ORO LOMA SANITARY DISTRICT

April 5, 2004

Ms. Eva Chu
Alameda County Health Care Services
EHS/Environmental Protection
1131 Harbor Bay Parkway, Suite 250
Alameda, CA, 94502-6577

Alameda County
APR 08 2004
Environmental Health

Re: Transmittal of Remedial Technology Evaluation and Work Plan
Site of Former 1,000 Gal. UST STID 1996 SITE No. RO0000288
Oro Loma Sanitary District's Service Center
2600 Grant Avenue, San Lorenzo, CA

Dear Ms. Chu:

In response to your agency's letter dated January 2, 2004, the District's consultants have performed an evaluation of site history and conditions, and remedial technologies that might be appropriate for remediation of gasoline-tainted ground at the tank site. Their study concludes that additional subsurface investigation needs to be performed to fill data gaps before the most appropriate technology(ies) can be determined. The three-fold objective of the Work Plan that we herewith submit for your review is to resolve those data gaps, conclude upon the most appropriate remedial technology(ies) and to develop a Corrective Action Plan (CAP). Please review the document and provide comments you deem appropriate.

The District directed its consultant, The Sutton Group, to proceed with that investigative work so that it can coordinated with the next quarterly sampling event (in April). We understand that the work will be complete the following month.

The District desires to work with the Agency and close this case in the most expeditious manner. However, the District has underway a major construction project to upgrade its treatment plant and coordinating that project is a severe burden on District's resources. This constrains its ability to directly manage the tank closure project. We request that you direct questions or concerns firstly through our consultant, John Sutton of The Sutton Group at 925-284-4208 whom we have requested to lead this effort. If it is necessary to talk with the District, please call me at (510) 481-6965.

Yours truly,

Oro Loma Sanitary District

Michael Cortez, PE
District Engineer

Attachment

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www.oroloma.org

RO-288

March 31, 2004
Project No. 3022.11

Remedial Technology Evaluation and Work Plan

for

Obtaining Site Closure

in the vicinity of the former

1,000 Gallon Gasoline Tank

at the

ORO LOMA SANITARY DISTRICT SERVICE CENTER
SAN LORENZO, CALIFORNIA

APR 0 8 2004

PREPARED FOR

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PREPARED BY

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ACRONYMS AND ABBREVIATIONS

ACEH	Alameda County Environmental Health
AS	Air sparging
bgs	Below ground surface
BOD	Biochemical oxygen demand
BTEX	Benzene, toluene, ethylbenzene, and total xylene
CAP	Corrective action plan
CIH	Certified Industrial Hygienest
COD	Chemical oxygen demand
CSM	Conceptual site model
DO	Dissolved oxygen
EPA	U.S. Environmental Protection Agency
$Mg(OH_2)$	Magnesium hydroxide
mg/kg	Milligrams per kilogram
mg/l	Milligrams per liter
MTBE	Methyl tert-butyl ether
MW	Monitoring well
LLTD	Low-temperature thermal desorption
NAPL	Non-aqueous phase liquid
O&M	Operations and maintenance
ORC	Oxygen release compound
ORP	Oxidation reduction potential
PETG	Polyethylene terephthalate glycol
PG&E	Pacific Gas & Electric
PID	Photoionization detector
POTW	Publicly-Owned Treatment Works
ppm	Parts per million
QA/QC	Quality assurance / quality control
RBCA	Risk-base corrective action
RI/FS	Remedial investigation / feasibility study
RWQCB	Regional Water Quality Control Board

ACRONYMS AND ABBREVIATIONS (continued)

SVE	Soil vapor extraction
SWRCB	State Water Resources Control Board
TPH	Total petroleum hydrocarbons
USCS	United Soil Classification System
UP	Union Pacific Railroad
USA	Underground Service Alert
UST	Underground storage tank
VOC	Volatile organic compound
YBM	Younger Bay Mud

1.0 INTRODUCTION

The purpose of this report is to evaluate potential remedial technologies and develop a work plan to collect additional data for obtaining site closure for the 1,000-gallon underground storage tank (UST) removed in 1994 (the "Site") at the Oro Loma Sanitary District (the "District"). The District, who owns the tank site, is a local public agency with responsibility for collecting and treating the sewage generated in San Lorenzo, Castro Valley, and part of San Leandro, CA (Figure 1). The District's offices and vehicle maintenance facility, where the tank was located, are located immediately east of the District's sewage treatment works (POTW).

The Alameda County Environmental Health (ACEH) Services Department's Environmental Protection Division responded to the District's Request for Case Closure, Site No. RO0000288 in a letter to the District on January 2, 2004. In their letter, ACEH identified the following three technical comments:

- Total petroleum hydrocarbons in groundwater remain elevated. The dissolved plume is not shrinking.
- No source removal (aside from removal of the former underground storage tank) was conducted at the Site. The continued detection of elevated gasoline constituents in groundwater may indicate that residual concentrations present in the soil are still a source of pollution.
- The vertical extent of the plume has not been delineated with confirmation soil samples.

ACEH requested that the District prepare a feasibility study report to evaluate cleanup alternatives to address the above technical comments and prepare a workplan for the remediation of soil and groundwater. Following a review of existing site data and potential remedial technologies, the District's consultant, the Sutton Group, decided that it was premature to perform a feasibility study due to several data gaps at the Site. The data gaps limit the Sutton Group from performing a realistic evaluation of in situ remedial technologies and costs for implementation. This report summarizes the location and history of the Site, summarizes the previous investigations performed at the Site, identifies data gaps, identifies and screens potentially applicable remedial technologies to attain site cleanup, and includes a work plan to address data gaps.

1.1 SITE LOCATION AND LAND USE

The former 1,000-gallon UST was located in the parking lot adjacent to the vehicle Maintenance Building at the District's Service Center at 2600 Grant Avenue in San Lorenzo in an un-incorporated area of Alameda County (Figure 2). The former UST was located south of the Maintenance Building and west of the Engineering Building. The District's POTW, located adjacent to the former UST site, was initially constructed in the 1940s. The Site is located approximately 1,000 feet inland from the San Francisco Bay shoreline. All of the land located to the west of the Site is associated with the District's POTW.

Other facilities along Grant Avenue include a major packaging manufacturer, several heavy construction equipment distributors, large distribution warehouses, a major Pacific Gas and Electric (PG&E) transformer farm, and contractor's material and equipment storage yards.

The adjoining land north of the Maintenance Building is owned by Alameda County and has historically been used as an asphalt disposal site. That land filling operation, which has been in progress for decades, extends to the levee that borders San Lorenzo Creek, a quarter mile to the north. A PG&E power line crosses this area to a major substation north of the county land.

Land immediately north of the POTW is the San Lorenzo shoreline. Land further north beyond San Lorenzo Creek is the San Leandro shoreline. Land south of the treatment plant, formerly salt evaporators, is the Hayward shoreline area. The Union Pacific (UP) (formerly Southern Pacific) Railway's main freight lines are located one half-mile to the east of the Site and serve the Port of Oakland. Beyond the UP tracks are San Lorenzo's residential neighborhoods.

1.2 SITE HISTORY

The 1,000-gallon UST was installed in 1978 and replaced a similar volume UST that was installed in 1961 at the same location. Inventory control showed the original tank to be leaking (The Sutton Group, 2002). There are few records of the original UST replacement but long-time employees reported that it was performed under the observation of the (then) San Lorenzo Fire Protection District's fire marshal, now with the successor Alameda County Fire Department. The 1,000-gallon UST installed in 1978 was used to store leaded gasoline until 1985 when it was converted to store unleaded gasoline. The UST remained in use until it was removed in May 1995. No leakage was observed with this UST.

1.3 REGIONAL GEOLOGY AND HYDROLOGY

The following sections summarize the regional and local geology, hydrology, and groundwater quality for the Site.

1.3.1 Regional Geology

The Site is comprised of artificial fill placed over bay land of the East Bay Plain Geomorphic Province. Recent nomenclature (RWQCB, 1999) identifies the bay land as the Young Bay Mud (YBM) unit of the Alameda Formation. Across the province, the YBM ranges in thickness from less than 1 foot to 75 feet. The YBM is underlain by the San Antonio Unit, an alluvial outwash deposit, which originated in the Oakland Hills, some 5 miles to the east. The alluvium is underlain by the Yerba Buena Mud Unit, formerly called Old Bay Mud. The YBM is a black to green, organic-rich clay being deposited today in the San Francisco Bay. The clay typically has high plasticity, high moisture content, high compressibility, and is essentially impervious. It contains occasional gravel and sand layers, shell fragments/layers, peat, and organic debris.

1.3.2 Regional Hydrolology

The Site is located within the San Lorenzo-San Leandro hydrogeological sub-area of the San Francisco Basin. The San Lorenzo and San Leandro sub areas are distinct areas based on the separate origins of the outwash materials. While the majority of these sub-basins are alluvial outwash, including sandy zones, the YBM that comprises the bayland of the site area forms a virtually impervious groundwater barrier. Groundwater from the outwash deposits exit to the Bay via the local stream channels. Shallow water in the YBM is bay-influenced and is thus brackish.

Regional groundwater flow across the East Bay Plain is generally to the west, i.e. from the Hayward Fault to the Bay, and generally correlates with topography, with flow direction and velocity influenced by buried stream channels that typically are oriented in an east-west direction. Groundwater flow in the site vicinity is to the south. Not only has this has been confirmed in the studies performed at the Site by this firm but the southward local flow of the San Lorenzo sub-area, is confirmed in the reference (RWQCB, 1999)[1].

1.3.3 Site Geology

The subsurface profile on the District property comprises man-made fill placed over bayland deposits. A layer of construction debris, including bricks, tile and some lumber is located between the bayland deposits and the fill. The debris was likely placed to improve site accessibility during original construction a half a century ago. The bayland soils immediately underlying the fill soils often have a peat layer or crusted clay surface, which is typically brown to black, about one foot thick, and with a noticeable organic odor.

A layer of fine, gray-to-black sand, which was typically clean but with silty or clayey stringers, and varying in thickness from one to almost 4 feet, underlies the crust in many of the test trenches and borings. The top of this sand layer is typically encountered between 3 ½ and 7 feet

[1] RWQCB, 1999 page 40: *In the very southern end of the study area, in the San Lorenzo Sub-Area, the direction of flow may not be this simple. The small set of water level measurements available seem to show that the groundwater in the upper aquifers may be flowing south, with the deeper aquifers, the Alameda Formation, moving north.*

below ground surface (bgs) where found, which is at the approximate native soil interface. The bottom of the sand layer is typically encountered between 6 and 10 feet bgs. The crust, peat, and sand layers were underlain by characteristic green to black, organic-rich, moderately to highly plastic, YBM clays.

Gravelly fill extended to depths of approximately five feet bgs in the borings drilled in Grant Avenue. The imported backfill placed around the trunk sewer lines in Grant Avenue pipes are open-work gravels, some of which extend to 16 feet bgs. The native soil profile was typical of the bayland, including a layer of brown, fibrous peat found at 12 to 13 ½ feet bgs.

