

San Mateo 9-38
Santa Margarita

March 9, 2001

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1220 Pacific Highway
San Diego, California 92132-5181

LAW Project No. 70300-7-0193

Attention: Ms. Mary Nguyen, P.E. (Code 5CEN.MN)
Remedial Project Manager

Subject: **Final Report of Water Quality Studies and
Proposed Watershed Monitoring Program for
Portions of San Mateo and Santa Margarita River Watersheds
Marine Corps Base, Camp Pendleton, California
Contract No. N68711-95-D-7573, D.O. 0021**

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Dear Ms. Nguyen:

LAWCRANDALL is pleased to submit the enclosed two copies of the *Final* report for the 1999 Water Quality Studies and Proposed Watershed Monitoring Program project. Six copies have been delivered to Mr. Larry Carlson at MCB Camp Pendleton. The report was prepared in accordance with the scope of work provided for Delivery Order 0021, Work Element 2, dated 19 June 1997.

We appreciate the opportunity to be of service on this project. If you have any questions regarding the *Final* report or any other aspects of the project, please call us at 858-278-3600.

Sincerely,

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A Division of Law Engineering and Environmental Services, Inc.

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Enclosure: 2 copies

cc: Mr. Larry Carlson, MCB Camp Pendleton (6 copies)

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EXECUTIVE SUMMARY

LAW conducted water quality studies at Marine Corps Base (MCB), Camp Pendleton, California to establish a baseline for the analysis of water quality trends to be used for evaluating the long term effects to groundwater, the Base's principal drinking water supply. Figure 1, shows the location of MCB, Camp Pendleton. The work consisted of compiling historical surface water quality data, re-establishing MCB Camp Pendleton's surface water quality monitoring program, supplementing the surface water quality monitoring by installing and sampling three groundwater monitoring wells, compiling data into a database, and analyzing the water quality data using graphical and statistical methods. The results of this work were used to prepare and justify a Watershed Monitoring Program (WMP) for portions of the San Mateo and Santa Margarita River Watersheds to protect the groundwater supply at MCB Camp Pendleton. Figure 2, shows the location of these two watersheds.

The WMP developed for MCB Camp Pendleton describes the monitoring system network, identifies chemical parameters for analysis that are indicative of changes in water quality, and specifies sampling procedures and analytical methods. It also establishes upper prediction limits (UPLs) for chemical parameters to indicate when action is needed to protect the Base's drinking water supply.

Water quality in the San Mateo Watershed was evaluated at three surface water locations: Cristianitos Creek near San Clemente (Station 509); San Mateo Creek at San Clemente (Station 510); and San Mateo Creek at San Onofre (Station 511). Surface water versus groundwater quality was evaluated from monitoring well MW-3 (Station 103) located in Cristianitos Creek. Figure 3 shows the location of these surface and groundwater monitoring stations.

Significant findings for the San Mateo Watershed include a statistical difference in water quality between Cristianitos Creek near San Clemente (Station 509) and San Mateo Creek at San Clemente (Station 510). Water at San Mateo Creek at San Onofre (Station 511), which is a mixture from Cristianitos Creek near San Clemente (Stations 509) and San Mateo Creek at San Clemente (Station 510), shows an influence from local activities as indicated by changes in sodium and nitrate concentrations. Nitrate at San Mateo Creek at San Onofre (Station 511) has exceeded drinking water maximum contaminate levels (MCLs) at least once since 1997. Water from Cristianitos Creek

near San Clemente (Station 509) strongly affects the water quality at San Mateo Creek at San Onofre (Station 511). At least once since 1997, the drinking water MCLs at one of the stations were exceeded for specific conductivity, total dissolved solids (TDS), manganese, iron, and fecal coliform. In addition, there is a significant difference in water quality between surface water at Cristianitos Creek near San Clemente (Station 509) and groundwater in MW-3 (Station 103). In general, water quality within the watershed is improving based on downward-trending data for many of the chemical parameters.

Water quality in the Santa Margarita River Watershed was evaluated at eight surface water locations. Three locations are along the Santa Margarita River: Santa Margarita River near Fallbrook (Station 501); Santa Margarita River near Temecula (Station 504); and Santa Margarita River at Ysidora (Station 508). Five locations are on tributary creeks to the Santa Margarita River: Sandia Creek near Fallbrook (Station 502); Rainbow Creek Near Fallbrook (Station 503); Murrieta Creek near Temecula (Station 505); De Luz Creek near Fallbrook (Station 506); and Fallbrook Creek near Fallbrook (Station 507). Surface water versus groundwater quality was evaluated from two monitoring wells located along the Santa Margarita River at De Luz Road (MW-1) and in De Luz Creek (MW-2). Figure 4 shows the location of these monitoring locations.

Significant findings for the Santa Margarita River Watershed include a statistical difference in water quality between tributaries of the Santa Margarita River. There is also a significant difference in water quality between surface water monitoring stations in comparison to nearby groundwater wells. Water quality is degrading in Sandia Creek near Fallbrook (Station 502) and De Luz Creek near Fallbrook (Station 506) from increasing concentrations of sodium, chloride, sulfate, and nitrate as indicated by the generally increasing trends for these parameters. Groundwater in MW-2 in De Luz Creek (Station 102) also contained nitrate at concentrations above the MCL. At least once since 1997, the drinking water MCLs was exceeded in 2 tributaries or in the Santa Margarita River for sulfate, manganese, specific conductance, and TDS. The MCL was also exceeded for nitrate in Rainbow Creek near Fallbrook (Station 503), chloride in Sandia Creek near Fallbrook (Station 502), and iron in De Luz Creek near Fallbrook (Station 506) and Sandia Creek near Fallbrook (Station 502) and in the Santa Margarita River near Fallbrook (Station 504). Water quality in the Santa Margarita River near Fallbrook (Station 501) and at Santa Margarita River at Ysidora (Station 508) is essentially the same. Water at these locations appears to be strongly influenced by water from

Sandia Creek near Fallbrook (Station 502). Overall, water quality in the Santa Margarita River Watershed is improving based upon downward-trending data. Significant improvement in water quality is seen on Rainbow Creek near Fallbrook (Station 503).

Based on the results of the present studies, we recommend that monitoring of selected surface water and groundwater quality sampling locations should be conducted quarterly. The monitoring should be conducted as part of a Watershed Monitoring Program that LAW has developed and which is presented in this report. The WMP includes UPLs, which are statistical limits that indicate whether a new sample value is elevated relative to background data. The UPLs were established based on analytical results for samples collected since 1997, when monitoring resumed. Most UPLs are below established MCLs or recommended levels for drinking water. However, UPLs for both watersheds are greater than MCLs or recommended levels for iron, manganese, total dissolved solids, and specific conductance.

We recommend that ten surface water sampling stations and three groundwater sampling stations be utilized. In the San Mateo Watershed, three surface water locations and one groundwater location should be sampled. In the Santa Margarita River Watershed, seven surface water and two groundwater locations should be sampled. Based on the statistical analyses discussed in Section 3 of this report, one surface water sampling location has been removed from the locations sampled during the 1997-1999 program. The station at Santa Margarita River at Ysidora (Station 508) was removed because its water quality is the same as that at Santa Margaret River near Fallbrook (Station 501).

For each sampling location in the San Mateo and Santa Margarita River Watersheds, we recommend the following analytical parameters be monitored: arsenic, phosphate, chloride, bicarbonate, sodium, calcium, specific conductance, fecal coliform, fluoride, lead, iron, manganese, surfactants (MBAS), methyl tert-butyl ether (MTBE), nitrate, thallium, total dissolved solids (TDS), and sulfate. These parameters were selected for at least one of the following reasons: 1) because they have maximum contaminant levels for drinking water; 2) they have historically exceeded MCLs; 3) they have exceeded the MCL at least once since 1997; 4) they are considered important indicators of water quality; and/or 5) they can give important indications of upstream contaminant release.

Analytical data gathered from implementation of the WMP should be incorporated into the database compiled for LAW's water quality studies for MCB Camp Pendleton during 1997-1999. A CD with the database is included in Appendix D of this report. The database will facilitate use of the new and existing data by subsequent users. The database is in Microsoft Access and is sufficiently versatile to allow graphical and statistical data analysis.

We recommend that, after each monitoring event, the analytical data be evaluated to identify UPL and MCL exceedances. The data should also be reported in written and electronic formats to MCB Camp Pendleton's Office of Water Resources. If a UPL for a given parameter is exceeded during a sampling event, additional investigation should be conducted. The affected sampling location should be sampled and analyzed again for the exceeded parameter as soon as practical. If the second sample also exceeds the UPL, continued monitoring at increasing frequencies (up to weekly) should be conducted, and an investigation undertaken that includes upstream sampling to determine the source of the exceedance. Detection of MTBE concentrations that exceed the MCL should be reported to the RWQCB. It is also advisable to discuss the findings with local agencies and interested parties, including the Santa Margarita River Watershed Committee.

Some of the UPLs established exceed MCLs or recommended levels for drinking water. The UPLs are based on a statistical comparison of water quality data obtained since 1997. Because the UPLs are greater than the MCLs or recommended level, it indicates that water quality in both the watersheds have repeatedly exceeded MCLs or recommended levels since 1997 for iron, manganese, TDS, and specific conductance. We recommend that an investigation be undertaken that includes upstream sampling and observation to determine the type of activity that may be creating the exceedance. Once identified discussions with local agencies and interested parties, including the Santa Margarita River Watershed Committee could potentially lead to modification of practices to reduce or eliminate the source.

The WMP approach and monitoring parameters should be re-evaluated about every three years, and no less frequently than every five years. UPLs should, according to statistical convention, be recalculated after every monitoring event to maintain their currency. However, since this monitoring is not a part of a regulatory mandated monitoring program, which would require recalculation after every monitoring event. In our opinion, the UPLs could be recalculated annually to reduce cost.

1.0 INTRODUCTION

This report presents the results of water quality studies conducted at Marine Corps Base (MCB), Camp Pendleton, California to establish a baseline for the analysis of the water quality trends to be used for evaluating the long term effects to groundwater, the Base's principal drinking water supply. The work consisted of compiling historic surface water quality data, re-establishing MCB Camp Pendleton's surface water quality monitoring program, supplementing the surface water quality monitoring program by installing and sampling three groundwater monitoring wells, compiling historic water quality records into a database, and analyzing the water quality data using graphical and statistical methods.

The results of this work were used to prepare and justify a Watershed Monitoring Program for portions of the San Mateo and Santa Margarita River Watersheds to protect the groundwater supply at MCB Camp Pendleton. The Watershed Monitoring Program describes the monitoring system network, identifies chemical parameters for analysis that are indicative of changes in water quality, and specifies sampling procedures and analytical methods. It also establishes upper prediction limits (UPLs) for chemical parameters to indicate when action is needed to protect the Base's drinking water supply.

1.1 SITE DESCRIPTION

MCB Camp Pendleton is located in northern San Diego County, California and comprises approximately 140,000 acres or 219 square miles (Figure 1). The Base is the Marine Corps' premier amphibious training facility. It is the only Marine Corps facility where amphibious training operations can be combined with elements of Marine Corps aviation and other supporting combat arms to develop, evaluate, and exercise the Marine Corps combat doctrine to the fullest extent.

MCB Camp Pendleton relies entirely on local groundwater resources for its drinking water. It is derived from the basins of four principal stream systems that flow through the Base and recharge the groundwater system before flowing into the Pacific Ocean. These basins are the San Mateo, the San Onofre, the Las Flores, and the Santa Margarita River basins. The groundwater system beneath MCB Camp Pendleton is recharged from local runoff into these basins and from an enhanced

recharge area at the Lake O'Neill diversion works. This project only assessed portions of the San Mateo and Santa Margarita River watersheds because their tributary area extends beyond the Base, where urban, rural, industrial, and agricultural activities are not controlled by MCB Camp Pendleton. A description of these two watersheds, potential sources of pollutants, and pertinent water quality information are presented in the following subsections.

1.1.1 San Mateo Watershed

The San Mateo Watershed covers 137 square miles of land a portion of which is located in the northwestern portion of MCB Camp Pendleton. Figure 2 shows the extent of the San Mateo Watershed. It extends about 22 miles inland from its discharge point into the Pacific Ocean. Its tributary area encompasses the west slope of the Santa Ana Mountains. San Mateo Creek drains the eastern portion of the watershed, and Cristianitos Creek drains the western portion. The two creeks merge on MCB Camp Pendleton in a narrow sediment-filled valley. MCB Camp Pendleton's water supply wells are located downstream of the confluence of these two creeks.

Recharge to groundwater in the San Mateo Watershed occurs primarily through direct infiltration of precipitation and surface runoff. Near the confluence of San Mateo and Cristianitos Creeks, MCB Camp Pendleton operates Sewage Treatment Plant No. 12. Treated wastewater is recharged through oxidation ponds into groundwater.

Most of the watershed is undeveloped. However, residential developments and portions of the City of San Clemente are located within the watershed outside of MCB Camp Pendleton.

Regular sampling of surface water in San Mateo and Cristianitos Creeks had been conducted by MCB Camp Pendleton's Natural Resources Office or affiliates for about 30 years, up until 1992. This current study resumed sampling at three locations beginning in December 1997. Figure 3 shows the locations of the monitoring stations. Previous studies have concluded the following in regard to water quality in this watershed:

- At San Mateo Creek at San Onofre (Station 511), TDS concentrations are high probably due to surface runoff and subsurface discharge from nearby agricultural areas (Leighton, 1987).

- At San Mateo Creek at San Clemente (Station 510), dissolved constituent concentrations are relatively consistent, except during periods of lower than average rainfall and during heavy seasonal precipitation. Dissolved constituent concentrations increase once per year coincident with the winter or wet months (Leighton, 1987).
- At the station designated as Cristianitos Creek near San Clemente (Station 509) the water has a relatively high TDS in comparison to San Mateo Creek at San Clemente (Station 510) (Leighton, 1987).

1.1.2 Santa Margarita River Watershed

The Santa Margarita River Watershed covers 742 square miles of land east of Lake Elsinore between the San Jacinto Mountains and Palomar Mountain, extending southwestward to the Pacific Ocean near Oceanside, California. Figures 2 and 4 show the extent of the watershed. The Santa Margarita River originates at the confluence of Temecula Creek and Murrieta Creek near the city of Temecula. Temecula Creek begins on the eastern slope of the Palomar Mountains and flows first generally northwest and then southwest through a series of valleys around the northeastern slope of these mountains until it joins with Murrieta Creek. Murrieta Creek begins on the northern slope of the Santa Rosa Plateau and flows generally southeastward through a wide valley near the foot of the east-facing plateau until it joins with Temecula Creek. The combined drainage area for Temecula and Murrieta Creeks is about 588 square miles.

From this confluence, the Santa Margarita River flows 27 miles to the Pacific Ocean. The river first descends through a twisting course for about six miles in the bottom of Temecula Canyon (the gorge), a steep-walled canyon cut through the Santa Margarita Mountains. Near the downstream mouth of this canyon, Rainbow Creek flows into the river from the east; about two miles further downstream Sandia Creek flows into the river from the north. Further downstream, De Luz Creek also flows into the Santa Margarita River from the north. The river then flows into a broad sediment-filled valley within MCB Camp Pendleton, where percolation through the coarse-grained soils recharges the groundwater. Finer-grained sediments that limit recharge from the river to the underlying sediments are present south of Basilone Road (Worts, 1954). MCB Camp Pendleton obtains its drinking water from wells in the alluvium in this valley. Most of the wells are not influenced by surface water, with the possible exceptions of Well Nos. 2673, 33924, and 33926 (MacDonald-Stephens, 1993).

The water in the Santa Margarita River originates from rainfall in the watershed, from discharges at Lake Skinner and Vail Lake, and from discharges from non-point sources.

There are four major population areas within the watershed. Two areas, the cities of Temecula and Murrieta, are located above the gorge, and two areas, the town of Fallbrook and MCB Camp Pendleton, are located below the gorge. Large agricultural areas are present near Fallbrook and Temecula. Avocados and citrus are the primary crops grown near Fallbrook. Outside of Temecula and Murrieta, grapes, sod, and various other dry farm crops are cultivated. In the mid-1980s, development in the Rainbow Creek area included several large nurseries, along with single family residences, irrigated orchards, field crops, and pastures (Cadmus, 1994). Sandia and De Luz Creeks also experienced agricultural and housing development in the mid-1980s (Harris, 1992).

In the Temecula and Murrieta areas, there are several water reclamation facilities. Reclaimed wastewater is used for irrigation at golf courses and sod farms, and spread in percolation ponds. Wastewater from Fallbrook is treated at a water reclamation plant and discharged to a land outfall that is connected to the City of Oceanside's ocean outfall outside the Santa Margarita River Watershed (NBS/Lowry, 1994).

