MARINE CORPS AIR STATION EL TORO
EL TORO, CALIFORNIA
INSTALLATION RESTORATION PROGRAM
PHASE I REMEDIAL INVESTIGATION
DRAFT TECHNICAL MEMORANDUM
7 May 1993

VOLUME I

PREPARED BY:
Southwest Division, Naval Facilities
Engineering Command
1220 Pacific Highway
San Diego, California 92132-5190

THROUGH:
CONTRACT #N68711-89-D-9296
CTO #145
DOCUMENT CONTROL NO:
CLE-C01-01F145-B18-0001

WITH:
Jacobs Engineering Group Inc.
3655 Nobel Drive, Suite 200
San Diego, California 92122

In association with:
International Technology Corporation
CH2M HILL

VOLUME II
CAN BE LOCATED UNDER
DOCUMENT NUMBER
M60050.000084

VOLUME III
CAN BE LOCATED UNDER
DOCUMENT NUMBER
M60050.000085

VOLUME IV
CAN BE LOCATED UNDER
DOCUMENT NUMBER
M60050.000086

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EXECUTIVE SUMMARY

The Naval Facilities Engineering Command, Southwest Division (SOUTHWESTDIV) has conducted a Phase I Remedial Investigation (RI) for the Marine Corps Air Station (MCAS) El Toro under the Comprehensive Long-term Environmental Action, Navy (CLEAN) Program. This Technical Memorandum summarizes the results of the Phase I RI. It is limited to the presentation and preliminary interpretation of data gathered in the first phase of field work and includes a preliminary baseline risk assessment. Detailed recommendations for the Phase II RI will be deferred to the upcoming Data Quality Objectives (DQOs) process.

Background Information

MCAS El Toro (the Station) is located in Orange County, California, near the City of Irvine. The Marine Corps established the Station in 1943, and it currently serves as the center for marine aviation operations on the Pacific Coast. The facility occupies 4,700 acres comprising hangars, flightline areas, maintenance areas, fueling facilities, a clinic, a golf course, and housing areas. Portions of land on-Station are leased to private companies for nursery and agricultural use.

Past operations and disposal practices are believed to have contaminated the groundwater in the vicinity of the Station. Previous studies conducted as part of the National Assessment and Control of Installation Pollutants (NACIP) program had identified 21 potential on-Station sources of contamination possibly resulting from past operations at the Station. During routine water quality monitoring in 1985, the Orange County Water District (OCWD) discovered trichloroethylene (TCE) in an irrigation well located about 3,000 feet west of the Station. Subsequent investigations by OCWD concluded that the TCE and other volatile organic compounds (VOCs) detected in groundwater had originated at MCAS El Toro.

As a result of these findings, the U.S. Environmental Protection Agency (EPA) placed the Station on the National Priorities List (NPL) in February 1990. The Marine Corps agreed to conduct a Remedial Investigation/Feasibility Study (RI/FS) in a Federal Facilities

Agreement (FFA) signed in October 1990. Twenty-two sites, including Site 18, the regional groundwater investigation, were included under the RI/FS. These sites were grouped into three Operable Units (OUs). OU-1 comprises the regional VOC groundwater investigation (Site 18), conducted both on- and off-Station. OU-2 includes the sites considered potential source areas for the regional groundwater VOC contamination: the four landfill sites (Sites 2, 3, 5, and 17) and the Petroleum Disposal Area (Site 10). The remaining 16 sites were grouped together as OU-3. These sites were considered to be potential sources for a variety of contaminants.

The overall goal of the MCAS El Toro RI/FS was to collect sufficient data to support informed risk management decisions within the time frame designated in the FFA. Phase I of the RI was directed at evaluating the source(s) of contamination for the observed regional groundwater west of the Station, and at determining initially whether contamination exists and is affecting the environment at sites in OU-2 and OU-3.

Scope of the Phase I RI

The scope of work for the Phase I RI was designed to meet the objectives listed above. The major tasks of the investigations were to:

- Install 95 groundwater monitoring wells, including four multiple-port wells and six clusters of wells completed at different depths.
- Collect and chemically analyze over 1,500 samples of sediments, surface water, surface and near-surface soils, vadose zone soil boring samples, and groundwater.
- Conduct aquifer pumping and slug tests on over 60 new wells.
- Resample and analyze groundwater in existing monitoring wells.
- Evaluate geological and hydrogeological data gathered.
- Perform a preliminary (human health and ecological) risk assessment.
- Document results in a Phase I RI Technical Memorandum.

Hydrogeology

Phase I field data showed that the depth to groundwater is shallowest in the foothills where it is 45 to 60 feet below ground surface (bgs). In the alluvial basin, groundwater is first encountered at a depth greater than 240 feet on the northern and eastern portion of the Station (along Irvine Blvd); the depth decreases about 85 feet bgs along the western boundary of the Station. Shallow groundwater in the MCAS El Toro vicinity appears to follow a regional horizontal hydraulic gradient of about 0.008 feet per foot to the northwest. However, the distribution of contaminants in groundwater suggests that, locally, groundwater may preferentially follow subsurface permeable units in a westerly direction. Deeper gradients may follow a more westerly direction in response to agricultural pumping. Data collected during the RI were inconclusive on this issue. Groundwater elevations collected from well clusters and multiple-port monitoring wells revealed a generally downward vertical gradient in the uppermost saturated zones, particularly in the summer months, again most likely in response to deep pumping of irrigation wells that lie west of MCAS El Toro.

The Station lies on Holocene and Pleistocene Age unconsolidated sediments consisting of mainly discontinuous lenses of clayey and silty sands contained within a complex assemblage of sandy clays and silts. Coarser materials tend to predominate near the foothills. Previous investigations and the present investigation suggest that relatively more permeable materials may form elongated deposits roughly corresponding to the current drainage pathways at the surface. The unconsolidated sediments overlie semiconsolidated low-permeability sediments of Pleistocene Age and older that are extensions of similar formations in the foothills surrounding the Station. Because these deposits are discontinuous and interbedded, it is not possible to discern discrete widespread aquifer units beneath MCAS El Toro. Data suggest that vertical hydraulic communication exists among the units, and that the unconsolidated sediments form a single heterogeneous aquifer system. Groundwater was typically found to be semiconfined in the uppermost permeable saturated unit encountered during drilling, with confinement increasing with depth. Aquifer testing during the RI indicated hydraulic conductivity values ranging from 0.2 to 65 feet/day in the shallow wells, with most values ranging from 1 to 20 feet/day. The average linear velocity of groundwater flow in general varied from about 0.2 to 0.5 feet/day, but ranged up to about 2 feet/day.

Nature and Extent of Contamination

Groundwater samples collected during the OU-1 (Site 18) investigation contain 24 VOCs, of which TCE was the most commonly detected. Other VOCs that appear to originate from on-Station sources include PCE, 1,1-DCE, 1,2-DCE, benzene, and carbon tetrachloride. Because these contaminants were detected at multiple sites, they will be discussed here as part of OU-1.

TCE and PCE were detected in groundwater mainly in two areas at MCAS El Toro: in the eastern portion of the Station near Site 2 (Magazine Road Landfill); and in the southwestern portion of the Station in a broad area that encompasses Site 7 (Drop Tank Drainage Area No. 2), Site 8 (DRMO Storage Yard), Site 9 (Crash Crew Pit No. 1), Site 10 (Petroleum Disposal Area), and Site 22 (TAFDS Area). However, TCE was detected in only four soil samples, three of which were collected below the water table from the screened interval of wells. The fourth was collected just above the water table in a well borehole at Site 7. TCE was also detected in a sediment sample below the CRDL at Site 2 (Magazine Road Landfill). PCE was detected in three surface or near-surface samples: two at one station at Site 10, and one beneath the former rubbish pile at Site 8. None of these samples are at concentrations sufficiently high to suggest that they are significant source areas.

Site 7 appears to define the upgradient extent of the groundwater VOC contamination on the northeast. Similarly, the Agua Chinon Wash appears to define the upgradient extent of the contamination on the south. Groundwater contamination on-Station also appears to be mainly confined to the uppermost permeable zone.

The highest concentration of TCE was found in Well 9_DBMW45 at Site 9. A sample collected from this well contained 2,000 μg/L of TCE. Other wells nearby that contained TCE in excess of 100 μg/L include Well 9_DGMW75, Well 7_DGMW72, Well 8_DGMW73 , Well 8_DGMW74, and Well 18_BGMW3E, located between Sites 7 and 10. No soil sample was collected at any of the sites near the main body of TCE contaminated groundwater on-Station that contained detectable levels of TCE, except for a sample collected a depth of 110 feet (4 feet above the water table) in the borehole for Well 7_DGMW71. The TCE concentration in this sample was 74 ug/kg. Low concentrations of TCE were detected in the vicinity in soil samples collected during the Resource Conservation and Recovery Act (RCRA) Facility Agreement (RFA) study for MCAS El Toro.

Limited data on detected TCE in soil samples imply that the actual source of the TCE has not been located. Even though a concentration of 2,000 μg/L is not close to the aqueous solubility of TCE, it is sufficiently high to suggest the presence of a nearby source. However, there is nothing in the historical record or in the sampling data that would implicate Site 9 as the source for the regional TCE groundwater contamination. Site 10 also does not appear to be the source of TCE in groundwater, in spite of historical evidence for potential TCE releases as part of dust suppression. TCE concentrations were detected in wells downgradient from Site 7 and upgradient from Sites 9 and 10 suggesting that TCE may have originated in this area. This is consistent with the historical record, which indicates that industrial maintenance and repair activities have occurred at this site over the years.

TCE seems to be migrating in a northwesterly direction generally consistent with the regional groundwater gradient. The TCE is drawn down into deeper zones as the lenses of high-permeable materials becomes thicker at depth toward the west, and in response to vertical gradients induced by operating irrigation wells. It is important to realize that the on-Statlon distribution of VOC contamination is based on data collected from only one groundwater sampling event. Future sampling events will further verify and characterize the nature and extent of the contamination.

1,1-DCE, 1,2-DCE, and carbon tetrachloride were also detected in groundwater samples collected in the southwestern portion of MCAS El Toro. It is unknown whether the 1,1-DCE and 1,2-DCE have separate sources or are biodegradation products of TCE and/or PCE.

Benzene was detected in groundwater samples collected from two locations at MCAS El Toro. One location was at Site 4 (the Ferrocene Spill Area), where the upgradient well contained benzene at a concentration of 3 μg/L. The other location was in the western portion of the Station, where benzene was found in samples collected from wells at Site 13 (the Oil Change Area) and Site 15 (the Suspended Fuel Tank Area). The highest value was from the upgradient well at Site 13 (730 μg/L). At Site 15, benzene was detected at 120 μg/L. Because benzene was detected in upgradient wells at both of these locations at MCAS El Toro, it is possible that it results from activities unrelated to the sites themselves, possibly nearby fuel tank farms. However, no layer of floating hydrocarbons was found in any RI monitoring well at MCAS El Toro. In addition, no benzene was found in any soil sample collected at MCAS El Toro.

No total recoverable petroleum hydrocarbons (TRPH) was detected in groundwater samples collected from Phase I RI monitoring wells. Total fuel hydrocarbons (TFH)-gasoline and TFH-diesel were detected in several samples, with the highest concentrations associated with the same areas in which benzene was collected.

Pesticides were detected in samples from five RI monitoring wells. Two of these were collected from wells in a cluster in a nursery located outside the Station boundary. One sample was collected from a well located downgradient of Site 3. Ten groundwater samples contained detectable concentrations of herbicides. The upgradient well at Site 12 contained detectable concentrations of 8 herbicides, including MCPA at and MCPP.

OU-2 includes sites originally thought to have the potential to contribute to the regional groundwater VOC contamination: Site 2 (Magazine Road Landfill); Site 3 (Original Landfill); Site 5 (Perimeter Road Landfill); Site 10 (Petroleum Disposal Area); and Site 17 (Communication Station Landfill). Of these sites, only Site 2 (Magazine Road Landfill) appears to have contributed to groundwater contamination. The remaining OU-2 sites, with the possible exception of Site 10, do not appear to be sources of the regional groundwater VOC contamination.

TCE was found in groundwater from each well at Site 2; the highest concentration was 82 μg/L in one of the downgradient wells. Other VOCs exceeding drinking water standards (Federal or State Maximum Contaminant Levels [MCLs]) include 1,2-dichloroethane (1,2-DCA) at 0.9 μg/L (estimated), 1,2-dichloroethylene (1,2-DCE) at 8 μg/L, and tetrachloroethylene (PCE) at 8 μg/L. No semivolatile organic compounds, petroleum hydrocarbons, pesticides or polychlorinated biphenyles (PCBs) were detected in groundwater samples. Most of the contaminants in surface water and sediments at Site 2 were found in the washes surrounding the landfill, and in the man-made channel incised into the landfill. Surface and near-surface soil samples contained low levels of a variety of contaminants, including toluene, petroleum hydrocarbons, and herbicides.

The detected contaminants in Sites 3, 5, 10, and 17 are limited mostly to petroleum hydrocarbons. Although VOCs were detected in the downgradient well at Site 10, it appears unlikely that the regional VOC contamination in groundwater originated from historic dust suppression activities at this site.

OU-3 sites, with the possible exception of Sites 7, 8, 9, and 22, also do not appear to be contributing to the regional groundwater VOC contamination. The most commonly detected contaminants at these sites are TRPH, TFH-diesel, and TFH-gasoline that are mostly confined to the first few feet of the subsurface soils. Groundwater samples collected from monitoring wells at Sites 7, 8, 9, and 22 have contained VOCs. Although it is suspected that one or more sources of VOCs may exist in the vicinity of these sites, the exact location of these suspected sources have not been identified.

Inorganic Groundwater Quality

The general inorganic chemistry of the regional groundwater underlying the Station changes dramatically across MCAS El Toro. The high TDS, sulfates, nitrates, and selenium in the groundwater appear to be caused by natural sources or previous land uses within the area. The occurrence and concentrations of sodium, calcium, and magnesium, along with bicarbonate, and chloride in groundwater also appears to represent background water quality.

Hydrogeologic Conceptual Model

Two potential migration pathways were postulated in the initial model for off-Station contaminant migration in groundwater, as described in the Phase I RI Sampling and Analysis Plan (SAP):

1. On-Station infiltration of contaminants to groundwater and lateral flow of contaminated groundwater off-Station.

2. Flow of contaminated surface water and sediments from on-Station source areas to off-Station locations through unlined washes; infiltration into groundwater and subsequent migration of contaminated groundwater.

The first pathway exists at MCAS El Toro. The location of the highest concentrations of VOCs (primarily TCE, PCE, and their potential degradation products) in groundwater indicate general source areas in the southwestern quadrant of the Station. The area of VOC groundwater contamination can be traced from the Station westward for approximately 3 miles.

The second pathway may have previously existed, but is difficult to substantiate. It appears that the Borrego Canyon, Agua Chinon, Bee Canyon, and Marshburn Channel Washes provide a potential recharge pathway to groundwater. Soil samples collected beneath Agua Chinon Wash contained TFH-gasoline, which could be leaching to the groundwater. Although groundwater from the nearest on-Station shallow well (18_BGMW05D) did not contain TFH-gasoline, a groundwater sample collected from the uppermost screen at multiple-port well 18_BGMP09 downstream (off-Station) along Agua Chinon Wash, did show 71 μg/L of TFH-gasoline. The finding is inconclusive but appears to indicate that the washes are a pathway for contaminant migration.

Discussion

A variety of contaminants have been detected in the groundwater, soil, surface water, and sediment at MCAS El Toro. Contaminants detected in soil and sediments have consisted primarily of relatively low concentrations of semivolatiles, petroleum hydrocarbons, pesticides and herbicides, with PCBs found at Sites 8, 11, and 12. VOCs have been relatively rare in soils, having been found for the most part at low concentrations. In particular, TCE was found in only one sediment sample and one vadose zone sample. On the other hand, semivolatiles, petroleum hydrocarbons, pesticides, and herbicides have been relatively rare in groundwater. Contaminants in groundwater have consisted mainly of VOCs. Groundwater data will be updated following the collection of a second round of samples from RI wells during Summer 1993. However, a preliminary conclusion may be made that existing data on the regional VOC contamination (Site 18, OU-1) in groundwater are adequate to proceed directly to an OU-1 and Record of Decision (ROD), without the necessity of a Phase II RI.

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ACRONYMS AND ABBREVIATIONS

ACER	Aircraft Expeditionary Refueling
AOC	areas of concern
ARAR	Applicable or Relevant and Appropriate Requirement
ASTM	American Society for Testing and Materials
AWQC	ambient air quality criteria
BCF	bioconcentration factor
Beylik	Beylik Drilling, Inc.
bgs	below ground surface
BHC	hexachlorocyclohexane
C	Centigrade
CAA	Clean Air Act
CARB	California Air Resources Board
CCME	Canadian Council of Ministries of the Environment
CDFG	California Department of Fish and Game
CEQA	California Environmental Quality Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLEAN	Comprehensive Long-Term Environmental Action, Navy
CLP	Contract Laboratory Program
CNDDB	The California Natural Diversity Data Base
COC	Contaminants of Concern
COPC	chemicals of potential concern
COPEC	Chemicals of potential ecological concern
CRDL	contract-required detection limits
CTO	Contract Task Order
CWA	Clean Water Act
DDT	dichlorodiphenyl-trichloroethane
DHS	Department of Health Services
DIRP	Department of Defense's Installation Restoration Program
DQO	Data Quality Objective
DRMO	Defense Reutilization and Marketing Office
EC	electrical conductance
EDMS/I	Environmental Database Management System/Informix
Eh	oxidation-reduction potential
em	electro magnetic
EOD	Explosive Ordnance Disposal
EPA	U.S. Environmental Protection Agency
F	Farenheit
FFA	Federal Facilities Agreement
FS	Feasibility Study
GAC	Granular Activated Carbon
GIS	Geographic Information System
gpm	gallons per minute
GPR	ground-penetrating radar
H	Henry's Law constant

ACRONYMS AND ABBREVIATIONS

HEAST	Health Effects Assessment Summary Table
hp	horsepower
IAS	Initial Assessment Study
ID	identification
IRIS	Integrated Risk Information System
IRWD	Irvine Ranch Water District
ISQL	Informix Standard Query Language
IT	International Technology Corporation
ITEMS	International Technology Environmental Database Management System
Jacobs	Jacobs Engineering Group Inc.
JMM	James M. Montgomery Engineers, Inc.
kg	kilogram
K_{oc}	organic carbon adsorption coefficient
L	liter
LEL	lowest effect level
LOAEL	Lowest Observed Adverse Effect Level
LUFT	Leaking Underground Fuel Tanks
MCAS	Marine Corps Air Station
MeCl	methylene chloride
MCL	Maximum Contaminant Levels
MCLG	MCL goal
mg	milligram
mm	millimeter
MP	multiple-port
MS	matrix spike
MSD	matrix spike duplicate
msl	mean sea level
MWD	Metropolitan Water District
NACIP	Navy Assessment and Control of Installation Pollutants
NAVFACENGCOM	Naval Facilities Engineering Command
NCP	National Contingency Plan
NEESA	Naval Energy and Environmental Support Activity
NOAEL	No Observed Adverse Effect Level
NPAQS	National Primary and Secondary Ambient Air Quality Standards
NPL	National Priorities List
O.D.	outside diameter
OCWD	Orange County Water District
OSWER	Office of Solid Water
OU	Operable Unit
OVA	organic vapor analyzer
PAH	polynuclear aromatic hydrocarbons
PC	personal computer
PCB	polychlorinated biphenyls
PCDD	octa-chlorinated dibenzo-p-dioxin
PCDF	dibenzofuran

ACRONYMS AND ABBREVIATIONS

PCE	perchloroethylene (also tetrachloroethylene)
PID	photo-ionization detector
POTW	publicly-owned treatment works
ppb	parts per billion
PPE	personal protective equipment
ppm	parts per million
ppmv	parts per million (volume)
PR	Preliminary Review
PRG	Preliminary Remedial Goals
PSI	Perimeter Study Investigation
PVC	polyvinyl chloride
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Remedial Facilities Assessment
RfC	reference concentration
RfD	reference dose
RI/FS	Remedial Investigation Feasibility Study
RI	Remedial Investigation
ROICC	Resident Officer in Charge of Construction
RWQCB	(California) Regional Water Quality Control Board
SAP	Sampling and Analysis Plan
SCAQMD	South Coast Air Quality Management District
SDG	sample delivery group
SDWA	Safe Drinking Water Act
SF	slope factor
SIPOA	Site Inspection Plan of Action
SOUTHWESTDIV	Southwest Division (Naval Facilities Engineering Command)
SP	spontaneous potential
Station	MCAS El Toro
SV	Sampling Visit
SVOC	semi-volitile organic compound
SWAT	Solid Waste Assessment Test
SWMU	solid waste management units
TAFDS	Tactical Air Fuel Dispensing System
TAL	Target Analyte List
TCE	trichloroethylene
TCL	Target Compound List
TDS	total dissolved solids
TEF	Toxicity Equivalence Factors
TFH	total fuel hydrocarbons
TIC	The Irvine Company
TIC	tentatively identified compounds
TIN	Triangulated Irregular Network
TM	Technical Memorandum
TOC	total organic carbons

ACRONYMS AND ABBREVIATIONS

TOX	total organic halogens
TPH	total petroleum hydrocarbons
TRPH	total recoverable petroleum hydrocarbons
TSCA	Toxic Substance Control Act
TSP	trisodium phosphate
UBK	Uptake Biokinetic Model
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UTM	Universal Transverse Mercator
VOA	volatile organic analyzer, volatile organic analysis
VOC	volatile organic compound
VSI	Visual Site Inspection
Westbay	Westbay Instruments, Ltd.
WHR	Wildlife - Habitat Relationships
WMP	Waste Management Plan
WSA	Waste Staging Area
WSF	Waste Storage Facility

1.0 INTRODUCTION

This Draft Remedial Investigation Technical Memorandum summarizes the results of the Phase I Remedial Investigation (RI) conducted at the Marine Corps Air Station (MCAS) El Toro. The Technical Memorandum was prepared in partial fulfillment of Contract Task Order (CTO) 145 under the Comprehensive Long-Term Environmental Action, Navy (CLEAN) Program under contract N68711-89-D-9296. The submittal date for this memorandum is 07 May 1993, as required by the Federal Facilities Agreement (FFA) for MCAS El Toro (the Station).

The content of this draft technical memorandum is limited to the presentation and preliminary interpretation of data gathered in the first phase of fieldwork. A preliminary baseline risk assessment is included. This technical memorandum is not a full RI report for Phase I activities, and does not recommend strategy for Phase II investigations. Development of the Data Quality Objectives (DQOs) process for CTO 145 will address how the Phase I data will be used to prepare the Phase II RI Sampling and Analysis Plan (SAP) and Work Plan.

This draft technical memorandum will not be revised. Review comments received from the regulatory agencies and other interested parties will be incorporated into the final RI Report for the MCAS El Toro RI/FS after the completion of Phase II.

The overall goal of the RI is to collect sufficient data to support informed risk management decisions within the time frame designated in the FFA. Phase I of the RI was directed at evaluating the source of contamination for the observed regional groundwater volatile organic compound (VOC) contamination west of the Station, and at making an initial determination as to whether contamination exists and is affecting the environment at the 22 investigation sites.

The 22 RI sites have been grouped into three operable units (OUs). OU-1 (Site 18) comprises the regional groundwater contamination investigation of areas both on-Station and off-Station in which VOC groundwater contamination exists. Of particular concern are groundwater concentrations of trichloroethylene (TCE) and tetrachloroethylene (PCE) that extend three miles west of the Station. OU-2 comprises the five on-Station sites that have been considered potential sources of the regional VOC groundwater contamination: four landfill sites (Sites 2, 3, 5, and 17) and the Petroleum Disposal Area (Site 10). The remaining 16 sites are grouped together as OU-3; they are potential sources for a variety of contaminants, but are not thought to be associated with groundwater contamination.

VOCs in regional groundwater may have originated in other sites not included in the Phase I RI. Therefore, a summary of the recently completed Resource Conservation and Recovery Act (RCRA) Facility Assessment (RFA) is also included in this technical memorandum (as Section 5).

Ninety-five groundwater monitoring wells were installed including 6 clusters of wells (completed at different depths) and 4 multiple-port wells. Over 1,500 samples of surface water runoff, sediment, surface and near-surface soils, vadose zone soils, and groundwater were collected. These samples were chemically analyzed for a full suite of chemicals: VOCs, semi-volatile organic compounds (SVOCs), metals and cyanide, pesticides, herbicides, total organic carbon (TOC), and petroleum hydrocarbons. Analytical data were validated in accordance with the EPA Contract Laboratory Program (CLP) guidelines.

U.S. Environmental Protection Agency (EPA) Maximum Contaminant Levels (MCLs) and State of California Action Levels were used for comparison of the concentrations of detected chemicals in groundwater. However, in accordance with the guidance from the Naval Facilities Engineering Command, (NAVFACENGCOM), Southwest Division (SOUTHWESTDIV), standards for the detected soil chemicals were not used to assess the significance of soil contamination. The Navy and regulatory agencies decided in 1992 that the criteria and statistical comparison procedures for soil contaminants would be developed during the DQOs process for CTO 145.

Because the DQO process has not been yet started, these comparison criteria have not been developed. The contaminant concentrations in soils will be compared to applicable standards and criteria during the DQO process and will be used to develop the Phase II RI Work Plan. This approach was presented and approved by the regulatory agencies at a meeting of the CTO 145 Remedial Project Managers on 24-25 March 1993. However, this technical memorandum uses California Leaking Underground Fuel Tanks (LUFT) action levels for qualitative comparisons of petroleum hydrocarbons. No decisions or recommendations are made or implied from these qualitative comparisons.

1.1 Statement of Purpose

The goal of the RI/FS is to collect sufficient data to support informed risk management decisions for MCAS El Toro within the time frame designated in the FFA. The Phase I RI is directed at determining the source of contamination for the observed regional groundwater contamination and evaluating whether groundwater contamination sources are a risk to human health and environment exists at OU-2 and OU-3 sites.

The general objectives for the Phase I RI are:

- Obtain initial samples of surface water, sediment, surface and subsurface soil, and groundwater to assess the presence of contamination at the 21 identified on-Station sites and, if present, evaluate the nature and extent of the contamination.
- At each site where contamination is detected, gather sufficient information to assess whether the site presents a risk or has the potential to cause a risk to human health or the environment and evaluate the main pathways of the conceptual site model.
- Collect sufficient analytical information to perform a preliminary baseline risk assessment.
- Obtain sufficient analytical data to evaluate whether Station operations have been responsible for or contributed to the VOC contamination of the nearby agricultural wells west of the Station.
- Refine the conceptual site model for the regional groundwater contamination by characterizing the source and pathways for VOC contamination.
- Gather preliminary data to establish viable remedial action alternatives.
- Evaluate whether emergency removal actions are necessary.

1.2 Report Organization

This Technical Memorandum, which documents information developed during the MCAS El Toro Phase I RI, comprises three companion volumes. Volume I is the main body of the report. Volumes II and III are a compendium of technical appendices providing detailed supporting information, data, and assessments that support the field study and analysis results and conclusions presented in Volume I. The appendices include a complete data listing of all laboratory analyses of the field samples from surface water, sediments, surface and near-surface soil, subsurface (vadose zone) soil, and groundwater.

Volume I of this Technical Memorandum is organized as follows:

- Section 1.0 presents background information on the Phase I RI investigation, including meteorology, regional geology, soils, geography, hydrogeology, surface water hydrology, land use, demographics, and ecology, as well as the MCAS El Toro site history, institutional and regulatory considerations, a review of previous and related ongoing investigations, and descriptions of the 21 RI sites.

- Section 2.0 documents the investigative methods employed to establish and conduct the RI field activities program, to assure and control the quality of sample data collected during these activities, and to analyze the resulting data.

- Section 3.0 summarizes the results of the field investigation activities for regional hydrogeology surface water and sediments.

- Section 4.0 briefly summarizes the nature and extent of contamination associated with the 21 sites within Operable Units 2 and 3 (OU-2 and OU-3) that were suspected sources of groundwater contamination targeted for Phase I investigation. In-depth discussion of each of the 21 sites are in Appendix B (in Volume II) of this Technical Memorandum.

- Section 5.0 summarizes the information developed during the MCAS El Toro RFA.

- Section 6.0 summarizes the nature and extent of regional groundwater contamination, as well as that of surface water and sediments associated with OU-1. In-depth coverage of this topic is detailed in Appendix A (in Volume II) of this Technical Memorandum.

- Section 7.0 discusses the results of the preliminary baseline human health and ecological risk assessments for the contaminants of concern identified by the field investigation. Supporting tables and calculations are provided in Appendix H of this Technical Memorandum.

- Section 8.0 summarizes the results and conclusions of this Phase I investigation.
- Section 9.0 provides a list of references.

1.3 Background Information

1.3.1 Site Investigation Boundaries

MCAS El Toro is about 8 miles southeast of the City of Santa Ana, California, at approximately 33 degrees 40 minutes north latitude and 117 degrees 40 minutes west longitude (Figure 1-1). The Station is within Township 6 South, Range 6 West.

The boundaries of MCAS El Toro comprise the investigation boundary for OU-2 and OU-3. The area designated OU-1, encompasses not only the Station, but also the off-Station area delineated by Harvard Drive, Trabuco Road, and the San Diego Freeway (see Figure 1-2).

1.3.2 Site History

In July 1942, construction of a Marine Corps pilots' fleet operational training facility began on 2,319 acres in Orange County, California. On 17 March 1943, that facility was commissioned as MCAS El Toro (Station). In 1950, the Station was selected for development as a master jet air station and permanent center for Marine aviation on the West Coast to support the operations and combat readiness of Fleet Marine Forces, Pacific. Between 1944 and 1977, an additional 2,379 acres of land were acquired to bring the Station to its present size of 4,698 acres. The stated mission of MCAS El Toro is to provide, maintain, and operate facilities, services, and material to support Marine Corps and Naval aviation-related operations and units.

1.3.3 Other Investigations

1.3.3.1 Previous Investigations

In 1985, Brown and Caldwell Engineers began work on an Initial Assessment Study (IAS) to locate potentially contaminated sites on the Station. This work was conducted for the Naval Facilities Engineering Command (NAVFACENGCOM) under the Navy Assessment and Control of Installation Pollutants (NACIP) program, which is the Navy's version of the Department of Defense's Installation Restoration Program (DIRP). The May 1986 IAS report identified 17 potential sources of contamination. No sampling was performed; the identification of potentially contaminated sites was based solely on the results of record searches and employee interviews. The IAS report recommended sampling locations and analytical parameters to confirm the suspected contamination.

In June 1985, while the IAS study was underway, the Orange County Water District (OCWD) discovered trichloroethylene (TCE) in an agricultural well (TIC 47) approximately 3,000 feet west of the Station. OCWD subsequently launched its own offsite investigation to determine the source and extent of the TCE contamination. After installing a network of monitoring wells and soil-vapor probes and reviewing the results of independent investigations by Cannon, Inc., and Wilma Pacific, Inc., OCWD concluded that the Station is the source of the contamination. These OCWD investigations continue to the present. (Herndon and Reilly, 1989; Herndon, 1990).

In 1987, James M. Montgomery Engineers, Inc. (JMM) was contracted by the Marine Corps to review the work done by Brown and Caldwell and to produce a Site Inspection Plan of Action (SIPOA). In July 1987, while the SIPOA study was underway, the California Regional Water Quality Control Board, Santa Ana Region (RWQCB) issued a cleanup and abatement order requiring the Station to initiate a perimeter groundwater VOC investigation and to submit a draft report. The SIPOA was released in August 1988 and included a recommendation of 19 sites for study and amended the site sampling plans proposed in the IAS report. One "site," designated Site 18, was intended to address the off-Station contaminant plume of

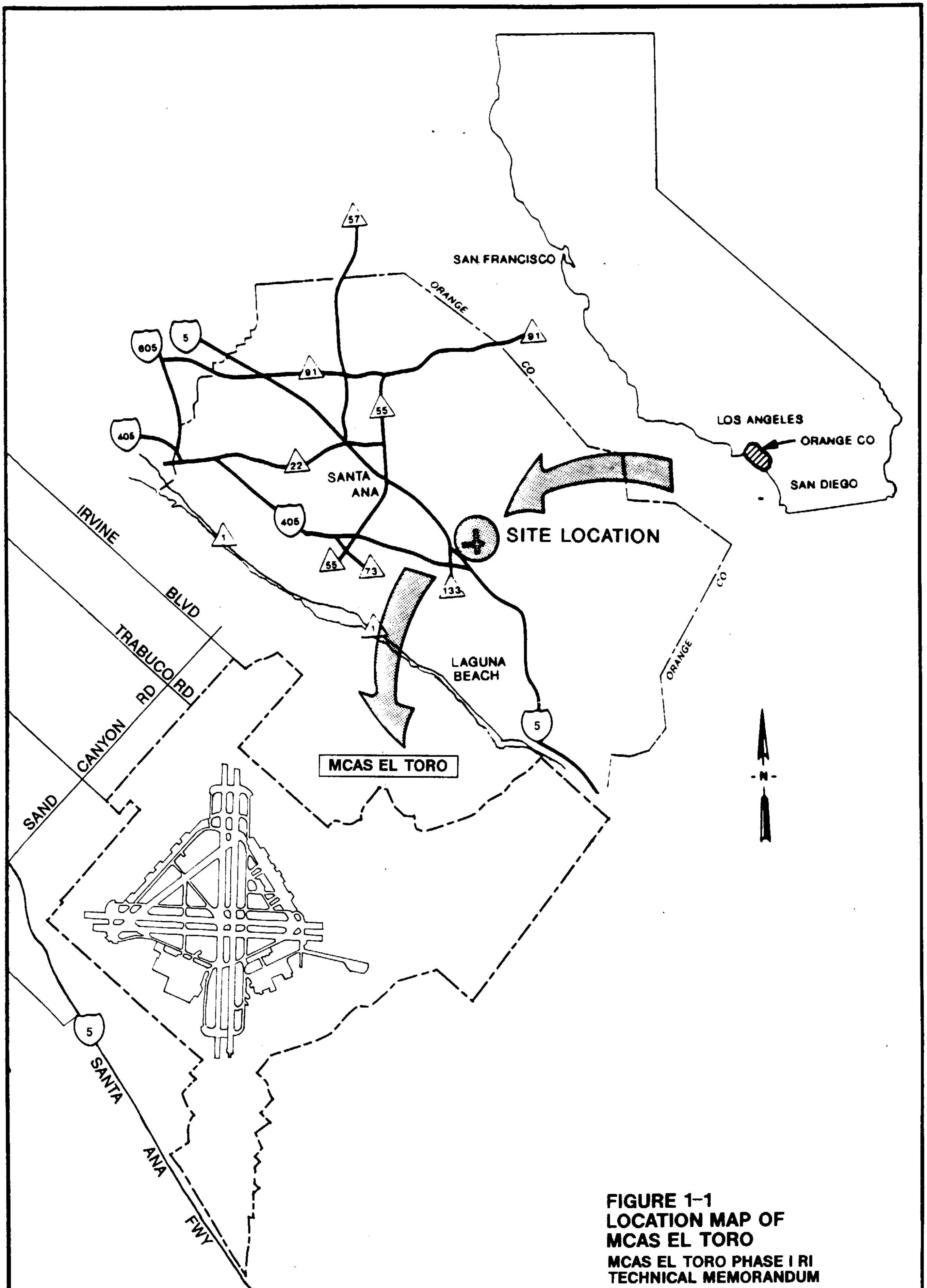

FIGURE 1–1
LOCATION MAP OF
MCAS EL TORO
MCAS EL TORO PHASE I RI
TECHNICAL MEMORANDUM

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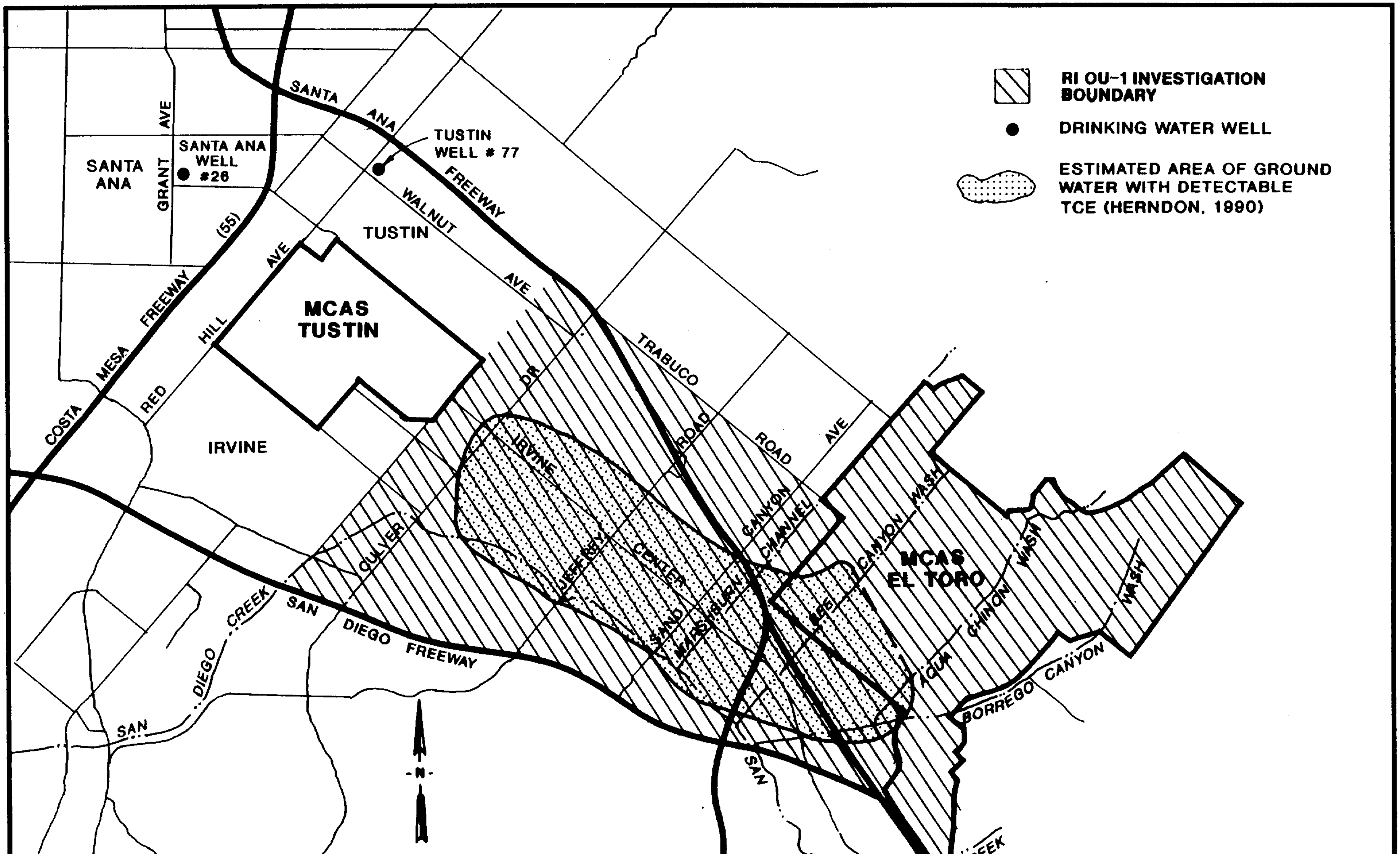

FIGURE 1-2
BOUNDARY OF REGIONAL GROUNDWATER CONTAMINATION INVESTIGATION
MCAS EL TORO PHASE I RI TECHNICAL MEMORANDUM

SOURCE OF MAPS: USGS 7.5 MINUTE QUADRANGLE MAPS TUSTIN (1981) AND EL TORO (1982)

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VOCs. This SIPOA report served as the Jacobs Team's starting point for developing the SAP for the 21 on-Station RI/FS sites.