Previous investigations at the Site have shown that contact between the YBM clays and the San Antonio Formation is at about 25 feet bgs. Brown clays are present beneath the Bay Mud and have been found at depths up to 51 feet bgs in borings drilled during a geotechnical investigation performed at the Site in 1995 (The Sutton Group, 1995a).

1.3.4 Site Hydrology

The depth to groundwater has been measured in temporary wells drilled during previous investigations (see Section 1.4) and in the three monitoring wells installed and monitored through 1999. Depth to groundwater measured for four quarters in the three monitoring wells (MW) installed in 1999 ranged between 4.5 and 8.5 feet bgs (average of 6.5 feet bgs) and showed approximately 1.7 feet of fluctuation in any well over the period. The on-site monitoring well, MW-3, had the highest groundwater level, while the surface elevation is a half a foot higher than at MW-1 and MW-2 in Grant Avenue. This is likely the result of de-watering effect of the gravel bedding that surrounds the sewer mains in Grant Avenue.

It has previously been shown that on-site shallow groundwater essentially is confined to a pervious sand layer located at approximately six feet bgs located above the Bay Mud (The Sutton Group, 1998a). Site groundwater generally flows southeasterly from the former UST area towards Grant Avenue where it is intercepted by the trench backfill of an abandoned sewer main beneath the sidewalk of the southwesterly-aligned Grant Avenue. This was demonstrated in the Supplemental Site Investigation (The Sutton Group, 1998a) and confirmed by the monitoring wells installed southwest to southeast, i.e. 'down gradient' of that alignment (The Sutton Group, 2002). Figure 3 includes a cross section cut from the former tank site, south across the width of Grant Avenue. The cross section, when combined with the groundwater levels measured in 1999 and the benzene plume concentrations presenting in Figure 4, confirm the local south to southeast gradient.

Local groundwater flow is also influenced by the gravel backfill in the on-site sewer line that extends under the parking lot area from the Maintenance Building to the new sewer line in the Grant Avenue sidewalk. The north-south orientation of the line also intercepts any groundwater flow towards the west, and directs it into the same sidewalk trench gravel. The high porosity gravel backfill, and westerly grade of the sidewalk sewer trench bottom provides a preferential pathway through the impervious YBM, a substantial potential difference (i.e. a 'sink') that intercepts all shallow groundwater flow and directs it towards the POTW.

1.3.4 Current Groundwater Quality and Beneficial Use

The 1999 California Regional Water Quality Control Board (RWQCB) report titled "East Bay Plain Groundwater Basin Beneficial Use Evaluation Report for Alameda and Contra Costa Counties" discusses the proposed re-zonation of the San Francisco Basin into three zones. The Site is located in "Zone C: - shallow, non-potable groundwater proposed for de-designation of the Municipal Supply Beneficial Use". The report presents a recommendation that the RWQCB should locally de-designate the municipal beneficial use for brackish, shallow groundwater in Bay-front artificial fill, young bay mud and the San Antonio Formation/Merritt Sand. The report also states "This groundwater meets the exemption criteria of the State Water Resources Control Board's (SWRCB's) Sources of Drinking Water Policy because the groundwater could not reasonably be expected to serve a public water supply and exceeds the 3,000 milligrams per liter (mg/L) total dissolved solids criteria." This proposed plan is the successor to the 'non-attainment zone' designation for the site area.

1.3.5 Conceptual Site Model

The conceptual site model (CSM) prepared by the Sutton Group proposes that off-site transport of petroleum constituents is likely occurring by groundwater migrating laterally in a southward direction along the thin sand lens under the parking lot area toward Grant Avenue where it is intercepted by several existing and abandoned sewer main lines in Grant Avenue. The gravel backfill and grade of the lines provide a preferential pathway which transports the flow in a westerly direction into the District's POTW.

1.4 PREVIOUS INVESTIGATIONS

The following sections include summaries of investigations performed at the Site between 1993 and present. These field investigations and reporting performed by the District have been performed under the direction and/or request of various ACEH case officers.

1.4.1 1993 Soil and Groundwater Investigation

A subsurface investigation of the UST area was initiated by another consultant in August 1993 and included drilling and collecting soil and grab groundwater samples from six borings (Figure 5). Analytical results showed total petroleum hydrocarbons (TPH) as gasoline at concentrations up to 4,300 milligrams per kilogram (mg/kg) [parts per million (ppm)] in soil samples and at concentrations up to 1,600 mg/L (ppm) in grab groundwater samples. Depth to groundwater was recorded at 6 feet bgs and no free product was identified (The Sutton Group, 1995b). The investigation was terminated due to interference with seismic retrofit work being performed on the adjacent Maintenance Building. Analytical results for the 1993 investigation are summarized in Table 1.

1.4.2 1994 Soil Investigation

The Sutton Group performed a site investigation in 1994 that consisted of excavating seven exploratory test trenches in the parking lot. Tasks included performing a visual inspection of the test pit sidewalls and collecting soil samples from the test pits. A thin (less than one foot thick) sand layer sandwiched between Bay Mud organic deposits was observed between 6 and 7 feet bgs in the first several trenches excavated (The Sutton Group, 2002). The depth to groundwater was similar to the depth to groundwater noted in the 1993 borings. The presence of the sand layer was unexpected and the subsequent trenches were excavated to shallower depths to prevent caving of the trench walls. Degraded TPH as gasoline was reported at concentrations up to 1,600 mg/kg in the soil samples collected from the test pits. Grab groundwater samples were not collected because of caving of trench walls (The Sutton Group, 1997). Analytical results for the 1994 investigation are summarized in Table 2.

1.4.3 1995 Tank Removal and Confirmation Sampling

The Sutton Group observed the removal of the 1,000-gallon UST in May 1995. Ms. Amy Leech with ACEH was on site during the tank removal. An 11-foot wide by 17-foot long pit was excavated to remove the 4-foot diameter tank. Some of the soil overlying the tank was stained in the vicinity of the fill pipe and also near the short service pump line, suggesting overfill spillage and fuel line leakage. The bottom of the tank was located at a depth of 7 feet bgs. The tank bottom was founded in pea gravel and groundwater was initially noted to be seeping into the pit excavation at 7.5 feet bgs (The Sutton Group, 2002). Both a representative from the Sutton Group and ACEH documented the absence of obvious tank leaks and no damage to the corrosion protection was observed. Little gasoline odor was noted in the shallow fill soil over the tank or the area of the service piping. No floating product was visually observed.

Excavation of the pea gravel exposed native soils similar to those encountered in the 1994 trench excavation. Excavation walls were relatively stable and shoring was not necessary during tank removal. Groundwater was later noted to be seeping from the pit end walls in bayland soils encountered at approximately 6 feet bgs. Soil samples were collected from each end of the tank pit and from beneath the supply line elbow in the fuel island. An additional soil sample was also collected from native soils beneath the location of the removed tank. The seepage of groundwater into the excavation was of insufficient volume to collect a grab groundwater sample. The thin (less than 1 foot thick) sand layer sandwiched between Bay Mud deposits and first identified during the 1994 test pit investigation was observed in the sidewalls of the tank excavation (The Sutton Group, 2002). Analytical results for soil samples collected during the 1995 tank removal are summarized in Table 3.

1.4.4 1995 Feasibility Study

Based on the data collected during the 1993, 1994, and 1995 tank removal activities, the Sutton Group performed a feasibility study in December 1995 and concluded that the best solution for tank site closure, based on then-current guidelines from the RWQCB, was removal of petroleum affected soil and on-site land farming of affected soil. The affected soil was located within an area generally south from the tank through the parking lot to near the south end of the Engineering Building. The Sutton Group performed a geotechnical investigation in July 1995 to provide data for the contractor's use in design of shoring for protection of the Engineering Building. Two geotechnical borings were drilled adjacent the Engineering Building to depths of 51 and 36 feet (Figure 5).

Through discussions with ACEH, the District decided not to excavate the petroleum-affected soil due to concerns that significant underpinning and shoring of the Engineering Building would be necessary. At that time, the RWQCB, ACEH, and the District discussed options for obtaining site closure. The RWQCB representative, Kevin Graves, suggested that the District apply for 'non-attainment zone' status and outlined a path towards achieving that designation with the intent of relieving the District of the need for remediation of the site soil. ACEH's representative, Tom Peacock, concurred with the proposed non-attainment zone designation for the Site.

1.4.5 1996 Soil and Groundwater Investigation

Per a request from ACEH, the District performed a soil and groundwater investigation at the Site in March 1996. A total of seven borings were drilled and soil samples collected at various depths between 1 ½ and 7 feet bgs (Figure 5). The borings were then extended to approximately 12 feet bgs and temporary well casings installed to facilitate collection of groundwater samples at each boring location. Groundwater was encountered between 5 and 8 feet bgs and grab groundwater samples collected from the borings and). Soil and groundwater samples were analyzed for TPH as gasoline, benzene, toluene, ethylbenzene, and xylene (BTEX), methyl tert-butyl ether (MTBE), and lead. Analytical results for soil and grab groundwater samples collected during the 1996 investigation are summarized in Table 4.

Based on the data collected during the 1996 investigation, ACEH's risk assessor recommended that the District perform an additional off-site plume definition and a Tier 1 risk-based corrective action (RBCA).

1.4.6 1998 Supplemental Soil and Groundwater Investigation

ACEH requested that the District perform a soil and groundwater investigation at the Site in May 1998 to demonstrate that the gravel backfill in the sanitary sewer lines was acting as a preferential pathway and diverting petroleum-affected groundwater towards the District's POTW. Soil and grab groundwater samples were collected from a total of six borings (The Sutton Group, 1998a). The boring locations are shown on Figure 5 and analytical results for soil and grab groundwater samples collected during the 1998 investigation are summarized in Table 5. Two indoor and one outdoor air samples were also collected over a 24-hour period to provide data for a RBCA risk assessment and evaluate if on-site personnel are being exposed to volatile organic compounds (VOC) volatilizing from groundwater, through soil, and into the Engineering Building through cracks in the walls and foundations.

Following the investigation, the Sutton Group prepared a summary report outlining the results of the soil, groundwater, and air samples. In addition, the report presented the results of the RBCA risk assessment performed by Barbara Marks, a Certified Industrial Hygienist (CIH), who was approved in advance by ACEH's risk assessor. The results of the RBCA risk assessment indicated that there was no significant health risk to the public or to the District's staff that could be attributed to petroleum-related constituents migrating from the source area (The Sutton Group, 2002). The groundwater sampling results validated the premise that the sewer lines along Grant Avenue are acting as lateral containment to off-site transport of petroleum-affected groundwater and then westward along the sewer line backfill towards the POTW (The Sutton Group, 1998a).

