1
5	0.14	14	9	10	12	19	24	26	30	30	30	25	18	247	67.5
10	0.28	18	13	14	18	23	25	30	30	30	31	26	22	280	76.5
50	1.42	25	19	20	24	29	30	31	31	30	31	29	28	327	89.3
100	2.83	26	19	22	27	31	30	31	31	30	31	29	29	336	91.8
500	14.17	28	25	27	30	31	30	31	31	30	31	30	31	355	97.0
1000	28.34	29	26	30	30	31	30	31	31	30	31	30	31	360	98.4
Maximum Number of Consecutive Days with Average Daily Flow NOT Exceeding the Specified Flow Rate.															
No Flow		13	16	0	17	31	30	31	31	30	31	30	31	291	79.5
0.1	0.003	13	16	0	17	31	30	31	31	30	31	30	31	291	79.5
0.5	0.014	13	16	15	29	31	30	31	31	30	31	30	31	318	86.9
1	0.03	24	16	26	30	31	30	31	31	30	31	30	31	341	93.2
5	0.14	31	28	31	30	31	30	31	31	30	31	30	31	365	99.7
10	0.28	31	28	31	30	31	30	31	31	30	31	30	31	365	99.7
50	1.42	31	29	31	30	31	30	31	31	30	31	30	31	366	100.0
100	2.83	31	29	31	30	31	30	31	31	30	31	30	31	366	100.0
500	14.17	31	29	31	30	31	30	31	31	30	31	30	31	366	100.0
1000	28.34	31	29	31	30	31	30	31	31	30	31	30	31	366	100.0

Table 16 Daily Low Flow Analyses for Trabuco Creek at Camino Capistrano (1980-1989)

Flows Not Excess of (cfs)	(cms)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Percent
Average Number of Days with Average Daily Flow NOT Exceeding the Specified Flow Rate															
No Flow		7	2	0	4	7	9	11	11	10	19	17	13	110	30.1
0.1	0.003	7	2	0	4	7	9	11	11	10	19	17	13	110	30.1
0.5	0.014	7	2	2	7	9	11	15	16	13	21	22	13	138	37.7
1	0.03	9	3	3	8	12	14	15	17	15	24	23	14	157	42.9
5	0.14	13	5	3	10	13	16	20	20	18	26	25	19	188	51.4
10	0.28	16	8	5	12	16	21	22	22	21	26	25	21	215	58.7
50	1.42	20	12	13	20	22	26	28	29	27	30	27	23	277	75.7
100	2.83	24	16	17	20	23	27	30	29	29	30	28	25	298	81.4
500	14.17	30	24	25	25	28	29	31	31	30	31	30	30	344	94.0
1000	28.34	30	26	27	26	30	30	31	31	30	31	30	30	352	96.2
Average Number of Consecutive Days with Average Daily Flow NOT Exceeding the Specified Flow Rate															
No Flow		5	2	0	3	7	9	10	8	8	14	10	10	86	23.5
0.1	0.003	5	2	0	3	7	9	10	8	8	14	10	10	86	23.5
0.5	0.014	5	2	2	6	8	10	14	13	10	15	12	12	109	29.8
1	0.03	6	2	2	6	11	14	14	15	13	18	15	12	128	35.0
5	0.14	10	4	3	8	13	15	19	18	16	20	17	16	159	43.4
10	0.28	13	5	4	9	15	20	21	20	19	24	20	19	189	51.6
50	1.42	17	11	12	19	22	26	28	28	26	26	23	21	259	70.8
100	2.83	20	14	17	20	23	27	29	29	26	28	25	23	281	76.8
500	14.17	27	20	24	24	28	29	31	29	29	29	27	27	324	88.5
1000	28.34	29	22	25	25	30	30	31	30	29	29	27	27	334	91.3
Maximum Number of Consecutive Days with Average Daily Flow NOT Exceeding the Specified Flow Rate.															
No Flow		23	9	0	19	31	30	31	31	30	31	25	29	289	79.0
0.1	0.003	23	9	0	19	31	30	31	31	30	31	25	29	289	79.0
0.5	0.014	23	9	18	30	31	30	31	31	30	31	25	31	320	87.4
1	0.03	23	9	21	30	31	30	31	31	30	31	30	31	328	89.6
5	0.14	27	17	25	30	31	30	31	31	30	31	30	31	344	94.0
10	0.28	31	18	31	30	31	30	31	31	30	31	30	31	355	97.0
50	1.42	31	28	31	30	31	30	31	31	30	31	30	31	365	99.7
100	2.83	31	28	31	30	31	30	31	31	30	31	30	31	365	99.7
500	14.17	31	29	31	30	31	30	31	31	30	31	30	31	366	100.0
1000	28.34	31	29	31	30	31	30	31	31	30	31	30	31	366	100.0

Table 17 Daily Low Flow Analyses for Oso Creek at Crown Valley Parkway (1980-1997)

Flows Not Excess of (cfs)	Flows Not Excess of (cms)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Percent
Average Number of Days with Average Daily Flow NOT Exceeding the Specified Flow Rate															
No Flow		0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
0.1	0.003	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
0.5	0.014	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1	0.03	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
5	0.14	11	10	10	14	15	15	16	16	15	14	14	14	164	44.8
10	0.28	13	12	13	15	16	17	17	17	16	16	15	14	181	49.5
50	1.42	19	14	17	18	25	25	26	25	20	21	19	20	249	68.0
100	2.83	26	22	25	25	29	29	29	29	24	28	27	27	320	87.4
500	14.17	29	27	29	29	31	30	31	31	30	31	29	30	357	97.5
1000	28.34	30	27	30	29	31	30	31	31	30	31	29	30	359	98.1
Average Number of Consecutive Days with Average Daily Flow NOT Exceeding the Specified Flow Rate															
No Flow		0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
0.1	0.003	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
0.5	0.014	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
1	0.03	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
5	0.14	7	6	7	10	14	14	15	16	14	13	11	9	136	37.2
10	0.28	9	8	10	13	14	16	16	17	15	15	12	10	155	42.3
50	1.42	15	10	13	17	22	23	23	23	19	19	16	16	216	59.0
100	2.83	20	15	18	23	27	26	27	28	22	24	22	22	274	74.9
500	14.17	25	22	25	26	31	30	31	31	29	28	23	26	327	89.3
1000	28.34	27	25	26	28	31	30	31	31	29	30	25	28	341	93.2
Maximum Number of Consecutive Days with Average Daily Flow NOT Exceeding the Specified Flow Rate.															
No Flow		0	0	0	0	0	3	0	0	0	1	0	0	4	1.1
0.1	0.003	0	0	0	0	0	3	0	0	0	1	0	0	4	1.1
0.5	0.014	0	0	0	0	0	3	0	0	0	1	0	0	4	1.1
1	0.03	0	0	0	0	0	3	0	0	0	1	0	0	4	1.1
5	0.14	25	26	28	30	31	30	31	31	30	31	30	31	354	96.7
10	0.28	26	28	31	30	31	30	31	31	30	31	30	31	360	98.4
50	1.42	31	28	31	30	31	30	31	31	30	31	30	31	365	99.7
100	2.83	31	28	31	30	31	30	31	31	30	31	30	31	365	99.7
500	14.17	31	29	31	30	31	30	31	31	30	31	30	31	366	100.0
1000	28.34	31	29	31	30	31	30	31	31	30	31	30	31	366	100.0

As mentioned earlier, there are also tributaries and storm drains that have taken the place of low order tributaries that are now witnessing year-round flow due to irrigation of surrounding residential and commercial properties. This flow carries contaminants such as bacteria, into downstream channel reaches, which would not have been historically linked during dry months. This issue is important, particularly in dealing with water quality problems and the formulation of solutions during development of watershed management and water quality improvement plans.

3.1.4 Sediment and Debris Yields

Sediment yields for the San Juan Creek watershed were estimated using the U.S. Army Corps of Engineers, Los Angeles District method for Prediction of Debris Yield (LAD Debris Method). Yields were estimated at concentration points, which represent the upstream starting locations for the hydraulic and sedimentation studies. Based on the analyses comparing the results of these two methods, it was recommended that the LAD Debris Method be used for estimating sediment and debris yields for natural areas (San Juan Creek and Trabuco Creek watersheds) and that MUSLE be used for more urban areas (Oso Creek watershed). Utilizing both methods, the results indicated that the estimated values are almost identical with the exception of the 2-year event results.

The determination of sediment yield is important in the understanding of the existing system. Sediment is the only source of sand for area beaches, and its depletion can have dire effects on beach sustainability. Sediment yield could also be affected by measures that would tend to trap sediment, such as dams and detention structures. These structures may be designed to pass sediment efficiently where this is a consideration, but must be taken into account in the formulation of alternative plans.

3.2 Hydraulic Analysis

The scope of the watershed study's hydraulic analysis includes the downstream portions of San Juan Creek, Trabuco Creek, Oso Creek, and Cañada Gobernadora. Specifically, hydraulic analysis was conducted for (1) a 17,100-meter (10.5-mile) length of San Juan Creek from just downstream of the Bell Creek confluence to the Pacific Ocean; (2) a 15,000-meter (9.5-mile) length of Trabuco Creek from a point in Plano Trabuco approximately 1,500 meters (0.9 miles) upstream of the Oso Parkway overcrossing to the San Juan Creek confluence; (3) a 6,600-meter (4-mile) length of Oso Creek from the I-5 overcrossing to the Trabuco Creek confluence; and (4) a 5,000-meter (3-mile) length of Cañada Gobernadora Creek from just downstream of the Coto de Caza golf course to the San Juan Creek confluence. Water surface profiles and floodplain limits were computed using the HEC-River Analysis System (HEC-RAS) computer program developed by the Corps.

In order to complete the hydraulic analysis, aerial photos taken in August 1998 were used to generate 1 inch = 100 meters, 1-meter contour interval topographic survey mapping. In addition, geometric data for bridges and culverts were gathered from as-built plans provided by various agencies including the County of Orange, Caltrans, and the City of San Juan Capistrano. Finally, locations of levees, block walls, and berms were ascertained through a combination of existing data from local agencies, aerial photos, and field reconnaissance.

The results of the frequency-overflow (a.k.a. "floodplain") mapping are shown in Figure 6 to Figure 15. These maps include inundation boundaries for the 100-, and 500-year flood events, based on Corps of Engineers criteria. Only a single set of maps was generated because analysis indicated little significant difference between present conditions (Year 2000) and future conditions (Year 2050). Water surface profiles are included in the Hydraulic Appendix.

The results of the hydraulic analysis and preliminary scour analysis indicate that there are two potential circumstances or mechanisms under which flood damage might occur in the watershed. The first of these is that of overtopping of the existing levee system. Hydraulic analysis indicates that the levees could be overtopped by flood events larger than a 2% exceedance (roughly 50-year) flood. The second of these is that of undermining and potential failure of the lining of the channel, with subsequent failure of the levee and inundation of surrounding floodplains. During the 1996 floods, which were of an approximate 4% exceedance (roughly 25-year) frequency, failure of the lining occurred. Were it not for efforts of the County with assistance from the Corps of Engineers, levee failure could have occurred. The assumed failure frequency for levee failure by undermining is based on recurrence of this event. This is a reasonable assumption based on the actual depth to toe on the channel lining in these reaches.

Figure 6. Overflow Map – Sheet 1

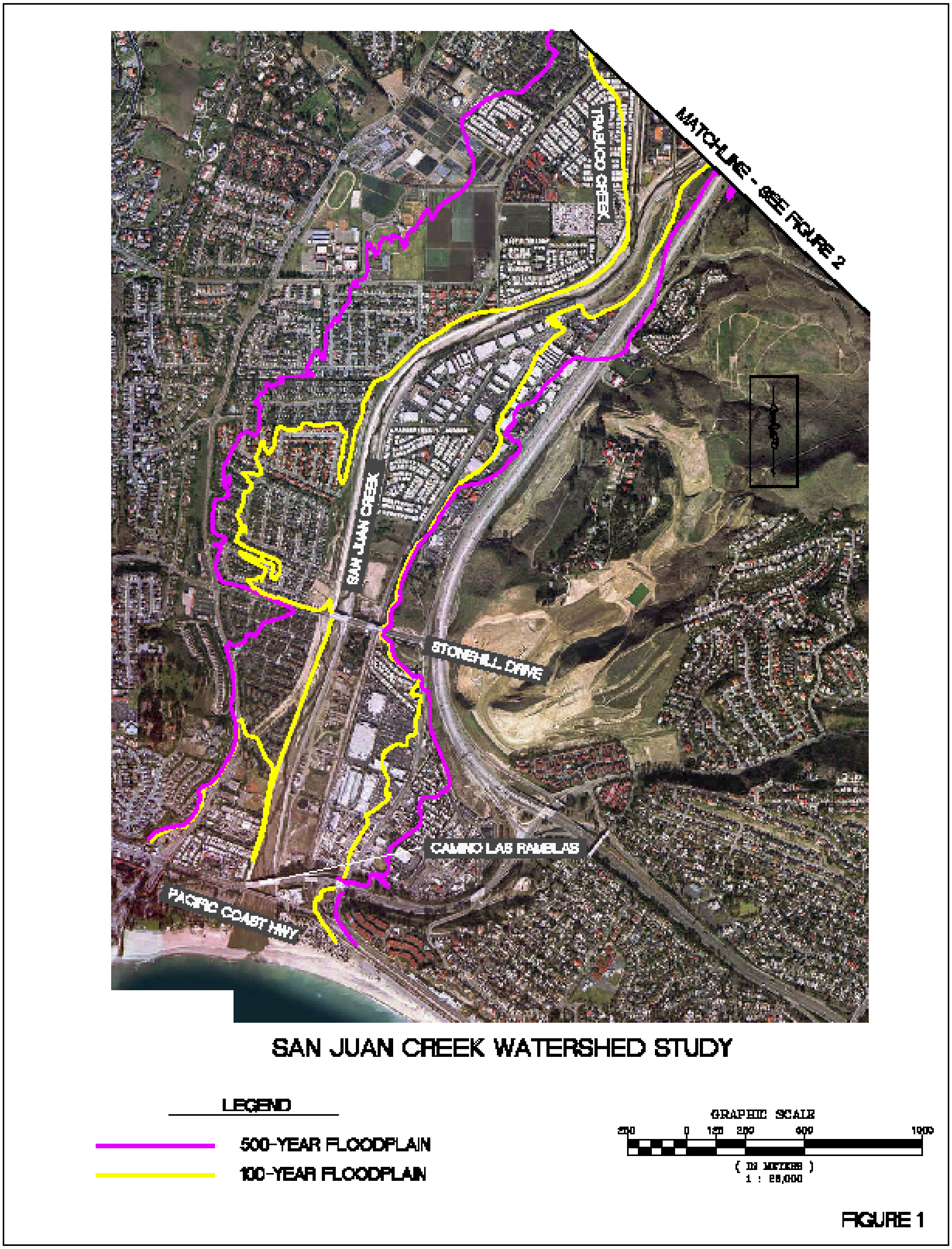


Figure 7. Overflow Map – Sheet 2

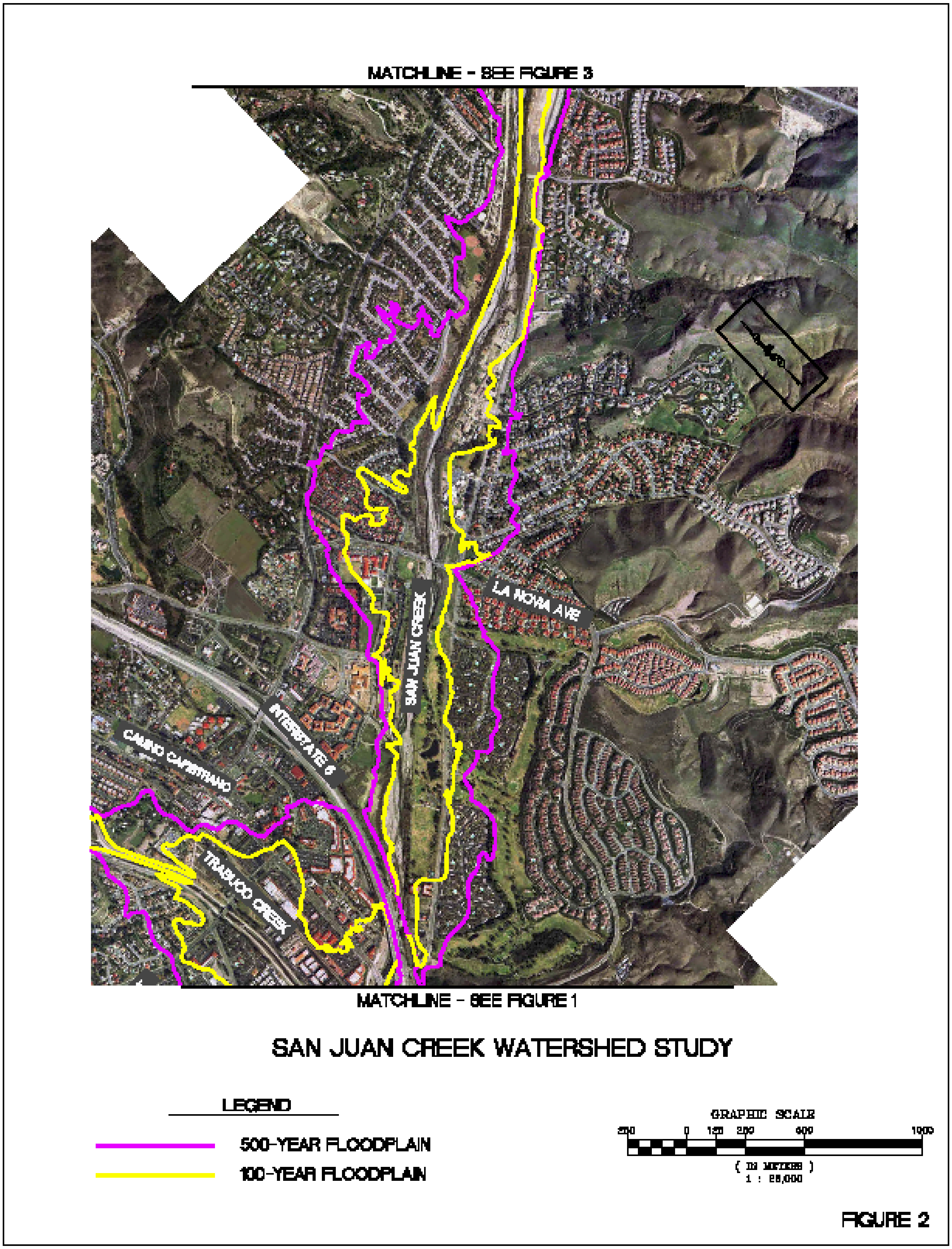


Figure 8. Overflow Map – Sheet 3

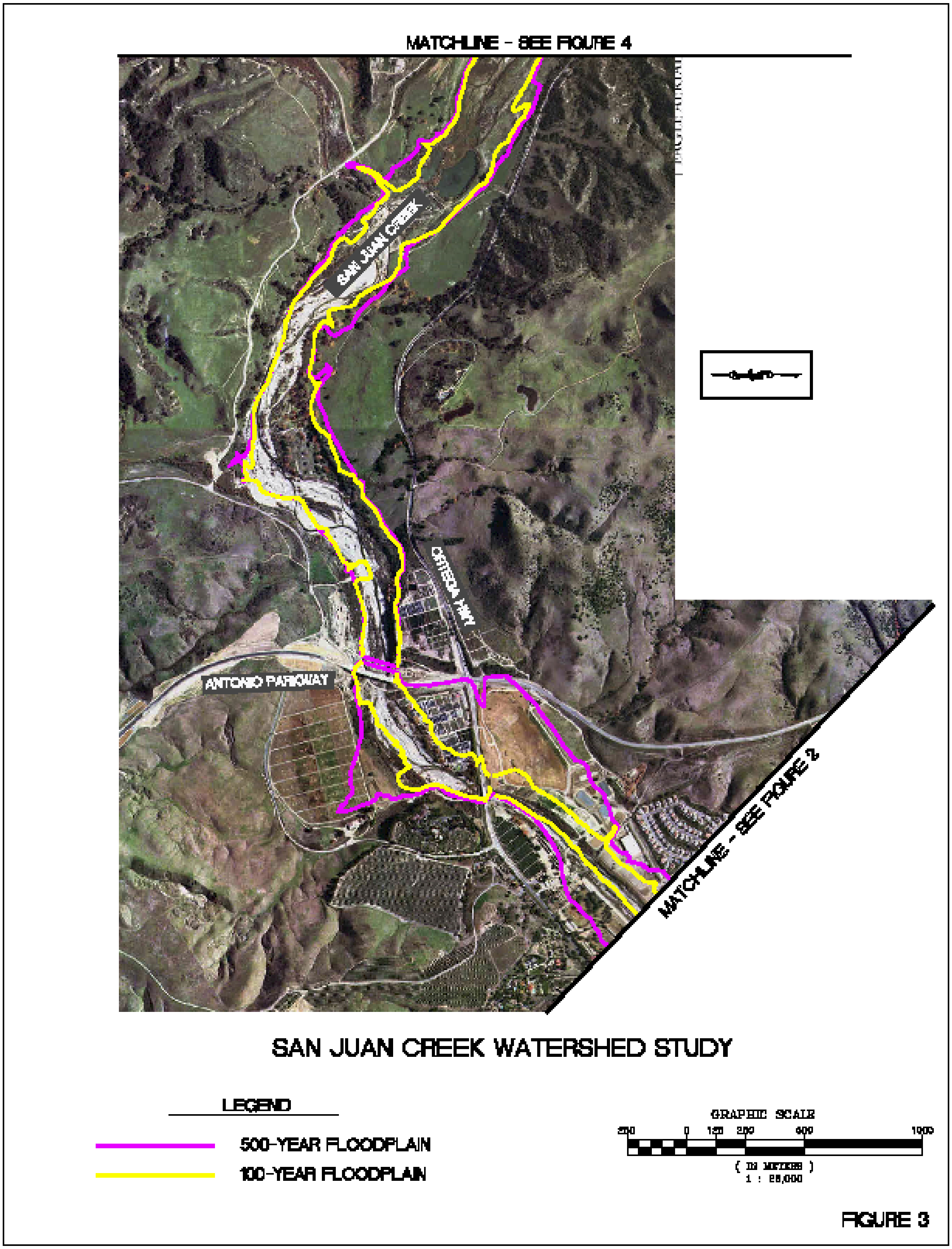


Figure 9. Overflow Map – Sheet 4

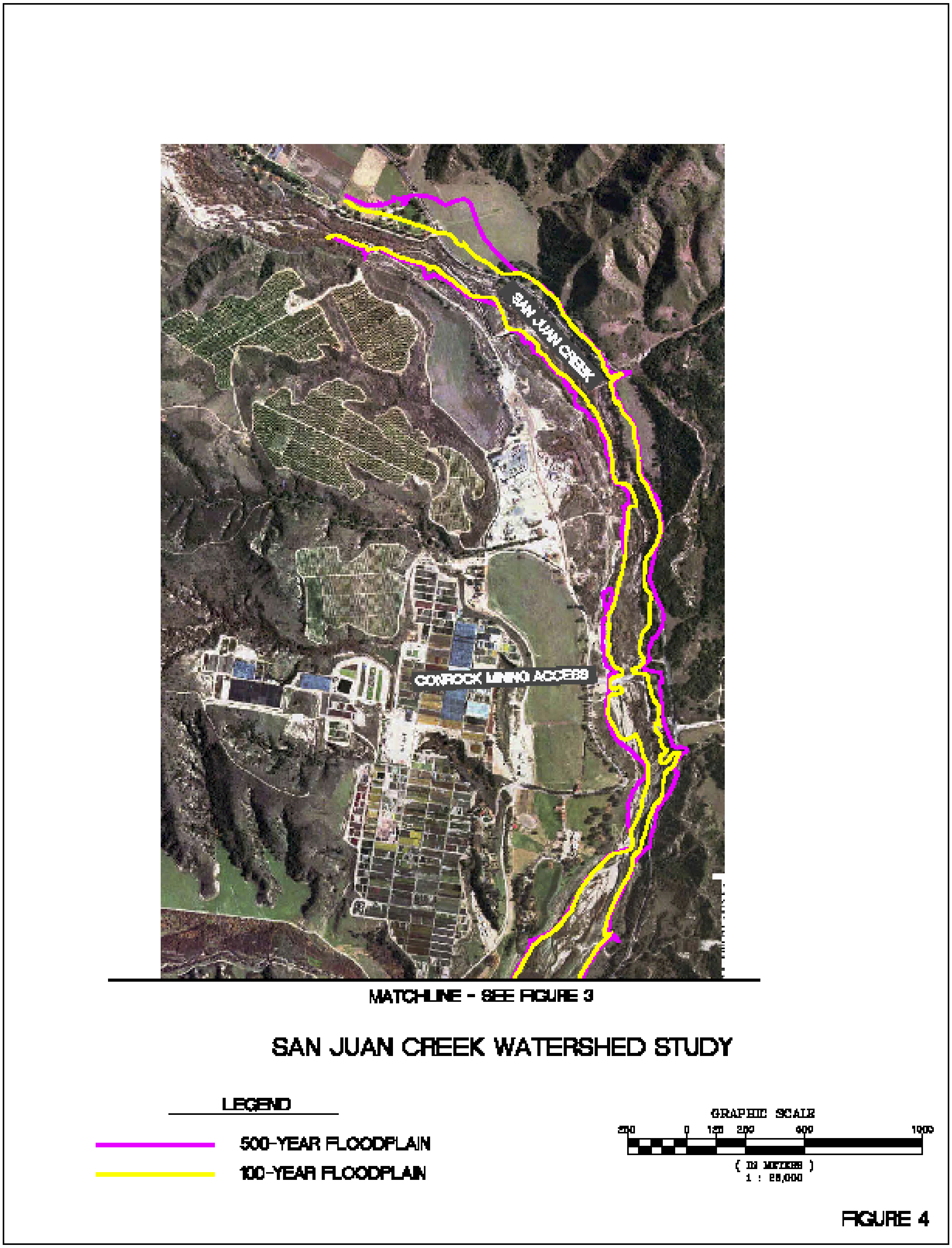


Figure 10. Overflow Map – Sheet 5

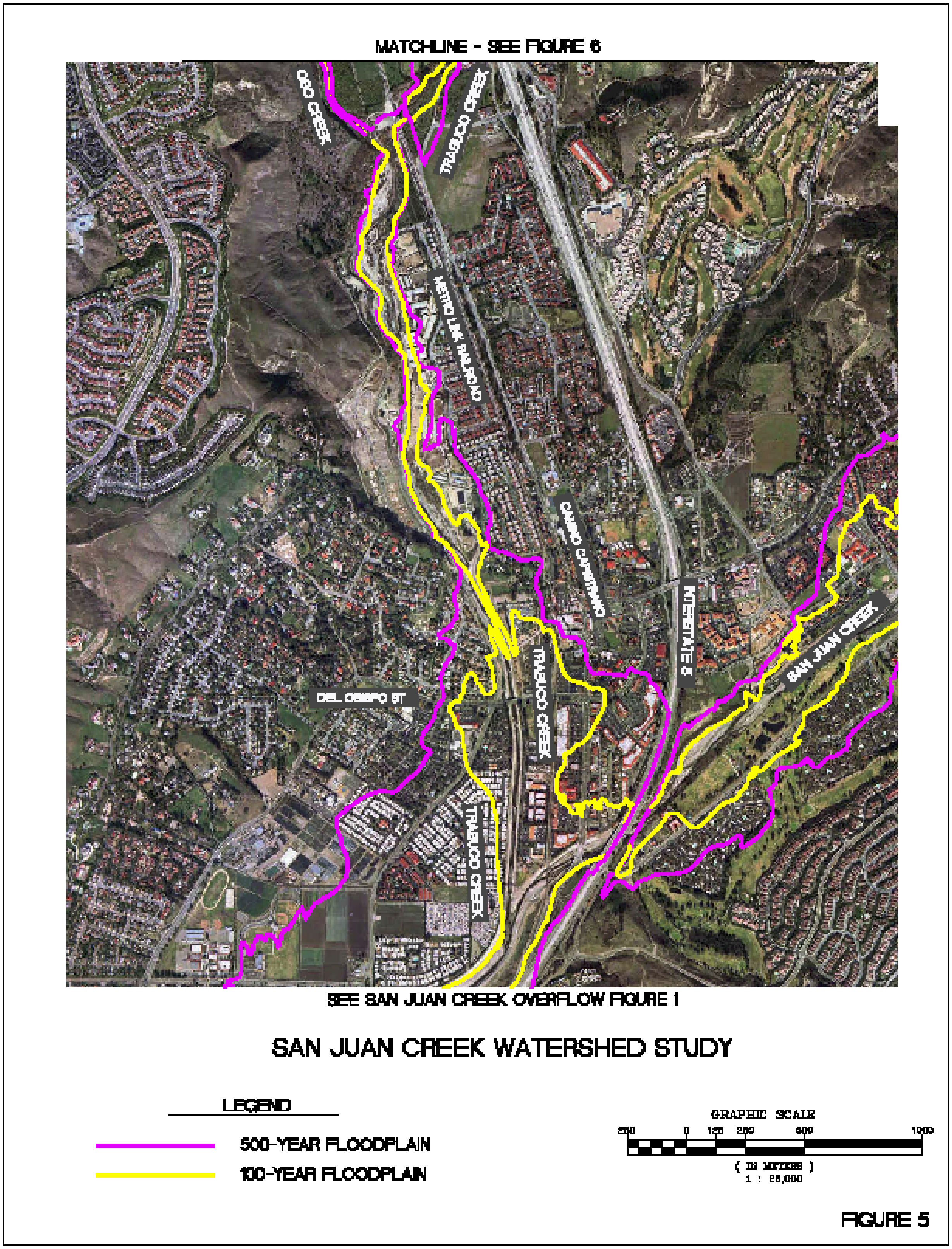


Figure 11. Overflow Map – Sheet 6

Figure 12. Overflow Map – Sheet 7

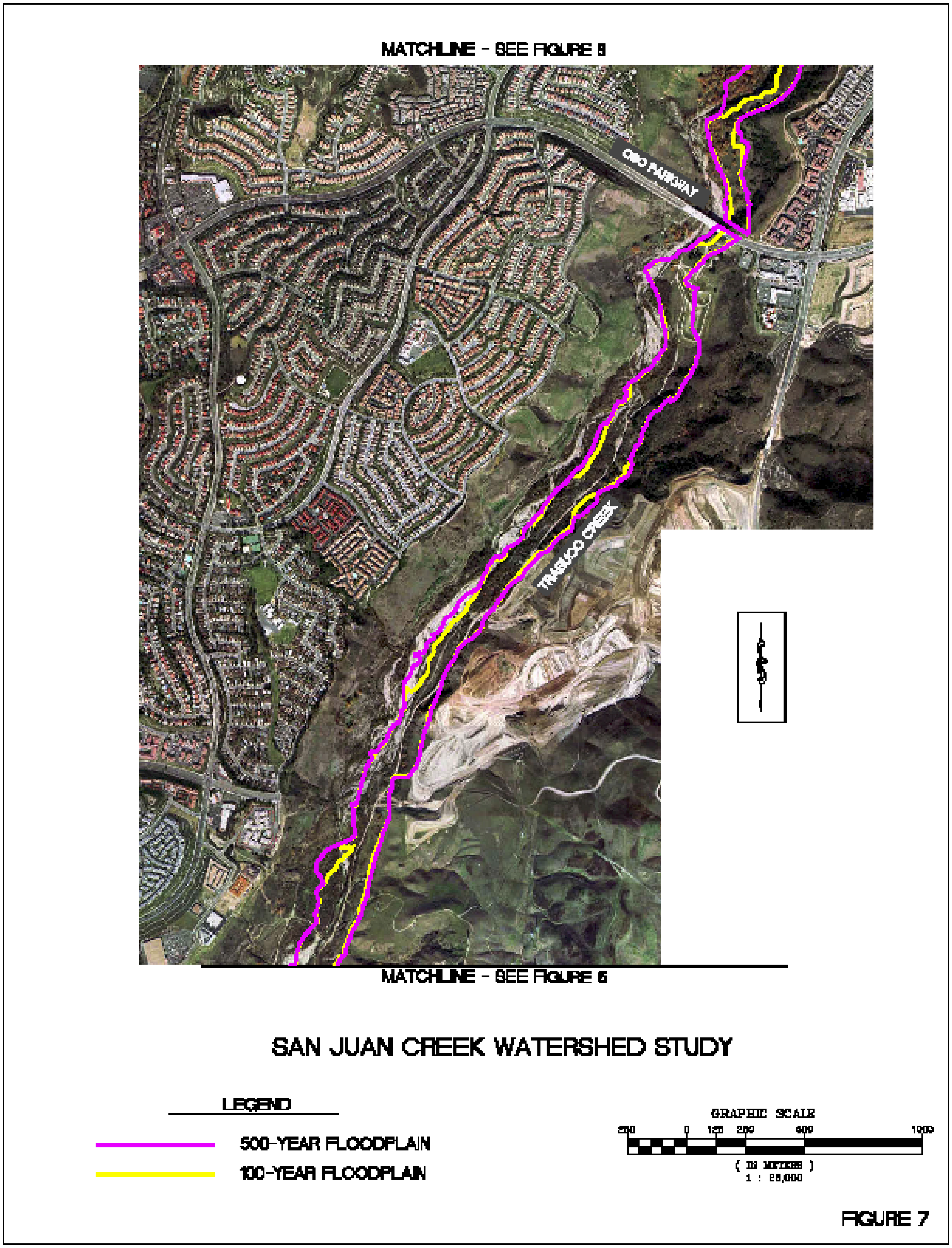


Figure 13. Overflow Map – Sheet 8

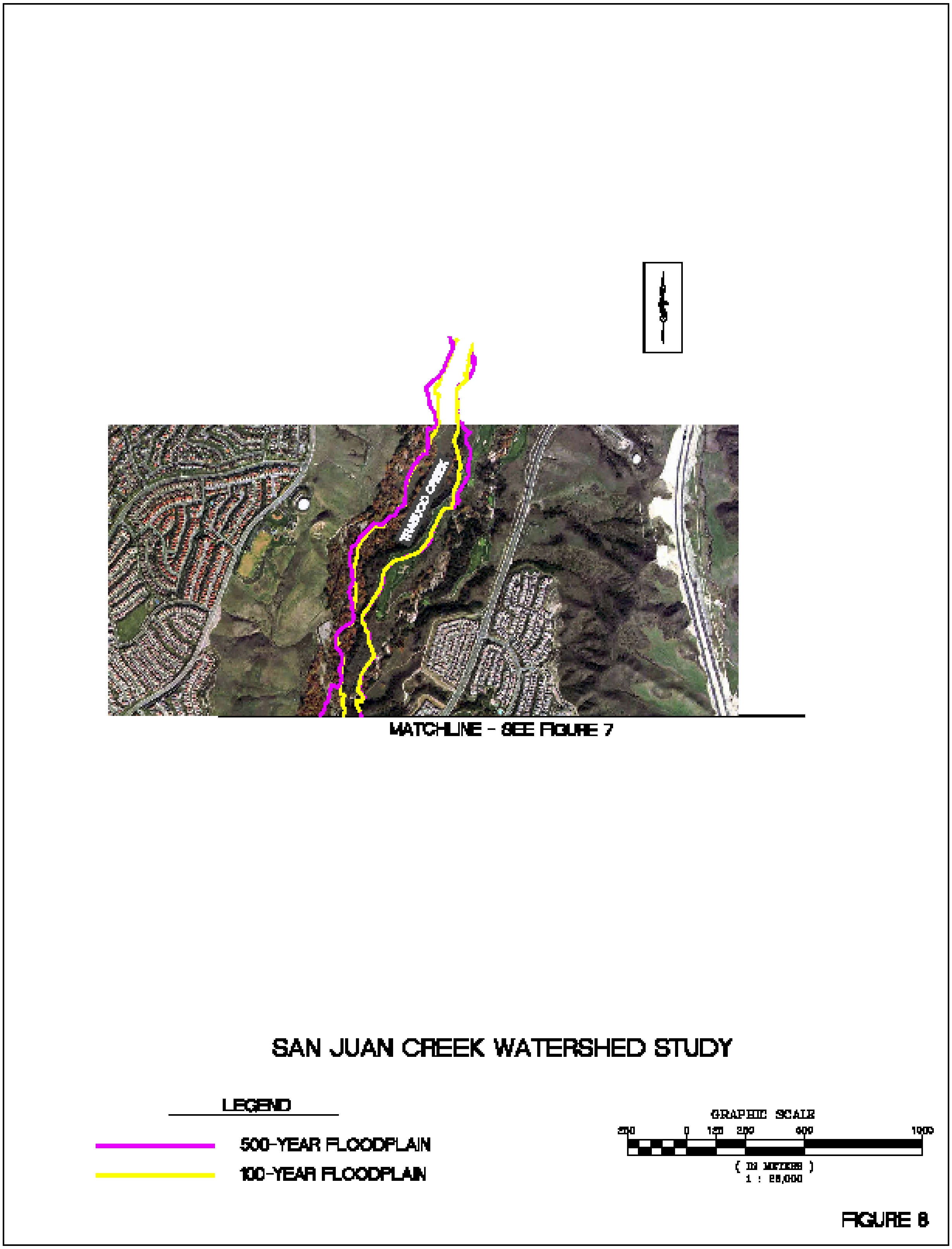


Figure 14. Overflow Map – Sheet 9

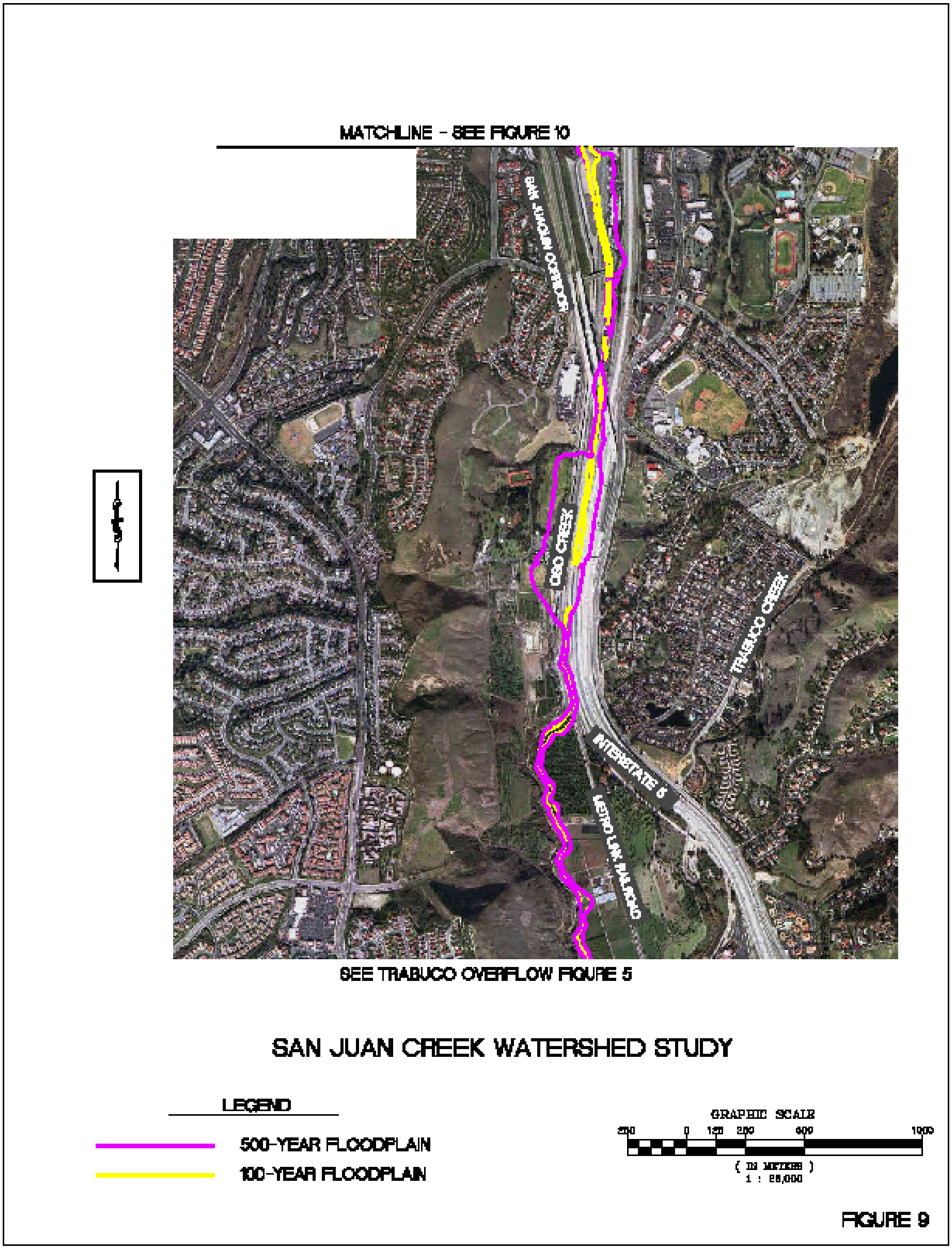


Figure 15. Overflow Map – Sheet 10

The number of structures potentially inundated during a 0.2% exceedance (~500-year) flood event are 2,439 residential, 1,144 manufactured (pre-assembled residential) and 536 commercial, for a total of 4119 structures. The value of these structures is approximately $822 million. Flood damage from a 0.2% exceedance event is estimated at $349,237,150, for a 1% exceedance (~100-year) event is estimated at $149,128,730, for a 2% exceedance (~50-year) event is estimated at $47,968,640, and for a 4% exceedance (~25-year) event is estimated at $885,870. These damages include structure and content damage, emergency and clean-up costs, land losses due to erosion, and damage to infrastructure such as bridges. The equivalent (average) annual expected damages for the entire watershed are $15,204,700. Because future flood peak discharges are not significantly different from the existing condition, and the inundatable area is currently fully developed, future flood damages (in year 2030; roughly the "average" of all future years) are only 4% higher than the base year of 2008 (assumed project completion). Most of the potential damage would occur downstream of La Novia Avenue on San Juan Creek, with the bulk between Trabuco Creek and the ocean, and on Trabuco Creek downstream of Del Obispo. The estimated inundated area for the 0.2% exceedance and 1% exceedance flood events is illustrated in Figure 6 to Figure 15.

It is important to note that the frequency-overflow maps presented in this report are not to be used for other purposes. These maps were developed solely and expressly for the purpose of identifying the expected probability of inundation, i.e., of the extent and depth of floodwater inundation on the floodplain. These maps were used in determining the expected damage during different flood events, and by extrapolation, when compared to potential projects developed to reduce damages, to identify projects that might have a positive benefit-to-cost ratio, a critical item in recommending Federal involvement in potential projects. These maps are not to be used for comparison to regulatory floodplain maps, which are developed to different criteria and used for a completely different purpose.

3.3 Geomorphic Analysis

A geomorphic analysis was conducted to assess the characteristics and general stability of San Juan, Trabuco, and Oso Creeks. Changes in the profile of these creeks over time were investigated in light of changes in development and flood history. The analysis relied primarily on field reconnaissance, historical maps, and previous reports.

Large storm events are often responsible for significant changes to stream profiles. The largest recorded flood events on San Juan Creek occurred in 1937, 1938, 1969, and 1995. Based on statistical analysis of gage data, these flows correlate to approximately 50-year events. In the past 25 years, large events have also occurred during 1978, 1980, 1983, 1993, and 1998. The largest flows recorded on Trabuco Creek occurred in 1937 and 1970.

3.3.1 San Juan Creek

Results of the geomorphic analyses on San Juan Creek from Bell Canyon to the ocean outlet show significant degradation from 1970 to 1984 and continuing lower rates of degradation through 1998. The lower and middle reaches (the ocean outfall to Lower Ortega Highway Bridge) show degradation of up to six feet in the reach above and below LaNovia Bridge down to Interstate 5 from 1970 to 1984 and then a slightly aggradational trend from 1984 to 1998. The significant downcutting of the channel, reflected in the 1984 bed profile is likely a result of the large flows experienced in this watershed in the 1978, 1980, and 1983 flood events. San Juan Creek's bed elevation has not recovered to its pre-1970 elevations. The lower and middle reaches are believed to be currently readjusting to a profile closer to the 1970 profile. The upper reaches (upstream of Lower Ortega Highway Bridge) do not appear to be making this adjustment.

The net effect of bed degradation is its impacts on associated resources, both natural and man-made. Bed degradation will eventually cause (and has already caused) the bed elevation to reach the level of buried pipelines, causing failure of water and sewer lines. It will cause erosion of bed sediments resulting in disappearance of habitat within the bed. If continuous, the resource will disappear permanently. It will also eventually cause the failure of structures and resources lining the bank, as these are undercut, fail into the channel, and are washed away. Bridge abutments, channel linings, land protection, riparian vegetation including trees, bushes and associated wildlife will all disappear. If erosion of the banks is continual, no resource value will exist in the future. San Juan Creek upstream of I-5 to somewhat upstream of LaNovia Avenue is now in a state of channel degradation. Stabilization is greatly needed in order for the resource to have some chance of sustainability.

3.3.2 Trabuco Creek

Results of the geomorphic analyses on Trabuco Creek show a general pattern of channel degradation from just upstream of the I-5 overcrossing to the San Juan Creek confluence during the years 1960 through 1998. Bed degradation on Trabuco Creek has amounted to over thirty feet in some locations, particularly immediately downstream of its confluence with Oso Creek. Significant degradation is also believed to be associated with the large storm event that occurred in 1983. Some sections in the reach immediately upstream of San Juan Creek have exhibited some recovery in later years, but not enough to fully recover from the 1983 flood event.

If the degradation on Trabuco Creek is allowed to continue in the future, there is little chance of resource value along the creek. Associated infrastructure, environmental resources, and adjacent land will be continually subject to attack, particularly during large flood events. Stabilization of Trabuco Creek downstream of the railroad crossing is needed if associated resources are to be protected from future attack.

3.4 Erosion and Sedimentation Analyses

Erosion and sedimentation analyses were performed in order to assess the effects of changes in the channel parameters or the hydrologic inputs that result from any proposed project alternatives. These analyses were performed using the Corps of Engineers' SAM Sediment Hydraulic Design Package. SAM is an integrated system of programs designed to aid engineers in the analyses associated with designing, operating, and maintaining flood control channels and stream restoration projects. SAM combines the hydraulic information and the bed material gradation information to compute the sediment transport capacity for a given cross section at a given discharge at a single point in time. These sediment transport rates can then be combined with hydrological information to compute the total sediment carrying capacity for that cross section. Complete erosion/sedimentation analyses are described in Section 6.0 of the Hydraulic Appendix - Without-Project Conditions.

Analysis of sediment conditions on San Juan and Trabuco Creeks indicate continued potential for sediment erosion. There is sufficient tractive force on the bed to provide the means for erosion, and little in the way of impediments to prevent it. Drop structure installation in the downstream reaches of San Juan and Trabuco Creeks has reduced downcutting in those areas, at the expense of migratory and other aquatic species passage. Unfortunately, downcutting has continued downstream of these structures, as they are spaced far apart and create sufficient drops to cause downstream scour problems. Extrapolation of this condition into future years provides the basis to estimate the threat to infrastructure crossing or adjacent to the creek. Unfortunately, a number of bridges crossing the creek appear to be at risk in the future if this condition is permitted to continue. This issue is fully developed in the plan formulation section and plays a large role in the development of alternative plans.

3.5 Non-Damaging Discharges for Structures

Many bridges cross San Juan, Trabuco, and Oso Creeks within the study area, and a number of reaches in these streams have bank and toe protection. The existing channel degradation problem, which is evident as a continual downcutting of the bed of the channel, has many potential implications to existing structures across the principal channels of the watershed. For the purposes of assessing trends in channel behavior, a preliminary analysis of scour was conducted. At this preliminary level of detail, a highly conservative approach was warranted. In the event that the issue of scour is addressed in future phases of study, a considerably more detailed analysis of each structure would need to be performed. Potential scour was evaluated at each of the structures crossing the stream channels. In the case of bridges, scour depths were compared to a depth of 1.5 meters (~5 feet) below the bottom of the pier footing. This assumes that the bridge no longer has an adequate safety factor against structural failure once flood flows have exposed 1.5 meters (~5 feet) of the piles that support the pier footing. In the case of bank protection, scour depths were compared to depth to the toe. This assumes that once the toe is undermined, the concrete will break away and expose the bank. Failure by other mechanisms is not considered.

Total scour for the 2-, 25-, 50-, 100-, 200-, and 500-year storm events was compared with the known or estimated depth of footings and foundations at bridge structures and bank protection along San Juan, Trabuco, and Oso Creeks (see Table 6.24 of the Hydraulic Appendix Without Project Conditions). The values estimated are potential scour depths and are not meant to be used as design values. In addition, failure is not likely to occur along the entire reach of the channel. The calculated scour is a conservative estimate that assumes the worst case of each scour element occurs at the same time and the same location. The computed scour depths were used only to make a determination of the potential for undermining and the frequency of scour, for the purposes of determining potential damages. A structure was classified as having little potential for damage if the scour associated with a 50- to 100-year flood flow does not pose a significant threat. Because of the preliminary nature of this analysis, no attempt was made to predict what event would cause failure of a structure. Based on the preliminary scour analysis, the following structures are identified for further detailed study to determine the potential risk of failure due to scour.

