SOUTHERN CALIFORNIA STEELHEAD PASSAGE ASSESSMENT LOWER SANTA MARGARITA RIVER, CALIFORNIA AND CUP SURFACE WATER AVAILABILITY ANALYSIS (TM 1.1)

Photo: Santa Margarita River looking southwest toward Ranch House and Airfield, Camp Pendleton, CA.

April 27, 2012

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W A T E R   R E S O U R C E   P R O F E S S I O N A L S
Northern California • Southern California • New Mexico • Arizona • Nevada • Colorado

Southern California Steelhead Passage Assessment, Lower Santa Margarita River, California and CUP Surface Water Availability Analysis (TM 1.1)

April 27, 2012

Prepared for:

United States Bureau of Reclamation
Fallbrook Public Utilities District
United States Marine Corps Base Camp Pendleton

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ACRONYM AND ABBREVIATION LIST

ACOE ..... Army Corps of Engineers
AF ..... Acre-feet
AFY ..... Acre-feet per Year
BA ..... Biological Assessment
Base ..... Marine Corps Base Camp Pendleton
BO ..... Biological Opinion
BPG ..... Biogeographic Population Groups
CCZCC ..... California Coastal Zone Conservation Commission
CDFG ..... California Department of Fish and Game
cfs ..... cubic feet per second
CMP ..... Corrugated Metal Pipe
CPEN ..... Marine Corps Base Camp Pendleton
CPFD ..... Camp Pendleton Fire Department
CUP ..... Conjunctive Use Project
CWRMA ..... Cooperative Water Resources Management Agreement
DHS ..... California Department of Health Services
DPS ..... Distinct Population Segment
EIR ..... Environmental Impact Report
EIS ..... Environmental Impact Statement
ESA ..... Endangered Species Act
FPUD ..... Fallbrook Public Utility District
ft ..... feet
ft/s ..... feet per second
GIS ..... Geographic Information System
gpd ..... Gallons per Day
gpm ..... Gallons per Minute
HA ..... Hydrologic Area
HSA ..... Hydrologic Sub-area
HSPF ..... Hydrologic Simulation Program - Fortran
HU ..... Hydrologic Unit
I-5 ..... Interstate 5
IHA ..... Indicators of Hydrologic Alternation
km ..... kilometer
LSMR Model ..... Lower Santa Margarita River Groundwater Model
m ..... meter
MOU ..... Memorandum of Understanding
MWD ..... Metropolitan Water District of Southern California
NOAA Fisheries ..... National Oceanic and Atmospheric Administration, National Marine Fisheries Service
NWS ..... National Weather Service
O. mykiss ..... *Oncorhynchus mykiss*
OWR ..... Camp Pendleton Office of Water Resources
POD ..... Point of Diversion

RCFCD ....Riverside County Flood Control and Water Conservation District
RCP .... Reinforced Concrete Pipe
RCWD.. Rancho California Water District
Reclamation .... U.S. Bureau of Reclamation
ROM ....Reservoir Operations Model
SMMWC..Santa Margarita Mutual Water Company
SWRCB... State Water Resources Control Board
SYRTAC...Santa Ynez River Technical Advisory Committee
TIN ....Triangulated Irregular Network
TM.. Technical Memorandum
TUCA... Trout Unlimited California
USFWS ....United States Fish and Wildlife Service
USGS ....United States Geological Survey
WSE .... Water Surface Elevation
WY ....Water Year

EXECUTIVE SUMMARY

The purpose of the Lower Santa Margarita River Steelhead Passage Assessment is to characterize the stream environment within the Lower Santa Margarita River as it relates to potential passage conditions for southern California steelhead (*Oncorhynchus mykiss*). The study was commissioned to identify impacts that might occur from a proposed water development project sponsored by the United States Bureau of Reclamation (Reclamation), the Fallbrook Public Utility District (FPUD), and Marine Corps Base Camp Pendleton (Base or CPEN). The Santa Margarita River Conjunctive Use Project (CUP) proposes to replace and/or enhance existing water diversion and recharge facilities that divert water from the Santa Margarita River for both surface and underground storage on CPEN. In addition to the improvements of existing facilities, the CUP proposes to construct new groundwater wells and a bi-directional pipeline and pump station to convey untreated groundwater from CPEN to the FPUD.

The proposed CUP seeks to increase total diversions from the Santa Margarita River by replacing the existing 100-cubic feet per second (cfs) capacity diversion and sheet pile weir with a 200-cfs capacity diversion and inflatable weir. The replacement of the sheet pile weir diversion structure and improvements to supporting conveyance and recharge facilities will increase existing average annual surface diversions from 6,200 acre-feet per year (AFY) to 11,100 AFY. Water diverted to underground storage by the CUP will be recovered through four new, and 12 existing, groundwater production wells located in the Lower Santa Margarita River Basin. These 16 total groundwater production wells will provide an average annual yield of 10,800 AFY, approximately 4,200 AFY more than currently produced. The CUP will rely on exercising vested and unperfected water rights to divert, store, and beneficially use the water from the Santa Margarita River.

The project proponents sought to prepare a technical analysis that would determine minimum flows for fish passage on the Lower Santa Margarita River. Initiated through discussions with National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NOAA Fisheries), a scope of work was developed that included a water rights, hydrologic, hydraulic, and biological investigation of the conditions in the Lower Santa Margarita River. In addition to describing the historical magnitude and pattern of discharge of the river, NOAA Fisheries requested a description of how the existing and future project facilities would affect the magnitude and pattern of historical discharge and opportunities for adult and juvenile steelhead migration. The field investigation and analysis of the conditions required to support *O. mykiss* passage in the Santa Margarita River took place between March and August 2011.

The field investigation included a longitudinal survey of the river thalweg, a habitat assessment, and three site-specific topographic surveys of representative sites that are potential barriers to fish passage. A hydraulic model was then developed at each of the potential barriers using the topographic data and reconstructed streamflow to develop a stage-discharge relationship at each site. Surface flow at each of the three sites was calculated using the Lower Santa Margarita River Groundwater Model (LSMR Model), originally developed for the CUP in 2007, which accounted for the effects of groundwater pumping on surface flow. Combining the results of the streamflow analysis and the stage-discharge relationship at each of the three sites, minimum flows were established based on passage criteria developed by Thompson (1972). The LSMR and hydraulic models were then used to investigate the occurrence of the minimum passage flows with existing and future project facilities. Each of the specific tasks performed to characterize the stream environment as it relates to potential fish passage conditions is discussed below in greater detail.

A nine-mile longitudinal profile of the Santa Margarita River was surveyed from the existing point of diversion (POD) to the estuary near the Stuart Mesa Bridge to identify potential barriers to fish passage. An assessment was then performed at each potential site to ascertain which potential barriers were the most challenging to fish passage, including characterization of river substrate and other physical parameters of the stream system. The reach is typified by a relatively low gradient (0.2%), meandering, actively migrating sand-bedded channel with broad vegetated floodplains supported by a shallow alluvial groundwater table. The predominant aquatic habitat feature within the survey area was generally found to be uniform glides or “flat water” with essentially laminar flow and relatively shallow depths. Substrate, however, was almost entirely shifting sand. Except in the lower Narrows where vegetation control on the channel allowed for pool formation, no pools were observed that could be characterized as “holding”, rearing, or over-summering areas for juvenile salmonids. However, qualitatively, there did appear to be adequate depths and habitat for anadromous fish passage (migration) throughout the reach.

Three critical sites that could pose potential barriers to fish passage were identified from the longitudinal survey and site assessment. A detailed topographic field survey was then performed at each of the three sites to characterize the bed of the stream channel in more detail for hydraulic modeling. A HEC-RAS hydraulic model was then constructed to develop a stage-discharge relationship at each site. The hydraulic model was then coupled with HEC-GeoRAS, a set of GIS tools specifically designed to provide pre and post-processing inputs to HEC-RAS, so physical parameters could be geo-referenced to the hydraulic model. By employing both HEC-RAS and HEC-GeoRAS, the river's hydraulic parameters, such as the water surface elevation, water depth, and flow velocity distribution, were effectively calculated and visualized on GIS platforms.

The Lower Santa Margarita River is an extremely dynamic system in which the river bed is constantly shifting due to its bed substrate and river morphology. As such, river cross-sections at the three critical sites will change in the future. While the actual physical locations of the potential barriers to fish passage may change, the characteristics of those barriers are not expected to vary from those characterized in this study. Hence, the three sites identified in this study are representative of typical barrier conditions and are appropriate for describing existing and future potential barriers to fish passage.

Reconstructed flow at the CUP POD was calculated based on the surface water model developed in Technical Memorandum (TM) 1.1, which is Appendix B of this report and an update to TM 1.0 (Reclamation, 2007a). The period of record used for the hydrologic analysis is from water year (WY) 1925 through WY 2009. The LSMR Model presented in TM 2.2, developed using the United States Geological Survey (USGS) MODFLOW surface and groundwater finite difference model, was used to simulate groundwater flow in the Lower Santa Margarita Basin (Reclamation, 2007b). Multiple model simulations were then performed to determine potential impact to streamflow at critical passage sites based on the historic use of existing facilities and the planned operation of future facilities.

NOAA Fisheries outlined the data and information required to improve their understanding of the hydrology of the Santa Margarita River and the impact of the proposed action on the hydrology in a February 22, 2011 letter (NOAA Fisheries, 2011). Three distinct periods of investigation were developed in order to describe streamflow in the Lower Santa Margarita River under each of these conditions: Unimpaired, Recent Historical, and Future Project. The Unimpaired period was based on hydrology during the 15-year period from WY 1931 through WY 1945. This period was chosen based on the availability of stream gage data characteristic of near-natural conditions. The Recent Historical period was based on hydrology during the 13-year period from WY 1997 through WY 2009; this period was chosen because detailed diversion data were available from CPEN. The Future Project period was also based upon WY 1997 through 2009 hydrology so that changes due to the proposed CUP could be compared to Recent Historical conditions.

These periods represent wetter than average conditions that specifically favor an analysis of streamflow that supports potential fish passage on the Santa Margarita River. The daily median streamflow during the Unimpaired (WY 1931 to WY 1945) period was 12 cfs compared to 14 cfs during the Recent Historical/Future Project (WY 1997 to WY 2009) periods. These median values are about 50% higher than the long-term daily median of 8 cfs seen in the period of record (WY 1925 to WY 2009).

This study's analysis of potential steelhead passage habitat is based on criteria developed for open stream channels by Thompson (1972). The Thompson fish passage criteria include a minimum water depth of 0.6 feet across a contiguous channel bottom equaling at least 10%, and a total of at least 25%, of the wetted channel width across the selected critical passage site. Applying these criteria to the stage-discharge relationships developed during the hydraulic modeling task provided the minimum flow criteria to support fish passage at each of the three sites. Sites 1, 2, and 3 require a minimum average daily flow of 166 cfs, 103 cfs, and 78 cfs, respectively, to meet the criteria. The minimum flow rate of 166 cfs at Site 1 was determined to limit potential fish passage throughout the entire Lower Santa Margarita River since minimum passage flow rates at Sites 2 and 3 were maintained when the minimum flow rate at Site 1 was met.

The magnitude and occurrence of the minimum passage flows was then evaluated for the three investigative periods. During the Unimpaired period, median daily streamflow during the Unimpaired period was 12 cfs, ranging from a minimum of one cfs to a maximum of 14,000 cfs. The average daily streamflow was 57 cfs, a rate approximately five times greater than the median. The minimum passage flow of 166 cfs at Site 1 occurred 4.9% of the time during the Unimpaired period. Under Unimpaired conditions, the Lower Santa Margarita River is flashy in nature; during years with drier-than-normal streamflow, passage opportunities do not exist due to the low magnitude, short duration, and infrequent occurrence of peak events.

The impact of the CUP was assessed by comparing the change in occurrence and duration of the minimum passage flows between the Recent Historical and Future Project scenarios. Specifically, the minimum passage flow at Site 1 was examined, as this was established as the limiting reach during the passage assessment. During the Recent Historical period, the minimum daily streamflow rate of 166 cfs at Site 1 occurs on 4.2% of days. As shown in Table ES-1, this compares to an occurrence percentage of 3.8% during the Future Project period.

TABLE ES.1 CHANGE IN OCCURRENCE OF MINIMUM FISH PASSAGE FLOW RATES

Investigative Period	Percent of Days in Which Flow[1] Exceeds 166 cfs at Site 1[2]
Recent Historical	4.2%
Future Project	3.8%

Notes:
1. Flow is the average daily flow.
2. The percent occurrence of minimum fish passage flows at Sites 2 and 3 decreases from the Recent Historical to Future Period, but remains more frequent than those at Site 1.

Flow duration during the two periods was examined by comparing the duration of events in which a minimum flow of 166-cfs is sustained at Site 1. The annual maximum duration event was examined for each year. As shown in Table ES.2, there is a slight increase in the number of years whose maximum event occurs for only one day. The occurrence of maximum-duration events of longer periods (5-days, 10-days or more) is not affected by the project.

TABLE ES.2 COMPARISON OF ANNUAL MAXIMUM DURATION EVENT AT SITE 1[1]

Annual Maximum Event Duration	Recent Historical Occurrence (Years)	Future Project Occurrence (Years)
1-Day	5 of 13	6 of 13
3-Day	4 of 13	3 of 13
5-Day	2 of 13	2 of 13
10-Day or more	2 of 13	2 of 13

Note:
1. There is only one Annual Maximum Duration Event for each of the 13 years during the Recent Historical and Future Project Investigative Periods.

The average duration of all 166-cfs events during the two investigative periods was also compared. The analysis was done for all 13 years, as well as for four representative wet and four representative dry years. As shown in Table ES.3, during wet years, the average duration decreases from 14.8 days under Recent Historical conditions to 13.8 days under Future Project conditions. During dry years the decrease is from 1.3 days to 0.5 days. During all 13 years of the analysis period, the average duration of all 166-cfs events decreases from 6.2 days to 5.9 days.

TABLE ES.3 AVERAGE DURATION OF 166-CFS EVENTS

	Average Duration of 166-cfs Events (Days)	
	Recent Historical	Future Project
Wet Years[1]	14.8	13.8
Dry Years[2]	1.3	0.5
All Years	6.2	5.9

Notes:
1. Wet years are 1998, 2001, 2005, and 2008.
2. Dry years are 1999, 2000, 2002, and 2007.

The three investigative periods in this study represent wetter-than-average conditions when compared to the streamflow during the entire period of record (WY 1925-2009). Flow in the Lower Santa Margarita River during the Unimpaired period likely did not support potential fish passage during years when streamflow was below average, but likely provided adequate passage during years with above-average streamflow.

Comparison of fish passage conditions between Recent Historical and Future Project conditions indicate that there is a slight reduction in the number of events that have the potential to support fish passage. Analysis in this report suggests that the CUP primarily affects the duration of shorter peak events (1-day, 3-day), and does not affect longer peak events (5-day, 10-day or more) when comparing CUP conditions to existing conditions.

A pool is required at the base of fish barriers in order for fish to accelerate to a speed that allows them to clear the structure. The general rule of thumb is that the pool below the structure needs to be 1.5 times as deep as the structure is high. For the proposed weir, consideration should be given to provide a pool at the base of the weir along with a notch at the same location so fish have both a pool to jump from and a target to jump toward. Alternatively, a fish ladder, or other passage structure, at the weir may be incorporated to provide fish passage.

The diversion itself should be screened to prevent the entrainment of downstream migrating juvenile steelhead into Lake O'Neill or into the infiltration ponds. These screens may be located on the river or at the diversions from the O'Neill Ditch, as long as enough flow enters the ditch to provide passage for juvenile steelhead through the remainder of the ditch and back into the river.

This report assessed fish passage at the POD and three downstream critical passage sites on the Santa Margarita River. The impact to the streamflow magnitude and pattern were analyzed during both existing (Recent Historical) and proposed CUP (Future Project) conditions. The results of this analysis showed the greatest amount of impact to the stream occurred during low flow conditions when fish passage would not occur. During wetter-than-normal years when high flow events equaled or exceeded minimum fish passage flow rates, there was minimal change to streamflow magnitude and pattern.

1.0 INTRODUCTION AND BACKGROUND

1.1 STUDY AUTHORITY AND PURPOSE

This study was jointly authorized by the United States Bureau of Reclamation (Reclamation), Fallbrook Public Utility District (FPUD), and the United States Marine Corps Base Camp Pendleton (CPEN or Base). The purpose of this study is to characterize the stream environment within the Lower Santa Margarita River as it relates to potential passage conditions for southern California steelhead (*Oncorhynchus mykiss*). This supports the Santa Margarita River Conjunctive Use Project (CUP or Project), water rights permit change petitions currently under review at the State Water Resources Control Board (SWRCB), the Environmental Impact Statement/Environmental Impact Report (EIS/EIR), and will provide important information for the Biological Assessment (BA) necessary for eventual Endangered Species Act (ESA) consultation regarding the proposed CUP. Stetson Engineers performed the survey, hydrology and hydraulic analysis associated with this report. Cardno ENTRIX performed the tasks and analyses associated with the identification of potential critical steelhead passage sites in the Lower Santa Margarita River and interpreted the hydrology and hydraulic information provided by Stetson Engineers under contract with FPUD.

1.2 REPORT CONTENTS

This report presents the findings from two distinct delivery requirements: identification of fish passage requirements in the Lower Santa Margarita River downstream of the existing sheet-pile weir and; an update to Technical Memorandum (TM) 1.0 describing water availability on the Santa Margarita River. While each of these study requirements could be considered as separate but supporting reports, they have been combined under one report in order to support the Santa Margarita River CUP. The scope of work that was followed to identify fish passage requirements was based on collaboration between the three parties and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NOAA Fisheries). The main body of the report addresses flows necessary to support potential southern California steelhead (*O. mykiss*) passage through the lower river and the tools that were developed to complete this assessment.

Appendix B contains an update to TM 1.0 "Statistical Analysis of Santa Margarita River Surface Water Availability at the Conjunctive Use Project's Point of Diversion" originally published by Reclamation and Stetson Engineers in April 2007. TM 1.0 surface water analysis was based on water year (WY) 1925 through WY 2005 hydrology measured at various streamflow and rainfall gages throughout the Santa Margarita River Watershed. The purpose of updating TM 1.0 is to include the most recent WY 2006 through WY 2009 data, in addition to incorporating all recent technical studies and reports that have increased the knowledge of physical processes that control the movement of water throughout the watershed. Statistics and results developed in the updated TM 1.0 and relied upon to assess fish passage are addressed in the main body of the report. The update to TM 1.0 contained in Appendix B is also known as TM 1.1.

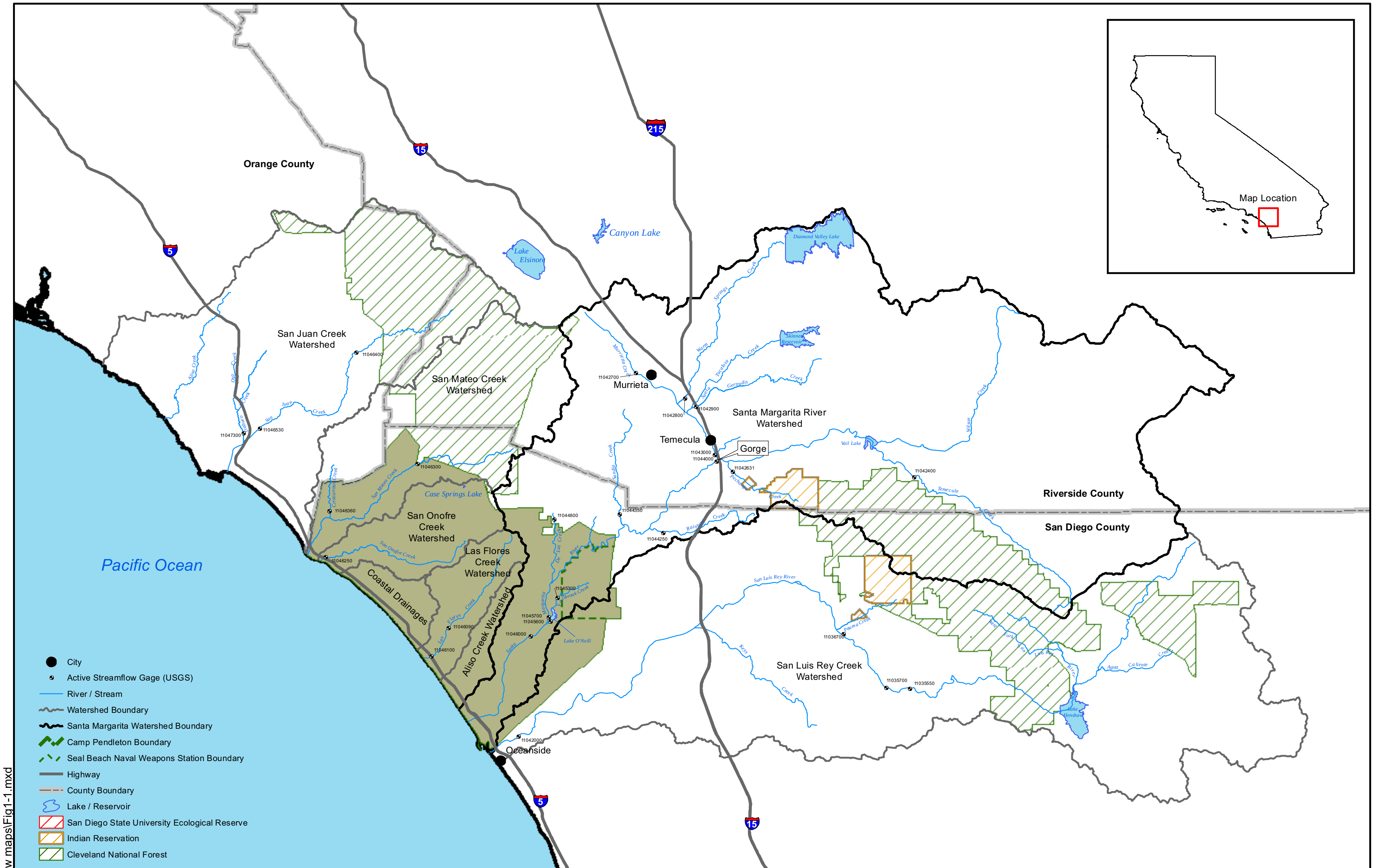
1.3 STUDY LOCATION

The Santa Margarita River Watershed consists of a lower and upper portion divided at the location referred to as the Gorge. The Upper Watershed includes the drainage area located above the confluence of Murrieta and Temecula Creeks. The Lower Watershed includes the drainage area downstream of the Gorge to the Pacific Ocean. The study area of this report is the area of the Lower Santa Margarita River Watershed located in northern San Diego County (Figure 1-1). Interstate-5 (I-5) is aligned in a northwest-southeast along the Pacific coast while I-15 is located east of the Gorge through the cities of Temecula and Murrieta. The cities and towns along the I-15 corridor are located in Riverside County and are up-gradient of the proposed project.

The focused portion of the study area includes the portion of the Santa Margarita River within the boundaries of CPEN stretching from the existing Point of Diversion (POD) to the estuary. Currently, CPEN's existing diversion and recharge facilities are located at the POD or points downstream. The recharge and diversion facilities associated with the proposed CUP will be located within the same footprint of existing facilities and will not affect flows upstream of the POD.

1.4 PROJECT BACKGROUND

The Santa Margarita River CUP represents a physical solution to a long-standing water rights dispute between CPEN and FPUD. Reclamation holds water rights, to the benefit of both parties, for the diversion and beneficial use of water from the Santa Margarita River. Although the purpose of this study is not to document the complete history of water rights, FPUD has been beneficially diverting and using water from the Santa Margarita River since 1927, while CPEN and its predecessors have exercised rights to the beneficial use of water since 1883. A legal dispute resulting in the adjudication of the Santa Margarita River (*United States v. Fallbrook PUD et. al*) began in 1951 and led to the development of the Santa Margarita River CUP. Reclamation's water rights are intended to support the development of the Santa Margarita River CUP and provide a means to complete the quantification of a portion of the water rights on the Lower Santa Margarita River.



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LOCATION OF STUDY AREA

FIGURE 1-1

Reclamation currently holds three unperfected water rights intended to appropriate surface water from the Santa Margarita River for use by the CUP. Two permits with priority dates of 1946 and 1947 were issued to FPUD for in-stream surface diversion of 10,000 acre-feet (AF) each and one permit was issued to CPEN in 1963 for 165,000 acre-feet per year (AFY) of surface storage. These water rights were the basis for the now-obsolete two-dam project that would have provided up to 185,000 AF of in-stream surface storage. Because of the adverse environmental impact of constructing in-stream dams on the Santa Margarita River, an alternative project design that relies on off-stream underground storage was considered.

The Santa Margarita River CUP is designed to result in minimal impact to the riverine habitat and the groundwater aquifer, while providing a long-term, sustainable water supply to the FPUD and CPEN. Development of the CUP requires coordination with the SWRCB in order to convert the existing water rights from in-stream surface storage to off-stream underground storage. Initiated in 2009, the process of converting the water rights permits requires a water rights change application to the SWRCB and coordination with state and federal resource agencies, including NOAA Fisheries.

In the spring of 2009, a juvenile *O. mykiss* was captured in the upper reaches of the Santa Margarita River aboard Base and was confirmed to be of wild steelhead ancestry through genetic analysis (NOAA Fisheries, 2010a). Subsequently, on August 6, 2010, NOAA Fisheries filed a formal protest letter against the water rights applications, citing the presence of endangered salmonids and expressing concerns over the potential impacts from the project on salmonid habitat (NOAA Fisheries, 2010b). As a result, an analysis of CUP effects on potential steelhead fish passage in the Lower Santa Margarita River was requested by the FPUD. Cardno ENTRIX fisheries biologists, under contract with FPUD, were requested to work in coordination with CPEN staff and their hydrological consultant, Stetson Engineers, to conduct a steelhead passage assessment of the Lower Santa Margarita River from Camp Pendleton's diversion structure to the estuary (a distance of about 9.0 river miles).

A proposed scope of work to survey and evaluate potential critical passage sites important to *O. mykiss* adult and juvenile life stage migrations in the Lower Santa Margarita River was provided to NOAA Fisheries in January 2011. Following a field visit on February 10, 2011, which included initial discussions between Cardno ENTRIX biologists, Stetson Engineers, NOAA Fisheries, and CPEN and FPUD staff, and receipt of a comment letter on February 16, 2011 from NOAA Fisheries, the assessment was refocused to evaluate passage conditions for southern California steelhead in the Lower Santa Margarita River.

The results of the steelhead passage assessment, along with an update to TM 1.0, are presented in the following report. The development of the hydrologic model that describes the daily flow characteristics of the Santa Margarita River at the proposed POD and other downstream locations is based on a combination of surface water, hydraulic, and groundwater modeling tools. The hydrologic tools are used to estimate both the yield of the Santa Margarita River CUP and any potential impact resulting from implementation of the CUP to downstream resources, including streamflow in the river. Combined with biological and ecological requirements of *O. mykiss*, assessment of fish passage conditions have been identified for various hydrologic conditions.

1.5 EXISTING FACILITIES AND OPERATIONS ON CPEN

Following the annexation of California to the United States, a patent to all the lands of Rancho Santa Margarita y Las Flores, currently Camp Pendleton, was issued in 1879. In 1882, the title to the Rancho passed to Richard O'Neill and James Flood who operated the land as a cattle and farming ranch until 1942 when it was sold to the United States. O'Neill Ditch and Lake were constructed in 1883 to support the ranch and farming activities. Groundwater wells were later developed in the early part of the twentieth century prior to and after the purchase of the ranch by the United States. The facilities described below, some of which were constructed in 1883, are still in operation today.

1.5.1 Existing Facilities

Existing facilities that divert water from the Santa Margarita River for beneficial use by Camp Pendleton include, but are not limited to: a diversion structure, a conveyance ditch, five recharge ponds and 12 recovery groundwater wells (Figure 1-2). The following is a short description of each of these facilities; additional information is included in the Permit 15000 Feasibility Study (Stetson, 2001).

Santa Margarita River Diversion Structure

The existing Santa Margarita River diversion structure was constructed in 1982 and consists of a steel sheet pile weir approximately 280 feet long. Depending on river stage, surface flows are impounded behind the weir, overflow the top of the weir, flow through one of two low-flow notches, or are diverted through a headgate into O'Neill Ditch through a 60 inch x 45 inch corrugated metal pipe (CMP). The existing diversion capacity at the sheet pile weir to divert water to the O'Neill Ditch is approximately 100 cubic feet per second (cfs).

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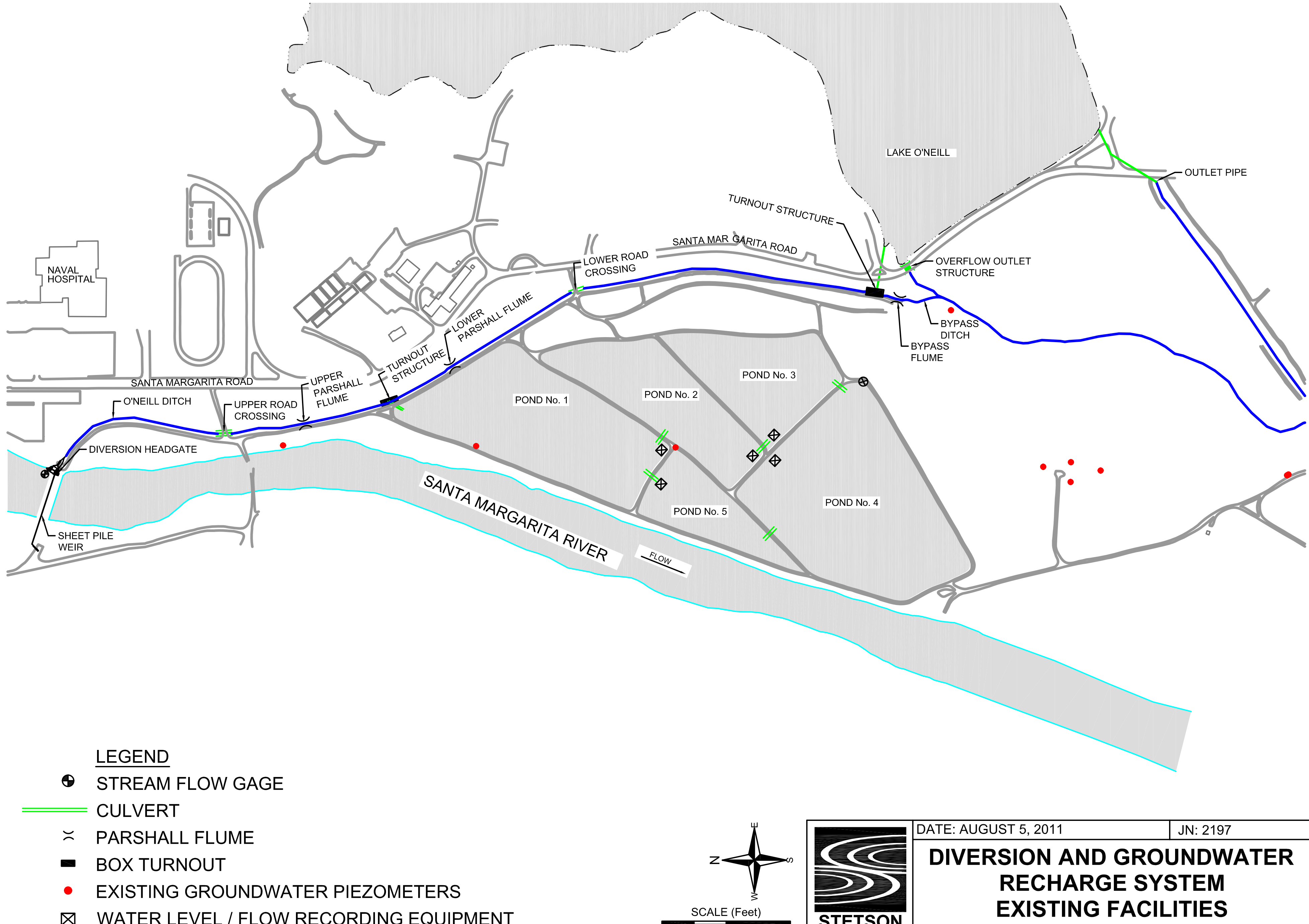

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DIVERSION AND GROUNDWATER RECHARGE SYSTEM EXISTING FACILITIES

SANTA MARGARITA RIVER

FIGURE 1-2

O'Neill Ditch

The O'Neill Ditch is an earthen channel that delivers water from the sheet pile weir to either Lake O'Neill or the five groundwater recharge ponds. The total length of O'Neill Ditch is 5,100 feet from the head of the channel to the turnout structure into Lake O'Neill. There are two road crossings, two concrete Parshall Flumes, two turnout structures, and one by-pass structure at the terminus of the ditch. The capacity varies throughout the length of the ditch, but is generally restricted to 60-cfs at the upper road crossing, a design capacity less than the sheet pile weir. Downstream of the by-pass structure to Lake O'Neill, water not diverted to storage flows in an earthen outflow ditch that also receives controlled and uncontrolled releases from the lake. The earthen outflow ditch is approximately 4,000 feet in length and joins the Santa Margarita River approximately three-quarters of a mile downstream of the sheet-pile weir.