1.4.7 1999 Soil and Groundwater Investigation

Following receipt of the summary report for the 1998 investigation, ACEH requested that the District install three groundwater monitoring wells around the Site and perform quarterly monitoring for a one-year period to confirm that petroleum-related constituents were contained on the District's property. ACEH subsequently verbally requested that the District perform a one-time sampling of the monitoring wells for seven oxygenates. ACEH's case officer at the time approved the work plan that presented the interpreted benzene plume contours, locations of the proposed wells, and proposed oxygenates sampling.

The monitoring wells (MW-1, MW-2, and MW-3) were drilled and installed at the Site in January 1999. Wells MW-1 and MW-2 were installed in an area south of the abandoned sewer main beneath the sidewalk of the southwesterly-aligned Grant Avenue and well MW-3 was installed in the western portion of the parking lot area (Figure 4). The monitoring wells were initially sampled during four quarterly sampling events (February 1999, May 1999, August 1999, and November 1999). The results for the four quarters of groundwater sampling events were summarized in a letter submitted to ACEH on January 17, 2000. Two additional sampling events were performed July 2003 and October 2003 for the three monitoring wells. The analytical results for the six quarterly sampling events conducted for MW-1, MW-2, and MW-3 are summarized in Table 6. Analytical results for soil samples collected from the three monitoring wells are summarized in Table 7. Analytical results of groundwater samples analyzed for selected fuel oxygenates and additives are summarized in Table 8.

Depth to groundwater was recorded in each monitoring well. Monitoring wells were sampled by purging three well volumes and then collecting groundwater samples using a clean, Teflon bailer at each well. Free product was not visually observed in the sample bailer during any of the quarterly sampling events but hydrocarbon sheen was observed in the groundwater samples collected from MW-4 (The Sutton Group, 2003).

TPH as gasoline, BTEX constituents, and MTBE were not detected in the groundwater samples collected during the six quarterly monitoring events performed for monitoring wells MW-1 and MW-2. MTBE was reported at concentrations up to 3.1 micrograms per linter (µg/L) [parts per billion (ppb)]. In general, the sampling results for MW-1 and MW-2 confirm that the abandoned sanitary line beneath the sidewalk of the southwesterly-aligned Grant Avenue is intercepting petroleum-related constituents in groundwater. Sampling results for MW-3 confirm that petroleum-related constituents are limited to the immediate area south of the former UST and have not spread laterally in a westerly direction.

1.4.8 2002 Soil and Groundwater Investigation

In 2001, ACEH requested that the District install two additional groundwater monitoring wells down gradient of the former UST location to document decreasing concentrations of petroleum constituents in the on-site plume. The two monitoring wells (MW-4 and MW-5) were drilled and completed in the District's parking lot in October 2002 and groundwater samples collected over five quarterly monitoring events (Figure 4). The data collected from these two wells were used to supplement the information collected from the three monitoring wells installed at the Site in 1999. The analytical results for the six quarterly sampling events conducted for MW-4 and MW-5 are summarized in Table 6.

The highest concentrations of TPH as gasoline (97 mg/l), ethyl benzene (4.9 mg/l), and total xylene (24 mg/l) were reported in the groundwater samples collected from well MW-4 in July 2003 (Table 6). The highest concentrations of benzene (12 mg/l) and toluene (9.3 mg/l) were reported in the quarterly groundwater samples collected from MW-4 in October 2003. Well MW-4 is located nearest the former UST location.

Concentrations of TPH as gasoline, BTEX constituents, and MTBE reported in groundwater samples collected from well MW-5 were lower than concentrations reported for MW-4 and generally showed decreasing concentration trends for the analytes sampled (Table 6).

1.5 DATA GAPS

A data gap was identified by ACEH in their January 2, 2004, response to the District for site closure. The vertical extent of the petroleum hydrocarbon plume has not been delineated with soil samples in and around the vicinity of the former UST during previous site investigations. Elevated concentrations of TPH as gasoline and BTEX constituents were reported in soil samples collected at the bottom of several borings (typically between 6 and 7 ½ feet bgs).

This data gap can be addressed by advancing several soil borings in the vicinity of the former UST area and collecting soil samples several feet below the lower interface between the thin sand layer and the Bay mud. Soil samples should be collected from multiple intervals at depths greater than 7 ½ feet bgs to ensure that the vertical extent of petroleum hydrocarbons in soil is fully characterized. Once the vertical extent of contamination is determined, the volume of petroleum-affected soil and groundwater can be determined.

A second potential data gap at the Site is whether floating product is present in the interior portions of the groundwater plume. To date, the presence of floating product has been monitored during the quarterly sampling events by visually inspecting the groundwater collected in sampling bailers. A floating product/water interface probe should be used in the on-site monitoring wells during the upcoming April 2004 and future quarterly sampling events. The interface probe is a proven technology that detects the presence of any non-aqueous phase liquids (NAPLs) in groundwater monitoring wells. The presence of floating product in the groundwater at the Site may be a continuing source for the elevated concentrations of TPH as gasoline and BTEX reported in two of the on-site monitoring wells. The presence or absence of floating product will also be an important factor in evaluating the effectiveness of the preferred remedial technology.

The third data gap identified at the Site is the lack of site-specific geochemical parameters including dissolved oxygen (DO) concentrations, oxidation reduction potential (ORP), dissolved iron and manganese concentrations, biochemical oxygen demand (BOD), and chemical oxygen demand (COD). No site-specific information is available for these geochemical parameters and this data is needed to further evaluate the effectiveness of in situ remedial technologies.

2.0 TECHNOLOGY SCREENING

This section identifies and evaluates the remedial technology types that may be applicable for the petroleum-related constituents that have been identified during the various soil and groundwater investigations performed at the Site.

2.1 IDENTIFICATION OF REMEDIAL TECHNOLOGIES

Remedial technologies were identified and classified as either in situ or ex situ. In situ remediation involves in-place treatment of petroleum-affected soil and groundwater. Ex situ remediation involves the excavation of petroleum affected soil and groundwater followed by treatment on site or transport to an off-site treatment and/or disposal area.

The Sutton Group prepared a remedial investigation / feasibility study (RI/FS) and corrective action plan (CAP) for the Site in December 1995 (The Sutton Group, 1995b). The RI/FS report evaluated the feasibility of several in situ remedial technologies including bioventing, air sparging, and SVE and several ex situ remedial technologies including low-temperature thermal desorption (LTTD), biopiles, and landfarming.

2.1.1 In Situ Remedial Technologies

Three in situ remedial technologies were evaluated in this report including:

- Bioremediation using Oxidation Release Compound (ORC)
- Bioventing
- Air Sparging (AS) with Soil Vapor Extraction (SVE)

2.1.2 Ex Situ Remedial Technologies

All ex situ remedial technologies or disposal options first include the mechanical excavation of petroleum-affected soil prior to off-site treatment and disposal or on-site treatment and disposal. Following mechanical excavation, typical ex situ treatment technologies used in remediation of petroleum hydrocarbons include:

- Off-site disposal at an approved landfill facility
- On-site land farming on District land adjacent to the POTW
- On-site biopiles on District land adjacent to the POTW
- LTTD

2.2 EVALUATION OF REMEDIAL TECHNOLOGIES

Several remedial technologies were evaluated for their effectiveness and implementability to remediate the petroleum constituents identified at the Site.

The effectiveness evaluation of each remedial technology considers the following:

- Effectiveness in eliminating, reducing, or controlling the current and potential risks and hazards for the petroleum constituents identified at the Site.
- Reliability and whether a remedial technology is proven with respect to the petroleum constituents identified at the Site.

The implementability evaluation of each remedial technology considers the technical and administrative feasibility of implementing the technology. Technical implementability relates to the difficulty associated with the actual construction and logistics of the remedial technology. Examples of administrative implementability of the proposed technologies include the time required for installation and ability to obtain necessary permits.

2.2.1 In Situ Treatment – Bioremediation Using ORC

In situ treatment by bioremediation using ORC is a process where subsurface aerobic bioremediation is accelerated through the addition of a patented formulation of magnesium peroxide into the subsurface soil and groundwater.

2.2.1.1 Bioremediation Using ORC – Effectiveness

Oxygen is often the limiting factor for aerobic microbes capable of biologically degrading petroleum hydrocarbons. Without adequate oxygen, contaminant degradation will either cease or may proceed by much slower anaerobic (oxygen free) processes. Depending on site conditions, a single application of ORC can release oxygen over a three-month to one-year period. Indigenous aerobic microbes flourish in the presence of the long-lasting oxygen source, accelerating natural attenuation of target contaminants such as gasoline-range hydrcarbons, BTEX, and MTBE.

The application of slow-release compounds such as ORC is ideal for sites where geological or physical conditions make active systems inappropriate. Particularly in clay soils, where pumping is difficult and sparging promotes channeling, the slow release of ORC has distinct advantages. The application of ORC has been documented in achieving site closure at numerous former leaky UST sites. ORC has become a highly known and widely used product to treat petroleum constituents in groundwater with more than 10 years of successful applications since its introduction in the early 1990s.

The effectiveness of bioremediation using ORC at the Site may be reduced if floating product is present in the groundwater plume. Although bioremediation using ORC can be used at sites with floating product, numerous repeated applications of ORC would be necessary to treat the continuing source of hydrocarbons to the plume and potentially make the technology cost prohibitive at the Site. In addition, the vertical extent of the plume has not been delineated to date and the treatment of high concentrations of TPH as gasoline and BTEX for a large-volume plume would substantially increase the amount of ORC and applications needed.

2.2.1.2 Bioremediation Using ORC – Implementability

ORC is highly implementable at the Site and typically is applied in the subsurface via direct push injection, borehole backfill, or filter socks. When using direct push and/or borehole backfill, ORC powder is mixed with water to form an injectable slurry. The slurry is then pumped into the subsurface under pressure where it disperses into the aquifer via diffusive and advective forces. In filter sock form, ORC is placed into monitoring wells where the compound reacts when contacted with groundwater. Upon exhaustion, which can take up to one year, filter socks can be removed and replaced to replenish the oxygen supply and continue treatment. The Site currently contains several monitoring wells that are located within the middle to down-gradient edge of the plume area. Several additional direct-push borings should also be advanced in the area of the former UST location and ORC added to increase the amount of up-gradient source removal at the Site.

ORC offers an in situ treatment that requires no aboveground equipment after initial injection, thereby allowing remediation without disrupting normal site activities. Applying ORC to the subsurface is fast and easy and leaves no visible sign of its application. The controlled rate of oxygen release by ORC avoids the potential hazards with injection of highly reactive materials such as hydrogen peroxide.

Besides oxygen, the only other by product of ORC's reaction with water is magnesium hydroxide $Mg(OH)_2$, or Milk of Magnesia, a substance routinely ingested as an antacid.

2.2.2 In Situ Treatment - Bioventing

Bioventing is an in situ remediation technology that uses indigenous microorganisms to biodegrade organic constituents adsorbed to soils in the unsaturated zone. Soils in the capillary fringe and the saturated zone are not affected. In bioventing, the activity of the indigenous bacteria is enhanced by inducing air (or oxygen) flow into the unsaturated zone (using extraction or injection wells) and, if necessary, by adding nutrients.