The potential failure of the structures listed in Table 18 could result in significant economic losses and repair costs. Since 1969, it is estimated that the Federal government, the County, the cities, and other entities in the San Juan Creek watershed have suffered significant costs associated with floooding, with $9.8 million in damages having been incurred during the years 1992 to 1998 ($1.64 million/year) in these categories. Potential expenditures in the future include potential bridge replacement due to undermining by channel degradation processes, amounting to $4.2 million per year, road repair, bank stabilization, and expenditures for repair of flood control facilities due to channel instability**.**

Adding credence to potential economic losses due to flooding events, recent floods have resulted in significant impacts to infrastructure. Along San Juan and Trabuco Creeks in February 1998, approximately 150 meters (500 feet) of slope paving was undermined and washed off the levee face, and a portion of the levee and embankment was washed out. The damage occurred along the south channel, approximately 365 meters (1,200 feet) downstream of the Trabuco Creek confluence. The flow during this storm was estimated to be approximately 590 cms, which corresponds to approximately a 25-year storm event.

Table 18 Structures Potentially "At-Risk" Due to Estimates Scour

Structure	Location	Watercourse	Public Safety Risk?		
			Yes	No	Undetermined
BRIDGES					
Pacific Coast Highway	--	San Juan		♦	
Camino Las Ramblas	--	San Juan	♦		
Stonehill Drive	--	San Juan	♦		
MetroLink Railroad	--	San Juan			♦
Camino Capistrano	--	San Juan	♦		
Interstate 5	--	San Juan	♦		
La Novia Avenue	--	San Juan	♦		
Lower Ortega Highway	--	San Juan	♦		
Antonio Parkway	--	San Juan		♦	
Del Obispo Street	--	Trabuco	♦		
MetroLink Railroad	--	Trabuco			♦
Oso Parkway	--	Oso			♦
BANK PROTECTION					
Sideslope Protection	106+00	San Juan	♦		
Sideslope Protection	118+00	San Juan		♦	
Sideslope Protection	125+00	San Juan	♦		
Sideslope Protection	136+00	San Juan	♦*		
Sideslope Protection	142+00	San Juan	♦		
Sideslope Protection	106+00	Trabuco	♦		
Sideslope Protection	113+50	Trabuco	♦		
Sideslope Protection	148+00	Trabuco	♦		

*Results only applicable along bend (134+00 to 138+00).

Along Trabuco Creek, the floods of February 1998 washed out a total of approximately 200 meters (700 feet) of sideslope paving in six different locations. Several of these washouts nearly resulted in a breaching of the levee and local residents were evacuated. All instances of damage except one occurred immediately downstream from grouted stone grade stabilizers, indicating that the slope paving had insufficient toe depth to withstand the scour caused by the increased turbulence in these locations. The peak flow was estimated to be 230 cms (about 8,000 cfs), which represents approximately a 25-year event. Extrapolation of the behavior of the channel, the frequency of the flood event on both channels, and the type of damage incurred provided the basis for estimating future without-project damages on both creeks due to undermining. In the absence of floodfighting efforts that temporarily stabilized the channel, the levee would have failed, with subsequent inundation of significant property on the floodplain.

While the County of Orange reports that the slope paving has withstood long-duration flows many times in the past, recent experience shows undermining of the slope paving during short-term, high-peak flows. This recent behavior may also reflect the advance downcutting of the channel in these reaches, and its potential during future flood events. The estimated peak discharges during the storm events leading to the failures were well below the design capacities for both San Juan and Trabuco Creeks.

Section Four

ENVIRONMENTAL AND CULTURAL STUDIES

The San Juan Creek watershed contains a wide variety of environmental resources, extending from headwaters to ocean, and from urban landscape to forested mountaintop. These resources include water, wildlife, cultural, and physical landscapes; in short, every physical entity that surrounds those that find themselves within the boundaries of the watershed itself. To accurately portray all of the environmental resources of the watershed would be an impossible task. They are changing daily, and in ways that no one could possibly anticipate. However, the job of this study is to address the problems impacting resources, and to recommend solutions to those problems. In doing so, the study team has to qualitatively and quantitatively describe the important attributes and functions of the resource being most affected in negative ways, and then to devise solutions that are the most cost-effective and acceptable means of reversing the damage.

A number of studies were performed in pursuance of that goal. Environmental studies included the characterization of many of the physical features of the watershed, and the way resource have been affected. The characterization included a look at the existing condition of resources, a best judgment as to their historical condition, and the same for the future "without-project" condition. This evaluation provides the study team with the information needed to assess the areas of highest impact. The areas that possess the greatest potential for improvement, and those areas that have little remaining potential. It provides the means to establish critical links, or means to reestablish habitats needed for particular species or groups of species and to develop a plan to address many of the problems facing the watershed in a way that is implementable and supportable.

To this end, the environmental resources of the watershed are evaluated qualitatively, and are discussed in the Environmental Appendix. The study team also made use of the draft Special Area Management Plan (SAMP) being developed by the Regulatory branch of the Corps of Engineers as a separate study effort. In that study effort, resources in certain areas of the watershed were evaluated using a "landscape-level" version of the Hydro-Geomorphic Method (HGM) of functional assessment of critical properties of the watershed. HGM evaluates a given stream reach based on its hydrologic, geochemical, and vegetative characteristics functionality.

It "ranks" a reach's ability to sustain wildlife and plant life, so that one can understand both its high quality and low quality aspects. This important tool is used in this study to determine the reaches of channel most impacted, and their relationship to upstream, downstream, and adjacent land areas. The study team also made use of "incremental analysis" to compare potential ecosystem restoration measures. This analysis compares measures to one another to determine the group of, or individual measures most cost-effective in restoring evaluated areas to a desired condition.

With the evaluation of reaches in hand, the study team was able to formulate measures, determine connectivity and sustainability issues, compare measures to one another, and to make a package of recommendations to be included in the watershed management plan.

The most serious environmental problems facing the watershed are water quality, degradation of biological resources, threatened and endangered species issues, cultural resource impacts, and aesthetic/livability issues. As the last issue is difficult to address in this context, it is integral to all the other issues, and by addressing degradation problems, can in itself also be addressed in a positive manner. Existing, historical, and future environmental resources are discussed in this section, and in more detail in the Environmental Appendix, with later discussion on plan formulation in that following section.

4.1 Water Quality

4.1.1 Surface Water

The San Juan Creek Watershed is within the jurisdiction of the San Diego Regional Water Quality Control Board (SDRWQCB), one of nine regional water quality control boards in California. The SDRWQCB places the San Juan Creek watershed within the San Juan Hydrologic Unit and the Mission Viejo Hydrologic Area.

There are currently no identifiable major point source dischargers of pollutants to the creeks of the watershed. Wastewater treatment facilities do not direct effluents into the creeks of the watershed. Therefore, water quality problems, except that of bacterial contamination, within the San Juan Creek watershed are believed to be primarily determined by non-point source storm water runoff from urbanized areas. There is apparently a significant, and as yet not completely defined, contribution of bacteria from wildlife sources outside of the developed areas. Because roughly one-third of the watershed has been developed, delivery of some portion of the contaminants to surface waters of the watershed may be attributed to human-related activities.

Contaminants of concern attributable to human activities include oil and grease from roadways, illicit dumping of petroleum products (e.g., waste motor oil, used antifreeze, etc.), and pesticides, herbicides, and fertilizers from golf courses, parks, and residential neighborhoods. A majority of this development has occurred along the I-5 corridor in the cities of Mission Viejo and San Juan Capistrano. Runoff from Mission Viejo primarily enters Trabuco and Oso Creeks while San Juan Creek receives runoff primarily from San Juan Capistrano. Other potential sources of contaminants to San Juan Creek may be from irrigated agriculture within the basin, as well as from mining and ranching operations.

Contaminants in the San Juan Creek watershed are not solely derived from human sources. A currently unknown volume of contaminants are also derived from other sources, including land-borne wildlife and avian populations, some of which are quite significant. Because the San Juan Creek watershed is a significant natural resource, it also contains a significant wildlife population. Bacterial contamination in the watershed is a combination of both human and wildlife sources. However, because the state-of-the-art in identification of sources is in its infancy, definitive identification of bacterial sources on a watershed-wide basis was not possible for this study effort.

Identification of contaminants and their sources is an expensive and long-term process of iterative testing, analysis, and additional testing. For this reason, treatment of all potential water quality problems will await more definitive results, which may take years. Thus, while one of the goals of this watershed study was to deal with perceived water quality problems, their solution will take far longer than the timeframe of this watershed study. However, given the early identification of bacteria as the primary contaminant of concern, initial study efforts in the water quality arena have focused on the identification of bacterial source areas within the San Juan Creek watershed. To this end, water quality studies conducted as part of this watershed study effort were focused on sampling and source tracking of bacterial pollution at numerous locations in the watershed. The results of this testing program indicated the following:

- Bacterial pollution measured by standard indicator organisms is ubiquitous in storm drains and creeks. Overall, storm drains have the highest concentrations of indicator organisms, creeks have lower concentrations, and the ocean the lowest.

- Concentrations of indicator organisms in storm drains and creeks are similar to what is expected from urban runoff. Levels indicative of large amounts of sewage contamination are not seen.

- All storm drains tested had high to moderate concentrations of indicator organisms.

- All creeks sites had moderate concentrations, including those occurring above areas of large human influence.

- Fecal coliform and enterococcus concentrations downstream of Pacific Coast Highway were markedly higher than further upstream. A possible explanation may be contamination from intervening storm drains or direct contamination by waterfowl in the estuary and creek mouth area.

- Overall water quality measured against current (REC-1) standards is poor. Storm drains and creeks meet REC-1 only rarely.

- While large storm drains have the highest concentrations, even intermittently-flowing storm drains are moderately contaminated.

- While human-related sources seem to be responsible for a significant portion of the contamination, samples taken in headwaters areas still have low to moderate levels of contamination.

Monitoring of the surface water was conducted by the Orange County Public Health Department and Laboratories and the County of Orange Public Facilities and Recreation Department. The locations and results of this testing program are provided as Exhibit A. Because of the identification and inclusion of the downstream reach of San Juan Creek on the California Regional Water Quality Control Board's list of impaired water bodies, it is expected that continued analysis and treatment of identified water quality problems will continue.

Based on testing of other constituents, the results indicate that the water quality objectives for the Mission Viejo Hydrologic Area are met in most instances. Other exceedances noted were periodic violation of total dissolved solids (TDS) standards. Heavy metals such as zinc and copper (likely derived from automobile use) also increased during storm events, but rarely exceeded standards. Turbidity values were substantially lower for samples taken during non-storm periods as compared to samples taken after storm events.

Because of its importance to residents, visitors, regulators and stakeholders, water quality issues are one of the primary areas of focus, both in the development of recommendations, and as a long-term course of action. Thus, plan formulation on water quality issues, although not as tightly focused as other issues during these initial phases, has to address numerous sources, areas of concern, and possible means of reducing the problem to manageable levels. This is discussed further in the section on plan formulation, and recommendations are made both in this report and in the watershed management plan.

4.1.2 Groundwater

The groundwater resource is important to numerous other aspects of the San Juan Creek watershed. It functions as a source, although limited, of water for the human population. It functions as a source of sustenance for wildlife populations. And lastly, as a source for vegetation. While the definitive study on groundwater for human uses in the watershed remains to be done, an understanding of its presence or absence, and its behavior, is needed to determine the sustainability and siting of ecosystem restoration projects.

Groundwater in the San Juan Creek watershed is generally concentrated in the alluvial fills, which occupy the valley areas, along both San Juan Creek and its many tributaries. Groundwater is in general unconfined, and flows from headwaters areas all the way to the ocean interface. Fill ranges from 60 meters or more at the ocean, to less than a meter in the highest elevations of the tributaries.

Groundwater movement in the watershed is influenced by the Cristianos fault, a north-south trending fault dissecting the watershed. The fault crosses (under) San Juan Creek approximately 5.6 kilometers (3.5 miles) upstream of the confluence of San Juan and Trabuco Creeks. The fault partitions the groundwater basin into upper and lower basins. While influential, the fault does not appear to have much effect on shallow groundwater flow, particularly as its effects vegetation and wildlife.

Historical sustained yield in the watershed is estimated at 6.4 cubic meters (5,200 acre-feet) per year. Sustained yield under ultimate build-out conditions is estimated at 11.1 cubic meters per year. Depth to groundwater has been estimated at 3.4 meters (11 feet) near the lower portion of San Juan Creek, to nearly 21 meters (70 feet) further upstream. Along some stretches of San Juan Creek, groundwater is forced to the surface, becoming surface flow in the creek. Some of this infiltrates into the creekbed further downstream, once more becoming groundwater.

Water quality studies done on the groundwater indicate that the major cause of concern is total dissolved solids (TDS). TDS increases as one approaches the ocean. Sulfates are nearly three times the recommended concentrate in two of three wells tested. Cadmium, iron, and manganese are also above recommended levels. Currently, due to these issues, groundwater is not used as a source of municipal drinking water supply.

Future development may put more pressure on use of this source for human use. It is also likely that increased human population may result in the contribution of more contaminants to the groundwater resource. This places even more importance on the addressing of water quality problems from all sources, as eventually this resource may be used for a broader variety of purposes. It is also important to recognize that the wildlife and vegetative resource depends on this source of water, and that its extraction must be limited to that level determined to be needed for sustenance of those resources. Because exact knowledge of the historical levels of groundwater, and its influence on surface water, are not yet understood, further study of this issue is strongly recommended.

4.2 Biological Resources

The biological resources of the San Juan Creek Watershed were assessed by various means. Existing data were evaluated from recent documentation and augmented by field reconnaissance. During these surveys, vegetation communities were mapped on March 1998 color aerial photographs. However, because of the late seasonal timing of these surveys, early seasonal ephemeral plant species should not have been observable. Lastly, though no focused sensitive species surveys were conducted, any sensitive species observed during the three surveys were recorded. General wildlife surveys were not conducted; however, wildlife species were recorded during the course of the vegetation surveys. Details of these surveys are provided in the Environmental Appendix.

4.2.1 Vegetation

Description of vegetational communities followed those of Holland (1986) and the County of Orange Habitat Classification System (1992). Scientific nomenclature followed that of Hickman (1993). A total of 16 vegetation communities were mapped within the San Juan Creek watershed as part of the County of Orange's regional vegetation mapping effort. Limited ground truthing and reconnaissance was performed at representative stands of some of the vegetation communities during August and September 1998 to obtain information on the sub-associations and species composition.

A diversity of vegetation communities typifies most portions of the San Juan Creek watershed that have not already been intensely developed. Riparian woodlands and forests occur along most portions of the stream courses that remain relatively undisturbed such as San Juan Creek from its headwaters to its confluence with Oso Creek; Cañada Gobernadora and its tributaries; Bell Canyon and its tributaries; many of the tributaries to San Juan Creek including Cold Spring, Hot Spring, Lion, Long, Lucas, and Verdugo Canyons; and Trabuco Creek and its tributaries including Tijeras Canyon. Sporadic patches of riparian habitat occur along Oso and Horno creeks, and a thin band of riparian vegetation occurs along Cañada Chiquita.

The slopes and mesa above the many stream courses and drainages are vegetated with either coastal sage scrub or chaparral communities. Coastal sage scrub is the dominant, upland vegetation community along the coastal, foothill slopes from west of Cañada Chiquita to the slopes west of Cold Spring Canyon. With increasing elevation, chaparral communities replace coastal sage scrub such as near the boundary of the Cleveland National Forest. Within the Cleveland National Forest (upper Oso, Trabuco, and Bell Canyon Creeks), coastal sage scrub is generally restricted to xeric, south facing slopes. Oak woodlands and forests become common at the upper reaches of the watershed on north-facing slopes and along drainages.

The portion of the watershed west and south of Cañada Gobernadora has undergone or is undergoing rapid development. Much of the natural vegetation within this area had been converted to agriculture uses and/or urbanization. Coastal sage scrub was most likely the natural vegetation community that was replaced by these other uses. Intense urbanization has occurred along the western and southern portions of the watershed within the communities of Mission Viejo, San Juan Capistrano, Laguna Niguel, Dana Point, Laguna Hills, Coto De Caza, Dove Canyon, and Rancho Santa Margarita. Extensive areas of agriculture and grasslands occur from the mesas to the east of Cañada Gobernadora southwest to the border of San Juan Capistrano and west to the border of Mission Viejo.

More detailed information of the scrub, chaparral, grassland, wetland, woodland, and forest communities, as well as those habitats associated with cliff and rock outcropping, coastal or marine areas within the watershed, freshwater water bodies, and agricultural, disturbed, or developed areas is provided in the Environmental Appendix.

4.2.2 Wildlife

The aforementioned vegetation communities provide habitat for a diverse fauna. Vegetation provides foraging habitat, breeding habitat, and cover, as well as wildlife movement corridors. At the landscape level, vegetation communities co-occur in a diverse mosaic. In this mosaic, ecotones are formed at the boundaries between vegetation communities. Ecotones generally contain a mixture of floral and faunal species from the adjacent communities and as such can typically support a higher diversity of species than the adjacent communities can. Ecotonal edges can be sharp, such as those between a marsh and upland area, or they can gradual, such as those between sage scrub and chaparral communities.

Wildlife species can be specialists (i.e., restricted to one or a few different habitats over their lifetime) or they can be generalists (i.e., having a broad range of habitats that they inhabit). Wildlife species may forage in one type of habitat yet breed in a different one. Similarly, wildlife species may spend a portion of the season in one habitat type and the remainder in another.

Because of the high diversity and mosaic distribution of vegetation within the watershed and diverse topographic features, the watershed supports a high diversity of wildlife species. This is especially evident in the undisturbed areas of the watershed such as the Cleveland National Forest. The *Planning Aid Report*, prepared by the USFWS (1996), for the "Aliso Creek and San Juan Creek Watershed Management Study, Orange and Riverside Counties, California" identified 12 species of invertebrates, five species of fish, 12 species of amphibians, 35 species of reptiles, 143 species of birds, and 42 species of mammals. A list of these species and the habitat(s) where they occur is provided in the Environmental Appendix.

4.2.3 Sensitive Resources

4.2.3.1 Sensitive Habitats

Sensitive habitats are communities that are distinguished in several ways: (1) identified by the California Department of Fish and Game (CDFG) with the Highest Inventory Priority (Holland 1986); (2) regulated by Federal or State agencies (e.g., wetland and riparian habitats); and/or (3) listed as Habitat Types of Special Interest in Orange County (County of Orange, 1992). Table 19 identifies all the Habitat Types of Special Interest in Orange County and provides their California National Diversity Data Base (CNDDB) designations. Habitats are generally considered sensitive because they support rare and endangered species and/or because very little of these habitat(s) remain. Many sensitive habitats have suffered significant losses due to urbanization or conversion to other habitat types such as agriculture. The communities identified as sensitive in Table 19 are discussed in fuller detail in the Alternatives Analysis Report..

4.2.3.2 Sensitive Species

Sensitive plant species are those that are federally listed by the USFWS (1998a), are State listed by the CDFG (1998b), occur on the California Native Plant Society's (CNPS) Inventory of Rare and Endangered Vascular Plants of California (1998), and/or are considered plant species of special interest within Orange County. Sensitive animal species are those that are federally listed by the USFWS (1998a), are state listed by the CDFG (1998a), and/or are considered special animals by the CDFG (1998c).

Table 19 Habitat Types of Special Interest in Orange County

Habitat Types of Special Interest	CNDDB Designations[1]		
	Communities with the Highest Inventory Priority	**Global Rank**	**State Rank**
1.1 Southern coastal foredunes[2]	Yes	G2	S2.1
1.2 Southern dune scrub[2]	Yes	G1	S1.1
2.1 Southern coastal bluff scrub[2]	Yes	G1	S1.1
2.2 Maritime succulent scrub[2]	Yes	G2	S1.1
2.3 Venturan-Diegan transitional sage scrub (four sub-types)	Yes	G3	S3.1
2.4 Southern cactus scrub	N/A	N/A	N/A
2.5 Riversidian coastal sage scrub	Yes	G3	S3.1
2.6 Floodplain sage scrub	Yes	G1	S1.1
3.6 Southern maritime chaparral	Yes	G1	S1.1
3.11 *Nolina* chaparral	N/A	N/A	N/A
4.2 *Elymus* grassland	N/A	G3	S3
4.3 Southern coastal needlegrass grassland	Yes	G3	S3.1
4.4 Deergrass grassland	N/A	G3	S3
4.5 Coast live oak savanna	N/A	N/A	N/A
5.1 Southern hardpan vernal pool	Yes	G1	S1.1
5.2 Alkali meadow	Yes	G3	S2.1
5.3 Freshwater seep	Yes	G4	S4
6.1 Southern coastal salt marsh[2]	Yes	G2	S2.1
6.2 Coastal brackish marsh	Yes	G2	S2.1
6.3 Cismontane alkali marsh	Yes	G1	S1.1
6.4 Coastal freshwater marsh	Yes	G3	S2.2
7.1 Riparian herb	N/A	N/A	N/A
7.2 Southern willow scrub	Yes	G3	S2.1
7.3 Mulefat scrub	N/A	G4	S4
7.6 Southern arroyo willow forest	Yes	G2	S2.1
7.7 Southern black willow forest	N/A	N/A	N/A
7.8 Southern cottonwood-willow riparian forest	Yes	G3	S3
7.9 White alder riparian forest	Yes	G3	S3

Table 19 Habitat Types of Special Interest in Orange County

Habitat Types of Special Interest	CNDDB Designations[1]		
	Communities with the Highest Inventory Priority	Global Rank	State Rank
7.10 Canyon live oak ravine forest	Yes	G3	S3.3
8.1 Coast live oak woodland	N/A	G4	S4
8.2 California walnut woodland[2]	Yes	G2	S2.1
8.3 Cismontane juniper woodland	N/A	G2	S2.1
9.1 Coast live oak forest	N/A	G4	S4
9.2 Canyon live oak forest	N/A	G4	S4
9.3 Coulter pine forest	N/A	G3	S3.2
9.4 Knobcone pine forest[2]	Yes	G4	S4
9.5 Southern interior cypress forest	Yes	G2	S2.1
9.6 Bigcone spruce-canyon live oak forest	N/A	G3	S3.1
10.1 Xeric cliff faces	N/A	N/A	N/A
10.2 Mesic cliff faces	N/A	N/A	N/A
10.3 Rock outcrops	N/A	N/A	N/A
11.1 Marine open water and subtidal	N/A	N/A	N/A
11.2 Bay and lagoon open water	N/A	N/A	N/A
11.3 Rocky shore and intertidal zone	N/A	N/A	N/A
11.4 Sandy beach and tidal flats	N/A	N/A	N/A
13.1 Perennial rivers and streams	N/A	N/A	N/A
13.2 Intermittent streams and creeks	N/A	N/A	N/A

[1] The Nature Conservancy Heritage Program Status Ranks (adopted by the CNDDB)

Global Ranks
G1: Fewer than 6 viable occurrences worldwide and/or 2,000 acres.
G2: 6-20 viable occurrences worldwide and/or 2,000-10,000 acres.
G3: 21-100 viable occurrences worldwide and/or 10,000-50,000 acres.
G4: Greater than 100 viable occurrences worldwide and/or greater than 50,000 acres.
G5: Community demonstrably secure due to worldwide abundance.

State Ranks
S1: Fewer than 6 viable occurrences statewide and/or 2,000 acres.
S2: 6-20 viable occurrences statewide and/or 2,000-10,000 acres.
S3: 21-100 viable occurrences statewide and/or 10,000-50,000 acres.
S4: Greater than 100 viable occurrences statewide and/or greater than 50,000 acres.
S5: Community demonstrably secure due to statewide abundance.

Threat Ranks
0.1: Very threatened.
0.2: Threatened
0.3: No current threats known

[2] Habitats with either no or low potential for occurrence within the San Juan Creek Watershed

A total of 18 federally listed species occur or have the potential to occur within the San Juan Creek Watershed. These species are:

- Thread-leaved brodiaea (*Brodiaea filifolia*)
- Big-leaved crown-beard (*Verbesina dissita*)
- Vernal pool fairy shrimp (*Branchinecta lynchi*)
- San Diego fairy shrimp (*Branchinecta sandiegonensis*)
- Riverside fairy shrimp (*Streptocephalus woottoni*)
- Quino checkerspot butterfly (*Emphydryas editha quino*)
- Tidewater goby (*Eucyclogobius newberryi*)
- Unarmored three-spined stickleback (*Gasterosteus aculeatus williamsoni*)
- California red-legged frog (*Rana aurora draytoni*)
- Arroyo southwestern toad (*Bufo microscaphus californicus*)
- Least Bell's vireo (*Vireo bellii pusillus*)
- Southwestern willow flycatcher (*Empidonax traillii extimus*)
- Coastal California gnatcatcher (*Polioptila californica californica*)
- California least tern (*Sterna antillarum browni*)
- Bald eagle (*Haliaeetus leucocephalus*)
- American peregrine falcon (*Falco peregrinus anatum*)
- Western snowy plover (*Charadrius alexandrinus nivosus*)
- Pacific pocket mouse (*Perognathus longimembris pacificus*)

This list was generated from a Planning Aid Report completed by the USFWS for San Juan Creek (USFWS, 1996). A detailed description of all the federally listed species that could potentially occur within the San Juan Creek Watershed is provided in the Environmental Appendix. These descriptions provide information on species' biology, distribution, habitat requirements, and historical trends. The Environmental Appendix also contains a list of an additional 50 sensitive species that potentially could occur within the San Juan Creek Watershed. The species included on this list reflect known occurrences from the following USGS Quads: El Toro, Santiago Peak, Alberhill, Sitton Peak, San Clemente, Dana Point, San Juan Capistrano, and Cañada Gobernadora, as portions of the San Juan Creek Watershed coincide with portions of these quads. Other site specific location information was gathered from the Foothill Transportation Corridor (FTC) Study (MBA, 1997). No detailed descriptions of the non-federally listed species' biology, distribution, habitat requirements, etc., are provided. In addition to the species listed in the Environmental Appendix, there are many other sensitive species that could occur within the watershed, but for which site-specific information was not available. These species are listed in the County of Orange's Habitat Classification System.

4.3 Cultural Resources

Cultural resource is a term that refers to the imprint of human occupation left on the landscape. This imprint is manifested in the form of prehistoric and historic archeological sites, historic buildings, structures, and objects. Archeological sites consist of artifacts, plant and faunal remains, trash deposits, and many types of features. Artifacts reflect anything that was manufactured or modified by human hands. Features can include structural remains, fire pits, and storage areas.

Cultural resource sites are both important to residents and scholars, but also in the plan formulation process. Cultural resource sites have the potential to be impacted by structural solutions, and thus an understanding as to their locations and extent in critical. Avoidance of known cultural resource sites is a factor in the siting of solutions, but if not possible, becomes an important factor in construction and operations and maintenance.

Prehistoric archeological sites are loci of human activity occurring before European contact. European contact was first made in the southwest with the Spanish entry into this watershed in the 1760's. Artifacts include flaked stone tools such as projectile points, knives, scrapers, and chopping tools; ground stone implements like manos and metates; plain and decorated ceramics; and features or facilities which include subterranean and above-ground architectural units, hearths, granaries and storage cysts, and trash deposits known as middens.

Historic archeological sites reflect occupation after the advent of written records. Material remains on historic archeological sites include refuse dumps, structure foundations, roads, privies, or any other physical evidence of historic occupation. Refuse consists of food waste, bottles, ceramic dinnerware, and cans. In a number of historic archeological situations privies are important because they often served as secondary trash deposits. There is usually a strong interplay between historic archeological sites and written records. The archeological data is frequently used to verify or supplement historic records. Historic structures include commercial and residential buildings, industrial facilities, bridges, and roadways.

There are two principal methods of locating cultural resources. Before starting a project, a records and literature search is conducted at any number of repositories of archeological site records. The search may show that an archeological or historical survey had been conducted, and some cultural resources were identified. That information may be enough to proceed with the significance evaluation stage of the project. If a conclusion was reached that (1) no previous survey had been done or (2) a previous survey was either out of date or inadequate, the project cultural resources expert, either a historian or archeologist, will need to carry out a pedestrian surface survey to determine if any cultural resources are within the proposed project boundaries.

After a cultural resource has been determined eligible for inclusion in the National Register, it is accorded the same level of protection as a property that is included. It then becomes formally known as a historic property regardless of age. Historic property status may be applied to individual cultural resources or to a group of cultural resources that are united by a theme or context. The combined historic properties are then designated as either a historic or archeological district and the individual elements are called contributors.

4.3.1 Records and Literature Search Results

A records and literature search was conducted at the South Central Coastal Information Center at the University of California, Los Angeles (UCLA). The information available at the Information Center consists of hardcopy of both current and historic records and maps. Using this information, the location and description of known historic and prehistoric resources can be determined. An analysis of this information makes it possible to evaluate the potential for resources to be located in areas that have not yet been surveyed. Furthermore, this information is useful in planning for future studies of an area.

No historic or prehistoric resources appear to be impacted by proposed alternative measures within the channels, except for the proposed detention basin on San Juan Creek at Cañada Gobernadora, and the detention basin on Trabuco Creek. The proposed detention basin on San Juan Creek at Cañada Gobernadora is located near known archaeological resource sites. These include CA-ORA-29, the Mission Viejo site. Recent subsurface investigations (Van Wormer, 2002) have uncovered significant remains, including evidence of two structures and numerous historic artifacts. Native American stone artifacts were also located. This site appears to be eligible for listing on the National Register of Historic places. In addition to the Mission Viejo site, prehistoric sites CA-ORA-1048, 1049, 1050, and 1121 are very close to the potentially inundated portion of the Cañada Gobernadora basin. The proposed detention basin on Trabuco Creek is located near site CA-RIV-1337. Prior to project implementation, an updated records and literature search, and pedestrian survey is recommended for each location to confirm the absence of resources.

Section Five

REGULATORY CONSIDERATIONS

This section, Regulatory Considerations, presents regulatory-related issues and considerations of importance to the San Juan Creek Watershed Study as identified by the Los Angeles District Regulatory Branch of the Corps of Engineers. Issues discussed in this section include (1) NEPA/CEQA compliance and cumulative impacts, (2) permit requirements, (3) operation and maintenance activities, (4) environmental restoration activities, and 5) implementation of a regulatory authorization instrument for an integrated watershed management plan.

The Regulatory Branch is participating in this watershed study and is also developing plans in response to permit requests in many locations in the San Juan Creek watershed. In addition, through funding provided by Congress, the Regulatory Branch has contracted the development of a watershed-wide environmental assessment of water and related land resources, utilizing a modified (landscape-level) application of the Hydro-Geomorphic Methodology (HGM) model of functional assessment. This assessment and the resulting plan developed by the Regulatory Branch will be used in response to a large permit request, resulting in a Special Area Management Plan (SAMP), for development on one of the largest privately held properties in the watershed, that of the Rancho Mission Viejo Company. The SAMP is discussed in more detail later in this section.

It is important to note that the reaches as discussed in this document, are different from the "functional reaches" defined in the SAMP. This should not be an issue except as a reminder to those with involvement in both efforts.

5.1 NEPA/CEQA Compliance

In the early stages of this watershed study, the Corps filed a Notice of Intent (NOI) to prepare a Programmatic Environmental Impact Statement/Environmental Impact Report (EIS/EIR) under the authority of the National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA). It was the intention of the Corps and County, as a jointly sponsored process, to have suitable documentation of proposed activities accompany the final watershed study report. This approach has had to be modified, due to the fact that no specific project recommendation will be forwarded to Congress with this document, and the report will not directly result in the implementation of any projects by the Corps. Instead, when the County or other local governments, or the Corps, in the future propose to implement actions identified conceptually in this report, environmental documents will be prepared at that time for the specific action or program, accompanied by a “spin-off” document dealing with a specific stand-alone project for authorization by Congress or other (presumably State) authority. The environmental documentation accompanying this report is referred to as an Environmental Assessment.

Any future NEPA/CEQA documents and consultation under the Endangered Species Act (ESA) will require an evaluation of cumulative impacts in the watershed and the extent to which proposed actions worsen or improve the existing habitat conditions. The Corp’s Regulatory Branch is responsible for assessing the extent of these cumulative impacts in rendering Section 404 permit decisions. This analysis includes an assessment of historic, current, and reasonably anticipated future activities in the watershed, by various entities, to evaluate the effects of proposed activities on watershed conditions.

5.2 Cumulative Impacts

The San Juan Creek watershed is in the process of experiencing rapid development of its remaining open space. The establishment of numerous parks and reserves in the watershed serve as evidence of the desire of the county, state, and local agencies and of individuals for protection of the area’s valuable natural resources. These parks offer refuge for sensitive plant and animal species and protect unique regional habitats and a variety of upland, riparian, and aquatic habitats. These parks also help to moderate the changes imposed on the hydrologic system. However, these parks are unable to prevent the continuing degradation within the watershed. Many of the natural functions of the creek corridor have been severely impaired resulting in environmental, social, and economic impacts. As development proceeds in a watershed, areas within the watershed can become increasingly sensitive to additional impacts, which can be observed by the elimination of habitats or species at specific sites, subareas, or the entire watershed.

Watershed and cumulative problems cannot be adequately addressed in a site-specific manner. Rather, a watershed-scale approach is necessary to understand the natural hydrologic and geomorphic processes that create and sustain habitats and how to maintain these natural processes over time. This watershed study provides a framework for such a watershed-scale approach.

Based on a search of the Corps' Regulatory database in 2002, approximately 104 Section 404 permits have been issued for activities in this watershed since passage of the CWA in 1972. This rate of permitting may be expected to continue in the near future as several large development proposals are evaluated and mitigation plans developed and agreed upon by various regulatory agencies. Some development in the San Juan Creek watershed occurred before the passage of the Clean Water Act in 1972, and many activities also occurred before the implementation of significant restrictions in the Regulatory Program in 1985 and 1996. Prior to 1985, the Los Angeles District Regulatory Branch had no authority to regulate discharges of fill materials in waters of the U.S. above the headwaters (areas where mean annual water flow is less than 5 cubic feet per second [0.14 m^3/s]). Thus, activities in the entire upper half and much of the lower half of the watershed did not require Section 404 authorization before 1985. In 1996, the reporting requirements associated with the Nationwide Permit program were substantially increased. Before 1996, impacts from individual projects totaling less than 1 acre [0.4 hectares] and not affecting Federally listed endangered or threatened species or cultural/archaeological resources were authorized to proceed without approval from regulatory authorities.

5.3 Operation and Maintenance Activities

Similar to the requirements for construction activities, discharge of any dredged or fill material into a water of the U.S. during the operation and maintenance (O&M) of an existing facility will first require authorization from the Corps Regulatory Branch, unless the Corps itself is the discharger. The following are examples of O&M activities that often involve discharges of dredged or fill material: clearing of vegetation, debris, and sediment from soft-bottomed channels and basins; repair of bank protection; and replacement of culverts. The Regulatory Branch is willing to work with local flood control and water districts to develop long-term maintenance programs for problem areas in the watershed. Depending on the nature and extent of the activities, the Regulatory Branch could issue individual permits or regional general permits for implementing activities in accordance with developed and approved maintenance plans.

5.4 Environmental Restoration Activities

The Los Angeles District Regulatory Branch is responsible for authorizing any restoration, creation, and enhancement activities that involve discharge of dredged or fill material in waters of the U.S., including wetlands. The Corps Regulatory Branch has recognized that there are numerous suitable restoration sites in this watershed. There are also numerous enhancement opportunities in the watershed, such as eradication efforts directed at giant reed (*Arundo donax).* The Regulatory Branch, environmental agencies and interest groups are interested in eliminating this noxious weed from the entire watershed. Once a local agency sponsor can be identified, the Regulatory Branch would be interested in setting up a mitigation banking instrument or an in-lieu fee program to formalize and coordinate this effort.

There are numerous other non-native and invasive species in this watershed that compromise riparian resource integrity. All parts of the watershed have been infested to differing degrees by pampass grass, tree tobacco, tamarisk, castor bean, various thistle species, pepper tree, eucalyptus tree, mustard, and vinca. Control of these species could be included in the mitigation bank or in-lieu fee program that the Regulatory Branch hopes to create for giant reed removal.

Habitat creation opportunities are generally limited by land availability and proximity to hydrologic sources. The Regulatory Branch prefers that any new habitat creation be done where the sites would be subject to natural hydrology (i.e., associated with a jurisdictional water of the U.S.). This desire has been incorporated into the plan formulation of ecosystem restoration alternatives developed for this watershed management effort and discussed later in this document. All recommended sites have access to naturally-occurring surface and groundwater flow for which supplementation is not needed.

Simple creek widening or lowering of upland terraces, where feasible in light of engineering constraints, can provide exceptional habitat creation opportunities. In addition, creation of detention basins can provide wetland creation opportunities while also satisfying flood control and water quality needs. Much of this thinking was utilized in the remainder of the study effort, focused on problems, opportunities, plan formulation, and development of a watershed management plan.

5.5 Integrated Watershed Plan Regulatory Authorization

One goal of the watershed study effort, which is viewed as a long-term iterative and changing process, is to provide *regulatory* tools for balancing competing uses of the river corridor and to efficiently manage watershed resources. Regulatory Guidance Letter 86-10 authorizes the Regulatory Branch to prepare (as mentioned earlier in this section) Special Area Management Plans (SAMPs) for regions with sensitive environmental resources that are subject to intense developmental pressure. This SAMP is being prepared for portions of the San Juan Creek watershed, primarily lands owned by the Rancho Mission Viejo Company.

The development of the SAMP requires a full accounting of watershed resources, their level of functioning, the competing land-uses, and cumulative impacts from past, present, and future activities in order to develop an efficient permitting scheme. Once a full assessment of these resources and interests is complete, the Regulatory Branch will be able to decide which activities and locations might be acceptable with minimal permitting requirements (i.e., under a Regional General Permit or verification under existing nationwide permits), which activities and locations might only be acceptable after intensive public and Regulatory review (i.e., an individual permit), and which activities and locations warrant more study. The ultimate purposes of the SAMP are to provide comprehensive planning of a large regulatory permit action that will increase efficiency, streamline the permitting process, and provide a foundation for watershed-level aquatic and riparian resource reserve program implementation. To date, Phase 1 of this process has been substantially completed. This includes the aquatic resource identification (delineation), and aquatic resource characterization (functional assessment). Development of criteria and alternatives, analysis and evaluation of the permittee's proposed projects, development of the aquatic reserve program, development of the draft restoration plan, and issuance of a draft EIS/EIR will follow in Phase 2. Phase 3 will result in the issuance of programmatic level permits and a final EIS/EIR.

Incorporation of efforts conducted under other programs will be another important aspect of Corps of Engineers Regulatory Branch and Planning Branch coordination. Modifications to the County of Orange's General Plan, the Natural Community Conservation Plan being developed by the County, Ranch, California Department of Fish and Game, and the SAMP/MSAA (State of California version of the SAMP – Master Streambed Alteration Agreement) being developed by COE Regulatory, the County, the Ranch, and California Department of Fish and Game, will need to be coordinated in future phases of study, and by all parties concerned.

Section Six

ECONOMIC STUDIES

This section presents a discussion of the economic analysis conducted for the watershed study. The importance of quantifying economic damages is their use in establishing Federal interest for project construction, in this particular case, for justification of flood control and channel stabilization measures. The Corps of Engineers must establish that the costs of a project are outweighed by its potential economic benefits in order for it to qualify for Federal cost-sharing. The purpose of the economic analysis is to measure the potential damages, for each potential flood event, due to flood inundation and erosion along San Juan, Trabuco, and Oso Creeks. Included in this discussion is a brief description of the methodologies used and a summary of the results of the economic analysis. Detailed documentation of the economic analysis is provided in the Economic Appendix.

6.1 Historic Flood Damages

Historic flooding and erosion damage was researched as part of the watershed study. Historic damages were quantified in Corps of Engineers reports, County reports, and discussion with city managers, utility agencies and water districts. Damage data on the recent El Niño winter storms of 1997 and 1998 were compiled primarily through correspondence with local/regional government bodies and utility districts. All dollar estimates of damages from past storms presented in this report have been converted to their equivalent value in 2002 dollars. A summary of these damages is presented in Table 20 and Table 21. Table 20 shows flooding and erosional damages from 1937 to 1995. Table 21 shows flooding and erosion damages from 1996 to 1999.

6.2 Economic Analysis Methodologies

This economic analysis was formulated in accordance with Corps of Engineers regulations and guidance. The base price level for the analysis is April 2002, and the period of analysis was 50 years. A discount rate of $6^1/_8$ percent is used. The analysis employed the HEC-Flood Damage Assessment (HEC-FDA) computer program to measure flood inundation damages in a risk-based environment. The most likely future year in the HEC-FDA model was set at year 2030 with a base year of 2008. The future year was determined based upon the projected growth for Orange County and the limited available developable land within the study area.

Structures within the San Juan Creek floodplain were identified by a combination of aerial photographs and field surveys. The floodplain was defined as everything contained within the 500-year event inundation area. The value of structure contents was estimated using the Depreciated Replacement Cost (DRC). For residential structures, content value was based on 50 percent of DRC. For industrial/commercial structures, content value was based on 100 percent of DRC.

Table 20 Historical Flood Damages, Erosion Damages, and Damages from Unknown Factors

(2002 Dollars)

Stream	Year	Damage	Type of Damage
San Juan Creek	1937	$24,442,000	Agriculture, buildings, highways, utilities
	1938	NA	Water lines, bridges, loss of life
	1969	$7,465,000	Recreational inundation, bridges, land loss
	1969	$7,916,000	Erosion of flood control facilities
	1993	$809,000	Erosion of sewer lines, flood control facilities
	1995	$1,491,000	Erosion of land, bridges, sewer line
	1995	$991,000	Recreational inundation
Trabuco Creek	1969	$5,119,000	Bridges, unknown factors
	1993	$985,000	Erosion damage to stream bank, water and sewer lines
	1995	$255,000	Erosion of stream bank and flood control channels
	1995	$118,000	Bike path damage
Oso Creek	1969	$247,000	Agricultural
	1983	$897,000	Sewer line erosion
	1993	$3,452,000	Sewer line, bank, flood control structure erosion
	1995	$1,039,000	Flood control channel infrastructure erosion

Sources: Corps of Engineers, Flood Plain Information Report, San Juan Creek; Corps of Engineers PL-99 After Action Report, 1998; County of Orange records, City of San Juan Capistrano, City of Dana Point, South Orange County Water Authority.

Table 21 1996-1999 Flooding and Erosion Damages Summary

(2002 Dollars)

Location	Owner	Description	Cost	Secondary Impacts
Doheny state Beach	State of California—Dept. of Parks and Recreation	Miscellaneous debris, hazardous and non-hazardous, including assorted plant material, (arundo sp.) was deposited on State Beach	$59,000	The establishment of the arundo sp. in Doheny state Beach.
Antonio Parkway at San Juan Creek	Antonio Parkway Bridge over San Juan Creek. Orange County Road Department	Bridge under construction was damaged by storm flow discharge. Partially completed work was destroyed. Damaged December 1997	$164,000	Delay in opening Antonio Parkway to public access.
From Coast Highway Bridge upstream to Camino Capistrano	San Juan Creek Channel (L01), Orange County Flood Control District	Off site lateral erosion created voids behind the channel slope paving at several locations. Damaged Winter 1996	$4,600	N/A
Upstream from Del Obispo Street (2 sites) San Juan Capistrano	Trabuco Creek Channel (L02), Orange County Flood Control District	Approximately 110 linear feet of concrete channel slope protection failed and collapsed. Damaged February 1998	$19,000	Reduced level of flood protection for surrounding community.
Upstream from Del Obispo Street (2 sites) San Juan Capistrano	Trabuco Creek Channel (L02), Orange County Flood Control District	Approximately 110 linear feet of concrete channel slope protection failed and collapsed. Damaged February 1998	$20,000	Reduced level of protection for surrounding community.
Downstream Del Obispo at City-owned pedestrian bridge crossing.	Trabuco Creek Channel (L02), Orange County Flood Control District	Concrete channel slope paving failed and collapsed at this site thereby threatening the city's bridge. The City relocated the bridge to a new location after the storm flows receded. Damaged December 1997	$42,000	Inaccessibility of city-owned bridge.
Approximately 6,000 linear feet from Stonehill Drive, San Juan Capistrano	San Juan Creek Channel (L01) Orange County Flood Control District	Approximately 505 linear feet of concrete channel slope protection failed and collapsed. Damaged February 1998	$97,000	Reduced level of flood protection for surrounding community.
Approximately 6,000 linear feet upstream from Stonehill Drive, San Juan Capistrano	San Juan Creek Channel (L01) Orange County Flood Control District	Approximately 505 linear feet of concrete channel slope protection failed and collapsed. Damaged February 1998	$545,000	Reduced level of flood protection for surrounding community.
Upstream from the I-5 Freeway (approximately 1000 feet)	Trabuco Creek Channel (L02) Orange County Flood Control District	Storm flows damaged pile driven slope protection fencing. Trees and general storm debris became caught upon the damaged fence. This debris then diverted flows against adjacent slopes. Damaged February 1998	$18,000	Damage to adjacent private property
Downstream from Camino Capistrano (Approximately 500 feet)	Trabuco Creek Channel (L02) Orange County Flood Control District	Storm debris diverting creek flow against levee embankment. Damaged Winter of 1996	$12,000	N/A
Downstream from Del Obispo Street (2 sites) San Juan Capistrano	Trabuco Creek Channel (L02) Orange County Flood Control District	Approximately 230 linear feet of concrete channel slop lining failed and collapsed. Damaged December 1997	$60,000	Reduced level of flood protection for surrounding community.
Downstream from Del Obispo Street (2 sites) San Juan	Trabuco Creek Channel (L02) Orange County Flood	Approximately 230 linear feet of concrete channel slope lining failed and collapsed. Damaged December 1997	$261,000	Reduced level of flood protection for surrounding

Table 21 1996-1999 Flooding and Erosion Damages Summary

(2002 Dollars)

Location	Owner	Description	Cost	Secondary Impacts
Capistrano	Control District			community.
Downstream from Del Obispo Street (3 sites) San Juan Capistrano	Trabuco Creek Channel (L02) Orange County Flood Control District	Approximately 310 linear feet of concrete channel slope paving failed and collapsed. Damaged February 1998	$66,000	Reduced level of flood protection for surrounding community.
Downstream from Del Obispo Street (3 sites) San Juan Capistrano	Trabuco Creek Channel (L02) Orange County Flood Control District	Approximately 310 linear feet of concrete channel slope paving failed and collapsed. Damaged February 1998	$355,000	Reduced level of flood protection for surrounding community.
Trabuco Creek at AT&SF Railroad Bridge	Moulton Niguel Water District; Santa Margarita Water District	March 1998 storms washed out natural creek bottom and broke a sewer line and an effluent transmission main. Temporary pumping was needed to bypass flows. Permanent fix included sheet piling for added protection to pipelines.	$1,642,000	Need a permanent solution for bank and stream bed stability.
Oso Creek along Camino Capistrano s/o of Avery Parkway	Moulton Niguel Water District; Santa Margarita Water District	El Nino storms of March 1998 caused slide that broke sewer line and caused sewage to flow into Oso Creek. Temporary pumps had to be installed to bypass sewage flow; pipe had to be replaced.	$415,000	All affected agencies are investigating a long term solution to stabilizing the banks of Oso Creek.
Oso Creek 4,000 feet North of Oso Creek & Trabuco Creek	Capistrano Valley Water District	1997-1998 rain season, El Nino, continued erosion to a point where a lens failure occurred. This failure impacted the Amtrak Railway, CVWD's 24" Line, a 30" Gas line, a sewer effluent line, and the I-5.	$55,000	CVWD has spent staff time valued at $10,000 NOTE: these figures don't include cost of repair to railroad, Camino Capistrano, I-5, 30" Gas Line, sewer line, or non domestic line
Hickey Creek at Shady Lane and Sycamore Drive	Trabuco Canyon Water District	During February 1998 storms, the creek eroded and exposed 6" AC pipeline crossing creek. Cobble rock pushed by rapidly moving streamflow impacted exposed pipeline, creating a 4" hole on upstream side. Pipe bedding was removed and replaced by cobble pushed from upstream sources by streamflow.	$16,000	Entire system in area of break was shut down in an attempt to locate damage. Customers without water for a full day.
34152 Del Obispo, Dana Point	South East Regional Reclamation Authority (SERRA)	A storm event on 1/28/80 and 1/29/80 pronounced runoff into the drainage areas to the north and northeast of the SERRA treatment facility in Dana Point. Normally, this runoff would have been carried via a system of culverts and ditches to San Juan Creek. Because some of the drainage system outlets to the creek were plugged, the runoff ponded at the facility's	$1,697,000	Untreated sewage from the facility impacted the outlet of San Juan Creek to the Pacific Ocean and subsequently the surrounding beaches.

Table 21 1996-1999 Flooding and Erosion Damages Summary

(2002 Dollars)

Location	Owner	Description	Cost	Secondary Impacts
		northern levee, forming a lake estimated to be 18.25 feet deep. On 1/29/80, the ponded runoff overtopped the levee, continuing until the levee was breached, causing the water to pour through the opening into the SERRA facility. The waters caused extensive damage to buildings and equipment and rendered the plant useless for treating wastewater until the damage was repaired.		

6.3 Without-Project Flood Inundation Damages

Expected annual damages to structures and their contents in the San Juan Creek watershed were estimated to provide a baseline forecast of anticipated future damages without the implementation of any new watershed management activities. This baseline will serve as the standard for comparison for any alternative plans proposed in the watershed study aimed at alleviating inundation damages.

As mentioned earlier in this report, historic flood damages were used to establish current and future potential flood damages by event. Analysis of past flood events indicates that there are two potential ways (mechanisms) that flood damages might occur. One is overtopping of the existing levee system. Based on the hydrologic/hydraulic analyses conducted during this study, the overtopping event is estimated to occur during a 2% exceedance (roughly a 50-year) flood event. Water would begin to overtop the levee, eventually inundating structures in the floodplain, with the number and location dependent on the magnitude (frequency) of the flood event. The 1% exceedance (roughly 100-year) and 0.2% exceedance (roughly 500-year) floodplain boundaries are illustrated in Section 3.2 of this report. The second way that flood damages may occur is that of undermining of the levee with subsequent failure and inundation of the floodplain. The frequency of undermining (a.k.a. “geotechnical” failure) was based on levee performance during the 1998 flood event. During that event, which was later estimate at approximately 4% exceedance (25-year) frequency, the levee linings on both Trabuco and San Juan Creeks began to fail by undermining. If it were not for emergency floodfighting conducted by the County of Orange with assistance from the Corps of Engineers, the levees could have failed, causing inundation of a portion of the floodplain. The potential frequency of future flooding then is based on this frequency, as it is assumed that future flood events of that magnitude may cause similar problems. While past events (prior to 1998) did not cause problems of this type, the extent to which downcutting (lowering of the channel bed due to erosion) has occurred to date has now caused there to be an inadequate degree of protection for the toe of the channel lining.