Septic disposal systems are widespread throughout unincorporated areas of the watershed. Private landowners and larger facilities, such as recreational vehicle parks and campgrounds, discharge to on-site systems.

Surface water quality in the Santa Margarita River and its tributaries has been monitored at multiple locations for several decades by agencies such as the United States Geological Survey (USGS), California Department of Water Resources, and MCB Camp Pendleton, among others. Resurrection of MCB Camp Pendleton's surface water quality monitoring program for this study involved sampling at eight of these USGS existing stations. Figure 4 shows the location of the monitoring stations. Previous water quality investigations noted changes in water quality in this watershed as summarized in the following:

- Water quality from De Luz Creek near Fallbrook (Station 506) has exceeded basin plan objectives for total dissolved solids (750 mg/L) since 1973. At times boron and sulfate have also exceeded basin standards (0.75 and 250 mg/L, respectively) (Leedshill-Herkenhoff, 1989). During the drought of 1974-77, concentrations of most parameters studied were higher.
- Water quality data from Fallbrook Creek near Fallbrook (Station 507) indicate TDS, sulfate, and boron frequently exceed basin standards. Nitrate concentrations increased during the drought of 1974-77. The City of Fallbrook discharged wastewater effluent into the Creek prior to 1983 (Leedshill-Herkenhoff, 1989).
- Data from the Santa Margarita River near Temecula (Station 504) and the Santa Margarita River near Fallbrook (Station 501) indicate that the water quality consistently meets the basin plan objectives except for TDS. Water quality appears to degrade between the Temecula and Fallbrook Stations. During the drought of 1974-77, TDS values were very high. Nitrate concentrations have increased rapidly since about 1978 (Leedshill-Herkenhoff, 1989).
- Water quality characterization by the California Department of Water Resources (1956) indicated Murrieta Creek near Temecula (Station 505) had sodium chloride water; De Luz Creek near Fallbrook (Station 506) had sodium bicarbonate water; Rainbow Creek near Fallbrook (Station 503) had no predominant character; the Santa Margarita River (Stations 501 and 504) and Sandia Creek near Fallbrook (Station 502) had a mixed sodium-calcium bicarbonate-chloride character; and Fallbrook Creek near Fallbrook (Station 507) had mixed sodium-calcium chloride-sulfate character.
- Agricultural activities around Rainbow Creek near Fallbrook (Station 503), upstream from Station 503 (Rainbow Creek near Fallbrook), have substantially elevated phosphate and nitrate concentrations since at least the mid-1980s (Cadmus, 1994). A Rainbow Creek Non-Point Source Nitrate Reduction Project was developed by the Mission Resource Conservation District.
- Very low levels of some BTXE (benzene, toluene, total xylene, and ethylbenzene) components were detected in 1992 at sampling locations in the Santa Margarita River Watershed (Law/Crandall, Inc., 1995).
- Low levels of Dieldrin and phthalate were detected at Fallbrook Creek in 1991 but may have been introduced in the laboratory (Law/Crandall, Inc., 1995).
- Low concentrations of bromoform were detected at Santa Margarita River at Temecula Gorge in 1992. Also hexachlorobenzene and dibromochloromethane were detected at the Rancho California 3cfs Meter Gorge that year (Law/Crandall, Inc., 1995).
- Vail Lake (Rancho California Water District) and Skinner Reservoir (Metropolitan Water District) discharge into Temecula Creek and a tributary of Murrieta Creek, respectively (Cadmus, 1994).

1.2 WATER QUALITY REGULATIONS

MCB Camp Pendleton relies solely on groundwater for its drinking water. Because surface water recharges the groundwater, surface water quality should meet drinking water standards, with a few exceptions such as turbidity and coliform, which can be removed during percolation through sediments.

California Department of Health Services (DHS) has established primary and secondary drinking water standards for all water served by water purveyors in California (California Code of Regulations (CCR), Title 22, Division 4, Chapter 15). Tables 1 through 5 list existing drinking water standards.

Several additional chemicals have recently become regulated or may become regulated in the near future. These include methyl tert-butyl ether (MTBE), perchlorate, arsenic, radon, and sulfate. The regulatory status for each of these chemicals is briefly described in the following paragraphs. MTBE, a volatile organic chemical used as an oxygenate in the blending of gasoline, is currently listed as an "unregulated chemical" for which monitoring is required, but no maximum contaminant level (MCL) applies. DHS recently developed a secondary standard (5 micrograms per liter ($\mu\text{g/L}$)) and has begun a process to develop a primary drinking water standard for MTBE. A proposed primary standard is planned for release for public comment in 1999. DHS will utilize the 14 $\mu\text{g/L}$ Public Health Goal for developing the primary standard.

Perchlorate is used in the manufacture of solid rocket propellant, munitions, and fireworks. DHS proposed identifying perchlorate as an "unregulated chemical" in July 1998 and established an action level of 18 $\mu\text{g/L}$. The regulation identifying perchlorate as an "unregulated chemical" is anticipated to be in place in 1999.

In accordance with the Safe Drinking Water Act (SDWA) Amendments of 1996, USEPA must develop arsenic, sulfate, and radon national primary drinking water regulations. The arsenic regulation must be proposed by January 2000 and finalized by January 2001. Prior to regulating sulfate, USEPA must conduct a study of sulfate in drinking water. USEPA has 30 months after the

enactment of the SDWA amendments to propose a maximum contaminant level goal and regulation for radon. The final rule must be promulgated one year thereafter.

Water quality objectives for surface water and groundwater have been developed by the San Diego Regional Water Quality Control Board (RWQCB). The San Diego Water Quality Control Plan (the Basin Plan) water quality objectives generally mimic drinking water standards but include a limit for boron, a common constituent of soap. Table 6 lists the Basin Plan objectives, which are not as extensive as parameters contained in the drinking water regulations.

1.3 PROJECT OBJECTIVES

The objectives of this project were to 1) develop a baseline analysis of the quality of surface water and groundwater near the upstream boundaries of MCB Camp Pendleton to be used for the interpretation of future water quality trends, 2) to establish upper prediction limits (UPLs) for water quality parameters to evaluate potential long-term impacts to the water supply, and 3) to develop a Watershed Monitoring Program for future implementation to continue to protect MCB Camp Pendleton's groundwater drinking water supply.

1.4 PROJECT APPROACH

Our approach to meet the project objectives was to compile a water quality database representative of the water quality in the watersheds, statistically and graphically analyze the data, and evaluate and interpret the results. Historical data were supplemented by surface water data collected quarterly from December 1997 to May 1999. Groundwater samples were collected from three monitoring wells installed by LAW in December 1997 to evaluate the quality of water in the sediments and the relationship of surface water quality to groundwater quality.

After compiling the water quality database, the data were analyzed using both graphical and statistical methods to determine:

- Both long term and short term trends in surface water quality;
- Whether the stations sampled were representative of surface water quality without redundancy;
- If surface water quality is representative of groundwater quality;
- Chemical parameters indicative of potential changes in water quality or pollution;
- Upper prediction limits for selected chemical parameters to identify when further action is needed to protect the Base's groundwater drinking water supply.

The results of the analysis were evaluated and used to prepare and justify a Watershed Monitoring Program for portions of the Santa Margarita River and San Mateo Watersheds to protect groundwater supplies at MCB Camp Pendleton. The Watershed Monitoring Program describes the monitoring system network, outlines sampling procedures, identifies chemical parameters for analysis that are indicative of changes in water quality, details sampling procedures, and documents analytical methods. It also establishes UPLs for chemical parameters to indicate when action is needed to protect the Base's drinking water supply.

2.0 WATER QUALITY CHARACTERIZATION ACTIVITIES

This section discusses the work performed, data collection and sampling locations, and methods and procedures used for this water quality evaluation. Summary tables of data gathered during this work were compiled.

2.1 PRECIPITATION STATIONS

MCB Camp Pendleton has a precipitation gauging station located at Marine Corps Air Station (MCAS) Camp Pendleton. A 10-year precipitation record (1989-1999) with daily measurements was obtained from the Air Station. In addition, monthly data from several precipitation stations off Base were used. The other stations used, along with the period of record, are San Clemente Dam (1940-1997), Oceanside Harbor (1955-1997), Escondido (1931-1979), and Escondido 2 (1979-1997). These measurements were used for the statistical analysis to assess if there was a correlation between water quality and rainfall amount. Appendix A contains the precipitation records.

2.2 STREAM GAUGING STATIONS

The USGS has developed an extensive network of stream gauging stations to measure the flow in the Santa Margarita River and its tributaries, and in Cristianitos and San Mateo Creeks. LAW selected the San Mateo Creek at San Onofre (Station 511) and Santa Margarita River near Fallbrook (Station 501) gauging stations to represent flow conditions within the San Mateo and Santa Margarita River Watersheds, respectively. These stations were selected to be representative because they: had a long period of record; were down stream of as many tributaries and creeks as possible to account for the total flow available for groundwater recharge, and if possible before significant percolation could occur that would reduce the surface water flow.

The stream gauge measurements were used during the statistical analysis to test for a correlation between stream flow and water quality. A direct correlation could provide support for a defensible monitoring frequency to be specified in the Watershed Monitoring Program. These gauging stations were also used as locations for surface water quality sampling. The locations of these stations are shown on Figures 3 and 4. The stream gauging records are in Appendix B.

2.3 STREAM SAMPLING STATIONS

LAW sampled eleven surface water locations along the Santa Margarita River and its tributaries, and along San Mateo and Cristianitos Creeks. The locations were selected by MCB Camp Pendleton staff based on the locations being representative of water quality in the river, creek, or major tributary; having a historic record of water quality data; and accessibility of the location. Table 7 lists the stations monitored during this study. This table also correlates LAW's station identification numbers with those of other agencies. Figures 3 and 4 show the locations of the sampling stations.

2.4 MONITORING WELL INSTALLATION

Three groundwater monitoring wells were installed by LAW adjacent to the Santa Margarita River (MW-1), De Luz Creek (MW-2), and Cristianitos Creek (MW-3) in December 1997 for groundwater quality sampling. Locations for these wells were selected as near surface water sampling locations as practical so a comparison of surface water and groundwater quality would be realistic. The wells were constructed of inert casing materials that were unlikely to affect the water quality. Figures 3 and 4 show the locations of the wells. Appendix C contains a description of the monitoring wells including lithologic logs and well construction details.

2.5 SURFACE AND GROUNDWATER SAMPLING AND ANALYSIS

LAW collected surface water and groundwater samples between December 1997 and May 1999 to document the current water quality at selected locations on San Mateo and Cristianitos Creeks, and the Santa Margarita River and its tributaries. MCB Camp Pendleton last conducted surface water quality sampling in 1992. This monitoring program resumed major portions of the previous sampling program.

LAW used a numerical scheme for identifying the discrete location and time frame in which a particular sample was collected. Each sample was assigned a six digit numerical code. The first digit was either a 1 (for a monitoring well) or a 5 (for a surface water location). The next two digits

identified the station location number, which ranged from 01 to 03 for monitoring wells and from 01 to 11 for surface water locations (Table 7). The final three digits identified the sampling event number, which for this project ranged from 001 to 007.

The following sections describe the procedures used to collect samples.

2.5.1 Groundwater Sampling

Groundwater samples were collected from each of the three-groundwater monitoring wells (sampling locations 101, 102, and 103) during seven sampling events. The sampling events were in December 1997 (semi-annual sampling), March 1998 (quarterly sampling), May 1998 (semi-annual), August 1998 (quarterly), November 1998 (semi-annual), February 1999 (quarterly), and May 1999 (semi-annual). Groundwater was sampled in accordance with the County of San Diego Site Assessment and Mitigation (SAM) Manual guidelines for sampling groundwater monitoring wells. The SAM Manual describes wells as either fast recharging or slow recharging. A fast recharging well recovers to 80 % or more of its static condition within two hours of purging. A slow recharging well recovers to 80 % of its static condition more than 2 hours after purging. According to these criteria, all three monitoring wells are fast recharging wells.

For sampling, each well was purged of three (3) borehole volumes of water using a bailer. The depth to the water level surface was measured before and after purging to determine the well drawdown. Once the water surface had recovered to at least 80% of the static condition, the well was sampled.

Groundwater samples were collected in disposable bailers. Water was poured directly from the bailer into laboratory prepared sample containers, which were then capped and placed in an ice chest. Samples for general minerals and metals were collected into plastic bottles while glass bottles were used for coliform and nitrate. A field test sample was collected into a disposable cup and tested at the well head for pH, specific conductance, and temperature using a Myron-L meter. Care was exercised to avoid personal contact, even with protective gloves, with the sampled water as such contact may impact certain analyses.

2.5.2 Surface Water Sampling

Surface water samples were collected at eleven surface water sampling locations (sampling locations 501 through 511) during seven sampling events. The sampling events took place in December 1997 (semi-annual sampling), March 1998 (quarterly sampling), May 1998 (semi-annual), August 1998 (quarterly), November 1998 (semi-annual), February 1999 (quarterly), and May 1999 (semi-annual).

Each sample was collected from a mid-stream area to represent cross-sectional homogeneity, not where the channel is constricted. The sampler entered the water downstream of the sample location and proceeded upstream to the sampling location. Surface water samples were collected facing the upstream direction to allow water to flow directly into the sample containers from the top six inches of flow. Floating debris such as leaves was avoided. The samples were collected directly into laboratory prepared bottles. Samples for general minerals and metals were collected into plastic bottles while samples for coliform and nitrate were collected into glass bottles. A sample of the water was also collected into a disposable cup for field parameters including pH, temperature, and specific conductance. These field test parameters were measured using a calibrated Myron-L meter.

Surface water samples could not be collected at Cristianitos Creek near San Clemente (Station 509) and San Mateo Creek at San Clemente (Station 510) during January 1998 due to lack of flow. Cristianitos Creek near San Clemente (Station 509) also could not be sampled during November 1998 due to lack of flow.

2.5.3 Sample Analysis

The surface water and groundwater samples were collected in laboratory-provided containers by LAW personnel. The samples were placed in an insulated cooler containing ice to keep the temperature of the samples at 4 ± 2 C until receipt at the State of California-certified laboratory. All sampling and sample handling was performed under chain-of-custody protocol. Water samples collected from the wells and the surface water locations were analyzed for those parameters

identified in Tables 8 and 9. Except for coliform analysis, all samples were analyzed by Law Environmental National Laboratories (LENL) of Pensacola, Florida. Coliform analysis was performed by Environmental Engineering Laboratories (EEL) of San Diego, California (Sampling Events 1 - 6) and Pat Chem Laboratories (PCL) of San Diego, California (Sampling Events 6 and 7). Appendix D-2 contains tabulated analytical data from the seven sampling events.

2.5.4 Quality Assurance/Quality Control

The project followed the protocols set forth in the project Work Plan (WP) and its associated quality assurance/quality control (QA/QC) protocol. The WP contains procedures for training, documentation, observations, methods of sample collection and containment, and sample custody. The subcontractor laboratory was responsible for internal quality control checks including documentation of instrumentation, standards and data, calibration and check standards, and control samples.

To assure that analytical data collected and reported from monitoring activities is scientifically valid, accurate, and consistent, the following steps were taken:

- Accuracy was assessed by comparing reported data to "true" values using calibration standards, reference samples, and spiked samples. The criterion for an accurate result for an analyte was its percent recovery being within control limits. There were no analytes identified in the laboratory QA/QC Reports with recoveries outside control limits.
- Precision was assessed at a frequency of 10 percent of the monitoring locations sampled through the collection and analysis of duplicate samples. The results of the duplicate samples were compared to the original sample to estimate a relative percent difference (RPD) between the two samples. The parameter-specific relative percent differences are in Appendix H. These values are viewed as a goal rather than a requirement due to the inherent variation in surface and ground water samples. The goals were met for 92% of all analytes.
- Representativeness of the proper design of the sampling program in terms of the selection of the sample locations and the adequacy of the number of samples collected met the requirements of the Work Plan.

2.6 WATER QUALITY DATABASE

Surface water quality data have been collected within the San Mátteo and Santa Margarita River Watersheds since the 1960s. Many of the sampling stations are clearly documented; however, many samples were collected at locations that are poorly defined. Only data from those stations that were clearly identifiable, had a period of record greater than three years, and corresponded to the stations used during sampling for this project were included in the database. Chemical data were collected from:

- USGS published reports;
- California Department of Water Resources reports;
- MCB Camp Pendleton, Office of Water Resources files;
- LAW's current surface and groundwater sampling program;
- Rancho California Water District; and
- Eastern Municipal Water District.