Groundwater Recharge Ponds

The groundwater recharge ponds were constructed between 1955 and 1962 and consist of over 49 acres of surface area and hold a volume of approximately 259 AF when full. The recharge ponds are formed by sand levees approximately 10-feet in height and are interconnected by buried, non-gated CMP pipes that pass flow between ponds. Water flows from one pond to the next when the elevation reaches the invert elevation of the CMP pipe that connects the pond to the next down-gradient pond. At the lower end of Pond No. 4, two 3-inch CMP pipes allow for overflow to spill back to the Santa Margarita River. Spill to the river has only been documented in 1983 since the river headgate and O'Neill Ditch are managed to prevent spills.

Lake O'Neill

Lake O'Neill is a man-made reservoir constructed originally in 1883 by forming an earthen levee across Fallbrook Creek, a tributary to the Santa Margarita River. Diversions from O'Neill Ditch to the lake are made through a concrete turnout structure and a 24-inch reinforced concrete pipe located at the lower end of O'Neill Ditch. A concrete overflow outlet structure with four 60-inch reinforced concrete pipes returns uncontrolled spills to a ditch that eventually drains back to the river. Lake water can also be returned to the river through an outlet pipe located in the southern corner of the lake. The existing capacity of the lake is approximately 1,260 AF (Stetson, 2004).

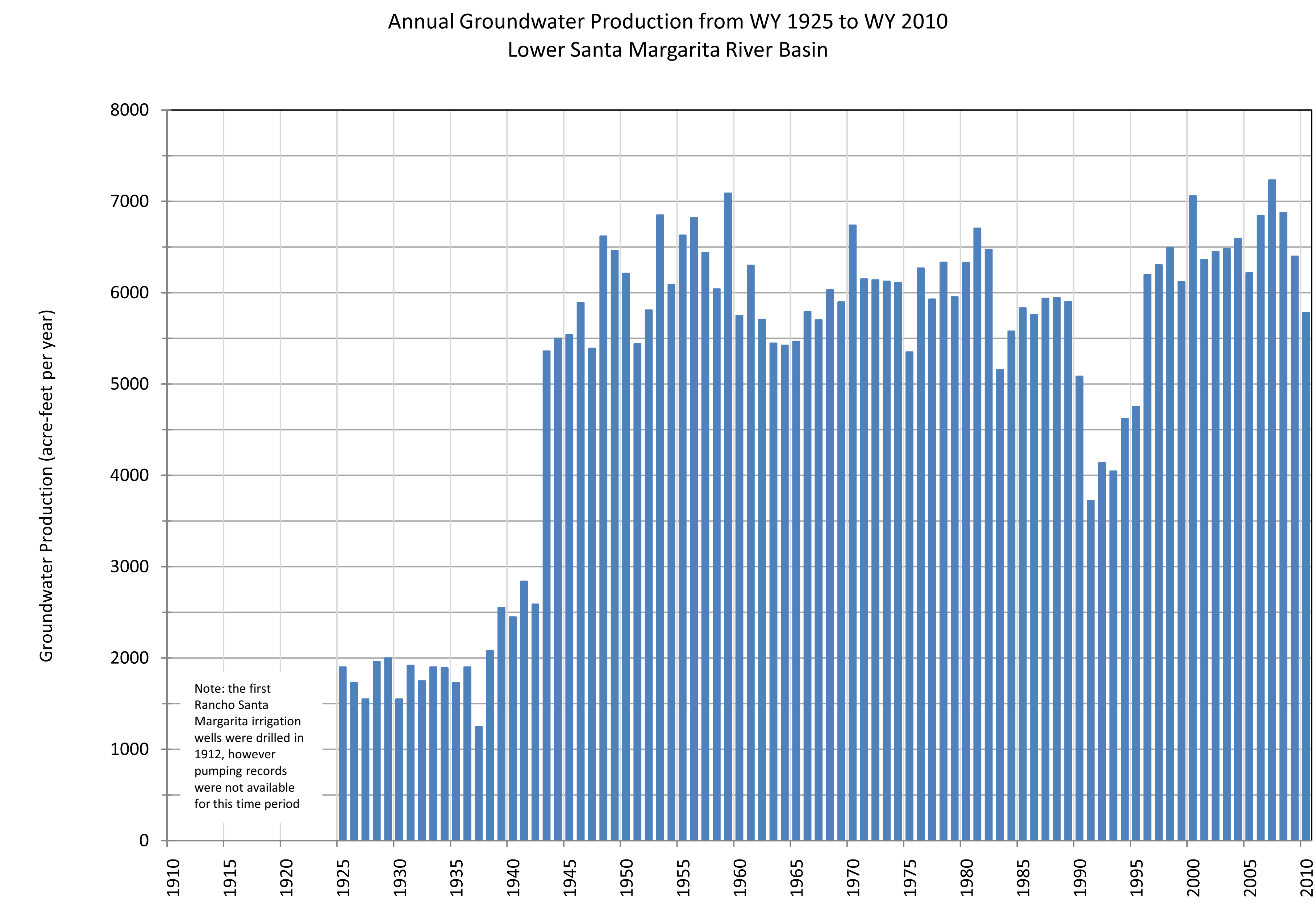
Recovery Wells

There are currently 12 groundwater wells located in the Upper Ysidora and Chappo Subbasins that recover groundwater that has been diverted through the existing diversion facilities and stored in the groundwater aquifer. Groundwater production wells screened within the highly permeable alluvium typically yield between 800 gallons per minute (gpm) to 1,200 gpm (OWR, 2010). While not described in this document, a network of raw water delivery pipelines conveys water to one of two iron/manganese water treatment facilities before delivery to Camp Pendleton's potable water distribution facilities.

1.5.2 Historical Groundwater Pumping and Surface Diversions

Rancho Santa Margarita drilled agricultural wells in the Santa Margarita River Basin in 1912, which is probably the start of pumping in this groundwater basin, though there are no available records of this time period that state when and how much water was used (Worts and Boss, 1954). Starting in 1924, approximately 1,000 acres in the Lower Ysidora Subbasin and 500 acres in the Chappo Subbasin were irrigated from agricultural wells, and about 500 acres were irrigated by surface water from Lake O'Neill. In 1938 and 1939, irrigated acreage was expanded by 1,000 acres on Stuart Mesa and 600 acres on the southern coastal terrace, respectively. It is estimated that an annual average of approximately 1,940 AF of groundwater pumping occurred between WY 1925 and WY 1941. Additional water supply for Base use started when the United States Navy acquired the Rancho in February 1942, while agricultural demand continued at historical levels. Average annual groundwater production from WY 1942 to WY 1960 was approximately 5,920 AFY: 1,860 AFY for irrigation use and 4,060 AFY for camp supply. From WY 1960 to WY 2010 the total groundwater pumping has remained about the same, but the irrigation pumping averaged 1,070 AFY and camp supply increased on average to 4,850 AFY. In WY 2010 agricultural pumping was reduced to 640 AF and eventually permanently eliminated in WY 2011. Groundwater pumping for military, domestic, and agricultural use from the Lower Santa Margarita Basin is shown in Figure 1-3. More recently, the groundwater production averaged 6,600 AFY between WY 1997 and WY2009.

Surface diversions from the Santa Margarita River to O'Neill Ditch began in 1883 following the completion of Lake O'Neill. Following construction of the recharge ponds in the early 1960s, O'Neill Ditch was used to convey surface water from the Santa Margarita River to both the lake and recharge ponds. Total surface diversions to Lake O'Neill and the recharge ponds averaged 7,000 AFY during the recent 13-year period from WY 1997 and WY 2009.



Note: This graph includes military, municipal and agricultural pumping. It does not include diversions to Lake O'Neill.

FIGURE 1-3

1.6 SANTA MARGARITA RIVER CUP

The proposed CUP has been designed to optimize the use of surface water without causing adverse environmental impact. Elevated surface flows from the Santa Margarita River during winter-time events would be diverted from the river to off-channel groundwater recharge ponds for subsequent recharge to CPEN's aquifer. Winter-time water is then stored underground until it is recovered through one of 16 groundwater wells located down gradient of the recharge ponds.

Water recovered from the groundwater wells is then distributed to both CPEN and FPUD for beneficial use within their respective service boundaries. The following section describes the facilities required to divert surface flows from the Santa Margarita River and distribute water for beneficial use.

1.6.1 Project Facilities

In addition to developing new facilities, the Project facilities will rely on the use of existing facilities already in use on Camp Pendleton (Figure 1-4). In some cases, existing facilities are being rehabilitated or improved to increase operational efficiency, while others are being included without improvement. The following section describes both new and existing facilities as they are intended to support the project.

Santa Margarita River Diversion Structure

The existing Santa Margarita River sheet pile weir diversion structure will be replaced by an inflatable weir that is intended to allow high flow events to pass. The inflatable weir consists of a rubber bladder and steel plates. The crest elevation of the proposed inflatable weir is 117.1 feet msl, 0.5 feet higher than the exiting sheet-pile weir (Reclamation, 2009). The existing sheet piles will be removed or used in the construction of the weir foundation based on final design. The design capacity of the weir and diversion structure will be approximately 200 cfs.

O'Neill Ditch

The O'Neill Ditch will be enlarged to a capacity of 200 cfs to the five existing and two rehabilitated groundwater recharge ponds. The improvements to O'Neill Ditch will include expanding the channel capacity, removing road crossings restrictions, installing new measuring devices, and new control structures. The total length of O'Neill Ditch will remain at 5,100 feet from the head of the channel to Lake O'Neill, but the capacity of the ditch and control facilities will be improved.

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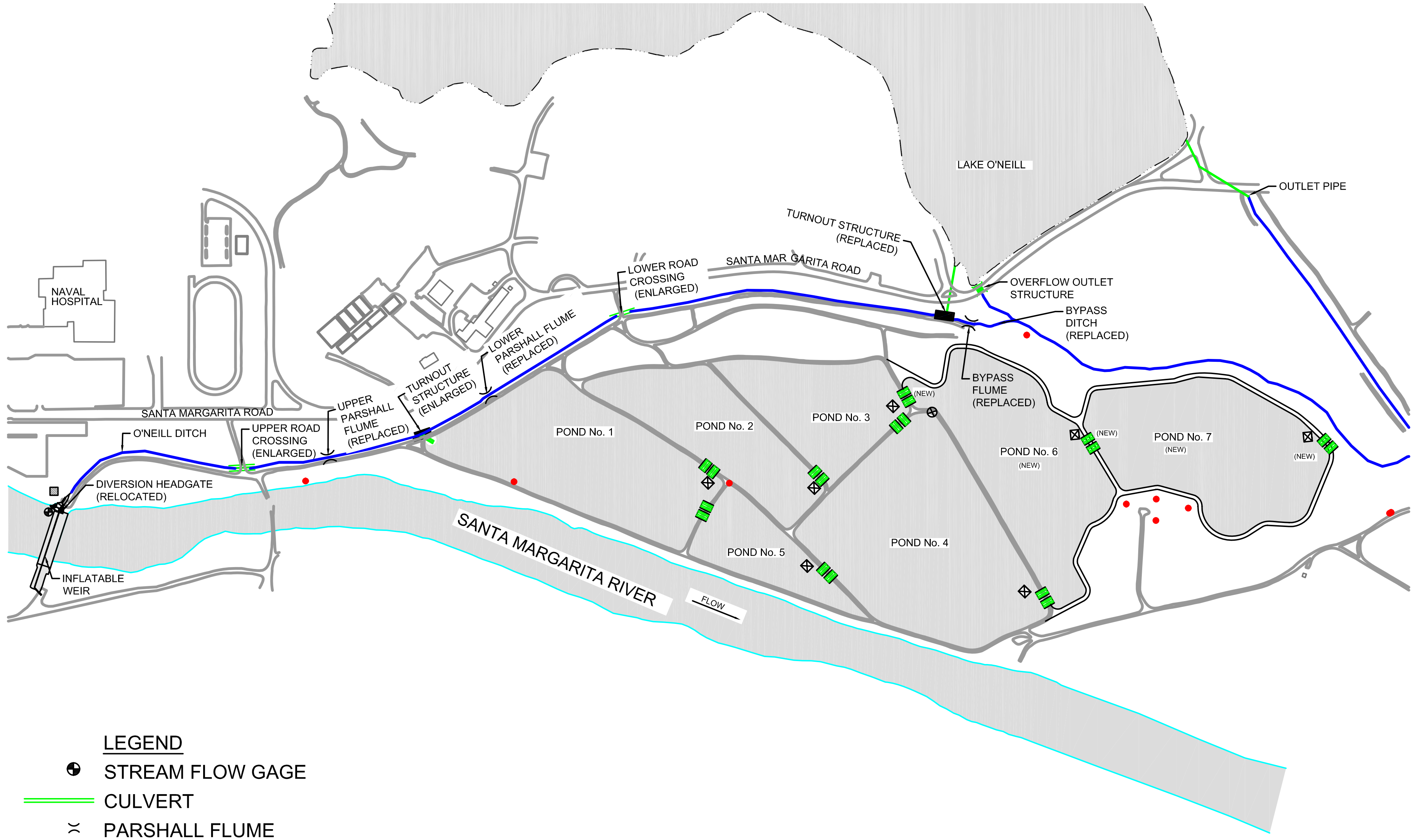

LEGEND

- STREAM FLOW GAGE
- CULVERT
- PARSHALL FLUME
- BOX TURNOUT
- EXISTING GROUNDWATER PIEZOMETERS
- NEW GROUNDWATER PIEZOMETERS
- SLIDING WEIR GATE STRUCTURE (100 CFS CAPACITY EACH)
- WATER LEVEL / FLOW RECORDING EQUIPMENT
- ELECTRICAL BUILDING

STETSON ENGINEERS INC.

DATE: AUGUST 5, 2011 | JN: 2197

DIVERSION AND GROUNDWATER RECHARGE SYSTEM CUP FACILITIES

SANTA MARGARITA RIVER

FIGURE 1-4

Groundwater Recharge Ponds

Groundwater recharge ponds 6 and 7 will be rehabilitated to expand the surface area of the existing ponds from 49 acres to 77 acres. The resulting capacity of the recharge ponds will increase from 259 AF to 398 AF. New control structures and measuring devices will be installed to improve management and infiltration of the recharge ponds. The proposed pond system will be operated to maximize infiltration through control of groundwater levels and available storage capacity in the aquifer.

Lake O'Neill

Improvements to Lake O'Neill include dredging to restore the lake to its original capacity of 1,680 AF. Suspended sediments carried in flows from both Fallbrook Creek and O'Neill ditch have accumulated in the lake and reduced storage capacity. Currently, CPEN is proposing a two-phase approach to restoring original lake capacity; Phase 1 dredging which is expected to occur in the fall of 2011.

Recovery Wells

The CUP proposed to add four additional groundwater wells located in the Upper Ysidora and Chappo Subbasins to recover water that was diverted through the existing and proposed diversion facilities and subsequently stored underground. Groundwater pumped from the aquifer is then conveyed through a raw water pipeline delivery system to Haybarn Canyon.

FPUD Bi-Directional Pipeline and Pump Stations

The CUP proposes to deliver water to FPUD through a new 18-inch bi-directional pipeline from Haybarn Canyon to the boundary of the FPUD service district. Water deliveries to both parties will be based on the CUP project delivery schedule and available supplies in the groundwater aquifer as determined by an adaptive management plan. During times of prolonged drought, emergency requirements, or environmental restrictions, the bi-directional pipeline will convey imported water from FPUD to CPEN to replace demand that would otherwise require groundwater pumping.

The CUP proposes two pump stations for conveyance of untreated groundwater to FPUD: a main pump station located in Haybarn Canyon and a booster station located along Ammunition Road at the boundary between CPEN and the Naval Weapons Station, Detachment Fallbrook. The pump stations will be sized to convey flows ranging between 2 cfs and 13 cfs depending on the hydrologic conditions and demand on CPEN.

Treatment and Conveyance Facilities in FPUD

Untreated water delivered from Haybarn Canyon to the FPUD boundary through the bi-directional pipeline will be treated to the appropriate level as determined by California Department of Health Services (DHS). Following treatment, water will be distributed through existing and new pipeline and pump station facilities for use by FPUD customers. Reclamation is currently studying the size and capacity of both the treatment and distribution facilities to be located in the FPUD service boundary.

1.6.2 Project Groundwater Pumping and Surface Diversions

Total Project related groundwater pumping includes pumping from historic and existing facilities as well as pumping from new facilities. Presently, existing groundwater pumping occurs from 12 wells located in the Upper Ysidora and Chappo Subbasins. The proposed project will add an additional four new wells which will also be located in the same two subbasins. The average monthly distribution of groundwater pumping has been designed to meet the demands of both Camp Pendleton and FPUD as shown in Figure 1-5. Maximum pumping will occur in the late spring and early summer to meet the peak demands of the parties. The CUP proposed groundwater production rate will average 10,800 AFY based on model simulation of a 50-year hydrologic period identical to that which occurred from WY 1952 to WY 2001.

The CUP proposes to increase surface diversions from the Santa Margarita River to Lake O'Neill through the replacement of the weir and enhancement of the existing ditch system. Based on these improvements, surface diversions during the 50-year model simulation are expected to average 8,800 AFY, ranging from a minimum of 1,700 AFY to a maximum of 19,300 AFY. Surface diversions include diversions to both Lake O'Neill and to the recharge ponds.

The operation of the inflatable weir and CUP adaptive management plan are expected to benefit both high and low flows in the river. The inflatable weir is designed to collapse during high flow events characterized by flow rates that exceed the 10-year flood recurrence interval, thus allowing for sediment to be carried to the ocean. Additionally, the design of the inflatable weir allows for a 3-cfs year-around bypass to maintain minimum flows past the diversion structure. The habitat impacted by the inundation area behind the inflatable weir is expected to improve by reducing impact to the high and low flow events on the river.

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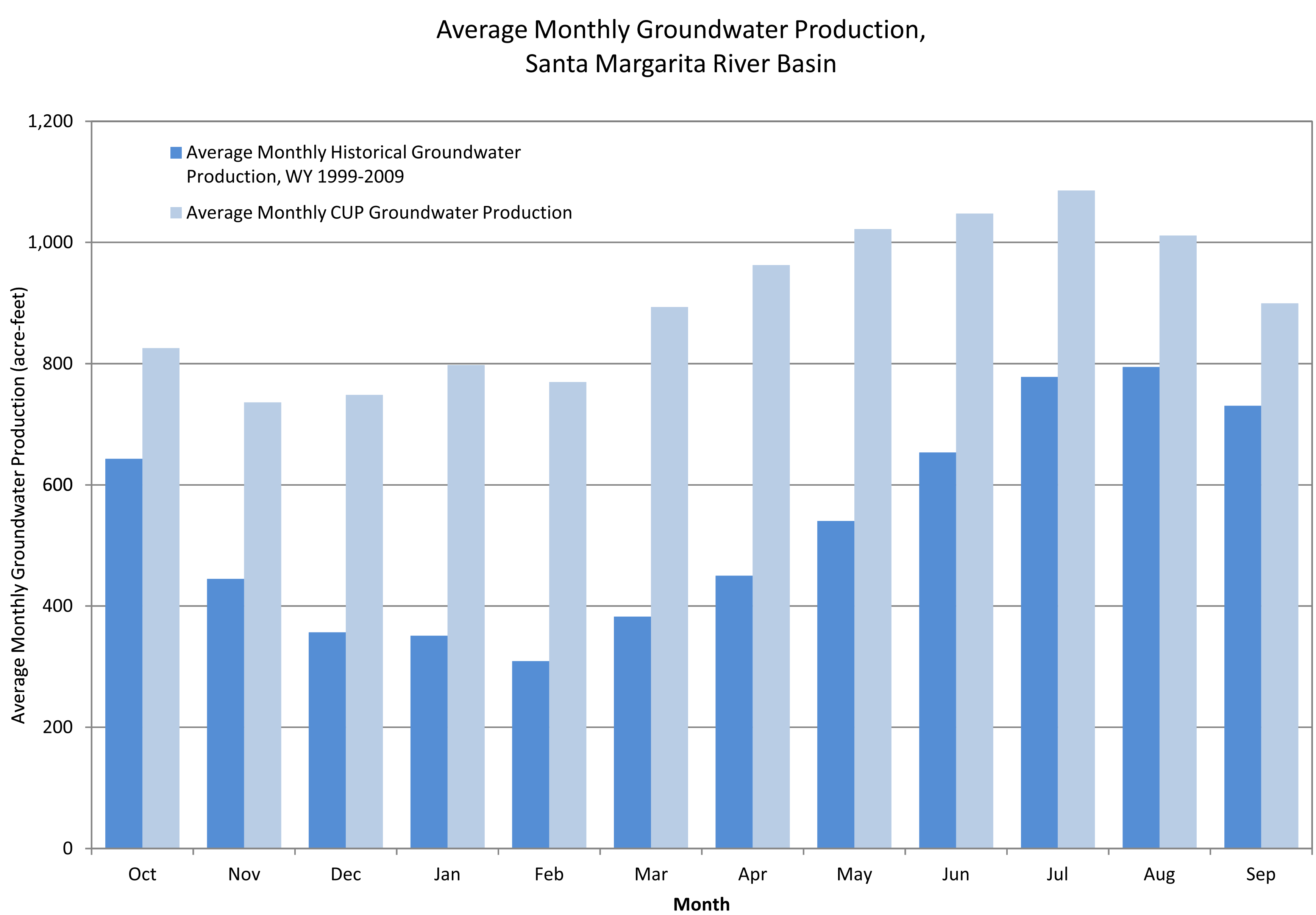


FIGURE 1-5

1.7 LEGAL HISTORY AND HISTORICAL WATER RIGHTS INVENTORY

Camp Pendleton currently uses water from the Santa Margarita River under three different water rights: a pre-1914 right to divert and store water in Lake O'Neill, a license to divert water to recharge ponds, and its riparian right. This section of the report briefly describes the legal disputes and outcomes as they relate to water rights in the Lower Santa Margarita River Watershed. Around the same time that the Mexican government granted the Santa Margarita y Las Flores land grant (now Camp Pendleton), the Pauba and Santa Rosa land grants were granted upstream in the areas now defined by the cities of Temecula and Murrieta. Although water projects were actively being investigated at the early part of the twentieth century, the legal battle for the Santa Margarita River commenced in 1924 in San Diego County Superior Court, as described in the following sections.

1.7.1 1940 Stipulated Judgment

In 1924, Rancho Santa Margarita y Las Flores brought suit against Vail Ranch, predecessor to the Rancho California Water District (RCWD). At that time, the two ranches were the only major water users on the Santa Margarita River and its tributaries. In 1930, after 444 court days, 55,171 pages of transcripts, and 2,201 exhibits, the court rendered its decision. An injunction was issued to Vail Ranch to reduce groundwater pumping and curb the adverse impact it had on the flow of the Santa Margarita River.

In the 1930s, following the California Supreme Court's order to retry the case, both litigation and negotiations between the two parties re-commenced. The result was a Stipulated Judgment issued in 1940 allocating 2/3 of the natural flow of the Santa Margarita River to Rancho Santa Margarita y Las Flores and 1/3 to Vail Ranch. As successors in interest to these parties, the United States and Camp Pendleton are allocated 2/3 of the natural flow of the Santa Margarita River while RCWD retains the remaining 1/3 share of the river. In addition to the division of streamflow between the two parties, the 1940 Stipulated Judgment also addressed issues such as minimum baseflows, groundwater pumping, and surface storage of flood flows.

One of the many provisions of the 1940 Stipulated Judgment established a minimum flow requirement of 3 cfs at the head of the Santa Margarita River (Gorge) between May 1st and October 31st of each year. The minimum flow of the river helped to provide surface water to the Santa Margarita y Las Flores Ranch and two other interveners to the state lawsuit. Although there are many other provisions of the 1940 Stipulated Judgment, the division of the natural flows of the Santa Margarita River and the establishment of a baseflow during the summer irrigation season provided a basis for the Cooperative Water Resources Management Agreement (CWRMA).

1.7.2 United States v Fallbrook Public Utility District (Case 1247)

In 1945, investigations toward a more dependable water supply were initiated by FPUD, the Department of the Navy, and Reclamation. A tentative agreement to build a reservoir at the De Luz dam site was reached between the parties in January 1949. Before a final agreement was reached, the United States filed Complaint Number 1247 against FPUD in 1951 to settle its rights to the waters of the Santa Margarita River. The defendants to this lawsuit included not only FPUD, but also approximately 6,000 landowners in the Santa Margarita River Watershed. The State of California acted as an intervener for its own rights as well as for the rights of its citizens.

A trial between the United States, the Santa Margarita Mutual Water Company (SMMWC), and the State of California was held. The outcome of this trial assigned the United States with prescriptive and riparian rights to the flow that remained after upstream diversions by Vail Company (pursuant to the Stipulated Judgment) and other riparian owners. Thus, it was determined that there were no surplus waters subject to appropriations by others. The United States Circuit Court of Appeals for the Ninth Circuit reversed this decision and ordered a new trial on appeals by the State of California and the SMMWC. During this trial, the court issued 45 Interlocutory Judgments identifying the riparian, appropriative and prescriptive rights to the waters of the Santa Margarita River and its tributaries. Although all existing water rights were identified in the Interlocutory Judgments, the court did not quantify water rights to the plaintiff, defendants and interveners. In 1963, the court issued an order establishing that there was surplus water subject to appropriation and that the United States had developed no prescriptive or appropriative rights other than for Lake O’Neill. The court also established that the 1940 Stipulated Judgment was no longer valid due to changed circumstances. The United States and FPUD appealed to the United States Court of Appeals for the Ninth Circuit. The decision by the appellate court upheld the findings from the lower court except that it reinstated the 1940 Stipulated Judgment.

On April 6, 1966, the District Court issued its Modified Final Judgment and Decree and reinstated the 1940 Stipulated Judgment. The District Court retains continuing jurisdiction of all surface water and supporting groundwater of the Santa Margarita River system. Water extracted from lands where underground water does not add to, contribute to and support the Santa Margarita River stream system was found to be outside the Court’s jurisdiction.

Although there were many important aspects of the 1960’s federal litigation, Interlocutory Judgments 24, 24A, and 37 established appropriative and riparian water rights for Camp Pendleton. Interlocutory Judgments 24 and 24A define the pre-1914 water right to divert and store water in

Lake O'Neill, while Interlocutory Judgment 37 defines the rights of the United States as a riparian landowner.

In 1968, following seventeen years of litigation in Federal Court, the division and allocation of water between the United States and FPUD had yet to be established. Therefore, upon the court's direction, the United States and FPUD entered into an agreement to jointly pursue a physical solution to the litigation and share the water produced by the Project. Under the terms of the agreement, referred to as the 1968 Memorandum of Understanding (MOU), the United States, through the Department of the Interior, agreed to conduct a feasibility study of the two-dam Santa Margarita Project. A jeopardy opinion by the Unites States Fish and Wildlife Service (USFWS) in 1986, and subsequent analysis indicating that the project would not be economically feasible, prevented the construction of the two-dam project (Leedshill, 1989).

1.7.3 Historical Water Rights Inventory

Historical appropriative water rights in the study area are summarized in Interlocutory Judgments 32, 32A (De Luz Creek), 39 and 39A (Santa Margarita River Watershed Below the Temecula Gorge and Above Naval Enclave). For a list of all historical appropriative water rights, see Appendix A. From 1925 to 1971, FPUD extracted water from the Santa Margarita River under Application 11586. Diversions were limited to 2.5 cfs and averaged 330 AFY. In addition to water used under appropriative rights, water was also used historically under riparian rights in the study area. A review of the Interlocutory Judgments mentioned in the previous section yields a description of riparian land parcels with rights to use water from the Santa Margarita River and its tributaries.

Historical water diversions and extractions carried out under riparian rights, as well as the appropriative rights listed in Appendix A, were estimated based on review of Interlocutory Judgments and earlier reports (Leedshill, 1988). The historical diversion, based on senior water rights, is used to adjust observed streamflow in order to estimate flow during unimpaired conditions on the Santa Margarita River. Based on available data and water rights records, the streamflow record for WY 1931 to WY 1945 should be adjusted 1,270 AFY to simulate unimpaired conditions.

Presently, Santa Margarita River water may be diverted and used under the water rights listed in Table 1.1. Below the Gorge, appropriative water rights held by others than CPEN or Reclamation total 4,833 gallons per day (gpd) of direct diversion and 4,108.5 AF of storage. There are 4,700 gpd of diversion rights and 100 AF of storage rights on DeLuz Creek, 0.5 AF of storage rights on Rainbow Creek, 8 AF of storage rights in Sandia Canyon, and 133 gpd of diversion rights and 4,000 AF of storage rights on the Santa Margarita River.

TABLE 1.1 APPROPRIATIVE AND OTHER WATER RIGHTS SANTA MARGARITA RIVER BELOW THE GORGE

Owner	Filing Date/ Date of Appropriation	Source Water	Amount	Use	Status
Pete and Dorothy Prestininzi	2/13/1962	De Luz Creek	ST-100 AF	D/I/R	License
William A. & Lois D. Cunningham	8/27/1985	De Luz Creek	DD-4700 gpd	D/I	
Shirley, Robert G. and Bobbi J.	8/3/1911	De Luz Creek	50 miner's inches, 65 AFY	I	Pre-1914
US Bureau of Reclamation	10/11/1946	Santa Margarita River	ST-10,000 AF	D/I/M	Permit
Fallbrook Public Utility District	11/28/1947	Santa Margarita River	ST-10,000 AF	D/I/M	Permit
US Bureau of Reclamation	11/28/1947	Santa Margarita River	ST-10,000 AF	D/I/M	Permit
US Department of the Navy	9/23/1963	Santa Margarita River	ST-4,000 AF	D/I/M/Z	License
US Bureau of Reclamation	9/23/1963	Santa Margarita River	ST-165,000 AF	D/I/M/Z	Permit
Judge Dial Perkins	12/26/1986	Santa Margarita River	DD-133.3 gpd	D	
George F. Yackey	12/27/1977	Sandia Canyon	ST – 8.0 AF	S	
Chris R. & Jeanette L. Duarte	12/16/1977	Rainbow Creek	ST – 0.5 AF	S	
United States	2/25/1905	Santa Margarita River	20 cfs, 1200 AFY	D/I	Pre-1914

Source: Santa Margarita River Watershed Annual Watermaster Report, Water Year 2008-09 Table 6.1. Charles W. Binder, September 2010.