6.3.1 Watershed Floodplain Inventory

To estimate expected annual (and by event frequency) flood inundation damages, a complete survey of structures within the San Juan Creek regulatory floodplain was conducted. This survey identified 4,119 structures at risk of flood inundation (Table 22). Residential structures include both single- and multiple-family structures. Buildings are the measure of multiple-family structures; therefore, the actual housing unit count would exceed the reported number. Manufactured represents manufactured residential housing**.** This represents all of the structures within the 500-year floodplain of San Juan, Trabuco, and Oso Creeks. Most of these structures are located within the City of San Juan Capistrano with a smaller number in the cities of Dana Point and Laguna Niguel.

Table 22 San Juan Creek Watershed Floodplain Inventory

		Number of Structures			Value of Structures (in $1,000s, 2002 Price Level)		
Stream	**Reach**	**NR**	**R**	**M[1]**	**NR**	**R**	**M[1]**
San Juan	Reach 1	194	97	306	66,097	34,542	12,395
	Reach 2	22	861	232	28,373	142,770	9,399
	Reach 3	40	124	171	32,470	16,894	6,927
	Reach 4	38	197	0	15,331	72,797	0
	Reach 5	59	662	0	11,085	126,639	0
Oso	Reach 1	28	0	0	30,384	0	0
Trabuco	Reach 1	66	104	435	57,793	25,817	17,621
	Reach 2	66	81	0	17,663	14,364	0
	Reach 3	23	0	0	6,690	0	0
	Reach 4	0	313	0	0	75,637	0
Total		536	2,439	1,144	265,886	509,460	46,342

NR – Non-residential; R – Residential; M – Manufactured
[1]Commonly referred to as mobile homes.

6.3.2 Flood Inundation Damages

Structural damages, i.e., damages to buildings and contents, are calculated using the HEC-FDA model. The analysis employed the levee function of the model to incorporate the failure potential of both undermining/scour and overtopping to levees. The levee function was also employed to model channel embankment heights where no levees are present. The results of the HEC-FDA model analysis are shown in the following sections with the residential component representing both residential and manufactured housing units. The economic evaluation of potential levee failure due to undermining/scour is provided in the Economic Appendix.

Based on the results of the HEC-FDA program, expected flood inundation damage in the San Juan Watershed study area for the base year equals $4,359,000 as summarized in Table 23.

Table 23 Expected Base Year Flood Inundation Damages – Analysis Year 2008

(in $1,000s, 2002 Price Level)

Stream	Expected Annual Flood Inundation Damage		
	Nonresidential	**Residential**	**Total**
San Juan Creek	1,440	1,867	3,307
Oso Creek	255	0	255
Trabuco Creek	243	554	797
Total	**1,938**	**2,421**	**4,359**

Inundation damages for the most likely future year 2030 are shown in Table 24.

Table 24 Expected Future Year Flood Inundation Damages – Analysis Year 2030

(in $1,000s, 2002 Price Level)

Stream	Expected Annual Flood Inundation Damage		
	Nonresidential	**Residential**	**Total**
San Juan Creek	1,542	1,904	3445
Oso Creek	255	0	255
Trabuco Creek	254	573	827
Total	**2,051**	**2,477**	**4,527**

Equivalent annual flood inundation damage is that damage caused by floodwater inundation, on average (averaged over the 50 year period of analysis) each year. This is done for comparison with the average cost of solutions/measures to allow for a direct comparison of costs and benefits. The equivalent annual flood inundation damage for the San Juan Creek Watershed area is estimated at $4,447,000 as shown in Table 25.

Table 25 Equivalent Annual Flood Inundation

(in $1000s, 2002 price level, $6^1/_8$ percent)

Stream	Expected Annual Flood Inundation Damage		
	Nonresidential	**Residential**	**Total**
San Juan Creek	1,493	1,886	3,379
Oso Creek	255	0	255
Trabuco Creek	249	564	813
Total	**1,997**	**2,450**	**4,447**

6.3.3 Bridge Erosion Risk Analysis

Channel scour poses a potential damage threat to many bridges in the watershed. A hydraulic analysis at each bridge location of the scour hazard was performed to estimate the potential for undermining over the period of analysis. A high likelihood of undermining, i.e., a 50 percent chance of failure due to erosion within the period of analysis, was set as the standard for the economic damage analysis. The analysis also assumes that certainty occurs at twice the timeframe of high likelihood. The results of this analysis are provided in the Economic Appendix.

The 1997 Reconnaissance Report for San Juan and Aliso Creeks cites the estimated replacement cost for the bridges in the study area at about $1.2 million per lane based on feedback from local agencies. For this analysis, that estimated replacement cost would also be used. The expected average annual cost for bridge replacement due to erosion-induced design safety criteria failure is $9,444,200, employing a Net Present Value technique and assuming a linear progression in the probability of failure.

6.3.4 Oso Creek Erosion Damages

In the May 1999 Oso Creek – Streambank Erosion Protection Study, the USACE reports that sewer, power, and telephone lines along Oso Creek are in danger of being eroded away during flood events. In the flood of 1993 (measured as an approximately 15-year event), flood fighting by the Moulton Niguel Water District required the performance of slope, manhole, and ballast repair at milepost 195 near Oso Creek at a cost of $14,200 (1993 dollars). In the El Niño storms of 1998 (25-year event), excessive erosion took place and pipelines needed to be protected, repaired, replaced, and relocated by Moulton Niguel Water District at a cost of $726,538 (1998 dollars). Erosion damages were also reported by San Diego Gas & Electric, Pacific Bell, AT&T, Quest, and MCI during the El Niño storms. Total erosion damage from El Niño to sewer, power, and telephone lines was $873,667.

The equivalent annual erosion damage on Oso Creek is estimated at $123,160 (1999 price level) using HEC's Expected Annual Damage model**.**

6.3.5 Emergency and Clean-Up Costs

Emergency and clean-up costs are calculated in a manner consistent with previous USACE studies and are based on the relationship between inundation damage and these costs. The calculation of expected annual emergency and clean-up costs utilizes the HEC-EAD model with the risk and uncertainty frequency/damage functions generated by the HEC-FDA model. The expected annual cost for flood-related emergency and clean-up costs for the San Juan Creek watershed is $1,190,410.

6.3.6 Flood Damage Summary

Total estimated economic damages due to flooding includes all of the above described categories. Combining these categories provides an overall estimate of average annual damages due to flooding. A summary of this is provided in Table 26.

Table 26 Annual Flood Damage Summary

Category	Equivalent Annual Damage
Structural Inundation	4,446,480
Bridge Failure	9,444,200
Oso Creek Erosion	123,610
Emergency & Clean-up	1,190,410
Total	**$15,204,700**

6.4 Water Demand and Supply Analysis

A water demand and supply analysis was conducted for this study. Based on population projects through the year 2020, there will be a significant new demand for municipal and industrial water in the watershed. This is summarized in Table 27 below. Greater detail on this subject is contained in the Economic Appendix.

Table 27 Water Demand Projection through 2020 – Agencies in the San Juan Creek Watershed

District	M&I Water Demand in Acre-Feet				
	2000	2005	2010	2015	2020
CVWD	8,500	9,000	9,500	10,100	10,700
MNWD	42,400	47,400	50,400	53,400	56,400
SMWD	28,300	39,600	44,200	49,600	55,000
SCWD	8,900	9,000	9,000	9,000	9,000
TCWD	3,900	4,300	4,700	4,800	4,800

*CVWD, SMWD and TCWD service areas are mostly within the watershed; MNWD’s service area is less than half in the watershed; SCWD’s service area is mostly outside of the watershed.

6.5 Baseline Recreation Analysis

The San Juan Creek Watershed is a popular Orange County recreation destination, offering a variety of recreation opportunities including camping, hiking, walking, biking, mountain biking, and nature appreciation. The watershed offers unique natural recreation opportunities in the increasingly developed region. A description of the recreational features within the watershed is provided in Section 2.4.1 of this report. A recreational market demand analysis was conducted for this study. The results indicate a significant demand and support for recreation improvement.

Damage during flood events to recreational facilities is significant. Several parks are directed affected by flooding and/or erosion, and as such are at risk during flood events. More detail on this analysis is provided in the Economic Appendix.

Section Seven

PLAN FORMULATION AND SCREENING OF POTENTIAL MEASURES

7.1 Introduction to Plan Formulation

Plan Formulation is the process of developing a broad array of potential solutions to each identified problem, and gradually narrowing down the list of potential solutions by identifying which alternatives maximize cost-effectiveness, minimize environmental impacts, and provide a sound engineering solution. The plan formulation process is highly iterative. Just when it may seem that the ideal solution is developed, additional information may come to light, a critical piece of the puzzle may be solved, or a new study completed that may change the entire direction of study. Plan formulation should be considered a success when a solution or plan is developed and implemented that best meets the needs of all concerned.

Plan Formulation, as conducted by the Corps of Engineers and other Federal agencies, requires that a number of iterative steps be followed. The first step, covered in the last section, is that of developing a list of as many possible single-purpose solutions (or "measures") as feasible. The list may be as far ranging as possible and includes anything that might provide a potential solution. The next step is to begin to screen out any measures that do not meet project objectives or that may make a solution impossible. Screening may show that a particular measure is infeasible from an engineering standpoint, it may show that a measure would be highly damaging to the environment, it may prove to be more expensive than other options that provide the same benefit, or it may indicate that it will simply not solve the problem or not in a way that is acceptable to residents of the watershed. All of these pieces of information are critical in the decision-making process.

Plan Formulation during this study process had to meet multiple objectives. It had to analyze alternatives in such a way as to satisfy both the requirements of the Corps' planning process and the needs of the local sponsor and stakeholders. Because some objectives of the watershed management process are not appropriate for the Corps' authorities, and therefore are not eligible for Federal cost sharing under Corps programs, different selection criteria must be applied to different projects.

Plan Formulation for Federal projects is a rigorous, multi-step process. In order for some of the potential projects outlined later in this report to be considered for Federal funding, it was necessary to evaluate them according to specific planning criteria. Planning for potential Federally cost-shared projects was done in accordance with guidance provided in Engineering Regulation (ER) 1105-2-100 “Planning Guidance Notebook.”

The Federal objective for water and related land resources projects is to contribute to national economic development (NED) consistent with protecting the Nation’s environment, in accordance with national environmental statutes, applicable executive orders, and other Federal planning requirements. The Federal objective is more specific than the study’s planning objectives, which are more specific in terms of expected or desired outputs. Water and related land resources project plans are formulated to alleviate specific problems and take advantage of opportunities in ways that contribute to study planning objectives. Contributions to national economic development (NED outputs) are increases in the net value of the national output of goods and services, expressed in monetary units. The goal of the planning process is to develop projects that satisfy study objectives in such a way that the benefit derived by the project exceeds its costs, thus contributing to national economic development. The project that maximizes net benefits becomes the NED Plan.

Ecosystem restoration is one of the primary missions of the Corps of Engineers’ Civil Works program. The Corps objective in ecosystem restoration planning is to contribute to national ecosystem restoration (NER). Contributions to national ecosystem restoration (NER outputs) are increases in the net quantity and/or quality of desired ecosystem resources. Measurement of NER is based on changes in ecological resource quality as a function of improvement in habitat quality and/or quantity and expressed quantitatively in physical units or indices (but not monetary units).

The Corps planning process follows six steps. The process is also applicable for many other types of studies and its wide use is encouraged. The six steps are:

Step 1 – Identify problems and opportunities (Section 1)

Step 2 – Inventory and forecast conditions (Sections 2, 3, 4, 5, and 6))

Step 3 – Formulate Alternative Plans (Section 7)

Step 4 – Evaluate Alternative Plans (Section 7)

Step 5 – Compare Alternative Plans (Section 7)

Step 6 – Select a Plan (Sections 7 and 8)

Measures that pass the initial screening may be combined with other measures to develop alternatives. A more detailed analysis of alternatives is then conducted. Information developed during this more detailed analysis of alternatives may include more detailed studies on hydrologic and hydraulic performance (i.e., how much does the alternative affect runoff in the channel, flow behavior, water velocity, and depth of water on the floodplain); sediment transport; groundwater effects; presence of hazardous, toxic, or radioactive wastes; cultural resource issues; real estate requirements; environmental resource issues, including analysis of ecosystem function and its comparison to project outputs; and costs and potential benefits (damages prevented or ecosystem benefits produced now and in the future). Those alternatives that achieve the desired objectives and are environmentally acceptable, economically justified, and technically feasible are forwarded into the final array of alternatives for determination of the National Economic Development (NED) plan (the plan that produces the greatest net benefit to the nation for those projects that produce a monetary benefit) or determination of the National Ecosystem Restoration (NER) plan (the plan that produces the highest net benefit to the affected ecosystem).

If the local sponsor wishes to pursue a different alternative, that plan becomes the locally preferred plan (LPP) and is also fully analyzed. Cost sharing for a project is based on the Federal contribution to the NED/NER plan.

7.2 General Planning Criteria, Objectives, and Constraints

7.2.1 General Planning Criteria

During the screening of preliminary measures, three general criteria are used. First, a measure that generally meets the objectives of the study must be feasible from an engineering standpoint. The project must be constructible and must be capable of meeting all applicable safety standards, using available technologies acceptable under Corps of Engineers guidelines and engineering regulations. Second, the project must be environmentally acceptable. Potential impacts must be mitigable, and the project must not induce unmitigable damage to entities outside the study area. Third, the project must be economically justified. The potential benefits of the project, either from a monetary or non-monetary standpoint, must exceed the costs of the project.

Once the initial screening is finished, those alternatives that are carried forward are examined under four additional criteria: (1) the potential project must be acceptable to local interests and the majority of residents of the area; (2) the project must be efficient. It must maximize the use of funds to the greatest extent possible; (3) the project must be effective. It must achieve the desired objectives to the maximum extent; and (4) the project must also be implementable.

Additional criteria will apply to different projects. The primary objective of an ecosystem restoration project might be the restoration of a particular habitat type, to the exclusion of other objectives. For this study, alternatives were examined for their ability to meet multiple objectives.

7.2.2 Planning Objectives

The objective of this study process is to provide recommendations and/or solutions to as many of the water and related land resource problems in the San Juan Creek watershed as possible. The objective of the Federal government is to participate as a partner in the process and in addition, to develop Federally-implementable projects that meet study objectives while maximizing use of Federal dollars. The specific Federal objective for this study is to reduce damages from flooding, to restore degraded ecosystems within a national framework, and to provide incidental recreation benefits in conjunction with projects of that nature. Recreation is discussed under both “Planning Objectives” and “Planning Constraints”.

The objective of the local sponsor is to solve the host of water and related land resource problems in the San Juan Creek watershed. The local sponsor hopes to address flooding issues, ecosystem degradation issues, water quality problems, recreation problems, and many others, in a comprehensive manner. The local sponsor would like to address these problems in a timely manner, at the least cost possible, and in a way that balances the often conflicting needs of local stakeholders.

While not directly incorporated into the alternatives analysis (due to the level of detail inherent in this stage of analysis), recreation is both a planning objective and constraint. The objective of recreation planning in this study effort is to incorporate features that allow passive recreation (such as hiking, biking, etc.) in a way that blends well with the existing resource and such measures that might be proposed. The recreation demand analysis discussed in the previous section indicates a strong economic (and societal) support for recreation as incidental to other project purposes. Following development of more detailed plans to address flooding and ecosystem restoration, recreation components should be incorporated into the design process is such a way that recreational possibilities are enhanced.

7.2.3 Planning Constraints

Constraints on the study process include the local sponsor's need for monetary or other assistance in the implementation of solutions. The local sponsor requires that projects recommended must achieve their objectives at a reasonable cost. The local sponsor is constrained to achieving multiple objectives from a single project.

Constraints on flood inundation reduction include the requirement that land is not removed from existing usage, that no damages are induced outside of the current flood prone area, and that more maintenance activities are not required. The local sponsor would like to avoid the use of additional exposed concrete in any projects.

Constraints on ecosystem restoration include the need for projects to provide for aquatic and non-aquatic species migration or movement along the riparian corridor. Ecosystem projects must not negatively affect the level of flood protection currently offered. Ecosystem restoration projects must not require excessive maintenance.

The local sponsor also desires that any ecosystem restoration measures not cause peripheral impacts to other resources. For example, if the local sponsor were to pursue certain ecosystem restoration components, they wish not to be held responsible for the potential impacts these might cause to water quality. If an ecosystem restoration component were to cause an increase in the waterfowl population, an agreement should be created that they not be held liable for the potential increase in bacterial production caused by the influx of birds above and beyond the existing population.

The local sponsor and residents also desire that recreation not be impacted by project implementation.

7.2.4 Watershed Problems and Potential Measures

The stakeholders group, study team, and other participants contributed to the development of a list of potential measures/solutions by participating at public and stakeholder meetings, writing to the Corps' Study Manager, attending field trips, and discussing these topics in a variety of circumstances. "Big" and "Small" drop structures refer to hard structural fixes installed within the bed of the channel perpendicularly across the channel (i.e., to the direction of flow) that prevent downcutting of the channel. The structures can be either "big", meaning a meter or more (several feet high or higher), and spaced long distances apart, or "small", meaning less than a meter in height and spaced more closely together. The latter, while potentially more expensive, have the benefit of being more passable to fish, and causing less downstream turbulence, conceivably an important issue in light of the undermining problem on the creek. "Geotechnical Instability" refers to an inherent instability in materials, either natural or placed by man, that would tend to result in failure with negative consequences. "Channel Instability" refers to a behavior of the channel that is causing negative impacts, in this case that the channel is downcutting and causing undermining of levees, reduction of protection to bridge piers and abutments, and undermining pipelines and other utility crossings. A matrix of potential measures/solutions is provided in Table 28 below.

Table 28 Watershed Problems and Potential Measures (Solutions)

Watershed Problems	Potential Measures
(a) Flood Inundation Damage to Structures *(Flood inundation damage to structures is limited to San Juan Creek reaches SJ-5 and SJ-6, and Trabuco Creek reach TR-7)*	• Floodwalls • Levees • Enlarge Channel • Floodproofing • Elevate Structures • Buy-Out • Dam or Detention
(b) Land Loss Due to Erosion *(Land loss due to erosion is primarily constrained to San Juan Creek reaches SJ-4 and SJ-5, Trabuco Creek reaches TR-5, TR-6, and TR-7, and Oso Creek reaches OS-3 and OS-4)*	• Let Channel Go/Accept Land Loss • Spot Check Problem Areas • Create Buffer • Lengthen Channel/Meander Belt • Big Drop Structures • Small Drop Structures • Reestablish "Pools & Riffles" • Relocate Infrastructure • Fill Channel to Prior Grade
(c) Channel Instability *(Channel instability is evident on all reaches of San Juan, Trabuco, and Oso Creeks, although this issue declines in impact in an upstream direction)*	• Let Channel Go/Remove Infrastructure • Create Buffer • Lengthen Channel/Meander Belt • Big Drop Structures • Small Drop Structures • Reestablish "Pools & Riffles" • Spot Check Problem Areas • Fill Channel to Prior Grade
(d) Infrastructure Destruction by Surface Water Flow *(Infrastructure destruction is occurring on San Juan Creek reaches SJ-4 through SJ-6, Trabuco Creek reaches TR-4*	• Let Channel Go/Remove Infrastructure • Create Buffer • Big Drop Structures/Backfill Erosion • Small Drop Structures/ Ditto

Table 28 Watershed Problems and Potential Measures (Solutions)

Watershed Problems	Potential Measures
through TR-7, and Oso Creek reaches OS-3 and OS-4)	• Reestablish "Pools & Riffles" • Spot Check Problem Areas • Fill Channel to Prior Grade
(e) Water Quality Problems in Ocean Nearshore Environment *(Water quality problems are evident in the ocean on either side of the San Juan Creek mouth. Water quality problems stem from watershed-wide sources)*	• Trace Source/Fine Responsible Party • Repair Broken Pipes • Replace Leaky Pipes • Educate Public • Implement BMP's • Reduce Watering • Reduce Fertilizer Application • Reduce Pesticide Application • Remove Homeless • Evaluate Outfalls • Monitor and Modify Behaviors
(f) Surface Water Quality Problems in Creek Mainstem and Tributaries *(As with water quality in the ocean, water quality problems are evident in all streams in the watershed, and stem from watershed-wide sources.)*	• Trace Source/Fine Responsible Party • Repair Broken Pipes • Replace Leaky Pipes • Educate Public • Implement BMP's • Reduce Watering • Reduce Fertilizer Application • Reduce Pesticide Application • Remove Homeless • Monitor and Modify Behaviors
(g) Water Quality Problems in Groundwater Aquifer(s) *(Water quality problems in groundwater primarily stem from minerals and salts occurring naturally in underground rock strata. These minerals and salts are evident over much of the watershed. There are limited extent groundwater problems stemming from site-specific issues that occur randomly throughout the watershed.)*	• Pump and Treat • Recharge to Dilute • Trace Source/Fine Responsible Party • Repair Broken Pipes • Replace Leaky Pipes • Educate Public • Implement BMP's • Reduce Watering • Reduce Fertilizer Application • Reduce Pesticide Application • Remove Homeless • Monitor and Modify Behaviors
(h) Loss of Floodplain Habitat *(The loss of habitat on the floodplains occurs throughout the watershed due to development pressure)*	• Purchase and Preserve • Let Channel Go/Recover Naturally • Create Buffer for Habitat • Replanting Campaign • Big Drop Structures Restore Floodplain • Small Drop Structures Same • Reestablish "Pools & Riffles" • Fill Channel to Prior Grade
(i) Loss of Riparian Habitat *(The loss of riparian zone habitat is related primarily to development in the zone, and channel modification. This has*	• Purchase and Preserve • Let Channel Go/Recover Naturally • Create Buffer for Habitat • Replanting Campaign

Table 28 Watershed Problems and Potential Measures (Solutions)

Watershed Problems	Potential Measures
occurred primarily in San Juan Creek reaches SJ-4 through SJ-6, all reaches of Trabuci Creek and Oso Creek, and numerous other tributaries)	• Big Drop Structures Restore Floodplain • Small Drop Structures Same • Reestablish "Pools & Riffles" • Fill Channel to Prior Grade
(j) Loss of Recreation Opportunities *(The loss of recreation opportunities is occurring as open space disappears and recreation becomes more limited in extent. The problem is watershed-wide)*	• Apply More Money to Problem • Set Aside More Property • Purchase Property for Recreation • Create More Parks • Use Roads for Trails
(k) Decline in Floodplain Moisture *(The decline in floodplain moisture has accompanied channel downcutting and reduction of surface and groundwater availability. The problem is primarily evident in downstream reaches of San Juan, Trabuco, and Oso Creeks)*	• Purchase and Preserve Property • Let Channel Go/Recover Naturally • Replanting Campaign • Big Drop Structures Restore Floodplain • Small Drop Structures Same • Reestablish "Pools & Riffles" • Fill Channel to Prior Grade • Apply Reclaimed Water
(l) Geotechnical Instability *(Geotechnical instability is site-specific, and evident throughout the watershed)*	• Reduce Undercutting • Greater Regulation • Reduce Watering
(m) Decline in Water Supply *(The decline in water supply is watershed-wide)*	• Reduce Pumping • Limit Development • Develop Recharge Capability • Apply Reclaimed Water
(n) Depletion of Sand Sources for Coastal Sand Replenishment *(Depletion of sand sources is occurring in all developed areas, primarily in the Oso and Trabuco watersheds)*	• Limit Development • Assure Sources by Purchase • Minimize Paving
(o) Higher Flood Peak Discharges for Given Storm Frequency *(Higher peak discharges are evident downstream of all developed areas)*	• Require On-site Detention • Alter Existing Drainage • Assure 100-year Flood Retention
(p) Decrease or Disappearance of Aquatic Species *(The disappearance of aquatic species is a watershed-wide problem)*	• Purchase and Preserve Property • Replanting Campaign/Trees • Big Drop Structures Restore Floodplain • Small Drop Structures Same • Reestablish "Pools & Riffles" • Fill Channel to Prior Grade/ Backfill • Apply Reclaimed Water • Restore Channel • Restore Breeding Zones • Clean Up Water
(q) Decrease or Disappearance of Riparian (non-Aquatic)	• Purchase and Preserve Property

Table 28 Watershed Problems and Potential Measures (Solutions)

Watershed Problems	Potential Measures
Species *(As with aquatic species, the disappearance of riparian-related species is a watershed-wide problem)*	• Replanting Campaign/Trees • Big Drop Structures Restore Floodplain • Small Drop Structures Same • Reestablish "Pools & Riffles" • Fill Channel to Prior Grade/ Backfill • Apply Reclaimed Water • Restore Channel • Restore Breeding Zones • Clean Up Water
(r) Decrease or Disappearance of Floodplain (non-Aquatic) Species *(As with aquatic and riparian species, the disappearance of species occupying the floodplain is a watershed-wide problem)*	• Purchase and Preserve Property • Replanting Campaign/Trees • Big Drop Structures Restore Floodplain • Small Drop Structures Same • Reestablish "Pools & Riffles" • Fill Channel to Prior Grade/ Backfill • Apply Reclaimed Water • Restore Channel • Restore Breeding Zones • Clean Up Water
(s) Invasive Species (Non-Native Species) *(Invasive species are a watershed-wide problem)*	• Exotics Removal Campaign • Use Mitigation Credits • Regulation of Non-Natives
(t) Declining Local Aesthetic Quality *(Although highly subjective, generally declining aesthetic quality is cited throughout the watershed)*	• Develop Management Plan • Educate Public and Government • Beautification Campaign • Limit Development
(u) Piecemeal treatment of Problems *(Piecemeal treatment of problems is a watershed-wide problem)*	• Develop Comprehensive Management Plan • Insist on Greater Coordination Amongst Agencies • Develop Better Solutions
(v) Excess Litigation Due to Watershed-Related Problems *(Excessive litigation is an outgrowth of a lack of understanding of regulatory permitting and may be addressed by watershed-wide treatment of issues)*	• Develop Regulatory Framework • Develop Comprehensive Management Plan • Insist on Greater Coordination Amongst Agencies • Develop Better Solutions
(w) Excessive Regulatory Actions *(As above, excessive regulatory actions are partly due to a lack of understanding of the permitting process, but also a lack of understanding of the resource. Also a watershed-wide problem)*	• Develop Regulatory Framework • Develop Comprehensive Management Plan • Insist on Greater Coordination Amongst Agencies • Develop Better Solutions
(x) Degradation of Cultural Resources *(Degradation of cultural resources is a site-specific issue, but primarily occurs through development pressure)*	• Develop Comprehensive Management Plan • Insist on Greater Coordination Amongst Agencies • Develop Better Solutions
(y) Degradation of Habitat for Endangered and Threatened	• Develop Regulatory Framework

Table 28 Watershed Problems and Potential Measures (Solutions)

Watershed Problems	Potential Measures
Species *(Degradation of habitat for T&E species is a watershed-wide problem)*	• Develop Comprehensive Management Plan • Insist on Greater Coordination Amongst Agencies • Develop Better Solutions • Purchase and Preserve Property • Replanting Campaign/Trees • Big Drop Structures Restore Floodplain • Small Drop Structures Same • Reestablish "Pools & Riffles" • Fill Channel to Prior Grade/ Backfill • Apply Reclaimed Water • Restore Channel • Restore Breeding Zones • Clean Up Water
(z) Degradation of Surface Water/Groundwater Interface *(Degradation of the surface/groundwater interface is primarily due to the conversion of open space to residential/commercial development. This is occurring watershed-wide, but may be dealt with by specific application of measures in zones of high potential recharge)*	• Develop Recharge Plan • Create Recharge Areas • Purchase and Preserve Property • Replanting Campaign/Trees • Reestablish "Pools & Riffles" • Fill Channel to Prior Grade/ Backfill • Apply Reclaimed Water • Restore Channel • Clean Up Water

As can be seen from this extensive list, many of the potential measures or solutions may be used to solve more than one problem. Notably, many of the environmental problems may be dealt with by application of the same group of measures. The process of developing measures to deal with as many of the problems on this list as possible involved the formulation of multi-purpose plans or solutions. Multi-purpose plans have the potential to result in great cost savings, and perhaps more importantly can be developed to integrate environmental needs with those of the human population. For instance, flood inundation damage reduction may be accomplished by single purpose means, such as channel enlargement, but may also incorporate features to provide wildlife benefit, channel stabilization, and prevention of infrastructure damage such as preventing damage to pipelines crossing the creek.

Several issues discussed above are directly tied to issues discussed, or dealt with more expeditiously elsewhere in the watershed. Therefore, the issues of water quality in the nearshore zone (issue "e"), and that of water quality in the groundwater aquifers (issue "g"), can be partly dealt with by addressing water quality throughout the watershed. If sources of pollution can be reduced in the urban areas of the watershed, then this will have a positive effect on both these issues. It is recognized that even the most optimistic plan cannot solve all of the problems in either, as the nearshore zone is also affected by activities outside the watershed (i.e., further upcoast), and that groundwater is also affected by native materials (i.e., inherently "salty" marine sediments that underlie the watershed). However, some measure of improvement is anticipated by dealing with these problems in other parts of the watershed. Thus, these issues will be "rolled into" the discussions on water quality henceforth.

The loss of recreation opportunities (issue "j") is discussed elsewhere under "Planning Objectives" and "Planning Constraints", but must be addressed primarily by other means, mainly County and City park planning efforts. However, incorporation of recreation opportunities into any potential Federal project is considered of high importance. Due to the limits on design detail imposed by this phase of the planning process, the actual incorporation of recreation will have to await a "spin-off" study devoted to planning of a Federal/local multi-purpose project.

The depletion of sand sources in the watershed (issue "n") is a highly sensitive issue that cannot be dealt with in this study except to urge local government to set aside open space both for its own sake, but also for the sake of area beaches. Beaches require a continual (or at least sporadic and substantial) source of beach sand, which can only come from the watershed. The cost of replenishment of beach sand by other than natural means is an extremely expensive proposition, and it can only be encouraged that local government provide the means to ensure a future source, or later pay the price of that omission.

The degradation of the groundwater/surface water interface (issue "z") is similar to that of sand replenishment, and equally as sensitive. It can only be dealt with by the set-aside of lands suitable for that purpose. Porous sand-bedded stream channels are the best means to continue groundwater recharge in a manner that is not highly costly, and therefore, again, the preservation of open space, particularly that of even small open channels, should be encouraged as part of the County and City planning processes. Although surface water/groundwater interfaces can be enhanced as part of potential projects, they will be more costly than natural means, and realistically with the many species issues that abound in the watershed, conversion of natural channel to enhance recharge areas is probably not affordable in most cases.

While it is necessary to examine measures that might only solve a single problem, for example where that might be the least expensive or least environmentally damaging alternative, many of the measures developed from this point forth were done in such a way that they might be later integrated with others for solution of multiple problems. In this way, the concept of preventing overtopping of the channel (and subsequent flood inundation of adjacent structures) was formulated in such a way that it could be combined with channel stabilization, which could be formulated to solve the infrastructure damage issue as well as the channel instability issue. Further, these measures were also formulated so that ecosystem restoration measures might be incorporated to provide a true multi-purpose project of benefit to the maximum number of both human and non-human beneficiaries.

The following problems and solutions were then grouped for possible integration:

a) Flood inundation damage, channel instability, infrastructure destruction, decline in floodplain moisture, loss of riparian habitat due to surface water erosion – San Juan Creek reaches SJ-4 through SJ-6, Trabuco Creek reaches TR-4 through TR-7, and Oso Creek reaches OS-3 and OS-4.

Potential solutions: Floodwalls, channel enlargement, detention, channel stabilization measures.

b) Water quality problems in ocean (nearshore zone), water quality problems in surface water, also dealing with those potentially in groundwater due to infiltration.

Potential solutions: Watershed-wide non-point source water clean-up campaign, spot treatment, BMP modification, source identification and specific area application – Application throughout San Juan Creek watershed, particularly developed areas and areas with high vector problems such as mouth of San Juan Creek.

c) Loss of floodplain, aquatic, and riparian habitat, disappearance of aquatic, floodplain species, declining local aesthetic qualities, invasive species, degradation of T&E species habitat.

Potential solutions: Development of watershed environmental resources (comprehensive) management plan, invasive species eradication plan, ecosystem restoration measures along San Juan Creek, channel stabilization – Application throughout San Juan Creek watershed with emphasis on restoration in reaches SJ-4 and SJ-5 of San Juan Creek.

In order to narrow down the range of measures, however, it was necessary as the next step to examine the relative value of some single purpose measures that might be integrated into a larger, more comprehensive plan for the watershed. This process began at the head of the list with one of the largest perceived problems in the watershed, that of floodwater inundation.

7.3 Flood Inundation Reduction Measures

The initial development of flood damage reduction measures indicated that many potential measures needed to be evaluated. These included non-structural measures, such as floodplain regulation, and structural measures, such as channelization. Some non-structural measures, such as flood insurance and floodplain regulation, are already being acted upon, but may not solve the entire problem. Flood inundation reduction measures were developed by a multi-disciplinary group of engineers, hydrologists and hydraulic engineers, environmental specialists, economists, biologists, geomorphologists, and agency representatives. Measures were formulated to address the problems specific to the San Juan Creek watershed. To meet the needs of the entire stakeholder group, measures also needed to take into account needs of the entities potentially impacted by implementation, wildlife needs, needs of the agencies responsible for maintaining such facilities, and needs of the public.

7.3.1 Flood Damage Reduction Objectives

The objective of the flood damage reduction measures initially developed for this study is to reduce damages from flooding to the maximum extent possible, while achieving those requirements necessary to qualify for Federal participation (i.e., benefits exceeding costs and engineering requirements). An additional objective on the part of the local sponsor is to reduce damages in a way acceptable to the parties suffering the damage.

Once the more detailed analysis was underway, it became clear that the San Juan Creek watershed channel system's instability has become a problem that impacts potential flood control solutions. Because the issue of channel downcutting is not a problem dealt with normally through standard operations and maintenance (O&M), it is not a problem within the local sponsor's ability to address. Therefore, an additional objective of the plan formulation process is the need to understand, develop solutions to, and address the channel downcutting problem so that failure of the existing levee system, and whatever modifications might be made to it to enhance levels of flood protection, are not compromised.

7.3.2 Development of Measures

A greater understanding of the frequency and process by which flood inundation occurs was developed by construction of a hydrologic model of the watershed. This model indicated that, while the downstream reaches (Reaches 5 and 6) are most heavily urbanized, most development in this watershed is outside the regulatory (a.k.a. "100-year") floodplain. However, there is a large amount of development within the 0.02% exceedance (roughly 500-year) floodplain, as so much of the remaining land in the watershed outside the floodplain is too steep for development. Much of the potential damageable property is within the cities of San Juan Capistrano and Dana Point. These are older communities that developed prior to implementation of Federal floodplain regulations, but have considerable development that might be damaged by flooding.

Development of measures focused on both structural measures, such as channel widening or detention, and non-structural measures, such as flood insurance or floodplain regulation. However, because floodplain management has been actively practiced by the County of Orange since the 1970s, and the number of structures that would be inundated by floods in the San Juan Creek watershed is somewhat constrained to the narrow band of land between the regulatory (100-year) floodplain boundary and the base of the hills, the focus of this group of measures was not watershed-wide, but rather focused on reducing damages to that area of the watershed in which most of the damages would be concentrated. Due to the recurring nature of the problem, the primary goal of inundation reduction measures is to reduce potential flood inundation damage to structures and contents. Reduction of damages to infrastructure, automobiles, and other real property is also a consideration of this group of measures. Measures were also further developed to assist in the reduction of emergency costs and maximize provision of public safety.

Additional measures were developed to restore channel stability (and hence, guarantee performance of the flood control system in the long-run). Because channel stability impacts both flood control system performance, and riparian ecosystem survivability, this issue was developed separately from both, but with the option of inclusion in the development of a comprehensive alternative.

7.3.3 Preliminary Array of Measures

A comprehensive list of structural and non-structural flood control measures that addresses the issues of flood inundation, sediment deposition, threats to public safety, and other associated costs was developed.

Structural measures include:

- Dams or detention basins (both off-line and on-line)
- Levees
- Floodwalls
- Enlargement of the Channel

Non-structural measures include:

- Flood Insurance
- Floodplain Regulation
- Emergency Response
- Evacuation
- Floodproofing
- Floodwarning
- Removal of Impediments to Flow

Measures developed to address channel instability included adding additional “toe-down” to existing structures, and installation of grade control structures to ensure the halting of additional downcutting of the channel bed.

7.3.4 Evaluation Criteria

As mentioned earlier, preliminary measures were initially evaluated according to three criteria: engineering feasibility, economic justifiability, and environmental acceptability. For a measure to be feasible from an engineering perspective, it would have to be constructible, would have to be able to meet safety regulations, and be designable to applicable Federal, Corps, and State criteria. A measure would also have to give some indication that its benefits would exceed its costs. A measure would also have to have potentially mitigable impacts.

If found to be feasible from an engineering, economic and environmental standpoint, each preliminary measure was then evaluated by four additional criteria: completeness, efficiency, effectiveness, and acceptability. Completeness is the extent to which an alternative plan addresses the stated problem. A complete plan is one that achieves all of the objectives set forth, without leaving one or more objectives unaddressed. Efficiency is the extent to which an alternative plan is the most cost-effective means of achieving the objectives. Effectiveness is the extent to which an alternative contributes to the planning objectives. Acceptability is the extent to which the alternative plan would be acceptable in terms of applicable laws, regulations, and public policies. Mitigation of adverse impacts is an integral component of each alternative.

Solicitation of public input provided an important element in the planning process. Participation in the stakeholder meetings provided a number of private citizens that attended these sessions the means to comment on, and guide plan formulation activities. One important part of public input was the identification of what eventually became the three primary goals for the study effort;

solution of the flooding problem, restoration of degraded habitats, and improvement of water quality. Problems viewed as having a less critical, or less immediate need, or those that required a wholly local solution, were gradually filtered out of the "problem list", at least insofar as this study effort was concerned. For instance, the problem of geotechnical slope stability is not one that can be addressed on a watershed-wide basis, but must be studies intensively on a case-by-case basis. In this case, the watershed study is not the most appropriate vehicle for addressing this problem, and this problem will only be dealt with in later phases, as more detailed information becomes available, and as site-specific solutions are sought.

7.3.5 Evaluation of Preliminary Flood Control and Channel Stabilization Measures

Flood inundation reduction measures in the preliminary array were evaluated for their ability to meet the study objectives, their implementability, their costs and potential benefits, and their impacts on environmental resources. Additionally, an initial evaluation of completeness, efficiency, effectiveness, and acceptability, was included in the screening. A matrix was developed to compare measures and as a tool in the initial screening of measures. This matrix follows the discussion, as Table 29.

7.3.6 Flood Control Measures

7.3.6.1 Traditional Dam

A traditional dam is a structure that would hold water behind an embankment until such time as release would be considered safe (i.e., would not cause downstream breakout). Evaluation of the traditional dam concept indicated that it could provide a solution to floodwater inundation downstream, but that it would not address channel stabilization and the potential for future flood damage posed by subsequent levee failure and adjacent property inundation. In addition, the traditional dam would be difficult to site, highly impacting environmentally, and economically unjustified. The cost of a traditional dam is far exceeded by its potential savings in future damages prevented. Because of the divided nature of the watershed (i.e., the Oso and Trabuco sub-watersheds controlling a large percentage of the watershed would not be covered), a single dam would not provide a complete solution to the problem. A dam is not an efficient use of Federal dollars and would not be acceptable to the local sponsor, residents of the watershed, and many local agencies. A traditional dam is not a complete solution, an efficient use of funding, nor is it environmentally acceptable. For these reasons, the traditional dam is not recommended for further analysis.

Table 29 Comparison of Preliminary Alternatives

Measure	Engineering Feasibility	Economic Justifiability	Environmental Acceptability	Completeness	Efficiency	Effectiveness	Acceptability
Flood Control							
Traditional Dam	Yes	No	No	Yes	No	No	No
Off-Line Detention Basin	Yes	No	Yes	No	No	No	Yes
On-Line Detention Basin	Yes	No	Yes	No	Yes	Yes	Yes
Levees	Yes	No	Yes	No	No	No	No
Floodwalls	Yes	Yes	Yes	Yes	Yes	Yes	No
Enlargement of Channel	Yes	No	Yes	Yes	No	Yes	No
Flood Insurance	NA	NA	NA	No	No	No	No
Floodplain Regulation	NA	NA	NA	No	No	No	No
Emergency Response	NA	NA	NA	No	No	No	No
Evacuation	NA	NA	NA	No	No	No	No
Floodproofing	Yes	No	No	No	No	No	No
Floodwarning	Yes	No	Yes	No	No	No	No
Removal of Impediments	Yes	No	No	No	No	No	No
Channel Stabilization							
"Toe-Down" Increase	Yes	No	Yes	No	No	No	Yes
Grade Stabilizers	Yes	Yes	Yes	Yes	Yes	Yes	Yes

7.3.6.2 Off-Line Detention Basin

An off-line detention basin is a structure that would hold water behind an embankment, or within an excavated area when the rate exceeds that which the downstream channel is capable of conveying safely (i.e., would not cause downstream breakout). The off-line basin would not block the channel, but would be filled via a diversion channel only during large flood events. Evaluation of the off-line detention basin indicated that it could provide only a partial solution to floodwater inundation downstream. Sites available for this purpose possess a limited capacity and are incapable of storing the floodwater volume associated with large flood events. In addition, it would not address channel stabilization and the potential for future flood damage posed by subsequent levee failure and adjacent property inundation. An off-line detention basin would be moderately impacting environmentally and would be economically unjustified due to the low level of protection possible. The cost of an off-line basin would far exceed the benefit created by the project. While a detention basin could provide some reduction in inundation damage, it is not an efficient use of Federal dollars. An off-line basin is not a complete solution nor an efficient use of funding. For these reasons, the off-line detention basin is not recommended for further analysis.

7.3.6.3 On-Line Detention Basin

An on-line detention basin is a structure that would hold water behind an embankment, or within an excavated area when the rate exceeds that which the downstream channel is capable of conveying safely (i.e., would not cause downstream breakout). The on-line basin, like a dam, would cross the channel, but would be filled only during large flood events. Evaluation of the on-line detention basin indicated that it could provide only a partial solution to floodwater inundation downstream. In addition, it would not address channel stabilization and the potential for future flood damage posed by subsequent levee failure and adjacent property inundation. Sites available for this purpose possess a limited capacity, with only two sites, one on Trabuco Creek and one on the San Juan Creek mainstem, capable of storing the floodwater volumes associated with large flood events. Even so, a detention basin or basins would only be capable of storing a portion of the volume required to maintain flow within the downstream channel. An on-line detention basin would be moderately impacting environmentally. At this stage of analysis, it was unknown whether or not a basin or basins would be economically justified. Because the detention basin concept could provide some reduction in inundation damage and in combination with other measures (such as floodwalls or levee improvements and channel stabilization measures) may provide a complete and acceptable solution to the problem, the on-line detention basin concept is recommended for further analysis.

7.3.6.4 Levees

A levee is an earthen structure that parallels the channel on either side, rising above the surrounding floodplain and increasing the capacity of the existing channel so that breakout only occurs in controlled locations and only during events which exceed the level of design (i.e., "100-year" for example). The levee concept simply creates more capacity within the channel for floodwaters to occupy when needed. San Juan Creek possesses flood control levees extending from the vicinity of I-5 on San Juan Creek proper, and upstream of Del Obispo on Trabuco Creek, downstream to the Pacific Ocean. These levees achieve a fairly high level of protection currently. Evaluation of the levee concept indicated that adding additional height to the existing levees could provide an additional increment of protection to properties outside the channel. However, raising the levee system would require purchase of a significant amount of property in the floodplain outside the levees, impacting the economic viability of the businesses it would be designed to protect. In addition, in order for a levee system to survive the continuing effects of channel instability, it would have to incorporate channel stabilization measures its re-design. A levee in this format would be economically unjustified due to the high cost of implementation when compared to the benefits it would create. While a levee would substantially reduce inundation damage in the watershed, it is not an efficient use of Federal dollars. For these reasons, raising the height of the existing levees is not recommended for further analysis at this time.

7.3.6.5 Floodwalls

A floodwall is a concrete or sheetpile structure that parallels the channel on either side, rising above the surrounding floodplain (or in this case above the existing levees), and increasing the capacity of the existing channel. The floodwall concept simply creates more capacity within the channel for floodwaters to occupy when needed. Evaluation of the floodwall indicated that it could provide a solution to floodwater inundation outside the channel, but that it would not address channel stabilization and the potential for future flood damage posed by subsequent levee failure and adjacent property inundation. A "stand-alone" floodwall could rise over ten feet above the existing levee or surrounding floodplain in some locations, severing wildlife passage, creating an aesthetic problem, and impacting existing recreational usage. In other ways, the floodwall concept would not be as impacting environmentally as other measures. The floodwall concept was initially judged potentially economically justified due to the lower cost of implementation compared to other measures. In addition, when combined with channel stabilization, and potentially other means of floodwater storage such as on-line detention, a project could be formulated that provides a complete, efficient, effective, and acceptable solution to the problems of floodwater inundation, channel instability, infrastructure destruction, and potentially land loss due to erosion in certain areas. For these reasons, the floodwall is recommended for further analysis.

7.3.6.6 Enlargement of the Channel

Enlargement of the channel involves excavation of additional channel capacity alongside or below the existing channel dimensions. It may be designed to any level of protection. An enlarged channel simply creates more capacity for floodwaters to occupy when needed. Evaluation of the enlarged channel concept indicated that it could provide a solution to floodwater inundation outside the channel. However, the channel would require significant land purchase and construction costs. Simple enlargement would not address channel stabilization and the potential for future flood damage posed by subsequent levee failure and adjacent property inundation. An enlarged channel would have substantial environmental impacts, but also has the potential to provide additional habitat in-channel if designed with excess capacity. Although it was initially believed that channel enlargement would be economically unjustified due to the high cost of implementation, an enlarged channel would substantially reduce inundation damage in the watershed and might be an acceptable solution to local residents, potentially as part of a locally-preferred plan. Particularly in the realm of selective enlargement in constricted areas, it was felt that channel enlargement might provide a viable solution, if only for certain reaches. For these reasons, enlargement of the channel is recommended for further analysis.

7.3.6.7 Flood Insurance

Flood Insurance involves the purchase of insurance to cover inundation damage in the event of a flood. It does nothing to solve the issue of flood inundation; it simply seeks to reimburse those entities suffering the economic impact of flooding. Purchase of flood insurance would do nothing to reduce damage, ensure public safety, or prevent emergency costs. Evaluation of the flood insurance concept indicated that most entities currently at risk in this watershed already have flood insurance. While flood insurance does provide an economical means of recouping expenditures due to flood inundation, it does not solve the problem and does not meet the planning objectives. It does not provide a solution to floodwater inundation outside the channel. Flood insurance does not create any environmental impacts, but does create some social effects. Although the costs of flood inundation are usually reimbursed to those suffering losses, the costs are also only borne by those few that suffer the problem. Although a fairly efficient use of Federal dollars, it is neither a complete nor acceptable solution. Because most residents of the regulatory floodplain already possess flood insurance and because flood insurance is not a complete solution, flood insurance is only carried forward as a component of a more comprehensive overall plan for damage reduction.

7.3.6.8 Floodplain Regulation

Floodplain regulation involves the control of construction activities and land uses in the floodplain to minimize potential damage in the event of a flood. It does nothing to solve the issue of flood inundation; it simply seeks to regulate floodplain uses to minimize current and future damage. Floodplain regulation does nothing to reduce damage unless regulation forces the removal of damageable property from the affected floodplain. It does nothing to ensure public safety or prevent emergency costs. Evaluation of the floodplain regulation concept indicated that the County and cities in the watershed are currently regulating floodplain usage and that damageable properties occupied the floodplain prior to institution of this process. While floodplain regulation does provide an economical means of reducing the potential for damage, this has largely already been done. It does not completely solve the problem and does not meet the planning objectives. It does not provide a solution to current floodwater inundation outside the channel. Floodplain regulation does not create any negative environmental impacts, but does create some social effects. Regulating the floodplain beyond the level currently in place would require considerable expenditure. Although a fairly efficient use of Federal (as opposed to local) dollars, it is neither a complete nor acceptable solution. Because floodplain regulation is currently in place in this watershed and does not provide a complete solution to the problem, it is not necessary to conduct further analysis on this measure. Floodplain regulation is recommended as a component of a larger, more comprehensive plan for damage reduction.

7.3.6.9 Emergency Response

Emergency response involves the development of an emergency plan that provides for dispatch of emergency services and a framework within which local agencies would operate during a flood event. It does nothing to solve the issue of flood inundation; it simply seeks to provide for public safety and spot treatment of problem areas. Emergency response does nothing to reduce damage in the affected floodplain. Emergency response does nothing to prevent emergency costs. While emergency response is already a part of existing agency operations, it does not meet all the planning objectives. It does not provide a solution to floodwater inundation outside the channel. In addition, while emergency response does not create any negative environmental impacts, it is also neither a complete or acceptable solution. For these reasons, emergency response does not require an additional analysis.

