5.0 CONCEPTUAL CONJUNCTIVE WATER REUSE MODEL

Advantages of developing a viable conjunctive use project for the Fallbrook PUD include: reduced dependency on imported water supplies, development of a local water supply, and reduced costs. Similarly, Camp Pendleton will benefit from the establishment of a connection to imported water supplies and upgrades to the existing ground-water diversion and recovery facilities. Both parties would benefit from improved potable water treatment, improved basin water quality, and settlement of the *United States v. Fallbrook PUD* case.

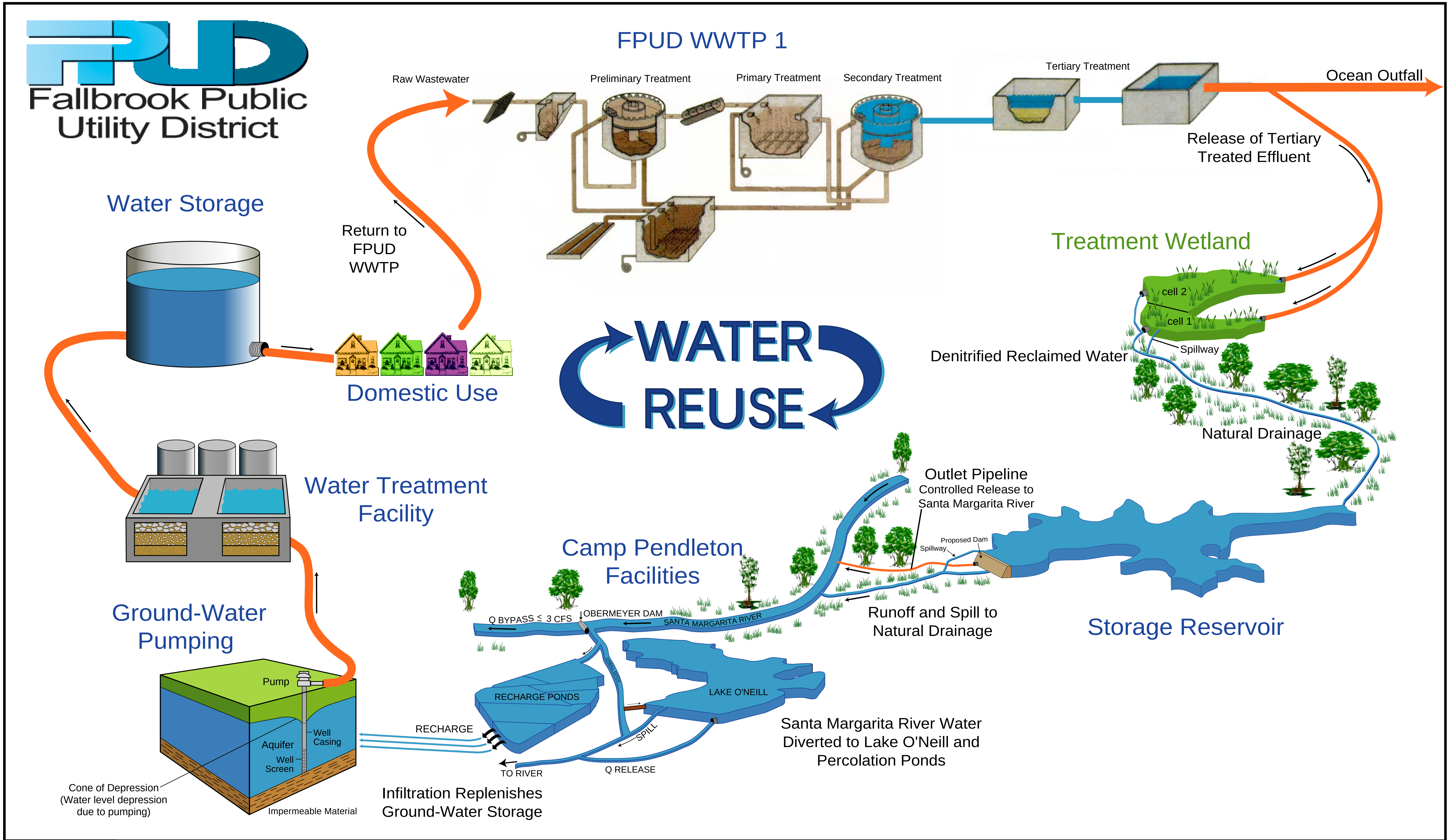
The conceptual design of the Fallbrook/Camp Pendleton conjunctive use project consists of two components: recycle and reuse, and diversion and recharge. The recycle and reuse component of the conjunctive use program includes an additional water supply consisting of reclaimed water from the Fallbrook PUD WWTP. The conceptual model that has been developed to support a conjunctive use program includes the following components (Figure 5-1).

TABLE 5-1
ELEMENTS OF THE RECYCLE AND REUSE COMPONENT OF THE CONJUNCTIVE USE PROJECT

Source and Supply	Combination of Santa Margarita River and Tertiary Treated Wastewater
Treatment Wetland	Denutrification pond to “polish” tertiary effluent
Storage Reservoir	Provide seasonal storage
Habitat Maintenance	Use of tertiary water to meet ecological demands
Ground-Water Pumping	Conjunctively manage basins for maximum diversion and storage
Water Treatment	Microfiltration and reverse osmosis of all project water
Conveyance Pipeline	Dual purpose pipeline to provide local water to Fallbrook and imported supplies to Camp Pendleton

In order to provide an alternative source of supply, tertiary treated wastewater will be released from Fallbrook’s existing ocean outfall to a set of treatment wetlands located on the Naval Weapons Station. The treatment wetlands will be maintained and managed to lower the average nitrogen level in the effluent from 7 mg/l to approximately 1 mg/l. Downstream of the treatment wetlands, a storage reservoir would store the "polished" effluent for release during the summer months. In order to achieve maximum beneficial use of the water, the stored water would be released during the summer and fall months when streamflow in the Santa Margarita River is at a minimum.

FIGURE 5-1



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Conceptual Model
Conjunctive Use Water Recycling Project

Legend

🟧	Pipeline
🟦	Natural Channel

The conjunctive use management of the lower basin would include increased pumping rates during the winter months and reduced ground-water withdrawals during the summer months. The conjunctive use pumping schedule maximizes the water that is diverted and stored in the lower basin while at the same time protecting the riparian corridor from adverse impacts due to increased pumping. All ground water produced under the conjunctive use program would be treated using advanced water treatment technologies, possibly micro-filtration and reverse osmosis. The excess water produced beyond the Base's demand would be conveyed to Fallbrook using the proposed conveyance pipeline.

5.1 COMPONENTS OF A CONJUNCTIVE USE PROGRAM

The following sections describe all possible components of a conjunctive use program that would beneficially support water supply for both the Fallbrook PUD and the Base. The conjunctive use program provides not only for increased dependable water supplies and economic alternatives to high cost imported supplies, but also for a physical solution to the long-standing legal dispute between the Fallbrook PUD and the Base. Furthermore, implementation of the recycle and reuse component of the conjunctive use program may result in overall improved water quality in the lower basin. The introduction of advanced water treatment facilities reduce total mineral concentrations in the Fallbrook PUD's potable water supply, resulting in reduced mineral concentrations in the source water that reaches the lower Santa Margarita River Basin.

In the engineering and economics sections of this report, Alternatives 9 and 10 are introduced that incorporate some or all of the components described below. Alternative 9 includes all facilities required for the release and reuse of tertiary treated wastewater, including the facilities required to extract ground water from the lower Santa Margarita basin. Alternative 10 includes all facilities included in Alternative 9, plus the facilities outlined in Alternative 3 of the Permit 15000 Study. While the results of Alternative 9 describe the beneficial impact of the use of the Fallbrook PUD's tertiary treated wastewater only, Alternative 10 provides for facilities that provide for the greatest quantity of local ground water for use by either the Fallbrook PUD or Camp Pendleton. The design and cost of the conveyance pipeline from the Base to the Fallbrook PUD is described in the NBS Lowery Report.

5.1.1 Source and Supply

The primary source and supply of water for the project will originate from the Santa Margarita River. Improvements to the diversion and recharge facilities discussed in Alternative 3 of the Permit 15000 Study will provide enhanced capabilities for the capture and recharge of winter flows. Alternative 3 project facilities include the installation of an Obermeyer Dam, increase capacity to the diversion headgate, increased capacity of the O'Neil ditch, the construction of two additional recharge ponds, improvements to the existing recharge ponds, and additional ground-water wells. The two additional recharge ponds will almost double the aerial extent of the existing recharge ponds, providing increased infiltration capacity and surface storage. The maximum rate of diversion will be approximately 200 cfs, occurring from October through April. The improvement to these facilities will allow for the proper management of flows to Lake O'Neil and the recharge ponds. The increase in winter ground-water pumping rates will create ground-water storage capacity in the aquifer and allow for stream diversions to infiltrate to the aquifer.

The water reuse cycle begins with the release of tertiary treated wastewater from the Fallbrook PUD WWTP. Presently this water is either sold as reclaimed water, or carried down an outfall pipeline to the Oceanside outfall. The recycle and reuse component of the project will include a pipeline connecting the ocean outfall with the treatment wetlands. After treatment and temporary storage, the water will be released from the storage reservoir to the main channel of the Santa Margarita River for maintenance of the riparian habitat. Both the ecology and urban water users will benefit from the in-stream flows and dry season ground-water pumping that will be supported by the releases of the new source of supply to the basin. The goal is to recycle the tertiary treated water before it reaches the ocean so that the Fallbrook PUD has the ability to reuse their water resources more effectively now and in the future.

5.1.2 Treatment Wetland

The tertiary treated wastewater releases will flow from the Fallbrook PUD's ocean outfall to a treatment wetland, constructed at the site of the existing "Depot Lake" (Figure 5-2). The proposed treatment wetland is designed to reduce nitrate levels in the effluent in order to meet basin management plans. A multi-cell treatment wetland has been designed to allow for operation and maintenance flexibility in the future.

The daily wastewater releases from the WWTP create the primary inflow to the treatment wetland. Precipitation, evaporation, and transpiration play an important role in the hydrologic balance of the treatment wetland, representing both gains and losses to the system. The outflow from the wetland is released to the natural drainage channel and flows by gravity to a storage reservoir. Erosion control devices will be installed to maintain the channel below the wetland. A spillway will allow for water to spill out of the wetland and into the natural channel during large precipitation events.