ST = Storage; DD= Direct Diversion; D = Domestic; I = Irrigation; M = Municipal; S = Storage.

In addition to appropriative water rights, riparian rights are also used to divert and use water in the Lower Santa Margarita River Watershed. Below the Gorge, existing water use from well production and surface diversion was approximately 712 AF during WY 2009: 656 AF were from DeLuz Creek, 9 AF were from Sandia Creek, and 47 AF were from the main-stem of the Santa Margarita River. Table 1.2 lists WY 2009 groundwater and surface water production downstream of the Gorge and above the POD by riparian and appropriative water rights holders.

TABLE 1.2 WY 2009 GROUNDWATER AND SURFACE WATER PRODUCTION FROM THE SANTA MARGARITA RIVER BELOW THE GORGE

Location and Current Owner	Use	Well Production (AF)	Surface Diversion (AF)
De Luz Creek			
Ezor, Albert E.	Irrigation	36.8	
Prestininzi, Pete and Dorothy N.	Irrigation	46	
Varela, Alfred	Irrigation	21.6	
Lake Forest LLC	Irrigation	66.2	
Wagner Family Trust	Irrigation	39.3	
Chambers, Robert R. and Cynthia M.	Irrigation	121	7
Welburn, Douglas J. and Sue	Irrigation	35	
Nezami, Mohammed Bluebird Ranch	Irrigation	162.18	31.48
Vanginkel, Norman and Deborah	Irrigation	82	
Rose Family 1985 Trust Ross Lake LLC	Irrigation		7
De Luz Creek Subtotal		610.08	45.48
Sandia Creek			
Cal June, Inc.	Irrigation		9
Sandia Creek Subtotal		0	9
Santa Margarita River Main-stem			
SDSU Foundation	Irrigation	4.31	43.1
SMR Main-stem Subtotal		4.31	43.1
SMR Below the Gorge Total		**614.39**	**97.58**

Source: Santa Margarita River Watershed Annual Watermaster Report, Water Year 2008-09 Appendix C. Charles W. Binder, September 2010.

2.0 SOUTHERN CALIFORNIA STEELHEAD TAXONOMY, LIFE HISTORY AND HABITAT

Steelhead represent the anadromous form of coastal rainbow trout, spending part of their life in oceanic and fresh waters. Rainbow trout spend their entire lifecycle in fresh water and may seed downstream habitats with juveniles that have the potential to exhibit the anadromous life-history trait. For purposes of this report, Santa Margarita River *O. mykiss*, with capability of anadromy and access to the ocean, are considered a potential southern California steelhead population.

2.1 CONSERVATION STATUS

Steelhead in southern California represent a "distinct population segment" (DPS) of the species *O. mykiss* that is ecologically and reproductively discrete from the remainder of the species along the west coast (NOAA Fisheries, 2012). In 1997, the southern California steelhead DPS was listed as an endangered species warranting federal protection under Section 7(a)(1) of the Endangered Species Act of 1973. Endangered status was reaffirmed in 2005 (NOAA Fisheries, 2006). The ESA listing provides protection to populations of southern California steelhead found from the Santa Maria River in southern San Luis Obispo County to the Tijuana River at the United States-Mexican border (NOAA Fisheries, 2012). Final critical habitat was designated for the southern California steelhead DPS in 2005 and generally includes most, but not all, occupied habitat from the Santa Maria River in southern San Luis Obispo County to San Mateo Creek in northern San Diego County (NOAA Fisheries, 2005). Critical habitat has not been designated in the Santa Margarita River.

In the recovery planning process, the Technical Review Team and NOAA Fisheries have proposed a structure for the southern California steelhead DPS which separates populations within the DPS into five distinct Biogeographic Population Groups (BPGs), based on where potential freshwater habitats are found (inland or coastal) and sorted into groups defined by contiguous areas with broadly similar physical geography and hydrology. Santa Margarita River steelhead fall within the Santa Catalina Gulf Coast BPG (NOAA Fisheries, 2012). Within the Southern California Steelhead Recovery Plan, NOAA Fisheries describes three levels of "core" populations. Those key watersheds and steelhead populations within those watersheds that would form the foundation of recovery for the species are classified as Core 1 populations, while those watersheds and populations which could contribute to the set of populations necessary to achieve certain recovery criteria such as minimum numbers of viable populations are categorized as a Core 2 populations within the a BPG. Core 3 watersheds or populations are not considered necessary to form the foundation for southern California steelhead recovery but nonetheless should be actively pursued as a precaution to reduce the overall risk of extinction (NOAA Fisheries, 2012). Santa Margarita River steelhead have been designated as a Core 1 population in the final recovery plan for southern California steelhead (NOAA Fisheries, 2012; Table 7-1). As a Core 1 population, it has a high priority for recovery.

2.2 SPECIES DESCRIPTION

The presence of an adipose fin separates *O. mykiss* from all other native freshwater fish in anadromous streams in coastal southern California (Moyle, 2002). Juvenile steelhead are "trout-like" in appearance, lightly to heavily spotted with small black spots on a greenish-bluish back and elsewhere on the body as well as the dorsal, caudal, and adipose fins. Juvenile and larger freshwater resident fish can have a red to pink stripe down the mid-sides. Sea run fish are larger, lose the pink stripe, and present an overall silvery appearance with a "steely" blue-grey color dorsally (Moyle, 2002). Adult steelhead have large mouths with well-developed teeth on the upper and lower jaws. The caudal fin is forked. Scales are small with 18-35 rows above the lateral line and 14-19 below (TUCA, 2009). Anadromous southern California steelhead may attain larger sizes than the resident form, up to 9 kg or more (Hubbs, 1946 as cited by TUCA, 2009).

2.3 LIFE HISTORY

Adult steelhead inhabit the coastal and open ocean, entering coastal streams to spawn during high winter flows (Shapovalov and Taft, 1954). Migration and life history patterns of southern California steelhead depend more strongly on rainfall and streamflow than is the case for steelhead populations further to the north (Moore, 1980; Busby *et al*, 1996; Titus *et al*, 2000). Unfortunately, there is relatively little life history information available for the southern California steelhead DPS.

Southern California steelhead spawning migrations occur from December through April whenever river conditions allow. After adults enter coastal streams they swim upstream to available spawning habitat. Spawning is generally though to occur in late winter and early spring, although the specific timing may vary among streams within the region (NOAA Fisheries, 2008). Once suitable spawning sites are reached, females excavate a nest in the streambed gravel and deposit their eggs. Fertilization of steelhead eggs by male steelhead occurs during the egg deposition process. Adult steelhead do not necessarily die after spawning and may return to the ocean to repeat the cycle (NOAA Fisheries, 2012). Fertilized steelhead embryos incubate from three weeks to two months, depending on water temperature (NOAA

Fisheries, 2008). Emerging as fry two to six weeks after hatching (NOAA Fisheries, 2008), juvenile steelhead may remain in freshwater for 1-3 years (TUCA, 2009), before migrating back to sea. Conditions of southern California streams are often inhospitable to juvenile development resulting in greater dependence of juveniles on coastal lagoons or cooler headwater stream reaches for rearing (TUCA, 2009). Juveniles eventually migrate to the ocean where they grow to adults over the course of one to four years, before returning to their natal streams to spawn (NOAA Fisheries, 2012). Figure 2-1 provides an illustration of life-history strategies that may occur within the southern California steelhead DPS, as described by NOAA Fisheries in their recent draft Southern California Steelhead Recovery Plan (NOAA Fisheries, 2012).

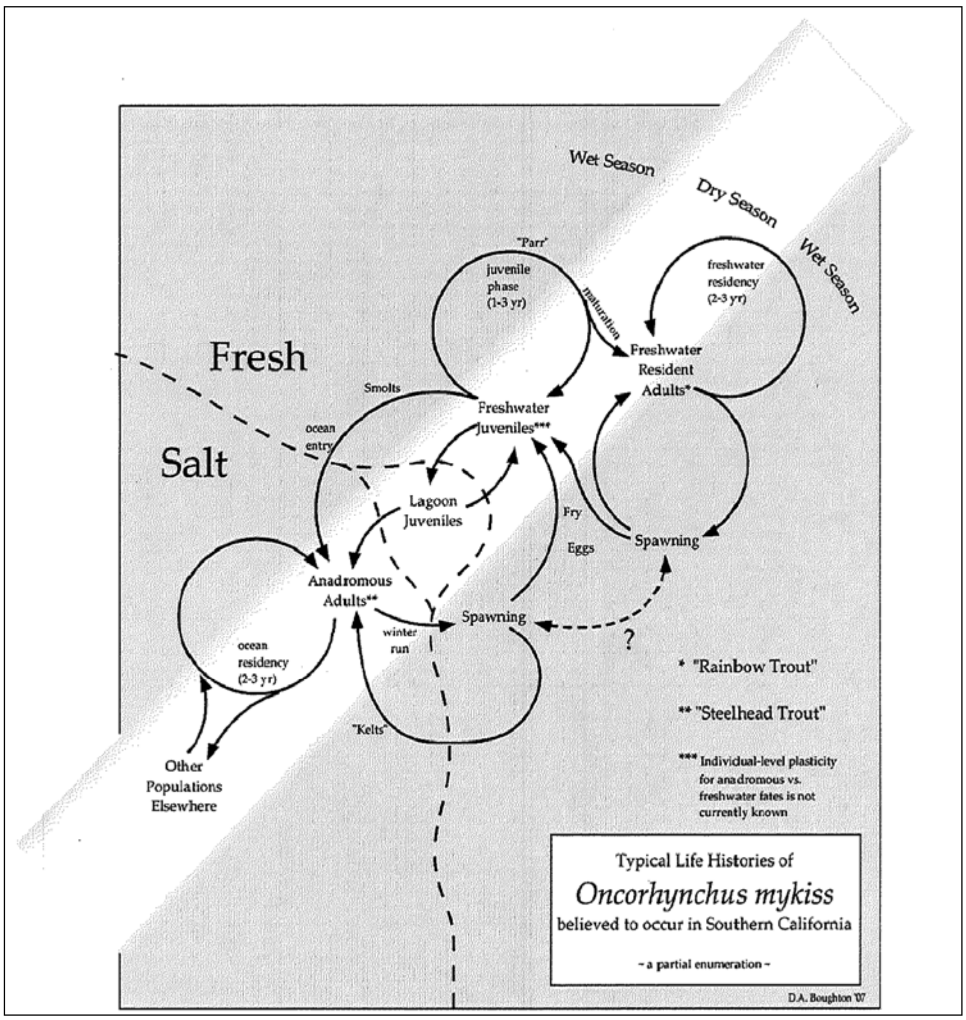


FIGURE 2-1 SUMMARY OF THE VARIOUS LIFE-HISTORY STRATEGIES EXHIBITED BY SOUTHERN CALIFORNIA *O. MYKISS*. [SOURCE: SOUTHERN CALIFORNIA STEELHEAD RECOVERY PLAN, NOAA FISHERIES 2012]

Southern California frequently experiences drought conditions that in some years limit accessibility of steelhead to coastal streams. This occurs when limited rainfall results in lower flows which are not sufficient to breach barrier sand bars at the mouth of many coastal streams. In such situations, southern California steelhead may need to spend additional years in the ocean environment before having a chance to reenter coastal streams to spawn.

Research conducted on more northern populations of steelhead found that they feed on various terrestrial and aquatic insects adjusting their seasonal diets to the aquatic and terrestrial insects available. Older steelhead feed primarily on zooplankton and invertebrate larvae, and nymphs. Mean prey size is typically less than 0.2 inches, although diets also included small terrestrial mammals, crayfish, and several species of fish (≤ 0.8 inches in total length) (Merz, 2002). Similar research conducted on southern California steelhead is not available (Rouse, personal communication, 9 March 2012). However, southern California steelhead would be expected to feed on similar organisms (Moyle, 2002).

2.4 STEELHEAD HABITAT

This study focused on passage and migratory habitat within the Lower Santa Margarita River and is based on direction received in the February 22, 2011 letter from NOAA Fisheries. As evident by the field investigation described below, only the river channel downstream of the POD was evaluated for suitable migration habitat. Although a discussion of spawning and rearing habitat for *O. mykiss* is included for completeness, this investigation confirmed a lack of any spawning habitat and only marginal conditions for rearing in the lower portion of the Santa Margarita River.

2.4.1 Migration Habitat

In coastal streams, steelhead typically migrate upstream when streamflows increase during winter storm events (Moyle, 2002) and/or after sandbars at the mouths of the coastal rivers are breached (Shapovalov and Taft, 1954). Depending on rainfall, upstream migration can typically occur from January through March in most southern California streams (Shapovalov, 1944a-b; Moyle and Yoshiyama, 1992; NOAA Fisheries, 1996). Passage criteria for migration of selected life stages of salmonids have been developed for a variety of situations (e.g. fishways, road crossings, culverts, etc) and have been reported in the literature (NOAA Fisheries, 2008 and 2003; Thompson 1972).

For steelhead and other salmonids, the ability to successfully pass upstream in open channels is frequently based on the Thompson criteria (Thompson, 1972) for depth of flow across critical passage cross sections within a given stream. The Thompson criteria apply a minimum depth of flow of 0.6 feet across at least 25% of the total wetted channel width and a contiguous portion equaling at least 10% of the total wetted width of critical passage cross sections. The Thompson criteria were developed from rivers in the Pacific Northwest and have been used in other southern California rivers including the Santa Clara (Harrison et al., 2006), Ventura (NOAA Fisheries, 2003), and Santa Ynez Rivers (SYRTAC, 1999). Several of these rivers have sandy substrate with unstable cross sections like the Santa Margarita River. Since the Thompson criteria are based on a stable cross section these criteria may have some limitations in predictability in sand bottom open channels such as the Lower Santa Margarita River. Specific criteria have not been developed for southern California rivers or for sand bedded rivers with unstable cross sections. The Thompson criteria were discussed with NOAA Fisheries staff during a February 10, 2011 field site visit and there was general concurrence that these criteria were applicable with the understanding that there may be some limitations and that no other criteria have been developed for southern California streams (A. Spina, personal communication, 10 Feb 2011).

2.4.2 Spawning and Rearing Habitat

Steelhead typically spawn in gravel substrate at pool heads, tail-outs, or in riffles (Moyle, 2002). Optimal size of gravel substrate ranges from 0.25 to 4 inches (Bjornn and Reiser, 1991). The female digs a pit in the gravel where she deposits her eggs. Often, more than one male will fertilize the eggs before the female covers the eggs with gravel, creating a redd (Moyle, 2002).

During incubation, sufficient water must circulate through redds to supply embryos with oxygen and remove waste products. An abundance of fine sediments can interfere with this process and result in embryo mortality (Bjornn and Reiser, 1991). Fertilized steelhead embryos hatch after three weeks to two months of incubation, depending on water temperature, and emerge as fry two to six weeks after hatching (NOAA Fisheries, 2008).

After emergence, fry initially occupy shallow water near the stream margin and then move into mid-channel habitat as they increase in size. Most juveniles occupy habitat adjacent to riffles and in pools. Steelhead require cool water typically under 21° Celsius that is also well oxygenated, although southern steelhead have demonstrated their ability to survive in warm (>21° Celsius) isolated pools with lower oxygen levels (TUCA, 2009). Instream cover such as cobble, rocks, undercut banks, large and small woody debris, and overhanging vegetation is important for juvenile steelhead survival.

The value of coastal estuaries/lagoons as rearing habitat for central, south-central and southern California steelhead varies depending on location along the coast. Estuaries/lagoons north of Point Conception that have deep-water areas, sufficient water quality, and invertebrate food resources can provide important seasonal rearing habitat during the spring, summer, and fall (Shapovalov and Taft, 1954; Smith, 1990; Bond, 2006). South of Point Conception, benthic fauna in the coastal lagoons shift away from an estuarine community toward a marine community. The habitat value of coastal lagoons for rearing steelhead from the Los Angeles Basin south is not well documented. Warburton et al (2000) note that the Santa Margarita estuary is defined by a freshwater section located upstream of Rifle Road, inhabited by exotic freshwater predatory species and a downstream segment inhabited by marine species. Consequently, the estuary does not appear to provide very suitable rearing habitat for steelhead.

The potential benefit to juvenile steelhead under the right lagoon/estuary conditions is rapid growth and an ability to attain a larger size before leaving their natal streams to the ocean environment (Smith, 1986). These larger fish have a greater likelihood of returning in subsequent years to spawn (Bond, 2006). In California, juveniles generally spend one to three years in freshwater before migrating to the ocean, which typically occurs between January and June (Shapovalov and Taft, 1954; Santa Ynez River Consensus Committee and Technical Advisory Committee, 1997; ENTRIX, 1996). It also appears that southern California steelhead may have adapted to the unpredictable climate with an ability to remain landlocked for many years or generations when access to the ocean is limited by hydrologic conditions (Titus et al., 1994; Hovey, 2004).

2.5 AVAILABLE HABITAT ON THE SANTA MARGARITA RIVER

The main channel of the Santa Margarita River consists of about 27 stream miles. Water flows southwest from the confluence of Temecula and Murrieta Creeks at the top of Temecula Canyon, entering the Pacific Ocean near Camp Del Mar (Becker and Reining, 2008). During the rainy season of November through April, streamflows increase, depending on the frequency and magnitude of storm events, then diminish during the summer months, often going dry throughout many of the reaches downstream of the POD.

Historically, the Santa Margarita River was thought to have provided habitat to support steelhead runs of unknown size at least through the late 1940's (USFWS, 1998). Anecdotal information, as cited in USFWS 1998, suggests that the steelhead population within the Santa Margarita River began to decline prior to the 1940's when a dry cycle began that lasted until the 1970's. The USFWS (1998) indicated that throughout the mid 1950's, there were extended periods when streamflow in the Santa Margarita River was inadequate to reach the ocean during the historically wet months of February through April, which would severely limit the opportunity for adult and juvenile steelhead to migrate. During this time, and also based on anecdotal information as reported in USFWS, 1998, it is believed that the landlocked steelhead population occupying the Santa Margarita River was greatly reduced during the summer months or likely extirpated due to competition, fishing pressure, and disease. Steelhead populations were further impacted by urban and agricultural development and introduction of exotic species in the upper watershed (USFWS, 1998). A study in May of 2000 was completed to assess the "Status and Distribution of Fishes in the Santa Margarita River Drainage" and determined excellent potential for reestablishment through deliberate re-introduction or possible natural re-colonization by steelhead if conditions were improved (Warburton et al., 2000). Potential steelhead rearing habitat was identified at several locations upstream of the POD: about 11-12 kilometers (km) on upper De Luz Creek; on Sandia Creek, starting from the mouth and extending about 4-5 km upstream; on the lower five km of Rainbow Creek; on Stone Creek from the mouth extending about two km upstream; and on the main river from about the De Luz Ford on the Base to the top of the Gorge, totaling about 32 km of river length (Warburton et al., 2000). Upstream of the Gorge, Temecula Creek dries for too great a distance or is inaccessible behind Lake Vail. The other tributaries, such as Arroyo Seco and Cottonwood Canyon, are too dry or have natural barriers to access headwater areas. Warburton et al (2000) surmised that the main stem of Temecula Creek down to the top of the Gorge was probably a major rearing and spawning area for steelhead before 1900.

Within the Santa Margarita River, potential steelhead spawning and rearing habitat occurs upstream of the CUP's POD and therefore would not be directly affected by the diversion. The lower Santa Margarita River (from the POD downstream to the estuary) is potentially a migration corridor for steelhead. The May 2000 survey, described by Warburton et al (2000), noted that the only areas with spawning potential were Roblar Creek below the barrier falls about 1.5 km above its confluence with De Luz Creek and the main river in the first three km below the crossing of De Luz Road. Within the boundaries of Camp Pendleton, the Santa Margarita River can be described as a sand-dominated, plain-bed stream with shallow depth of flows over sandbars. The entire lower river (downstream of the POD) is flat water habitat with no pools or riffles (USFWS, 1998). Giant reed (*Arundo donax*), and willow (*Salix spp*) are the dominant bank vegetation. Upstream of Camp Pendleton, habitat changes slightly to incorporate a small percentage of riffles and pools with greater heterogeneous conditions (USFWS, 1998). River water temperatures near Fallbrook recorded in 1995 and 1996 show that average monthly temperatures in July, August, and September exceed the reported lethal limit for steelhead (>25° Celsius) (USFWS, 1998), further evidence supporting the lack of rearing habitat in the Lower Santa Margarita River.

2.6 STEELHEAD OCCURRENCE IN THE SANTA MARGARITA RIVER

There is limited documentation regarding the abundance of anadromous steelhead in the Santa Margarita River. In May 1939, the University of Michigan collected what was identified as a juvenile steelhead/rainbow trout from the lower river for its zoological museum collection (Swift et al., 1993). It is believed that adult steelhead may have ascended the Santa Margarita River into the 1970's (Swift, 1975 as cited in Higgins, 1991). The California Department of Fish and Game (CDFG) has planted hatchery rainbow trout in portions of the Santa Margarita River as recently as 1984, but Higgins (1991) saw no evidence of a naturalized population resulting from these plants. De Luz Creek, a tributary to the Santa Margarita, has also received CDFG plants of hatchery rainbow trout.

The earliest documentation of steelhead within the Santa Margarita River is almost entirely anecdotal. During the 1940's there is some documentation of adult steelhead in the Santa Margarita River, although their numbers were low (USFWS, 1998). As late as 1958 there were stated observations of steelhead near the mouth of the Santa Margarita River (California Coastal Zone Conservation Commision, 1975, as cited in USFWS, 1998). A comprehensive survey of the Santa Margarita River drainage was conducted over a three year period, from the fall of 1997 through the spring of 2000, with the objective of exhaustively establishing the extent of the distribution of native and exotic fish species. *O. mykiss* were not reported among the eleven species of fish (two native species and nine introduced species) found within the Santa Margarita River (Warburton et al., 2000).

Recently, NOAA Fisheries reported that a tissue sample obtained from an *O. mykiss* captured in the Santa Margarita River during the spring of 2009 was identified through genetic testing to be of wild steelhead ancestry with no indication of hatchery origin (NOAA Fisheries, 2010a). Although genetic testing of the tissue sample positively identified the captured *O. mykiss* to be of wild steelhead ancestry, an otolith sample was not taken which would have confirmed whether the fish was an offspring of wild native resident trout or wild steelhead which had migrated upstream (Kalish, 1990; Volk et al., 2000).

Based on available water temperature data it is unlikely that the lower Santa Margarita River (downstream of the POD) supports a year round steelhead population as average summer (May through September) water temperatures may exceed the reported lethal limit for steelhead (>25ºC). As mentioned in Section 2.5, river water temperatures near Fallbrook recorded in 1995 and 1996 showed that average monthly temperatures in July, August and September exceeded the reported lethal limit (USFWS, 1998). In addition, river water temperatures at the FPUD sump near Fallbrook during water years 2008 and 2009 have been reported at or near the reported lethal limit, especially during the months of July and August (Stetson, 2010b). These data suggest the lack of suitable rearing habitat for steelhead in the lower Santa Margarita River due to excessive water temperatures during the summer months. In contrast, water temperatures in the Lower Santa Margarita River during the steelhead migration period (January through March) may be suitable for steelhead adults and juveniles, thus enabling migration to and from rearing and spawning areas that could be located further upstream in the Santa Margarita River or its tributaries.

3.0 FIELD SURVEY AND HYDRAULIC MODELING

A field survey of the Santa Margarita River channel was conducted from the sheet pile weir in the Upper Ysidora Subbasin through the Lower Ysidora Narrows (Figure 3-1). Longitudinal and cross-sectional profiles were developed from the survey data and three representative sites were chosen to investigate and describe fish passage criteria in the Lower Santa Margarita River. A HEC-RAS hydraulic model was used to develop stage-flow relationships for each site based on the channel morphology and to assess the minimum flow passage criteria of anadromous fish.

3.1 TOPOGRAPHIC, GEOMORPHIC AND BIOLOGICAL CHARACTERIZATION

The steelhead passage assessment took place on the Lower Santa Margarita River from the location of the current diversion structure to the estuary, a 9-mile reach of stream channel characterized by long-term sediment storage and active transport. The reach is typified by a relatively low gradient (0.2%), and a meandering, actively migrating sand-bedded channel with broad, vegetated floodplains. The Lower Santa Margarita River is confined by the Ysidora Narrows beginning about three miles upstream from the Pacific Ocean. The channel is also an actively migrating sand-bedded channel in the Narrows, supported by a shallow alluvial groundwater table.

3.1.1 Longitudinal Profile Survey to Identify Potential Fish Passage Barriers

During the week of March 8, 2011, a field survey of the longitudinal profile of the Santa Margarita River was conducted from the sheet pile weir to the estuary near the Stuart Mesa Bridge, approximately 9.23 river miles. The survey was conducted over the course of five days, with a three-person crew utilizing a Leica theodolite (total station model TCR-705), staff rods, and stationing prisms. The survey transect was tied to known coordinates and datum on the upstream end near the Naval Hospital, and on the downstream end near the estuary. The survey data was used to develop a longitudinal profile of the river, which was used in the identification of potential critical passage sites for the river channel. The resulting longitudinal survey and water surface profile is depicted in Figure 3-2.

Coordinated field investigations at six potential sites were undertaken on April 18th and 19th, 2011 following a review of the longitudinal survey profiles. Stetson hydraulic engineers, Cardno ENTRIX fish biologists, and the Base's fisheries biologist visited six reaches along the Santa Margarita River that were selected based on shallow depth of flow or bar features that may present the most limiting passage conditions. Three of the reaches were recognized as the most

NOTES:
1. AERIAL PHOTO SHOWN IS DATED 2007.
2. SURVEY DATA SHOWN WAS COLLECTED ON MARCH 8-12, 2011.

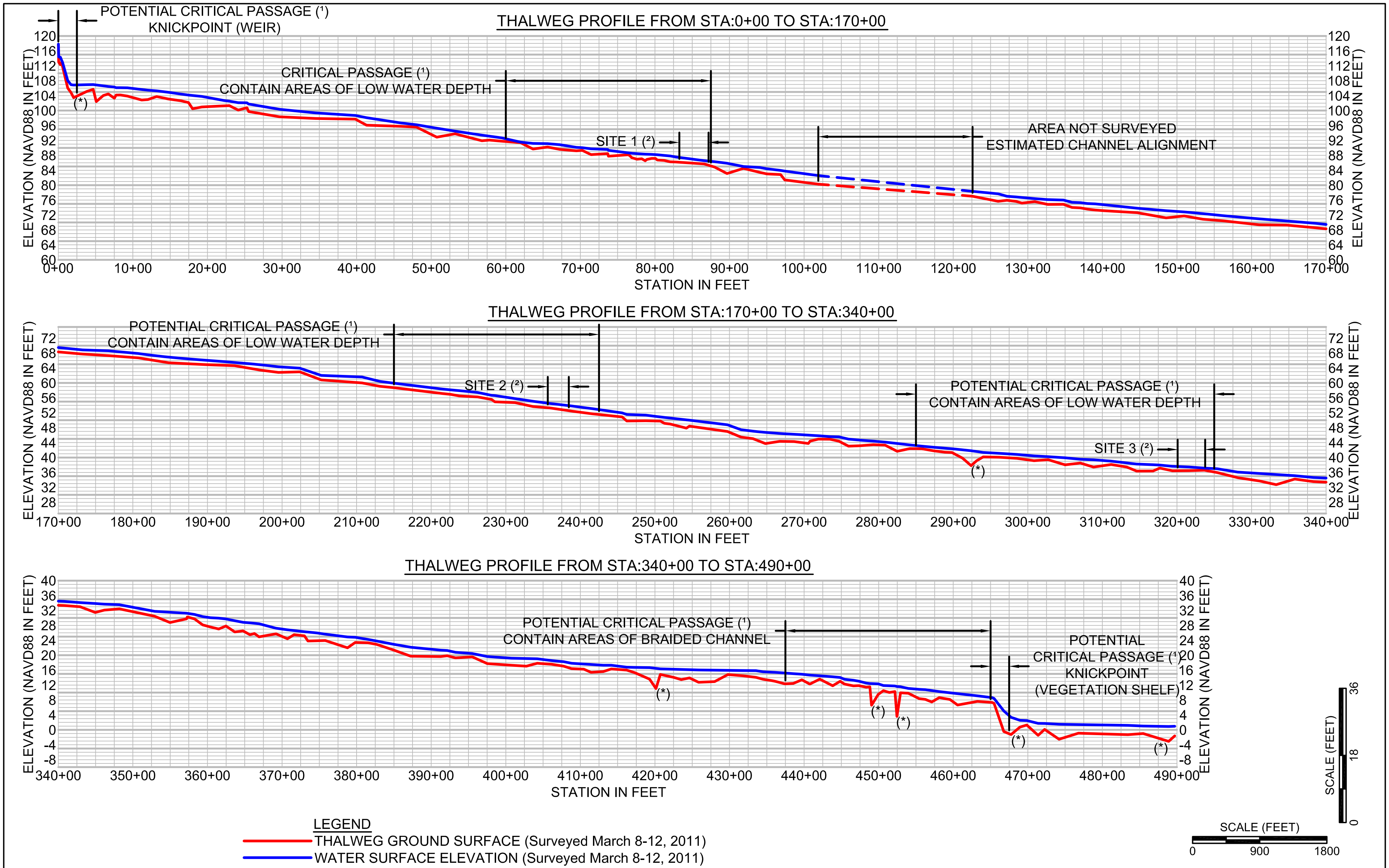
STETSON ENGINEERS INC.

LOCATION AND EXTENT OF LONGITUDINAL SURVEY

MARINE CORPS BASE CAMP PENDLETON - SAN DIEGO, CA

N W E S

SCALE (MILES) 0 0.25 0.5 1



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LONGITUDINAL THALWEG AND WATER SURFACE PROFILE, MARCH 2011

MARINE CORPS BASE CAMP PENDLETON - SAN DIEGO, CA

NOTES:
(*) ESTIMATED POOL BOTTOM ELEVATION.
(¹) 6 REACHES IDENTIFIED DURING THE MARCH 2011 SURVEY EVENT AS POTENTIAL CRITICAL PASSAGE REACHES.
(²) 3 CRITICAL PASSAGE SITES DETERMINED DURING APRIL 2011 FIELD VISIT AS REQUIRING FURTHER INVESTIGATION.

FIGURE 3-2

characteristic of critical salmonid fish passage sites in the Lower Santa Margarita River due to their shallow sandy substrate.

The predominant aquatic habitat feature within the survey area was generally found to be uniform glides or "flat water" with essentially laminar flow and relatively shallow depths. Some areas, especially within the river reach described as "The Narrows" had limited undercut banks, in-water debris, or overhanging brush that could constitute effective cover for fish. Substrate, however, was almost entirely shifting sand. No pools were observed that could be characterized as "holding", rearing or over-summering areas for juvenile salmonids. However, qualitatively, there did appear to be adequate depths and habitat for anadromous fish passage throughout the reach, at the water level present during the time of the survey.

Additional field survey measurements were collected for the three chosen river segments to characterize the topography of the stream channel in more detail and to provide a comprehensive overview of each of the chosen sites. Surveying was conducted utilizing a total station, staff rods, and stationing prisms and was tied to the prior March 2011 survey control points. The field data were compiled and analyzed using AutoCAD. Topographical survey data are shown in Appendix E, and include the river channel and cross-sections along the thalweg at each site. The topographical field surveys were used to determine the migration-limiting corridors and define representative cross-sections for hydraulic modeling.