7.3.6.10 Evacuation

Evacuation involves the development of an emergency plan that provides for the physical removal of residents of the floodplain on a temporary basis in the event of a flood. It does nothing to solve the issue of flood inundation; it simply seeks to provide for public safety during hazardous flooding conditions. Evacuation does nothing to reduce damage in the affected floodplain. Evacuation does nothing to prevent emergency costs. While evacuation is part of the emergency operations of local agencies, it does not meet all the planning objectives. It does not provide a solution to floodwater inundation outside the channel. Moreover, while evacuation does not create any negative environmental impacts, it is neither a complete or acceptable solution. For these reasons, evacuation is not recommended for further analysis.

7.3.6.11 Floodproofing

Floodproofing involves the treatment of buildings and infrastructure in the floodplain to allow them to survive flood inundation without significant damage. Floodproofing may involve sealing the outside surfaces of structures, installation of watertight doors and windows, movement of structure contents to higher floors in the structure, or construction of watertight housings that prevent floodwater inundation of valuable infrastructure. It does nothing to prevent flood inundation of the floodplain; it simply seeks to prevent damage to damageable property. Floodproofing does nothing to provide for public safety during hazardous flooding conditions. Floodproofing does nothing to prevent floodwater breakout onto valuable floodplain properties. Floodproofing does nothing to prevent emergency costs. Floodproofing does not create any negative environmental impacts. Because most structures in the floodplain are only rarely inundated, and floodproofing costs are substantial on an individual basis, this measure was not economically justified. With over four thousand structures in the floodplain, this measure was one of the most costly per dollar of damage prevented of all the inundation reduction measures examined. For that reason, it is not recommended for further analysis.

7.3.6.12 Removal of Impediments to Flow

Removal of impediments to flow in San Juan Creek involves the removal of vegetation, sediment, and debris that interferes with the conveyance of floodflows through a certain reach of channel. Removal may involve mechanical or human actions. Impediments would normally be completely removed from the channel, but only in those locations that actually need greater capacity, not as a widespread treatment. Removal of impediments does nothing to solve the issue of flood inundation; it simply improves capacity in undersized reaches to obtain a more uniform capacity throughout the channel system. Capacity increase is limited by the degree of improvement possible; it does not enlarge the channel beyond its maximum existing capacity. Removal does little to provide for public safety during hazardous flooding conditions. Removal of impediments does nothing to reduce damage in the affected floodplain. It does nothing to prevent emergency costs. Evaluation of this concept indicated that there is little to be gained from this method on San Juan Creek. There are no large vegetal or debris “plugs” by which removal would result in significantly greater capacity. Removal of impediments to flow on San Juan Creek does not meet the planning objectives. It does not provide a solution to floodwater inundation outside the channel. Removal of impediments to flow has the potential to create negative environmental impacts, as removal of vegetation carries along with it the potential loss of habitat. Although it is oftentimes a fairly efficient use of funds, in this case it is neither a complete or acceptable solution. For these reasons, removal of impediments is not recommended for further analysis.

Because undersized bridge cross-sections can be an impediment to flow, examination of the potential benefit of individual bridge replacement or capacity improvement by expansion of the bridge profile will be conducted as part of structural analyses of individual flood reduction plans.

7.3.7 Channel Stabilization Measures

While channel stabilization measures are a means to reduce land loss due to erosion and infrastructure damage by surface water runoff, such as damage caused to bridge abutments or pipelines due to floodflow scour, it is also a flood inundation reduction measure. This is due to conclusions resulting from hydrologic and hydraulic modeling of the watershed that prior to levee overtopping, there is a significant, and potentially more frequent risk for levee failure due to undermining and subsequent floodplain inundation. As a result of the technical analyses, it was found that there is sufficient evidence that levee failure will be more frequent than overtopping of the levee system, and also that many of the "inundation reduction" measures discussed in the prior section will not function in the absence of channel stabilization. For instance, if the levees were to be increased in height to accommodate a 1% exceedance flood, there would still remain a substantial chance that floods of less than this magnitude would cause inundation damage due to failure of the levee prior to overtopping. Therefore, while several channel stabilization measures are discussed as "stand-alone" projects in the following section, it is recognized that any comprehensive plan to reduce flood damage must include channel stabilization as a required component.

7.3.7.1 "Toe-Down" Option

This measure provides for additional "toe-down" to be added to the base of each structure crossing or paralleling San Juan Creek or its tributaries. This would require the calculation of scour depth, and the adding on of additional channel lining depth or pier depth to bridges and other protective structures. Preliminary analysis of this measure indicated that it would be extremely expensive. Given the preliminary level of this analysis it was impossible to determine a likely scour depth or needed increase in structure depth. Therefore, a conservative approach was taken, and an assumed 6 feet of depth added on to each structure. Preliminary cost estimates indicated that this method would likely be the most expensive of all options, and is therefore not recommended for further pursuit at this level of study. If, at a later stage of study, a grade stabilization approach is determined to be infeasible, this option may be retained for restudy. However, at this time the toe-down option will not be carried forward for further analysis.

7.3.7.2 Grade Stabilizer Option

This measure consists of installing hard structures across the channel bed, at intervals to be determined by equilibrium analysis and geomorphic studies. Options examined included placement of large structures far apart, or placement of smaller structures closer together. Preliminary analysis indicated that large structures would not be passable to fish during large events, and that a large structure would tend to cause greater scour downstream, an approach that would tend to further undermine the existing levee system. The development of this option indicated that grade stabilization is a viable solution to the problem of invert downcutting, and that it might be done at a cost that would be economically feasible. Therefore, various grade stabilization options were carried forward for further study.

7.3.8 Resource Agency Comments – Preliminary Plan Formulation

Because this preliminary phase of analysis will not undergo official agency review (this will be done on completion of the decision document), no official response to these measures has been generated. However, continued discussion with resource agency staff indicates that there are some measures anticipated to be more environmentally damaging than others. Those measures focusing on the improvement of existing facilities (such as levee improvements) are anticipated to cause the least damage, and are therefore more acceptable in concept than measures that would be sited in areas of higher habitat value (such as detention basins). For example, because of its potential to sever wildlife movement corridors, the resource agencies do not support the floodwall concept for this watershed. Because of these issues, detailed studies of each alternative taken past this phase of study will be required. Most notably, the issue of habitat connectivity will need to be examined in greater detail. The U.S. Fish and Wildlife Services has stated that they would be highly supportive of plans to regain connectivity between upstream headwater reaches of San Juan Creek and the Pacific Ocean. Currently, several impediments to passage exist on both San Juan and Trabuco Creeks. While studies examining the engineering, economic, and environmental feasibility of potential measures will continue past generation of this milestone product, the incorporation of "passage" measures, or components of a larger more comprehensive plan, will be key in seeking out and obtaining resource agency acceptance. The identification of areas of critical or sensitive habitats and the avoidance of impacts to these areas will also be a critical element in continued phases of planning.

7.4 Ecosystem Restoration Measures

A multi-disciplinary team of environmental specialists, biologists, representatives from resource agencies, engineers, hydrologists and hydraulic engineers, cost estimators, geomorphologists, designers, and local agency representatives developed ecosystem restoration measures. The following is a synopsis of ecosystem restoration measures, including an analysis of their potential for Federal involvement, their objectives, constraints, and a recommendation for pursuit or deletion from later phases of study.

7.4.1 Ecosystem Restoration Objectives

The objective of ecosystem restoration is to restore degraded ecosystems to a prior, more desirable condition. In the case of the San Juan Creek watershed, almost all habitats have been severely reduced in both extent and quality from their historic conditions. Terrestrial riparian and aquatic habitat has been particularly hard hit, as the channel system of San Juan Creek has been severely modified by both human and other influences. As the channel of San Juan Creek becomes more unstable, vegetation that formerly covered the banks and bed is lost to erosion. Riparian habitat disappears. Loss of bed material results in a loss of breeding, foraging, and resting habitat. Species and food sources that rely on this habitat also disappear. Segmentation of the riparian corridor by drop structures and "dead" channel reaches cuts off access for wildlife to upper reaches of the watershed. Water temperatures rise beyond the point of tolerance. Dissolved oxygen levels drop below sustaining levels. Sediment chokes needed in-stream habitats. The objective of ecosystem restoration on San Juan Creek is the restoration of those habitats most in need of assistance, reversal of negative trends, and re-creation of more desirable and more historic environmental conditions in the watershed.

7.4.2 Development of Measures

Potential measures for ecosystem restoration in the San Juan Creek watershed were developed through discussion and observation on site visits, discussions with resource agency staff, analysis of existing databases, "brainstorming" by Corps and other environmental experts, analysis of functional assessment data, and iteration of ideas from the public, interested individuals, agencies, residents of the watershed, senior staff from Corps, the local sponsor, and other responsible entities. A preliminary list of measures was developed and analysis performed so that the improvement by a particular measure could be compared to the existing condition. Those measures warranting further analysis were carried forward into the next phase of study.

7.4.3 Preliminary Array of Measures

A comprehensive list of structural and non-structural ecosystem restoration measures was developed to address the issues of channel degradation, floodplain soil moisture drainage, loss of in-stream habitat, loss of riparian corridor habitat, loss of adjacent floodplain habitat, loss of aquatic species, loss of riparian zone terrestrial species, exotic species infestation, and ecosystem-impacting issues such as heightened water temperatures, low dissolved oxygen content, and high suspended sediment load.

Structural measures include:

- Restoration of riparian and wetland habitats, San Juan Creek Mainstem
- Restoration of riparian and wetland habitats, Trabuco Creek
- Restoration of riparian and wetland habitats, Oso Creek
- Stream Lengthening
- Fish Habitat Restoration
- Modification of Existing Grade Control Structures

Non-structural measures include:

- Ecosystem Management Plan, San Juan Creek Watershed
- Watershed Education Plan (Public and Private Institutions)
- Non-Point Source Public Awareness Plan
- Institution and Monitoring of Best Management Practices (BMPs)
- San Juan Creek Riparian Zone Revegetation Plan
- Stabilization of the channel by non-structural means
- Exotic Species Eradication

7.4.4 Evaluation Criteria

Preliminary measures were initially evaluated according to three criteria: engineering feasibility, economic justifiability, and environmental acceptability. For a measure to be feasible from an engineering perspective, it would have to be constructible; able to meet safety regulations; and designable to applicable Federal, Corps, and potentially state criteria. A measure would also have to give some indication that its benefits (environmentally) would justify its costs. A measure would also have to have mitigable impacts.

Each preliminary measure was then evaluated by four additional criteria: completeness, efficiency, effectiveness, and acceptability. Completeness is the extent to which an alternative plan addresses the stated problem. A complete plan is one that achieves all of the objectives set forth without leaving one or more objectives unaddressed. Efficiency is the extent to which an alternative plan is the most cost-effective means of achieving the objectives. Effectiveness is the extent to which an alternative contributes to the planning objectives. Acceptability is the extent to which the alternative plan would be acceptable in terms of applicable laws, regulations, and public policies. Mitigation of adverse impacts is an integral component of each alternative.

7.4.5 Evaluation of Preliminary Measures

Ecosystem restoration measures in the preliminary array were evaluated for their ability to meet the study objectives, their implementability, their costs and potential benefits, and their impacts on environmental resources, both positive and negative. A matrix was developed to compare measures and as a tool in the initial screening of measures. This comparison is presented in Table 30.

Table 30 Comparison of Preliminary Ecosystem Restoration Alternatives

Measure	Engineering Feasibility	Economic Justifiability	Environmental Acceptability	Completeness	Efficiency	Effectiveness	Acceptability
Restoration, San Juan Creek	Yes	*	Yes	No	Yes	Yes	Yes
Restoration, Trabuco Creek	Yes	*	Yes	No	No	Yes	Yes
Restoration, Oso Creek	Yes	*	Yes	No	No	Yes	Yes
Stream Lengthening	No	*	No	No	No	No	No
Fish Habitat Restoration	Yes	*	No	No	No	No	No
Modify Grade Controls	Yes	*	Yes	No	Yes	Yes	Yes
Ecosystem Management Plan, San Juan Creek Watershed	NA	*	Yes	No	Yes	Yes	Yes
Watershed Education Plan	NA	*	Yes	No	Yes	Yes	Yes
Non-Point Source Public Awareness Plan	NA	*	Yes	No	Yes	Yes	Yes
Institution and Monitoring of Best Management Practices (BMPs)	Yes	*	Yes	No	Yes	Yes	Yes
San Juan Creek Riparian Zone Revegetation Plan	Yes	*	Yes	No	Yes	No	No
Stabilization of the channel by non-structural means	Yes	*	Yes	No	No	No	No
Exotic Species Eradication	Yes	*	Yes	No	Yes	Yes	Yes

Environmental benefits are not evaluated based on economic justifiability.

7.4.5.1 Restoration of Riparian and Wetland Habitats, San Juan Creek Mainstem

Restoration of wetlands on the San Juan Creek mainstem channel would involve reconnection, contouring, and reestablishment of habitat (either by design or by natural revegetation) along the creek and potentially adjacent floodplain surface. The goal would be restoration of former wetlands functions and values. These sites might be off-line or on-line. There are a number of sites along the channel that were identified as having potential for moderate gains in function in the event of restoration. For example, the channel upstream of La Novia Bridge was identified as a suitable site. The site formerly maintained a riparian corridor of identified high value, maintained both an aquatic and terrestrial wildlife population, and functioned as a corridor to reaches upstream and downstream. The problem with this site and all others on the mainstem of San Juan Creek is the degree to which these sites are now disconnected from the existing channel system upstream and downstream of the site and the degree to which the habitat has been damaged. In addition, because of flood capacity needs, it is impossible to allow the channel to revegetate completely within its existing dimensions. Use of similar sites on San Juan Creek would also require considerable excavation to meet the needs of flood control and at the same time allow vegetative growth sufficient to regain a semblance of former habitat value. Nevertheless, a number of sites were identified in this phase of study that have potential to generate a significant benefit to wildlife, as well as restore vital wetlands functions to the creek. Therefore, restoration of riparian habitats and wetlands on San Juan Creek's mainstem is recommended for further study, both as a stand-alone measure and as a potential component of a larger, more comprehensive alternative.

7.4.5.2 Restoration of Riparian and Wetland Habitats, Trabuco Creek

As with San Juan Creek's mainstem, restoration of wetlands on Trabuco Creek would involve reconnection, contouring, and reestablishment of habitat (either by design or by natural revegetation) along the creek and potentially adjacent floodplain surface. The goal would be restoration of former wetlands functions and values. These sites might be off-line or on-line. There are a number of sites along Trabuco Creek that were identified as having potential for moderate gains in function in the event of restoration. Because of flood capacity needs, it is impossible to allow the channel to revegetate completely within its existing dimensions. Use of similar sites elsewhere on Trabuco Creek would also require considerable excavation to meet the needs of flood control and at the same time allow vegetative growth sufficient to regain former habitat value. Nevertheless, several sites were identified in this phase of study that have potential to generate a significant benefit to wildlife, as well as restore vital wetlands functions to the creek. Therefore, restoration of riparian habitats and wetlands on Trabuco Creek is recommended for further study, both as a stand-alone measure and as a potential component of a larger, more comprehensive alternative.

7.4.5.3 Restoration of Riparian and Wetland Habitats, Oso Creek

As with Trabuco Creek, restoration of riparian habitats and wetlands on Oso Creek would involve reconnection, contouring, and reestablishment of habitat (either by design or by natural revegetation) along the creek and potentially adjacent floodplain surface. The goal would be restoration of former wetlands functions and values. These sites might be off-line or on-line. There are several sites along Oso Creek that were identified as having potential for moderate gains in function in the event of restoration. Because of flood capacity needs, it is impossible to allow the channel to revegetate completely within its existing dimensions. Use of similar sites elsewhere on Oso Creek would also require considerable excavation to meet the needs of flood control and at the same time allow vegetative growth sufficient to regain former habitat value. Nevertheless, several sites were identified in this phase of study that have potential to generate a significant benefit to wildlife, as well as restore vital wetlands functions to the creek. Therefore, restoration of riparian habitats and wetlands on Oso Creek is recommended for further study, both as a stand-alone measure and as a potential component of a larger, more comprehensive alternative.

7.4.5.4 Stream Lengthening

The focus of several suggestions on ecosystem restoration in the San Juan Creek watershed was to provide more habitat by lengthening of the channel. Study of the San Juan Creek mainstem channel indicates that some measure of stream lengthening could be accommodated. However, this change would result in some change in equilibrium conditions, and this measure would lower slope and also lessen sediment transport. This is not necessarily a good thing for San Juan Creek, although it might seem so on first impression. Lowering of channel slope will lower water velocity. This could potentially impact sediment transport and sand delivery to the Ocean. For nearby beach areas already in a state of undernourishment, this effect would be highly impacting. In addition, this measure would require large amounts of real estate, both for channel re-siting and as a buffer against erosion. Comparison of the potential benefit to those of previously-discussed measures indicates that this measure may not be as cost-effective or as beneficial as those discussed above. For these reasons, stream lengthening should not be carried forward for further analysis.

7.4.5.5 Fish Habitat Restoration

Restoration of fish habitat was recognized as potentially an important ecosystem restoration measure. This measure would consist of recreating the structure of the channel bed in such a way as to provide habitat, particularly breeding habitat, for aquatic species. This could involve the installation of suitable substrate in areas determined to be suited for eventual reestablishment of fish and associated aquatic species. There are several sites that were identified during the course of study that are suitable for fish habitat restoration.

Restoration of fish habitat would provide one of the key ingredients of a comprehensive plan, allowing the return (breeding) of riparian-dependent wildlife. It was also recognized that this measure would require further study to determine its ultimate value as part of an ecosystem restoration program. It was also understood that this measure would not function as a stand-alone measure due to its lack of survivability in this environment. It would also require incorporation of other features to provide a comprehensive ecosystem restoration alternative. Because these habitats already exist in the headwaters areas, which are more suitable for implementation of this concept, there is little benefit to this measure unless incorporated into a larger off-line concept. Therefore, it is recommended that fish habitat only be carried forward into the next phase of study as part of a potentially larger, more comprehensive plan.

7.4.5.6 Modification of Existing Grade Control Structures

Following several site visits to the watershed and discussions on restoration of the channel system, it was recognized that modification of the existing grade control structures on San Juan Creek could yield significant benefits to wildlife, as well as potentially lowering water temperatures and increasing dissolved oxygen. Drop structures in particular form a significant barrier to wildlife, as well as having negative effects on the water itself.

Modification of the structures to provide fish passage and water turbulence (and hence aeration) was recognized as a potentially highly productive ecosystem restoration measure. Installation of a fish ladder was examined as the means of providing environmental benefits. Restoration of connectivity to the channel system would provide one of the key ingredients of a comprehensive plan, allowing the return of riparian-dependent wildlife. It was recognized that this measure would require further study to determine its ultimate value as part of an ecosystem restoration program. It is also understood that this measure might require incorporation of other features to provide a comprehensive ecosystem restoration alternative. Therefore, it is recommended that modification of drop structures be carried forward into the next phase of study, potentially as part of a larger, more comprehensive plan.

7.4.5.7 Ecosystem Management Plan, San Juan Creek Watershed

Development of an ecosystem management plan for the entire San Juan Creek watershed was recognized as a viable ecosystem restoration measure. An ecosystem restoration plan would provide for the management of resources in the watershed, as well as recommendations to reverse negative trends, establish Best Management Practices (BMPs), and provide for monitoring.

An ecosystem management plan could include information on existing environmental resources and trends for the future. It could include management recommendations. It could include critical information on threatened and endangered species, areas of special concern, critical habitat, and points of contact. It might include information on regulatory concerns and permitting. It might also include recommendations on treatment of problem areas, mitigation areas, and current and expected future projects in the watershed that would potentially interact with environmental resources.

Given the limited time that the Corps has in the study (and potentially construction) process and given the fact that the Corps will not be involved in future monitoring and maintenance activities, an ecosystem management plan could also include recommendations in those areas. Because of the critical need for structural modifications to the ecosystem as part of a complete program for ecosystem restoration in the watershed, an ecosystem management plan will not provide a complete solution to the many problems evident along San Juan Creek. For this reason, it is recommended that an ecosystem management plan be forwarded into the later phase of analysis only as part of a comprehensive ecosystem restoration alternative.

7.4.5.8 Watershed Education Plan (Public and Private Institutions)

A watershed education plan would involve the preparation of a document containing information, coursework, curricula, resources, and teaching plans to provide educators with the necessary support to teach students the same information, at perhaps a greater level of detail, as might be provided in an earth science program.

This document could be furnished to science teachers in area schools to develop an understanding of how a watershed functions. It could instruct students in biology, geology, basic hydrology, and other sciences applicable to an understanding of the watershed. Coursework could be specifically oriented to accommodate the particular needs of the residents of the watershed. Teaching of this material would foster future stewardship of the water and related land resources of the watershed.

Evaluation of this measure indicated high levels of support at every level of involvement. The local sponsor, resource agencies, educators, city representatives, and residents support it. Development of a watershed education plan is not a complete solution to the problems in the watershed. However, it is recognized that this measure is a critical element of a comprehensive solution to the problems facing the watershed. Therefore, it is recommended that this measure be carried forward for further analysis as a potential component of a larger, more comprehensive alternative.

7.4.5.9 Non-Point Source Public Awareness Plan

Development of a non-point source public awareness plan was included as a viable ecosystem restoration measure. A non-point source plan would heighten awareness of the problems in the watershed. It would point out destructive activities. It would provide recommendations for improving the water resource. A public awareness plan might point out things that a resident might do to lessen the impacts of individuals and foster involvement at the local level. Non-point source public awareness plans have proven helpful in other areas of the country.

Evaluation of this measure also indicated high levels of support at every level of involvement. This measure is supported by the local sponsor, resource agencies, educators, city representatives, and residents. Development of a non-point source public awareness plan is not a complete solution to the problems in the watershed. However, it is recognized that this measure is a critical element of a comprehensive solution to the problems facing the watershed. This measure may be combined with others to address multiple parties. Therefore, it is recommended that this measure be carried forward for further analysis as a potential component of a larger, more comprehensive alternative.

7.4.5.10 Institution and Monitoring of Best Management Practices (BMPs)

Best Management Practices are measures that address a variety of impacting activities in a given area. BMPs might include recommendations for managing erosion on land undergoing construction activities, street sweeping, pet waste management, or lawn watering instructions. There are few limitations on what a Best Management Practice might be. BMPs are already used in the San Juan Creek watershed to a varied extent. There appears to be a piecemeal application of BMPs throughout the watershed. It is also not completely understood just how effective some of these measures might be in this particular watershed.

Development of a list of BMPs, together with instructions on who and what might be instituted, would be a valuable component of a comprehensive plan. Perhaps most importantly, monitoring of BMP effectiveness would be an important decision-making tool for local entities. This would provide the means for cities and the County to evaluate whether or not money is well spent. BMPs expected to yield little improvement could be eliminated, and perhaps replaced with more effective measures. It is understood that BMPs alone will not solve many of the problems facing the San Juan Creek watershed. Therefore, it is recommended that this measure be carried forward for further analysis only as a potential component of a larger, more comprehensive alternative.

7.4.5.11 San Juan Creek Riparian Zone Revegetation Plan

Revegetation of San Juan Creek's riparian zone is viewed as a critical element in restoring the ecosystem. Revegetation will bring the obvious benefits of supplying habitat for aquatic and non-aquatic species. Revegetation will also contribute to the lowering of water temperatures, currently a large constraint on ecosystem restoration.

Unfortunately, revegetation of San Juan Creek is not possible as a stand-alone measure. The creek is currently so structurally unstable that revegetation efforts have a high likelihood of failure in the absence of structural stabilization measures. For this reason, carrying forward a revegetation concept as a stand-alone measure is not recommended. However, due to the importance of revegetation as a component of any meaningful ecosystem restoration campaign, it is recommended that this measure be forwarded for further study as an element of a larger, more comprehensive alternative.

7.4.5.12 Stabilization of the Channel by Non-Structural Means

Stabilization of the channel by non-structural means would involve "letting the creek go" in regards to the channel stability issue. That is, that the expectation would be that the creek would, by itself, eventually reach a condition of equilibrium, in which water and sediment inflow would be balanced, and the creek would be restored to a stable form. Various non-structural means might be implemented to encourage the creek to begin the reversal of its current negative trend.

Geomorphic studies conducted to this end have indicated that there is no physical restraint to continued channel degradation. In fact, there is an expectation that channel downcutting and, hence, channel widening and bank collapse will continue into the foreseeable future.

While this methodology might work in certain environments, it is not believed to be a valid approach for San Juan Creek. As there is currently an excess of tractive force available and little hope of reversal in the trend toward higher discharges and lower sediment loads, there is no reason to believe that the trend of downcutting will end.

Although some measures recommended for further pursuit, such as revegetation, will certainly act in a non-structural manner toward the enhancement of channel stability, pursuit of non-structural measures of stabilizing San Juan Creek is not recommended for further study.

7.4.5.13 Exotic Species Eradication

Exotic species eradication is viewed as an extremely important component of ecosystem restoration for San Juan Creek. Exotic species eradication will replace non-native species of low habitat value with native species of high resource value.

As with revegetation, exotic species eradication is not considered to be viable as a stand-alone measure. The creek is currently so structurally unstable that areas in which exotics are removed will have a high likelihood of reinfestation in a short period of time in the absence of structural stabilization measures. Many exotics, particularly arundo donax, have a higher likelihood of survival during the early stages of life in a disturbed environment. If a “top of the watershed to bottom of the watershed” stand-alone approach were pursued in a continually unstable channel system, the reintroduction of these exotics would be more likely. For this reason, carrying forward an exotic species eradication concept as a stand-alone measure is not recommended. However, due to the importance of exotic species eradication as a component of any meaningful ecosystem restoration campaign, it is recommended that this measure be forwarded for further study as an element of a larger, more comprehensive alternative.

7.4.6 Resource Agency Comments

As with the development of flood inundation reduction measures, because this preliminary phase of analysis will not undergo official agency review (and will be done on completion of the decision document), no official response to these measures has been generated. However, continued discussion with resource agency staff indicates that there are some measures anticipated to be more environmentally beneficial than others. Those measures focusing on the inclusion of riparian/wetland restoration within the channel or in an enlarged channel cross-section are seen to be the most beneficial because they provide resting areas for fish and are productive in their own right. Other concepts, such as stand-alone fish habitat restoration, obtained less support because it is viewed as not providing as great a benefit. In particular, the issue of habitat connectivity will need to be examined in greater detail. The U.S. Fish and Wildlife Services has stated that they would be highly supportive of plans to regain connectivity between upstream headwater reaches of San Juan Creek and the Pacific Ocean. Currently, several impediments to passage exist on both San Juan and Trabuco Creeks. While studies examining the engineering, economic, and environmental feasibility of potential measures will continue past generation of this milestone product, the incorporation of “passage” measures or components of a larger more comprehensive plan will be key in seeking out and obtaining resource agency acceptance. The identification of areas of critical or sensitive habitats and the avoidance of impacts to these same areas will also be a critical element in continued phases of planning.

7.5 Water Quality Measures

Development of water quality measures involved the input of the County of Orange Public Facilities and Resources Department, the Orange County Health Department, the California Regional Water Quality Control Board, water quality engineers, technical staff, and many interested individuals. Based on water quality tests conducted in this phase of study, certain constituents are identified as exceeding health standards for several beneficial uses. Primary among these is bacteria. Because of bacterial contamination, the lower mile and a half of San Juan Creek is designated as impaired on the Clean Water Act Section 303(d) list. Water quality measures are focused on enhancement of water quality, with the eventual goal of meeting existing standards.

Because of the need to evaluate existing water quality and determine suitable measures for implementation to address the problem, a study was conducted (concurrent with this study) by the Orange County Public Facilities and Resources Department. This study summarized existing information and conducted water quality tests for e-coli and enterococcus at numerous sites throughout the watershed. This study is summarized in Section 6. Unfortunately, as study of this issue is ongoing and expensive, no definitive treatment of this issue is possible at this time. Rather, a number of recommendations were developed for potential pursuit by local interests. Evaluation of potential measures was conducted by means of a matrix of potential impacts.

7.5.1 Objectives

The San Juan Creek Watershed has been impacted by a variety of physical and environmental factors. These include increased runoff and erosion due to development, channel confinement by drainage structures; new and exacerbated pollutant loadings including metals, oil and grease, pesticides and pathogens; the introduction of exotic organisms; and the impact of significant wildlife populations. Many of these changes have produced secondary changes in the ecology of the creek resulting in less shade and higher water temperatures. Even climate may have contributed to reducing instream biologic diversity, such as when heavy storms in 1983 apparently eliminated large amphibians and some non-native fish populations. Because of these impacts, the watershed no longer meets all of its potential beneficial uses.

One goal of this study is to develop identifiable objectives that demonstrate or monitor progress in returning the full range of beneficial uses to the watershed and returning the creekside habitat to a more natural condition. Ideally, these objectives would monitor physical, chemical, and biologic parameters and indices to track a variety of parameters to demonstrate improvement in multiple watershed facets. Eventually, this may even allow correlations to be developed relating the return of some biologic indices to the reduction of same parameter, which could then be targeted in other parts of the watershed to facilitate expansion of that biologic indicator.

The primary objective of this portion of the study effort is to develop and recommend measures to enhance water quality in the San Juan Creek watershed.

7.5.2 Development of Water Quality Measures

Measures were developed with the participation of the study team, Orange County Public Facilities and Resources Department, technical staff, and a variety of interested individuals. Measures were developed for their perceived ability to address one or more existing water quality problems. Ongoing stakeholder participation has indicated that primary emphasis should be placed the bacteriological problem, with toxicity and other pollutants as a secondary goal.

7.5.2.1 Preliminary Array of Water Quality Measures

The preliminary array of water quality improvement measures includes:

- Education
- Public awareness campaigns
- Wetlands creation
- On-site biofiltration/infiltration (BMP)
- Landscape controls (BMP)
- Pet waste control enforcement (BMP)
- Retrofitting of existing drainage system (BMP)
- Exotic species eradication
- Stream stabilization/habitat restoration
- BMP monitoring and evaluation plan, and
- Management programs

Each of the measures is felt to have significant potential for improving water quality.

7.5.3 Evaluation of Measures

The evaluation of measures involved a somewhat subjective approach to decision-making, as no consensus currently exists on how to evaluate potential improvement. Examination of the proposed measures led to a recommendation as to how a particular measure might be performed, particularly in regards to the major objective of the water quality study effort, the reduction of bacterial counts in as many reaches of the creek as possible. The "big picture" view of the watershed is important, because although only the lower mile and a half of the creek is designated as impaired, the entire creek is targeted to meet standards.

7.5.3.1 Evaluation Criteria

Input from the study team included the perceived benefits for each measure in terms of previously established parameters. Perceived water quality benefits were defined by the parameters of greatest concern, namely bacteria, aquatic toxicity, and temperature. Each measure was evaluated on its probability of reducing concentrations of fecal coliform, reducing aquatic toxicity, and reducing water temperature. Cost was also a criterion in the valuation.

7.5.3.2 Resource Agency Involvement

Many public agencies are interested in the evaluation of water quality enhancement measures. Even more await the results of application of those measures. Comment received from the resource agencies led to additional measures and changing direction.

Most comment received has been on the public and resource agency focus on bacterial contamination. Given the agency focus on meeting standards for REC-1 usage, their primary goal is of addressing water quality problems, not only for the 1.5 miles of impaired creek, but for the entire watershed. Unfortunately, with the limited knowledge base at this time, no definitive approach can be taken.

7.6 Further Screening of Measures

As discussed in the previous sub-section of the report, the screening of potential measures involved the comparison of each by the same general criteria of engineering, environmental, and economic feasibility, and the elimination of measures from further study on the basis of being unable to meet one or more key criteria. While the issues of effectiveness, efficiency, completeness and acceptability were initially examined and judgments made as to a measure's ability to meet those criteria, not having met one or more of these was dealt with by further refinement and modification (and were therefore not insurmountable criteria). No measure should be forwarded for further study if it cannot be engineered soundly, is not cost effective, or is highly damaging to the environment. So as not to eliminate measures that might prove to be valid, additional development and refinement of measures was required. Those measures determined to be feasible from an engineering, environmental, and economic standpoint were further refined to maximize project performance, minimize cost and provide a minimum of impacts to the environment. However, each of these was also developed in consideration of additional criteria toward judging a potential project's feasibility.

Measures were evaluated for their preliminary costs and potential benefits; for their engineering feasibility; and environmental feasibility. They were also further developed to be more effective, more efficient, more complete, and more acceptable to local interests. Additionally, each measure was evaluated for its potential impact on flooding; water quality; air quality; noise conditions; hazardous, toxic, and radioactive wastes; vegetation; wildlife; endangered and threatened species; cultural resources; aesthetics; employment and labor; business and government activity; public health and safety; public facilities; and recreation. Because detailed analyses have not been conducted on each of these issues, many of the effects may be speculative, but overall provide the means by which to compare and contrast remaining measures/alternatives.

It is important to note that because of the necessity of evaluating individual measure performance in the absence of any other component or issue that might affect project performance, and thus skew the individual contribution in comparison with other like measures, the further screening of measures is done for “stand-alone” measures, and will be done for multi-purpose (multi-component) “alternatives” as the plan formulation process continues. For example, flood control measures need to be evaluated in terms of cost-effectiveness and other criteria prior to combination with other measures that yield other (potentially intangible) benefits. This allows the study team to select the component (or components) that solve that problem at the least cost before it is combined. Thus, the recommended multi-purpose project should be a combination of measures that stand on their own, and are the group that is demonstrated to provide the greatest benefit for its combined cost.

7.6.1 Further Screening of Flood Control Measures and the Development of Alternatives

Initial screening of flood control measures was based on additional analysis of project performance, while keeping in consideration the meeting of the criteria discussed above. This additional evaluation indicated that several measures were not capable of meeting the goals and objectives of the study on a “stand alone” basis. However, it was noted that several measures might be combined to meet the criteria of effectiveness or acceptability. Measures combined to meet project objectives become project alternatives. For instance, while it was noted that a single detention basin could not be constructed capable of significantly reducing flood damages on all tributaries, the combination of floodwalls and a basin might meet the objectives, and became an alternative forwarded for reconsideration.

As mentioned in Section 7.5, It became evident during technical analysis of the channel system that levee height increase or floodwall extension to the existing levee system would not function in the absence of channel stabilization. Additionally, while upstream detention will detain the excess volume of floodflow that is currently capable of overtopping the channel, there is a substantial risk of inundation due to levee failure even if a detention basin were installed upstream. Although they can be separated conceptually, in reality a floodwall or levee concept may fail unless channel stabilization is performed. Additionally, while the channel stabilization measures might be constructed conceptually as a stand-alone project, its implementation might cause a decrease in channel capacity if that measure were formulated to result in the raising of the invert to its original design grade. Thus, implementation of the channel stabilization measure(s) could conceivably cause a disbenefit by causing an increase in the occurrence of overtopping over current (but not as originally designed) conditions. This issue can be overcome by the adding on of additional height to compensate for the decreased capacity caused by channel infilling, or by construction of the grade stabilization "at-grade" with scour protection immediately downstream of each structure. This is the approach taken in the next phase of analysis. In order to analyze this situation, additional alternatives for flood damage reduction were created. These alternatives combine channel stabilization with a variety of flood damage reduction measures. These alternatives are the only technically feasible solutions to the flood damage problem in this watershed.

Remaining measures were further developed to allow direct comparison of each on an "apples to apples" basis. The uniform basis by which each forwarded measure was evaluated was their performance in controlling a 1% exceedance flood event. Preliminary design of each measure was performed to allow detailed analysis of performance, and the development of cost estimates. Once the hydrologic model was developed, the 1% exceedance flood event was run through the modeled measure and reductions in flood damages noted. Preliminary costs for construction, operations and maintenance, environmental mitigation were also developed, in order to compare the potential damage reduction to potential costs of an implemented project. Additional refinements were geared toward the meeting of additional objectives, notably those of completeness, efficiency, effectiveness, and acceptability. Preliminary analysis of remaining measures/alternatives indicated that channel stabilization, in concert with either floodwalls, detention basins or channel widening provided the greatest damage reduction, the only technically feasible solution, and the most effective achievement of study objectives. Combined alternatives including channel stabilization, floodwalls and a detention basin on San Juan Creek, channel stabilization, floodwalls and a detention basin on Trabuco Creek, a combination of channel stabilization, floodwalls and detention on San Juan and Trabuco Creeks, and the Floodwall and Channel Stabilization Alternative. Based on this analysis, preliminary designs and cost estimates for each measure/alternative were fully developed and a comparison matrix developed.

Flood control measures selected for further analysis include:

- Channel Stabilization, Floodwalls and Detention Basin on San Juan Creek
- Channel Stabilization, Floodwalls and Detention Basin on Trabuco Creek

- Channel Stabilization, Floodwalls and Detention Basins on San Juan and Trabuco Creeks
- Channel Stabilization and Channel Widening
- Channel Stabilization and Floodwalls

Channel stabilization measures selected for further analysis include:

- Moderately-spaced structures covering San Juan, Trabuco and Oso Creeks
- Closely-spaced structures covering San Juan, Trabuco and Oso Creeks
- Moderately-spaced structures covering limited portions of San Juan and Trabuco Creeks
- Closely-spaced structures covering limited portions of San Juan and Trabuco Creeks

As Federal participation is not the only criteria by which these measures should be examined, the pursuit of measures found unjustified for recommendation as the Corps of Engineers' National Economic Development (NED) plan, but potentially recommended as a Locally-Preferred Plan (LPP) also required that more detailed analysis be done on each.

More detailed analysis of the detention basin options indicated that neither detention basin alone would provide a sufficient level of reduction in flood damages. Therefore, each basin was combined with floodwalls (and channel stabilization) in this phase as a forwarded alternative. In addition, channel stabilization analysis indicated that closely-spaced grade stabilizers would be considerably more costly than moderately-spaced structures, with the same benefit. Therefore, continued efforts focused on the development of environmentally feasible, but moderately-spaced structures passable to migratory and resident fish, for all tributaries, as well as a more discrete plan for stabilization of the most critical project reaches.

Equivalent annual flood inundation damages due to structural inundation, incurred emergency and clean up costs, amounts to $5,636,890.00. Equivalent annual bridge failure damages due to undermining of piers and abutments, amounts to $9,444,200. Equivalent annual flood erosion damage to lands, primarily along Oso Creek, amounts to $123,610. Net damages attributable to channel overtopping alone amount to $3,115,240 on an equivalent annual basis. Net damage attributable to channel failure (referred to as "geotechnical" failure as opposed to overtopping failure) amount to $1,075,900 on the same basis, with prevention of bridge failure as an added potential benefit. Combined potential flood damage by both mechanisms (overtopping or undermining) amounts to $4,191,140 annually. Therefore, additional refinement of both flood inundation reduction and channel stabilization was performed with reduction of those damages in mind. For example, an alternative that includes components directed at channel stabilization in a zone or reach of channel with little infrastructure or risk of damage in the event of failure is not productive, and efforts were therefore directed at development of alternatives that directly impact the areas of concern.

7.6.2 Further Screening of Ecosystem Restoration Measures and the Development of Alternatives

Ecosystem restoration measures were evaluated and screened based on their potential contribution to the improvement of ecosystem conditions in the watershed. Understanding that more detailed analysis needed to be conducted, only those measures clearly believed to be of little value were dropped in the screening. Further analysis of the preliminary measures indicated that restoration of habitats along San Juan, Trabuco and Oso Creeks could be linked in concept to provide some measure of connectivity along the creek. "Pockets" of restoration might provide a greater assurance of implementability, as well as the provision of resting areas in the passage of fish upstream. Therefore, additional refinement of these three restoration measures resulted in the development of a number of restoration sites at intervals along the creek, rather than a large-scale general concept from upstream end to downstream end. Recognition of the need for integration of other measures into a more comprehensive plan lead to the inclusion of both fish habitat needs and revegetation needs into each of the above "pocket" restoration measures. Based on this phase of analysis, the following measures were recommended for further evaluation, as potential components of a comprehensive alternative package for ecosystem restoration:

- No-Action Plan
- Ecosystem Restoration of San Juan Creek between Stonehill and Pacific Coast Highway
- Ecosystem Restoration of San Juan Creek at Maintenance Site
- Ecosystem Restoration of San Juan Creek Upstream of La Novia
- Ecosystem Restoration of San Juan Creek Downstream of Antonio Parkway
- Ecosystem Restoration of San Juan Creek Upstream of Antonio Parkway
- Ecosystem Restoration of San Juan Creek at Quarry
- Ecosystem Restoration of Oso Creek at Galivan Basin
- Ecosystem Restoration of Oso Creek at Golf Course
- Ecosystem Restoration of Trabuco Creek at I-5 Crossing
- Ecosystem Restoration of Trabuco Creek East of Lakes
- Ecosystem Restoration of Oso and Trabuco Confluence
- Modification of Grade Controls for Fish Passage

- Ecosystem Management Plan
- Watershed Education Plan
- Non-Point Source Awareness Plan
- Best Management Practices (BMPs)
- Exotic Species Eradication

Application of an evaluation tool, which evaluates the "functional capacity" of a given potential restoration site, was used in the following phase to compare measures to one another, and to generate a scale of cost effectiveness. This analysis was used in the further refinement of plans, and to ultimately determine the preferred alternative(s) for implementation.

7.6.3 Further Screening of Water Quality Measures and Development of Alternatives

Further screening of water quality measures involved the ranking of watershed treatment components, based on literature, field observation, and opinion of the stakeholders and agency staff. Because further analysis outside the timeframe of this study effort will be necessary to intelligently apply specific actions to specific problem areas, it is not possible to develop a definitive list of water quality improvement projects at this time. However, use of the water quality study done in the adjoining Aliso Creek watershed is highly useful on an interim basis, to begin to apply measures toward solving water quality problems in the San Juan Creek watershed. It is recognized that this application should only be done on an interim basis until such studies are completed that identify both specific problem areas, the constituents and exceedances of concern, and allow development of measures directed at that specific site. Because the primary constituent of concern in both watersheds is the same, many of the measures analyzed for improvement in Aliso Creek may be applied to San Juan Creek.

Since specific data on the direct benefits of the measures are not available, priority rankings were assigned by rating relative benefits. Measures with high potential water quality benefit were ranked relative to other measures on a scale of one to twelve. Components were also ranked relative to potential implementation costs. The lowest number is the top ranking. The lowest overall score is the highest ranked water quality measure. The results of this screening are shown in Table 31.

Table 31 Screening of Water Quality Measures

Watershed Measure	Bacteria	Toxins	Temp.	Cost	Score	Rank
Ecosystem Restoration/Wetlands	7-10	7-10	2-6	7-11	26-33	6-10
Watershed Education	3	2	8	3	16	1-2
Non-Point Source Awareness Campaign	4	3	7	2	16	1-2
BMP Monitoring/Evaluation	12	11	11	6	40	11
Constructed Water Quality Wetlands	2	5	1	10	18	3
Retrofitting of Existing Drainage	11	6	9	12	38	10
Landscape Controls	5	1	10	5	21	5
Pet Waste Enforcement	1	12	12	1	26	6-8
Biofiltration	6	4	5	4	19	4

Based on this screening, water quality improvement due to habitat restoration, BMP monitoring, or retrofitting of existing drainages may not produce as much benefit as watershed education efforts, non-point source awareness campaigns, wetlands constructed exclusively for water quality improvement, landscape controls, and biofiltration.

7.7 Final Array of Measures, Evaluation, and Development of Alternative Plans

The screened final array of measures was evaluated in this phase of study at a higher level of detail so that the list can be pared down to a final array of preliminary alternatives. The purpose of this exercise is two-fold. First, this report must make a determination of whether or not there is a Federal interest in the recommended plan (or portions thereof). The Corps of Engineers has the authority and mandate to address problems in flood control, ecosystem restoration, and incidental recreation, and must therefore be provided the means by which to establish whether or not further study is warranted, with a potential for cost-sharing in eventual project implementation. Second, the local sponsor needs the means by which to judge the cost-effectiveness and benefits of potential projects that might not warrant Federal involvement, and the means by which to prioritize project implementation.

The final array must consist of alternatives that address the identified problem, appear to be cost-effective, and appear to do a better job than other methods developed for the same purpose. The final screening of alternatives and evaluation in comparison with other measures results in a package of measures that can be combined together as multi-objective alternative plans. The goal of this entire process is to develop a plan that addresses as many of the problems as possible, with minimal overlap, and at the best possible cost, while meeting standards and criteria established for projects of this type. In this phase, final measures are developed in detail utilizing updated project mapping and the findings of the hydrologic, hydraulic, sedimentation, environmental, design, cost, and geomorphic analyses. Further screening, both of single measures, and multi-objective alternative plans, is once again based on the following criteria:

(a) Effectiveness: Effectiveness can be judged by how well a measure addresses the objective. All of the remaining measures, and newly developed alternatives are moderately to highly effective means of addressing the flood damage, ecosystem degradation, water quality, and other problems related to water resources. Effectiveness will be further examined through use of benefit-cost analysis for projects that generate monetary benefits, or incremental analysis of ecosystem restoration for projects that generate non-monetary benefits.

(b) Efficiency: Efficiency can be judged as how well a measure addresses the objective based on its costs, while minimizing the extent of its features. Remaining measures, and newly developed alternatives are moderately to highly efficient at reducing flood damages, addressing ecosystem degradation, and addressing water quality issues. Efficiency will be further examined through use of benefit-cost analysis for projects that generate monetary benefits, or incremental analysis of ecosystem restoration for projects that generate non-monetary benefits.

(c) Completeness: Completeness is simply how well the measure addresses all of the objectives, and whether or not it provides a complete solution to the problem. Only certain measures can function as stand-alone projects, and must be combined into alternatives to function as complete projects. Completeness will be further addressed through the combination of measures into comprehensive multi-purpose alternatives.

(d) Acceptability: Acceptability is simply whether or not a measure may be viewed as acceptable by local interests. This is perhaps the final means of determining whether or not a project is ultimately implemented, as the community in which a project is sited should be the ultimate determinant as to acceptability.

Because the remaining measures/alternatives have already met the criteria of being potentially feasible from an engineering, environmental, and economic standpoint, and additional judgment of whether or not additional analysis is necessary will be based on a greater knowledge base, additional description of each alternative is warranted.

The figures following the text in this report contain illustrations of each management measure. A description of each preliminary alternative, and its potential costs and benefits is discussed in greater detail below. A summary of the findings of the results of the detailed cost-benefit analyses and ecosystem benefit analyses follow this discussion.

7.7.1 Description of Preliminary Flood Control Alternatives

7.7.1.1 FC-1: No Action Plan

The No-Action Plan assumes that flooding continues to occur in a manner similar to that of the recent past, and that no added level of protection is provided to the flood control system, including measures to address the downcutting and potential panel failure in the existing channel. Two "conditions" are analyzed in the development of the No-Action Plan. The first, the "existing condition", is the condition of the watershed at the point of initial analysis, in this case the base year of 2008. The second, the "future without-project condition", is that of the watershed, from a flooding standpoint, fifty years into the future (the period of analysis for Federal planning purposes). These two conditions are integrated over the period of analysis, and adjusted for inflationary trends, to arrive at an average annual damage figure for the watershed.

The "No-Action Plan" for the San Juan Creek watershed assumes that damages continue to accrue at an appropriate rate based on conditions expected in the watershed over the next 50 years, based on the most current planning documents and development or re-development guidance from the cities and County. Because remaining development in the watershed is required to minimize increases in discharge to the downstream channel that might arise from changes to watershed characteristics, only a small change in discharge for a given frequency flood event is expected to occur. Therefore, damages over the assumed 50-year period of analysis are only expected to rise by approximately 10% over the period of analysis (adjusted to the base year of 2008). Under a "without-project", or expected condition in future years in the absence of measures to solve the flooding problem, neither the existing channel system nor some of the bridges that cross the channel may be capable of safely conducting large floodflows without damage.

Damages expected under different frequency flood events were determined by use of a hydrologic and hydraulic model of the watershed, and an economic model developed for use in this study. The modeling effort utilized both HEC-1 and HEC-RAS, which are Corps of Engineers hydrologic and hydraulic models developed expressly for flood analysis. The economic impacts of flooding were developed by use of the Corps of Engineers' HEC-FDA (Hydrologic Engineering Center – Flood Damage Assessment) model. The modeling was used to develop relationships between flow frequency, breakout location, depths of flooding in the overbank area, and extent of the breakout. The models used in this analysis were developed expressly and solely for the purposes of determining expected damages from a variety of flood events, under conditions of expected probability, and should not be compared to floodplain maps used for other purposes, particularly those of the regulatory "100-year" floodplain as defined by the Federal Emergency Management Agency (FEMA) for use in the Flood Insurance Program.

There are approximately 4,119 structures in the 0.2% exceedance (roughly equivalent to the "500-year") floodplain of San Juan Creek and its principal tributaries. The net monetary value of these structures and their contents are in the neighborhood of $822 million. Equivalent annual flood inundation damages (i.e., damages caused by floodwaters to the structure itself and its contents) over this period due to simple overtopping of the existing channel levees are expected to be approximately $2.45 million per year for residential properties and $1.99 million for non-residential properties, for a total of $4.45 million.

There are approximately $9.44 million in expected average annual costs for bridge replacement due to scour and undermining. In addition to this, there are expected to be approximately $1.19 million in flood-related emergency and clean-up costs. Total damages then (for base year 2008) are expected to be approximately $15.2 million annually (including bridge damages).

7.7.1.2 FC-2: Floodwalls (or Levees) ONLY

The "All Floodwall Plan" (Figure 16, Figure 17, and Figure 20) utilizes floodwalls to ensure in-channel confinement of floodflows up to and including a 1% exceedance flood event. This alternative was developed to prevent damages occurring from overtopping of the channel *only*. Because the scour analysis indicates that floodwalls will not solve the inundation problem without accompanying channel stabilization measures, it is discussed in detail here only for the purposes of imparting its contribution to inundation reduction by overtopping alone, and in all future discussion beyond this section, is assumed to be combined with channel stabilization measures as part of a comprehensive alternative. The detailed discussion of floodwall features is included only here, although it is included in other alternatives, for the sake of brevity.