Over 32,000 water quality results were inputted into the database. Table 7 lists the stations with water quality data contained in the database. The locations of these stations are shown on Figures 3 and 4. Appendix D-1 contains a compact disc (CD) with the database compiled in ACCESS. Appendix D-3 lists other sources of available water quality data that were not included in the database because the location was not well defined, the sampling station had a short period of record, or the station was not on the Santa Margarita River, San Mateo Creek, or Cristianitos Creek. Figure D-1 shows the known locations of some of these samples.

2.7 DATA ANALYSIS

The goals of the analysis of the water quality data were to justify the selection of monitoring locations and chemical parameters to detect trends in water quality and to establish UPLs for water quality parameters to indicate when water supplies at MCB Camp Pendleton may be threatened and warrant further investigation or action. This information was used to prepare the Watershed Monitoring Program. Both graphical and statistical data analysis methods were chosen and are described in the following subsections.

2.7.1 Graphical Analysis

The data collected were graphed prior to statistical analyses to visually evaluate the data for trends and to evaluate the relationship of surface water and groundwater quality. The EPA technical guidance document states that visually observing data for trends is an appropriate method, especially when the data are non-parametric.

2.7.1.1 Trend Graphs

LAW plotted the water quality data collected for the eleven surface water and three groundwater monitoring stations in the San Mateo and Santa Margarita River Watersheds to graphically display the concentrations for each analytical parameter over time. The graphs were used to visually evaluate the data for trends and to relate significant changes in water quality to potential sources. The graphs also served to provide a visual examination of the changes in water quality to verify the results of the statistical analysis. Where a constituent was not detected with repeat sampling, the graphs also were used to justify elimination of that parameter from sampling in the Watershed Monitoring Program.

Trend plots were developed for each surface water and groundwater monitoring station for each chemical parameter with sufficient data. Some parameters had been sampled infrequently in the past and contained very few data points. The parameters graphed are:

- Major anions including bicarbonate, carbonate, chloride, and sulfate (HCO_3 , CO_3 , Cl , and SO_4);
- Major cations including calcium, sodium, magnesium, and potassium (Ca , Na , Mg , K);
- TDS, pH, hardness, and specific conductance;
- Nitrate as nitrogen, and phosphorus converted from phosphate;
- Metals including copper, iron, lead, mercury, manganese, and zinc (Cu , Fe , Pb , Hg , Mn , Zn).

Appendix E contains the graphs of these plots for each monitoring location shown on Figures 3 and 4.

2.7.1.2 Piper Diagrams

Graphs of water quality can be used to interpret whether water is from the same source, from a different source, or is mixed. LAW used Piper diagrams to assess whether groundwater and surface water have similar quality to help justify the monitoring locations for the Watershed Monitoring Program. Appendix F contains Piper diagrams for each monitoring location.

To create a trilinear plot, the percentage of each major ion is calculated based on the total cations or anions. The percentage of major cations and percentage of major anions are then potted onto the two lower triangles on the diagram. The apex of these triangles represents a 100% concentration of each major anion and cation. The cation point from the lower left triangle is projected onto the diamond area of the diagram parallel to the magnesium axis and the anion point is projected onto the diamond area of the diagram parallel to the sulfate axis until the lines intersect. This point represents the distribution of the major ions in the water sample.

LAW used the analytical results from 1997 through 1999 to compare surface water and groundwater quality. This period was selected for analysis because LAW installed the monitoring wells in 1997 and since then, surface water sampling and groundwater sampling has occurred concurrently. Separate graphs were initially prepared for each monitoring location to evaluate if the quality of water varies by season. Surface water monitoring stations were also plotted with nearby monitoring wells to evaluate if the waters have similar quality. Piper Diagrams using the historical data were prepared for each station with the exception of stations 502, 504, and 508 that did not have ion data sets for trilinear plots. These diagrams are located in appendix F.

2.7.2 Statistical Analysis

Environmental data is often difficult to interpret because the analytical results often contain "less than" values (non-detectable concentrations), results that are extremely high and anomalous to the rest of the data (outliers), and is often influenced by natural factors that produce cyclic variations

(climatic factors such as recharge from rain). Over the last twenty years use of statistics to interpret environmental data has been refined and has gained more acceptance. USEPA has led this effort to establish standard methods for the evaluation of data from contaminated sites. Statistical methods provide a defensible, standardized approach of interpreting the data to provide a yes/no response as to whether a current analytical result is significantly different than previous analyses and whether any corrective action is required. LAW used statistical methods to analyze water quality data gathered between 1997 and 1999 to establish a current baseline for water quality in the Santa Margarita River and San Mateo River watersheds.

In general, the methods used can be divided into two categories, data management and statistical evaluations. During the data management phase the analytical data set is evaluated for anomalous results, the number of non-detectable results and detection limits. Using approved methods the data set is then manipulated to establish a data set suitable for statistical evaluation. The data set is then checked to determine if the data is normal (produces a bell shaped curve), log normal (where the logarithm of the data is analyzed) or non-parametric (the data set does not conform to a general linear model). Based on these categories the data is then analyzed using the appropriate equations to determine whether there are significant differences in the data and to define an UPL. The UPL is a concentration that, if exceeded, indicates the water quality has degraded from the baseline.

LAW used these methods to determine:

- If there is a statistically significant difference between monitoring stations within each watershed, with the purpose of deciding which monitoring points should be included in the Watershed Monitoring Program.
- If the analyses are affected by weather or seasonal variations, with the purpose of deciding the frequency of monitoring.
- UPLs for chemical parameters, with the purpose of establishing concentration limits to indicate when MCB Camp Pendleton needs to take action to protect its groundwater supplies.

LAW used SYSTAT™ and Microsoft Excel™ software to evaluate surface and groundwater data from monitoring locations in the San Mateo and Santa Margarita River Watersheds. The following

sub-sections describe the methods used for data management (Sections 2.7.2.1 and 2.7.2.2) and for statistical analysis (Sections 2.7.2.3 through 2.7.2.7).

2.7.2.1 Outlier Analysis

Outliers are measurements that are extremely large or small relative to the rest of the data and, therefore, are suspected of misrepresenting the population from which they were collected. Outliers may result from transcription errors, data-coding errors, or measurement system problems such as instrument breakdown. However, outliers may also represent true extreme values of a distribution (for instance, a spill into the waterway) and indicate more variability in the population than was expected. Not removing true outliers and removing false outliers both lead to a distortion of estimates of the population parameters.

For this analysis potential outliers were identified graphically using trend plots (described in Section 2.7.1.1). Each suspected outlier was compared to its original data source and corrected or discarded if incorrect. No outliers were discarded solely for their extreme value.

2.7.2.2 Sorting by Frequency of Non-Detection

The statistical method used to compute control limits was largely dependent on the frequency of non-detects of a given parameter. A non-detect result implies some uncertainty of the concentration of that result because the true value is somewhere between zero and the sample-specific detection limit (DL). The handling of non-detects is paramount to the statistical procedures for determining control limits. Furthermore, as the proportion of non-detects in a data set increases, so does the uncertainty in the summary statistics computed for the data set. For this reason, the USEPA recommends segregating data into four classes based on the percentage of non-detects (USEPA, 1998). For the purposes of this report data sets are referred to as types A through D, as described below:

Data Set Type	Percent Non-Detect Values	Statistical Analysis Method
A	0%	No adjustment
B	0% to <15%	Replace non-detects with one-half the detection limit
C	15% to 50%	Cohen's Adjustment or Trimmed Mean

D	>50%	Non-parametric
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Each parameter's data type is listed in Tables 10 and 11.

2.7.2.3 Data Normality Analysis

After outliers were deselected, the surface water and groundwater data were plotted for each parameter using normal, log transform, and exponential distribution probability plots with the SYSTAT™ statistical software program. Probability plots using each method are in Appendix G. These plots identified parameters as normally distributed or non-parametric. The results of normality analysis are presented in Tables 10 and 11. Normal data are listed as "N" and non-parametric data are listed as "NP."

Mean

The mean is the average of the values in the data set. It was calculated using the formula:

$$\bar{x} = \sum_{i=1}^n \left(\frac{x_i}{n} \right)$$

where

\bar{x}	=	The mean of the data set
x_i	=	An individual data point within the data set
n	=	The total number of points in the data set

Means were computed for data set types A, B, and C.

a. Variance

The variance of a data set is the mean square deviation from the data set mean. Variances were calculated for type A, B, and C data sets using the formula:

$$s^2 = \sum_{i=1}^n \frac{(x_i - \bar{x})^2}{(n-1)}$$

where

s^2	=	The variance of the data set
\bar{x}	=	The mean of the data set
x_i	=	An individual data point within the data set
n	=	The total number of points in the data set

Standard Deviation

The standard deviation (s) of a data set is the square root of the variance (described in the preceding equation). Standard deviations were calculated for data set types A, B, and C.

b.

c. Upper Prediction Limits - Normal Distribution

For data sets with a normal distribution, a parametric upper prediction limit (UPL) that achieved 95 percent coverage was constructed using methods outlined by the USEPA (1992). A UPL is a statistical limit that indicates whether a new sample value is elevated relative to background data. In order to construct a parametric UPL that satisfies USEPA criteria, the USEPA recommends a minimum of eight data points (USEPA, 1992). For the San Mateo Watershed, each parameter data set has 25 data points; for the Santa Margarita River Watershed, each parameter data set has 70 data points. The parametric UPL was constructed using the formula:

$$UPL = \bar{x} + t(v, \alpha) \cdot s \cdot \sqrt{1 + \frac{1}{n}}$$

where

UPL	=	the parametric upper prediction limit for a parameter
\bar{x}	=	The mean of the background data set
t	=	The 95th percentile of the Bonferroni t-statistic as a function of degrees of freedom (v), and total probability of a type I error (α)
n	=	The number of data points in a background data set
v	=	The degrees of freedom in the background data set
α	=	The probability of a type I error (false positive), for this project, $\alpha = 0.05$
s	=	The standard deviation of the background data set

The 95th percentile Bonferroni t-statistic values that were used in the UPL calculations are presented in Table A-1 in published literature (USEPA, 1998).

Upper Prediction Limit - Non-Parametric Distribution

For data sets that were neither normally nor log-normally distributed, type D data sets, a non-parametric UPL was constructed using the maximum contaminant level (MCL) divided by two or the detection limit (DL), whichever is larger.

2.7.2.4 Cohen's Adjustment

For Type C data, where non-detects were 15% to 50% of the total data set, Cohen's adjustment method was used to compensate for non-detects that are real values that exist below the DL and that have been censored at their detection limit.

Cohen's adjustment technique adjusts the mean and standard deviation by the following procedures. First, the mean and variance (\bar{x}_d and V_d) of the detected values greater than or equal to the DL were calculated. Then two parameters (h and γ) were calculated as follows (USEPA 1998):

$$h = \frac{(n-m)}{n}$$

$$\gamma = \frac{V_d}{(\bar{x}_d - SQL)^2}$$

where

n	=	The total number of points in the data set (including non-detects)
m	=	The number of detects in the data set
\bar{x}_d	=	Mean of values greater than or equal to the SQL
V_d	=	The coefficient of variation of values greater than or equal to the SQL
SQL	=	The non-varying sample quantitation limit
h	=	h Cohen's Adjustment parameter
γ	=	γ Cohen's Adjustment parameter

The values h and γ were used to determine the value of λ from published literature (Table A-10, Appendix A of USEPA 1998). Double linear interpolation was used when exact tabulated values for h and γ were not available. The calculations for h , γ , and λ are included in Appendix G.

The adjusted mean for detect values (\bar{x}'_d) was calculated by the formula:

$$\bar{x}'_d = \bar{x}_d - \lambda(\bar{x}_d - DL)$$

The adjusted standard deviation for detect values (s'_d) was calculated by the formula:

$$s'_d = \sqrt{s_d^2 + \lambda(\bar{x}_d - DL)^2}$$

where

\bar{x}'_d	=	The adjusted mean of detect values
s'_d	=	The adjusted standard deviation of detect values
\bar{x}_d	=	The mean of the detect values
s_d	=	The standard deviation of detect values
DL	=	The non-varying sample detection limit

If the calculated γ for the use of Cohen's adjustment was beyond the range of Table A-10 (>1.00), the Trimmed Mean adjustment was used.

2.7.2.5 Trimmed Mean

Trimming discards the data in the tail ends of a data set to develop an unbiased estimate of the population mean. For environmental data, non-detects usually occur in the left tail of the data distribution. Therefore, trimming the data can be used to adjust the data set to account for non-detects when estimating the mean. Developing a 100p% trimmed mean involves trimming p% of the data in both the lower and upper tails. The trimmed mean is calculated using the following steps:

p	=	the percent of non-detects in the data set
n	=	the total number of points in the data set

t = the integer part of the product np

Delete the t smallest values of the data set and t largest values of the data set.

Compute the mean of the remaining $n-2t$ values using the equation above.

2.7.2.6 Analysis of Variance

Analysis of variance (ANOVA) was performed on parameters from the water quality data set using the SYSTAT™ software. The purpose of performing the ANOVA was to evaluate if there were significant differences between the water quality at sampling locations within each watershed. Least Squares Means plots for various analytical parameters are included in Appendix G. These plots show the mean values of the parameter on the y-axis for each monitoring location on the x-axis. For each sample station (SID\$) a confidence interval is displayed in the vertical direction. When these intervals overlap it indicates there is no significant difference between means.

2.7.2.7 Pearson Correlation

Pearson correlation was used to measure the linear relationship between two sets of data. The Pearson correlation coefficient (r) is calculated using the following formula:

where

X = label for a variable from one data set

Y = label for the same variable from the other data set

N = number of data pairs

3.0 WATER QUALITY EVALUATION RESULTS

The evaluation of the relationship of surface water quality and groundwater quality in regard to protecting MCB Camp Pendleton's groundwater drinking water supply was accomplished using a variety of graphical and statistical methods. The relationships of surface water quality and groundwater quality were assessed using data from the monitoring wells installed for this project and data from surface water sampling locations. The results of the evaluation were incorporated into the Watershed Monitoring Program.

3.1 SAN MATEO WATERSHED

This section discusses the analysis of water quality data from three surface water monitoring stations and one groundwater monitoring well for the San Mateo Watershed. Figure 3 shows the location of the monitoring stations. Included in the analysis is a comparison of rainfall and gauging station measurements to water quality parameters to assess their relationships to water quality.

3.1.1 Trend Analysis

Trend plots from the database were generated for each of the chemical parameters analyzed. Appendix E contains these trend graphs. The plots were visually evaluated to:

- Detect obvious trends in chemical parameter concentrations over time, either short term or long term;
- Determine if parameters exceeded the drinking water maximum contaminant level (MCL) or basin plan objectives; and
- Assess if high concentrations could be traced to a tributary or creek, an indicator parameter.

A variety of patterns were observed, ranging from a scattering of data without a definite pattern to clearly identifiable trends. Table 8 provides a summary of these trends which are described below.

- Several constituents, such as cyanide and biochemical oxygen demand (BOD), had less than five measurements. Trends could not be discerned with these few measurements.

- Over 20 samples for the four monitoring locations in the San Mateo watershed were submitted for analysis of mercury content. Mercury was not detected in these samples. Cyanide was also not detected, although very few samples were analyzed for cyanide for each monitoring location.
- Flat trending data were observed for cyanide, hydroxide, iron, lead, manganese, mercury, potassium and sulfate; however, some higher concentrations were observed.
- Downward trends, which suggest an improvement in water quality, were observed for calcium, carbonate, chloride, specific conductance, copper, hardness, magnesium, potassium, sodium, and TDS.
- An apparent cyclic trend (potentially seasonal) was observed for TDS and pH.
- Historic increasing trends were observed from 1967 through 1976 for calcium, hardness, sulfate, and TDS. Since 1976, a downward trend is observed in the data. The downward trend suggests an improvement in the water quality over time.
- Different concentrations were observed for arsenic and phosphate among surface water sampling locations and between surface water and groundwater samples.

The trend analysis data were also evaluated to check the results for constituents that exceeded the drinking water MCLs. MCLs were exceeded in the historic record for:

- Nitrate, TDS, sulfate, manganese, iron, and specific conductance at Cristianitos Creek near San Clemente, San Mateo Creek at San Clemente, and San Mateo Creek at San Onofre (Stations 509, 510, and 511);
- Chloride and copper at Cristianitos Creek near San Clemente (Station 509);
- Fluoride at Cristianitos Creek near San Clemente (Station 509) and San Mateo Creek at San Clemente (Station 510);
- MBAS at San Mateo Creek at San Onofre (Station 511);
- Arsenic and lead at San Mateo Creek at San Clemente (Station 510) and at San Onofre (Station 511).