The other three locations that were identified during the initial survey as potential areas for further investigation for salmonid passage were dismissed from further investigation during the field visit. One location was immediately downstream of the sheet-pile weir and was recognized as a potential limiting passage reach due to the high gradient and riprap armament placed on the downstream side of the weir. The other two locations identified as potential locations of limited fish passage occur near the Narrows between the Lower Ysidora Subbasin and the lagoon: one, a section of river with high gradient, and the other a braided channel section. These three locations were visited or reviewed and dismissed due to limited concern for current and/or future post-CUP fish passage.

3.1.2 Biological Survey and Habitat Characterization

The longitudinal survey described in section 3.1.1 qualitatively characterized potential channel habitat conditions (i.e. runs, holding pools) within the study reach along with geomorphic features (i.e. sandbars, bedrock outcroppings) and identified potential critical passage sites (see below) for anadromous fish within the Lower Santa Margarita River downstream of the POD. Nearly the entire reach from upstream of the Lower Narrows to the

POD is run habitat. A few holding pools were observed in the Lower Narrow, located immediately upstream from the estuary.

3.1.3 Characterization of Three Potential Critical Passage Sites

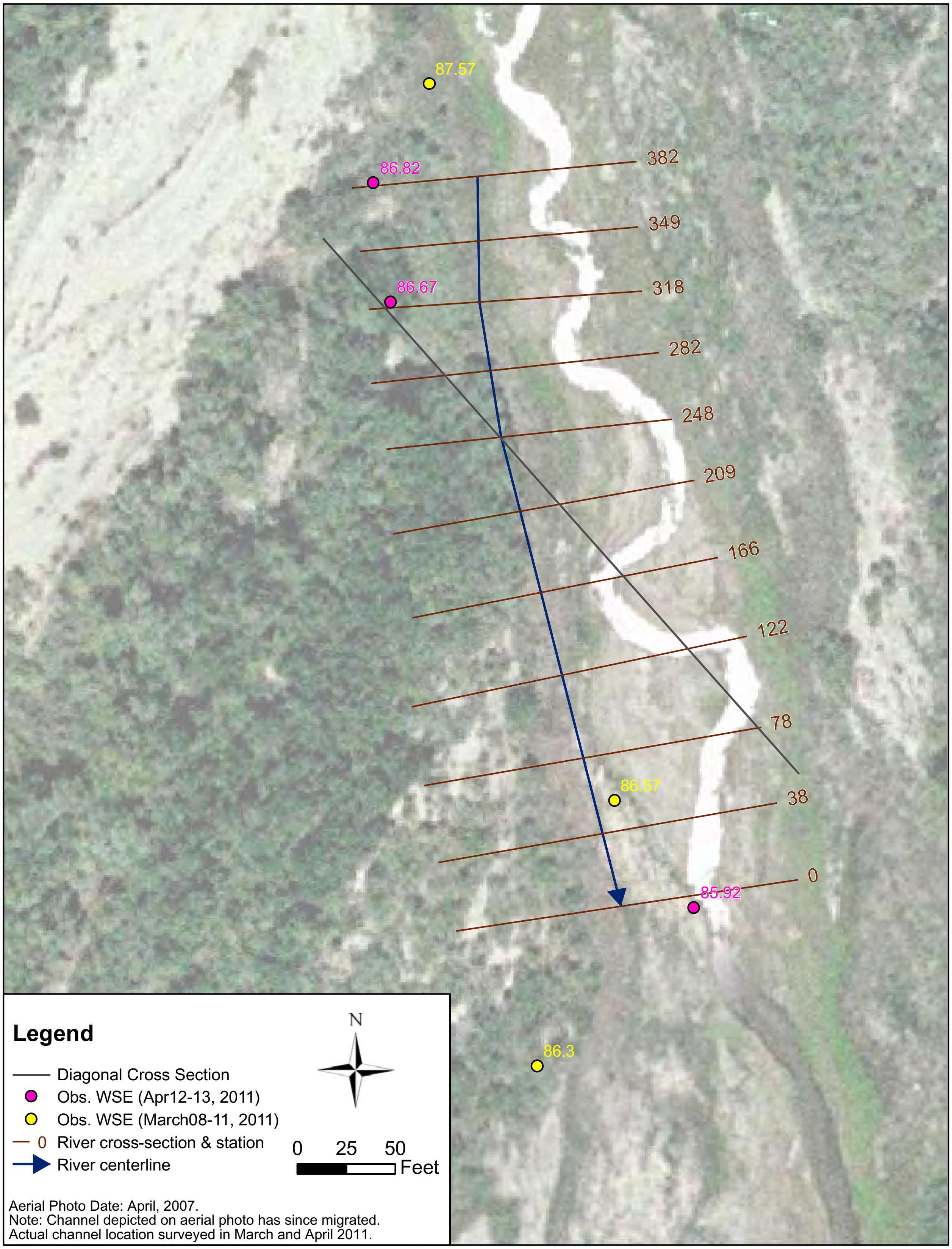
Geomorphology, hydrology, and available habitat data collected as part of this assessment and previous studies (USFWS, 1998) were used to select representative "critical passage sites" for flow modeling and potential passage assessment within the study area. Based on our initial longitudinal survey of the Santa Margarita River from the POD to the estuary (see above), three potential critical passage sites were selected for further analysis. The general location and physical characteristics of the three selected sites are provided in Figure 3-1 and Table 3.1, respectively. The fish passage cross-sections for the three sites are shown in Figures 3-3, 3-4, and 3-5. Initially five additional cross-sections were added at Site 1 in order to describe a proposed diagonal biological cross-section (grey line in Figure 3-3). The diagonal biological cross-section was disregarded in the final analysis due to its inappropriate orientation. Sites 1, 2, and 3 are typical low-flow channels with wide, flat, and low longitudinal gradients.

TABLE 3.1 GENERAL PHYSICAL CHARACTERISTICS OF SITE LOCATIONS

ID	Location	Length (ft)	Width (ft)	Gradient	River Bed Conditions
Site 1	~1 mile above gage[1]	380	140-175	0.246%	sandy, clear, vegetation free
Site 2	~2 miles below gage	285	56-130	0.365%	sandy, clear, vegetation free
Site 3	~3.5 miles below gage	360	110-140	0.285%	sandy, clear, vegetation free

Note:
1. "Gage" is the USGS Gage at Ysidora (11046000)

Although the actual physical locations of the potential barriers to fish passage may change in the future, the characteristics that describe those barriers are not expected to vary from those surveyed in this study. Hence, the three sites identified in this study are representative of typical barrier conditions and are appropriate for describing existing and future potential barriers to fish passage.



JobFolder/12199-5007/FinalFigures(2011-08-03)/Fig 3-3 Site 1 - Fish XS.ai

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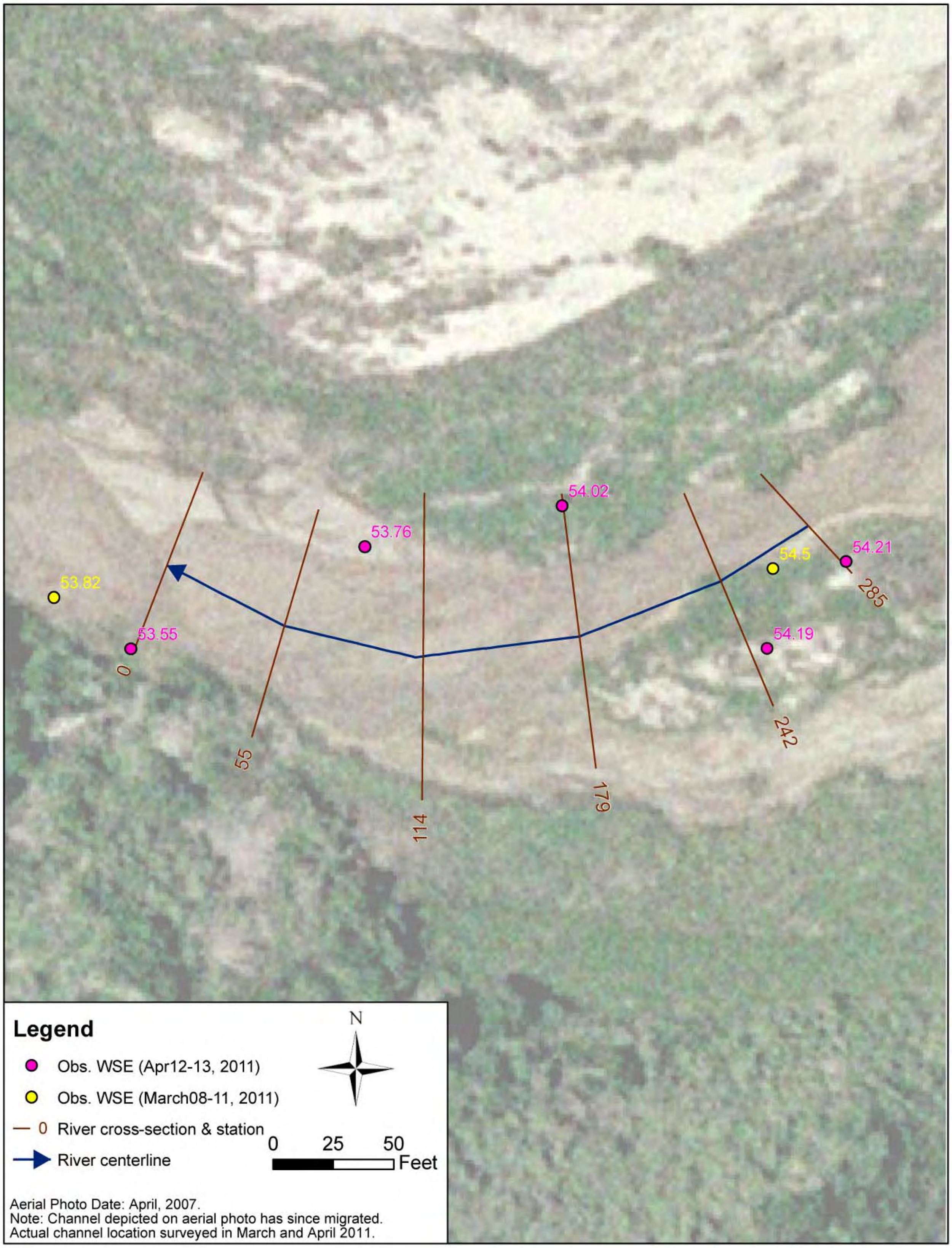
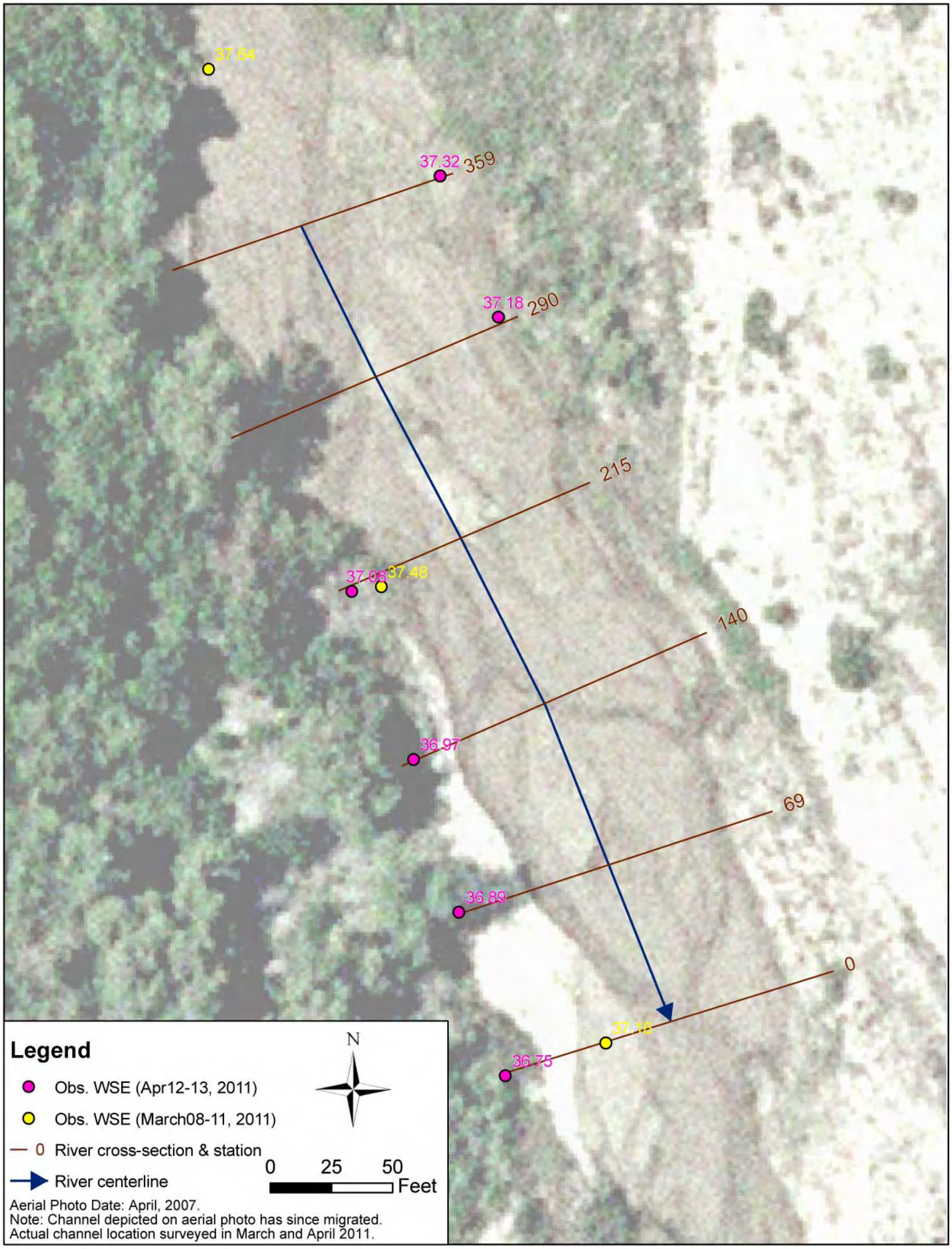
SITE 1: MODEL LAYOUT AND OBSERVED WATER SURFACE ELEVATION



STETSON ENGINEERS INC.

SITE 2: MODEL LAYOUT AND OBSERVED WATER SURFACE ELEVATION



JobFolder/12199-5007/FinalFigures(2011-08-03)/Fig 3-5 Site 3 - Fish XS.ai

STETSON ENGINEERS INC.

SITE 3: MODEL LAYOUT AND OBSERVED WATER SURFACE ELEVATION

3.2 HEC-RAS HYDRAULIC MODEL DEVELOPMENT

HEC-RAS (current version 4.1.0) is a computer program developed by the Army Corps of Engineers (ACOE) to model the hydraulics of one-dimensional flow through natural rivers and other channels. HEC-RAS is often used to calculate the water surface profile, flow depth, and flow velocity for a given flow event in an open channel. The HEC-RAS hydraulic models developed for the fish passage study relied on the geo-referencing tool, HEC-GeoRAS (current version 4.3), which is a set of ArcGIS tools specifically designed to pre-process inputs to HEC-RAS and post-process outputs from HEC-RAS models. By using both HEC-RAS and HEC-GeoRAS, the river hydraulic parameters, such as the water surface elevation, water depth, and flow velocity distribution, can be effectively calculated and visualized on GIS platforms.

Considering that the three typical cross-sections selected for the fish passage study are small (less than 380 feet in length) and far apart from each other, three separate HEC-RAS models were developed for the three sites.

The first step in developing the HEC-RAS model for each of the three Sites was to create the river geometry files. HEC-RAS "sees" the river geometry by a series of cross-sections along the reach that are perpendicular to the overall stream flow direction. The placement and spacing intervals of such cross-sections should capture the channel geometry variations. Based on the general cross-section placement guidelines and site specifics, a total of six model cross-sections were developed for each of the three sites. HEC-GeoRAS was then used to delineate the geo-referenced model cross-sections and to extract cross-section profiles from the Triangulated Irregular Network (TIN) surface constructed using the topographic survey data. The model layouts, together with field-surveyed water surface elevations (WSE), are shown in Figures 3-3, 3-4, and 3-5.

The three HEC-RAS models were developed as steady-state models to simulate flow within the measured cross-sectional areas of the channel (*i.e.,* less variation in flow hydrograph). The boundary conditions at the downstream and upstream ends for all the three models were set as *normal depth*, which means the water surface gradient and the channel bottom gradient were basically the same and the water depth generally remains constant. The use of normal depth as the boundary condition is reasonable, because these sites are quite flat with low channel bed gradients, and the water surface profiles are smooth. The "mixed flow regime" option was used for model runs, which allows the models to automatically determine whether the flow is to be sub-critical or super-critical.

3.2.1 HEC-RAS Model Calibration and Verification

The flow data for model calibration and verification were based on the observations at the United States Geological Survey (USGS) flow gage at Ysidora (USGS #11046000). The stream hydrograph from February 26, 2011 through April 17, 2011 during the period of the two field investigations is shown in Figure 3-6. The data from the April 12-13 topographic survey were used for model calibration due to the stable flow of the river. The data collected during the March 8-10 survey were used for verification. The flow rate measured at the Ysidora gage was 66 cfs during the April survey while the flow rate varied between 109 cfs and 134 cfs during the March survey (Table 3.2). It was assumed that the recorded flow rate at the Ysidora gage represents the actual flow rates at the three sites during the spring. This assumption was reasonable as evidenced by the model calibration results.

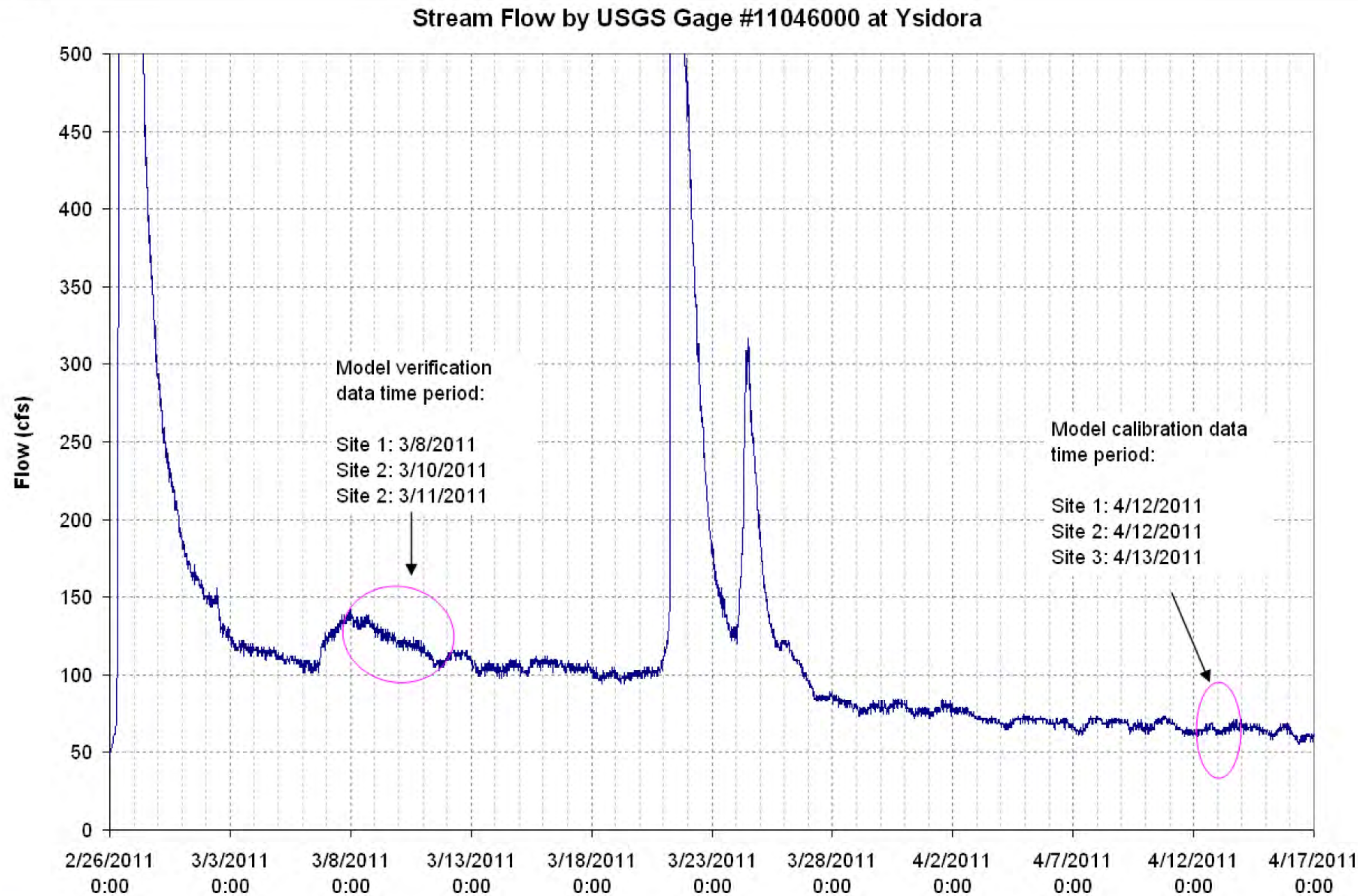
TABLE 3.2 DATA FOR CALIBRATION AND VERIFICATION OF HEC-RAS MODELS

	Calibration			Verification	
ID	**Date**	**Flow (cfs)**	**WSE (ft)**	**Date**	**Flow (cfs)**
Site 1	4/12/11	66	85.52 - 86.82	3/8/11	134
Site 2	4/12/11	66	53.55 - 54.21	3/10/11	119
Site 3	4/13/11	66	36.75 - 37.32	3/11/11	109

Note: Corresponding water surface elevation flows measured in the field for verification are shown on Figures 3-3 through 3-5.

Model calibration is a process to adjust river bed roughness, or Manning's "n", within a reasonable range so that the model computed water surface elevations match measured values. The reasonable range of Manning's n for the three sites was estimated to be within 0.02 – 0.04, based on literature values for a natural river bed that is clear, sandy, and free of vegetation. By trial and error, a Manning's n of 0.025 was determined to be the calibrated river bed roughness for all the three sites. The comparison between the model-computed and field-observed water surface profiles is shown in Appendix F (Figures F1a, F1c, and F1e). These results shown in the figures indicate all the three models are well calibrated.

Model verification is a process to examine if the model performs well with a different set of flow rate and water surface profile data. The verification model run results are shown in Appendix F (Figures F1b, F1d, and F1f). The results from these figures indicate that all three models tend to slightly underestimate water surface profiles by 0.13 – 0.34 feet (1.5 – 4 inches). However, these models are still considered successfully verified because: (1) the absolute errors are small; (2) the water surface elevations were surveyed in a separate field trip using different



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PROVISIONAL WINTERTIME DAILY STREAMFLOW AT USGS GAGE AT YSIDORA #11046000
DECEMBER THROUGH APRIL, 2011

FIGURE 3-6

control points, which could contain consistent discrepancies in elevations; and (3) the stream flow for the verification time period was not as stable as that for calibration time period, which could introduce flow estimate errors for the sites. Overall, the HEC-RAS models for the three sites are well calibrated and verified, and are appropriate for running flow simulations within the measured banks of the cross-sectional area.

3.2.2 HEC-RAS Model Simulations

The HEC-RAS models for the three sites were first used for two objectives: (1) determination of the low flow (non-flood flow) channel bankfull capacity; and (2) determination of the elevation versus flow rate rating curves up to bankfull capacity.

The low-flow bankfull capacity of the measured cross-sectional area is the flow rate at which the model-computed water surface profile begins to touch the lowest top of banks at the model cross-sections. By trial and error, it was determined that the full capacity for Sites 1, 2, and 3 is 1,200 cfs, 350 cfs, and 1,000 cfs, respectively.

The water surface elevation versus flow rating curves were determined by running a series of flows through the models at 5-cfs increments for flows less than 100 cfs, and 100-cfs increments for flows between 100 cfs and the bankfull capacity. The rating curves for the three sites are shown in Appendix F (Figures F1a, F1b, and F1c).

The three calibrated HEC-RAS models were then used to analyze fish passage at the three sites. A description of these procedures is given in Section 5.3.

4.0 LOWER SANTA MARGARITA RIVER HYDROLOGY

The 744-square mile Santa Margarita River Watershed lies in both San Diego and Riverside Counties, including over 60 square miles of the watershed located within the boundaries of Camp Pendleton. The Santa Margarita River Watershed may be divided into two distinct subwatersheds referred to as the Upper Watershed and Lower Watershed (Figure 4-1). The Upper Watershed includes the watershed and drainage area located above the confluence of Murrieta and Temecula Creeks, a point referred to as the Gorge. The Lower Watershed includes the drainage area downstream of the Gorge to the Pacific Ocean. Major tributaries in the Lower Watershed include De Luz, Sandia, and Rainbow Creeks, all of which are monitored and measured by the USGS.

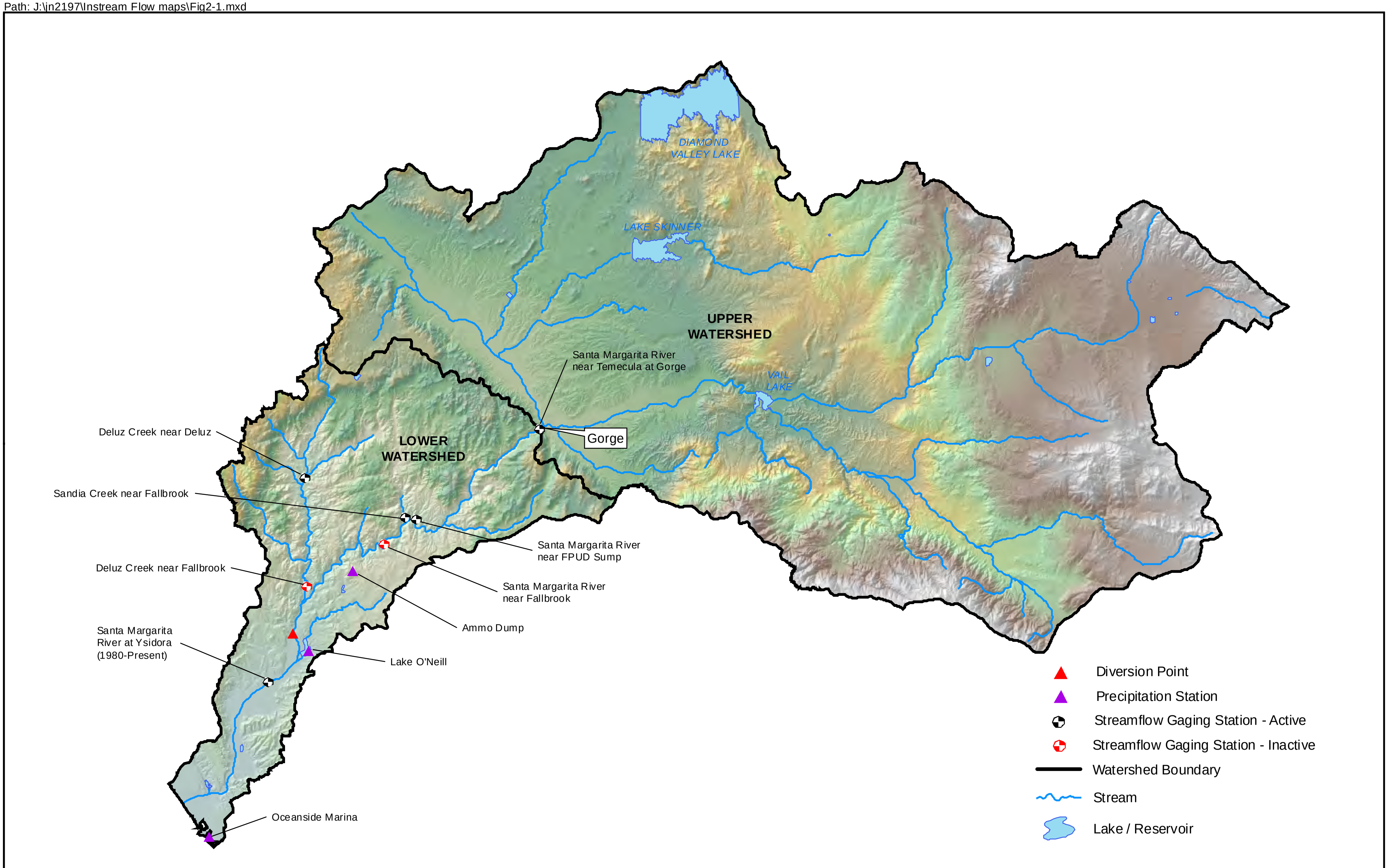
The groundwater basins in the Santa Margarita River Watershed may also be divided into the Upper and Lower Basins. The Upper Basin commonly refers to the Murrieta-Temecula groundwater basin located up-gradient of the Gorge; additionally, the Anza Basin, separate from the Murrieta-Temecula basin, is also located up-gradient of the Gorge. The Lower Basin includes the groundwater basin located entirely on Camp Pendleton which is further divided into the Upper Ysidora, Chappo, and Lower Ysidora Subbasins.

The Lower Santa Margarita Basin is typified by a relatively flat alluvial floodplain that drains from the northeast to the southwest. Surface water and groundwater occur in the alluvial regions that are bounded by rock units that form sloped borders to the north and to the south of the alluvium. The 27-mile long Santa Margarita River begins at the Gorge and terminates at the Pacific Ocean. The watershed is identified by the USGS as the Santa Margarita Hydrologic Unit (HU) 18070302. The SWRCB classification system designates the Lower Santa Margarita River Watershed as the Ysidora Hydrologic Area (HA) 902.10. The Ysidora HA is further subdivided into the Upper Ysidora Hydrologic Sub-Area (HAS) 902.13, the Chappo HSA 902.12, and the Lower Ysidora HSA 902.11. The Base's Lower Santa Margarita Basin groundwater production wells are located within these three subbasins.

4.1 CLIMATE AND PRECIPITATION

Climate at the Base is characteristic of a Mediterranean climate, with hot dry summers and mild wet winters. It can be described as a semi-arid coastal climate typical of southern California and is controlled by the Pacific Ocean, which provides light to moderate precipitation during the winter months (November to April). Occasional heavy rains, creating major flooding events for this region, typically occur in the winter months between December and March.

Path: J:\jn2197\Instream Flow maps\Fig2-1.mxd



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SANTA MARGARITA RIVER WATERSHED STREAM AND PRECIPITATION GAGE LOCATIONS

FIGURE 4-1

Summer streamflows are low, and often go subterranean in the dry months of June to October since 90% of the precipitation occurs during the winter months.

Temperatures generally range between 33° and 90° Fahrenheit. The region is exposed to dry easterly Santa Ana winds in the fall and heavy fog in the summer. Frosts are light and infrequent, occurring occasionally in winter, with the growing season ranging from 345 to 360 days. The average annual temperature is about 63° Fahrenheit. The average daily high is 75°, and the low is 53° (Malloy, 2006).

Precipitation stations on and near the Base are listed in Table 4.1. Precipitation is monitored by the Camp Pendleton Fire Department (CPFD), the National Weather Service (NWS), Riverside County Flood Control and Water Conservation District (RCFCD), and the Naval Weapons Station, Fallbrook Annex (FNWS). Precipitation is monitored daily at all stations.

TABLE 4.1 PRECIPITATION STATIONS ON OR NEAR CAMP PENDLETON

Station Name	Operating Agency	Elevation[1] (ft above MSL)	Latitude[2]	Longitude[2]
Ammo Dump	FNWS	1,068	33°22’53”	117°17’08”
Lake O'Neill	CPFD	120	33°19’46”	-117°19’10”
Oceanside Marina	NWS	100	33°12’35”	-117°23’42”
Wildomar	RCFCD	1,255	33°37’30”	-117°20’06”

Notes:
1. Elevation referenced to National Geodetic Vertical Datum of 1929 (NGVD29).
2. Latitude and Longitude referenced to North American Datum of 1927 (NAD27) except Oceanside Marina which is referenced to North American Datum of 1983 (NAD83).