The 1% exceedance flood event was used for the analysis of all flood damage reduction alternatives so that they could be compared on an equivalent damage reduction ("apples to apples") basis. The 1% exceedance event is a flood event that would be equaled or exceeded, on average, only once in a one hundred year period. It is, as discussed above, only roughly equivalent to what has been commonly referred to as a "100-year flood". The floodwall plan was developed by modeling a confining wall (where needed) on one or both banks, to ensure floodflow confinement to the channel for all events up to and including the desired frequency of flood event.

The floodwall plan does not theoretically require bridge replacement of all bridges crossing the creek (even those under capacity bridges) to achieve its goals, as the floodwalls can be raised to a height necessary to encompass flows from the 1% exceedance flood event, even when "backwater" effects cause flow to back up in the channel upstream of a bridge. However, the bridges that do not possess adequate "carrying capacity" for large floods may cause such large backwater effects that the bridge may be overtopped, and a breakout through the bridge opening may occur. Additionally, it was recognized that confinement of the flow to excessive depth has the potential for increased scour of the channel bed at the bridge piers, and may thus cause failure of the bridge itself, also a mechanism for breakout. Therefore, the floodwall plan included individual bridge replacement to determine the effects of their replacement on a case-by-case basis.

Preliminary scour analysis indicated the necessity of replacing three key bridges in the watershed, even in the event of total confinement of floodflows to the channel (aside from the bridge/roadway openings). These bridges are the bridge over San Juan Creek at Pacific Coast Highway (PCH), the bridge over San Juan Creek at La Novia Avenue, and the bridge over Trabuco Creek at Del Obispo Street. These bridges were judged, at a preliminary level of analysis, of being subject to overtopping and/or scour sufficient to cause failure, and hence, breakout during the design event, regardless of floodwall height or potential bridge opening blockage (i.e., by "stop logs" or other means). In addition, this analysis indicated the failure of the channel system prior to overtopping (referred to as "geotechnical failure" to distinguish it from "overtopping failure").

FC-2: Floodwalls (or Levee) Only

Pros:

- ✓ Least expensive solution
- ✓ Minimal environmental mitigation
- ✓ Easily implementable

Cons:

- × Visually unappealing
- × Cannot be implemented with channel stabilization
- × Blocks cross-channel wildlife transit
- × Potential impacts to recreation

The plan would require an over 2 meter high floodwall immediately upstream of Pacific Coast Highway, tapering quickly down to one half meter several hundred meters upstream. A similar floodwall height would be required immediately upstream of Stonehill Drive Bridge, also tapering down to a half meter several thousand feet upstream. The floodwall would continue upstream past the confluence of San Juan and Trabuco Creeks, with again, a 2-meter high floodwall immediately upstream of Interstate 5. A floodwall would no longer be necessary as one approaches the Ortega Highway Bridge. On Trabuco Creek a floodwall would be required to a point upstream of Del Obispo Street Bridge. The floodwall would be either of “L” type or “T” type construction, depending on total height required (Sheet 12 of FC-2). The “T” type is required for all reaches in which flood heights are expected to be 2 meters or higher above the existing levee or bank top. The “T” floodwall would present some difficulties accommodating a road or trail due to the width of the flanges required at its base. The height of the floodwall may be further reduced in some cases by the complete replacement of certain bridges, most notably Pacific Coast Highway, particularly if that replacement includes modification for increased capacity, of the bridge’s associated channel cross-section at and upstream of the bridge. The PCH Bridge is an impediment to flow during the 100-year event, although its replacement poses its own problems due to the necessity of raising the bridge, and the need to extend its approaches on both sides of the bridge. The key ingredient in this replacement is, however, the elimination of its numerous piers, with their attendant potential for debris blockage and further reduction of the bridge and associated channel cross-section’s carrying capacity. The replacement of bridges with inadequate capacity does not eliminate the need for floodwalls at these locations, however; it only reduces the height of the structure.

Alternative FC-2 would additionally involve the installation of 10,030 meters of concrete floodwall of 0.5 to 2.0 meters in height, and 1,514 meters of concrete floodwall in excess of 2.0 meters in height, which includes 40 meters of floodwall 4.0 meters in height. There would also be 1,137 meters of floodwall of 1.5 meters or less in height on Trabuco Creek.

The construction cost of this alternative, exclusive of mitigation and real estate needs, would be approximately $13.0 million. Thus, with real estate costs of approximately $784,000, the cost exclusive of mitigation would be approximately $14 million. This includes replacement of Pacific Coast Highway, La Novia Avenue, and the Del Obispo Street Bridge on Trabuco Creek. This is the least costly, but most aesthetically impacting alternative of those examined. The assumption is made that existing flood control levees will be capable of ensuring containment of flood events up to the point that the floodwalls become necessary (i.e., safely pass floods that do not exceed existing channel capacity), and are capable of supporting installation of such a floodwall system, through the period of analysis of 50 years, by such means are determined appropriate.

7.7.1.3 FC-3: Detention Basin on San Juan Creek

This alternative assumes that floodflow containment within the channel would be achieved by a combination of storage of floodflows on San Juan Creek in a basin constructed for that purpose, and floodwalls of reduced height on San Juan Creek downstream of the basin, as well as floodwalls on Trabuco Creek (Figure 18 and 19). This alternative was developed to prevent damages occurring from overtopping of the channel *only*. Because the scour analysis indicates that a detention basin will not solve the inundation problem without accompanying channel stabilization and limited floodwalls downstream, it is discussed in detail here only for the purposes of imparting its contribution to inundation reduction by overtopping alone, and in all future discussion beyond this section, is assumed to be combined with channel stabilization measures as part of a comprehensive alternative. The detailed discussion of features is included only here, although it is included in other alternatives, for the sake of brevity.

Initial siting of the basin consisted of analysis of several sites along San Juan Creek. Final siting of the basin was arrived at by consideration of impacts to existing development, the location of environmental resources and their associated costs of mitigation, considerations of adequate storage capacity, and technical considerations regarding basin integrity and construction. The preliminary basin siting is located on San Juan Creek immediately upstream of Antonio Parkway, a location that is less environmentally sensitive than others (although potentially may impact habitat of Southwest Arroyo Toad and other T&E species), is not too far upstream to provide the needed reduction in discharge, and provides minimal interference with existing infrastructure or development. This location is not necessarily the final siting, but was done from the consideration of minimization of cost and other considerations noted above.

The provision of storage on San Juan Creek reduces the required floodwall height along San Juan Creek, and eliminates the need for it in some locations. Storage on San Juan Creek does not eliminate the need for an extensive floodwall immediately

FC-3: Detention Basin on San Juan Creek

Pros:

- ✓ Reduces height of downstream floodwalls
- ✓ Less visual/aesthetic impact
- ✓ Fewer potential impacts to recreation

Cons:

- × Environmentally impacting
- × Impacts other uses at basin site
- × Must be combined with channel stabilization
- × More expensive than floodwalls

upstream of PCH or Stonehill. The floodwalls would be of identical design to those of Alternative 2, with the exception of height. The basin itself would be of earthen construction, with 3 to 1 slopes on both sides. The basin was designed with riprap slopes approximately one half meter thick. The basin embankment would be approximately 24 meters high (65 feet), and 400 meters long, with a base width of approximately 140 meters. The impoundment area during a 100-year flood event would extend upstream almost to the Conrock access road, and a short distance upstream on Cañada Gobernadora. Basin construction would require the relocation of several small roads and some utilities, although existing development would not be impacted. The basin would store approximately 5,700 acre-feet of water when full to the spillway crest. Flows would pass through the basin by means of an unregulated double reinforced concrete 12’ x 9’ box culvert, providing discharge and sediment transport through the basin for most events. A stilling basin and concrete spillway would occupy the center of the structure, with protective wing walls. There would be a grouted stone apron at the downstream end of the stilling basin to control erosion. Toe-down depth on the structure would be approximately 5 meters. The pool at spillway crest would be approximately 15 meters deep. No excavation within the reservoir area would be performed, and no permanent pool established in this alternative. The basin, as designed as a flood control structure only, would not be capable of storing water long-term (outside the limited period of floodwater storage), as no clay core was included in the design.

Provision of ecosystem restoration or groundwater recharge within the reservoir area would be possible, as the area within the basin is suitable for either. Environmental mitigation for this alternative may be substantial, as the area has been identified as habitat for several Federally or State-listed endangered, threatened or sensitive species, including arroyo toad.

Alternative FC-3 would additionally involved the installation of 8,497 meters (compared to the 10,030 meters of Alternative FC-2) of concrete floodwall of 0.5 to 2.0 meters in height, and 662 meters (compared to the 1,514 meters of Alternative 2) of concrete floodwall in excess of 2.0 meters in height, with 140 meters of that consisting of floodwall 3.0 meters in height, and none in excess of that figure. There would also be 1,141 meters of flood wall of 1.5 meters or less in height on Trabuco Creek. The basin would require approximately 349,000 cubic meters of excavation, 297,000 cubic meters of structural fill utilizing on-site materials, 343,600 cubic meters of imported structural fill material, 52,000 cubic meters of common fill, 17,400 cubic meters of rip-rap protection (18” thick with a D50 of 12”), 3,900 cubic meters of concrete for the spillway lining, 13,300 cubic meters of excavation in the stilling basin, 2,150 cubic meters of concrete for the stilling basin lining, 120 cubic meters of concrete for the stilling basin retaining wall, 2,700 cubic meters of rip-rap protection for the stilling basin, and 130 meters of concrete double 12’ x 9’ box culvert for the basin outlet.

The cost of this alternative, including mitigation, is approximately $26.3 million. With real estate costs of approximately $5.0 million, the cost would be approximately $31.3 million This alternative includes replacement of PCH and La Novia bridges. This alternative is more costly, but is also more aesthetically acceptable than Alternative 2, due to the reduced height of floodwalls on much of San Juan and lower Trabuco Creeks. It is likely to have much higher mitigation costs than alternative 2, as the basin area has been identified as high quality habitat. The assumption is made that existing flood control structures will be capable of ensuring containment of flood events up to the point that the floodwalls become necessary (i.e., safely pass floods that do not exceed existing channel capacity), and are capable of supporting installation of such a floodwall system, through the period of analysis of 50 years, by such means are determined appropriate.

7.7.1.4 FC-4: Detention Basin on Trabuco Creek

This alternative consists of a detention basin on Trabuco Creek only, and floodwalls on San Juan Creek and Trabuco Creek (Figure 21). This alternative was developed to prevent damages occurring from overtopping of the channel *only*. Because the scour analysis indicates that a detention basin will not solve the inundation problem without accompanying channel stabilization measures, it is discussed in detail here only for the purposes of imparting its contribution to inundation reduction by overtopping alone, and in all future discussion beyond this section, is assumed to be combined with channel stabilization measures as part of a comprehensive alternative. The detailed discussion of features is included only here, although it is included in other alternatives, for the sake of brevity.

The basin would be sited on Trabuco Creek upstream of Station 171+00, a location that may be less environmentally sensitive than others (although still potentially impacting T&E species habitat), is not too far upstream to provide the needed reduction in discharge, and provides minimal interference with existing infrastructure or development. The provision of storage on Trabuco Creek reduces the required

FC-4: Detention Basin on Trabuco Creek

Pros:
- ✓ Reduces height of downstream floodwalls
- ✓ Less visual/aesthetic impact
- ✓ Fewer potential impacts to recreation

Cons:
- × Environmentally impacting
- × Impacts other uses at basin site
- × Must be combined with channel stabilization
- × More expensive than FC-3

floodwall height along the creek downstream, but still requires floodwalls on San Juan Creek. Storage on Trabuco Creek does not eliminate the need for a floodwall immediately upstream of PCH or Stonehill, although it does reduce the height of the structure. The floodwalls would be of identical design to those of Alternative 2 with the exception of height (Sheets 2 through 9 of FC-4). The basin itself would be of earthen construction, with 3 to 1 slopes on both sides (Sheet 13 of FC-4). The basin was designed with rip-rap slopes approximately one half meter thick (Sheet 14 of FC-4). The basin embankment would be approximately 20 meters high (60 feet), and 510 meters long, with a base width of approximately 130 meters. The impoundment area during a 100-year flood event would extend upstream approximately 1400 meters (Sheet 13 of FC-4). Basin construction would require the relocation of several small roads and some utilities, although existing development would not be impacted. The basin would store approximately 2,700 acre-feet of water during the design event (1% exceedance). Flows would pass through the basin by means of an unregulated 12’ x 9’ reinforced concrete box culvert, providing discharge and sediment transport through the basin for most events. A stilling basin and concrete spillway would occupy the center of the structure, with protective wing walls. There would be a grouted stone apron at the downstream end of the stilling basin to control erosion. Toe-down depth on the structure would be approximately 5 meters. The pool at spillway crest would be approximately 13 meters deep. No excavation within the reservoir area would be performed, and no permanent pool established in this alternative. The basin would not be capable of storing water beyond the period of floodwater storage, as no clay core was included in the design.

Provision of ecosystem restoration or groundwater recharge within the reservoir area would be possible, as the area within the basin is suitable for either. Environmental mitigation for this alternative may be substantial, as the area has been identified as habitat for several Federally or State-listed endangered, threatened, or sensitive species, including arroyo toad.

Alternative 4 would involved the installation of 8,265 meters (compared to the 10,030 meters of Alternative 2) of concrete floodwall of 0.5 to 2.0 meters in height, and 741 meters (compared to the 1,514 meters of Alternative 2) of concrete floodwall in excess of 2.0 meters in height, with 396 meters of that consisting of floodwall 3.0 meters in height, and none in excess of that figure. There would also be 428 meters (compared to the 1,137 meters of Alternative 2) of flood wall on Trabuco Creek, all of it 0.5 meters or less in height. The basin would require 397,863 cubic meters of excavation, 339,452 cubic meters of structural fill utilizing on-site materials, 355,275 cubic meters of imported structural fill material, 58,412 cubic meters of common fill, 24,390 cubic meters of rip-rap protection (18” thick with a D50 of 12”), 2,475 cubic meters of concrete for the spillway lining, 8,050 cubic meters of excavation in the stilling basin, 1,432 cubic meters of concrete for the stilling basin lining, 120 cubic meters of concrete for the stilling basin retaining wall, 1,798 cubic meters of rip-rap protection for the stilling basin, and 110 meters of concrete 12’ x 9’ box culvert for the basin outlet.

The cost of this alternative, including mitigation, is approximately $25.7 million. With real estate costs of approximately $7.0 million, the cost exclusive of mitigation would be approximately $32.7 million. This alternative includes replacement of PCH, La Novia and Del Obispo bridges. This alternative is certainly more costly, but is more aesthetically acceptable than Alternative 2, and does not provide as great a reduction in flood inundation per dollar as Alternative 3. It is likely to have much higher mitigation costs than alternative 2, though less than Alternative 3, as the basin area has also been identified as high quality habitat, but of lesser area than Alt. 3. The assumption is made that existing flood control structures downstream will be capable of ensuring containment of the 100-year and lesser flood events through the period of analysis of 50 years by such means are determined appropriate.

7.7.1.5 FC-5: Detention Basins on San Juan and Trabuco Creeks

This alternative consists of detention basins on both San Juan and Trabuco Creeks, and limited lengths of floodwall of minimal height on San Juan Creek downstream of the basin, and an extremely minimal floodwall on Trabuco Creek upstream of Del Obispo and also at the Oso Creek confluence (Figure 18, Figure 19, Figure 21). This alternative was developed to prevent damages occurring from overtopping of the channel *only*. Because the scour analysis indicates that detention basins will not solve the inundation problem without accompanying channel stabilization measures, it is discussed in detail here only for the purposes of imparting its contribution to inundation reduction by overtopping alone, and in all future discussion beyond this section, is assumed to be combined with channel stabilization measures as part of a comprehensive alternative. The detailed discussion of features is included only here, although it is included in other alternatives, for the sake of brevity.

The basins would be sited identically to Alternatives 3 and 4. The floodwalls would be of identical design to those of Alternative 2 with the exception of height. The basins would be of identical construction. No excavation within the reservoir areas would be performed, and no permanent pools established in this alternative. The basins would not be capable of storing water beyond the period of floodwater storage, as no clay core was included in the design.

Provision of ecosystem restoration or groundwater recharge within the reservoir areas would be possible, as the area within the basins is suitable for either. Environmental mitigation for this alternative may be the most substantial of all alternatives examined, as the areas have been identified as habitat for several identified species.

Alternative 5 would involved the installation of 6,425 meters (compared to the 10,030 meters of Alternative 2) of concrete floodwall of 0.5 to 2.0 meters in height, and 722 meters (compared to the 1,514 meters of Alternative 2) of concrete floodwall in excess of 2.0 meters in height, with 73 meters of that consisting of floodwall 3.0 meters in height, and none in excess of that figure. There would also be 428 meters (compared to the 1,137 meters of Alternative 2) of flood wall on Trabuco Creek, all of it 0.5 meters or less in height. The basin on San Juan Creek would require approximately 349,000 cubic meters of excavation, 297,000 cubic meters of structural fill utilizing on-site materials, 343,600 cubic meters of imported structural fill material, 52,000 cubic meters of common fill, 17,400 cubic meters of rip-rap protection (18" thick with a D50 of 12"), 3,900 cubic meters of concrete for the spillway lining, 13,300 cubic meters of excavation in the stilling basin, 2,150 cubic meters of concrete for the stilling basin lining, 120 cubic meters of concrete for the stilling basin retaining wall, 2,700 cubic meters of rip-rap protection for the stilling basin, and 127 meters of concrete 12' x 9' box culvert for the basin outlet. The basin on Trabuco Creek would require approximately 398,000 cubic meters of excavation, 339,500 cubic meters of structural fill utilizing on-site materials, 355,300 cubic meters of imported structural fill material, 58,400 cubic meters of common fill, 24,400 cubic meters of rip-rap protection (18" thick with a D50 of 12"), 2,475 cubic meters of concrete for the spillway lining, 8,050 cubic meters of excavation in the stilling basin, 1,430 cubic meters of concrete for the stilling basin lining, 120 cubic meters of concrete for the stilling basin retaining wall, 1,800 cubic meters of rip-rap protection for the stilling basin, and 110 meters of concrete 12' x 9' box culvert for the basin outlet.

The cost of this alternative, including mitigation, is approximately $39.9 million. With real estate costs of approximately $11.3 million, the cost exclusive of mitigation would be approximately $51.2 million. This alternative includes replacement of PCH, La Novia and Del Obispo bridges. This alternative is certainly more costly,

FC-5: Detention Basins on San Juan and Trabuco Creeks

Pros:

- ✓ Largest reduction in height of downstream floodwalls
- ✓ Less visual/aesthetic impact
- ✓ Fewer potential impacts to recreation

Cons:

- × Environmentally impacting
- × Impacts other uses at basin sites
- × Must be combined with channel stabilization
- × Most expensive basin alternative

but is more aesthetically acceptable than Alternatives 2 through 4. It is likely to have the highest mitigation costs of those examined, as both basin areas have been identified as high quality habitat. The assumption is made that existing flood control structures downstream will be capable of ensuring containment of the 100-year and lesser flood events through the period of analysis of 50 years by such means are determined appropriate.

7.7.1.6 FC-6: Channel Widening

This alternative consists of widening the channel of San Juan Creek to provide greater capacity within the channel system (Figure 16 and Figure 20). This alternative was developed to prevent damages occurring from overtopping of the channel *only*. The widening would extend from the Ocean upstream to some 600 meters upstream of La Novia (Sheets 3 through 6 of FC-6), and upstream along Trabuco Creek approximately 650 meters upstream of Del Obispo (Sheet 7 of FC-6). The side of the channel on which widening was conducted is the side on which development is less extensive, which varies along San Juan Creek, but is the east side of the channel on Trabuco. This will result in the dislocation of the minimum number of structures, although the land required is significant. The widening is approximately 20 meters additional width throughout the reaches defined. All bridges crossing the channel in this alternative would have to be lengthened by means of construction of additional "bays" on the side excavated.

Alternative 6 would require approximately 19,200 cubic meters of concrete demolition, 648,000 cubic meters of excavation, 78,000 cubic meters of on-site materials compaction, 118,000 cubic meters of common fill, and 34,400 cubic meters of concrete lining to a toe-down depth of 3 meters on San Juan Creek. On Trabuco Creek, Alternative 6 would require 5,600 cubic meters of concrete demolition, 127,000 cubic meters of excavation, 600 cubic meters of on-site materials compaction, 30,000 cubic meters of common fill, and 6,500 cubic meters of concrete lining to a toe-down depth of 3 meters.

FC-6: Channel Widening

Pros:
- ✓ No requirement for floodwalls
- ✓ Less visual/aesthetic impact
- ✓ Few potential impacts to recreation

Cons:
- × Impacts properties alongside channel
- × Requires extension of all bridges
- × Must be combined with channel stabilization
- × Most expensive option

The cost of this alternative, including mitigation, is approximately $30.9 million. With real estate costs of approximately $17.7 million, the cost exclusive of mitigation would be approximately $48.6 million. This is the most costly of all flood control alternatives examined, though only minimally more than Alternative 5. This alternative includes replacement of PCH and La Novia bridges, and modification of Stonehill, Metrolink, and Camino Capistrano bridges. While the most costly of those examined, this is primarily due to the large amounts of real estate required. Mitigation costs should be somewhat larger than Alternative 2, but less than 3 through 5.

7.7.1.7 FC-7: Floodwalls (or Levees) and Channel Stabilization

This alternative was developed to prevent damages occurring from overtopping of the channel and by levee failure by undermining. The "Floodwall and Channel Stabilization Plan" utilizes channel grade stabilizers to ensure existing levee and bridge integrity and floodwalls to ensure in-channel confinement of flood flows up to and including a nominal 1% exceedance flood event. The nominal 1% exceedance flood event was also used for the analysis of this flood damage reduction alternative so that all alternatives could be compared on an equivalent damage reduction basis. The key difference between this alternative and alternatives FC-2 through FC-6 is the inclusion of channel stabilization, and is therefore the first technically feasible alternative to reduce flood damages by both potential mechanisms of failure. While it is necessary to analyze potential measures or alternatives separately to determine the potential damage reduction offered by each element (as done in FC-2 through FC-6 and CS-1 through CS-2a), this alternative combines two elements to determine the potential damage reduction as a package, so as to determine the potential net benefit of a combined alternative.

FC-7: Floodwalls (or Levees) and Channel Stabilization

Pros:

- ✓ Solves both overtopping and undermining problems
- ✓ Least cost solution to both problems
- ✓ Potentially Federally cost-shared
- ✓ Minimally environmentally impacting

Cons:

- × Visually/Aesthetically unappealing
- × Blocks cross-channel wildlife transit
- × May impact recreation

Alternative FC-7 combines the overtopping protection of alternative FC-2 with the levee failure stabilization offered by Alternatives CS-1a and CS-2a (which follow in the next sub-section). This combination is the least costly means of addressing both problems, as it includes the least number of features required to address each. The elements of FC-2, CS-1a, and CS-2a are as described in other sections of the report.

7.7.1.8 FC-8: Floodwalls (or Levees), Detention on San Juan Creek, and Channel Stabilization

This alternative was developed to prevent damages occurring from overtopping of the channel and by levee failure by undermining, with less visual impact to downstream residents of the watershed. The "Floodwall, San Juan Detention and Channel Stabilization Plan" utilizes channel grade stabilizers to ensure existing levee and bridge integrity, detention on San Juan Creek, and floodwalls to ensure in-channel confinement of flood flows up to and including a nominal 1% exceedance flood event. The nominal 1% exceedance flood event was also used for the analysis of this flood damage reduction alternative so that all alternatives could be compared on an equivalent damage reduction basis. The key difference between this alternative FC-3 is the inclusion of channel stabilization, and therefore reduces flood damages by both potential mechanisms of failure. While it is necessary to analyze potential measures or alternatives separately to determine the potential damage reduction offered by each element (as done in FC-2 through FC-6 and CS-1 through CS-2a), this alternative combines three elements to determine the potential damage reduction as a package, so as to determine the potential net benefit of a combined alternative.

FC-8: Floodwalls, San Juan Detention, and Channel Stabilization

Pros:

- ✓ Solves both overtopping and undermining problems
- ✓ Potentially Federally cost-shared
- ✓ Visually less impacting to residents

Cons:

- × May cause impacts to T&E species
- × Blocks cross-channel wildlife transit
- × May impact recreation

Alternative FC-8 combines the overtopping protection of alternatives FC-2 (as modified in reduced height form) and FC-3, with the levee failure stabilization offered by Alternatives CS-1a and CS-2a (which follow in the next sub-section). This combination is a more costly means of addressing both problems, as it includes more features. The details of FC-2, FC-3, CS-1a, and CS-2a are as described in other sections of the report.

7.7.1.9 FC-9: Floodwalls (or Levees), Detention on Trabuco Creek, and Channel Stabilization

This alternative was developed to prevent damages occurring from overtopping of the channel and by levee failure by undermining, with less visual impact to downstream residents of the watershed. The "Floodwall, Trabuco Detention and Channel Stabilization Plan" utilizes channel grade stabilizers to ensure existing levee and bridge integrity, detention on Trabuco Creek, and floodwalls to ensure in-channel confinement of flood flows up to and including a nominal 1% exceedance flood event. The nominal 1% exceedance flood event was also used for the analysis of this flood damage reduction alternative so that all alternatives could be compared on an equivalent damage reduction basis. The key difference between this alternative FC-4 is the inclusion of channel stabilization, and therefore reduces flood damages by both potential mechanisms of failure. While it is necessary to analyze potential measures or alternatives separately to determine the potential damage reduction offered by each element (as done in FC-2 through FC-6 and CS-1 through CS-2a), this alternative combines three elements to determine the potential damage reduction as a package, so as to determine the potential net benefit of a combined alternative.

FC-9: Floodwalls, Trabuco Detention, and Channel Stabilization

Pros:

- ✓ Solves both overtopping and undermining problems
- ✓ Potentially Federally cost-shared
- ✓ Visually less impacting to residents

Cons:

- × May cause impacts to T&E species
- × Blocks cross-channel wildlife transit
- × May impact recreation
- × Is not the NED Plan
- × More expensive than FC-8

Alternative FC-9 combines the overtopping protection of alternatives FC-2 (as modified in reduced height form) and FC-4, with the levee failure stabilization offered by Alternatives CS-1a and CS-2a (which follow in the next sub-section). This combination is an even more costly means of addressing both problems, as it includes more features. The details of FC-2, FC-4, CS-1a, and CS-2a are as described in other sections of the report.

7.7.1.10 FC-10: Floodwalls (or Levees), Detention on San Juan and Trabuco Creeks, and Channel Stabilization

FC-8: Floodwalls, Detention on San Juan/Trabuco, & Channel Stabilization

Pros:

- ✓ Solves both overtopping and undermining problems
- ✓ Potentially Federally cost-shared
- ✓ Visually less impacting to residents

Cons:

- × May cause impacts to T&E species
- × Blocks cross-channel wildlife transit
- × May impact recreation
- × Is not the NED Plan
- × Perhaps most costly flood control plan

This alternative was developed to prevent damages occurring from overtopping of the channel and by levee failure by undermining, with less visual impact to downstream residents of the watershed. The "Floodwall, San Juan and Trabuco Detention and Channel Stabilization Plan" utilizes channel grade stabilizers to ensure existing levee and bridge integrity, detention on both San Juan and Trabuco Creeks, and floodwalls to ensure in-channel confinement of flood flows up to and including a nominal 1%

exceedance flood event. The nominal 1% exceedance flood event was also used for the analysis of this flood damage reduction alternative so that all alternatives could be compared on an equivalent damage reduction basis. The key difference between this alternative FC-5 is the inclusion of channel stabilization, and therefore reduces flood damages by both potential mechanisms of failure. While it is necessary to analyze potential measures or alternatives separately to determine the potential damage reduction offered by each element (as done in FC-2 through FC-6 and CS-1 through CS-2a), this alternative combines four elements to determine the potential damage reduction as a package, so as to determine the potential net benefit of a combined alternative.

Alternative FC-10 combines the overtopping protection of alternatives FC-2 (as modified in reduced height form) and FC-5, with the levee failure stabilization offered by Alternatives CS-1a and CS-2a (which follow in the next sub-section). This combination is possibly the most costly means of addressing both problems, as it includes four features. The details of FC-2, FC-5, CS-1a, and CS-2a are as described in other sections of the report.

7.7.2 Channel Stabilization

7.7.2.1 CS-1: San Juan Creek

Stabilization of San Juan Creek would entail the construction of a total of seven grade stabilizers in the reach between Station 122+00 (upstream of Stonehill), and Station 233+50 (downstream of Conrock access road) on San Juan Creek. This alternative does not address channel stabilization on any tributary to San Juan Creek. These structures would each span the width of the channel. The structures were designed to prevent further downcutting of the channel, although localized scour would still be possible, and could pose a continued threat to existing infrastructure and channel linings. A structure would be located at the San Juan/Trabuco confluence to enhance stability at this critical location. The invert would be raised as much as 2 meters in some locations. There would be a potential loss of capacity in those reaches, due to the added material on the invert, although this would be minimal. Fish passage would be designed into the structure, with a low-flow "path" or paths through the structure. Each structure would consist of a grouted

CS-1: San Juan Creek

Pros:

- ✓ Solves undermining problems on San Juan Creek
- ✓ May provide opportunity to restore fish passage
- ✓ Potentially Federally cost-shared
- ✓ Minimally environmentally impacting

Cons:

- ✗ Expensive
- ✗ Does not provide solution to problem on tributaries

rip-rap invert, a series of 0.3 meter low-flow drops for passage, and 2 or 3 to 1 side slopes of Armorflex or its equivalent to encourage vegetative regrowth on the banks (Sheets 11 and 12 of CS-1). Scour would be circumvented by a soil cement cut-off at the upstream end. The rip-rap of the structure could be covered with soil, either mechanically, or by natural infilling of the channel. Modified slopes of less than 1% would lessen water velocities, reducing scour potential, and providing for more "residence time" for the flow, slightly enhancing recharge.

The channel stabilization plan would require 112 hectares of clearing and stripping, approximately 233,000 cubic meters of excavation, 202,000 cubic meters of shaped and compacted fill material, 65,000 cubic meters of excavation and stockpiling fill for the soil cement cut-off, 21,500 cubic meters of installed soil cement, 43,000 cubic meters of structural backfill, 2,800 square meters of Armorflex revetment, 4,400 square meters of hand placed grouted rip-rap, 8,400 square meters of dumped rip-rap, 2,800 square meters of filter fabric, and 0.3 hectare revegetated side slope on San Juan Creek.

The cost of this alternative, including mitigation cost, would be approximately $7.8 million for San Juan Creek alone. This alternative may not completely solve the problem of potential levee failure by undercutting. The issue of localized scour has the potential to undermine, and cause failure of levee panels that have insufficient toe depth. This would need to be examined using a detailed scour model should there be interest in pursuing this alternative.

7.7.2.2 CS-1a: San Juan Creek – Leveed Section

CS-1a: San Juan Creek – Leveed Section

Pros:

- ✓ Solves undermining problems on San Juan Creek
- ✓ May provide opportunity to restore fish passage
- ✓ Potentially Federally cost-shared
- ✓ Minimally environmentally impacting

Cons:

- ✗ Does not provide solution to undermining problem on Trabuco Creek

This measure consists of four grade stabilizers on San Juan Creek within the leveed channel section to solve only the problem of geotechnical failure of the channel system by undermining.

7.7.2.3 CS-2: Trabuco Creek

Because Trabuco Creek is undergoing considerably more downcutting than San Juan Creek, and the creek itself is steeper, stabilization of the creek would likely require 14 structures to stabilize the channel while also providing for fish passage. The structures would be located between Stations 118+00 (upstream of Del Obispo) and the AT&SF crossing of the creek at Station 136+00. Some of the structures would be very close together, due to the necessity of providing a minimum height for fish passage, and the need to reduce slope to a long-term equilibrium slope without excessive structure height. Other features of the plan are as above.

On Trabuco Creek, the channel stabilization plan would require 15 hectares of clearing and stripping, approximately 43,000 cubic meters of excavation, 55,000 cubic meters of shaped and compacted fill material, 85,000 cubic meters of excavation and stockpiling fill for the soil cement cut-off, 32,000 cubic meters of installed soil cement, 53,000 cubic meters of structural backfill, 10,700 square meters of Armorflex revetment, 20,000 square meters of hand placed grouted rip-rap, 15,500 square meters of dumped rip-rap, 10,700 square meters of filter fabric, and 1.1 hectare revegetated side slope.

CS-2: Trabuco Creek

Pros:
- ✓ Solves undermining problems on Trabuco Creek
- ✓ May provide opportunity to restore fish passage on Trabuco Creek

Cons:
- × Most expensive channel stabilization element
- × Does not provide solution to problem on San Juan Creek or other tributaries
- × Potentially not Federally cost-shared

The cost of this alternative, including mitigation cost, would be approximately $9.9 million for Trabuco Creek alone. This alternative may not completely solve the problem of potential levee failure by undercutting. The issue of localized scour has the potential to undermine, and cause failure of levee panels that have insufficient toe depth. This would need to be examined using a detailed scour model should there be interest in pursuing this alternative.

7.7.2.4 CS-2a: Trabuco Creek – Leveed Section

CS-2a: Trabuco Creek – Leveed Section

Pros:

- ✓ Solves undermining problems on Trabuco Creek
- ✓ May provide opportunity to restore limited fish passage on Trabuco Creek
- ✓ Potentially Federally cost-shared

Cons:

- × Does not provide solution to problem on San Juan Creek or other tributaries

This measure consists only of two grade stabilizers on Trabuco Creek within the leveed channel section to solve only the problem of geotechnical failure of the channel system by undermining. This alternative is not a complete solution to the undermining problem, but provides enough stabilization in the reach of Trabuco Creek that is at risk of undermining and subsequent levee failure and flooding of adjacent properties.

7.7.2.5 CS-3: Oso Creek

Because Oso Creek is also undergoing even more downcutting than San Juan or Trabuco Creeks, stabilization of the creek would likely require a total of 13 structures (Figures 29 and 30). The structures would be located between Stations 110+00 and the downstream end of the box channel at Station 121+00. Some of the structures would be very close together, due to the necessity of reducing slope to a long-term equilibrium slope. Other features of the plan are as above.

On Oso Creek, the channel stabilization plan would require 2 hectares of clearing and stripping, approximately 10,000 cubic meters of excavation, 35,000 cubic meters of shaped and compacted fill material, 12,000 cubic meters of excavation and stockpiling fill for the soil cement cut-off, 3,800 cubic meters of installed soil cement, 8,100 cubic meters of structural backfill, 18,000 square meters of Armorflex revetment, 2,200 square meters of hand placed grouted rip-rap, 1,500 square meters of dumped rip-rap, 18,000 square meters of filter fabric, and 3.6 hectare revegetated side slope.

CS-3: Oso Creek

Pros:

- ✓ Solves undermining problems on Oso Creek
- ✓ May provide opportunity to restore limited fish passage on Oso Creek
- ✓ May provide incidental benefits to roads and railroad

Cons:

- × Most expensive channel stabilization element
- × Does not provide solution to problem on San Juan Creek or other tributaries

The cost of this alternative, including mitigation cost, would be approximately $8.1 million for Oso Creek alone. With real estate costs of approximately $2.4 million, the cost exclusive of mitigation would be approximately $10.5 million.

The total cost for CS-1, CS-2, and CS-3 would be approximately $28.2 million.

7.7.3 Ecosystem Restoration

The following measures are presented in Figure 31 (Plates) and Figure 32 (Aerial).

7.7.3.1 ER-1: Stonehill to PCH

This restoration alternative consists of the excavation of the east (south) bank of San Juan Creek between Camino Las Ramblas bridge and Stonehill Drive bridge to the level of the existing invert (Figure 25). The excavated area would be utilized as a riparian zone with reconstructed wetlands, riparian and upland plantings, and general reestablishment of a broad riparian community in the downstream reach of San Juan Creek. Restoration of the area would include removal of non-native vegetation, revegetation of native wetland, riparian, and upland species, and construction of a setback levee to contain flows.

ER-1: Stonehill to PCH

Pros:

- ✓ Provides 247% improvement in habitat value at this site
- ✓ Provides 12.1 acres of restored wetland/riparian habitat
- ✓ May provide opportunity to serve as first resting spot for fish in transit up San Juan Creek

Cons:

- ✗ Expensive restoration element
- ✗ Will impact other planned uses at site
- ✗ Requires large amount of excavation

Alternative ER-1 would require 4 weeks of dewatering, 12.1 hectares of clearing and stripping, approximately 339,000 cubic meters of excavation, 2.3 hectares of revegetated upland, 12.1 hectares of revegetated wetland and riparian vegetation, 1.2 hectares of non-native vegetation removal, 26,000 cubic meters of shaped and compacted fill for the new set-back levee, 59,700 cubic meters of excavation and stockpiling for the same, 1,100 meters of saw-cut concrete and concrete edge repair, 33,700 cubic meters of structural backfill, 1,800 cubic meters of demolished and removed concrete embankment, and 279,300 cubic meters of excess disposed fill.

This alternative would generate 8.85 habitat units. At a cost of approximately $14 million for construction and $13 million for real estate, the cost per unit of habitat (a unit is a dimensionless numerical device to compare habitat value on a relative basis) would be $196,515/unit.

7.7.3.2 ER-2: Maintenance Site Upstream of I-5

This restoration alternative consists of the excavation of the west (north) bank of San Juan Creek between Interstate 5 bridge and Station 152+20, a distance of approximately 680 meters, to the level of the existing invert (Figure 26). The excavated area would be utilized as a riparian zone with reconstructed wetlands, riparian and upland plantings, and general reestablishment of a broad riparian community in this reach of San Juan Creek. Restoration of the area would include clearing and stripping, removal of non-native vegetation, revegetation of native wetland, riparian, and upland species, and construction of a setback levee to contain flows.

Alternative ER-2 would require 4 weeks of dewatering, 3.2 hectares of clearing and stripping, approximately 46,000 cubic meters of excavation, 1.2 hectares of revegetated upland, 3.2 hectares of revegetated wetland and riparian vegetation, 1.2 hectares of non-native vegetation removal, 3,500 cubic meters of removed and stockpiled rip-rap, and 46,000 cubic meters of excess disposed fill.

This alternative would generate 2.23 habitat units. At a cost of approximately $2.7 million for construction and $6.8 million for real estate, the cost per unit of habitat would be $273,216/unit.

ER-2: Maintenance Site Upstream of I-5

Pros:

- ✓ Provides 45% improvement in habitat value at this site
- ✓ Provides 3.2 acres of restored wetland/riparian habitat
- ✓ May provide opportunity to serve as first resting spot for fish in transit up San Juan Creek

Cons:

- ✗ Will impact other planned uses at site
- ✗ Requires large amount of excavation

7.7.3.3 ER-3: Upstream of La Novia

This restoration alternative consists of the excavation of the west (north) bank of San Juan Creek between La Novia bridge and Station 170+00, a distance of approximately 1,000 meters, to the level of the existing invert (Figure 27). The excavated area would be utilized as a riparian zone with reconstructed wetlands and riparian plantings, and general reestablishment of a broad riparian community in this reach of San Juan Creek. There would be a broad upland zone established between existing development and the riparian zone. Restoration of the area would include clearing and stripping, removal of non-native vegetation, and revegetation of native wetland, riparian, and upland species.

Alternative ER-3 would require 4 weeks of dewatering, 0.9 hectares of clearing and stripping, approximately 102,000 cubic meters of excavation, 4.3 hectares of revegetated upland, 0.9 hectares of revegetated wetland and riparian vegetation, 3.2 hectares of non-native vegetation removal, and 102,000 cubic meters of excess disposed fill.

This alternative would generate 3.72 habitat units. At a cost of approximately $4.3 million for construction and $9.9 million for real estate, the cost per unit of habitat would be $246,425/unit.

ER-3: Upstream of La Novia

Pros:

- ✓ Provides 39% improvement in habitat value at this site
- ✓ Provides 0.9 acres of restored wetland/riparian habitat
- ✓ May provide opportunity to serve as first resting spot for fish in transit up San Juan Creek

Cons:

- × Requires large amount of excavation
- × May impact other uses at this site

7.7.3.4 ER-4: Downstream of Antonio Parkway

This restoration alternative consists of the excavation of the west (north) bank of San Juan Creek between Ortega Highway at Station 189+00 and Antonio Parkway, a distance of approximately 800 meters, to the level of the existing invert (Figure 28). The excavated area would be utilized to extend the riparian zone inland and recreate the upland transition zone between existing development and the riparian zone. The entire area would be enlarged and enhanced for greater habitat value. Restoration of the area would include clearing and stripping, removal of non-native vegetation, and revegetation of native wetland, riparian, and upland species.

ER-4: Downstream of Antonio Parkway

Pros:

- ✓ Provides 39% improvement in habitat value at this site
- ✓ Provides 2.4 acres of restored wetland/riparian habitat
- ✓ May provide opportunity to serve as first resting spot for fish in transit up San Juan Creek

Cons:

- × Requires large amount of excavation
- × May impact other uses at this site

Alternative ER-4 would require 4 weeks of dewatering, 2.4 hectares of clearing and stripping, approximately 650 cubic meters of excavation, 3.3 hectares of revegetated upland, 2.4 hectares of revegetated riparian vegetation, 3.3 hectares of non-native vegetation removal, and 650 cubic meters of excess disposed fill.

This alternative would generate 3.30 habitat units. At a cost of approximately $0.9 million for construction and $10.6 million for real estate, the cost per unit of habitat would be

$224,103/unit.

7.7.3.5 ER-5: Upstream of Antonio Parkway

This restoration alternative consists of the excavation of the west (north) bank of San Juan Creek between Antonio Parkway and Station 212+00 upstream of Antonio Parkway, a distance of approximately 1,500 meters, to the level of the existing invert (Figure 29). The excavated area would be utilized to extend the riparian zone inland and recreate the upland transition zone between existing development and the riparian zone. The entire area would be enlarged and enhanced for greater habitat value. Restoration of the area would include clearing and stripping, removal of non-native vegetation, and revegetation of native wetland, riparian, and upland species.

ER-5: Upstream of Antonio Parkway

Pros:

- ✓ Provides 31% improvement in habitat value at this site
- ✓ Provides 13.0 acres of restored wetland/riparian habitat
- ✓ May be combined with basin alternatives and provide additional opportunity to serve as resting spot for fish in transit up San Juan Creek

Cons:

- × May impact other uses at this site

Alternative ER-5 would require 4 weeks of dewatering, 13.0 hectares of clearing and stripping, 600 cubic meters of excavation, 3.6 hectares of revegetated upland, 13.0 hectares of revegetated riparian vegetation, 3.6 hectares of non-native vegetation removal, and 600 cubic meters of excess disposed fill.

This alternative would generate 9.16 habitat units. At a cost of approximately $2.8 million for construction and $34.6 million for real estate, the cost per unit of habitat would be $263,343/unit.

7.7.3.6 ER-6: Upstream of Conrock Quarry Bridge

This restoration alternative consists of the excavation of the west (north) bank of San Juan Creek between the Conrock access road at Station 242+00 and Station 261+00, a distance of approximately 1,900 meters, to the level of the existing invert (Figure 30 and Figure 31). The excavated area would be utilized to extend the riparian zone inland and recreate the upland transition zone between existing development and the riparian zone. The entire area would be enlarged and enhanced for greater habitat value. Restoration of the area would include clearing and stripping, removal of non-native vegetation, and revegetation of native wetland, riparian, and upland species.

Alternative ER-6 would require 4 weeks of dewatering, 28.4 hectares of clearing and stripping, 38,000 cubic meters of excavation, 21.7 hectares of revegetated upland, 28.4 hectares of revegetated riparian vegetation, 3.6 hectares of non-native vegetation removal, and 38,000 cubic meters of excess disposed fill.

This alternative would generate 18.98 habitat units. At a cost of approximately $8.7 million for construction and $43.7 million for real estate, the cost per unit of habitat would be $178,183/unit.

ER-6: Upstream of Conrock Quarry Bridge

Pros:

- ✓ Provides 68% improvement in habitat value at this site
- ✓ Provides 28.4 acres of restored wetland/riparian habitat
- ✓ Provides critical link between upstream and downstream areas

Cons:

- ✗ May impact other uses at this site

7.7.3.7 ER-7: Oso Creek at Galivan Detention Basin

This restoration alternative consists of the excavation within the Galivan Detention Basin on Oso Creek upstream of Station 153+00, a distance of approximately 700 meters (Figure 32). The excavated area would be utilized to reestablish wetlands, riparian, and upland habitats within the basin confines. Recreation of upland habitat would create a transition zone between existing development and the riparian zone. The entire area would be enlarged and enhanced for greater habitat value. Restoration of the area would include clearing and stripping, removal of non-native vegetation, and revegetation of native wetland, riparian, and upland species.

ER-7: Oso Creek at Galivan Detention Basin

Pros:

- ✓ Provides 36% improvement in habitat value at this site
- ✓ Provides 6.8 acres of restored wetland/riparian habitat
- ✓ Provides dual benefits and aesthetic improvement to existing basin site

Cons:

- ✗ May create maintenance cost increase for local sponsor
- ✗ May create difficulty in sediment removal in absence of "safe harbor" agreement

Alternative ER-7 would require 4 weeks of dewatering, 6.8 hectares of clearing and stripping, 19,450 cubic meters of excavation, 16,300 cubic meters of grading and shaping, 2.4 hectares of revegetated upland, 6.8 hectares of revegetated riparian vegetation, 1.2 hectares of non-native vegetation removal, and 19,250 cubic meters of excess disposed fill.

This alternative would generate 3.28 habitat units. At a cost of approximately $2.4 million for construction and $5.3 million for real estate, the cost per unit of habitat would be $151,445/unit.

7.7.3.8 ER-8: Oso Creek at Mission Viejo Country Club Golf Course

This restoration alternative consists of the excavation of both banks of Oso Creek between Interstate 5 and the golf course crossing, a distance of approximately 1,100 meters (Figure 33). The excavated area would be utilized to provide an upland buffer and extend the riparian zone, creating a transition zone between existing development and the riparian zone. Pocket wetlands would be recreated along the channel for greater habitat value. Restoration of the area would include clearing and stripping, removal of non-native vegetation, and revegetation of native wetland, riparian, and upland species.

ER-8: Oso Creek at Mission Viejo Country Club Golf Course

Pros:

- ✓ Provides 80% improvement in habitat value at this site
- ✓ Provides 2.7 acres of restored wetland/riparian habitat
- ✓ May provide sediment trapping and water quality improvements for golf course

Cons:

- × May impact other uses at this site
- × Most expensive restoration alternative

Alternative ER-8 would require 4 weeks of dewatering, 2.7 hectares of clearing and stripping, 12,500 cubic meters of excavation, 1.2 hectares of revegetated upland, 2.7 hectares of revegetated riparian vegetation, 0.7 hectares of non-native vegetation removal, and 11,600 cubic meters of excess disposed fill.

This alternative would generate 0.77 habitat units. At a cost of approximately $1.15 million for construction and $13.7 million for real estate, the cost per unit of habitat would be $1,244,212/unit.

7.7.3.9 ER-9: Trabuco Creek Downstream of I-5/Camino Capistrano

This restoration alternative consists of the excavation of both banks of Trabuco Creek immediately downstream of the Interstate 5 bridge, for a distance of approximately 300 meters (Figure 34). The excavated area would be utilized to extend the riparian zone inland and recreate the upland transition zone between existing development and the riparian zone. The entire area would be enlarged and enhanced for greater habitat value. A series of weirs/grade stabilizers would be installed to recreate the "steps" in the former profile that safely dropped floodflows to a lower level downstream. Restoration of the area would include clearing and stripping, removal of non-native vegetation, and revegetation of native wetland, riparian, and upland species.

ER-9: Trabuco Creek Downstream of I-5/Camino Capistrano

Pros:
- ✓ Provides 168% improvement in habitat value at this site
- ✓ Provides 1.2 acres of restored wetland/riparian habitat
- ✓ May provide solution to problem of blockage of fish passage at this site

Cons:
- × May impact other uses at this site
- × Most require additional measures to fully implement

Alternative ER-9 would require 4 weeks of dewatering, 1.2 hectares of clearing and stripping, 25,900 cubic meters of excavation, 1.6 hectares of revegetated upland, 1.2 hectares of revegetated riparian vegetation, 1.6 hectares of non-native vegetation removal, and 25,100 cubic meters of excess disposed fill.

This alternative would generate 0.85 habitat units. At a cost of approximately $1.6 million for construction and $2.1 million for real estate, the cost per unit of habitat would be $281,483/unit.

7.7.3.10 ER-10: Trabuco Creek East of Lakes

This restoration alternative consists of the excavation of both banks of Trabuco Creek between Station 165+00 and Station 175+00, a distance of approximately 1,000 meters (Figure 35). The excavated area would be utilized to extend the riparian zone inland and recreate the upland transition zone between existing development and the riparian zone. The entire area would be enlarged and enhanced for greater habitat value. Restoration of the area would include clearing and stripping, removal of non-native vegetation, and revegetation of native wetland, riparian, and upland species.

Alternative ER-10 would require 4 weeks of dewatering, 10.7 hectares of clearing and stripping, 28,800 cubic meters of excavation, 10.1 hectares of revegetated upland, 10.7 hectares of revegetated riparian vegetation, 10.1 hectares of non-native vegetation removal, and 28,600 cubic meters of excess disposed fill.

This alternative would generate 2.76 habitat units. At a cost of approximately $4.25 million for construction and $16.8 million for real estate, the cost per unit of habitat would be $493,106/unit.