In July 1987, while the SIPOA study was underway, the California Regional Water Quality Control Board, Santa Ana Region (RWQCB) issued a cleanup and abatement order requiring MCAS El Toro to initiate a perimeter groundwater VOC investigation and to submit a draft report. In 1988, JMM was again contracted by the Marine Corps to conduct a Perimeter Study Investigation (PSI) to study VOC contamination along the southwestern boundary of the Station. This study addressed RWQCB's concerns that the Station was a potential source of a VOC groundwater plume that extended 4 miles off-Station. The PSI results indicated that VOCs were present in the shallow groundwater near the Station boundary.

As a consequence, an interim groundwater pump and treatment system was installed at this boundary. This system, which began operation on 15 June 1989, can pump and treat approximately 30 gallons per minute (gpm) of groundwater from three extraction wells. VOC-contaminated water is sent to an onsite granular activated carbon (GAC) unit for treatment, and the effluent is used to irrigate the Station golf course. Trichloroethylene (TCE) and perchloroethylene (PCE) composite concentrations in the influent to the treatment system have been in the range of 10-160 and 25-100 parts per billion (ppb), respectively.

The discovery of TCE and PCE so close to the downgradient boundary prompted the Station to contract with JMM to prepare an off-Station Remedial Investigation Work Plan. This plan was completed in March 1990, and included recommendations for monitoring well installations to further delineate the extent of contamination by complementing the OCWD network of monitoring wells. The recommendations of the off-Station Remedial Investigation Work Plan were not implemented by the Station, but served as a starting point for the SAP for the Regional Groundwater VOC Investigation (Site 18).

In June 1988, the U.S. Environmental Protection Agency (EPA) recommended listing the Station on the National Priorities List (NPL) of the Superfund Program because of the presence of VOC contamination at the Station boundary and the detection of VOCs in the agricultural wells to the west. The Station was listed on the NPL in February 1990. An FFA among EPA, RWQCB, California Department of Health Services (now known as California EPA-DTSC) and Department of Navy was signed in October 1990.

In December 1989, the Jacobs Team was contracted to prepare an RI/FS Work Plan and associated documents for the Station. The team reviewed the reports cited above, as well as other documents pertinent to past disposal practices at the Station. The total number of sites to be investigated was 22 (including the regional groundwater VOC investigation as Site 18).

In May 1988, the Marine Corps submitted Air Solid Waste Assessment Test (SWAT) proposals for all four Station landfills to the South Coast Air Quality Management District (SCAQMD). Following SCAQMD approval, Strata Technologies, Inc. conducted the field work (meteorological and geophysical surveys, and sampling of landfill gas, ambient air, and surface gas) and issued draft reports in October 1990 (Strata, 1990). The geophysical surveys using ground-penetrating radar (GPR) were partially successful at defining the landfill perimeters. TCE, PCE, chloroform, and benzene were detected in landfill gas samples in concentrations above the minimum detection limits determined by the California Air Resources Board (CARB). Methylene chloride (MeCl) has also been detected in the landfill gasses at the Station; due to inadequate decontamination procedures, however, the field system blanks were also contaminated with MeCl. The ambient air samples collected at the Station landfills contained concentrations of MeCl, trichloroethane (TCA), and PCE near the CARB detection limits; these concentrations, based on upwind and downwind measurements, were not necessarily attributable to emissions from these landfills.

1.3.3.2 Ongoing Related Investigations

Two related ongoing investigations are being conducted at MCAS El Toro under RCRA: a RCRA Facilities Assessment (RFA) to evaluate whether an additional 140 sites at MCAS El Toro require further investigation under the RI/FS program and an Underground Storage Tank (UST) investigation at the Tank 398 Area. The draft

RFA Report was submitted in March 1993 and is summarized in Section 5.0 of this report. Investigations at the Tank 398 area to assess the extent the extent of subsurface JP-5 jet fuel contamination and evaluate potential remediation methods have been completed by Stollar and Associates (1990) and Jacobs (09 June 1992). Jacobs is currently completing a second phase of site investigation and treatability studies at the Tank 398 Area.

1.3.4 Regulatory Basis

This investigation is being conducted under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 as amended. The work was planned and performed in accordance with the National Contingency Plan (NCP) and with guidance developed by EPA for implementation of the NCP *(Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA, October 1988, OSWER Directive 9355.3-01).*

The EPA Superfund program requires that hazardous waste sites listed on EPA's National Priorities List (NPL) undergo a Remedial Investigation/Feasibility Study (RI/FS). The RI determines the nature and extent of contamination and assesses whether the site poses a risk to human health and the environment. If risk exists, an FS is conducted to evaluate remedial responses. Because of the size and complexity of many NPL sites, this work is often conducted in phases: preliminary site investigation, followed by preliminary evaluations of remedial responses, leading to further site investigation, and then final analysis of potential remedial alternatives. Reports to document this work following EPA RI/FS guidance must then be developed for public review and comment.

MCAS El Toro was placed on the NPL on in February 1990. In October 1990 EPA, the State of California Department of Health Services (DHS), the Santa Ana Regional Water Quality Control Board (RWQCB) and the Department of Navy signed a Federal Facilities Agreement (FFA) to conduct an RI/FS for MCAS El Toro following the NCP and EPA Guidance. Under the FFA, the Department of Navy is the lead agency; EPA and the State of California (now known as California EPA-Department of Toxic Substances Control [DTSC]) perform oversight roles.

The Navy has now completed Phase 1 of the RI for 22 sites identified for evaluation in three operable units (OUs). This document, the MCAS El Toro Phase I RI Technical Memorandum (TM), is submitted in fulfillment of an FFA milestone as a summary of the Phase I results. This TM is not intended as a full RI Report as described and outlined in the EPA RI/FS Guidance (EPA, 1988). Following completion of the full RI/FS, a comprehensive RI Report will be developed in accordance with the NCP and EPA Guidance.

In March 1993, MCAS El Toro was on the proposed list (BRACI III) of military facilities considered for base closures.

Under the terms of the FFA, base closure would not affect the Navy's obligations to conduct the RI/FS and to comply with the other requirements of the FFA (FFA Section 37, "Base Closure.")

1.3.5 Topography and Geography

MCAS El Toro is situated on the edge of the Tustin Plain, a gently sloping surface of alluvial fan deposits derived mainly from the Santa Ana Mountains (Yerkes et al., 1965, Figure 1-3). The Tustin Plain, bounded on the north and east by the Santa Ana Mountains and on the south by the San Joaquin Hills, is at the southeast end of the Los Angeles Basin, a large sedimentary basin in the Peninsular Ranges Geologic Province (Yerkes et al., 1965). The plain also lies in the so-called "Central Block" of the Los Angeles Basin, which is bounded on the north by the Whittier fault zone and on the south by the Newport-Inglewood Fault zone (CDMG, 1984).

MCAS El Toro extends across the Tustin Plain into the Santa Ana Mountains. Most of the Station slopes gently down to the west-southwest. Elevations range from about 215 feet above mean sea level (msl) in the west corner of the facility to about 800 feet above msl in the east corner in the foothills of the Santa Ana Mountains (Figure 1-4). The Santa Ana Mountains rise steeply north and east of the station; their highest peak (6,698 feet) is 10 miles east of the Station (Brown and Caldwell, 1986). The San Joaquin Hills slope up gradually to the south; their highest point (1,170 feet above msl) is 10 miles south of the Station (Brown and Caldwell (B), 1986). The land to the northwest of the Station is relatively level.

1.3.6 Weather and Climate

MCAS El Toro has a Mediterranean Climate, characterized by cool, moist winters and warm, dry summers. Early morning fogs are typical of the late spring and early summer. Annual precipitation averages 12.2 inches with most occurring in November through April. Winter temperatures seldom drop below freezing; the mean low is 37 degrees Fahrenheit (F) (SAP, 1991). Summer temperatures rarely exceed 100 degrees F. Night temperatures are generally cool throughout the year. From March through October, the prevailing wind is from the west and averages 6 knots. From November through February, the prevailing wind is from the east and averages 4 knots. During the late fall and early winter, strong dry gusty offshore winds (known locally as "Santa Ana winds") are common.

Table 1-1 provides average temperatures, precipitation, and wind speeds for MCAS El Toro by month.

1.3.7 Soils

The fate and transport of soil contaminants depend, in part, on the soil properties of permeability, porosity, organic matter content, and mineral surface area available for cation exchange.

Soils are a function of parent material, topography, climate, and time. A soil series consists of a group of soils with almost identical profiles. All the soils in a given series have major horizons that are similar in thickness, sequence, characteristics, except for different textures in the surface layers.

Within the MCAS El Toro boundary and in the area south of Irvine Center Boulevard, only four soil mapping units are recognized (Figure 1-5) (Wachtell, 1978). Another dozen or so units occur in the foothills portion of the Station. The Myford sandy loam, with thick surface, and 2 to 9 percent slopes, predominates in the southern corner of the Station. The Sorrento loam, with 2 to 9 percent slopes occurs in a band stretching from the western corner eastward across the Station. The San Emigdio fine sandy loam with 0 to 2 percent slopes occurs in the northern corner of the Station. The nearly level Metz loamy sand occupies an area along the northeast portion of the Station.

The soil mapping units in the foothill portion of MCAS El Toro are more numerous and occur in smaller discreet units. The difference between the main portion of the Station and the outlying area is that in the foothills the parent materials are more heterogeneous and the slopes differ. Table 1-2 summaries the properties of the soil units on-Station and in the vicinity of MCAS El Toro.

Each soil mapping unit belongs to one of four hydrologic soil groups (Wachtell, 1978), as summarized in the following table. These groups define how well water will infiltrate into the soil when it is saturated.

- Group A Soils - High infiltration rate (and low runoff potential) even when thoroughly wet, and a high rate of water transmission.
- Group B Soils - Moderate infiltration rate when thoroughly wet, and a moderately fine to moderately coarse texture.
- Group C Soils - Slow infiltration rate when thoroughly wet, and a moderately fine or fine texture that retards water transmission.
- Group D Soils - Very slow infiltration rate (with a high runoff potential) when thoroughly wet.

The distribution of these soil groups at the Phase I RI sites is summarized below.

Phase I RI Site	Hydrologic Soil Group(s)
1	B and D
2	A and C
3 and 4	A
17	B, C and D
5-16, 19, 20, and 22	B

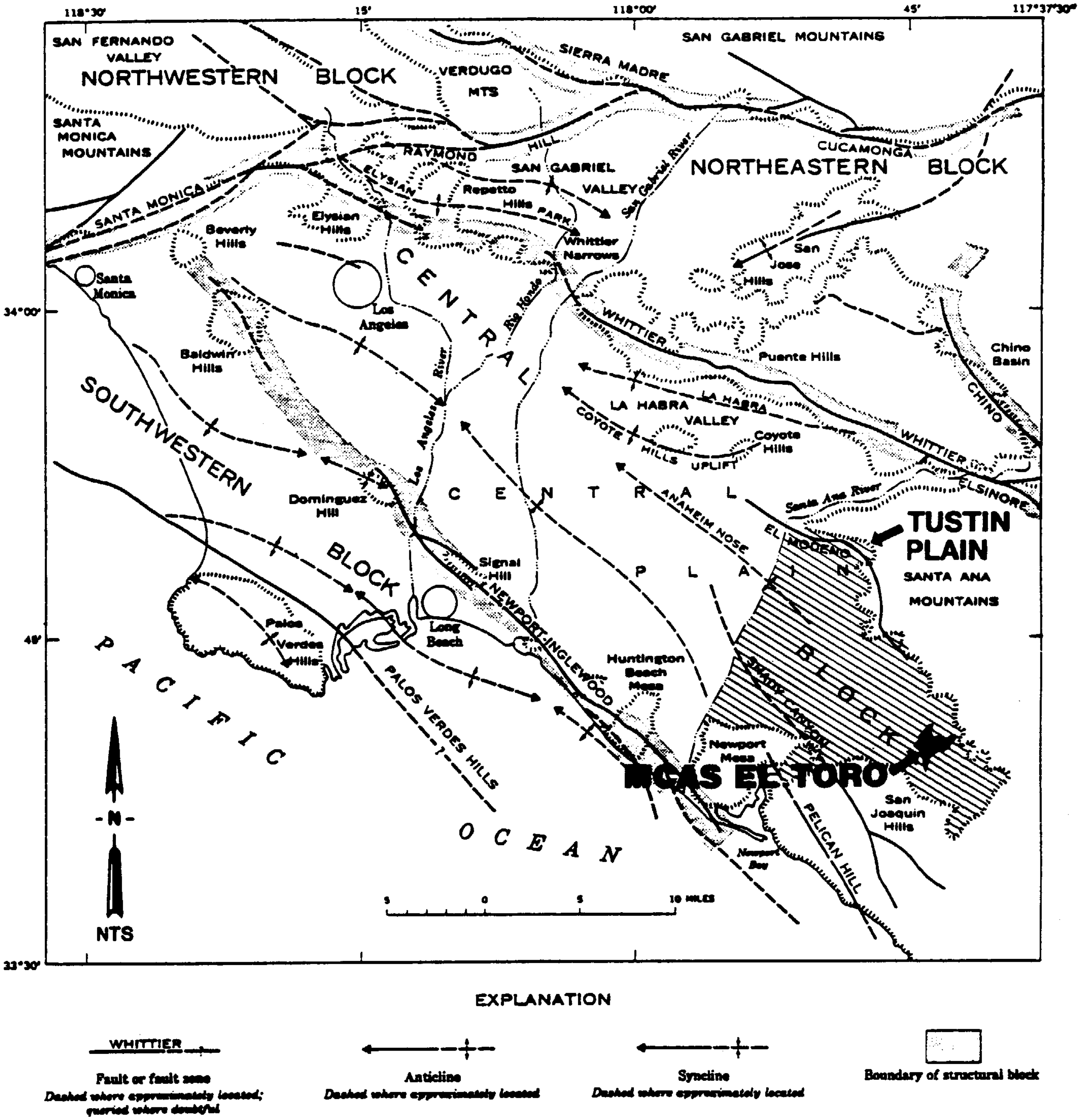

FIGURE 1-3
MAJOR STRUCTURAL AND PHYSIOGRAPHIC FEATURES OF THE LOS ANGELES BASIN
MCAS EL TORO PHASE I RI TECHNICAL MEMORANDUM

SOURCE: YERKES, ET AL, 1965

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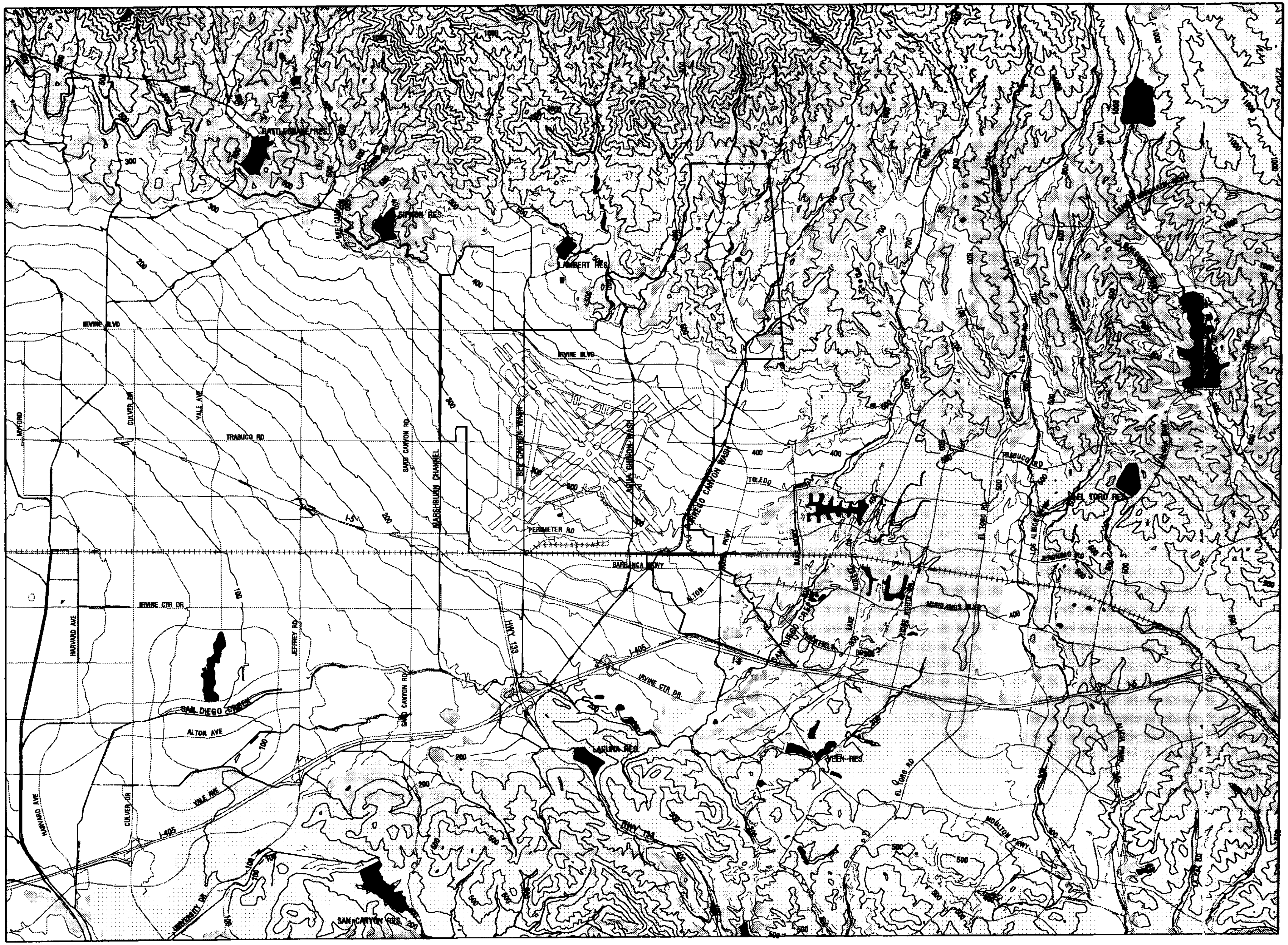

FIGURE 1-4
REGIONAL TOPOGRAPHIC CONTOURS AND SURFACE WATER FEATURES

MCAS EL TORO PHASE I RI
TECHNICAL MEMORANDUM

PAGE NUMBER 1-20

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FEATURES:

MCAS EL TORO

LAKE OR RESERVOIR

ROAD

RAILROAD

AIRFIELD

WASH OR STREAM

SOIL UNITS:
BALCOM 112,113
BOSANKO 127,128
BOTELLA 133
CALLEGUAS 134
CAPISTRANO 136
CIENEBA 141,142
CORRALITOS 146
CROPLEY 149
METZ 163
MOCHO 167
MYFORD 173,175,176,177,179
PITS 185
RIVERWASH 191
SAN ANDREAS 193
SAN EMIGDIO 194,195
SOPER 202
SORRENTO 205,206,207,208,209
UNKNOWN 999

SOURCE: WACHTELL, 1989

N

0 1400 2800 5600
SCALE IN FEET

FIGURE 1-5
ON-STATION SOIL UNITS

MCAS EL TORO PHASE I RI
TECHNICAL MEMORANDUM

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Table 1-1
Climate at MCAS El Toro (Annual Averages)
MCAS El Toro Phase I RI Technical Memorandum

Period	Temperature			Average Precipitation (in.)	Surface Wind	
	Average Low (°F)	Average (°F)	Average High (°F)		Most Frequent Direction	Average Speed (knots)
January	45	55	65	2.4	E	4
February	46	56	66	2.1	E	4
March	47	57	67	2.3	W	5
April	49	60	70	1.1	W	7
May	53	63	72	0.2	W	6
June	57	67	77	0.1	W	6
July	61	67	82	0.1	W	6
August	62	72	83	trace	W	6
September	60	71	82	0.3	W	6
October	56	67	77	0.3	W	6
November	50	61	71	1.5	E	4
December	46	56	66	1.8	E	4
Annual Average	53	63	73			5
Average Annual Total				12.2		

Source: USMC, 1992

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Table 1-2
Summary of Local Soils Data
MCAS El Toro Phase I RI Technical Memorandum

Page 1 of 5

ID No.	Soil Series and Phase Name (Slope in %)	Depth[a] (in)	Parent Material	Perme-ability (in/hr)	Available Water (in/in)	pH Range	Hyd. Grp[b]	RI/FS Sites
100	Alo clay 9-30	25	Calcareous sandstone & shale	0.06-0.2	0.14-0.17	6.1-8.4	D	
101	Alo clay 15-30	25	Calcareous sandstone & shale	0.06-0.2	0.14-0.17	6.1-8.4	D	
102	Alo clay 30-50	25	Calcareous sandstone & shale	0.06-0.2	0.14-0.17	6.1-8.4	D	
104	Alo Variant clay 15-30	40	Calcareous sandstone & shale	0.06-0.2	0.14-0.17	6.1-8.4	D	
105	Alo Variant clay 30-50	40	Calcareous sandstone & shale	0.06-0.2	0.14-0.17	6.1-8.4	D	
106	Anaheim loam 15-30	26	Sandstone & shale	0.6-2.0	0.15-0.17	6.1-7.8	C	
107	Anaheim loam 30-50	26	Sandstone & shale	0.6-2.0	0.15-0.17	6.1-7.8	C	
108	Anaheim clay loam 15-30	26	Sandstone & shale	0.2-0.6	0.17-0.19	6.1-7.8	C	
109	Anaheim clay loam 30-50	26	Sandstone & shale	0.2-0.6	0.17-0.19	6.1-7.8	C	
110	Anaheim clay loam 50-75	26	Sandstone & shale	0.2-0.6	0.17-0.19	6.1-7.8	C	
111	Balcom clay loam 9-15	30	Sandstone, calcareous shale & marl	0.2-0.6	0.15-0.17	7.9-8.4	B	
112	Balcom clay loam 15-30	30	Sandstone, calcareous shale & marl	0.2-0.6	0.15-0.17	7.9-8.4	B	1
113	Balcom clay loam 30-50	30	Sandstone, calcareous shale & marl	0.2-0.6	0.15-0.17	7.9-8.4	B	1
117	Blasingame stony loam 9-30	26	Metamorphic or granitic rocks	0.6-2.0	0.11-0.13	6.1-7.3	C	
126	Bosanko clay 9-15	37	Sandstone & calcareous shale	0.06-0.2	0.14-0.17	6.1-8.4	D	
127	Bosanko clay 15-30	37	Sandstone & calcareous shale	0.06-0.2	0.14-0.17	6.1-8.4	D	
128	Bosanko clay 30-50	37	Sandstone & calcareous shale	0.06-0.2	0.14-0.17	6.1-8.4	D	
129	Bosanko-Balcom complex 15-30	37	Sandstone & calcareous shale	0.06-0.2	0.14-0.17	6.1-8.4	D	

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Table 1-2
Summary of Local Soils Data
MCAS El Toro Phase I RI Technical Memorandum

Page 2 of 5

ID No.	Soil Series and Phase Name (Slope in %)		Depth[a] (in)	Parent Material	Perme-ability (in/hr)	Available Water (in/in)	pH Range	Hyd. Grp[b]	RI/FS Sites
130	Bosanko-Balcom complex	30-50	37	Sandstone & calcareous shale	0.06-0.2	0.14-0.17	6.1-8.4	D	
131	Botella loam	2-9	66	Alluvial fans	0.6-2.0	0.15-0.18	6.1-7.3	B	
132	Botella clay loam	2-9	66	Alluvial fans	0.6-2.0	0.15-0.18	6.1-7.3	B	
133	Botella clay loam	9-15	66	Alluvial fans	0.2-0.6	0.15-0.18	6.1-7.3	B	17
134	Calleguas clay loam	50-75	15	Calcareous sandstone & shale	0.6-2.0	0.15-0.18	7.9-8.4	D	1
135	Capistrano sandy loam	2-9	65	Granitic alluvium	2.0-6.0	0.09-0.13	5.6-7.3	B	
136	Capistrano sandy loam	9-15	65	Granitic alluvium	2.0-6.0	0.09-0.13	5.6-7.3	B	
139	Chino silty clay loam	0-2	60	Alluvial fans	0.2-0.6	0.16-0.22	7.9-8.4	C	
140	Chino silty clay loam	0-2	60	Alluvial fans	0.2-0.6	0.16-0.22	7.9-8.4	C	
141	Cieneba sandy loam	15-30	17	Granitic rocks	2.0-6.0	0.13-0.16	5.6-7.3	C	
142	Cieneba sandy loam, eroded	30-75	7	Granitic rocks	2.0-6.0	0.13-0.16	5.6-7.3	C	
145	Cieneba-Rock outcrop complex	30-75	7	Granitic rocks	20.-6.0	0.13-0.16	5.6-7.3	C	
146	Corralitos loamy sand	0-2	80	Alluvial fans	6.0-20	0.07-0.09	5.6-7.3	A	
147	Corralitos loamy sand, moderately fine substratum	0-2	80	Alluvial fans	6.0-20	0.07-0.09	5.6-7.3	A	
149	Cropley clay	2-9	65	Alluvial fans	0.06-0.2	0.13-0.17	6.6-8.4	D	1

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Table 1-2
Summary of Local Soils Data
MCAS El Toro Phase I RI Technical Memorandum

Page 3 of 5

ID No.	Soil Series and Phase Name (Slope In %)		Depth[a] (in)	Parent Material	Perme-ability (in/hr)	Available Water (in/in)	pH Range	Hyd. Grp[b]	RI/FS Sites
154	Gabino gravelly clay loam	15-50	38	Alluvial terraces, with conglom-erate	0.2-0.6	0.12-0.17	5.6-6.5	D	
163	Metz loamy sand	0-2	63	Alluvial fans & flood plains	6.0-20	0.07-0.11	6.6-8.4	A	2,3,4
164	Metz loamy sand, moderately fine substratum	0-2	63	Alluvial fans & flood plains	6.0-20	0.07-0.11	6.6-8.4	A	
165	Mocho sandy loam	0-2	61	Alluvial fans & flood plains	0.6-2.0	0.16-0.20	7.9-8.4	B	
166	Mocho loam	0-2	61	Alluvial fans & flood plains	0.6-2.0	0.16-0.20	7.9-8.4	B	
167	Mocho loam	2-9	61	Alluvial fans	0.6-2.0	0.16-0.20	7.9-8.4	B	
173	Myford sandy loam	2-9	79	Marine terraces	2.0-6.0	0.10-0.14	5.1-6.0	D	
174	Myford sandy loam, eroded	2-9	79	Marine terraces	2.0-6.0	0.10-0.14	5.1-6.0	D	
175	Myford sandy loam	9-15	79	Marine terraces	2.0-6.0	0.10-0.14	5.1-6.0	D	
176	Myford sandy loam	15-30	79	Marine terraces	2.0-6.0	0.10-0.14	5.1-6.0	D	
177	Myford sandy loam, eroded	9-30	79	Marine terraces	2.0-6.0	0.10-0.14	5.1-6.0	D	
178	Myford sandy loam, thick surface	0-2	79	Marine terraces	2.0-6.0	0.10-0.14	5.1-6.0	D	
179	Myford sandy loam, thick surface	2-9	79	Marine terraces	2.0-6.0	0.10-0.14	5.1-6.0	D	
184	Omni clay drained	0-2	60	Flood plains	0.06-0.6	0.14-0.20	7.9-9.0	D	
185	Pits			Miscellaneous					

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Table 1-2
Summary of Local Soils Data
MCAS El Toro Phase I RI Technical Memorandum

Page 4 of 5

ID No.	Soil Series and Phase Name (Slope in %)		Depth[a] (in)	Parent Material	Perme-ability (in/hr)	Available Water (in/in)	pH Range	Hyd. Grp[b]	RI/FS Sites
191	Riverwash			Alluvium					2
192	Rock outcrop - Cieneba complex	30-75		Sandstone or granite					
193	San Andreas sandy loam	15-30	31	Sandstone	2.0-6.0	0.11-0.17	5.6-6.5	B	
194	San Emigdio fine sandy loam	0-2	67	Alluvial fans & flood plains	2.0-6.0	0.12-0.17	7.9-8.4	B	20
195	San Emigdio fine sandy loam	2-9	61	Alluvial fans & flood plains	2.0-6.0	0.12-0.17	7.9-8.4	B	1
196	San Emigdio fine sandy loam, moderately fine substratum	0-2	61	Alluvial fans & flood plains	2.0-6.0	0.12-0.17	7.9-8.4	B	
200	Soper loam	30-50	29	Sandstone & conglom-erate	0.6-2.0	0.15-0.20	6.1-7.3	C	2
202	Soper gravelly loam	30-50	29	Sandstone & conglom-erate	0.6-2.0	0.13-0.18	6.1-7.3	C	17
203	Soper cobbly loam	15-50	29	Sandstone & conglom-erate	0.6-2.0	0.13-0.18	6.1-7.3	C	
205	Sorrento sandy loam	0-2	72	Alluvial fans & flood plains	2.0-6.0	0.15-0.18	6.1-8.4	B	
206	Sorrento loam	0-2	72	Alluvial fans & flood plains	0.6-2.0	0.16-0.21	6.1-8.4	B	1, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 19, 21, 22
207	Sorrento loam	2-9	72	Alluvial fans & flood plains	0.6-2.0	0.16-0.21	6.1-8.4	B	1

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Table 1-2
Summary of Local Soils Data
MCAS El Toro Phase I RI Technical Memorandum

ID No.	Soil Series and Phase Name (Slope in %)	Depth[a] (in)	Parent Material	Perme-ability (in/hr)	Available Water (in/in)	pH Range	Hyd. Grp[b]	RI/FS Sites
208	Sorrento clay loam 0-2	72	Alluvial fans & flood plains	0.6-2.0	0.18-0.21	6.1-8.4	B	
209	Sorrento clay loam slope 2-9	72	Alluvial fans & flood plains	0.6-2.0	0.18-0.21	6.1-8.4	B	
217	Xeralfic Arents 2-9	60	Cut and fill terraces					
221	Yorba gravelly sandy loam 2-9	63	Alluvial terraces	0.6-6.0	0.07-0.10	5.6-6.5	D	
222	Yorba gravelly sandy loam 9-15	63	Alluvial terraces	0.6-6.0	0.07-0.10	5.6-6.5	D	
224	Yorba cobbly sandy loam 9-30	63	Alluvial terraces	0.6-6.0	0.07-0.10	5.6-6.5	D	
225	Yorba cobbly sandy loam, eroded 9-30	63	Alluvial terraces	0.6-6.0	0.07-0.10	5.6-6.5	D	
226	Yorba cobbly sandy loam 30-50	63	Alluvial terraces	0.6-6.0	0.07-0.10	5.6-6.5	D	

Source: Wachtell, 1978.
[a]Maximum depth of the soil profile above bedrock or weathered bedrock
[b]Hydrologic Soil Group - indicative of runoff from precipitation:
- Group A: High infiltration
- Group B: Moderate infiltration
- Group C: Slow infiltration
- Group D: Very slow infiltration

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The hydrologic soil groups are an indicator of the potential for mobile aqueous phase contaminants to migrate vertically into the soil.

1.3.8 Geology

This subsection provides a summary of background information on the geology of the MCAS El Toro vicinity. A discussion of the interpreted subsurface geology at MCAS El Toro based on the data derived from the Phase I RI is provided in Section 3.1 Additional geologic cross sections of the 22 RI sites are provided in Appendix A-1 and B-1 through B-22.

1.3.8.1 Stratigraphy

MCAS El Toro is chiefly underlain by Tertiary sedimentary rocks, which are overlain by Quaternary surficial units. Five (1974) reports that the Cenozoic rocks have a maximum composite exposed thickness of 5,000 feet in the south half of the El Toro Quadrangle. The rest of the study area consists of Cretaceous sedimentary rocks and slightly metamorphosed Jurassic sedimentary and volcanic rocks. The geologic units are discussed in more detail below, from most recent to older units. Figure 1-6 shows the stratigraphic units described below. Table 1-3 summarizes stratigraphic information for the MCAS El Toro area (formation names, geologic ages, and approximate thickness).

MCAS El Toro lies on alluvial fan deposits derived mainly from the Santa Ana Mountains. These Holocene materials consist of isolated coarse-grained stream-channel deposits contained within a matrix of fine-grained overbank deposits that range in thickness up to 300 feet (Herndon and Reilly, 1989). The eastern portion of Tustin Plan, near MCAS El Toro, is discussed in Section 3.

The Holocene alluvial materials conformably overlie Pleistocene Age sediments predominantly composed of interlayered fine-grained lagoonal and near-shore marine deposits. These materials become increasingly mixed with beach sands, terrace, and stream-channel deposits in the eastern portion of the Tustin Plain and along the plain margins. Thus, the Quaternary deposits form a heterogeneous mixture of silts and clays with interbedded sands and fine gravels that range in thickness up to 500 feet in the western portion of the Tustin Plain (Singer, 1973). The eastern portion of Tustin Plain, near MCAS El Toro, is discussed in Section 3.