The analytical data collected since 1997 show MCLs were exceeded at least once for:

- TDS and specific conductance at Cristianitos Creek near San Clemente (Station 509) and San Mateo Creek at San Onofre (Station 511);

- Nitrate at San Mateo Creek at San Onofre (Station 511);
- Manganese and iron at Cristianitos Creek near San Clemente (Station 509) and San Mateo Creek at San Onofre (Station 511);
- Fecal coliform at Cristianitos Creek near San Clemente (Station 509) and San Mateo Creek at San Clemente (Station 510);
- Lead in groundwater at MW-3 (Station 103).

A statistical approach was taken to evaluate the trend data. Least squares linear regressions were fitted to some of the data to develop an equation for forecasting water quality. However, because the data sets have large standard deviations the use of these trend lines is not recommended for forecasting water quality.

Based on the trend analysis and a comparison of the analytical results to MCLs, parametric intra-monitoring point, parametric statistical comparison to gauging station measurements, and statistical historical versus current data (1997 to 1999) were performed for the six parameters that currently exceed the MCLs. These analyses were also performed for arsenic, calcium, bicarbonate, chloride, sodium, and phosphate, which had different concentrations in the monitoring well samples and surface water samples as identified in the trend graphs and Piper diagrams.

The historical data was reviewed, and it was found that the concentrations of the following metals were below their regulated MCLs: antimony, barium, beryllium, cadmium, chromium, mercury, nickel, and selenium.

3.1.2 Piper Diagrams

Piper diagrams were used to evaluate if the surface water monitoring locations in the San Mateo Watershed had similar or dissimilar water quality from 1997 to 1999 and to determine if the water quality of the groundwater is similar or dissimilar to surface water. Appendix F contains the Piper diagrams for each monitoring location.

The surface water quality in Cristianitos Creek near San Clemente (Station 509) and San Mateo Creek at San Clemente (Station 510) is dissimilar. Figure 5 shows the water quality for Cristianitos

Creek (Station 509) plots in a fairly tight grouping. The water is characterized as a calcium chloride water. In comparison the water in San Mateo Creek (Station 510) is a calcium bicarbonate water as indicated by the tight grouping to the left of the samples from Cristianitos Creek (Station 509). The tight groupings of each plot show that the water quality varies very little between winter and summer and that the sources of the water are constant.

Figure 6 shows that water from Cristianitos Creek (Station 509) and San Mateo Creek (Station 510) mix below the confluence of these streams at San Mateo Creek at San Onofre (Station 511). The plot shows that the water at Station 511 is predominantly from Cristianitos Creek, with very little influence from San Mateo Creek. However, during March 1998 water at Station 511 (sample 511002) had a plot that was more similar to water from San Mateo Creek. This difference appears to be related to the above average precipitation recorded that year during March and the preceding months. This relationship suggests that either the flow in Cristianitos Creek is greater than flow in San Mateo Creek or that most of the water in San Mateo Creek percolates into the subsurface. In August of 1998, Station 511 (sample 511004) had a water quality different than that of either San Mateo or Cristianitos Creeks. It appears that sodium, in a source of flow on the Base, contributed water to the creek down gradient of Stations 509 and 510.

Groundwater monitoring well MW-3 (Station 103) is located within the Cristianitos Creek drainage area, upstream from the surface water sampling location at Station 509. As shown on Figure 7, the water in Station 103 is a calcium chloride water, which is similar in composition to the surface water at Station 509. However, in March 1998 (sample 103002), the water quality in monitoring well MW-3 was characterized as calcium bicarbonate, different than the water in Cristianitos Creek.

The plots of the historical data (Appendix F) show a similar relationship as described above with waters from Cristianitos Creek having the most influence on the water quality at Station 511.

3.1.3 Statistical Analysis

The following subsections discuss the statistical methods used, the statistical results, and the upper prediction limits for use in future monitoring.

3.1.3.1 Statistical Approach

The chemical data set for the San Mateo Watershed was evaluated to select the appropriate method for statistical analysis. A summary of the statistics for the San Mateo Watershed is presented in Table 10. Values were calculated for each of 33 water quality parameters for the period from 1997 to 1999 based on data type (described in Section 2.7.2.2) and on probability plots. Data were tested using normal, log-transformed normal, exponential, and chi-squared probability plots. These plots are included in Appendix G. The statistical distributions selected are as follows:

Non-parametric	Normal	Log Transformed Normal
Arsenic	Alkalinity	Phosphorus
Biochemical Oxygen Demand	Bicarbonate	Potassium
Copper	Boron	
Cyanide	Calcium	
Fecal Coliform	Carbonate	
Hydroxide	Chloride	
Lead	Conductivity	
Mercury	Fluoride	
Nitrate	Hardness	
Nitrogen	Iron	
Oil & Grease	Magnesium	
Surfactants	Manganese	
Total Coliform	pH	
Zinc	Sodium	
	Sulfate	
	Total Dissolved Solids	
	Total Organic Carbon	

The Cohen adjustment was used on the boron, carbonate, and total organic carbon (TOC) data sets and the Trimmed Mean adjustment was used on the iron, manganese, phosphorus, and potassium data sets. The statistical parameters - mean, standard deviation, variance, and upper prediction limit - were calculated from the adjusted data sets.

3.1.3.2 Statistical Relationships

Statistical analysis was used to evaluate if variations in the chemical parameters were related to rainfall or stream gauge measurements and whether the analyses were significantly different between monitoring points. The goals of the statistical analysis were to define the frequency and sample locations of future monitoring events.

Precipitation and daily stream flow values were plotted over a time scale from October 1993 through September 1997 to evaluate their correlation. The rain events were recorded daily at the Marine Corps Air Station, Camp Pendleton and the flow data was from the U.S. Geological Survey gauging station (No.11046360) at Cristianitos Creek near San Clemente. Figure 8a shows the entire time span and Figures 8b and 8c show expanded portions of the data to provide more details. The Pearson correlation coefficient is 0.445. This is a poor correlation and probably results from several rain events occurring after a dry period and the ground absorbing the water with no runoff to the creek. Figure 8c shows 13 rain days when there was no additional flow recorded in the creek. The figures also show that stream flow increased several times during the year when there was no rainfall, probably due to discharges from unknown sources that may have contained poor quality water. This also affected the correlation. This occurred on 12/31/97, 4/26/98, 7/5/98, 7/10/98, and 7/26/98. Because of the poor correlation to rainfall and the apparent unscheduled discharges (other than from rainfall) that appear to occur, the frequency of monitoring cannot be limited to just certain portions of the year.

Gauging station measurements were plotted over time from 1997 through 1999 to evaluate if chemical concentrations correlated with stream gauge measurements. Previous authors evaluation suggested some seasonal cyclic variations in TDS. Trend plots evaluated for this project also suggested an apparent cyclic nature possibly seasonal for TDS and pH. However, plots (included in Appendix E) of stream flow and TDS for each monitoring location do not show a consistent correlation for all monitoring stations. Therefore, statistically there is no correlation.

Analysis of variance (ANOVA) least squares means was used to evaluate if there was a statistical difference between the monitoring stations for those chemical parameters that had a normal distribution, had established water quality goals, and were suggested by other methods to possibly be

statistically different. The ANOVA set the baseline conditions for the watershed for comparison of future results. The plots for bicarbonate, calcium, chloride, conductance, fluoride, iron, magnesium, manganese, pH, phosphorus, sulfate, sodium, and TDS are in Appendix G. These plots show significant differences between surface water monitoring Stations 509 and 510. Station 511 is located downstream from the confluence of San Mateo Creek and Cristianitos Creek and, as expected, the results fall between the results of Stations 509 and 510 except for nitrate and fluoride. The plots for iron, magnesium, manganese, and pH indicate surface water quality is not the only factor in the quality of groundwater measured at Station 103. The nonparametric constituents had too few data points for statistical calculations.

3.1.3.3 Upper Prediction Limits

Upper prediction limits (UPLs) were statistically calculated for 31 chemical parameters contained within the chemical database. UPLs were not calculated for total or fecal coliform because results for those parameters are reported by the laboratory as a statistical "most probable number" which is a step function. Calculating a UPL from a step function is not appropriate. Exceeding the UPL for a parameter in a future sampling event would indicate that, the water quality in the San Mateo Watershed is degraded compared to the baseline calculated in this report. UPLs from Table 10 are presented below. It should be noted that UPLs for conductance, iron, manganese, and TDS exceed MCLs.

Parameter	UPL	Units	Parameter	UPL	Units
Alkalinity	223	mg/L	Lead	0.0075	mg/L
Arsenic	0.025	mg/L	Magnesium	39	mg/L
Bicarbonate	220	mg/L	Manganese	1.7*	mg/L
BOD	2	mg/L	Mercury	0.001	mg/L
Boron	0.5	mg/L	Nitrate	23	mg/L
Calcium	116	mg/L	Nitrogen	5	mg/L
Carbonate	5.5	mg/L	Oil & Grease	1	mg/L
Chloride	151	mg/L	pH	9	pH
Conductivity	1244**	µmhos/cm	Phosphorus	0.4	mg/L
Copper	0.5	mg/L	Potassium	5.0	mg/L
Cyanide	0.1	mg/L	Sodium	116	mg/L
Fluoride	0.5	mg/L	Sulfate	230	mg/L

Parameter	UPL	Units	Parameter	UPL	Units
Hardness	434	mg/L	Surfactants	0.25	mg/L
Hydroxide	0.5	mg/L	TDS	778**	mg/L
Iron	23*	mg/L	TOC	7.4	mg/L
			Zinc	2.5	mg/L

Notes:

*- Exceeds MCL for Drinking Water

** - Exceeds Recommended Levels for Drinking Water

3.2 SANTA MARGARITA RIVER WATERSHED

This section discusses the analyses of water quality data from eight surface water monitoring stations and two groundwater monitoring wells for the Santa Margarita River Watershed. Figure 4 shows the location of the monitoring locations. Included in the analysis is a comparison of rainfall and gauging station measurements to water quality parameters to assess their relationships to water quality.

3.2.1 Trend Analysis

The chemical database was used to generate trend plots for each of the chemical parameters that were analyzed. Appendix E contains the trend graphs. The plots were visually evaluated to:

- Detect obvious trends in chemical parameter concentrations over time, either short term or long term;
- Determine if parameters exceeded the drinking water maximum contaminant level (MCL) or basin plan objectives; and
- Assess if high concentrations could be traced to a tributary or creek.

A variety of trends were observed, ranging from a scattering of data without a definite pattern to clearly identifiable trends. Table 9 provides a summary of these trends, which are described below.

- Several constituents, such as cyanide, had less than five measurements. Trends could not be discerned with these few measurements.

- Over 20 samples for the three monitoring locations in the Santa Margarita River Watershed were submitted for analysis of mercury. Mercury was not detected in the samples.
- Flat trending data was observed for arsenic, hydroxide, iron, lead, manganese, mercury, and potassium; however, some high concentrations were observed.
- Downward trends, which suggest an improvement in water quality, were observed for bicarbonate, boron, carbonate, copper, fluoride, and nitrate. Nitrate may be increasing at Sandia Creek near Fallbrook (Station 502) and De Luz Creeks near Fallbrook (Station 506).
- A cyclic (seasonal) trend was observed for alkalinity and chloride.
- Increasing trends were observed for bicarbonate and hardness on Rainbow Creek near Fallbrook (Station 503) and Fallbrook Creek near Fallbrook (Station 507).
- Increasing trends were observed for sodium and sulfate on Sandia Creek near Fallbrook (Station 502) and De Luz Creek near Fallbrook (Station 506).
- Increasing trends were observed for calcium and manganese.
- TDS and specific conductance have varying patterns. Increasing trends for TDS and specific conductance were seen at De Luz near Fallbrook (Station 506) and Rainbow Creek near Fallbrook (Station 503).
- Historical increasing trends were observed from 1961 through 1983 for specific conductance and TDS in Murrieta Creek near Temecula (Station 505) and in Rainbow Creek near Fallbrook (Station 503) between 1961 through 1987. Since then, the levels dropped and have maintained a relatively constant value. However, some are still above the MCL
- Bicarbonate, calcium, magnesium, hardness, and phosphate all were showing increasing trends.
- Different water quality was observed for arsenic in the surface water samples and in surface water versus groundwater.

Historically, the following parameters have exceeded the MCL at least once:

- MBAS at Rainbow Creek near Fallbrook (Station 503);
- Nitrate at Santa Margarita River near Fallbrook (Station 501), Sandia Creek near Fallbrook (Station 502), Rainbow Creek near Fallbrook (Station 503), Murrieta Creek

at Temecula (Station 505), De Luz Creek near Fallbrook (Station 506), Fallbrook Creek near Fallbrook (Station 507), and the Santa Margarita River at Ysidora (Station 508);

- Sulfate in groundwater at DeLuz Creek near Fallbrook (Station 506), Santa Margarita River near Fallbrook (Station 501), Sandia Creek near Fallbrook (Station 502), Rainbow Creek near Fallbrook (Station 503), Murrieta Creek near Temecula (Station 505), and Fallbrook Creek near Fallbrook (Station 507);
- Manganese at Fallbrook Creek near Fallbrook (Station 507), De Luz Creek near Fallbrook (Station 506), and Rainbow Creek near Fallbrook (Station 503);
- Chloride at Murrieta Creek at Temecula (Station 505), Fallbrook Creek near Fallbrook (Station 507), and DeLuz Creek near Fallbrook (Station 506);
- Conductivity, TDS, and iron at all stations;
- Fluoride at the Santa Margarita River near Fallbrook (Station 501), Rainbow Creek near Fallbrook (Station 503), the Santa Margarita River near Temecula (Station 504), Murrieta Creek at Temecula (Station 505), De Luz Creek near Fallbrook (Station 506), and Fallbrook Creek near Fallbrook (Station 507);
- Arsenic at the Santa Margarita River near Fallbrook (Station 501), Rainbow Creek near Fallbrook (Station 503), and De Luz Creek near Fallbrook (Station 506);
- Fecal coliform at the Santa Margarita River near Temecula (Station 501), Sandia Creek near Fallbrook (Station 502), Rainbow Creek near Fallbrook (Station 503), Santa Margarita River near Temecula (Station 504), Murrieta Creek at Temecula (Station 505), De Luz Creek near Fallbrook (Station 506), Fallbrook Creek near Fallbrook (Station 507), and the Santa Margarita River at Ysidora (Station 508); and
- Lead at the Santa Margarita River near Fallbrook (Station 501), Murrieta Creek at Temecula (Station 505), De Luz Creek near Fallbrook (Station 506), and Fallbrook Creek near Fallbrook (Station 507).

Review of the trend analyses data also showed that the MCL is currently being exceeded for:

- Nitrate at Rainbow Creek near Fallbrook (Station 503);
- Sulfate, iron, manganese, TDS and specific conductance at all surface water monitoring stations;
- Chloride at Sandia Creek near Fallbrook (Station 502);

- Lead at Rainbow Creek near Fallbrook (Station 503), the Santa Margarita River near Temecula (Station 504), De Luz Creek near Fallbrook (Station 506), Fallbrook Creek near Fallbrook (Station 507), and in both MW-1 and MW-2 (Stations 101 and 102); and
- Nitrate in groundwater at MW-2, the De Luz Creek well (Station 102).

A statistical approach was taken to evaluate the trend data. Least squares linear regressions were fitted to some of the data to develop an equation for forecasting water quality. However, because the data sets have large standard deviations the use of these trend lines are not recommended for forecasting water quality.

Based on the trend analysis and a comparison of the analytical results to MCLs, parametric intra-monitoring point, parametric statistical comparison to gauging station measurements and statistical historical versus current data (1997 to 1999) were performed for the seven parameters that currently exceed the MCLs. These analyses were also performed for arsenic, calcium, carbonate, sodium, and chloride, which had different concentrations in the monitoring well samples and surface water samples as identified in the trend graphs and Piper diagrams.

3.2.2 Piper Diagrams

Piper diagrams were used to evaluate if the surface water monitoring locations in the Santa Margarita River Watershed had similar or dissimilar water quality from 1997 to 1999 and to determine if the water quality of the groundwater and surface water is similar or dissimilar. Appendix F contains the Piper diagrams for each monitoring location.