ER-10: Trabuco Creek East of Lakes

Pros:
- ✓ Provides 114% improvement in habitat value at this site
- ✓ Provides 10.7 acres of restored wetland/riparian habitat

Cons:
- × May impact other uses at this site
- × Expensive compared to other ecosystem restoration alternatives

7.7.3.11 ER-11: Trabuco Creek at Oso/Trabuco Confluence

<u>ER-11: Trabuco Creek at Oso/Trabuco Confluence</u>

Pros:

- ✓ Provides 33% improvement in habitat value at this site
- ✓ Provides 12.5 acres of restored wetland/riparian habitat
- ✓ May provide critical restoration of fish passage leading to upstream areas

Cons:

- × May impact other uses at this site
- × Expensive compared to other ecosystem restoration alternatives

This restoration alternative consists of the complete recreation of the highly degraded environment of the Oso and Trabuco Creeks confluence between Station 130+00 on Trabuco Creek downstream and Station 107+00 on Oso Creek and Station 145+00 on Trabuco Creek upstream, a distance of approximately 1,500 meters (Figure 36). This area has been enormously impacted by channel downcutting, headcut advancement, and loss of almost all original habitat in the reach. The restored area would recreate the riparian zone and recreate the upland transition zone between existing development and the riparian zone. The entire area would be enlarged and enhanced for greater habitat value. A series of weirs/grade control structures would be installed to recreate the "pools and riffles" inherent in the natural stream profile. Restoration of the area would include clearing and stripping, removal of non-native vegetation, and revegetation of native wetland, riparian, and upland species.

Alternative ER-11 would require 4 weeks of dewatering, 12.5 hectares of clearing and stripping, 455,000 cubic meters of excavation, 5.3 hectares of revegetated upland, 12.5 hectares of revegetated riparian vegetation, 5.3 hectares of non-native vegetation removal, and 456,400 cubic meters of excess disposed fill.

This alternative would generate 4.39 habitat units. At a cost of approximately $19.4 million for construction and $14.9 million for real estate, the cost per unit of habitat would be $503,960/unit.