The deeper Quaternary sediments may be equivalent to the lower Pleistocene San Pedro Formation, which consists of semiconsolidated silts, clays, and sands with interbedded limestone. These lagoonal and shallow marine deposits are considered to be a major water-bearing unit in the region, but may not extend beneath MCAS El Toro (Brown and Caldwell, 1986).

The Pleistocene deposits unconformably overlie older semiconsolidated marine sandstones, siltstones, and conglomerates of late Miocene to late Pliocene age; these units comprise the Niguel, Fernando, and Capistrano Formations. These semiconsolidated sediments are considered the top of the bedrock near MCAS El Toro. The lower Pliocene Fernando Formation, considered to be the major aquifer in the Irvine area, is the base of the water-bearing units (Herndon and Reilly, 1989). This formation probably interfingers with marine clayey and sandy siltstones of the Capistrano and Niguel Formations west of MCAS El Toro, and together they range up to 1,500 feet in thickness (JMM, 1988).

Beneath the semiconsolidated rocks lie a very thick sequence of interbedded Paleocene, Eocene, and Miocene marine and nonmarine sedimentary rocks and volcanic rocks of the Puente, Monterey, Topanga, Vaqueros, Sespe, Santiago, and Silverado Formations (Table 1-3). The Vaqueros and Sespe Formations that crop out in the Santa Ana Mountains northeast of MCAS El Toro are not differentiated.

Beneath the Cenozoic rocks are several thousand feet of Cretaceous sandstone, siltstone, and conglomerate of the Williams, Ladd, and Trabuco Formations that are found in the subsurface only (Fife, 1974, and Yerkes et al., 1965). The Cretaceous units nonconformably overlie Jurassic basement of crystalline metamorphic and igneous rocks. The Cretaceous units, which crop out in the

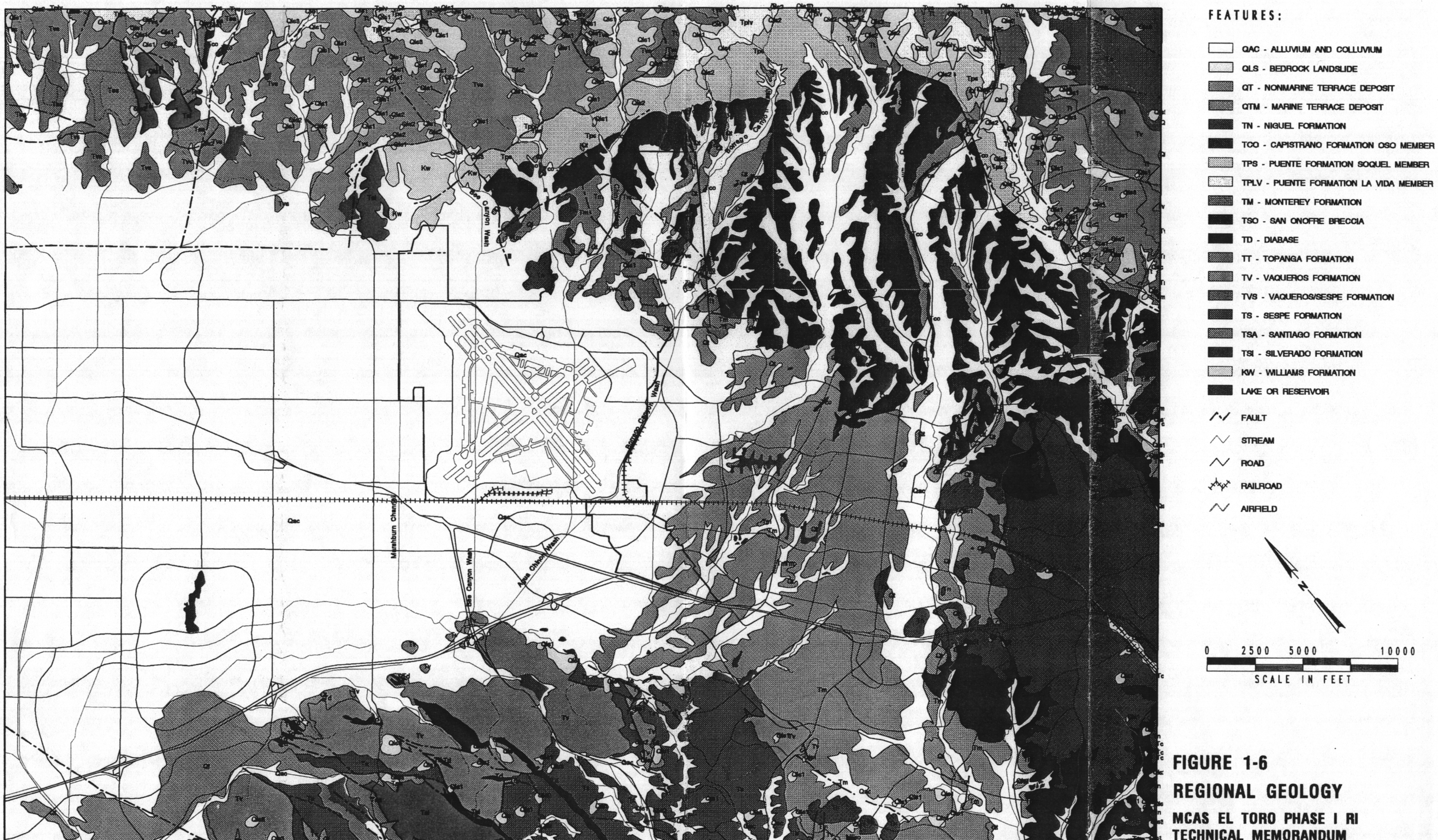

FIGURE 1-6
REGIONAL GEOLOGY
MCAS EL TORO PHASE I RI
TECHNICAL MEMORANDUM

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Table 1-3
Stratigraphic Units Near MCAS El Toro
MCAS El Toro Phase I RI Technical Memorandum

Geologic Time			Formation or Geologic Unit	Approximate Thickness (ft.)[a]
Era	Period	Epoch		
Cenozoic	Quaternary	Holocene	Alluvial, stream terrace, and beach deposits	Up to 300[b]
		Pleistocene	Marine terrace deposits and nonmarine fluvial terrace deposits	O to 350
			San Pedro	Up to 1,000
	Tertiary	Pliocene	Niguel	350
			Fernando	1,300
			Capistrano	2,400
		Miocene	Puente	2,000
			Monterey	>1,500
			Diabase	
			Topanga	>1,500
			Vaqueros	Up to 3,800
		Eocene	Sespe	2,450
			Santiago	>775
		Paleocene	Silverado	1,875
Mesozoic	Cretaceous		Williams	1,500
			Ladd	>1,000
			Trabuco	575
	Jurassic		Santiago Peak Volcanics	1,500
			Bedford Canyon	Unknown

[a]Yerkes et al., 1965
[b]Herndon and Reilly, 1989

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Santa Ana Mountains, include slightly metamorphosed sedimentary and volcanic rocks of the Bedford Canyon Formation and the Santiago Peak Volcanics (Fife, 1974).

1.3.8.2 Structural Geology

As discussed earlier, MCAS El Toro is on the Tustin Plain at the southeastern end of the Los Angeles Basin. The Tustin Plain basin boundaries are discussed in Section 1.3.5. The Los Angeles Basin is characterized by a northwest-trending, doubly plunging synclinal trough, greater than 30,000 feet deep. The depression of the Los Angeles Basin began in middle Miocene time. The basin boundaries are described in more detail in Section 3.1.2.

In the study area, several faults and folds are found on the flanks of the Los Angeles Basin syncline (Figure 1-3). Three northwest trending faults (Shady Canyon, Pelican Hill, and Newport-Inglewood) are less than 10 miles southwest of the Station. The Shady Canyon Fault is a normal fault with the west side down. The Pelican Hill Fault, probably a branch of the Newport-Inglewood Fault, is a right-lateral strike-slip fault (Miller and Tan, 1976). Of these faults, only the Newport-Inglewood Fault (also a right-lateral strike-slip fault) is considered active, with Holocene movement. The Cristianitos Fault, a north-south trending high-angle normal fault, is 3 miles east of MCAS El Toro. This fault appears to converge with a system of northwest trending frontal faults along the southwest side of the Santa Ana Mountains (Fife, 1974). The Elsinore-Whittier and the San Andreas Faults are 13 and 30 miles north of MCAS El Toro, respectively. Information on faults in the vicinity of MCAS El Toro is summarized in Table 1-4 (fault names, location in relation to MCAS El Toro, fault types, fault orientation, movement direction, and time of most recent reported movement).

1.3.9 Groundwater and Hydrogeology

MCAS El Toro lies within the Irvine Groundwater Basin (Irvine Basin), a subbasin of the Los Angeles Groundwater Basin. The Irvine Basin is located southeast and adjacent to the Main Orange County Groundwater Basin (Figure 1-7, Groundwater Basin Boundaries near MCAS El Toro).

Although the aquifers beneath the Irvine Basin are in hydraulic contact with the Main Orange County Groundwater Basin, it is difficult to make correlations among specific aquifer zones. This is due to a facies change in which coarse coastal plain sediments in the Main Basin grade into finer-grained bay-type deposits near the western boundary of the Irvine Basin (Banks et al., 1984). Aquifers in the Irvine area are much thinner, separated by thicker sequences of clay and silt layers, are less continuous, have less areal extent, and have lower permeabilities (Banks et al., 1984).

Aquifer zones in the Irvine Subbasin tend to be composed of occasional discontinuous lenses of clayey and silty sands and fine gravels contained within acomplex assemblage of sandy clays and sandy silts. Herndon (1990) indicated that coarser-grained sediments northwest of the Station appear to form elongated deposits aligned in the general direction of San Diego Creek. Herndon and Reilly (1989) have indicated that the sandy lenticular nature of the aquitards (silts and clays) probably allows groundwater to flow between the aquifer zones. Thus, rather than being separated into identifiable aquifers that may be correlated from place to place, the groundwater may be considered to flow in a single, large-scale heterogeneous system (Herndon and Reilly, 1989). In addition, Phase I results indicate possible westerly oriented permeable sediments, normal to the strike of the Santa Ana Mountains, at MCAS El Toro (see Section 3).

1.3.9.1 Hydrogeologic Units

Geologic and hydrogeologic units in the Irvine area have been correlated in several reports, including Banks et al., 1984; Camp, Dresser, and McKee, 1984; Brown and Caldwell, 1986; and California Department of Water Resources, 1967. (See Table 1-5, [Correlation of Geologic and Hydrogeologic Units]). Three general aquifer systems have been identified near the Station: a shallow and perched aquifer system, a middle or principal aquifer zone, and a lower hydrogeologic system (bedrock near the Station).

Table 1-4
Faults in the Vicinity of MCAS El Toro
MCAS EL Toro Phase I RI Technical Memorandum

Fault	Location (from Station)	Orientation	Type	Movement Direction	Latest Reported Movement
Shady Canyon	4 miles SW	NW	Normal	SW down	Pre-middle Miocene[a]
Pelican Hill	7 miles SW	NW	Strike-slip	Right-lateral	Late Pliocene[b]
Newport-Inglewood	10 miles SW[c]	NW	Strike-slip	Right-lateral	Quaternary
San Andreas	43 miles NE[c]	NW	Strike-slip	Right-lateral	Holocene
San Jacinto	36 miles NE	NW	Strike-slip	Right-lateral	Holocene
Elsinore-Whittier	14 miles NE[c]	NW	Strike-slip	Right-lateral	Holocene
Christianitos	3 miles E	N	Normal	W down	Pliocene

[a]Yerkes et al., 1965
[b]Brown and Caldwell, 1986
[c]Fife, 1974

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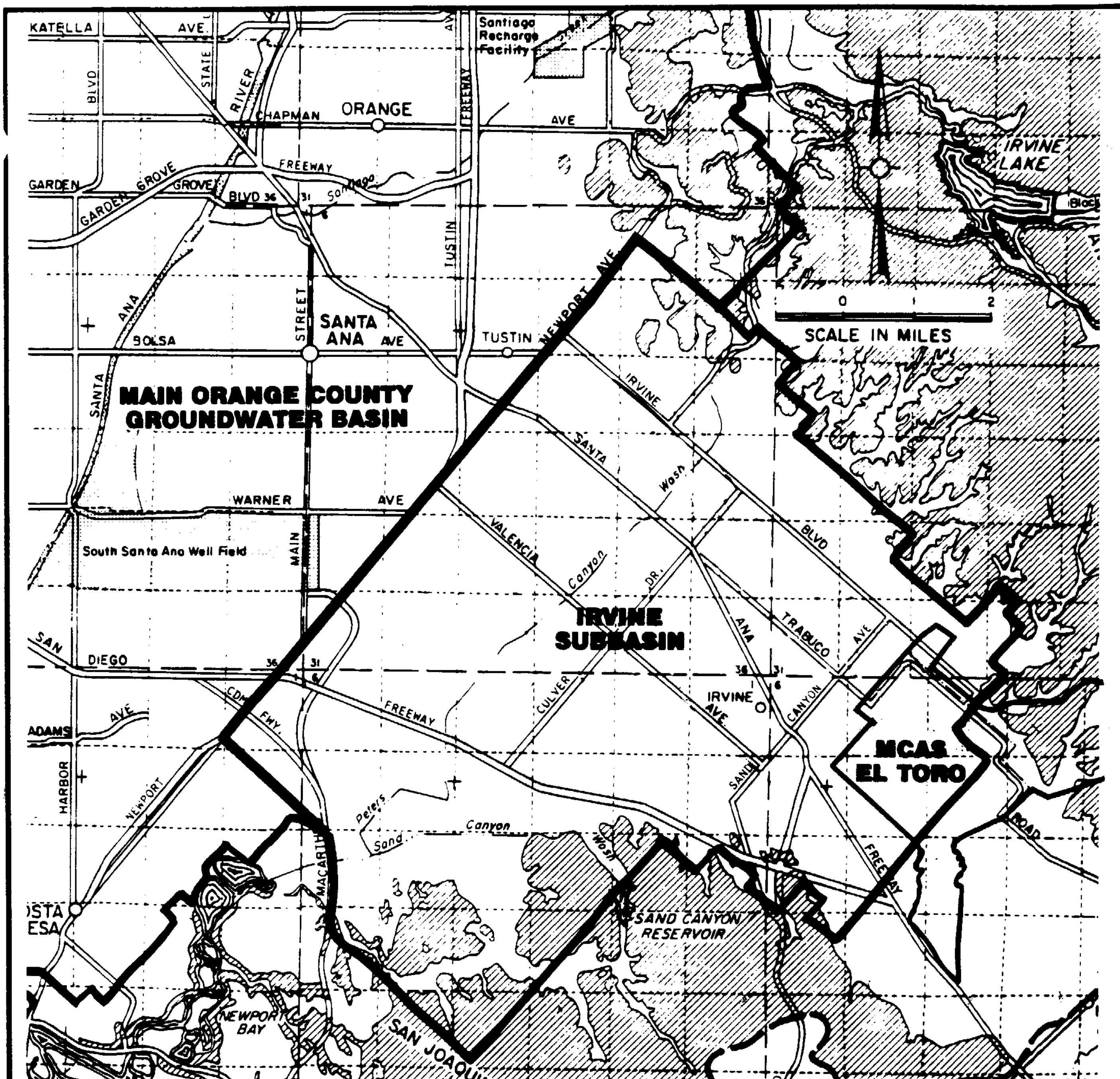

LEGEND

BEDROCK

FIGURE 1-7
GROUNDWATER BASIN BOUNDARIES NEAR AND AT MCAS EL TORO
MCAS EL TORO PHASE I RI TECHNICAL MEMORANDUM

Source: Banks, 1984 and California DWR, 1967

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Near MCAS El Toro, localized perched or semi-perched aquifers occur in the shallow aquifer system to depths of about 200 feet below ground surface (bgs) (Singer, 1973). However, Phase I results indicate very little perching at the Station. The shallow aquifers at the Station are semi-confined units which become increasingly confined with depth (see Section 3). Aquifer sediments consist of Holocene and late Pleistocene alluvium and terrace deposits. This aquifer system is separated from the systems below by extensive silt and clay layers (Brown and Caldwell, 1986).

The principal aquifer zone occurs between 100 and 750 feet bgs. This aquifer system, which is the main water production zone for the Irvine area, chiefly comprises the early Pleistocene San Pedro Formation in the eastern Tustin Plain (Brown and Caldwell, 1986). Beneath the Station, this zone is likely comprised of Pleistocene terrace and alluvial deposits. Phase I results are discussed in Section 3.

The lower hydrogeologic system, defined here as bedrock, comprises pre-Quaternary, semiconsolidated, low-permeability sedimentary rocks. Near the Station, these sediments have been classified by Banks (1984) as nonwater-bearing (aquitards) based on well logs. Herndon (1990) reports an average depth to bedrock of 500 to 600 feet along Irvine Center Drive. The depth to bedrock decreases abruptly to the southwest along San Diego Creek (150 to 250 feet bgs) and deepens to the northwest (over 1,100 feet bgs at the edge of the Irvine Basin). During the Phase I, field investigation, even shallower bedrock depths were encountered along San Diego Creek (50 feet) (see Section 3).

1.3.9.2 Groundwater Recharge and Discharge

The groundwater system beneath the Tustin Plain has been divided into a forebay area and a pressure area. The forebay area lies along the margin of the Basin, where relatively shallow and coarse-grained sediments overlie semiconsolidated rock. Groundwater is thought to occur under unconfined conditions in this area. Recharge to the regional system takes place in the forebay area primarily along washes that exit the Santa Ana Mountains. The pressure area lies in the central portion of the basin, where sediments are thicker and relatively finer-grained. Productive aquifers in this area are present mainly in deeper zones that become increasingly confined with depth.

MCAS El Toro lies along the margin of the Tustin Basin groundwater system. Although the boundary between the forebay and pressure area varies seasonally and yearly according to the amount of groundwater recharge and withdrawal, the Station is situated mainly in the forebay area (Brown and Caldwell, 1986). Thus, geologic materials are relatively coarser than those in the central portion of the basin. However, Phase I field investigation results indicate that semiconfined rather than unconfined conditions occur at MCAS El Toro (see Section 3). Recharge to the regional system may take place on-Station as infiltration of surface water along washes and swales and as subsurface inflow along permeable zones. Groundwater discharges through irrigation wells or moves westward to the Main Orange County Basin (Banks et al., 1984). During 1989, about 10,000 acre-feet of groundwater were pumped from the Irvine Basin, mostly for irrigation during the summer months (Herndon, 1990).

1.3.9.3 Groundwater Flow

Horizontal Flow. In 1989, along the southwest perimeter of the facility, the depth to groundwater ranged from 82 to 122 feet bgs (JMM, 1990). Reduced pumping and water imports in the past 20 years have allowed groundwater levels to rise as much as 100 feet (SAP, 1991) (Herndon and Reilly, 1989). Groundwater within the foothills, where it occurs, is reported to be within 50 feet of the ground surface (JMM, 1988). Current depths to water, generally consistent with those above, are described in more detail in Section 3.

According to 1989 water levels, the direction of flow along the southwest boundary of MCAS El Toro was northwest at a gradient of 0.0066 (JMM, 1989). Current flow directions and gradients, which are similar to those above, are discussed in Section 3. Regional flow has been west and northwest since the 1940s, and controlled locally by large pumping depressions. In 1988, the regional

Table 1-5
Correlation of Geologic and Hydrogeologic Units in Tustin and Main Orange County Basins
MCAS El Toro Phase I RI Technical Memorandum

	Coastal Plain[a]	Brown & Caldwell (1986)		Aquifer System Designations				CDWR (1967)	
				CDM (1984)		Banks et al. (1984)			
Formation Name	**Name**	**Name**	**Depth (ft bgs)**	**Name**	**Depth (ft bgs)**	**Name**	**Depth (ft bgs)**	**Name**	**Thick-ness (ft)**
Recent Alluvium	Talbert	Shallow and Upper Aquifer System	Variable <200	Perched Zone	<10	Semi-perched		Upper Aquifer System	800 avg. to 1,100
Stream Terrace Deposits and Older Alluvium	Alpha Beta Lambda			Shallow Zone	Bottom, 300 Max.	Shallow	50 to 100		
San Pedro Formation	Omicron Rho Main	Middle Aquifer System	100	Deep Zone	Bottom, 950 Max.	Principal Aquifer Zone	200 to Base	Middle Aquifer System	<50 to >1,600
Fernando Group (Pico Formation Equivalent)		Lower Aquifer System	(Believed to be absent)	Not Included in this report		Lower Aquifer System	Top (1,300 to 1,900)	Lower Aquifer System	1,400+

Avg. = Average
Max. = Maximum
ft bgs = Feet below ground surface

Source: Initial Assessment Study, Brown & Caldwell, 1986.

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gradient was calculated to be 0.008 (Herndon and Reilly, 1989). From 1969 to 1982, Banks (1984) reported an average gradient of .0046 to the northwest in the principal aquifer zone in the Irvine area. Yearly gradients in the principal aquifer zone are summarized in Table 1-6 (Hydraulic Gradients in the Principal Aquifer Zone in the Irvine Area).

Vertical Flow. Vertical hydraulic gradients measured in multiple-completion wells west of the Station indicated downward flow in the upper 400 feet, probably in response to pumping in irrigation wells in this area (Herndon and Reilly, 1989). A downward vertical gradient may occur for the same reason at the Station. However, limited past investigations at MCAS El Toro have failed to detect a vertical gradient in multiple-depth cluster wells installed at the facility (JMM, 1990).

1.3.9.4 Hydraulic Parameters

Aquifer tests in monitoring wells installed on and near the Station generated hydraulic conductivity estimates of 2.2 to 36 feet per day (ft/day), with an average of 30 ft/day determined in a 72-hour aquifer test (JMM, 1990). A 72-hour test performed by OCWD in the basin west of the Station found the hydraulic conductivity to be 21 ft/day. The average linear groundwater velocity was estimated to be 0.7 to 4 ft/day (Herndon and Reilly, 1989). Phase I field investigation aquifer parameters are discussed in Section 3.1.3 and Appendix F.

Hydraulic parameters of aquifers in the Tustin Subbasin, Main Orange County Groundwater Basin, and the forebay and pressure areas are summarized in Table 1-7 (Hydraulic Parameters of Aquifers Near MCAS El Toro). In general, transmissivities of Irvine area aquifers are lower than those of Main Basin aquifers. Aquifer transmissivities range up to 13,000 ft^2/day in the Irvine Basin and from 8,000 to 40,000 ft^2/day in the Main Basin. Aquifer storage coefficients in the confined area range from 0.0005 to 0.0563. Specific yields of unconfined aquifers in the forebay area range from 0.036 to 0.2 (3.6 to 20 percent) (USGS, 1966; USGS, 1971; OCWD, 1983; and JMM, 1983).

1.3.9.5 Groundwater Chemistry

In addition to the VOC contamination described earlier, other contaminants have been associated with the historical degradation of shallow groundwater quality in the Irvine area. Increases in the levels of total dissolved solids (TDS), selenium, and nitrates in the groundwater have been related to agricultural activities and incursions of lower-quality water from the margins of the Basin under the influence of pumping wells. The largest area of groundwater remaining unaffected by this contamination lies in deeper zones in the central pressure area of the Basin (Banks et al., 1984).

Investigations by OCWD northwest of the Station have revealed the presence of three hydrochemical facies in groundwater related to depth in the aquifer (see Table 1-8, Hydrochemical Facies of Groundwater in the Irvine Basin). The first facies, characteristic of shallow groundwater lying within 200 feet of the ground surface, contains relatively high levels of TDS and nitrate and is dominated by calcium and sulfate ions. The second facies, characteristic of groundwater lying between 200 and 450 feet deep, contains lower levels of TDS and nitrate and is dominated by sodium, calcium, and bicarbonate ions; this zone is where VOC contamination has occurred. The third facies occurs in the lower hydrogeologic "bedrock" system at depths greater than 450 feet and contains relatively high levels of TDS, relatively low levels of nitrate, and is dominated by sodium and sulfate ions (Herndon and Reilly, 1989). Preliminary work performed at MCAS El Toro has generally confirmed these findings (JMM, 1990).

1.3.9.6 Groundwater Pumpage

Groundwater in the vicinity of the site is used largely for agriculture. Groundwater wells currently being so used include Wells TIC-107, TIC-108, TIC-111, and TIC-113 (northwest of the Station) and Wells TIC-47, TIC-78, TIC-106, and ET-1 (west of the Station) (OCWD, 1993). (See Plate 1-1 at the end of this section).

Potable water for the areas around MCAS El Toro is provided by the Metropolitan Water District (MWD). Water supplied to the central portion of Orange County

Table 1-6
Hydraulic Gradients in the Principal Aquifer Zone in the Irvine Area
MCAS El Toro Phase I RI Technical Memorandum

Year (as of 1 November)	Hydraulic Gradient 10^{-3} ft/ft
1969-70	2.4
1970-71	5.0
1971-72	NA
1972-73	5.8
1973-74	NA
1974-75	6.3
1975-76	4.7
1976-77	3.0
1977-78	7.0
1978-79	3.3
1979-80	3.9
1980-81	6.3
1981-82	2.6
Average	4.6

Source: Banks et al., 1984

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Table 1-7
Hydraulic Parameters near MCAS El Toro
MCAS El Toro Phase I RI Technical Memorandum

Source	Hydraulic Conductivity (K) (ft/day)	Transmissivity (T) (ft^2/day)	Specific Yield (S_y)	Storage Coefficient (S)
On or Near Station				
OCWD, 1989	21			
JMM, 1989	2.2 - 36 30 average			
Irvine Area				
OCWD, 1989		2,000 - 5,500		0.0005
Singer, USGS, 1973		3,300 - 13,000		
Banks et al., 1984		0 - 8,000	0.036 - 0.185; 0.075 avg.	0.0005
Orange County Coastal Plain (Main Basin)				
CA DWR, 1967		8,000 - 40,000		<.001
Forebay Area				
USGS, 1966; USGS, 1971			0.2	
OCWD, 1983			0.075 - 0.125	
JMM, 1983			0.075	
Pressure Area				
USGS, 1966				0.001
USGS, 1971				0.001 - 0.01
JMM, 1978				0.0001 - 0.01
OCWD-IRWD, 1980				0.00059
OCWD, 1983				0.0075 - 0.0563
JMM, 1983				0.0005

Source: Banks et al., 1984

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Table 1-8
Hydrochemical Facies in the Irvine Basin
MCAS El Toro Phase I RI/FS Technical Memorandum

Parameter	Facies 1	Facies 2	Facies 3
Depth Interval[a] (feet)	<200	200-500	>500
Total Dissolved Solids[a] (mg/L)	1500-3100	500-1500	1500-2200
Dominant Cation[b]	Ca	Na, Ca	Na
Dominant Anion[b]	SO_4, Cl	HCO_3, Cl	SO_4, CL
Nitrate (as N)[b] (mg/l)	14-38	ND-23	ND-7.7

[a]Herndon, 1990
[b]Herndon and Reilly, 1989
ND=Nondetect.

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(including the City of Irvine) is supplemented primarily through local groundwater. Other drinking water production wells in the vicinity are City of Tustin well (number 77), near the junction of Walnut Avenue and Red Hill Avenue, and a City of Santa Ana well (number 26), located near the junction of Grant Avenue and Walnut Avenue (OCWD, 1993).

Groundwater in the region is not directly pumped for drinking water on-Station. Potable water is supplied by the Irvine Ranch Water District (IRWD), which receives its water from the Metropolitan Water District (MWD). Up to 70 percent of this water is imported from various sources, and the remainder is from local resources (including surface water runoff and groundwater). The IRWD also supplies nonpotable water to the Station to irrigate the outleased agricultural areas. One on-Station groundwater well that belongs to The Irvine Company (TIC), Well TIC-55, at the westernmost end of the east-west runway, is used for irrigation (OCWD, 1993) [Plate 1-1 at the end of this section]. The well pumps into the regional irrigation distribution system.

1.3.10 Surface Water Hydrology

Surface drainage near MCAS El Toro generally flows southwest, following the slope of the land perpendicular to the trend of the Santa Ana Mountains. Several washes originate in the hills northeast of the Station and flow through or adjacent to the Station en route to San Diego Creek. Off-Station drainage from the hills and upgradient irrigated farmlands combines with on-Station runoff (generated from the Station's extensive paved surfaces) at the Station and flows into four main drainage channels (Figure 1-4).

Three of these drainage channels are continuous with natural washes that originate in the Santa Ana Mountains (Borrego Canyon, Agua Chinon, and Bee Canyon); the fourth channel is Marshburn Channel.

The southernmost wash is Borrego Canyon Wash, which flows along the southeast boundary of MCAS El Toro. The wash is unlined in the Santa Ana Mountains; downstream of Irvine Boulevard, it is lined (Figure 1-4). Borrego

Canyon Wash crosses the Station's southern corner and joins Agua Chinon Wash about 1/4 mile from the Station's boundary.

Both the Agua Chinon and the Bee Canyon Washes cross the central portion of the Station and receive runoff mainly through storm sewers. Their flow is contained in culverts through most of their paths cross the station. Both washes are unlined along several hundred feet at the southwest edge of the Station and are then again culverted beneath the Irvine Spectrum development adjacent to the southwestern boundary of the Station. Surface water may infiltrate through the bottom of the unlined portions of the culverts. The lined culverts may also act as a source of infiltrate to groundwater, since the concrete lining is cracked in many places as shown by vegetation growth. Agua Chinon Wash flows into San Diego Creek just east of the intersection of the San Diego and Laguna Beach Freeways, about 1 mile downstream of its confluence with Borrego Canyon Wash. Bee Canyon Wash flows into San Diego Creek just northeast of the same intersection, about 1,500 feet north of Agua Chinon Wash.

Marshburn Channel is a lined drainage channel that runs along the northwestern boundary of MCAS El Toro and receives runoff from the western part of the Station. This channel flows into San Diego Creek about 3/4 mile northwest of Bee Canyon Wash.

Just southwest of the Station, the San Diego Creek runs through mainly commercial and agricultural areas. Approximately 5 miles downstream from the Station, the creek runs through a recreational area that includes hiking and bicycle paths. The creek flows into Upper Newport Bay about 7 miles downstream from its intersection with the Marshburn Channel. Recreational uses of the Bay include swimming and fishing. The Upper Newport Bay is an ecological preserve used by migratory birds.

1.3.11 Land Use

MCAS El Toro is bordered on the south and west by the City of Irvine and on the north and east by unincorporated lands. The Station and some of these unincorporated lands fall within the City of Irvine's "sphere of influence." The City of Irvine controls development in surrounding areas that are suitable for urbanization; however, local jurisdictions do not have authority over federal lands (MCAS El Toro, 1991).

1.3.11.1 Current On-Station Land Use

MCAS El Toro encompasses 7.4 square miles (about 4,700 acres). Approximately 1,000 acres are designated for outleases because airfield safety clearances render it unsuitable for any other use. The outleased lands are at the corners of the Station and are used for agricultural purposes, including nurseries, livestock grazing, and crop production. Crops grown on-Station include strawberries, winter celery, tomatoes, and avocados (MCAS El Toro, 1991).

Land use on-Station is laid out in four quadrants, as defined by the bisecting north-south and east-west runways:

- The northwest quadrant contains administrative services, the Station headquarters, family and bachelor housing, and community support services.
- The northeast quadrant primarily houses activities of the Marine Aircraft Group (including training, maintenance, supply and storage, and airfield operations); as well as additional family housing and community services. It also contains additional ordnance storage in areas isolated by topographic relief and distance from other development (MCAS El Toro, 1991).
- The southeast quadrant houses additional administrative and maintenance functions, ordnance storage, and the Station's golf course.
- The southwest quadrant primarily houses maintenance, supply and storage, and limited administrative services.

A boundary fence surrounds the Station and access is limited to four gates. Only two of the gates are open 24 hours: the Main Gate (off Trabuco Road) and Gate No. 2 (off Irvine Boulevard).

1.3.11.2 Current Off-Station Land Use

Historically the land use around MCAS El Toro has been largely agricultural. However, the land to the south, southeast, and southwest has been developed recently as commercial, light industrial, and residential (Figure 1-8). Currently expanding commercial areas include the Irvine Business Complex, located 5 miles northwest; the Irvine Industrial Complex-East on the southern border; and the Golden Triangle, 1/2 mile west (MCAS El Toro, 1991). Additional residential areas are located to the northwest and west of the Station. Adjacent land on the northwest and northeast is used for agriculture.

1.3.11.3 Future Land Use

Growth projections through the year 2000 for the area surrounding the Station indicate continued urbanization. The City of Irvine plans to continue both residential and commercial growth, with construction of 8,800 to 13,188 new residential units over the next 5 years. Most of the new residences will be constructed in the low-density areas north, northeast, and southwest of the Station (City of Irvine, 1991).

MCAS El Toro is currently on the list of military bases planned for closure; potential future uses of the Station land are commercial development, residential development, or a public airport.

1.3.12 Demographics

MCAS El Toro, which provides services, facilities, and materials to support Navy and Marine Corps aviation, employs both civilians and military personnel. Data collected in 1990 indicates that 1,926 civilians and 7,188 military personnel were present on the Station (MCAS El Toro, 1991).

FIGURE 1-8

REGIONAL LAND USE (1990)

MCAS EL TORO PHASE I RI TECHNICAL MEMORANDUM

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Housing for on-Station military personnel is primarily in the northwest quadrant of the base (near the Main Gate) and in the northeast quadrant (across from Irvine Boulevard). The Station has 1,188 family housing units that serve both officers and enlisted personnel. Bachelor officer and enlisted quarters are in separate complexes within the northwest quadrant, and house 4,380 personnel. A temporary lodging for newly transferred personnel, also in the northwest quadrant, provides housing for up to 24 families (MCAS El Toro, 1991).

The estimated population in the City of Irvine in 1990 was 105,311. Population projections indicate further increases to 118,570 persons by the year 2000 and 208,200 by the year 2020 (MCAS El Toro, 1991). Population growth has occurred primarily in the central residential districts within 2 to 3 miles of the Station. The districts with the highest population density are west and northwest of the Station. Medium-density districts are southeast, and low-density districts are southwest, north and northeast (MCAS El Toro, 1991).

A potentially sensitive on-Station subpopulation is the children who live in on-Station housing. In addition, a child development center, which can accommodate up to 470 children, is located in the northeast quadrant. Potentially sensitive subpopulations within the Irvine area consist of the very young and the elderly. Approximately 6.8 percent of the population is less than 5 years of age and 3.7 percent is over the age of 65 (City of Irvine, 1991).

1.3.13 Ecology

The *Initial Assessment Study* (Brown and Caldwell, 1986) described the biological features and existing habitats of MCAS El Toro. Ecological descriptions based on a reconnaissance survey conducted in early May 1992 note habitats with a few typical plants and animals occurring in them, as well as the threatened or endangered species known or expected to occur in the area.

Lists of plant and animal species observed or expected at MCAS El Toro are in Appendix H3. Scientific nomenclature for plant species follows that of Munz and Keck (1968); vegetation community descriptions follow Holland (1986) and the

Wildlife-Habitat Relationships (WHR) classifications (Mayer and Laudenslayer, 1988).

1.3.13.1 Habitats

Ninety percent of the native habitats have been cleared for agriculture, housing, and Station operations. In the specific sites investigated in this Phase I RI, three habitats predominate: annual grassland (70 percent), coastal sage scrub, and riparian woodland (Brown and Caldwell, 1986). Individuals of many wildlife species typically include multiple habitat types within their home range. Animal movement between habitat types or between patches of the same habitat type is facilitated by corridors of habitat or cover acceptable to the species. Maintaining corridors of appropriate habitat is a critical factor in enabling individuals to find adequate food, water, nesting or denning sites, and breeding opportunities, and to allow seasonal movement (such as between summer and winter ranges).

Annual Grassland. The Station's predominant annual grassland habitat comprises several species that are adapted to semidesert conditions: bromegrass, wild oat grasses, filaree, and mustards. The species composition is greatly influenced by seasonal and annual fluctuations in weather patterns. Plants found in this habitat may also occur as understory plants in other nearby habitats. Many wildlife species use annual grasslands for foraging, but some require other special habitat features (such as cliffs, ponds, and woody plants) for cover, breeding, and escape. The wildlife typical of this habitat includes western toads, Pacific treefrogs, red-tailed hawks, mourning doves, cliff swallows, northern mockingbirds, western meadowlarks, California ground squirrels, southwestern pocket gophers, desert cottontails, and coyotes.