Orographic features significantly affect precipitation throughout the watersheds. Hills deflect moisture-laden air masses upward, causing them to cool and precipitate moisture. Most precipitation is associated with low intensity storms in winter and spring. The average annual precipitation is significantly less in the lower portions of the watersheds due to the lower elevations. Statistics for each station for the period of record are given in Table 4.2.

TABLE 4.2 PERIOD OF RECORD STATISTICS FOR PRECIPITATION STATIONS

Station Name	Period of Record (WY)	Precipitation (inches)			
		Average	Median	Max	Min
Ammo Dump	2002 – 2009	12.5	10.7	30.4	0.1
Lake O'Neill	1876 – 2009 [1]	14.0	12.2	35.0	4.3
Oceanside Marina	1944 – 2005 [2]	10.4	9.0	24.6	3.8
Wildomar	1914 – 2009	13.8	11.7	34.8	3.1

Notes:
1. Lake O'Neill records are monthly from 1876-1913 and daily thereafter.
2. Records at Oceanside Marina for WY 2006-2009 are poor and statistics cannot be computed.

4.2 STREAMFLOW RECORDS AND DATA

A summary of streamflow station information and flow statistics for USGS streamflow gages is shown in Table 4.3 and Appendix B. There are seven streamflow gages in the Santa Margarita River Watershed used to reconstruct flow at the POD. The longest continuous streamflow record is at the Santa Margarita River near Temecula (11044000) which began in February of 1923. Collectively, the streamflow data show that the Santa Margarita River is a perennial stream in the upper reach and intermittent in the lower reach.

TABLE 4.3 STREAM GAGING STATIONS USED TO RECONSTRUCT STREAMFLOW IN THE SANTA MARGARITA RIVER AT THE POD

Station Name	USGS Station ID No.	Operating Agency	Period of Record	Drainage Area[1] (square miles)
Santa Margarita River near Temecula (Gorge)	11044000	USGS	2/23-Present	588.0
Santa Margarita River at FPUD Sump	11044300	USGS	10/89-Present	620.3
Sandia Creek near Fallbrook	11044350	USGS	10/89-Present	19.7
Santa Margarita River near Fallbrook	11044500	USGS	10/24-9/80	644.1
De Luz Creek near De Luz	11044800	USGS	10/92-Present	33.1
De Luz Creek near Fallbrook	11044900	USGS	10/51-9/67	47.4
Santa Margarita River at Ysidora (various locations)	11046000	USGS	3/23-Present	723.0

Note: 1. Drainage areas for gages 11044000 and 1104600 from USGS. Drainage areas for gages 11044300, 11044350, 11044500, 11044800 and 11044900 delineated using 1/3 Arc Second DEM, USGS, multiple years.

Additional streamflow and hydrologic data are available for the Santa Margarita River Watershed upstream of the Gorge, including: the main tributaries of Murrieta and Temecula Creeks; and minor tributaries such as Santa Gertrudis, Warm Springs, and Pechanga Creeks. Vail Lake is a 49,000 AF reservoir located on Temecula Creek that operates under Permit 4032 to divert up to 40,000 AFY during the winter period of November through April. Skinner Reservoir and Diamond Valley Lake are imported water storage reservoirs owned by the Municipal Water District of Southern California (MWD) and are operated under a MOU with the Santa Margarita River Watermaster. Generally, the MOU allows the storage reservoirs to capture naturally occurring inflows which are subsequently released over time. Data for the creeks and reservoirs are available from the USGS, Watermaster, and MWD.

The daily streamflow hydrograph of the Santa Margarita River near Temecula (USGS 11044000) is shown for the period WY 1923 through WY 2010 (Figure 4-2). The extreme variation in average daily flow, ranging between 1 cfs and 33,000 cfs, is characteristic of many southwestern United States stream systems that are driven by intense winter-time rainfall events. Extended hydrologic wet and dry cycles are also characteristic of the Santa Margarita River Watershed as depicted by both winter-time peak events and spring and summer-time base flows. The period from WY 1958 through 1965 is generally considered one of the driest periods of record while the late 1970s and early 1980s were some of the wettest years on record. The impact of upstream urbanization, historical water management practices, and increased water use is depicted by the long-term decline in baseflows that occurred through the 1980s and increased frequency (flashiness) of winter-time runoff events. Increases in summer-time baseflows, beginning in the 1990s, is due enforcement of the 1940 Stipulated Judgment and later through the CWRMA, which was implemented in 2003.

The flows that occur at the Santa Margarita River near Temecula gage are generally indicative of the flows at the POD on Camp Pendleton. While there are variations between northern Pacific storms that tend to affect streamflow throughout the entire watershed and El Niño driven storms that disproportionally affect the lower portion of the watershed, the entire watershed experiences a wide variation in wet and dry cycles.

4.3 Previous Hydrologic Modeling Investigation – Indicators of Hydrologic Alteration (IHA)

The February 22, 2011 letter from NOAA Fisheries specifically requested results from an IHA analysis of the Santa Margarita River streamflow that was performed during the settlement negotiations that led to the CWRMA flow augmentation schedule. The IHA model program relies on daily stream flow values in order to characterize five components of flow regime

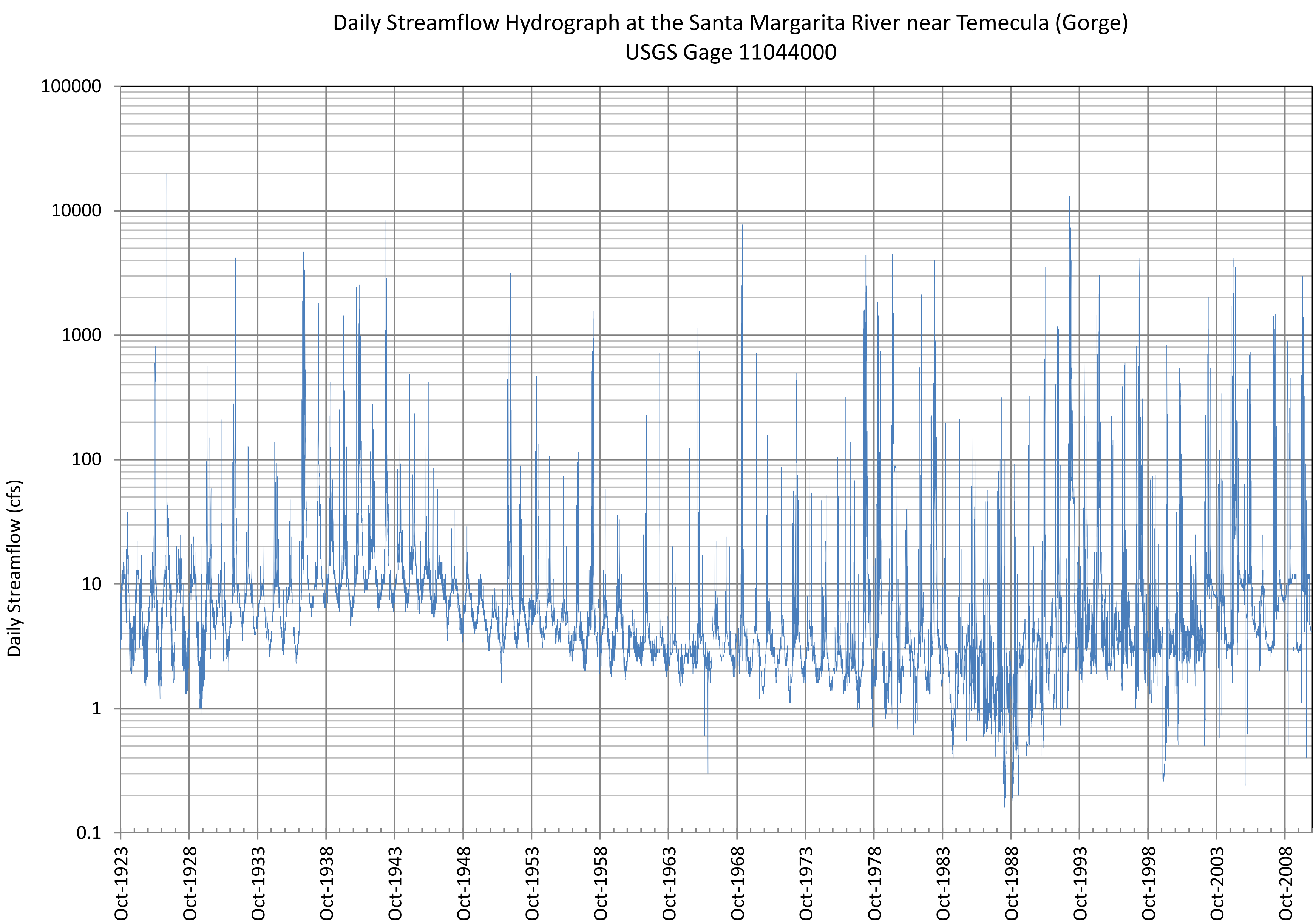

Daily Streamflow Hydrograph at the Santa Margarita River near Temecula (Gorge)
USGS Gage 11044000
Daily Streamflow (cfs)
100000
10000
1000
100
10
1
0.1
Oct-1923
Oct-1928
Oct-1933
Oct-1938
Oct-1943
Oct-1948
Oct-1953
Oct-1958
Oct-1963
Oct-1968
Oct-1973
Oct-1978
Oct-1983
Oct-1988
Oct-1993
Oct-1998
Oct-2003
Oct-2008

FIGURE 4-2

critical for ecological processes: magnitude, frequency, duration, timing, and rate of change of hydrologic conditions. A limited model analysis was performed, during 1999 or 2000, at the request of the United States and RCWD to characterize the natural variability of the Santa Margarita River at the Gorge.

TABLE 4.4 CWRMA TABLE 5 FLOW REQUIREMENTS AT THE GORGE

Month	Critically Dry Flow (cfs)	Below Normal Flow (cfs)	Above Normal Flow (cfs)	Very Wet Flow (cfs)
Winter	4.5	8.0	17.8	24.1
May	3.8	5.7	11.7	15.7
June	3.3	4.9	9.4	12.2
July	3.0	4.3	7.8	9.7
August	3.0	4.4	7.6	9.2
September	3.0	4.1	7.4	9.4
October	3.0	3.9	7.7	10.1
November	3.0	4.5	8.8	11.5
December	3.3	5.3	10.4	13.5

The results of the IHA model were not directly used in the current CWRMA augmentation schedule; rather the IHA results became the basis for developing the temporal portion of the flow augmentation schedule at the Gorge. The results of the model are reflected in the CWRMA's monthly and winter-time flow requirements (Table 4.4). The natural variability of the Santa Margarita River at the Gorge is best described by a single January 1 through April 30 winter flow requirement and eight separate monthly flow requirements for the remaining part of the year. Statistical methods were then substituted for the IHA model in order to eliminate the effect of peak flows and to provide a basis for establishing Critically Dry, Below Normal, Above Normal, and Very Wet hydrologic conditions.

The underlying principle of the CWRMA is to re-establish the natural variability of both winter-time and summer-time baseflows at the Gorge and to allow flood flows to continue unimpeded. Hence, the Hydrologic Simulation Program Fortran (HSPF) model was used to simulate daily streamflow at the Gorge based on precipitation so that natural flow could be estimated. Statistical methods were then applied to the natural flow values to identify winter-time and non-winter monthly flows that are used to establish the variability identified by the IHA analysis.

4.4 HYDROLOGIC PERIOD OF RECORD

Hydrologic records of streamflow are available for the 85-year period from WY 1925 through WY 2009. The continuous record of average daily streamflow at the POD was developed as described in TM 1.1 (Appendix B).

The distribution of hydrologic conditions that occurred over the 85-year period of record is presented for four different hydrologic conditions: Very Dry, Below Normal, Above Normal, and Very Wet (Table 4.5). The hydrologic conditions are based on the total streamflow at the POD that occurs between October 1 and April 30 (see development of conditions in TM 1.1). This metric is referred to as "wintertime streamflow". Flow at the POD, instead of precipitation, is used to describe hydrologic conditions since it is less influenced by the difference in short duration–high intensity rainfall events compared to less intense, but more frequent storms. Hydrologic conditions determined by streamflow account for antecedent conditions due to varying rainfall patterns and long-term impacts from upstream water development.

TABLE 4.5 DISTRIBUTION OF HYDROLOGIC CONDITIONS BASED ON WY 1925 TO WY 2009 PERIOD OF RECORD

Hydrologic Condition	Range of Wintertime Streamflow (AF)	Percent Occurrence (%)
Very Wet	>55,600	19%
Above Normal	12,800 to 55,600	31%
Below Normal	5,000 to 12,799	25%
Very Dry	<5,000	25%

Notes: Wintertime streamflow is the cumulative flow volume from October 1 through April 30 of each year as estimated at the POD. Statistical data presented in TM 1.1. (Appendix B)

The hydrologic conditions that describe the Lower Santa Margarita River evenly divide the years in the record between wetter than normal years and drier than normal years. "Normal" is defined as the 50th percentile of wintertime streamflow (12,800 AF wintertime streamflow). In other words, 50% of the years are Very Wet or Above Normal, and 50% of the years are Below Normal or Very Dry. Very Wet hydrologic conditions occur on the Santa Margarita River approximately 1 out of every 5 years (19%), compared to Very Dry conditions that occur approximately 1 out of every 4 years (25%).

4.5 HYDROLOGIC PERIODS OF INVESTIGATION

NOAA Fisheries outlined the data and information required to improve their understanding of the hydrology of the Santa Margarita River and the impact of the proposed action on the hydrology in their February 22, 2011 letter. The following items were requested in order to evaluate how the project may influence flow of the Lower Santa Margarita River:

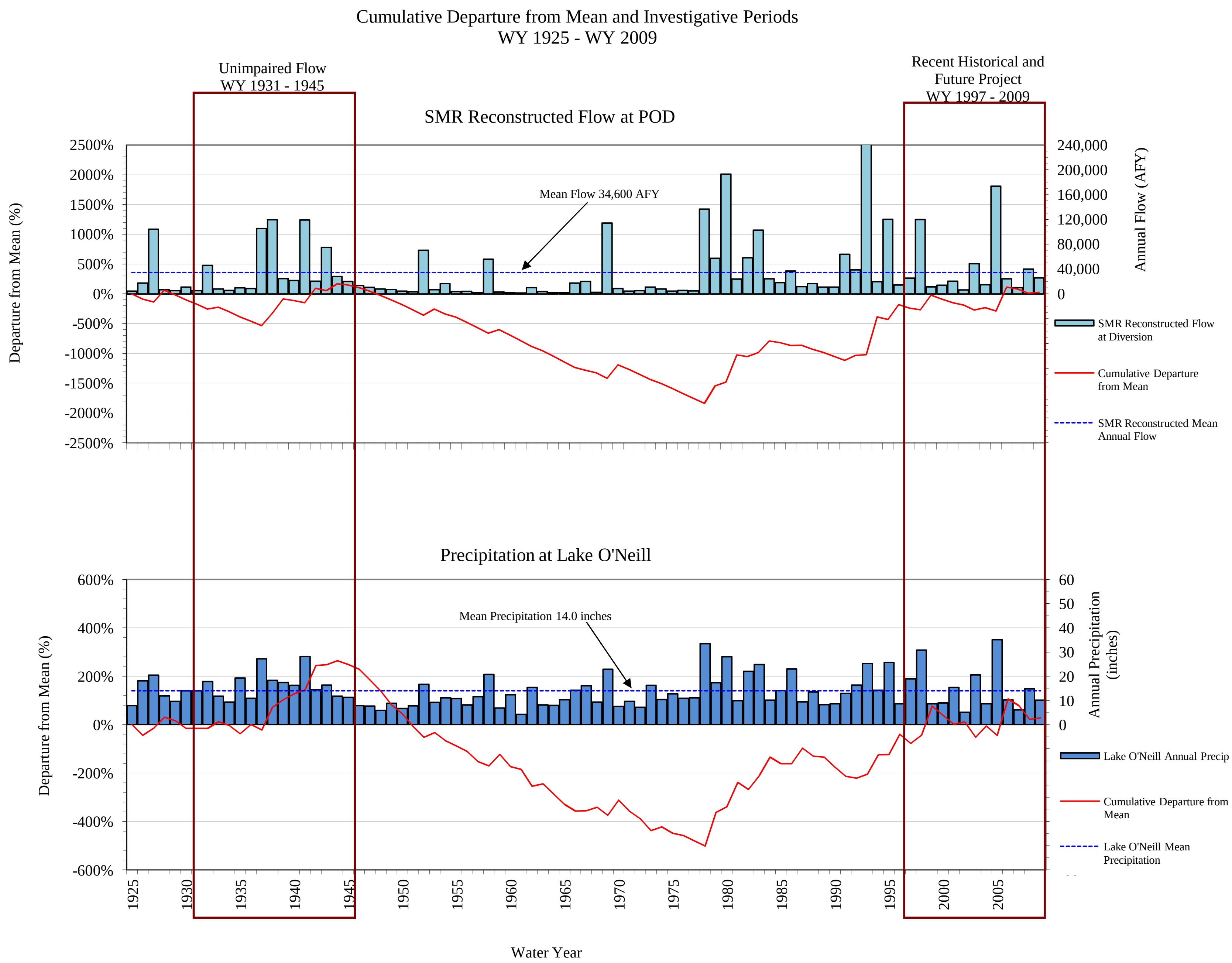
(1) "the historical magnitude and pattern of discharge in the Lower Santa Margarita River;

(2) how the existing facility affects the magnitude and pattern of historical discharge and steelhead migration opportunities; and,

(3) how the proposed action would affect the magnitude and pattern of historical discharge and steelhead migrations opportunities."

Based on these recommendations, three distinct periods of investigation were developed in order to describe streamflow in the Lower Santa Margarita River under each of these conditions: Unimpaired, Recent Historical, and Future Project. The three continuous periods were chosen from the available WY 1925 through WY 2009 reconstructed streamflow data that best represent the conditions required for each period to be studied. Each of the three investigative periods is characterized by wetter than normal conditions to assure flows that support potential fish passage could be analyzed in this study (Figure 4-3). The flow conditions representative of the prolonged drought period that occurred during the 1950s and 1960s were purposely excluded from the analysis for fish passage because drought conditions precluded passage during this period.

The Unimpaired period is based on hydrology that occurred between WY 1931 and WY 1945 and is adjusted to account for all known surface water and groundwater diversions below the Gorge. The Recent Historical period is based on the WY 1997 through WY 2009 period and reflects both diversion and pumping impacts on Camp Pendleton as well as impacts that occurred upstream of the POD, including impacts from development in the cities of Murrieta and Temecula above the Gorge. Finally, the Future Project period is based on the same hydrology (WY 1997-WY2009) that occurred during the Recent Historical period, but includes project-related infrastructure and management scenarios consistent with the proposed CUP.



Cumulative Departure from Mean and Investigative Periods
WY 1925 - WY 2009
Unimpaired Flow
WY 1931 - 1945
Recent Historical and
Future Project
WY 1997 - 2009
SMR Reconstructed Flow at POD
Mean Flow 34,600 AFY
Departure from Mean (%)
Annual Flow (AFY)
2500%
2000%
1500%
1000%
500%
0%
-500%
-1000%
-1500%
-2000%
-2500%
240,000
200,000
160,000
120,000
80,000
40,000
0
SMR Reconstructed Flow at Diversion
Cumulative Departure from Mean
SMR Reconstructed Mean Annual Flow
Precipitation at Lake O'Neill
Mean Precipitation 14.0 inches
Departure from Mean (%)
Annual Precipitation (inches)
600%
400%
200%
0%
-200%
-400%
-600%
60
50
40
30
20
10
0
Lake O'Neill Annual Precip
Cumulative Departure from Mean
Lake O'Neill Mean Precipitation
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
Water Year

FIGURE 4-3

As requested by NOAA Fisheries, the quantity (magnitude) of flows for each of the three investigative periods is described below. The duration (pattern) of flow is addressed in Section 5.4, and is analyzed in the context of the passage assessment described in Section 5.3.

4.5.1 Hydrology during the Unimpaired Period

The WY 1931 through WY 1945 record was chosen to characterize streamflow at the POD during the Unimpaired period due to the availability of gage data and minimum impacts from water development in the Upper Basin. Known diversions that occurred downstream of the Gorge between WY 1931 and WY 1945 were added to historical gaged data to reconstruct Unimpaired streamflow at the POD. All pre-1914, appropriative water rights data, and available groundwater pumping records identified in the water rights inventory task were accounted for during the reconstruction of streamflow during this early period.

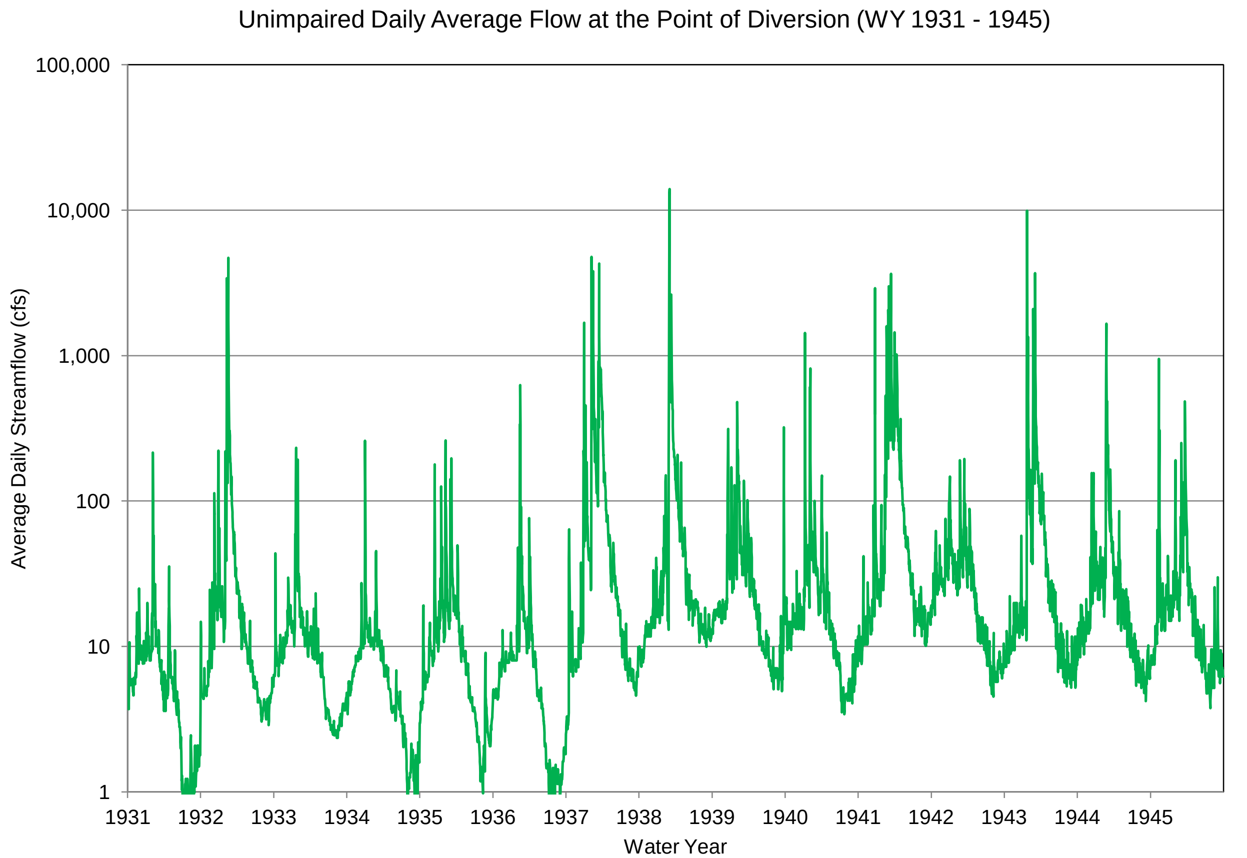
The Unimpaired period contains Very Dry, Below Normal, Above Normal, and Very Wet hydrologic conditions during relatively undeveloped conditions in the watershed (Table 4.6). This period represents a subset of years when streamflow impacts due to upstream pumping and diversions were at their minimum and dams had not yet been constructed.

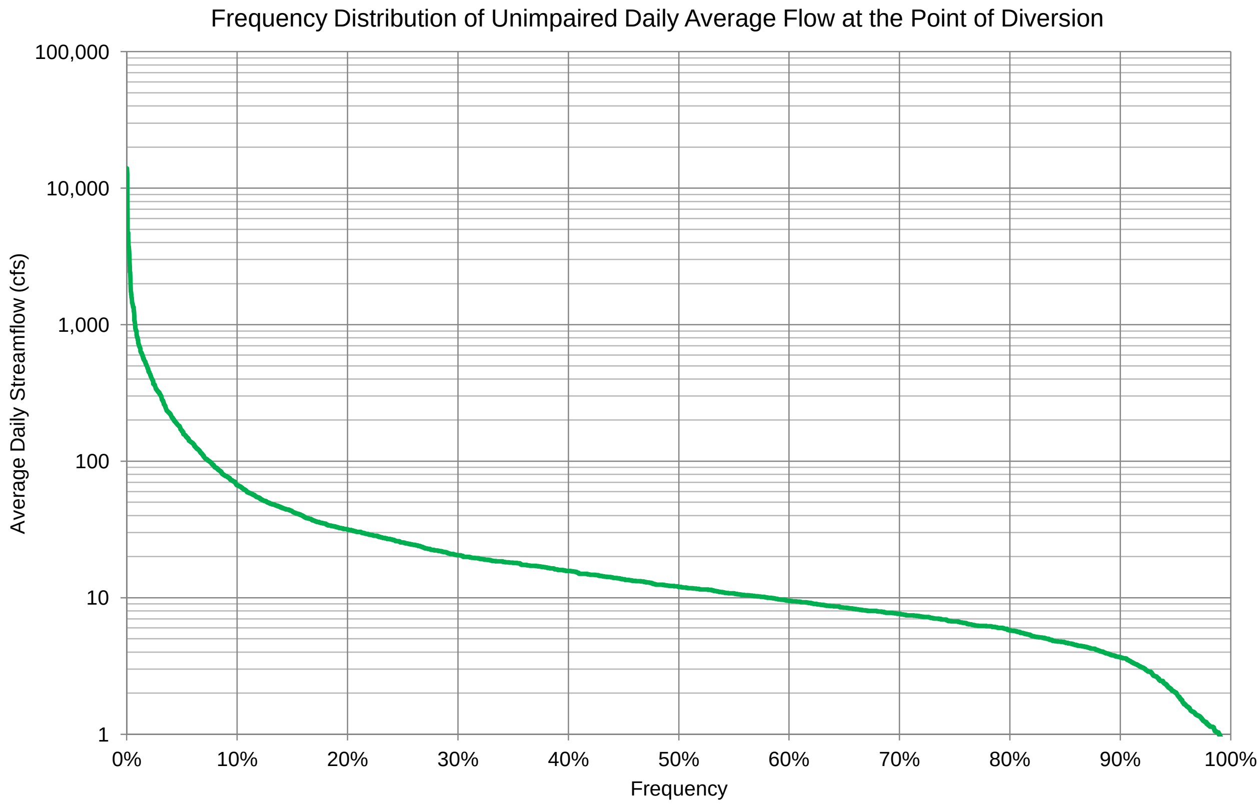
TABLE 4.6 DISTRIBUTION OF HYDROLOGIC CONDITIONS DURING UNIMPAIRED PERIOD

Hydrologic Condition	Number of Years in Period	Percent Occurrence (%)	Average Annual Streamflow (AF)
Very Wet	4	20%	105,200
Above Normal	6	47%	27,100
Below Normal	3	20%	9,100
Very Dry	2	13%	5,600
All Years	**15**	**100%**	**41,500**

Note: Statistical data presented in TM 1.1. (Appendix B)

Average daily flows at the POD during the Unimpaired period are shown in Figure 4-4. The upper graph represents the continuous daily record while the lower graph provides the percent occurrence of daily average streamflow during the 15-year period. The variability of streamflow during this hydrologic condition reflects the flashy nature of the Santa Margarita River. Median daily average streamflow was 12 cfs, ranging from 0.6 cfs to 13,950 cfs (Table 4.7). Average daily flow was 57 cfs, approximately five times the median flow rate. The


Unimpaired Daily Average Flow at the Point of Diversion (WY 1931 - 1945)
Average Daily Streamflow (cfs)
100,000
10,000
1,000
100
10
1
1931
1932
1933
1934
1935
1936
1937
1938
1939
1940
1941
1942
1943
1944
1945
Water Year


Frequency Distribution of Unimpaired Daily Average Flow at the Point of Diversion
Average Daily Streamflow (cfs)
100,000
10,000
1,000
100
10
1
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Frequency

variability of streamflow is characterized by infrequent, high volume wet season streamflow events compared to normally occurring baseflows.

There is a wide range of streamflow variability in the Lower Santa Margarita River throughout the year, as well as variability from one year to the next. The minimum and maximum daily streamflow during Very Dry and Below Normal Hydrologic years ranged from 0.6 cfs to 630 cfs, respectively. Similarly, the minimum and maximum daily streamflow during Above Normal and Very Wet Hydrologic years ranged from 2.9 cfs to 13,950 cfs, respectively. While there is as much as a 5,000 fold difference in average daily streamflow during Very Wet conditions, the 5-fold difference between the median and average daily flow underscores the variability that occurs on the stream system every year.

TABLE 4.7 UNIMPAIRED: DAILY STREAMFLOW AT THE POD FOR DIFFERENT HYDROLOGIC CONDITIONS

		Hydrologic Condition			
Statistic	**All Years (cfs)**	**Very Dry (cfs)**	**Below Normal (cfs)**	**Above Normal (cfs)**	**Very Wet (cfs)**
Average	57	7.8	12.6	37.5	145.3
Median (50th percentile)	12	5.6	7.7	16.0	18.8
Minimum	0.6	0.6	0.7	2.9	2.5
Maximum	13,950	260	630	4,700	13,950

Note: During the 15-year Unimpaired period, these statistics are calculated for: 2 very dry years; 3 below normal years; 6 above normal years, and 4 very wet years.

4.5.2 Hydrology during the Recent Historical Period

Hydrology and water development facilities located upstream of the POD influence the magnitude and pattern of flow in the Lower Santa Margarita River. These facilities and water management practices include, but are not limited to: dams, groundwater pumping, water imports, urban runoff, recycled water use, stormwater runoff, and land development. The hydrologic period used to simulate streamflow conditions during Recent Historical includes the impacts that have occurred over time due to these upstream facilities.

The hydrology during the Recent Historical period is based on historical streamflow and precipitation that occurred between WY 1997 through WY 2009. Recent Historical hydrology is based on estimates of the actual streamflow that occurred at the point of diversion. Average annual streamflow for Recent Historical at the POD is approximately the same as average annual streamflow during the Unimpaired period of WY 1931 to 1945. Table 4.8 summarizes the hydrologic conditions during the Recent Historical period.