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Proposed Treatment Wetland Site

Existing "Depot Lake" and Spillway

October 15, 2001

FIGURE 5-2

5.1.3 Storage Reservoir

A storage reservoir has been designed to capture and store the releases from the treatment wetlands following nitrate reduction of the tertiary treated wastewater. The storage reservoir is designed to store seven months of wastewater releases and allow for controlled releases during the subsequent five months. Between July and November, controlled releases will be delivered to the Santa Margarita River through a 5,800 foot HDPE pipeline. A spillway and bypass facility has been designed to allow for natural inflow to pass through the reservoir and dam. The reservoir capacity is designed to capture the median natural inflow for controlled release to the natural drainage. The spillway will allow for uncontrolled releases to the natural drainage during the remaining 50% of the natural runoff events.

5.1.4 Release for Habitat Maintenance

Controlled releases from the reservoir will blend with the Santa Margarita River to provide water that supports the riparian habitat in the lower Santa Margarita River basin. The timing of these controlled releases allows for ground-water pumping to remain unimpeded during the dry summer months. The benefit of these releases to both the habitat and the two parties will be realized not only during the dry summer months, but also during the years of extended drought.

The reservoir and dam is designed to allow for the controlled and uncontrolled bypass of natural inflows formed during storm events. Both the controlled and uncontrolled bypass of natural runoff will serve to maintain natural conditions in the natural drainage channel between the reservoir and the Santa Margarita River. Direct releases from the reservoir to the Santa Margarita River reduce operation and maintenance of the natural drainage and prevent changes to the natural habitat in this area.

5.1.5 Ground-Water Conjunctive Use Pumping

Ground water will be conjunctively managed to maximize the amount of water that can be diverted from the Santa Margarita River and stored in the aquifers on the Base. The development of a ground-water conjunctive use program will provide the Fallbrook PUD the maximum amount of local ground-water supplies and help the Base avoid regulatory issues with regard to habitat maintenance along the Santa Margarita River’s riparian corridor. One of the most important aspects of the proposed conjunctive use pumping is that maximum ground-water withdrawals occur during the winter months when habitat maintenance requirements are at a minimum. During the dry summer months, ground-water withdrawal rates are reduced to support sensitive habitat.

The quantity of ground water produced during the winter months is beyond the Base’s historical or build-out demand, requiring the need to partner with the Fallbrook PUD. The excess supply, beyond the Base’s demand, will be treated and pumped to Fallbrook using the proposed conveyance pipeline. The reduced quantity of ground water produced in the dry summer months will be used to meet the Base’s demand, with any excess, if available, pumped to Fallbrook. Figure 5-3 provides a graphical representation of a possible conjunctive use pumping schedule.

5.1.6 Advanced Water Treatment Facilities

All ground-water withdrawals for domestic, municipal, and military demands by the Fallbrook PUD and the Base will be delivered to an advanced water treatment facility. The long-term impact of this advanced treatment process will result in lower mineral concentrations in water that is re-introduced into the recycle and reuse component of the conjunctive use program. As imported supplies are replaced by local ground-water supplies that have undergone advanced water treatment, the mineral concentration in both the Fallbrook PUD’s and the Base’s potable water supply will be reduced. The subsequent wastewater will also benefit from the advanced potable water treatment, resulting in lower mineral concentrations of water that is reintroduced to the lower Santa Margarita River Basin. This process will not only benefit the Fallbrook PUD, but also the Base's wastewater facilities. The path, design, and cost of an actual treatment facility falls outside the scope of this study, but for completeness a brief explanation of a few treatment options are presented here.

5.1.6.1 Micro-Filtration

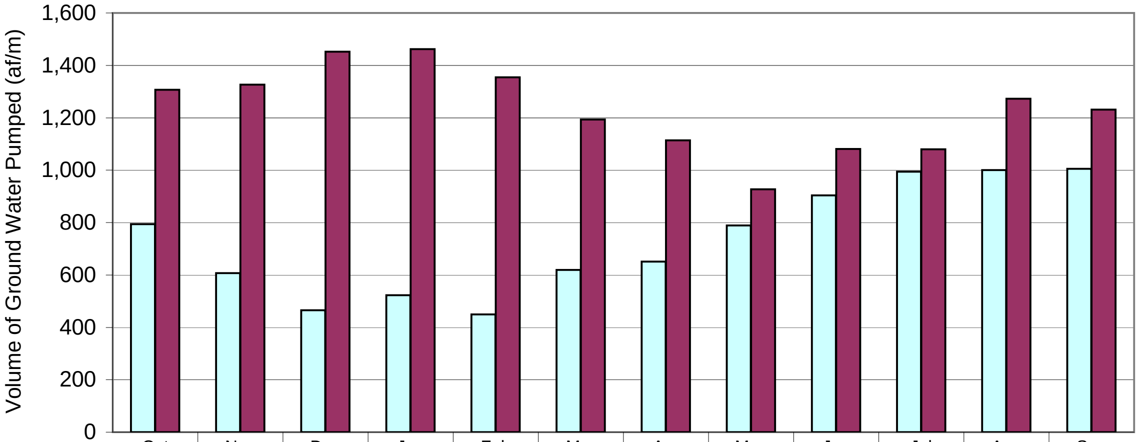
Microfiltration (MF) utilizes membranes to filter components of a pressurized wastewater stream. Microfiltration is capable of removing particles in the macro molecular range (0.5µm to 2.0 µm) such as *Giardia* cysts and some bacteria. The process is often used as a pretreatment for reverse osmosis. Microfiltration membranes have larger pore sizes than those used in reverse osmosis (0.001 µm) and are effective in removing the larger particles that may cause increased fouling (clogging) of the costly reverse osmosis membranes. Operating pressures of approximately 1 to 25 psi are required for this process compared to 200 to 1,000 psi for reverse osmosis. Microfiltration provides an efficient and economical means of advanced filtration for use in small water treatment systems and as a pretreatment for reverse osmosis.

5.1.6.2 Reverse Osmosis

Reverse osmosis (RO) is the most common process for reducing the salinity of brackish ground water, while also improving the overall water quality. This physical process involves the

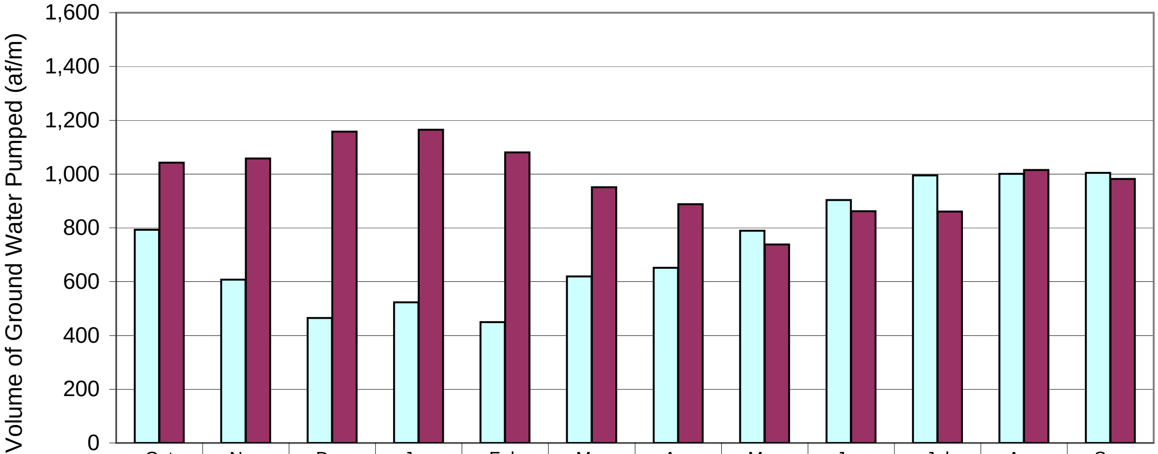
FIGURE 5-3

F3 Pumping during Normal Streamflow (af/m)



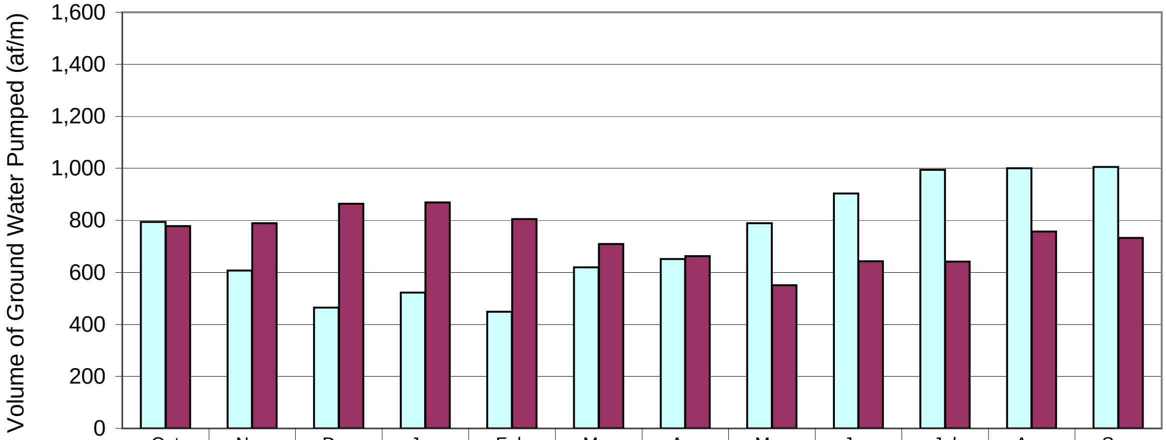
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual Total
☐ CP Buildout	793	607	465	523	449	619	651	789	903	994	1,001	1,005	8,800
■ F3	1,307	1,327	1,452	1,462	1,355	1,193	1,114	926	1,081	1,080	1,273	1,231	14,800

F3 Pumping during Second Below Normal Winter (af/m)



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual Total
☐ CP Buildout	793	607	465	523	449	619	651	789	903	994	1,001	1,005	8,800
■ F3-3K	1,042	1,058	1,158	1,165	1,080	951	888	739	862	861	1,015	981	11,800