Figure 16. Reach SJ6 – Alternative Locations

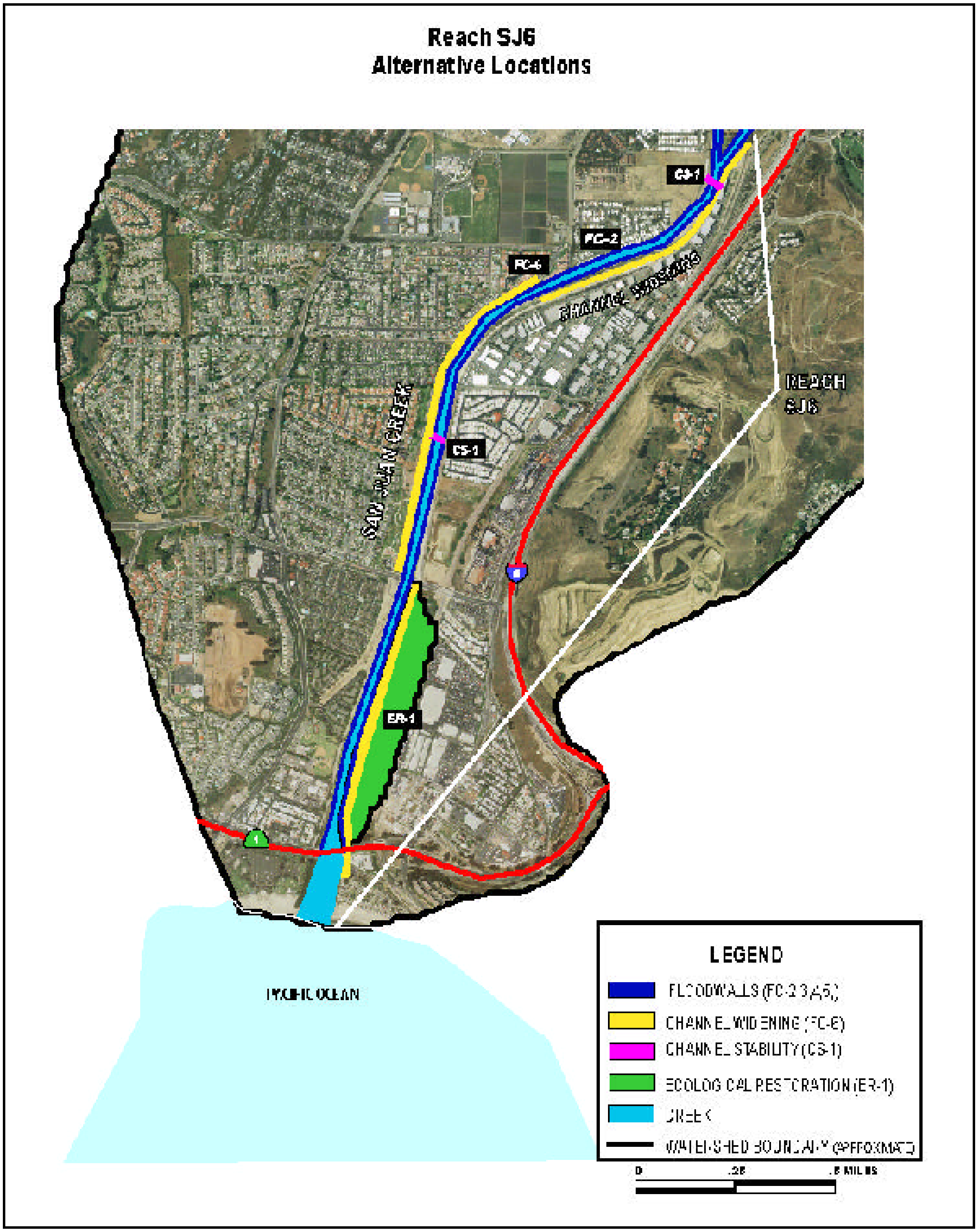


Figure 17. Reach SJ5 – Alternative Locations

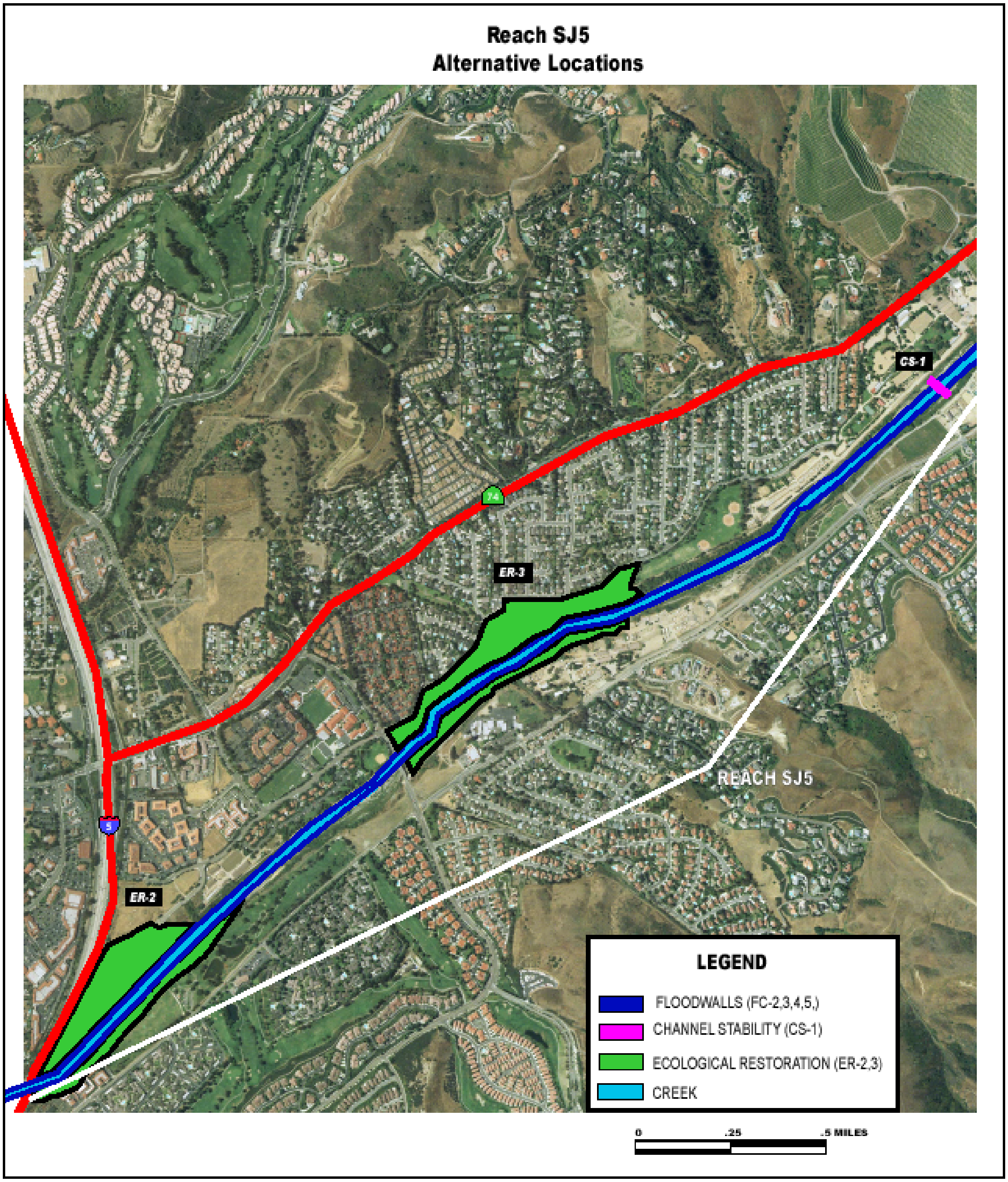


Figure 18. Reach SJ4 – Alternative Locations

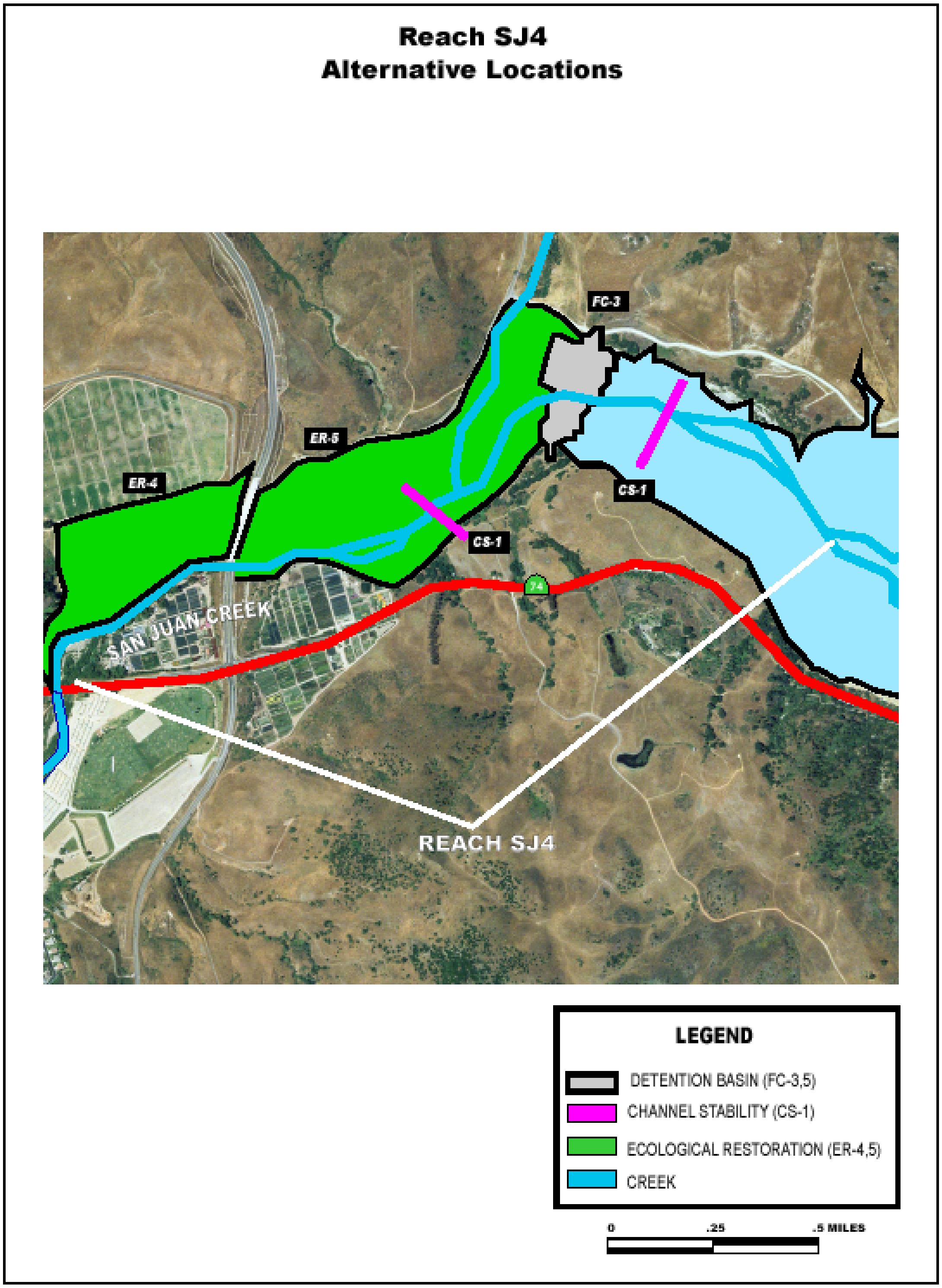


Figure 19. Reach SJ3 – Alternative Locations

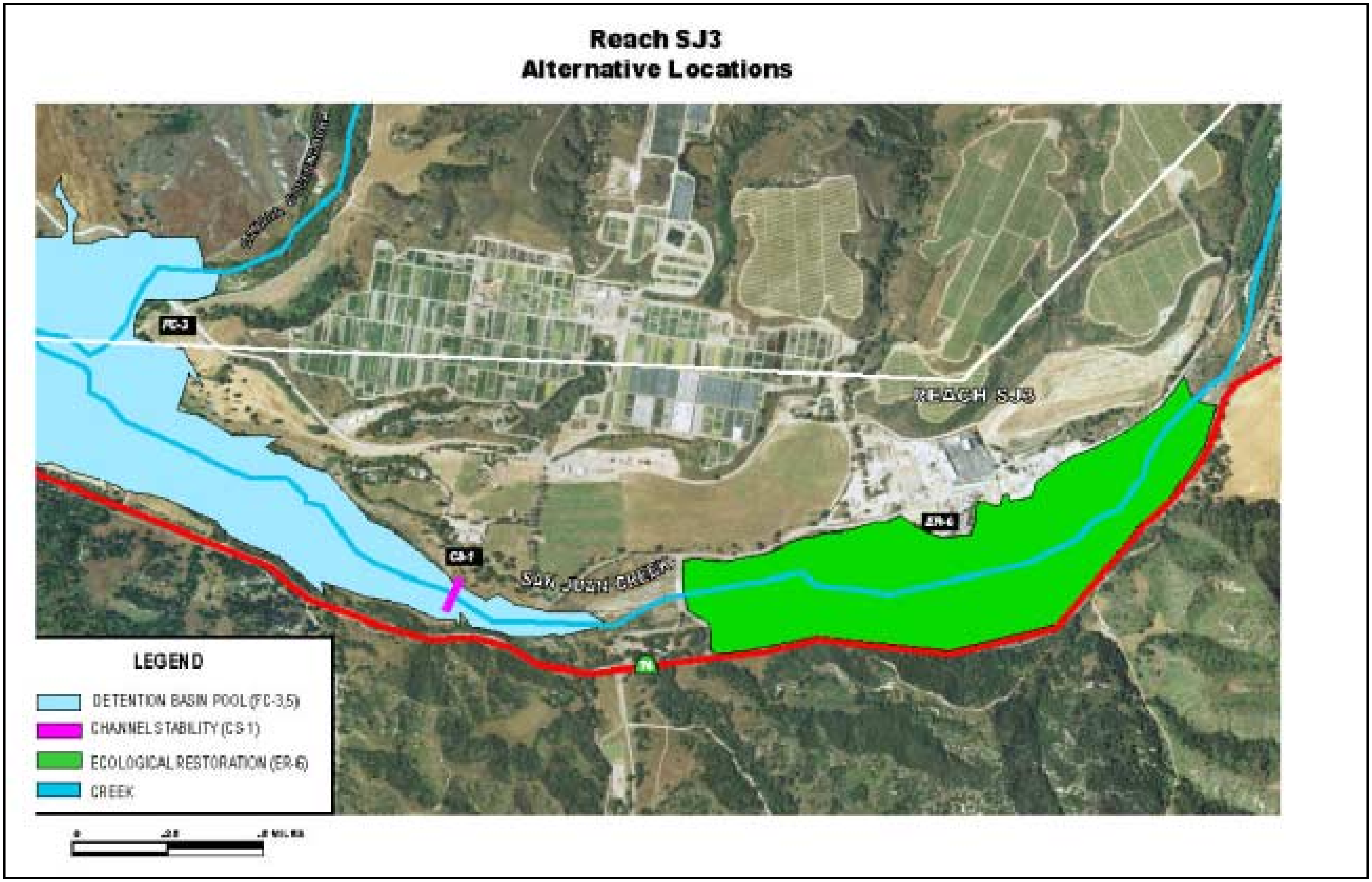


Figure 20. Reaches TR5, TR6, and TR7 – Alternative Locations

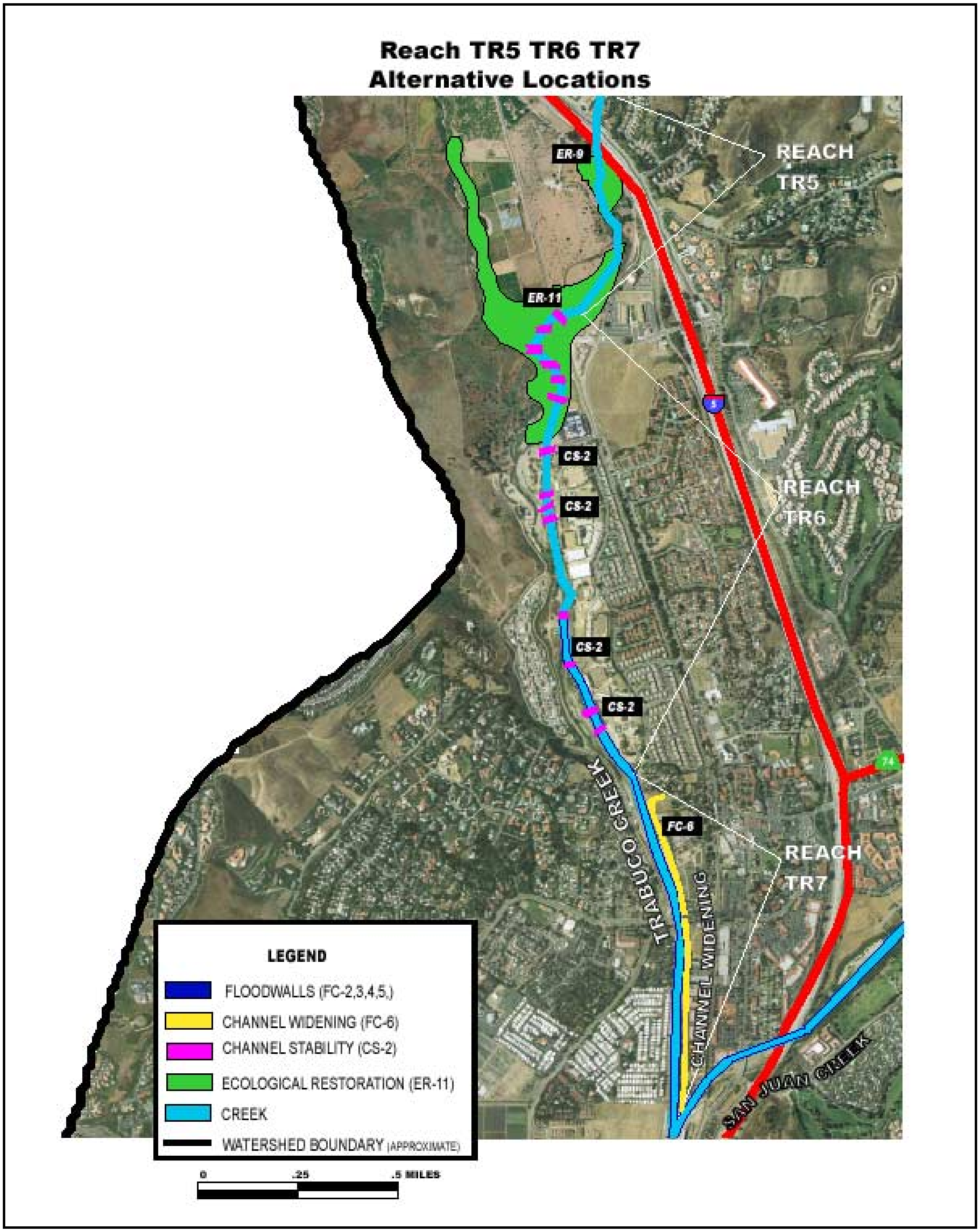


Figure 21. Reach TR3 – Alternative Locations

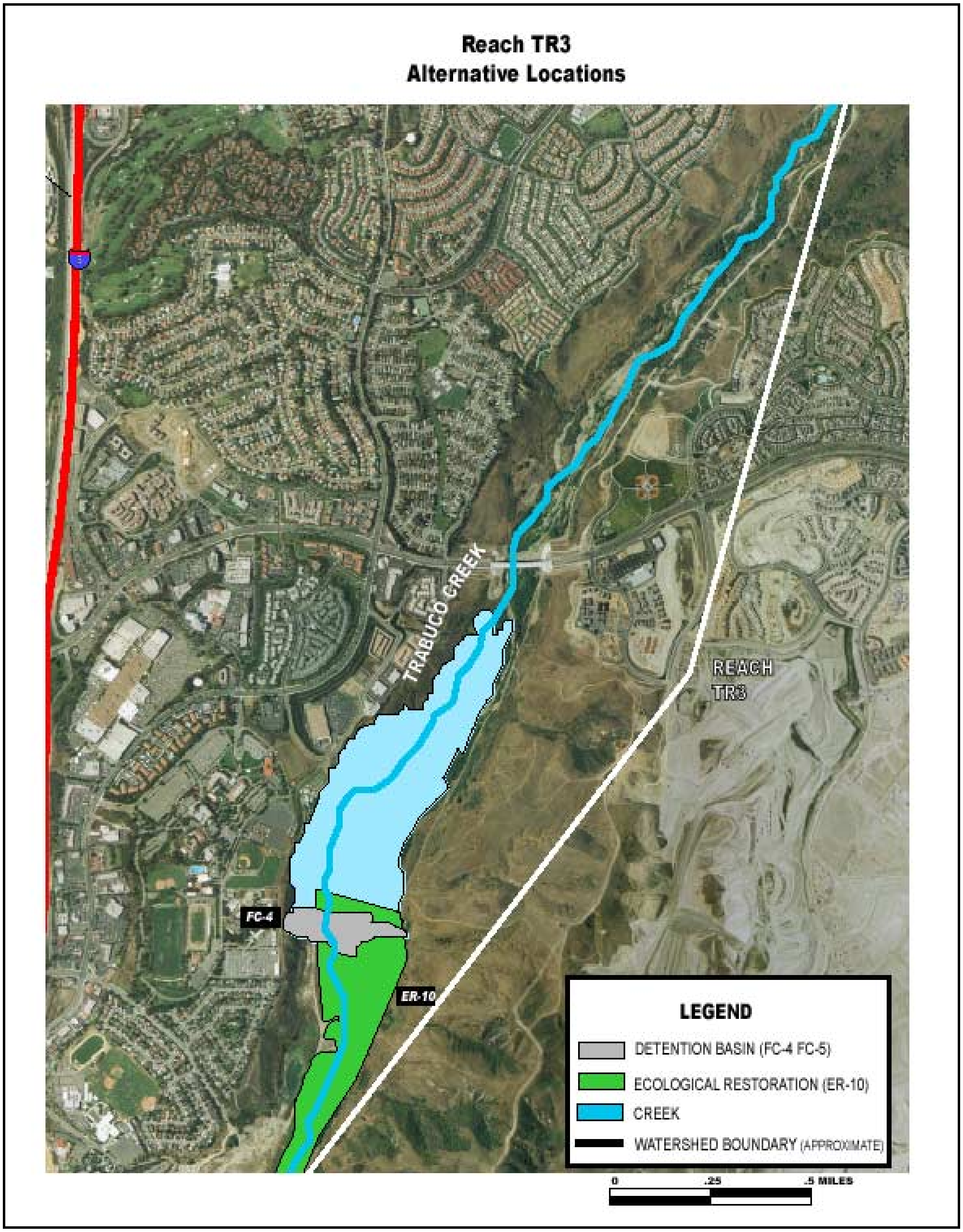


Figure 22. Reach OS4 – Alternative Locations

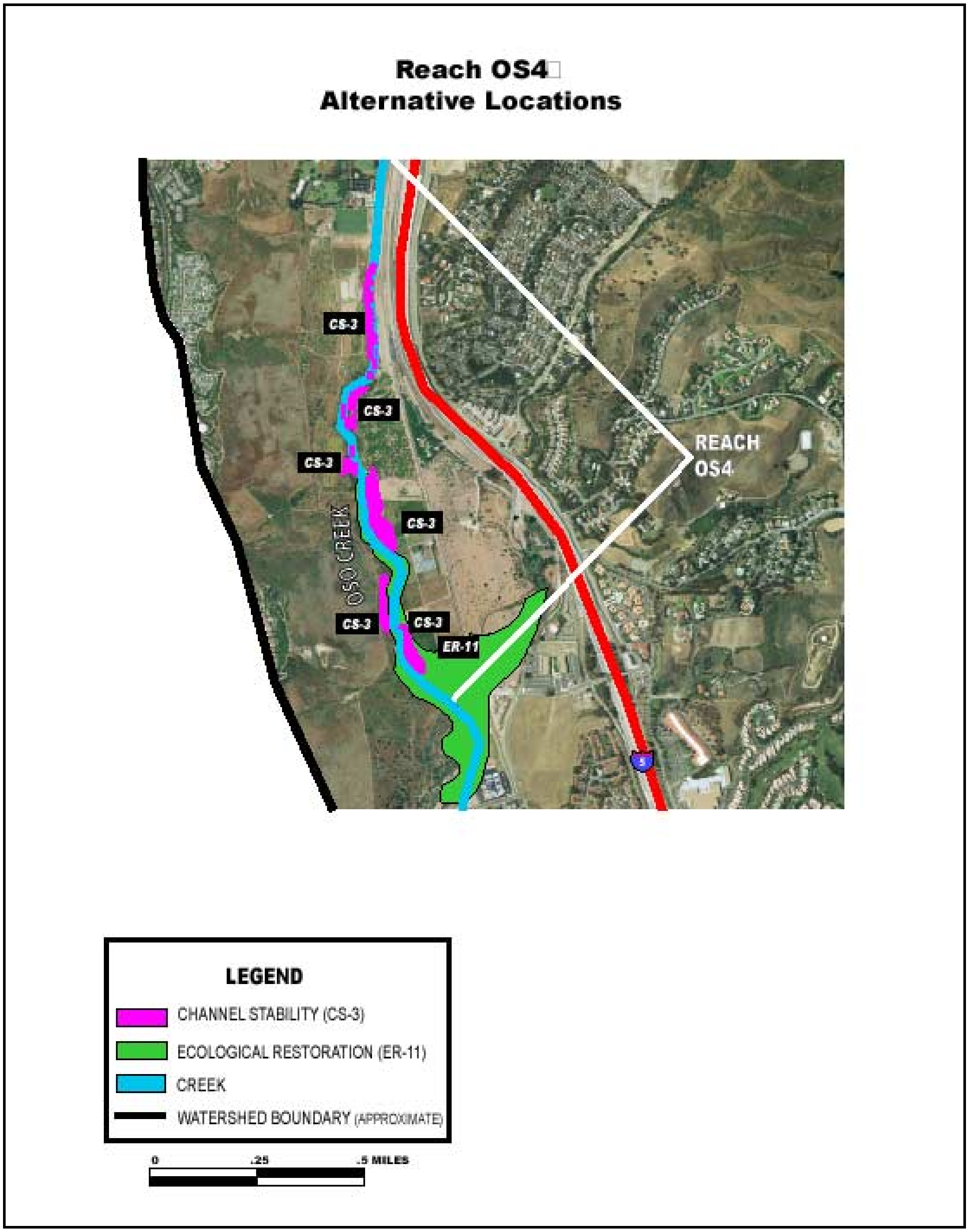


Figure 23. Reach OS3 – Alternative Locations

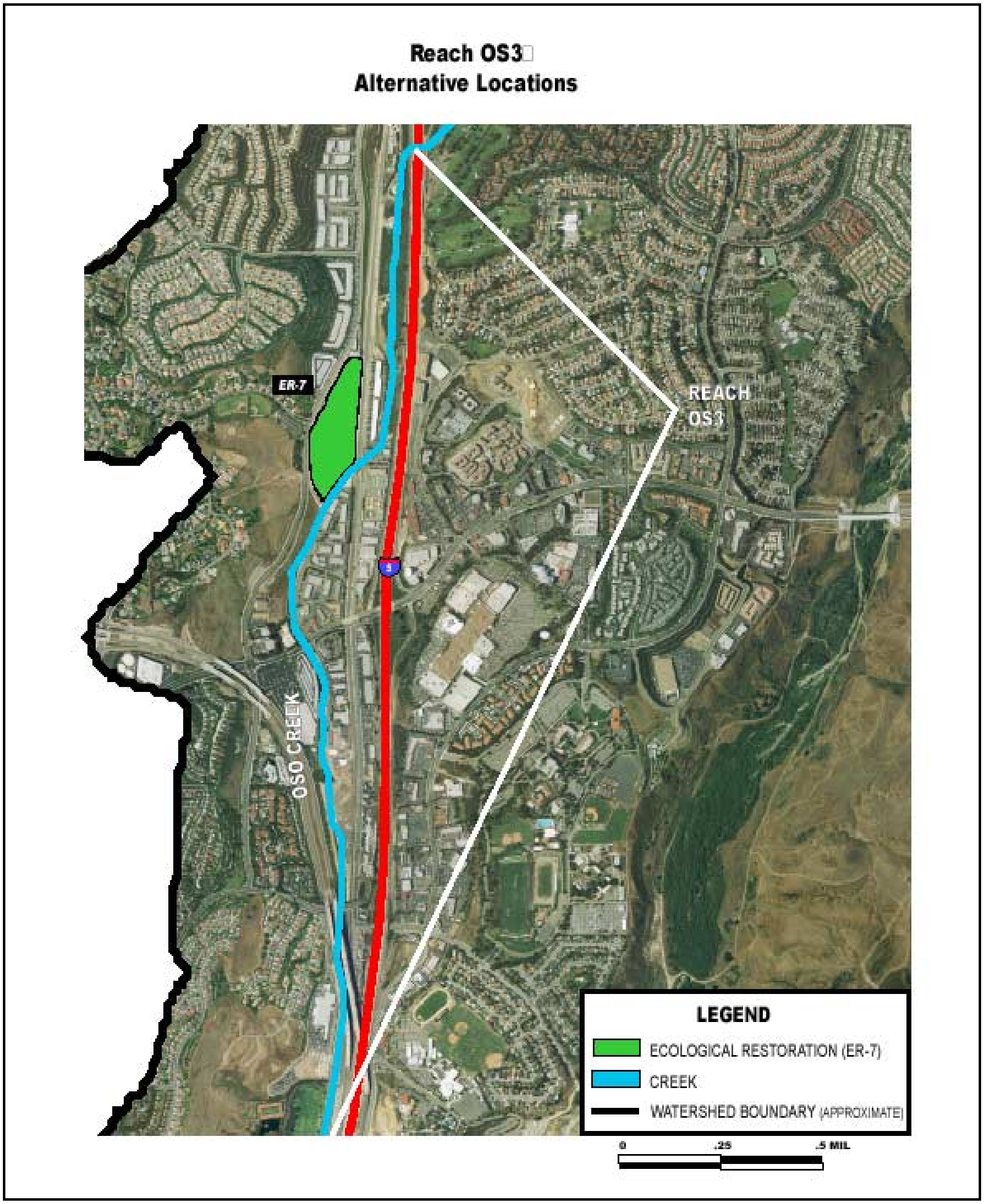


Figure 24. Reach OS2 – Alternative Locations

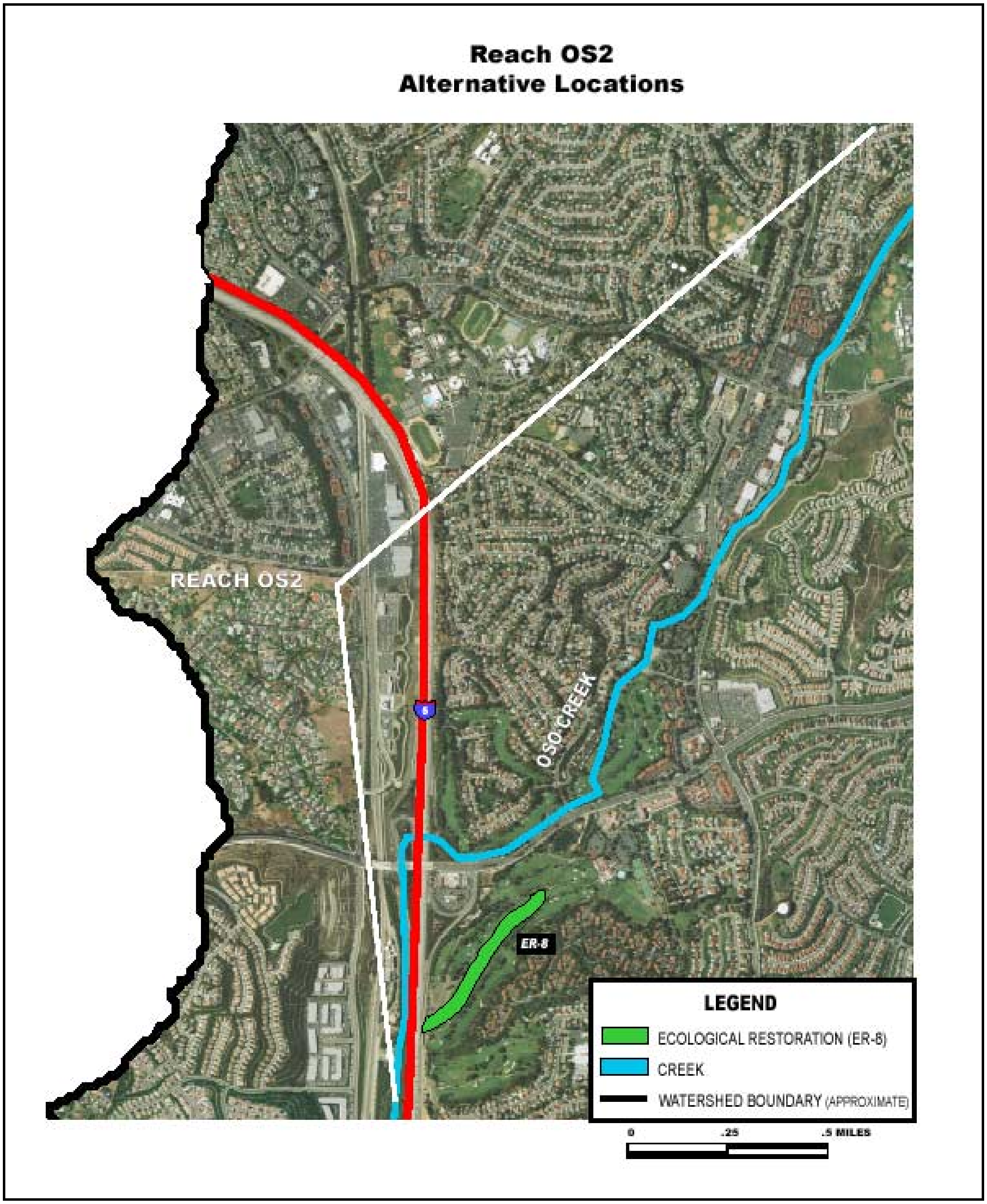


Figure 25. ER-1 Pacific Coast to Highway to Stonehill Drive Bridge

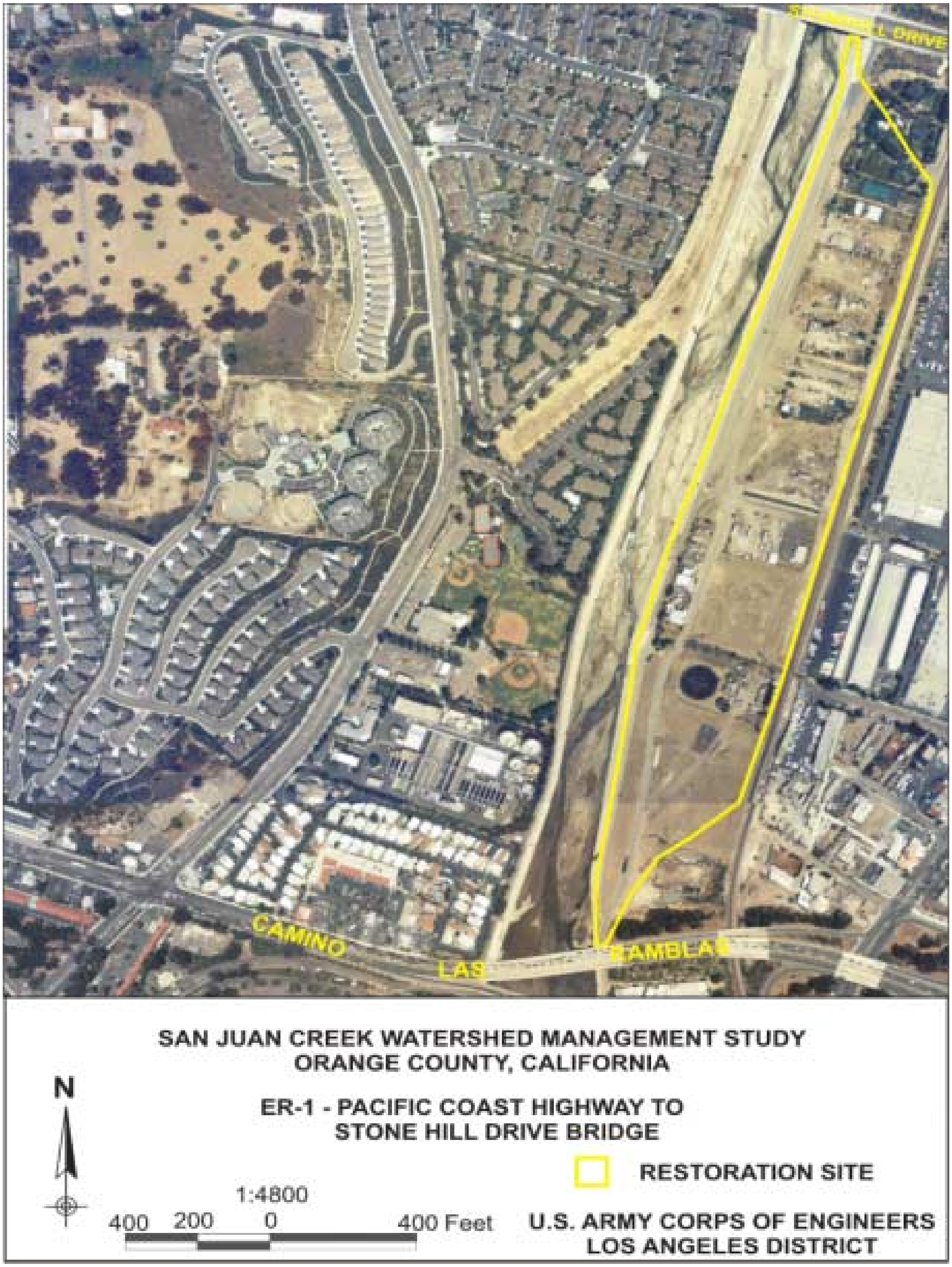


Figure 26. ER-2 Maintenance Site Upstream of I-5

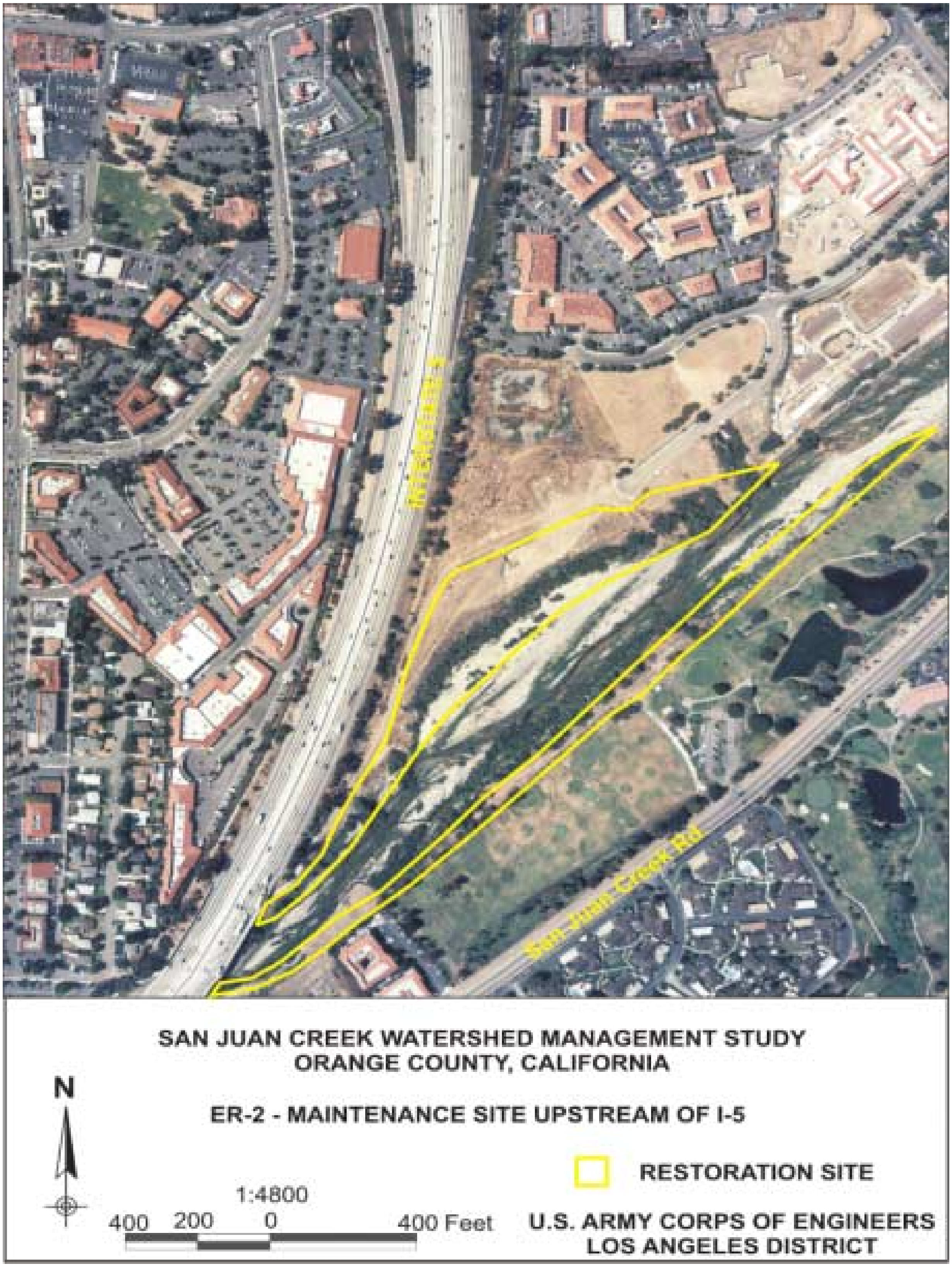


Figure 27. ER-3 Upstream of La Novia Bridge

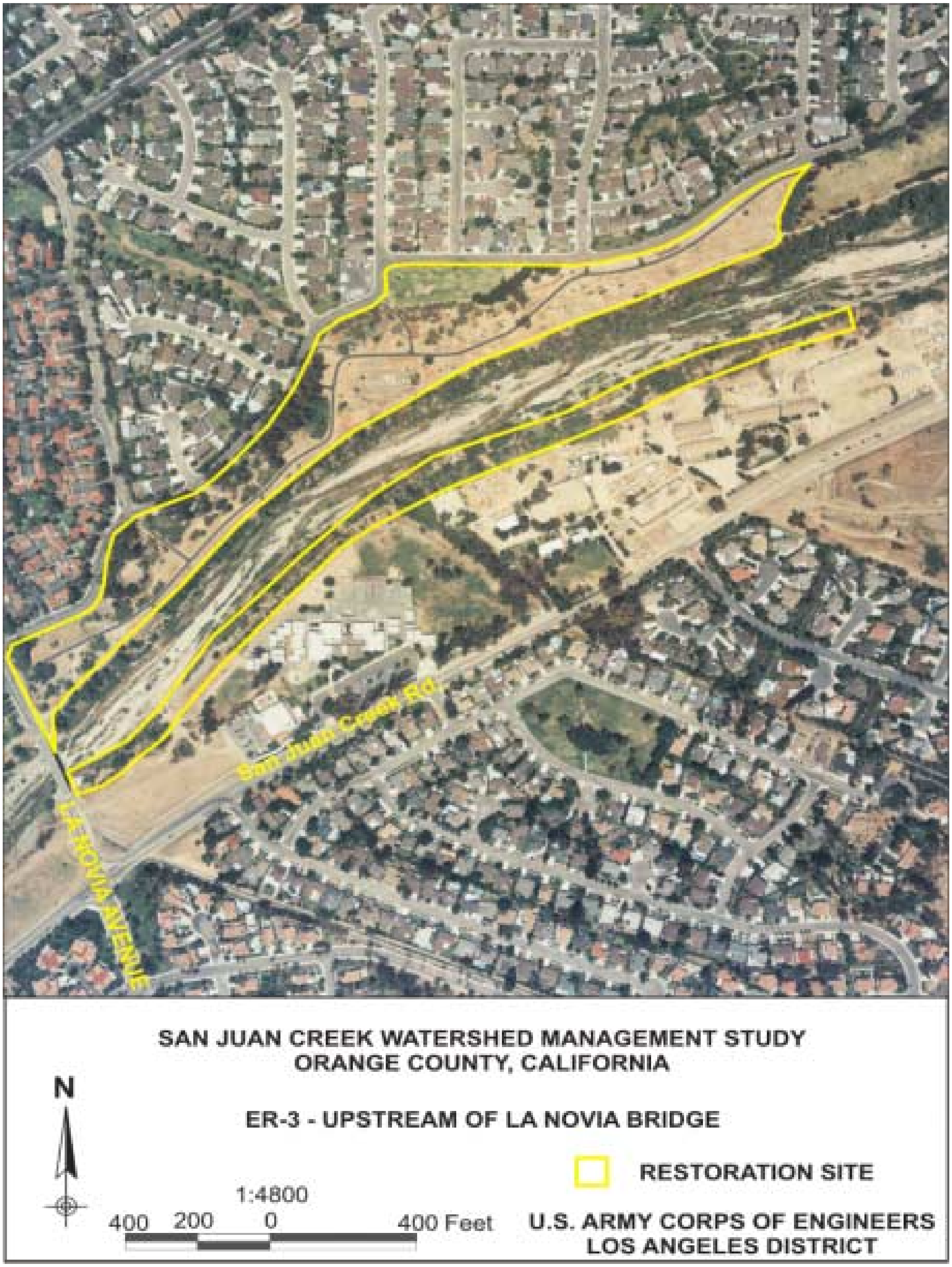


Figure 28. ER-4 Downstream of Antonio Parkway

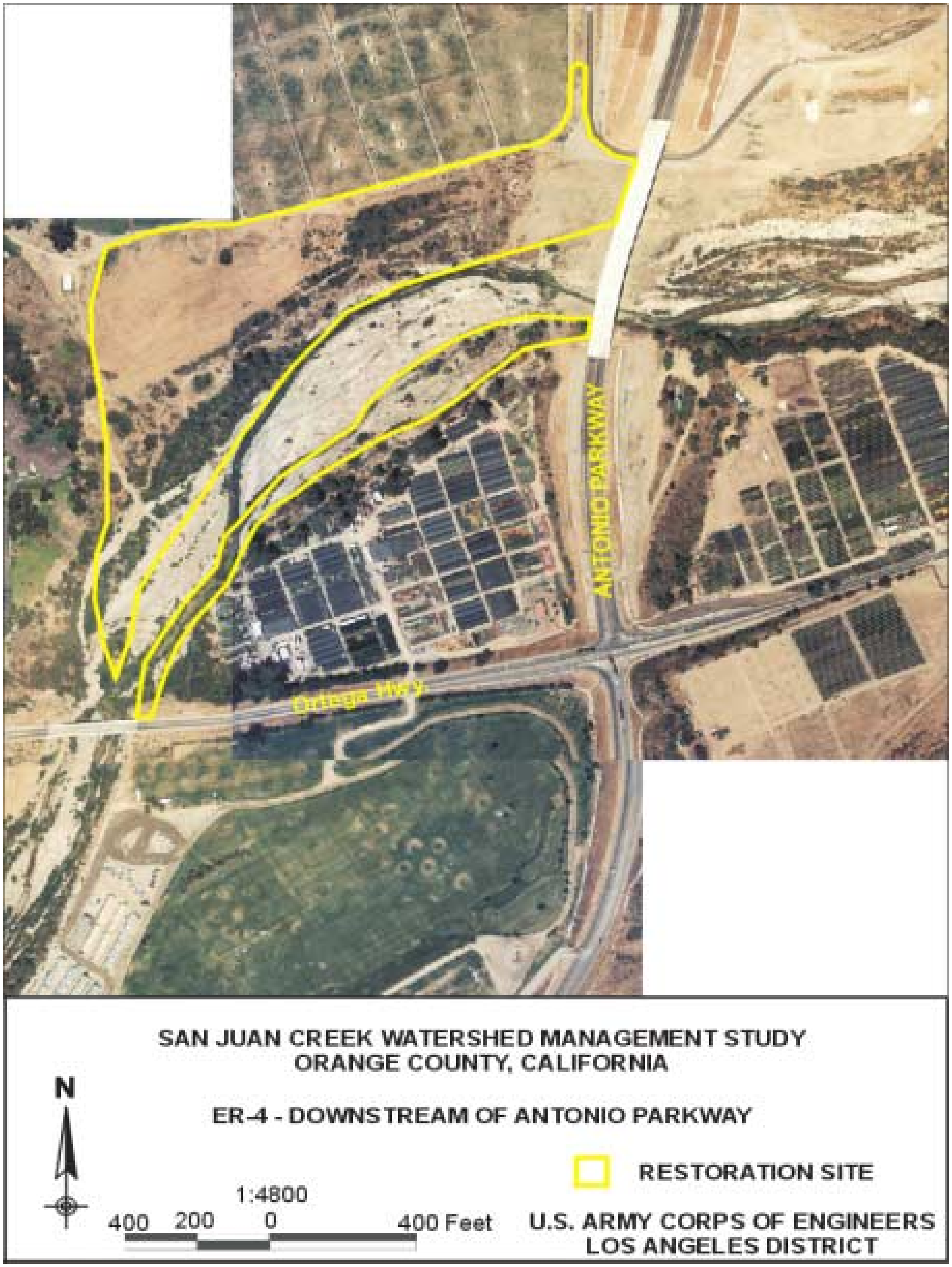


Figure 29. ER-5 Upstream of San Antonio Parkway

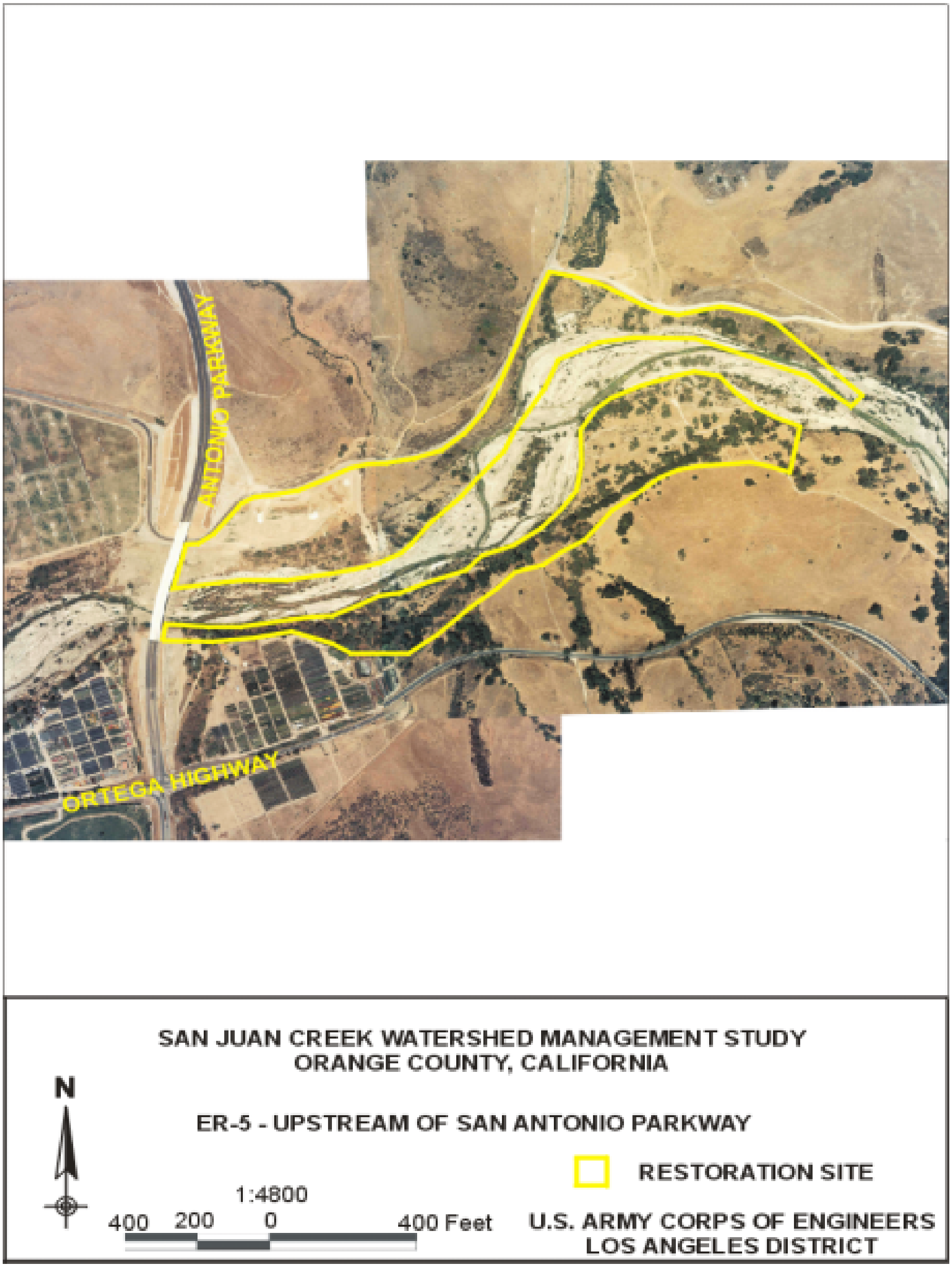


Figure 30. ER-6(1) Upstream of Conrock Quarry Bridge

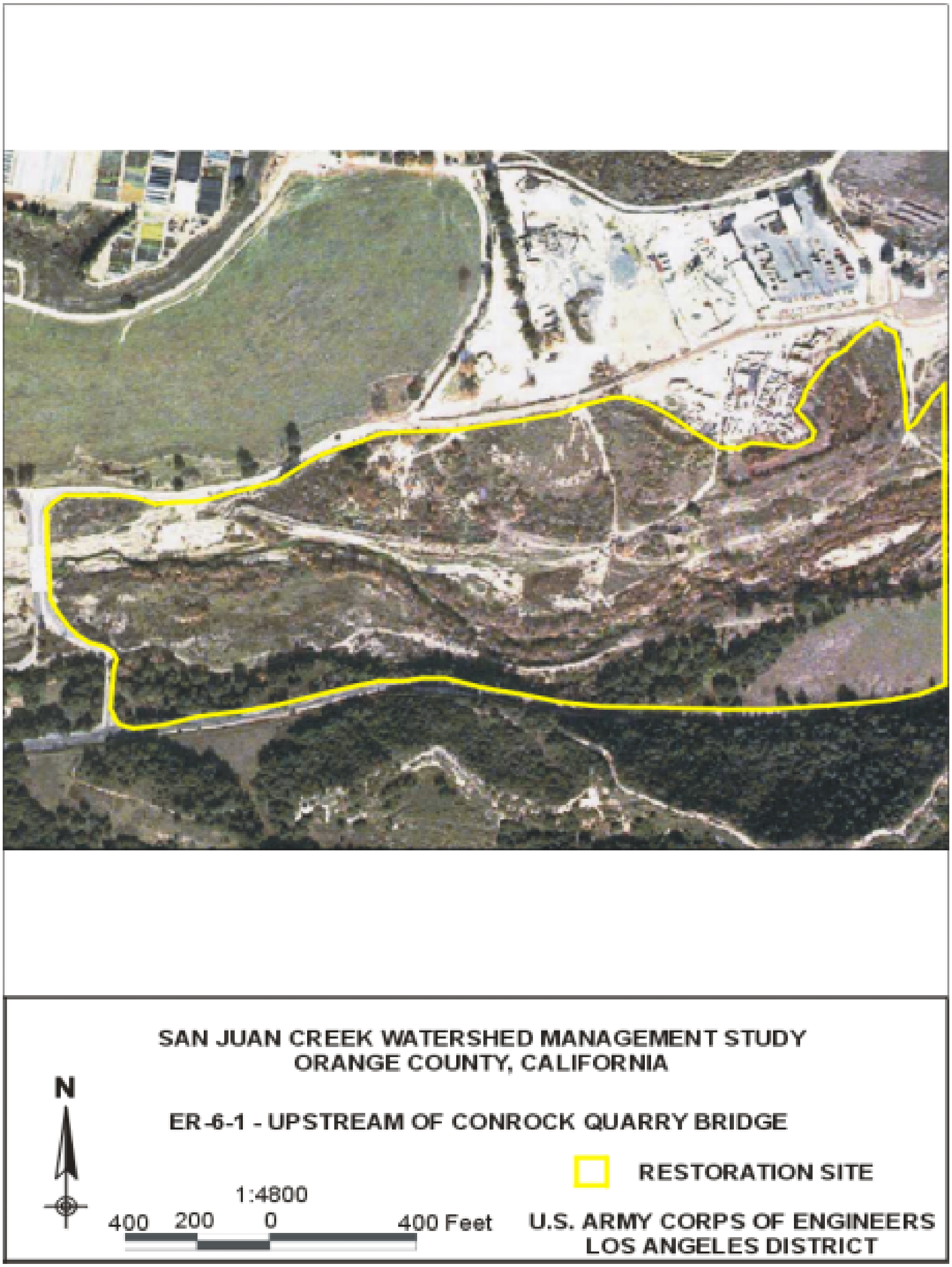


Figure 31. ER-6(2) Upstream of Conrock Quarry Bridge

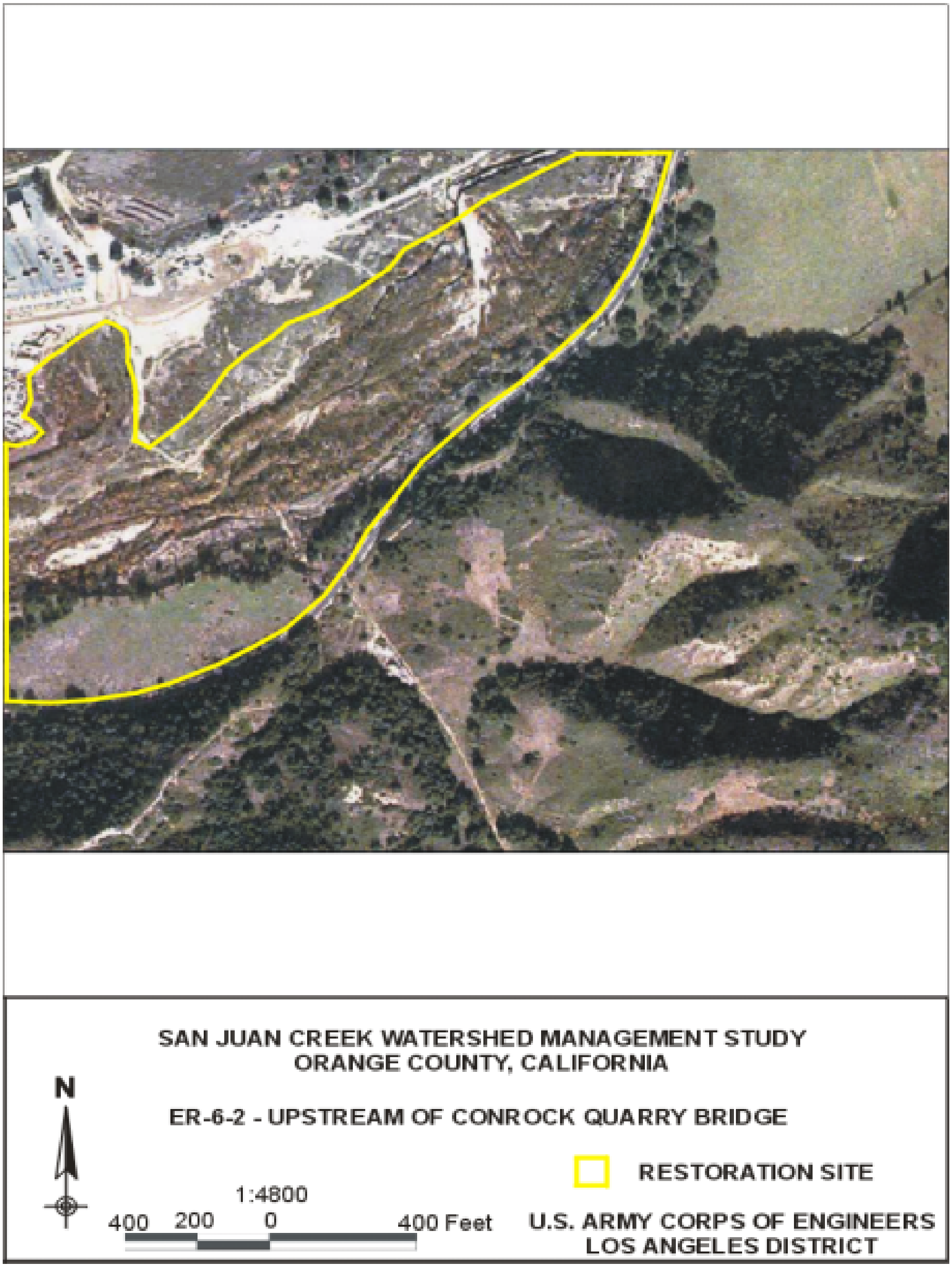


Figure 32. ER-7 Gallivan Detention Basin

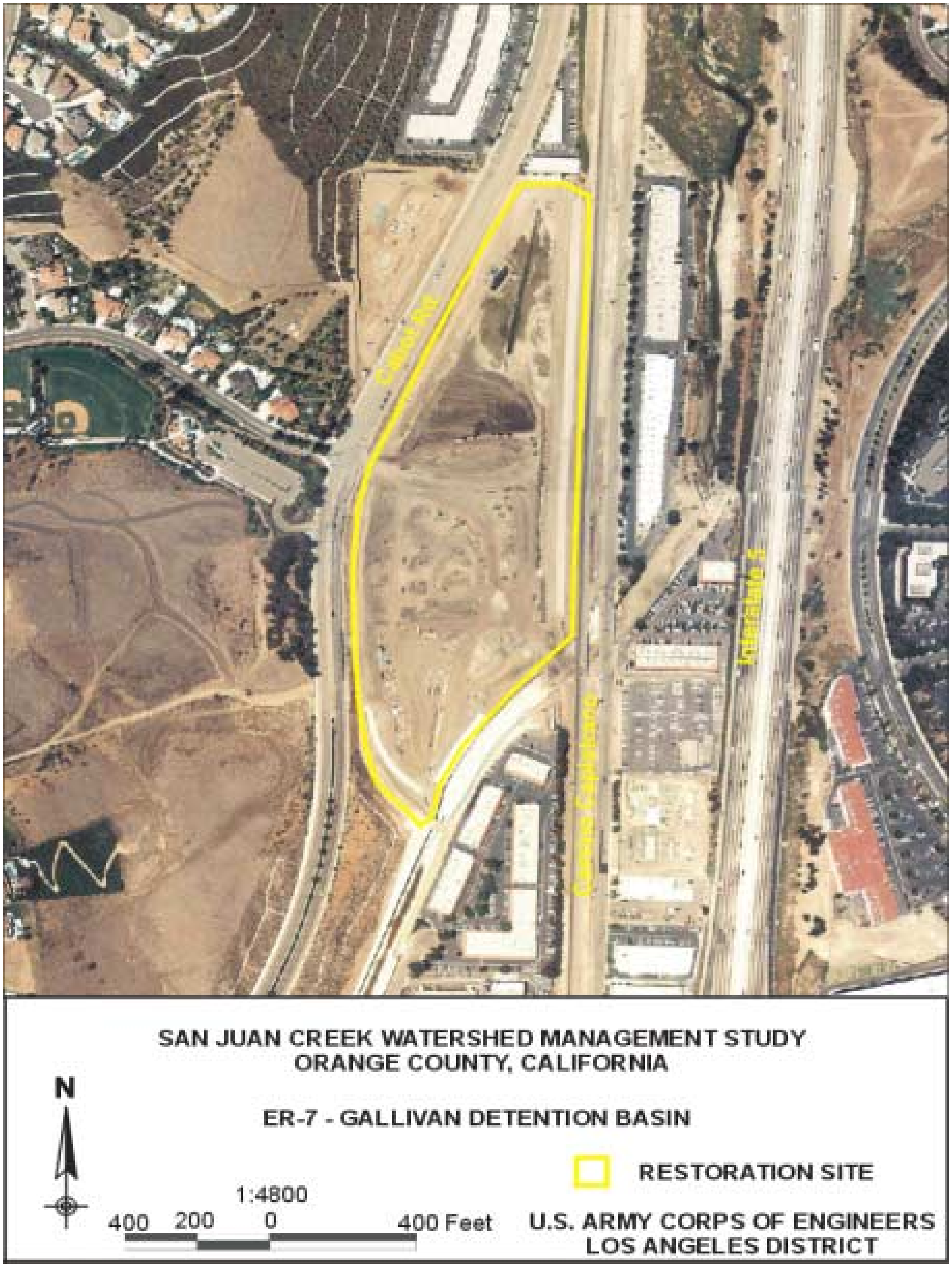


Figure 33. ER-8 Oso Creek at Golf Course

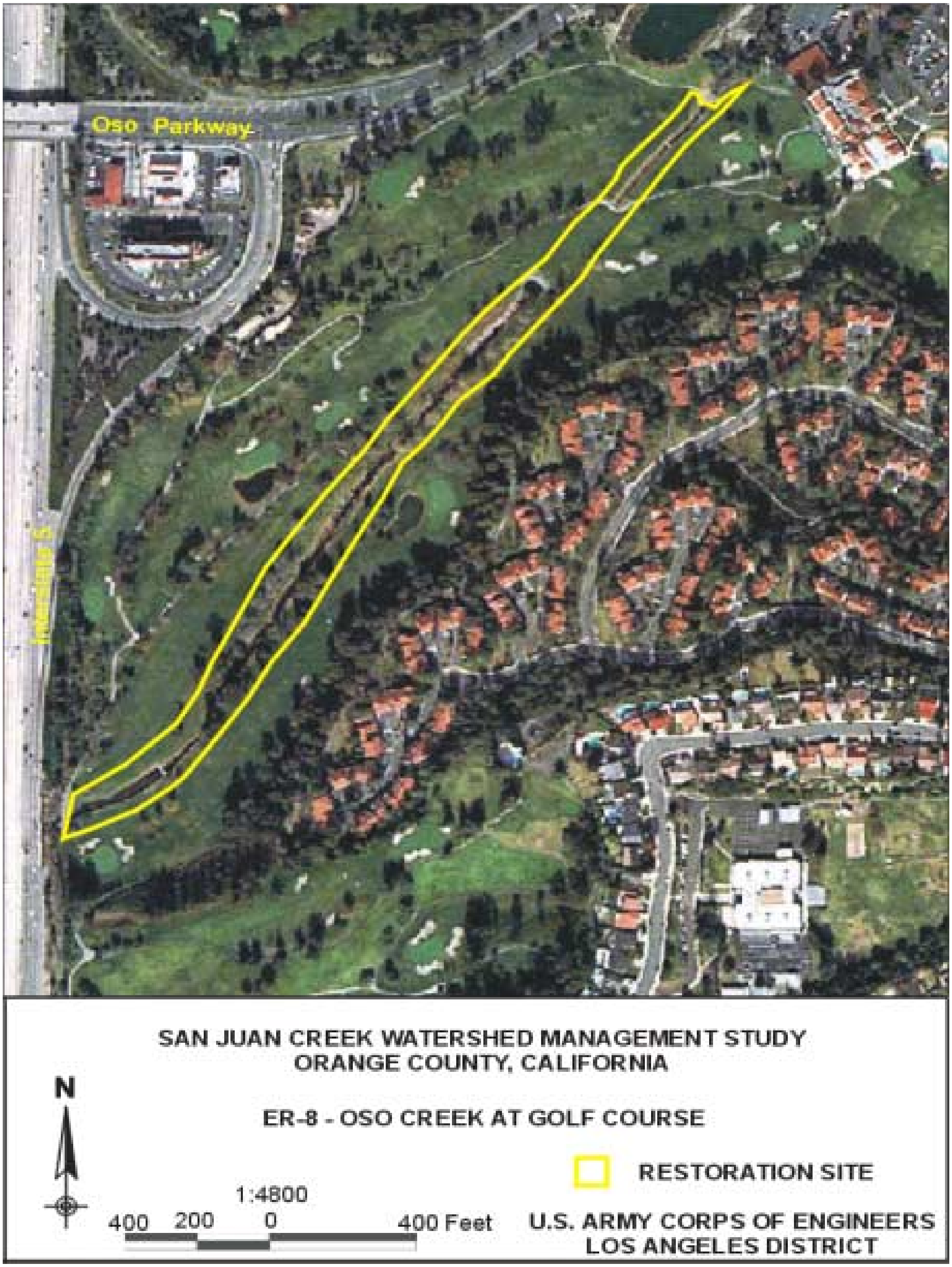


Figure 34. ER-9 Trabuco Creek at the I-5 Crossing

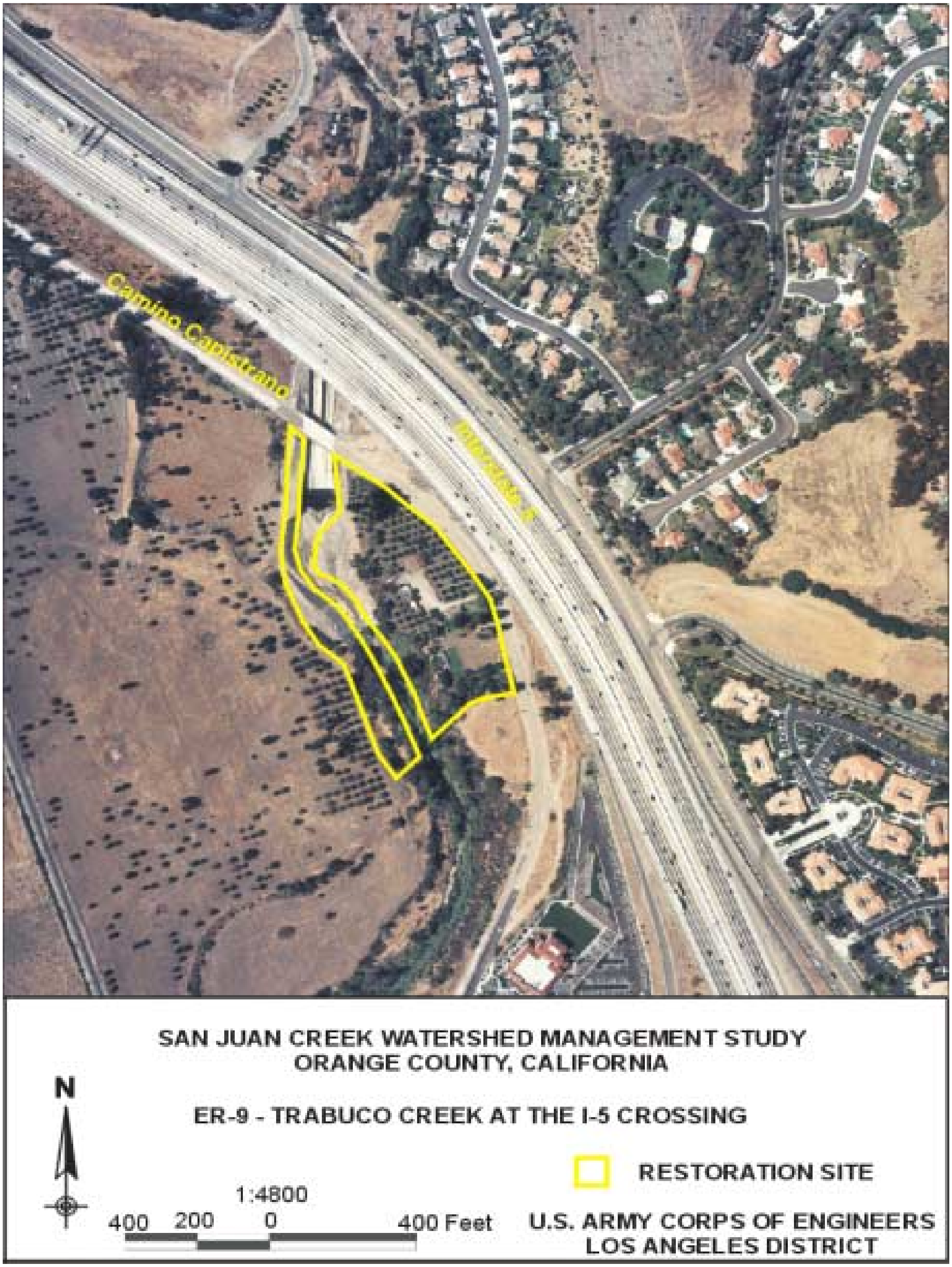


Figure 35. ER-10 Trabuco Creek East of Lakes

Figure 36. ER-11 Oso and Trabuco Creeks Confluence

7.7.4 Results of NED Analysis of Flood Control and Channel Stabilization Alternatives

One of the critical aspects of the study process is the determination of Federal interest. Simply put, Federal interest is the decision of whether or not the Federal government can cost-share in project construction. This is based on number of factors discussed earlier in this report, but ultimately must be demonstrated by whether or not the benefits of the project exceed that of its costs. This analysis is based than on the Benefit to Cost Ration, of B/C Ratio, which for Federal interest to be established, must exceed 1.0 to 1 (1:1).

As mentioned earlier, the B/C ratios for various alternatives were established by calculating the "equivalent annual" damages, or annualized average damages expected to occur over the 50-year period of analysis that are prevented by the completed project, and comparing that to the annualized costs of the project. A ratio of benefits to costs is then generated for each alternative.

The Corps of Engineers is required to identify the alternative that maximizes the benefits (the net difference between benefits and costs expressed in dollars), as the National Economic Development (NED) Plan. That plan is used as the basis for cost-sharing, either when the NED plan is pursued, or when another plan is pursued by local government as a "Locally Preferred Plan" (LPP).

No Locally Preferred Plan has been identified at this time. Therefore, the study team will identify the NED Plan to:

(1) Establish Federal interest, and;

(2) Demonstrate to local interests the potential cost-share that the Federal government might contribute as applied to the Locally Preferred Plan.

Because no flood control measure that solely deals with overtopping will ensure integrity of the levee, such as a stand-along floodwall or detention plan, these plans are neither complete, acceptable, or technically feasible, and cannot be forwarded into the final array of alternatives.

Therefore, the final array of alternatives for food control/channel stabilization consists only of:

(1) Floodwall and Channel Stabilization Plan (FC-7);

(2) Limited Floodwall, Detention on San Juan Creek and Channel Stabilization Plan (FC-8);

(3) Limited Floodwall, Detention on Trabuco Creek and Channel Stabilization Plan (FC-9);

(4) Limited Floodwall, Detention on San Juan and Trabuco Creeks and Channel Stabilization Plan (FC-10).

A summary of the cost-benefit analysis of the flood control, channel stabilization, and combined alternatives forwarded into this phase is discussed below.

Equivalent annual flood inundation damage for the San Juan Watershed area is estimated at $4,446,480, as shown in Table 32.

Table 32 Equivalent Annual Flood Inundation Damages – San Juan Watershed

(in $1,000s, 2002 Price level, $6^1/_8$ percent)

Stream	Expected Annual Flood Inundation Damage		
	Nonresidential	Residential	Total
San Juan Creek	1,492.71	1,885.83	3,378.54
Oso Creek	255.34	0.00	255.34
Trabuco Creek	248.85	563.75	812.60
Total	**1,996.90**	**2,449.58**	**4,446.48**

Equivalent annual emergency and clean-up costs for the San Juan watershed is estimated at $1,190,410, as shown in Table 33.

Table 33 Equivalent Annual Emergency and Clean-Up Costs

(in $1000s, 2002 Price level)

Creek	Residential			Non-Residential
	Clean-up	Public Assistance	Temporary Relocation	Clean-up
San Juan	377.17	282.87	56.57	194.05
Trabuco	122.75	84.56	16.91	32.34
Oso	0.00	0.00	0.00	33.19
Total	**489.92**	**367.43**	**73.48**	**259.58**

As shown below, the equivalent and expected annual damages from flooding in the San Juan Creek watershed is estimated at $15.2 million.

Table 34 Without-Project Equivalent Annual Damage Summary

Category	Equivalent Annual Damage
Structural Inundation	4,446,480
Bridge Failure	9,444,200
Oso Creek Erosion	123,610
Emergency & Clean-up	1,190,410
Total	**$15,204,700**

IMPORTANT NOTE: Because the technical analyses required to fully evaluate the issue of potential bridge failure due to undermining was performed at a preliminary level of detail during this phase of study, it was included as a separate line item in the above table for information purposes only. While it is recognized that bridge failure as a damage category is extremely important (as reflected in Table 34 above), it is felt that a detailed hydraulic scour study of each *bridge's behavior under a variety of flood events must be undertaken to more accurately determine the potential frequency of bridge failure, and must be conducted in the next phase of study. Nevertheless, benefits and costs presented in the following summary of economic analysis included ALL damage categories, including bridge failure prevention. Determination of Federal interest is established by determining the plan that demonstrates the maximum net benefit of all plans presented in the final array of alternatives shown above.*

Table 35 illustrates the potential total damages under the without-project condition, the anticipated remaining with-project damages not prevented with that alternative in place, the anticipated damage reduction yielded by each alternative, the economic cost of the alternative, the preliminary B/C ratio of the alternative, and the net benefits of each alternative.

This information demonstrates that the combination of floodwalls and channel stabilization measures CS-1a and CS-2a, referred to as Flood Control Alternative FC-7 is the NED Plan by virtue of maximization of net benefits. This plan then becomes the basis for cost-sharing for the Locally Preferred Plan, if one is determined to be better in the interests of residents and the local sponsor(s).

The NED Plan, also referred to earlier in the text as the "Floodwall and Channel Stabilization Plan", utilizes channel grade stabilizers to ensure existing levee integrity and floodwalls to ensure in-channel confinement of flood flows up to and including a nominal 1% exceedance flood event.

A preliminary optimization of this alternative was conducted for the purposes of determining the most cost-effective level of protection. The preliminary optimization showed that neither a 2% exceedance (50-year) plan, nor a 0.2% exceedance (500-year) plan produced a higher net benefit. The 2% exceedance plan does not produce a high level of damage reduction due to the significant damages left unaddressed. The 500-year plan requires an unreasonable number (and height) of bridge replacements, as well as floodwall heights, for the damages prevented. Therefore, for the purposes of demonstrating Federal interest, the nominal 1% exceedance level of protection floodwall and channel stabilization plan is the NED plan.

The NED Plan combines the flood protection of alternative FC-2 with the stabilization offered through CS-1a and CS-2a. These elements are as described in previous sections of this report.

Table 35 Cost and Benefits Summary Table – Flood Damage Reduction Alternatives

Flood Damage Reduction Alternative		Without-Project	With-Project	Damage Reduction	Cost	B/C	Net Benefit
Floodwalls Only	FC 2	3,972.79	3,346.02	626.77	943,200	0.66	-316,430
Detention Basin on San Juan Creek	FC 3	3,972.79	2,797.97	1,174.84	2,145,200	0.55	-970,380
Detention Basin on Trabuco Creek	FC 4	3,972.79	2,962.65	1,010.14	2,239,800	0.45	-1,229,660
Detention on San Juan and Trabuco	FC 5	3,972.79	2,616.29	1,356.50	3,506,500	0.39	-2,150,000
Channel Widening	FC 6	6,235.99	2,354.47	6,340.41	3,331,900	1.9	3,008,510
Floodwalls & Channel Stabilization	**FC 7**	**14,792.56**	**3,346.02**	**11,446.54**	**1,373,400**	**8.33**	**10,073,140**
San Juan Detention, Walls, Channel Stabilization	FC 8	14,792.56	2,797.97	11,994.59	2,575,400	4.66	9,419,190
Trabuco Detention, Walls, Channel Stabilization	FC 9	14,792.56	2,962.65	11,829.91	2,670,000	4.43	9,159,910
Both Basins, Floodwalls, Channel Stabilization	FC 10	14,792.56	2,616.29	12,176.27	3,936,700	3.09	8,239,570
San Juan Entire Channel Stabilization	CS 1	13,733.41	5,627.39	8,106.02	536,100	15.12	7,569,920
San Juan Ltd. Channel Stabilization	CS 1a	13,733.41	5,627.39	8,106.02	189,700	42.73	7,916,320
Trabuco Entire Channel Stabilization	CS 2	3,322.38	608.60	2,713.78	679,700	3.99	2,034,080
Trabuco Ltd. Channel Stabilization	CS 2a	3,322.38	608.60	2,713.78	240,500	11.28	2, 473,280

Assuming that stabilization measures are in place, the construction cost of this alternative, including mitigation and real estate costs, would be approximately $20.2 million. Assuming a two-year construction schedule, interest during construction (IDC) would be $1,041,300; thus increasing the economic cost of this alternative to $21,275,800. Amortization of the economic cost over 50-years at an interest rate of $6^{1}/_{8}$ percent yields an annual cost of $1,373,400.

The NED Plan (Alternative FC-7) would reduce equivalent annual inundation related damages by $11,446,540 along both San Juan and Trabuco Creeks.

Table 36 FC-7 Floodwalls (or Levees) and Channel Stabilization Equivalent Annual Damage Reduction

(in $1000s, 2002 Price Level)

	Without-Project	**With-Project**	**Damage Reduction**
Non-Residential	1,741.56	1,078.29	663.27
Residential	2,449.58	1,541.70	907.88
Emergency & Other	1,157.22	726.03	431.19
Total Inundation	*5,348.36*	*3,346.02*	*2,002.20*
Bridge Failure	9,444.20	0.00	9,444.20
Total Damages	**14792.56**	**3346.02**	**11446.54**

National Economic Development (NED) economics for alternative FC-7 are shown below.

Table 37 NED Economics – Alternative FC-7

	Annual Cost & Benefits
Flood Inundation Reduction Benefits	2,002.34
Bridge Failure Reduction Benefits	9,444.20
Total Benefits	11,446.54
Economic Cost	*1,373.40*
B/C Ratio – Total Benefits	8.33
Net Benefits – Total Benefits	10,073.14

7.8 Summary of Alternatives Analysis and Plan Selection Process

7.8.1 Flood Control

As shown in Table 35 based on this feasibility level of analysis, there is no “stand-alone” overtopping flood inundation reduction alternative that is technically feasible or generates a positive benefit-cost ratio. This may be expected, as the potential for levee failure and subsequent flooding of adjacent floodplain properties remains a threat. All of the channel stabilization plans generate a positive benefit-cost ratio, but do not generate as high a net benefit as FC-7. The alternative combining both a floodwall for flood damage reduction due to overtopping of the channel plus channel stabilization for prevention of undermining and subsequent levee failure (Alternative FC-7) has the highest net benefit of any alternative examined, demonstrates Federal interest in implementation by virtue of a positive Benefit-Cost ratio, and is therefore the NED Plan.

7.8.2 Ecosystem Restoration

As can be seen from Table 38, based on this feasibility level of analysis, all alternatives for ecosystem restoration generate significant benefits. Percent improvement at each site varies from 14% at site ER-10, to a 336% improvement at site ER-7. However, selection of the NER plan for ecosystem restoration must be generated by application of an incremental analysis of the alternatives. This analysis indicates the most cost-effective alternatives, with a graphical display that allows the selection of the alternative or package of alternatives, which provide the most significant improvement per dollar.

Examination of the data yielded by the ecosystem restoration alternative analysis and incremental analysis indicate that Ecosystem Restoration alternatives ER-7, ER-6, ER-1, ER-4, ER-3, ER-5, ER-2, and ER-9 (in descending order of cost-effectiveness) provide the most benefit at the least cost, and that each added increment (for instance adding ER-6 onto ER-7) provides a significant added benefit at only a slightly increased cost per unit. Alternatives ER-8, ER-10, and ER-11 are significantly more expensive on a unit cost basis than the others. All of these alternatives (ER-1 through ER-7 and ER-9) maximize the use of available space, and therefore maximize the unit return per dollar at each site. Each of these alternatives is exclusive, and can function as a stand-alone project. However, each is viewed as being a piece of a larger goal to restore connectivity to the larger San Juan Creek system. Therefore, the package of ecosystem restoration alternatives consisting of alternatives ER-1, ER-2, ER-3, ER-4, ER-5, ER-6, ER-7, and ER-9 are recommended as the preliminary NER plan, and recommended for inclusion in the larger comprehensive plan for flood control, ecosystem restoration, and comprehensive watershed management for the San Juan Creek watershed. Because implementation of ER-1 may not be acceptable to local interests, and may be, in fact, not critical to the function of the remainder of the array, further pursuit of this issue is recommended.

Table 38 Final Average Annual HU Score Improvements for Future With-Project Conditions at Each Restoration Site[1]

Site Name	Existing FCI	Future Average Annual FCI[2]	Area[3] (Ha)	Existing HUs[4]	Future Average Annual HUs[5]	Average Annual HU Score Improvement[6]	Percent Improvement[7]
ER-1	0.16	0.55	22.5	3.59	12.44	8.86	247%
ER-2	0.50	0.73	9.8	4.92	7.15	2.23	45%
ER-3	0.56	0.78	17.1	9.54	13.26	3.72	39%
ER-4	0.55	0.76	15.3	8.37	11.67	3.29	39%
ER-5	0.59	0.77	49.9	29.24	38.40	9.16	31%
ER-6	0.44	0.74	63.1	27.99	46.97	18.99	68%
ER-7	0.11	0.46	9.2	0.98	4.26	3.29	336%
ER-8	0.25	0.45	3.9	0.98	1.75	0.78	80%
ER-9	0.14	0.37	3.7	0.51	1.36	0.85	168%
ER-10	0.79	0.90	24.3	19.19	21.95	2.76	14%
ER-11	0.61	0.82	21.5	13.17	17.56	4.38	33%

[1]See the Environmental Appendix for a detailed description of the calculations for these scores.
[2]Scores for years 1, 25, 40, and 50 were averaged.
[3]Area reflects the total restoration alternative project footprint.
[4]Result of multiplying the existing FCI by the total project area
[5]Result of multiplying the future average annual FCI by the total project area
[6]Difference between future average annual HUs and existing HUs
[7]Average annual HU score improvement divided by existing HUs

7.9 Recommended Plan

The development of alternative plans for addressing problems in the San Juan Creek watershed involved numerous individuals, agencies, and stakeholders. The process was an iterative, and often difficult task. The determination of the "best" plan to address each problem was not always decided on by its potential cost, or its perceived value by a single group. The determination of the "best" plan for flood control, channel stabilization, and ecosystem restoration from a Federal perspective was based on numerous criteria and studies, which were not always applicable to projects that may be implemented at the local level. Therefore, a combination of monetary and non-monetary, societal and environmental, situational, and political perspectives were evaluated, with numerous trade-offs in the process. While the Federally cost-shared project was decided on technical, monetary (economic), environmental, efficiency, effectiveness, and acceptability standards, it must be recognized that at the local level, the reality is the ability of the local sponsors to pay for some of the measures formulated. Thus, a balance had to be achieved while addressing as many of the problems as possible. The list of recommendations is not exhaustive, simply because it is not reasonable to expect that everything can be addressed in a timely manner.

Determination of Federal interest, reflected in the NED/NER Plan, is based on the above criteria, but is ultimately determined by the maximization of net benefits, both monetary and non-monetary. As mentioned earlier, the development of alternative measures focused on the lower reaches of the watershed since there are few flooding, channel degradation or ecosystem degradation problems in the upper reaches. Different levee and bridge failure scenarios were investigated to address flooding and channel degradation problems in the downstream reaches, including the undermining of levees and the overtopping of levees. Scour along the channel bottom (invert) has exposed some of the footings of the concrete slope protection (panels) in these downstream reaches. Panel failures have occurred in recent high flow events, including the 1998 flood, estimated as a 4% exceedance (approximately 25-year) event. A preliminary scour analysis indicated areas where panel failure could occur. Panel failure, in turn may result in a breach in the levees and flooding of nearby structures within the floodplain. The scour of the channel leading to potential panel failure is the baseline conditions assumption for flooding within the lower reaches of the watershed. The channel may also be exceeded by overtopping of the levee system, currently estimated to occur at a 2% exceedance (~50-year) event.

Estimates of economic damages related to flooding, and emergency and clean-up costs begin when the non-damaging discharge event has been exceeded. The non-damaging discharge before undermining of the channel begins is assumed to be slightly less than the 4% exceedance (~25-year event), with a discharge rate of approximately 451 cms (15,900 cfs) on San Juan Creek downstream of Interstate 5, 640 cms (22,600 cfs) at the ocean, and approximately 244 cms (8,600 cfs) on Trabuco Creek upstream of the San Juan confluence. If the channel were to resist undermining (for instance, if channel stabilization measures were in place), overtopping would begin to occur at an approximate 2% exceedance event (~50-year). Above the 2% exceedance flood event, it is assumed that flows will break out of the levee system, and flow out to an extent and depth depending on the ultimate size remaining portions of the existing levees will also be overtopped increasing the potential for flood damages. Damage estimates include impacts to structures and contents, emergency clean up costs, and the potential for bridge failure. Bridge failure is possible due to the scour exposing bridge footings leading to undermining and collapse of the structure. The bridges that are at risk from undermining/scour of piers and abutments include Stonehill Drive, Camino Capistrano, Interstate 5 (although this bridge may now be protected by a invert stabilizer immediately downstream), La Novia, and Lower Ortega Highway bridges on San Juan Creek, and Del Obispo Street bridge on Trabuco Creek. Exceedance of design safety criteria may occur in as little as a 20% exceedance (~5-year) event to a 4% exceedance (~25-year) event, based on currently invert elevations compared to toe-down of piers. New floodplain mapping for specific flood events, including the 1% exceedance and 0.2% exceedance (~100-year and 500-year, respectively) events was prepared for this study to support the analyses, but should not be used to replace existing FEMA floodplain mapping (see Figure 6 to Figure 15).

Approximately 2,439 residential, 1,144 manufactured (pre-assembled residential), and 536 non-residential structures occupy the floodplain. The damages by flood event frequency, which again includes emergency and clean-up costs, are approximately $886,000, $47,969,000, $149,129,000, and $349,237,000 for the 4% exceedance, 2% exceedance, 1% exceedance, and 0.2% exceedance flood events, respectively.

Ecosystem degradation is evident almost everywhere within the lower reaches of the watershed. The problems relate to the impacts of development within this area. Seasonal watercourses within this watershed now have perennial flow due to higher base flows during the dry seasons. This has altered the habitat base, impacting dominant species types and diversification. Exotic and invasive plant species such as *Arundo Donax*, the Giant Reed, have overwhelmed the system further degrading the value of the remaining habitat. Channel erosion is clearly evident in the downstream reaches of Oso Creek and Trabuco Creek, affecting not only the habitat within the watercourses, but surrounding overbank areas that rely on the water table for growth and sustainability. The lower reaches of San Juan mainstem are barren of any significant amounts of vegetation that assist in improving water quality, reducing water temperatures, and providing forage areas for migratory fish and birds. To characterize and quantify the existing habitat and compare that to potential restoration measures, a non-monetary analysis was performed. A modified hydrogeomorphic method (HGM) analysis was used for this study. Results are presented in Functional Capacity Units (FCUs). Opportunities for ecosystem restoration measures were confined to existing channel and overbank areas, where connectivity to existing healthy habitat areas was possible, and where lands were still open space. More discussion of the environmental studies and results are presented in Section 4 of this report.

Alternative measures were prepared to address the list of more refined problems and opportunities identified subsequent to the preparation of the baseline conditions analysis.

Preliminary measures addressed such categories as ecosystem restoration, flood control, channel stabilization, public education, management practices, and water quality. Each category had multiple components. For example, ecosystem restoration measures included stream lengthening, fish passage, revegetation, public awareness and education plans, and exotic species eradication. The measures could be addressed in multiple ways, through future Federal involvement in an implementation project, by local governments, volunteer groups, schools, or private citizens. A screening process was used to refine the list of alternative measures based on economic, environmental, engineering, societal, cultural, infrastructure, and public acceptability, as well as on other criteria. A "trade-off" analysis was used, and is presented herein, to narrow down a field of potential solutions to the most cost-effective, least environmentally impacting, locally acceptable, and technically soundest solutions possible.

Combinations of these measures formed the alternative plans that are addressed in Section 7 and are analyzed in comparison with one another to determine that alternative plan (package of recommendations) being recommended for potential implementation as both Federal and local projects. The primary focus of the Federally cost-shared implementation projects are ecosystem restoration, flood control and channel stabilization, with some "incidental" water quality, water supply and recreation benefits. Other recommendations for which there is no Corps of Engineers authority to pursue (as cost-shared projects) include water quality improvement measures, public education, and pursuit of exotic species eradication measures. These may, however, be pursued using funding from other sources, including State and regulatory permit fee funding.

The goal of these recommendations is to establish a framework where negative trends may be reversed, projects may be implemented, and wise stewardship of the resource may be encouraged. It is recognized that many of the recommendations may be controversial in nature for one reason or another. Further screening of alternatives will likely occur following public input received on this draft report.

7.9.1 Draft Recommendations for the Watershed Management Plan

- Establish a "watershed keeper" (steward) committee funded jointly and administered by the County and cities that will coordinate, integrate and leverage programs and projects by cities, county, schools, universities, utility districts, public and private entities. This will guide implementation of the local action items (evaluating BMPs, conducting water quality monitoring, identifying grants and corporate sponsors for special projects, organizing volunteer efforts, etc.), and provide the means by which planning and implementation will occur once this initial study effort is complete.

- Fully implement a watershed-wide monitoring program as part of the watershed stewardship program. Monitor continuing problem areas; monitor project performance, monitor efficacy of established programs for Water Quality, Exotic Species, 404 permits, Channel degradation trends, wildlife surveys conducted each year, completed and proposed projects in the watershed, and annual flooding and/or erosion damages. An annual or bi-annual "State of the Watershed" report could be issued, possibly on an Internet website, and also by attachment to utility bills or other existing dissemination programs.

- Strengthen the existing Water Quality Monitoring Program, building on existing testing activities by the County and others. Expand the testing program to include testing sites based on results of prior testing. For example, upstream extension of test sites should occur by first testing immediate upstream tributaries or drainage systems, not by random coverage based on downstream results. To do this will require both time and funding on a long-term basis. A "shotgun" approach will not make best use of the limited resources currently available. It is important to conduct regular testing, to thoroughly evaluate results, to determine appropriate actions based on that evaluation, and adjust the approach as needed.

- Implement Best Management Practices and other water quality treatment alternatives at the local and regional level. There remains a great deal of uncertainty regarding the sources and locations of bacterial contamination in the watershed and ocean nearshore zone. It is strongly recommended that remaining studies on water quality issues first focus on identifying both sources and locations of bacterial contamination before any large-scale projects are considered. Once site-specific information can be developed which indicates particular "hot spots", treatment wetlands or directed water quality improvement measures should be implemented. Initial follow-on efforts should be focused on the implementation of on-site biofiltration/infiltration treatment, landscape controls aimed at reduction of water runoff, reduction of pesticide and fertilizer application, and enforcement of ordinances aimed at pet waste control. The study team should then seek out and obtain grants to aid in these costly efforts from the Environmental Protection Agency, the State of California, and from other granting bodies. Further, the study team also recommends that the long-term effort must include evaluation of the effectiveness of implemented BMPs and adjust as needed.

- Utilizing Exotic Species Eradication guidelines, establish a program for elimination of exotic species in the watershed. Critical in this program is the need to conduct initial eradication efforts in an upstream-to-downstream approach. It is recommended that a "pool" of funding be established, involving Corps of Engineers Regulatory Branch, State of California Department of Fish and Game, and other resource agencies, to address this program in a systematic manner. Random eradication efforts have shown themselves to be ineffective, as upstream stands of exotics may re-infest areas cleared in prior efforts. A plan and schedule of activities should be established in coordination with all of the relevant agencies that is broadly distributed by both hard and electronic media. A long-term monitoring plan should be included in the coordination.

- Develop a Watershed Education Program. Establish objectives, goals, curricula, schools involved, teaching requirements, funding sources, and a teaching plan. Develop and distribute the non-point source public awareness plan.

- Create and distribute a short "Refrigerator List" of things that can be done by individuals to improve watershed health. Examples include supplying phone numbers, points of contact, and recommendations regarding fertilizer and pesticide application, pet waste clean-up, recycling, wise water use, and other actions that can be done by everyone in the watershed. The tone of the list should be friendly and informative, with features designed to catch the interest of individuals so that it does not become an additional piece of trash but is displayed prominently in the home. It is the hope of the study team that more residents and visitors to the watershed might be encouraged to become involved. The first step is to catch their interest and convince them that they can contribute to the solutions.

- Support local interest and the Federal interest in a recommended plan for a combination of channel stabilization, flood damage reduction and ecosystem restoration. The plan may be revised during this phase of the study based on feedback from the Sponsor and the stakeholders. If there were local support for the final recommended plan, a cost-shared "spin-off" study would be initiated for project implementation at the end of the watershed study. Detailed investigations would be required to optimize the plan to determine the best method and spacing of channel grade stabilization, and location and sizing of flood control features, to further examine the long-term sustainability of the ecosystem restoration measures, and to consider other objectives such as water quality improvements, beach nourishment, water supply and recreation. The "spin-off" study would require preparation of a NEPA/CEQA document. More details of the plan are presented in the following section.

- Under the Corps of Engineers Continuing Authorities Program (CAP), utilize Section 14 Emergency Streambank Erosion Control study authority to investigate and prioritize treatment of erosion sites that would not be covered by implementation of the larger flood control and channel stabilization project.

7.9.2 The Preliminary Recommended Plan for Federal (Corps of Engineers) Pursuit

A combination of measures is necessary to address the flood damage, channel stability, and ecosystem restoration problems. Channel stabilization is required to ensure that the existing levees do not fail due to existing channel scour and subsequent channel lining/levee failure potential. Stabilization is also required to address the potential for bridge failure due to scour and subsequent failure. However, if channel stabilization were in place, overtopping of the levee system would still be possible. The additional structural inclusion of floodwalls is required to contain the less frequent, but larger storm events above 2% exceedance (50-year) that will continue to overtop the levee system.