TABLE 4.8 SUMMARY OF RECENT HISTORICAL HYDROLOGIC CONDITIONS AT THE POD

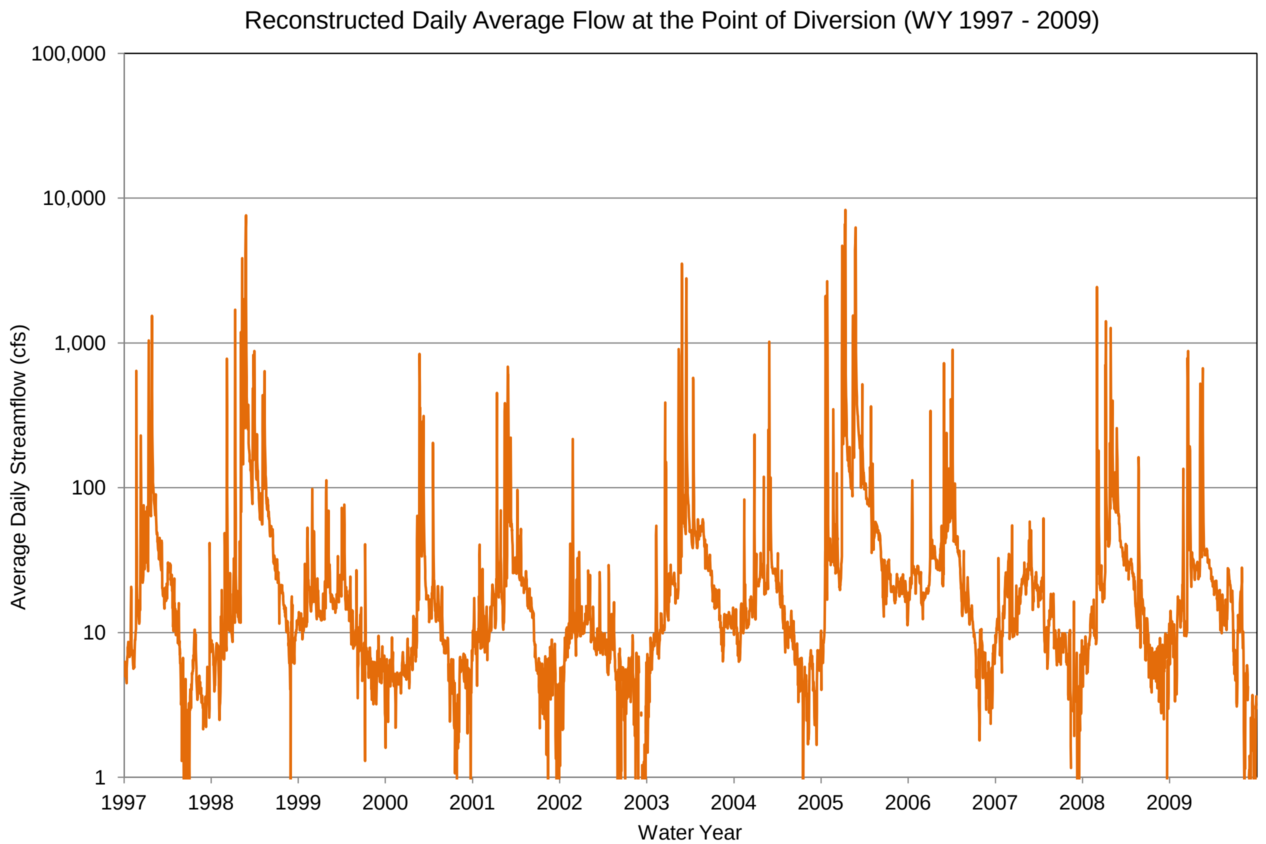
Hydrologic Condition	Number of Years in Period	Percent Occurrence (%)	Average Annual Flow (AF)
Very Wet	1	8	146,600
Above Normal	4	31	30,600
Below Normal	6	46	12,600
Very Dry	2	15	6,300
All Years	**13**	**100%**	**41,000**

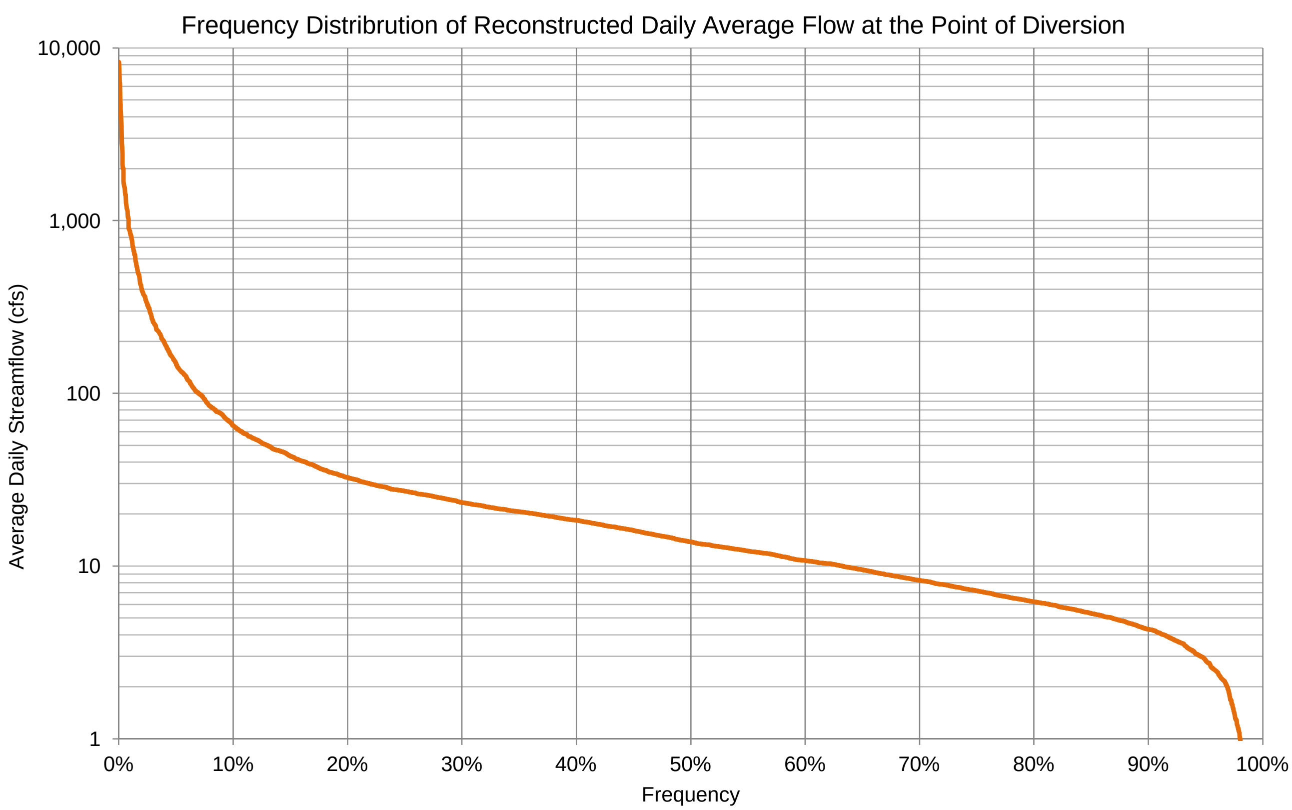
Notes: Hydrologic Conditions based on the 13-year period from WY 1997 through WY 2009. Statistical data presented in TM 1.1 (Appendix B).

Average daily flows at the POD during the Recent Historical period are shown in Figure 4-5. The upper graph represents the continuous daily record while the lower graph provides the percent occurrence of daily average streamflow during the 13-year period. Streamflow variability during the Recent Historical period is demonstrated by the difference between average and median daily flow that occurs during wetter than average conditions. For example, during Very Wet years in the Recent Historical period, average flows are 200 cfs, while median flows are 31 cfs, indicating that this flow regime is characterized by infrequent events with large flow volumes. The magnitude of flow at the POD during the Recent Historical period is presented in Table 4.9.

TABLE 4.9 STREAMFLOW AT THE POINT OF DIVERSION (POD) DURING RECENT HISTORICAL PERIOD

		Hydrologic Condition			
Statistic	**All Years (cfs)**	**Very Dry (cfs)**	**Below Normal (cfs)**	**Above Normal (cfs)**	**Very Wet (cfs)**
Average	57	8.7	17	42	200
Median (50 Percentile)	14	7.7	11	16	31
Minimum	0.0	0.0	0.0	0.0	0.1
Maximum	8,300	220	1,020	3,530	8,300





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Review of the streamflow hydrograph during Very Dry and Below Normal conditions shows that flow is commonly intermittent during winter months. Short-duration peak events occur for periods of one day or less and are separated by prolonged periods of no or little baseflow. Infrequent storm events driven by below-normal precipitation have a large temporal component that prevents elevated baseflows that might support fish passage. Based on these infrequent short duration events during Very Dry and Below Normal conditions, fish passage is likely to occur only during the Above Normal and Very Wet conditions.

4.5.3 Hydrology during the Future Project Period

Future Project hydrology is nearly identical to Recent Historical streamflow. The magnitude of flow during these two periods varies slightly during low flows due to differences between historical augmentation and projected future augmentation[1]. Table 4.10 provides the distribution of hydrologic conditions during the Future Project period. The percent occurrence of each type of condition is identical to that of the Recent Historical period (Table 4.8). Table 4.11 gives the streamflow statistics for each type of hydrologic condition. Average daily flows and daily frequency for the Future Project period are nearly identical to those shown in Figure 4-5 for the Recent Historical period.

TABLE 4.10 SUMMARY OF FUTURE PROJECT HYDROLOGIC CONDITIONS AT THE POD

Hydrologic Condition	Number of Years in Period	Percent Occurrence (%)	Average Annual Flow (AF)
Very Wet	1	8	147,300
Above Normal	4	31	30,900
Below Normal	6	46	13,400
Very Dry	2	15	6,600
All Years	**13**	**100%**	**41,600**

Notes: Hydrologic Conditions based on the 13-year period from WY 1997 through WY 2009. Statistical data presented in TM 1.1 (Appendix B).

[1] Future Project flows differ from Recent Historical flows due to simulated CWRMA augmentation during the Future period that did not occur during the Recent Historical. These differences affect flows less than 11.5 cfs.

TABLE 4.11 STREAMFLOW AT THE POINT OF DIVERSION (POD) DURING FUTURE PROJECT PERIOD

		Hydrologic Condition			
Statistic	**All Years (cfs)**	**Very Dry (cfs)**	**Below Normal (cfs)**	**Above Normal (cfs)**	**Very Wet (cfs)**
Average	57	9.0	18	43	200
Median (50 Percentile)	15	8.2	12	17	33
Minimum	0.0	0.2	0.0	0.0	4.0
Maximum	8,300	220	1,020	3,530	8,300

Notes: Streamflow is nearly identical to that during the Recent Historical period. Minor differences are due to simulated future CWRMA augmentation during the Future Period.

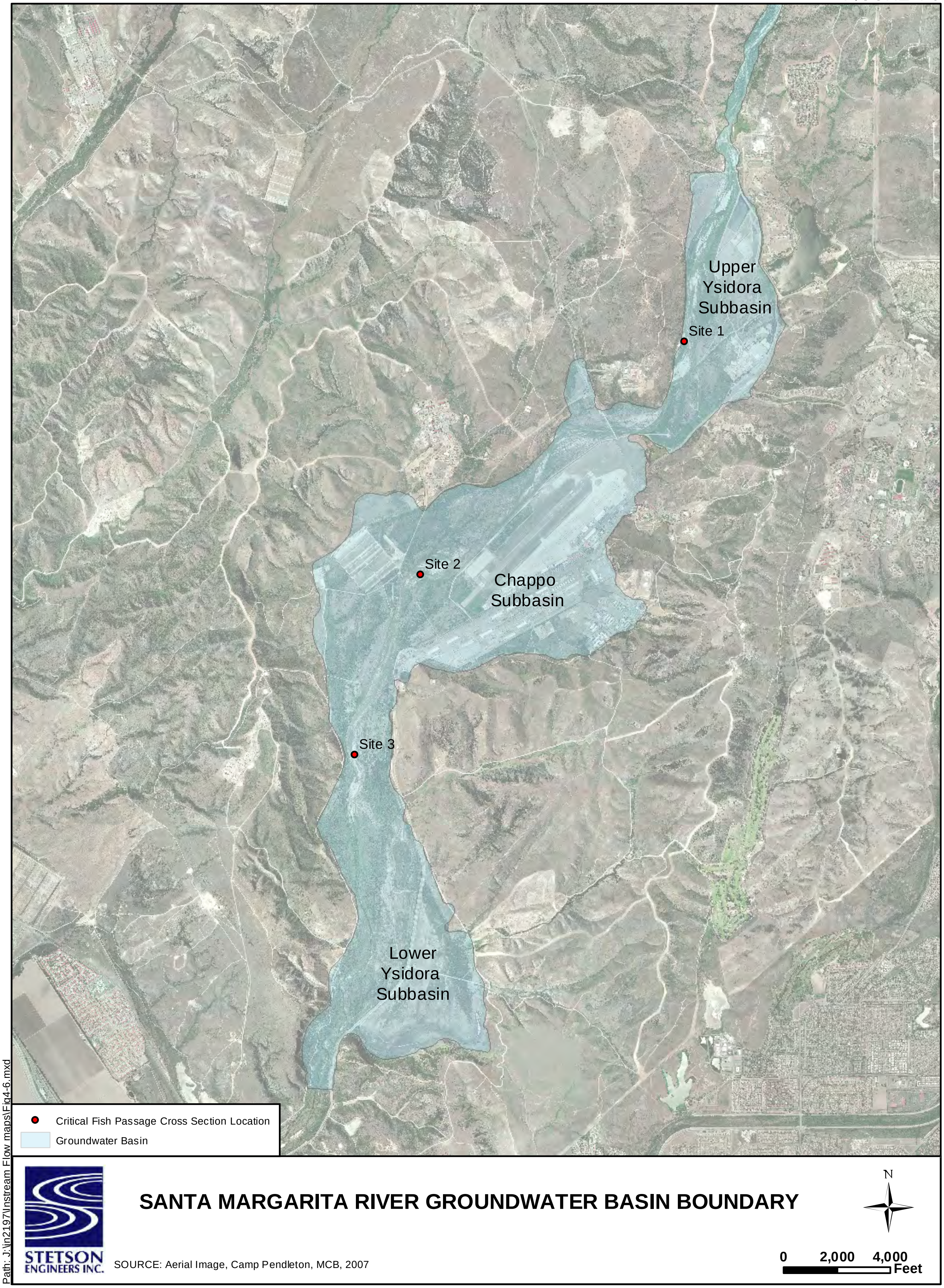
4.6 GROUNDWATER HYDROGEOLOGY

After the Santa Margarita River passes the POD, the impact of groundwater hydrogeology influences the Santa Margarita River streamflow as it passes through Camp Pendleton. The existing Lower Santa Margarita River Groundwater Model (LSMR Model) was employed in order to determine how facilities and groundwater management affects the flow of the river during the Unimpaired, Recent Historical, and Future Project periods. The LSMR Model accounts for the effects from anthropogenic interactions with the natural system: stream diversions to the recharge ponds and Lake O'Neill; spills and releases from the lake; and production well pumping. As described in detail below, three management scenarios were simulated using the LSMR Model for the three investigative periods in order to determine flow rates at Sites 1, 2, and 3.

4.6.1 Camp Pendleton Groundwater Model and Development

The Santa Margarita River is a typical semi-arid coastal stream that flows in the winter and spring subsequent to seasonal storms; and then looses surface flow during the late spring, summer, and fall (Worts and Boss, 1954). When flowing, the river traverses over approximately eight miles of stream deposits, recharging the coarse grained alluvial sediments and filling the groundwater aquifer below.

The groundwater basin extends from just upstream of the POD to the Lower Ysidora Narrows (Figure 4-6). There are naturally occurring older consolidated bedrock constrictions near Topamai Bridge and at sewage pump station 3 that divide the groundwater basin into three subbasins. The surrounding low permeability bedrock extends to depth beneath the alluvial fill,



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STETSON ENGINEERS INC.

SANTA MARGARITA RIVER GROUNDWATER BASIN BOUNDARY

SOURCE: Aerial Image, Camp Pendleton, MCB, 2007 defining the extents of the highly permeable groundwater aquifer. The alluvium consists of unconsolidated or weakly consolidated sediments ranging in size from boulders, gravel, and sand to silt and clay. Generally, the sediments are loosely compacted and contain interconnected pore spaces through which groundwater moves. The pore spaces in these deposits are also capable of storing appreciable quantities of groundwater.

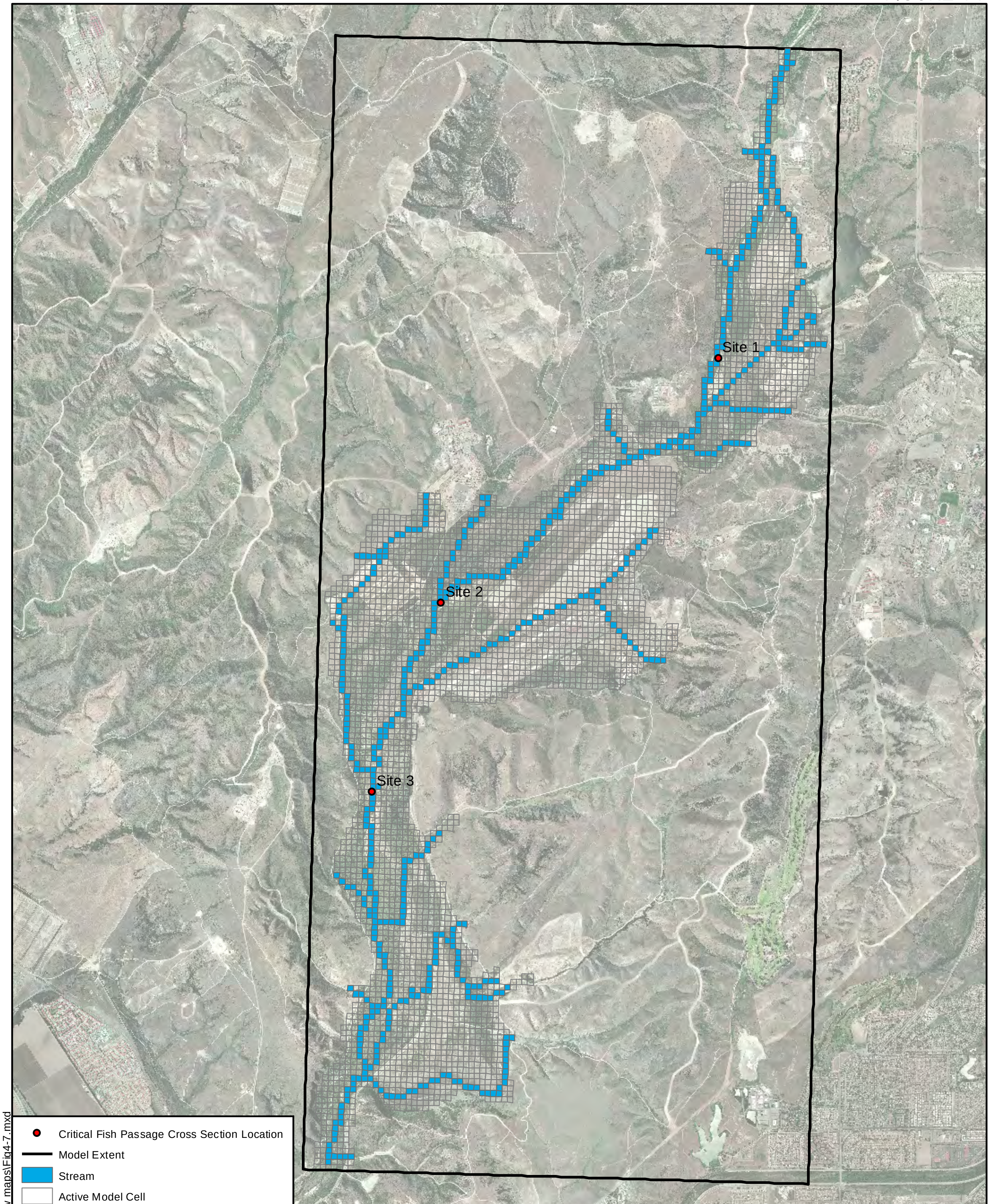
Under certain conditions, the groundwater aquifer provides baseflow to the stream. At the downstream end of each subbasin, a geological narrows constricts the down gradient subsurface groundwater movement causing the groundwater table to rise. Rising groundwater results in baseflow to the stream at these reaches, even during the dry summer and autumn months. During most years, the Santa Margarita River recharges the groundwater aquifer during the wet season, and the aquifer supplies baseflow to some of the river reaches during the dry season. During consecutive dry years, the groundwater table lowers to a point where there is no baseflow. Following a prolonged drought, it may take multiple years for the Santa Margarita River to fully recharge the groundwater aquifer.

Because gaged streamflow data do not exist at locations other than the USGS gage at Ysidora, the LSMR Model was used to estimate daily streamflow at the three critical sites downstream of the POD. A description of the model runs and hydrologic budgets for each simulation is described in the sections below.

4.6.2 Model Structure and MODFLOW Stream Package

The LSMR Model (Stetson, 2010a) uses the MODFLOW-2005 (Harbaugh, 2005) finite difference model code to simulate groundwater and surface water flow and storage in the Lower Santa Margarita River Basin. MODFLOW-2005 consists of a main program with different modular subroutines that incorporate specific hydrologic features within the basin, e.g. stream (STR), wells (WEL), recharge (RCH), evapotranspiration (EVT), etc. Each MODFLOW package allows for that component of the hydrologic budget to be examined independently. The benefit specifically for this study was the available output from the STR package at specific stream cells correlated with the stream cross sections of concern for the steelhead migration opportunities. Figure 4-7 shows the distribution of the 59 stream segments and 673 stream cells that represent the surface water components in the LSMR Model.

The two-layer LSMR Model consists of 202 rows and 90 columns spaced at 200-foot intervals forming a grid. The model solves the flow equation for each of the 7,780 active cells representing the groundwater aquifer for each stress period. Monthly stress periods are simulated to capture the movement of groundwater and seasonal variations observed in the



SIMULATED MODEL CELLS FOR STREAM AND TRIBUTARIES; LSMR MODEL

STETSON ENGINEERS INC.

SOURCE: Aerial Image, Camp Pendleton, MCB, 2007

N

0 2,000 4,000 Feet

Path: J:\in2197\Instream Flow maps\Fig4-7.mxd existing water level and stream gage data. Further details of the model setup, hydraulic parameters, and calibration have been described in the most recent April 2010 model update (Stetson, 2010a). A description of the LSMR Model is included in Appendix D.

The MODFLOW model is coupled with the Reservoir Operations Model [ROM] (Stetson, 2001; Reclamation, 2007b) for flow input into the STR package. The ROM calculates daily diversions to the Recharge Ponds and Lake O'Neill, pond infiltration rates, and spills and releases from Lake O'Neill (see ROM description in Appendix D). Existing daily streamflow and precipitation gage data were used to estimate the available flow at the POD in the Upper Ysidora Subbasin. The daily water accounting is based on water availability, the physical diversion structure and system constraints, and the Base's water rights. The daily surface water flow and infiltration rates were converted to monthly values for input into the STR package of the groundwater model. An additional facet to the interface between the daily ROM and the monthly groundwater model was incorporated into the Instream Flow Study – proportioning the monthly streamflow output from the groundwater model into daily streamflow at specific cross sections of concern for fish migration.

4.6.3 Groundwater Simulation for Unimpaired Period

The LSMR Model was used to investigate stream conditions during the Unimpaired period from WY 1931-1945. Streamflow model output was developed at each potential critical fish passage site. An Unimpaired flow model run was constructed for this study representing hydrologic conditions for WY 1931 through WY 1945. Daily flow rates for the Santa Margarita River at the POD developed in TM 1.1 and described above in Section 4.2 were used to estimate flow into the model boundary. Side tributary runoff was developed from streamflow and precipitation gages using the ROM. These daily streamflow values were then summarized as monthly values for the LSMR Model input. The model simulation for the Unimpaired period was based on correcting for all known surface water diversions and groundwater pumping.

Table 4.12 is the average annual hydrologic budget for the 13-year Unimpaired period; annual results from the LSMR Model output have been compiled and summarized in Appendix C (Tables C-1 through C-3, Figure C-1). Streamflow into the model ranged from 5,800 AF in WY 1934 to 120,000 AF in WY 1938, with an average annual of 41,500 AFY and a median of 21,900 AFY. This wide range and difference between average and median streamflow demonstrates the typical flashiness of the river system in this southwestern coastal stream. Fallbrook Creek and other side tributary drainages contributed an additional 4,300 AFY, for a total of 45,800 AFY of surface water into the Lower Santa Margarita River Basin. The LSMR

Model showed a net loss of surface water in the Basin during Unimpaired flow conditions resulting in an average annual streamflow out of 43,000 AFY. This net loss is mainly due to phreatophyte evapotranspiration (ET).

TABLE 4.12 HYDROLOGIC BUDGET FOR UNIMPAIRED PERIOD WY 1931 – WY 1945

	Upper Ysidora Subbasin (AFY)	Chappo Subbasin (AFY)	Lower Ysidora Subbasin (AFY)	LSMR Basin (AFY)
Inflow:				
Santa Margarita River Inflow	41,500	42,800	42,800	41,500
Subsurface Underflow*	600	700	400	600
Lake O'Neill Spill and Release	0	0	0	0
Fallbrook Creek Bypass	1,200	0	0	1,200
Minor Tributary Drainages	800	1,400	900	3,100
Precipitation	200	400	200	800
Total Inflow:	44,300	45,300	44,000	47,100
Outflow:				
Santa Margarita River Outflow	42,800	42,800	43,200	43,200
Subsurface Underflow*	700	400	100	100
Groundwater Pumping	0	0	0	0
Evapotranspiration*	800	2,000	900	3,800
Diversions to Lake O'Neill	0	0	0	0
Total Outflow:	44,400	45,300	44,200	47,100
Net Change in Storage:	-100	0	100	0

Notes: "*" implies subbasin averages are based on the last rate of the stress period. Due to the differences in hydrologic conditions, this table is not directly comparable to the other hydrologic tables in this for Recent Historical and Future Project conditions. Values are rounded to the nearest 100 AF, which may result in a summation rounding error.

ET from Lake O'Neill and surrounding plant communities is accounted for in the ROM, which considers water balances outside the LSMR Model domain.

4.6.4 Groundwater Simulation for Recent Historical Period

A 13-year Recent Historical flow model run was established for this study representing hydrologic conditions for WY 1997 through WY 2009. The 2010 LSMR Model was recalibrated in order to extend the original calibration by one year to include the 13-year Recent Historical period (Stetson, 2010a). Daily flow rates for the Santa Margarita River at the POD were developed as described in TM 1.1 (Appendix B). Recent Historical monthly operation records for Lake O'Neill and the recharge ponds (OWR, 2010) were used as input into the LSMR Model. Surface water diversions, diversions to Lake O'Neill, diversions to off-stream recharge basins, and groundwater pumping were simulated based on actual data collected during this period.

Table 4.13 gives the average annual hydrologic budget for the Recent Historical model run for each subbasin and the overall Lower Santa Margarita River Basin; annual results from the LSMR Model have been compiled and summarized in Appendix C (Table C-4 through C-6, Figure C-2). Streamflow into the basin ranged from 6,300 AF in WY 2002 to 173,400 AF in WY 2005, with an average annual rate of 41,000 AFY and a median of 24,200 AFY. Fallbrook Creek and other side tributary drainages contributed an additional 3,000 AFY. There is a net loss of surface water in the basin during Recent Historical flow conditions resulting in an average annual streamflow out of 35,200 AFY. This net loss is mainly due to groundwater pumping, ET, and diversions to Lake O'Neill.

The model calculates phreatophyte ET based on a linear interpretation of maximum potential ET, wherein the maximum ET occurs when groundwater levels are at ground surface. MODFLOW uses a linear relationship in which the ET potential reaches zero at the root extinction depth estimated to be 15 feet below the surface. Hence, a reduction in model generated ET does not necessarily indicate that vegetation die off is occurring; rather it likely indicates that plant communities may be stressed under certain conditions.

TABLE 4.13 HYDROLOGIC BUDGET FOR RECENT HISTORICAL PERIOD (WY 1997 – WY 2009)

	Upper Ysidora Subbasin (AFY)	Chappo Subbasin (AFY)	Lower Ysidora Subbasin (AFY)	LSMR Basin (AFY)
Inflow:				
Santa Margarita River Inflow	41,000	38,900	36,200	41,000
Subsurface Underflow*	600	1,000	200	600
Lake O'Neill Spill and Release	700	0	0	700
Fallbrook Creek Bypass	1,000	0	0	1,000
Wastewater Oxidation Ponds	0	0	0	0
Minor Tributary Drainages	500	900	600	2,000
Precipitation	200	300	200	600
Total Inflow:	44,100	41,100	37,200	46,000
Outflow:				
Santa Margarita River Outflow	38,900	36,200	35,200	35,200
Subsurface Underflow*	1,000	200	0	0
Groundwater Pumping	2,100	3,200	1,200	6,600
Evapotranspiration*	900	1,500	800	3,200
Diversions to Lake O'Neill	1,100	0	0	1,100
Total Outflow:	44,100	41,100	37,200	46,100
Net Change in Storage:	0	0	0	-100

Notes: "*" implies subbasin averages are based on the last rate of the stress period. Values are rounded to the nearest 100 AF, which may result in a summation rounding error.

ET from Lake O'Neill and surrounding plant communities is accounted for in the ROM which considers water balances outside the LSMR Model domain.

4.6.5 Groundwater Simulation for Future Project Period

The Future Project LSMR Model run considers the effects of optimizing the diversion schedule and increasing pumping for the proposed CUP. The 13-year model run is based on the WY 1997 to WY 2009 hydrology that was used for the Recent Historical period[2]. The major differences between the two model simulations are the facilities and groundwater management

[2] There are minor differences in the two streamflow records due to CWRMA, which began in 2003: The Recent Historical record includes all actual augmentation (a previous augmentation program which was active in WY 1997-2002, and the actual CWRMA program from WY 2003 to 2009); however, the Future Project record is intended to represent future conditions, and as such, the historical augmentation from WY 1997-2002 was removed and replaced by simulated future CWRMA augmentation.

practices within each investigative period. The Future Project simulation includes proposed CUP facilities described in Section 1.6 of this report, namely enhancements to existing facilities and four new groundwater wells. Other differing factors, which have a more minor impact than the proposed CUP facilities, include the removal of wastewater oxidation ponds and the elimination of agricultural pumping in the Future Project scenario. Surface water diversions, diversions to Lake O'Neill, diversions to off-stream recharge basins, and groundwater pumping were simulated based on planned Project operations.

When compared to the Recent Historical period, groundwater pumping under the Future Project increases from 6,600 AFY to 11,800 AFY, including a maximum withdrawal rate of 15,000 AFY. Surface diversions from the river during the Future Project were calculated from the ROM to average 13,400 AFY, compared to 6,100 AFY which occured the Recent Historical period. Due to the wetter-than-normal hydrologic conditions that characterize these investigative periods, surface diversions during the 13-year Future Period were greater than the 8,800 AFY 50-year average for the proposed CUP.

The average annual hydrologic budget for the Future Project model run for each subbasin and the overall Lower Santa Margarita River Basin is shown in Table 4.14. Streamflow into the basin ranged from 6,600 AF to 173,400 AF, with an annual average of 41,600 AFY and a median of 24,200 AFY. Fallbrook Creek and other side tributary drainages contributed an additional 3,000 AFY. There is a net loss of surface water in the Basin during Future Project flow conditions resulting in an average annual streamflow out of 30,400 AFY. This net loss is mainly due to groundwater pumping and phreatophyte ET.

The Net Change in Groundwater Storage does not equal zero during the 13-year Future Project model conditions since it does not necessarily reflect the impacts from long-term CUP pumping program. The CUP groundwater pumping program accounts for antecedent conditions in order to protect long-term declines in groundwater storage by reducing pumping rates following observations of declined water levels. The result of the proposed CUP pumping program is that long-term groundwater storage levels are maintained by reducing pumping and controlling aquifer storage levels. The CUP's Adaptive Management Plan is formulated to monitor and adjust aquifer storage levels to maintain physical and environmental management objectives established for the Lower Santa Margarita Basin. The Adaptive Management Plan will recommend annual CUP groundwater pumping schedules to maintain aquifer storage levels through logic-based decision making using the LSMR Model.