F3 Pumping Following Third Below Normal Winter



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual Total
☐ CP Buildout	793	607	465	523	449	619	651	789	903	994	1,001	1,005	8,800
■ F3-6K	777	789	863	869	805	709	662	551	643	642	757	732	8,800

forced passage of water through a membrane to accomplish the separation of water from a solution of dissolved salts (Viessman and Hammer, 1993). The membrane is designed to allow only ions the size of water molecules to pass, leaving organic compounds, metals, salts, nitrogen, and microbes behind. An RO system can reduce the total dissolved solids (TDS) concentration from upwards of 1,000 mg/L to less than 20 mg/L. Up to 99.9% removal of organic compounds, metals, and microbes can also be achieved using an RO system. (Black & Veatch Repot)

5.1.6.3 Disinfection

Chlorination and ultraviolet irradiation (UV) are two common disinfection techniques used to treat replenished ground-water sources. Chlorination is achieved by using a liquid form a chlorine known as sodium hypochlorite (NaOCl). The byproducts of sodium hypochlorite are virtually identical to those of chlorine, but there is no potential for chlorine gas leaks when using NaOCl liquid as compared to chlorine gas. Sodium hypochlorite is an effective disinfection mechanism for the array of pathogens and viruses that may be present in the recycled water (Black & Veatch Report). Ultraviolet (UV) light posses unique disinfection capabilities, which attacks bacteria cells at the DNA level. These harmful rays are able to destroy pathogens present in the water. The primary advantages of using UV radiation is the lack of any chemical byproduct, and the relatively inexpensive cost for disinfecting higher quality waters. Although, UV is only moderately effective in warding off Giardia and Cryptosporidium cysts.

5.1.7 Conveyance Pipeline

The final component of the conjunctive use program is a conveyance pipeline that delivers potable water from the advanced water treatment facilities to the Fallbrook PUD, and to a lesser extent, to portions of the Base. The pipeline should be designed to deliver water from the proposed treatment facilities in Haybarn Canyon along Vandergrift Boulevard to Ammunition Road. The pipeline then continues along Ammunition Road, crossing the Naval Weapons Station, terminating in the Fallbrook PUD’s service area. The path, design, and cost of the conveyance pipeline falls outside the scope of this study.

The pipeline should be designed to meet the ground-water withdrawal rates that are described in the ground-water conjunctive use pumping schedule. In comparison to the NBS Lowery Report, the capacity of the pipeline and related pumping facilities are increased in order to deliver the excess production during the peak winter pumping months.

5.2 CONJUNCTIVE USE MANAGEMENT BENEFITS

The coordinated and integrated management of the study area’s surface and ground-water resources, under a conjunctive use management program, aims to optimize the joint use of all water resources. This approach to water planning would require a comprehensive consideration of the parties’ water objectives and the matching of the characteristics of different supplies (such as quality, availability, cost, and reliability) to the requirements of different water demands as conditions change inside and outside of the region. In general, greater benefits from the conjunctive management of all water supplies together can be achieved over the isolated management of each individual supply system.

The recycling and reuse of water supplies increases the efficiency of water delivery systems, not only in the immediate region, but also throughout southern California. For example, the Bay-Delta system provides the water supply for a wide range of instream, riparian, and other beneficial uses. Making more efficient use of water is an important way to reduce the mismatch between the available water supply and timing and the combined beneficial needs for that water. Water use efficiency measures include various programs that seek to reduce the demand for water and increase the reuse of water in the system. These measures include various methods of agricultural and urban conservation, water recycling, and reclamation.

The Fallbrook PUD and the Base’s conjunctive use program provides a plan that implements conservation measures by increasing local water supplies and reducing inefficiencies in the region-wide supply system. The conjunctive use program manages surface and ground-water supplies for the benefit of the local water users, including ecological demands dependent on the riparian corridor of the Santa Margarita River. The additional component of the reuse of treated wastewater flows increases the overall efficiency of water used throughout the region. The generalized plan for a conjunctive use program within the Santa Margarita River Basin successfully combines water supply management techniques with ecological demands through the use of conservation and reuse measures.

6.0 HYDROLOGIC ANALYSES

Hydrologic analyses for the conjunctive use program include the use of both surface and ground-water models to account for the flow of water through surface impoundments and their subsequent release to the river and ground-water systems. The focus of the various analyses described in this section is to account for the release and path of tertiary treated wastewater at the treatment wetlands, to the point which extractions are made from the ground-water aquifer. The use of these models allow engineers to accurately account for released flows, as well as naturally occurring flows, that impact the required design size of each of the facilities. Hydrologic analyses incorporate an iterative process that allows the engineer to optimize the design of the project based on a given set of assumptions.

The scope of these analyses is to address multiple scenarios for diverting reclaimed water from the Fallbrook PUD WWTP 1 for utilization in a conjunctive water use program. Factors that impact the results of these analyses includes the size and location of existing facilities, contributing watershed drainage areas, hydrologic conditions, surface diversion schedules, and ground-water extraction rates. Three scenarios were reviewed in order to address the design and size of each component of the conjunctive use project. These three scenarios included release of 1,500 AFY, 2,500 AFY, and 3,500 AFY of tertiary treated wastewater from the Fallbrook PUD's treatment facilities. The purpose of choosing these three scenarios is to provide decision makers with the necessary data to apply the appropriate water management techniques to minimize costs and maximize water availability and supply.

The surface water analysis is based on general principals of hydrology and hydraulics. A Reclaimed Water Reservoir Operations Model (RWROM) was developed to serve as an accounting tool of all the surface water in the system, noting losses, gains, storage, and releases. Following the routing through the RWROM, the Camp Pendleton Reservoir Operations Model (CPROM), developed in the Permit 15000 Study, was utilized to estimate the rate and timing of surface diversions from the Santa Margarita River to the recharge ponds and Lake O'Neil. The CPROM is designed to provide input data for the ground-water model, while also providing a balanced water budget for the surface water within the system.

A MODFLOW™ ground-water model (developed in the Permit 15000 Feasibility Study) was used to run multiple simulations for each alternative to explore how different hydrologic factors would affect the ground-water system. The ground-water model accounts for variations in hydrologic conditions and its effect on the ability to extract ground water while measuring related impacts to the environment. Similar to the surface water model, the ground-water model provides a tool that describes all inflows and outflows to a basin, allowing for the engineer to maintain a balanced water budget under changing conditions. The ground-water model optimized the amount of water available for extraction and use in the conjunctive use program while simultaneously meeting environmental constraints.

6.1 PROJECT SCENARIOS

In order to evaluate and optimize the size of project facilities, three release scenarios of tertiary treated wastewater from the Fallbrook PUD were analyzed: 1,500 AFY, 2,500 AFY, and 3,500 AFY. Table 6-1provides a statistical summary of the Fallbrook PUD's estimated wastewater releases over the 20-year model period. The minimum, maximum, and average releases vary from the prescribed flow of each scenario due to available capacity at the existing wastewater treatment facility. Except for the 1,500 AFY scenario, the available water for all other scenarios are ramped-up over 20 years due to today's existing effluent volume of 2,240 AFY. Due to the ramping-up to build-out conditions, the release goal of 2,500 AFY will not first be achieved until model year 11. In order to meet the 3,500 AFY release goal, an increase in the plant's operating capacity or a third party source is required. Scenario 3 assumptions include that by model year 20 the plant would be able to produce 3,500 AFY (3.125MGD) of treated water. All previous years were calculated by adding the difference between the 3,500 AFY goal and the projected annual flow in model year 20 (2,757 AFY) to the projected annual flow for a given year. Figure 6-1 shows the four curves representing the wastewater releases from the Fallbrook PUD WWTP 1 under current projection rates and for the three water reuse scenarios.

TABLE 6-1:

Summary of Fallbrook PUD's WWTP Annual Releases for Each Scenario

MODEL YEAR	Projected Annual Flow (AFY)	Scenario 1 1500 (AFY)	Scenario 2 2500 (AFY)	Scenario 3 3500 (AFY)
TOTAL	49,821	30,000	48,558	64,688
Average	2,491	1,500	2,428	3,234
Median	2,486	1,500	2,486	3,230
Maximum	2,757	1,500	2,500	3,500
Minimum	2,242	1,500	2,242	2,986

6.2 SURFACE WATER ANALYSIS

The surface water analysis is based on general principals of hydrology and hydraulics. A Reclaimed Water Reservoir Operations Model (RWROM) was developed to simulate the surface water in the system, noting losses, gains, storage, and releases. The hydrologic model begins with the release of tertiary treated wastewater from the Fallbrook PUD WWTP. The model tracks the wastewater releases from the Fallbrook PUD WWTP 1 to a treatment wetland constructed at the existing "Depot Lake" in the natural drainage area. The primary function of