When extraction wells are used for bioventing, the process is similar to SVE. However, while SVE removes constituents primarily through volatilization, bioventing systems promote biodegradation of constituents and minimize volatilization (generally by using lower air flow rates than for SVE). In practice, some degree of volatilization and biodegradation occurs when either SVE or bioventing is used.

2.2.2.1 Bioventing – Effectiveness

Bioventing is not appropriate for sites with shallow groundwater tables located less than 3 feet below the land surface. Special considerations must be taken for sites with a groundwater table located less than 10 feet below the land surface because groundwater upwelling can occur within bioventing wells under vacuum pressures, potentially occluding screens and reducing or eliminating vacuum-induced soil vapor flow. This potential problem is not encountered if injection wells are used instead of extraction wells to induce air flow.

Soil structure and stratification are important to bioventing because they affect how and where soil vapors will flow within the soil matrix when extracted or injected. Structural characteristics such as microfracturing can result in higher permeabilities than expected for certain soils (e.g., clays). Increased flow will occur in the fractured but not in the unfractured media. Stratification of soils with different permeabilities can dramatically increase the lateral flow of soil vapors in more permeable strata while reducing the soil vapor flow through less permeable strata. This preferential flow behavior can lead to ineffective or extended remedial times for less-permeable strata or to the possible spreading of contamination if injection wells are used.

Bioventing is not expected to be an effective treatment technology for the remediation of petroleum hydrocarbons at the Site due to the shallow depth to groundwater and the low permeability of the Bay Muds that are predominant at the Site.

2.2.2.2 Bioventing – Implementability

In general, remedial approaches that rely on biological processes should be subject to field pilot studies to verify and quantify the potential effectiveness of the approach and provide data necessary to design the system. For bioventing, these studies may range in scope and complexity from a simple soil column test or microbial count to field respirometry tests and soil vapor extraction (or injection) pilot studies. The scope of pilot testing or laboratory studies should be commensurate with the size of the area to be remediated, the reduction in constituent concentration required, and the results of the initial effectiveness screening.

Bioventing systems typically consist of one or more injection wells, an air blower, and numerous monitoring well points where air samples can be collected. Bioventing systems are relatively simple to install and operate but do require O&M over the life of the system to collect air samples, adjust system air injection rates, and monitor system performance. Bioventing is an implementable technology at the Site but pilot testing would be needed to for system design.

2.2.3 In Situ Treatment – AS with SVE

AS, which is also known as "in situ air stripping" and "in situ volatilization," involves the injection of contaminant-free air into the subsurface saturated zone, enabling a phase transfer of hydrocarbons from a dissolved state to a vapor phase. The air is then vented through the unsaturated zone. AS is most often used together with SVE but it can also be used with other remedial technologies. When AS is combined with SVE, the SVE system creates a negative pressure in the unsaturated zone through a series of extraction wells to control the vapor plume migration. This combined system is called AS/SVE.

2.2.3.1 AS with SVE – Effectiveness

When used appropriately, AS has been found to be effective in reducing concentrations of VOCs found in petroleum products at UST sites. AS is generally more applicable to the lighter gasoline constituents (i.e., BTEX), because they readily transfer from the dissolved to the gaseous phase. Appropriate use of air sparging may require that it be combined with other remedial methods (e.g., SVE or pump-and-treat). An AS system can use either vertical or horizontal sparge wells.

A pilot test is recommended for evaluating SVE effectiveness and design parameters for any site, especially where SVE is expected to be only marginally to moderately effective. Pilot studies typically include short-term (1 to 30 days) extraction of soil vapors from a single extraction well, which may be an existing monitoring well at the Site. However, longer pilot studies (up to 6 months) that utilize more than one extraction well may be appropriate for larger sites. Different extraction rates and wellhead vacuums are applied to the extraction wells to determine the optimal operating conditions.

The effectiveness of AS depends primarily on two factors:

- Vapor/dissolved phase partitioning of the constituents determines the equilibrium distribution of a constituent between the dissolved phase and the vapor phase. Vapor/dissolved phase partitioning is, therefore, a significant factor in determining the rate at which dissolved constituents can be transferred to the vapor phase.
- Permeability of the soil determines the rate at which air can be injected into the saturated zone. The permeability of the soil affects the rate of air and vapor movement through the soil; the higher the permeability of the soil, the faster the movement and (ideally) the greater the amount of vapors that can be extracted. It is the other significant factor in determining the mass transfer rate of the constituents from the dissolved phase to the vapor phase.

In general, AS is more effective for constituents with greater volatility and lower solubility and for soils with higher permeability. The rate at which the constituent mass will be removed decreases as AS operations proceed and concentrations of dissolved constituents are reduced.

Soil characteristics will also determine the preferred zones of vapor flow in the vadose zone, thereby indicating the ease with which vapors can be controlled and extracted using SVE (if used). Stratified or highly variable heterogeneous soils typically create the greatest barriers to air sparging. Both the injected air and the stripped vapors will travel along the paths of least resistance (coarse-grained zones) and could travel a great lateral distance from the injection point. This phenomenon could result in the contaminant-laden sparge vapors migrating outside the vapor extraction control area.

The effectiveness of an AS/SVE system would be substantially reduced by the local geology at the Site (thin sand layer sandwiched between low-permeable man-made fill and Bay Muds). The effective recovery of injected air into subsurface strata would also be problematic at the Site.

2.2.3.2 AS with SVE – Implementability

AS/SVE systems are constructed with readily available equipment and are relatively simple to install. They can be installed with relatively little disturbance to existing site operations. An air permit from the Bay Area Air Quality Management District (BAAQMD) will likely be necessary for air emissions from the SVE system. AS/SVE is an implementable technology at the Site but pilot testing would be needed for system design.

2.2.4 Excavation with Ex Situ Treatment

Mechanical excavation has been identified as a potential remedial treatment technology. This technology involves removing contaminated soil with standard construction equipment such as bulldozers and front-end loaders, and backfilling the excavation with clean or treated soil. Excavated soil can be remediated through off-site disposal of soil, on-site land farming at the POTW, on-site biopiles at the POTW, and LTTD.

The 1995 RI/FS and corrective action plan prepared by the Sutton Group identified excavation of contaminated soils followed by on-site landfarming of petroleum-affected soils as the most feasible remedial alternative (The Sutton Group, 1995b). Through discussions with ACEH, the District decided not to excavate the petroleum-affected soil due to concerns that significant underpinning and shoring of the Engineering Building would be necessary. The Mechanical and Engineering Buildings continue to be integral parts of the day-to-day operation of the Oro Loma Sanitary District's sanitary sewer network and POTW, therefore, excavation and ex situ remediation of petroleum hydrocarbons are not considered an implementable technology at the Site.

2.3 COMPARISON OF REMEDIAL TECHNOLOGIES

As discussed in Section 2.2, several in situ and ex situ remedial technologies were evaluated for their effectiveness and implementability to remediate the petroleum constituents identified at the Site. A comparative analysis was conducted to evaluate the performance of the remedial technologies (Table 9). Based on the comparative analysis and existing site data, in situ bioremediation using ORC is potentially a good candidate for reducing the mass of petroleum-related constituents and achieving site closure. Additional data needs to be collected to evaluate if bioremediation using ORC is technically and economically feasible to treat the concentrations of TPH as gasoline and BTEX reported at the Site.

Since ORC is a passive, in situ approach, substantial design, capital, and O&M costs are avoided. Actively engineered systems such as pump and treat or air sparging with SVE are expensive, time-consuming, and often require extensive system design. Furthermore, by providing a constant, steady oxygen source, ORC reduces operations and maintenance (O&M) costs compared to the repeated or continuous injections associated with other chemical oxygen sources.

The use of ORC eliminates the long-term monitoring costs associated with natural attenuation. By accelerating the rate of natural attenuation, ORC decreases the time to site closure. This eliminates the cost of long-term quarterly or yearly monitoring events that would be required for unassisted natural attenuation. Treatment with ORC is typically:

- ¼ to ½ the cost of air sparging with vapor containment
- Equal to or less than the cost of excavation, hauling, and disposal of residual hydrocarbons from the bottom of excavations
- Less than the long-term monitoring costs of unassisted natural attenuation sites

- ¼ to ½ the cost of using a pump and treat system.

In situ remediation using bioventing and AS with SVE are not considered to be effective technologies to achieve site closure due to the shallow depth to groundwater and the low permeability of the Bay Muds that are predominant at the Site. The excavation and ex situ remediation of petroleum hydrocarbons are not considered an implementable technology at the Site because of concerns that significant underpinning and shoring of the Engineering Building would be necessary.

3.0 WORK PLAN

The following section outlines the additional proposed field activities that are necessary to address site data gaps and collect additional information needed to further evaluate the effectiveness and cost of implementing bioremediation using ORC. Data collected during the proposed field activities will be used to develop a CAP that identifies the selected remedial technology to achieve site closure.

3.1 PROPOSED SITE ACTIVITIES

Three data gaps have been identified at the Site including:

- The vertical extent of the petroleum hydrocarbon plume has not been delineated with confirmation soil samples in and around the vicinity of the former UST. Once the vertical extent of contamination is determined, the volume of petroleum-affected soil and groundwater can be determined.

- Confirmation that floating product is not present in the interior portions of the groundwater plume.

- Site-specific information on numerous geochemical parameters including DO concentrations, ORP, dissolved iron and manganese concentrations, BOD, and COD is necessary to complete the evaluation of the effectiveness and costs for remediation using ORC.

3.1.1 Delineating the Vertical Extent of Petroleum-Affected Soil

The vertical extent of petroleum-affected soil will be delineated by advancing three Geoprobe soil borings in the vicinity of the former UST area and collecting soil samples several feet below the lower interface between the thin sand layer and the Bay mud. Soil samples will be collected from multiple intervals at depths greater than 7 ½ feet bgs to ensure that the vertical extent of petroleum hydrocarbons in soil is fully characterized.

Soil samples will be collected using a 4-foot-long, 1.5-inch-diameter Geoprobe sampling spoon (macro core) with polyethylene terephthalate glycol (PETG) liners (or equivalent), which are transparent and inert to petroleum hydrocarbons. Discrete soil samples for laboratory analysis of TPH as gasoline, BTEX, and MTBE will be collected and submitted to the analytical laboratory. For quality assurance/quality control (QA/QC), one QC trip blank will be included in each cooler and the trip blank analyzed for the same analytical methods as the soil samples being shipped in the cooler.

An interface probe will be used to measure depth to groundwater and monitor the presence or absence of floating product in the Geoprobe borings. A lithologic log of each boring will be prepared using the United Soil Classified System (USCS). Soil samples will be screened on site using a photoionization detector (PID). Samples will be labeled with the project number, boring number, sample depth interval, date of collection, and analytical method required. Soil samples will be packaged, preserved, and shipped to the analytical laboratory under a chain of custody form in accordance with standard U.S. Environmental Protection Agency (EPA) protocol. Grab groundwater samples will not be collected from the three Geoprobe borings. The locations of the proposed soil borings are shown on Figure 6.