TABLE 4.14 HYDROLOGIC BUDGET FOR FUTURE PROJECT

	Upper Ysidora Subbasin (AFY)	Chappo Subbasin (AFY)	Lower Ysidora Subbasin (AFY)	LSMR Basin (AFY)
Inflow:				
Santa Margarita River Inflow	41,600	34,000	29,800	41,600
Subsurface Underflow*	600	1,600	700	600
Lake O'Neill Spill and Release	1,100	0	0	1,100
Fallbrook Creek Bypass	1,000	0	0	1,000
Wastewater Oxidation Ponds	0	0	0	0
Minor Tributary Drainages	500	900	600	2,000
Precipitation	200	300	200	600
Total Inflow:	44,900	36,700	31,400	46,900
Outflow:				
Santa Margarita River Outflow	34,000	29,800	30,400	30,400
Subsurface Underflow*	1,600	700	100	100
Groundwater Pumping	6,800	5,000	0	11,800
Evapotranspiration*	800	1,000	800	2,600
Diversions to Lake O'Neill	1,700	0	0	1,700
Total Outflow:	44,900	36,500	31,300	46,500
Net Change in Storage:	-100	-200	-100	-300

Notes: "*" implies subbasin averages are based on the last rate of the stress period. These 13-year water budget results are a subset of the 50-year balanced CUP Model and an extended model simulation. The 50-year model also incorporates extended drought conditions that are not considered in this study. Values are rounded to the nearest 100 AF, which may result in a summation rounding error.

ET from Lake O'Neill and surrounding plant communities is accounted for in the ROM which considers water balances outside the LSMR Model domain.

The reduction in ET from 3,200 AFY during the Recent Historical period, to 2,600 AFY during Future Project period represents an overall decrease in groundwater available to support riparian vegetation. The reduction in ET is consistent with a lower water table resulting from the proposed CUP and does not necessarily indicate a reduction in live vegetation. The 600 AFY ET reduction does, however, represent a reduced potential ET to riparian vegetation over all three subbasins, an impact that may manifest itself as added stress on the plants.

5.0 RESULTS OF ANADROMOUS FISH PASSAGE ASSESSMENT

The following fish passage assessment relies on the hydrologic and hydraulic analysis to describe minimum flow passage criteria at each of the three critical passage sites. A description of the changes in flow regime, both magnitude and pattern, are provided for both the Recent Historical and Future Project periods. Following presentation of the results identified during the Lower Santa Margarita River fish passage assessment, Section 6 of this report provides a discussion based on the comparison of Future Project conditions to existing conditions.

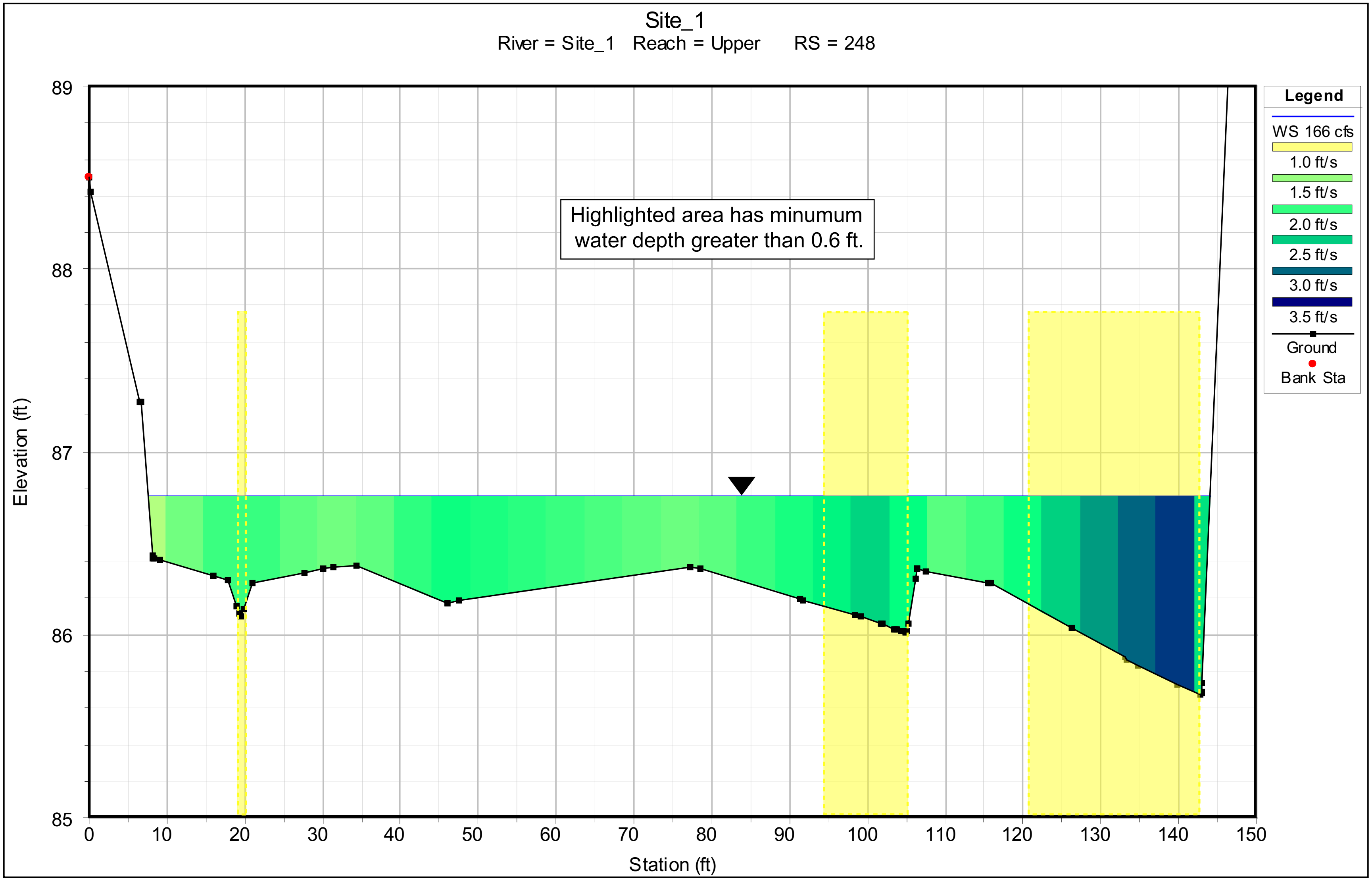
5.1 HABITAT CHARACTERISTICS WITHIN THE LOWER SANTA MARGARITA RIVER

Except for the Lower Ysidora Narrows, nearly the entire nine mile channel from the estuary to the POD was composed of a shallow, sand-bedded, run habitat. The March 2011 field survey (Section 3.1) only identified pool features within the Lower Ysidora Narrows. Average water depth was observed to be 0.3 meters (m) with a maximum depth of 0.9 m. This is supported by the fact that nearly all of the 285 points surveyed along the channel thalweg field survey indicated a sandy substrate. The four exceptions were one survey point with gravel substrate, two with organic substrate, and one with riprap substrate. Qualitative observations over the entire length of the surveyed portion of the river corridor indicated a dominance of sand on the bed. Geomorphically, this was represented by waves of sand moving downstream by traction and saltation through the Upper Ysidora and Chappo Subbasins. It was observed that this migration of sand appeared to result in the near constant change in the channel bed and location of bars as well as the channel thalweg. The field data were compiled and analyzed using AutoCAD. The thalweg profiles and water surface elevations were shown in Figure 3-2. Small-scale plates showing both plan views and longitudinal profiles of the river from the sheet-pile weir to the downstream limits of the survey are included as Appendix E.

5.2 RESULTS OF THE CHANNEL HABITAT RECONNAISSANCE SURVEY

The Lower Santa Margarita River, between the POD and the estuary, is characteristic of a shallow, wide sand bed within a floodplain river channel common to many southern California coastal streams. Within the area surveyed, the Santa Margarita River wetted channel is broad and shallow with a uniform substrate of shifting sand.

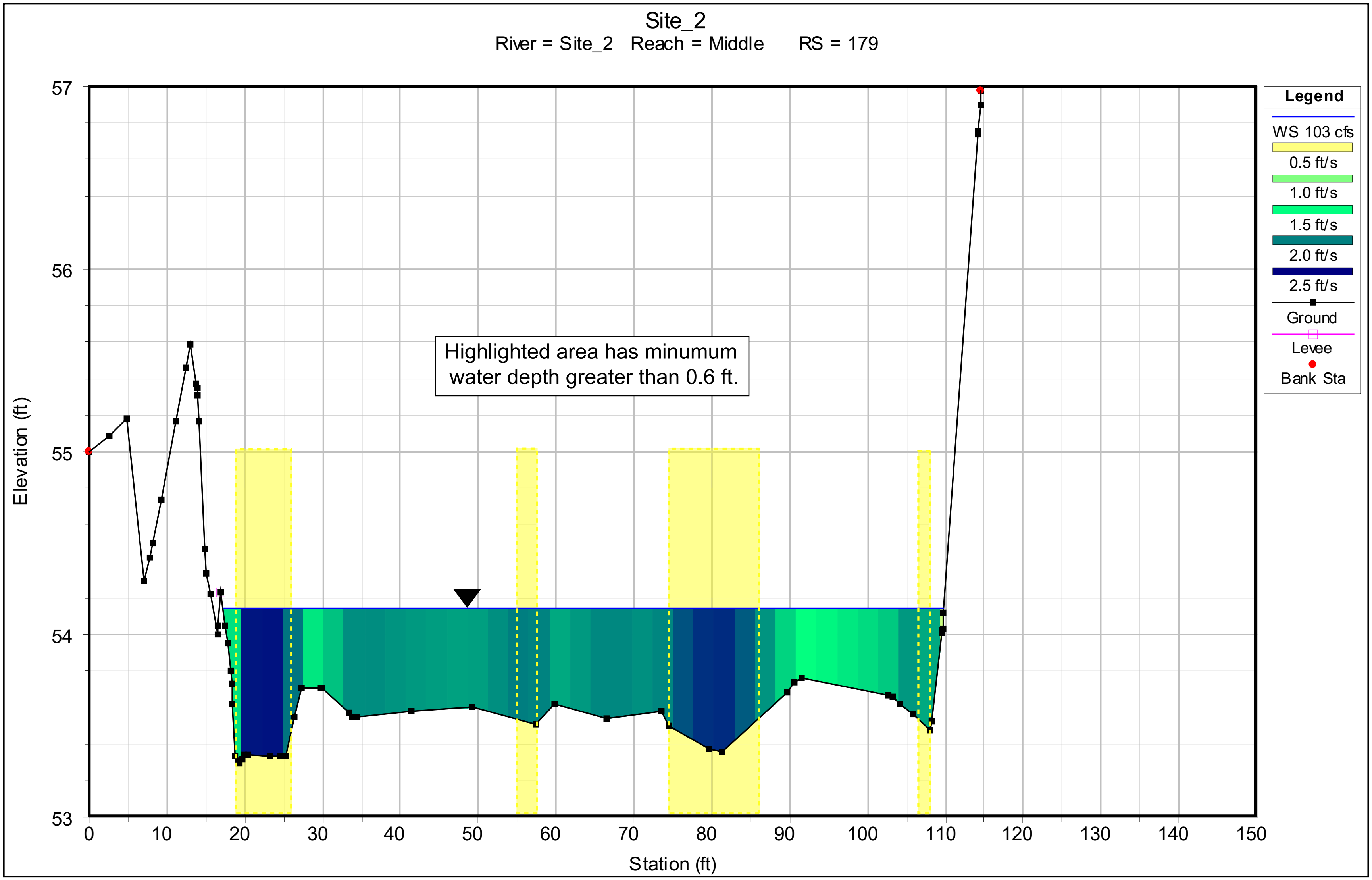
The predominant aquatic habitat feature within the survey area was generally found to be uniform runs or glides, essentially “flat water” with limited deep water and overall shallow habitat. A main thalweg was evident along most of the channel and secondary channels often



STETSON ENGINEERS INC.

SITE 1: FISH PASSAGE CROSS-SECTION PROFILE

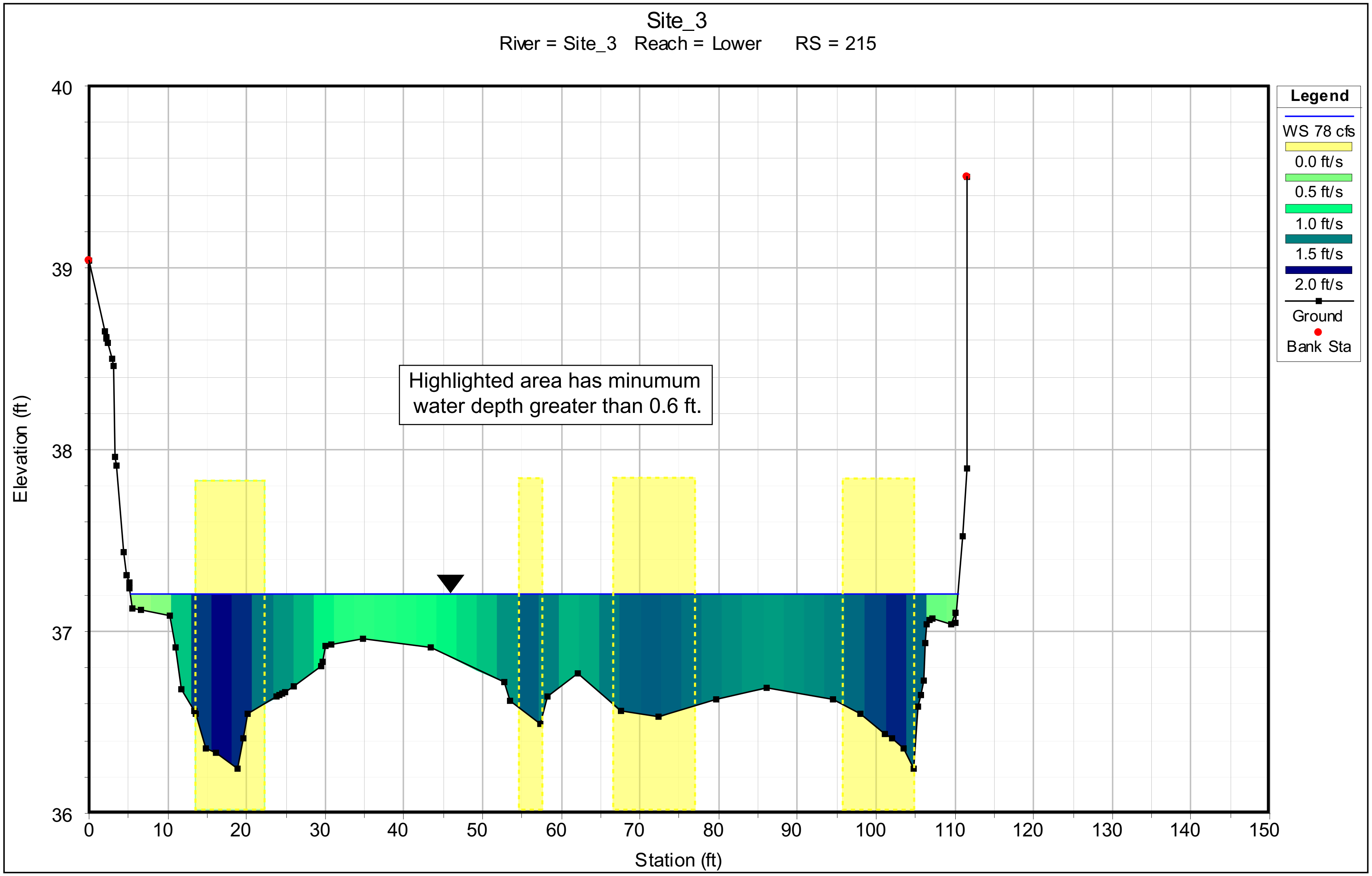
FIGURE 5-1



STETSON ENGINEERS INC.

SITE 2: FISH PASSAGE CROSS-SECTION PROFILE

FIGURE 5-2



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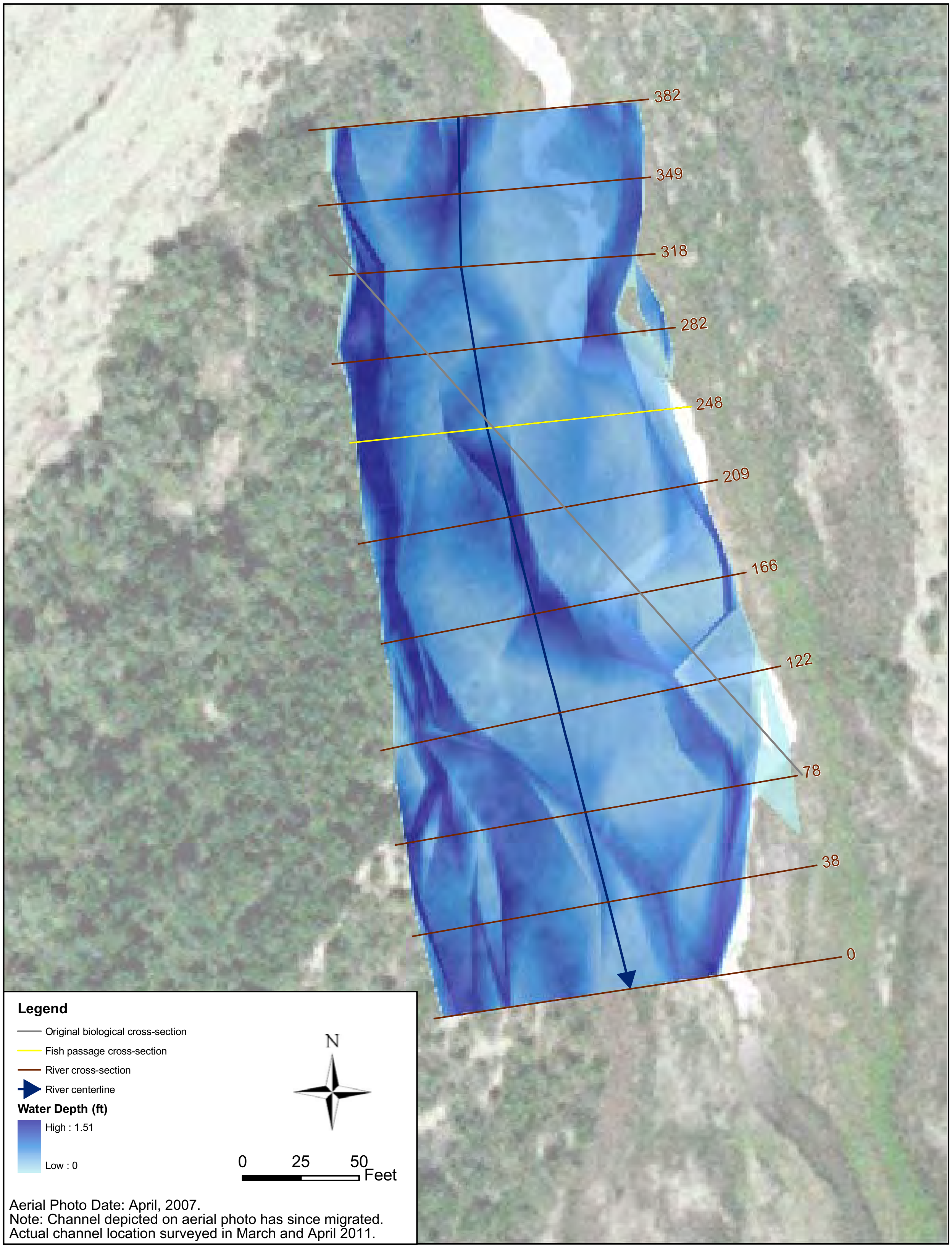
SITE 3: FISH PASSAGE CROSS-SECTION PROFILE

FIGURE 5-3

FIGURE 5-4



JobFolder/12199-5007/FinalFigures(2011-08-03)/Fig 3-7 Site 1 - Water Depth (166 cfs).ai

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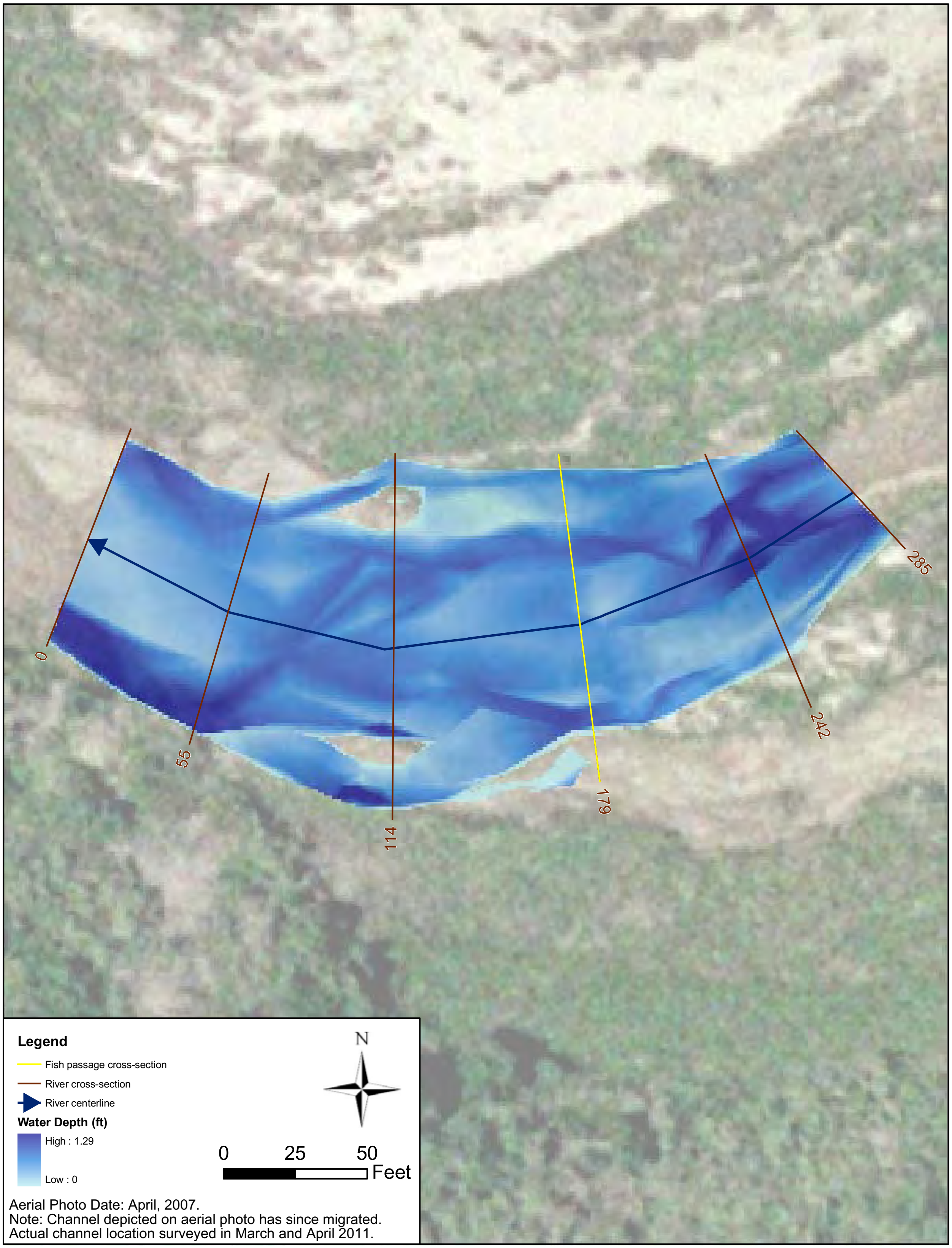
SITE 1: FISH PASSAGE HYDRAULIC MODEL
WATER DEPTH WITH MINIMUM PASSAGE FLOW OF 166 CFS



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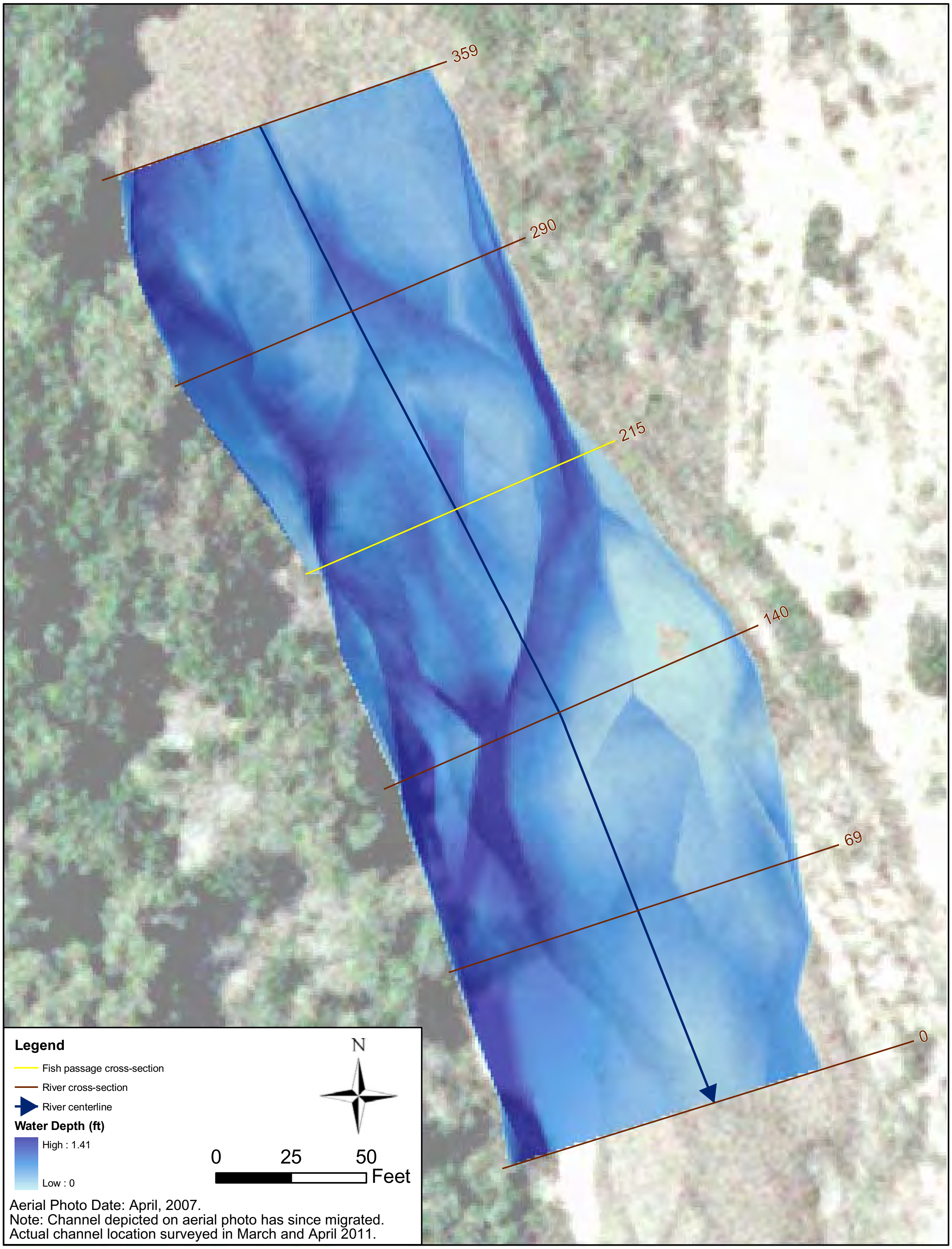
SITE 2: FISH PASSAGE HYDRAULIC MODEL
WATER DEPTH WITH MINIMUM PASSAGE FLOW OF 103 CFS

FIGURE 5-6



STETSON ENGINEERS INC.

SITE 3: FISH PASSAGE HYDRAULIC MODEL
WATER DEPTH WITH MINIMUM PASSAGE FLOW OF 78 CFS

JobFolder/12199-5007/FinalFigures(2011-08-03)/Fig 3-9 Site 3 - Water Depth (78 cfs).ai occurred along each bank, particularly when the bank was vegetated or otherwise resistant to erosion. Within the Lower Ysidora Narrows there was limited pool development influenced by emergent and woody vegetation, in-water debris, or overhanging vegetation. Potentially, this short reach, immediately upstream of the estuary, could provide some holding habitat for adults or rearing habitat for juveniles if water temperatures are suitable during the summer/fall period. Substrate, however, was almost either shifting sand or hardpan clay or peat, meaning that benthic macroinvertebrate production (i.e. aquatic insects), important as a food source for many fish species (including *O. mykiss*), was likely extremely limited. Except for the Lower Ysidora Narrows, no pools were observed that would function as "holding", rearing or over-summering habitat for juvenile salmonids. However, qualitatively, there did appear to be habitat of adequate depth for both adult and juvenile anadromous fish passage throughout the surveyed reach at the observed flows.

5.3 RESULTS OF THE HYDRAULIC ANALYSIS FOR FISH PASSAGE

Potential steelhead passage was assessed using criteria developed for open stream channels by Thompson (1972). These criteria use channel dimension, depth and velocity to determine if the transect is passable by upstream migrants. The specific criteria are based on body size and species. These criteria are used to assess passage in natural channels with open channel flow. Although there are some limitations regarding the use of the Thompson criteria for this assessment, no other criteria have been developed for southern California streams and there was general concurrence that these criteria could be applied for this assessment (see section 2.4.1).

5.3.1 Passage Criteria

The anadromous fish passage criteria from Thompson (1972) applied in this assessment were:

- a minimum water depth of 0.6 feet across a contiguous channel bottom equaling at least 10% of wetted channel width;
- a minimum water depth of 0.6 feet over at least 25% of the total wetted channel width; and,
- velocity less than 8 feet per second (ft/s).

We recognize that steelhead have a higher burst swimming speed but used 8.0 ft/s as a sustained swimming speed that would be appropriate to apply to open channel conditions. In fact, modeled velocities for this assessment were much lower than 8 ft/s, so velocity was not limiting passage in this analysis (see section 5.3.3).

5.3.2 Hydraulic Analysis Procedures

The hydraulic models prepared for the three critical sites were used to determine the flow rates that met both the 10% and 25% water depth criteria. The iterative procedures used to determine the minimum instream flow rates for the fish passage cross-sections are as follows:

- Discretize the fish passage cross-section data pairs into points at 0.5-foot intervals;
- Make an initial estimate of the water surface elevation that might meet the fish passage criteria;
- Calculate water depth at each discretized point; count the total wetted points and the points that have a water depth ≥ 0.6ft;
- Determine whether the estimated water surface elevation meets both 10% continuous and 25% total criteria;
- If criteria not met, make a new estimate and repeat the above steps until both criteria are met;
- In HEC-RAS, make an estimate of flow rate corresponding to chosen water surface elevation and run the model;
- Compare the model-computed water surface elevation at the fish passage cross-section with the target water surface elevation;
- If the computed water surface elevation does not equal the target water surface elevation, make another model iteration until the computed water surface elevation equals the target water surface elevation; and,
- Check flow velocity at flow rate

5.3.3 Determination of Minimum Fish Passage Flow Rates

Following the analysis procedures described above, the minimum fish passage flows at the three sites were determined and the maximum flow velocities were examined. Table 5.1summarizes the minimum fish passage flows at Sites 1, 2, and 3. Figures 5-1, 5-2, and 5-3 depict the stream bed elevation, the minimum water surface elevation to maintain 0.6 feet, and the bankfull elevation at Sites 1, 2, and 3, respectively. Figures 5-4, 5-5, and 5-6 show the plan view of the hydraulic models at each site and depict the water depth at each site's respective minimum flow. The resulting water depth inundation and flow velocity mapping are shown in Appendix F, Figures F3a through F3f. The details of the water depths and flow velocities at each point across the fish passage cross-sections are also included in Appendix F. Results showed that for all flows up to the bankfull flow, flow velocity did not exceed the 8 ft/s criterion at any site.