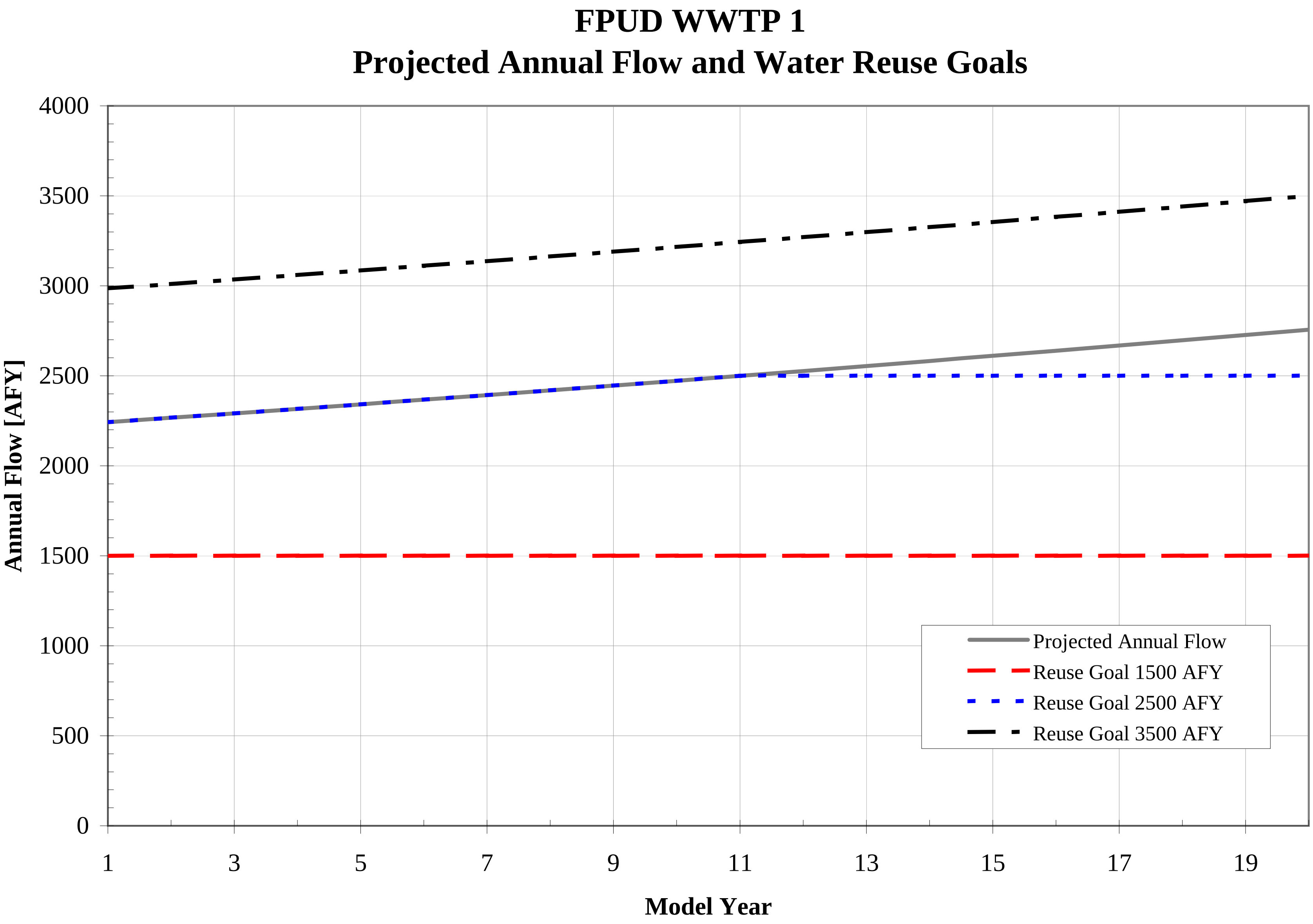

FPUD WWTP 1
Projected Annual Flow and Water Reuse Goals
Annual Flow [AFY]
4000
3500
3000
2500
2000
1500
1000
500
0
1
3
5
7
9
11
13
15
17
19
Model Year
Projected Annual Flow
Reuse Goal 1500 AFY
Reuse Goal 2500 AFY
Reuse Goal 3500 AFY

FIGURE 6-1

the proposed treatment wetland is to remove nitrate from the wastewater releases. The outflow from the treatment wetland is routed through the natural channel into a storage reservoir. The water is then stored in the reservoir for a period up to seven months before it is released via pipeline into the Santa Margarita River. Precipitation, evaporation and transpiration all play an important role in accounting for the water budget. The RWROM analyzes the path of the tertiary treated wastewater from the Fallbrook PUD WWTP to the release of reclaimed water into the Santa Margarita River. A schematic representation of the RWOM is shown in Figure 6-2.

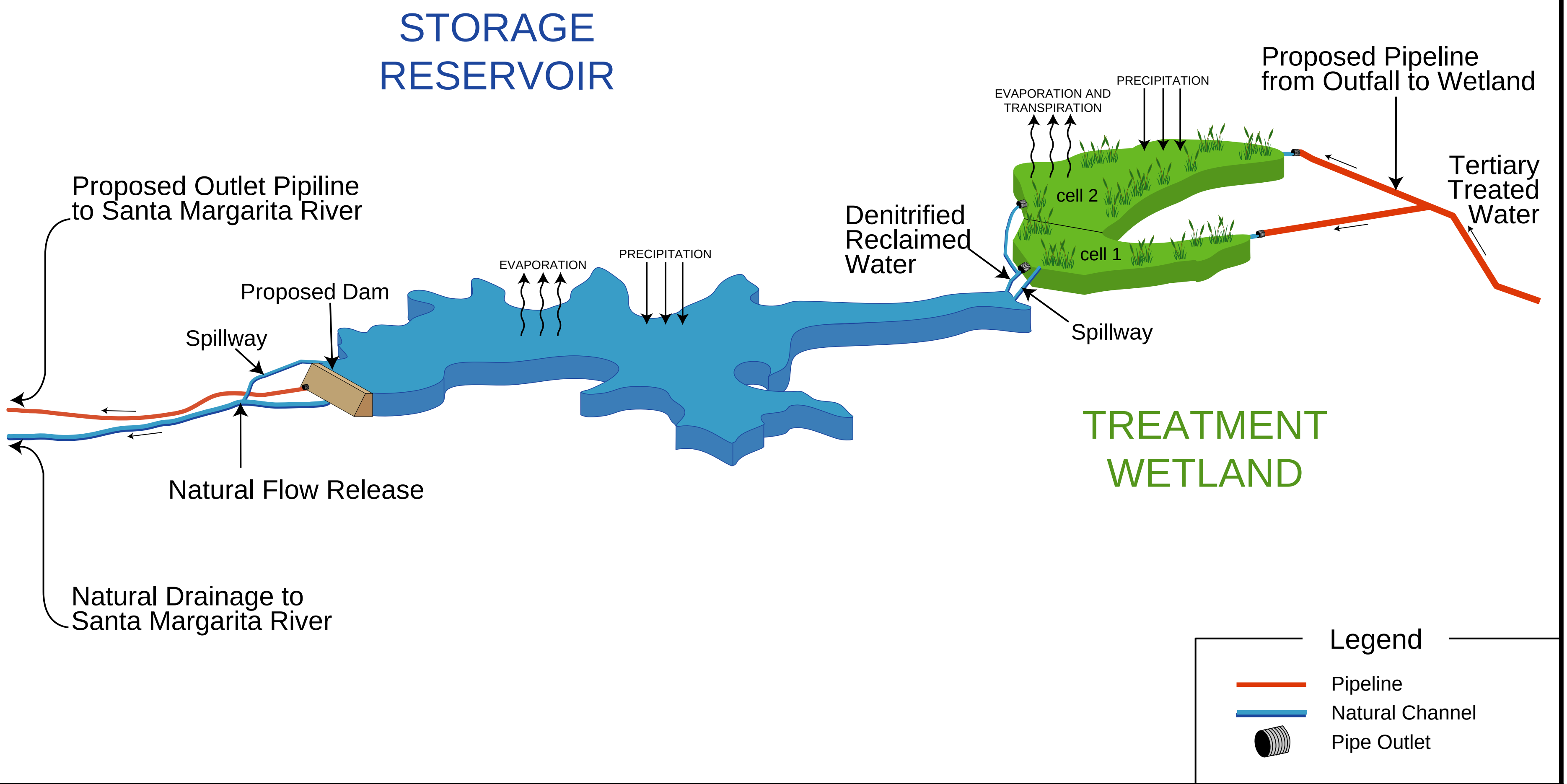
6.2.1 Treatment Wetland

The RWROM simulates steady state conditions for the treatment wetland. The net outflow from the wetland is a function of the flow that enters the wetland plus the net effect of all losses and gains in the system. The daily wastewater releases from the WWTP create the primary inflow to the treatment wetland. In order to account for the daily fluctuation in the WWTP effluent over a given year, a trend line representing these fluctuations was developed (Chapter 4). The purpose of this calculation was to determine an average daily percentage of total annual effluent released from the Fallbrook PUD WWTP. The daily percentage was multiplied by the annual WWTP release for each scenario to develop the daily WWTP release schedule used in the RWROM.

The inflow to the wetland is conveyed from a HDPE pipeline connected to the Fallbrook PUD’s ocean outfall line. The losses incurred in the pipeline, between the plant and the treatment wetland, are assumed to be negligible. It was also assumed that surface runoff to this point would have a minimal affect on the hydraulics of the wetland. The outflow from the wetland passes through a five-foot ft weir box into the natural drainage channel. Erosion control devices will be installed to maintain the channel below the wetland. Further design details are specified in Chapter 7.

The hydraulic capacity of the wetland, for Scenarios 1 to 3, is designed to convey the daily wastewater releases through the wetland with a minimum hydraulic retention time of 4 days. Hydraulic retention time is defined as a measure of the average time that water remains in the wetland (Mitsch and Gosselink 1993), and is calculated as flow divided by volume. The significance of the hydraulic retention time on nitrate removal is discussed in Chapter 7 of this study.

Precipitation, evaporation, and transpiration play an important role in the hydrologic balance of the treatment wetlands in the RWROM. For simplicity, it was assumed that the wetland area defined for each scenario was completely inundated to a depth of approximately two feet. Therefore, the effective surface area of the wetland remains constant throughout the model period, and steady state conditions apply (i.e. inflow = outflow + gains – losses).



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Reclaimed Water Reservoir Operations Model

October 15, 2001

FIGURE 6-2

6.2.1.1 Precipitation

Precipitation falls on the open water surface area of the treatment wetland, acting as a gain to the water budget. Hourly and daily data from the Oceanside rainfall gage in southern California was used to calculate precipitation runoff. Data sets were obtained from the Desert Research Institute. Monthly precipitation values at Oceanside are shown in the Appendix. The hourly Oceanside Precipitation gage data (obtained from the DRI) was used to simulate rainfall from October 1, 1979 to September 30, 1999. There were two substantial periods of missing data during wet years (8/1/93 to 4/24/94, and 12/16/97 to 10/2/98). Monthly data from the Lake O'Neil station was used to substitute the missing data values.

6.2.1.2 Evaporation and Transpiration

Evaporation and transpiration occur over the entire area of the treatment wetland, acting as a loss to the water budget. It was assumed that the open water surface area experiences evaporative losses, while the dense array of wetland vegetation lose water through the surfaces of plant leaves and stems. Both losses were calculated on a daily basis based on the assumption that the total wetland area is inundated and covered with vegetation.