3.1.2 Monitoring the Presence or Absence of Floating Product

An interface probe will be used to monitor for the presence or absence of floating product during the proposed Geoprobe soil investigation and also during the upcoming April 2004 and future quarterly groundwater monitoring well sampling events. The interface probe is a proven technology that detects the presence of NAPLs in groundwater. Measurements of depth to groundwater and the presence or absence floating product will be recorded in the field on water-quality forms.

3.1.3 Sampling Monitoring Wells for Geochemical Parameters

Geochemical parameters including DO, ORP, dissolved iron and manganese concentrations, BOD, and COD will be monitored during the quarterly groundwater monitoring well sampling scheduled in April 2004. The samples for geochemical parameters will be collected after three well volumes are purged from the monitoring wells. DO and ORP measurements will be performed in the field along with temperature, conductivity, and pH using a field test meter. Samples will be collected for dissolved iron, dissolved manganese, BOD, and COD and immediately submitted to a State-certified laboratory. The samples submitted to the analytical laboratory will be immediately filtered through a 0.45-micron filer and preserved with nitric acid as specified in the respective EPA method protocols.

3.2 UNDERGROUND UTILITY LOCATION

The planned soil boring investigation will involve intrusive tasks, as a result, care must be exercised to ensure personnel safety and to protect underground utilities from potential damage. Existing engineering plans, drawings, diagrams, and other information showing underground utilities will be used to reposition the proposed soil boring locations, if necessary. Underground Services Alert (USA) will also be notified after the proposed boring locations have been marked in the field.

3.3 PERMITTING

A drilling permit for the three proposed soil borings will be obtained through ACEH.

3.4 INVESTIGATION DERIVED WASTE

Soil generated during the advancement of Geoprobe borings will be placed on visqueen at a designated location at the Site, for eventual disposition by the District. Purge water collected from monitoring wells will be temporarily contained in 55-gallon drums at the Site and later, with District approval, discharged into the sanitary sewer system for treatment at the District's POTW.

3.5 EVALUATION AND REPORTING

The Sutton Group will evaluate the data collected during the field investigation and upcoming April quarterly monitoring event and prepare a CAP report outlining the proposed remedial action to achieve site closure. The CAP report will evaluate if bioremediation using ORC is technically and economically feasible for the concentrations of TPH as gasoline, BTEX, and MTBE that have been reported at the Site.

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The Sutton Group. 1997. "Work Plan for Supplemental Site Evaluation in the vicinity of the former site of the 1,000 Gallon Gasoline Tank at the Oro Loma Sanitary District Service Center, San Lorenzo, California." October.

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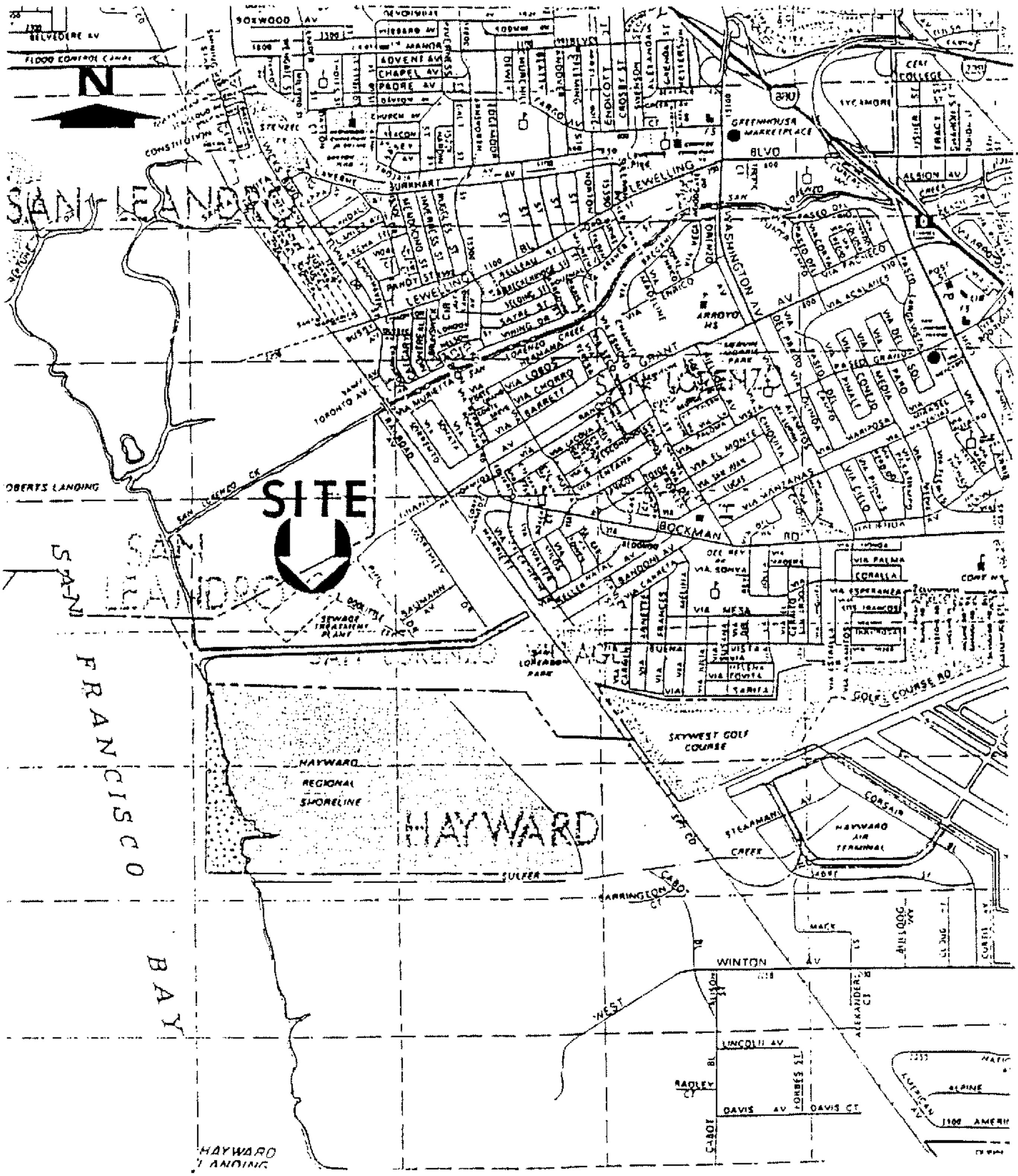