Coastal Sage Scrub. Coastal sage scrub habitat is found on dry hillsides and other stable terrain, and is dominated by 3- to 5-foot shrubs with woody bases and shallow roots. Plant species observed in this habitat include California sagebrush, purple sage, black sage, and buckwheat. Common wildlife species are side-blotched lizards, western fence lizards, skunks, turkey vultures, red-tailed hawks, California quail, greater roadrunners, western screech owls, great horned owls, common ravens, rufous-sided towhees, Anna's hummingbirds, house finches, deer mice, cactus mice, Pacific kangaroo rats, California pocket mice, and coyotes.

Riparian Woodland. Riparian woodland habitat occurs along portions of Borrego Canyon Wash, Bee Canyon Wash, Agua Chinon Wash, and San Diego Creek. This habitat is characterized by willows, cottonwoods, alders, and oaks. The understory includes mostly annual grassland habitat species, wild rose, monkey flowers, hemlock, and (in wetter places) cattail. Common wildlife species are bullfrogs, great blue herons, American coots, American kestrels, black-shouldered kites, ash-throated flycatchers, bushtits, northern flickers, American and lesser goldfinches, orange-crowned warblers, song sparrows, brush rabbits, raccoons, and coyotes.

1.3.13.2 Natural Communities

Several sensitive natural communities were identified by the California Natural Diversity Data Base (CNDDB, 1993) as potentially occurring near MCAS El Toro:

- Southern coast live oak riparian forest
- Southern sycamore alder riparian woodland
- Southern cottonwood willow riparian forest
- Southern riparian scrub
- Valley needlegrass grassland

One or more special-status wildlife species are typically found in each of these sensitive communities.

1.3.13.3 Special-Status Wildlife Species

Almost all species of birds in the United States are protected by the 1972 Migratory Bird Treaty Act. This act protects birds from unregulated "take," which can include poisoning by hazardous wastes. Special-status wildlife species include those listed as:

- Threatened or endangered (or as candidates for such listing) by the U.S. Fish and Wildlife Service (USFWS) and the California Department of Fish and Game (CDFG)
- CDFG fully protected species
- Species of special concern

Special-status animal species include:

- Animals listed or proposed for listing as threatened or endangered under the federal Endangered Species Act of 1973 as amended (50 CFR 17.11).
- Animals that are Category 1 or 2 candidates for listing as threatened or endangered under the federal Endangered Species Act (54 Federal Register 554, 6 January 1989). Category 1 candidates are those for which the USFWS has sufficient information to support listing as threatened or endangered. Category 2 candidates are those for which further information is required to determine their appropriate status
- Animals listed or proposed for listing under the California Endangered Species Act (14 CCR 670 *et seq.*)
- Animals fully protected in California by the California Fish and Game Code (Sections 3511 [birds], 4700 [mammals], and 5050 [amphibians and reptiles]), which prohibits at any time the taking or possession of protected animals or parts thereof
- Animals that meet the definitions of rare or endangered under the California Environmental Quality Act (CEQA guidelines, Section 15380)
- Animal "Species of Special Concern" to the CDFG (birds [Remsen, 1978] and mammals [Williams, 1986] not included in CDFG code)

Descriptions of the 12 special-status species known to occur or expected to occur near MCAS El Toro follow. These species were identified through the WHR database (see Subsection 2.2.8) and reconnaissance-level site survey.

San Diego horned lizard. The San Diego horned lizard is a California Species of Special Concern and a federal Category 2 Candidate for listing. Horned lizards feed mainly on ants and small beetles, but also eat other insects such as wasps, grasshoppers, flies, and caterpillars. For protection from predators, they primarily rely on camouflage, but also burrow into loose soil to avoid predators and extreme heat. Horned lizards hibernate in winter, burrowed into the soil under surface objects or in mammal burrows and crevices. Their reproductive period varies (depending on local conditions) from late May through June. Predators of horned lizards include leopard lizards, snakes, loggerhead shrikes, and hawks (CDFG, 1988).

Orange-throated whiptail. The orange-throated whiptail (lizard) is a California Species of Special Concern and a Category 2 Candidate for federal listing. They actively forage through surface debris for small arthropods in the coastal sage scrub habitat. Adults are active from early spring to late summer, and juveniles can be active into December. Home ranges overlap among individuals; they probably are not territorial. The breeding activities of these lizards begin in April, egg laying continues to mid-July, and the young hatch in August and early September. Adults are prey for diurnal snakes and predatory birds (CDFG, 1988).

Northern harrier. The northern harrier is a State Species of Special Concern. Northern harriers feed mostly on voles, but also eat other small mammals, birds, frogs, reptiles, crustaceans, and insects. They usually nest on the ground in shrubby vegetation in emergent wetland, along rivers or lakes, in grasslands, or on sagebrush flats. Their breeding season is from April to September. MCAS El Toro and surrounding agricultural habitats provide suitable habitat for harriers.

Cooper's hawk. Cooper's hawk is a State Species of Special Concern. These hawks prefer dense, even-aged, single-layered forest canopies for nesting. Their current breeding status is not well known in California. They feed mostly on small birds, but will also prey on small mammals, reptiles, amphibians, and insects.

Golden eagle. The golden eagle is a fully protected species in California and is included on CDFG's list of Species of Special Concern. Golden eagles are also federally protected under the Bald and Golden Eagle Protection Act. The species has been observed throughout California, but occurs primarily in open habitats in mountains and hills. Golden eagles usually nest on cliffs or rock outcrops; they hunt in open habitats (usually grasslands), often in pairs. They prey mostly on rodents, rabbits, and hares. Threats to golden eagles are habitat loss, hunting by livestock owners, poisoning from bait intended for coyotes, and electrocution from power lines (Ehrlich et al., 1988).

Peregrine falcon. The peregrine falcon is both Federal and State Endangered and is a California Protected species. These birds nest on high cliffs or man-made structures, and occasionally will nest in trees, snag cavities, or old nests of other raptors. They feed mostly on birds of up to duck size, but will sometimes feed on mammals, insects, or fish.

Prairie falcon. The prairie falcon is a Species of Special Concern in California. Prairie falcons generally nest on a sheltered cliff ledge overlooking an open area; they may also use an old eagle or raven stick nest on a cliff or bluff. Breeding occurs from mid-February through mid-September, with the peak season being April to August. They eat mostly small mammals and some small birds and reptiles.

Burrowing owl. The burrowing owl is a CDFG Species of Special Concern. The species is rare or absent in much of Southern California; where it does occur, it is generally uncommon. The decline of this species is attributed to habitat loss from agricultural and urban development. These owls are found in open, dry grassland areas. They eat mostly insects, but also feed upon small mammals, reptiles, birds, and carrion. Burrowing owls use existing burrows (especially those of ground squirrels) for shelter and nesting cover.

Coastal cactus wren. The coastal cactus wren, a California Species of Special Concern, is found in thickets of coastal sage scrub habitat. They forage on the ground and in low vegetation for insects, spiders, other small invertebrates, cactus fruits, nectar and seeds. Cactus wrens nest in tall branching cactus, usually about 4-5 feet above the ground. They breed from March into June, laying four or five eggs that hatch after 18 days. The young leave the nest after about 21 days and may return to help feed the young from a later brood. Cactus wrens are preyed on by domestic cats, roadrunners, shrikes, and snakes (CDFG, 1990a).

California gnatcatcher. The California gnatcatcher is a federal Threatened Species (Federal Register, 30 March 1993) and a CDFG Species of Special Concern. Gnatcatchers feed on insects and spiders gleaned from shrub foliage. They nest and roost in low, dense shrubs in washes, on mesas, and on slopes of coastal hills. The breeding season is April through May, and clutches average four eggs. Cowbird parasitism of nests is believed to be an important cause of the decline of this species population (CDFG, 1990a).

Tricolored blackbird. The tricolored blackbird is a federal Category 2 Candidate and a CDFG Species of Special Concern. They are colonial nesting birds that prefer to nest in freshwater marshy areas with heavy vegetative growth. They are typically found nesting in cattails or tules; however, the specific type of vegetation is probably of less importance than is the requirement for wetland habitat. Tricolored blackbirds have been seen nesting in other vegetation, including thickets of blackberry, willow, and wild rose. They are nomadic and could potentially occur in the project area.

Little pocket mouse. The little pocket mouse is a CDFG Species of Special Concern. They are small granivores adapted for desert life, feeding mostly on seeds found beneath the shrub canopy. They prefer sandy soils for digging burrows, but may also be found on gravel washes and on stony soils. Their reproductive season is from January to August, depending on temperature and food supply; they bear one litter per year of four or five young. Their predators include snakes, owls, grasshopper mice, and other predatory mammals. Their population decline is from a severe and continuing loss of habitat (CDFG, 1990b).

Several special-status species are associated with the Upper Newport Bay Ecological Reserve and habitats, downstream of the MCAS El Toro drainage:

- Four state and federally Endangered species (least Bell's vireo, light-footed clapper rail, California least tern, and California brown pelican)
- One state Endangered and federal Category 2 Candidate (Belding's savannah sparrow)
- One state Threatened and federal Category 1 Candidate (California black rail)

These and other wildlife species may be affected by drainage from the Borrego Canyon, Bee Canyon, and Agua Chinon Washes that drain MCAS El Toro via San Diego Creek.

1.4 Remedial Investigation Site Descriptions

The *Initial Assessment Study* (Brown and Caldwell, 1986) identified 17 sites that were believed to contain substances hazardous to humans and the environment. Site 18 was added to the original list after the California Regional Water Quality Control Board (RWQCB), Santa Ana Region, issued Cleanup and Abatement Order No. 87-97 to address the water contamination of the groundwater by volatile organic compounds (VOCs). Sites 19 through 22 were added on the basis of information obtained from the *MCAS El Toro and Tustin Site Inspection Plan of Action* (JMM, 1988). The information on site histories in this subsection is primarily from the BC and the JMM reports. The locations of Phase I RI sites are shown on Figure 1-9.

1.4.1 Site 1 (OU-3) - Explosive Ordnance Disposal Range

The Explosive Ordnance Disposal (EOD) Range is in the extreme northeast portion of MCAS El Toro. The location is in the foothills of the Santa Ana Mountains at an elevation of about 700 feet above mean sea level (msl), about 400 feet higher than the main portion of the MCAS. The EOD Range is situated along a minor tributary of the Borrego Canyon Wash. A small water retention pond is located immediately northeast (upgradient) of the range. The site is completely fenced and has a guard gate, and controlled access to the area is enforced. Soil in the range is disked frequently for weed control.

The site is normally used for the detonation and disposal of small munitions (flares and small ordnance). It is not known how long this site has been used for EOD. However, trenching activities and site staining have been observed in aerial photographs taken as early as 1952, with most of these activities observed in the extreme southern portion of the site. In addition, review of additional historic aerial photos indicates that post-1952 activities on this site appear to be confined to the north of the original trench.

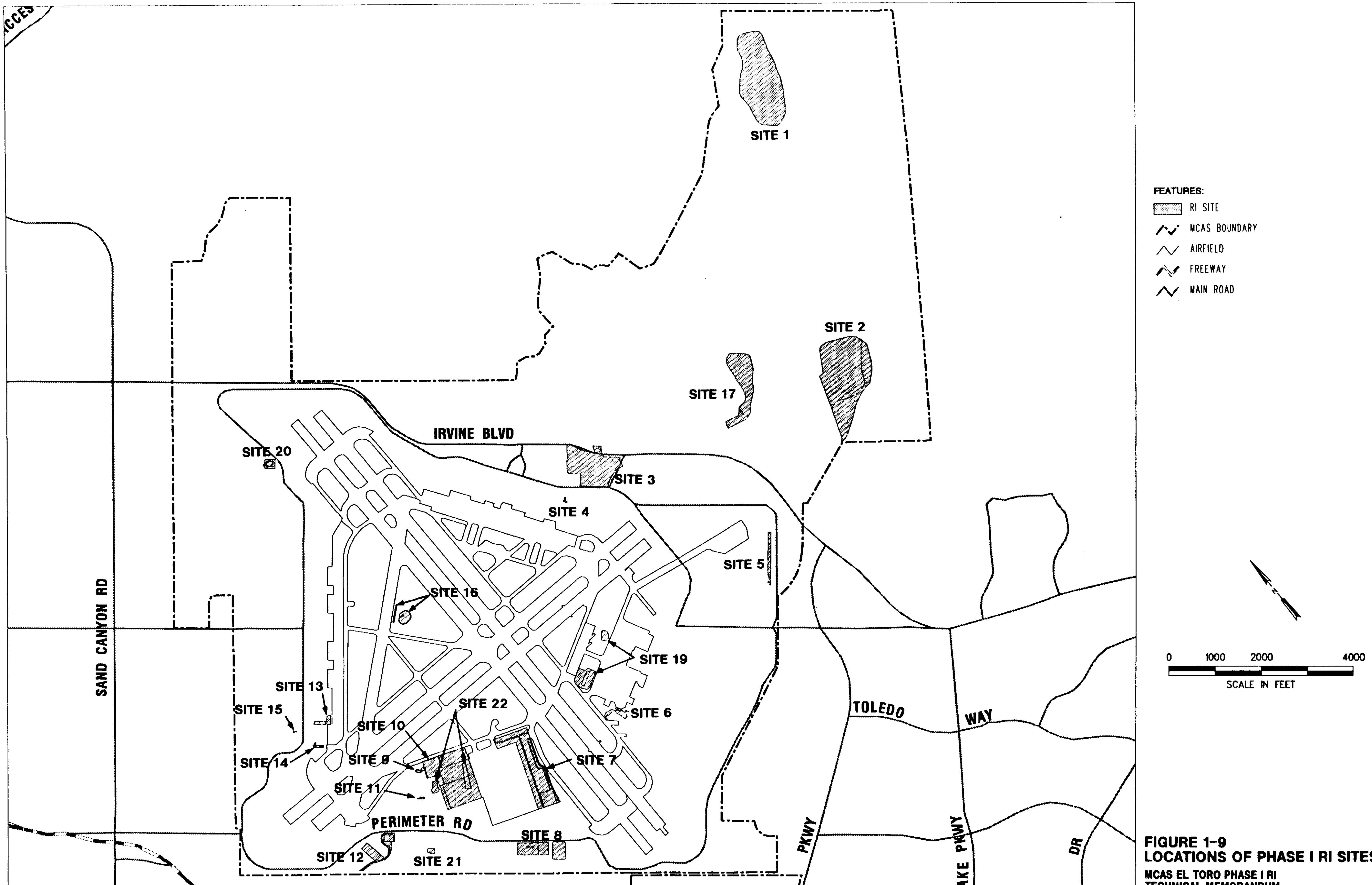

FIGURE 1-9
LOCATIONS OF PHASE I RI SITES
MCAS EL TORO PHASE I RI
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In 1982, drums containing about 2,000 gallons of sulfur trioxide chlorosulfonic acid (FS smoke) were disposed of in trenches in the northern part of the site. The disposal method was to partially bury the drums, then rupture them with small explosive charges. FS smoke is a water-reactive compound that degrades to an acidic material on contact with water. It was estimated that as much as 75 percent of the FS smoke (1,500 gallons) may have remained after the explosions. There are also unsubstantiated reports that a portion of the site was used to dispose of low-level radioactive material.

It is unknown whether undetonated explosives or drums are still present at the EOD Range, buried beneath the soil. At present, munitions are exploded in shallow trenches, which are continually filled with soil and re-excavated.

1.4.2 Site 2 (OU-2) - Magazine Road Landfill

The Magazine Road Landfill occupies about 22 acres between Borrego Canyon Wash and one of its tributaries. The site is bisected by a man-made drainage channel. The landfill is in an area that was used as a gravel borrow pit. The remains of the old borrow pit are still visible as a depression at the upper end of the channel.

The Magazine Road Landfill appears to date to at least 1959, at which point the first landfill activities (a large borrow pit and a fill area) on this site were observed in aerial photographs. The borrow pit appears to reach its largest extent in a 1970 aerial photograph, while refuse, debris, stained areas, liquid, mounded material, and trenches are also evident. Subsequent aerial photographs indicate that landfill activities at the site appear to have declined significantly by 1980, although evidence of such activities (stained areas, pits, trenches, ground scars, and debris piles) is present in the aerial photographic record as late as 1991.

During this period, solid wastes from MCAS El Toro and some waste from MCAS Tustin were disposed of at this landfill. Previous reports estimate that between 800,000 and 1,000,000 cubic yards of material were placed in the landfill during its operational life. This material consisted of construction debris, municipal waste, batteries, waste oils, hydraulic fluids, paint residues, transformers, and solvents. Unlike at earlier landfills, wastes placed in this landfill were not burned for volume reduction. During subsurface gas probe surveys by a previous contractor, methane was detected within the landfill at levels as high as 45 percent.

1.4.3 Site 3 (OU-2) - Original Landfill

The Original Landfill site is between Perimeter Road and North Marine Way along Agua Chinon Wash. The landfill was used from 1943 to 1955 as a cut-and-fill facility in conjunction with burning to reduce waste volume. A 1952 aerial photograph shows two excavations east of Agua Chinon Wash and evidence of possible staining to the west of the wash. The potential for two additional trenches west of the wash was evident in a 1963 photo. By 1965, the aerial photographic record indicates that all activities east of the wash had ceased. A 1970 photo evidences numerous stained areas north of the current location of Building 746, as well as debris piles to the north of the Motor Pool. Evidence of staining further suggests that liquids may have flowed to the drainage channels west of the Motor Pool, with a potential to affect the sediments in Agua Chinon Wash. No landfilling activities were evident in the aerial photographic record post-1980.

Previous reports estimate that 163,500 to 243,000 cubic yards of material were placed in this landfill during its operation and burned before burial. Chloroform, trichloroethylene (TCE) and perchloroethylene (PCE) were detected in the landfill gas samples in concentrations in the hundreds of parts per billion. During the gas probe surveys no methane was detected. Wastes potentially to be found in this landfill include metals, incinerator ash, solvents, paint residues, hydraulic fluids, engine coolants, construction debris, oily waste, municipal solid waste, and various inert solid waste.

The RI/FS decontamination facility and waste staging area were constructed on this location.

1.4.4 Site 4 (OU-3) - Ferrocene Spill Area

The Ferrocene Spill Area is southeast of Building 658, an engine testing facility. A dirt drainage ditch, southwest of the spill site, discharges into a catch basin for Agua Chinon Wash.

In August 1983, approximately 5 gallons of ferrocene and hydrocarbon carrier solution were spilled onto the ground. Reportedly, (Brown and Caldwell, 1986), a 500-gallon tank was being washed when its contents overflowed, and the rinse water containing the ferrocene and hydrocarbon carrier solution drained into the drainage ditch. The apparent hydrocarbon staining at this site has also been considered a potential contaminant. The RWQCB originally listed this site as a potential TCE source because Building 658 is used as an engine test facility.

1.4.5 Site 5 (OU-2) - Perimeter Road Landfill

The Perimeter Road Landfill is north of Gate No. 3 near the MCAS El Toro boundary. Borrego Canyon Wash is approximately 800 feet south-southeast of the landfill.

This landfill was activated in 1955 after the operations at the Original Landfill were phased out. Wastes were buried at this landfill until the late 1960s, when the Magazine Road Landfill was opened. The Perimeter Road Landfill was a cut-and-fill operation, typically burning wastes before burial to reduce their volume. Reports have estimated the waste volumes at between 50,000 and 60,000 cubic yards.

Wastes disposed of in this landfill include burnable trash, municipal solid waste, unspecified fuels, oils, solvents, cleaning fluids, scrap metal, paint residues, and other waste materials. Any waste generated on the facility may have been disposed in this landfill. No methane was detected during the gas probe surveys.

1.4.6 Site 6 (OU-3) - Drop Tank Drainage Area No. 1

Drop Tank Drainage Area No. 1 is a grassy area southwest of Building 727 in the southern quadrant of the Station. From 1969 to 1983, aircraft drop tanks reportedly were routinely transported to this area, where their remaining fuel would be drained; the JP-5 fuel remnants were washed out onto the concrete apron. The fuel and wash/rinse water drained off the concrete apron onto the adjacent grassy area. Runoff from the site flows through a small swale (located west of the tank drainage area) into a ditch that flows along a runway to a catch basin.

Drum storage was evident in an open storage area of the site in 1965 and 1970 aerial photographs. An unidentified liquid, observed in 1970 and 1980 photos, appears to flow from an area north of the site, in the vicinity of Buildings 714 and 761, to the southwest, terminating in a stained area. This stained area continued to be present in aerial photos as late as 1981. An additional stained area was observed approximately 250 feet west of the site in a 1986 photo, while a 1991 photo evidenced a partially filled impoundment of unknown function immediately west of the site.

Previous investigators estimated that 1,400 gallons of JP-5 fuel had drained onto the vegetated area, based on an assumed spillage of 50 gallons per month from 1969 to 1983. It was reported that waste lubricant oils from maintenance operations had been stored in drums and staged in this area, and that waste oil spills and drum leaks had occasionally occurred. Previous investigations estimated that 300 gallons of waste oils were spilled at this site.

1.4.7 Site 7 (OU-3) - Drop Tank Drainage Area No. 2

Drop Tank Drainage Area No. 2 is in the southwest quadrant of the Station, north and east of Hangar Buildings 295 and 296. From 1969 to 1983, aircraft drop tanks reportedly were drained of residual JP-5 fuel in this area. However, historic aerial photos from 1965 evidence numerous stained areas within the open storage area and throughout the paved surfaces.

The site has five areas of concern: 1) the edge of the pad north of Building 295 where drop tanks were drained/washed and fuel residuals/rinsate would drain from the pad onto an adjacent grassy area; 2) the former edge of the pad east of Buildings 295 and 296 (pre-1980), where drop tank drainage and flushing also reportedly occurred; 3) the current edge of the pad east of Buildings 295 and 296; 4) the drainage east of the pad; and 5) the open unpaved area south of Building 296.

Waste lubrication oils from nearby maintenance buildings were also disposed of in this area.

In addition, from 1972 to 1978, portions of this area served as an unpaved parking lot, and lubrication oils were applied for dust control. The concrete pad was placed in 1978. Finally, in 1982, 2,000 gallons of JP-5 were accidently spilled from a tank truck in this area. The JP-5 was washed with water onto the soil at the edge of the pad. A surface drainageway runs to the south.

1.4.8 Site 8 (OU-3) - DRMO Storage Area

The Defense Reutilization and Marketing Office (DRMO) Storage Yard is on the southwest corner of the intersection of Marine Way and "R" Street. The yard, which is fenced and unpaved, has been used since the mid-1970s by MCAS El Toro and MCAS Tustin. However, refuse piles and staining are evident in the yard from aerial photos as early as 1952. The yard is used as a storage area for various scrap and salvage materials, including mechanical and electrical components, and the storage of containerized liquids of unknown composition. A polychlorinated biphenyl (PCB) spill occurred in 1984; contaminated soils in the immediate vicinity were excavated to 1 foot belowgrade and transported to an offsite disposal facility.

The Old Salvage Yard, located southeast of the DRMO Yard across R Street, is an elevated pad, gravel-topped, and several feet above the surrounding street culverts. This salvage yard, used as a parking lot today, evidenced possible staining in 1965 and 1970 aerial photos. Both areas were investigated.

1.4.9 Site 9 (OU-2) - Crash Crew Pit No. 1

Crash Crew Pit No. 1 was used from 1965 through 1971 for firefighter training. The site is to the west of Sites 10 and 22, and north of Site 11. A pit was filled with water and layered with 100 to 500 gallons of JP-5 fuel, aviation gasoline, and other liquid waste; the liquids were then ignited for firefighting practice. Previous investigations have estimated that about 123,700 gallons of waste liquids were used for these practices.

Historical aerial photography (1970) was used to determine the pit's approximate location. Based on this photographic evidence, the presence of a possible second pit adjacent to the main pit is suspected.

1.4.10 Site 10 (OU-2) - Petroleum Disposal Area

The Petroleum Disposal Area is south of Building 435 and east of Building 369. The area, which is about 1,200 feet long by 800 feet wide, is covered with aircraft matting and a concrete apron. Site 22, the Tactical Air Fuel Dispensing System (TAFDS), is adjacent to Site 10. Sites 10 and 22 are also just east of Sites 9 and 11.

Photographic evidence from 1952 through 1970 indicates that various petroleum and solvent products were applied to an increasing area of the site for dust control. About 52,000 gallons of waste crankcase oil, antifreeze, hydraulic and transmission fluids, motor oils, and solvents may have used. This amount is based on the assumption that about 500 gallons were used every 3 months for 13 years. In addition, probable liquid and trenches are apparent at the western portion of the site in a 1952 aerial photo. Since the practice has been stopped, the areas that were sprayed have been excavated and paved with concrete or built over.

1.4.11 Site 11 (OU-3) - Transformer Storage Area

The Transformer Storage Area is a 30- by 30-foot concrete pad on the northeast side of Building 369, adjacent to Sites 9, 10, and 22. A 3-foot-wide, asphalt-lined drainage ditch is adjacent to this area. This ditch drains to the northwest, turns, and drains onto the street that runs to the southwest of Building 369. A catch basin that discharges into Bee Canyon Wash is west of Building 369. This basin receives runoff from a wide area near Building 369.

On the basis of aerial photos, approximately 50 to 75 transformers appear to have been stored on the pad from 1965 through 1983. Reportedly, five transformers leaked and one spilled, leading to an estimated 60 gallons of PCB transformer oil that may have leaked onto the concrete pad. The PCB oil would probably have run off the concrete pad into the adjacent drainage ditch and surrounding soils. In 1983, the transformers were removed and disposed of off-Station.

1.4.12 Site 12 (OU-3) - Sludge Drying Beds

From 1943 through 1972, MCAS El Toro operated a secondary wastewater treatment plant. The sludge from the plant was dewatered in the main Sludge Drying Beds, which occupied an approximate 135- by 210-foot area. In addition, other sludge drying beds were observed lying to the west of the main drying beds between Plant Road and Bee Canyon Wash in a 1952 aerial photograph. When the plant was closed, the sludge may have been abandoned in the drying beds and eventually plowed under.

The contaminants of concern from this sludge may include heavy metals, such as silver, arsenic, cadmium, copper, mercury, nickel, lead, selenium, and zinc. These heavy metals may have come from a plating shop that was located on-Station and discharged its wastewater into the treatment facility system for several years during the 1940s.

1.4.13 Site 13 (OU-3) - Oil Change Area

The 1/4-acre Oil Change Area is in the southwest corner of the Station, northeast of Building 242 along the fence line, just east of a tank storage area. Heavy staining was evident along the open area between the tank farm and Building 242 in a 1952 aerial photo. The area of staining had expanded further south and east in 1965-1980 photos. Previous investigators estimated that about 7,000 gallons of crankcase oil were drained from heavy equipment directly onto the ground at this site.

1.4.14 Site 14 (OU-3) - Battery Acid Disposal Area

Site 14 is about 200 yards southwest of Site 13. The Battery Acid Disposal Area is about 50 feet southwest of Building 245, which was formerly a heavy equipment maintenance shop. An L-shaped strip of land, about 50 feet long on the west, 75 feet long on the south, and 2 to 3 feet wide, is the area of investigation. A catch basin is west of this patch of land and receives water from a drainage ditch that runs parallel to the long side of the L-shaped area. The catch basin discharges into Bee Canyon Wash.

Reportedly, from 1977 through 1983, batteries from facility vehicles were drained onto the soil; surface water runoff from washing down the asphalt drained onto this area. In a 1970 aerial photograph, un unidentified liquid appears to have ponded around Building 243, located north of the site, and to have flowed past the western portion of the site. A 1986 photo also shows evidence of liquids and staining to the west. Previous investigators estimated the volume of battery acid (sulfuric acid) to be 210 gallons. Paints were also reportedly disposed of in this area.

1.4.15 Site 15 (OU-3) - Suspended Fuel Tanks

Site 15 is north of Building 31 and west of Building 29 along West Marine Way, within a fenced yard. The area of investigation consists of two areas where stained soils were evident beneath former elevated fuel tanks. No surface water bodies, drainage ditches, or catch basins are nearby. Two 500-gallon elevated diesel tanks were located at this site from about 1979 through mid-1984. Reportedly, an estimated 500 gallons of diesel fuel leaked onto the soil from these tanks' fueling hoses and nozzles.

1.4.16 Site 16 (OU-3) - Crash Crew Pit No. 2

Crash Crew Pit No. 2 is in the central runway area near the current fire-training area. A drainage ditch along the runway northwest of Site 16 discharges into Bee Canyon Wash.

From 1972 through 1985, three pits at this site were used for crash crew training in extinguishing fires. The main pit was used for larger fire-training exercises and was periodically filled with water, then covered with a mixture of JP-5, leaded aviation gasoline, hydraulic fluid, and crankcase oil, and ignited. The secondary holding pit was used for storing the residual liquids from the main pit. A smaller third pit was used for practicing with handheld fire extinguishers. Previous investigators have estimated that about 275,000 gallons of residual fluids may have been placed in these pits. Of this amount, perhaps 10 percent, or 24,700 gallons, actually infiltrated the soil. Small quantities of napalm, white phosphorus, and magnesium phosphate were also burned at this site.

1.4.17 Site 17 (OU-2) - Communication Station Landfill

The Communication Station Landfill lies approximately 1,800 feet west of the Magazine Road Landfill and covers a 26-acre rectangular area in a small canyon. The landfill is located adjacent to a hill that has been leveled for flight paths. Soil from this hill and the landfill itself have buried the natural drainage.

The landfill reportedly was used from 1981 through 1983 as a Station-wide disposal facility, although aerial photographic evidence indicates landfilling activities were under way as early as 1970, and continuing through 1986. Any waste that was generated from the Station during the landfill's operation may have been disposed of at the Communication Station Landfill. Potential wastes here include domestic waste and rubble (e.g., couches, washing machines, and refrigerators), cooking greases, oils and fuels from sumps, empty drums, and other unknown material. Assuming that a full vacuum truck discharged its load at Site 17 an average of once a month, as much as 36,000 gallons of liquid waste may have been dumped at this site. No methane was detected during the gas probe survey.

1.4.18 Site 18 (OU-1) - Regional VOC Investigation

Investigations conducted by the Orange County Water District (OCWD) west of MCAS El Toro concluded that groundwater contaminated with trichloroethylene (TCE) occurs off-Station mainly at depths ranging from 200 to 450 feet below the ground surface, and extends as much as 4 miles from the Station boundary.

Investigations conducted by MCAS El Toro delineated three areas of VOC contamination in shallow groundwater on or near the Station. Two of these areas are where Bee Canyon Wash and Agua Chinon Wash exit the facility; the third area is near Site 14. Soil gas surveys conducted by MCAS El Toro have generally confirmed these areas, and have also identified potential contamination near the intersection of the Laguna Beach and Santa Ana Freeways.

1.4.19 Site 19 (OU-3) - Aircraft Expeditionary Refueling (ACER) Site

At the Aircraft Expeditionary Refueling (ACER) Site, six aboveground bladder tanks, each storing 20,000 gallons of JP-5 fuel, were surrounded by 4-foot-high berms. These bladder tanks were installed in 1964 and were used until 1987. An estimated 15,000 gallons of JP-5 fuel were spilled in 1986 after a bladder rupture. An investigation following the rupture found total hydrocarbons in the soil ranging up to a maximum of 11,300 milligrams per kilogram (mg/kg). All the fuel bladders were later removed and the soil was excavated to a depth of 15 feet over a 30-square-foot area. Minor spills and leaks also occurred throughout the operational period of the facility. A 300-by-60-foot area has been excavated to a depth of 2 feet; the soil is stockpiled at the site.

1.4.20 Site 20 (OU-3) - Hobby Shop

The Hobby Shop is in Building 626 near the intersection of North 9th Street and West Marine Way. Since 1967, military personnel have used this shop to service privately owned vehicles. A 600-gallon underground waste oil tank, which is emptied periodically by a private contractor, is about 10 feet from the northwest side of the building. The ground surface around the tank and leading to the building, as well as part of the building wall, are stained black from oil.

Three 700-gallon oil/water separators are also located at this site; the oil is emptied periodically by a contractor. Water drains from the separators into a ditch that runs along North 9th Street; the sides of this ditch are stained black. There are also three 50-gallon solvent parts tanks at the Hobby Shop. Sludge from these tanks is dispersed to the oil/water separators, while solvent is disposed of in drums. Before 1976, kerosene reportedly was used to wash down the asphalt pavement in the compound.

1.4.21 Site 21 (OU-3) - Materials Management Group, Building 320

The Materials Management Group serves as a supply distribution center for MCAS El Toro and other Marine Corps facilities. Drums of contaminated material are stored outside Building 320, and potential contaminants may have leaked from them. However, no documented leakage or spillage has occurred. In 1964, about 1,000 drums were stored there; by 1986 there were only 100 to 125 drums.

1.4.22 Site 22 (OU-3) - Tactical Air Fuel Dispensing System

The Tactical Air Fuel Dispensing System (TAFDS) is adjacent to and west of Site 10, the Petroleum Disposal Area. This area has an undocumented history of spills and leaks. As evidenced in 1965 and 1970 aerial photos, the TAFDS originally was located at the eastern portion of the Petroleum Disposal Area (Site 10), an area which shows heaving staining as early as 1952. Relocation of the TAFDS to the west of Site 10 is shown in 1980 and 1986 photos.