TABLE 5.1 HYDRAULIC ANALYSIS RESULTS FOR FISH PASSAGE FLOW RATES AT SITES 1,2 AND 3 BASED ON THE THOMPSON CRITERIA

Location	Minimum Flow (cfs)	Total Width of X-Section (ft)	Width of 10% Continuous X-Section (ft)	Total Width of 25% X-Section (ft)
Site 1	166	136	22.0	35.5
Site 2	103	93	12.0	24.5
Site 3	78	105	11.0	30.0

At Site 1, the minimum flow rate is 166 cfs in order to meet fish passage criteria. The maximum flow velocity at this flow rate is 3.23 ft/s along the fish passage cross-section, and 3.33 ft/s over the entire site. At the bankfull flow rate of 1,200 cfs, the maximum flow velocity increases to 5.75 ft/s along the fish passage cross-section, and 6.01 ft/s over the entire site. The site was suitable for fish passage within the flow range of 166 cfs to 1,200 cfs. Flow rates greater than 1,200 cfs will flow outside the channel onto the surrounding floodplain.

At Site 2, the minimum flow rate was 103 cfs in order to meet fish passage criteria. The maximum flow velocity at this flow rate is 2.43 ft/s along the fish passage cross-section, and 3.68 ft/s over the entire site. At the bankfull flow rate of 350 cfs, the maximum flow velocity increased to 3.35 ft/s along the fish passage cross-section, and 5.18 ft/s over the entire site. Site 2 was suitable for fish passage within the flow range of 103 cfs to 350 cfs. Flow rates greater than 350 cfs will flow outside the channel onto the surrounding floodplain.

At Site 3, the minimum flow rate is 78 cfs in order to meet fish passage criteria. The maximum flow velocity at this flow rate is 1.99 ft/s along the fish passage cross-section, and 3.10 ft/s over the entire site. At the bankfull flow rate of 1,000 cfs, the maximum flow velocity increases to 5.33 ft/s along the fish passage cross-section, and 5.96 ft/s over the entire site. Site 3 was suitable for fish passage within the flow range of 78 cfs to 1,000 cfs. Flow rates greater than 1,000 cfs will flow outside the channel onto the surrounding floodplain.

5.4 MAGNITUDE OF FLOW AT CRITICAL PASSAGE SITES

The hydrology, hydraulic model, and groundwater model described in previous chapters were used to assess streamflow magnitude at the three critical downstream sites under various project conditions. The groundwater model was used to determine daily streamflow at the three critical passage sites during each of the investigative periods. Due to the monthly stress periods employed by the groundwater model, an algorithm was developed to provide daily flows at each passage site based on flow at the POD.

The daily occurrence of the minimum passage flows was then assessed based on the results from the groundwater model. Site 1 is the limiting reach of the stream, in that it requires the greatest streamflow, based on the Thompson criteria. Because of that, the occurrence of the minimum flows has been assessed using the 166-cfs flow determined for Site 1.

5.4.1 Unimpaired Flow Magnitude

Statistics of daily streamflow at the POD, Site 1, Site 2, and Site 3 are provided in Table 5.2 for the Unimpaired period. The trend of the statistical values reflects a hydrologic system that is unimpaired; streamflow values increase downstream as there is more drainage area contributing flow. The minimum flow of 0.0 cfs at each of the critical passage sites reflects that the river is intermittent and ceases to flow continuously during prolonged dry conditions.

TABLE 5.2 UNIMPAIRED: STATISTICAL SUMMARY OF DAILY STREAMFLOW AT POD AND THREE CRITICAL SITES

Statistics / Frequency	POD (cfs)	Site 1 (cfs)	Site 2 (cfs)	Site 3 (cfs)
Average	57	55	58	59
Median	12	10	10	10
Minimum Flow	0.6	0.0	0.0	0.0
Maximum Flow	13,950	13,960	14,460	14,560

5.4.2 Recent Historical Flow Magnitude

A summary of daily streamflow statistics at the POD, Site 1, Site 2, and Site 3 is provided in Table 5.3 for the Recent Historical period. Consistent with Camp Pendleton's existing 100-cfs sheet pile weir diversion and water management practices, both average and median daily Streamflow decreases from the POD to Site 1. Additional impacts to daily streamflow from the POD to the three critical fish passage sites are due to groundwater pumping, Lake O'Neill operations, and other water management related operations. Maximum daily streamflow generally increases from the POD toward the ocean.

The 166-cfs daily flow occurrence represents the amount of time that the flow equals or exceeds the minimum flow established for fish passage at Site 1. The 166-cfs flow value may also be used to compare flow between the POD and Site 1. Based on existing water management practices on Camp Pendleton, the minimum flow established for fish passage occurred at Site 1 on 4.2% of the days during the Recent Historical period. The corresponding flow at the POD with an occurrence percentage of 4.2% is 182 cfs.

TABLE 5.3 RECENT HISTORICAL: STATISTICAL SUMMARY OF DAILY STREAMFLOW

Statistics / Frequency	POD (cfs)	Site 1 (cfs)	Site 2 (cfs)	Site 3 (cfs)
Average	57	50	51	50
Median	14	9.2	8.8	6.4
Minimum Flow	0.0	0.0	0.0	0.0
Maximum Flow	8,300	8,200	8,400	8,400
166-cfs Daily Flow Occurrence	4.6%	4.2%	n/a	n/a

Notes: The percent occurrence of 166-cfs flow at Sites 2 and 3 is not shown since the minimum flow requirement is less than 166 cfs. Based on their minimum flow rates of 103 cfs and 78 cfs at Sites 2 and 3, their recurrence intervals are 6.6% and 8.0%, respectively.

5.4.3 Future Project Flow Magnitude

A summary of daily streamflow statistics at the POD, Site 1, Site 2, and Site 3 is provided in Table 5.4 for the Future Project period. The CUP facilities and water management practices described earlier in this report were used to simulate future project flows at the POD and each of the three critical fish passage sites. The statistical trend for average and median daily streamflow reflects the impact of a 200-cfs surface diversion at the POD. Similar to the Unimpaired and Recent Historical periods, maximum daily surface flow increases toward the ocean regardless of the diversion.

TABLE 5.4 FUTURE PROJECT: STATISTICAL SUMMARY OF DAILY STREAMFLOW

Statistics / Frequency	POD (cfs)	Site 1 (cfs)	Site 2 (cfs)	Site 3 (cfs)
Average	57	45	43	42
Median	15	6.4	2.5	0.2
Minimum Flow	0.0	0.0	0.0	0.0
Maximum Flow	8,300	8,000	8,000	8,100
166-cfs Flow Recurrence	4.6%	3.8%	n/a	n/a

Notes: The recurrence interval for the 166-cfs event at Sites 2 and 3 is not shown since the minimum flow rate is less than 166 cfs. Based on their minimum flow rates of 103 cfs and 78 cfs at Sites 2 and 3, their recurrence intervals are 5.7% and 6.7%, respectively.

The 166-cfs daily flow occurrence during the Future Project period represents the amount of time that the flow equals or exceeds the minimum flow established for fish passage at Site 1. Based on future CUP water management practices on Camp Pendleton, the minimum flow established for fish passage occurs at Site 1 on 3.8% of the days during the Future Project period. The corresponding flow at the POD with an occurrence percentage of 3.8% is 204 cfs.

5.5 PATTERN OF MINIMUM PASSAGE FLOW RATES

The pattern of minimum passage flows has been analyzed for the three investigative periods. Site 1 is the limiting location for fish passage; that is, when minimum flows at Site 1 are satisfied, minimum flows at Sites 2 and 3 are also satisfied. Following that, the analysis of the pattern and occurrence of flows has been done only at Site 1. All flows discussed in this analysis represent average daily flows.

The pattern of streamflow during the three investigative periods is described based on the 166-cfs minimum flow at Site 1, as determined from the Thompson criteria. For this analysis, an "event" is defined as a continuous period of streamflow with flow equal to or greater than 166 cfs. Flow duration was also assessed by reviewing the maximum duration event in each year. The maximum duration event is the longest period in a given year in which average daily flows were continuously sustained at a flow equal to or greater than 166 cfs. The minimum duration of an event is one day.

5.5.1 Pattern of Flow during the Unimpaired Period

During the Unimpaired period, there were an average of three events per year during which the average daily flow was equal to or greater than 166 cfs at Site 1. The average duration of each event was 5.3 days. During the 15-year period, seven years (47%) had between one and two events greater than 166 cfs; six years had between three and four events; while two years (WY 1937 and WY 1945) had more than five separate events (Table 5.5). During the Unimpaired period, each year had at least one event in which average daily flow equaled or exceeded 166 cfs.

TABLE 5.5 UNIMPAIRED: NUMBER OF EVENTS PER YEAR EXCEEDING MINIMUM PASSAGE FLOW

Events Per Year	Occurrence (Years)	Occurrence (%)
0	0 of 15	0%
1 – 2	7 of 15	47%
3 – 4	6 of 15	40%
>5	2 of 15	13%

During 14 of the 15 years of the Unimpaired period, the first event of each winter period was characterized by continuous flows whose duration was less than three days. Table 5.6 describes the distribution of each year's maximum duration event, independent of the number of events that occurred during the years. Generally, long duration streamflow events lasting longer than 10 days were preceded by either single or multiple 1-Day or 3-Day events. The average duration of all events during the 15-year period was 12 days, ranging from only one day during drier years to a maximum of 67 days during the wettest year.

TABLE 5.6 UNIMPAIRED: SUMMARY OF LONGEST-DURATION EVENTS AT SITE 1

Annual Maximum Duration Event	Occurrence (Year)	Occurrence (%)
1-Day	6 of 15	40%
3-Day	2 of 15	13%
5-Day	1 of 15	7%
10-Day or More	6 of 15	40%

Note: The 10-Day event includes all flows that had durations ten days or longer.

5.5.2 Pattern of Flow during Recent Historical Period

During the 13-year Recent Historical period, two of the 13 years had no event greater than or equal to 166 cfs. One of 13 years had 1-2 events per year, while five years had 3-4 events per year. Five years out of 13 had five or more events. The number of events exceeding the minimum passage flow at Site 1 during the Recent Historical period is shown in Table 5.7.

TABLE 5.7 RECENT HISTORICAL: NUMBER OF EVENTS PER YEAR EXCEEDING MINIMUM FISH PASSAGE FLOW AT SITE 1

Events Per Year	Occurrence (Years)	Occurrence (%)
0	2 of 13	15%
1 – 2	1 of 13	9%
3 – 4	5 of 13	38%
≥5	5 of 13	38%

The years with five or more events were also the same years that had maximum event durations of at least ten days, with some events lasting as long as 26 days. The typical pattern established during these years were multiple 1-Day and 3-Day events followed by events lasting longer than ten days. Generally, multiple short-duration storms established the physical conditions in the streambed necessary to support subsequent longer-duration events.

Most years (9 of the 13 years) had a maximum duration event lasting either 1 day or 3 days. Only two of the 13 years contained continuous, 166-cfs flow events lasting more than 10 days. A summary of the duration of each year's maximum event is shown in Table 5.8 for the Recent Historical period. The average duration of all events during the 13-year Recent Historical period was 6.2 days, ranging from 1.3 days during the driest year to 26 days during the wettest year.

TABLE 5.8 RECENT HISTORICAL: SUMMARY OF LONGEST-DURATION EVENTS AT SITE 1

Annual Maximum Duration Event	Occurrence (Years)	Occurrence (%)
1-Day	5 of 13	38%
3-Day	4 of 13	32%
5-Day	2 of 13	15%
10-Day or more	2 of 13	15%

Note: This is the longest duration in each year with continuous streamflow greater than or equal to 166 cfs.

5.5.3 Pattern of Flow during Future Project Period

Events with flows exceeding the 166-cfs minimum fish passage flow were also assessed for the 13-year Future Project period. Three of the 13 years (23%) had more than five events equal to or greater than 166 cfs. Almost one quarter of all years had only one or two events that sustained the minimum passage flows, while almost one half of the 13 years had between three and four events annually. The pattern of streamflow at Site 1 during the Future Project period is shown in Table 5.9.

TABLE 5.9 FUTURE PROJECT: NUMBER OF EVENTS PER YEAR EXCEEDING MINIMUM FISH PASSAGE FLOW AT SITE 1

Events Per Year	Occurrence (Years)	Occurrence (%)
0	3 of 13	23%
1 – 2	1 of 13	8%
3 – 4	6 of 13	46%
≥5	3 of 13	23%

The maximum duration event in each year with sustained flows greater than or equal to 166 cfs was also computed for the Future Project period. Nine of the 13 years (70%) during the Future Project period had events whose maximum duration was three days or less. Two of the 13 years contained continuous 166-cfs events lasting more than 10 days. A summary of the maximum event duration of each year is shown in Table 5.10 for the Future Project period. The average duration of all events during the Future Project period was 5.9 days, ranging from 0.5 days during the driest year to 23 days during the wettest year.

TABLE 5.10 FUTURE PROJECT: SUMMARY OF LONGEST-DURATION EVENTS AT SITE 1

Annual Maximum Event Duration	Occurrence (Number of Year)	Occurrence (%)
1-Day	6 of 13	46%
3-Day	3 of 13	24%
5-Day	2 of 13	15%
10-Day or more	2 of 13	15%

Note: This is the longest duration in each year with continuous streamflow greater than or equal to 166 cfs.

The Future Project period had a similar pattern of events as the Recent Historical period. Review of the data indicates that the short duration events, 1-Day and 3-Day events, were affected by the proposed CUP. Specifically, there was one less 3-Day event and one more 1-Day event during the Future Project period when compared to the Recent Historical. With regards to event duration, the two years that had flow events lasting ten days or longer were preceded by multiple 1-Day and 3-Day events. Analysis of the flow conditions indicated that these naturally occurring short-duration events were necessary to establish subsequent longer-duration events.

6.0 Discussion

Investigation of fish passage in the Lower Santa Margarita River commenced with a thalweg survey and biological assessment in March 2011. Three sites were identified as potential barriers to fish passage and were further investigated to characterize their physical properties influencing passage conditions. Numerical hydraulic and hydrogeologic methods were then used to reconstruct flow at the three sites so passage conditions could be assessed using the Thompson fish passage criteria.

In order to assess potential impacts to fish passage in the Lower Santa Margarita River, three investigative periods were identified from the hydrologic period of record that began in 1923. Termed the Unimpaired, Recent Historical, and Future Project periods, both flow magnitude and pattern were described for various hydrologic conditions. The three investigative periods represent wetter than normal conditions in order to assure fish passage conditions could be described. Generally, the three investigative periods are 20% wetter than the average conditions that have occurred over the hydrologic period of record that spans from 1923 to the present.

There are limitations to the use of the data and results presented in this study. As previously indicated, the statistics and findings based on the three investigative periods represent conclusions that may be reached during wetter than normal conditions. While variable and unpredictable, future hydrologic conditions may be expected to mimic long-term historical conditions that are drier than the Unimpaired, Recent Historical, or Future Project conditions.

Another limitation is the constantly migrating bed of the Santa Margarita River system at the three critical passage sites. The migrating sand substrate of the channel bottom shifts due to streamflow associated with large storm events as well as normal base flows. While the topography of the channel bottom may no longer exist as measured in March and April 2011, the limitations to fish passage due to the geomorphic characteristics and processes that control the stream bottom remain valid. While this factor is not a limitation to the use of the results from this study, the dynamic nature of the stream system should be considered when conducting future investigations or monitoring programs.

The Santa Margarita River is characterized by a high variability in flow both annually and from year-to-year. During Unimpaired conditions, average daily flow rates vary from 2.5 cfs to more than 13,950 cfs during the course of one year due to long dry periods and high intensity rainfall events. Similarly, average daily streamflow varies from 7.8 cfs during Very

Dry hydrologic years to 145 cfs during Very Wet years. Investigation of these hydrological statistics indicates that the opportunity for fish passage in the Lower Santa Margarita River is limited to a window that occurs only during wetter-than-normal hydrologic conditions. The following section of this report addresses the key changes in flow magnitude and pattern between Unimpaired, Recent Historical, and Future Project conditions as they relate to potential fish passage.

6.1 FLOW MAGNITUDE AND OCCURRENCE

Flow magnitude during the three investigative periods was assessed based on the Thompson criteria for fish passage. The result of applying these criteria was that a flow rate of 166 cfs was required at Site 1, 103 cfs at Site 2, and 78 cfs at Site 3 to support fish passage using the Thompson criteria. Because passage criteria at Sites 2 and 3 were always met when streamflow exceeded 166 cfs at Site 1, the discussion of the results on the Lower Santa Margarita River is focused on meeting flow magnitude at Site 1. It appears that water depth may be the key factor in determining fish passage capability at critical sites downstream of the POD and that water velocity is not an important factor. This is based on results of the hydraulic analysis (see section 5.3.3) where 5.75 ft/s is the maximum velocity projected at any of the three critical passage sites in this assessment.

6.1.1 Average versus Median Streamflow During the Unimpaired Period

The opportunity for fish passage in the Lower Santa Margarita River is directly related to the magnitude of streamflow. During the Unimpaired period (WY 1931-1945), the disparity between median and average streamflow in wet years suggests there were high-volume peak storm events that resulted in elevated flows with the potential to support fish passage. In contrast, during dry hydrologic years, the similarity of the average and median daily flows suggests there were few, if any, peak events that would have supported fish passage. Therefore, in more than half the years during the Unimpaired period, fish passage may not have been possible.

6.1.2 Recent Historical and Future Project Streamflow

Streamflow for the Recent Historical and Future Project periods is based upon hydrology that occurred from WY 1997-2009[3]. Similar to the Unimpaired period, streamflow during the Recent Historical and Future Project periods is characterized by high-volume peak events during

[3] This period has different hydrology than the Unimpaired period, which is based on hydrology from WY 1931-1945. The flows during these periods have similar averages (57 cfs) and both contain wetter-than-average flows. However, because of the differing time periods, flow statistics may not be directly compared.

wetter-than-normal years. In contrast, drier-than-normal years have flows of short duration and with few peaks to support potential fish passage.

The impact of the CUP facilities and management may be assessed by comparing the changes in streamflow magnitude under Recent Historical conditions to that of Future Project conditions. Table 6.1 compares the flow magnitude between the POD and Site 1 during the Recent Historical and Future Project periods. At the POD (prior to diversions from the river), flows are nearly identical[4]. At Site 1, the average streamflow decreases from 50 cfs to 45 cfs, while the median decreases from 9.2 cfs to 6.4 cfs. This is due to the operations of the CUP.

TABLE 6.1 COMPARISON OF MAGNITUDE OF FLOW BETWEEN POD AND SITE 1

		Site 1	
Statistic	**POD (cfs)**	**Recent Historical (cfs)**	**Future Project (cfs)**
Average	57	50	45
Median	14	9.2	6.4
Minimum Flow	0.0	0.0	0.0
Maximum Flow	8,300	8,200	8,000

Notes: Flows at the POD are nearly identical for Recent Historical and Future Project conditions, except for small differences due to simulated future CWRMA augmentation. The median flow at the POD during Future Project conditions is 15 cfs compared to 14 cfs during Recent Historical.

The change in occurrence of the minimum passage flow established in section 5.3.3 may be used to assess the impact of the Project on potential fish passage. The occurrence of the minimum flows is given below at the POD and at Site 1. Occurrence of minimum flows at Sites 2 and 3 is not shown, as Site 1 is the limiting reach in the system that requires the greatest streamflow.

At the POD, the minimum flow of 166 cfs is equaled or exceeded 4.6% of the time during both the Recent Historical and Future Project periods. The percent occurrence[5] of the minimum fish passage flow of 166-cfs at Site 1 decreases from 4.2% to 3.8% due to the implementation and management of the CUP facilities (Table 6.2). This translates to a reduction in flow on 19 days during the 13-year period, or an average reduction of 1.5 days per year.

[4] Flows during the Recent Historical and Future Project periods are nearly identical, except for small differences in simulated Future CWRMA augmentation. See section 4.5.3.
[5] Percent occurrence is the percent of days during the 13-year record in which the average daily flow is greater than or equal to the minimum fish passage flow at Site 1.

TABLE 6.2 CHANGE IN OCCURRENCE OF MINIMUM FISH PASSAGE FLOW RATES

Investigative Period	Percent of Days in Which Flow[1] Exceeds 166 cfs: POD	Site 1[2]
Recent Historical	4.6%	4.2%
Future Project	4.6%	3.8%

Notes:
1. Flow is the average daily flow.
2. The percent occurrence of minimum fish passage flows at Sites 2 and 3 decreases from the Recent Historical to Future Period, but remains more frequent than those at Site 1.

6.2 COMPARISON OF PATTERN OF FLOW

The pattern of flow during the Recent Historical and Future Project periods was assessed in order to determine the impact of the Project on streamflow events[6]. The pattern of flow is characterized with respect to the minimum flow of 166 cfs established for Site 1, as this is the limiting reach.

As established in section 5.5, an "event" is defined as a continuous period of streamflow with flow equal to or greater than the minimum flow of 166 cfs established for Site 1. Table 6.3 compares the number of events per year that occur at Site 1 under Recent Historical and Future Project conditions. Under Recent Historical, two of the 13 years have no such events, while under Future Project, three of 13 years have no events. There is no change in the number of years which have one to two events. The number of years with three to four events increases from five to six years, while the number of years with five or more events decreases from five to three. The change in occurrence of events is depicted in Figure 6-1.

TABLE 6.3 CHANGE IN THE NUMBER OF EVENTS PER YEAR IN EXCESS OF MINIMUM FISH PASSAGE CRITERIA AT SITE 1

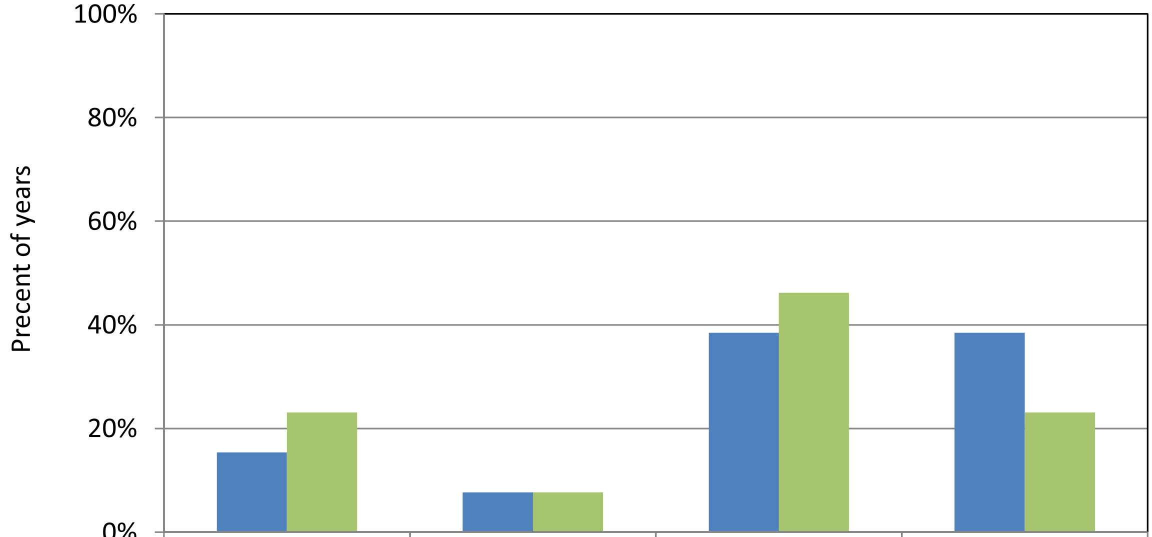
Number of Events Per Year	Recent Historical Occurrence (Years)	Future Project Occurrence (Years)
0	2 of 13	3 of 13
1 – 2	1 of 13	1 of 13
3 – 4	5 of 13	6 of 13
≥5	5 of 13	3 of 13

[6] Due to differing hydrologic periods, flow duration during the Unimpaired Period (WY 1931-1945) may not be directly compared to flow duration during the Recent Historical and Future Project period (WY 1997-2009)

FIGURE 6-1

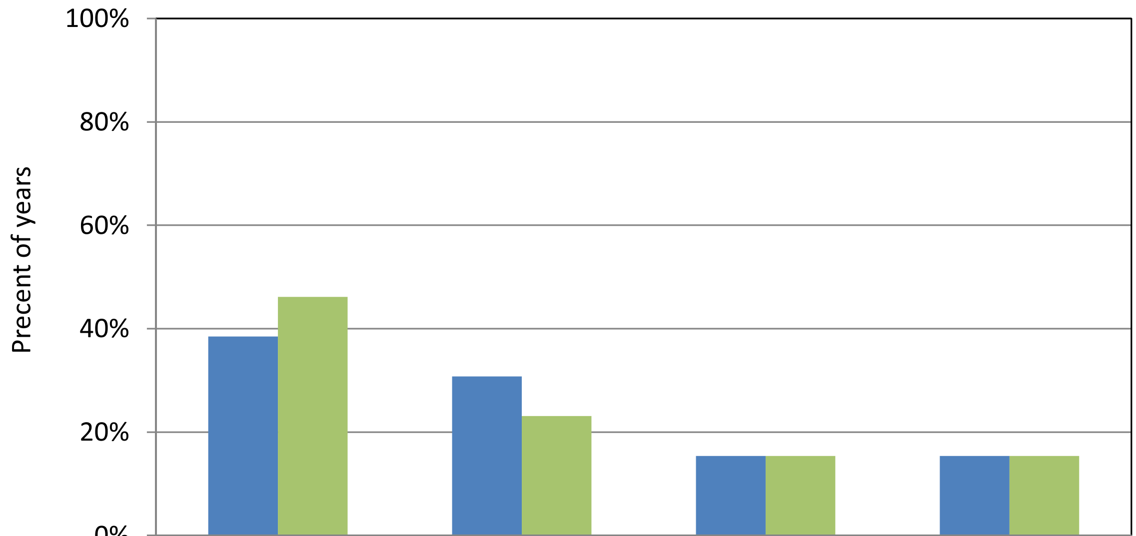
CUP IMPACT TO STREAMFLOW PATTERN AT SITE 1
DURING RECENT HISTORICAL AND FUTURE PROJECT PERIOD

Average Number of Streamflow Events per Year
Greater than 166 cfs



	0 events	1-2 events	3-4 events	>5 events
Recent Historical	15%	8%	38%	38%
Future Project	23%	8%	46%	23%

Maximum Annual Event Duration
Greater than 166 cfs



	1-Day	3-Day	5-Day	10-Day
Recent Historical	38%	31%	15%	15%
Future Project	46%	23%	15%	15%

Based on WY 1997 through WY 2009 Hydrology

DATA\2405\002-Steelhead\Report\Steelhead Draft December 2011\Supporting Spreadsheets\Figure 6-1 Hist & Future Strflw Pattern Comparison.xlsxGraphs

The maximum duration of a 166-cfs event in each year was also compared. As shown in Table 6.4, there is a slight increase in the number of years whose maximum event occurs for only one day. The occurrence of maximum-duration events of longer periods (5-days, 10-days or more) is not affected by the project.

TABLE 6.4 COMPARISON OF ANNUAL MAXIMUM DURATION EVENT AT SITE 1

Annual Maximum Event Duration	Recent Historical Occurrence (Years)	Future Project Occurrence (Years)
1-Day	5 of 13	6 of 13
3-Day	4 of 13	3 of 13
5-Day	2 of 13	2 of 13
10-Day or more	2 of 13	2 of 13

The average duration of all 166-cfs events during the two investigative periods is compared in Table 6.5. During wetter-than-average years, the average duration decreases from 14.8 days under Recent Historical conditions to 13.8 days under Future Project conditions. During drier than normal years, the average event duration decreases from 1.25 days to 0.5 days. During all 13 years of the analysis period, the average duration of all 166-cfs events decreases from 6.2 days to 5.9 days.

TABLE 6.5 AVERAGE DURATION OF 166-CFS EVENTS

	Average Duration of 166-cfs Events (Days)	
	Recent Historical	Future Project
Wet Years[1]	14.8	13.8
Dry Years[2]	1.3	0.5
All Years	6.2	5.9

Notes: Wet years are 1998, 2001, 2005, and 2008. Dry years are 1999, 2000, 2002, and 2007.

Comparison of fish passage conditions between Recent Historical and Future Project conditions indicates that there is a slight reduction in the number of events that have the potential to support fish passage. The project-related facilities and water management practices affect short-duration events that typically last three days or less. Longer duration flows that last for ten or more days do not appear to be affected by CUP related facilities.

6.3 FUTURE PROJECT FISH PASSAGE AND SCREENING AT THE POINT OF DIVERSION

There is no fish passage or screening at the diversion weir or the intake to the O'Neill Ditch under existing conditions. The weir is low enough that it is likely passable at moderate to high flows when the higher flows reduce the water surface elevation difference at the weir crest. Based on increasing the weir height, passage conditions would be improved under Future Project conditions if the project also installed fish ladders or other passage facilities at the diversion weir and screened the diversion intake.

Fish use visual cues to select upstream routes at falls and other sites where there is concentrated or turbulent flow. A broad crested weir confuses fish because there is no distinct point where the flow is concentrated for fish to jump toward. This can be solved by lowering part of the weir, providing a notch in the weir, or by providing a ladder through or around the weir.

At sites where migrating steelhead have to jump over barriers, a pool is needed at the base of the structure in order for fish to accelerate to a speed that allows them to clear the structure. The general rule of thumb is that the pool below the structure needs to be 1.5 times as deep as the structure is high. Since the existing weir is buttressed by rip rap along the downstream face, there is no pool at the base from which to jump. For the new weir, consideration should be given to provide a pool at the base of the weir along with a notch at the same location so fish have both a pool to jump from and a target to jump toward. Alternatively, a fish ladder at the weir may be incorporated to provide fish passage.

The diversion itself should be screened to prevent the entrainment of downstream migrating juvenile steelhead into Lake O'Neill or into the infiltration ponds. Screens that are designed to operate at maximum diversion rates, and that consider debris loading and changing water levels, would need to be designed to meet screening criteria established by the agencies. These screens may be located on the river or at the diversions from the O'Neill Ditch, as long as enough flow enters the ditch to provide passage for juvenile steelhead through the remainder of the ditch and back into the river.

6.4 DISCUSSION SUMMARY

The previous sections of this report outlined the methodology followed to assess fish passage on the Lower Santa Margarita River below the POD. Based on the Thompson criteria, fish passage conditions at Site 1 are the limiting factor due to the broad low-gradient nature of the stream-bottom. The results of this analysis found that when the minimum fish passage flow of 166 cfs is maintained at Site 1, minimum flow rates at Sites 2 and 3 were maintained. A short summary of the study's findings is presented below:

- Under Unimpaired conditions, the Lower Santa Margarita River is flashy in nature; during years with drier-than-normal streamflow, passage opportunities do not exist due to the low magnitude, short duration, and infrequent occurrence of peak events.

- Analysis in this report suggests that the CUP primarily affects the duration of shorter peak events (1-day, 3-day), and does not affect longer peak events (5-day, 10-day or more) when comparing Future Project (CUP) to Recent Historical (existing) conditions.

- In order to promote potential fish passage, a notch in the weir, a pool at the bottom of the weir, a fish ladder, or other passage structure is recommended for the proposed weir. Fish screens are also recommended to prevent entrainment of juvenile steelhead in the project.

- The CUP may affect the number of short-duration peak events that occur each year, but does not likely affect the duration of the longest event that occurs each year.

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