SOURCE: THOMAS BROS MAPS. ALAMEDA COUNTY. CALIFORNIA   Scale 1" = 2500 feet

THE SUTTON GROUP

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SITE LOCATION MAP

WORK PLAN FOR MONITORING WELL INSTALLATION

1,000 Gallon Gasoline Tank Site

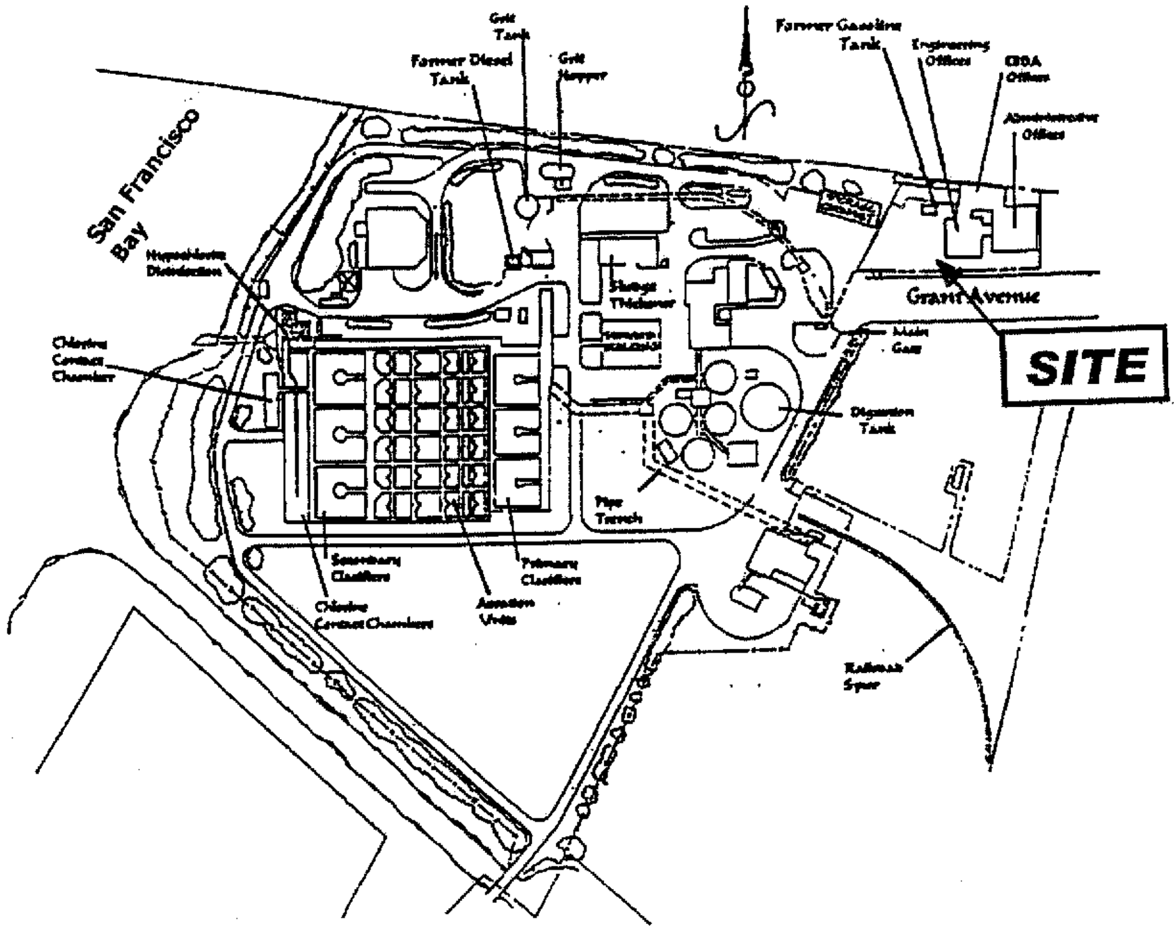
ORO LOMA SANITARY DISTRICT

San Lorenzo, California

PROJECT No. 3022.9

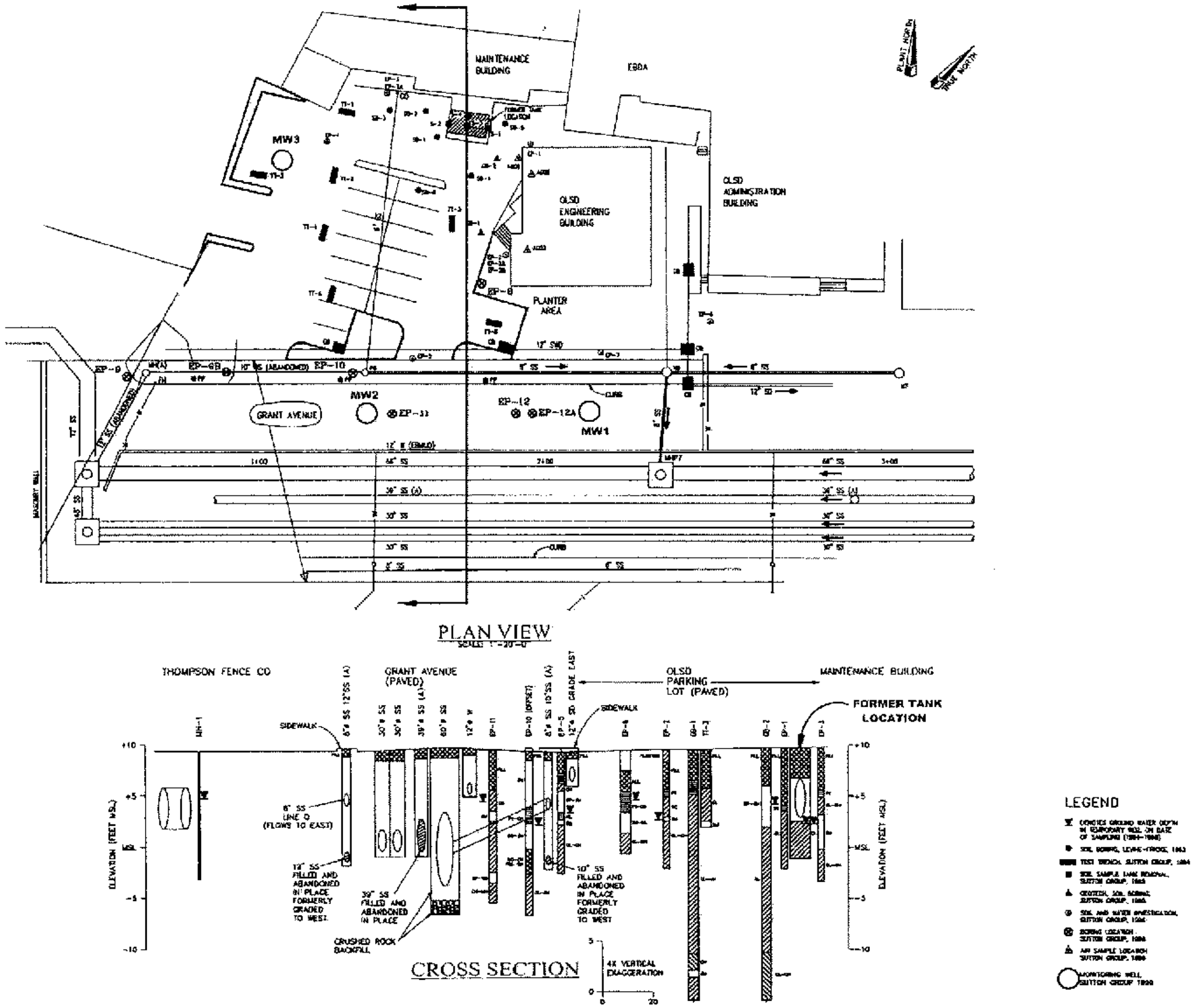
FIGURE 1

Revision o 12/21/98



THE SUTTON GROUP	PLANT AREA MAP	PROJECT No. 3022.10
Engineering and Environmental Services 3708 Mount Diablo Blvd, Suite 215 Lafayette, California, 94549 Phone: (925).284-4208 Fax: (925).284-4189	ORO LOMA SANITARY DISTRICT SERVICE CENTER 2600 GRANT AVENUE, SAN LORENZO, CA	**FIGURE 2** 4/29/02

3022.10 WP Fig2



Revision	Description	Submit	Appr'd	Date
Refer to Original for Latest Revision				

Reference Information and Notes:

Designed: JRS
Drawn: JRS
Checked: JRS
Date: 4/30/02

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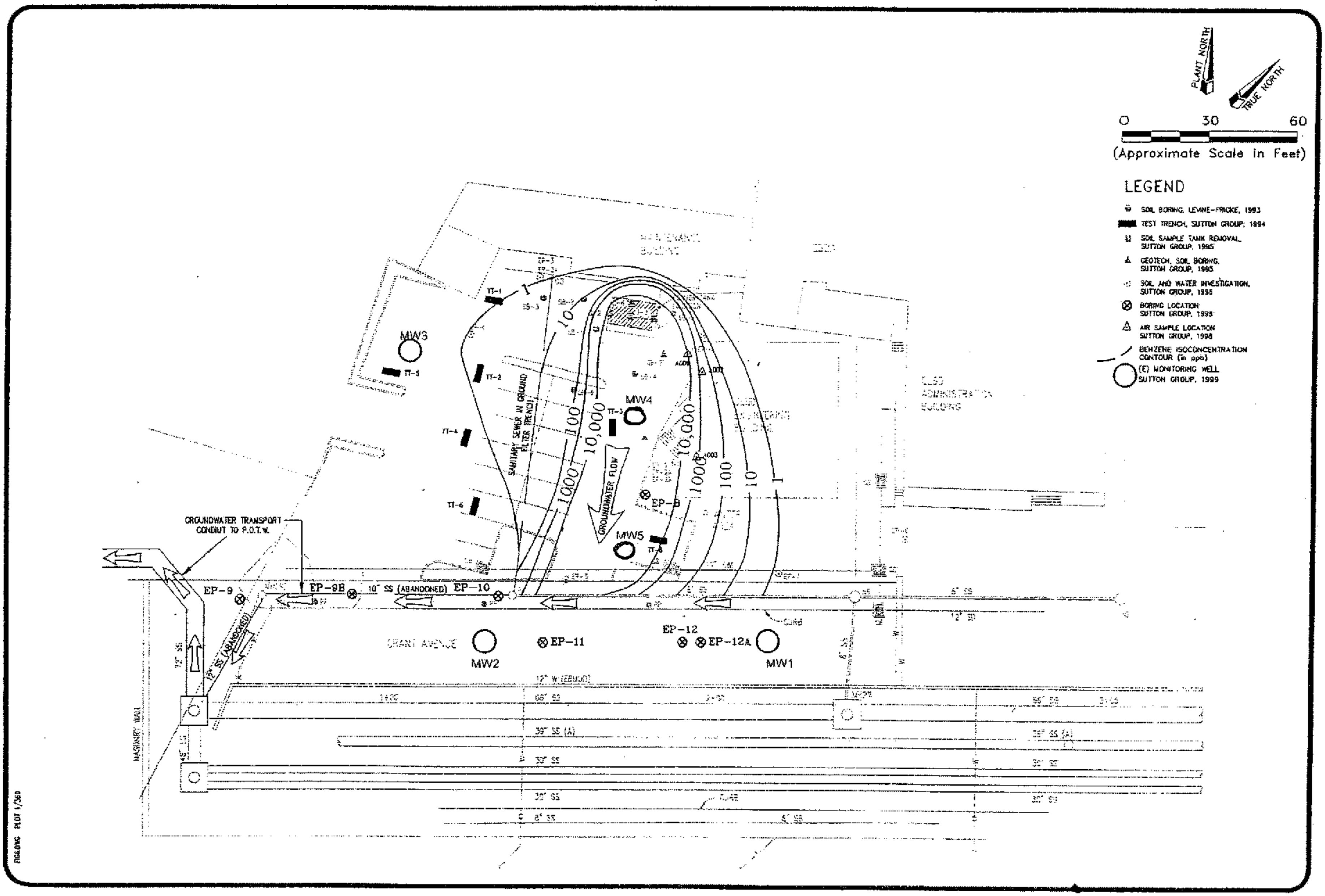
ORO LOMA SANITARY DISTRICT

Gasoline Tank Area
Site Plan & Cross Section

Scale: AS SHOWN
Job No. 3022.10
Sheet: FIGURE 3



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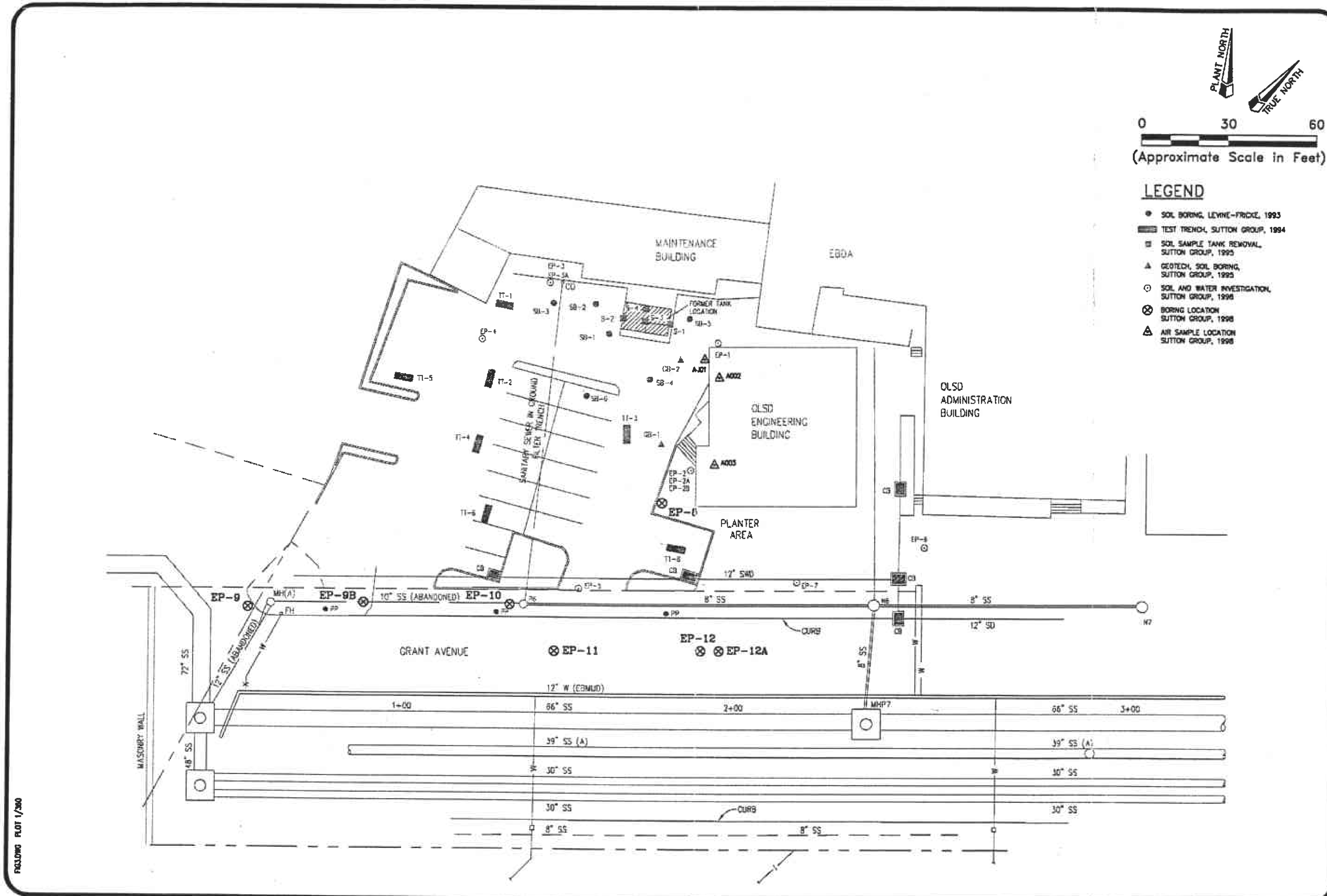
Benzene Plume Map