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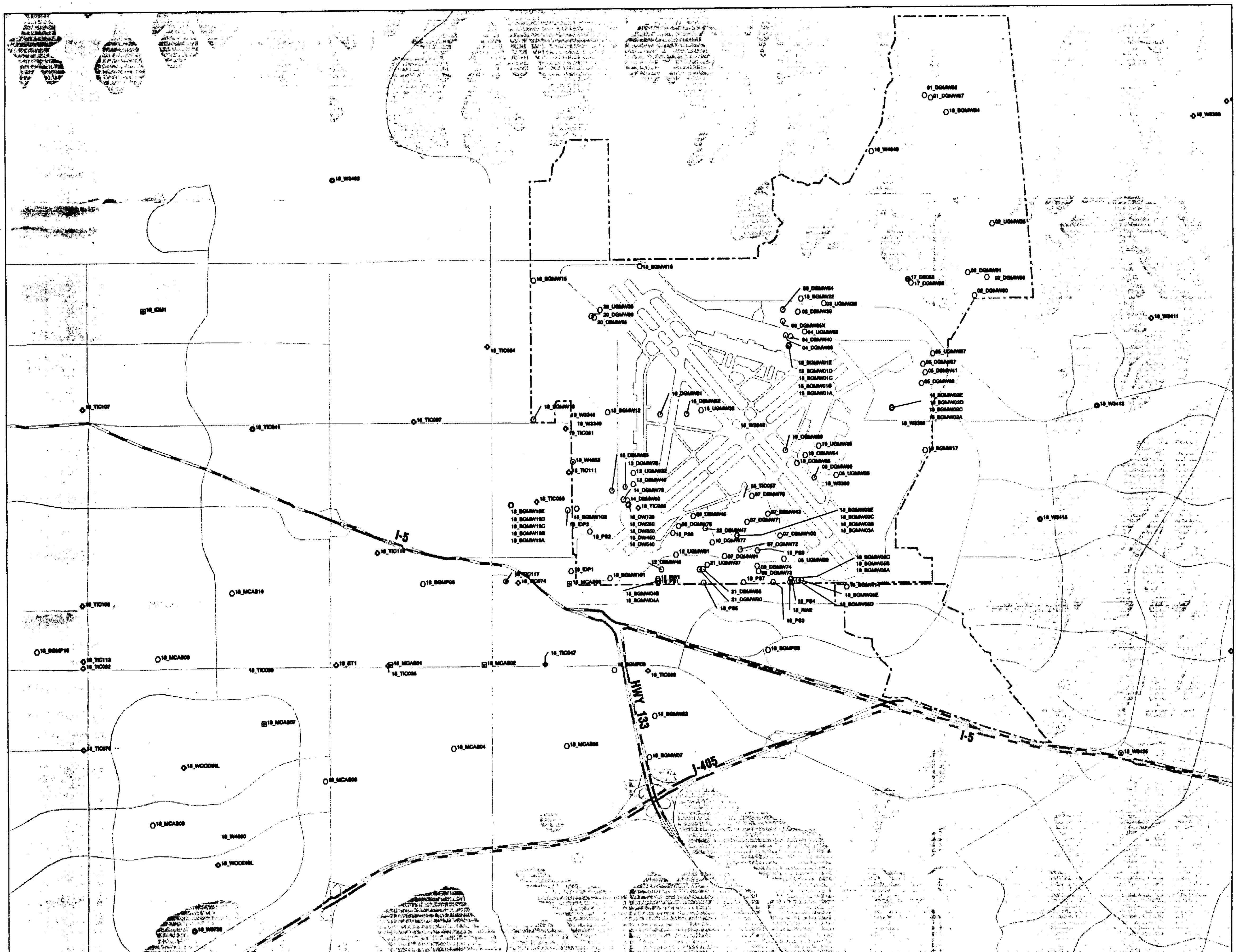

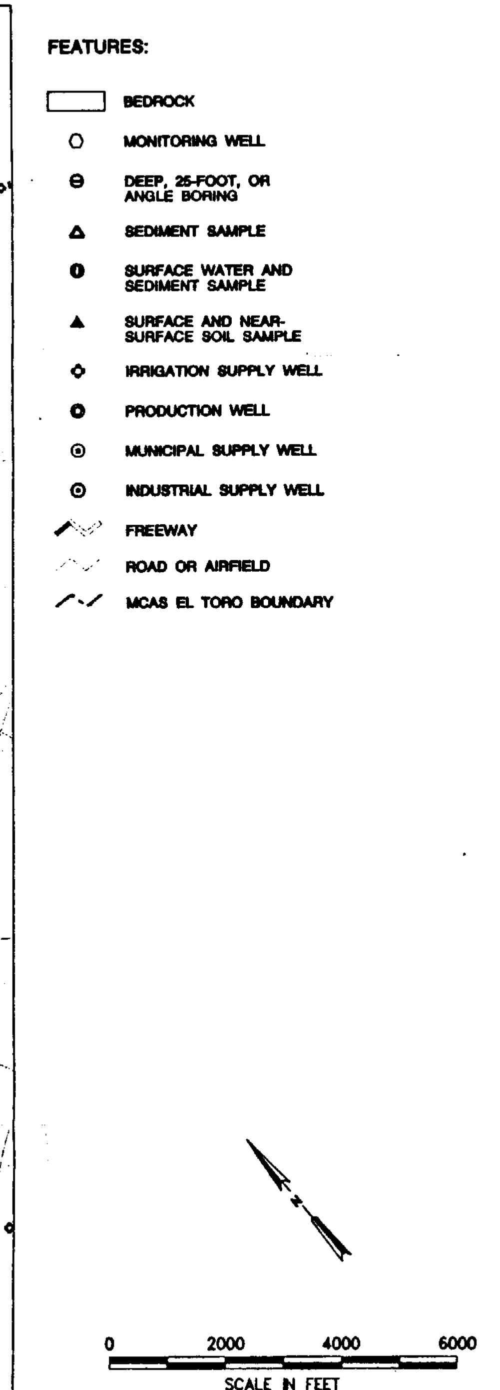

PLATE 1-1
LOCATIONS OF REGIONAL WELLS
MCAS EL TORO PHASE I RI TECHNICAL MEMORANDUM

2.0 INVESTIGATION METHODS

Site investigation rationale and field procedures for the MCAS El Toro Phase I RI were in accordance with the *Draft Final Sampling and Analysis Plan (SAP)*, 28 February 1991 and the *Draft Final Sampling and Analysis Plan Amendment (SAP Amendment)*, 26 August 1992, with exceptions as noted herein. This section describes the investigation methods and procedures used for:

- Preliminary activities (Subsection 2.1)
- Field methods for site characterization (2.2)
- Field quality assurance and quality control (QA/QC) (2.3)
- Data collection field changes (2.4)
- Waste management (2.5)
- Laboratory QA/QC (2.6)
- Data evaluation methods for site characterization (2.7)
- Ecological investigations (2.8)

2.1 Preliminary Activities

Before beginning field work, the Jacobs Engineering Group Inc. (Jacobs) Team obtained regulatory agency permits and licenses; provided agency notification; retained a well drilling subcontractor to drill the boreholes, install groundwater monitoring wells, and dispose of wastes generated during the drilling and sampling program; and obtained site approval and underground utilities clearance.

2.1.1 Regulatory Permits, Licenses, and Notification

The Jacobs Team obtained site access and drilling permits required by regulatory agencies for the installation of the monitoring wells. Several licenses required by the state or county (such as the C-57 State Well Driller's License) were held by the well drilling subcontractor. In compliance with the regulatory permits, the relevant agencies were notified at least 2 days before the start of field work, as documented by:

- Request for Access and Well Drilling Consents, 01 July 1991.
- Consent To Access and Drill Groundwater Monitoring Wells, 20 April 1992 .

- Final Permit and Site Access Package, addressed to Dan Matsui, Orange County Health Care Agency, Environmental Health Division, (April 1993).

2.1.2 Drilling Subcontract

Requests for Proposal for the installation of the groundwater monitoring wells were sent to prequalified drilling subcontractors on 05 July 1991. Beylik Drilling, Inc., (Beylik) of La Habra, California, was selected as the drilling subcontractor and a subcontract was executed between Jacobs and Beylik on 19 March 1992. The drilling subcontract was a fixed unit price contract with a not-to-exceed price of $3,454,439, which was subsequently modified by change order. Beylik was contractually responsible for drilling, sampling, well installation and development, video inspection, pump installation, and transport on treatment of investigation-derived waste.

2.1.3 Health and Safety Requirements

Personal protective equipment (PPE) used for each site is specified in the *Final Health and Safety Plan (HSP)*, 7 March 1992. The *HSP* defines the PPE level (B, C, or D) used at the start of each boring or well, details the types of health and safety monitoring equipment used at each site, and specifies the action levels associated with the equipment.

Most drilling was conducted with personnel in Level D PPE. Level B PPE was used when drilling at some sites with suspected landfill gas emission (Sites 2 and 17, Site 21 at the angle boring at Site 16, and at angle borings along the Bee Canyon and Agua Chinon washes). Well development and sampling activities were performed in Level D PPE.

2.1.4 Site Approval and Utilities Clearance

Preparation for drilling activities included obtaining approval from the Station for on-Station sampling locations and from The Irvine Company (TIC) for most of the off-Station locations. All drilling locations were also cleared for underground utilities.

Approval of on-Station drilling locations were obtained by coordinating with the Resident Officer in Charge of Construction (ROICC). The ROICC facilitated meetings with different Station points-of-contact. Utilities were cleared at sites by first reviewing utilities maps provided by the Station. Geophysical surveys using both ground-penetrating radar (GPR) and electromagnetic (EM) conductivity were conducted at each drilling location. The surveys provided working areas of approximately 15 feet in radius at each location. Field surveys were then conducted with the ROICC for final approval.

Numerous meetings were held with TIC to discuss off-Station drilling locations. Since TIC owns the majority of land surrounding the Station, approval for the locations were obtained from the property owner. Underground Services Alert was contacted before drilling began.

2.2 Field Methods for Site Characterization

This subsection describes general and specific field procedures and activities for the RI Phase I field work, which was conducted from May 1992 to February 1993.

2.2.1 General Description of Field Activities

The field work for the MCAS El Toro Phase I RI included sampling and analyzing surface water, sediment, surface and near-surface (shallow) soils, vadose zone (subsurface) soils, and groundwater. Field activities were recorded in bound field notebooks, which are held in the project files. Upon completion, the sampling, boring, and well locations were surveyed for horizontal and vertical position (location and elevation). The field work was performed in general accordance with the well drilling subcontract documents, including subcontract modifications, the *SAP*, and the *SAP Amendment*.

The locations of the MCAS El Toro Phase I RI groundwater monitoring wells are shown in Figure 2-1 and Plate 2-1. The Navy will propose a monitoring network of some of these wells for its routine groundwater sampling.

All monitoring wells, soil borings, and soil, sediment, and surface water sampling locations were assigned station identification codes.

- The first two numbers and the underscore (_) indicate the site numbers which range from 00_ through 22_.

  00_ = background station outside MCAS El Toro boundaries.
  18_ = station identifying locations relating to OU-1.
  01_ to 17_ and 19_ to 22_ = Station identifying locations relating to OU-2 and OU-3.

- Letters following the _, alone or in combination, indicate the function and/or location of the station. For monitoring wells and soil borings drilled to depths greater than 5 feet:

  AB= 60-foot-long boring drilled at a 30-degree angle
  25B= 25-foot boring
  DB= Deep boring drilled into or adjacent to suspected contamination source
  DBMW= Deep boring completed as monitoring well
  MP= Multiport (Westbay) well
  MW= Monitoring Well

- For shallow soil borings, and soil, sediment, and surface water sampling locations:

  AC = Agua Chinon Wash
  BE = Bee Canyon Wash
  BG = Background sample (Used with 00_ and 18_ sites)
    BGA = Background Off_station Agricultural Area Sample for Pesticides/Herbicides
    BGC = Background Off-Station Commercial Area Sample for Pesticides/Herbicides
    BGN = Background Off-Station Sample for Metals
    BGR = Background Off-Station Residential Sample for Pesticides/Herbicides
  BO = Borrego Canyon Wash
  CB= Catch basin
  DC= San Diego Creek
  DD= Drain ditch
  DG= Location downgradient from suspected site contamination source
  EF= East Fork of Borrego Canyon Wash
  GN= Sample within the general boundaries of a site
  FB= Fuel Bladder

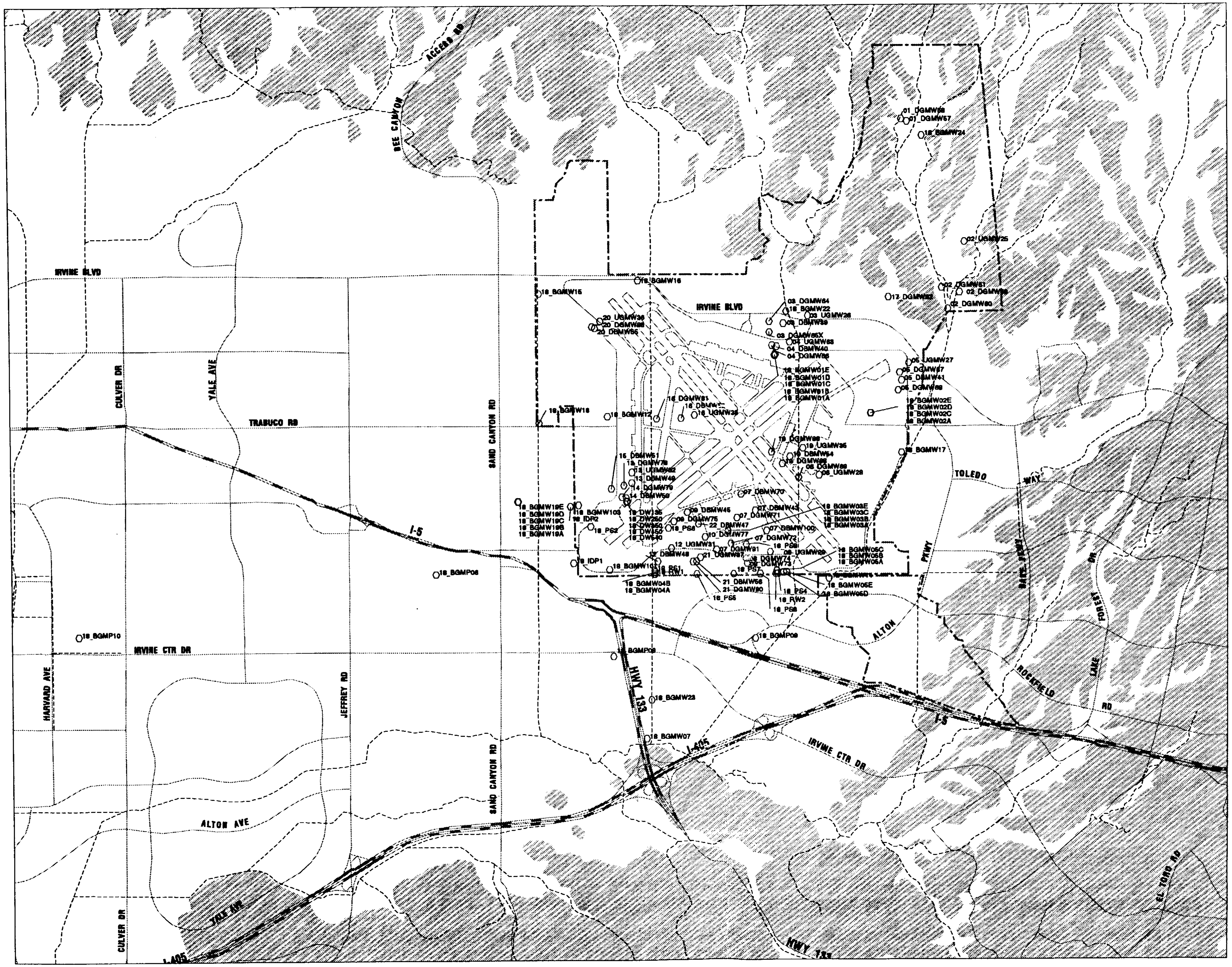

FIGURE 2-1

LOCATIONS OF WELLS MONITORED DURING PHASE I RI

MCAS EL TORO PHASE I RI TECHNICAL MEMORANDUM

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LF= Landfill
MC= Marshburn Channel
MM= Man-made channel
NP= Edge of the new pavement
OP= Edge of the old pavement
PCB= Polychlorinated byphenol
PT= Pit or trench area
RE= Refuse area
RIG= Well drilling rig (and number); no survey point
S= Soil or sediment sample associated with other identifier
SA= Stain area
SL= Sludge drying area or sludge storage area
UG= Location upgradient from suspected site contamination
WF= West Fork of Borrego Canyon Wash
X= Extra location (may or may not have a survey point)

Examples of station identification codes and the associated monitoring wells, soil borings, or sample locations are:

- 18_BGMW5A: Well 5A, a Site 18 background monitoring well
- 01_DGMW57: Well 57, a downgradient monitoring well at Site 1
- 08_25B203: 25-ft Boring 203 at Site 8
- 19_AB217: Angle Boring 217 at Site 19
- 03_DBMW39: Well 39 at Site 3. It was drilled and sampled at closely spaced depth intervals (as a deep boring) prior to completion as a monitoring well.
- 09_PT1: A surface soil sampling location in one of the fire fighting pits at Site 9
- 02_WF1: The sediment and surface water sampling location at the West Fork of Borrego Canyon Wash at Site 2

For brevity, monitoring wells and soil borings may also be identified without their site numbers;

- For example; 18_BGMW5A can be referred to as MW5A or Well 5A
- 03_DBMW39 can be referred to as MW39 or Well 39
- 19_AB217 can be referred to as AB217
- MW5A or Well 5A refers to 18_BGMW5A
- AB217 refers to 19_AB217

2.2.2 Surface Water Investigations

Surface-water samples were collected from drainage courses in washes at Sites 2 and 3 and upstream and downstream of MCAS El Toro during rainfall events in accordance with the *SAP*. A photograph of each site was taken to document flow conditions; the photographs are in the project files. The samples were collected in polyethylene beakers and poured into sample bottles; new beakers were used at each sampling site. Sampling progressed from downstream to upstream in each drainage course.

Electrical conductivity, pH, and temperature of the surface water were measured immediately after each sample was collected. One deviation from the *SAP* occurred during surface water sampling. The samples for dissolved metals analysis were not filtered in the field because the filters became clogged by the high suspended sediment content; instead, these samples were filtered and preserved by the laboratory prior to analysis.

To estimate the flow rate, approximate measurements of the streamflow depth, width, and velocity were made in the field. The velocity was approximated by placing a floating object in the water and using a watch to determine the time it took for the object to travel a known distance. The flow rate was then approximated by multiplying this velocity by the cross-sectional area of the stream. Stream flow rates are presented in Section 3.0 and in the specific site discussions (Appendix B).

2.2.3 Sediment Investigations

As part of the regional groundwater VOC investigation, sediment samples were collected from drainage courses in washes upstream and downstream of MCAS El Toro. Sediment samples were also collected from washes at Sites 2 and 3 and from catch basins that receive runoff water at Sites 4, 6, 7, 12, 14, 20, and 21.

At each sampling location, an established volume of sediment (based on the analyses required) was collected with a stainless-steel trowel or hand auger at two depths, 0 to 6 inches and 18 to 24 inches. If contamination was visually evident or if soil vapor headspace analyses indicated the possible presence of VOCs, samples were also collected from 4 feet below ground surface (bgs).

2.2.4 Surface and Near-Surface Soil Investigations

Surface and shallow soils were collected from all OU-2 and OU-3 sites, typically in conjunction with deeper soil samples at the same location, to provide a more complete vertical characterization of the vadose zone.

The surface and shallow sampling points were established by measurements from known locations. Surface grass, if present, was removed before sampling. At each sampling location, an established volume of soil was sampled with a stainless-steel trowel or hand auger. For surface soil samples, soil was collected from a depth of 0 to 6 inches; for shallow soil samples, soil was collected from both 0 to 6 inches and 18 to 24 inches. If contamination was visually evident or if soil vapor headspace analyses indicated the possible presence of VOCs, an additional sample was taken at 4 feet.

2.2.5 Vadose Zone Soil Investigations

The vadose zone investigations consisted of drilling and sampling the soils between 5 feet bgs and the groundwater table.

2.2.5.1 Drilling Procedures

Beylik drilled and constructed 93 groundwater monitoring wells and 2 piezometers, and drilled 30 soil borings, at the locations shown in Plate 2-1. Two boreholes, one with well casing, were abandoned. Four of the monitoring wells are Westbay System multiple-port (MP) wells; these wells have several screened intervals that can be sampled separately. The remaining 89 monitoring wells are conventional wells with a single-well screen. At several sites, groups of wells with different screened intervals (well clusters) were installed. The wells range in depths from 60 to 465 feet (Appendix E). Table 2-1 summarizes the well (station) identification number, depth, surface completion, screen interval, casing diameter, and type of pump installed at each well.

Thirteen drilling rigs (of four types) were used: four direct mud rotary, three dual-tube percussion, two air rotary casing drive, and four hollow-stem auger. In addition, seven Smeal truck-mounted pump service rigs (5T or 8T) were used for well development, dedicated pump installation, and aquifer parameter measurements.

Twenty feet of well screen for each monitoring well was planned in the *SAP*; however, because of the expected drop in groundwater levels from the operation of the Irvine Desalter Project, the well screen for almost all the shallow wells was increased to 40 feet, as described in the *SAP Amendment*, to extend their useful life. The Desalter Project, which is planned to begin operation in October 1995, will create an estimated drawdown of 50 feet at the western perimeter of MCAS El Toro after 3 years of operation. Many of the Phase I monitoring wells on the western side of MCAS El Toro will go dry after the Desalter Project begins operation.

Fluids and cuttings produced during drilling were containerized and disposed of as described in Subsection 2.5.3.

Descriptions of specific drilling procedures used during the field investigation are presented below.

Direct Mud Rotary

Twenty-six monitoring wells and one piezometer were drilled by direct mud rotary drilling with Ingersoll Rand TH-100, Bratt 22, and Porta-Drill TKT-500 truck-mounted drilling rigs.

Boreholes drilled with mud rotary methods ranged from about 85 to 1,200 feet deep. At most of these wells, a 14-inch-diameter conductor casing was installed in the top 10 to 20 feet bgs to stabilize the top of the borehole.

Table 2-1
Summary of Well Completion and Pump Installation
MCAS El Toro Phase I RI Technical Memorandum

Sheet 1 of 4

Site No.	Station Identification	Surface Completion[a] (above or below ground)	Casing Diameter (in)	Static Depth to Water on 19-21 Jan. 1993 (ft)	Screen Interval (ft - ft)	Total Depth of Well (ft)	Dedicated Pump Information: Pump[b] ID	Drop Pipe & Wire Depth (ft)	Packer[c] Depth (ft)
Phase I RI/FS Wells									
18	18_BGMW1A	A	5	249	466-486	491	4"-HH	465	462
	18_BGMW1B	A	5	215	396-416	421	4"-HH	395	392
	18_BGMW1C	A	5	215	330-350	355	4"-HH	329	326
	18_BGMW1D	A	5	216	242-262	267	4"	231	
	18_BGMW1E	A	4	215	205-225	230	2"	224	
18	18_BGMW2A	A	5	176	462-482	487	4"-HH	461	458
	18_BGMW2C	A	5	176	358-378	383	4"-HH	357	354
	18_BGMW2D	A	5	177	294-314	319	4"-HH	293	290
	18_BGMW2E	A	5	181	198-233	338	2"	200	
18	18_BGMW3A	B	5	118	370-390	395	4"	369	366
	18_BGMW3B	B	5	110	280-300	305	4"	279	276
	18_BGMW3C	B	5	112	222-242	247	4"	221	218
	18_BGMW3E	B	4	112	124-164	169	2"[d]	160	
18	18_BGMW4A	A	5	94	286-306	311	4"	285	282
	18_BGMW4B	A	4	85	190-210	215	4"	189	
18	18_BGMW5A	B	5	88	462-482	487	4"-HH	461	458
	18_BGMW5B	B	5	88	321-341	346	4"	320	317
	18_BGMW5C	B	5	85	225-245	250	4"	223	221
18	18_BGMW5D	B	6	86	83-133	138	4"	126	
	18_BGMW5E	B	2	85	80-130	135	None	N.A.	
18	18_BGMP06	A	4			495	Westbay Well- 5 intervals		
	Screen				445-455				
	Screen				380-390				
	Screen				295-305				
	Screen				168-178				
	Screen				105-115				
18	18_BGMW07	A	4	22	25-65	70	2"[d]	60	
18	18_BGMP08	A	4			488	Westbay Well- 4 intervals		
	Screen				439-449				
	Screen				297-307				
	Screen				126-136				
	Screen				61-71				
18	18_BGMP09	B	4			503	Westbay Well- 6 intervals		
	Screen				453-463				
	Screen				375-385				
	Screen				278-268				
	Screen				222-232				
	Screen				133-143				
	Screen				59-69				
18	18_BGMP10	B	4			1052	Westbay Well - 6 intervals		
	Screen				1001-1011				
	Screen				886-896				
	Screen				752-762				
	Screen				563-573				
	Screen				429-449				
	Screen				218-228				
18	18_BGMW12	B	4	163	165-205	210	2"	200	
18	18_BGMW14	A	4	72	75-115	120	2"	113	

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Table 2-1
Summary of Well Completion and Pump Installation
MCAS El Toro Phase I RI Technical Memorandum

Sheet 2 of 4

Site No.	Station Identification	Surface Completion[a] (above or below ground)	Casing Diameter (in)	Static Depth to Water on 19-21 Jan. 1993 (ft)	Screen Interval (ft - ft)	Total Depth of Well (ft)	Dedicated Pump Information		
							Pump[b] ID	Drop Pipe & Wire Depth (ft)	Packer[c] Depth (ft)
18	18_BGMW15	B	4	176	175-215	220	2"	214	
18	18_BGMW16	A	5	228	223-263	268	4"-HH	252	
18	18_BGMW17	B	5	148	215-255	260	4"	231	
18	18_BGMW18	A	4	139	140-180	185	2"	175	
18	18_BGMW19A 18_BGMW19B 18_BGMW19C 18_BGMW19D 18_BGMW19E	A A A A A	5 5 5 5 4	104 105 101 97 97	448-468 400-420 257-277 150-170 98-138	473 425 482 175 143	4" 4" 4" 4" 2"	447 390 256 165 137	444 396 253
18	18_BGMW22	A	5	246	247-287	292	4"	285	
18	18_BGMW23	A	4	30	64-104	109	4"	94	
18	18_BGMW24	A	4	47	51-71	76	2"	63	
2	02_UGMW25	A	4	50	55-75	80	2"	72	
3	03_UGMW26	A	5	233	230-270	175	4"-HH	265	
5	05_UGMW27	A	5	193	198-238	243	4"	231	
6	06_UGMW28	B	4	144	140-180	185	2"	175	
8	08_UGMW29	B	4	91	95-135	140	2"	132	
12	12_UGMW31	B	4	102	105-145	150	4"	140	
13	13_UGMW32	B	4	141	144-184	189	2"	181	
16	16_UGMW33	B	4	181	180-220	225	2"	219	
19	19_UGMW35	B	4	159	148-185	190	2"	181	
20	20_UGMW36	A	4	196	183-223	228	2"	222	
21	21_UGMW21	B	4	96	89-130	135	2"	125	
3	03_DBMW39	A	5	241	230-270	275	4"-HH	265	
4	04_DBMW40	A	4	223	220-260	265	4"	252	
5	05_DBMW41	A	4	185	182-222	227	2"	221	
7	07_DBMW43	B	4	119	150-190	195	2"	188	
9	09_DBMW45	A	4	125	117-157	162	2"	147	
22	22_DBMW22	A	4	120	116-156	161	2"	147	
12	12_DBMW48	A	4	96	95-135	140	2"	132	
13	13_DBMW49	A	4	136	142-182	187	2"	175	
14	14_DBMW50	A	4	126	120-160	165	2"	150	
15	15_DBMW51	B	4	127	125-165	170	2"	162	
16	16_DBMW52	B	4	179	182-222	227	2"	220	
19	19_DBMW54	A	4	150	141-181	186	2"	175	

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Table 2-1
Summary of Well Completion and Pump Installation
MCAS El Toro Phase I RI Technical Memorandum

Site No.	Station Identification	Surface Completion[a] (above or below ground)	Casing Diameter (in)	Static Depth to Water on 19-21 Jan. 1993 (ft)	Screen Interval (ft - ft)	Total Depth of Well (ft)	Dedicated Pump Information		
							Pump[b] ID	Drop Pipe & Wire Depth (ft)	Packer[c] Depth (ft)
20	20_DBMW55	B	4	190	187-227	232	2"	222	
21	21_DBMW56	B	4	95	92-132	137	2"	130	
1	01_DGMW57	A	4	58	63-83	88	2"	81	
1	01_DGMW58	A	4	53	57-77	82	2"	75	
2	02_DGMW59	A	4	57	69-89	94	2"	85	
2	02_DGMW60	A	4	42	80-100	105	2"	98	
2	02_DGMW61	A	4	54	80-100	105	2"	98	
4	04_UGMW63	A	5	223	235-275	280	4"-HH	262	
3	03_DGMW64	B	5	243	245-285	290	2"	280	
3	03_DGMW65	A	5	234	230-270	275	2"	268	
4	04_DGMW66	A	5	224	250-290	295	4"	252	
5	05_DGMW67	A	5	189	187-227	232	4"	220	
5	05_DGMW68	A	5	188	190-210	215	2"	208	
6	06_DGMW69	B	4	140	150-190	195	2"	187	
7	07_DGMW70	B	4	147	125-165	170	2"	163	
7	07_DBMW71	B	4	115	115-155	160	2"	153	
7	07_DGMW72	B	4	108	110-150	155	2"	147	
8	08_DGMW73	B	4	89	90-130	135	2"	125	
8	08_DGMW74	A	4	90	90-130	135	2"	125	
9	09_DGMW75	A	4	119	114-154	159	4"	153	
10	10_DGMW77	B	4	111	130-170	175	4"	165	
13	13_DGMW78	B	4	133	127-167	172	2"	168	
14	14_DGMW79	B	4	125	118-158	163	2"	150	
16	16_DGMW81	B	4	174	176-216	221	2"	214	
17	17_DGMW82	A	5		235-255	260	4"	252	
19	19_DGMW85	B	4	148	143-183	188	2"	181	
19	19_DGMW86	B	4	158	158-198	203	2"	197	
20	20_DGMW88	A	4	190	185-225	230	2"	223	
21	21_DGMW90	B	4	95	95-135	140	2"	125	
7	07_DGMW91	B	4	108	110-150	155	2"	147	
7	07_DBMW100	B	4	109	131-171	176	4"	168	
18	18_BGMW101	A	4	86	90-130	135	4"	126	
18	18_GBMW103	A	4	116	395-495	500	None	NA	

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Table 2-1
Summary of Well Completion and Pump Installation
MCAS El Toro Phase I RI Technical Memorandum

Site No.	Station Identification	Surface Completion[a] (above or below ground)	Casing Diameter (in)	Static Depth to Water on 19-21 Jan. 1993 (ft)	Screen Interval (ft - ft)	Total Depth of Well (ft)	Dedicated Pump Information		
							Pump[b] ID	Drop Pipe & Wire Depth (ft)	Packer[c] Depth (ft)
Previously Drilled Wells									
18	PS1		4	92	102-122	122			
18	PS2		4	105	103-133	133.1			
18	PS3		4	89	102-122	122			
18	PS4		4	82	98-118	118.5			
18	PS5		4	93	106-126	126.5			
18	PS6		4	117	130-150	151			
18	PS7		4	91	106-126	126.5			
18	PS8		4	108	125-145	145.5			
18	RW1			94	430-470				
18	RW2			82	270-310				
18	DW135			124	115-135	135			
18	DW250			124	215-250	254			
18	DW350			124	310-350	350			
18	DW450			125	420-450	454			
18	DW540			125	490-540	541			

[a]A = above ground; B = below ground.
[b]Pump I.D. indicates nominal diameter: 4" = Grundfos Model 10E-11 (3/4hp) pump per specifications; 4"-HH = Grundfos Model 5S07-18 (3/4-hp) pump; 2" = Grundfos Rediflow 2 pump.

Discharge pipes are stainless steel:
1/2-inch-diameter for 2-inch-diameter pumps
1-inch diameter (or 1-1/4-inch reduced to 1-inch for the top joint) for 4-inch-diameter pumps
A 1-inch-diameter PCV sounding tube was used on all installations.
[c]Packer installations are 4 feet above the screen. The pump in a packer installation was set 1 foot above the top of the screen.

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Drilling mud consisted of bentonite mixed with water drawn from fire hydrants. The viscosity and density of the drilling mud were tested periodically and maintained within limits suitable to the site conditions. At most locations, no additives were used in the drilling mud. However, an environmentally safe and industry-acceptable additive (Drillpac) was used at the MP wells where swelling clay was encountered. The clay swelled during drilling such that the driller had difficulty maintaining a uniform diameter hole; use of the additive in the drilling mud maintained the stability of the hole during drilling and sampling.

At the deepest well at each well cluster, and at each MP well, a 6-inch-diameter test boring (a pilot hole) was drilled and sampled to a specified depth and then geophysically logged. The depths of the screen intervals for the cluster and MP wells were selected on the basis of geophysical logs at the pilot holes.

After selecting the well screen interval or intervals, any portions of the pilot holes below the screen interval and sumps were grouted from the bottom up with cement or Volclay grout using a tremie pipe. The pilot holes were then reamed to a diameter of about 12 1/4 inches and completed as monitoring wells.

Dual-Tube Percussion

Thirteen 10-inch-diameter boreholes (100 to 280 feet deep) were drilled using dual-tube percussion hammer Becker DWP-1200 and Drill System 520 truck-mounted drilling rigs. The outside diameter (O.D.) of the outer tube was 12 inches, and the inside diameter of the inner tube was 9 inches.

Air Rotary Casing Drive

Four monitoring wells and one piezometer were advanced using air rotary casing drive drilling with Porta Drill TLS or Dresser T-70W truck-mounted drilling rigs.

Hollow-Stem Auger

Eighty boreholes, including 50 wells and 30 soil borings, were advanced using hollow-stem auger drilling with CME-95, CME-75, Failing F-10, or Mobile B-61 truck-mounted drilling rigs. This method is in accordance with the latest revisions of the American Society for Testing and Materials (ASTM) D 1452.

Of the 30 soil borings, 13 were angle borings drilled to 60-foot depths and 14 were 25-foot-deep soil borings; these holes were drilled using 8-inch-O.D. hollow-stem augers. The three deep borings and all the wells were drilled with 12-inch O.D. hollow-stem augers with high-torque CME-95 or Failing F-10 drill rigs. The high-torque rigs were substituted for the dual-tube rigs that had difficulty drilling through the tight clay soils.

The vadose zone beneath the washes was sampled via angle borings drilled with a CME-75 truck-mounted rig. The boreholes were drilled on both sides of the washes at the points at which each wash exits MCAS El Toro. Each angle boring was drilled from the bank of the wash at a 30-degree angle from vertical and extended beneath the unlined portion of the wash. The angle borings were drilled 60 feet as measured down the hole, or about 50 feet bgs.

2.2.5.2 Formation Sampling

Soil samples were collected for chemical analysis at specified intervals during drilling. Drive samples were collected with 18- or 24-inch-long standard (3-inch-O.D.) or a modified (2.5-inch-O.D.) California split-spoon samplers on a downhole hammer or by coring into specified depth zones. The sample barrels were equipped with either 3- or 6-inch-long stainless steel sleeves. Occasionally, Christiansen 94-millimeter (mm) wireline coring tools were used to obtain cored soil samples during drilling when a downhole hammer/soil sampler was found to be inefficient in obtaining subsurface soil samples.

On retrieval, one of the sleeves was emptied into a zip-top plastic bag or soil headspace jar for headspace analysis with either an HNu or OVA total organic vapor meter; the remaining sleeves were covered with Teflon sheets and plastic end caps, then sealed with electrical tape. Sample sleeves were selected for detailed chemical analysis based on the sample headspace results, the number of sleeves available, and the lithology.

The sampling schemes for monitoring wells, deep borings, angle borings, and 25-foot borings were different and are discussed in detail in the *SAP*. Analyses requested can be found in data tables in Appendices A and B. Samples taken from each well and soil boring are indicated on the individual boring logs, provided in Appendix K. Grab samples were used for the following:

Grab samples of drill cuttings were collected at regular intervals when drive or core samples were not taken; these samples were used for lithologic logging and measurement of soil vapor headspace concentrations. The cuttings were placed in plastic bags and labeled with the boring number and depth. Grab samples were collected from the cuttings pile at boreholes drilled with bucket and hollow-stem auger rigs. At dual-tube and air rotary casing drive rigs, the samples were collected as cuttings exited the cyclone separator. At mud rotary rigs, cuttings were rinsed from drilling mud as the mud moved from the borehole to the shale shaker.

Drive or core samples and samples of drill cuttings were collected at regular intervals to provide information on the subsurface lithology. Core or drive samples were preferred to cuttings because of the relatively intact nature of the samples; when core or drive samples were not available, drill cuttings were used to indicate the general nature of the subsurface soils. Boring logs describing the lithology were developed based on visual examination of these samples. Occasionally, other information on subsurface lithology was identified from drilling rates and rig reaction (chatter), and logged. The boring logs show the surface elevation of each boring, dates on which the boring was started and finished, type of drill rig used, drilling rate, name of the field geologist logging the borehole, and soil sampling information (including classification by the Unified Soil Classification System). A complete set of boring logs is included in Appendix K.

Immediately upon reaching the total depth of the pilot hole or corehole at each well cluster or MP well, the holes were geophysically logged by Welenco (Bakersfield, California), a subcontractor to Beylik. The subsurface lithology recorded on the boring logs was confirmed by the geophysical logs, and the information on the two logs was used to select the monitoring well depths and screen intervals. Geophysical surveys of resistivity (16- and 64-inch normal), spontaneous potential (SP), and natural gamma were conducted. Geophysical logging was completed at 11 wells: 1A, 2A, 3A, 4A, 5A, 6, 7, 8, 9, 10, and 19A; the geophysical logs are provided in Appendix K.

In separate operations, if the caliper log showed that the borehole was not adequately open, the borehole was re-reamed and a second caliper log made. The reamed borehole diameters were measured with a caliper prior to installing casing on selected wells.

Welenco video logged the inside of the casing on the four MP wells: 6, 8, 9, and 10. Video logging was also performed for wells in which there was a question on casing condition (3E, 7, 15, 18, 27, 43, 45, 47, 55, 65, and 67). Video tapes of these wells are available in the project file.