Water in the upper portion of the Santa Margarita River is from Murrieta Creek (Station 505), Temecula Creek (Station 504 combined with flow from 505), and several tributaries including Sandia Creek (Station 502) and Rainbow Creek (Station 503). Water in these creeks and tributaries mixes and is monitored at Station 501, Santa Margarita River near Fallbrook. Figure 9 shows the plot of the water quality at these stations during August 1998. The plot shows the water from Murrieta Creek (Station 505) is a sodium chloride water. Temecula Creek does influence the water quality in the Santa Margarita River (Station 504) as shown by a slight decrease in sodium. Water from Sandia Creek is different and is a calcium chloride water. Graphs in Appendix F show the

water in Murrieta and Temecula Creeks varies throughout the year. However, the water from Sandia Creek is consistent with little to no seasonal change. Figure 9 shows that at Station 501 (Santa Margarita River near Fallbrook), which is downstream from these other sources which has waters from the creeks and tributaries have mixed resulting in a calcium chloride water. This suggests that Sandia Creek (Station 502) has a larger flow and hence a strong influence on the water quality in the Santa Margarita River or those geologic materials containing calcium has affected the water quality.

The surface water quality in the lower portion of the Santa Margarita River is measured at two locations along the river - one on the Base (Santa Margarita River at Ysidora [Station 508]) and one in the river at the Fallbrook Public Utilities District (FPUD) sump (Santa Margarita River near Fallbrook [Station 501]). Figure 10 shows the water quality at the two stations is calcium chloride in character. The water at these two locations is almost identical, except in May 1999 (sample 508007) when water from a different source must have increased the sodium content at Station 508. Figure 11 shows the water quality at the monitoring stations upstream of Station 508 for May 1999. Sodium is present in water samples from both Murrieta and Temecula Creeks (Stations 504 and 505); however, these stations are upstream of Station 501. Station 501 is a mixture of water from these two stations, yet it does not compare with sample 508007. De Luz Creek (Station 506), which merges with the Santa Margarita River downstream of Station 501, Santa Margarita River near Fallbrook, could have an effect on the water quality seen at Station 508, Santa Margarita River near Ysidora. As shown on Figure 11, water from De Luz Creek is calcium chloride in character and is not the source of sodium measured at Station 508. Both Stations 501 and 101, Santa Margarita River near Fallbrook and MW-1, have sodium chloride water. Monitoring well MW-1 (Station 101), which is downstream of Station 501, contains sodium bicarbonate water. It appears that the source of the sodium water is from Fallbrook Creek (Station 507) or less likely from groundwater MW-1 (Station 101) that emerges as surface water. Low flows in the Santa Margarita River and releases from Lake O'Neill appear to have affected surface water quality at Station 508, Santa Margarita River at Ysidora, during May 1999. Otherwise, water samples collected at either Station 501 or 508 are representative of water in the Santa Margarita River.

Groundwater monitoring well MW-1 (Station 101) is located near surface water monitoring Station 501, Santa Margarita River near Fallbrook. As shown on Figure 12, the water in MW-1 is

usually a calcium bicarbonate water, which is different than the calcium chloride water in the Santa Margarita River at Station 501 (Figure 13). Only once, in March 1998 at Stations 101 and 501, was the water in a monitoring well nearly identical in character to water in the Santa Margarita River. This suggests there is little, if any recharge to groundwater from the river in the gorge. The plot does suggest that some water from the river mixed with the groundwater during June and November 1998 and February and May 1999. In February and August 1998, the river did not appear to affect groundwater quality. Because there does not appear to be a relationship to seasonal changes it is our opinion that either:

- Sediment thickness within the river channel and fluctuating depth to groundwater affect how much the river recharges the groundwater and affects its water quality, or
- Fine-grained sediment accumulation in the river channel reduces recharge through the coarser-grained sediments unless high flows remove the fine-grained sediments blocking the pore spaces.

In contrast to MW-1, MW-2 (Station 102) shows a strong relationship of water quality with surface water Station 506 (De Luz Creek near Fallbrook). Figure 13 shows this relationship. However, the water quality of a few groundwater samples does not relate directly with the quality of surface water samples. This occurred during the first and second sampling rounds when surface and groundwater sampling events were separated by about 7 to 14 days. Based on estimated groundwater velocities and travel times through sand and gravel, a particle of water would take about 3 to 14 days to travel from the creek to the groundwater well. In March 1998, dissimilar water quality was noted when the surface and groundwater samples were collected within only one day of each other. This disparity could be caused by a change in surface water that occurred days prior to sampling the surface water or by groundwater with different water quality.

Piper Diagrams of the historical data indicate the water quality has remained consistent for Stations 501 Santa Margarita River near Fallbrook, 505 Murrieta Creek near Temecula, and 507 Fallbrook Creek near Fallbrook. There has been a shift in anions at Station 503 Rainbow Creek near Fallbrook from bicarbonate to sulfate. At Station 506 Del Luz Creek near Fallbrook the anion shift was from bicarbonate to chloride.

3.2.3 Statistical Analyses

This sections discusses the results of the statistical methods used, statistical results, and provides upper predictive limits for use in future monitoring for the Santa Margarita River Watershed.

3.2.3.1 Statistical Approach

The chemical data set for the Santa Margarita Watershed was evaluated to select the appropriate method for statistical analysis. The summary statistics for the Santa Margarita Watershed are presented in Table 11. Values were calculated for each of 33 water quality parameters based on the data type (as described in Section 2.7.2.2) and on probability plots. Data were tested using normal, log transformed normal, exponential, and chi-squared probability plots. These plots are included in Appendix G. The statistical distributions selected are as follows:

Non-Parametric	Normal	Log Transformed Normal
Arsenic	Alkalinity	Bicarbonate
Biochemical Oxygen Demand	Boron	Fluoride
Copper	Calcium	Iron
Cyanide	Carbonate	Phosphorus
Fecal Coliform	Chloride	Potassium
Hydroxide	Conductivity	
Lead	Hardness	
Mercury	Magnesium	
Nitrogen	Manganese	
Oil & Grease	Nitrate	
Surfactants	pH	
Total Coliform	Sodium	
Zinc	Sulfate	
	Total Dissolved Solids	
	Total Organic Carbon	

The Cohen adjustment was used on the boron and carbonate data sets. The statistical parameters, mean, standard deviation variance, and upper prediction limit were calculated from the adjusted data sets.

3.2.3.2 Statistical Relationships

Statistical analysis was used to evaluate if variations in the chemical parameters were related to rainfall or stream gauge measurements and whether the analyses were significantly different between monitoring points. The goals of the statistical analysis were to define when to monitor and where to monitor.

Precipitation and daily stream flow values were plotted over a time scale from October 1993 through September 1997 to evaluate their correlation. The rain events were recorded daily at the Marine Corps Air Station, Camp Pendleton and the flow was from the U.S. Geological Survey gauging station located on the Santa Margarita River near Fallbrook (USGS No.11044330). Figure 14a shows the entire time span and Figures 14b and 14c show expanded portions of the data to provide more details. The Pearson correlation coefficient is 0.665. This is a poor correlation and probably results from several rain events occurring after a dry period and the ground absorbing the water with no runoff to the river. Figures 14b and 14c show periods when the stream flow peaks prior to the peak in precipitation (for example on 3/25/98 and 5/5/98). This anomaly is probably due to the timing of flow measurements taken relative to the rain event and the fast surface drainage from the watershed. Figure 14b also shows at least four increases in flow during a period with no recorded rain events (6/23/98, 7/1/98, 7/5/98, and 7/11/98), indicating non-weather related releases occurred upstream. Because of the poor correlation to rainfall and the fact that discharges other than from rainfall are randomly occurring, the frequency of monitoring cannot be limited to just certain portions of the year.

Gauging station measurements were plotted over time from 1997 through 1999 to evaluate if chemical concentrations correlated with stream gauge measurements. Evaluation by previous authors suggested some seasonal cyclic variations in TDS; however, plots (included in Appendix E) of stream flow and TDS for each monitoring location do not show a consistent correlation for all monitoring stations. Therefore, statistically there is no correlation.

Analysis of variance (ANOVA) least squares means was used to evaluate if there was a statistical difference between the monitoring stations for those chemical parameters that had a normal

distribution, had established water quality goals, and suggested by other methods to have a statistical difference. The ANOVA set the baseline conditions for the watershed for comparison of future results. The plots for bicarbonate, calcium, chloride, conductance, fluoride, iron, manganese, nitrate, pH, sulfate, sodium, and TDS are in Appendix G. These plots show significant differences between monitoring well MW-1 (Station 101) and surface water in the Santa Margarita River near Fallbrook (Station 501) for chloride, fluoride, iron, manganese, and sulfate. Also statistically different water quality was observed between monitoring well MW-2 (Station 102) and surface water in De Luz Creek near Fallbrook (Station 506) for iron, nitrate, manganese, and sulfate. There is possibly a significant difference for TDS; however, the specific conductance, which directly relates to TDS does not show a difference. Monitoring locations on Murrieta Creek near Temecula (Station 505) and the Santa Margarita River near Temecula (Station 504) displayed no significant differences, except for calcium. Monitoring locations on De Luz Creek (Station 506), Fallbrook Creek (Station 507), Santa Margarita River near Fallbrook (Station 501), and the Santa Margarita River at Ysidora (Station 508) displayed no significant differences. The nonparametric constituents had too few data points for statistical calculations.

3.2.3.3 Upper Prediction Limits

Upper prediction limits (UPLs) were statistically calculated for 31 chemical parameters contained within the chemical database. UPLs were not calculated for total or fecal coliform because results for those parameters are reported by the laboratory as a statistical "most probable number" which is a step function. Calculating a UPL from a step function is not appropriate. Exceeding the UPL for a parameter in a future sampling event would indicate that the Santa Margarita River Watershed water quality is degraded compared to the baseline calculated in this report. UPLs from Table 11 are presented below. It should be noted that UPLs for conductance, iron, manganese, sulfate, and TDS exceed MCLs.

Parameter	UPL	Units	Parameter	UPL	Units
Alkalinity	365	mg/L	Lead	0.0075	Mg/L
Arsenic	0.025	mg/L	Magnesium	62	Mg/L
Bicarbonate	362	mg/L	Manganese	0.91*	Mg/L
BOD	2	mg/L	Mercury	0.001	Mg/L
Boron	0.39	mg/L	Nitrate	14	Mg/L
Calcium	132	mg/L	Nitrogen	5	Mg/L

Parameter	UPL	Units	Parameter	UPL	Units
Carbonate	4.6	mg/L	Oil & Grease	1	Mg/L
Chloride	230	mg/L	pH	8.6	pH
Conductivity	1595**	µmhos/cm	Phosphorus	1.0	Mg/L
Copper	0.5	mg/L	Potassium	9.1	Mg/L
Cyanide	0.1	mg/L	Sodium	144	Mg/L
Fluoride	0.99	mg/L	Sulfate	343**	Mg/L
Hardness	597	mg/L	Surfactants	0.25	Mg/L
Hydroxide	0.5	mg/L	TDS	1027**	Mg/L
Iron	17*	mg/L	TOC	22	Mg/L
			Zinc	2.5	Mg/L

- Exceeds MCL

** - Exceeds Recommended MCL

4.0 WATERSHED MONITORING PROGRAM

The Watershed Monitoring Program (WMP) is designed to monitor the surface water sources that recharge the groundwater used by MCB Camp Pendleton. It is based on information presented in the preceding sections of this report. The purpose of the WMP is to indicate to the Base when a water quality parameter exceeds an upper prediction limit (UPL), indicating that the water quality has degraded below the baseline conditions and that action should be taken to identify and mitigate the source of the problem. This WMP is for portions of the San Mateo and Santa Margarita River Watersheds located on or adjacent to MCB Camp Pendleton.

4.1 MONITORING STATION LOCATIONS

We recommend that ten surface water sampling stations and three groundwater sampling stations be utilized. In the San Mateo Watershed, three surface water locations and one groundwater location should be sampled. In the Santa Margarita River Watershed, seven surface water and two groundwater locations should be sampled. Based on the statistical analyses discussed in Section 3 of this report, one surface water sampling location has been removed from the locations sampled during the 1997-1999 program. Station 508, Santa Margarita River at Ysidora, was removed because its water quality is the same as that of Station 501, Santa Margarita River near Fallbrook. Justification for selecting the surface water and groundwater sampling locations for each watershed is presented in the following subsections.

4.1.1 San Mateo Watershed

The results of the trend analysis, Piper diagrams and statistical analysis were used to decide which monitoring stations in the San Mateo Watershed are representative of the water quality.

The trend analyses showed most parameters were either flat lying or are currently decreasing. There were no increasing trends in this watershed. There were recognizable differences in quality between surface water stations and also between surface water and groundwater. Water quality differences were observed for:

- Arsenic historically has been detected at San Mateo Creek at San Clemente (Station 510), and San Mateo Creek at San Onofre (Station 511), but not at Cristianitos Creek near San Clemente (Station 509). Since 1997 arsenic was not detected in any surface water stations but was detected in the groundwater monitoring well MW-3 (Station 103).
- Phosphate historically has had higher concentrations in San Mateo Creek at San Clemente (Station 510) and San Mateo Creek at San Onofre (Station 511) than at Cristianitos Creek near San Clemente (Station 509). Phosphate is currently higher in groundwater, MW-3 (Station 103) than at any surface water station monitored in this watershed.

The review of the trend analyses also showed that the MCL has been exceeded at least once since 1997 for:

- TDS and specific conductance at Cristianitos Creek near San Clemente (Station 509) and San Mateo Creek at San Onofre (Station 511);
- Nitrate at San Mateo Creek at San Onofre (Station 511);
- Manganese and iron at Cristianitos Creek near San Clemente (Station 509) and San Mateo Creek at San Onofre (Station 511);
- Fecal coliform at Cristianitos Creek near San Clemente (Station 509) and San Mateo Creek at San Clemente (Station 510);
- Lead in groundwater at MW-3 (Station 103).

The Piper diagrams showed:

- The water in Cristianitos Creek near San Clemente (Station 509) is a calcium chloride water and the water in San Mateo Creek at San Clemente (Station 510) is calcium bicarbonate.
- Water in San Mateo Creek at San Onofre (Station 511) is a mixture of water from these creeks, but at times is affected by activities that occur downstream from Stations 509 and 510.
- Groundwater quality in MW-3 (Station 103) is different than surface water quality at Station 509, Cristianitos Creek near San Clemente.

The results of the statistical analysis showed:

- The statistical analysis for variance using the least square means method confirmed that there is a statistical difference in water quality between Cristianitos Creek near San Clemente (Station 509) and San Mateo Creek at San Clemente (Station 510).
- There is a statistical difference in the water quality at San Mateo Creek at San Onofre (Station 511) compared to Cristianitos Creek near San Clemente (Station 509) and San Mateo Creek at San Clemente (Station 510) for fluoride and nitrate.
- There is a statistical difference in water quality between groundwater at MW-3 in Cristianitos Creek (Station 103) and surface water at Cristianitos Creek near San Clemente (Station 509), as indicated by iron, magnesium, manganese, and pH concentrations.
- Water at San Mateo Creek at San Onofre (Station 511), being a mixture of Stations 509 and 510, usually is not statistically different.

The recommended surface water sampling stations in the San Mateo Watershed are based on the trend analysis, Piper diagrams and the statistical analysis. The statistical analysis detected significant differences between Cristianitos Creek near San Clemente (Station 509); San Mateo

Creek at San Clemente (Station 510) and MW-3 (Station 103). The Piper diagrams also showed a similar relation as indicated by the statistical analyses but also showed water at San Mateo Creek at San Onofre (Station 511) is being locally affected by agricultural sources. Evaluation of the trend graphs and the data show that current MCLs are at times exceeding drinking water standards for fecal coliform, lead, iron, manganese, nitrate (as nitrogen), specific conductance, and TDS at different locations throughout the watershed at the different stations. It also showed a difference between arsenic and phosphate.

Based on these results, the recommended surface water monitoring stations in the San Mateo Watershed are Cristianitos Creek near San Clemente (Station 509), San Mateo Creek at San Clemente (Station 510) and San Mateo Creek at San Onofre (Station 511). We also recommend sampling groundwater at MW-3, the Cristianitos Creek well (Station 103).

4.1.2 Santa Margarita River Watershed

The results of the trend analysis, Piper diagrams and statistical analysis were used to decide which monitoring stations in the Santa Margarita Watershed are representative of the water quality.

The trend analyses showed recognizable differences in quality between surface water stations and also between surface water and groundwater. Historical water quality trends were observed at:

- Sandia (Station 502) and De Luz (Station 506) Creeks where sodium, chloride, sulfate, and nitrate are increasing;
- Rainbow Creek (Station 503) and Fallbrook Creek (Station 507) where bicarbonate are increasing;
- Temecula (Station 504) and Murrieta (Station 505) Creeks, where phosphate is currently increasing;
- Temecula (Station 504) and Murrieta (Station 505) Creeks, where TDS and specific conductance have increased in the past; and
- Rainbow Creek (Station 503), where nitrate was increasing but has since declined.