Evaporation removes water from the surface area of an open body of water. Transpiration removes water from the surface area of a plant. The monthly values, shown in Table 6-2 below, were applied on a daily basis to the surface area of the treatment pond. The consumptive use rates for water surface evaporation and transpiration were calculated from climate stations and University of California crop requirement (Baseline ETo) stations in the region of the study area (Stetson Engineers, April 1995).

TABLE 6-2

EVAPORATION AND TRANSPIRATION RATES

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
EVAPORATION													
Inches/ Month	2.51	3.20	4.45	5.41	6.44	6.98	7.67	7.41	6.16	4.42	2.96	2.35	59.96
Inches/ Day	0.08	0.11	0.14	0.18	0.21	0.23	0.25	0.24	0.21	0.14	0.10	0.08	N/A
TRANSPIRATION													
Inches/ Month	2.31	2.92	4.06	4.94	5.87	6.37	6.99	6.75	5.62	4.03	2.70	2.15	54.71
Inches/ Day	0.07	0.10	0.13	0.16	0.19	0.21	0.23	0.22	0.19	0.13	0.09	0.07	N/A

Note: N/A indicates "not applicable".

6.2.1.3 Outflow from Treatment Wetland

The daily outflow is equal to the inflow on that day, minus the evaporation and transpiration for that day, plus any precipitation falling on the wetland surface (Table 6-3). Water is released from the treatment wetland via a five foot weir box, through a culvert under the levee, and into the natural drainage channel below. Erosion control devices will be used to minimize the impact on the natural channel Details about the hydraulic structures and flow paths in the wetland are discussed in Chapter 7.

TABLE 6-3

NET LOSSES FROM TREATMENT WETLAND

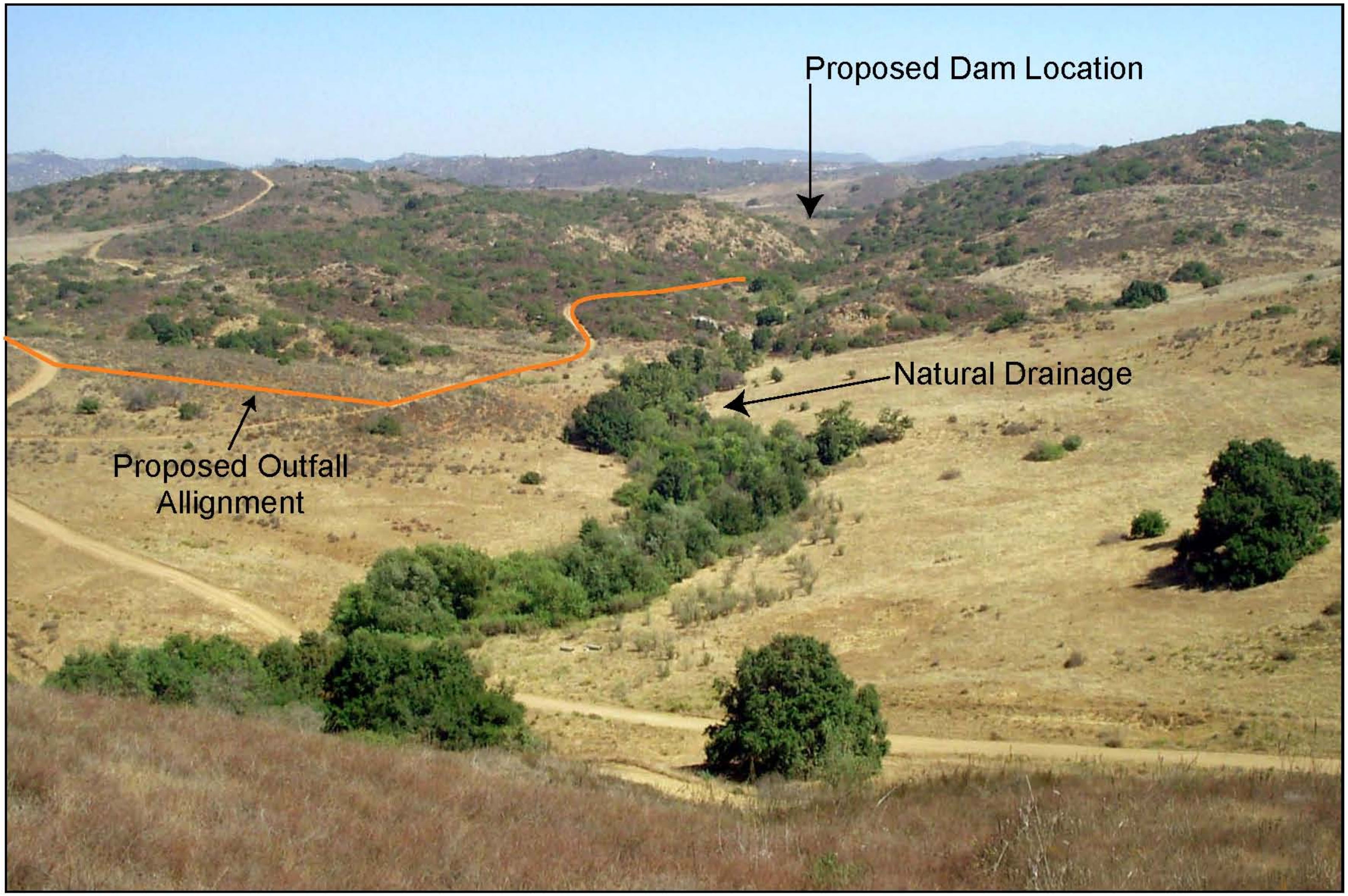
Average Annual	Unit	Scenario1 1500 AFY	Scenario 2 2500 AFY	Scenario 3 3500 AFY
Release from WWTP to Wetland`	(AFY)	1,500	2,430	3,230
Release from Wetland to Reservoir	(AFY)	1,410	2,300	3,040
Effective Evaporation & Evapotranspiration Losses	**(AFY)**	**90**	**130**	**190**

6.2.2 Natural Drainage Area

The natural drainage area of the upland area that contains the treatment wetland and storage reservoir site totals over 1,500 acres. The natural waterway is characterized as an ephemeral creek, flowing only during periods of intense precipitation. Most storm rainfall becomes direct runoff, and little infiltration occurs. Basin yields from this type of watershed are generally the result of direct runoff from larges storms. (Chow et. al., 1988).

For the purpose of modeling surface run-off to both the treatment wetland and reservoir site, the natural drainage area described in Chapter 3 was further subdivided. The portion of runoff that contributes only to the treatment wetland was delineated from the portion of runoff that contributes to the entire upper drainage area, including the reservoir.

Based on a site visit to the Naval Weapons Station on November 25th and 26th, 2001, a number of observations about the natural drainage area were made. The existing channel and banks are choked with dense riparian vegetation, whereas the floodplain land use is more closely related to a natural pasture or range. The channel intersects both paved and unpaved roads as it moves from the upper watershed until it meets the Santa Margarita River. Most of the road crossings consist of one or more three to four foot diameter culverts lying at the channel invert. At some of these locations the culverts are ineffective due to poor placement or blockage by excessive woody debris (Figure 6-3). Due to the extent of vegetation in the channel, a level



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Proposed Reservoir Site and Natural Drainage

October 15, 2001

FIGURE 6-3

survey was not performed. A qualitative assessment of the channel geometry reveals a slightly U-shaped channel with a top width of approximately 6 to 10 feet.

6.2.2.1 SCS Method

The contribution of runoff from the natural drainage to reservoir #4 was computed using the Soil Conservation Service Curve Number Method. The Soil Conservation Service (SCS, 1972) developed a method for computing abstractions from storm rainfall (Chow et. al., 1988). The SCS method was used to approximate flows after peak precipitation events during the model period.

The basic equation for computing the depth of excess rainfall or direct runoff from a storm by the SCS method is:

$$P_e = \frac{(P - 0.2S)^2}{P - 0.8S}$$

The variables in the SCS method include: P_e = rainfall excess (direct runoff), P = total rainfall, and S = potential maximum water retention. To standardize this equation for different watersheds, a dimensionless curve number (CN) is defined, such that for impervious water surfaces CN=100, and for natural surfaces CN<100. The curve number is a function of the soil types and land uses of a particular area. Table 6-4 lists the curve numbers chosen for the streamflow model. The curve number and S are related by the equation:

$$S = 1000/CN - 10.$$

TABLE 6-4:
CURVE NUMBERS FOR SUB-BASIN RUNOFF USED IN THE SCS METHOD

Upper Drainage Area			Lower Drainage Area		
CN	**S**		**CN**	**S**	
71.4	4.00	**Normal**	70.7	4.14	**Normal**
85.2	1.74	**Wet**	84.8	1.80	**Wet**
51.2	9.52	**Dry**	50.4	9.85	**Dry**

The delineation of each of the natural drainage areas and soil types was shown in Chapter 3 (Figure 3-5). The upper drainage area contributes to the total volume entering the storage reservoir, therefore the quantity of runoff from the natural drainage area was instrumental to the design of the reservoir. The lower drainage area will flow through the natural channel, into the Santa Margarita River as in existing conditions. This water was already accounted for in the Santa Margarita baseflow.

The USDA SCS Method was applied to determine the hydrologic soil group and associated CN for each land use. The land use for the areas of interest was assumed to be 100% pasture. The classification of native pasture or range was assumed to be fair. According to the Hydrology section of the SCS National Engineering Handbook, fair pasture is defined as not heavily grazed with plant cover on 1/2 to 3/4 of the area. The normal curve numbers used to calculate wet, dry, and antecedent moisture conditions were derived from the hydrologic soil analysis.

6.2.2.2 Surface Runoff

The daily surface runoff for the natural drainage area was calculated using the SCS Method. The baseflow in the natural ephemeral stream was assumed to be zero. The annual total runoff contribution from both the upper and lower drainages is show in Table 6-5.

TABLE 6-5

ANNUAL SURFACE RUN-OFF CONTRIBUTIONS FOR THE UPPER AND LOWER SUB-BASINS

Water Year	Upper Basin Annual Runoff (AFY)	Lower Basin Annual Runoff (AFY)	Total Natural Drainage Annual Runoff (AFY)
Total	**3,284**	**825**	**4,109**
Average	164	41	205
Median	144	36	180
Max	518	131	649
Min	9	2	12

The capacity of the reservoir was designed to store the upper basin surface runoff occurring in a median year (144 AF) plus 7 months of wastewater releases.