Gasoline Tank Area
ORO LOMA SANITARY DISTRICT
SAN LORENZO, CALIFORNIA

PROJECT NO. 3022.10

FIGURE 4

04/30/02



PROJECT NO. 3022.8

FIGURE 5

Location of Borings for 1993 Investigation, 1995 Geotechnical Investigation, 1996 Investigation, and 1998 Supplemental Investigation

ORO LOMA SANITARY DISTRICT
SAN LORENZO, CALIFORNIA

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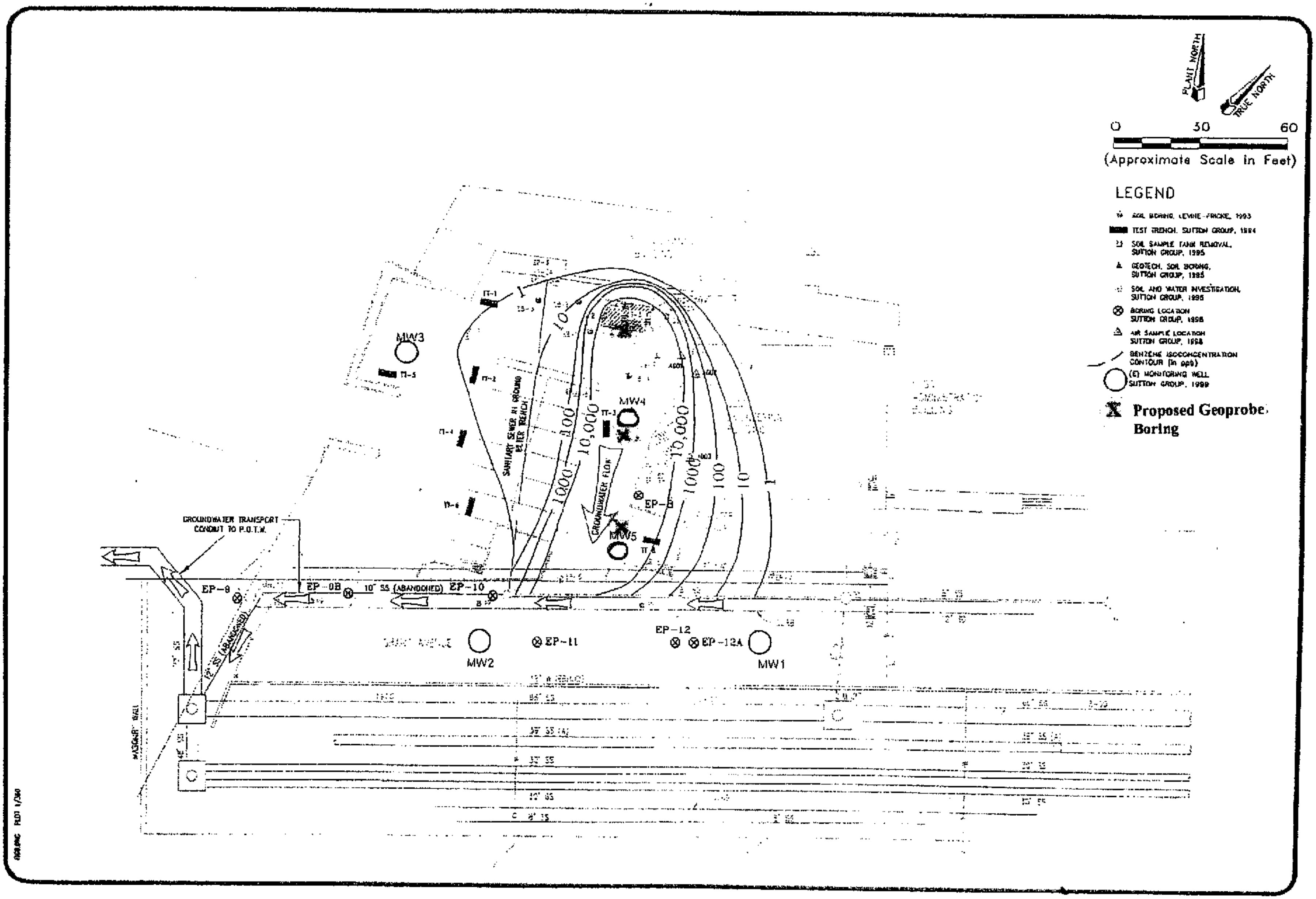

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Proposed Geoprobe Boring Locations

Gasoline Tank Area
ORO LOMA SANITARY DISTRICT
SAN LORENZO, CALIFORNIA

PROJECT NO. 3022.10

FIGURE 6

04/30/02

Table 1
Analytical Results for Soil and Groundwater, 1993 Investigation
Former 1,000-Gallon UST Site, Oro Loma Sanitary District
San Lorenzo, CA

Analytical Results - Soil Samples							
Boring ID	**Depth** (ft)	**TPH-g** (mg/kg)	**Benzene** (mg/kg)	**Toluene** (mg/kg)	**Ethyl Benzene** (mg/kg)	**Xylenes** (mg/kg)	**Lead, total** (mg/kg)
SB1	5.5	2,100	23	200	55	330	NA
SB2	3.5	4,300	14	250	130	680	NA
SB4	3.5	1,100	11	51	39	210	NA
SB5	3.5	3.2	0.25	ND	0.27	0.83	NA
SB6	3.5	160	2.8	14	5.9	26	NA
SB6	5.5	2,100	14	210	80	430	NA
SB6	7.5	1,500	4.8	120	61	340	NA
MDLs*	soil (mg/kg)	0.2	0.005	0.005	0.005	0.005	5
Analytical Results - Grab Groundwater Samples							
		(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
SB3	GW	**0.12**	**0.0007**	ND	ND	ND	NA
SB4	GW	**1,600**	**27**	**39**	**4.2**	**22**	NA
SB5	GW	**1,100**	**8**	**29**	**4.2**	**20**	NA
MDLs*	water (mg/l)	0.05	0.0005	0.0005	0.0005	0.0005	NA

Notes:

GW = groundwater
mg/kg = milligrams per kilogram
mg/l = milligrams per liter
MDL = method detection limits
NA = not analyzed
ND = not detected at concentration greater than MDL
TPH-g = total petroleum hydrocarbons as gasoline
* Refer to laboratory report for complete listing of results

Table 2
Analytical Results for Soil, 1994 Investigation
Former 1,000-Gallon UST Site, Oro Loma Sanitary District
San Lorenzo, CA

Analytical Results - Soil Samples								
Trench No.	Sample Depth (ft)	TPH-g (mg/kg)	Benzene (mg/kg)	Toluene (mg/kg)	Ethyl Benzene (mg/kg)	Xylenes (mg/kg)	LEAD, total (mg/kg)	LEAD, sol. (mg/kg)
TT-1	4.5-5.0	ND	ND	ND	ND	ND	**57**	**1.8**
TT-2	2.5-3.0	ND	ND	ND	ND	**0.007**	ND	--
TT-2	6.0-6.5	ND	ND	ND	ND	ND	**21**	--
TT-2	7.0-7.5	ND	**0.015**	ND	ND	**0.015**	**15**	--
TT-3	2.0-2.5	ND	ND	ND	ND	ND	ND	--
TT-3	3.5-4.0	**160**	**4.7**	**25**	**4.6**	**22**	**31**	**5.3**
TT-3	6.0-6.5	**1,600**	**8.8**	**77**	**25**	**130**	**7.4**	--
TT-4	5.0-5.5	ND	ND	**0.009**	ND	**0.008**	**9.3**	--
TT-5	2.5-3.0	ND	ND	ND	ND	ND	ND	--
TT-5	5.5-6.0	ND	ND	ND	ND	ND	**37**	**0.2**
TT-8	2.0-2.5	ND	ND	ND	ND	ND	ND	--
MDLs*	soil (mg/kg)	1.0	0.005	0.005	0.005	0.005	5	0.1

Notes:

mg/kg = milligrams per kilogram

mg/l = milligrams per liter

MDL = method detection limits

ND = not detected at concentration greater than MDL

TPH-g = total petroleum hydrocarbons as gasoline

TT = test trench

* Refer to Laboratory Report for complete listing of results

Table 3
Analytical Results for Soil Samples - 1995 UST Removal
Former 1,000-Gallon UST Site, Oro Loma Sanitary District
San Lorenzo, CA

Analytical Results - Soil Samples										
Sample ID	**Location**	**Depth** ft	**TPH-gas** (mg/kg)	**Benzene** (mg/kg)	**Toluene** (mg/kg)	**Ethyl Benzene** (mg/kg)	**Xylenes** (mg/kg)	**Lead, total** (mg/kg)	**Lead, sol.** (mg/kg)
S1	East End of Tank Pit	5.8	**1,900**	**7.1**	**57**	39	**190**	**18**	NA
S2	West End of Tank Pit	6	**3,300**	**37**	**18**	**61**	**350**	**260**	**6.4**
S3	Center of Tank Pit	11.5	**43**	**0.3**	**0.56**	**0.41**	**1.7**	ND	NA
S4	Island: beneath fuel pipe	1.5	**49**	**0.25**	**0.28**	**0.45**	**2.6**	**15**	NA
MDLs*			0.2	0.005	0.005	0.005	0.005	5	0.1

Notes:

mg/kg = milligrams per kilogram
MDL = method detection limits
NA = not analyzed
ND = not detected at concentration greater than MDL
TPH-g = total petroleum hydrocarbons as gasoline
* Refer to laboratory report for complete listing of results

Table 4
Analytical Results for Soil and Groundwater, 1996 Investigation
Former 1,000-Gallon UST Site, Oro Loma Sanitary District
San Lorenzo, CA