2.2.6 Groundwater Investigations

The groundwater investigations described in this subsection include:

- Monitoring well construction and pump installation (2.2.6.1)
- Water level measurements (2.2.6.2)
- Measurement of aquifer parameters (2.2.6.3)
- Groundwater quality sampling (2.2.6.4)

2.2.6.1 Monitoring Well Construction and Pump Installation

Well construction began immediately after each borehole was drilled or reamed to the designated depth. A typical wellhead completion diagram and well completion diagrams for each monitoring well are provided in Appendix E. The basic sequence of events was to:

- Drill the well
- Select the well screen interval based on the well log
- Install the well casing and screen
- Place the filter pack and seal the well with grout
- Develop the well
- Construct the surface completion
- Install the dedicated pump

Components of the drilling and development equipment were decontaminated prior to use at each well. When outside water was introduced into the well during drilling, only potable municipal water was used. Development water was contained and disposed of as described in Subsection 2.5.

Conductor Casing

A permanent, 14-inch-diameter mild steel conductor casing was installed in each mud rotary well to stabilize the near-surface portion of the borehole. An oversized borehole for the conductor casing was drilled by the mud rig using a large auger. The surface casing was grouted into place with cement-bentonite grout containing at least 5 percent bentonite. The grout set up overnight before drilling activities resumed. The maximum depth of surface casings was 20 feet bgs.

Casing and Well Screen Installation

The single-screen wells were generally constructed of a combination of polyvinyl chloride (PVC) casing, stainless steel wire-wrapped screen and a stainless steel closed bottom sump. Most wells that are less than about 220 feet in depth were constructed with 4-inch-diameter Schedule 40 PVC. The hydrostatic pressure and heat of formation created during grout setup could cause the Schedule 40 PVC casing to collapse during construction of deeper wells. Therefore, it was determined that Schedule 80 PVC casing was needed for wells deeper than about 220 feet. In order to use thicker casing and still have room for a 4-inch-diameter pump, 5-inch-diameter casing was used for these deeper wells. The stainless steel sump is Type 304, Schedule 5S, flush-threaded, with a diameter of 4 or 5 inches. The well screen is Type 304 stainless steel, 0.020-inch slot wire-wrapped screen. All casing was flush-threaded; lubricants and glue were not used. Stainless steel centralizers were generally placed above and below the well screen.

Gravel Pack and Well Seal Installation

After the casing was installed to the specified depth, the gravel pack was installed in the annulus between the well screen and borehole. A layer of transition sand was then placed above the gravel pack. Bentonite pellets or a betonite mixture was placed above the transition sand as a well seal. Sand and grout were tremied in place in boreholes containing drilling mud or water; the materials were allowed to free-fall into dry (cased) boreholes when dual-tube percussion and hollow-stem auger rigs were used. The typical installation procedure consisted of the following steps:

- The exterior of the screened interval was filled with gravel pack (Monterey #3 sand). The gravel pack extended from the bottom of the borehole to at least 3 feet above the screen. If a tremie pipe was used, the sand was flushed down the tremie pipe with potable water.
- At least 2 feet of fine-grained silica transition sand was placed on top of the gravel pack.
- A bentonite seal consisting of at least 5 feet of pellets or thick bentonite slurry was placed on top of the transition sand to separate the grout from the sand with an impermeable barrier.
- The remainder of the annulus was filled to the surface with either cement/bentonite grout (5 percent bentonite) or Volclay grout. For depths greater than about 250 feet, the grout was poured in two stages and allowed to harden between stages; this procedure helped reduce both the heat generated during grout setup and the hydrostatic pressure on the casing.

Well Development

Monitoring wells were developed with a truck-mounted Smeal well development rig by repeated bailing or air lifting, swabbing, pumping, and surging techniques. The basic procedure was:

- The accumulated solids, including drilling mud, were bailed from the well.
- The screened interval was swabbed.
- The bailing and swabbing cycles were continued until a minimal amount of sand was present in the well following swabbing.
- The well was pumped and surged with a submersible pump until the discharge was clear and free of fines, as determined by the site hydrogeologist. Pumping and surging typically took 20 to 30 hours per well (or per screen interval for MP wells).

Wells in low-yield formations were developed by bailing accumulated solids and water until the well became dry; swabbing the screened interval after the well recovered; and repeating cycles of bailing, recovering, and swabbing.

The static water level, initial pH, temperature, and specific electrical conductance (EC) were measured before well development was begun. The quantity of water removed from the well was then measured. As each well volume of water was removed, pH, temperature, and EC were measured and recorded. Development was considered complete when the specific capacity of the well no longer increases, in addition to the water being free of visible turbidity and suspended sediments, and three successive measurements of pH, temperature, and EC remained stable.

In the first three months of drilling activities, a groundwater sample was collected prior to completing well development, and analyzed for VOCs with 48-hour turnaround to provide rapid feedback on the presence of contaminants. This procedure was stopped due to concerns that the samples were not representative.

Pump Selection and Installation

Dedicated submersible pumps were installed in each well to decrease the purge time required for groundwater sampling and to conduct aquifer tests for estimates of aquifer parameters. Table 2-1 presents the selected pump type, model, and depth for each well. The pumps were generally set near the bottom of the screened interval. Factors considered in selecting the pumps for each well were the static water level, the well yield and drawdown observed during development, the depth to the top of the screened interval, and the purge volume required for sampling (at least three well volumes).

Packers were installed in 16 wells in which the minimum purge volume would have been more than 250 gallons. The bottom of the packers were typically installed 4 feet above the well screen, as shown in Table 2-1.

Three models of pumps were dedicated, most wells were equipped with Grundfos Rediflow 2-inch-diameter, variable-speed pumps. The associated controller converts 1/3-horsepower (hp) single-phase power from a generator or 220-volt line current to 3-phase, variable-speed power.

Two 4-inch-diameter pumps were used: a 10-gpm, 11-stage 3/4-hp Grundfos pump, and a 5-gpm, 18-stage 3/4-hp Grundfos pump. The lower-yield, higher-head pump was used in deep, low-yield wells where neither the 2-inch diameter nor the 10-gpm pump would operate effectively. The same 240-volt, single-phase control box can be used on either 4-inch-diameter pump.

Each pump is fitted with a stainless steel discharge pipe from the pump head to the surface; 1-inch-or 1-1/4-inch-diameter discharge pipes were installed on the 4-inch-diameter Grundfos pumps, and 1/2-inch-diameter pipes were installed at the 2-inch-diameter pumps. For measuring water levels, a 1-inch-diameter PVC sounding tube was installed from the surface to just above the pump depth.

Wellhead Completion

For most single-screen installations, the top of the well casing is fitted with a well seal or cap with openings and accessories for purging and sampling. The wells have a stainless steel discharge pipe extending through the well seal that can be fitted with a stainless steel tee during sampling. One side of the tee features a spigot for attaching a discharge hose and a shutoff valve. The other side of the tee has a 1/4-inch-diameter ball valve for collecting samples. The 20-ampere male electrical plug for the pump passes through the well seal to be connected to an external 220-volt power source. The end of the sounding tube also extends through the well seal.

Well 5E is a 2-inch-diameter piezometer used for static water level measurements only; this well is not equipped with a pump and is completed in a flush-mounted road box with a PVC cap. Well 103 is a 4-inch-diameter, mild-steel-cased-piezometer; it is also not equipped with a pump and is completed with an above-ground surface completion.

Three basic types of surface completions were constructed for the wells: above-ground locking boxes with guard posts, flush-mounted road boxes, and flush-mounted heavy-load boxes. Upon completion of each above-ground well, a 4-inch-thick concrete pad (30 by 48 inches) was constructed around the casing. A metal box (2 by 3 by 1.5 feet high) with a locking hasp was attached to the concrete pad to protect the well casing. The protective boxes were painted bright yellow to make them visible to equipment and vehicle operators. Wells with above-ground surface completions also had three cement-filled steel guard posts (bollards) installed to protect the wellhead and metal box; the bollards extend 3 feet above ground and are painted bright yellow. Wells in parking lots and roadways were completed with flush-mounted, traffic-rated steel vaults, cemented flush with the road surface. Heavy-duty boxes were used in areas where the well could be subject to aircraft or heavy-vehicle wheel loads. A permanent identification plate that provides the well number, construction date, measuring point, depth of well, and depth of screened interval was installed on the inside of each box lid or the underside of the flush-mounted plate.

Construction of Typical MP Monitoring Wells

Four MP monitoring wells were installed at Wells 6, 8, 9, and 10. The MP wells were installed by Westbay Instruments, Ltd., (Westbay) of Vancouver, Canada, as a subcontractor to Beylik. The Westbay casing system incorporates valved couplings, casing, and permanently inflated packers into a single instrumentation string; this string was installed inside a cased borehole with multiple-screened intervals. A detailed description of the MP system, including sampling and operation, is provided in Appendix G.

The outer well casing consists of 4-inch-I.D., Schedule 5S, Type 304, stainless steel and Schedule 40 mild steel, with 10-foot screened intervals (0.02-inch-slot Type 304 stainless steel screen) installed in a 12-inch-diameter boring. To minimize the potential impact of corrosion of the well screen or casing on the water quality samples over the 30-year design life of the well, a 10- to 15-foot length of stainless steel blank casing was installed between the stainless steel screen and the mild steel casing. Thus, any cathodic corrosion, if it occurs, will be at the interface between the stainless and mild steel in the blank stainless steel casing, and not in the screen.

Gravel pack and grout seals were placed similarly to those in conventional wells. Each well screen interval had gravel pack, transition sand, a bentonite seal, and a grout seal. The grout seal was introduced slowly at specified depths with a tremie pipe to within approximately 10 feet of the bottom of the next screen interval.

Each screened interval was developed similarly to those for conventional wells. After well development, Welenco performed a video log to determine the condition of the well. The MP casing system was then installed by Westbay technicians. The packers were set against the inside of blank stainless steel casing below and above each screen section.

The greatest risk of cross-contamination between permeable subsurface units occurred after well development and before installation of the MP casing system—the 12 to 24 hours required to install and inflate the hydraulic packers the day after well development was completed. To minimize the potential for downward cross-contamination, the MP well was continuously pumped during this period. After the MP instrumentation was installed, each pumping port was opened and that interval was pumped for at least 2 hours at a maximum rate of 1 to 5 gpm to purge the well of stagnant groundwater for final development. Only one pumping port was open at a time.

The well completion reports prepared by Westbay are in Appendix G. The appendixes to the completion reports are not included in this document, but are available in project files.

2.2.6.2 Water-Level Measurements

Starting in July 1992, the Jacobs Team measured the static water level at existing wells each month. New wells completed at the time of measurement and wells from prior investigations (such as PS and RW wells) were included in each round of measurements. See Figure 2-1 and Plate 2-1.

Previous water-level data available at the site had indicated that the groundwater flow beneath the Station was predominantly west; recent measurements indicate that the groundwater flows primarily to the northwest. Using this information, some downgradient and upgradient wells were relocated with respect to the flow of groundwater and the contaminant concentration.

The depth-to-water measurements were made with Solinist water-level meters marked in 0.01-foot increments. The bottom 1.0 foot of the water-level meter tape was decontaminated after each use. Before obtaining water level readings, organic vapors were monitored with HNu photoionization meters fitted with either a 10.2-eV or an 11.7-eV probe. Data were recorded in a field log.

2.2.6.3 Measurement of Aquifer Parameters

Aquifer parameters, including hydraulic conductivity and transmissivity, were calculated for about half of the wells by either pumping tests or slug tests. Pumping tests were performed where possible, and slug tests were performed at wells completed in low-yield formations. The range of aquifer parameters is provided in the discussion of hydrogeologic properties in Subsection 3.1.3. A more detailed discussion of field procedures and the methods of aquifer and slug test analysis are provided in Appendix F.

Pumping tests consisted of a scheduled 4-hour, constant-flow-rate pumping test followed by a recovery test. The flow rate selected for each test was based on the well capacity and drawdown, as observed during well development. Field parameters were monitored throughout the test, including temperature, pH, and electrical conductivity. Water levels and flow rates are in Appendix F. Field parameters for each test were reported on field data sheets, available in the project file.

Slug tests were completed in wells that were estimated to not sustain a constant flow rate greater than 1 gpm for 4 hours. Slug tests entailed removing a known volume of water from the well with a bailer, then measuring the depths to water as the well recovered to at least 90 percent of the pretest level. Water-level measurements were recorded over periods of 4 to 24 hours, depending on the recovery rate, with automatic data loggers equipped with pressure transducers. Water levels and other pertinent information from the tests are included in Appendix F.

A well was installed at 5D to enable a long-term pumping test. At this location, the proposed aquifer test consisted of scheduled 48 hours of pumping, followed by 48 hours of monitored recovery. Automatic data loggers attached to pressure transducers monitored the response in the pumping well, the 2-inch-diameter observation piezometer (Well 5E), all wells in the well cluster (Wells 5A, 5B, and 5C), and existing wells nearby (Wells PS-4 and RW-2). The aquifer hydraulic conductivity and storage coefficient were derived by using observation wells.

Before conducting the long-term pumping test, a trial test was performed to determine the proper discharge rate. A pump was selected that could provide both sufficient drawdown in the pumping well to appropriately stress the aquifer (as determined by the supervising hydrogeologist) and perform continuously for 72 hours. Barometric pressure data were collected using a barometric pressure transducer attached to one of the same data loggers used during testing. Barometric pressure data were also collected during the aquifer test, and water-level data were corrected for barometric pressure changes. The test was actually performed for 27 hours because of excessive (greater than anticipated) drawdown. See Appendix F for a full discussion of the aquifer test results.

Long-term pumping tests (approximately 30 hours) were also performed on two wells owned by the OCWD. During pumping of wells IDP1 and IDP2, water levels were monitored at Well 103, a piezometer drilled specifically to support the OCWD tests. Results for pumping at Well IDP1 are included in Appendix F. (Results for pumping at Well IDP2 were not available at this writing.)

Long-term water-level monitoring was conducted in wells located throughout the Station to monitor the effects of pumping by area production wells. Water-level fluctuations due to barometric effects were also assessed in wells instrumented with barometric pressure transducers.

2.2.6.4 Groundwater Quality Sampling

Groundwater samples were collected during aquifer testing and routine sampling of completed wells, between August 1992 and January 1993. Details of sampling methods, volumes, containers, field procedures, and requested analyses are covered in the *SAP* and *SAP Amendment*.

Where practical, groundwater samples were collected for laboratory analysis during pumping tests of new wells. The samples were collected after a minimum of 3 well volumes had been discharged and field parameters had been stabilized. In other wells, the dedicated pump was used to collect the groundwater sample. A few samples were collected using pumps borrowed from Beylik. Analyses requested for routine sampling are provided in the *SAP Amendment* and listed in data tables in Appendixes A and B.

Wells fitted with submersible pumps were typically sampled after field parameters had stabilized and a minimum of three well volumes had been purged from the well.

All newly installed monitoring wells were sampled for groundwater quality, except

MW-103 and MW-5E, which were observation wells only. Water quality samples were also collected from 14 previously installed wells: RW1, RW2, PS2, PS3, PS4, PS5, PS6, PS7, PS8, DW135, DW250, DW350, DW450, and DW540. Sampling was completed using a nondedicated, 2-inch-diameter Grundfos Rediflow pump.

Borehole volumes were calculated before going into the field to ensure adequate storage volume for purge water. Once at the well site, the water level was measured and the borehole volume was recalculated.

After purging, the pump speed was reduced (2-inch-diameter pump) or the sampling side of the sampling "T" was throttled (4-inch-diameter pump), and the samples were taken with the appropriate container(s). If filtering was necessary, an in-line filter was attached to the discharge. Sample bottles were prelabeled and chain-of-custody forms were initiated at the well site. Water samples were placed on ice in coolers immediately after collection and were re-iced before shipment.

Groundwater samples were collected from the depth-discrete sampling ports inside the MP casing with a specially designed sampling tool. The tool was lowered to the desired sampling port and activated from the surface to open the port. The attached sampling vessel (up to 1 liter in volume) was filled, then the port was closed and the tool brought to the surface. Multiple trips to each port were required to obtain an adequate sample. This procedure was repeated until all ports had been sampled. The tools were decontaminated between ports.

2.2.6.5 Water Source Sampling

In addition to duplicate samples for quality control, samples were periodically taken from the sources of potable water used for drilling. Fourteen such samples were obtained. Although it was discouraged, because introduced water is a possible source of chemicals detected in the groundwater samples, water was added to most well borings during the course of the drilling. The majority of chemicals detected in the potable water samples are trihalomethanes, which are expected in water that has been disinfected. Some chemicals are found at levels less than laboratory blank criteria, including trihalomethanes. These compounds were 2-butanone, acetone, chloromethane, chloroform, methylene chloride, chlorodibromomethane, carbon disulfide, and benzene.

Two phthalates were detected in potable water used for drilling: benzyl butyl phthalate at an estimated 4 μg/L and bis(2-ethylhexyl)phthalate at 22 μg/L. The latter could be a contaminant from an improperly decontaminated supply hose.

TPH-diesel at 4,110 μg/L and 1,010 μg/L was detected in two samples. These potable water samples came from a built-in truck water tank, and probably indicate a lack of attention to cleanliness when filling or servicing the truck.

2.2.7 Survey of Sampling Locations

Each monitoring well, soil boring, and surface sampling location was surveyed between August 1992 and February 1993 to establish its location and elevation. For each monitoring well, data was collected on its x-y position (northing, easting) relative to the State Plane Coordinate System and the elevation of the well casing at the surface (at the casing notch on the north side). Table E-1 (in Appendix E) contains the data collected from the survey. Some background soil sampling locations were in remote areas, so were located by scaling from USGS quadrangle maps.

2.3 Field QA/QC Procedures

2.3.1 Sample Identification

Except for the first two rounds of surface-water samples, each sample number begins with "S145" to designate it a MCAS El Toro RI/FS sample. The next 4 digits designate the sample medium:

0001 to 0999 = Surface water runoff
1000 to 1999 = Sediment
2000 to 3999 = Groundwater
4000 to 5999 = Shallow (surface and near-surface) soil (<4ft.)

6000 to 7999 = Vadose zone soil boring (>5ft.)
8000 to 8999 = Wastewater
9000 to 9999 = Waste Soil

For example,"S1459123" designates a waste soil sample.

Sample numbers were preassigned and stored in a database. They were retrieved from the database by the Sample Manager and assigned to the field crews daily.

During drilling, soil samples were taken at specified depth intervals. A limited number of these samples were submitted for laboratory analysis on the basis of appearance and soil vapor headspace values. In order to prevent confusion, temporary sample numbers (specimen numbers) for samples were assigned by the Sample Team Leader and entered into the bound field notebook. Soil samples were held for up to two days in order to select the samples with the highest headspace concentrations for analysis, then either discarded or submitted to the laboratory as samples for analysis. When a decision was made as to which specimen to send to the laboratory as a sample, its assigned sample number (different from its specimen number) was entered into the field notebook.

Chain-of-custody forms were initiated by the Sample Team Leader, who relinquished custody of the samples to the Sample Manager, who in turn relinquished custody to the courier service.

As samples were shipped, their sample numbers and other pertinent database information were entered into the sample tracking database from the chain-of-custody forms. When a sample chain-of-custody form contained multiple sample time entries, the time entered on the chain-of-custody form "Sampled by and Title" box was the latest time. Depth bgs and notations such as "rinsate" or "duplicate" were entered on the last sheet of the chain-of-custody form, which was retained (not forwarded to the laboratory).

2.3.2 Handling and Shipping

Soil samples from borings were collected in stainless steel sleeves. The sleeve was removed from the sampler, a sheet of Teflon was placed on each end of the sleeve, plastic end caps were put on the sleeve over the Teflon, and the end caps were taped to the sleeve. Each sleeve was labeled, sealed in a plastic bag, then packed in ice in a cooler.

Water sample containers were wrapped with bubble wrap and packed into iced coolers. Ice was double-bagged in sealable plastic bags and placed in the coolers. The chain-of-custody forms were taped to the inside of the cooler lid and the lid was taped shut over a custody seal. Water samples were also placed in an ice chest after labeling. Their relatively high temperature (25+ degrees C) melted the ice rapidly, so most of these samples were stored overnight in a refrigerator to cool them before shipping.

Most samples were sent to the laboratories via Federal Express. However, when sampling activity was high, both soil and water samples to be analyzed in San Diego were sent via a courier service.

2.3.3 Trip Blanks

Trip blanks were supplied by the laboratory performing the organic compound analyses and refrigerated until used. Each sample collection team carried a trip blank into the field; however, if samples from more than one location were consolidated in one cooler, only one trip blank per cooler was returned to the laboratory.

2.3.4 Duplicates

One duplicate sample was scheduled for every 10 samples taken. Duplicate samples were assigned sample numbers in the same manner as the environmental samples.

2.3.5 Rinsates and Equipment Blanks

Rinsates (soil) and equipment blanks (water) were collected at a rate of approximately one for every 10 samples taken. Rinsate samples were collected by retaining the final rinse water following decontamination of soil sampling equipment. The rinsate samples collected for VOC and SVOC analyses used organics-free HPLC water. Equipment blanks were collected in a similar fashion by collecting the final rinse water following the decontamination of groundwater sampling equipment. Groundwater sampling equipment includes stainless steel sampling tees, PVC sampling tees, and ancillary equipment.

2.3.6 Decontamination of Drilling and Sampling Equipment

Prescribed decontamination procedures were followed for all equipment used for drilling, sampling, and measuring, as described below.

Drilling Rigs. After initial mobilization to MCAS El Toro, each drilling rig (including drill bits, drilling rods, and all other support equipment) was steam-cleaned with pressurized hot water to remove soil, mud, and potential contaminants. After each well installation (before moving to the next well location), the rig and other equipment were again thoroughly steam-cleaned. The well screen and casing were also steam-cleaned before installation. Geophysical logging tools and well development and pump testing equipment were similarly decontaminated before being used.

Split-Spoon Sampler. The modified California split-spoon sampler was decontaminated between trips into the borehole according to the following procedure:

- Wash with nonphosphate detergent.
- Rinse with tap water.
- Rinse with de-ionized water.
- Rinse with methanol.
- Rinse with de-ionized water.
- Air dry.

Driller-Owned Submersible Pumps. Submersible pumps used when sampling groundwater were decontaminated as follows:

- Rinse pump with a high-pressure hot-water washer.
- Place pump in a 55-gallon drum and flush the inside of the pump with a solution of trisodium phosphate (TSP) and water.
- Place pump in a 55-gallon drum of fresh water and flush pump thoroughly.
- Repeat above three steps for the piping and fittings.

Depth-to-Water Measuring Equipment. To avoid chemical cross-contamination between wells, the sounder, steel tapes, and transducer cables were decontaminated upon removal from each well as follows (per Subsection 6.6.4 of the *SAP*):

- Clean with a disposable, soap-impregnated cloth.
- Rinse with fresh water.
- Rinse with distilled water.

2.3.7 Matrix Spike/Matrix Spike Duplicate (MS/MSD) Samples

MS/MSD samples were provided to the laboratory at the rate of about one for every 20 samples. These samples were collected for use in evaluating laboratory QA/QC. MS/MSD samples are twice the volume of an environmental sample. Each was assigned the same number as its associated sample.

2.4 Data Collection Field Changes

After the *SAP* was prepared, site boundaries at the majority of the sites were redefined and sampling strata for surface and near-surface soil samples were identified based primarily upon additional aerial photography analysis. As a result, some of the well and boring locations and most of the soil sampling locations were changed. The number of samples and analytes specified was also changed based on the new information. Refer to the *SAP* (Subsections 4.2 and 4.12) and the *SAP Amendment*, which documented the changes. Additional field changes were required and discussed in brief below. Detailed discussion of differences from the *SAP* and *SAP Amendment* are discussed in Appendixes A and B.

2.4.1 Changes to Wells

Changes to the locations of monitoring wells after the *SAP Amendment* were based on an improved understanding of groundwater flow directions. Wells were repositioned to locations which were hydraulically upgradient and downgradient of the sites, and not cross-gradient. Other field changes were:

- The piezometer drilled to support OCWD's pumping tests at two extraction wells was positioned after consultation with the water agency.
- The most northwestern MP Well (at Irvine Center Drive and Hearthstone) was deepened from 500 to 1,200 feet to ensure that the complete vertical extent of the aquifers was monitored.
- The casing collapsed in Well 65 (Site 3). The well was redrilled and the original well abandoned to California standards.
- Well 53 (Site 17) was abandoned when the equipment used for drilling could not go deeper.
- Submersible dedicated pumps were installed in all wells, instead of only 60.

2.4.2 Changes in Soil Sampling Locations

Slight adjustments to soil sampling locations were made due to field conditions, such as presence of obstructions not previously known.

2.4.3 Changes in Sample Analyses and Protocol

During well development, groundwater samples were scheduled for fast-turnaround VOC analysis. After approximately 10 samples had been tested, this procedure was discontinued, because the samples tested were showing only low or nondetected values of VOCs.

2.5 Waste Management

Wastes generated during the Phase I RI were managed in accordance with the MCAS El Toro Final Waste Management Plan (WMP [14 December 1991]), as amended by decisions reached at MCAS El Toro managers' meetings with the regulatory agencies throughout Phase I. These waste management changes are documented in meeting minutes and other written records.

Solid and liquid wastes were generated during the Phase I RI. Most of the solid wastes were drill cuttings and PPE generated from drilling and sampling activities. Other solid wastes were sediments from treatment of wastewater and drilling mud, solids generated at the decontamination pad, and miscellaneous trash. Liquid wastes consisted primarily of well development water, well purge water, aquifer test water, and decontamination water.

All waste soils generated at the drilling sites, and other solids from the drilling mud and high-solids wastewater were containerized in roll-off bins or drums. A full-time Waste Manager tracked these solid wastes with an internal accounting system from their origination points to the Waste Staging Area (WSA) to the final on-Station long-term storage facility. The wastes were classified according to their hazard potential and managed accordingly as described in Subsection 2.5.2. Waste classification was based on analysis of samples collected directly from the roll-off bins, or environmental samples associated with soils containerized in drums. Of the total of about 1,300 cubic yards of waste soils and other solids, none were hazardous according to existing federal or California state regulations; about 400 cubic yards were classified as designated waste, and the remaining 900 cubic yards were deemed nonhazardous. All such solid wastes are currently stored in one of two bermed cells at the on-Station Waste Storage Facility (WSF). The WSF, situated on top of Site 5 (Perimeter Road Landfill), was specially constructed to manage such RI-derived wastes. Final treatment, if needed, and/or disposal of wastes will be determined later.

All PPE was assumed to be hazardous and was disposed of properly at an off-Station Class I landfill. All miscellaneous trash was handled as common trash and was disposed of properly at an off-Station municipal landfill.

A total of about 1.4 million gallons of wastewater, including rainwater and other incidental wastewater collected in the WSA, was treated by a triple-bed granular activated carbon (GAC) treatment system (Figure 2-2). The GAC system is located within the WSA, which in turn is situated on top of Site 3 (Original Landfill). The treated effluent was discharged into the storage tank used to store water for irrigating the Station's golf course. The primary objective of the treatment system was to remove dissolved contaminants. The treated effluent was sampled and analyzed on a regular schedule to confirm effective operation of the GAC system. None of the water discharged has exceeded any effluent limits.

2.5.1 Sources of Wastes

The solid and liquid wastes generated during the RI had several sources, as described below.

2.5.1.1 Solid Waste

Solid wastes generated included:

- Drill cuttings
- Personal protective equipment (PPE)
- Solids from centrifuge processing
- Settled solids from the decontamination pad
- Miscellaneous trash

Drill Cuttings

Drill cuttings brought to the surface during drilling were containerized in 12-cubic-yard roll-off bins or 55-gallon drums at the drill site.

PPE

Potentially hazardous PPE was produced during drilling, sample collection, and aquifer testing. Waste PPE included used Tyvek suits, rain suits, rubber gloves, rubber boots, respirator cartridges, and other disposable equipment. Used filter

04-30-93

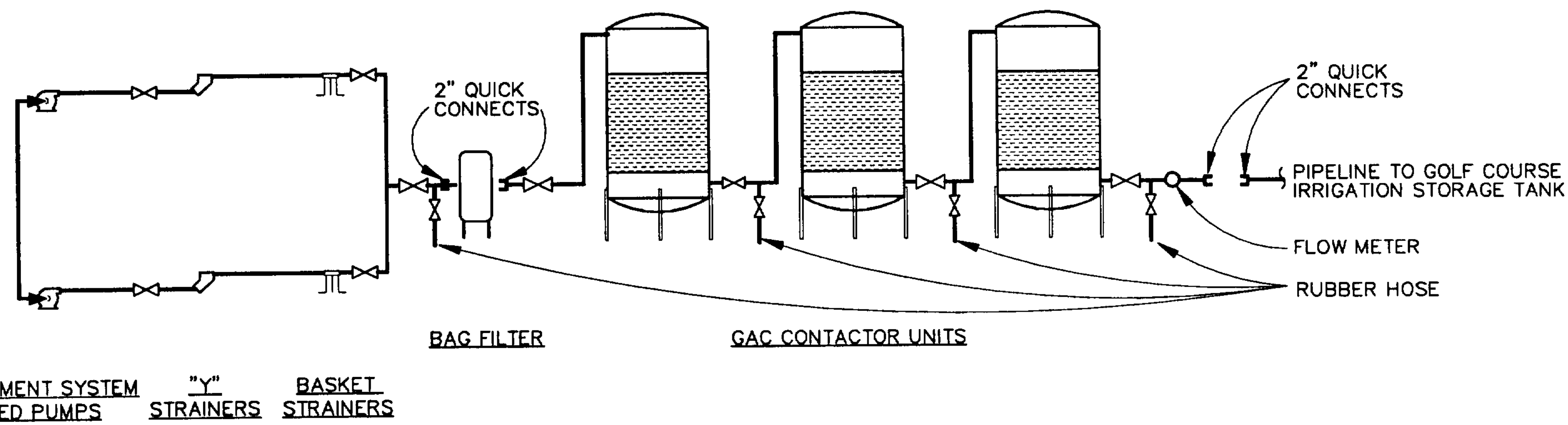

FIGURE 2-2
GAC CONTACTOR UNIT TREATMENT SYSTEM
MCAS EL TORO PHASE I RI
TECHNICAL MEMORANDUM

H: \FIGURES\SCO31981.RV\31981-2.DWG

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bags from the GAC treatment system and empty plastic muriatic acid bottles were also managed similarly to waste PPE.

Solids from Centrifuge Processing

Various types of liquid wastes with high solids content, such as drilling mud, decontamination water, and well development water, were generated. Because of their solids content, they required centrifuging prior to treatment by the GAC system. The mud rotary drilling method uses a drilling fluid of water and bentonite additives. Waste drilling mud, which has the consistency of a slurry, also contained soil cuttings. Water with diluted drilling mud and suspended solids was routinely generated from drilling equipment steam cleaning activities and well development. Water used to decontaminate drill rigs, development rigs, sampling equipment, vacuum trucks, roll-off bins, and water tanks was generated primarily at the on-Station decontamination pad. Well development water was generated when flushing the wells.

Waste drilling mud was contained at the drill site in portable holding tanks and transferred to 22,000-gallon Baker tanks. The waste liquid was then processed with a centrifuge system that separated the solids from the liquid. The solids were then stored in roll-off bins, and the liquid was processed through the GAC system.

Water from the decontamination pad was first pumped into a 6,500-gallon polyethylene holding tank; when the tank was full, it was emptied by the vacuum truck into the larger Baker tanks located at the WSA. Well development water was pumped directly from the vacuum trucks into the Baker tanks. When the suspended solids had settled, the clear water was pumped off the top and processed by the GAC system. The tank bottoms were pumped to another Baker tank for centrifuge processing. The solids generated after centrifuging were stored in roll-off bins, as described above.

Settled Solids from the Decontamination Pad

Waste soils and other solids that remained at the bottom of the decontamination pad sump were removed routinely and transferred to roll-off bins.

Miscellaneous Trash

Common household-type trash (not directly associated with sampling) was also generated, such as miscellaneous paper, wrappers, cups, and plastics. These wastes were not tracked and were disposed of as municipal wastes.

2.5.1.2 Liquid Waste

Liquid wastes generated included:

- Well development water
- Well purge water
- Aquifer test water
- Decontamination water
- Water from centrifuge processing of high solids water
- Rainwater

Because well purge water and aquifer test water contained a minimal amount of suspended sediments, the solids were settled in the holding tanks before processing the water through the GAC system.

2.5.2 Hazard Categories of Wastes

Proper waste management was contingent on waste classification according to applicable federal and state regulations (as discussed in the WMP) and as advised by regulatory agencies throughout the project. Laboratory analyses of waste samples were performed to help classify the wastes.

2.5.2.1 Classifications

Waste waters were not evaluated according to any hazard classification schemes because they were treated and processed through the GAC system; however, confirmation sampling was performed as described below.

Solid wastes were classified in three waste categories:

- Hazardous wastes
- Designated wastes
- Nonhazardous wastes

Hazardous Wastes

Wastes were classified as hazardous if their hazard potential met either the federal regulatory definitions as specified in the Code of Federal Regulations (CFR), Volume 40, Parts 260 to 268 (40 CFR 260 to 268), and/or state regulations as specified in various sections of Title 22 California Code of Regulations (22 CCR). (Note: California has recodified Title 22 CCR to obtain RCRA authorization; the old, but more familiar, references are used here when referring to California's hazardous waste citations.) None of the wastes generated during the RI were classified as hazardous. The Station classified all waste PPE as hazardous, regardless of its real hazard potential; none of the other generated wastes were classified as hazardous.

Designated Wastes

Wastes were classified as designated if, although their hazard potential fell below federal and/or state hazardous criteria (as defined in the federal and state citations above), they may pose potential hazards to the quality of the groundwater beneath MCAS El Toro. The California RWQCB has made provisions (in Title 23 CCR) to establish specific water quality objectives to regulate disposal of designated wastes on land. For the MCAS El Toro Phase I RI, solid wastes were compared against threshold levels for metals (derived from on-Station background soil samples), for organics (based on available drinking water standards and detection limits), and for petroleum and fuel hydrocarbons concentrations.

Nonhazardous Wastes

Wastes were classified as nonhazardous only when their hazard potential fell below federal and/or state hazardous criteria (defined in the regulatory citations listed above), and when they also were determined not to degrade the groundwater quality.

2.5.2.2 Analyses

Available information on potential wastes and contaminants for each site was reviewed to develop the analytical testing requirements for that site. Required analyses for solid wastes are listed in Table 2-2.

As indicated previously, although wastewaters were not classified, they were analyzed to ensure that they had not exceeded effluent limitations established for treated wastewaters discharged to the Station's golf course. Wastewater analysis was also designed to assess the performance of the GAC contactor units. Although the triple-bed system was designed to prevent breakthrough, a primary objective of the analysis was to gauge whether breakthrough occurs earlier than anticipated. Analyses performed were:

- Total dissolved solids (TDS)
- Nitrate/nitrite
- pH
- Metals
- Volatile organic compounds (VOCs)
- Semivolatile organic compounds (SVOCs)
- Total recoverable petroleum hydrocarbons (TPH)
- Pesticides and polychlorinated biphenyls(PCBs)
- Herbicides

Table 2-2
Required Analyses for Solid Wastes
MCAS El Toro Phase I RI Technical Memorandum

Site	VOCs[a]	SVOCs[b]	Pesti-cides/ PCBs[c]	Herbi-cides	TRPH[d]	Metals	Organic Lead	Reactivity-Total Sulfide	Reactivity-Total Cyanide	Dioxins and Furans
1	X	X			X	X		X		X
2	X	X	X	X	X	X				X
3	X	X	X	X	X	X				X
4	X	X			X	X				
5	X	X	X	X	X	X	X			X
6	X	X			X	X				
7	X	X	X		X	X				
8	X	X	X		X	X				
9	X	X			X	X	X			
10	X	X	X	X	X	X				
11	X	X	X							
12			X		X	X		X	X	
13	X	X			X	X				
14	X	X	X		X	X				
15	X	X			X	X				
16	X	X	X		X	X	X			X
17	X	X	X	X	X	X	X	X	X	
18	X	X			X	X	X			
19	X	X			X	X				
20	X	X			X	X				
21	X	X	X	X	X	X			X	
22	X	X	X	X	X	X				

[a]VOCs = Volatile Organic Compounds
[b]SVOCs = Semivolatile Organic Compounds
[c]PCBs = Polychlorinated Biphenyls
[d]TRPH = Total Recoverable Petroleum Hydrocarbon

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2.5.2.3 Sample Collection

Waste soil cuttings were containerized in roll-off bins and drums. The drums were used for cuttings from sites that were suspected to have the greatest hazard potential. The smaller capacities of the drums provided the benefit of segregating potentially hazardous cuttings from nonhazardous cuttings because drilling often cuts through zones of different contamination.