6.2.3 Storage Reservoir

The storage reservoir was designed to hold 7 months of wastewater releases plus the median inflow from the natural basin surface runoff. The RWROM simulates steady state conditions, with flow entering and exiting the reservoir, while accounting for losses, gains, and changes to storage in the system (Figure 6-2).

The inflow to the reservoir is calculated as the daily treatment wetland release plus the natural surface runoff from the upper basin. The reservoir experiences losses and gains due to evaporation and precipitation respectively. Again, Oceanside precipitation values and the evaporation rates shown in Table 7 were used to simulate the effective losses for the reservoir. The outflow from the storage reservoir is prevalent in three forms; pipe release, natural runoff bypass release, and spillway spills.

6.2.3.1 Losses and Gains

Losses and gains from the storage reservoir include evaporation, and precipitation respectively. The calculation of these quantities allowed for a more accurate estimate of the amount of water released from the reservoir. Oceanside precipitation values and the evaporation values were used to simulate the effective losses for the reservoir. Infiltration rates from the reservoir were assumed to be negligible. There are limited losses in the system due to the shallow soil depth with impermeable bedrock underlay. Water that does infiltrate will most likely resurface in the reservoir or further downstream in the watershed.

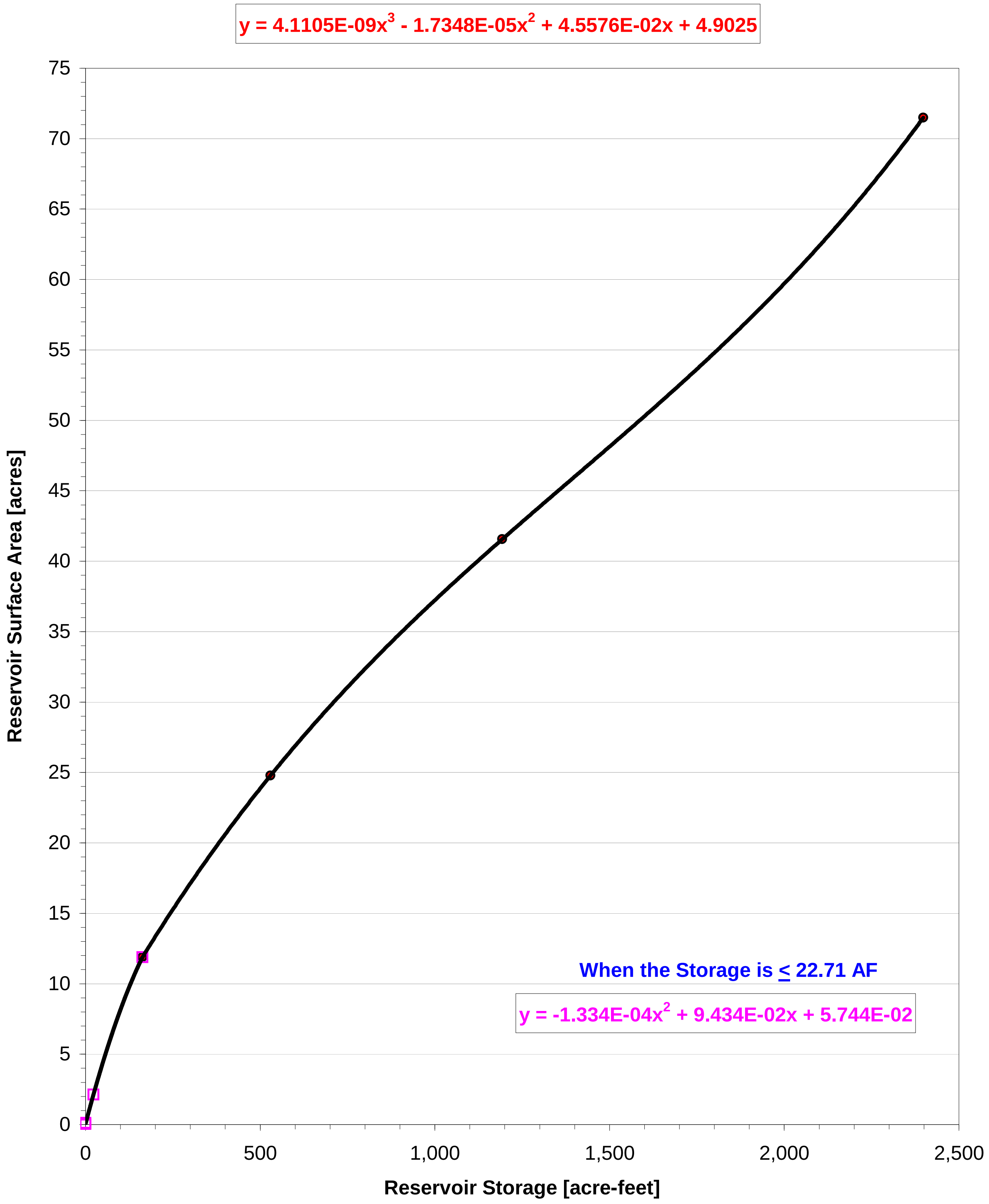
The evaporation rate for each month and the daily precipitation were applied to the surface area of the reservoir on a daily basis. The surface area changes relative to the volume of water in the reservoir. Topographic contour lines and CADD design drawings were used to construct a graph of Volume vs. Surface Area (Figure 6-4). A trendline for this graph was used to calculate the volume of loss from evaporation each day, based on the daily changes in the volume of the reservoir.

6.2.3.2 Outflow from Storage Reservoir

Water is released from the storage reservoir in three forms; pipe release, natural runoff bypass release, and spillway spills. The timing of release is a function of the optimal reservoir operations and an adaptive management strategy. A more detailed explanation of the dam outworks is discusses in Chapter 7.

Pipe releases occur over a five-month period from July through November. The pipe release is calculated by dividing the total volume of the reservoir on the last day of storage (June 30th) by the five-month release period (153 days). The pipe releases will flow by gravity through approximately 1 mile of HDPE pipeline until it reaches the Santa Margarita River. At this point, the reclaimed water blends with the river flow, providing water for the maintenance of riparian habitat along the Santa Margarita River channel.

FIGURE 6-4



Reservoir Site No. 4
Surface Area vs. Storage Capacity

$y = 4.1105E\text{-}09x^3 - 1.7348E\text{-}05x^2 + 4.5576E\text{-}02x + 4.9025$

When the Storage is ≤ 22.71 AF

$y = -1.334E\text{-}04x^2 + 9.434E\text{-}02x + 5.744E\text{-}02$

Natural runoff is bypassed through a release pipe perpendicular to the primary pipe release. The objective is to allow the surface runoff to continue down the natural drainage path in order to maintain a healthy channel and supply water to the established riparian vegetation. The RWROM assumes that the daily influx of surface runoff is immediately released into the natural channel. This water is not considered to be reclaimed water, but is accounted for in the sizing of the reservoir, pipelines, and hydraulic structures at the outlet of the dam.

Spillway spills constitute the remaining outflow from the storage reservoir. Spills from the reservoir occur when the water surface elevation reaches the spillway crest elevation, which is unique for each scenario (see Chapter 7). Due to the extra space allocation for surface runoff, and a management strategy to bypass these flows through the natural drainage, the RWROM calculated no spill for the 20-year model simulation.

The performance of the storage reservoir in the RWROM is shown in Table 6-6 below.

TABLE 6-6:

STORAGE RESERVOIR PERFORMANCE (RWROM)

Average Annual	Unit	Scenario 1 1500 AFY	Scenario 2 2500 AFY	Scenario 3 3500 AFY
Release from Wetland to Reservoir	(AFY)	1,410	2,300	3,040
Release from Reservoir to SMR	(AFY)	1,330	2,180	2,900
Spill	(AFY)	0	0	0
Effective Reservoir Evaporative Losses	(AFY)	80	120	140
Effective Reservoir and Treatment Wetlands Evaporative Losses	(AFY)	170	250	330

6.3 GROUND-WATER MODEL

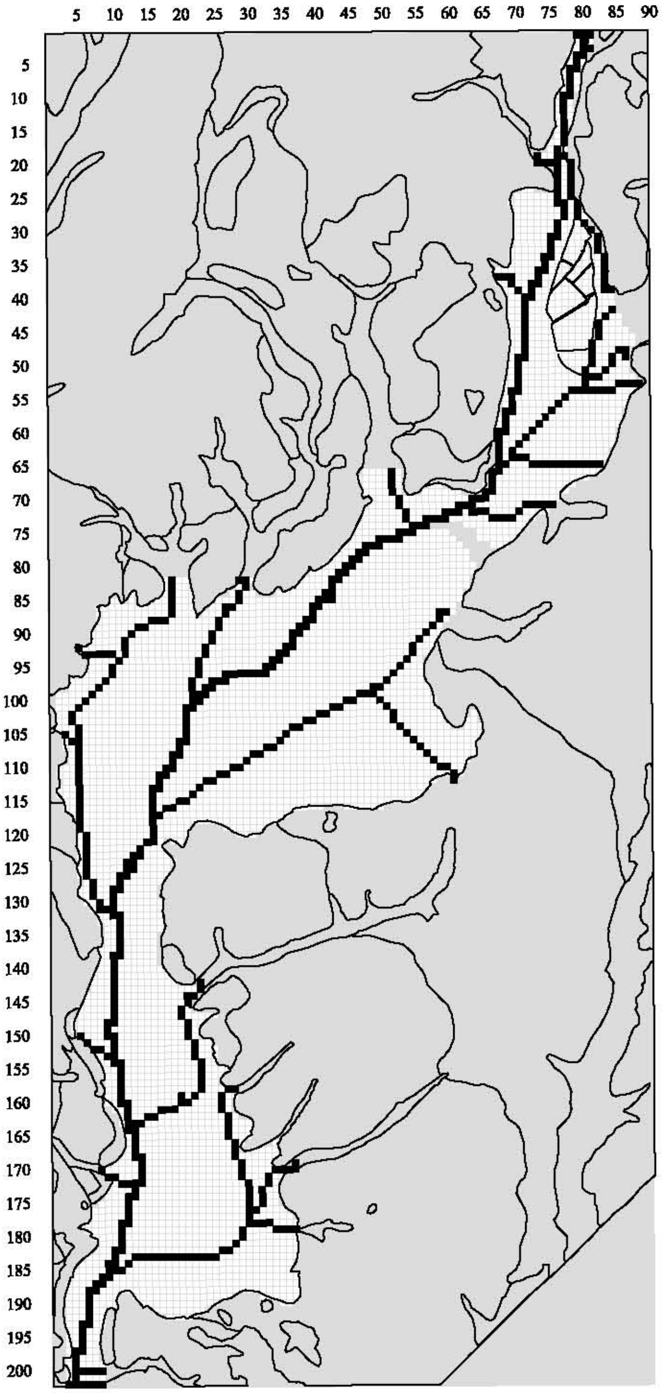
The ground-water model described in this section is a summary of the data and text provided in Chapter 4 of the Permit 15000 Study. For the purpose of completeness, much of the information provided in the previous study has been included in this report for reference. A complete description of the calibration and construction of the ground-water model is also provided in the Appendix D to the Permit 15000 Study. The following sections describe the construction and calibration of the ground-water model. The results from the ground-water model's application to the conjunctive use project are presented in the following chapters.