Analytical Results - Soil Samples								
Boring ID	**Depth**	**TPH-g**	**Benzene**	**Toluene**	**Ethyl Benzene**	**Total Xylenes**	**MTBE**	**Lead, total**
	(ft)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
EP-1	6.5-7	**4.5**	ND	ND	ND	**0.059**	ND	**7.7**
EP-2	6.5-7	**1,800**	**21**	**120**	**3.5**	**180**	ND*	**16**
EP-2B	2.5-3	ND	ND	ND	ND	ND	NA	**13**
EP-2B	3.1-3.6	ND	ND	ND	ND	ND	NA	ND
EP-3[1]	3.0-3.5	(810)	(8.7)	(47)	(14)	(72)	NA	NA
EP-3	6.5-7	**5.3**	ND	ND	ND	**0.036**	ND	ND
EP-3A	1.5-2	ND	ND	ND	ND	ND	NA	NA
EP-3B	3.5-4	ND	ND	ND	ND	ND	ND	NA
EP-3B	4.5-5	**1.5**	ND	ND	ND	**0.01**	NA	NA
EP-5	3.5-4	**29**	**1.5**	**0.24**	**0.9**	**2.2**	NA	**49**
EP-6	3.5-4	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**46**
MDLs*	soil (mg/kg)	1	0.005	0.005	0.005	0.005	0.25 - 6	5
Analytical Results - Grab Groundwater Samples								
		(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
EP-1	GW	**0.51***	**0.031***	0.0074*	0.0038*	0.015*	0.019*	ND
EP-2	GW	**230***	**23***	**47***	**4.3***	**21***	**3.9***	0.000074*
EP-3	GW	**0.21**	**0.0058**	**0.0026**	**0.001**	**0.031**	**0.0054**	0.000016
EP-4	GW	**ND**	**0.0023**	**0.00097**	**ND**	**0.00059**	**0.036**	0.000015
EP-5	GW	**64***	**8.8***	**4.8***	**1.1***	**4.8***	**ND***	ND
EP-6	GW	**ND**	**ND**	**0.00099**	**ND**	**0.001**	**ND**	0.000019
EP-7	GW	ND	0.00053	0.0021	0.00053	0.0029	ND	ND
MDLs*	water (mg/l)	0.05	0.0005	0.0005	0.0005	0.0005	0.0025	NA

Notes:

GW = groundwater

mg/kg = milligrams per kilogram

mg/l = milligrams per liter

MDL = method detection limits

MTBE = methyl-tert butyl ether

NA = not analyzed

ND = not detected at concentration greater than MDL

TPH-g = total petroleum hydrocarbons as gasoline

* Indicates detection limits raised due to positive gasoline result. Refer to laboratory report for detection limits for noted sample.

Table 5
Analytical Results for Soil and Groundwater, 1998 Supplemental Investigation
Former 1,000-Gallon UST Site, Oro Loma Sanitary District
San Lorenzo, CA

Analytical Results - Soil Samples								
Boring ID	**Depth** (ft)	**TPH-g** (mg/kg)	**Benzene** (mg/kg)	**Toluene** (mg/kg)	**Ethyl Benzene** (mg/kg)	**Total Xylenes** (mg/kg)	**MTBE** (mg/kg)	**Lead, total** (mg/kg)
EP-8	3.5-4	NA	ND	ND	ND	ND	NA	NA
EP-9	3.5-4	NA	ND	**0.005**	ND	ND	NA	NA
EP-9B	6-6.5	NA	ND	ND	ND	ND	NA	NA
EP-10	NS	NS	NS	NS	NS	NS	NS	NS
EP-11	2.5-3	NA	ND	ND	ND	ND	NA	NA
EP-12	3.5-4	NA	ND	**0.007**	ND	**0.014**	NA	NA
MDLs*	soil (mg/kg)	--	0.005	0.005	0.005	0.005	--	--
Analytical Results - Grab Groundwater Samples								
		(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
EP-8	GW	NA	**24***	**44***	NA	NA	**4.9**	NA
EP-10	GW	NA	**12***	**13***	NA	NA	**1.1***	NA
EP-9B	GW	NA	**0.00081**	ND	NA	NA	**0.0052**	NA
EP-9	GW	NA	ND	ND	NA	NA	ND	NA
EP-11	GW	NA	ND	ND	NA	NA	ND	NA
EP-12	GW	NA	ND	ND	NA	NA	ND	NA
MDLs*	water (mg/l)	0.05	0.0005	0.0005	0.0005	0.0005	0.0025	NA

Notes:

GW = groundwater

mg/kg = milligrams per kilogram

mg/l = milligrams per liter

MDL = method detection limits

MTBE = methyl-tert butyl ether

NA = not analyzed

ND = not detected at concentration greater than MDL

NS = not sampled

TPH-g = total petroleum hydrocarbons as gasoline

* Indicates detection limits raised due to positive gasoline result. Refer to laboratory report for detection limits for noted sample.

Table 6
Analytical Results for Quarterly Monitoring Well Groundwater Samples
Former 1,000-Gallon UST Site, Oro Loma Sanitary District
San Lorenzo, CA

Sample Location	Sample Date	TPH-g ug/l	Benzene ug/l	Toluene ug/l	Ethyl Benzene ug/l	Xylenes (total) ug/l	MTBE ug/l
MW-1	2/19/99	ND	ND	ND	ND	ND	ND
	5/10/99	ND	ND	ND	ND	ND	ND
	8/30/99	NA	ND	ND	ND	ND	ND
	11/23/99	ND	ND	ND	ND	ND	ND
(Dup)	11/23/99	ND	ND	ND	ND	ND	ND
	7/25/03	ND	ND	ND	ND	ND	ND
	10/30/03	NA					
MW-2	2/19/99	ND	ND	ND	ND	ND	ND
	5/10/99	ND	ND	ND	ND	ND	ND
	8/30/99	NA	ND	ND	ND	ND	ND
	11/23/99	ND	ND	ND	ND	ND	ND
	7/25/03	ND	ND	ND	ND	ND	< 1
	10/30/03	NA					
MW-3	2/19/99	ND	ND	ND	ND	ND	**1.5** (1)
DUP	2/19/99	ND	ND	ND	ND	ND	NA
	5/10/99	ND	ND	ND	ND	ND	**1.5** (2)
	8/30/99	NA	ND	ND	ND	ND	ND
	11/23/99	ND	ND	0.69 (3)	0.58 (3)	1.3 (3)	**ND**
	1/6/00	ND	ND	ND	ND	ND	**3.1** (4)
DUP	1/6/00	ND	ND	ND	ND	ND	**2.6** (4)
MW-4	10/21/02	NA	5,800	6,200	3,500	18,000	140
	1/28/03	NA	7,200	3,500	2,700	15,000	130
	4/28/03	NA	5,700	850	ND<120	10,000	200
	7/25/03	97,000	11,000	8,400	4,900	24,000	ND<250
	10/30/03	77,000	12,000	9,300	3,200	16,000	ND<200
MW-5	12/21/02	65,000	12,000*	20,000*	1,600*	7,100*	ND<100
	1/28/03	NA	9,100	6,600	720	4,000	ND<100
	4/28/03	NA	12,000	8,300	ND<250	2,100	ND<250
	7/25/03	62,000	13,000	14,000	1,300	5,200	ND<250
	10/30/03	33,000	7,500	2,200	490	1,600	ND<100
Reporting Limits		50.0	0.50	0.50	0.50	0.50	2.00 u/n

Notes:

ND = not detected at concentration greater than reporting limit. NA = not analyzed.

u/n = unless noted otherwise, reporting limit.

(1) Analyzed by EPA Method 8260B. Reporting limit was 1 ug/l.

(2) Estimated · Estimated value below method reporting limit of 2 ug/l.

(3) Inconsistent contaminant pattern reported. Sample result spurious and resampled.

(4) Resampled and analyzed at different laboratory. Reporting limit at 2.5 ug/l.

Table 7
Analytical Results for Soil Samples Collected at Monitoring Well Locations
Former 1,000-Gallon UST Site, Oro Loma Sanitary District
San Lorenzo, CA

Sample Location	Sample Depth (ft)	Sample Date	TPH-g mg/kg	Benzene mg/kg	Toluene mg/kg	Ethyl Benzene mg/kg	Xylenes (total) mg/kg
MW-1	3.5 - 4	2/12/1999	ND	ND	ND	ND	ND
MW-2	3.5 - 4	2/12/1999	1.35	0.004	ND	ND	ND
	5.5 - 6	2/12/1999	ND	ND	ND	ND	ND
MW-3	3.5 - 4	2/12/1999	ND	ND	ND	ND	ND
	6 - 6.5	2/12/1999	ND	ND	ND	ND	ND
Reporting Limits			0.4	0.002	0.002	0.002	0.004

Notes:

mg/kg = milligrams per kilogram
MW = monitoring well
ND = not detected at concentration greater than reporting limit.
TPH-g = total petroleum hydrocarbon as gasoline

Table 8
Analytical Results for Monitoring Well Groundwater Samples for Selected Oxygenates and Additives
Former 1,000-Gallon UST Site, Oro Loma Sanitary District
San Lorenzo, CA

Sample Location	Sample Date	TAME	TBA	DIPE	EDB	EDC / 1,2 DCA)	Ethanol	ETBE	MTBE
		ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
MW-1	2/19/1999	ND	ND	ND	ND	ND	ND	ND	ND
MW-2	2/19/1999	ND	ND	ND	ND	ND	ND	ND	ND
MW-3	2/19/1999	ND	ND	ND	ND	ND	ND	ND	1.49
Reporting Limits		1.0	20.0	1.0	0.5	0.5	100	1.0	1.0

Notes:

DIPE = Di-Isopropyl Ether
EDB = 1,2 Dibromo Ethane
EDC = 1.2 Dichloro Ethane
ETBE = Ethyl Tert-butyl Ether
MTBE = Methyl-tert Butyl Ether
ND = not detected at concentration greater than reporting limit.
TAME = Tert-amyl Methyl Ether
TBA = Tert-butyl Alcohol
ug/l - micrograms per liter (parts per billion).

Samples analyzed per EPA Methods 8015M and 8020.

Table 9
Analysis of In Situ and Ex Situ Remedial Technologies
Former 1,000-Gallon UST Site, Oro Lomo Sanitary District
San Lorenzo, CA

	In Situ Remedial Technologies			Ex Site Remedial Technologies
Evaluation Criteria	Bioremediation using ORC	Bioventing	AS with SVE	Excavation with Off-Site or On-Site Treatment and Disposal [a]
Effectiveness	0 [b]	-1	-1	+1
Implementability	+1	-1	+1	-1
Overall Rating	**+1**	**0**	**0**	**0**

Notes:

+1 = best performance for meeting evaluation criteria
0 = moderate performance for meeting evaluation criteria
-1 = worst performance for meeting evalulation criteria
(a) On-site treatment technologies include land farming or biopiles at the POTW and low-temperature termal desorption
(b) Additional data need to be collected to further evaluated the effectiveness and costs of ORC at the site.
AS = air sparging
ORC = oxygen release compound
SVE = soil vapor extraction