Ecosystem degradation problems similarly require a group of measures spaced along San Juan Creek that will provide restoration of riparian and upland habitats, buffer zones, revegetation of several habitat types, and spaced "resting" points along the channel to ensure some likelihood of aquatic species habitation.

This study recommends pursuit of a multi-purpose flood damage reduction, channel stabilization and ecosystem restoration alternative. The flood damage reduction portion of this plan (Alternative FC-7) concentrates on the lower reaches of San Juan (SJ-5 and SJ-6) and Trabuco Creeks (TR-7) that contain the highest potential for flood damage. The recommended plan components for flood control and channel stabilization possess a preliminary Benefit-Cost ratio of 8.3 to 1, and yields a net benefit of $10,073,000 annually. The ecosystem restoration components of this alternative (Alternatives ER-2 through ER-7, and ER-9) possess the highest potential for improvement of degraded environmental resources on San Juan Creek, with the greatest cost-effectiveness of all measures examined. The costs of this restoration range from

$151,000 to $281,000 per habitat unit, which compares favorably to other restoration projects in this region of the country. While the ecosystem restoration alternatives may be implemented individually and are highly productive environmentally on their own, these measures were developed and integrated with the flood damage reduction/channel stabilization portion, and are therefore recommended for implementation based on their maximization of both environmental and economic benefits.

The preliminary recommended plan maximizes both monetary and non-monetary benefits. It is also known as the "National Economic Development/ National Ecosystem Restoration (NED/NER) Plan" using Federal planning guidance language. The NED/NER Plan is economically justified, environmentally beneficial, and is sound from an engineering standpoint.

The total cost of the NED/NER plan is $43,522,755, and would be cost-shared on a 65% Federal/35% Non-Federal basis, based on current guidance for Federal flood damage reduction/ecosystem restoration projects funded by Congress through the Corps of Engineers. The potential Non-Federal share is anticipated to be approximately $15,233,000. While a combined NED/NER plan has been identified, it is recognized that the local sponsor and residents of the watershed may not support the floodwall plan as designed. No Locally Preferred Plan (LPP) has been identified to date. Therefore, a "spin-off" phase will serve to both optimize the NED/NER plan, as well as fully develop the Locally Preferred Plan, if different. Because of the inseparability of the solutions for flood inundation reduction and channel stabilization, and the necessity of including the ecosystem restoration alternatives in the planning and design process for proper integration, any follow-on phase consisting of a "spin-off" study, should be authorized for the joint purposes of addressing flood damage reduction, channel stability, ecosystem restoration, and incidental recreation.

The combined NED/NER plan for flood damage reduction and ecosystem restoration is a combination of alternatives FC-7, ER-2 through ER-7, and ER-9. This plan maximizes net monetary benefits and provides the greatest environmental benefit return for the dollar of all plans evaluated.

It is recommended that the next phase of this study effort be focused on optimization of the NED/NER plan, and development of a Locally Preferred Plan, should the local sponsor and residents of the watershed desire it.

8.1 Development of Watershed Management Plan

The next step in the process of developing a package of alternative plans for the San Juan Creek watershed is the integration of alternatives recommended in the last phase (Section 7) into a Watershed Management Plan. All the screened alternatives discussed in the last section were evaluated, combined, and evaluated again by means of a trade-off analysis to determine the best combination of features. Because of the complexity and multiple objectives of the group of alternatives, the Watershed Management Plan was developed to evaluate the plans and present a comprehensive package of alternative plans for implementation.

In formulating the final watershed management plan, the preliminary array of alternative plans were once again evaluated against the four additional screening criteria: (1) effectiveness, (2) efficiency, (3) acceptability, and (4) completeness. Additionally, so as to cover as many potential areas of impact or benefits as possible, alternatives were also evaluated for their potential effects to hazardous and/or toxic waste sites, vegetation, wildlife, endangered and/or threatened species, cultural resources, aesthetics, employment and labor, business and local government activity, water quality, air quality, noise pollution, public health and safety, public facilities, and recreation. Plans which met the greatest array of objectives while not significantly impacting any major criteria were further considered, while those that fail to meet any single critical objective required that they be reformulated or removed from further consideration.

Criteria for Final Screening of Watershed Alternative Plans

✓ EFFECTIVENESS
✓ EFFICIENCY
✓ ACCEPTABILITY
✓ COMPLETENESS

The alternative plans composing the final array do not generate the same types of benefits. Benefits for ecosystem restoration accrue to the wildlife and habitat restored. Benefits for flood inundation reduction accrue in the money saved (over the project's life) by reduction of flooding to structures and contents, and flood damages to infrastructure like bridges and channels. Benefits from campaigns like education, or other measures may be largely unquantifiable, and therefore only justifiable from an assessment of their contribution to a number of watershed properties, including long-term health, aesthetics, social aspects, quality of life, and so on. For these reasons, the final array had to be evaluated using a number of different tools. These are discussed, and the results of the assessment presented, in the following sections.

While application cost-benefit analysis or ecosystem benefit analysis is usable to decide between projects that generate those types of benefits, it is not applicable to those projects that generate unquantifiable benefits. For example, benefits of watershed education may be unquantifiable, either monetarily or environmentally. This is currently the case for most Best Management Practices (BMPs), water quality improvement projects, education programs, and monitoring plans. Although they generate some tangible benefit, the current state of science in regards to applying quantitative benefits is too debatable to apply to this study. This evaluation had to take the subjective approach of discussing potential impacts and evaluating their potential magnitude. This information is contained in the “trade-off” matrices that follow the text in this section.

As this phase of study progressed and more information was developed, and with added input from a variety of people, including individuals familiar with the watershed and watershed resources, County, City, water district, and agency staff, the study team, and residents of the watershed, an understanding of what measures might necessitate further combination developed. This input provided the means to establish other potential effects or impacts of the proposed alternatives. Some of this input is discussed here.

Public and agency input on the NED plan(s) for flood control indicated that a floodwall plan at the NED level of protection may be unacceptable to local interests and residents. This is partly due to the height of proposed floodwalls at certain locations, but also due to the perceived “balancing” of aesthetic impacts between upstream, midstream, and downstream reaches. In addition, the local sponsor does not want the potential impacts to recreation that may be caused by implementation of a floodwall plan. Finally, the local sponsor provided the opinion that they would like to evaluate potential optimization of the design-level of protection, perhaps for a 95% confidence 1% exceedance flood event, and that cost-sharing for an alternative plan which might garner greater public support might be based on that equation. This issue is highlighted in the trade-off analysis.

The potential impact of the floodwall alternative on recreation is an important one. The existing levee system is currently utilized as an extremely popular recreational resource. The implementation of a large floodwall scheme may preclude the continued existence of the biking and walking trail that currently occupies the top of this structure through its entire length. There would be significant opposition to an alternative that produces such an impact. This is also highlighted in the trade-off analysis.

The local sponsor would also like the opportunity to further examine the need for channel stabilization structures originally included in, but not recommended, as part of channel stabilization alternatives CS-1 and CS-2.

Finally, the local sponsor would like the opportunity to examine additional alternatives to ecosystem restoration alternative ER-1, as there appear to be constraints on the purchase of that site. Representatives from the U.S. Fish and Wildlife Services have indicated the potential for inclusion of other as yet undeveloped measures in place of ER-1 that would provide for connectivity between the Ocean and the first resting haven as one proceeds upstream. Discussions following presentation of the preliminary alternatives seemed to indicate the possibility of including large boulders in the channel as a means to provide an alternative resting site by creation of eddies in the flow regime. Unfortunately, the inclusion of measures such as this will require detailed hydraulic modeling of these features to ensure that they do not create zones of localized scour, and potentially provide the means to destabilize other reaches of channel or further undermine existing levee protection.

Because the local sponsor may have significant concerns over the potential implementation of the flood inundation reduction plan portion of the NED plan, it may be necessary to develop a Locally-Preferred Plan. The local sponsor and stakeholders are unprepared to provide a definitive assessment of their needs at this time. Due to the high profile of this plan and its included projects, it may require considerable effort and time before that plan is forthcoming. This provides all the more impetus to studying these issues in a follow-on phase.

Matrices illustrating the key components of the trade-off analysis for flood control and ecosystem restoration are provided on the following pages.

Table 39 Flood Control Trade-off Matrix

Issue Addressed Measure Involved	Benefits Exceed Costs?	Engr. Feasible?	Env. Feasible?	Flooding Effect	Water Quality	Air Quality	Noise Conditions	Hazardous, Toxic Wastes	Vegetation
No Action	NA	NA	NA	Damages >$10 mil annually	Continued Decline	No Effect	No Effect	No Effect	Declining Quality & Extent
FC-2	No	No	Yes	Not completely addressed	Temporary Decline (Constrct)	Temporary Decline (Constrct)	Temporary Increase (Constrct)	Unknown but not expected	Minimal
FC-3	No	No	Yes	Not completely addressed	Temporary Decline (Constrct)	Temporary Decline (Constrct)	Temporary Increase (Constrct)	Unknown but not expected	Moderate at basin site
FC-4	No	No	Yes	Not completely addressed	Temporary Decline (Constrct)	Temporary Decline (Constrct)	Temporary Increase (Constrct)	Unknown but not expected	Moderate at basin site
FC-5	No	No	Yes	Not completely addressed	Temporary Decline (Constrct)	Temporary Decline (Constrct)	Temporary Increase (Constrct)	Unknown but not expected	Moderate at basin sites
FC-6	No	Yes	Yes	Not completely addressed	Temporary Decline (Constrct)	Temporary Decline (Constrct)	Temporary Increase (Constrct)	Unknown but not expected	Moderate along channel
FC-7	Yes	Yes	Yes	Now minimal	Temporary Decline (Constrct)	Temporary Decline (Constrct)	Temporary Increase (Constrct)	Unknown but not expected	Minimal
FC-8	Yes	Yes	Yes	Now minimal	Temporary Decline (Constrct)	Temporary Decline (Constrct)	Temporary Increase (Constrct)	Unknown but not expected	Moderate at basin site
FC-9	Yes	Yes	Yes	Now Minimal	Temporary Decline (Constrct)	Temporary Decline (Constrct)	Temporary Increase (Constrct)	Unknown but not expected	Moderate at basin site
FC-10	Yes	Yes	Yes	Now minimal	Temporary Decline (Constrct)	Temporary Decline (Constrct)	Temporary Increase (Constrct)	Unknown but not expected	Moderate at basin sites
CS-1	Yes	Yes	Yes	Protects to 25-year	Temporary Decline (Constrct)	Temporary Decline (Constrct)	Temporary Increase (Constrct)	Unknown but not expected	Minimal
CS-1a	Yes	Yes	Yes	Protects to 25-Year	Temporary Decline (Constrct)	Temporary Decline (Constrct)	Temporary Increase (Constrct)	Unknown but not expected	Minimal
CS-2	Yes	Yes	Yes	Protects to 25-year	Temporary Decline (Constrct)	Temporary Decline (Constrct)	Temporary Increase (Constrct)	Unknown but not expected	Minimal
CS-2a	Yes	Yes	Yes	Protects to 25-year	Temporary Decline (Constrct)	Temporary Decline (Constrct)	Temporary Increase (Constrct)	Unknown but not expected	Minimal

Table 40 Flood Control Trade-off Matrix (continued)

Issue Addressed Measure Involved	Wildlife	Endangered Threatened Species	Cultural Resources	Aesthetics	Employment /Labor	Business, Govt. Activity	Public Health, Safety	Public Facilities	Recreation
No Action	Declining Quality & Diversity	Declining Habitat	No Effect	No Effect	No Effect	Continued Loss of Public $	Continued Threat to Safety	Continued Threat	Continued Damage to Recreation
FC-2	Blocks trans-channel migration	Unknown	Currently Unknown	Large impact to channel areas	Temporary Employment	Temporary Increase	Increase in Safety	Improvement	Currently Unknown
FC-3	May affect T&E species	May affect T&E species	May affect known sites	Lesser impacts expected	Temporary Employment	Temporary Increase	Improved Safety	Improvement	Currently Unknown
FC-4	May affect T&E species	May affect T&E species	May affect known sites	Lesser impacts expected	Temporary Employment	Temporary Increase	Improved Safety	Improvement	Currently Unknown
FC-5	May affect T&E species	May affect T&E species	May affect known sites	Lesser impacts expected	Temporary Employment	Temporary Increase	Improved Safety	Improvement	Currently Unknown
FC-6	May affect T&E species	May affect T&E species	May affect known sites	Lesser impacts expected	Temporary Employment	Temporary Increase	Improved Safety	Improvement	Currently Unknown
FC-7	Blocks trans-channel migration	Unknown	Not expected	Large impact to channel areas	Temporary Employment	Temporary Increase	Improved Safety	Improvement	Currently Unknown
FC-8	May affect T&E species	May affect T&E species	May affect known sites	Lesser impacts expected	Temporary Employment	Temporary Increase	Improved Safety	Improvement	Currently Unknown
FC-9	May affect T&E species	May affect T&E species	May affect known sites	Lesser impacts expected	Temporary Employment	Temporary Increase	Improved Safety	Improvement	Currently Unknown
FC-10	May affect T&E species	May affect T&E species	May affect known sites	Lesser impacts expected	Temporary Employment	Temporary Increase	Improved Safety	Improvement	Currently Unknown
CS-1	Minimal	Not expected to impact	Not expected to impact	Not expected to impact	Temporary Employment	Temporary Increase	Improved Safety	Improvement	Currently Unknown
CS-1a	Minimal	Not expected to impact	Not expected to impact	Not expected to impact	Temporary Employment	Temporary Increase	Improved Safety	Improvement	Currently Unknown
CS-2	Minimal	Not expected to impact	Not expected to impact	Not expected to impact	Temporary Employment	Temporary Increase	Improved Safety	Improvement	Currently Unknown
CS-2a	Minimal	Not expected to impact	Not expected to impact	Not expected to impact	Temporary Employment	Temporary Increase	Improved Safety	Improvement	Currently Unknown

Table 40 Ecosystem Restoration Trade-off Matrix

Issue Addressed Measure Involved	Benefits Exceed Costs?	Engr. Feasible?	Env. Feasible?	Flooding Effect	Water Quality	Air Quality	Noise Conditions	Hazardous, Toxic Wastes	Vegetation
No Action	NA	NA	NA	Minimal Impact	General Decline in Quality	No Effect	No Effect	Unknown	Declining Quality & Extent
ER-1	No	Yes	Yes	Minimal Impact	May Reduce NO3&PO4	Temporary Decline (Construc)	Temporary Decline (Construc)	Unknown	Improved Extent & Diversity
ER-2	Yes	Yes	Yes	Minimal Impact	May Reduce NO3&PO4	Temporary Decline (Construc)	Temporary Decline (Construc)	Unknown	Improved Extent & Diversity
ER-3	Yes	Yes	Yes	Minimal Impact	May Reduce NO3&PO4	Temporary Decline (Construc)	Temporary Decline (Construc)	Unknown	Improved Extent & Diversity
ER-4	Yes	Yes	Yes	Minimal Impact	May Reduce NO3&PO4	Temporary Decline (Construc)	Temporary Decline (Construc)	Unknown	Improved Extent & Diversity
ER-5	Yes	Yes	Yes	Minimal Impact	Improve Temp, DO, Turbidity	Temporary Decline (Construc)	Temporary Decline (Construc)	Unknown	Improved Extent & Diversity
ER-6	Yes	Yes	Yes	Minimal Impact	Improve Temp, DO, Turbidity	Temporary Decline (Construc)	Temporary Decline (Construc)	Unknown	Improved Extent & Diversity
ER-7	Yes	Yes	Yes	Minimal Impact	Improve Temp, DO, Turbidity	Temporary Decline (Construc)	Temporary Decline (Construc)	Unknown	Improved Extent & Diversity
ER-8	No	Yes	Yes	Minimal Impact	Improve Temp, DO, Turbidity	Temporary Decline (Construc)	Temporary Decline (Construc)	Unknown	Improved Extent & Diversity
ER-9	No	Yes	Yes	Minimal Impact	Improve Temp, DO, Turbidity	Temporary Decline (Construc)	Temporary Decline (Construc)	Unknown	Improved Extent & Diversity
ER-10	No	Yes	Yes	Minimal Impact	Improve Temp, DO, Turbidity	Temporary Decline (Construc)	Temporary Decline (Construc)	Unknown	Improved Extent & Diversity
ER-11	No	Yes	Yes	Minimal Impact	Unknown	Temporary Decline (Construc)	Temporary Decline (Construc)	Unknown	Improved Extent & Diversity

Table 41 Ecosystem Restoration Trade-off Matrix (continued)

Issue Addressed Measure Involved	Wildlife	Endangered Threatened Species	Cultural Resources	Aesthetics	Employment/ Labor	Business, Govt. Activity	Public Health-Safety	Public Facilities	Recreation
No Action	Declining Quality & Diversity	Declining Habitat	No Effect	No Effect	No Effect	No Effect	No Effect	May Increase	No Effect
ER-1	Improved Extent & Diversity	Improved Extent & Diversity	Currently Unknown	Increase in Quality	Temporary Increase (Construc)	Temporary Increase (Construc)	No Effect	No Effect	No Effect
ER-2	Improved Extent & Diversity	Improved Extent & Diversity	Currently Unknown	Increase in Quality	Temporary Increase (Construc)	Temporary Increase (Construc)	No Effect	No Effect	No Effect
ER-3	Improved Extent & Diversity	Improved Extent & Diversity	Currently Unknown	Increase in Quality	Temporary Increase (Construc)	Temporary Increase (Construc)	No Effect	No Effect	No Effect
ER-4	Improved Extent & Diversity	Improved Extent & Diversity	Currently Unknown	Increase in Quality	Temporary Increase (Construc)	Temporary Increase (Construc)	No Effect	No Effect	No Effect
ER-5	Improved Extent & Diversity	Improved Extent & Diversity	Currently Unknown	Increase in Quality	Temporary Increase (Construc)	Temporary Increase (Construc)	No Effect	No Effect	No Effect
ER-6	Improved Extent & Diversity	Improved Extent & Diversity	Currently Unknown	Increase in Quality	Temporary Increase (Construc)	Temporary Increase (Construc)	No Effect	No Effect	No Effect
ER-7	Improved Extent & Diversity	Improved Extent & Diversity	Currently Unknown	Increase in Quality	Temporary Increase (Construc)	Temporary Increase (Construc)	No Effect	No Effect	No Effect
ER-8	Improved Extent & Diversity	Improved Extent & Diversity	Currently Unknown	Increase in Quality	Temporary Increase (Construc)	Temporary Increase (Construc)	No Effect	No Effect	No Effect
ER-9	Improved Extent & Diversity	Improved Extent & Diversity	Currently Unknown	Increase in Quality	Temporary Increase (Construc)	Temporary Increase (Construc)	No Effect	No Effect	No Effect
ER-10	Improved Extent & Diversity	Improved Extent & Diversity	Currently Unknown	Increase in Quality	Temporary Increase (Construc)	Temporary Increase	Unknown	No Effect	No Effect
ER-11	Improved Extent & Diversity	Improved Extent & Diversity	Currently Unknown	Increase in Quality	Temporary Increase (Construc)	Temporary Increase	Unknown	No Effect	No Effect

Table 41 Other Measures Trade-off Matrix

Issue Addressed Measure Involved	Benefits Exceed Costs?	Engr. Feasible?	Env. Feasible?	Flooding Effect	Water Quality	Air Quality	Noise Conditions	Hazardous, Toxic Wastes	Vegetation
No Action	NA	NA	NA	Minimal Impact	General Decline in Quality	No Effect	No Effect	Unknown	Declining Quality & Extent
Watershed Education	Yes	Yes	Yes	Minimal Impact	Expected Watershed Improvement	Possible Effect	No expected effect	Unknown	Improved Extent & Diversity
Non-Point Source Public Awareness Plan	Yes	Yes	Yes	Minimal Impact	Expected Watershed Improvement	No expected effect	No expected effect	Unknown	Improved Extent & Diversity
Water Quality Wetlands	Unknown	Yes	Yes	Minimal Impact	Expected downstream benefit	No expected effect	No expected effect	Unknown	Improved Extent & Diversity
On-site Biofiltration	Unknown	Yes	Yes	Minimal Impact	Expected downstream benefit	No expected effect	No expected effect	Unknown	Improved Extent & Diversity
Landscape Controls	Yes	Yes	Yes	Minimal Impact	Expected downstream benefit	No expected effect	No expected effect	Unknown	Improved Extent & Diversity
Enforce Ordinances	Yes	Yes	Yes	Minimal Impact	Expected Improvement	No expected effect	No expected effect	Unknown	Improved Extent & Diversity
Retrofitting Drainage	Unknown	Yes	Yes	Minimal Impact	Expected downstream benefit	Possible effect	No expected effect	Unknown	Improved Extent & Diversity
BMP Monitoring, Evaluation	Unknown	Yes	Yes	Minimal Impact	Expected Improvement	Possible effect	No expected effect	Unknown	Improved Extent & Diversity
Exotic Species Eradication	Unknown	Yes	Yes	Minimal Impact	Unknown	Temporary during removal	No expected effect	Unknown	Improved Extent & Diversity

Table 43 Other Measures Trade-off Matrix (continued)

Issue Addressed Measure Involved	Wildlife	Endangered Threatened Species	Cultural Resources	Aesthetics	Employment/ Labor	Business/Govt. Activity	Public Health-Safety	Public Facilities	Recreation
No Action	Declining Quality & Diversity	Declining Habitat	No Effect	No Effect	No Effect	No Effect	No Effect	May Increase	No Effect
Watershed Education	Improved Extent & Diversity	Improved Extent & Diversity	Currently Unknown	Increase in Quality	No expected effect	No expected effect	No Effect	No Effect	No Effect
Non-Point Source Public Awareness Plan	Improved Extent & Diversity	Improved Extent & Diversity	Currently Unknown	Increase in Quality	No expected effect	No expected effect	No Effect	No Effect	No Effect
Water Quality Wetlands	Improved Extent & Diversity	Improved Extent & Diversity	Currently Unknown	Increase in Quality	No expected effect	No expected effect	No Effect	No Effect	No Effect
On-site Biofiltration	Improved Extent & Diversity	Improved Extent & Diversity	Currently Unknown	Increase in Quality	No expected effect	No expected effect	No Effect	No Effect	No Effect
Landscape Controls	Improved Extent & Diversity	Improved Extent & Diversity	Currently Unknown	Increase in Quality	No expected effect	No expected effect	No Effect	No Effect	No Effect
Enforce Ordinances	Improved Extent & Diversity	Improved Extent & Diversity	Currently Unknown	Increase in Quality	No expected effect	No expected effect	No Effect	No Effect	No Effect
Retrofitting Drainage	Improved Extent & Diversity	Improved Extent & Diversity	Currently Unknown	Increase in Quality	No expected effect	No expected effect	No Effect	No Effect	No Effect
BMP Monitoring, Evaluation	Improved Extent & Diversity	Improved Extent & Diversity	Currently Unknown	Increase in Quality	No expected effect	No expected effect	No Effect	No Effect	No Effect
Exotic Species Eradication	Improved Extent & Diversity	Improved Extent & Diversity	Currently Unknown	Increase in Quality	Unknown	Unknown	No Effect	No Effect	No Effect

8.2 Description of the Watershed Management Plan

The result of the iterative plan formulation process was the development of a recommended plan for watershed management in the San Juan Creek watershed. The plan considered the effects of a broad array of measures and alternatives that provide solutions to the many problems impacting the watershed. The selection process takes into account cost-effectiveness, ecosystem benefits, and impacts and benefits to a broad array of other resources and entities.

The watershed management plan integrates elements for the reduction of flood damages, restoration of degraded ecosystems, an initial plan for water quality improvement, and other measures to enhance watershed health. This section provides a summary of the alternatives recommended for implementation under the watershed management plan for the San Juan Creek watershed.

8.2.1 Flood Damage Reduction

The study effort has identified a potential Federal interest in flood damage reduction. This study identified the potential NED plan for flood damage reduction, as defined by its maximization of potential net benefits. The NED plan consists of a floodwall extension to existing levees on San Juan and Trabuco Creeks (FC-7), with a limited channel stabilization element on both to ensure long-term integrity in the face of the existing channel degradation problem. However, despite the identification of this NED plan, this plan may never be pursued.

It is recommended that further study be undertaken on the flood control/channel stabilization plan for the watershed. This study should take the form of a "spin-off" feasibility study that will serve as the decision document to be forwarded to Congress as the vehicle to obtain funding. If the local sponsor finds the floodwall portion of the NED plan for flood damage reduction unacceptable due to its impacts on aesthetic quality (due to excessive height and intrusive qualities), impacts to recreation, and other aspects, they may wish to focus additional study on the development of a Locally Preferred Plan (LPP). An optimization of the floodwall/channel stabilization plan should be carried out, for the purposes of establishing the cost-sharing that might be applied to a locally-preferred plan. That LPP has not yet been agreed upon, but will likely include detention components as an offset for the increased floodwall height of the NED plan. The local sponsor is highly supportive of the efforts so far, and is supportive of the NED channel stabilization plan element.

8.2.2 Ecosystem Restoration

The study has identified a package of eight ecosystem restoration measures (ER-1 through 7 and ER-9) as having high potential benefits. One of these (ER-1) may be unsupported by the local sponsor, but its primary purpose may be achieved by other means. The package of measures were combined as a comprehensive alternative for ecosystem restoration and should be optimized during a "spin-off" study to combine flood damage reduction, ecosystem restoration, and incidental recreation.

8.2.3 Water Quality Improvement

The study evaluated a number of water quality improvement measures. While evaluation of these does not lend itself to justification by economic or environmental benefit quantification, the subjective approach taken resulted in the judgment that a package of measures consisting of watershed education, non-point source awareness campaigns, water quality improvement wetlands, landscape controls, and biofiltration will yield the greatest benefit for the costs.

Table 42 Priority Ranking of Measures for Water Quality Improvement Benefit

Watershed Measure	Ranking
Watershed Education	1
Non-point Source Public Awareness Plan	2
Water Quality Wetlands Construction	3
On-Site Biofiltration/Infiltration Treatment	4
Landscape Controls to Reduce Water, Fertilizer, Pesticide Application	5
Enforcement of Ordinances Related to Pet Wastes	6
Ecosystem/Habitat Restoration	7-10
Retrofitting of Existing Drainage BMP	11
BMP Monitoring and Evaluation	12

8.3 Watershed Management Plan Elements – Summary of Benefits and Costs

This section provides summaries of each of the watershed management plan elements for the San Juan Watershed Study. Each summary, as shown in Table 43, provides a general description of the elements, a summary of benefits and costs, a list of potential agencies for implementation, and a qualitative assessment of implementation priority. The implementation priority is based upon professional judgment of the study team on the immediacy of need, dependence of each element on the implementation of other elements, and estimates of costs and benefits.

<table>
<tr><th colspan="4">Table 43 Benefits, Costs, Implementation, and Priority</th></tr>
<tr><td>Element 1:</td><td colspan="3">San Juan Creek Flood Damage Reduction (Alternatives FC-7 or LPP, and CS1a and CS-2a)</td></tr>
<tr><td>Description:</td><td colspan="3">Located on the Reaches of San Juan Creek between Interstate 5 and the Pacific Ocean, and Trabuco Creek between Del Obispo and its confluence with San Juan Creek.

Includes:
• Floodwalls (NED) or combination of floodwalls and detention (LPP) to reduce inundation damage;
• Grade stabilization of invert over same area to prevent failure of levees and restore grade for ecosystem integrity; and
• Replacement of 3 bridges to increase capacity.</td></tr>
<tr><td>Summary of Benefits and Costs:</td><td colspan="3">Potential annual net benefits of $925,020 for CS-1a, $450,580 for CS-2a, and $626,770 for FC-2.

Annualized cost of $189,750 for CS-1a, $240,500 for CS-2a, and $943,200 for FC-2.

Additional environmental benefits not quantifiable in the benefit calculations include restoration of habitat connectivity (through fish passage incorporation) and temperature reductions associated with increased aeration of flow.</td></tr>
<tr><td>Potential Agencies for Implementation:</td><td colspan="3">U.S. Army Corps of Engineers Los Angeles District (General Investigation), State, and Local Agencies</td></tr>
<tr><td rowspan="2">Priority Ranking:</td><td>Immediate</td><td>Short-Term</td><td>Long-Term</td></tr>
<tr><td></td><td>✓</td><td></td></tr>
</table>

<table>
<tr><td>Element 2:</td><td colspan="3">San Juan Creek Ecosystem Restoration</td></tr>
<tr><td>Description:</td><td colspan="3">Ecosystem restoration: Excavation of additional area for riparian habitat restoration, restoration of native species, revegetation efforts, creation of backwater and wetlands areas; restoration of upland buffer zone to ensure minimization of outside impacts. Alternative would restore at number of sites spread along riparian corridor to enhance connectivity and fish passage.</td></tr>
<tr><td>Summary of Benefits and Costs:</td><td colspan="3">Potential costs of $151,445 to $281,483 per unit of habitat increased over existing condition. Potential benefit realized by improvement of 31% to 336% improvement over existing conditions. NER plan will provide important connectivity from headwaters to ocean, will provide resting havens, and important riparian, wetland, and upland habitat improvements.</td></tr>
<tr><td>Potential Agencies for Implementation:</td><td colspan="3">U.S. Army Corps of Engineers, State and local agencies.</td></tr>
<tr><td rowspan="2">Priority Ranking:</td><td>Immediate</td><td>Short-Term</td><td>Long-Term</td></tr>
<tr><td></td><td>✓</td><td></td></tr>
</table>

Element 3:	**Water Quality Improvement Measures**		
Description:	Watershed-wide education, awareness campaigns, constructed wetlands, landscape control, and biofiltration.		
Summary of Benefits and Costs:	Costs for this component are undetermined and would vary based upon the intensity of the program to be developed.		
Potential Agencies for Implementation:	State and Local Agencies		
Priority Ranking:	Immediate	Short-Term	Long-Term
		✓	

Section Nine

IMPLEMENTATION AND MONITORING

This section outlines how the recommended plan should be implemented, and how watershed problems should be monitored, both for existing issues, and after construction of alternative plans.

9.1 Implementation

Elements of the recommended Watershed Management Plan (WMP) must be implemented in a logical order. There are some alternative plans that rely on the existence of others to function. There are also issues that need to dealt with, evaluated, and decisions made regarding the pursuit of others prior to implementation.

9.1.1 The First Year

First and foremost, the County, as local sponsor for the plan, must continue to seek Congressional support to pursue the "spin-off" studies needed to get Federal funding for construction of the San Juan Creek Flood Damage Reduction and Ecosystem Restoration project. Once this support is obtained, and funding allocated, the additional studies may take place that will allow optimization of the plan and completion of the report to Congress that will allow construction of the largest and most important element of the plan to reduced flood damage and initiate ecosystem restoration.

Second, application of Best Management Practices, where these are not being uniformly applied, should be pursued. Recommendation at the local level of the BMP portion of the WMP should occur following the completion, and approval, of this report.

Third, pursuit of water quality testing, monitoring, and most importantly, intelligent interpretation of results, must continue. The County has a long-term plan for addressing the water quality issue. The problem is that the science of tracking and solving water quality problems is an extremely expensive proposition. One must remember that water quality problems have always been with us, and that solutions will take time, reevaluation, and more money than may be available at any one time.

Fourth, a campaign for exotic species eradication should be undertaken. Measures must begin in the upstream-most areas of the watershed to prevent reinfestation of cleared reaches. This campaign need not address areas that may be involved in construction of structural measures downstream, unless later determine that construction activities will not occur. The campaign must be largely complete for areas upstream of construction reaches prior to initiation of construction. Funding for implementation of exotic species eradication may be obtained through mitigation for on-going projects, mitigation for unpermitted regulatory actions, or other means. For good sources of information on additional funding sources see Section 7.0 of the Exotic Species Removal Plan (Potential Funding Sources) and the EPA website on watershed funding sources.

Fifth, a Watershed Education Plan would be a valuable, and long-term asset to the communities in the watershed. Funding for this program may be sought at the State level, but also through contributions from schools of higher learning, philanthropic organizations, and others. Although this is a long-term measure, there is no better time than the present to get the ball rolling.

Lastly, the continued participation of the County, cities, water districts, and others in a long-term stewardship program is encouraged. After the study is completed, it is imperative that concerned parties continue to monitor progress, ensure that efforts are achieving their objectives, and that new problems are dealt with in a timely, non-confrontational manner.

9.1.2 The Next Few Years

First, completion of the “spin-off” study needed for Congressional authorization of the San Juan Creek Flood Damage Reduction and Ecosystem Restoration project. This project functions as the keystone for several upstream plans, but is also the most critical element of the damage reduction, stabilization and restoration effort in this watershed. Completion of this study should be targeted for fiscal year 2004.

Second, water quality wetlands and treatment projects: It is anticipated that in the next few years, testing will indicate numerous “hot spots” of bacterial exceedances in the watershed. Implementation of the water quality monitoring program will point out areas of greatest need, particularly after the results of recent water quality improvement projects begin to accumulate. It is likely that testing may change priorities, and that existing priority sites may give way to higher priority sites, depending on results. Given that application of demands by water quality oversight agencies will likely require cities and the County to direct more effort at sites not yet determined to be problem areas, this campaign may operate independently of any other efforts, and are not dependent on any alternative plans discussed here. Regardless, plans for water quality improvement should be pursued.

Third, erosion sites on San Juan Creek and tributaries must be monitored, and if warranted, funds directed toward treatment. Alternately, a request may be issued from the city in which the problem resides to the Corps of Engineers for consideration as an emergency streambank erosion control project (Section 14), for which a letter to the Corps will be required. The Corps will then study the site and determine if Federal participation is warranted. These sites are not currently critical, although at least one site not discussed here may warrant immediate attention.

9.1.3 For the Long Term

First, long-term monitoring of performance for projects, BMPs, and other measures must occur. The process through which this might occur would be under the auspices of the stewardship program administered by the County. This is discussed below.

Second, continued pursuit of the funding needed for construction of the San Juan Creek Flood Damage Reduction and Ecosystem Restoration project must occur. This will take the continued efforts of elected officials, particularly at the County and Congressional level, to ensure that this happens.

9.2 Monitoring

9.2.1 The First Year

The initial recommendation for monitoring is the establishment of a County-lead stewardship program. This program can act as the clearinghouse for data, a discussion forum, and decision-making body for future efforts. It is recommended that each year, a one-day "state of the watershed meeting" be held. At this meeting the participants go over general data and observations from the past year or two and assess what direction they are going in. It should be considered an annual or biannual physical for the watershed. Types of data they may monitor could include:

a. Water Quality;
b. Exotic Species – It would be very simple to have someone document the extent of infestation of arundo and salt cedar and report on the success of removal efforts;
c. 404 permits – Regulatory could easily provide a summary of 404 permits and mitigation projects in the watershed;
d. Channel degradation trends – Establish key spots and do annual cross sections to monitor aggradation/degradation trends;
e. Summary of wildlife surveys conducted each year – This would not entail funding any new species surveys, but would just be a compilation of new data (from whatever source) to make use of the available data;
f. Summary of completed and proposed projects in the watershed and potential funding sources for future work. Including restoration, enhancement, parks, infrastructure, etc.;
g. Summary of annual flooding and/or erosion damages if any;
h. Opportunities for watershed clean-up days and/or environmental education events.

First, the County, as local sponsor for the plan, will be asked to continue water quality monitoring. A sound basis for this monitoring will be established, and testing conducted. Analysis of the data will indicate areas of greatest need. Future efforts may be prioritized and directed on the basis of what the monitoring indicates.

Second, no less important than this monitoring will be monitoring of existing problem locations for issues other than water quality. This will include the channel system on San Juan, Trabuco, Oso, and other creek systems. Degradation of the system must be evaluated, at least every year.

Third, evaluation of BMP performance will also be needed. Misdirection of funding will impact problem treatment in other locations. BMPs that fail to achieve the desired objective must be eliminated in favor of other measures. This must be done on an iterative basis. Monitoring should occur on a yearly, or better, bi-annual basis.

Fourth, monitoring of exotic species removal and eradication efforts must be conducted. Monitoring by university students as part of their curricula may be possible. Monitoring should occur on a yearly, or better, bi-annual basis.

Fifth, monitoring of watershed education should occur. Schools that teach material that lends itself to earth science laboratory participation might consider a long-term monitoring aspect to the curriculum. Monitoring should occur on a yearly, or better, bi-annual basis.

9.2.2 For the Long Term

Monitoring of project performance should continue. This may involve site visits and potentially survey of the project sites, any new erosion control or bridge protection projects, and other water resource-related projects.

Monitoring of water quality wetlands, erosion sites, and ecosystem restoration sites must continue in the long-term. It is important to identify areas of need before large problems develop. Monitoring of the situation on San Juan Creek in its downstream reaches is important, as continued scour of the channel, or vegetation die-off, may impact overall goals for the alternative.

Long-term monitoring of performance for BMPs must occur. The process through which this might occur would be under the auspices of the stewardship program administered by the County.

Section Ten

PUBLIC AND AGENCY COORDINATION

This study effort included extensive public and agency coordination. The study effort involved the creation of a study team of technical and planning staff that met regularly (on a monthly or bi-monthly basis), and of a stakeholders' group which met on a monthly or bi-monthly basis, generally within the watershed. The stakeholders' group consisted of anyone that wished to attend, but regularly hosted members of the Surfrider Foundation, the Clean Water Now! Coalition, U.S. Fish and Wildlife Services, California Department of Fish and Game, the co-sponsors, water districts, and City and County staff, concerned residents, the League of Women Voters, Orange County Department of Public Health, State Parks, Orange County Public Facilities and Resources Department, Orange County Planning, Supervisor Tom Wilson of the 5^{th} District, the San Diego Regional Water Quality Control Board, the Corps of Engineers, and others.

Agency coordination and public input was very important in the plan formulation of measures, alternative plans, and plan selection. A tremendous volume of opinion, data, insight, and oversight was provided by the above groups and individuals.

Aside from the regular stakeholders meetings, several public information meetings were held, primarily at the beginning of the study effort. These meetings solicited input, allowed venting of frustrations, explained the study process, and in later phases, disseminated findings of the numerous studies conducted.

The public and agency interaction was a critical element of the process, and greatly contributed to a positive conclusion.

It is anticipated that a public review of this document may be forthcoming. Those results may be incorporated in the final document.

Section Eleven

CONCLUSIONS

The San Juan Creek Watershed study process has been a difficult and sometime contentious process. The beginnings of this study extend back almost a decade. It has only been through the involvement of a dedicated and committed group of individuals that this process resulted in such a detailed and well-analyzed package of recommendations.

The watershed study process has been highly iterative. Numerous times, the study team, local sponsor, and stakeholders have had to revise, reformulate, and reanalyze measures in an attempt to meet multiple objectives and satisfy numerous parties.

The watershed study reveals the need for projects addressing flood damage reduction, channel stability, ecosystem restoration, water quality, education, and stewardship issues. The recommendations attempt to balance these sometime competing needs with an approach that minimizes potential overlap, and instead allows alternative plans to compliment one another.

Details on alternatives recommended for implementation are contained in Sections 7 through 10, on plan formulation, the watershed management plan, implementation, and monitoring.

Section Twelve

RECOMMENDATIONS

Based on the information generated during the course of this study, particularly those unpaid individuals that took it on themselves to pursue these problems on their own time, the conclusion can be made that the San Juan Creek watershed is not in a proper state of balance. In fact, the study identified that several issues are such that if not addressed, will lead to increasingly greater losses to residents, environmental resources and economic activities. Most of the problems documented cannot be attributed to any one single entity, but rather are a result of the collective impacts of those of us who live, work or play in the watershed.

Because of the inter-connected nature of all of the resources, and problems, no one plan will solve all issues. Nor will a solution happen in the near term. Addressing the problems of the watershed will be a long-term and costly enterprise. This cooperative study recommends an array of structural and non-structural alternative plans, that when implemented together over time can help restore an environmentally sustainable, healthy, and economically viable watershed community. The burden of solving the problems in the watershed will be likely spread across numerous entities, requiring on-going cooperation and financial support.

Based on the qualitative and quantitative findings of the feasibility study, it is recommended that the components of the watershed management plan be implemented (also discussed in Section 11, Implementation).

Recommendations for the San Juan Creek Watershed are as follows:

The San Juan Creek watershed study effort identified numerous opportunities for improvement. These opportunities were developed into potential solutions. Comparison of many potential solutions resulted in the elimination of many from further consideration. This was done based on economic, environmental, engineering, societal, cultural, infrastructure, public acceptability, and other criteria. A "trade-off" analysis was used, and is presented herein, to narrow down a field of potential solutions to the most cost-effective, least environmentally impacting, locally acceptable, and soundest engineering solutions possible. Recommendations presented include those that address the flooding problem, channel instability, environmental degradation, water quality, and incidental water supply and recreation. Recommendations are presented to encourage residents to modify behaviors that impact watershed health, to further study means to reestablish fish passage on the mainstem of San Juan Creek to its headwaters areas, and to restore degraded riparian habitats at numerous locations throughout the watershed. The goal of these recommendations is to establish a framework through which negative trends may be reversed, by which needed projects may be implemented, and by which means wise stewardship of the resource might be encouraged.

Study of flood damage reduction measures indicates that no simple solution to flood damage caused by overtopping of the existing levee system can be identified at this time. The long-term survivability of the existing levee system under conditions of increased floodflow depth or duration without channel stabilization measures in place makes an engineering solution to overtopping uncertain. Measures addressing overtopping alone have also been demonstrated to be economically infeasible unless combined with other measures to ensure channel stability. This is because many potential damage categories would not be addressed by the addition of floodwalls, detention basins, or channel widening alone. The watershed study identifies several measures that provide an economically and environmentally feasible solution to the problem of channel downcutting and instability. Several upstream reaches of Trabuco Creek, and the adjoining downstream portion of Oso Creek, however, would require a large number of structures to reverse the degradational trend, and these solutions remain economically infeasible. While not economically supportable for Federal cost-sharing, stabilization of these reaches of Trabuco and Oso Creeks are still recommended for pursuit by local or regional interests. This study effort does recommend a multi-purpose flood damage reduction/ecosystem restoration (including channel stabilization) alternative (FC-7) concentrating on the reaches of San Juan (SJ-5 and SJ-6) and Trabuco Creeks (TR-7) that contain the highest potential in flood damage and ecosystem restoration alternatives (ER-2 through ER-7 and ER-9) that possess the highest potential for improvement of degraded environmental resources. This alternative is identified as the National Economic Development/National Environmental Restoration (NED/NER) Plan, and is economically justified, minimally impacting environmentally, and sound from an engineering standpoint. The ecosystem restoration alternative may be implemented either individually by measure or as a group, is highly productive environmentally, is integrated with the flood damage reduction/channel stabilization alternative recommended, and each measure of which is cost effective based on its potential benefits.

Based on the studies conducted during this effort, the preliminary National Economic Development (NED) plan is Alternative FC-7, a multi-purpose flood damage reduction/channel stabilization plan. This alternative consists of a combination of floodwalls on top of the existing levee system and grade stabilization of the downstream portions of San Juan and Trabuco

Creeks. This project has a preliminary benefit to cost ratio of 8.3 to 1. The annualized cost of this alternative (including interest during construction) is approximately $1,373,000. The flood inundation and other damage reduction benefits to be realized by this project are approximately $11,446,000. Net benefits realized are approximately $10,073,000 annually. The National Ecosystem Restoration (NER) plan is identified of Alternatives ER-2 through 7 and ER-9. This package of measures consists of purchase of riparian-related properties, excavation and recontouring, native vegetation re-establishment, and restoration of riparian, wetland, and upland habitats along San Juan Creek. The costs of this restoration range from $151,000 to $281,000 per habitat unit. The identified NED/NER plan consists of both of these elements, as they were developed in concert, and are complimentary to one another. The total cost of the NED/NER plan is $43,522,755, and would be cost-shared on a 65% Federal/35% Non-Federal basis, based on current guidance for Federal flood damage reduction/ecosystem restoration projects funded by Congress through the Corps of Engineers. The potential Non-Federal share is anticipated to be approximately $15,233,000. While a combined NED/NER plan has been identified, it is recognized that the local sponsor and residents of the watershed may not support the floodwall plan as designed. The issues may be both as to aesthetics as well as impacts to existing recreation. No Locally Preferred Plan (LPP) has been identified to date. Therefore, the "spin-off" phase will serve to both optimize the NED/NER plan, as well as fully develop the Locally Preferred Plan, if different. Because of the inseparability of the solutions for flood inundation reduction and channel stabilization, and the necessity of including the ecosystem restoration alternatives in the planning and design process for proper integration, the follow-on phase consisting of a "spin-off" study, should be authorized for the joint purposes of addressing flood damage reduction, channel stability, ecosystem restoration, and incidental recreation.

Recommendations for the San Juan Creek Watershed are as follows:

(1) Continue the County's productive relationship with Congress to seek out and obtain funding for the "spin-off" phase of the Corps of Engineers feasibility study effort, focusing on optimization and finalization of flood damage reduction/channel stabilization alternative FC-7, ecosystem restoration alternatives ER-2 through 7 and ER-9, and recreation for the San Juan Creek watershed. The remaining study effort is recommended for optimization of the alternative for flood damage reduction/channel stabilization, to determine the best method and spacing of channel grade stabilization, to further examine means to reduce the costs of the ecosystem restoration package, most notably by reducing real estate costs, and to examine in the context of the above alternatives what best means can be provided for recreation along the project reach. Once these issues are resolved,

the cost allocation and apportionment can be applied to both NED/NER and Locally-Preferred plans, and a recommendation can be made to Congress. It is also recommended that a point-of-contact be appointed for this effort, with the goal of pursuing funding through construction through that office.

(2) Implement Best Management Practices and other water quality treatment alternatives at the local and regional level. There remains a great deal of uncertainty regarding the sources and locations of bacterial contamination in the watershed and ocean nearshore zone. It is strongly recommended that remaining study on water quality issues first focus on identifying both sources and locations of bacterial contamination before any large-scale projects be considered. It is very important to recognize that funding directed at treatment wetlands or other structural measures may yield a poor result if it not first understood exactly where, and from what the bacteria is produced. Key amongst these issues is that of identifying human and non-human sources, as management of animal sources may be difficult, if not impossible. Focus initial follow-on efforts on the implementation of on-site biofiltration/infiltration treatment, landscape controls aimed at reduction of water, pesticide and fertilizer application, and enforcement of ordinances aimed at pet waste control. Seek out and obtain grants to aid in these costly efforts from the Environmental Protection Agency, the State of California, and from other granting bodies. Further, the study team also recommends that the long-term effort must include evaluation of the effectiveness of existing BMPs, and adjustment as needed. Once site-specific information can be developed which indicates particular "hot spots", treatment wetlands or directive water quality improvement "plants" may be implemented.

(3) Strengthen the existing Water Quality Monitoring Program, building on existing testing activities by the County and others. Expand the testing program to include testing sites based on results of prior testing. For example, the systematic upstream extension of test sites based on downstream results should occur by first testing on immediate upstream tributaries or drainage systems, not by random coverage. To do this will require both time and funding on a long-term basis. A "shotgun" approach will not make best use of the limited resources currently available. It is important to conduct regular testing, to thoroughly evaluate results, to determine appropriate actions based on that evaluation, and adjust the approach as needed.

(4) Utilizing Exotic Species Eradication guidelines, establish a program for elimination of exotic species in watershed. Critical in this program is the need to conduct initial

eradication efforts in an upstream-to-downstream approach. It is recommended that a "pool" of funding be established, involving Corps of Engineers Regulatory Branch, State of California Department of Fish and Game, and other resource agencies, to address this program in a systematic manner. Random eradication efforts have shown themselves to be ineffective, as upstream stands of exotics may re-infest areas cleared in prior efforts. Obtain funding through regulatory programs and other mitigation efforts, establish a schedule of activities that is broadly distributed by both hard and electronic media, and establish a plan of action for tributaries, then mainstem, including a long-term monitoring plan.

(5) Develop a Watershed Education Program. Establish objectives, goals, curricula, schools involved, teaching requirements, funding sources, and a teaching plan. Develop and distribute the non-point source public awareness plan.

(6) Establish a "watershed keeper" (steward) committee funded jointly by the County and cities that will coordinate, integrate and leverage programs and projects by cities, county, schools, universities, utility districts, public and private entities. This will guide implementation of the local action items (BMPs, conduct water quality monitoring, identify grants and corporate sponsors for special projects, organize volunteer efforts, etc.), and provide the means by which planning and implementation will occur once this initial study effort is complete.

(7) Under the Corps of Engineers' Section 14 Emergency Streambank Erosion Control study authority, investigate and prioritize treatment of erosion sites that would not be covered by implementation of the larger flood control and channel stabilization project.

(8) Fully implement a watershed-wide monitoring program as part of the watershed stewardship program. Monitor continuing problem areas; monitor project performance, monitor efficacy of established programs for Water Quality, Exotic Species, 404 permits, Channel degradation trends, wildlife surveys conducted each year, completed and proposed projects in the watershed, and annual flooding and/or erosion damages. An annual or biannual "State of the Watershed" report could be issued, possibly on an Internet website, and by attachment to utility bills or other existing dissemination programs.

(9) Finally, create and distribute a “Refrigerator List” of ten things that can be done by individuals to improve watershed health. These ten things can include phone numbers, points of contact, and recommendations regarding fertilizer and pesticide application, pet waste clean-up, recycling, wise water use, and other actions that can be done by everyone in the watershed. The tone of the list should be friendly and informative, with features designed to catch the interest of individuals so that it does not become an additional piece of trash but is displayed prominently in the home. It is the hope of the study team that more residents and visitors to the watershed might be encouraged to become involved. The first step is to catch their interest and convince them that they can contribute to the solutions.