A ground-water flow model (Model), developed in the Permit 15000 Study, was used to simulate the impacts to the ground-water basin due to historical hydrology and water management practices that affect the hydrologic condition of the Upper Ysidora, Chappo, and Lower Ysidora sub-basins. The Model also provides the necessary tool to measure the changes in ground-water conditions and the potential affect to riparian vegetation and streamflow in the study area, as various stresses are applied in relationship with development of Permit 15000 and the conjunctive use project. Changes in ground-water pumping, streamflow, diversions, and wastewater releases are simulated so that each of these stresses can be reviewed to estimate their potential impact to the condition and health of the Santa Margarita River and the sub-basins. The impacts of these stresses were measured as changes in the overall water budget, changes in ground-water levels, and changes in evapotranspiration (ET) demands.

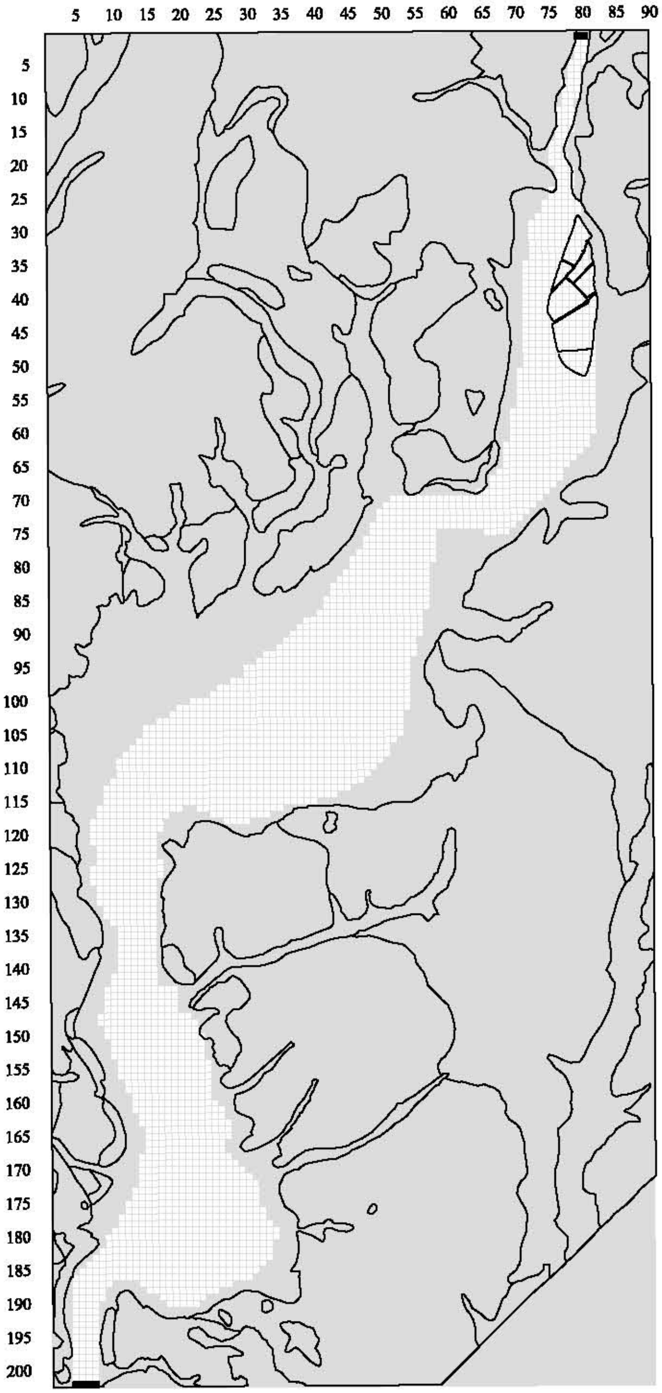
The Model described in this report is used in Chapter 8 to estimate the impact of each of two different project alternatives that could be constructed to operate a conjunctive use project. Equally important, the Model described in this report may also be used in the future as a management tool to determine the best location for ground-water pumping, effects of adding or removing sources of water from the basin, and use in negotiations with local, state and federal regulators. A particle tracking or contaminant transport package may also be added to the Model to estimate the impacts of pumping and hydrologic conditions on the transport and movement of organic and inorganic compounds in each of the three sub-basins. The Model is the compilation of all-environmental, wastewater, and water supply data on the Base and should be managed and maintained into the future in order to maximize water supply and minimize impact to the environment.

The Model consists of two layers, 202 rows, 90 columns, and 7,390 active cells (Figure 6-5). A 20-year calibration period from water year (WY) 1980 through 1999 was established to simulate extended wet and dry periods. Monthly stress periods were simulated to capture the seasonal variations observed in the existing water level and stream gage data. The Santa Margarita River was simulated to have the flexibility to be a gaining, losing, or dry stream at different stream reaches or with different seasonal variations.

The surface water models described in the previous sections were used as an input to the Model. In addition to these flows, the surface water model also estimated tributary inflow to the Model area from smaller streams located below the confluence of the Santa Margarita River and De Luz Creek. All estimates of streamflow, available water for diversion, and tributary inflow were calculated on a daily basis using hourly precipitation available from the Oceanside gaging station.



Ground-Water Model
Layer 1



Ground-Water Model
Layer 2

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■ STREAM CELL
▨ NO FLOW CELL
☐ ACTIVE CELL
〜 OUTLINE OF GEOLOGIC UNITS
■ GENERAL HEAD BOUNDARY CELL
FINITE DIFFERENCE GRID (200 ft. x 200ft.)

GROUND- WATER MODEL
BOUNDARY CONDITIONS AND
ACTIVE CELLS

6.3.1 Ground-Water Model Construction

The selected numerical model, MODFLOW™ (McDonald and Harbaugh, 1988) is a three-dimensional ground-water flow model developed by the USGS. MODFLOW™ uses mathematical expressions to represent the ground-water flow system, including boundary conditions, hydrogeologic attributes of the aquifer, and simplifying assumptions to capture the heterogeneities of the subsurface.

The model area extends from the bedrock narrows just north of the naval hospital to the narrows just south of the Lower Ysidora. The Model was constructed with two layers representing the two Quaternary alluvial units described in Chapter 3. The upper layer was assigned properties of an unconfined layer to capture the water table aquifer characteristics of the upper alluvium. The bottom layer of the Model was assigned an aquifer type of an unconfined unit with variable transmissivity, allowing for variability in the saturated thickness of the lower alluvium. Two layers were chosen to represent the alluvial aquifer in all three sub-basins. Well logs and cross sections of the Lower Santa Margarita River ground-water basin Worts and Boss, 1954; Shleman, 1978) show a coarser (cobbles, gravel and sand) lower alluvium beneath a finer (gravel, sand, silt, and clay) upper alluvium. Though the ground-water basin is considered to be one aquifer, the two layers fallow for the simulation of variable materials. Each layer is discretized into rows and columns with 200-foot by 200-foot spacing. There are 202 rows and 90 columns.

The top of the Model was assigned elevations based on the Army Corps of Engineers 5-foot interval topographical survey (MCB-CP, 1999). Well logs and geologic cross sections were used to determine the elevations of the interface of the upper and lower alluvium and the depth to bedrock (Worts and Boss, 1954). There is a general downward slope of the interface between the two layers from the northeast edge (south of the De Luz confluence) of the model domain toward the southwest edge (Lower Ysidora narrows). The finite-difference grid was constructed to account for the changes in elevations and downward slope of the surface and contacts from north to south.

The steady-state Model was constructed with monthly stress periods. During each stress period, streamflow, recharge, evapotranspiration, pumping rates, etc. remained constant. Average values for each month were used as input into the Model for each of these parameters, such that the Model simulates average constant conditions throughout each month. The average monthly values accounted for variation in the seasonal natural system with the highest stream flows and precipitation during the winter season and a dry climate during the summer and autumn.

6.3.2 Model Scenarios of Anticipated Basin Changes

The calibrated Model was used as a predictive tool to ascertain the potential effect of various stresses and changes to the ground-water system that are expected to occur in the future. These anticipated changes include: removal of Camp Pendleton's wastewater from the Santa Margarita River basin, augmentation to streamflow due to an agreement with the RCWD, and increased ground-water pumping. Table 6-7 below summarizes the model runs that were performed to estimate the impact of these future changes to the ground-water system on the Base.