The review of the trend analyses data also showed that the MCL is currently being exceeded for:

- Nitrate at Rainbow Creek (Station 503);
- Sulfate, iron, manganese, TDS and specific conductance at all surface water monitoring stations; and
- Chloride at Sandia Creek (Station 502).

The Piper diagrams showed that:

- Similar water quality (calcium chloride in nature) was observed at the Santa Margarita River near Fallbrook (Station 501) and at the Santa Margarita River at Ysidora (Station 508). Water quality at Station 508 is affected by water quality discharging from Fallbrook Creek (Station 507) and when water is released from Lake O'Neill. Station 507 has sodium chloride water.
- Water quality from De Luz Creek near Fallbrook (Station 506), which joins the Santa Margarita River between Stations 501 and 508, has similar water quality to Station 508.
- The Santa Margarita River near Fallbrook (Station 501) is a mixture of water from Sandia Creek near Fallbrook (Station 502), Rainbow Creek near Fallbrook (Station 503), Murrieta Creek near Temecula (Station 505), and from Temecula Creek. The water from these creeks has different water quality ranging from calcium chloride to sodium chloride water. The water in the Santa Margarita River near Fallbrook at Station 501 is strongly influenced by Sandia Creek (Station 502).
- Groundwater at MW-1 (Station 101) is different than surface water in the Santa Margarita River at nearby surface water sampling Station 501. The water in the monitoring well is calcium bicarbonate and the surface water is calcium chloride. The river has only minor influence on the groundwater quality.
- Groundwater in MW-2 (Station 102) is similar to that in De Luz Creek as observed at nearby surface water sampling Station 506. However, when surface and groundwater sampling times were separated by several days, the water quality was different.

The results of the statistical analysis showed there were statistically significant differences in water quality at the following locations:

- Between monitoring well MW-1 (Station 101) and surface water in the Santa Margarita River near Fallbrook (Station 501) for bicarbonate, chloride, fluoride, iron, manganese, sodium, and sulfate.

- Between monitoring well MW-2 (Station 102) and surface water in De Luz Creek near Fallbrook (Station 506) for iron, nitrate, manganese, and sulfate. There is possibly a significant difference for TDS; however, specific conductance, which is a parameter with a direct relationship to TDS, does not correlate.
- Monitoring locations on Murrieta Creek near Temecula (Station 505) and the Santa Margarita River near Temecula (Station 504) displayed no significant differences except for calcium.
- Rainbow Creek near Fallbrook (Station 503) showed a significant difference for phosphate compared to the rest of the monitoring stations.
- Monitoring well MW-1 (Station 101) showed a statistical difference for sodium compared to the rest of the monitoring stations.
- Sandia Creek near Fallbrook (Station 502) and MW-1 (Station 101) showed a significant difference for chloride compared to the rest of the stations.
- Fallbrook Creek near Fallbrook (Station 507) and MW-1 (Station 101) showed a significant difference for bicarbonate compared to the rest of the stations.
- De Luz Creek near Fallbrook (Station 506), Fallbrook Creek near Fallbrook (Station 507), the Santa Margarita River near Fallbrook (Station 501), and the Santa Margarita River at Ysidora (Station 508) displayed no significant differences.

The recommended surface water sampling stations in the Santa Margarita River Watershed are based on the trend analysis, Piper diagrams and the statistical analysis. The statistical analysis detected significant differences in the surface water quality for bicarbonate, calcium, chloride, sodium, and phosphate. The Piper diagrams also showed that water quality was different within the Santa Margarita River and its tributaries for bicarbonate, calcium, chloride, and sodium. Evaluation of the trend graphs and the data show that current concentrations are at times exceeding drinking water standards for chloride, specific conductance, iron, manganese, nitrate (as nitrogen), sulfate, and TDS at different locations throughout the watershed.

Because some of these parameters exceed the MCLs and there are statistical differences in water quality at all monitoring stations; all stations except one should be included in future monitoring efforts. However, as shown by both the Piper diagrams and statistical analysis, water quality at Stations 501 and 508, Santa Margarita River near Fallbrook and Santa Margarita River at Ysidora, respectively, is nearly identical. There was only one time when parameter concentrations at Station 508 differed from Station 501, and it was probably due to an influence from Fallbrook Creek

(Station 507). Because of the similarity of water quality and the fact that Station 507 is being monitored, we recommend that Station 508, Santa Margarita River at Ysidora, be deleted from the WMP. This approach will still enable tracking of increasing trends for sodium, chloride, and sulfate on Sandia Creek near Fallbrook (Station 502) and De Luz Creek near Fallbrook (Station 506). Weak trends are also present for nitrate on both of these watersheds.

We also recommend sampling groundwater at MW-1, the Santa Margarita River at De Luz Road well (Station 101), and MW-2, the De Luz Creek well (Station 102). At times, these monitoring stations have different water quality than in nearby surface water stations. Interpretation of both Piper diagrams and statistical analysis results substantiated the difference in water quality. The locations of these wells, adjacent to important surface waterways near the Base boundaries, are ideal for the proposed monitoring.

4.2 MONITORING FREQUENCY

Based on the results of this study, we recommend quarterly monitoring of the surface water and groundwater quality. Attempts to correlate the water quality to rainfall and stream gauge measurements did not produce a high enough confidence level to reduce the monitoring frequency to specific times of the year, such as during the spring, summer, and fall. Discharges occur within both watersheds that cannot be predicted; therefore, we recommend quarterly sampling.

4.3 ANALYTICAL PARAMETERS

Based upon the results of our analysis, the following analytical parameters should be analyzed for stations in the San Mateo and Santa Margarita River Watersheds: arsenic, bicarbonate, calcium, chloride, sodium, specific conductance, fecal coliform, fluoride, lead, iron, manganese, methyl tert-butyl ether (MTBE), nitrate, phosphate, sodium, specific conductance, sulfate, surfactants (MBAS), thallium, and total dissolved solids (TDS). Table 12 lists the analytical parameters, along with the EPA methods, detection limits, and general QA/QC requirements.

Because many of the parameters are components of a general mineral analysis, it will be more cost-effective to specify the general mineral analysis rather than request selected parameters. The general mineral analysis can vary from laboratory to laboratory, but typically includes the following:

Bicarbonate	Sulfate
Carbonate	Surfactants (MBAS)
Hydroxide	Total Dissolved Solids (TDS)
Alkalinity (as CaCO ₃)	Aluminum
Chloride	Calcium
Conductivity	Copper
Fluoride	Iron
Hardness	Magnesium
Nitrate (as Nitrogen)	Manganese
pH	Potassium
Sodium	Zinc

The following subsections provide the justification for selection of the monitoring parameters.

4.3.1 San Mateo Watershed

The analytical parameters selected for monitoring in the San Mateo Watershed were selected for at least one of the following reasons:

- Concentrations have historically exceeded the MCL for drinking water;
- Concentrations have exceeded the MCL for drinking water at least once since monitoring resumed in 1997;
- It is considered an important indicator of water quality; or
- It can indicate an upstream contaminant release.

The trend analysis indicated MCLs were exceeded in the historical record for:

- Nitrate, TDS, sulfate, manganese, iron, and specific conductance at Cristianitos Creek near San Clemente, San Mateo Creek at San Clemente, and San Mateo Creek at San Onofre (Stations 509, 510, and 511);

- Chloride and copper at Cristianitos Creek near San Clemente (Station 509);
- Fluoride at Cristianitos Creek near San Clemente (Station 509) and San Mateo Creek at San Clemente (Station 510);
- MBAS and lead at San Mateo Creek at San Onofre (Station 511); and
- Arsenic at San Mateo Creek at San Clemente (Station 510) and at San Mateo Creek at San Onofre (Station 511).

The analytical data collected since 1997 show MCLs were exceeded at least once for:

- TDS and specific conductance at Cristianitos Creek near San Clemente (Station 509) and at San Mateo Creek at San Onofre (Station 511);
- Nitrate at San Mateo Creek at San Onofre (Station 511);
- Manganese at Cristianitos Creek near San Clemente (Station 509);
- Iron at Cristianitos Creek near San Clemente (Station 509), San Mateo Creek at San Clemente (Station 510), and San Mateo Creek at San Onofre (Station 511);
- Fecal coliform at Cristianitos Creek near San Clemente (Station 509) and San Mateo Creek at San Clemente (Station 510); and
- Lead in groundwater at MW-3 (Station 103).

Trend analysis, Piper diagrams, and statistical analysis showed differences in water quality exist in the watershed. The differences in water quality are most noticeable for arsenic, phosphate, chloride, bicarbonate, calcium, bicarbonate, sodium, specific conductance, fluoride, TDS, and sulfate.

MTBE has typically not been analyzed in surface water collected from the San Mateo Watershed. It is highly soluble in water and would be detected before other constituents of gasoline. Although it is presently considered an "unregulated chemical," we included MTBE because it is a growing concern in surface water and groundwater quality. DHS plans to propose a primary drinking water standard for MTBE in the near future. The continued use of this compound in gasoline is being debated. Based on its doubtful future use in gasoline this monitoring parameter should only be evaluated annually to determine if monitoring is still warranted.

Based upon the results of this study, the following parameters should be monitored in the San Mateo Watershed: arsenic, bicarbonate, calcium, chloride, sodium, specific conductance, fecal coliform, fluoride, lead, iron, manganese, methyl tert-butyl ether (), nitrate, phosphate, sodium, specific conductance, sulfate, surfactants (MBAS), thallium, and total dissolved solids (TDS).

We do not recommend monitoring for the following parameters that were monitored during 1997-1999: boron, cyanide, mercury, oil and grease, biochemical oxygen demand (BOD), and total organic carbon (TOC). These parameters were excluded for one of the following reasons:

- It has no MCL for drinking water; and
- It was consistently not detected or detected at such low levels that it does not appear to be a significant concern.

Volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), and radiological constituents are all regulated. These chemicals have apparently not been tested in surface water in the San Mateo Watershed. VOCs are unlikely to be present due to their high volatility and the fact that natural streams aerate the water. Naturally occurring organic carbon in the water and plant life tend to absorb SVOCs. We do not recommend including these parameters for routine watershed monitoring. Radiological parameters are also not recommended for monitoring due to their unlikely occurrence.

4.3.2 Santa Margarita River Watershed

The analytical parameters selected for monitoring in the Santa Margarita River Watershed were selected for at least one of the following reasons:

- Concentrations have historically exceeded the MCL for drinking water;
- Concentrations have exceeded the MCL for drinking water at least once since sampling resumed in 1997;
- It is considered an important indicator of water quality; or
- It can indicate an upstream contaminant release.

Historical water quality trends were observed at:

- Sandia Creek (Stations 502), where, chloride (from 1981 to 1991), sodium, and sulfate are increasing;
- De Luz Creek (Station 506), where sodium,(from 1979 to 1989), chloride, and sulfate are increasing;
-
- Rainbow Creek (Stations 503), where bicarbonate after 1987 is increasing;
- Fallbrook Creek (Stations 503), where sodium (from 1983 to 1987) and bicarbonate (from 1973 to 1987) are increasing;
- Murrieta Creek near Temecula (Station 505), where TDS and specific conductance have increased in the past; and
- Rainbow Creek near Fallbrook (Station 503) where nitrate was increasing but has since declined.

Historically, the following parameters have exceeded the MCL at least once:

- MBAS at Rainbow Creek near Fallbrook (Station 503);
- Nitrate at Santa Margarita River near Fallbrook (Station 501), Sandia Creek near Fallbrook (Station 502), Rainbow Creek near Fallbrook (Station 503), Murrieta Creek at Temecula (Station 505), De Luz Creek near Fallbrook (Station 506), Fallbrook Creek near Fallbrook (Station 507), and the Santa Margarita River at Ysidora (Station 508);
- Sulfate in groundwater at DeLuz Creek near Fallbrook (Station 506), Santa Margarita River near Fallbrook (Station 501), Sandia Creek near Fallbrook (Station 502), Rainbow Creek near Fallbrook (Station 503), Murrieta Creek near Temecula (Station 505), and Fallbrook Creek near Fallbrook (Station 507);
- Manganese at Fallbrook Creek near Fallbrook (Station 507), De Luz Creek near Fallbrook (Station 506), and Rainbow Creek near Fallbrook (Station 503);
- Chloride at Murrieta Creek at Temecula (Station 505), Fallbrook Creek near Fallbrook (Station 507), and DeLuz Creek near Fallbrook (Station 506);
- Conductivity, TDS, and iron at all stations;

- Fluoride at the Santa Margarita River near Fallbrook (Station 501), Rainbow Creek, the Santa Margarita River near Temecula, Murrieta Creek, De Luz Creek, and Fallbrook Creek near Fallbrook;
- Arsenic at the Santa Margarita River near Fallbrook (Station 501), Rainbow Creek near Fallbrook (Station 503), De Luz near Fallbrook (Station 506);
- Fecal coliform at the Santa Margarita River near Temecula (Station 501), Sandia Creek near Fallbrook (Station 502), Rainbow Creek near Fallbrook (Station 503), Santa Margarita River near Temecula (Station 504), Murrieta Creek near Temecula (Station 505), De Luz Creek near Fallbrook (Station 506), Fallbrook Creek near Fallbrook (Station 507), and the Santa Margarita River at Ysidora (Station 508);
- Lead at the Santa Margarita River near Fallbrook (Station 501), Murrieta Creek near Temecula (Station 505), De Luz Creek near Fallbrook (Station 506), and Fallbrook Creek near Fallbrook (Station 507).
- Thallium at the Santa Margarita River near Fallbrook and Temecula (Stations 501 and 504).

Review of the trend analyses data also showed that the MCL is currently being exceeded for:

- Nitrate at Rainbow Creek near Fallbrook (Station 503);
- Sulfate, iron, manganese, TDS and specific conductance at all surface water monitoring stations;
- Chloride at Sandia Creek near Fallbrook (Station 502);
- Lead at Rainbow Creek near Fallbrook (Station 503), the Santa Margarita River near Temecula (Station 504), De Luz Creek near Fallbrook (Station 506), Fallbrook Creek near Fallbrook (Station 507), and in both MW-1 and MW-2 (Stations 101 and 102); and
- Nitrate in groundwater at MW-2, the De Luz Creek well (Station 102).

Trend analysis, Piper diagrams, and statistical analysis show differences in water quality within the watershed. Arsenic, chloride, bicarbonate, sodium, calcium, and phosphate concentrations vary among sampling locations.

MTBE has typically not been analyzed in surface water collected from the Santa Margarita River Watershed. In comparison to BTEX, MTBE is more soluble in water, is not significantly affected by adsorption or biodegradation, and does not readily volatilize once in contact with water. Because of these characteristics MTBE would be detected before other gasoline parameters. In 1992, gasoline constituents were detected in the Santa Margarita River, apparently as a result of contaminated groundwater seeping into Murrieta Creek. Although it is presently considered an "unregulated chemical," we included MTBE because it is a growing concern in surface water and groundwater quality and components of gasoline have been detected in the past. DHS plans to propose a primary drinking water standard for MTBE in the near future. The continued use of this compound in gasoline is being debated. Based on its doubtful future use in gasoline, it should only be evaluated annually to determine if monitoring is still warranted.

As mentioned previously, components of gasoline (benzene, toluene, total xylenes, and ethylbenzene [BTXE]) were detected in the Santa Margarita River in 1992. Because MTBE analysis is being recommended, and it is more soluble than BTEX compounds, BTXE is not recommended as a routine monitoring parameter. Should MTBE be detected, confirmation sampling should include an analysis for BTEX as described in Section 4.7.

Based upon the results of this study, the following parameters should be monitored in the Santa Margarita River Watershed: arsenic, bicarbonate, calcium, chloride, sodium, specific conductance, fecal coliform, fluoride, lead, iron, manganese, methyl tert-butyl ether (MTBE), nitrate, phosphate, sodium, specific conductance, sulfate, surfactants (MBAS), thallium, and total dissolved solids (TDS).

We do not recommend monitoring for the following parameters that were monitored during 1997-1999: boron, cyanide, mercury, oil and grease, biochemical oxygen demand (BOD), and total organic carbon (TOC). These parameters were excluded for one of the following reasons:

- It has no MCL for drinking water; or
- It was consistently not detected or detected at such low levels that it does not appear to be a significant concern.

Volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), and radiological constituents are all regulated. These chemicals, except for radiological constituents were tested in 1991 and 1992 for surface water in the Santa Margarita River Watershed. Other than for low levels of a few unregulated chemicals, and some BTXE chemicals associated with gasoline contaminated groundwater discharge, VOCs and SVOCs were not found. This is expected as volatile organic compounds are unlikely to be present due to their high volatility and the fact that natural streams aerate the water. Naturally occurring organic carbon in the water and plant life tend to absorb SVOCs, herbicides, and pesticides. We do not recommend including these parameters for routine watershed monitoring. Radiological constituents, which have been detected at concentrations that were below MCLs in water supply wells within the watershed, are not recommended for routine monitoring.

4.4 MONITORING TECHNIQUES

Monitoring proposed for the WMP includes sampling of groundwater and surface water. The groundwater sampling should be performed in accordance with the current County of San Diego Site Assessment and Mitigation Manual guidelines (the SAM Manual). The SAM Manual describes well purging and sampling procedures for fast and slow recharging wells. The three groundwater monitoring wells installed by LAW are fast recharging wells, meaning each well recovers to 80 % or more of its static condition within two hours after purging.

Groundwater samples should be collected in disposable decontaminated bailers after purging. The bailer is lowered into the well and allowed to fill. The contents of the bailer are used to fill each sample container. The water in the bailer should be poured directly into laboratory-prepared bottles, which are then capped. Appendix H lists the sizes and types of bottles, along with preservatives that should be in the bottles. Care should be taken to avoid personal contact with the sampled water, even when wearing protective gloves, as such contact may affect certain analyses.

When sampling surface water, the sample should be collected from an area exhibiting cross-sectional homogeneity, not where the channel is constricted. The sampler should enter the stream or creek downstream of the sample location and proceed upstream to the sample location. The sampler

should face the upstream direction to collect the sample and the sample should be collected directly into the sample containers from the top six inches of flow. The container should be capped immediately after it is filled. As with the ground water sampling, care should be taken to avoid personal contact with the sampled water, even when wearing protective gloves, as such contact may affect certain analyses. Collection of floating debris, such as leaves, should be avoided. The samples for metals should be collected in laboratory-prepared bottles that do not contain preservatives. Appendix H lists the types and sizes of bottles to be used. The laboratory should be instructed to filter the samples before preserving to eliminate detections caused by particulate matter and sediments.

A numerical scheme for identifying the discrete location and time frame in which a particular sample was collected and was developed for this project and should be used in the future when collecting samples. Each sample should be assigned a six digit numerical code. The first digit will be either a 1 (for a monitoring well) or a 5 (for a surface water location). The next two digits will identify the station location number, which will range from 01 to 03 for monitoring wells and from 01 to 11 for surface water locations (Table 7). The final three digits identified will be the sampling event number, which for this project ranged to begin at 008 and continue consecutively.

The water samples should be collected in appropriate sample containers. After being filled, the sample container should be placed in a clean, insulated cooler chest containing ice to keep the temperature at 4 ± 2 C during transfer to a California-certified laboratory. All sampling and sample handling should be performed under chain-of-custody protocol.

Water samples collected from the monitoring wells and the surface water locations should be analyzed for those parameters identified in Section 4.3.

4.5 QUALITY ASSURANCE/QUALITY CONTROL

Quality Assurance/Quality Control is an essential element of the sampling program. The goal is to provide that sampling and analytical data collected and reported are scientifically valid, verifiable, and consistent.

Chain-of-custody forms are contained in Appendix H.

A Data Quality Assessment (DQA) will be performed after analytical data has been collected and analyzed. A DQA assists in evaluating whether analytical procedures, sampling procedures, and field measurements meet the project objectives and represent actual field conditions. The DQA will consist of calculating precision and accuracy.

4.6 DATA MANAGEMENT

Analytical data from the WMP should be incorporated into the database compiled for MCB Camp Pendleton during this study. A copy of that database on compact disc is included in Appendix D. This will facilitate use of the new and existing data by subsequent users. The database, which is in Microsoft Access, can be used for data analysis such as data plots of trends or statistical comparison between multiple sampling locations.

We recommend that the analytical data generated from each monitoring event be reported in both written and electronic formats to MCB Camp Pendleton's Office of Water Resources. Results of each monitoring event should be evaluated to identify UPL and MCL exceedances. This degree of awareness and review will maximize protection of MCB Camp Pendleton's groundwater supply.

4.7 UPPER PREDICTION LIMITS

This study developed upper prediction limits (UPLs) for target parameters proposed for monitoring in both the San Mateo and Santa Margarita River Watersheds. The UPLs developed by LAW in this study are presented below. They are intended to represent threshold levels that, if exceeded, would indicate a change from baseline conditions and a potential impact to MCB Camp Pendleton's drinking water supply. The UPLs were also set with the intention that they could provide an "early warning" of changed, and potentially adverse, water quality conditions before the Base drinking water supply was put at risk.

SAN MATEO WATERSHED UPLs					
Parameter	UPL	Units	Parameter	UPL	Units

SAN MATEO WATERSHED UPLs					
Parameter	UPL	Units	Parameter	UPL	Units
Alkalinity	223	mg/L	Lead	0.0075	mg/L
Arsenic	0.025	mg/L	Magnesium	39	mg/L
Bicarbonate	220	mg/L	Manganese*	1.7	mg/L
BOD	2	mg/L	Mercury	0.001	mg/L
Boron	0.5	mg/L	Nitrate	23	mg/L
Calcium	116	mg/L	Nitrogen	5	mg/L
Carbonate	5.5	mg/L	Oil & Grease	1	mg/L
Chloride	151	mg/L	pH	9	pH
Conductivity	1244*	µmhos/cm	Phosphorus	0.4	mg/L
Copper	0.5	mg/L	Potassium	5.0	mg/L
Cyanide	0.1	mg/L	Sodium	116	mg/L
Fluoride	0.5	mg/L	Sulfate	230	mg/L
Hardness	434	mg/L	Surfactants	0.25	mg/L
Hydroxide	0.5	mg/L	TDS*	778	mg/L
Iron	23*	mg/L	TOC	7.4	mg/L
			Zinc	2.5	mg/L

* - Exceeds MCL.

SANTA MARGARIATA WATERSHED UPLs					
Parameter	UPL	Units	Parameter	UPL	Units
Alkalinity	365	mg/L	Lead	0.0075	mg/L
Arsenic	0.025	mg/L	Magnesium	62	mg/L
Bicarbonate	362	mg/L	Manganese	0.91*	mg/L
BOD	2	mg/L	Mercury	0.001	mg/L
Boron	0.39	mg/L	Nitrate	14	mg/L
Calcium	132	mg/L	Nitrogen	5	mg/L
Carbonate	4.6	mg/L	Oil & Grease	1	mg/L
Chloride	230	mg/L	pH	8.6	pH
Conductivity	1595*	µmhos/cm	Phosphorus	1.0	mg/L
Copper	0.5	mg/L	Potassium	9.1	mg/L
Cyanide	0.1	mg/L	Sodium	144	mg/L
Fluoride	0.99	mg/L	Sulfate	343*	mg/L
Hardness	597	mg/L	Surfactants	0.25	mg/L
Hydroxide	0.5	mg/L	TDS	1027*	mg/L
Iron	17*	mg/L	TOC	22	mg/L
			Zinc	2.5	mg/L

* - Exceeds MCL.

The UPLs were established based on analytical results for samples collected since 1997, when monitoring resumed. Most UPLs are below established MCLs or recommended levels for drinking water. However, UPLs for both watersheds are greater than MCLs or recommended levels for iron, manganese, total dissolved solids, and specific conductance.

4.8 ADDITIONAL INVESTIGATION

After a monitoring event is completed and the laboratory analytical results are received, the data should be reviewed for UPL exceedances. If a UPL for a given parameter is exceeded, the following investigative steps should be taken.

The affected sampling location should be re-sampled as soon as practical and the sample analyzed for the parameter exceeded. If the second sample also exceeds the UPL, a preliminary investigation should be initiated as described below. If necessary, the monitoring frequency for the parameter that exceeded the UPL should be increased (up to weekly).

The investigation should also include upstream sampling and observation of the drainage area to determine the source or potential cause of the parameter exceedance. Depending upon the source and type of contaminant detected, it may be advisable to report the findings to the RWQCB and to discuss the issue with local agencies and interested parties, including the Santa Margarita River Watershed Committee. If MTBE concentrations are detected that exceed the UPL, MCL, or San Diego Basin Objectives, the findings should be reported to the RWQCB and testing initiated for benzene, toluene, total xylenes, and ethylbenzene (BTXE).

The WMP approach and monitoring parameters should be re-evaluated about every three years, but no less frequently than every five years. Upper prediction limits (UPLS) according to statistical convention should be re-calculated after every monitoring event to keep them current. However, since this monitoring is not part of a regulatory mandated program, which would require re-

calculation after every monitoring event, it is our opinion the UPLs could be re-calculated annually to reduce costs.

5.0 CONCLUSIONS AND RECOMMENDATIONS

The results of this evaluation indicate that statistically significant differences in water quality exist within the San Mateo and Santa Margarita River Watersheds. After proving that different water quality exists through trend analysis, Piper diagrams, and statistical methods, the baseline water quality data were used to develop upper prediction limits (UPLs) to indicate when MCB Camp Pendleton should take action to protect their groundwater supplies. Overall, the water quality is improving for many of the water quality parameters in the watersheds but there are several parameters that are exceeding MCLs or are showing trends of increasing concentrations.

Significant findings for the San Mateo Watershed include a statistical difference in water quality between San Mateo Creek at San Clemente (Station 510) and Cristianitos Creek near San Clemente (Station 509). Water at San Mateo Creek at San Onofre (Station 511) which is a mixture from Stations 509 and 510, shows an influence from local activities as indicated by changes in sodium and nitrate concentrations. Nitrate at Station 511 has exceeded drinking water MCLs at least once since 1997. Water from Cristianitos Creek strongly affects the water quality at Station 511. At least once since 1997, the drinking water MCLs were exceeded for specific conductance, TDS, manganese, iron, and fecal coliform. In addition, there is a significant difference in water quality between surface water at Cristianitos Creek near San Clemente (Station 509) and groundwater in MW-3 (Station 103).

Significant findings for the Santa Margarita River Watershed include a statistical difference in water quality between tributaries of the Santa Margarita River. There is also a significant difference in water quality between surface water monitoring stations in comparison to nearby groundwater wells. Water quality is degrading in Sandia and De Luz Creeks from increasing concentrations of sodium, chloride, sulfate, and nitrate as indicated by the generally increasing trends for these parameters. Land use changes in these two tributary areas should be monitored to prevent further degradation of the water quality. Groundwater in MW-2 (Station 102) near De Luz Creek also contained nitrate at concentrations above the MCL. At least once since 1997, the drinking water MCLs were exceeded in all tributaries or in the Santa Margarita River for sulfate, manganese, specific conductance, and TDS. The MCL was also exceeded for nitrate in Rainbow Creek, chloride in Sandia Creek, and iron in De Luz and Sandia Creeks and in the Santa Margarita River near Fallbrook (Station 501). Water

quality in the Santa Margarita River at Fallbrook (Station 501) and at Ysidora (Station 508) is essentially the same. Water at these locations appears to be strongly influenced by water from Sandia Creek.

The WMP developed for MCB Camp Pendleton describes the monitoring system network, identifies chemical parameters for analysis that are indicative of changes in water quality, and specifies the sampling procedures and analytical methods to be used. It also identifies upper prediction limits (UPLs) for chemical parameters to indicate when action is needed to protect the Base's drinking water supply.

We recommend that ten surface water sampling stations and three groundwater sampling stations be utilized. In the San Mateo Watershed, three surface water locations and one groundwater location should be sampled. In the Santa Margarita River Watershed, seven surface water and two groundwater locations should be sampled. Based on the statistical analyses discussed in Section 3 of this report, one surface water sampling location has been removed from the locations sampled during the 1997-1999 program. Santa Margarita River at Ysidora (Station 508) was removed because its water quality is the same as that at Station 501, Santa Margarita River near Fallbrook.

Based on the results of the present studies, we recommend that monitoring of selected surface water and groundwater quality sampling locations should be conducted quarterly.

For each sampling location in the San Mateo and Santa Margarita River Watersheds, we recommend the following analytical parameters be monitored: arsenic, phosphate, chloride, bicarbonate, sodium, calcium, specific conductance, fecal coliform, fluoride, lead, iron, manganese, surfactants (MBAS); thallium, methyl tert-butyl ether (MTBE), nitrate, total dissolved solids (TDS), and sulfate. These parameters were selected for at least one of the following reasons: 1) because they have maximum contaminant levels for drinking water; 2) they have historically exceeded MCLs; 3) they have exceeded the MCL at least once since 1997; 4) they are considered important indicators of water quality; and 5) they can give important indications of upstream contaminant release.

Analytical data gathered from implementation of the WMP should be incorporated into the database compiled for LAW's water quality studies for MCB Camp Pendleton during 1997-1999. A CD with

the database is included in Appendix D of this report. The database will facilitate use of the new and existing data by subsequent users. The database is in Microsoft Access and is sufficiently versatile to allow graphical and statistical data analysis.

We recommend that after each monitoring event, the analytical data be evaluated to identify UPL and MCL exceedances. The data should be reported in written and electronic formats to MCB Camp Pendleton's Office of Water Resources. If a UPL for a given parameter is exceeded during a sampling event, additional investigation should be conducted. The affected sampling location should be re-sampled and analyzed for the exceeded parameter as soon as practical. If the second sample also exceeds the UPL, continued monitoring at increasing frequencies (up to weekly) should be conducted, and an investigation undertaken that includes upstream sampling and observations to determine the source of the exceedance. Detection of MTBE concentrations that exceeded the UPL, MCL, or San Diego Basin Plan Objectives should be reported to the RWQCB. It also may be advisable to discuss the findings with local regulatory agencies.

Some of the UPLs established exceed MCLs or recommended levels for drinking water. The UPLs are based on a statistical comparison of water quality data obtained since 1997. Because the UPLs are greater than the MCLs or recommended level, it indicates that water quality in both the watersheds have repeatedly exceeded MCLs or recommended levels for iron, manganese, total dissolved solids, and specific conductance. We recommend that an investigation be undertaken that includes upstream sampling and observation to determine the type of activity that may be creating the exceedance. Once identified discussions local agencies and interested parties, including the Santa Margarita River Watershed Committee, which could potentially lead to modification of practices to reduce or eliminate the source.

The WMP approach and monitoring parameters should be re-evaluated about every three years, and no less frequently than every five years. Upper prediction limits (UPLs), according to statistical convention, should be re-calculated after every monitoring event to maintain their currency. However, since this monitoring is not part of a regulatory mandated program, which would require re-calculation after each monitoring event, it is our opinion the UPLs could be re-calculated annually to reduce costs.