The cuttings in the roll-off bins were classified from representative samples; these samples were collected by compositing subsamples of soil situated at four locations at the top of each roll-off bin, as specified in the WMP. Minor changes in protocol were made when necessitated by field conditions and worker safety. The sample collection equipment was decontaminated between uses.

In general, waste samples were not collected from the cuttings contained in drums in order to reduce the analytical costs. Waste soils in drums were classified on the basis of associated subsurface soil samples, or the drums were transferred to bins for sampling and analysis.

Three drums of drilling cuttings were classified by the analysis of environmental samples associated with the drummed wastes. For example, a 60-foot angle boring drilled at Agua Chinon Wash would have generated three drums of drill cuttings; six samples were collected from the boring and analyzed. Depending on the laboratory analytical results, each drum was classified accordingly. To be conservative in waste classification, the highest concentrations from the six samples were used to represent the entire angle boring; if any of the six samples showed contaminant concentrations at designated levels, then all three drums were classified as designated. It was necessary to transfer contents of some unlabeled drums and drums with illegible labeling into smaller 3-cubic yard bins for sampling and analysis. Two composite samples were taken from these bins for laboratory analysis.

Water samples were taken at different stages of treatment about every 2 weeks. Three samples were collected in each round, at the following sampling points (refer to Figure 2-2):

- Before the bag filter for the GAC system
- After the first GAC column
- After the third GAC column, before discharge to the golf course

The following field and laboratory QA/QC samples were also taken:

- One duplicate sample for every 10 waste samples
- One matrix spike/matrix spike duplicate (MS/MSD) for every 20 waste samples
- One equipment rinsate sample for every 20 waste samples
- One trip blank for each environmental medium included with each shipment containing waste samples requiring VOC analysis

2.5.3 Waste Management Techniques

The large volume of potentially hazardous solid and liquid wastes generated during the RI required a waste tracking system and proper waste management techniques.

2.5.3.1 Waste Tracking

A system was developed to track the wastes generated. Soil cuttings at each drill site were first containerized in 12-cubic-yard roll-off bins. These bins were then moved to the on-Station WSA, and staged there until they were sampled and properly classified. The Waste Manager documented the following information:

- Roll-off bin number
- Origination point of the waste (well or boring and site numbers)
- Approximate volume of waste
- Date the waste was generated
- Date the waste was transferred to the WSA
- Date the waste was sampled
- Sample identification (ID) number
- Laboratory analyses requested
- Type of QA/QC samples, if applicable
- Date the waste was classified

- Soil classification
- Date the waste was transferred to the WSF
- Final on-Station destination (nonhazardous or designated cell of WSF)

A similar tracking system was attempted for the drummed wastes. Many of the 25- and 60-foot borings drilled were suspected to have high hazard potentials; their drill cuttings were containerized in 55-gallon drums. Cuttings from boreholes with high headspace readings were also drummed. Although the drums were also labeled by origination point, depth interval, and date, much of the label information on some of the drums became illegible before classification. In such cases, the drum contents were transferred to a 3-cubic-yard bin and sampled prior to categorizing the waste.

The Waste Manager also tracked the volumes of wastewater and rainwater processed through the GAC system.

2.5.3.2 Waste Staging Area

The WSA served as a central clearinghouse for all solid and liquid wastes generated during the RI. Samples were collected from roll-off bins transferred to the WSA. Upon waste classification, the wastes containerized in bins and drums were then transferred to one of two cells at the WSF.

The WSA is located on the north side of the intersection of North Marine Way and the Gate 2 entrance road and is situated on top of Site 3 (Perimeter Road Landfill). The WSA is a 482-by-123-foot concrete pad that is sloped at a 1 percent cross fall toward the east-west centerline, and sloped at a 2.5 percent on the east-west centerline into a 1-foot-wide trench drain. In the event of rain, water collected within the WSA was designed to drain to the trench drain and to be collected in a concrete sump (10 by 10 by 4 feet). Water from the sump could then be pumped automatically into two 22,000-gallon Baker tanks for processing by the GAC system. The WSA, and the surge tank capacity of the GAC system, were designed to contain and to treat rainwater generated by a 25-year, 24-hour rainfall event.

Per agreement with the regulatory agencies, rainfall runoff collected at the Waste Staging Area (WSA) while investigation-derived waste was present was required to be treated by the granular activated carbon (GAC) system prior to discharge. The majority of collected rainwater was processed through the GAC system as planned.

MCAS El Toro experienced record rainfalls from December 1992 through February 1993. Several rainfall events exceeded the design capacity (25-year, 24-hour rainfall event) of the containment system of the WSA and the holding tank capacity of the GAC treatment system. During the heaviest rainfall, some of the rainwater that collected within the WSA overflowed the berm into the adjacent Agua Chinon Wash. To minimize potential impacts, pumping of rainwater from the sump into the two Baker tanks was started as soon as possible after rainfall began. During the heaviest storms, pumping was augmented by portable gasoline-powered pumps. With this technique, all of the "first flush" runoff from the WSA was collected in the Baker tanks prior to overflow of runoff into the adjacent wash.

2.5.3.3 On-Station Waste Storage Facility

An on-Station WSF was constructed for long-term storage of drill cuttings and solids generated from drilling mud and wastewaters with a high solids content. The wastes transferred to the facility are meant to be stored until final treatment and disposal alternatives for soils remediation have been evaluated. The WSF is an unlined, bermed 200- by 450-foot area that is situated on top of Site 5 (Perimeter Road Landfill). It is divided into two approximately equal cells, for storage of nonhazardous and designated wastes. The north half (referred to as the "clean" area) has a 1-foot berm and stores nonhazardous wastes. The south half has a 3-foot berm and stores designated wastes.

All designated wastes transferred from the WSA to the WSF were placed between Hypalon plastic liners in configurations termed "burritos." Waste soils totaling 185 roll-off bins were generated during the RI; wastes in 53 of these bins (about 400 cubic yards) were classified as designated, and those in the remaining

132 bins (about 900 cubic yards) were classified as nonhazardous. Of the drummed wastes, about 50 cubic yards and 10 cubic yards were classified as designated and nonhazardous, respectively.

2.5.3.4 GAC Treatment and On-Station Discharge

Wastewaters were processed through the on-Station GAC treatment system, and totaled 1,437,110 gallons. Of this water, about 217,580 gallons were rainwater.

The GAC system consists of three 2000-pound-capacity GAC adsorber units connected in series, with two feedwater pumps, two "Y" strainers, two basket strainers, and one bag filter. The strainers and bag filter were used to prevent sand and other particulates from entering the GAC contactor units, where they could potentially reduce the sorption capacity. The contactor units were backwashed occasionally by operating the system in a downflow configuration in which each contactor unit had only one inlet and one outlet open. The flow rate through the GAC system ranged between 10 gallons per minute (gpm) and 15 gpm, and averaged 12 gpm.

The pH of all wastewater transferred to the Baker tanks (which served as surge tanks and settling tanks) was checked. If the wastewater was clear and its pH measured between 6.5 and 8.5, it was processed through the GAC system. If the pH was greater than 8.5, muriatic acid was added to lower the pH before GAC processing; this addition also helped to settle the suspended sediments. If the pH level was less than 6.5, lime was added to raise the pH level to between 6.5 and 8.5 before processing.

Treated wastewater from the GAC was then pumped through a PVC pipe (2-1/2-inch-diameter, Schedule 40) to the 5-million-gallon holding tank for water irrigating the golf course. The tank is filled with Irvine Ranch Water District (IRWD) reclaimed water. When in operation, the GAC system effluent makes up less than one percent of total irrigation waters.

The PVC pipeline is buried 6 to 8 inches belowgrade. Currently, plans are underway to replace the pipeline with 2-1/2-inch-diameter Schedule 80 PVC.

2.5.3.5 Off-Station Class I Landfill

Waste PPE was collected in plastic trash bags and containerized in roll-off bins. After the bins were full, the Waste Manager prepared a manifest that was signed by the assigned ROICC for the RI. The manifest accompanied each waste PPE shipment sent off-Station to a certified Class I landfill. The waste was transported by a subcontractor to Beylik.

2.5.3.6 Off-Station Class III Landfill

Miscellaneous "household" trash was stored separately in plastic trash bags, then disposed off-Station to a Class III (municipal) landfill through a contract trash source.

2.6 Laboratory QA/QC and Data Validation

2.6.1 Analytical Methodology

Environmental samples were analyzed by the methodology detailed in the MCAS El Toro *Quality Assurance Project Plan* (QAPP) (Appendix A of the *SAP*). The analytical parameters and methods are provided in Tables 2-3 and 2-4.

VOCs, SVOCs, pesticides, PCBs, metals, and cyanide were analyzed per EPA Contract Laboratory Program (CLP) protocols (EPA, September 1991; EPA, August 1991). The standard EPA methods referenced in Tables 2-3 and 2-4 were used for the parameters that are not covered under the EPA CLP protocols. The quality assurance/quality control (QA/QC) methodology implemented for the non-CLP parameters followed the procedures in Attachment 2 of the *QAPP*. The quality control methodology for non-CLP parameters followed EPA Region IX specifications (EPA, December 1989). These specifications detail analytical procedures and detection limits, calibration procedures and criteria, internal quality

Table 2-3
Analytical Parameters, Method, and Quality Assurance Objectives for Soil and Sediment Analyses
MCAS El Toro Phase I RI Technical Memorandum

Parameter	Method	Target Detection Limit[a]	Accuracy (% Recovery)	Precision (Relative % Deviation)	Completeness (%)
Volatile organic compounds	CLP[b]	CLP[b]	CLP[b]	CLP[b]	90
Semivolatile organic compounds	CLP[b]	CLP[b]	CLP[b]	CLP[b]	90
Pesticides and PCBs	CLP[b]	CLP[b]	CLP[b]	CLP[b]	90
Metals and Cyanide	CLP[b]	CLP[b]	CLP[b]	CLP[b]	90
Dioxins and dibenzofurans (total tetra through octa isomers)	8280[c]	0.1-5.0μg/kg	40-140	±60	90
Fuel hydrocarbons (TFH)	California method[d]	Gasoline 5 mg/kg; Diesel 10 mg/kg	d	d	90
Petroleum hydrocarbons (TRPH)	418.1	1 mg/kg	N/A	N/A	90
Nitrate and nitrite	352[c] or 353[c]	1 mg/kg	70-130	±30	90

[a]These are target values; actual limits depend on nature of specific matrix and will be reported.
[b]Contract Laboratory Program (CLP) procedures and quality control limits are defined in EPA contracts IFBS WA-85-J664/J680 and WP-85-J838/J839, or the latest contracts. Table 4-7 (SAP) shows detection limits; accuracy and precision values are shown in Attachment 1 (QAPP).
[c]Procedure given in Section 5 (SAP) and Attachment 2.
[d]California Regional Water Quality Control Board, Leaking Underground Fuel Tank Field Manual: Guidelines for Site Assessment, Cleanup and Underground Storage Tank Closure. December 1987. Accuracy and precision limits to be developed by laboratory per procedure; 50-150 percent and ±50 percent can be estimated for accuracy and precision respectively.

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Table 2-4
Analytical Parameters, Method, and Quality Assurance Objectives for Water Analyses
MCAS El Toro Phase I RI Technical Memo

Parameter	Method	Target Detection Limit[a]	Accuracy (% Recovery)	Precision (Relative % Deviation)	Completeness (%)
Volatile organic compounds	CLP[b]/SAS[c,d]	CLP[b]/SAS[c]	CLP[b]	CLP[b]	90
Semivolatile organic compounds	CLP[b]	CLP[b]	CLP[b]	CLP[b]	90
Pesticides and PCBs	CLP[b]	CLP[b]	CLP[b]	CLP[b]	90
Dioxins and dibenzofurans (total tetra through octo isomers)	8280[d]	1-50 ng/l	40-140	±60	90
Fuel hydrocarbons (TFH)	California method[d,e]	Gasoline 5 mg/L Diesel 0.5 mg/L			90
Petroleum hydrocarbons (TRPH)	418.1[d,f]	1 mg/L	N/A	N/A	N/A
Chloride	3253[d,f] or 3000[d,f]	5 mg/L	75-125	±25	90
Sulfate	3752 or 3754[d,f]	5 mg/L	75-125	±25	90
Alkalinity as $CaCO_3$	403[d,g]	2-20 mg/L	N/A	±25	90
Nitrate and nitrite	3522[d,f] or 3533[d,f] or 3000[df]	0.1 mg/L	75-125	±25	90
Gross alpha/beta	703[g]	N/A	N/A	N/A	90
Total dissolved solids (TDS)	1601[d,f]	3 mg/L	N/A	±10	90
Total nitrogen, Kjeldahl	351[d,f]	1.1 mg/L	75-125	±25	90
Ammonia	350[d,f]	1.1 mg/L	75-125	±25	90
pH	Field manual	N/A	N/A	±25	90
Electrical Conductivity	Field manual	N/A	N/A	±25	90

[a]These are target values; actual limits depend on nature of specific matrix and will be reported.
[b]Contract Laboratory Program (CLP) procedures and quality control limits are defined in EPA contracts IFB. WA.85.J664/J680 and WP-85-J838/J839, or the latest contracts. Table 4-7 (SAP) shows detection limits; accuracy and precision values are shown in Attachment 1 (QAPP).
[c]SAS: Special Analytical Services for volatiles since lower detection limits than CLP limits to be requested.
[d]Procedure given in Section 5 (SAP) and Attachment 2.
[e]California Regional Water Quality Control Board, Leaking Underground Fuel Tank Field Manual: Guidelines for Site Assessment, Cleanup and Underground Storage Tank Closure. December 1987. Accuracy and precision limits to be developed by laboratory per procedure; 50-150 percent and ±50 percent can be estimated for accuracy and precision respectively.
[f]U.S. Environmental Protection Agency. 1979. Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020, revised March 1983.
[g]American Public Health Association. Standard Methods for the Examination of Water and Wastewater. 16th Edition (1985).

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control checks and corrective action, data calculations and reporting units, documentation, and deliverable items. The implementation of these specifications has ensured data of known quality.

In addition to having CLP capability, the laboratories that completed the sample analyses are state-certified and approved by the Naval Energy and Environmental Support Activity (NEESA). The laboratories were audited by the State of California and NEESA, as well as by the MCAS El Toro Phase I RI project team. Analytical data were reviewed at the laboratory as well as outside the laboratory by independent subcontractors for conformance to the above-noted protocols. The data were validated by contractors outside the laboratories to ensure that the specifications had been implemented for each sample and parameters. The data validation process is further described below.

2.6.2 Data Validation

The data validation followed the EPA *Functional Guidelines* (EPA, July 1988; EPA, June 1991). Individual data validation reports were prepared for each specific sample delivery group (SDG) and each specific chemical parameter. The laboratories group samples into SDGs; the samples in an SDG have common QC data, as they are run consecutively. The individual data validation reports from the data validation subcontractors were subsectioned per the table of contents of the EPA *Functional Guidelines*. Each section detailed analytical protocol deviations, if any. The subsections summarized the data that did not meet QA/QC requirements, if any, with the following minimum information:

- Affected sample numbers
- Affected parameters
- Specific quantitative deviation from the QC requirements
- EPA criteria for the noted deviation
- Applicable data validation flags per EPA guidelines

- Data validation flag description, whether it was due to laboratory error (designated as "protocol" flag) or due to matrix, analytical, or instrument limitations ("advisory" flag).

These SDG-specific detailed reports are in the project file.

One hundred percent of the sample analyses were reviewed for all QC data per EPA guidelines to include checks for proper methodology, level of QC effort (frequency of runs), and for conformance to EPA-defined quantitative control limits. This resulted in sample-specific data validation flags for all analytical data. Ten percent of the samples were checked for raw data errors (i.e., calculation algorithms, transcription errors, and special identification errors). Raw data checks result in reported concentration corrections, if any. Raw data checks on 10 percent of the samples did not show any significant errors.

Data validation flags (also known as data usability flags) for the specific SDGs were summarized in tables contained in the data validation reports from the validation subcontractors. The protocol flags were entered into the database and are shown with all reported analytical data in this report. These flags and their meanings are listed below:

- U Concentration is less than the listed value (not detected).
- J Estimated value is for qualitative use only (organic parameters).
- R Data are restricted and may not be used for any purpose.
- UJ Concentration is less than the estimated detection limit; detection limit should be used qualitatively and may bias result to false negative.
- b Estimated value is below the detection limit (inorganic parameters).

Data flags originating from the laboratory were received in the electronic data reports and hard copy reports from the laboratory. These flags are present in the database, but, with the exception of the "U" flag, are not shown in the data summaries in this report.

Qualification of sample analyses for contamination observed in laboratory blank samples was detailed in the data validation reports from the validation subcontractors. These qualifications have been incorporated into the data used in this report. Qualification of sample analyses for trip blank contamination, if any, must be completed on a sample-by-sample basis.

2.6.3 Data Assessment

Validated data has met and exceeded project quality assurance goals as described in the *QAPP* and the attached tables. Data are over 95 percent complete. With the current state of practice in this area, this database is of the highest quality and provides detailed QC information to establish reproducibility and comparability. Accuracy and precision values as defined in the QAPP have been summarized and included in the project file along with data validation reports for data users.

2.7 Data Evaluation Methods for Site Characterization

2.7.1 Data Management

The MCAS El Toro Phase I RI required analytical data summaries, statistics, data listings, and geographic analyses. The compilation of approximately 2,500 samples and their analyses was accomplished by automating the procedures.

2.7.1.1 Database Development

The sampling, data analysis, and documentation required were anticipated to be extensive and fast-paced. During the development of the MCAS El Toro Data Management Plan (23 April 1992), several software options were evaluated for use in the Phase I RI, including commercially available and privately developed environmental database systems. The sample tracking system chosen was Sampson, a Paradox-based relational database system developed by CH2M HILL. The selected environmental database system was EDMS/I (Environmental Database Management System/Informix). Informix is a full-featured database management software with flexible querying, data integrity checks, rollback functions, etc. SOUTHWESTDIV is in the process of acquiring ITEMS (International Technology Environmental Database Management System) from International Technology Corporation (IT) to retain the master database for Navy and regulatory agency use. Data from the RI in EDMS/I will be provided to the Navy in text files as specified by the Navy for upload into the ITEMS database.

2.7.1.2 Sample Tracking

Sample tracking for relatively small environmental projects has generally been accomplished using established manual procedures, such as tables and spreadsheets. However, the volume of RI sampling information and the need to track thousands of samples from field to laboratory to project office required an automated approach. The originally planned software for sample tracking, Sampson (written in Paradox), was enhanced to meet the increasing demands of the RI, and became the current system called Delilah. Delilah is a more comprehensive and flexible system than Sampson.

Information from the *SAP*, such as location, depth, sample analysis, and matrix, was entered into Delilah prior to and during field work. Delilah was used to provide sample planning information in the field, information for the Chain of Custody (COC) form, sampling instructions for the field crews, sample shipping information, and monitoring of receipt of sample results from the laboratories. Delilah's flexibility also allowed for monitoring laboratory cost during field work, uploading location and sampling data into EDMS/I, and creating spreadsheets for the Data Validation Team.

Sample number, matrix, analyses requested, and sampling date from Delilah were provided to the Data Validation Team in the form of Excel spreadsheets, enabling them to more easily process the flow of sample information.

2.7.1.3 Environmental Database System

EDMS/I was enhanced for efficient data uploads from Delilah (location and sampling information) and the CLEAN standard laboratory electronic data. The initial EDMS/I database was a single-user system on one IBM-compatible personal computer (PC). Due to the voluminous laboratory data, project time constraints, and the need for ARC/INFO software to directly access the data, a client/server version of EDMS/I was developed. This allowed five data entry operators and data managers to upload, edit, and report data simultaneously using one master database. The pace of uploading and editing was increased dramatically. Also, ARC/INFO was able to select data directly from the EDMS/I database for geographic analyses.

2.7.1.4 Data Entry

Locational and sampling information was loaded into EDMS/I from diskettes received from the Sample Manager in the field office. These data were compared against copies of the COC form to verify accuracy and make corrections.

Diskettes and hard copy reports with sample concentration, laboratory flags, and analytical data were required from the laboratories per laboratory contract specifications. The Jacobs Team communicated closely with SOUTHWESTDIV and IT in establishing a specific standard CLEAN laboratory text file format, then specified that this text file structure be used by the laboratories. Test diskettes were provided each laboratory and each laboratory was informed of any required inconsistencies or adjustments.

A utility program was created to read text files from the laboratory diskettes and convert them into Informix tables. These data were loaded into temporary EDMS/I tables and compared to the sample chemical dictionary and analytical data tables to verify proper matching. Verification reports of each data set were printed and used to check laboratory data. Laboratories were notified and new diskettes requested when errors were observed.

The laboratories used for the RI analyses were not able to provide tentatively identified compounds (TICs) directly from the analytical instruments into the laboratory electronic data; therefore, these data were manually entered into EDMS/I by data entry operators. Verification reports were printed and used for checking data entry accuracy.

The Validation Team provided instructions to the Data Management Team for editing qualifier flags to properly reflect data validation results. These data were edited when data validation summary reports were received from the Data Validation Team. Upon completion of data entry of validation results, the data were ready for data reporting.

2.7.1.5 Data Reporting

EDMS/I was used for matrix, statistical, and summary reports. Data were also extracted in the form of text files for project team members. EDMS/I data was queried by site, location, matrix, analysis and a variety of detailed information, which allowed for multiple variations of information retrieval.

Even with the variations of information retrieval available from EDMS/I, the project team required *ad hoc* data retrieval beyond its current capabilities. Using Informix Standard Query Language (ISQL), data were extracted from the EDMS/I system for processing by Fortran and Paradox programs. These data within Paradox allowed for extreme flexibility in data retrieval using a vast array of table relations, summaries, and queries for reports and spreadsheets. Access of EDMS/I data by ARC/INFO was further refined by combining several Informix tables into individual view tables for specific constituents.

2.7.2 Geographic Information System (GIS)

A GIS was used to produce a spatial inventory of surface and subsurface environmental characteristics of MCAS El Toro and surrounding areas. The GIS, containing the locations of all monitoring wells and soil boring sampling sites, was linked to a chemical database constructed from the results of the laboratory analyses of the samples. The linked data were then analyzed to identify potential areas of contamination and contaminant sources. GIS plots were generated to display the environmental characteristics and analysis results. Other data were prepared and accessed to provide decision support and locational references.

Arc/Info GIS software was used on Sun Workstations for the data conversion, analysis, and product development. The chemical data was accessed from the EDMS/I database. The basic GIS tasks undertaken for the RI were data needs assessment, database development, data analysis, and product generation, as briefly described below.

2.7.2.1 Data Needs Assessment

The RI data needs were based primarily on analysis and product requirements, as determined by interviews of senior project task managers, a preliminary assessment of MCAS El Toro area characteristics, and reviews of products developed for other groundwater (RI/FS) projects. Research was then conducted to locate and evaluate existing source information, which surfaced in digital, map, tabular, and other forms. Each potential data source was evaluated for accuracy, reliability, and content before using it for analysis and display.

The needs assessment identified base data (planimetric features that provide locational references) and interpretive layers (features referenced with codes that are used for analysis and display). The base and interpretive data acquired and converted for use during the RI (and the source of the data) follow:

<u>Base Data:</u>

Airfields - Midstates Engineering and Airborne Systems
Roads and railroads - Midstates Engineering, Airborne Systems, and ETAK
Building footprints - Midstates Engineering and Airborne Systems
Washes and rivers - U.S. Geological Survey

Interpretive Data:

Potential contaminant area sites - The Jacobs Team
Well sampling sites - The Jacobs Team and Orange County Water District (OCWD)
Soil boring sampling sites - The Jacobs Team
Soil series types - Soil Conservation Service (SCS)
Groundwater contours - The Jacobs Team and OCWD
Geology and faults - OCWD (California Division of Mines and Geology, 1981)
Topographic contours and slope - Airborne Systems and OCWD
Land use - Orange County Forecast and Analysis Center
MCAS and regional study areas - The Jacobs Team

2.7.2.2 Database Development

As the various data sources were acquired by the Jacobs Team, procedures were developed to convert and standardize them for analysis and display. The conversion procedures varied, depending on the type of source information. For example, the contaminant area sites and SCS soils were converted using conventional digitizing techniques, the well and soil boring sites were generated from ASCII data files of survey information, and data obtained from OCWD were the Arc/Info format.

The base data acquired from Midstates Engineering and Airborne Systems were converted using complex and labor-intensive procedures. The Midstates source data was digitized in 1985 for the entire MCAS El Toro. In 1991, Airborne (using photogrammetric techniques) generated additional files containing updates and limited revisions of the Midstates data. Approximately 300 Intergraph ".dgn" files provided by the two suppliers were converted as Arc/Info airfield, road, railroad and building coverages, then merged as individual data layers for MCAS El Toro. Finally, the spatial coordinates of the Midstates base data layers were adjusted to match the high-resolution Airborne data, and the two data sets were merged.

Topographic contours were also provided by Airborne in the base data files. These files were also converted into Arc/Info coverages, then merged to form a single 10-foot contour data layer. Extensive code revisions were made to re-assign accurate elevations to the contour lines.

After the various data layers were converted to the Arc/Info format, the coordinates of the layers were standardized. This required transforming them into double-precision meters in the Universal Transverse Mercator (UTM) projection referenced to the North American Datum 1983.

On completion of the conversion and standardization of the base and interpretive data, a formal database structure was designed and produced to facilitate its use by both casual and experienced users. In addition, a summary data dictionary was compiled to identify the feature types, attribute code categories, codes, and text annotation of each layer.

As the GIS database was developed, data related to the well and soil boring samples were entered into EDMS/I. Station identification numbers that contain the well and boring sampling sites, referenced in the EDMS/I and the GIS, may be used to relate the two systems for analysis and product development.

2.7.2.3 Data Analysis

The Arc/Info GIS software and EDMS/I database were linked in order to associate chemical sample data with the appropriate well and soil boring sites. Areas of detected contaminants in groundwater were identified and are referenced to the chemical data in EDMS/I. Groundwater surfaces were generated using the TIN software module and engineering interpretation of groundwater data.

2.7.2.4 Product Generation

Plots and tabular listings were generated with GIS tools; most of the formal products are report plots. These were prepared at three scales (for presentation of the site, MCAS El Toro, and the region). Formal, consistent plot formats (comprising title, legend, scale bar, and north arrow) for a wide variety of data displays were developed, then refined and finalized by the project team. Base and interpretive data were displayed in the data window. In addition, informal tabular reports were generated throughout the RI to measure (areas and lengths of) the various layer features, such as the areas of industrial land use types and the total length of paved roads on the Station.

2.8 Ecological Investigations

The biological resources (both wildlife and botanical) were characterized through a field reconnaissance survey performed 4-10 May 1992 and referenced to existing database records. Field reconnaissance included observations of the characteristic habitat and occurrences of plant and animal species at various sites on and near MCAS El Toro. Personnel from the California Department of Fish and Game (CDFG) and the U.S. Fish and Wildlife Service (USFWS) were contacted. Two published databases were consulted: The California Natural Diversity Data Base (CNDDB) and the California Wildlife-Habitat Relationships (WHR) System. The CNDDB search was limited to special-status species and sensitive habitats in six 7.5-minute U.S. Geological Survey (USGS) quadrangles: Cañada Gobernadora, El Toro, Laguna Beach, San Juan Capistrano, Santiago Peak, and Tustin (CDFG, 1993). The WHR search was limited to the latitude and longitude of the Santa Ana Mountains (33-34° by 117-118°).

2.8.1 CNDDB

The CNDDB (maintained by CDFG) compiles locality, habitat, and status information for sensitive plant and animal species and sensitive habitats, obtained from herbaria, university staff, scientific publications, members of organizations such as the California Native Plant Society and the Audubon Society, agency biologists, and environmental consultants. Data may be accessed by USGS quadrangle, county, or element name (species or habitat). Data are compiled by opportunistic rather than systematic means, and so may not include all species and habitats of concern for all geographic areas.

2.8.2 WHR

The WHR database was created through multiagency cooperation and is maintained by CDFG. Its components are used to assess the species occurrence, habitat requirements, life history, and relative abundance of terrestrial vertebrates.

WHR information is obtained from university staff, scientific publications, members of ecological societies, agency biologists, and environmental consultants. Priority was given to the predictive ability of the system, which resulted in a systematic and thorough integration of its information base. Data for a specific location are accessed by selecting a variety of location parameters, such as county, resource agency region, hydrologic unit, latitude and longitude, the dominant habitat type, and special elements.

A list of the wildlife species that potentially occur at MCAS El Toro was generated from the WHR database (CDFG, 1989). This list was then revised, using professional opinion and knowledge of the species to make it Station-specific, and is included in Appendix H4 as Table H4-1. Although WHR is the most comprehensive system now available for assessing the status of vertebrate species and their habitats in California, it has only recently become available and is still undergoing testing and refinement. Consequently, every species identified through WHR was cross-referenced with information accessed through the CNDDB and carefully scrutinized by project biologists for accuracy of habitat associations, geographic distributions, and listing status.

2.8.3 Field Surveys

Field reconnaissance was conducted over the entire MCAS El Toro to identify biological resources and sensitive habitats within each investigation site. These sites were identified from maps at the time the surveys were conducted. Thus, the reconnaissance included a general survey of all the potentially affected areas, although none was assessed to the level of detail that will be required for a definitive determination of species occurrence.

The considerable experience of project biologists with California's sensitive plant and animal species helped prevent species omissions and incorrect inclusion of species and habitats potentially affected by the project. It must be emphasized, however, that, in this phase of the project, no species-specific surveys were conducted to determine actual occurrence of species, and the use of these databases should not be considered as a replacement for field verification of habitat or species present near the Station.

Surveys were limited to a short period in early May 1992. Without a chance to conduct detailed surveys to verify the information from CNDDB and WHR, and without the information to determine former (predeveloped) presence or absence of special-status species in developed areas, a conservative approach was used in assessing the species potentially occurring on the Station or affected by activities nearby. Species for which habitat was known to occur were assumed to exist or to have been present before changes to the habitat.

3.0 SUMMARY OF FIELD RESULTS: REGIONAL HYDROGEOLOGY, SURFACE WATER, AND SEDIMENTS

This section summarizes the physical hydrogeology of the MCAS El Toro vicinity (Subsection 3.1) and the OU-1 (Site 18) surface water and sediment investigation (Subsection 3.2) at MCAS El Toro, utilizing the field information generated during the MCAS El Toro Phase I RI field investigation. Information on regional geology and groundwater was discussed in Subsection 1.3. Groundwater quality and the nature and extent of groundwater contamination are described in Appendix A1. Hydrogeologic information for each of the 22 RI sites is provided in Appendix A1 (Site 18) and the Appendix B subappendixes (the remaining 21 sites).

3.1 Hydrogeology

The hydrogeology beneath MCAS El Toro (the Station) is defined by the hydrostratigraphy, the aquifer system boundaries, the aquifer parameters, and the groundwater flow components.

3.1.1 Hydrostratigraphy

Plate 3-1 presents two regional cross sections (whose locations are shown in Figure 3-1) showing the hydrostratigraphy of the Irvine sub basin, and Figure 3-1 shows the locations of these cross sections. The east-west cross section (A-A') begins in the foothills at Site 2 and ends at the Site 18 multiple-port well (approximately 3.3 miles west-northwest of the western corner of the Station). The north-south cross section (B-B') is just west of the Station boundary. More detailed site-specific geologic cross sections are in the individual site discussions (Appendix B). Detailed lithologic logs are in Appendix K.

The sediments encountered during well drilling for the Phase I RI consist of unconsolidated clays and silts with interbedded sands and gravels. These unconsolidated sediments are typical of alluvial, floodplain, and shallow marine deposits that formed from the poorly consolidated sedimentary formations that underlie the surrounding foothills. Silts and clays predominate in the central and northwestern portion of the Station; sands are more common near the foothills.

The sands are predominantly well graded (poorly sorted), ranging from coarse to fine and commonly containing clay streaks. In a few instances, pelecypods and other shells were brought up with the drill cuttings. Clays exhibit medium plasticity and contain sand.

The geologic formations, especially those that compose the uppermost portion of the aquifer, are heterogeneous and of limited lateral continuity. These alluvial and floodplain deposits cannot be correlated with certainty. The aquifer consists of heterogeneous lenses of coarser sediments interbedded with fine-grained silts and clays. Geophysical logs from Site 18 well clusters and multiple-port wells that were drilled with mud rotary equipment indicate that at depth, in the marine deposits, the units are more uniform and laterally extensive.

The two marine formations, the Niguel Formation (which crops out west of Agua Chinon Wash) and the Oso Member of the Capistrano Formation (Figure 1-6), form the deeper part of the aquifer beneath the Tustin Plain (Singer, 1973). Only wells at Site 1 (EOD Range) and Site 2 (Magazine Road Landfill) are believed to be screened into the Oso Member.

The alluvium, the underlying flood plain units, and the two marine units in the foothills of the Santa Ana Mountains northeast of the Station form the regional aquifer. On a macro scale, the heterogeneous group of units acts as a single water-bearing and water-producing unit.

Because of the discontinuous nature of the deposits, it is not possible to discern the discrete widespread aquifer units beneath MCAS El Toro. Hydrogeologic data suggests that vertical hydraulic communication exists beneath the units. Groundwater was typically found to be semi confined beneath the uppermost permeable saturated unit encountered during drilling, with confinement increasing with depth.

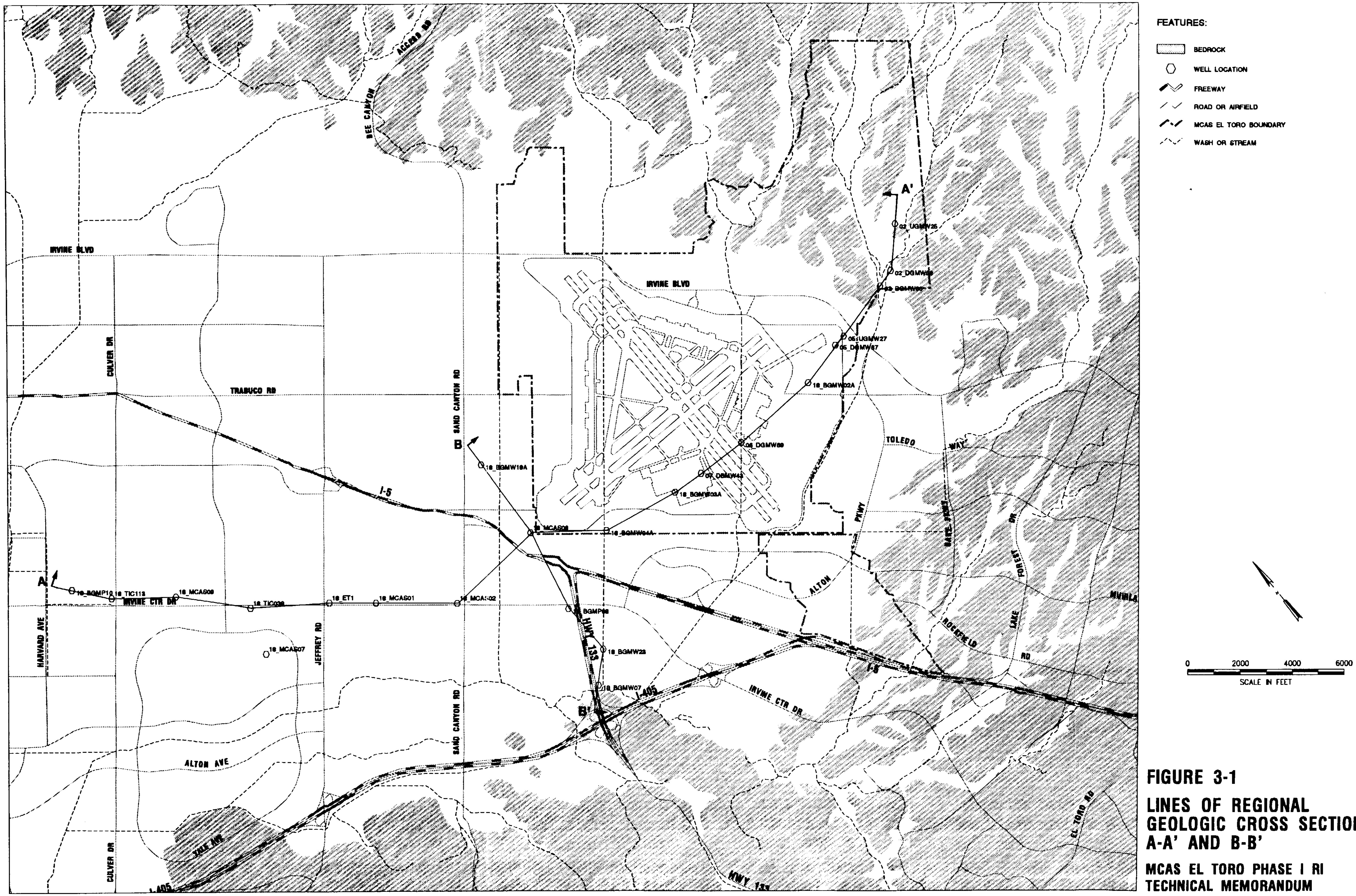

FIGURE 3-1

LINES OF REGIONAL GEOLOGIC CROSS SECTIONS A-A' AND B-B'

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Previous studies suggested unconfined groundwater conditions beneath MCAS El Toro (Brown and Caldwell, 1986). Actual field observations indicated that groundwater beneath MCAS El Toro is semi-confined. Groundwater levels in completed monitoring wells rose up to seven feet above the elevation where groundwater was first encountered. Perched groundwater was not observed. Information gathered during drilling shows that depth to groundwater is shallowest in the foothills, where it is about 45 to 60 feet below ground surface (bgs). In the alluvial basin, groundwater is first encountered at a depth greater than 240 feet on the north eastern edge of the Station along Irvine Boulevard, and decreases to a depth of 85 feet bgs along the southwestern boundary.