TABLE 6-7

Summary of Model Scenarios for Anticipated Basin Changes

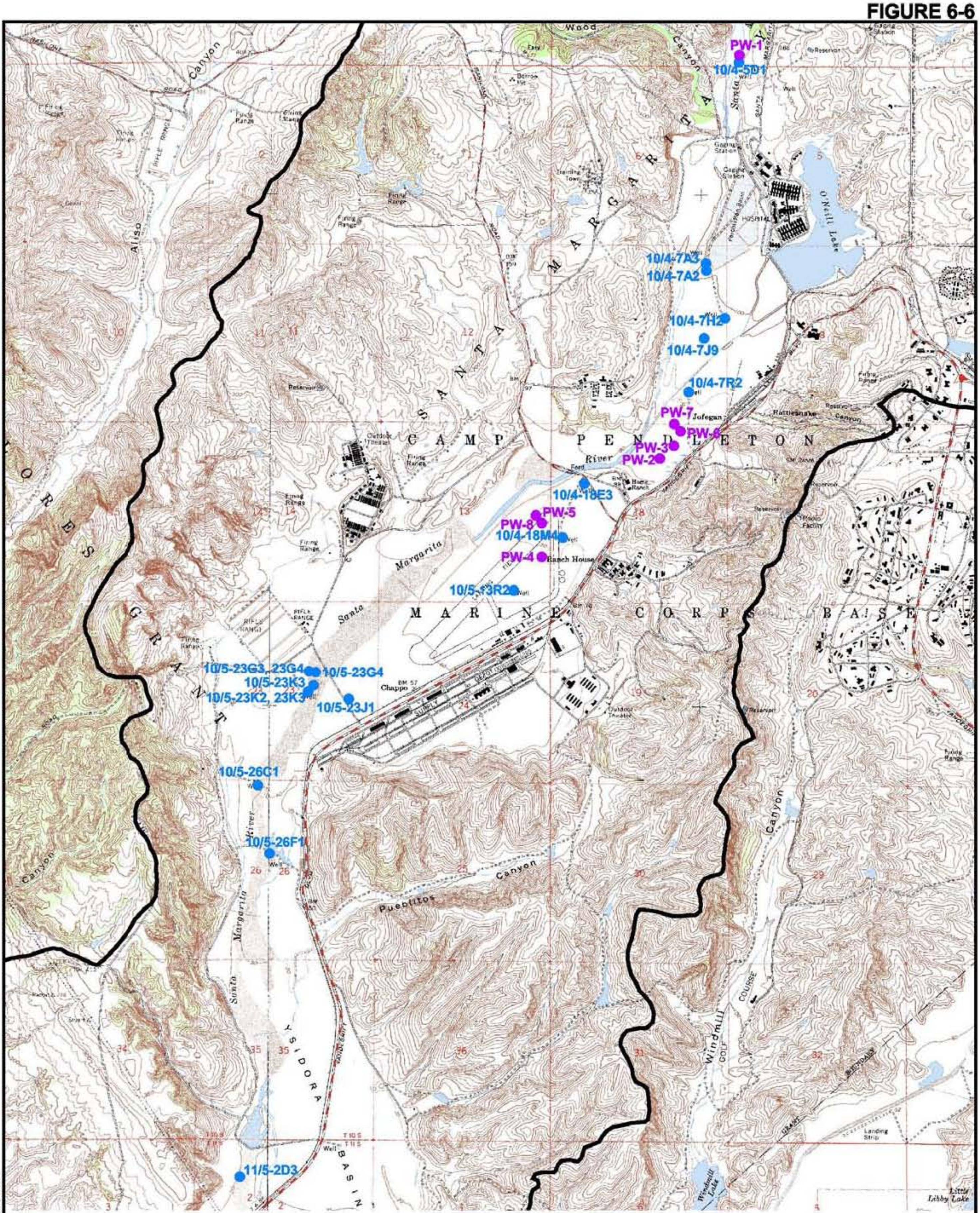
Run #	SMR Flow	Ground-Water Pumping	Wastewater Release	Comment
1	H	H	Yes	Calibration Run
2	H	H	No	Effect of no Wastewater Release
3	A	H	Yes	Effect of Augmented Flows
4	A	F1	No	Effect of F1 Pumping
5	A	F2	No	Effect of F2 Pumping
6	A	F3	No	Effect of F3 Pumping
7	H	F3	No	Effect of F3 Pumping with no Augmentation or Wastewater Flows

Notes:
H indicates 1980 to 1999 historical value
A indicates Augmented streamflow due to the RCWD Agreement
F1 indicates 14,800 AFY ground-water pumping
F2 indicates 14,800 AFY conjunctive use ground-water pumping
F3 indicates 14,050 AFY conjunctive use ground-water pumping

Different pumping scenarios were analyzed to determine optimal ground-water pumping management practices during seasonal changes as well as extended dry periods. Camp Pendleton's historical maximum use of water from the lower Santa Margarita River basin is 8,300 AFY with a build-out demand estimate at 8,800 AFY (MCB-CP, 2001). The existing average annual ground-water well production rate for WY 1980 through 1999 is 5,555 AFY, ranging from 3,724 AF in WY 1991 to 6,705 AF in WY 1981. The F1 pumping schedule was developed from the average historical (WY 1980-1999) monthly distribution of production with historical maximum production occurring in July and August of each year and minimum production occurring during the winter months. This pumping schedule includes 6 new production wells and increases the average annual production to 14,800 AFY in a direct proportion to the historical demand, independent of management for drought or wet years. Model locations for the 6 proposed wells (designated by "PW-X") are shown in Figure 6-6.

The F2 pumping schedule also maximizes annual ground-water production of 14,800 AFY, but shifts the maximum production rates to occur in the winter months. Monthly pumping

FIGURE 6-6



Wells

● Existing Well

● Proposed Well

0 0.5 1 Miles

N

EXISTING AND PROPOSED GROUND WATER WELLS

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j:/jn1922/fallbrookgwwells_c.apr 02/06/02 rates for a potential build-out demand of 8,800 AFY were based proportionally to 1980-1999 historical average monthly pumping. The F3 pumping schedule is similar to F2 with the maximum production in winter months, but includes management practices that reduce ground-water production by 3,000 AFY starting during the summer months following the second below normal winter/spring streamflow. If the below normal streamflow continues through a third consecutive winter/spring, ground-water production will be curtailed by an additional 3,000 AFY until normal or above normal streamflow conditions return. Figure 5-3 compares the different monthly F3 pumping schedules during these different conditions. Reduced percentages of F3 pumping were also considered to minimize impacts to riparian habitat during dry years and increase diversions from the river. These reduced F3 production schedules will be discussed under different Alternatives in Chapter 8. Table 6-8 summarizes the average annual pumping volumes and number of wells for the pumping schedules studied.

TABLE 6-8

Summary of Ground-Water Production Schedules

Pumping Schedule	Annual Median Ground-Water Production (AFY)	Number of Proposed Wells (PW)	
F1	14,800	6	**Increase proportional to historical monthly pumping; maximum production in summer months.**
F2	14,800	6	**Increase proportional to historical annual pumping; maximum production in winter months.**
F3	14,800	6	**Identical to F2 pumping with dry year management reduction of 3,000 AFY during second dry summer; reduction of 6,000 AFY during third dry summer until next year that normal stream flow occurs.**
80% F3	11,850	4	**80% of F3 production, installing 3 proposed wells in the Upper Ysidora and 1 proposed well in the Chappo.**
90% F3	13,320	5	**90% of F3 production, installing 3 proposed wells in the Upper Ysidora and 2 proposed well in the Chappo.**
95 % F3	14,050	6	**95% of F3 production, installing 4 proposed wells in the Upper Ysidora and 2 proposed well in the Chappo.**

The distribution of ground-water pumping in the Upper Ysidora sub-basin has been established to maximize the yield from the Lower Santa Margarita River basin. Among other recommendations, the 1987 Basewide Study suggests increasing ground-water pumping to safe yield, purchasing imported water supplies to meet excess demand, interconnecting the north and south water systems, and protecting the Base's rights to waters of the Santa Margarita River. The pumping schedule outlined herein meets the recommendations of the earlier study. The excess water produced under the F2 and F3 pumping scenarios may be used to offset the purchase of imported water supplies through the establishment of a conjunctive use project with the Fallbrook PUD. The F2 and F3 pumping scenarios maximize the safe-yield of the Lower Santa Margarita River basin while at the same time protecting all of the Base's valuable water rights.

Elimination of the Base's wastewater discharge to the river and oxidation ponds shows decreases in evapotranspiration and streamflow out of the Lower Ysidora. As would be expected from the conceptual model, the Model predicts the impact to be greater during consecutive years of below normal streamflow and precipitation. The modeled effects of augmented flows under historical conditions of pumping and wastewater discharge shows an increase in stream leakance (water flow through the streambed recharging the ground-water aquifer) and an increase in streamflow out of the model area. The Model showed reduced evapotranspiration with F1's maximum pumping in summer months compared with F2's maximum pumping in the winter months, indicating less ground water available for riparian vegetation. By adding the management plan of reduced pumping during continued dry years with F3 pumping, this impact was further reduced.

6.3.3 Model Results

Comparison of the Model's transient calibration to the observed data in the Lower Santa Margarita Basin between water years 1980 to 1999 shows that the Model is an excellent tool for simulating both surface and ground-water conditions on the Upper Ysidora, Chappo, and Lower Ysidora sub-basins. Due to the monthly time steps, the Model matches the seasonal variation in water levels throughout all three sub-basins. The Model is also able to closely match streamflow records at the Ysidora gage, especially during low and medium flows during the last ten years of records. The minor discrepancies in the difference between observed and simulated streamflow at the Ysidora gage between 1980 and 1989 are likely due to the use of simulated streamflow during this period.

The model budget, accounting for the inflows and outflows to the ground-water aquifer, had an average annual percent discrepancy of ±0.02% (10 AFY), ranging from ±0.00% to ±0.05% (26 AFY). The Model was able to calculate a solution under highly variable streamflow, recharge rates, and pumping schedules. The calibrated model run shows the dominating influence of the Santa Margarita River on the ground-water basin. Stream leakance into the ground-water aquifer historically accounts for approximately 63% of the ground-water budget, and infiltration from the recharge ponds and oxidation ponds accounts for approximately 24% of the ground-water budget.

The high degree of calibration between observed and simulated data suggest that the Model is an excellent tool for defining the impacts to the ground-water basin due to future changed conditions. The Model's ability to account for changes in surface flow, wastewater influences, ground-water pumping, and other fluxes that affect the surface water and ground water in the three sub-basins suggest that the Model can be used for estimating any potential impacts due to future increases in diversions and ground-water pumping. Increased surface diversions from the Santa Margarita River, additional water supply from the Fallbrook PUD, and increased ground-water pumping from the ground-water basins, above baseline conditions, are identified in Alternatives 9 and 10 Chapter 8. The Model is used as a tool in each of these alternatives to define the impact of the project on the surface water, ground water, and riparian resources in each of the three sub-basins.