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TABLE 1
MAXIMUM CONTAMINANT LEVELS FOR VOLATILE ORGANIC CHEMICALS

Chemical	MCL (mg/L)*
Benzene	0.001
Carbon Tetrachloride	0.0005
1,2-Dichlorobenzene	0.600
1,4-Dichlorobenzene	0.005
1,1-Dichloroethane	0.005
1,2-Dichloroethane	0.0005
1,1-Dichloroethylene	0.006
cis-1,2-Dichloroethylene	0.006
trans-1,2-Dichloroethylene	0.010
Dichloromethane	0.005
1,2-Dichloropropane	0.005
1,3-Dichloropropene	0.0005
Ethylbenzene	0.700
Monochlorobenzene	0.070
Styrene	0.100
1,1,2,2-Tetrachloroethane	0.001
Tetrachloroethylene	0.005
Toluene	0.150
1,2,4-Trichlorobenzene	0.070
1,1,1-Trichloroethane	0.200
1,1,2-Trichloroethane	0.005
Trichloroethylene	0.005
Trichlorofluoromethane	0.150
1,1,2-Trichloro-1,2,2-Trifluoroethane	1.200

Reference:

22 CCR 64444 and 22 CCR 64445.1

Notes:

*Primary MCLs for Drinking Water
MCL - Maximum Contaminant Level
mg/L - Milligrams per liter

TABLE 2
MAXIMUM CONTAMINANT LEVELS FOR NON-VOLATILE SYNTHETIC
ORGANIC CHEMICALS

Chemical	MCL (mg/L)*
Alachlor	0.002
Atrazine	0.003
Bentazon	0.018
Benzo (a) pyrene	0.0002
Carbofuran	0.018
Chlordane	0.0001
2,4-D	0.07
Dalapon	0.2
Dibromochloropropane	0.0002
Di (2-ethylhexyl) adipate	0.4
Di (2-ethylhexyl) phthalate	0.004
Dinoseb	0.007
Diquat	0.02
Endothall	0.1
Endrin	0.002
Ethylene Dibromide	0.0005
Glyphosate	0.7
Heptachlor	0.00001
Heptachlor Epoxide	0.00001
Hexachlorobenzene	0.001
Hexachlorocyclopentadiene	0.05
Lindane	0.0002
Methoxychlor	0.04
Molinate	0.02
Oxamyl	0.2
Pentachlorophenol	0.001
Picloram	0.5
Polychlorinated Biphenyls	0.0005
Simazine	0.004
Thiobencarb	0.07
Toxaphene	0.003
2,3,7,8-TCDD (Dioxin)	3×10^{-8}
2,4,5-TP (Silvex)	0.05

Reference:
 22 CCR 64444 and 22 CCR 64445.1

Notes:
 *Primary MCLs for Drinking Water
 MCL – Maximum Contaminant Level
 mg/L – Milligrams per liter

TABLE 3
MAXIMUM CONTAMINANT LEVELS FOR INORGANIC CHEMICALS

Chemical	MCL (mg/L)*
Aluminum	1.00
Antimony	0.006
Arsenic	0.05
Asbestos	7 MFL
Barium	1.00
Beryllium	0.004
Cadmium	0.005
Chromium	0.05
Cyanide	0.20
Fluoride	2.00
Mercury	0.002
Nickel	0.10
Nitrate (as NO ₃)	45.00
Nitrate + Nitrite (sum as Nitrogen)	10.00
Nitrite (as Nitrogen)	1.00
Selenium	0.50
Thallium	0.002

Reference:
22 CCR 64431 and 22 CCR 64432

Notes:
*Primary MCLs for Drinking Water MFL = million fibers per liter; MCL for fibers exceeding 10 µm in length.
MCL – Maximum Contaminant Level
mg/L – Milligrams per liter

TABLE 4
MAXIMUM CONTAMINANT LEVELS FOR GENERAL
PHYSICAL/MINERAL PARAMETERS

Parameter	MCL*
Aluminum	0.2 mg/L
Copper	1.0 mg/L
Corrosivity	Non-corrosive
Foaming Agents (MBAS)	0.5 mg/L
Iron	0.3 mg/L
Manganese	0.05 mg/L
Odor – Threshold	3 Units
Silver	0.1 mg/L
Thiobencarb	0.001 mg/L
Turbidity	5 Units
Zinc	5.0 mg/L
Specific Conductivity	900 µmhos**
Total Dissolved Solids	500 mg/L**
Chloride	250 mg/L**
Sulfate	250 mg/L**
Bicarbonate	None
Carbonate	None
Hydroxide Alkalinity	None
Calcium	None
Magnesium	None
Sodium	None
Total Hardness	None
MTBE	0.005 mg/L

Reference:
22 CCR 64449

Notes:

*Primary MCLs for Drinking Water, Unless Noted Otherwise

** Secondary Recommended Level for Drinking Water

MBAS – Methylene blue active substance

MCL – Maximum Contaminant Level

MTBE – Methyl tert-Butyl Ether

**TABLE 5
 UNREGULATED ORGANIC CHEMICALS**

Chemical	Synonyms
1,1,1,2-Tetrachloroethane	
1,1-Dichloropropene	
1,2,3-Trichlorobenzene	1,2,3-TCB
1,2,3-Trichloropropane	Allyl Trichloride
1,2,4-Trimethylbenzene	Pseudocumene
1,3,5-Trimethylbenzene	Mesitylene
1,3-Dichlorobenzene	m-Dichlorobenzene
1,3-Dichloropropane	
1-Phenylpropane	n-Propylbenzene
2,2-Dichloropropane	
2-Chlorotoluene	o-Chlorotoluene
3-Hydroxycarbofuran	
4-Chlorotoluene	p-Chlorotoluene
Aldicarb	
Aldicarb Sulfone	
Aldicarb Sulfoxide	
Aldrin	Aldrec, Aldron
Bromacil	HYVAR X, HYVAR XL
Bromobenzene	Monobromobenzene
Bromochloromethane	Chlorobromomethane
Bromodichloromethane	Dichlorobromomethane
Bromoform	Tribromomethane
Bromomethane	Methyl Bromide
Butachlor	Butanex, Lambast, Machete
Carbaryl	Sevin
Chlorodibromomethane	Dibromochloromethane
Chloroethane	Ethyl Chloride
Chloroform	Trichloromethane
Chloromethane	Methyl Chloride
Chlorothalonil	BRAVO
Dibromomethane	Methylene Bromide
Dicamba	Banex, Banvel, Dianat
Dichlorodifluoromethane	Difluorodichloromethane
Dieldrin	
Dimethoate	CYGON
Diuron	KARMEX, KROVAR
Hexachlorobutadiene	Perchlorobutadiene
Isopropylbenzene	Cumene
Methomyl	Lannate
Methyl tert-Butyl Ether	MTBE

TABLE 5 (continued)
UNREGULATED ORGANIC CHEMICALS

Chemical	Synonyms
Metolachlor	Metelilachlor
Metribuzin	Lexone, Sencor, Sencoral
Naphthalene	Naphtalin
n-Butylbenzene	1-Phenylbutane
p-Isopropyltoluene	p-Cymene
Prometryn	CAPAROL
Propachlor	Albrass, Ramrod
sec-Butylbenzene	2-Phenylbutane
tert-Butylbenzene	2-Methyl-2-phenylpropane
tert-Amyl Methyl Ether	TAME

Reference:
22 CCR 64450

TABLE 6
RWQCB WATER QUALITY OBJECTIVES – INLAND SURFACE WATER

Inland Surface Water	Station	Hydrologic Unit Basin Number	Constituent (mg/L)							
			TDS	Cl	SO4	Fe	Mn	MBAS	B	F
Santa Margarita Hydrologic Unit		902.00								
Gavilan HSA										
Santa Margarita River near Fallbrook	501	2.22	750	250	250	0.3	0.05	0.5	0.75	1.10
Sandia Creek near Fallbrook	502	2.22	750	250	250	0.3	0.05	0.5	0.75	1.10
Rainbow Creek near Fallbrook	503	2.22	750	250	250	0.3	0.05	0.5	0.75	1.10
Wolf HSA										
Santa Margarita River near Temecula	504	2.52	750	250	250	0.3	0.05	0.5	0.75	1.10
Murrieta HA										
Murrieta Creek at Temecula	505	2.30	750	300	300	0.3	0.05	0.5	0.75	1.10
De Luz Creek HSA										
De Luz Creek near Fallbrook	506	2.21	750	250	250	0.3	0.05	0.5	0.75	1.10
Ysidora HA										
Fallbrook Creek near Fallbrook	507	2.10	750	300	300	0.3	0.05	0.5	0.75	1.10
Santa Margarita River at Ysidora	508	2.10	750	300	300	0.3	0.05	0.5	0.75	1.10
San Juan Hydrologic Unit		901.00								
San Mateo Canyon HA										
Cristianitos Creek near San Clemente	509	1.40	500	250	250	0.3	0.05	0.5	0.75	1.0
San Mateo Creek at San Clemente	510	1.40	500	250	250	0.3	0.05	0.5	0.75	1.0
San Mateo Creek at San Onofre	511	1.40	500	250	250	0.3	0.05	0.5	0.75	1.0

Reference:

San Diego Regional Water Quality Control Board's "Water Quality Control Plan for the San Diego Basin" dated September 1994

Notes:

TDS – Total dissolved solids
 Cl – Chloride
 SO₄ – Sulfate
 Fe – Iron
 Mn – Manganese

MBAS – Methylene blue active substance
 B – Baron
 F – Fluoride
 HA – Hydrologic Area
 HSA – Hydrologic Sub Area (Lower case letters indicate endnotes following the table.)

TABLE 7
WATER QUALITY SAMPLING LOCATIONS

LAW Station No.	USGS Station No.	Station Name	Latitude	Longitude	Period of Record
501	X-2-1350.00 11044300	Santa Margarita River near Fallbrook	332449	1171425	1961-1993 and 1997-1999
502	11044350	Sandia Creek near Fallbrook	332528	1171454	1982-1993 and 1997-1999
503	11044250	Rainbow Creek near Fallbrook	332427	1171200	1970-1993 and 1997-1999
504	X-2-1425.00 11044000	Santa Margarita River near Temecula	332826	1170829	1983-1994 and 1997-1999
505	11043000	Murrieta Creek near Temecula	332847	1170835	1965-1993 and 1997-1999
506	X-2-1235.50 11044900	De Luz Creek near Fallbrook ⁽¹⁾	332511	1171915	1968-1993 and 1997-1999
507	11045300	Fallbrook Creek near Fallbrook	332049	1171901	1965-1993 and 1997-1999
508	11046000	Santa Margarita River at Ysidora	331413	1172314	1997-1999
509	11046360	Cristianitos Creek near San Clemente	332541	1173403	1967-1987 and 1997-1999
510	11046300	San Mateo Creek at San Clemente	332815	1172820	1969-1988 and 1997-1999
511	11046370	San Mateo Creek at San Onofre	332400	1173509	1970-1988 and 1997-1999
101	None	MW-1 Santa Margarita River at De Luz Road	332400	1171541	1997-1999
102	None	MW-2 De Luz Creek	332426	1171904	1997-1999
103	None	MW-3 Cristianitos Creek	332704	1173405	1997-1999

Notes:

(1) Historical data from "De Luz Creek at McDowell" used.

APPENDIX B

STREAM GAUGING STATION RECORDS

APPENDIX C-1

MONITORING WELL COMPLETION REPORT

APPENDIX C-1

MONITORING WELL COMPLETION REPORT

Permitting and Drilling Site Clearance

For the installation of the three ground water monitoring wells, LAW obtained a drilling permit from the County of San Diego (Appendix C-2). The proposed drilling sites were marked in the field and scanned for utility clearance by Underground Service Alert, by the Base utility locating office, and by URS, a private utility locating company. In addition, the proposed drilling sites were observed for surficial indications of historical and cultural artifacts by Mr. Stan Berryman, an archaeologist with the MCB Camp Pendleton Assistant Chief of Staff, Environmental Security (AC/S, ES). Mr. Berryman did not identify artifacts at the surface but based on previous investigations in the vicinity, recommended observation of the initial 10 feet of drilling in monitoring well MW-3 by an observer trained in archaeological excavation. A representative of KEA Environmental provided the requested archaeological monitoring, and reported that no such artifacts were observed.

MCB Camp Pendleton prepared a PED (Preliminary Environmental Data) and a Clean Water Act (CWA) Section 404 nation wide 5 (NW5) permit application. The PED was used by ES to prepare a "Categorical eXclusion" (Cat-X) which resolved National Environmental Protection Act concerns. Then ES used the NW5 application to apply for that permit from the Army Corps of Engineers, Los Angeles District (ACE). Once the ACE was satisfied with the Cat-X and NW5 application, they approved it pending certification under Section 401, which is an action by the Regional Water Quality Control Board.

Drilling

The borings for the wells were drilled using truck-mounted hollow-stem augers and air rotary drilling equipment. All down-hole drilling equipment was steam-cleaned prior to each use. Each boring was logged during drilling.

Monitoring Well Construction and Development

Monitoring well construction was performed in accordance with the SAMD Site Assessment and Mitigation Manual (the SAM Manual) guidelines and the drilling permit issued for the work. The wells were constructed with 4-inch diameter schedule 40 PVC casing and screen. The well screen had a slot-size of 0.020 inches. Blank casing was placed from the top of the screen to the ground surface. The wells were constructed with Monterey No. 3 sand for gravel pack. An outer steel casing rising out of the concrete pad was installed, with a locking "J-plug" in the top of the casing and a locking outer well cap to protect the well at the surface. Lithologic logs and well construction details are presented in Appendix C-3.

Each well was developed to establish hydraulic continuity with the aquifer. Development consisted of mechanically surging each well for at least fifteen (15) minutes using a surge block. Each well was then purged of approximately two (2) to three (3) well volumes of water (as defined in the SAM Manual) in order to remove fine-grained sediments from the well.

Waste Management

Soil cuttings and waste water derived from drilling, development and purging the monitoring wells, and from decontamination of field equipment, were disposed in a manner identified in the environmental documentation prepared by the Base's Environmental Security Office. All liquids were disposed within the project's "footprint" at each well site. All soil cuttings were used to level areas within the footprints.

APPENDIX C-3

LITHOLOGIC LOGS AND WELL CONSTRUCTION DETAILS

APPENDIX D-1

COMPACT DISC (CD) OF WATER QUALITY DATABASE

APPENDIX D-3

OTHER SOURCES OF WATER QUALITY DATA

NOTES ON TREND GRAPHS

1. Graphs are organized alphabetically by analyte. Analytes are separated by blue pages.
2. Units for all analytes (except conductivity and pH) are milligrams per liter (mg/L).
3. Units for conductivity are micromhos per centimeter (umhos/cm).
4. Units for pH are pH units.

INDEX TO STATIONS

SURFACE WATER MONITORING LOCATIONS	
Station 501	Santa Margarita River near Fallbrook
Station 502	Sandia Creek near Fallbrook
Station 503	Rainbow Creek near Fallbrook
Station 504	Santa Margarita River near Temecula
Station 505	Murrieta Creek near Temecula
Station 506	De Luz Creek near Fallbrook
Station 507	Fallbrook Creek near Fallbrook
Station 508	Santa Margarita River at Ysidora
Station 509	Cristianitos Creek near San Clemente
Station 510	San Mateo Creek at San Clemente
Station 511	San Mateo Creek at San Onofre
GROUNDWATER MONITORING LOCATIONS	
MW-1	Santa Margarita River at De Luz Road
MW-2	De Luz Creek
MW-3	Cristianitos Creek

**OTHER SURFACE WATER ANALYTICAL DATA
AVAILABLE FROM MCB, CAMP PENDLETON
OFFICE OF WATER RESOURCES**

Brood Mare Pond, Surface Water Analytical Data 1955-1985.

California State Water Quality Samples, Off and On Base Sites, Surface Water Analytical Data 1975-1979.

Case Springs, Surface Water Analytical Data 1959-1987.

De Luz Road at SMR (Off Base), Surface Water Analytical Data 1991-1993.

Depot Lake N.W.S., Surface Water Analytical Data 1971-1975.

Fallbrook Creek at N.W.S., Surface Water Analytical Data 1982-1993.

Group 12 Lake N.W.S. (9/433M), Surface Water Analytical Data 1971-1975.

Group 12 Lakes N.W.S. (9/428P), Surface Water Analytical Data 1971-1975.

Historical-Fallbrook Creek at N.W.S., Surface Water Analytical Data 1965-1982.

Historical-San Onofre Ford at Basilone Road, Surface Water Analytical Data 1974-1980.

Historical-Sewage Effluent by Day, Plant #1, 16 Nov 54 to 14 Oct 81, Surface Water Analytical Data 1954-1981.

Historical-Sewage Effluent by Day, Plant #2, 16 Oct 54 to 14 Nov 81, Surface Water Analytical Data 1955-1981.

Historical-Sewage Effluent by Plant/by Month, Surface Water Analytical Data 1965-1981.

Historical-Temecula Creek at Interstate 15, Surface Water Analytical Data 1961-1982.

Jacinto Pond, Surface Water Analytical Data 1971.

Lake O'Neill, Surface Water Analytical Data 1952-1987.

Las Flores Pond, Surface Water Analytical Data 1961-1987.

Las Pulgas, Surface Water Analytical Data 1980-1986.

II.

III. Little Case Springs, Surface Water Analytical Data 1985-1987.

Miscellaneous, Surface Water Analytical Data 1952-1987.

Miscellaneous, Surface Water Analytical Data 1977.
Pilgrim Pond, Surface Water Analytical Data 1986.

Plant #1 Outfall – Urine Pond (Lake), Surface Water Analytical Data 1955-1986.

Plant #2 – Pond #2, Surface Water Analytical Data 1985-1987.

Sewage Effluent Flow-by Day, Plant 1, Surface Water Analytical Data 1981-1992.

SMR at De Luz Road, Surface Water Analytical Data 1986-1988.

SMR-Up Rainbow Creek, Surface Water Analytical Data 1991-1993.

Surface Water Analysis Impoundment Structures – Camp Pendleton Fallbrook N.W.S.,
Miscellaneous Surface Water Analytical Data 1977-1982.

Temecula Creek at Interstate 15, Surface Water Analytical Data 1982-1993 and 1961-1987 (two
separate sets of data).

Wild Cat #1 and #2, Surface Water Analytical Data 1973.

APPENDIX F
PIPER DIAGRAMS

APPENDIX H

QUALITY ASSURANCE/QUALITY CONTROL OBJECTIVES