3.1.2 Aquifer System Boundaries

Semiconsolidated low-permeability sediments that are extensions of the sedimentary geologic formations in the San Joaquin Hills are believed to constitute the base of the productive aquifer in the Irvine Subbasin. The drilling program indicates that beneath portions of the Station and to the southwest, the consolidated and semiconsolidated low-permeability sedimentary rocks function as a single hydrogeologic unit distinct from the alluvial aquifers. In the foothills to the north and east, the alluvium-bedrock acts as a single hydrogeologic unit.

These semiconsolidated low-permeability formations can be recognized in boreholes several ways: The formations are generally blue or gray (as opposed to tan or brown for the alluvial, floodplain, and permeable marine deposits); the low water-producing formations are more cemented (as indicated by slower drilling) or are almost all clay; and geophysical logs often show an increase in gamma-ray values. The groundwater from the "bedrock" formations is typically a sodium chloride water, with high total dissolved solids (TDS).

The depth to the base of the aquifer ranges from about 85 feet in Well 18_BGMW07, off Station near San Diego Creek (Plate 3-1, Section BB") to more than 1,000 feet below the surface at Well 18_BGMP10 at Irvine Center Drive and Hearthstone (Plate 3-1, Section AA'). At Well 18_BGMP10, near Irvine Center Drive and Hearthstone, the base of the aquifer is a sticky blue clay. In wells south of the Station and beneath the Station, bedrock is a greenish, siliceous shale or sandstone.

During the Phase I RI drilling, the deepest screened intervals in Wells 18_BGMW01, 18_BGMW05, and 18_BGMP09 were constructed into the semi-consolidated low-permeability aquifer below the potable water aquifer. The groundwater is high in sodium chloride and the formations are more indurated.

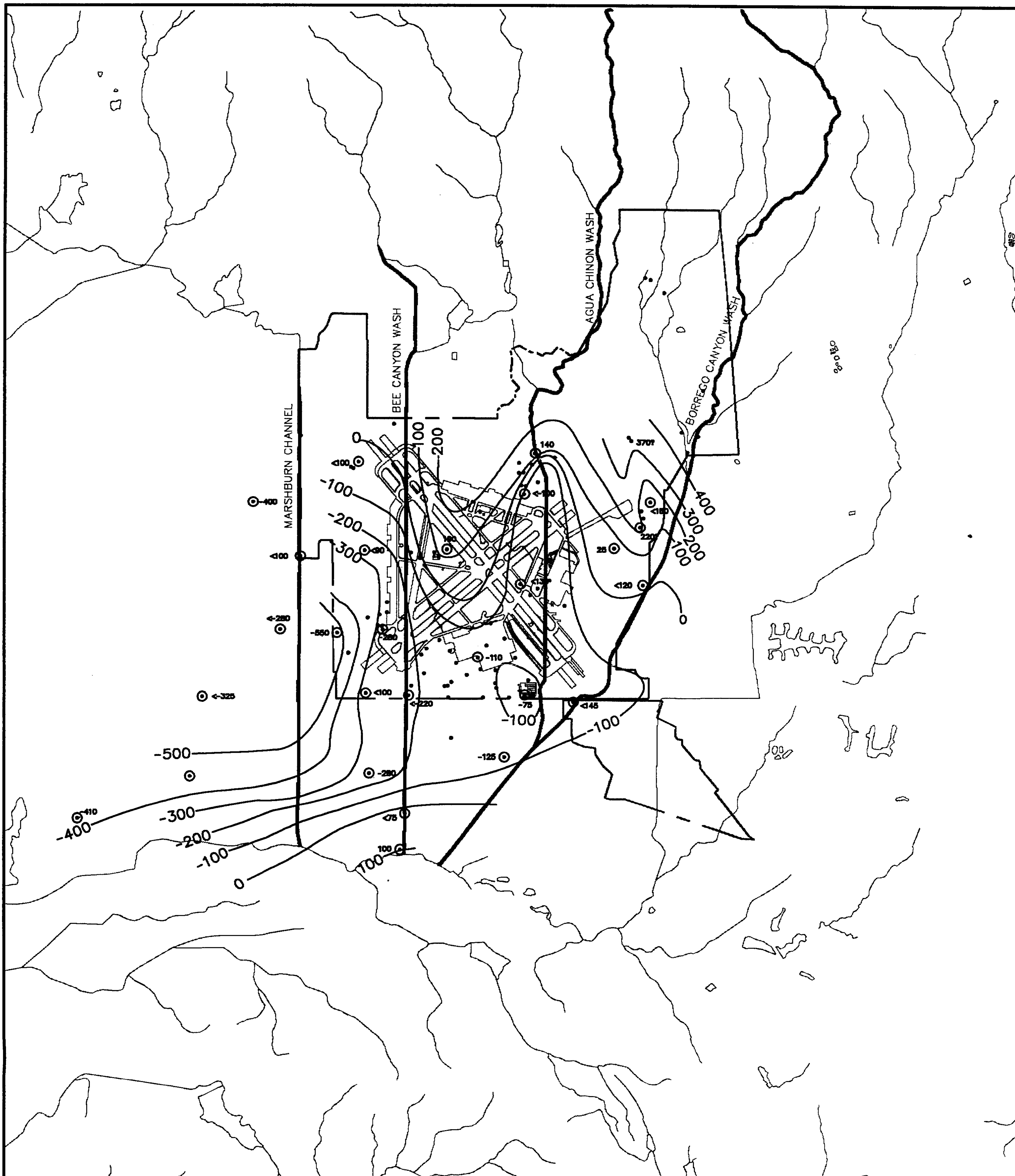
The wells in the foothills (Sites 1, 2, and 17) were constructed into the marine sediments, but the Oso Member is a unit of the regional aquifer. The potentiometric surface of the regional water body cuts across the alluvial-sedimenatry formation boundary, and the water quality is similar to the groundwater quality at depth in the regional aquifer.

One well each at Sites 5, 6, and 16, and Sites 18 Wells 18_BGMW02A and 18_BGMW03A were constructed so that the screens were set just above the semiconsolidated low-permeability bedrock. Figure 3-2 shows one interpretation of contours on the surface of low permeability semi consolidated formations that form the base of the regional aquifer.

The boundaries of the regional Tustin Basin aquifer system are the Santa Ana Mountains, the San Joaquin Hills, and the topographic divide between them southeast of the Station. These boundaries are well beyond the area of investigation for the Phase I RI. There is no distinct downgradient boundary; it may be generally defined as the eastern boundary of the Main Orange County Groundwater Basin.

3.1.3 Aquifer Parameters

Field methods, analysis methods, and results of approximately 60 pumping and slug tests are described in Appendix F. Information on hydraulic conductivities at each of the Westbay well ports is in Appendix G.



FEATURES:

MAJOR WASH OR STREAM

MCAS BOUNDARY

WASH OR STREAM

-325 BEDROCK ELEVATION CONTROL POINT

<-325 BEDROCK KNOWN TO BE DEEPER THAN SHOWN ELEVATION

WELL

-500 BEDROCK CONTOUR ELEVATION

BEDROCK = SEMICONSOLIDATED, LOW-PERMEABILITY SEDIMENTS

N

0 2000' 4000' 6000'

SCALE IN FEET

FIGURE 3-2
BEDROCK ELEVATION CONTOUR MAP
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3.1.3.1 Hydraulic Conductivities and Transmissivities

Calculated hydraulic conductivities for the wells screened into the uppermost aquifer range from 0.03 feet per day (ft/day) at Site 16 (Crash Crew Pit 2) to 65 ft/day at Site 9 (Crash Crew Pit 2). Aquifer parameters listed in Table 3-1. The areal distribution of parameters is shown in Figure 3-3.

Hydraulic conductivities of the uppermost portion of the aquifer in the area encompassing the southwest quadrant of the Station (Sites 7, 9, 10, and 22) appear to be higher than average. Conversely, the aquifers penetrated by wells in the areas north and southeast of the Station appear to have lower-than-average hydraulic conductivities.

Cluster wells screened in intermediate to deeper portions of the alluvial aquifer have hydraulic conductivities ranging from 10 to 65 feet per day. Wells screened near the base of the aquifer or constructed into the semiconsolidated low-permeability sediments (bedrock) generally have hydraulic conductivities of less than 1 foot per day.

Hydraulic conductivities for each 10-foot screen length at the four multiple-port monitoring wells were calculated by the well completion installers from Westbay Instruments, Inc. The values are summarized in Table 3-2. The methodology is described in Appendix G.

Only relatively thin sections (10 to 40 feet) of the aquifer were measured in each pumping or slug test. Thus no one value is representative of the aquifer. The values are useful for determining relative water movement in a portion of the aquifer.

3.1.3.2 Storativity

Storativity was determined from three pumping tests that included observation wells. The estimated storativity values were 0.013 at Wells 18_BGMW05E/18_BGMW05D, 0.00078 at Wells 18_BGMW05B/18_RW2, and 0.00063 at Wells 18_BGMW103/18_IDP2. Each of the three pairs of wells was screened at similar intervals.

The first value was obtained from pumping and observation wells completed in the uppermost portion of the aquifer near the site where Agua Chinon Wash exists the Station. The second pair of wells, also screened at similar depths (approximately 300 feet bgs), are in the same area near Agua Chinon Wash. Well 18_BGMW103, screened from 395 to 495 feet below the surface, was constructed specifically as an observation well for test pumping of Well IDP1 (a proposed Desalter project pumping well) screened from about 200 to 700 feet bgs. The pumping test was conducted by the Orange County Water District, while the observation well was monitored by the RI project team.

The first storage coefficent is from a pumping test in the uppermost portion of the aquifer; the aquifer system here may or may not have been confined during the later stages of pumping. The two values in the 10^{-4} range are from portions of the aquifer that are screened at depths below the potentiometric surface.

Storage coefficients were also calculated from 15 slug tests (Appendix F). Portions of the aquifer tested ranged from the most near-surface screened areas to the deepest screened areas in the semiconsolidated low-permeability aquifer beneath the alluvial aquifers. Values ranged from about 10^{-3} to 10^{-8}. The method used to determine these storativity values depends on "curve fitting," and the values should be used with caution.

3.1.3.3 Leakance Factor

Vertical movement of water through units of lower permeability can be a major source of water to wells in aquifers consisting of alternating layers of coarse- and

Table 3-1
Summary of Aquifer Parameters
MCAS El Toro Phase I RI Technical Memorandum

Site No.	Well No.	Test Analysis Method (a)	Test Type (b)	Transmissivity (ft*ft/day)	Hydraulic Conductivity (ft/day)	Storage Coefficient (c)	Leakance Factor
Operable Unit OU-1							
18	1B	B&R / CBP	S	4.6	0.23	4 E-04	
	1E	B&R	S	22	2.0		
	2A	B&R / CBP	S	0.15	0.01	5 E-04	
	2C	B&R	S	3.7	0.19		
	2D	Th: Recovery	P	0.57	0.03		
	2D	B&R	S	0.28	0.01		
	2E	C-J: Pumping	P	28	0.69		
	3A	Th: Recovery	P	900	45.0		
	3B	Th: Recovery	P	1080	53.9		
	3E	CBP	S	9.0	0.22	2 E-06	
	4A	C-J: Pumping	P	350	17.3		
	4B	C-J: Pumping	P	190	9.5		
	5A	B&R	S	0.18	0.01		
	5B	Th: Recovery	P	250	12.4		
	5B/RW-2	H: Pumping	P	396	9.9	7.8 E-04	0.1
	5C	C-J: Pumping	P	1260	63.0		
	5D	Th: Recovery	P	1230	28.5		
	5D/5E	H: Pumping	P	1250	27.8	1.3 E-02	0.1
	12	Th: Recovery	P	0.42	0.01		
	14	C-J: Pumping	P	170	4.3		
	15	Th: Recovery	P	0.61	0.02		
	16	C-J: Pumping	P	400	11.4		
	17	Th: Recovery	P	290	7.3		
	18	Th: Recovery	P	47	1.2		
	19C	Th: Recovery	P	250	12.5		
	19D	C-J: Pumping	P	3480	174		
	19E	B&R / CBP	S	9.0	0.22	5 E-03	
	22	Th: Recovery	P	230	5.8		
	24	B&R / CBP	S	43	2.2	1 E-03	
	101	C-J: Pumping	P	190	4.7		
	IDP1	C-J: Pumping	P	4170	34.8		
	IDP1/103	H: Pumping	P	5680	56.8	6.3 E-04	0.05
Operable Unit OU-2							
2	25	B&R	S	91	4.7		
	59	B&R	S	35	1.7		
	60	B&R / CBP	S	14	0.52	2 E-04	
	61	B&R / CBP	S	7.6	0.38	9 E-05	
3	26	C-J: Pumping	P	390	10.3		
	39	C-J: Pumping	P	55	1.9		
	64	CBP	S	120	3.0	8 E-07	
	65A	B&R	S	230	6.5		
5	67	Th: Recovery	P	1670	44.1		
	68	B&R / CBP	S	68	3.4	8 E-05	
10	77	Th: Recovery	P	1690	42.4		

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Table 3-1
Summary of Aquifer Parameters
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No.	No.	Method (a)	(b)	(ft*ft/day)	(ft/day)	(c)	Factor
Operable Unit OU-3							
1	57	B&R	S	24	1.2		
4	63	Th: Recovery	P	160	4.0		
	66	Th: Recovery	P	450	11.3		
6	69	B&R / CBP	S	44	1.1	2 E-04	
7	70	B&R / CBP	S	100	2.7	1 E-05	
	72	Th: Recovery	P	320	8.1		
	91	B&R	S	170	4.3		
	100	B&R	S	80	2.0		
8	29	B&R / CBP	S	7.2	0.18	6 E-08	
	73	B&R	S	570	14.3		
	74	Th: Recovery	P	920	23.1		
9	75	Th: Recovery	P	2280	65.1		
12	31	C-J: Pumping	P	170	4.3		
	48	B&R / CBP	S	380	9.7	1 E-05	
13	32	B&R / CBP	S	47	1.1	8 E-05	
	78	Th: Recovery	P	690	21.4		
15	51	B&R	S	20	0.52		
16	33	B&R	S	1.1	0.03		
	52	B&R / CBP	S	28	0.69	3 E-03	
19	54	B&R	S	26	0.86		
	85	B&R	S	13	0.37		
20	88	B&R	S	11	0.29		
21	56	Th: Recovery	P	720	19.6		
22	47	C-J: Pumping	P	260	7.1		

Source: Table F-2 (Appendix F)

(a) Test Analysis Method

B&R: Bouwer and Rice (1976), and Bouwer (1989)

CBP: Cooper, Bredehoeft and Papadopulos (1967)

C-J: Cooper-Jacob (1946)

H: Hantush (1960)

Th: Theis - Recovery (1935)

(b) Test Type

S: Slug test

P: Pumping test

(c) Storage coefficients calculated for slug test results used the Cooper, Bredehoeft and Papadopulos method. The values are sensitive to the curve-fitting process and are only order of magnitude estimates.

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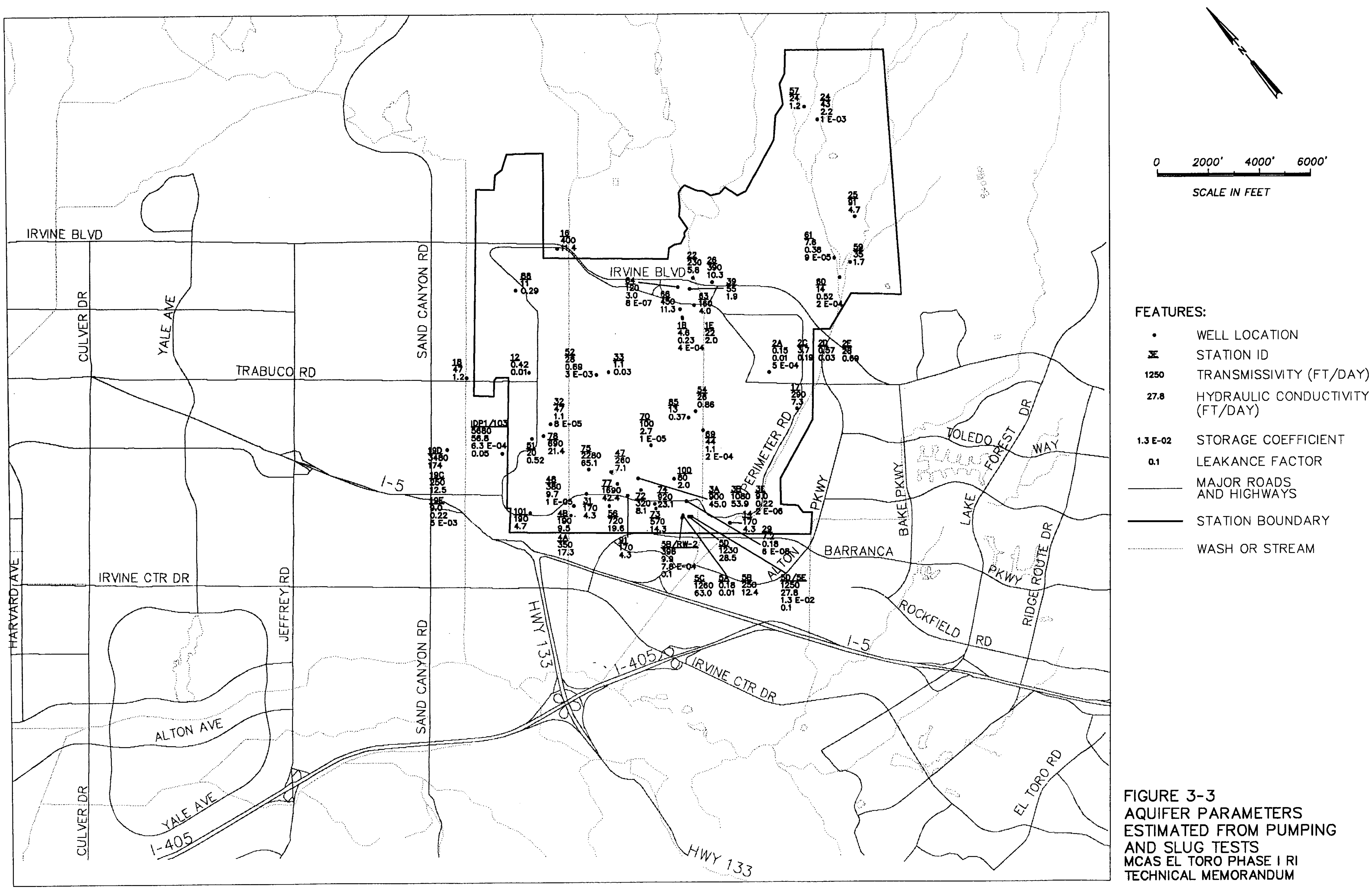

FIGURE 3-3
AQUIFER PARAMETERS
ESTIMATED FROM PUMPING
AND SLUG TESTS
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Table 3-2
Summary of Hydraulic Conductivity Values for Multiple-Port Wells 6, 8, 9, and 10

Westbay Multiport Station Identification	Depth (ft bgs)	Hydraulic Conductivity (ft/day)
18_BGMP06	109	0.54
	173	5.1
	299	0.54
	384	0.43
	449	0.12
18_BGMP08	75	0.14
	135	1.2
	305	(Value too high to monitor)
	447	0.31
18_BGMP09	67	0.6
	142	(Value too high to monitor)
	226	0.43
	278	1.9
	383	0.31
	462	0.04
18_BGMP10	222	1.4
	432	0.17
	567	0.14
	762	0.26
	887	0.17
	1,001	0.6

Source: Appendix G, Westbay Well Reports

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fine-grained sediments. Three values of ß (Hantush 1960), the leakage factor for vertical groundwater movement through less permeable layers, were calculated. The values ranged from 0.05 to 0.1. The pumping tests were relatively short-term, therefore these values should be considered approximate.

3.1.4 Hydraulic Gradients

On the basis of potentiometric head in the uppermost portion of the aquifer, recharge to the area beneath MCAS El Toro is from the southeast and the east. At Sites 1 and 2, water levels rise in direct response to precipitation.

3.1.4.1 Horizontal Hydraulic Gradients

Regional groundwater flow is toward the northwest, with an average groundwater gradient of about 0.008 foot per feet, or 44 feet per mile. This is consistent with regional water-level maps prepared by OCWD. Depth-to-water measurements during a 7-month period from late July 1992 through February 1993 indicate that, with minor variation, the regional direction of flow and gradient is consistent. Figures 3-4a through 3-4c show water-elevation contours for the uppermost portion of the aquifer during September 1992, December 1992, and February 1993, respectively. Data for depth-to-water measurements and calculations of water-level elevations, for all seven rounds of sampling, are in Tables 3-3a through 3-3g. Calculated average linear groundwater velocities at indivdual sites are summarized in Table 3-4.

Only minor changes in the groundwater flow direction are shown by the groundwater-elevation contour maps for the period July 1992 to February 1993 (Figures 3-4a through 3-4c). These maps suggest that the uppermost aquifer is not affected by pumping of deeper hydrogeologic units.

3.1.4.2 Vertical Hydraulic Gradients

Vertical hydraulic gradients can be inferred from reviewing relative water-level elevations in Well Clusters 1, 2, 3, 4, 5, and 19, which were drilled for this project, and from the DW well cluster, drilled as part of the *MCAS El Toro Perimeter Study* (JMM, 1989). Figure 3-5 shows water-level elevations at three typical clusters.

During the period of record, the hydraulic gradient at Well Cluster 1 has been upward and downward from the intervals measured by Wells 18_BGMW01B and 18_BGMW01C. Well 18_BGMW01A is completed into the low permeability semi consolidated sediments that underlie the aquifer. Recovery after pumping requires a period of months instead of hours or days. The approximately 35-foot decrease in water-level elevation between October and December was caused by an attempt at redevelopment.

At Well Cluster 2, the hydraulic gradient from successive deeper wells is upward. The potentiometric surface at Well 18_BGMW02A (deepest screen) has the highest elevation head, while Well 18_BGMW02E (the most shallow screen) always has the lowest elevation head. The potentiometric elevations represented by the two intermediate screens cross in early October, indicating a reversal of gradient at the end of the irrigation season. The pressure surfaces in the two deepest zones rise beginning in December, probably in response to precipitation in the recharge zone in the foothills. The surface in Well 18-BGMW02E may be beginning to rise in response to direct precipitation after the January 19, 1993, measurement.

The hydraulic gradient profiles at Well Cluster 3 indicate that the hydraulic gradient in the uppermost portion of the aquifer (Well 18_BGMW03E) is downward during the summer when pumping is heaviest. When pumping is reduced in the fall, the intermediate aquifers recover until their potentiometric surfaces are above the shallow potentiometric surface. The Well 18_BGMW03A potentiometric elevation rise is a combination of reduced pumping and pressure increase caused by precipitation and recharge in the foothills area.

3.1.5 Average Linear Groundwater Flow Velocities

The average linear groundwater flow velocities in the uppermost aquifer across the Station are in the range of 0.02 to 1.7 feet per day, as summarized in Table 3-4.

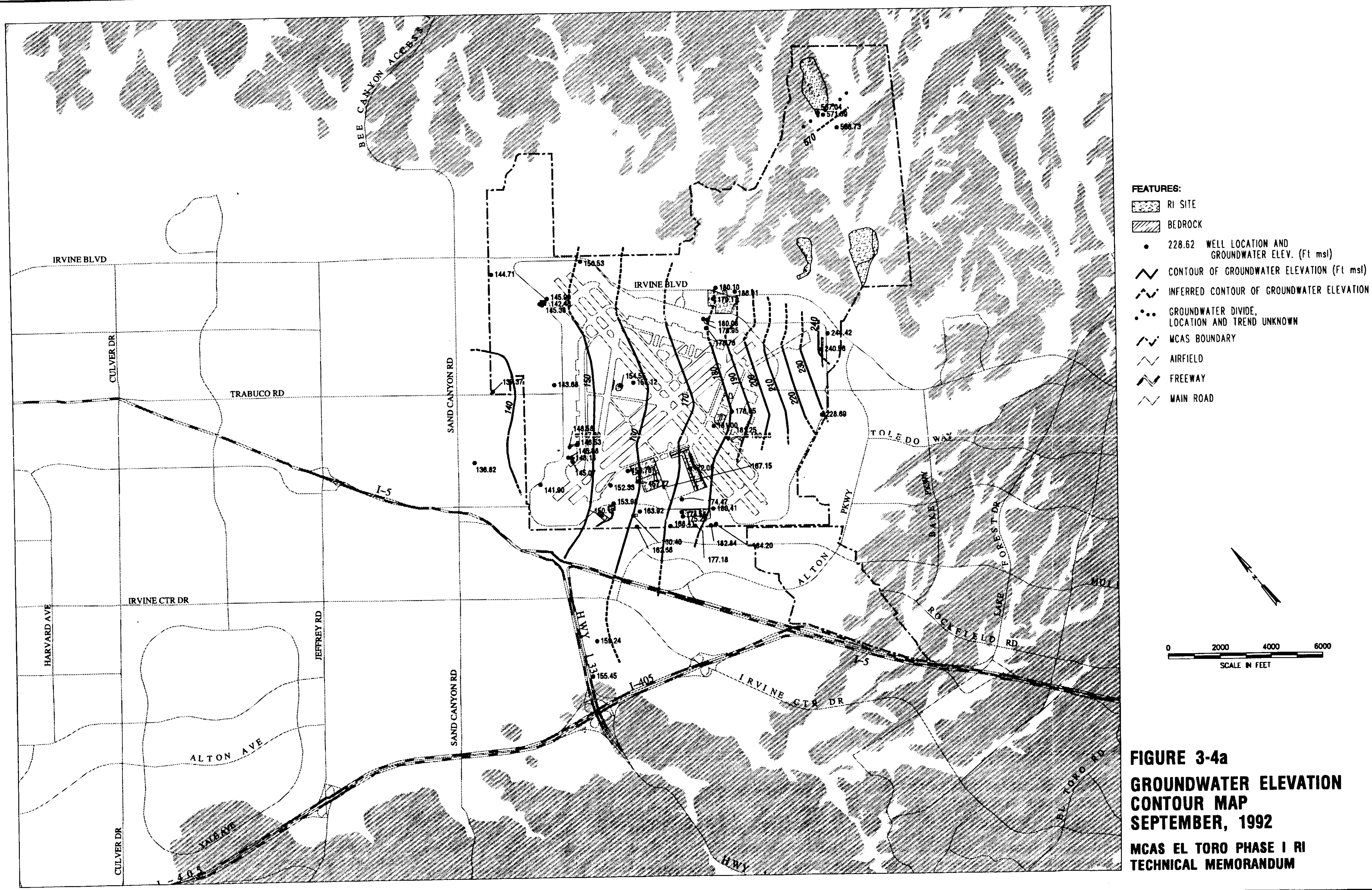

FIGURE 3-4a
GROUNDWATER ELEVATION CONTOUR MAP SEPTEMBER, 1992
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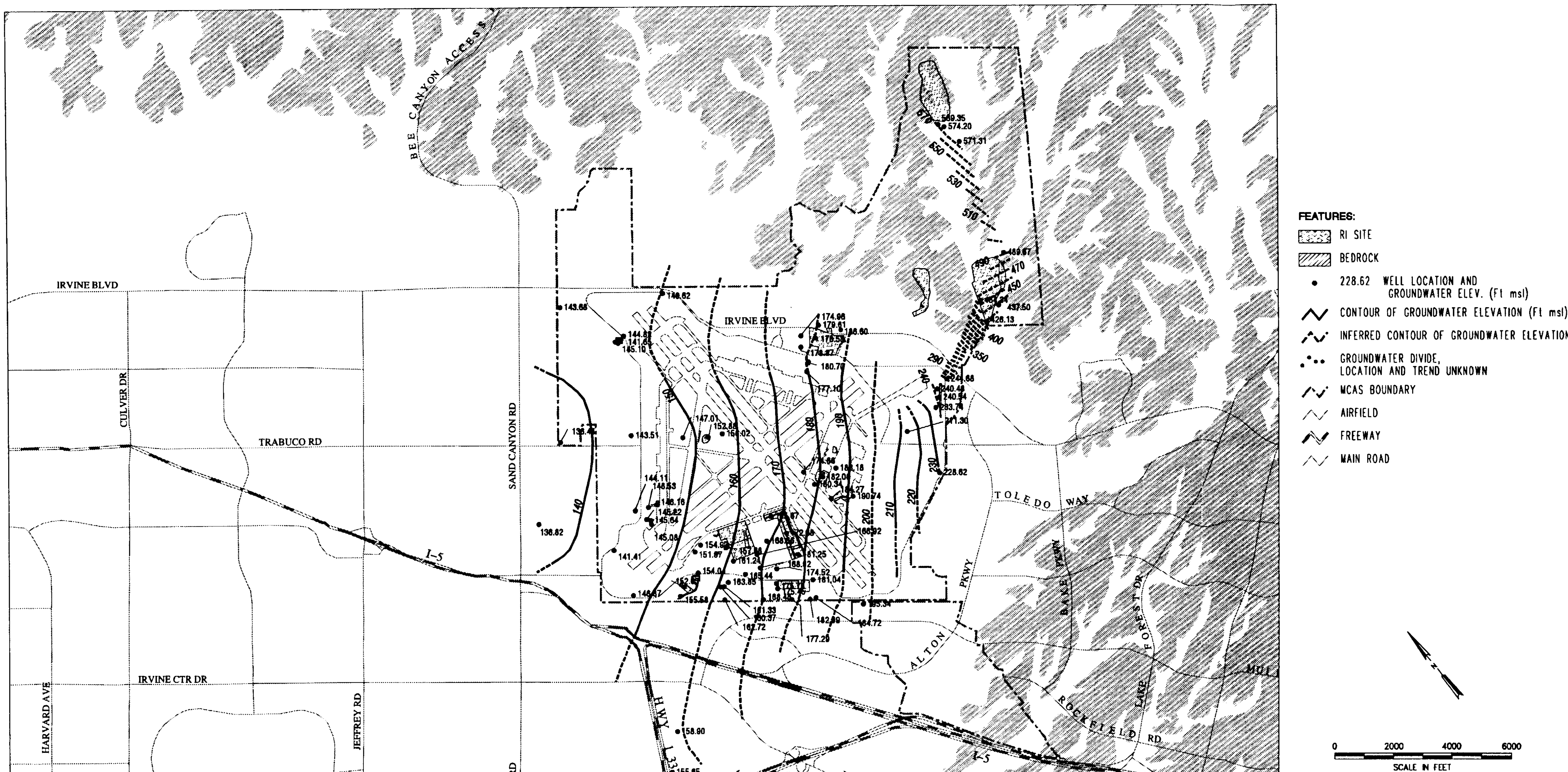

FIGURE 3-4b

GROUNDWATER ELEVATION CONTOUR MAP DECEMBER, 1992

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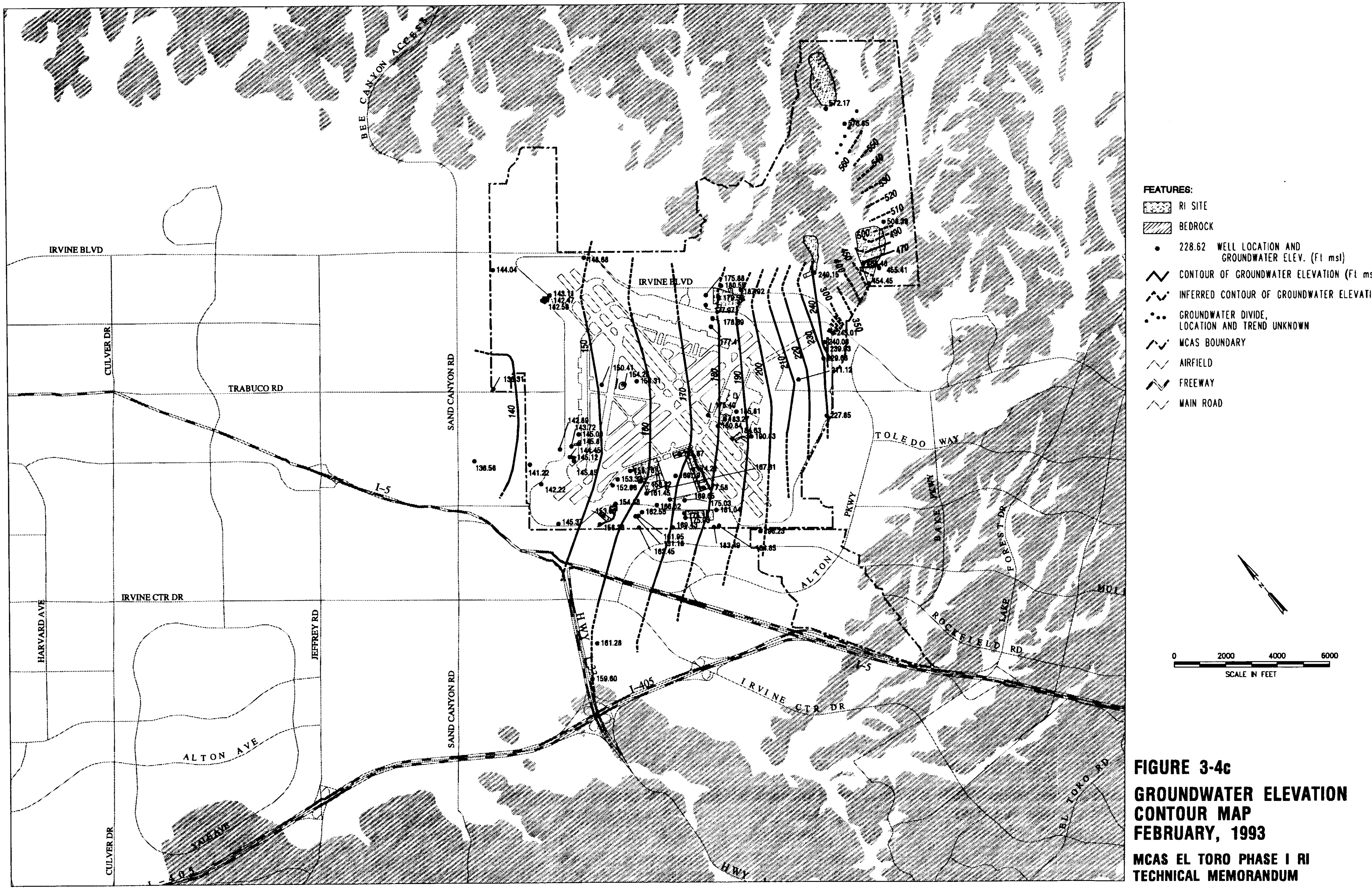

FIGURE 3-4c
GROUNDWATER ELEVATION CONTOUR MAP FEBRUARY, 1993
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